Deconstructive Isomerization of Azetidinols *via* C-C Bond Cleavage Enabled by *N*-Heterocyclic Carbene (NHC) Catalysis

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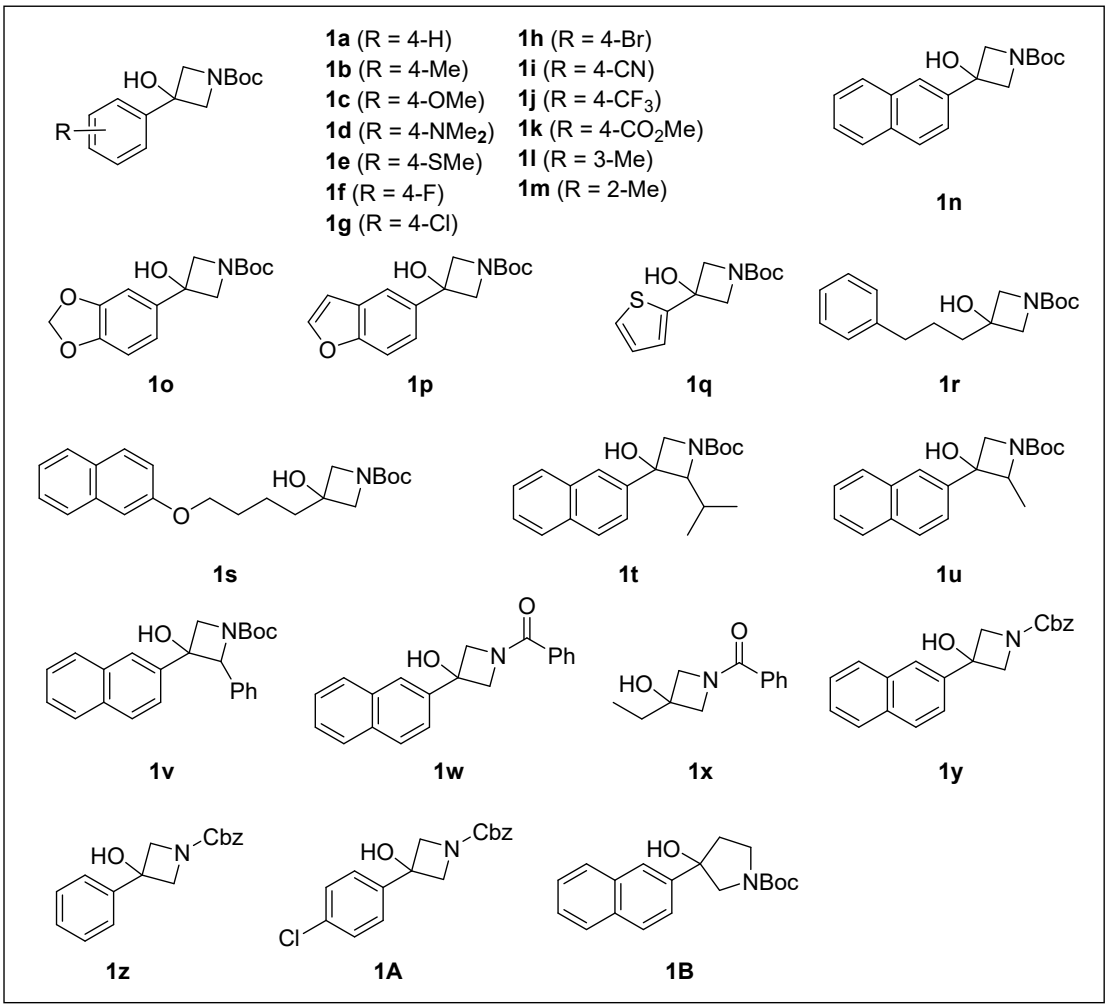
1. General Information

Unless otherwise noted, all reactions were carried out in flame-dried reaction vessels with Teflon screw caps under nitrogen. Solvents were purified and dried according to standard methods prior to use. All commercially available reagents were obtained from chemical suppliers and used after proper purification if necessary. Flash column chromatography was performed on silica gel (200-300 mesh) with the indicated solvent mixtures. TLC analysis was performed on pre-coated, glass-backed silica gel plates and visualized with UV light.

