Supporting Information

The Synthesis of Cycloalka[*b*]furans via an Au(I)-Catalyzed Tandem Reaction of 3-Yne-1,2-diols

Wei-Ting Liu,[†] Zheng-Liang Xu,[†] Xue-Qing Mou,[†] Jie Wang,[†] Bang-Hong Zhang,[†] Wen Bao,[†] Shao-Hua Wang, *[†‡] Dongjun Lee,[†] Lin-Sheng Lei[†]

[†] *School of Pharmacy & State Key Laboratory of Applied Organic Chemistry Lanzhou University, Lanzhou 730000, P. R. China;* [‡]*Key Laboratory of Drug Targeting and Drug Delivery System, Ministry of Education, Sichuan University, Chengdu, P. R. China.*

Email: wangshh@lzu.edu.cn

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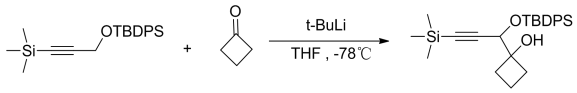
1. General information:

All reactions under standard conditions were carried out under air or argon, dry atmosphere and monitored by thin-layer chromatography (TLC) on gel F254 plates. All products were purified through silica gel chromatography (200~300 mesh). Column chromatography was carried out with light petroleum ether (bp. 60~90 ºC), ethyl acetate and dichloromethane as eluent. ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$, acetone-d_6 or C_6D_6 on 400 MHz instruments and spectral data were reported in ppm. High-resolution mass spectral analysis (HRMS) data were measured on the Apex II by means of the ESI technique. Melting point was measured with SGW-X4B instrument.

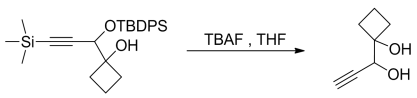
2. Preparation and characterization of substrates

Substrates **1a**, **1b**, **1e**, **1q** were prepared using a known strategy.[1] However, the other Substrates were prepared by the improved way showing below.

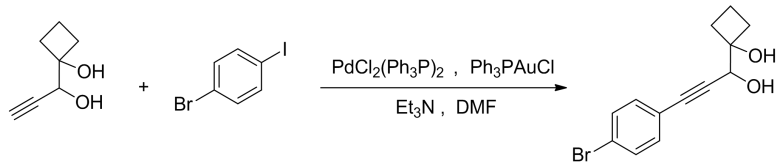
To a solution of trimethylsilylacetylene (5.56 g, 8 mL, 57 mmol) in dry tetrahydrofuran was added *n*-butyllithium (2.5 M in *n*-hexane) (25 mL, 62.7 mmol) at -78 ºC under argon atmosphere. Then transferred the reaction flask to room temperature. After the reaction mixture was stirred for 1 h, Paraformaldehyde (2.7 g, 91.2 mmol) was added. Then raised the temperature to 45 ºC and stirred the reaction mixture for another 4 h, the reaction mixture would be very thickness. At this time, TBDPSCl (19.8 g, 17 mL, 68.4 mmol) and imidazole (7.6 g, 119.7 mmol) was added. Stirred for 15 min. The aqueous layer was extracted three times with EtOAc and the combined organic layers were washed with brine, dried over sodium sulfate, and evaporated to dryness and purified by column chromatography to afford pure desired product (16.7 g, 82%).



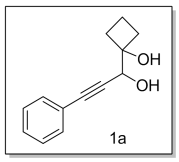
To a solution of tert-butyldiphenyl ((3-(trimethylsilyl) prop-2-yn-1-yl)oxy) silane (3.5 g, 5.41 mmol) in dry tetrahydrofuran was added tert-butyllithium (*t*-BuLi) (1.3 M in *n*-hexane) (8.3 mL, 10.81 mmol) at -78 ºC under argon atmosphere. After the reaction mixture was stirred for 2 h at the same temperature, cyclobutanone (1.61 mL, 21.63 mmol) was added dropwise. The reaction mixture was stirred for another 2 h. Upon completion of the reaction (monitored by TLC). The reaction mixture was quenched by slow addition of aqueous solution of saturated ammonium chloride solution. The aqueous layer was extracted three times with EtOAc and the combined organic layers were washed with brine, dried over sodium sulfate, and evaporated to dryness and purified by column chromatography to afford pure desired product (1.90 g, 80% yield).



To a stirred solution of 1-(1-((tert-butyldiphenylsilyl)oxy)-3-phenylprop-2-yn-1-yl) cyclobutanol (1.90 g, 4.31 mmol) in dry tetrahydrofuran (30 mL) was added tetrabutylammonium fluoride (2.26 g, 8.64 mmol) at room temperature under argon atmosphere. The reaction mixture was stirred for 1 h. Upon completion of the reaction (monitored by TLC), the reaction mixture was quenched by slow addition of water. The aqueous layer was extracted three times with EtOAc and the combined organic layers were washed with brine, dried over sodium sulfate, and evaporated to dryness and purified by column chromatography to afford pure desired product 1r (0.77 g, 88% yield) as a colorless oil.

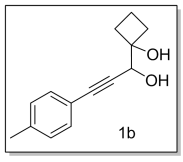


This reaction was referenced the strategy designed by Panda.[2] To a 20 mL test tube equipped with a magnetic stir bar was added 1-bromo-4-iodobenzene (247 mg, 0.87 mmol), 1r (100 mg, 0.79 mmol), dissolved with 1 mL DMF. Then the tube was filled with argon, $PdCl_2(Ph_3P)_2$ (11 mg, 0.16 mmol), Ph_3PAuCl (7.8 mg, 0.16 mmol) and Et_3N (330 μL, 2.38 mmol). The reaction mixture was stired for 4 h. After 4 h, the reaction was quenched by 3 mL water and the aqueous layer was extracted three times with EtOAc and the combined organic layers were washed with brine, dried over sodium sulfate, and evaporated to dryness and purified by column chromatography to afford pure desired product (1l) 1-(3-(4-bromophenyl)-1-hydroxyprop-2-yn-1-yl) cyclobutanol as a colorless amorphous solid.



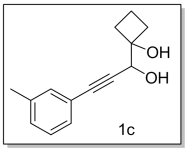
1-(3-phenylprop-2-yn-1-yl)cyclobutanol **(1a)**

1a as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.48–7.42 (m, 2H), 7.33–7.27 (m, 3H), 4.57 (s, 1H), 2.81(s, 2H), 2.40–2.24 (m, 2H), 2.20–2.06 (m, 2H), 1.92–1.80 (m, 1H), 1.68 (m, 1H); **^{13}CNMR** (100 MHz, $CDCl_3$) δ 131.80, 128.58, 128.27, 122.20, 86.71, 85.61, 68.09, 32.07, 31.69, 11.98; **HRMS** (ESI) calcd for $C_{13}H_{14}O_2$ $[M+NH_4]^+$: 220.1332, found 220.1329.



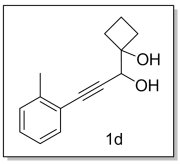
1-(3-(p-tolyl)prop-2-yn-1-yl)cyclobutanol **(1b)**

1b as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.34 (d, *J* = 8.1 Hz, 2H), 7.08 (d, *J* = 8.0 Hz, 2H), 4. 57 (s, 1H), 3.38 (s, 2H), 2.39–2.24 (m, 5H), 2.20–2.06 (m, 2H), 1.90–1.75 (m, 1H), 1.73–1.54 (m, 1 H);**^{13}C NMR** (100 MHz, $CDCl_3$) δ 138.73, 131.80, 129.09, 119.28, 86.24, 85.72, 76.78, 68.14, 32.06, 31.85, 21.52, 12.15; **HRMS** (ESI) calcd for $C_{14}H_{16}O_2$ $[M+NH_4]^+$: 234.1489, found 234.1486.



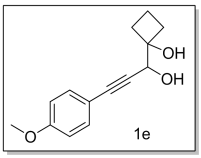
1-(1-hydroxy-3-(m-tolyl)prop-2-yn-1-yl)cyclobutanol (**1c**)

1c as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.27–7.14 (m, 4H), 4.56 (s, 1H), 2.47 (s, 2H), 2.38–2.30 (m, 5H), 2.19–2.09 (m, 2H), 1.93–1.83 (m, 1H), 1.75–1.72 (m, 2H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 138.07, 132.42, 129.57, 128.91, 128.24, 121.96, 86.20, 85.93, 76.64, 68.21, 32.19, 31.62, 21.18, 11.98; **HRMS** (ESI) calcd for $C_{14}H_{16}O_2$ $[M+Na]^+$: 239.1043, found 239.1039.



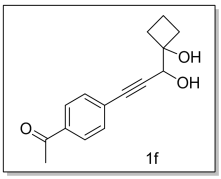
1-(1-hydroxy-3-(o-tolyl)prop-2-yn-1-yl)cyclobutanol **(1d)**

1d as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.42 (d, *J* = 8.0 Hz, 1H), 7.26 – 7.19 (m, 2H), 7.14 (d, J = 6.6 Hz, 1H), 4.61 (s, 1H), 2.49 – 2.39 (m, 4H), 2.38 – 2.33 (m, 2H), 2.26 – 2.11 (m, 3H), 1.89 (d, J = 10.8 Hz, 1H), 1.71 – 1.69 (m, 1H); **^{13}C NMR** (101 MHz, Acetone) δ 140.90, 132.73, 130.35, 129.17, 126.55, 123.88, 94.40, 83.40, 77.28, 68.75, 32.67, 29.65, 20.84, 12.81; **HRMS** (ESI) calcd for $C_{14}H_{16}O_2$ $[M+NH_4]^+$: 234.1489, found 234.1488.



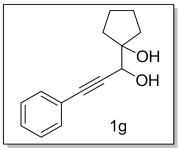
1-(1-hydroxy-3-(4-methoxyphenyl)prop-2-yn-1-yl)cyclobutanol **(1e)**

1e as a colorless oil. **^{1}H NMR** (300 MHz, $CDCl_3$) δ 7.50–7.33 (m, 2H), 6.90–6.75 (m, 2H), 4.55(s, 1H), 3.80 (s, 3H), 2.71 (s, 2H), 2.39–2.24 (m, 2H), 2.21–2.04 (m, 2H), 1.93–1.80 (m,1H), 1.73–1.61 (m, 1H); **^{13}C NMR** (75 MHz, $CDCl_3$) δ 159.77, 133.28, 114.20, 113.90, 85.61, 85.20, 68.16, 55.26, 32.13, 31.61, 11.96; **HRMS** (ESI) calcd for $C_{14}H_{16}O_3$ $[M+H]^+$: 233.1172, found 233.1169.



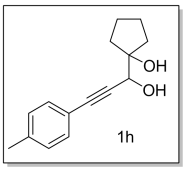
1-(4-(3-hydroxy-3-(1-hydroxycyclobutyl)prop-1-yn-1-yl)phenyl)ethanone **(1f)**

1f as a colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.4 Hz, 2H), 7.48 (d, *J* = 8.0 Hz, 2H), 4.59 (s, 1H), 3.27 (s, 1H), 3.07 (s, 1H), 2.56 (s, 3H), 2.36–2.29 (m, 2H), 2.17–2.096 (m, 2H), 1.90–1.80 (m, 1H), 1.71–1.64 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 197.60, 136.41, 131.96, 128.21, 127.25, 90.42, 84.63, 76.61, 68.05, 32.14, 32.03, 26.62, 12.04; **HRMS** (ESI) calcd for $C_{15}H_{16}O_3$ $[M+Na]^+$: 267.0993, found 267.0992.



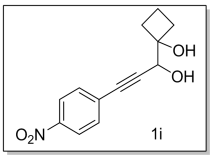
1-(1-hydroxy-3-phenylprop-2-yn-1-yl)cyclopentanol **(1g)**

1g as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.43–7.41 (m, 2H), 7.29–7.24 (m, 3H), 4.53 (s, 1H), 3.72 (s, 1H), 2.88 (s, 1H), 2.00–1.64 (m, 8H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 131.66, 128.41, 128.18, 122.26, 87.74, 85.56, 84.89, 69.32, 36.61, 36.32, 24.59, 24.47; **HRMS** (ESI) calcd for $C_{14}H_{16}O_2$ $[M+Na]^+$: 239.1047, found 239.1043.



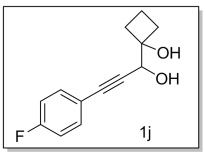
1-(1-hydroxy-3-(p-tolyl)prop-2-yn-1-yl)cyclopentanol **(1h)**

1h as a colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.32 (d, *J* = 8.0 Hz, 2H), 7.10 (d, *J* = 8.0 Hz, 2H), 4.50 (s, 1H), 3.19 (s, 1H), 2.53 (s, 1H), 2.34 (s, 3H), 2.01–1.91 (m, 1H), 1.90–1.79 (m, 3H), 1.78–1.62 (m, 4H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 138.73, 131.51, 128.85, 119.23, 86.95, 85.92, 85.13, 69.76, 36.52, 25.76, 24.50, 24.20, 21.59; **HRMS** (ESI) calcd for $C_{15}H_{18}O_2$ $[M+Na]^+$: 253.1202, found 253.1199.



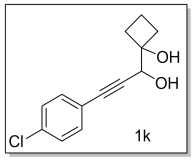
1-(1-hydroxy-3-(4-nitrophenyl)prop-2-yn-1-yl)cyclobutanol **(1i)**

1i as a orange colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.2 Hz, 2H), 7.59 (d, *J* = 8.0 Hz, 2H), 4.62 (s, 1H), 2.55 (d, *J* = 6.0 Hz, 1H), 2.39–2.34 (m, 3H), 2.17–2.15 (m, 2H), 1.91–1.1.89 (m, 1H), 1.72–1.65 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 147.35, 132.63, 129.11, 123.59, 92.17, 83.72, 76.54, 68.07, 32.32, 32.15, 11.94; **HRMS** (ESI) calcd for $C_{13}H_{13}NO_4$ $[M+Na]^+$: 226.0839, found 226.0838.



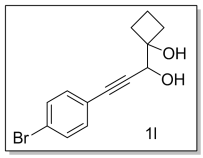
1-(3-(4-fluorophenyl)-1-hydroxyprop-2-yn-1-yl)cyclobutanol **(1j)**

1j as a colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.44–7.39 (m, 2H), 7.01–6.95 (m, 2H), 4.55 (s, 1H), 2.99 (s, 2H), 2.36–2.27 (m, 2H), 2.17–2.08 (m, 2H), 1.90–1.80 (m, 1H), 1.71–1.62 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.30(d, *J* = 12.0 Hz), 133.73(d, *J* = 8.4 Hz), 118.27(d, *J* = 3.6 Hz), 115.57(d, *J* = 22.0 Hz), 86.60, 84.71, 67.70, 32.24, 31.48, 11.96; **HRMS** (ESI) calcd for $C_{13}H_{13}FO_2$ $[M+Na]^+$: 243.0798, found 243.0792.



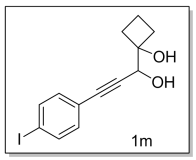
1-(3-(4-chlorophenyl)-1-hydroxyprop-2-yn-1-yl)cyclobutanol **(1k)**

1k as a colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.37 (d, *J* = 8.4 Hz, 2H), 7.28 (d, *J* = 8.8 Hz, 2H), 4.56 (s, 1H), 2.62(s,2H), 2.35–2.29 (m, 2H), 2.15–2.09 (m, 2H), 1.92–1.82 (m, 1H), 1.73–1.66 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 134.75, 133.07, 128.69, 120.71, 87.71, 84.56, 76.59, 68.11, 32.19, 31.85, 11.97; **HRMS** (ESI) calcd for $C_{13}H_{13}ClO_2$ $[M+Na]^+$: 254.0496, found 259.0494.



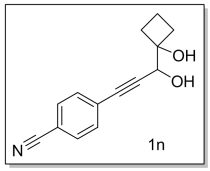
1-(3-(4-bromophenyl)-1-hydroxyprop-2-yn-1-yl)cyclobutanol **(1l)**

1l as a colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.42 (d, *J* = 8.4 Hz, 2H), 7.28 (d, *J* = 8.0 Hz, 2H), 4.54 (s, 1H), 2.98 (s, 2H), 2.33–2.29 (m, 2H), 2.12 (dd, *J* = 18.4, 9.6 Hz, 2H), 1.90–1.80 (m, 1H), 1.71–1.59 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 133.21, 131.55, 122.88, 121.14, 87.95, 84.49, 76.56, 68.00, 32.07, 31.85, 11.96; **HRMS** (ESI) calcd for $C_{13}H_{13}BrO_2$ $[M+Na]^+$: 302.9991, found 302.9989.



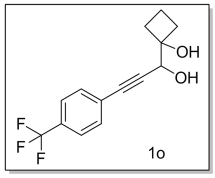
1-(1-hydroxy-3-(4-iodophenyl)prop-2-yn-1-yl)cyclobutanol **(1m)**

1m as a colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.67 (d, *J* = 8.4 Hz, 2H), 7.18 (d, *J* = 8.4 Hz, 2H), 4.57 (s, 1H), 2.66 (s, 2H), 2.35–2.29 (m, 2H), 2.17–2.09 (m, 2H), 1.92–1.83 (m, 1H), 1.72–1.63 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 137.53, 133.32, 121.71, 94.67, 88.17, 84.77, 76.57, 68.12, 32.21, 31.86, 11.98; **HRMS** (ESI) calcd for $C_{13}H_{13}IO_2$ $[M+Na]^+$: 350.9852, found 350.9850.



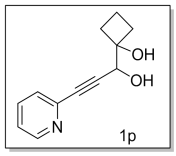
4-(3-hydroxy-3-(1-hydroxycyclobutyl)prop-1-yn-1-yl)benzonitrile **(1n)**

1n as a colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60–7.57 (m, 2H), 7.52–7.50 (m, 2H), 4.58 (s, 1H), 2.89 (s, 1H), 2.70 (s, 1H), 2.35–2.29 (m, 2H), 2.18–2.10 (m, 2H), 1.92–1.82 (m, 1H), 1.70–1.62 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 132.37, 132.03, 127.25, 118.30, 111.97, 91.46, 83.86, 76.55, 68.01, 32.23, 32.12, 11.97; **HRMS** (ESI) calcd for $C_{14}H_{13}NO_2$ $[M+Na]^+$: 250.0838, found 250.0836.



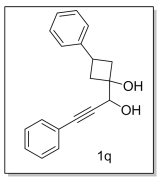
1-(1-hydroxy-3-(4-(trifluoromethyl)phenyl)prop-2-yn-1-yl)cyclobutanol **(1o)**

1o as a colorless amorphous solid. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.54 (s, 4H), 4.59 (s, 1H), 2.89 (d, *J* = 22.2 Hz, 2H), 2.37–2.30 (m, 2H), 2.18–2.11 (m, 2H), 1.93–1.83 (m, 1H), 1.73–1.68 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 132.08, 130.40(q, *J* = 33.0Hz), 127.85, 126.04, 125.31, 125.27, 125.24, 125.20, 125.15, 122.44, 89.30, 84.24, 76.62, 68.03, 32.18, 31.98, 11.98; **HRMS** (ESI) calcd for $C_{14}H_{13}F_3O_2$ $[M+Na]^+$: 293.0760, found 293.0758.



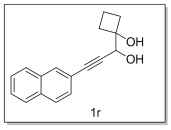
1-(1-hydroxy-3-(pyridin-2-yl)prop-2-yn-1-yl)cyclobutanol **(1p)**

1p as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.56 (d, *J* = 4.6 Hz, 1H), 7.67–7.62 (m, 1H), 7.43 (d, *J* = 7.8 Hz, 1H), 7.28–7.22 (m, 1H), 4.61 (s, 1H), 4.43 (s, 2H), 2.38–2.31 (m, 2H), 2.24–2.12 (m, 2H), 2.07–1.83 (m, 1H), 1.71–1.64 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 149.53, 142.46, 136.54, 127.33, 123.19, 88.62, 83.99, 76.55, 67.85, 32.12, 31.83, 12.18; **HRMS** (ESI) calcd for $C_{12}H_{13}NO_2$ $[M+H]^+$: 204.1021, found 204.1019.



1-(1-hydroxy-3-phenylprop-2-yn-1-yl)-3-phenylcyclobutanol (**1q**)

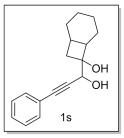
1q as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.49–7.46 (m, 2H), 7.35–7.18 (m, 8H), 4.70(s, 1H), 3.29–3.18 (m, 1H), 2.86–2.83 (m, 2H), 2.65–2.55 (m, 2H), 2.35–2.26 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 144.92, 131.80, 128.64, 128.31, 126.56, 126.01, 122.08, 86.62, 85.80, 72.74, 68.09, 40.15, 39.65, 29.98; **HRMS** (ESI) calcd for $C_{19}H_{18}O_2$ $[M+NH_4]^+$: 296.1645, found 296.1642.



1-(1-hydroxy-3-(naphthalen-2-yl)prop-2-yn-1-yl)cyclobutanol **(1r)**

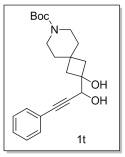
1r as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.97 (s, 1H), 7.86 – 7.69 (m, 3H), 7.56 – 7.40 (m, 3H), 4.66 (s, 1H), 3.37 (s, 1H), 3.15(s,1H), 2.39 (m, 2H), 2.26 – 2.12 (m, 2H), 1.93 – 1.82 (m, 1H), 1.71 (m, 1H); **^{13}C NMR** (101 MHz,) δ 132.78, 132.72, 131.80, 128.31, 127.91, 127.65, 126.73,

126.50, 119.41, 87.03, 85.87, 76.66, 68.08, 32.06, 31.79, 12.02; **HRMS** (ESI) calcd for $C_{17}H_{16}O_2$ $[M+H]^+$: 253.1223, found 253.1213.



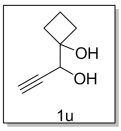
7-(1-hydroxy-3-phenylprop-2-yn-1-yl)bicyclo[*4.2.0*]octan-7-ol **(1s)**

1s as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.45 – 7.43 (m, 2H), 7.34-7.27 (m, 3H), 4.59 (d, J = 6.8 Hz, 1H), 2.49 – 2.42 (m, 2H), 2.31 – 2.21 (m, 1H), 2.02 – 1.97 (m, 1H), 1.81 – 1.50 (m, 8H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 131.81, 128.62, 128.32, 122.37, 86.99, 85.86, 75.88, 68.63, 39.08, 33.61, 26.17, 24.09, 22.27, 21.57, 21.03; **HRMS** (ESI) calcd for $C_{17}H_{20}O_2$ $[M+H]^+$: 257.1536, found 257.1526.



tert-butyl 2-hydroxy-2-(1-hydroxy-3-phenylprop-2-yn-1-yl)-7-azaspiro[*3.5*]nonane-7-carboxylate **(1t)**

1t as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.42 (m, 2H), 7.35 – 7.26 (m, 3H), 4.44 (d, J = 6.4 Hz, 1H), 3.38 – 3.35 (m, 2H), 3.31 – 3.29 (m, 2H), 2.44 – 2.39 (m, 2H), 2.23 – 2.17 (m, 2H), 1.92-1.89 (m, 2H), 1.86-1.58 (m, 2H), 1.45 (s, 9H); ^{13}C NMR (151 MHz, $CDCl_3$) δ 154.97, 131.77, 128.82, 128.40, 121.97, 86.59, 86.50, 79.35, 72.86, 70.05, 41.32, 41.12, 38.19, 37.27, 29.59, 28.47; **HRMS** (ESI) calcd for $C_{22}H_{29}NO_4$ $[M+H]^+$: 372.2169, found 372.2159.



1-(1-hydroxyprop-2-yn-1-yl)cyclobutanol **(1u)**

1u as a colorless oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 4.30 (s, 1H), 3.85 (s, 2H), 2.44 (d, *J* = 2.0 Hz, 1H), 2.24–2.17 (m, 2H), 2.08–2.01 (m, 2H), 1.82–1.73 (m, 1H),1.62–1.51(m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 81.87, 76.45, 73.77, 67.19, 31.72, 11.97; **HRMS** (ESI) calcd for $C_7H_{10}O_2$ $[M+Na]^+$: 149.0573, found 149.0571.

3. General experimental procedure for products

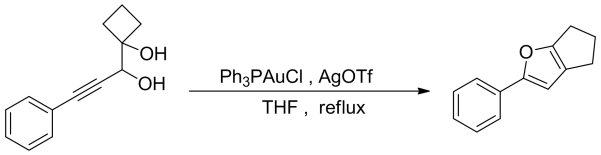
3.1 Optimization of the tandem reaction conditions

Entry	Catalyst (mol%)	Solvent	T (ºC)	Yield[b] (%)
1	Ph_3PAuCl+AgOTf (10)	*n*-hexane	80	8
2	Ph_3PAuCl+AgOTf (10)	DCE	80	30
3	Ph_3PAuCl+AgOTf (10)	$CHCl_3$	reflux	26

4	Ph_3PAuCl+AgOTf (10)	THF	reflux	41
5	Ph_3PAuCl+AgOTf (10)	THF	r.t.	trace
6	Ph_3PAuCl+AgOTf (10)	THF	40	27
7	Ph_3PAuCl+AgOTf (5)	THF	reflux	46
8	Ph_3PAuCl+AgOTf (1)	THF	reflux	56
9	Ph_3PAuCl+AgOTf (0.5)	THF	reflux	78
10	Ph_3PAuCl+AgOTf (0.2)	THF	reflux	73
11	Ph_3PAuCl+AgOTf (0.1)	THF	reflux	24
12	$RuCl_3$ (10)	THF	reflux	trace
13	$FeCl_3$ (10)	THF	reflux	[e]n.d.
14	$AgNO_3$ (10)	THF	reflux	[e]n.d.
15[f]	Ph_3PAuCl+AgOTf (0.5)	THF	reflux	12
16	AgO (10)	THF	reflux	11
17	$IrCl_3$ (10)	THF	reflux	trace
18	$Cu(OAc)_2$ (10)	THF	reflux	[e]n.d.
19	CuCl (10)	THF	reflux	trace
20	$Cu(OTf)_2$ (10)	THF	reflux	trace
21	AgOAc (10)	THF	reflux	[e]n.d.
22	$AgNO_2$ (10)	THF	reflux	[e]n.d.
23	$Yb(OTf)_3$ (10)	THF	reflux	trace
24	AuCl (0.5)	THF	reflux	10
25	Au[P(t-Bu)$_2$(o-biphenyl)]Cl+AgOTf (0.5)	THF	reflux	21
26	AuCl+$AgSbF_6$ (0.5)	THF	reflux	trace
27	IPrAuCl+$AgSbF_6$ (0.5)	THF	reflux	12
28	IPrAuCl+AgOTf (0.5)	THF	reflux	[e]n.d.
29	Ph_3PAuCl (0.5)	THF	reflux	[e]n.d.
30	AgOTf (0.5)	THF	reflux	[e]n.d.
31[c]	Ph_3PAuCl+$AgNTf_2$ (0.5)	THF	reflux	17
32[c]	Ph_3PAuCl+$AgPF_6$ (0.5)	THF	reflux	[e]n.d.
33[c]	Ph_3PAuCl+$AgBF_4$ (0.5)	THF	reflux	21
34[c]	Ph_3PAuCl+AgOTf (0.5)	THF	reflux	82
35[cd]	Ph_3PAuCl+AgOTf (0.5)	THF	reflux	86

[a]Reaction conditions: without other notification, all of the reactions were performed with 1-(1-hydroxy-3-phenylprop-2-yn-1-yl)cyclobutanol (0.5 mmol), catalyst in solvent (1.5 mL) under Ar for 4 h. [b]Isolated yield. [c]The amout of solvent is 3 mL. [d]under air. [e]n.d. = not detected. [f] Reaction condition is MW, 70 ºC,0.5h.

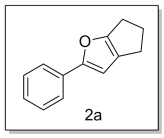
3.2. General experimental procedure for products 2a-2q using 2a as an example



To a stirred solution of 1-(1-hydroxy-3-phenylprop-2-yn-1-yl) cyclobutanol (100 mg, 0.5 mmol) in THF (3 mL) was successively added PPh_3AuCl (2.5 mg, 0.005 mmol) and AgOTf (1.3 mg, 0.005

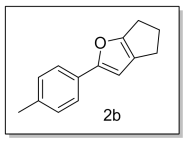
mmol) at 70 ºC under air. The reaction would be stirred for 4 h, then quenched by water (2 mL). The aqueous layer was extracted three times with EtOAc and the combined organic layers were washed with brine, dried over sodium sulfate, and evaporated to dryness and purified by column chromatography to afford pure desired product **2a** (78 mg, 86%) as a white solid.

4. Characterization of products 2a-2q



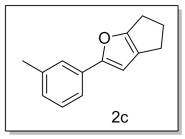
2-phenyl-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2a)**

2a (78 mg) was obtained through the general procedure in 86% yield as a white solid. mp 53.8–54.2 ºC; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.64 (d, *J* = 7.2 Hz, 2H), 7.42–7.31 (m, 2H), 7.27–7.16 (m, 1H), 6.69 (s, 1H), 2.74–2. 70 (m, 2H), 2.57–2.53 (m, 2H), 2.48–2.43 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 160.46, 158.49, 132.93, 129.69, 128.71, 127.68, 123.86, 104.81, 28.47, 25.29, 24.13; **HRMS** (ESI) calcd for $C_{13}H_{12}O$ $[M+H]^+$: 185.0963, found 185.0961.



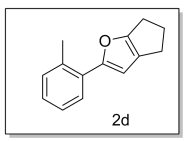
2-(p-tolyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan**(2b)**

2b (76 mg) was obtained through the general procedure in 83% yield as a white solid. mp 56.6–57.2 ºC; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.53 (d, *J* = 8.2 Hz, 2H), 7.18 (d, *J* = 8.0 Hz, 2H), 6.61 (s, 1H), 2.73–2.69 (m, 2H), 2.54–2.52 (m, 2H), 2.48–2.41(m, 2H), 2.31 (s, 3H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 159.96, 158.76, 137.36, 130.32, 128.60, 123.92, 104.05, 28.49, 25.30, 24.17, 21.34; **HRMS** (ESI) calcd for $C_{14}H_{14}O$ $[M+H]^+$: 199.1117, found 199.1110.



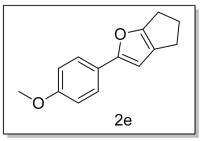
2-(m-tolyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2c)**

2c (47 mg) was obtained through the general procedure in 51% yield as a colorless oil; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.47–7.42 (m, 2H), 7.24 (t, *J* = 8.0 Hz, 1H), 7.04 (d, *J* = 7.6 Hz, 1H), 6.66 (s, 1H), 2.74–2.70 (m, 2H), 2.57–2.53 (m, 2H), 2.49–2.34(m,2H), 2.34 (s, 3H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 160.26, 158.63, 139.12, 132.85, 129.58, 128.61, 128.42, 124.40, 121.07, 104.63, 28.42, 25.24, 24.10, 21.58; **HRMS** (ESI) calcd for $C_{14}H_{14}O$ $[M+H]^+$: 199.1117, found 199.1115.



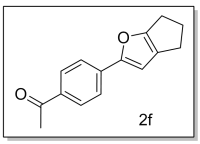
2-(o-tolyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2d)**

2d (71 mg) was obtained through the general procedure in 78% yield as a colorless oil. **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.66–7.60 (m, 1H), 7.26–7.15 (m, 3H), 6.51 (s, 1H), 2.75–2.72 (m, 2H), 2.58–2.56 (m, 2H), 2.50–2.46 (m, 5H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 155.54 , 153.51 , 130.19 , 127.66 , 127.60 , 124.04 , 123.39 , 122.82 , 122.48 , 104.01 , 24.05 , 20.82 , 19.74 , 17.83; **HRMS** (ESI) calcd for $C_{14}H_{14}O$ $[M+K]^+$: 237.0688, found 237.0686.



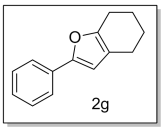
2-(4-methoxyphenyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2e)**

2e (64 mg) was obtained through the general procedure in 70% yield as a colorless amorphous solid; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.59–7.55 (m, 2H), 6.96–6.92 (m, 2H), 6.53 (s, 1H), 3.81 (s, 3H), 2.72–2.68 (m, 2H), 2.56–2.51 (m, 2H), 2.48–2.41 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 159.92, 159.49, 158.66, 128.53, 125.95, 125.37, 115.15, 103.12, 55.73, 28.47, 25.27, 24.17; **HRMS** (ESI) calcd for $C_{14}H_{14}O_2$ $[M+H]^+$: 215.1089, found 215.1087.



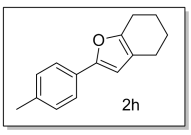
1-(4-(5,6-dihydro-4*H*-cyclopenta[*b*]furan-2-yl)phenyl)ethanone **(2f)**

2f (68 mg) was obtained through the general procedure in 73% yield as a colorless amorphous solid; **^{1}H NMR** (400 MHz, C_6D_6) δ 7.89 (d, *J* = 8.8 Hz, 2H), 7.65 (d, *J* = 8.2 Hz, 2H), 7.23 (s, 3H), 6.45 (s, 1H), 2.47 (t, *J* = 7.6 Hz, 2H), 2.38 (t, *J* = 6.8 Hz, 2H), 2.19 (s, 3H), 2.17–2.03 (m, 2H); **^{13}C NMR** (101 MHz, C_6D_6) δ 195.63, 161.32, 157.11, 135.93, 135.63, 129.32, 122.91, 106.29, 27.88, 26.07, 24.88, 23.55; **HRMS** (ESI) calcd for $C_{15}H_{14}O_2$ $[M+H]^+$: 227.1067, found 227.1058.



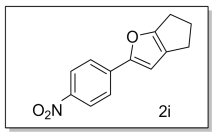
2-phenyl-4,5,6,7-tetrahydrobenzofuran **(2g)**

2g (40 mg) was obtained through the general procedure in 44% yield as a colorless oil; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.70–7.60 (m, 2H), 7.40–7.31 (m, 2H), 7.25–7.15 (m, 1H), 6.62 (s, 1H), 2.64–2.60 (m, 2H), 2.46–2.42 (m, 2H), 1.89–1.81 (m, 2H), 1.77–1.70 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 152.81, 151.95, 132.88, 130.04, 128.02, 124.40, 120.46, 107.64, 24.35, 24.30, 23.23; **HRMS** (ESI) calcd for $C_{14}H_{14}O$ $[M+H]^+$: 199.1117, found 199.1110.



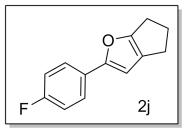
2-(p-tolyl)-4,5,6,7-tetrahydrobenzofuran **(2h)**

2h (35 mg) was obtained through the general procedure in 38% yield as a colorless oil; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.53 (d, *J* = 8.0 Hz, 2H), 7.18 (d, *J* = 8.0 Hz, 2H), 6.54 (s, 1H), 2.63–2.59 (m, 2H), 2.45–2.41 (m, 2H), 2.31 (s, 3H), 1.90–1.79 (m, 2H), 1.78–1.68 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 152.62, 151.05, 137.25, 130.24, 129.85, 124.02, 119.91, 106.45, 23.96, 23.92, 23.88, 22.83, 21.27; **HRMS** (ESI) calcd for $C_{15}H_{16}O$ $[M+H]^+$: 213.1274, found 213.1265.



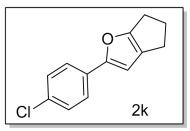
2-(4-nitrophenyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2i)**

2i (72 mg) was obtained through the general procedure in 77% yield as a orange colorless amorphous solid; **^{1}H NMR** (400 MHz, acetone-d_6) δ 8.20 (d, *J* = 8.8 Hz, 2H), 7.68 (d, *J* = 8.8 Hz, 2H), 6.74 (s, 1H), 2.81–2.77 (m, 2H), 2.63–2.59 (m, 2H), 2.53–2.46 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 162.69, 155.31, 145.70, 137.40, 128.75, 124.36, 122.86, 107.75, 27.69, 24.84, 23.35; **HRMS** (ESI) calcd for $C_{13}H_{11}NO_3$ $[M+H]^+$: 203.0812, found 203.0808.



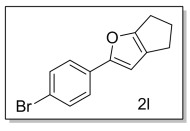
2-(4-fluorophenyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2j)**

2j (80 mg) was obtained through the general procedure in 87% yield as a white solid. mp 57.8–58.4 ºC; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.68–7.64 (m, 2H), 7.16–7.12 (m, 2H), 6.65 (s, 1H), 2.73–2.69 (m, 2H), 2.56–2.53 (m, 2H), 2.49–2.41 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 162.74(d, *J* = 243 Hz), 160.50, 157.59, 129.58(d, *J* = 3 Hz), 128.80, 125.84(d, *J* = 8 Hz), 116.56(d, *J* = 22 Hz), 116.45, 104.72, 104.71, 28.49, 25.29, 24.13; **HRMS** (ESI) calcd for $C_{13}H_{11}FO[M+H]^+$: 203.0867, found 203.0858.



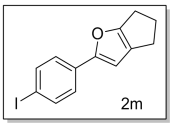
2-(4-chlorophenyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2k)**

2k (85 mg) was obtained through the general procedure in 92% yield as a white solid. mp 73.1–74.6 ºC; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.65–7.62 (m, 2H), 7.38–7.37 (m, 2H), 6.73 (s, 1H), 2.74–2.70 (m, 2H), 2.57–2.54 (m, 2H), 2.50–2.42(m,2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 160.98, 157.27, 132.63, 131.65, 129.78, 128.94, 125.34, 105.56, 28.44, 25.25, 24.05; **HRMS** (ESI) calcd for $C_{13}H_{11}ClO$ $[M+H]^+$: 219.0571, found 219.0564.



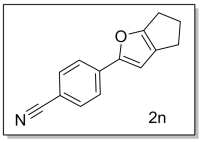
2-(4-bromophenyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2l)**

2l (77 mg) was obtained through the general procedure in 82% yield as a white solid. mp 84.6–85.7 ºC; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.59–7.50 (m, 4H), 6.74 (s, 1H), 2.75–2.68 (m, 2H), 2.58–2.51 (m, 2H), 2.50–2.41 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 161.08, 157.30, 132.76, 132.03, 128.99, 125.63, 120.68, 105.69, 28.47, 25.29, 24.08; **HRMS** (ESI) calcd for $C_{13}H_{11}BrO$ $[M+H]^+$: 263.0066, found 263.0057.



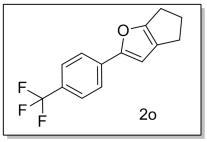
2-(4-iodophenyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2m)**

2m (76 mg) was obtained through the general procedure in 80% yield as a white solid. mp 100.3–101.1 ºC; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.73 (d, *J* = 8.4 Hz, 2H), 7.44 (d, *J* = 8.4 Hz, 2H), 6.76 (s, 1H), 2.73–2.7 (m, 2H), 2.57–2.53 (m, 2H), 2.49–2.42 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 161.09, 157.32, 138.73, 132.41, 128.94, 125.70, 105.73, 91.82, 28.41, 25.24, 24.02; **HRMS** (ESI) calcd for $C_{13}H_{11}IO$ $[M+H]^+$: 310.9927, found 310.9918.



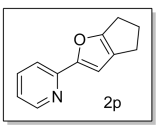
4-(5,6-dihydro-4*H*-cyclopenta[*b*]furan-2-yl)benzonitrile **(2n)**

2n (68 mg) was obtained through the general procedure in 81% yield as a colorless amorphous solid; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.79–7.77 (m, 2H), 7.74–7.72 (m, 2H), 6.94 (s, 1H), 2.77–2.73 (m, 2H), 2.59–2.55 (m, 2H), 2.51–2.44 (m, 2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 162.72, 156.55, 136.50, 133.59, 129.52, 124.04, 119.62, 110.28, 108.21, 28.39, 25.25, 23.92; **HRMS** (ESI) calcd for $C_{14}H_{11}NO$ $[M+H]^+$: 210.0913, found 210.0905.



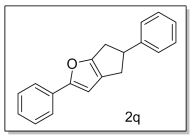
2-(4-(trifluoromethyl)phenyl)-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2o)**

2o (58 mg) was obtained through the general procedure in 62% yield as a yellow solid. mp 81.2-81.9 ºC; **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.83 (d, *J* = 8.4 Hz, 2H), 7.69 (d, *J* = 8.4 Hz, 2H), 6.90 (s, 1H), 2.77–2.74 (m, 2H), 2.60–2.56(m, 2H), 2.52–2.44(m,2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 162.11, 156.87, 136.30, 129.27, 128.55(q, *J* = 33.0 Hz), 126.71(q, *J* =4.0 Hz), 125.58(q, *J* = 270.0 Hz), 124.03, 107.30, 28.45, 25.28, 24.00; **HRMS** (ESI) calcd for $C_{14}H_{11}F_3O$ $[M+H]^+$: 253.0835, found 253.0826.



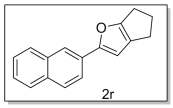
2-(5,6-dihydro-4*H*-cyclopenta[*b*]furan-2-yl)pyridine **(2p)**

2p (38 mg) was obtained through the general procedure in 42% yield as a colorless crystal. mp 85.9-86.3 ºC; **^{1}H NMR** (400 MHz, acetone-d_6) δ 8.51–8.49 (m, 1H), 7.78–7.74 (m, 1H), 7,63–7.61 (m, 1H), 7.18–7.15 (m, 1H), 6.95 (s, 1H), 2.76–2.72 (m, 2H), 2.59–2.55 (m, 2H), 2.51–2.43(m,2H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 161.87, 158.72, 150.98, 150.55, 137.51, 129.01, 122.37, 118.20, 107.92, 28.43, 25.27, 24.00; **HRMS** (ESI) calcd for $C_{12}H_{11}NO$ $[M+H]^+$: 186.0913, found 186.0906.