The ^{1}H NMR and ^{13}C NMR spectra were recorded on a Bruker 400 AV or 500 AV spectrometers. Chemical shifts (δ) were reported as parts per million (ppm) downfield from tetramethylsilane and the following abbreviations were used to identify the multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, dd = doublet of doublets, dt = doublet of triplets, dq = doublet of quartets, br = broad and all combinations thereof can be explained by their integral parts. Coupling constant (*J*) was reported in hertz unit (Hz). The high resolution mass spectra (HRMS) were recorded on an Agilent 6210 LC/TOF spectrometer.

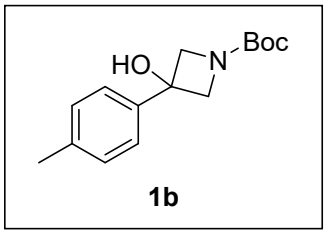
2. Preparation of Substrates



General procedure[1]: 3-Azetidinone (5 mmol) was dissolved in 10 mL of dried THF in 50 mL Schlenk tube under N_2. Grignard reagent (1.1 equiv) was added dropwise with stirring under ice bath. Then it was allowed to warm to room temperature and stirred overnight. After completion, the mixture was quenched with NH_4Cl (aq.). The aqueous layer was extracted with ethyl acetate (3×20 mL). The combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. After removal of the solvent in vacuo, the crude mixture was purified by flash column chromatography on silica gel to give the desired azetidinols. All the azetidinols were synthesized according this general procedure. **1y** were synthesized from N-Boc-3-pyrrolidinone according this procedure. Substrates **1a**[1], **1c**[1], **1d**[2], **1f**[1], **1g**[1], **1h**[1], **1j**[1], **1m**[3], **1q**[1], **1B**[4] were prepared according to the general procedure and their structural

characterization were in line with previous literature.

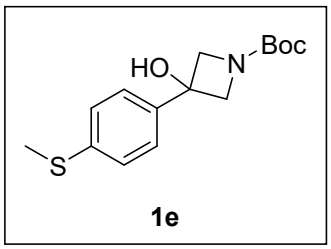
***tert*-butyl 3-hydroxy-3-(p-tolyl)azetidine-1-carboxylate (1b)**



1b

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.36 (d, *J* = 8.2 Hz, 2H), 7.18 (d, *J* = 8.0 Hz, 2H), δ 4.19 (d, *J* = 9.1 Hz, 1H), 4.14 (d, *J* = 9.2 Hz, 1H), 4.09 (s, 1H), 2.35 (s, 3H), 1.45 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.5, 140.5, 137.2, 129.1, 124.5, 79.8, 70.9, 64.2, 28.3, 20.9. **HRMS(ESI)** Calculated for $C_{14}H_{20}O_3N^-$ ([M-H]$^-$): 262.1449, found: 262.1447.

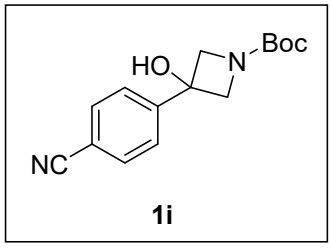
***tert*-butyl 3-hydroxy-3-(4-(methylthio)phenyl)azetidine-1-carboxylate (1e)**



1e

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.38 (d, *J* = 8.4 Hz, 2H), 7.22 (d, *J* = 8.4 Hz, 2H), 4.34 (s, 1H), 4.13 (s, 4H), 2.46 (s, 3H), 1.43 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.4, 140.4, 137.8, 126.5, 125.1, 78.0, 70.6, 64.3, 28.3, 15.7. **HRMS(ESI)** Calculated for $C_{15}H_{20}O_3NS^-$ ([M-H]$^-$): 294.1169, found: 294.1172.