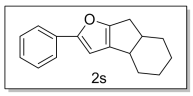
2,5-diphenyl-5,6-dihydro-4*H*-cyclopenta[*b*]furan **(2q)**

2q (41 mg) was obtained through the general procedure in 78% yield as colorless amorphous solid. **^{1}H NMR** (400 MHz, acetone-d_6) δ 7.68 (d, *J* = 7.4 Hz, 2H), 7.44–7.17 (m, 8H), 6.75 (s, 1H), 4.17–4.04 (m, 1H), 3.23 (dd, *J* = 15.6, 9.2 Hz, 1H), 3.06 (dd, *J* = 14.8, 8.8 Hz, 1H), 2.91–2.78 (m, 1H), 2.67–2.62 (m, 1H); **^{13}C NMR** (101 MHz, acetone-d_6) δ 158.63, 158.51, 147.23, 132.80, 129.73, 129.56, 127.84, 127.81, 127.58, 127.31, 123.93, 104.73, 49.18, 34.60, 33.82; **HRMS** (ESI) calcd for $C_{19}H_{16}O$ $[M+H]^+$: 261.1274, found 261.1264.



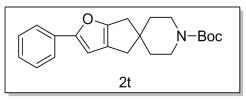
2-(naphthalen-2-yl)-5,6-dihydro-4H-cyclopenta[*b*]furan **(2r)**

2r (67 mg) was obtained through the general procedure in 72% yield as a white solid. mp 88.9-91.3 ºC; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.81-7.78 (m, 3H), 7.70 (d, *J* = 10.4 Hz, 1H), 7.45-7.41(m, 2H), 6.64 (s, 1H), 2.79 – 2.50 (m, 6H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.03, 157.64, 133.67, 132.35, 129.18, 128.23,128.80, 127.80, 127.69, 126.35, 125.49, 121.97, 120.96, 104.28, 27.75, 24.85, 23.56; **HRMS** (ESI) calcd for $C_{17}H_{14}O$ $[M+H]^+$: 235.1117, found 235.1111.



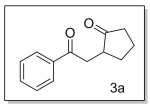
2-phenyl-4,5,6,7,7a,8-hexahydro-3bH-indeno[*2,1-b*]furan **(2s)**

2s (80 mg) was obtained through the general procedure in 86% yield as a colorless amorphous solid; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60 (dd, J = 0.8, 1.2 Hz, 2H), 7.35 – 7.31 (m, 2H), 7.25 – 7.16 (m, 1H), 6.52 (s, 1H), 2.87 – 2.73 (m, 3H), 2.51 – 2.46 (m, 1H), 1.68-1.63 (m, 1H), 1.54 – 1.45 (m, 2H), 1.44 – 1.43 (m, 4H), 1.42 – 1.41 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 158.96, 156.58, 131.98, 131.93, 128.56, 126.44, 122.99, 102.90, 42.71, 36.87, 30.81, 29.21, 28.73, 22.86, 22.79; **HRMS** (ESI) calcd for $C_{17}H_{18}O$ $[M+H]^+$: 239.1430, found 239.1421.



tert-butyl 2-phenyl-4,6-dihydrospiro[cyclopenta[*b*]furan-5,4'-piperidine]-1'-carboxylate **(2t)**

2t (69 mg) was obtained through the general procedure in 72% yield as a colorless amorphous solid; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.60 – 7.58 (m, 2H), 7.36 – 7.32 (m, 2H), 7.22 – 7.18 (m, 1H), 6.50 (s, 1H), 3.55-3.50 (m, 2H), 3.44 – 3.37 (m, 2H), 2.68 (s, 2H), 2.48 (s, 2H), 1.72-1.70 (m, 4H), 1.47 (s, 9H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 157.56, 156.48, 154.89, 131.66, 128.60, 126.72, 124.76, 123.07, 103.69, 79.42, 47.44, 38.25, 37.55, 36.86, 28.48; **HRMS** (ESI) calcd for $C_{22}H_{27}NO_3$ $[M+H]^+$: 354.2064, found 354.2049.



2-(2-oxo-2-phenylethyl)cyclopentanone **(3a)**

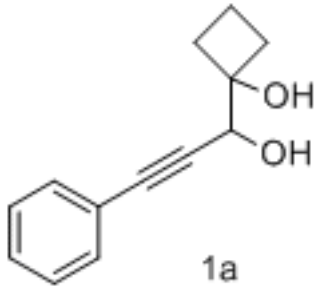
3a (56 mg) was obtained through the general procedure in 56% yield as white amorphous solid; **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.00–7.91 (m, 2H), 7.58–7.55 (m, 1H), 7.46 (m, 2H), 3.53 (dd, *J* = 16.0, 4.0 Hz, 1H), 3.05 (dd, *J* = 16.0, 8.0 Hz, 1H), 2.72–2.58 (m, 1H), 2.47–2.21 (m, 3H), 2.14–2.04 (m, 1H), 1.93–1.79 (m, 1H), 1.63–1.59 (m, 1H); **^{13}C NMR** (101 MHz, $CDCl_3$) δ 220.32, 197.95, 136.62, 133.23, 128.62, 128.04, 45.09, 38.65, 37.56, 29.72, 20.85; **HRMS** (ESI) calcd for $C_{13}H_{14}O_2$ $[M+H]^+$: 203.1077, found 203.1067.

5. References

[1] X.-Q. Mou, Z.-L. Xu, S.-H. Wang, D.-Y. Zhu, J. Wang, W. Bao, S.-J. Zhou, C. Yang, D. Zhang, *Chemical Communications* **2015**, *51*, 12064-12067.

[2] B. Panda, T. K. Sarkar, *Synthesis* **2013**, *45*, 817-829.

6. ^{1}H NMR and ^{13}C NMR spectra for substrates and products



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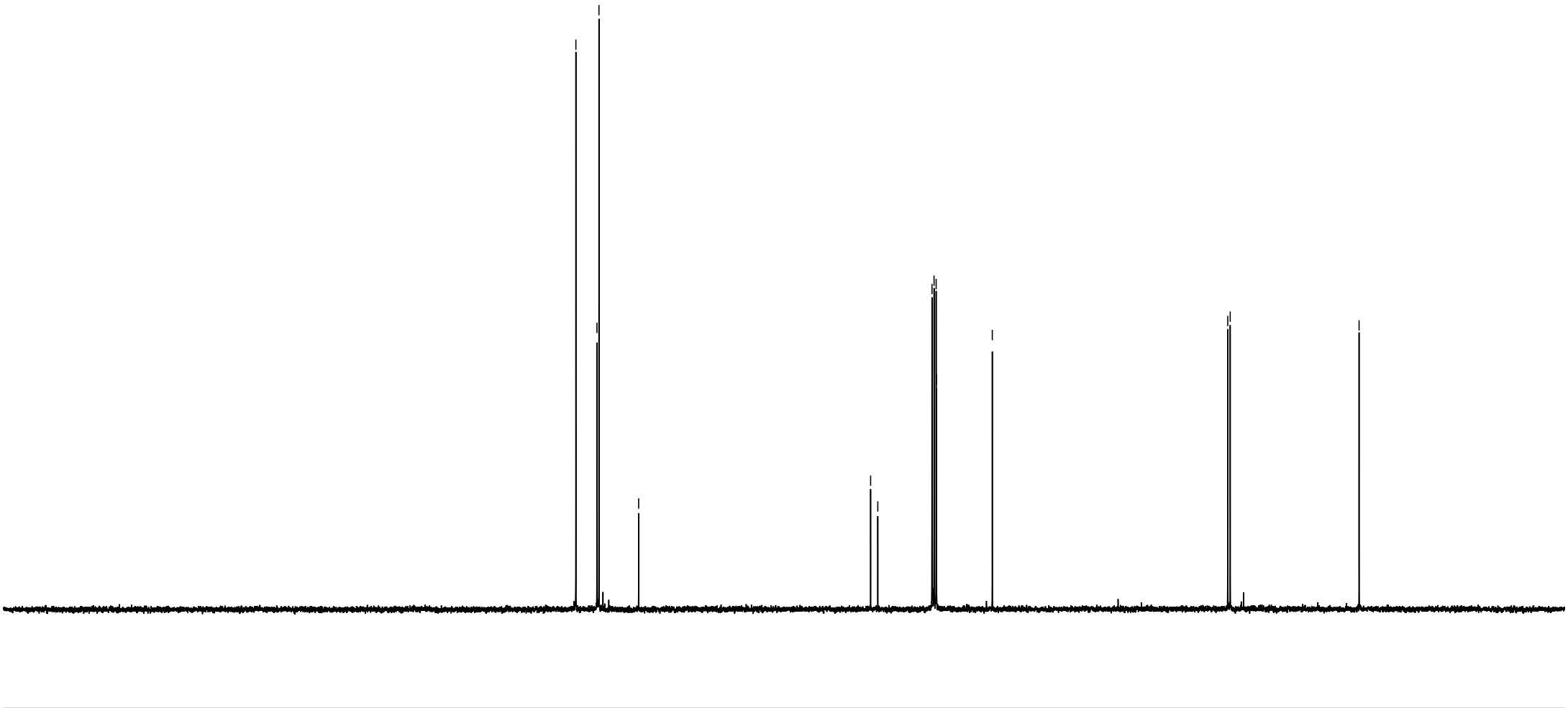

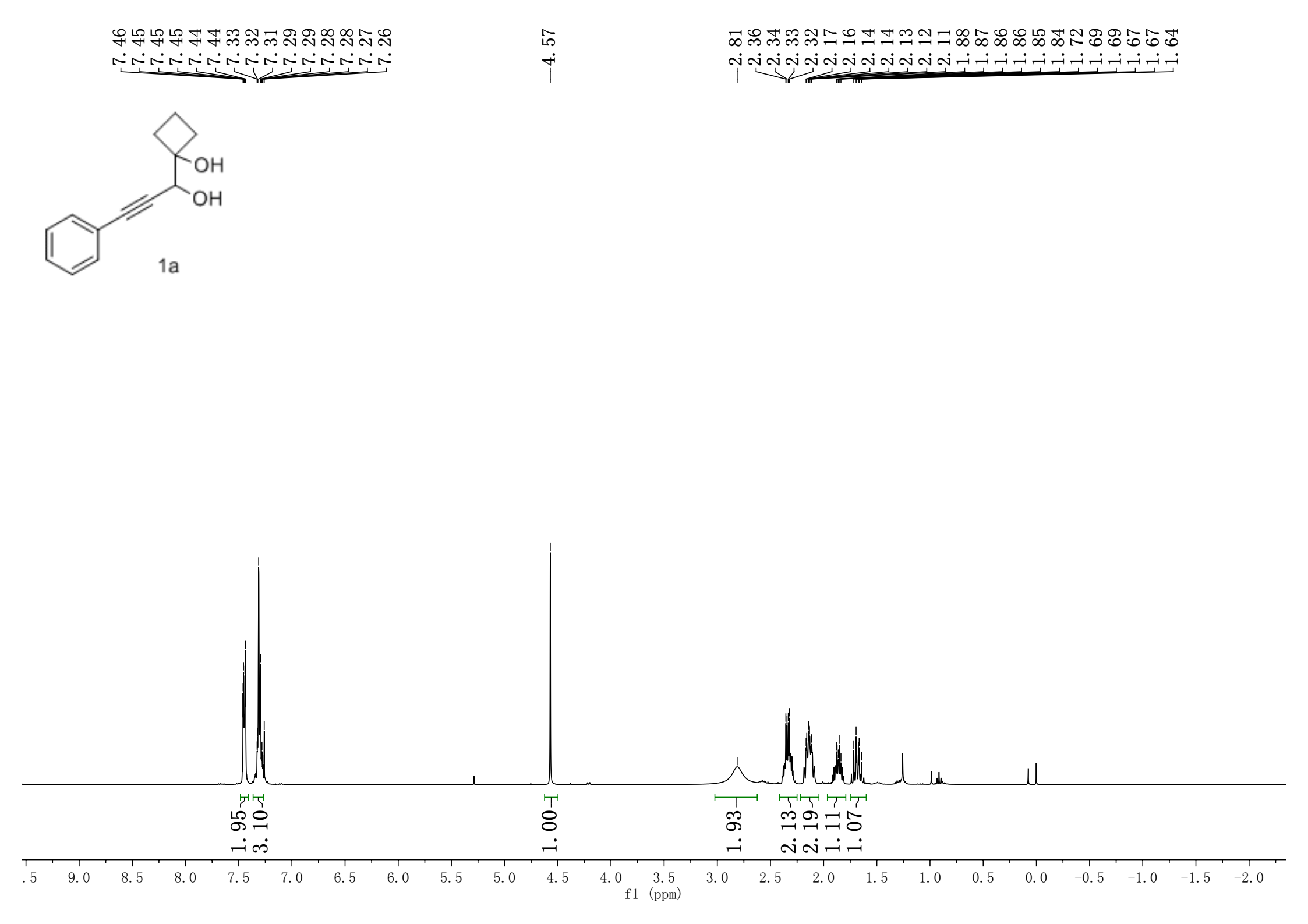
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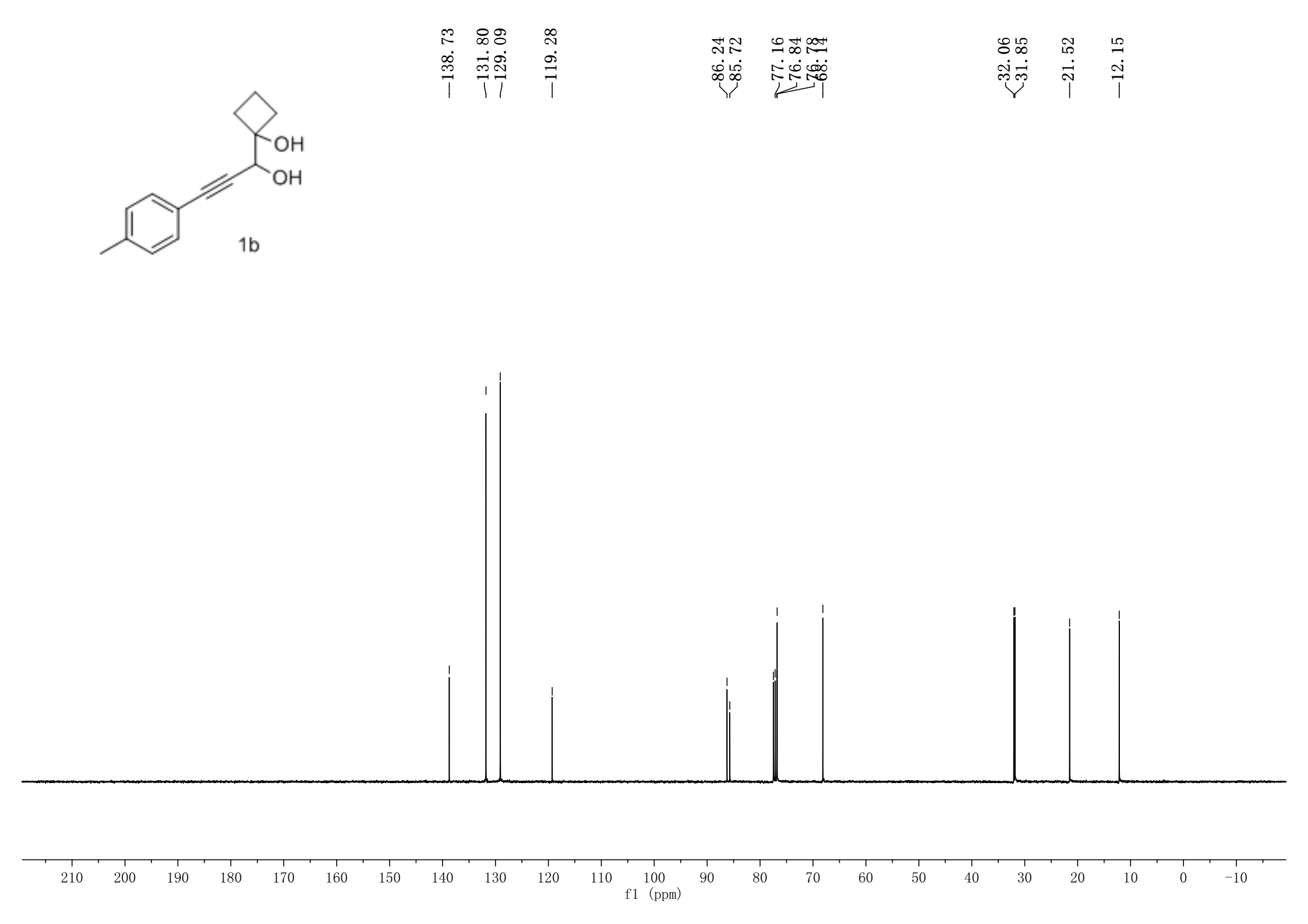
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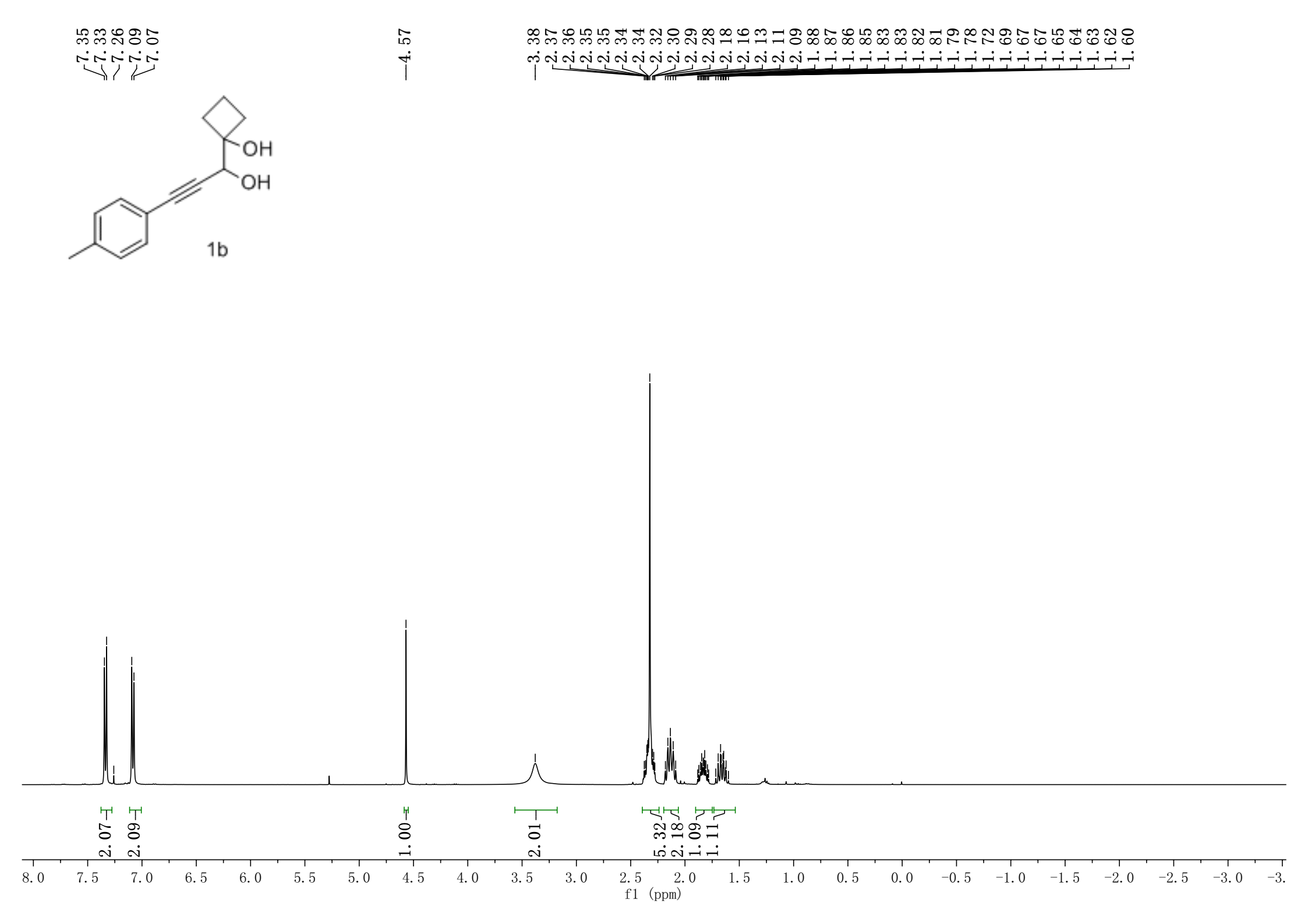
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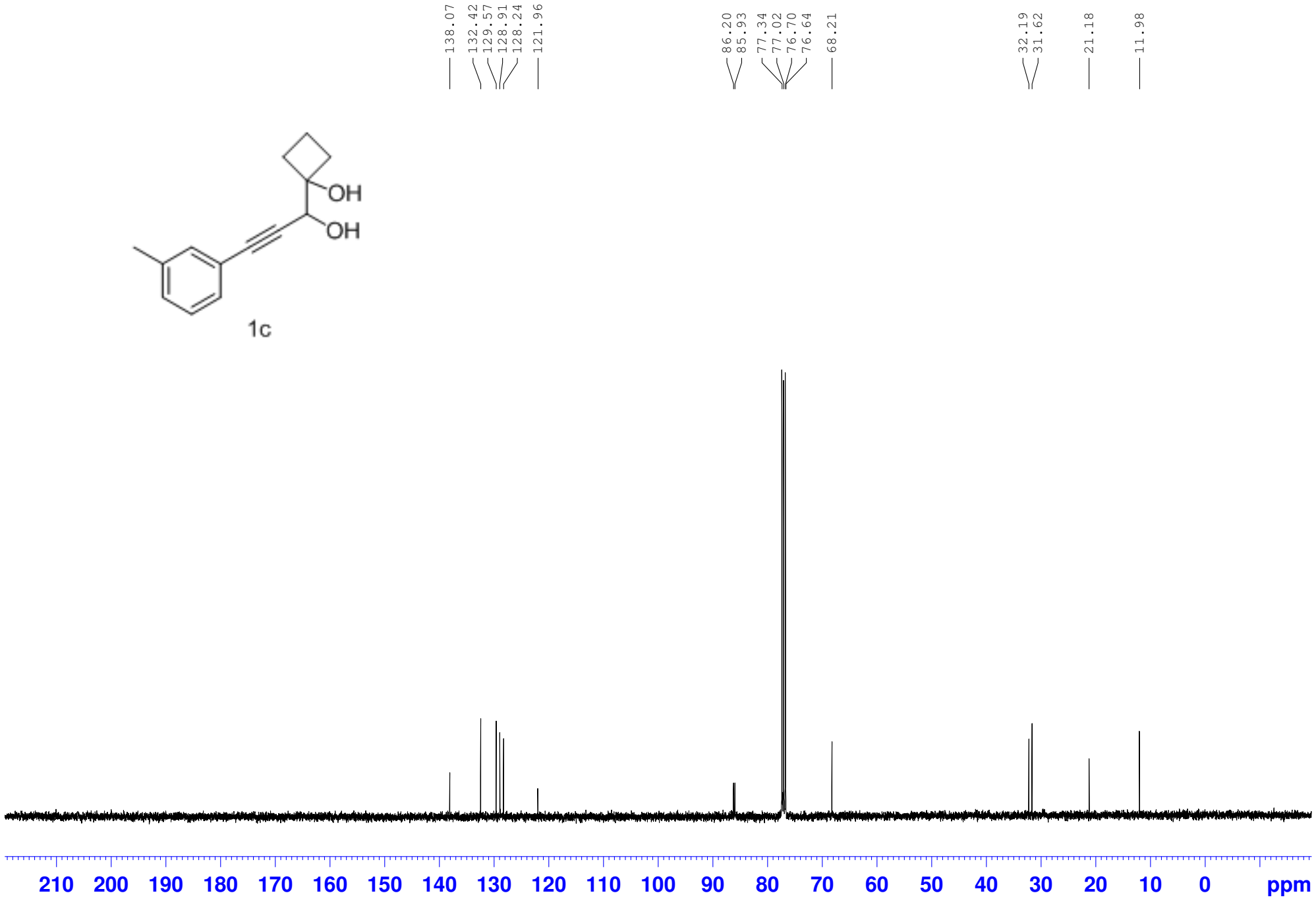
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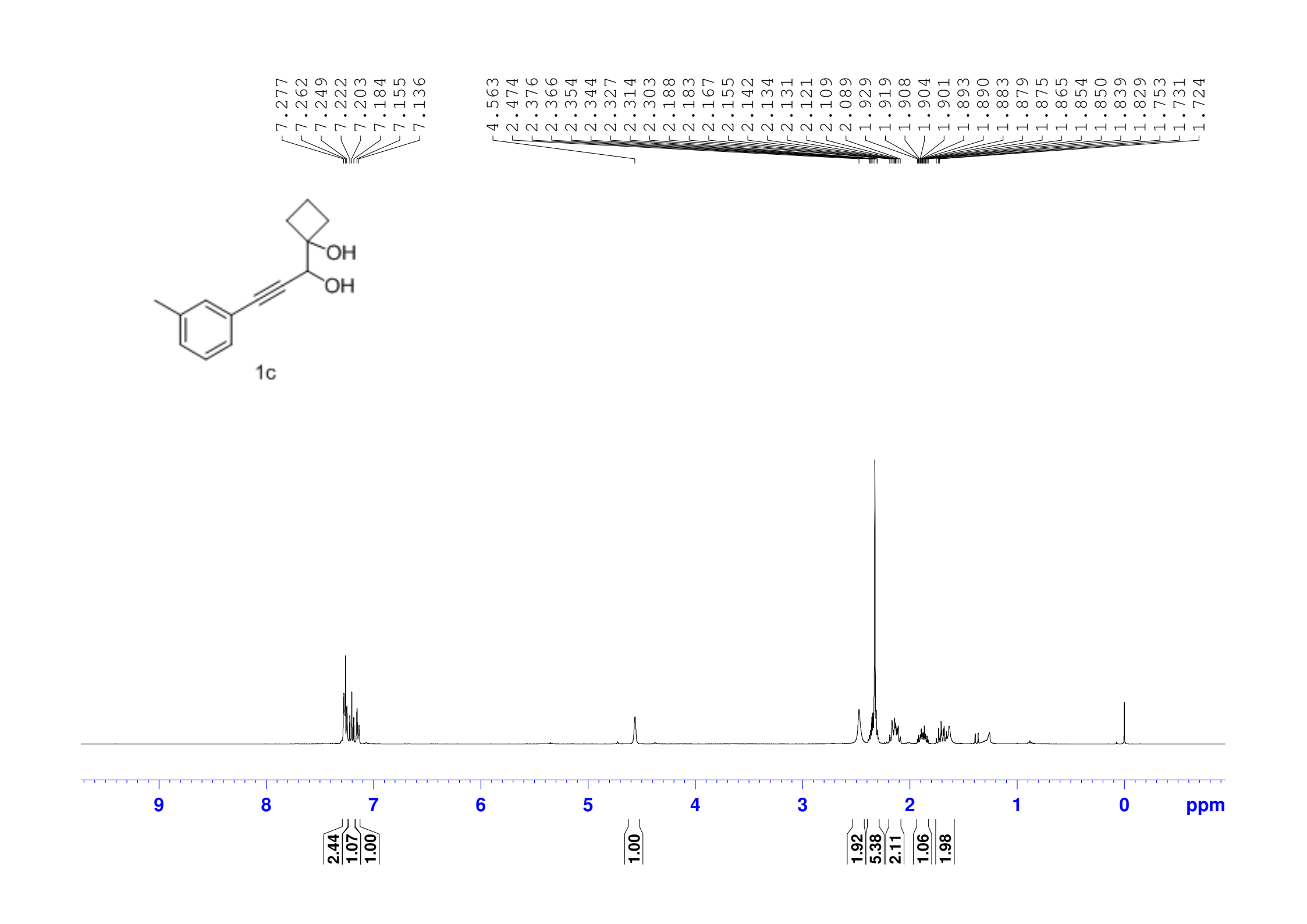
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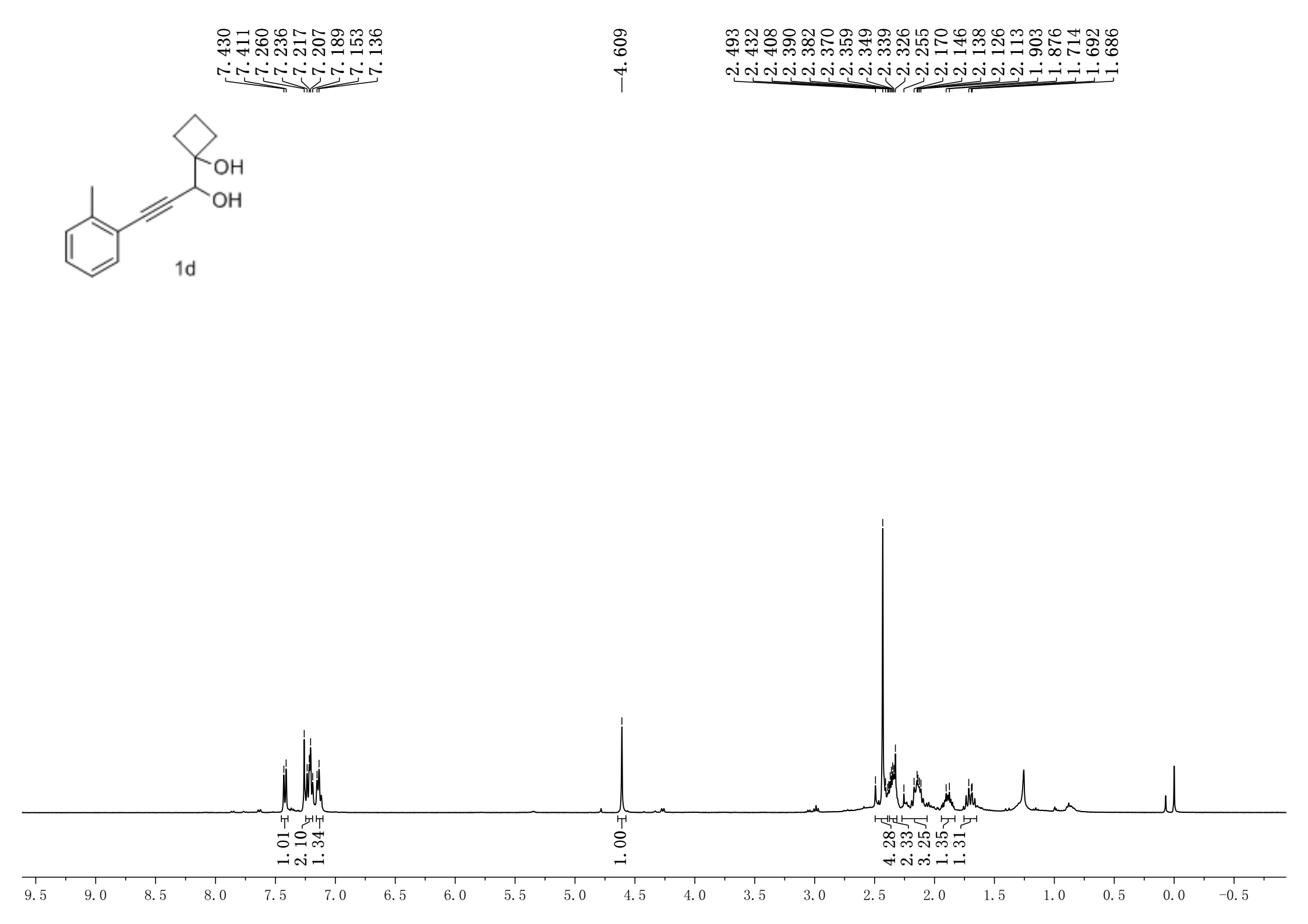
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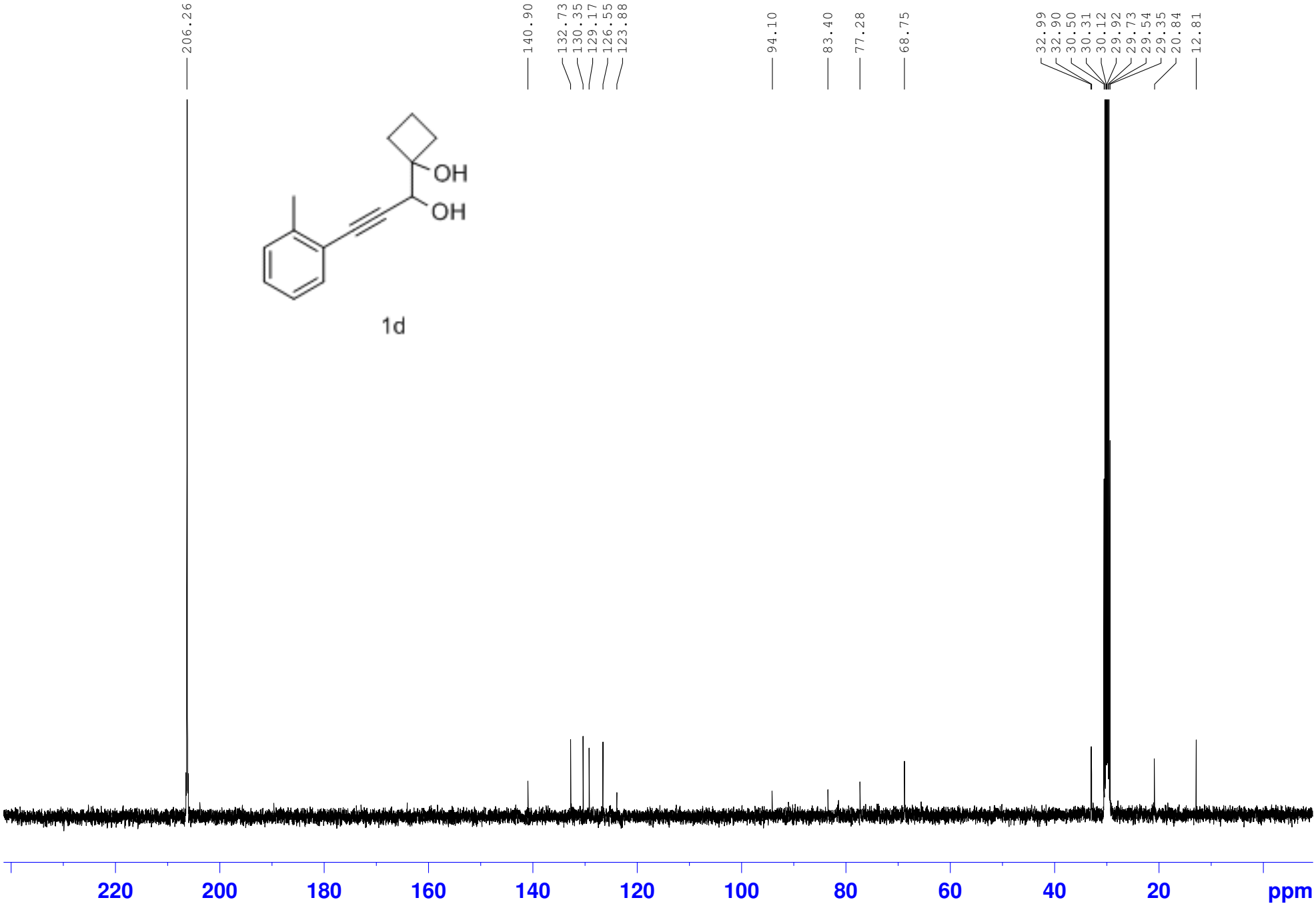
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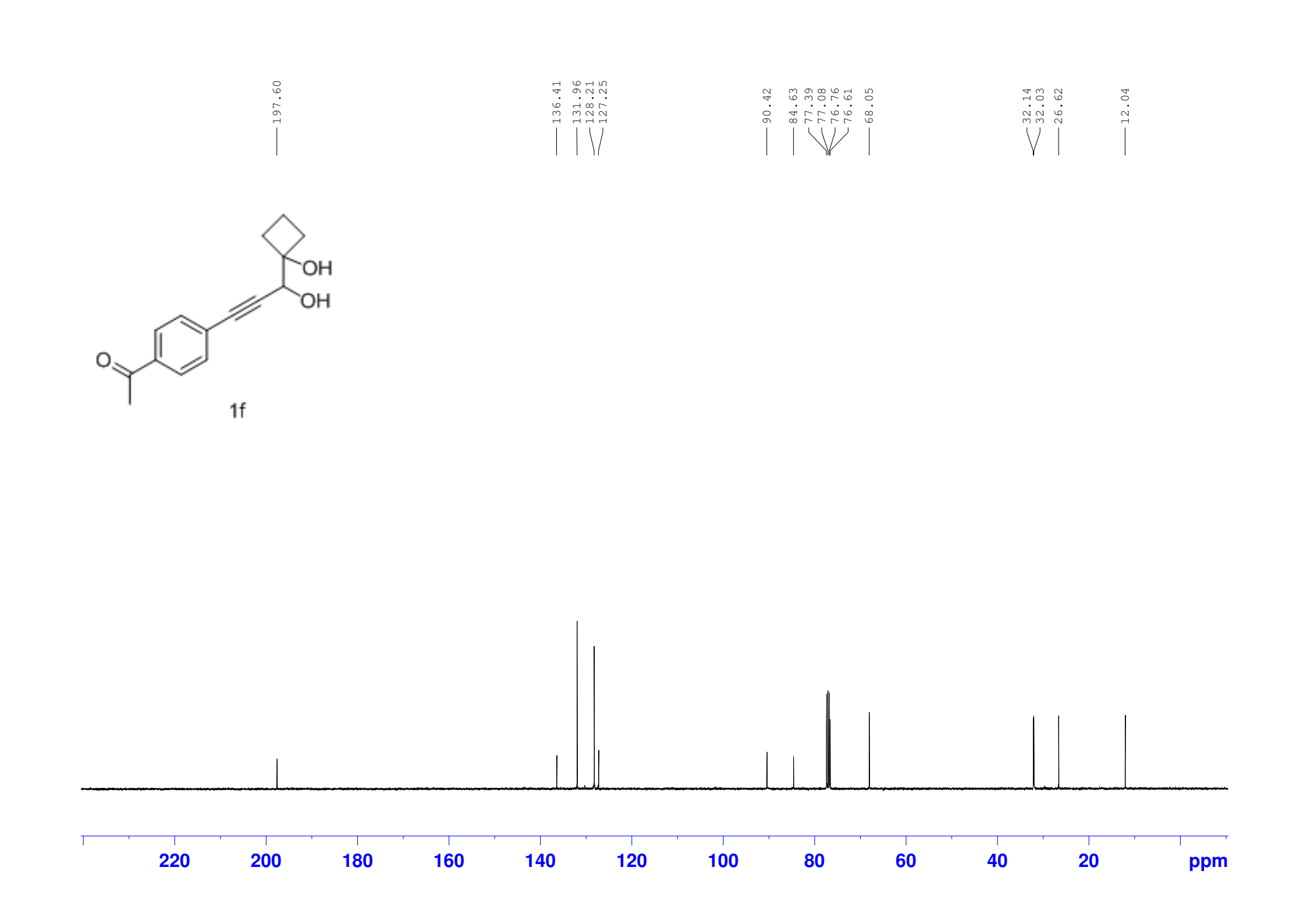
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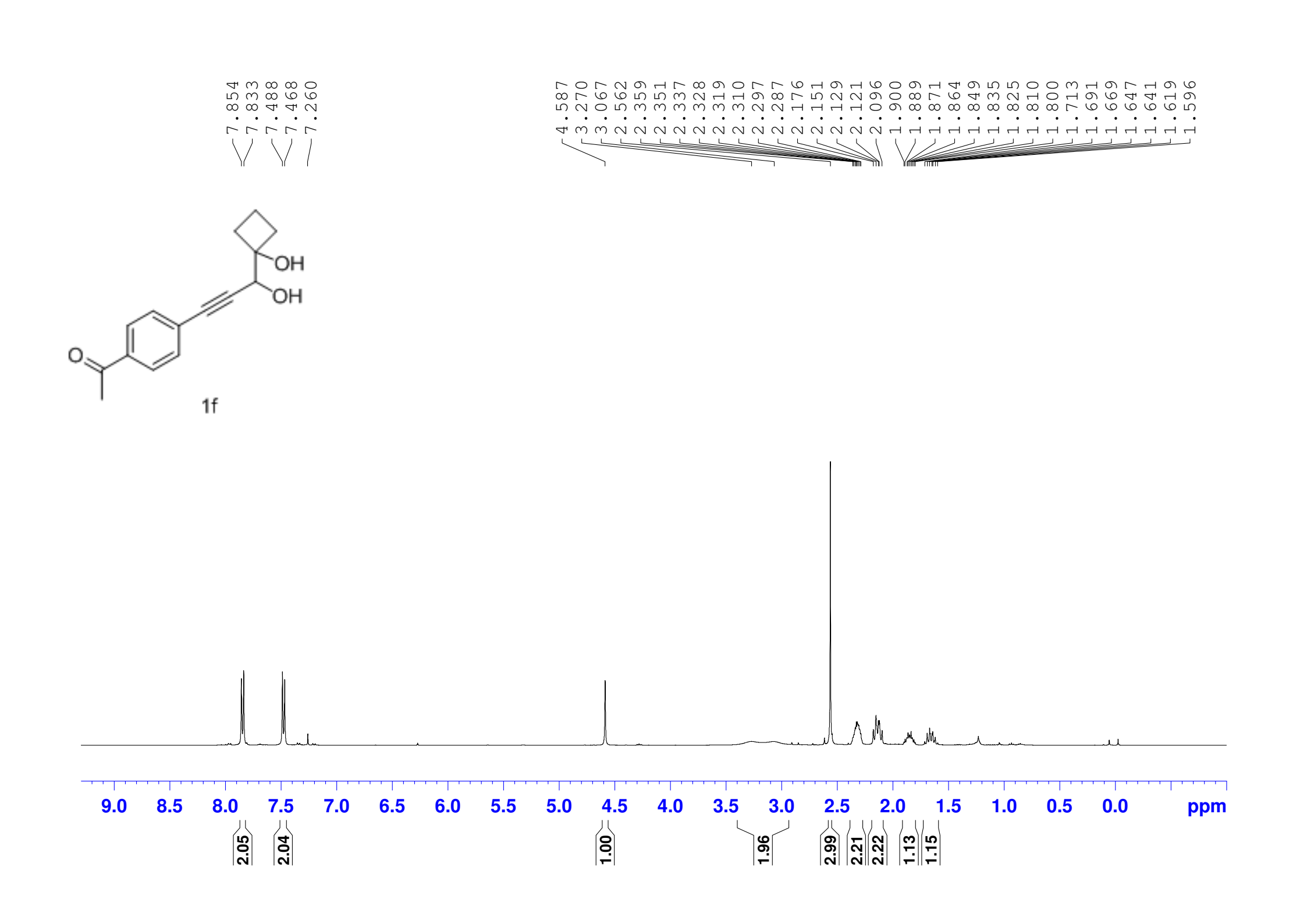
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2.151
2.129
2.121
2.096
1.900
1.889
1.871
1.864
1.849
1.835
1.825
1.810
1.800
1.713
1.691
1.669
1.647
1.641
1.619
1.596
OH
OH
O
1f
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
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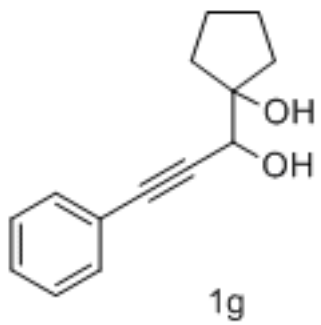
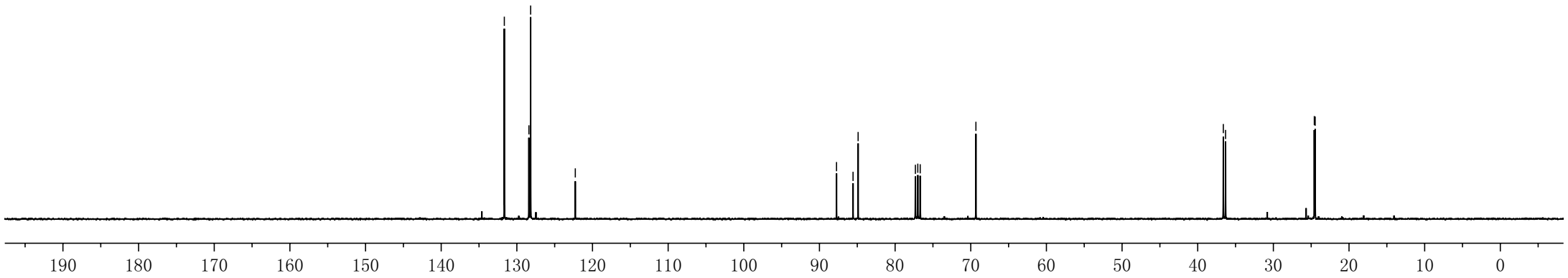
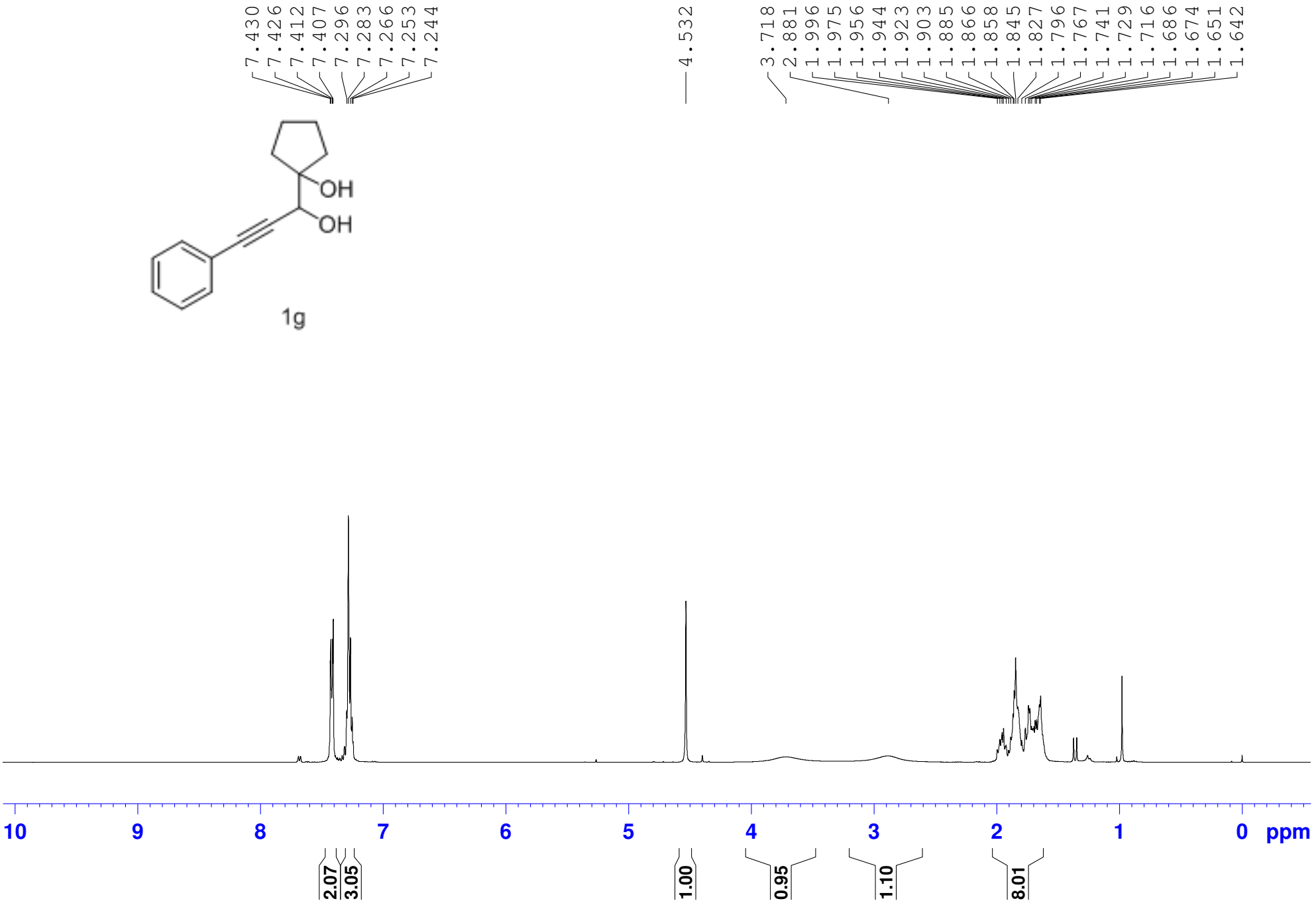
2.04
1.00
1.96
2.99
2.21
2.22
1.13
1.15