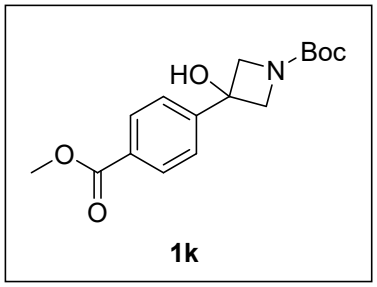
***tert*-butyl 3-(4-cyanophenyl)-3-hydroxyazetidine-1-carboxylate (1i)**



1i

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.67–7.59 (m, 4H), 4.96 (s, 1H), 4.17 (d, *J* = 9.4 Hz, 2H), 4.08 (d, *J* = 9.4 Hz, 2H), 1.39 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.4, 149.2, 132.1, 125.3, 118.5, 111.0, 80.4, 70.1, 64.7, 28.2. **HRMS(ESI)** Calculated for $C_{15}H_{17}O_3N_2^-$ ([M-H]$^-$): 273.1245, found: 273.1238.

***tert*-butyl 3-hydroxy-3-(4-(methoxycarbonyl)phenyl)azetidine-1-carboxylate (1k)**

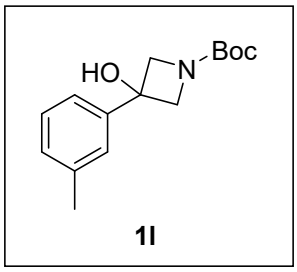


1k

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.4 Hz, 2H), 7.56 (d, *J* = 8.4 Hz, 2H), 4.70 (s, 1H), δ 4.18 (d, *J* = 9.3

Hz, 1H), 4.14 (d, *J* = 9.2 Hz, 1H), 3.88 (s, 3H), 1.42 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 166.8, 156.5, 148.8, 129.7, 129.2, 124.5, 80.2, 70.5, 64.7, 52.1, 28.3. **HRMS(ESI)** Calculated for $C_{16}H_{20}O_5N^-$ ([M-H]$^-$): 306.1341, found: 306.1350.

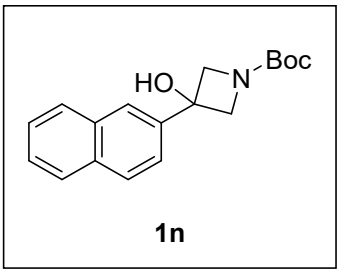
***tert*-butyl 3-hydroxy-3-(m-tolyl)azetidine-1-carboxylate (1l)**



1l

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33–7.24 (m, 3H), 7.16–7.08 (m, 1H), δ 4.21 (d, *J* = 9.2 Hz, 1H), 4.15 (d, *J* = 9.2 Hz, 1H), 4.04 (s, 1H), 2.37 (s, 3H), 1.46 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.5, 143.4, 138.1, 128.4, 128.3, 125.3, 121.6, 79.9, 71.0, 64.2, 28.3, 21.4. **HRMS(ESI)** Calculated for $C_{14}H_{20}O_3N^-$ ([M-H]$^-$): 262.1449, found: 262.1447.

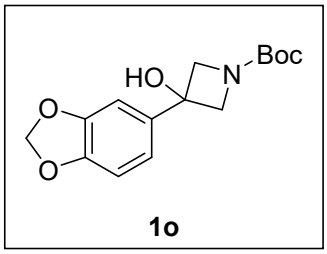
***tert*-butyl 3-hydroxy-3-(naphthalen-2-yl)azetidine-1-carboxylate (1n)**



1n

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 (s, 1H), 7.86–7.78 (m, 3H), 7.56 (dd, J_1 = 8.6, J_2 = 1.8 Hz, 1H), 7.52–7.45 (m, 2H), 4.36–4.22 (m, 5H), 1.48 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.5, 140.6, 132.9, 132.6, 128.5, 128.1, 127.5, 126.3, 126.1, 123.2, 122.8, 80.0, 71.0, 64.1, 28.3. **HRMS(ESI)** Calculated for $C_{18}H_{20}O_3N^-$ ([M-H]$^-$): 298.1449, found: 298.1450.