1g

131.655
128.406
128.177
122.273
87.743
85.560
84.889
77.318
77.000
76.682
69.319
36.614
36.318
24.588
24.472

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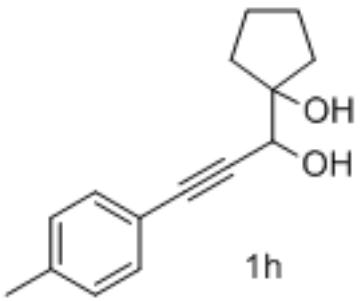
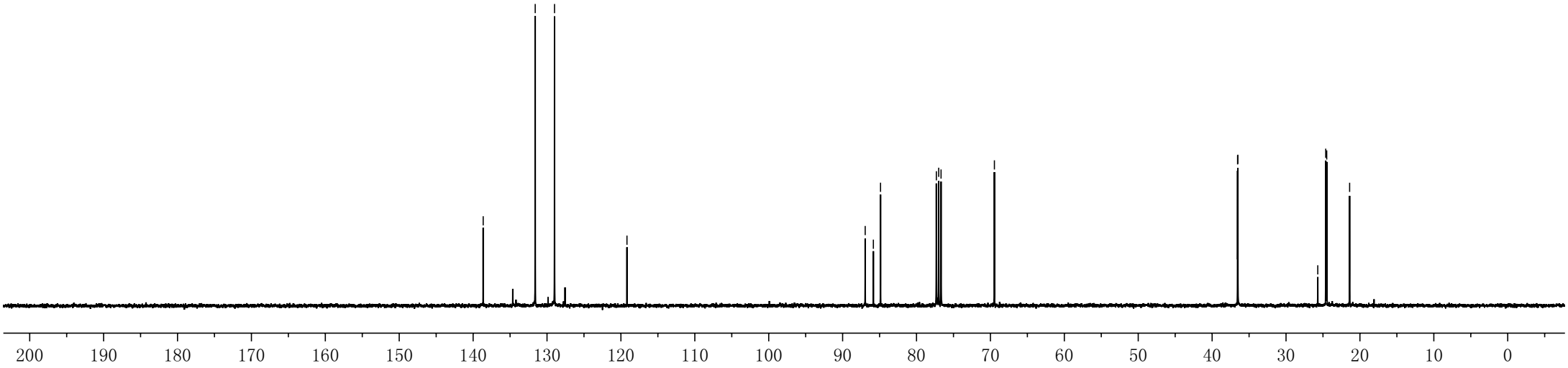
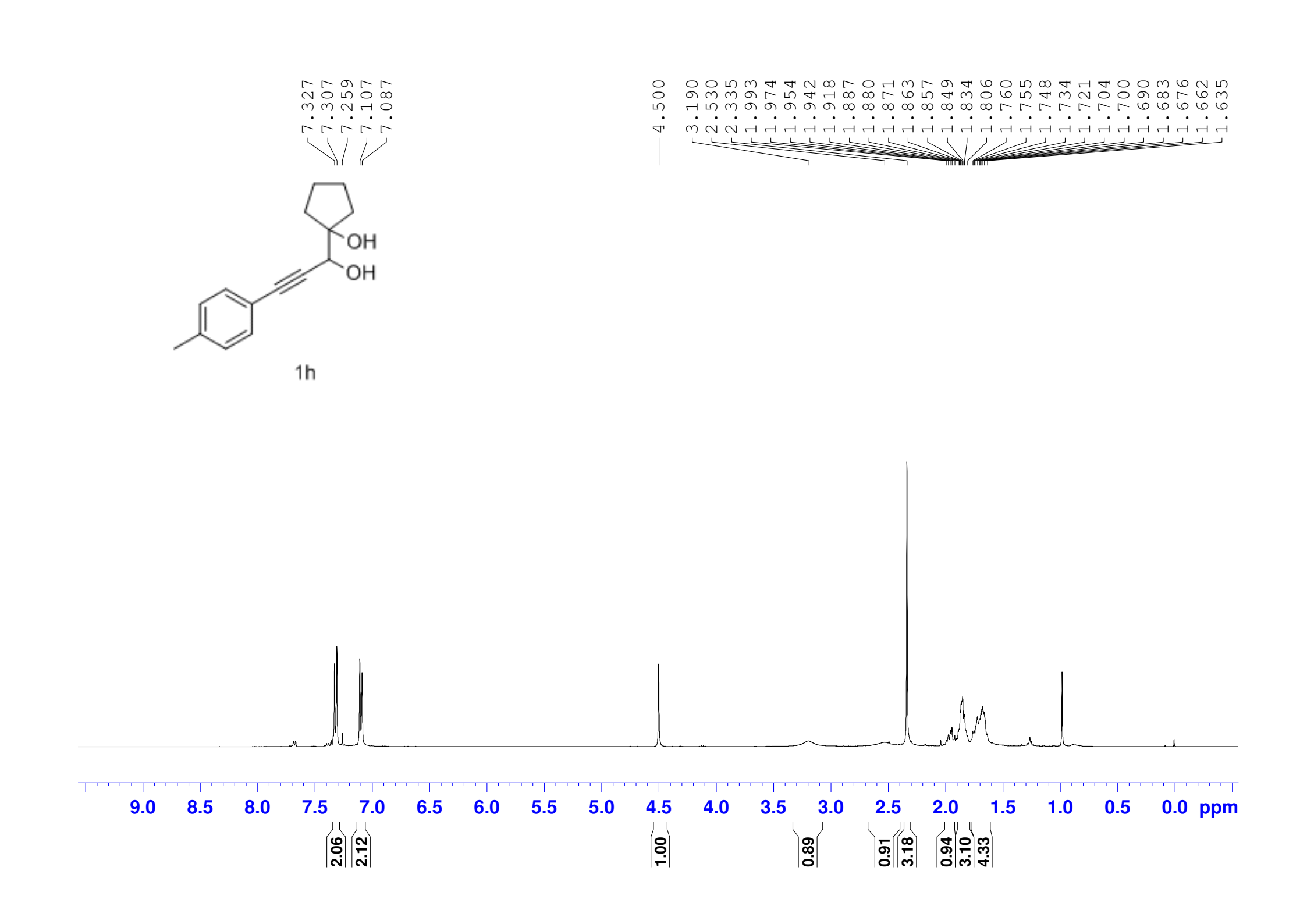
7.426
7.412
7.407
7.296
7.283
7.266
7.253
7.244
4.532
3.718
2.881
1.996
1.975
1.956
1.944
1.923
1.903
1.885
1.866
1.858
1.845
1.827
1.796
1.767
1.741
1.729
1.716
1.686
1.674
1.651
1.642
OH
OH
1g
10
9
8
7
6
5
4
3
2
1
0
ppm
2.07
3.05
1.00
0.95
1.10
8.01



1h

138.638
131.598
128.985
119.181
86.946
85.839
84.869
77.318
77.000
76.682
69.462
36.555
36.519
25.705
24.628
24.494
21.393

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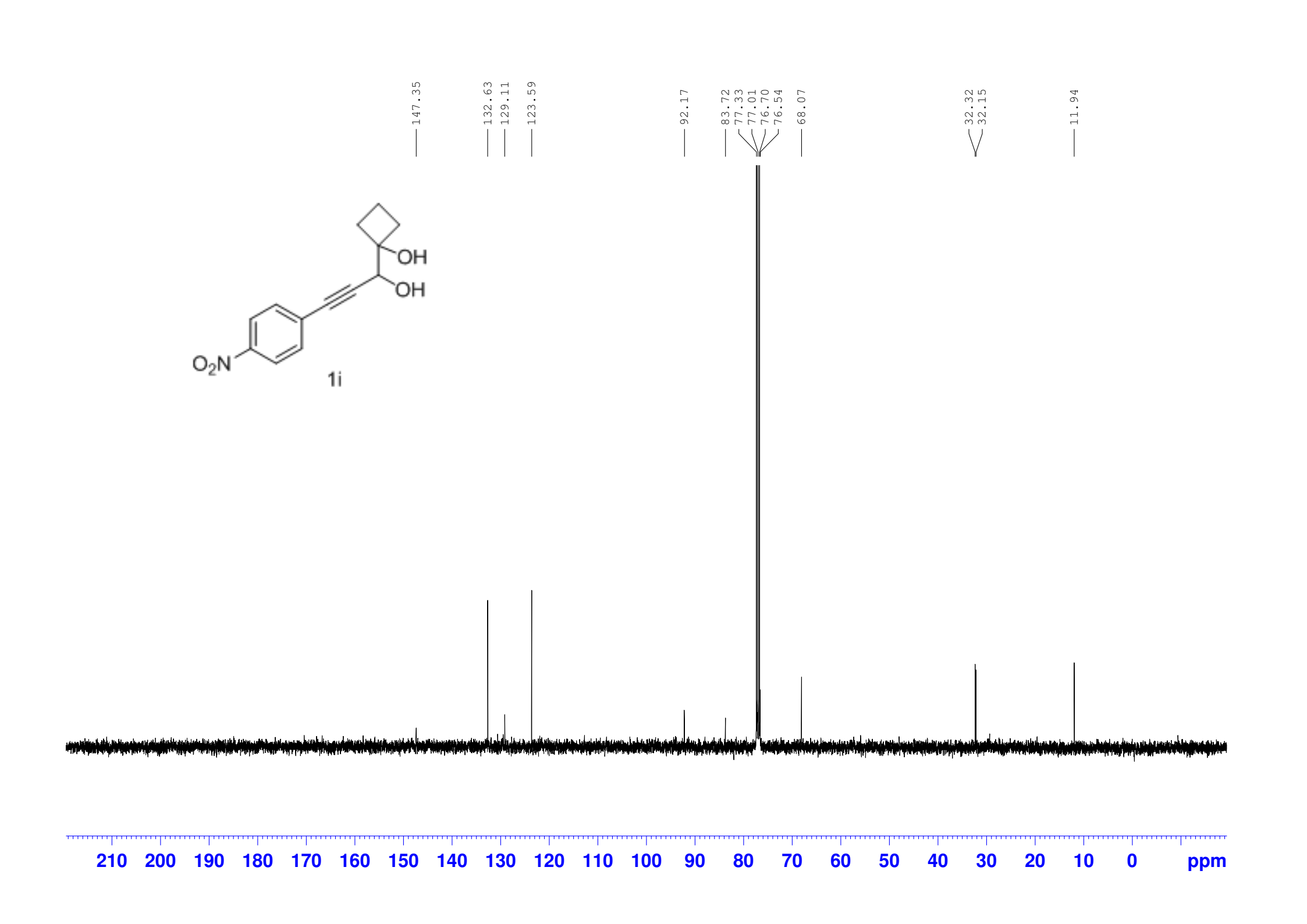
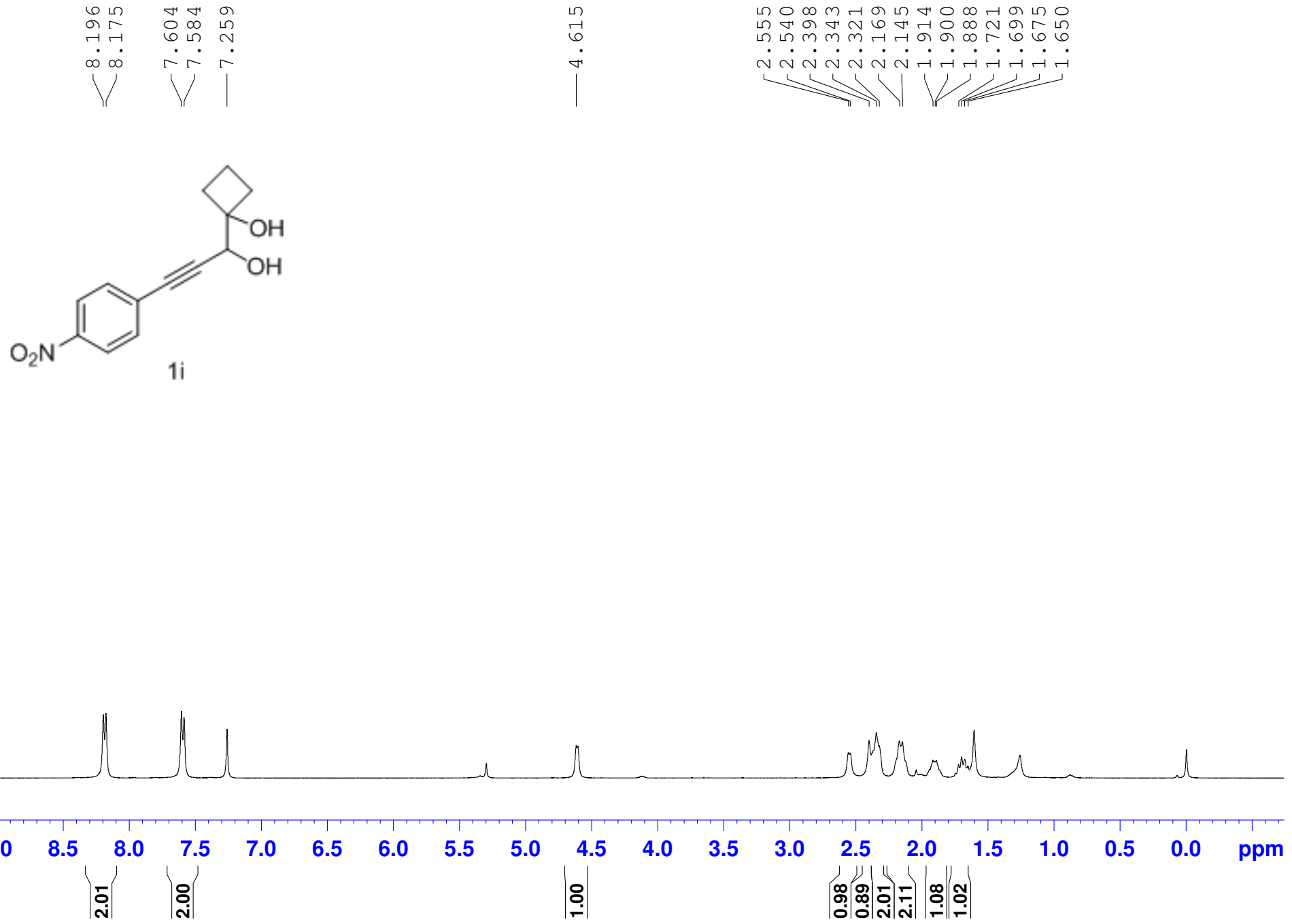
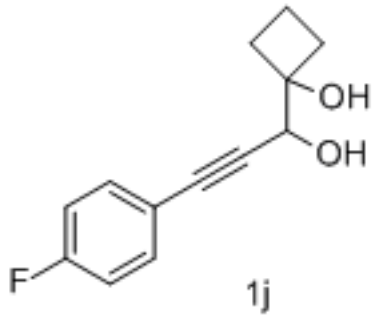
7.307
7.259
7.107
7.087
4.500
3.190
2.530
2.335
1.993
1.974
1.954
1.942
1.918
1.887
1.880
1.871
1.863
1.857
1.849
1.834
1.806
1.760
1.755
1.748
1.734
1.721
1.704
1.700
1.690
1.683
1.676
1.662
1.635
OH
OH
1h
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.06
2.12
1.00
0.89
0.91
3.18
0.94
3.10
4.33

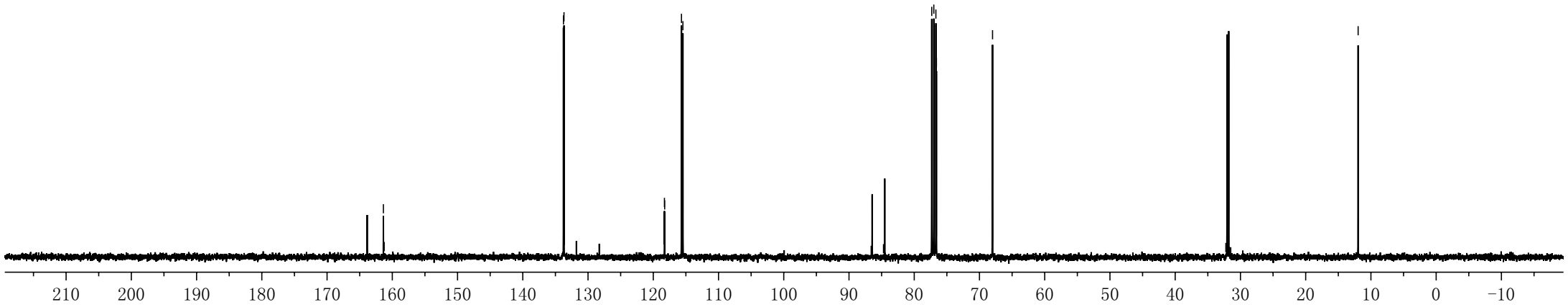

147.35
132.63
129.11
123.59
92.17
83.72
77.33
77.01
76.70
76.54
68.07
32.32
32.15
11.94
OH
OH
O2N
1i
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

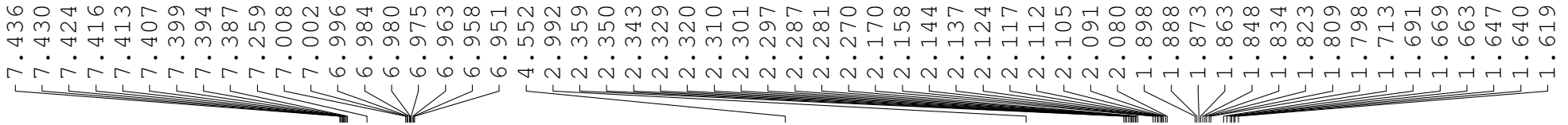

8.196
8.175
7.604
7.584
7.259
4.615
2.555
2.540
2.398
2.343
2.321
2.169
2.145
1.914
1.900
1.888
1.721
1.699
1.675
1.650
OH
OH
O2N
1i
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ppm
2.01
2.00
1.00
0.98
0.89
2.01
2.11
1.08
1.02



1j

161.364
161.244
133.768
133.684
118.290
118.254
115.678
115.458
86.604
84.713
77.317
77.000
76.682
67.997
32.239
31.482
11.961

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7.430
7.424
7.416
7.413
7.407
7.399
7.394
7.387
7.259
7.008
7.002
6.996
6.984
6.980
6.975
6.963
6.958
6.951
4.552
2.992
2.359
2.350
2.343
2.329
2.320
2.310
2.301
2.297
2.287
2.281
2.270
2.170
2.158
2.144
2.137
2.124
2.117
2.112
2.105
2.091
2.080
1.898
1.888
1.873
1.863
1.848
1.834
1.823
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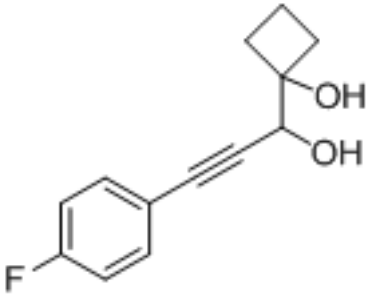
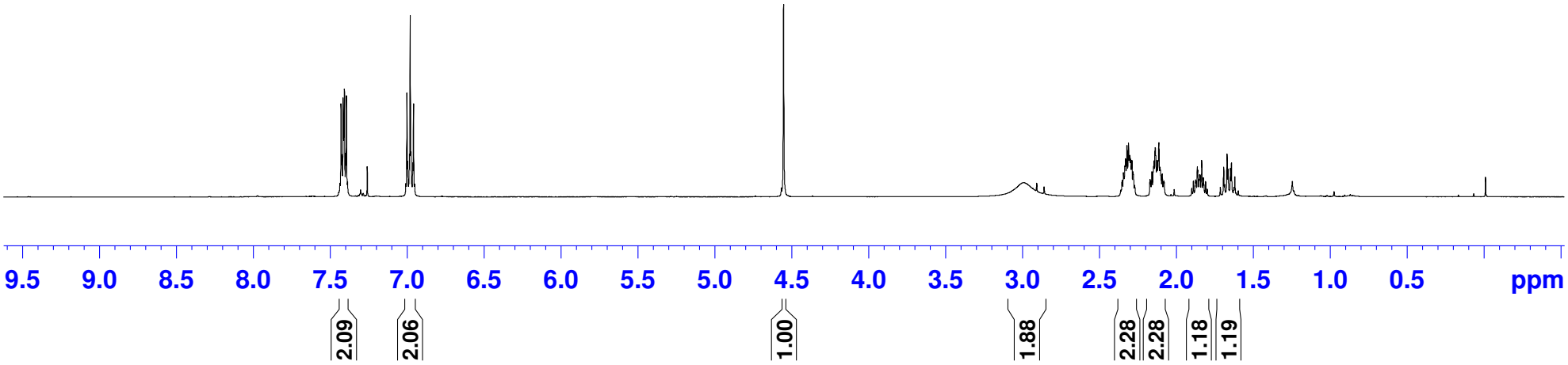
1.669
1.663
1.647
1.640
1.619


OH
OH
F

1j


9.5
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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
ppm
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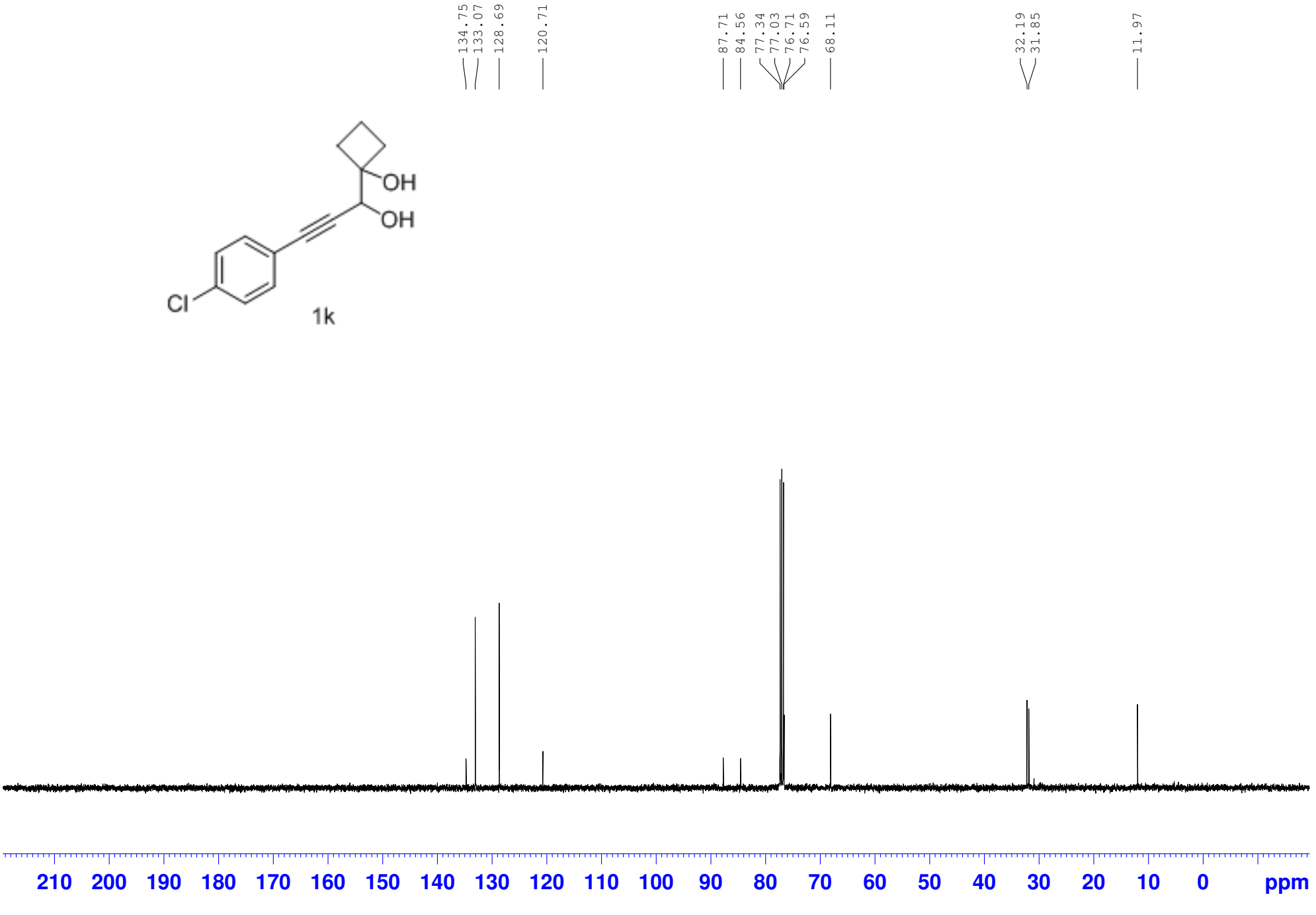
2.06
1.00
1.88
2.28
2.28
1.18
1.19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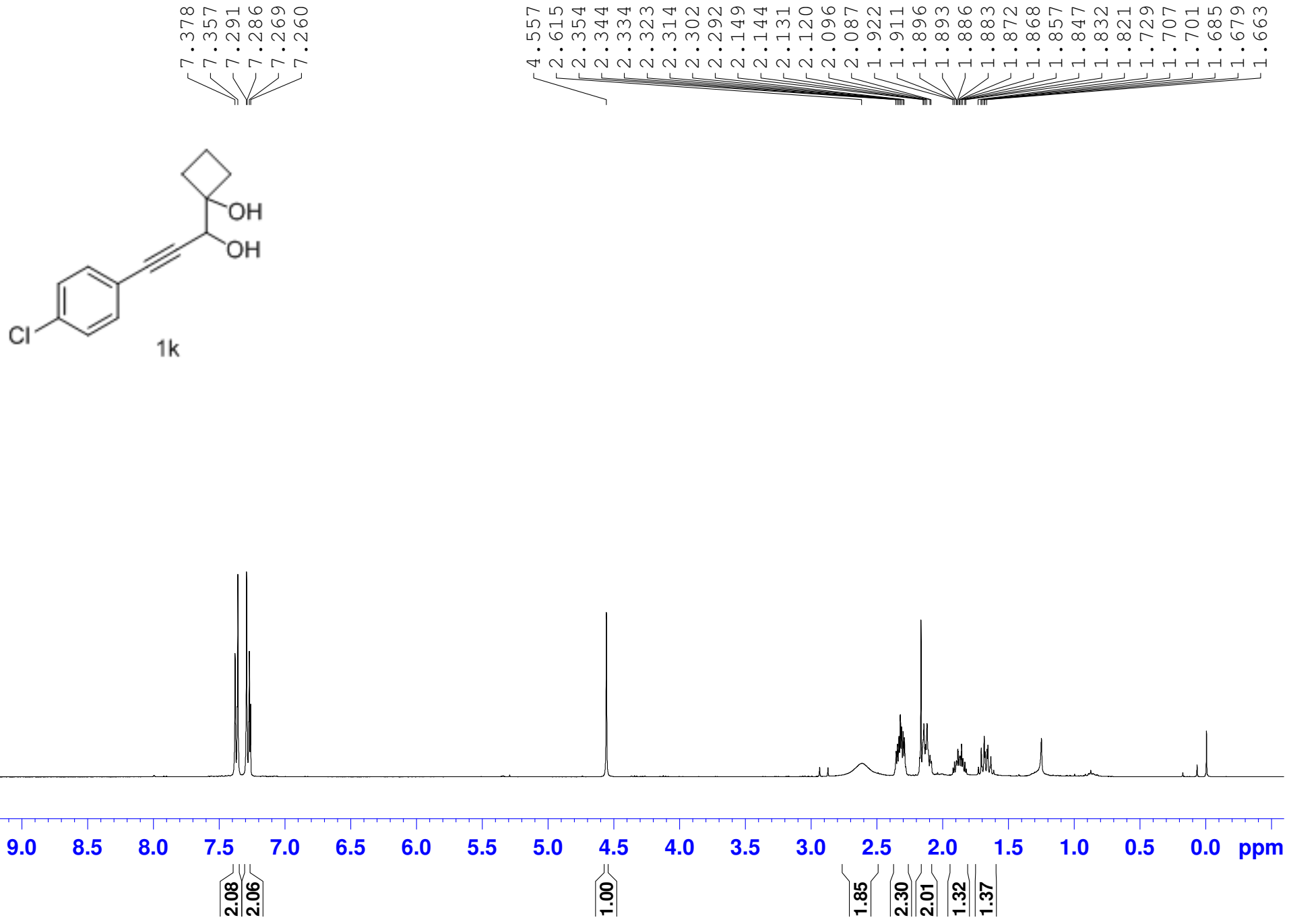
128.69
120.71
87.71
84.56
77.34
77.03
76.71
76.59
68.11
32.19
31.85
11.97
OH
OH
Cl
1k
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


7.378
7.357
7.291
7.286
7.269
7.260
4.557
2.615
2.354
2.344
2.334
2.323
2.314
2.302
2.292
2.149
2.144
2.131
2.120
2.096
2.087
1.922
1.911
1.896
1.893
1.886
1.883
1.872
1.868
1.857
1.847
1.832
1.821
1.729
1.707
1.701
1.685
1.679
1.663
OH
OH
Cl
1k
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
ppm
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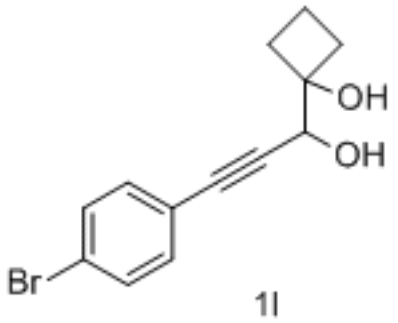
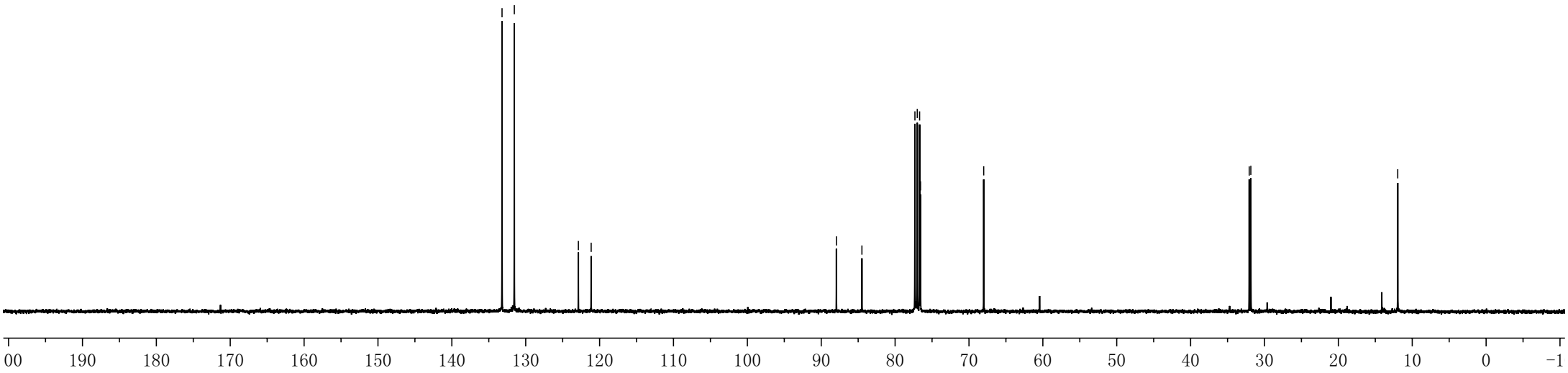
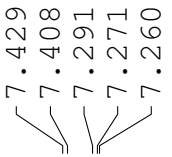
2.06
1.00
1.85
2.30
2.01
1.32
1.37



1l

133.206
131.545
122.875
121.141
87.947
84.492
77.318
77.000
76.682
76.556
68.007
32.066
31.847
11.962

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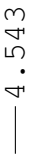
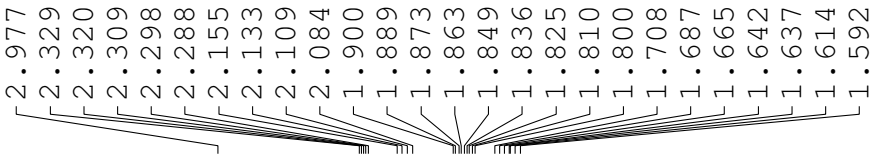
7.291
7.271
7.260


4.543


2.977
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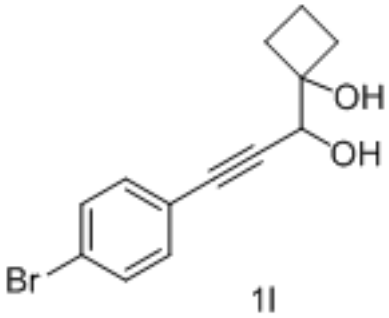
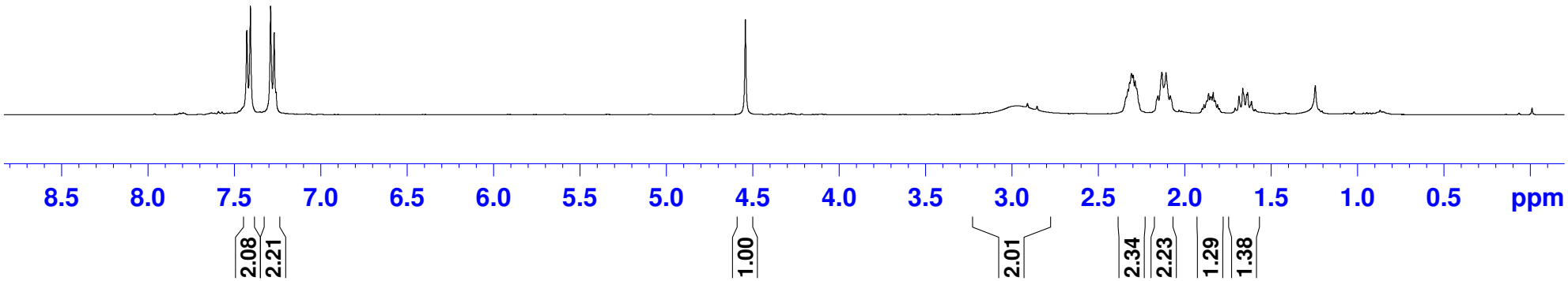
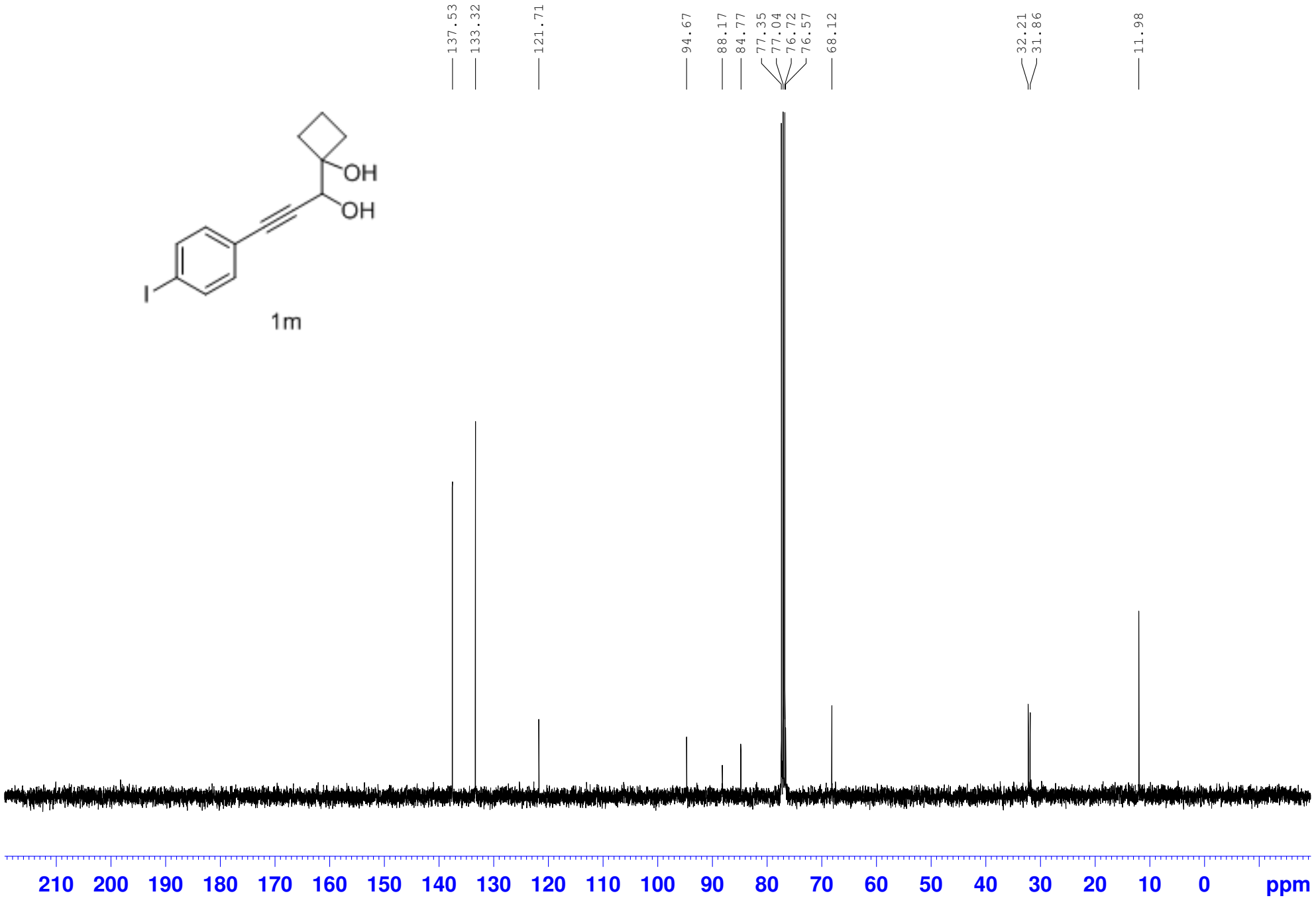
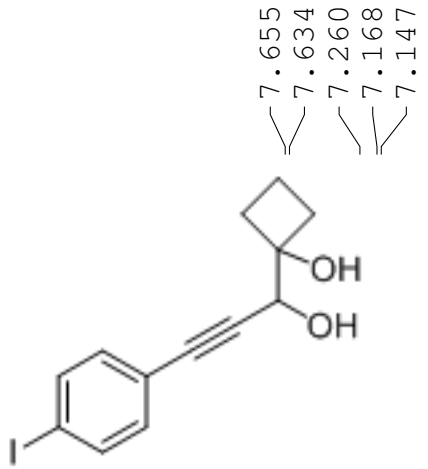
2.320
2.309
2.298
2.288
2.155
2.133
2.109
2.084
1.900
1.889
1.873
1.863
1.849
1.836
1.825
1.810
1.800
1.708
1.687
1.665
1.642
1.637
1.614
1.592


OH
OH
Br

1l


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
ppm
2.08
2.21
1.00
2.01
2.34
2.23
1.29
1.38


137.53
133.32
121.71
94.67
88.17
84.77
77.35
77.04
76.72
76.57
68.12
32.21
31.86
11.98
OH
OH
I
1m
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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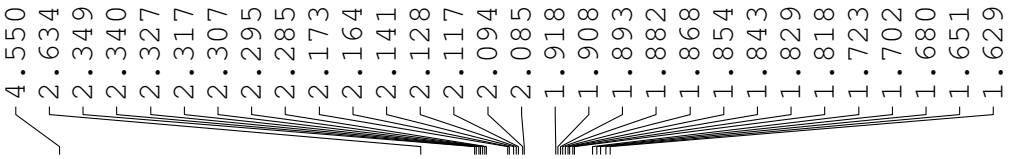
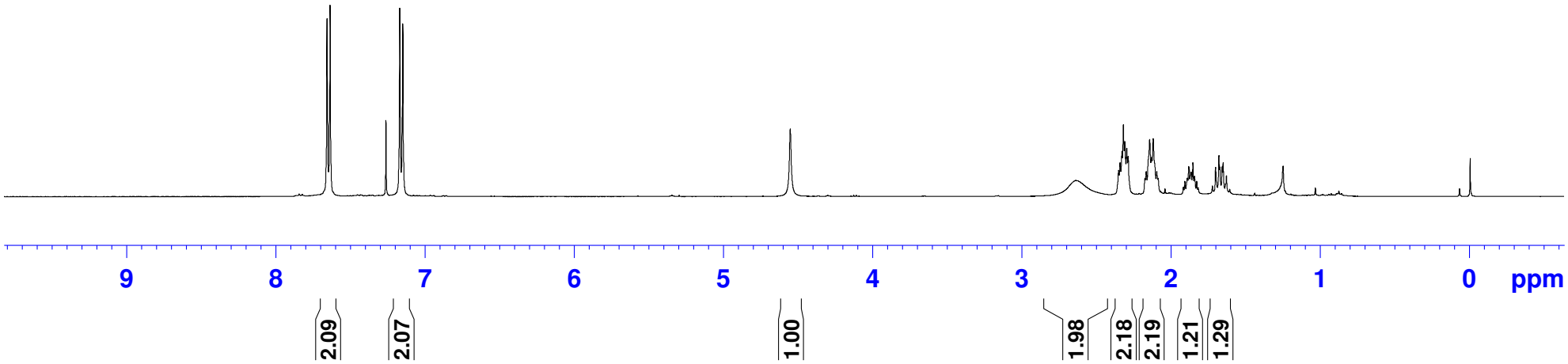
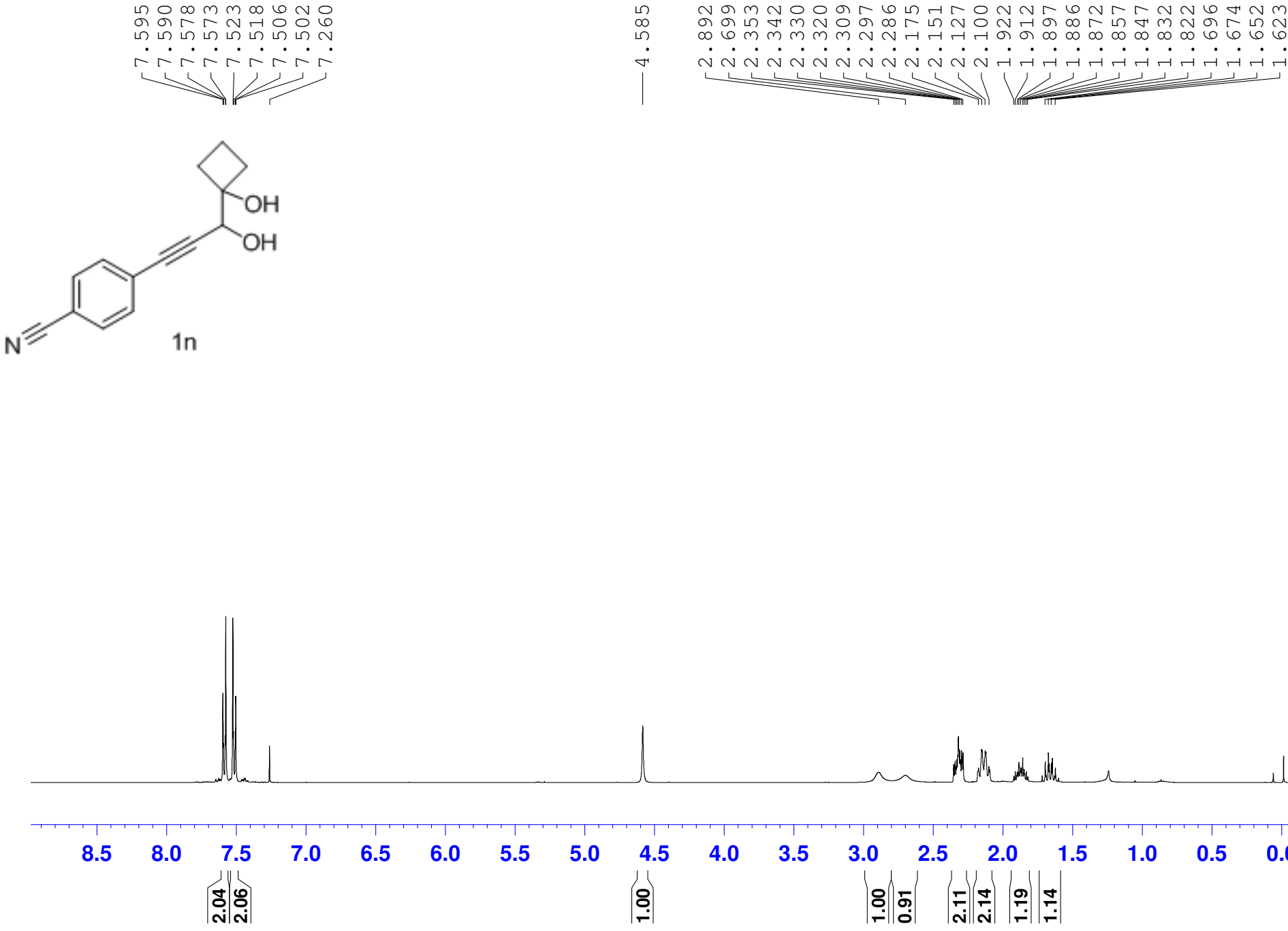
7.634
7.260
7.168
7.147
OH
OH
I

1m


4.550
2.634
2.349
2.340
2.327
2.317
2.307
2.295
2.285
2.173
2.164
2.141
2.128
2.117
2.094
2.085
1.918
1.908
1.893
1.882
1.868
1.854
1.843
1.829
1.818
1.723
1.702
1.680
1.651
1.629


9
8
7
6
5
4
3
2
1
0
ppm
2.09
2.07
1.00
1.98
2.18
2.19
1.21
1.29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7.578
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7.523
7.518
7.506
7.502
7.260
4.585
2.892
2.699
2.353
2.342
2.330
2.320
2.309
2.297
2.286
2.175
2.151
2.127
2.100
1.922
1.912
1.897
1.886
1.872
1.857
1.847
1.832
1.822
1.696
1.674
1.652
1.623
OH
OH
N
1n
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
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ppm
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2.06
1.00
1.00
0.91
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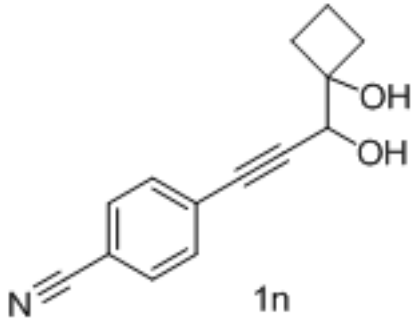
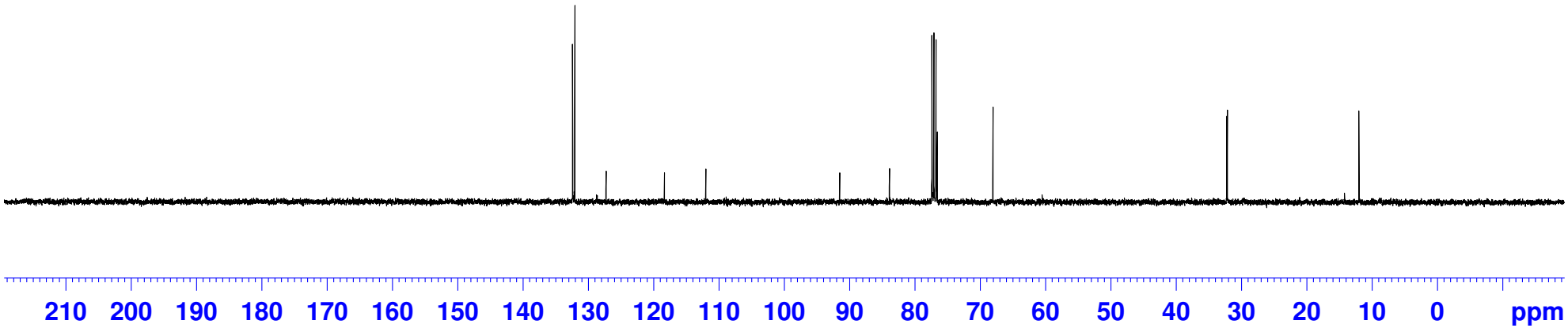
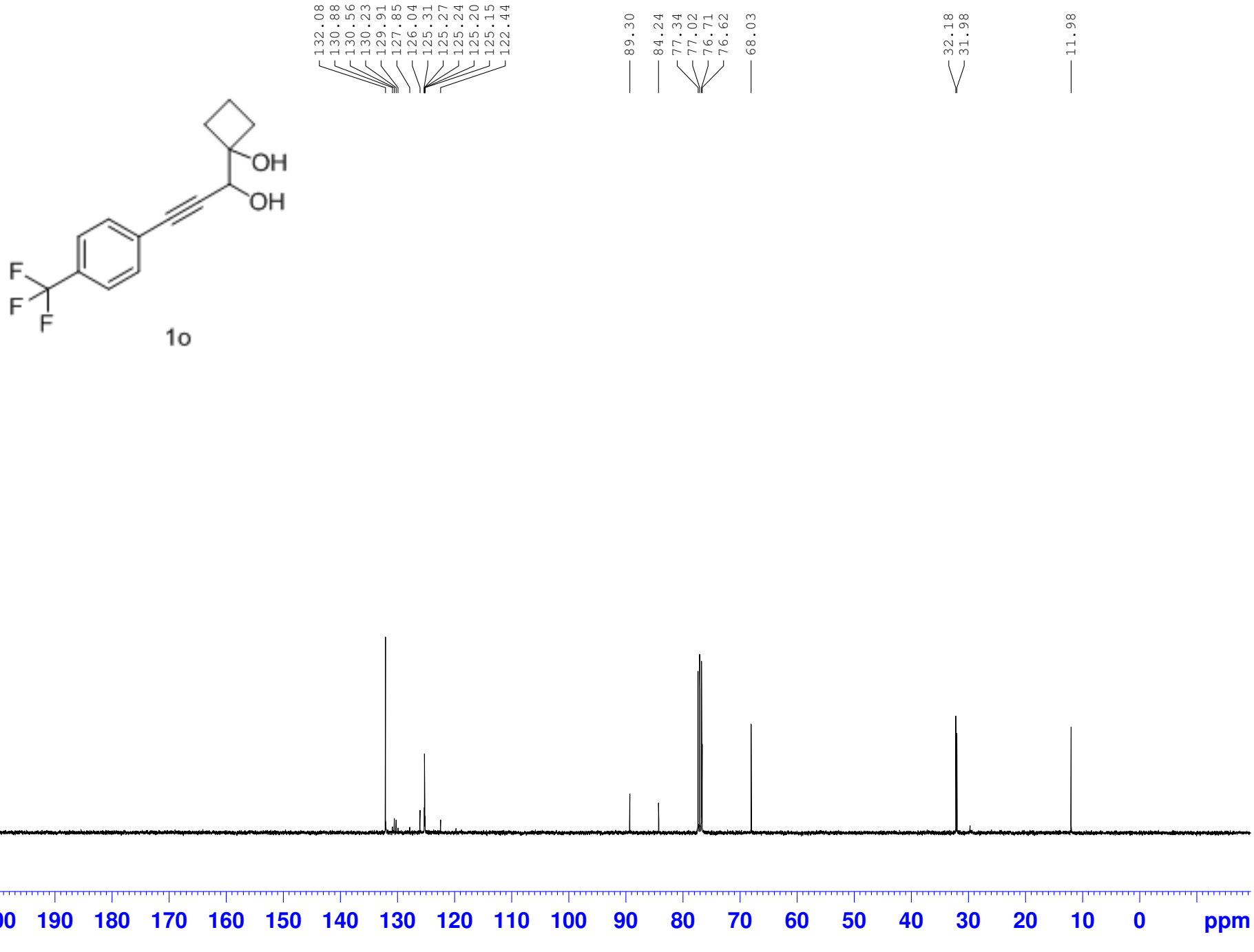
2.14
1.19
1.14



1n

132.37
132.03
127.25
118.30
111.97
91.46
83.86
77.37
77.05
76.73
76.55
68.01
32.23
32.12
11.97

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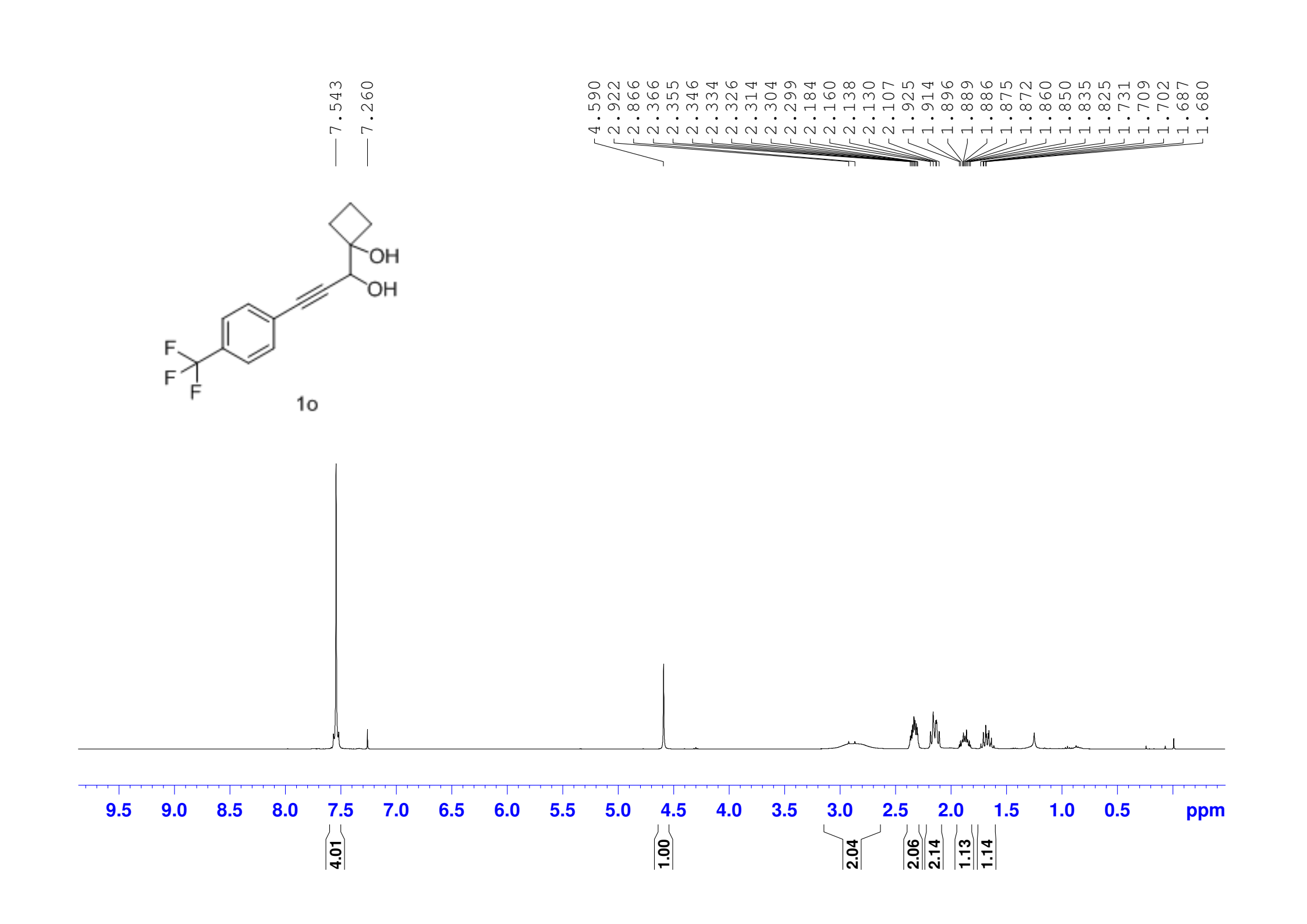
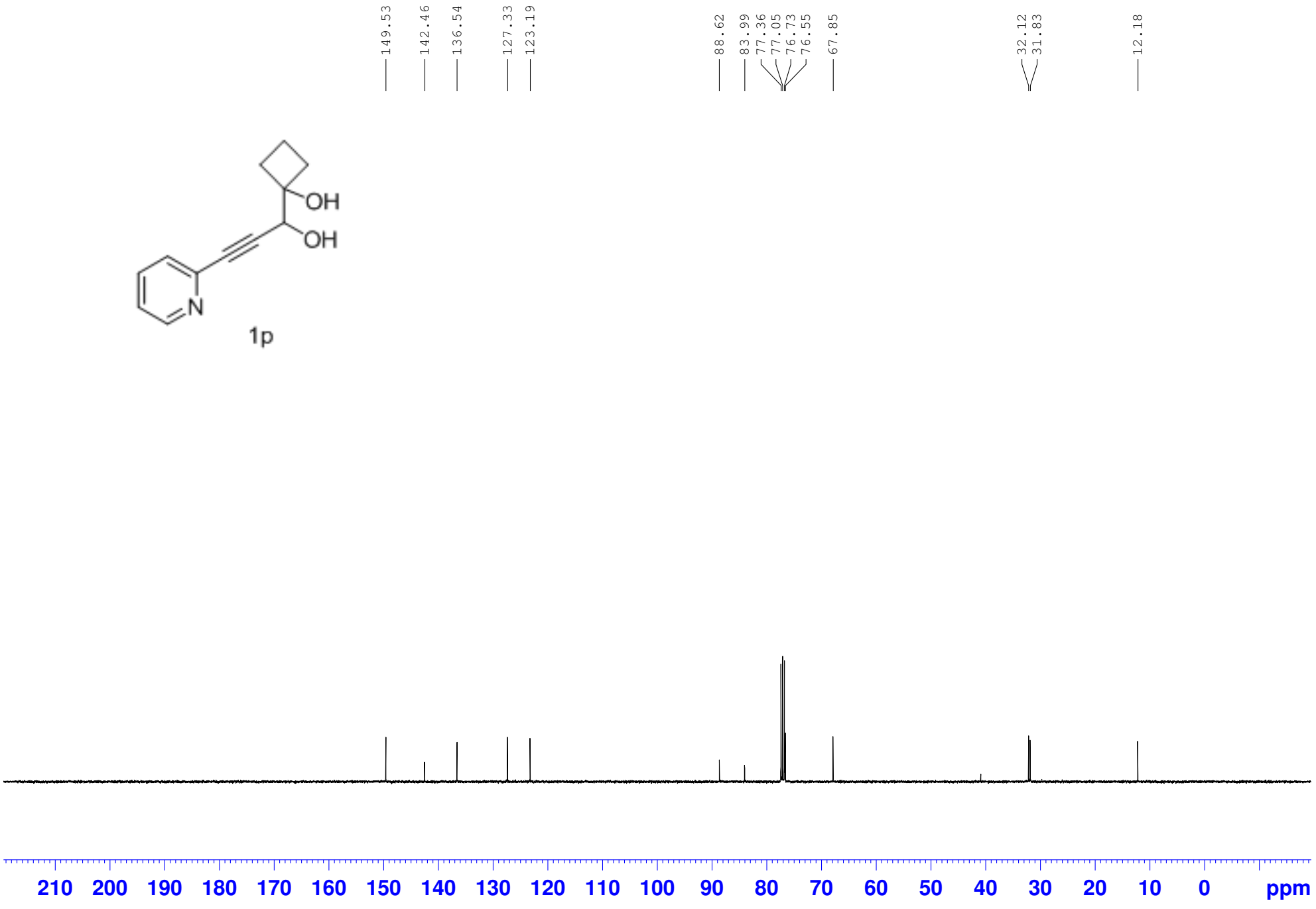
130.88
130.56
130.23
129.91
127.85
126.04
125.31
125.27
125.24
125.20
125.15
122.44
89.30
84.24
77.34
77.02
76.71
76.62
68.03
32.18
31.98
11.98
OH
OH
F
F
F
1o
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm


7.543
7.260
4.590
2.922
2.866
2.366
2.355
2.346
2.334
2.326
2.314
2.304
2.299
2.184
2.160
2.138
2.130
2.107
1.925
1.914
1.896
1.889
1.886
1.875
1.872
1.860
1.850
1.835
1.825
1.731
1.709
1.702
1.687
1.680
OH
OH
F
F
F
1o
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
ppm
4.01
1.00
2.04
2.06
2.14
1.13
1.14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77.36
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76.73
76.55
67.85
32.12
31.83
12.18
OH
OH
N
1p
210
200
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180
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140
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100
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60
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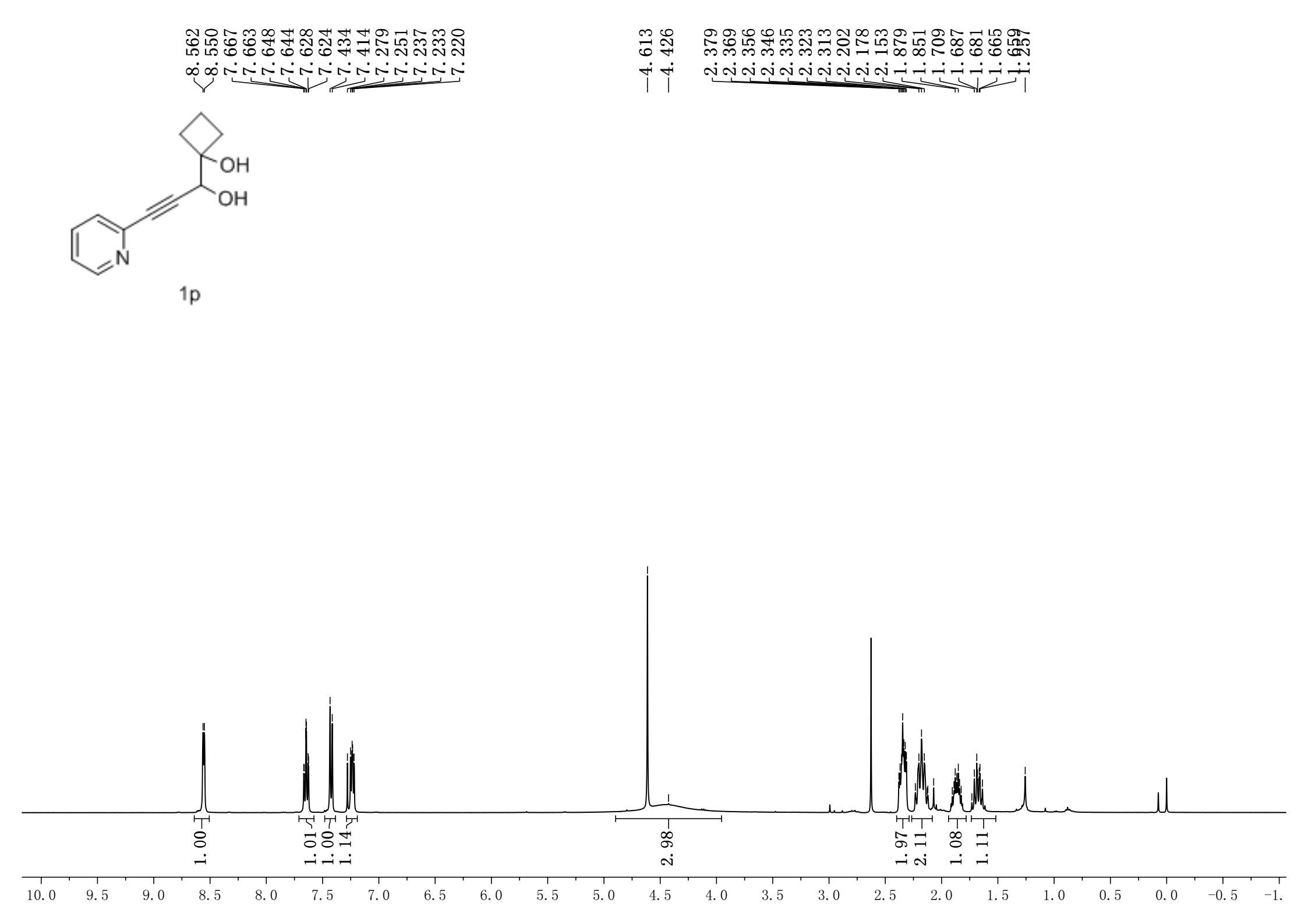
30
20
10
0
ppm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7.624
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7.237
7.233
7.220
4.613
4.426
2.379
2.369
2.356
2.346
2.335
2.323
2.313
2.202
2.178
2.153
1.879
1.851
1.709
1.687
1.681
1.665
OH
OH
N
1p
1.00
1.01
1.00
1.14
2.98
1.97
2.11
1.08
1.11
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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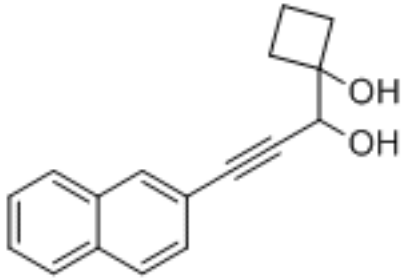
-0.5



1r

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132.720
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127.913
127.653
126.731
126.499
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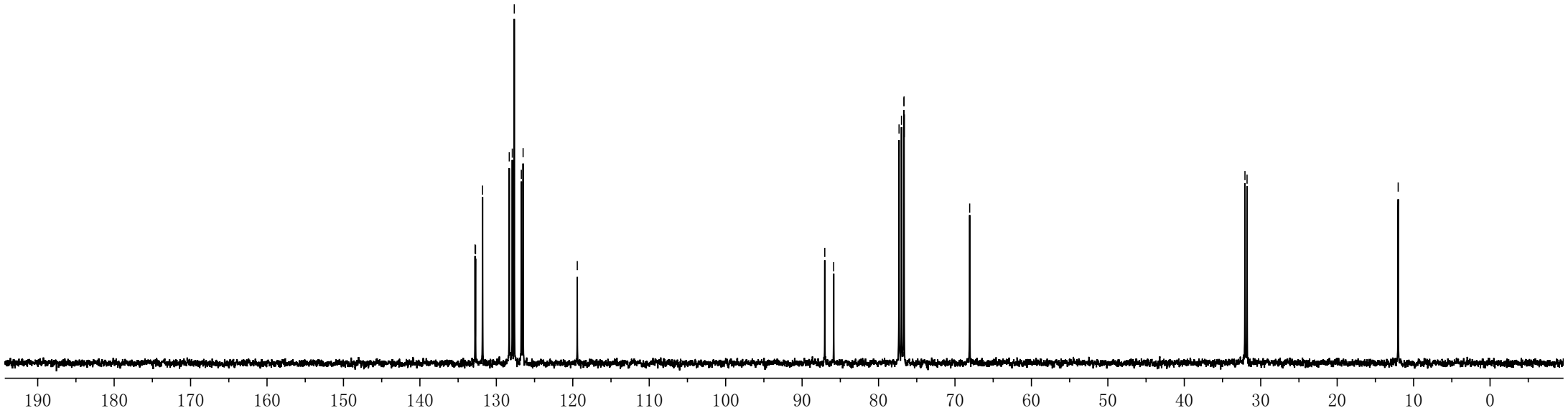
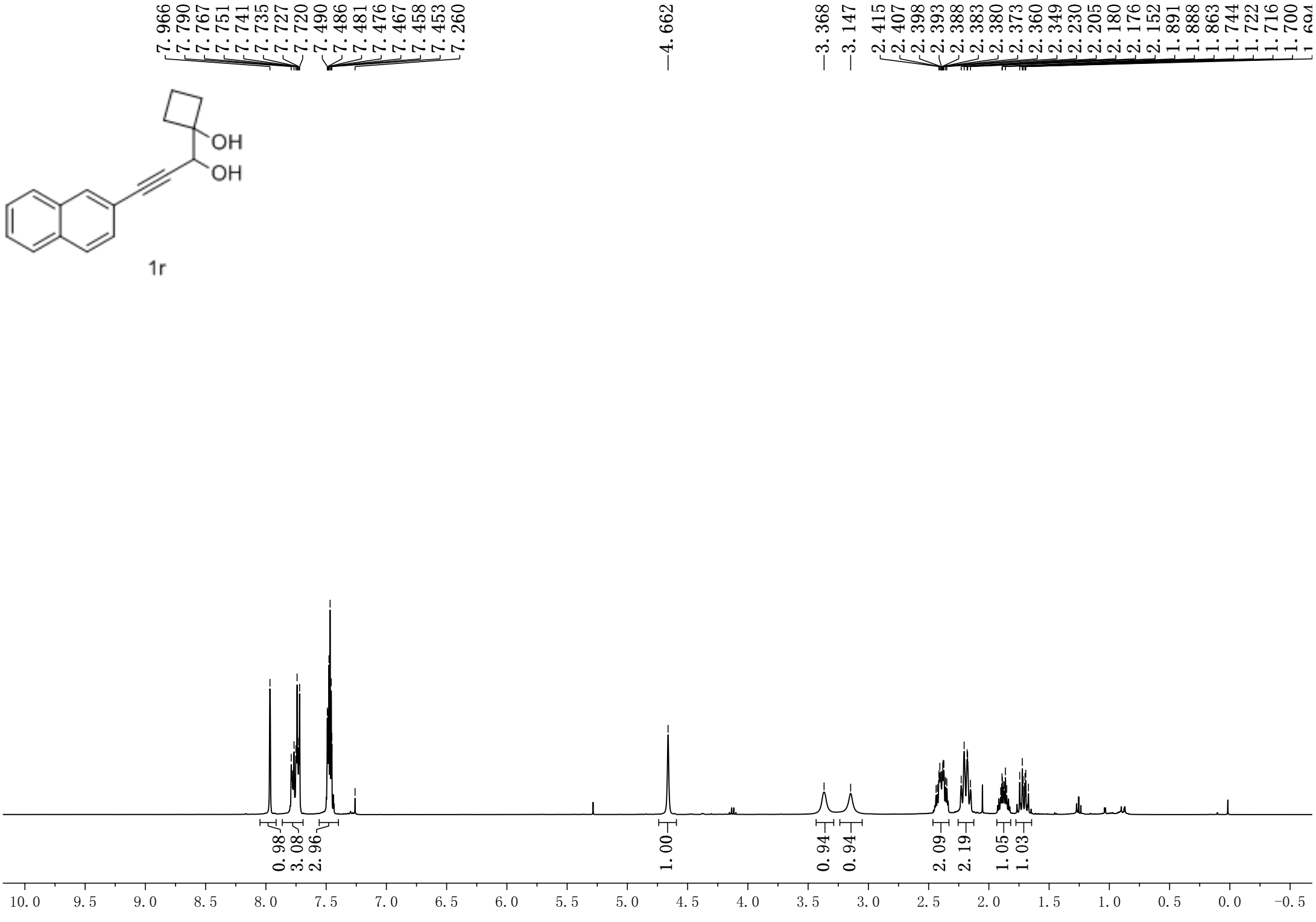
85.867
77.318
77.000
76.678
76.660
68.076
32.064
31.789
12.019

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7.720
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7.481
7.476
7.467
7.458
7.453
7.260
4.662
3.368
3.147
2.415
2.407
2.398
2.393
2.388
2.383
2.380
2.373
2.360
2.349
2.230
2.205
2.180
2.176
2.152
1.891
1.888
1.863
1.744
1.722
1.716
1.700
OH
OH
1r
0.98
3.08
2.96
1.00
0.94
0.94
2.09
2.19
1.05
1.03
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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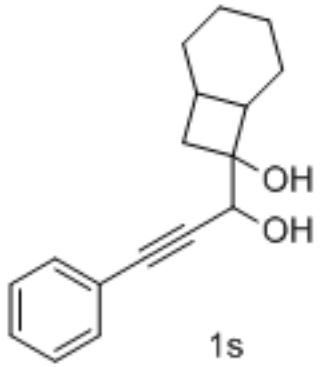