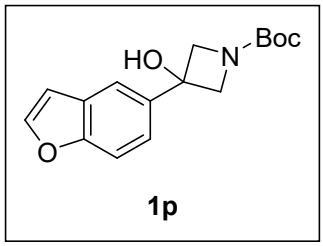
***tert*-butyl 3-(benzo[d][1,3]dioxol-5-yl)-3-hydroxyazetidine-1-carboxylate (1o)**



1o

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.00–6.89 (m, 2H), 6.77 (d, *J* = 8.0 Hz, 1H), 5.93 (s, 2H), 4.16–4.08 (m, 5H), 1.43 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.5, 147.8, 146.9, 137.6, 117.9, 107.9, 105.6, 101.0, 79.9, 70.9, 64.4, 28.3. **HRMS(ESI)** Calculated for $C_{15}H_{18}O_5N^-$ ([M-H]$^-$): 292.1190, found: 292.1191.

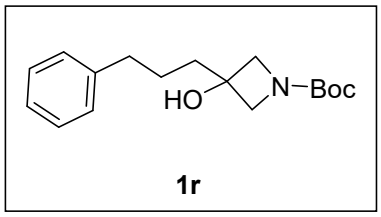
***tert*-butyl 3-(benzofuran-5-yl)-3-hydroxyazetidine-1-carboxylate (1p)**



1p

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.70 (d, J = 1.7 Hz, 1H), 7.63 (d, J = 2.2 Hz, 1H), 7.47 (d, J = 8.6 Hz, 1H), 7.39 (dd, J_1 = 8.6, J_2 = 1.9 Hz, 1H), 6.77–6.71 (m, 1H), δ 4.26 (d, J = 9.2 Hz, 1H), 4.20 (d, J = 9.2 Hz, 1H), 4.17 (s, 1H), 1.44 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.6, 154.3, 145.7, 138.3, 127.4, 121.3, 117.5, 111.4, 106.7, 80.0, 71.3, 64.6, 28.4. **HRMS(ESI)** Calculated for $C_{16}H_{18}O_4N^-$ ([M-H]$^-$): 288.1241, found: 288.1245.

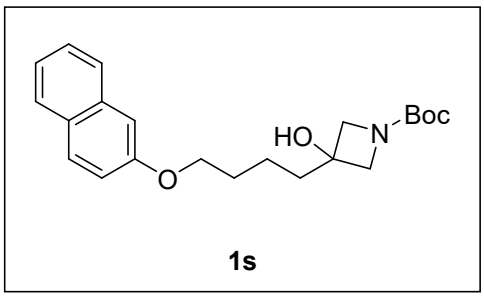
***tert*-butyl 3-hydroxy-3-(3-phenylpropyl)azetidine-1-carboxylate (1r)**



1r

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.29 (t, J = 7.6 Hz, 2H), 7.23–7.18 (m, 3H), 3.89–3.67 (m, 4H), 3.54 (s, 1H), 2.66 (dd, J_1 = 6.6 Hz, J_2 = 3.6 Hz, 2H), 1.75 (d, J = 3.6 Hz, 4H), 1.44 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.5, 141.9, 128.3, 128.3, 125.8, 79.6, 70.1, 61.9, 38.3, 35.7, 28.3, 25.0. **HRMS(ESI)** Calculated for $C_{17}H_{24}O_3N^-$ ([M-H]$^-$): 290.1762, found: 290.1764.

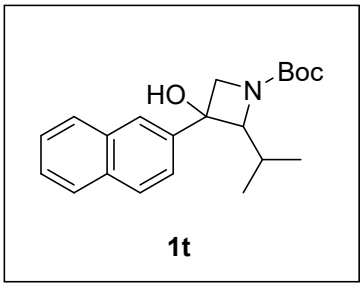
***tert*-butyl 3-hydroxy-3-(4-(naphthalen-2-yloxy)butyl)azetidine-1-carboxylate (1s)**



1s

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81–7.70 (m, 3H), 7.50–7.40 (m, 1H), 7.38–7.31 (m, 1H), 7.21–7.10 (m, 2H), 4.11–4.03 (m, 2H), 3.92–3.79 (m, 4H), 3.73–3.47 (m, 1H), 1.98–1.85 (m, 2H), 1.85–1.77 (m, 2H), 1.67–1.54 (m, 2H), 1.46 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.8, 156.5, 134.5, 129.3, 129.2, 128.8, 127.5, 126.6, 126.2, 126.2, 123.4, 123.4, 118.9, 118.8, 106.6, 79.7, 70.2, 67.6, 62.0, 38.5, 29.2, 28.3, 20.1. **HRMS(ESI)** Calculated for $C_{22}H_{29}O_4NNa^+$ ([M+Na]$^+$): 394.1994, found: 394.1984.