1s

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86.989
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77.000
76.682
75.880
68.632
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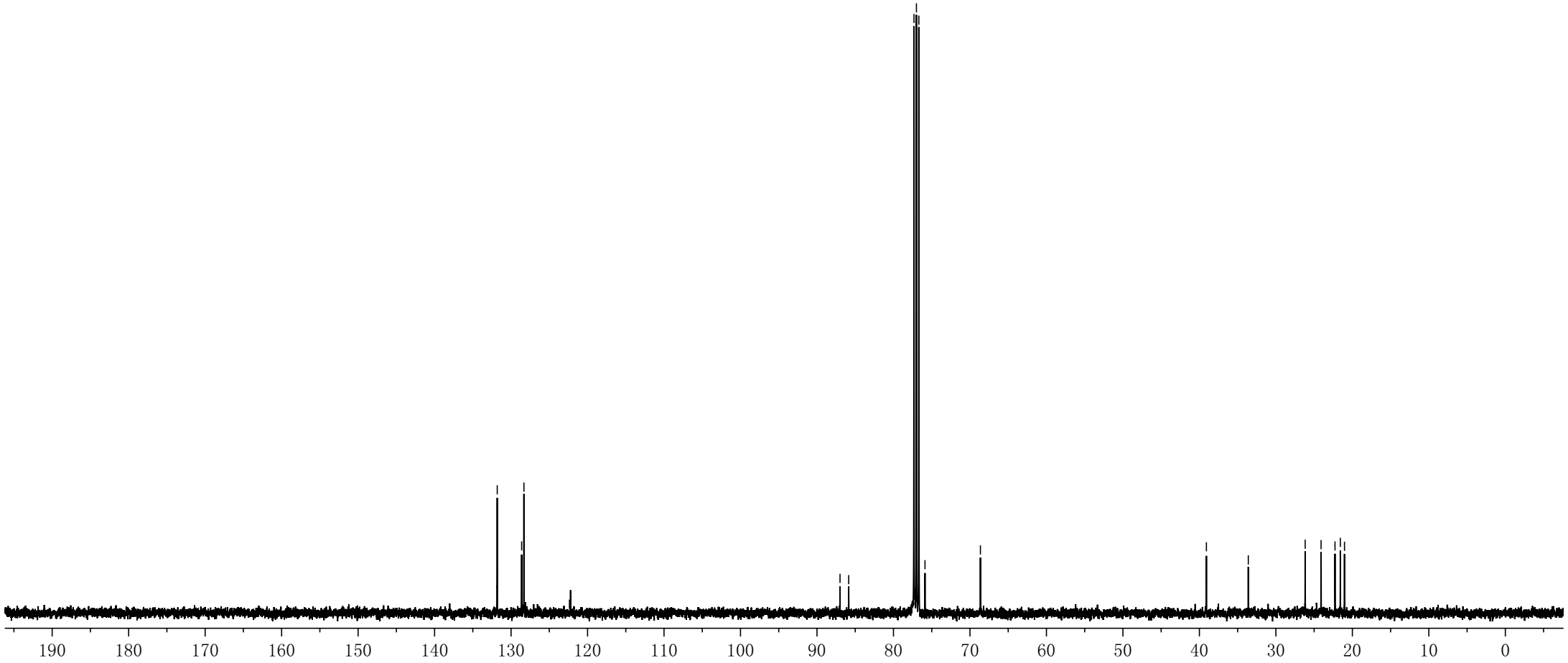
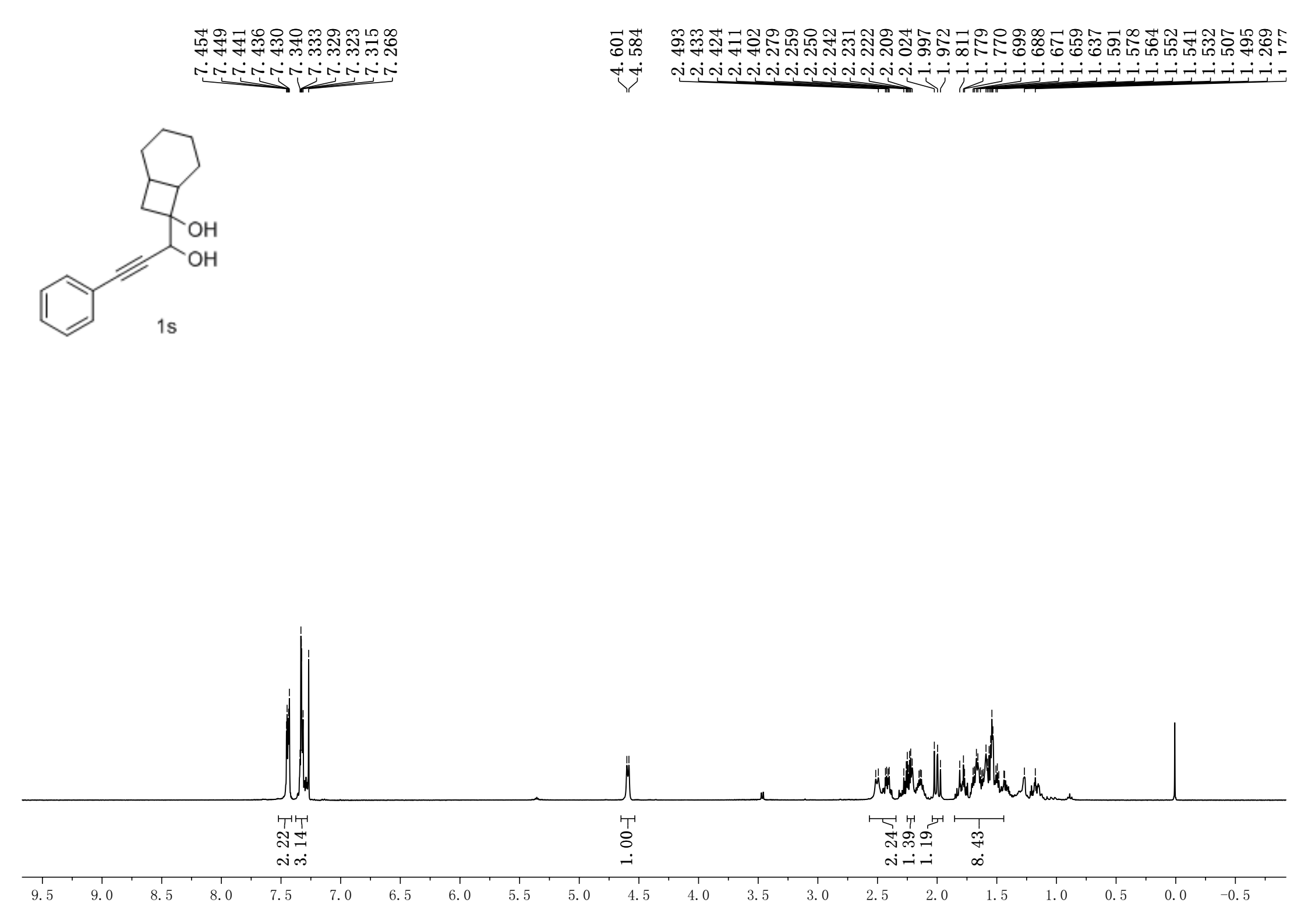
33.606
26.170
24.091
22.270
21.572
21.030

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7.449
7.441
7.436
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7.340
7.333
7.329
7.323
7.315
7.268
4.601
4.584
2.493
2.433
2.424
2.411
2.402
2.279
2.259
2.250
2.242
2.231
2.222
2.209
2.024
1.997
1.972
1.811
1.779
1.770
1.699
1.688
1.671
1.659
1.637
1.591
1.578
1.564
1.552
1.541
1.532
1.507
1.495
1.269
OH
OH
1s
2.22
3.14
1.00
2.24
1.39
1.19
8.43
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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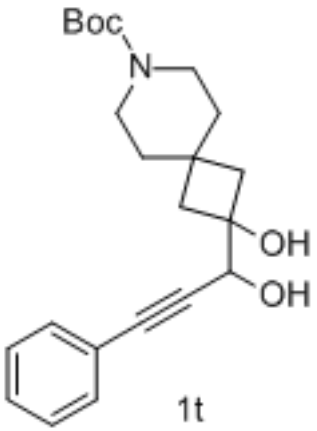

1t

154.965
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128.821
128.400
121.970
86.589
86.499
79.353
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77.000
76.788
72.859
70.053
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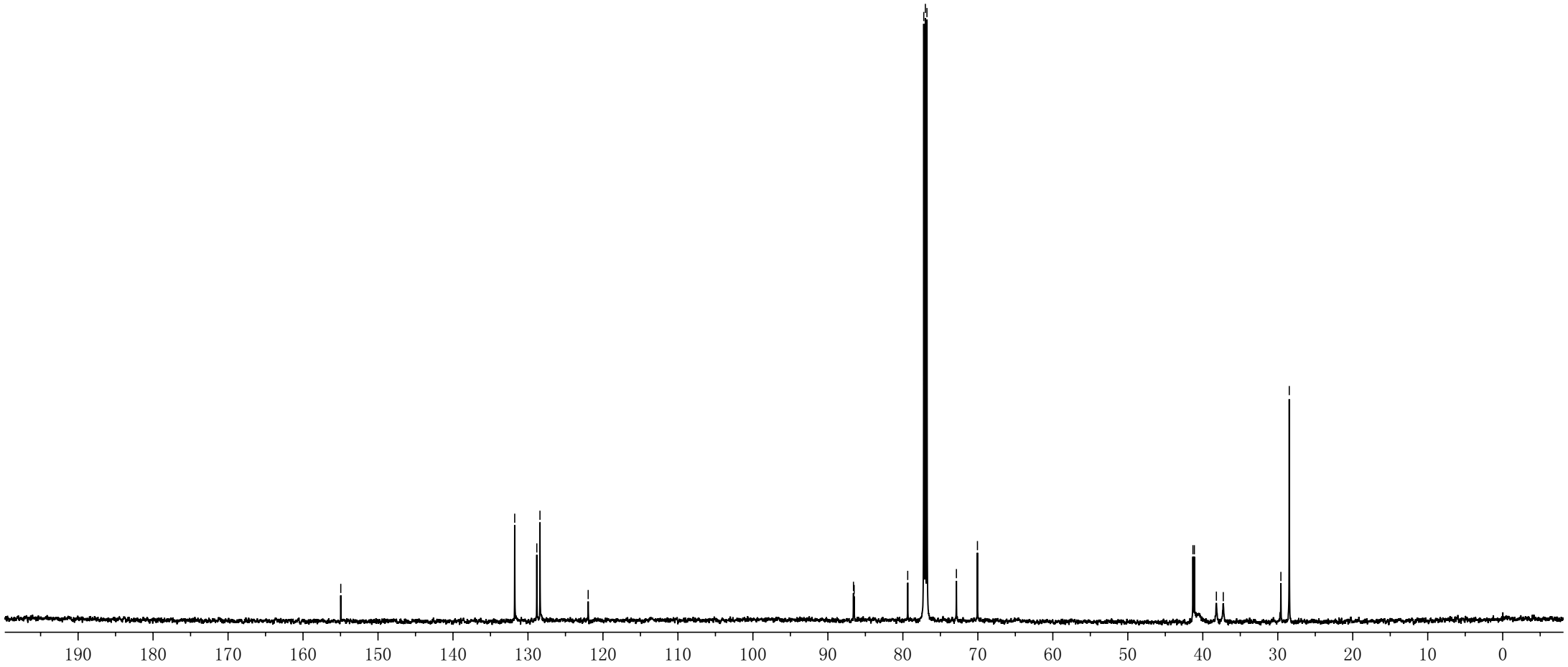
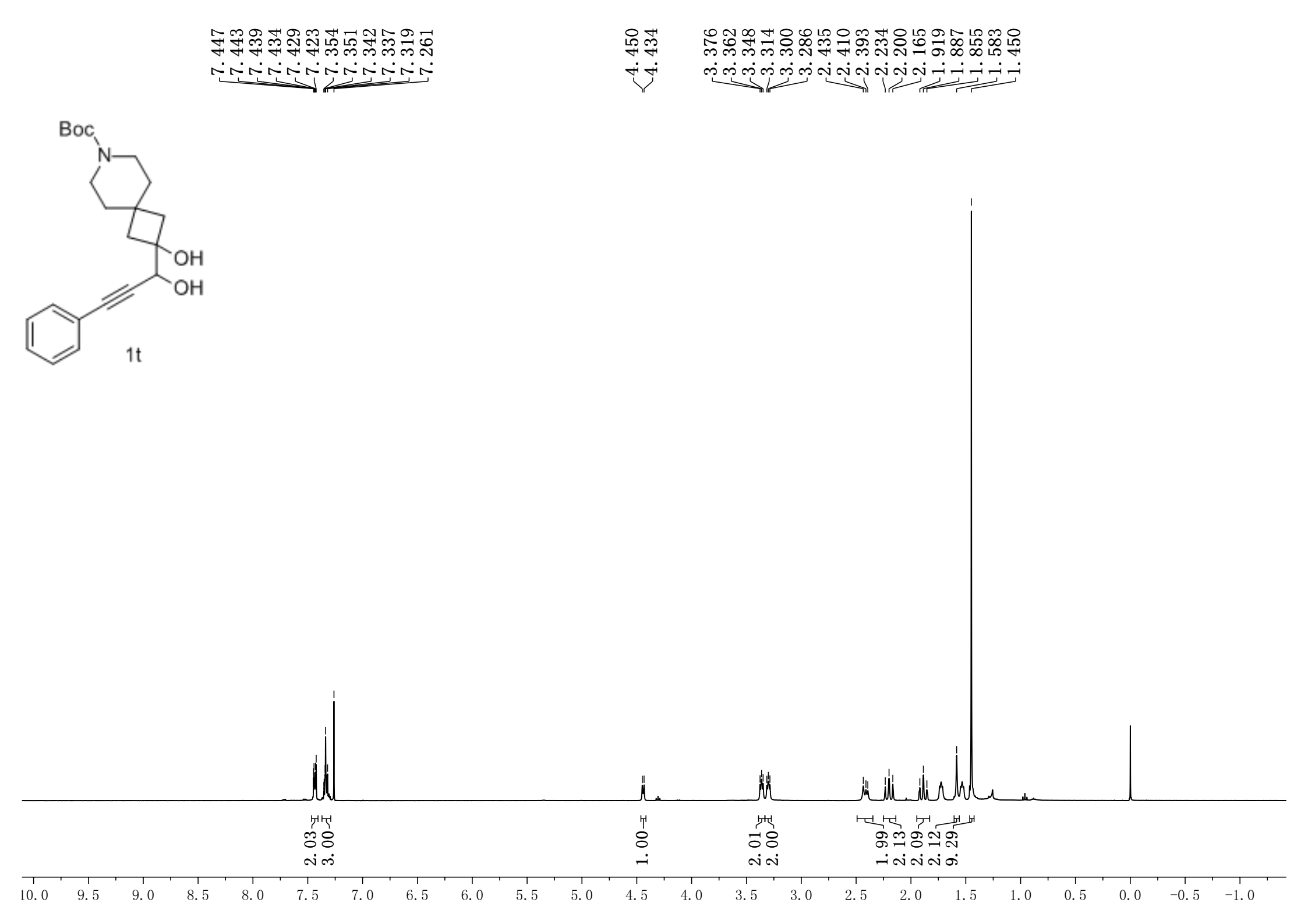
41.124
38.187
37.268
29.585
28.466

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7.439
7.434
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7.351
7.342
7.337
7.319
7.261
4.450
4.434
3.376
3.362
3.348
3.314
3.300
3.286
2.435
2.410
2.393
2.234
2.200
2.165
1.919
1.887
1.855
1.583
1.450
Boc
N
OH
OH
1t
2.03
3.00
1.00
2.01
2.00
1.99
2.13
2.09
2.12
9.29
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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3.0
2.5
2.0
1.5
1.0
0.5
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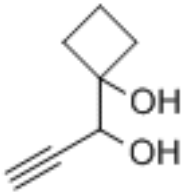
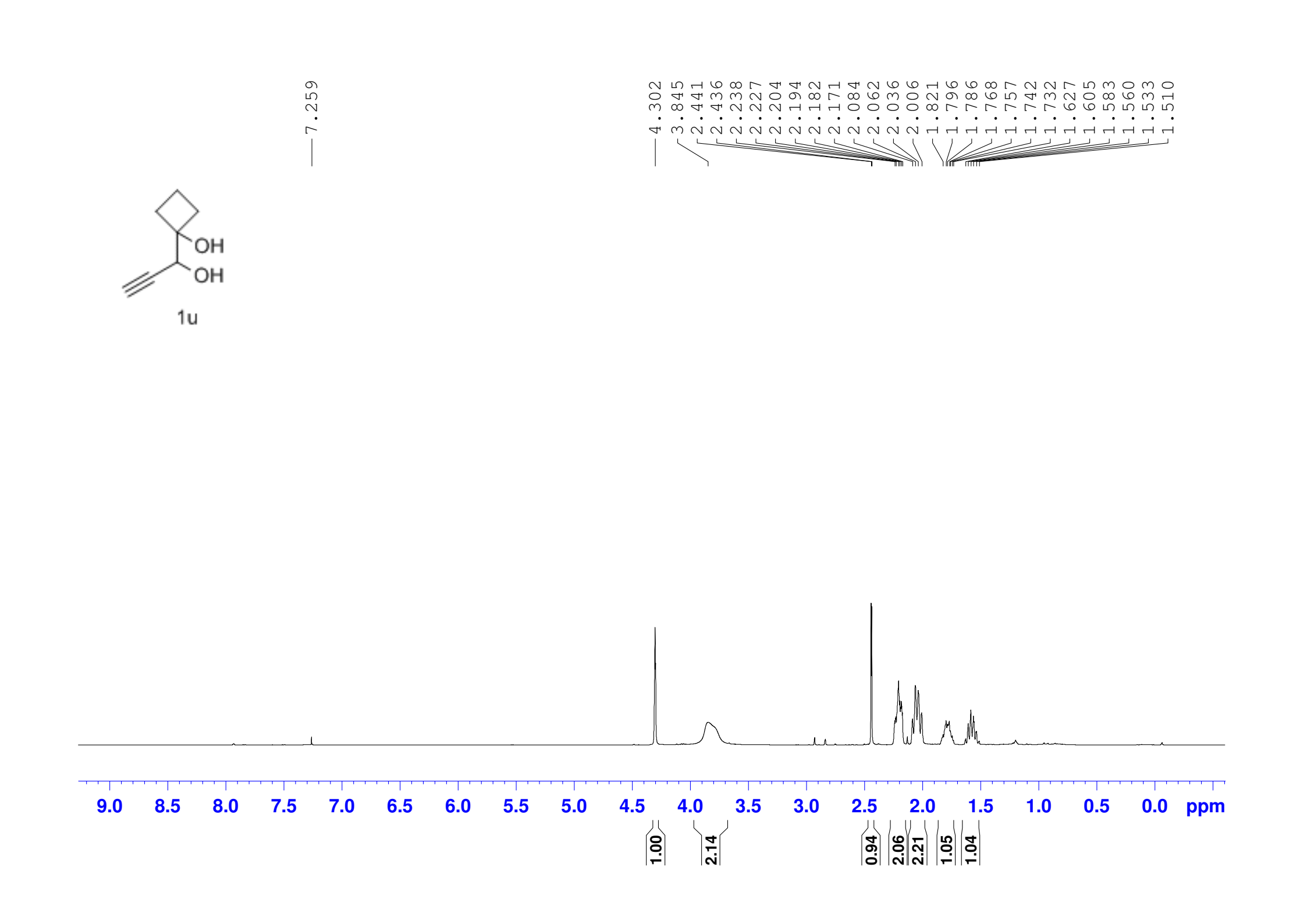
-0.5
-1.0



1u

81.87
77.44
77.13
76.81
76.45
73.77
67.19
31.72
11.97

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm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2.182
2.171
2.084
2.062
2.036
2.006
1.821
1.796
1.786
1.768
1.757
1.742
1.732
1.627
1.605
1.583
1.560
1.533
1.510
OH
OH
1u
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
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0.5
0.0
ppm
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0.94
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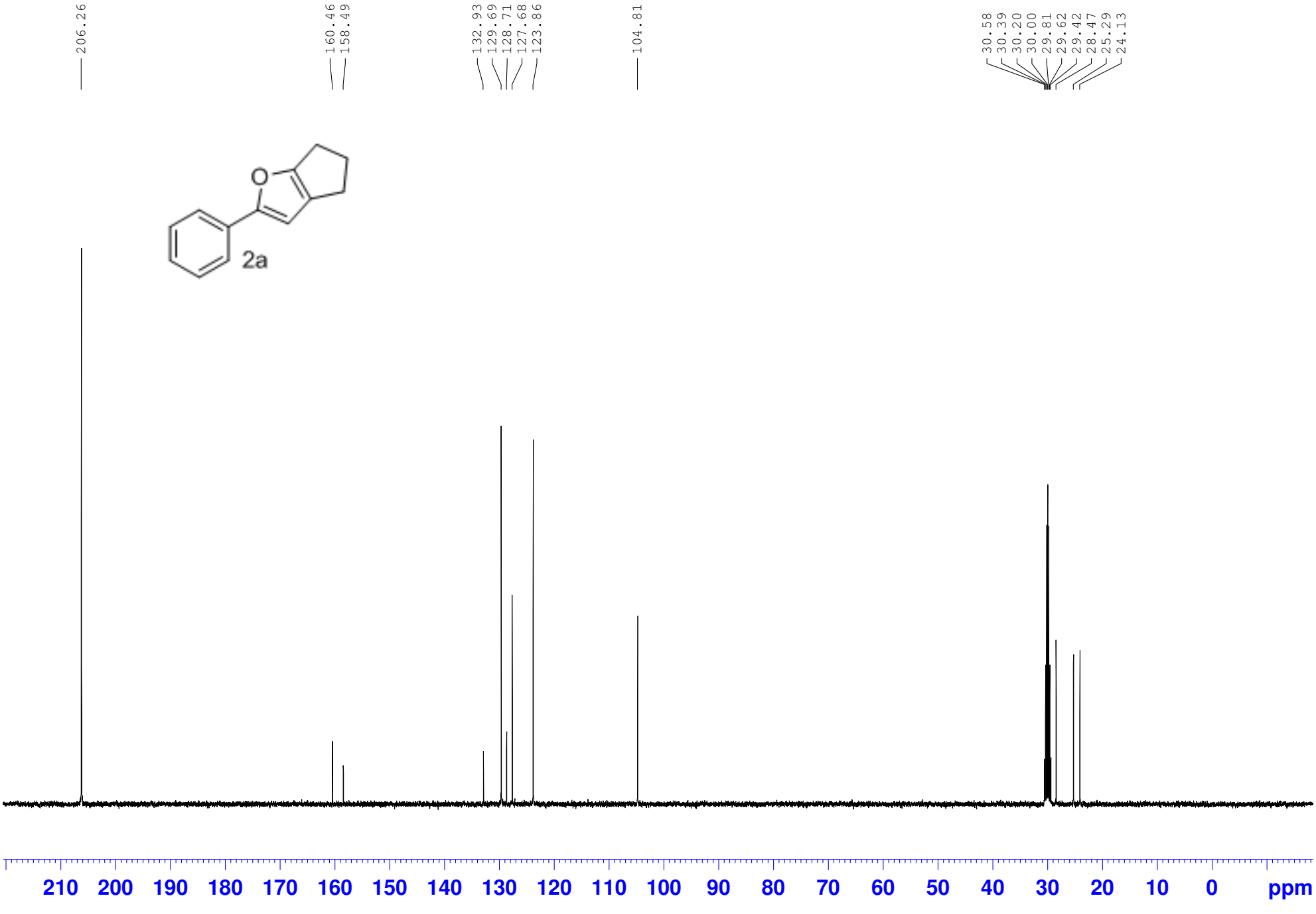
1.05
1.04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160.46
158.49
132.93
129.69
128.71
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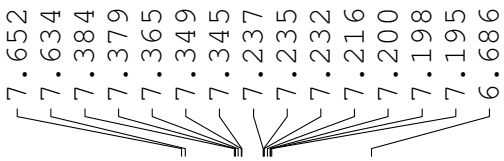
123.86
104.81
30.58
30.39
30.20
30.00
29.81
29.62
29.42
28.47
25.29
24.13
O
2a
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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7.216
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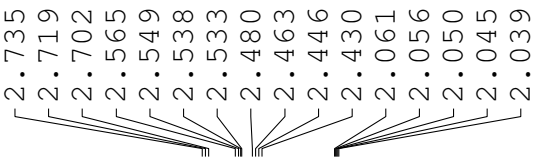
7.195
6.686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2.702
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2.533
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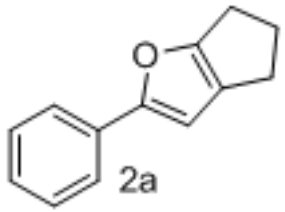
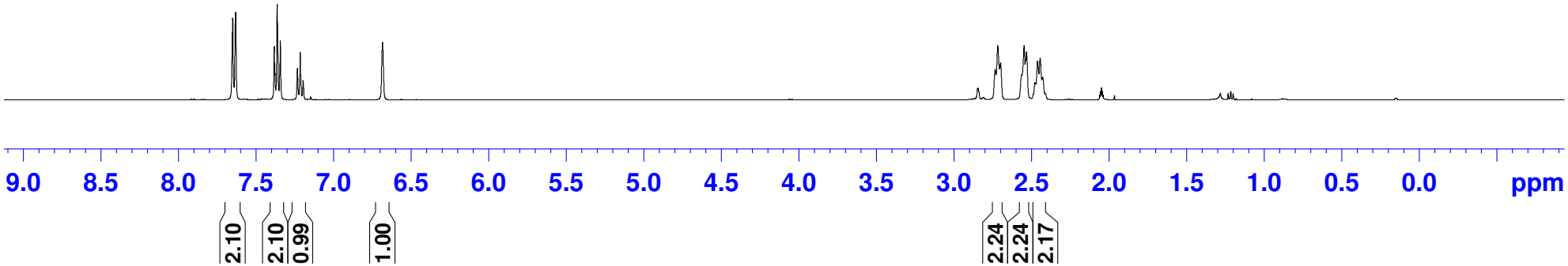
2.463
2.446
2.430
2.061
2.056
2.050
2.045
2.039


O
2a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5.5
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4.5
4.0
3.5
3.0
2.5
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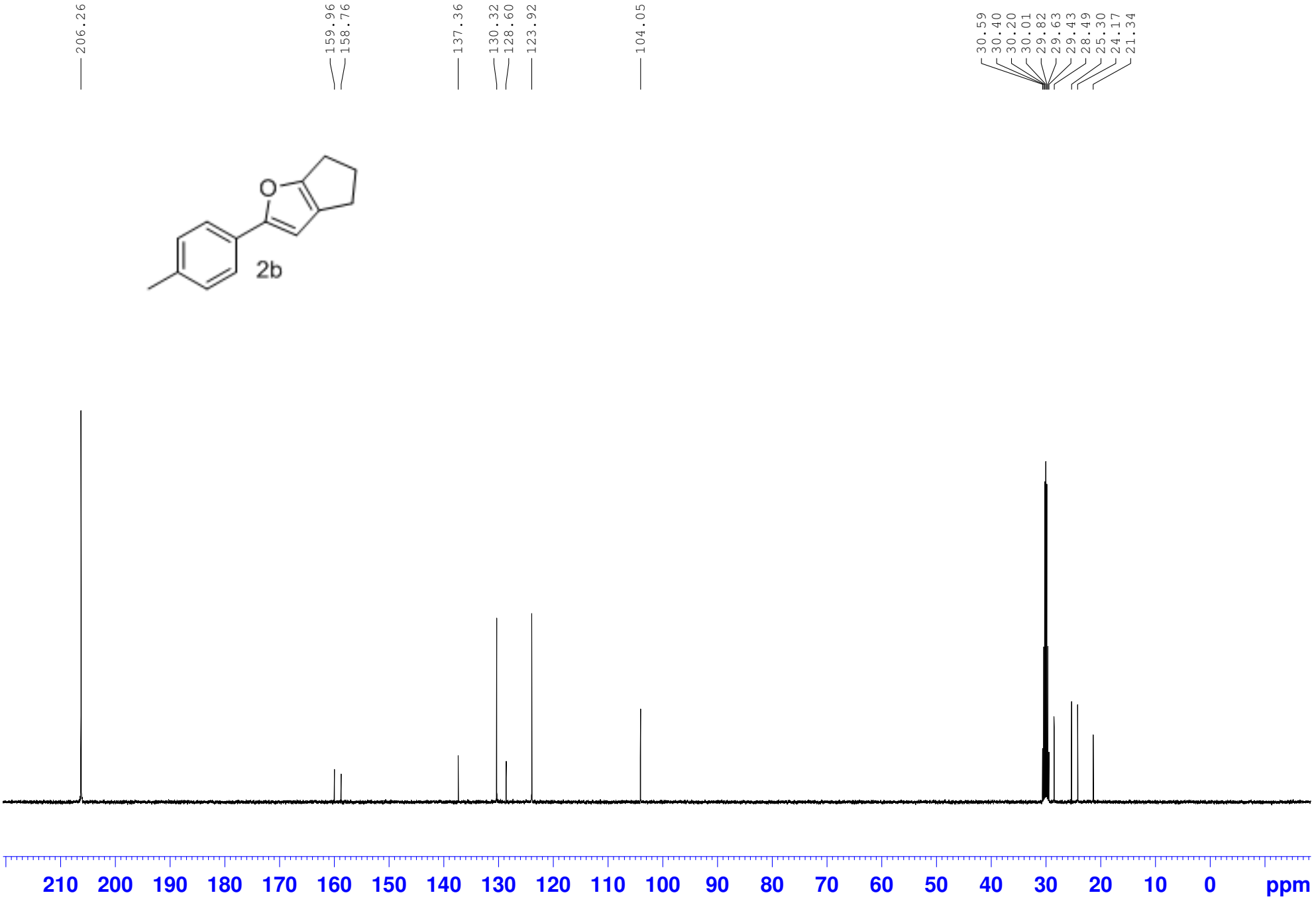
0.5
0.0
ppm
2.10
2.10
0.99
1.00
2.24
2.24
2.17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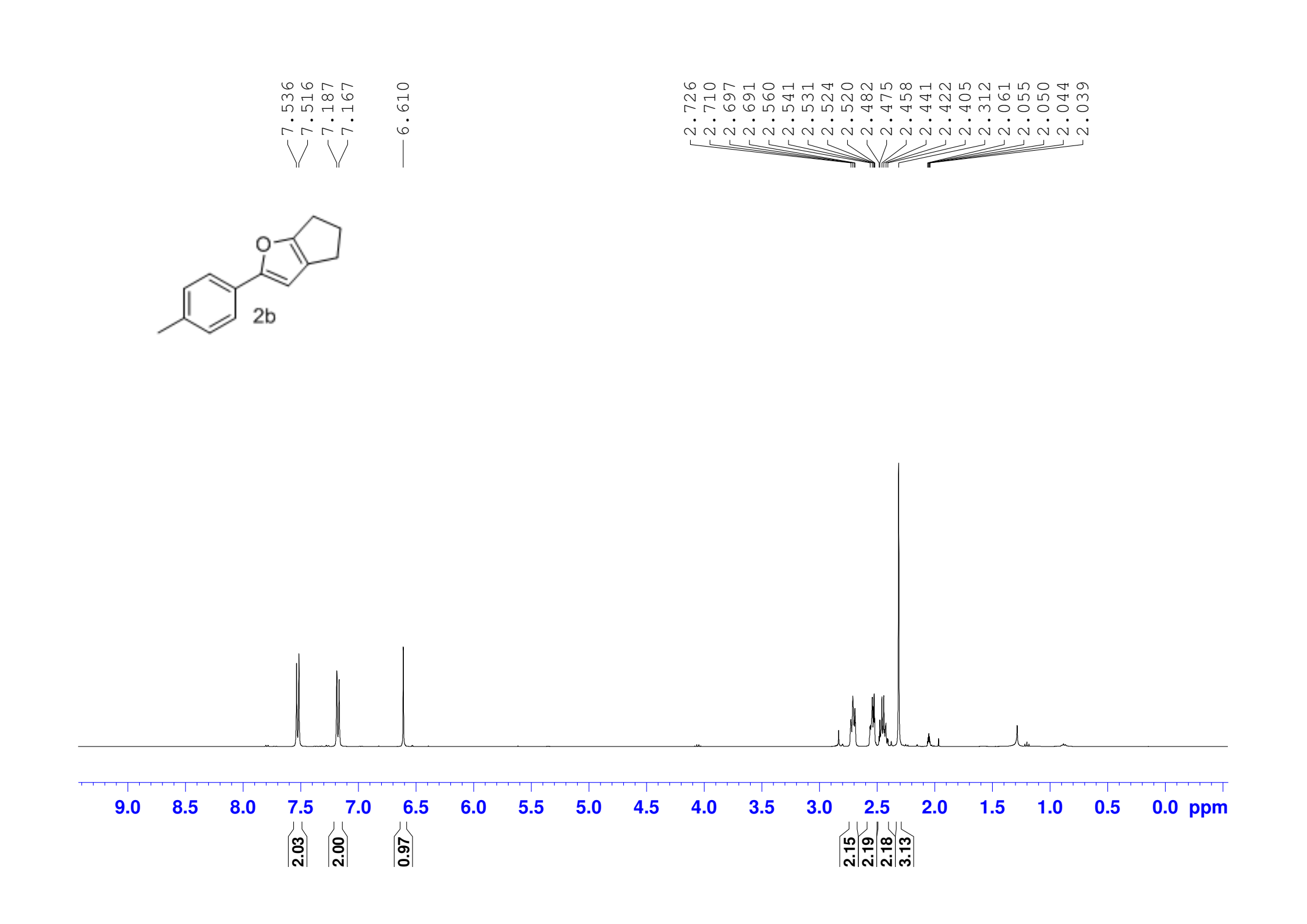
130.32
128.60
123.92
104.05
30.59
30.40
30.20
30.01
29.82
29.63
29.43
28.49
25.30
24.17
21.34
O
2b
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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2.531
2.524
2.520
2.482
2.475
2.458
2.441
2.422
2.405
2.312
2.061
2.055
2.050
2.044
2.039
O
2b
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
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0.5
0.0
ppm
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2.00
0.97
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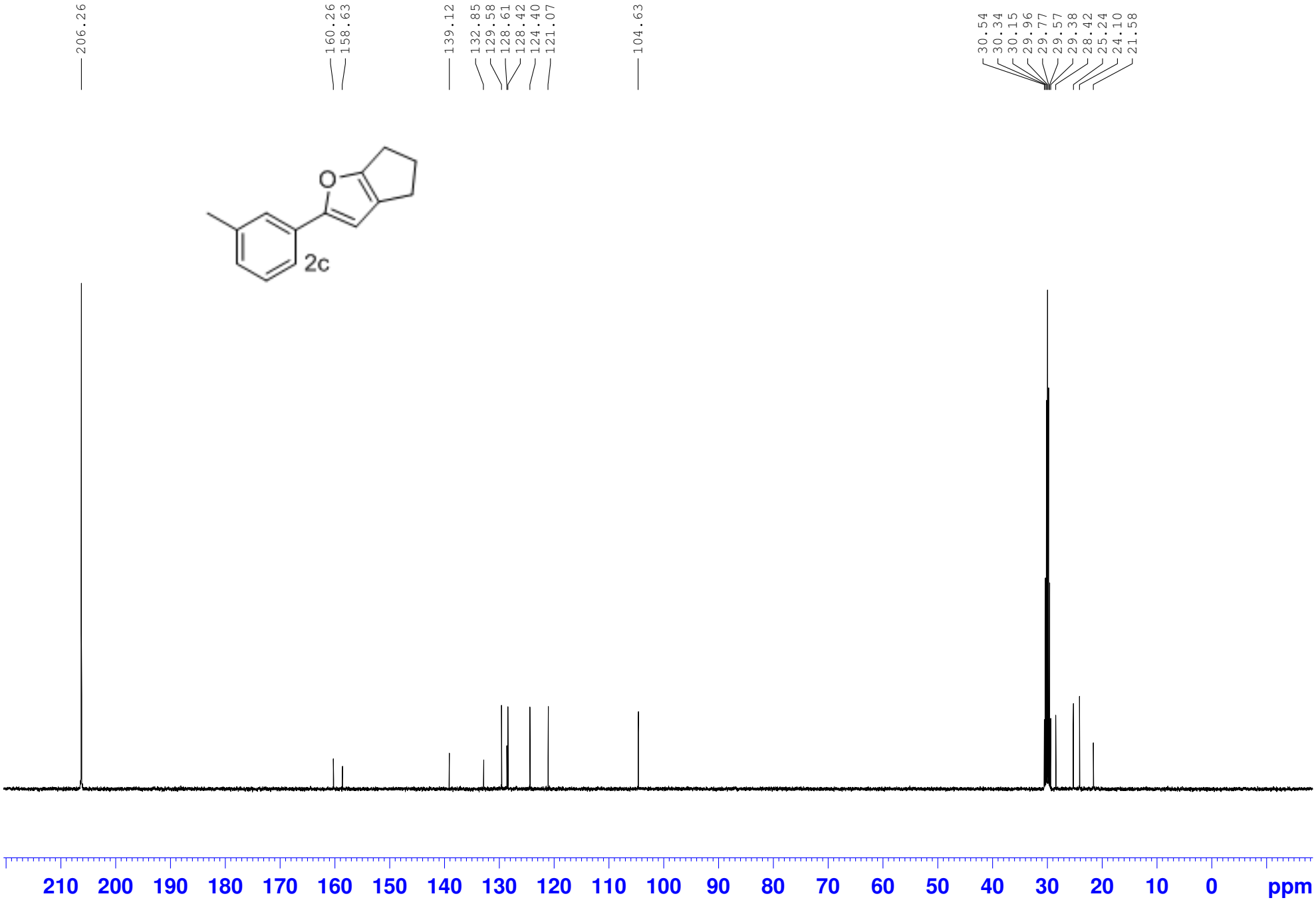
2.19
2.18
3.13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129.58
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128.42
124.40
121.07
104.63
30.54
30.34
30.15
29.96
29.77
29.57
29.38
28.42
25.24
24.10
21.58
O
2c
210
200
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180
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140
130
120
110
100
90
80
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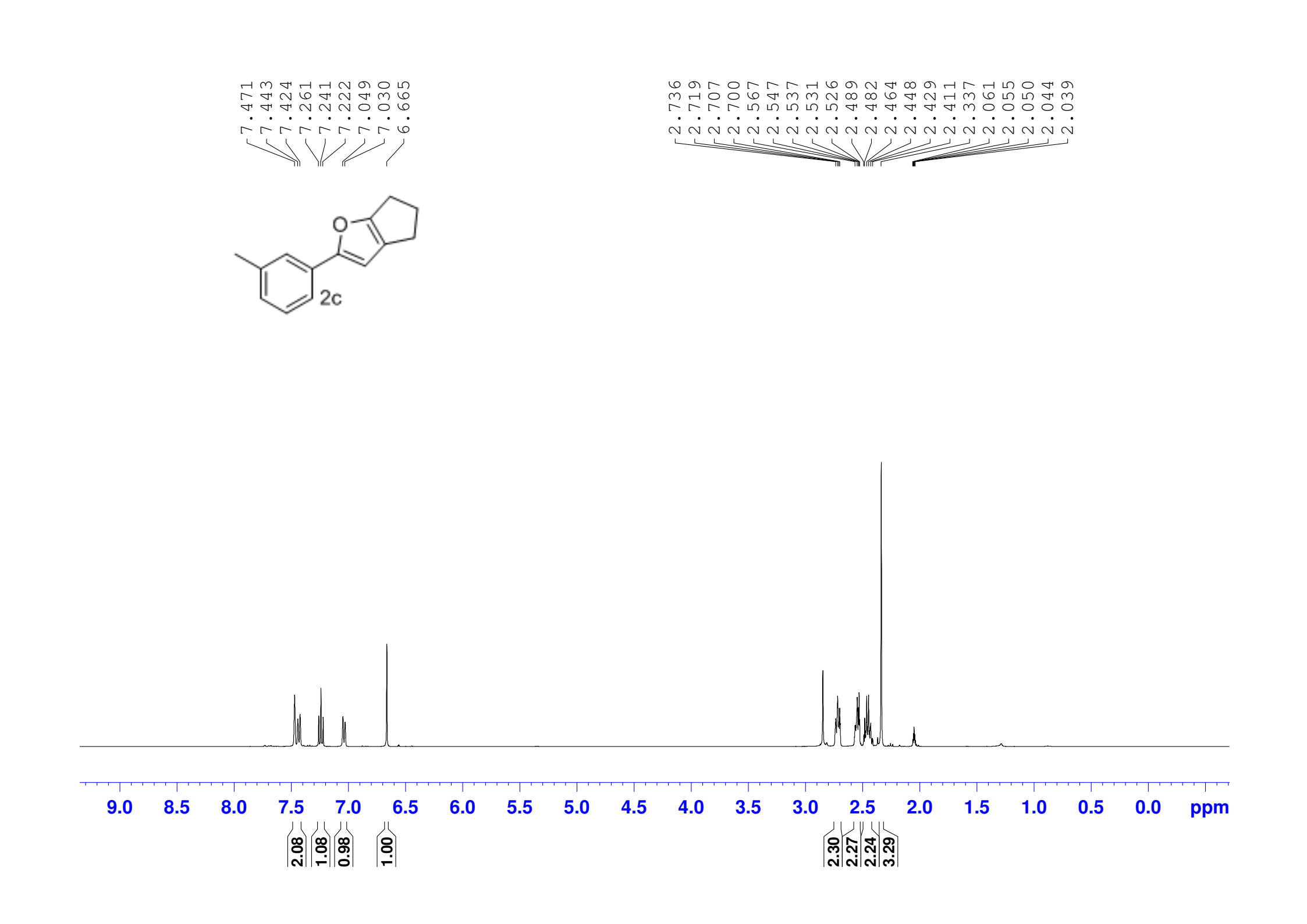
60
50
40
30
20
10
0
ppm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7.030
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2.707
2.700
2.567
2.547
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2.489
2.482
2.464
2.448
2.429
2.411
2.337
2.061
2.055
2.050
2.044
2.039
O
2c
9.0
8.5
8.0
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7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
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ppm
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1.00
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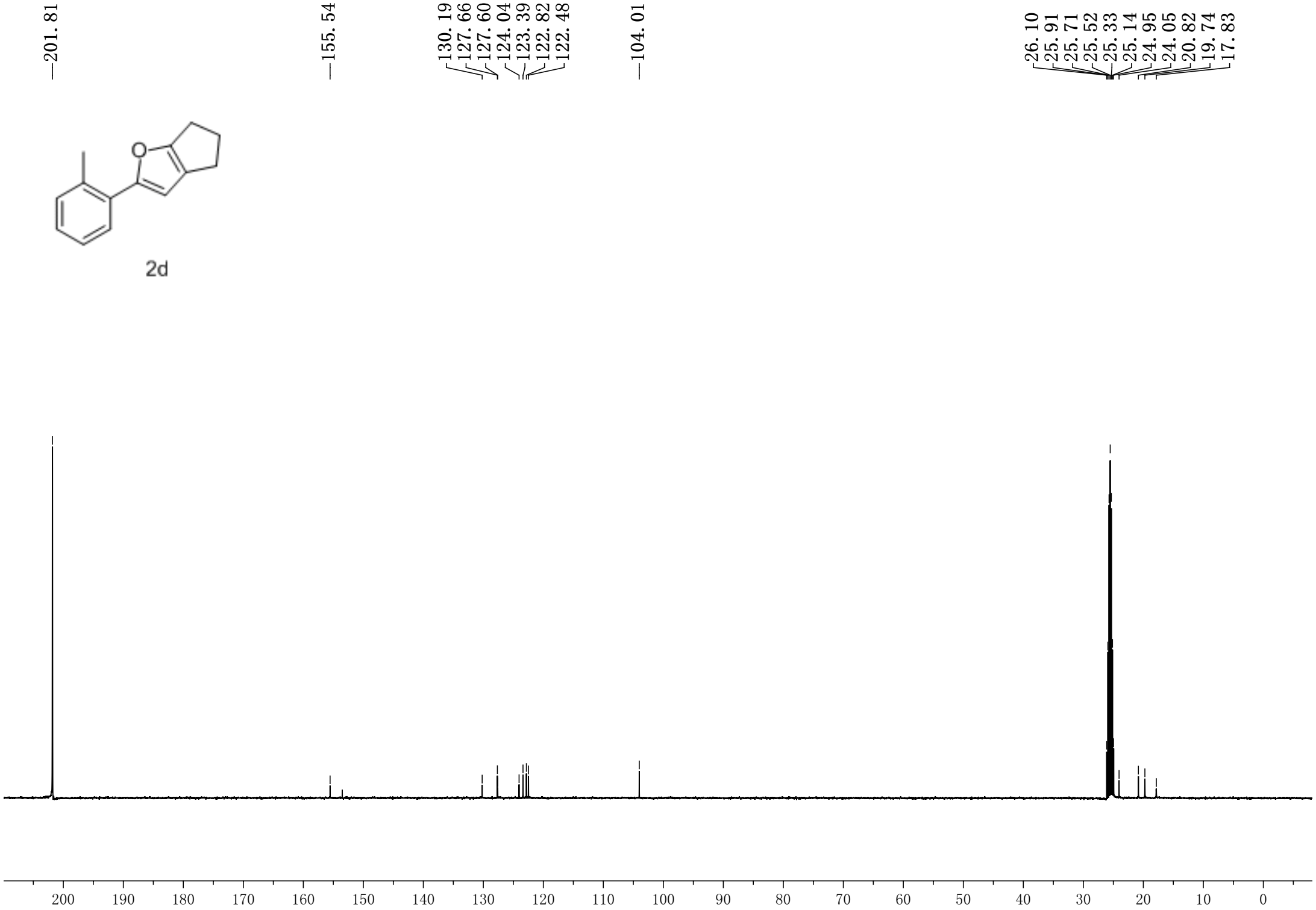
2.24
3.29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122.82
122.48
104.01
26.10
25.91
25.71
25.52
25.33
25.14
24.95
24.05
20.82
19.74
17.83
O
2d
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150
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130
120
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70
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30
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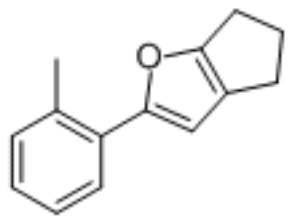
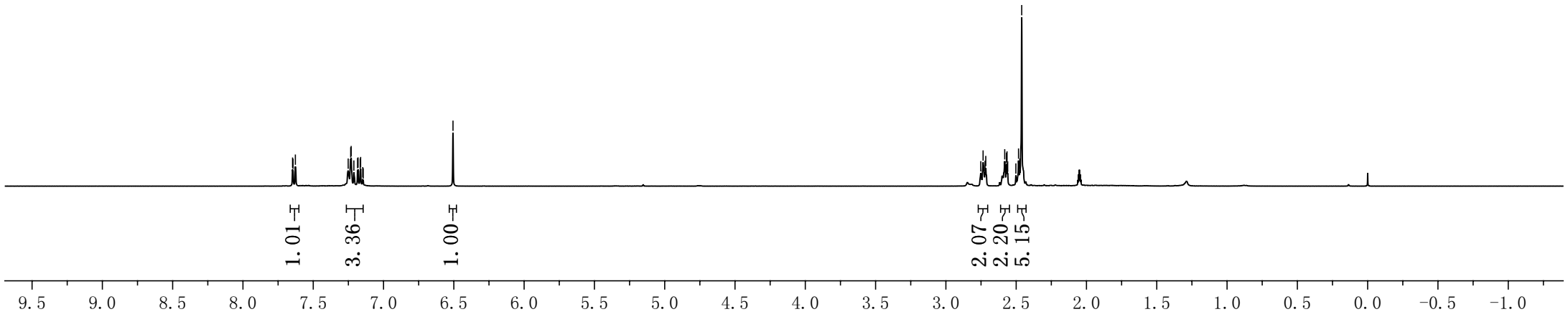
10
0