***tert*-butyl 3-hydroxy-2-isopropyl-3-(naphthalen-2-yl)azetidine-1-carboxylate (1t)**

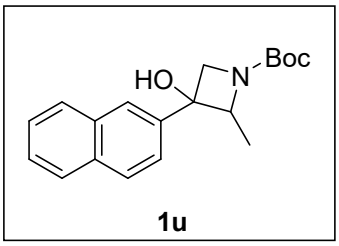


1t

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.93 (d, J = 1.4 Hz, 1H),

7.91–7.81 (m, 3H), 7.55 (dd, J_1 = 8.6, J_2 = 1.9 Hz, 1H), 7.53–7.47 (m, 2H), 4.41 (d, J = 9.9 Hz, 1H), 4.17–4.04 (m, 2H), 2.98 (s, 1H), 2.47–2.31 (m, 1H), 1.49 (s, 9H), 1.11 (d, J = 6.8 Hz, 3H), 1.01 (d, J = 6.6 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 157.5, 142.0, 133.0, 132.6, 128.8, 128.2, 127.5, 126.4, 126.2, 122.9, 122.7, 79.9, 79.1, 73.4, 63.6, 29.4, 28.3, 19.7, 19.5. **HRMS(ESI)** Calculated for $C_{21}H_{26}O_3N^-$ ([M-H]$^-$): 340.1918, found: 340.1921.

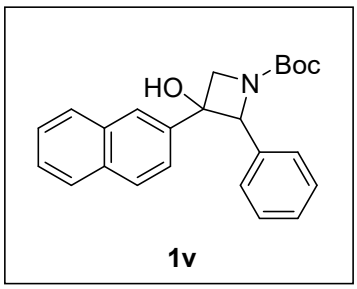
***tert*-butyl 3-hydroxy-2-methyl-3-(naphthalen-2-yl)azetidine-1-carboxylate (1u)**



1u

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 (d, J = 1.3 Hz, 1H), 7.86–7.79 (m, 3H), 7.56–7.45 (m, 3H), 4.56 (s, 1H), 4.33 (d, J = 9.4 Hz, 1H), 4.17–4.04 (m, 1H), 3.63 (s, 1H), 1.53 (d, J = 6.4 Hz, 3H), 1.48 (s, 9H). **^{13}C NMR (126 MHz, $CDCl_3$)** δ 156.4, 141.0, 132.9, 132.6, 128.5, 128.1, 127.5, 126.3, 126.1, 123.3, 122.9, 79.7, 72.6, 68.7, 61.8, 28.4, 14.2. **HRMS(ESI)** Calculated for $C_{19}H_{22}O_3N^-$ ([M-H]$^-$): 312.1605, found: 312.1608.

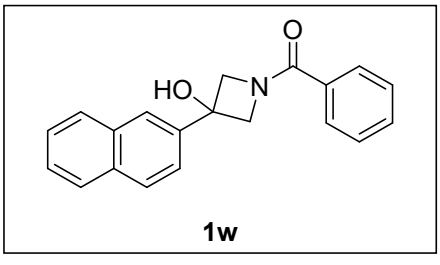
***tert*-butyl 3-hydroxy-3-(naphthalen-2-yl)-2-phenylazetidine-1-carboxylate (1v)**



1v

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.02 (s, 1H), 7.95 (d, J = 8.6 Hz, 1H), 7.92–7.85 (m, 2H), 7.72–7.65 (m, 1H), 7.58–7.49 (m, 2H), 7.48–7.42 (m, 2H), 7.42–7.33 (m, 3H), 5.57 (s, 1H), 4.58 (d, J = 9.2 Hz, 1H), 4.24 (d, J = 9.6 Hz, 1H), 2.25 (s, 1H), 1.43 (s, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.3, 140.5, 135.0, 133.0, 132.8, 128.8, 128.8, 128.4, 128.3, 127.6, 127.0, 126.5, 126.3, 123.5, 122.8, 80.2, 73.2, 28.3. **HRMS(ESI)** Calculated for $C_{24}H_{24}O_3N^-$ ([M-H]$^-$): 374.1762, found: 374.1765.

(3-hydroxy-3-(naphthalen-2-yl)azetidin-1-yl)(phenyl)methanone (1w)

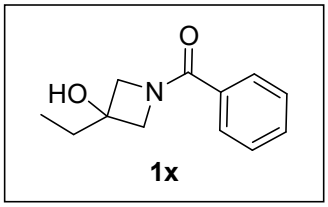


1w

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 (s, 1H), 7.84–7.74 (m, 3H), 7.61–7.51 (m, 3H), 7.51–7.45 (m,

2H), 7.45–7.40 (m, 1H), 7.37–7.28 (m, 2H), 5.47 (s, 1H), 4.74–4.44 (m, 4H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 170.5, 140.2, 132.8, 132.6, 132.6, 131.1, 128.6, 128.3, 128.1, 127.8, 127.5, 126.3, 126.1, 123.4, 122.7, 71.3, 68.3, 63.7. **HRMS(ESI)** Calculated for $C_{20}H_{16}O_2N^-$ ([M-H]$^-$): 302.1187, found: 302.1188.

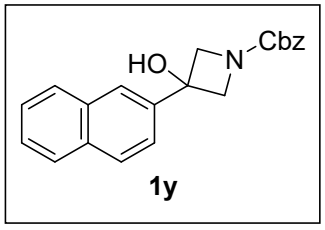
(3-ethyl-3-hydroxyazetidin-1-yl)(phenyl)methanone (1x)



1x

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.54–7.49 (m, 2H), 7.42–7.36 (m, 1H), 7.34–7.29 (m, 2H), 4.83 (s, 1H), 4.19–3.96 (m, 4H), 1.70 (q, J = 7.4 Hz, 2H), 0.89 (t, J = 7.4 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 170.2, 132.9, 130.9, 128.2, 127.7, 70.7, 65.5, 61.2, 31.4, 7.4. **HRMS(ESI)** Calculated for $C_{12}H_{14}NO_2^-$ ([M-H]$^-$): 204.2495, found: 204.2498.

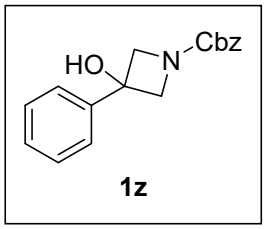
benzyl 3-hydroxy-3-(naphthalen-2-yl)azetidine-1-carboxylate (1y)



1y

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.93 (d, J = 1.3 Hz, 1H), 7.89–7.79 (m, 3H), 7.59–7.54 (m, 1H), 7.54–7.49 (m, 2H), 7.39–7.30 (m, 5H), 5.12 (s, 2H), 4.42 (d, J = 9.3 Hz, 2H), 4.33 (d, J = 9.3 Hz, 2H), 4.02 (s, 1H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.6, 140.1, 136.2, 132.8, 132.6, 128.7, 128.4, 128.1, 128.0, 127.9, 127.5, 126.4, 126.2, 123.3, 122.7, 71.5, 67.0, 64.1. **HRMS(ESI)** Calculated for $C_{21}H_{18}NO_3^-$ ([M-H]$^-$): 332.1287, found: 332.1290.