2d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9.0
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7.5
7.0
6.5
6.0
5.5
5.0
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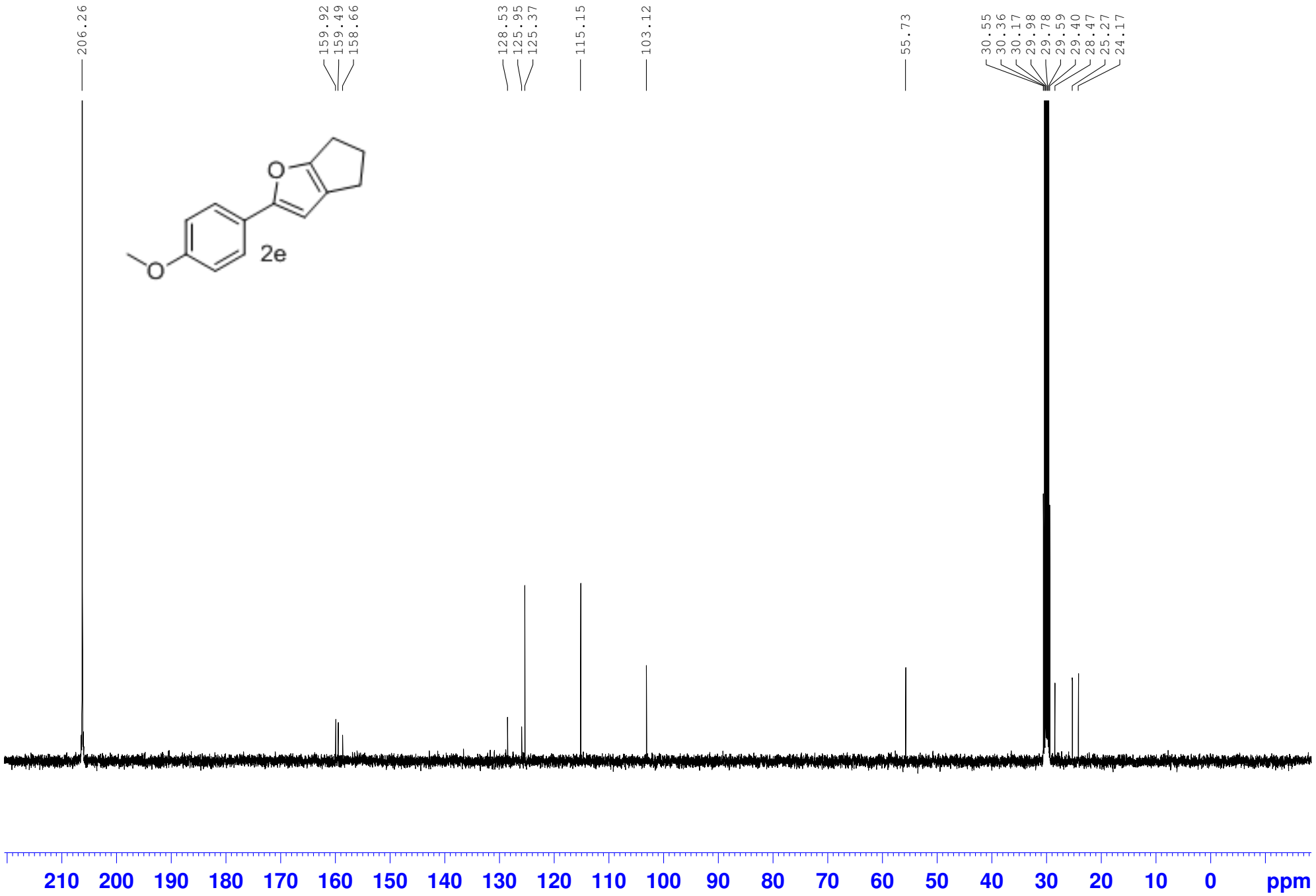
−0.5
−1.0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125.95
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115.15
103.12
55.73
30.55
30.36
30.17
29.98
29.78
29.59
29.40
28.47
25.27
24.17
O
O
2e
210
200
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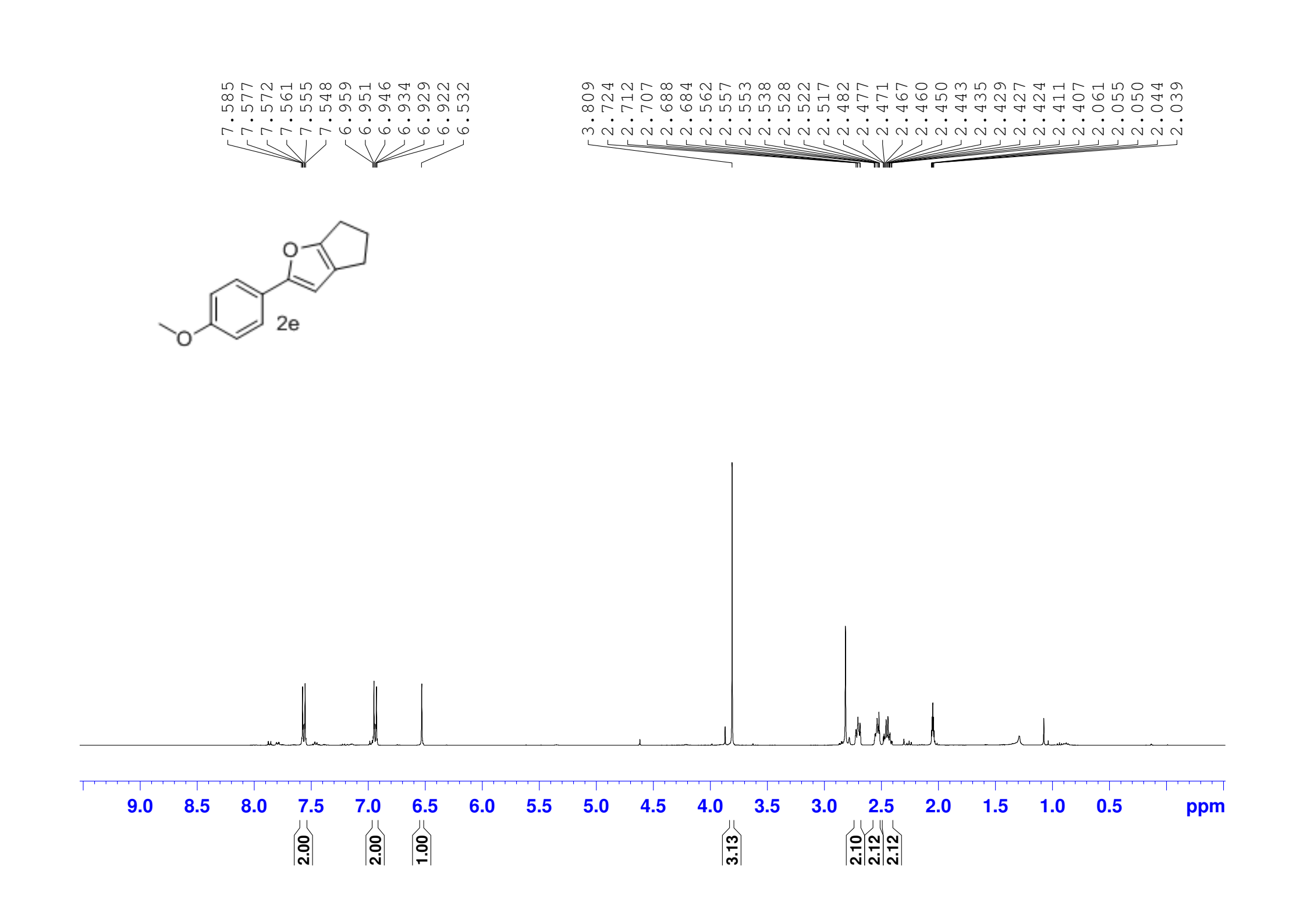
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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6.532
3.809
2.724
2.712
2.707
2.688
2.684
2.562
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2.538
2.528
2.522
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2.435
2.429
2.427
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2.407
2.061
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2.050
2.044
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O
O
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5.0
4.5
4.0
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3.0
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1.5
1.0
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ppm
2.00
2.00
1.00
3.13
2.10
2.12
2.12


195.63
161.32
157.11
135.93
135.63
129.32
128.28
128.04
127.80
122.91
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24.88
23.55
O
O
2f
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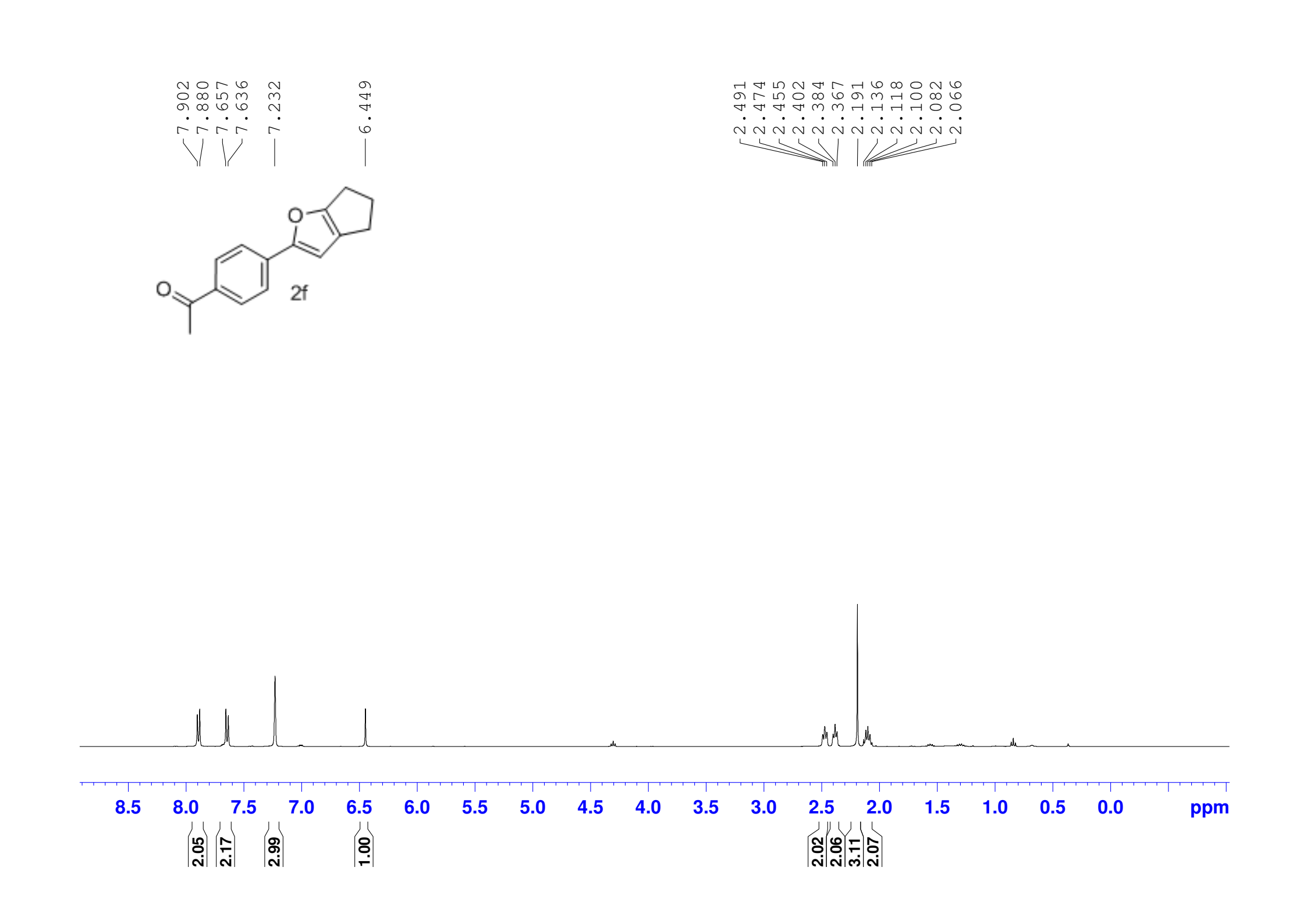
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2.474
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2.384
2.367
2.191
2.136
2.118
2.100
2.082
2.066
O
O
2f
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
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0.0
ppm
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2.17
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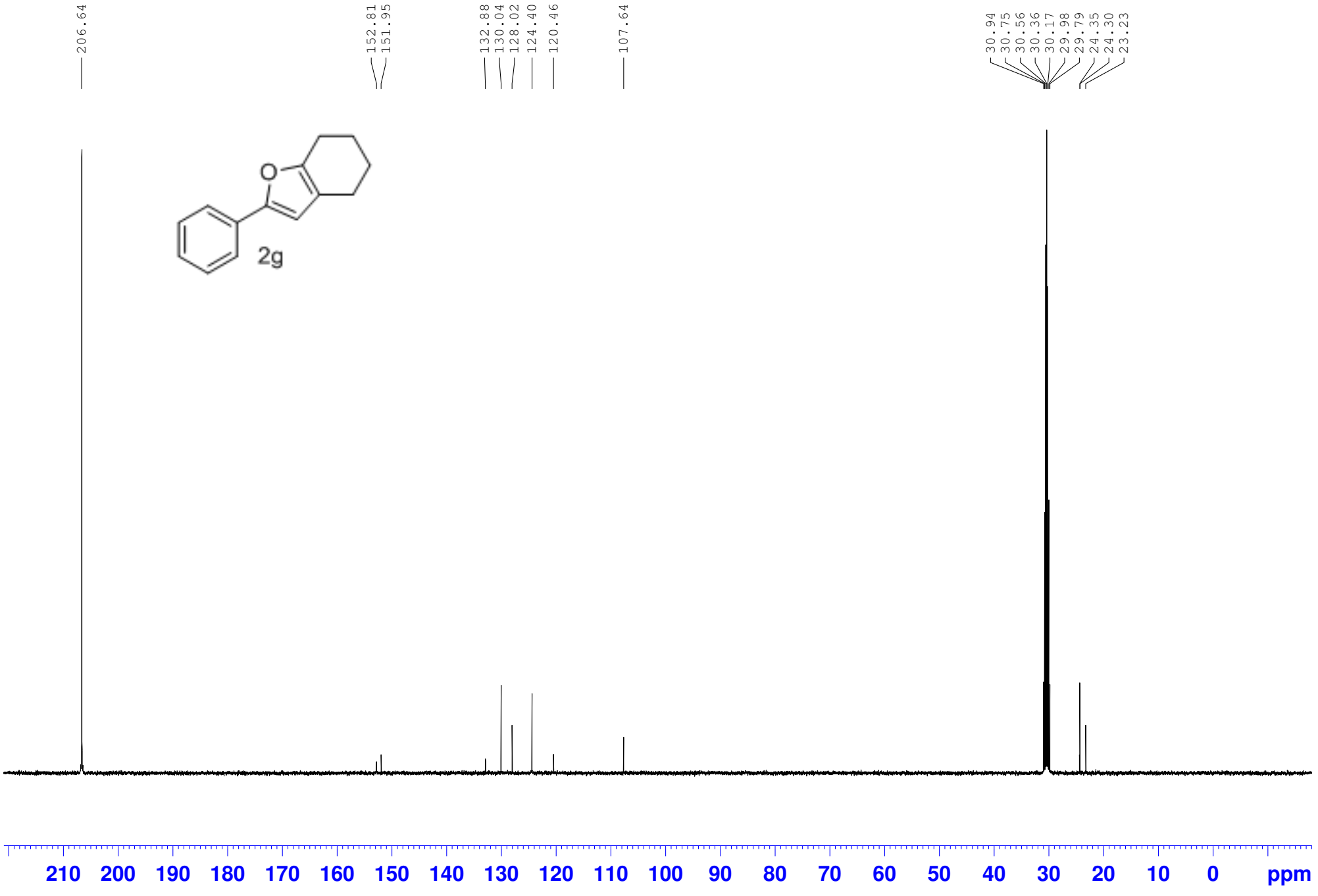
1.00
2.02
2.06
3.11
2.07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30.56
30.36
30.17
29.98
29.79
24.35
24.30
23.23
O
2g
210
200
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180
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140
130
120
110
100
90
80
70
60
50
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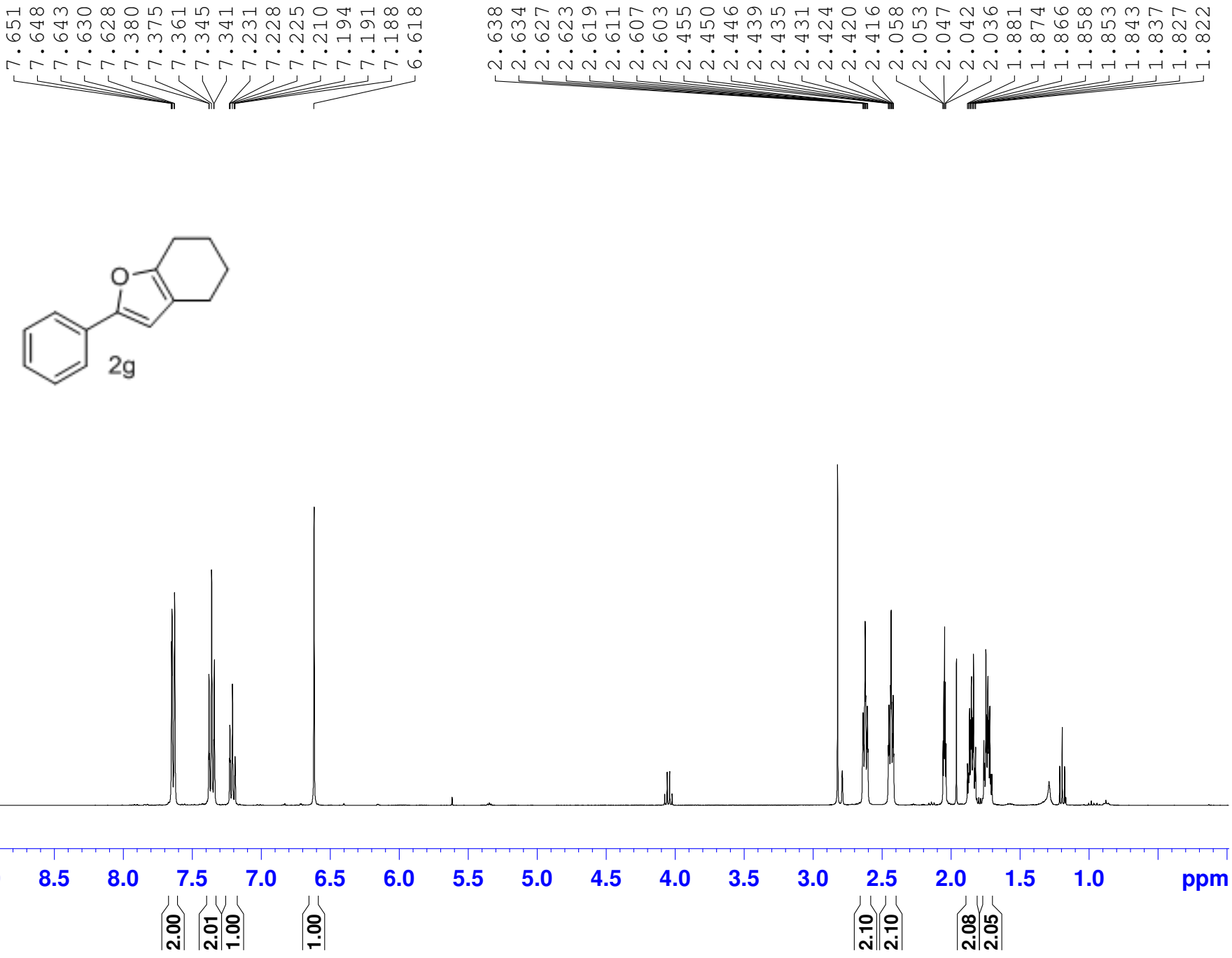
30
20
10
0
ppm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7.228
7.225
7.210
7.194
7.191
7.188
6.618
2.638
2.634
2.627
2.623
2.619
2.611
2.607
2.603
2.455
2.450
2.446
2.439
2.435
2.431
2.424
2.420
2.416
2.058
2.053
2.047
2.042
2.036
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1.874
1.866
1.858
1.853
1.843
1.837
1.827
1.822
O
2g
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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
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1.0
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1.00
1.00
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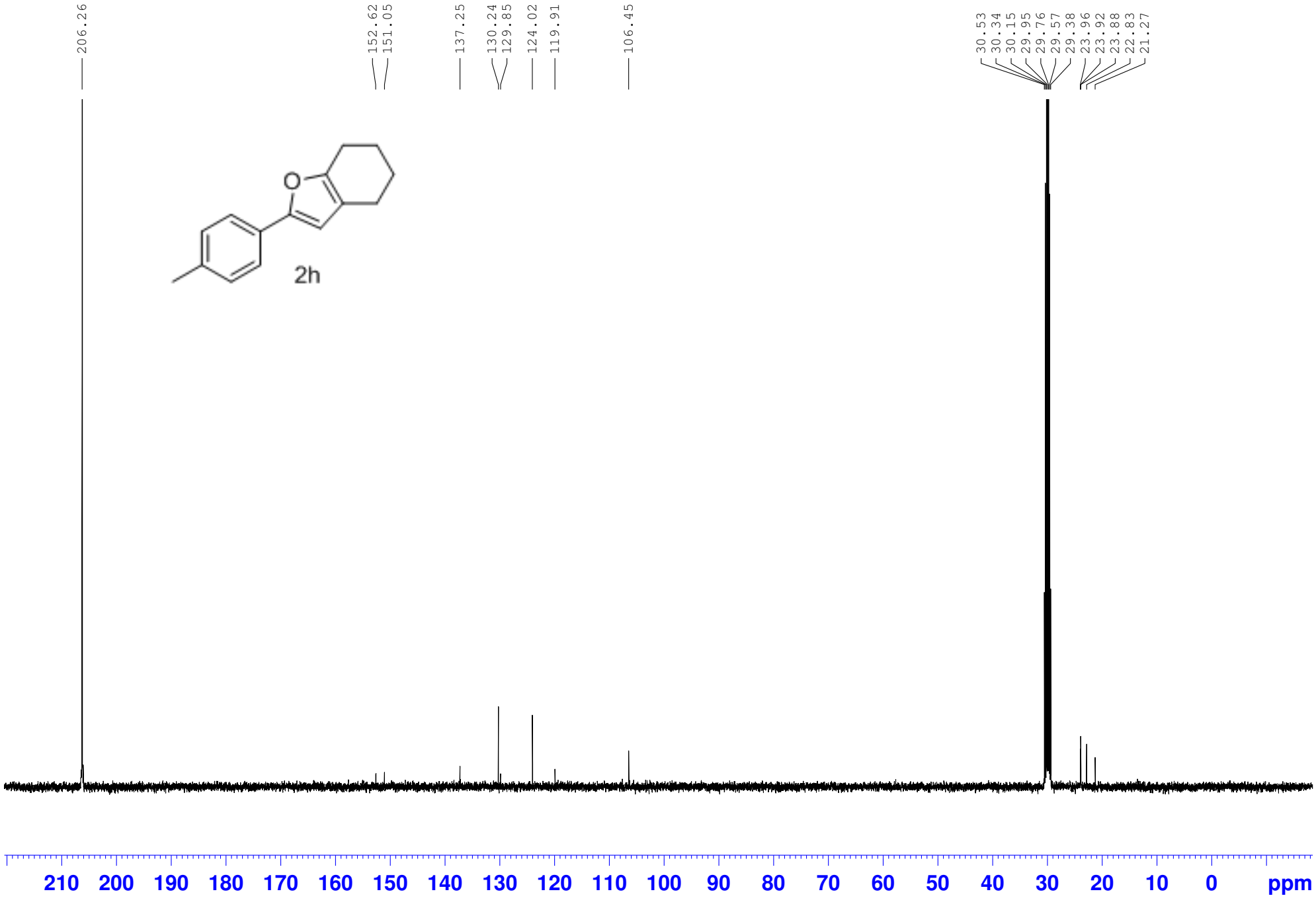
2.10
2.08
2.05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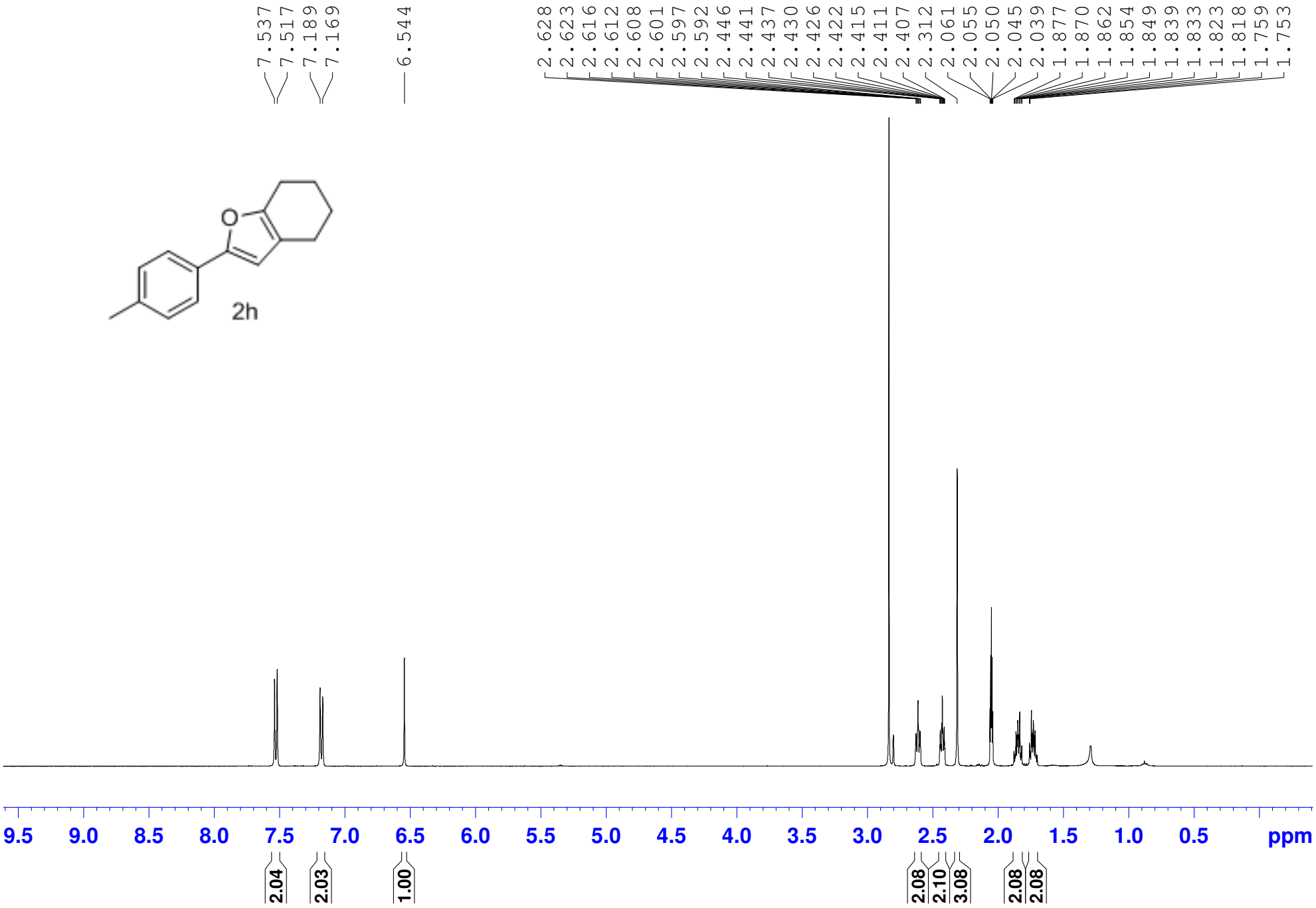
29.76
29.57
29.38
23.96
23.92
23.88
22.83
21.27
O
2h
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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7.517
7.189
7.169
6.544
2.628
2.623
2.616
2.612
2.608
2.601
2.597
2.592
2.446
2.441
2.437
2.430
2.426
2.422
2.415
2.411
2.407
2.312
2.061
2.055
2.050
2.045
2.039
1.877
1.870
1.862
1.854
1.849
1.839
1.833
1.823
1.818
1.759
1.753
O
2h
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
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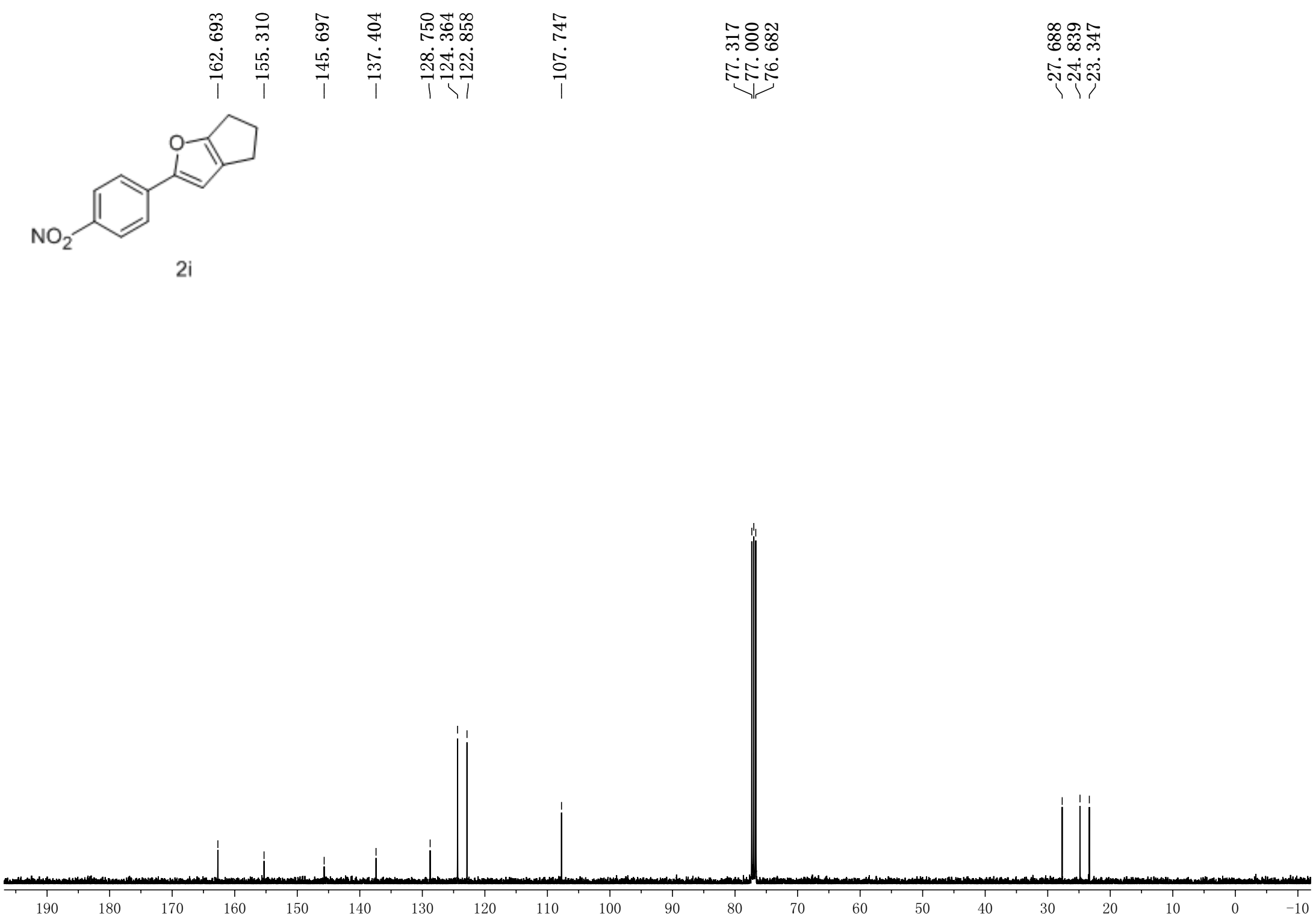
2.03
1.00
2.08
2.10
3.08
2.08
2.08

O
NO2

2i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122.858
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77.000
76.682
27.688
24.839
23.347
190
180
170
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150
140
130
120
110
100
90
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60
50
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30
20
10
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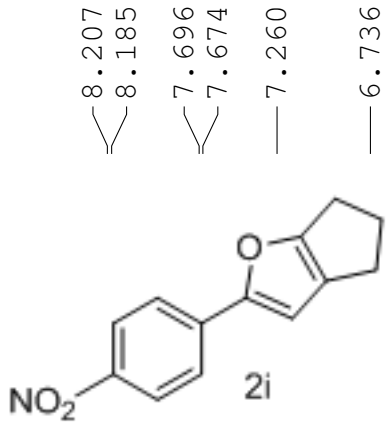
-10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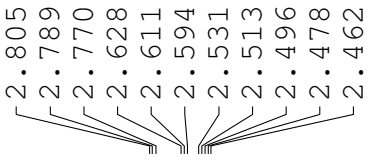
8.185
7.696
7.674
7.260
6.736
O
NO2
2i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2.770
2.628
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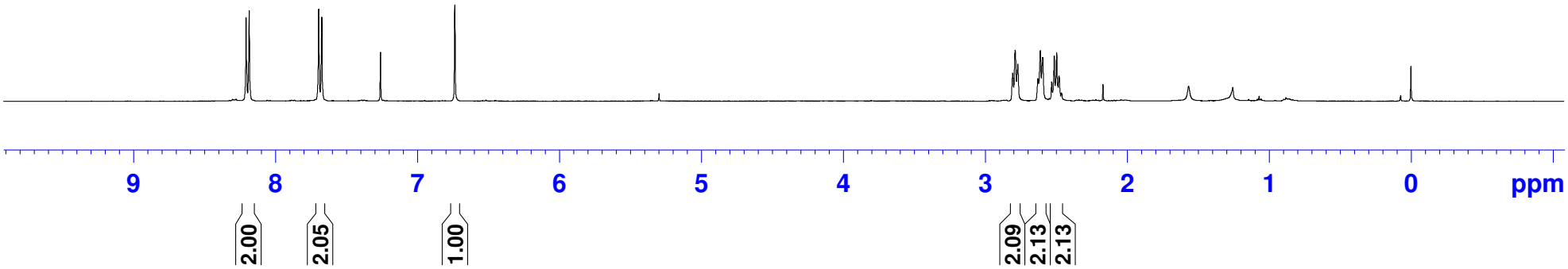
2.594
2.531
2.513
2.496
2.478
2.462


9
8
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4
3
2
1
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ppm
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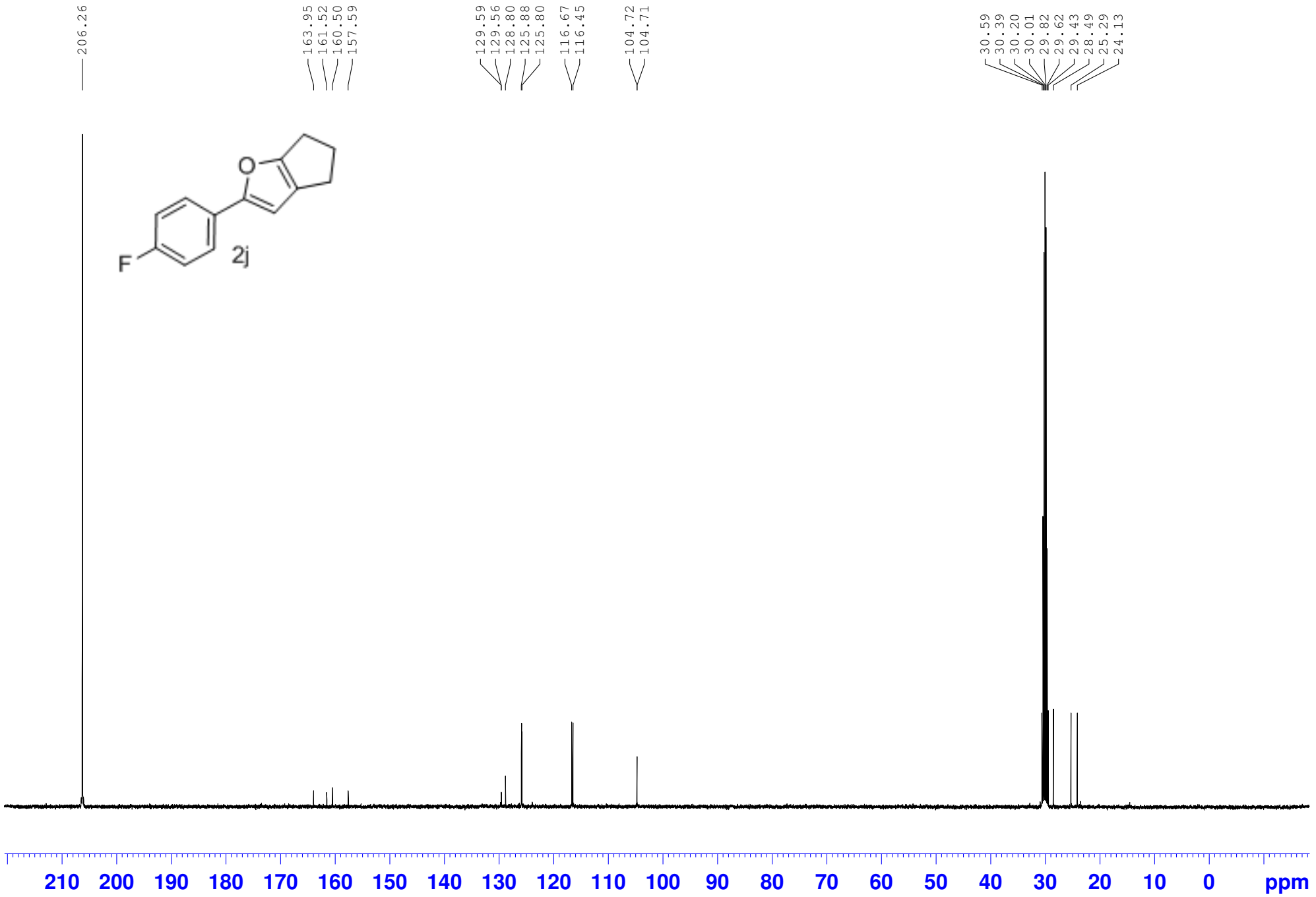
2.05
1.00
2.09
2.13
2.13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129.59
129.56
128.80
125.88
125.80
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116.45
104.72
104.71
30.59
30.39
30.20
30.01
29.82
29.62
29.43
28.49
25.29
24.13
O
F
2j
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