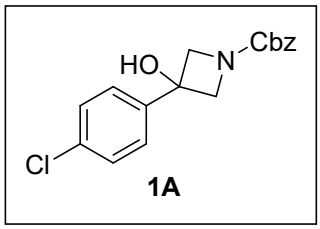
benzyl 3-hydroxy-3-phenylazetidine-1-carboxylate (1z)



1z

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.48–7.43 (m, 2H), 7.37 (dd, J_1 = 10.4, J_2 = 4.8 Hz, 2H), 7.35–7.25 (m, 6H), 5.08 (s, 2H), 4.30 (d, J = 9.3 Hz, 2H), 4.22 (d, J = 9.3 Hz, 2H), 3.42 (s, 1H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.6, 143.0 (s), 136.4, 128.7, 128.5, 128.1,128.0, 124.6, 71.7, 67.0, 64.4. **HRMS(ESI)** Calculated for $C_{17}H_{16}NO_3^-$ ([M-H]$^-$): 282.1135, found: 282.1138.

benzyl 3-(4-chlorophenyl)-3-hydroxyazetidine-1-carboxylate (1A)



1A

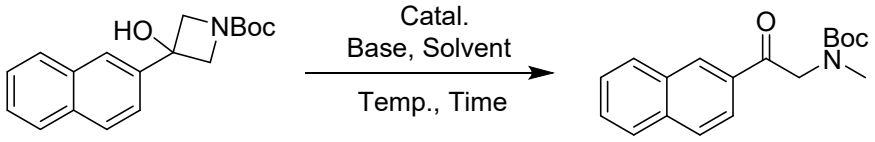
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44–7.37 (m, 2H), 7.37–7.25 (m, 7H), 5.08 (s, 2H), 4.28–4.15 (m, 4H), 3.66 (s, 1H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 156.6, 141.6, 136.2, 133.8, 128.7, 128.5, 128.2, 128.0, 126.0, 71.1, 67.1, 64.7.

HRMS(ESI) Calculated for $C_{17}H_{15}ClNO_3^-$ ($[M-H]^-$): 316.0745, found: 316.0748.

3 NHC-Catalyzed Deconstructive Isomerization of Azetidinols

3.1 Optimization of reaction conditions

Survey of the reaction parameters[a]