7.680
7.674
7.666
7.657
7.649
7.644
7.160
7.137
7.120
7.115
6.654

2.730
2.714
2.695
2.563
2.560
2.545
2.534
2.528
2.487
2.480
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2.447
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2.414
2.410
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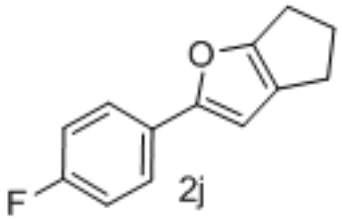
2.050
2.045
2.039



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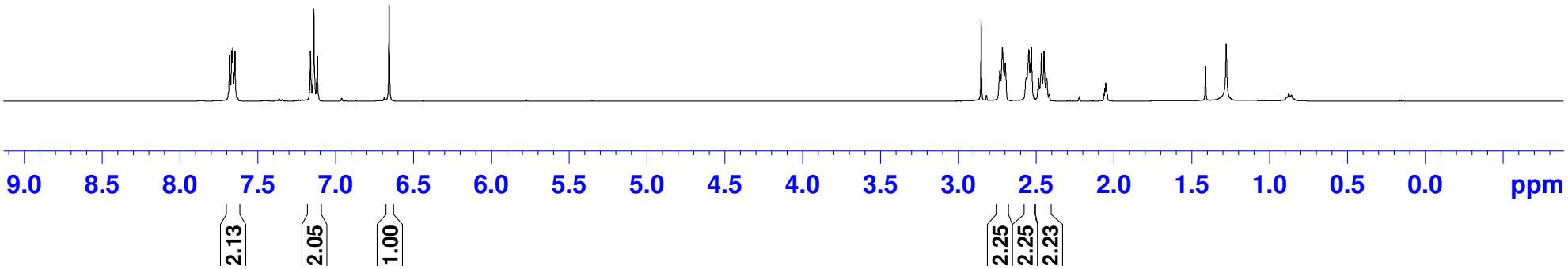

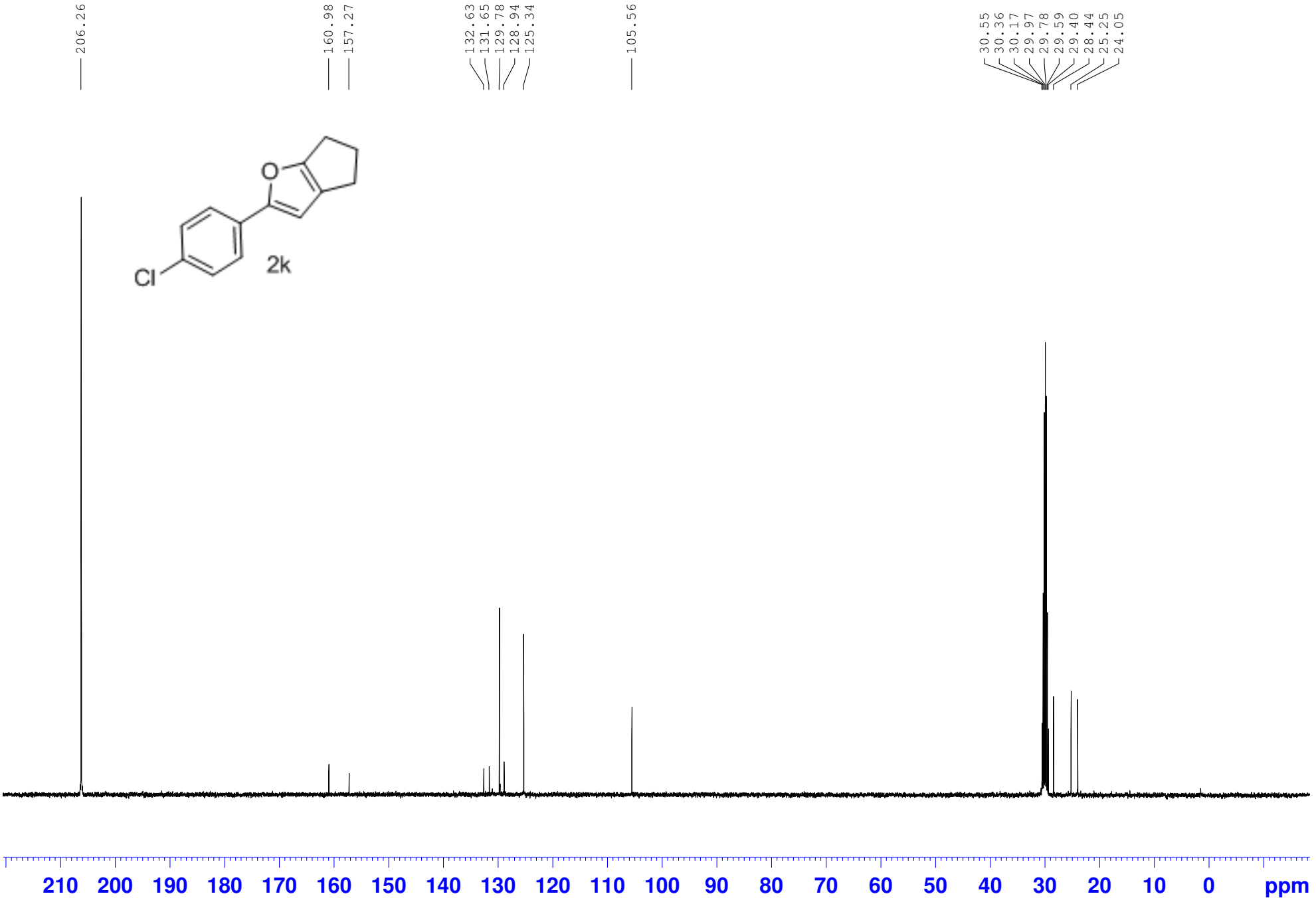
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125.34
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30.55
30.36
30.17
29.97
29.78
29.59
29.40
28.44
25.25
24.05
O
Cl
2k
210
200
190
180
170
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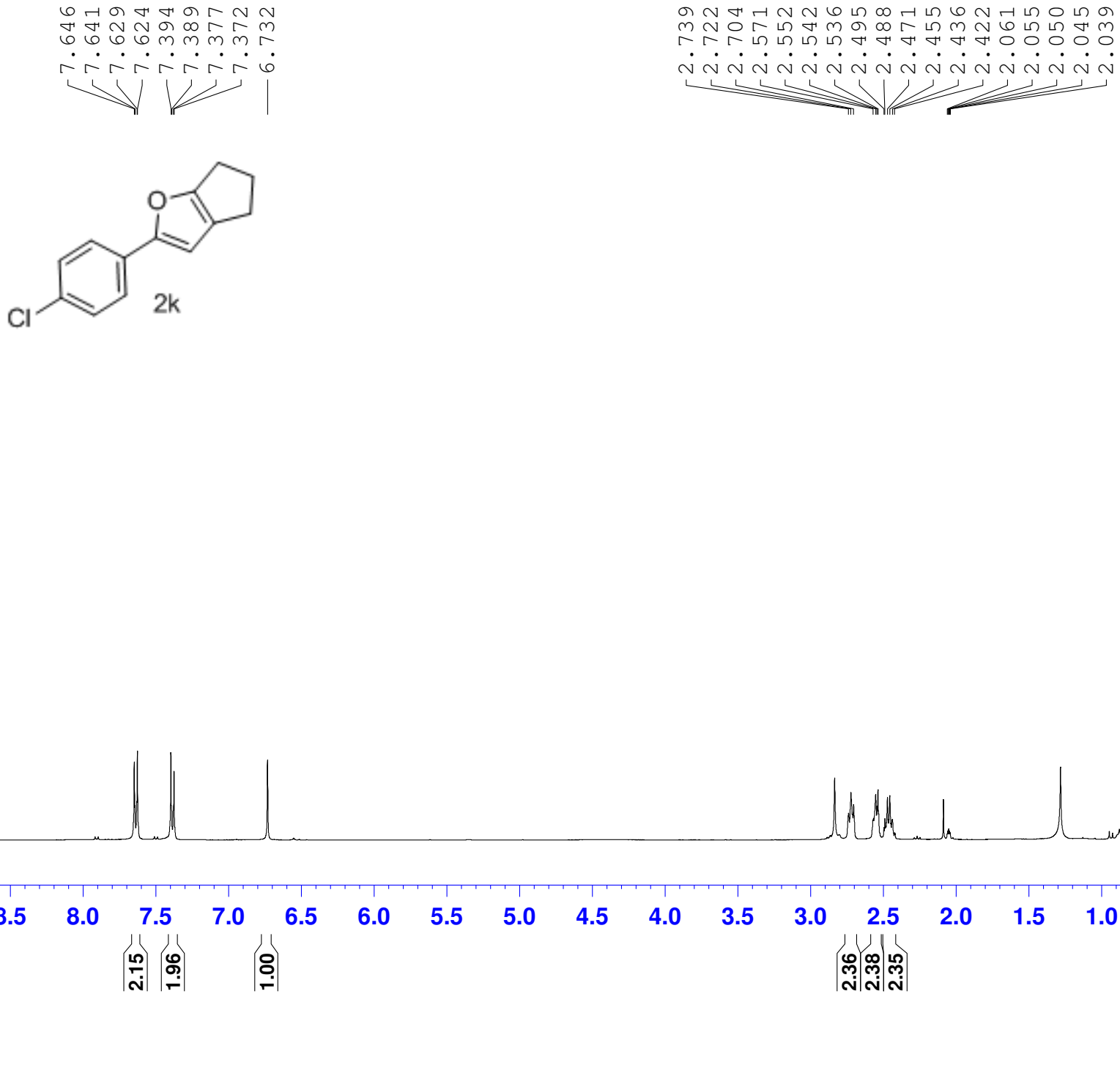
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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7.372
6.732
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2.722
2.704
2.571
2.552
2.542
2.536
2.495
2.488
2.471
2.455
2.436
2.422
2.061
2.055
2.050
2.045
2.039
O
Cl
2k
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
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1.0
0.5
0.0
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1.96
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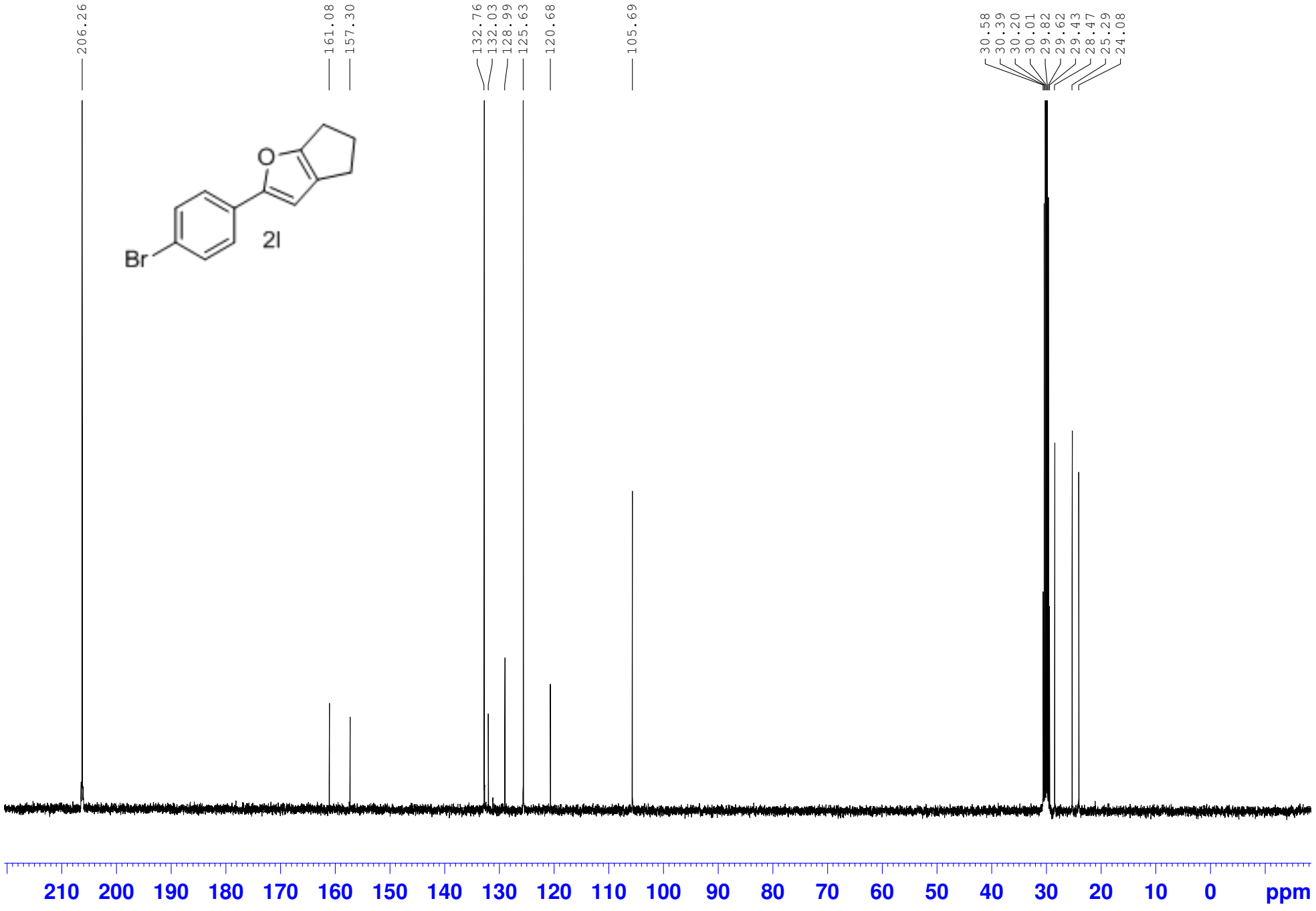
2.38
2.35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132.03
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120.68
105.69
30.58
30.39
30.20
30.01
29.82
29.62
29.43
28.47
25.29
24.08
O
Br
2l
210
200
190
180
170
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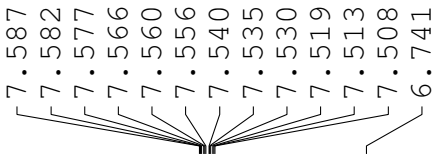
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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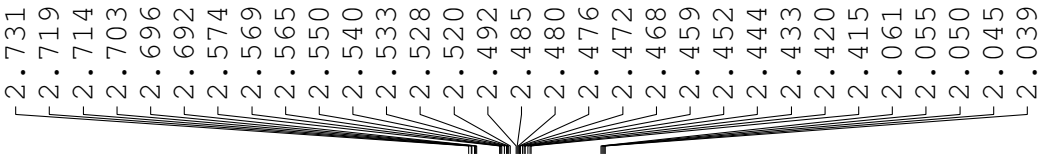
7.508
6.741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2.569
2.565
2.550
2.540
2.533
2.528
2.520
2.492
2.485
2.480
2.476
2.472
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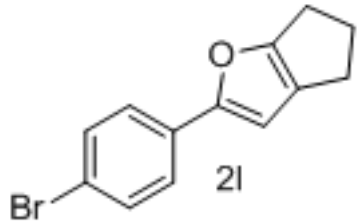
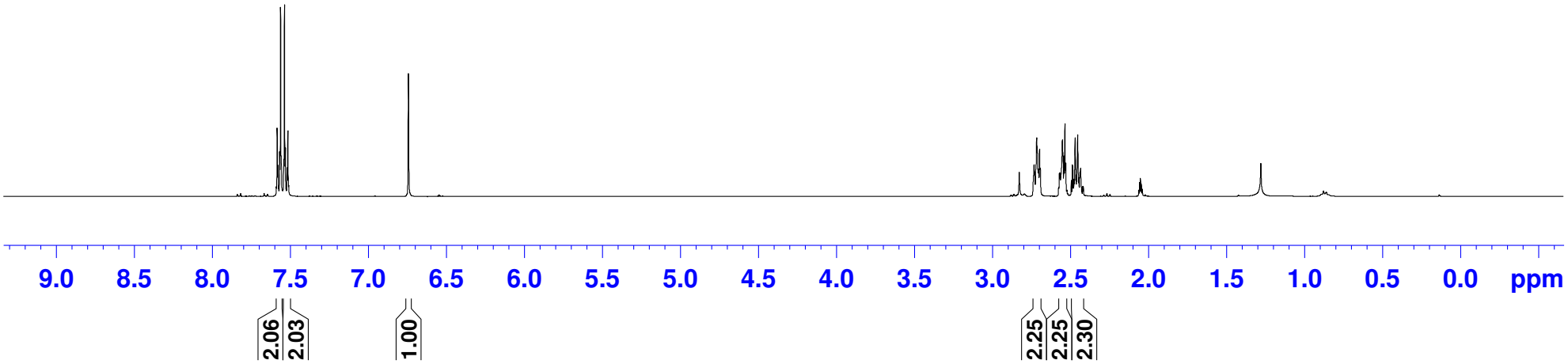
2.459
2.452
2.444
2.433
2.420
2.415
2.061
2.055
2.050
2.045
2.039


O
Br
2l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4.0
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3.0
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2.03
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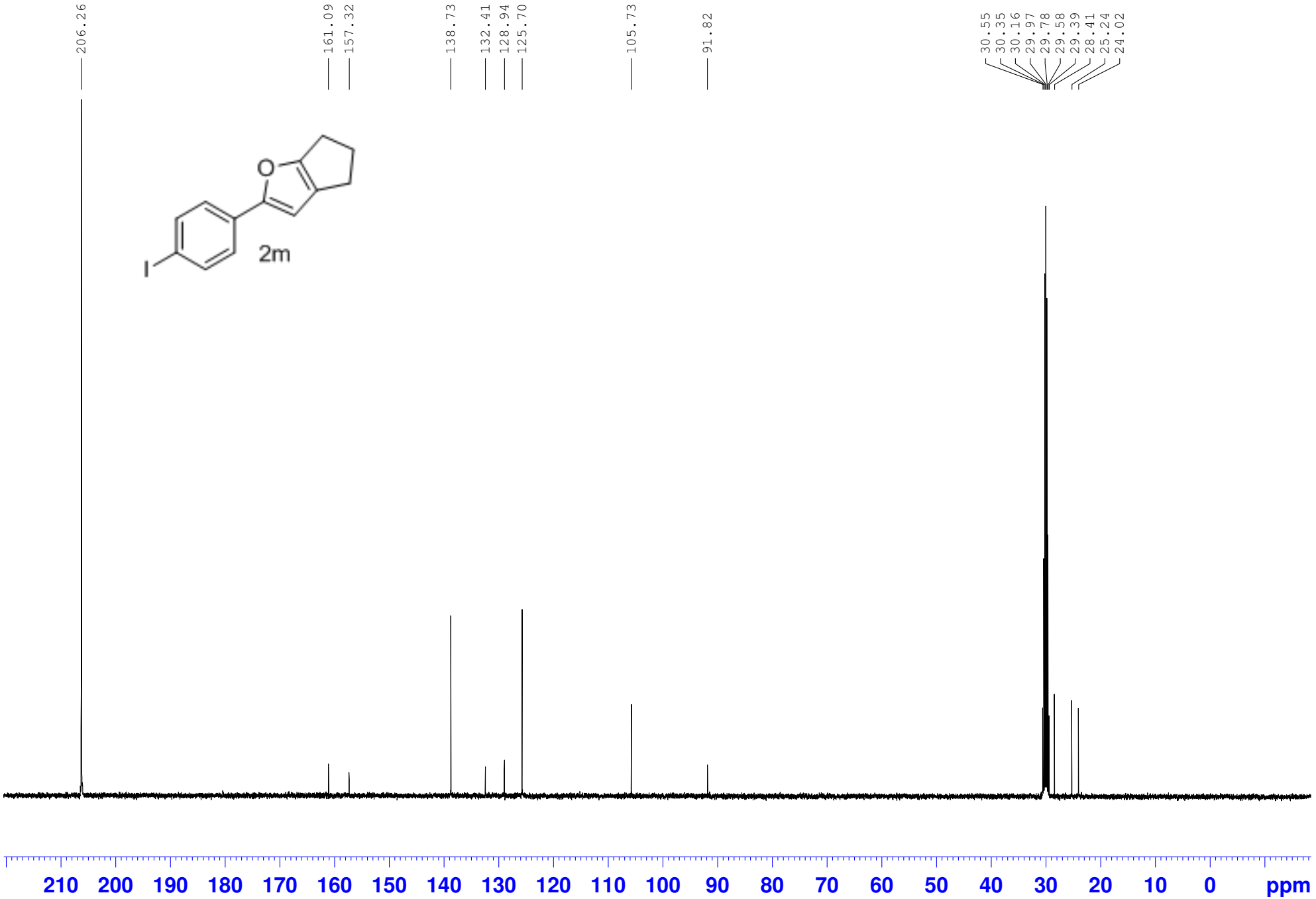
2.30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30.35
30.16
29.97
29.78
29.58
29.39
28.41
25.24
24.02
O
I
2m
210
200
190
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140
130
120
110
100
90
80
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60
50
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20
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0
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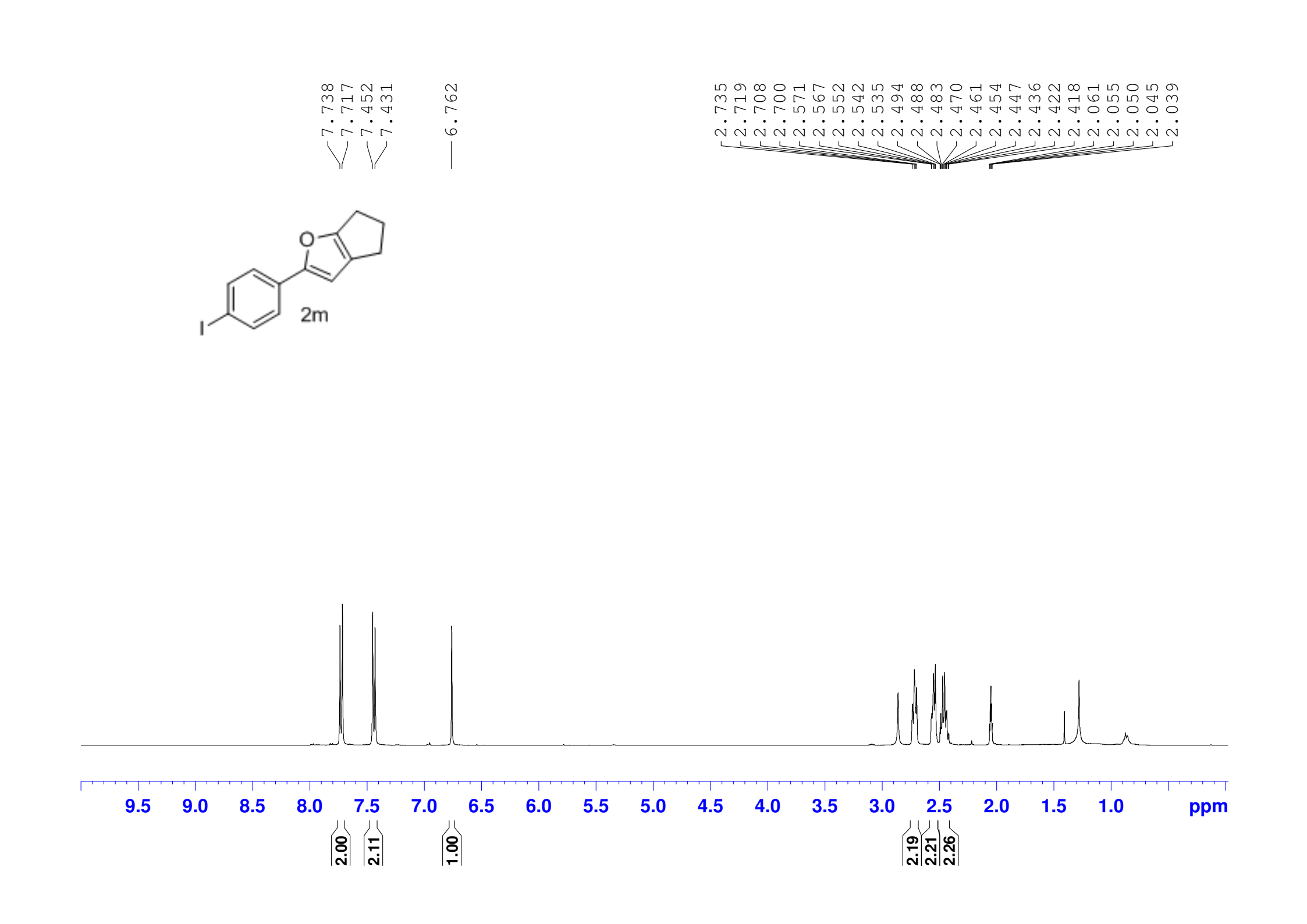
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2.542
2.535
2.494
2.488
2.483
2.470
2.461
2.454
2.447
2.436
2.422
2.418
2.061
2.055
2.050
2.045
2.039
O
I
2m
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7.0
6.5
6.0
5.5
5.0
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4.0
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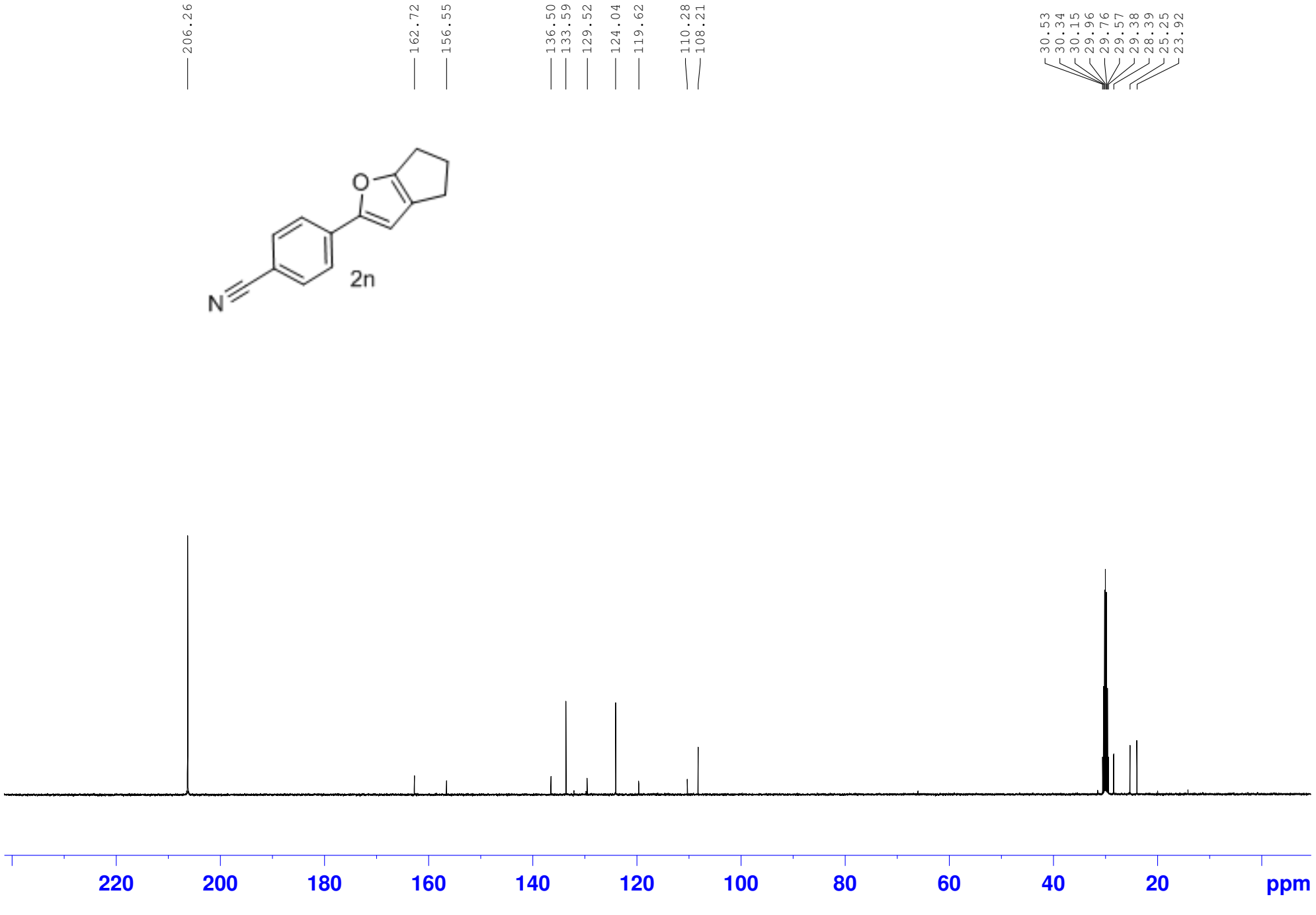
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29.76
29.57
29.38
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N
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60
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20
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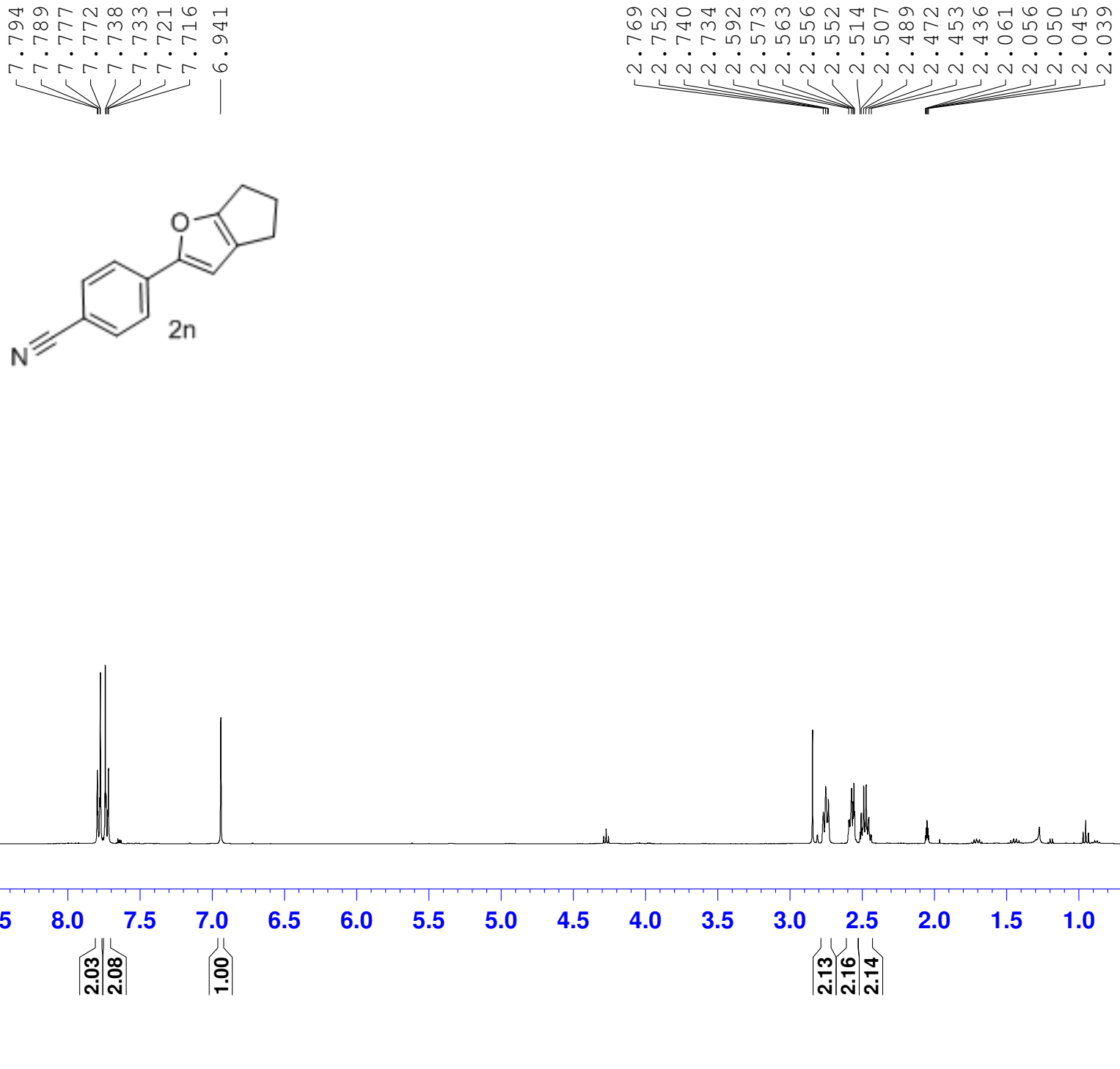
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2.740
2.734
2.592
2.573
2.563
2.556
2.552
2.514
2.507
2.489
2.472
2.453
2.436
2.061
2.056
2.050
2.045
2.039
O
N
2n
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7.0
6.5
6.0
5.5
5.0
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4.0
3.5
3.0
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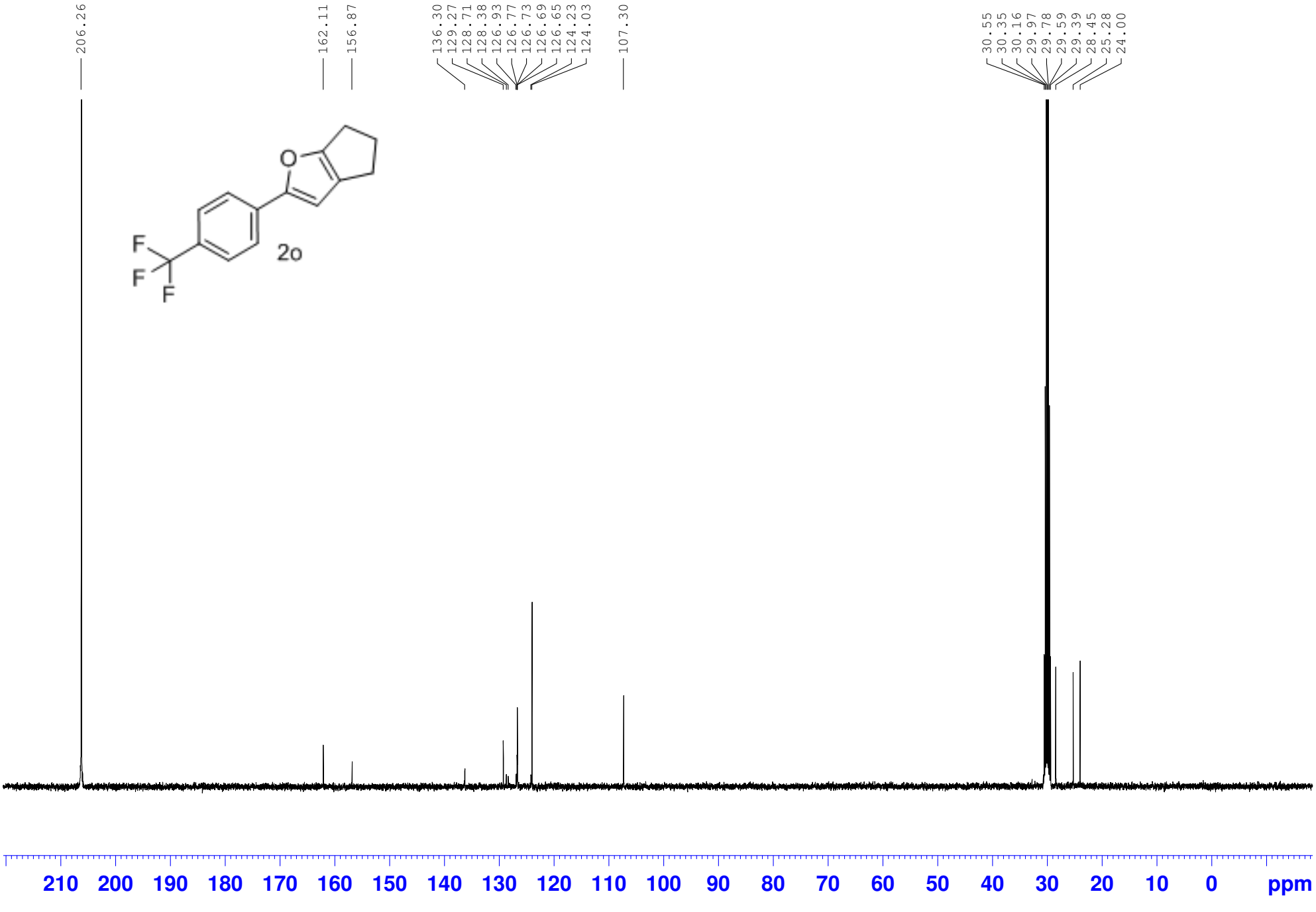
2.16
2.14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126.73
126.69
126.65
124.23
124.03
107.30
30.55
30.35
30.16
29.97
29.78
29.59
29.39
28.45
25.28
24.00
O
F
F
F
2o
210
200
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140
130
120
110
100
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60
50
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20
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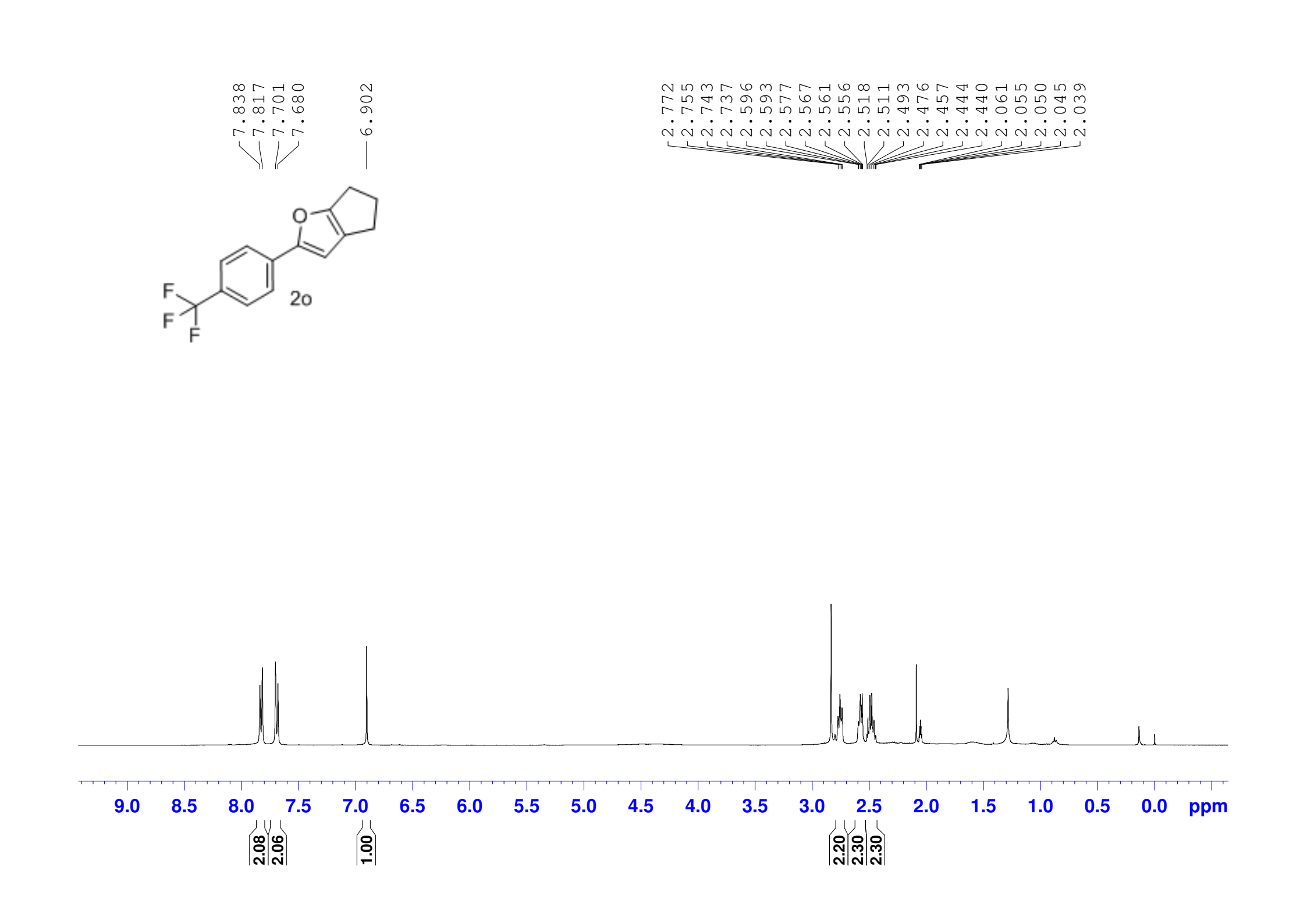
0
ppm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2.593
2.577
2.567
2.561
2.556
2.518
2.511
2.493
2.476
2.457
2.444
2.440
2.061
2.055
2.050
2.045
2.039
O
F
F
F
2o
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8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
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1.0
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ppm
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2.06
1.00
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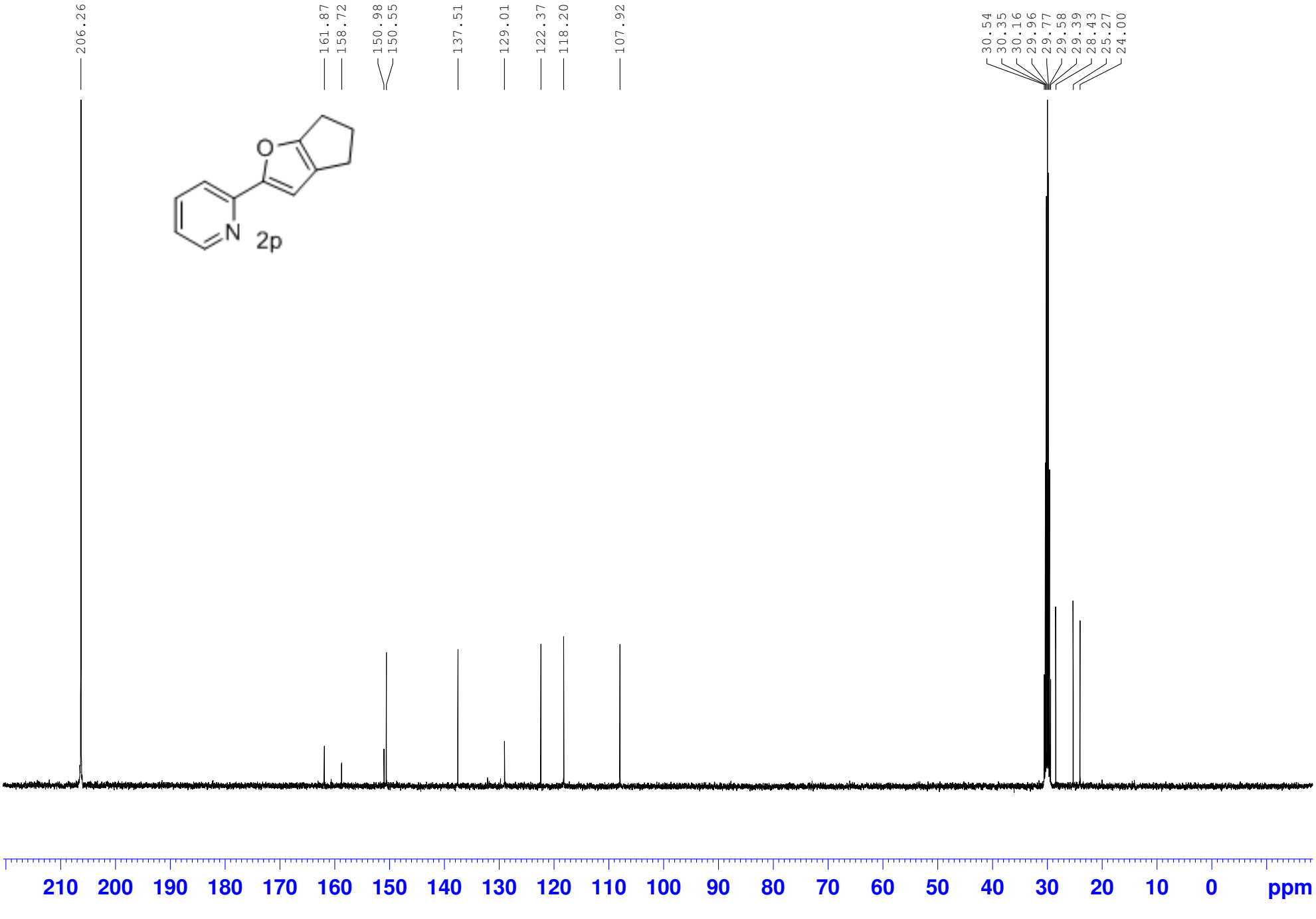
2.30
2.30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107.92
30.54
30.35
30.16
29.96
29.77
29.58
29.39
28.43
25.27
24.00
O
N
2p
210
200
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180
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140
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120
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100
90
80
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60
50
40
30
20
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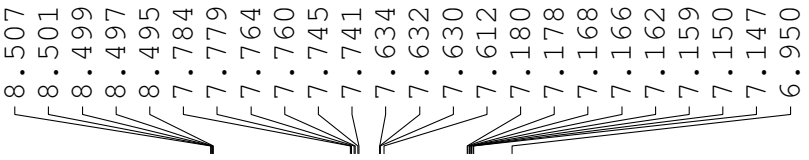
0
ppm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8.497
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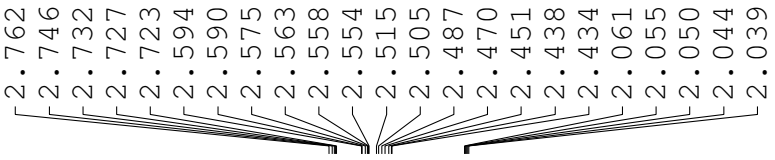
7.634
7.632
7.630
7.612
7.180
7.178
7.168
7.166
7.162
7.159
7.150
7.147
6.950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2.746
2.732
2.727
2.723
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2.575
2.563
2.558
2.554
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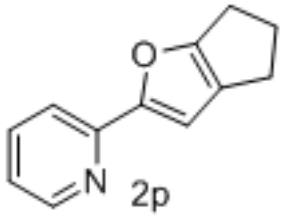
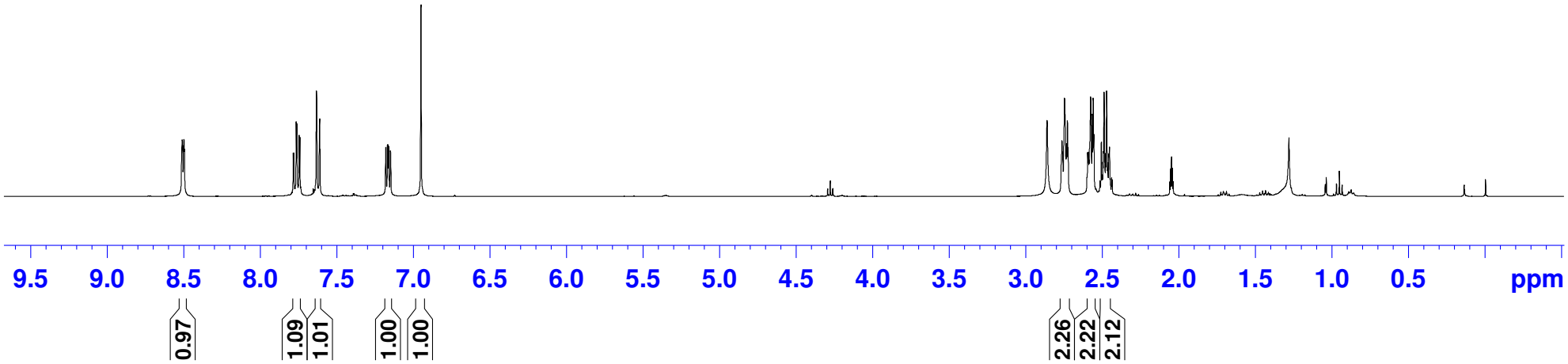
2.505
2.487
2.470
2.451
2.438
2.434
2.061
2.055
2.050
2.044
2.039


O
N
2p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8.0
7.5
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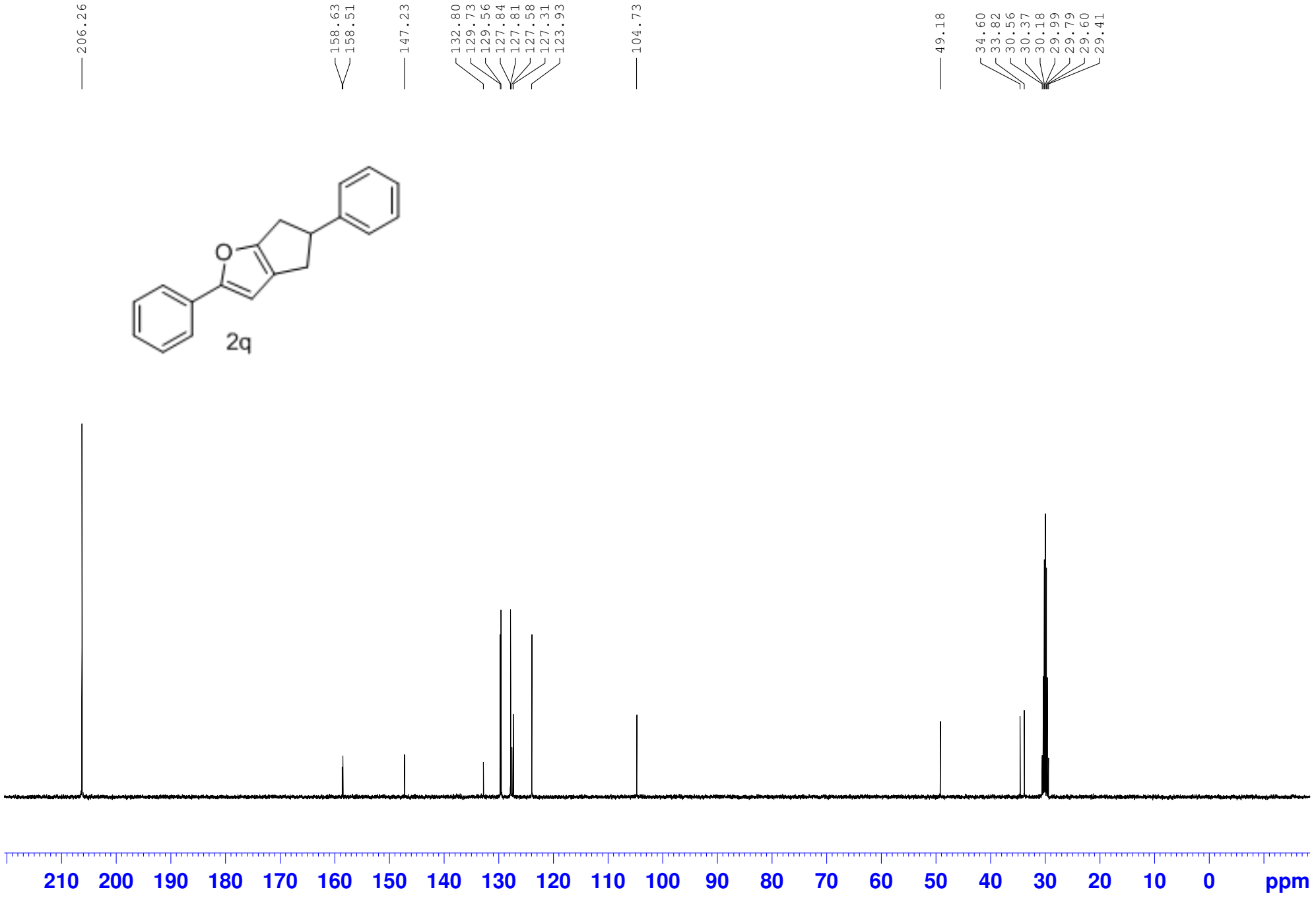
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
0.97
1.09
1.01
1.00
1.00
2.26
2.22
2.12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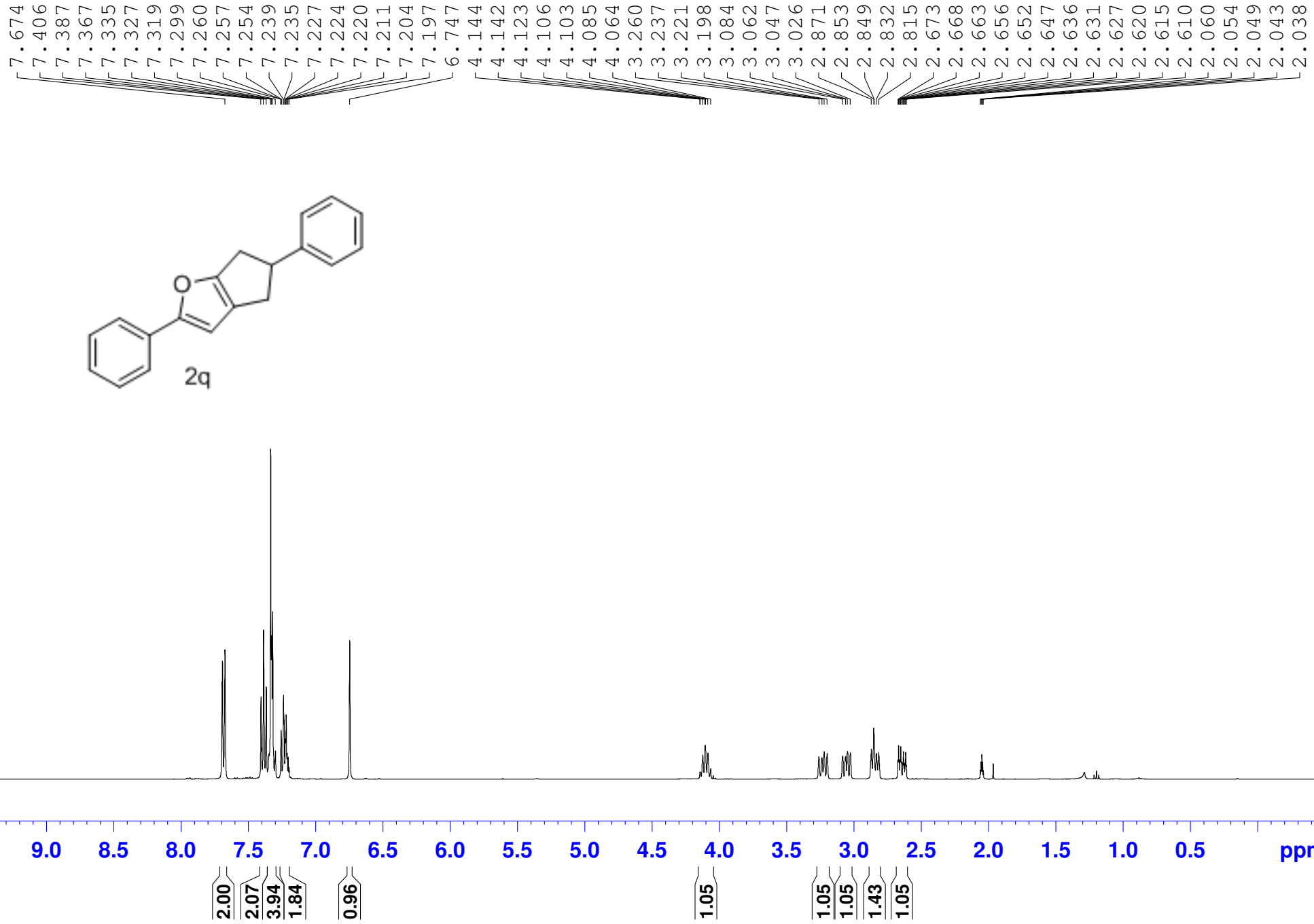
158.63
158.51
147.23
132.80
129.73
129.56
127.84
127.81
127.58
127.31
123.93
104.73
49.18
34.60
33.82
30.56
30.37
30.18
29.99
29.79
29.60
29.41
O
2q
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm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7.387
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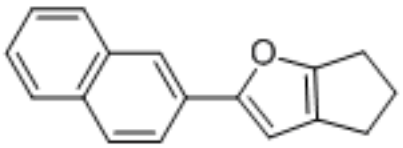
7.335
7.327
7.319
7.299
7.260
7.257
7.254
7.239
7.235
7.227
7.224
7.220
7.211
7.204
7.197
6.747
4.144
4.142
4.123
4.106
4.103
4.085
4.064
3.260
3.237
3.221
3.198
3.084
3.062
3.047
3.026
2.871
2.853
2.849
2.832
2.815
2.673
2.668
2.663
2.656
2.652
2.647
2.636
2.631
2.627
2.620
2.615
2.610
2.060
2.054
2.049
2.043
2.038
O
2q
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
ppm
2.00
2.07
3.94
1.84
0.96
1.05
1.05
1.05
1.43
1.05

160.034
157.643
133.673
132.354
129.183
128.232
127.999
127.800
127.692
126.346
125.487
121.965
120.960
104.279
77.318
77.000
76.682
27.750
24.848
23.559



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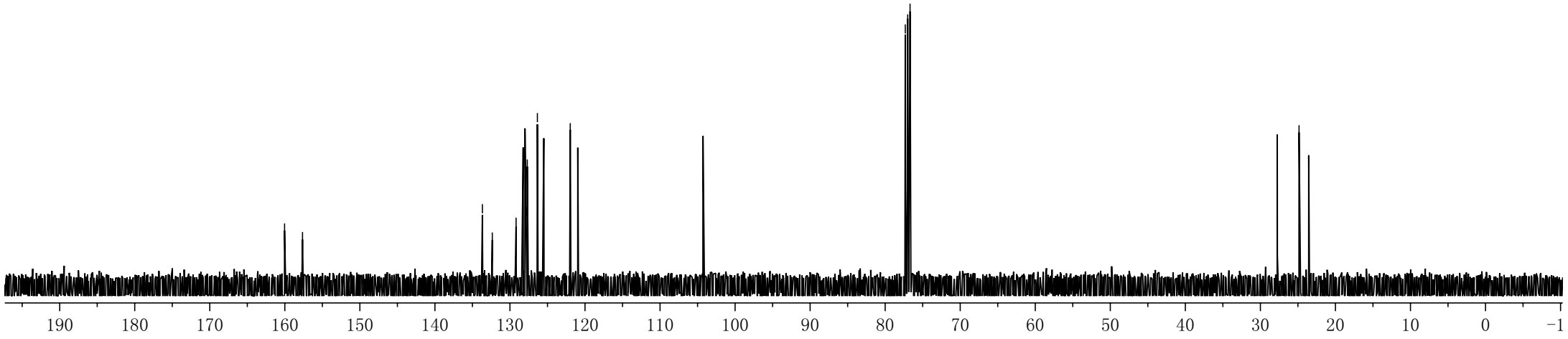
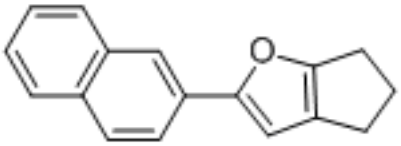


8.058
7.811
7.784
7.714
7.688
7.453
7.448
7.409
7.405
7.249
6.639

2.793
2.775
2.612
2.597
2.589
2.503



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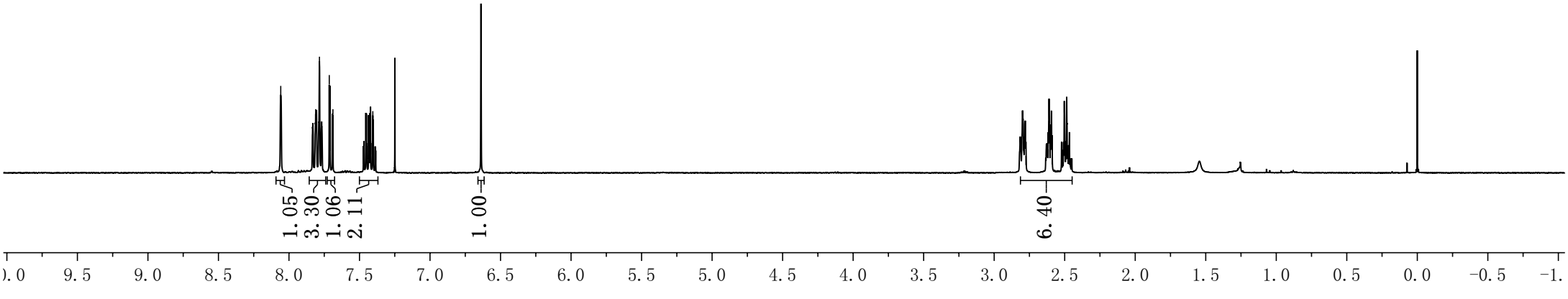
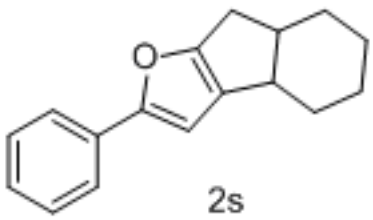
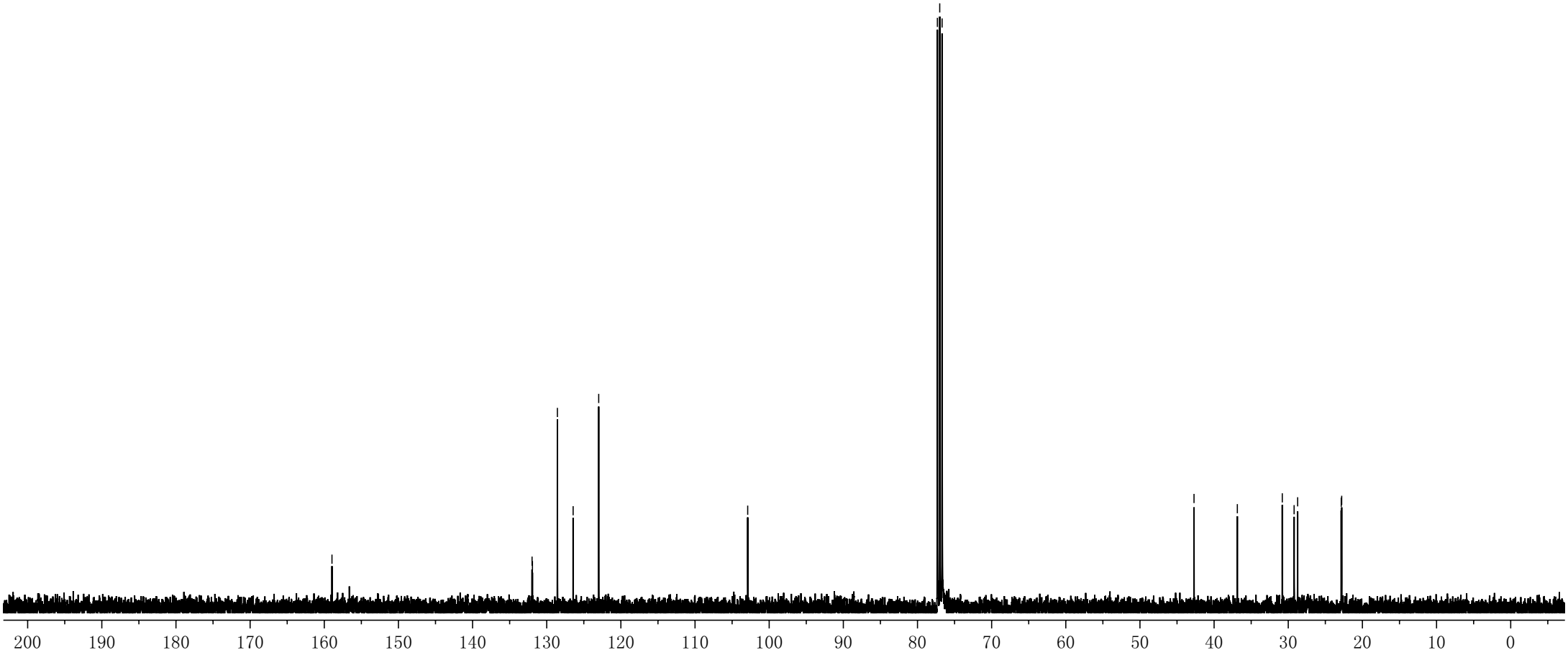




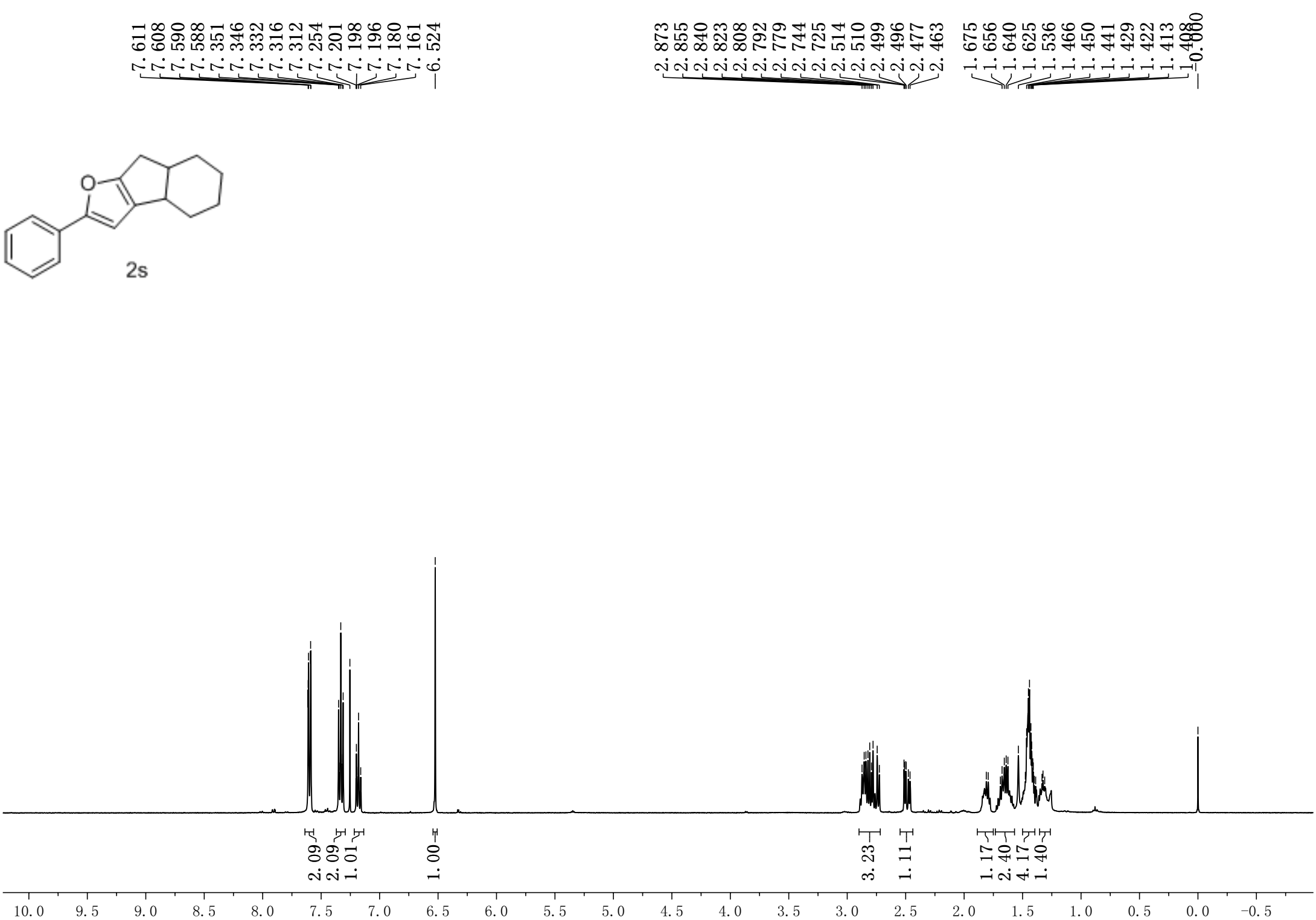
2s

158.962
156.576
131.979
131.927
128.561
126.439
122.990
102.897
77.318
77.000
76.683
42.709
36.865
30.806
29.210
28.733
22.856
22.792



O

2s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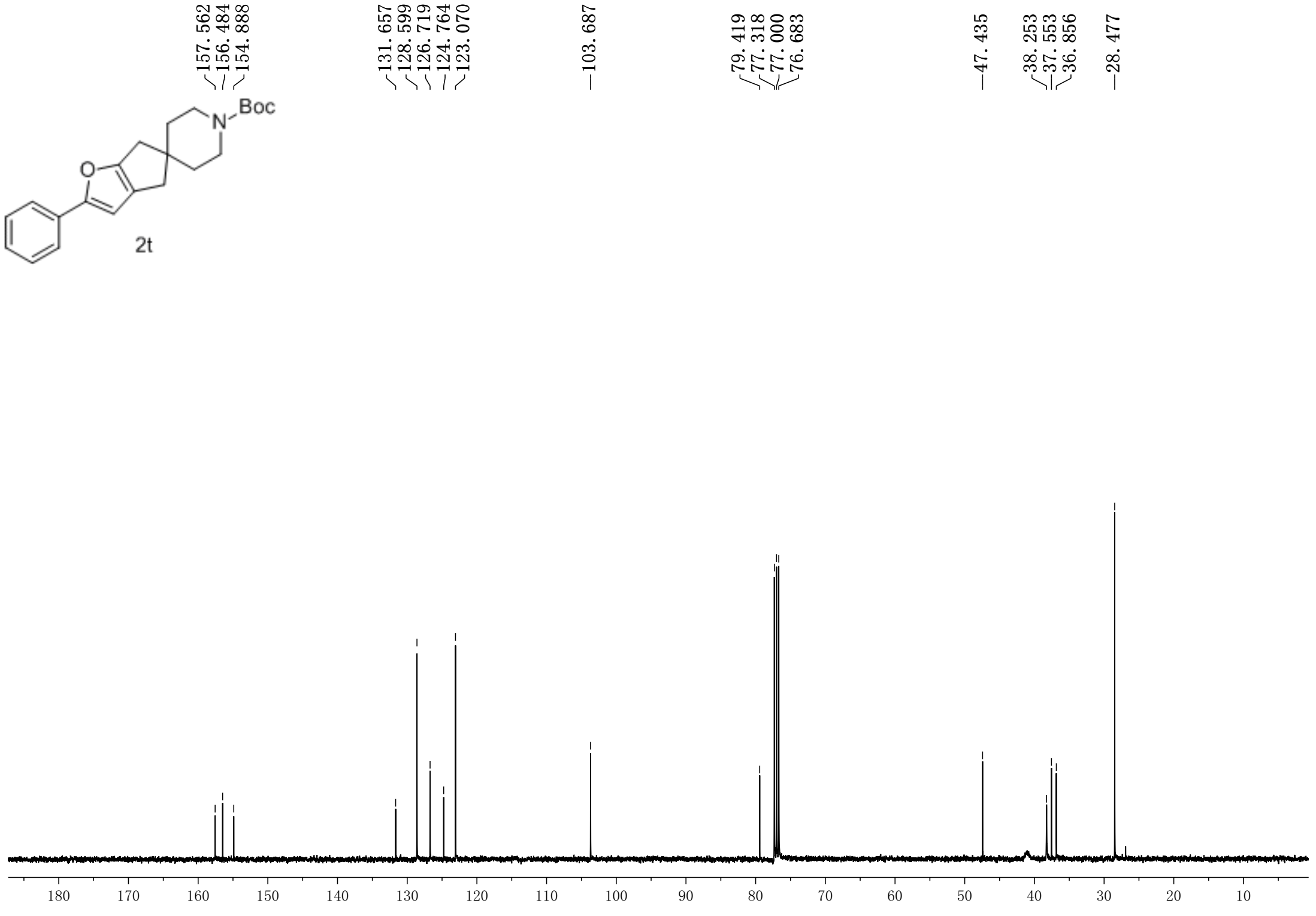
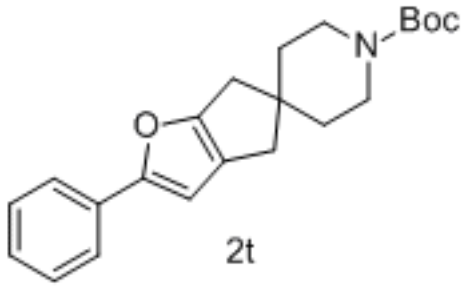
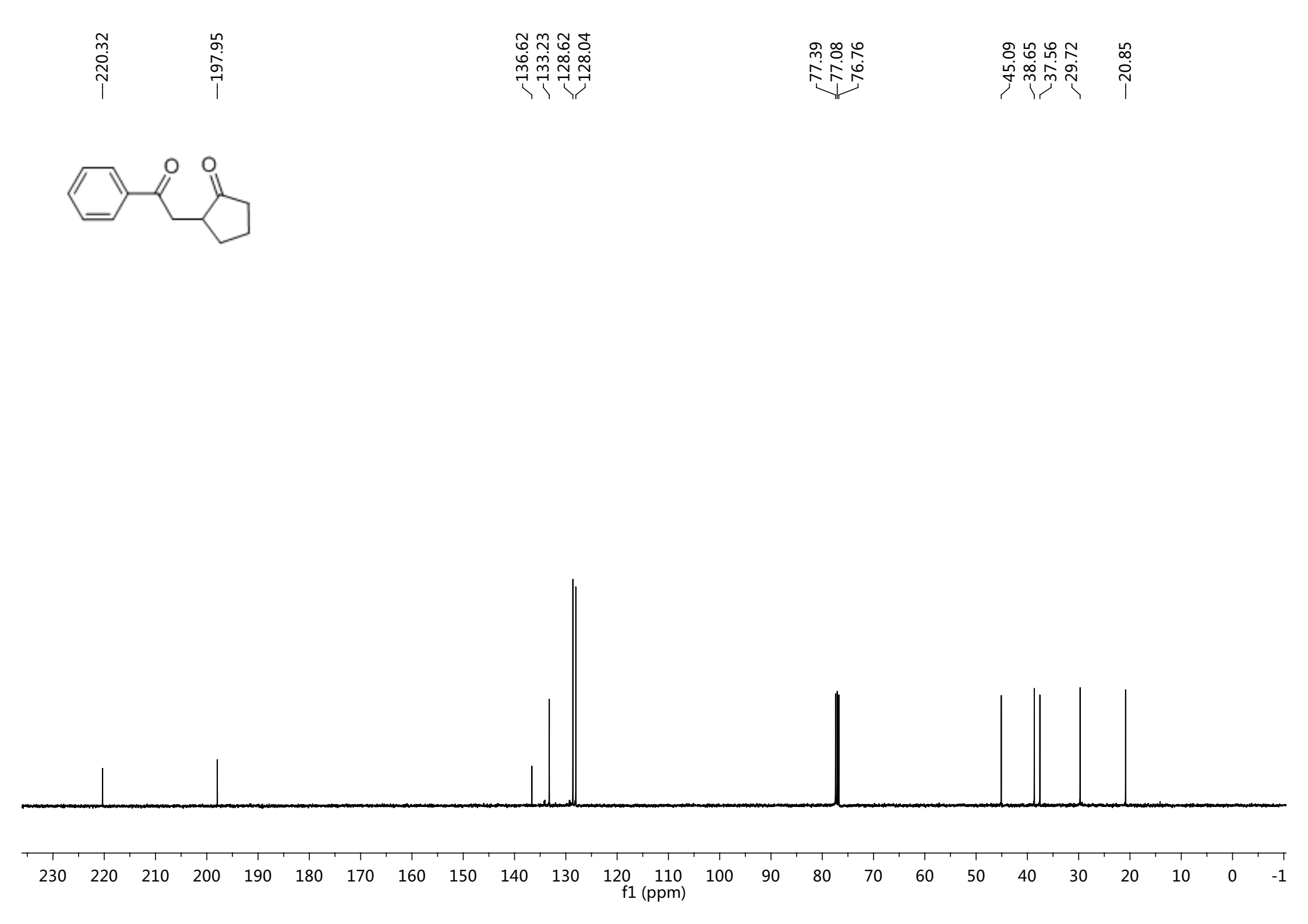
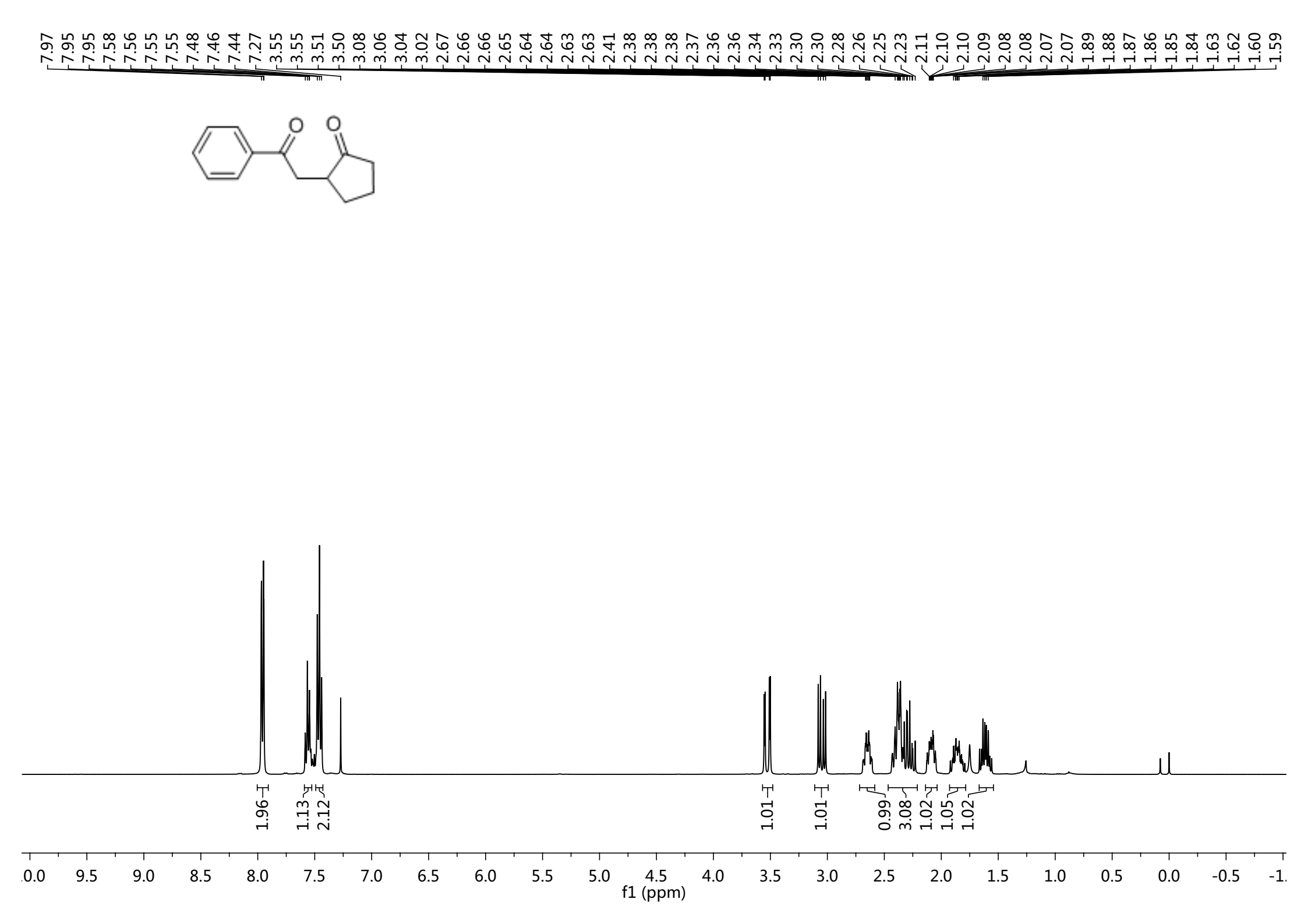
7.588
7.351
7.346
7.332
7.316
7.312
7.254
7.201
7.198
7.196
7.180
7.161
6.524
2.873
2.855
2.840
2.823
2.808
2.792
2.779
2.744
2.725
2.514
2.510
2.499
2.496
2.477
2.463
1.675
1.656
1.640
1.625
1.536
1.466
1.450
1.441
1.429
1.422
1.413
1.408
0.000
2.09
2.09
1.01
1.00
3.23
1.11
1.17
2.40
4.17
1.40
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5


157.562
156.484
154.888
131.657
128.599
126.719
124.764
123.070
103.687
79.419
77.318
77.000
76.683
47.435
38.253
37.553
36.856
28.477
Boc
N
O
2t
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10



2t


220.32
197.95
136.62
133.23
128.62
128.04
77.39
77.08
76.76
45.09
38.65
37.56
29.72
20.85
O
O
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-1
f1 (ppm)


7.97 7.95 7.95 7.58 7.56 7.55 7.55 7.48 7.46 7.44 7.27 3.55 3.55 3.51 3.50 3.08 3.06 3.04 3.02 2.67 2.66 2.66 2.65 2.64 2.64 2.63 2.63 2.41 2.38 2.38 2.38 2.37 2.36 2.36 2.34 2.33 2.30 2.30 2.28 2.26 2.25 2.23 2.11 2.10 2.10 2.09 2.08 2.08 2.07 2.07 1.89 1.88 1.87 1.86 1.85 1.84 1.63 1.62 1.60 1.59
O
O
1.96
1.13
2.12
1.01
1.01
0.99
3.08
1.02
1.05
1.02
f1 (ppm)