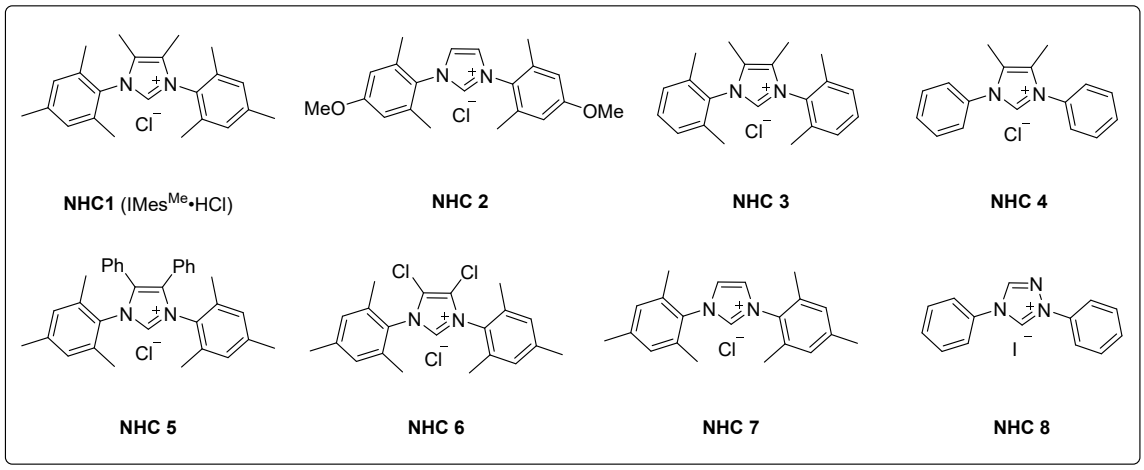


1n **2n**

Entry	Catal./equiv.	Base/equiv.	Temp./ °C	Solvent/mL	Yield/%
1	***NHC 1 (0.1)***	*NaO*t*-Bu (0.15)*	*130*	*Toluene (1)*	*96*
2	**NHC 2** (0.1)	NaO*t*-Bu (0.15)	130	Toluene (1)	95
3	**NHC 3** (0.1)	NaO*t*-Bu (0.15)	130	Toluene (1)	91
4	**NHC 4** (0.1)	NaO*t*-Bu (0.15)	130	Toluene (1)	15
5	**NHC 5** (0.1)	NaO*t*-Bu (0.15)	130	Toluene (1)	45
6	**NHC 6** (0.1)	NaO*t*-Bu (0.15)	130	Toluene (1)	34
7	**NHC 7** (0.1)	NaO*t*-Bu (0.15)	130	Toluene (1)	0
8	**NHC 8** (0.1)	NaO*t*-Bu (0.15)	130	Toluene (1)	trace
9	**NHC 1** (0.05)	NaO*t*-Bu (0.075)	130	Toluene (1)	54
10	-[b]	NaO*t*-Bu (0.15)	130	Toluene (1)	0
11	-[b]	NaO*t*-Bu (1)	130	Toluene (1)	0
12	**NHC 1** (0.1)	-[c]	130	Toluene (1)	0
13	DABCO (0.1)	-[c]	130	Toluene (1)	0
14	PPh_3 (0.1)	-[c]	130	Toluene (1)	0
15	**NHC 1** (0.1)	Na_2CO_3 (0.15)	130	Toluene (1)	73
16	**NHC 1** (0.1)	K_3PO_4 (0.15)	130	Toluene (1)	95
17	**NHC 1** (0.1)	KO*t*-Bu (0.15)	130	Toluene (1)	87
18	**NHC 1** (0.1)	NaOEt (0.15)	130	Toluene (1)	94
19	**NHC 1** (0.1)	NaH (0.15)	130	Toluene (1)	90
20	**NHC 1** (0.1)	LiOt-Bu (0.15)	130	Toluene (1)	68
21	**NHC 1** (0.1)	DABCO (0.15)	130	Toluene (1)	0

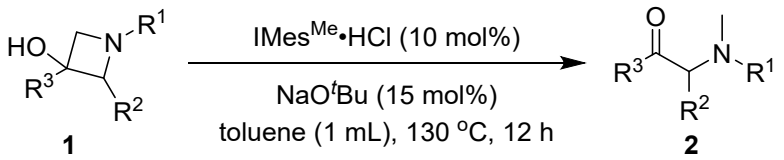
22	**NHC 1** (0.1)	DBU (0.15)	130	Toluene (1)	trace
23	**NHC 1** (0.1)	Et_3N (0.15)	130	Toluene (1)	0
24	**NHC 1** (0.1)	NaO*t*-Bu (0.15)	110	Toluene (1)	76
25	**NHC 1** (0.1)	NaO*t*-Bu (0.15)	130	Xylene (1)	81
26	**NHC 1** (0.1)	NaO*t*-Bu (0.15)	130	CH_3CN (1)	78
27	**NHC 1** (0.1)	NaO*t*-Bu (0.15)	130	Dioxane (1)	41
28	**NHC 1** (0.1)	NaO*t*-Bu (0.15)	130	THF (1)	5
29	**NHC 1** (0.1)	NaO*t*-Bu (0.15)	130	DMF (1)	46
30	**NHC 1** (0.1)	NaO*t*-Bu (0.15)	130	Toluene (1)	88[d]

[a]Reaction conditions unless otherwise noted: **1n** (0.4 mmol), Catal. (0.04 mmol), Solvent (1 mL), Base (0.06 mmol), for 12 h under N_2 atmosphere. [b]No catalyst. [c]No base. [d]for 8 h.



3.2 Experimental details and characterization of products

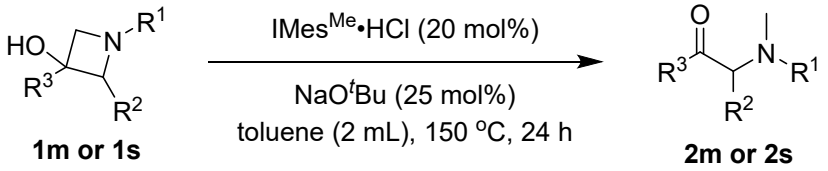
Typical procedure:



To a 25 ml flame-dried Schlenk tube containing a stirring bar was added $IMes^{Me}$·HCl (**NHC 1**, 0.04 mmol, 14.7 mg.), NaO*t*-Bu (0.06 mmol, 6.0 mg), *tert*-butyl 3-hydroxy-3-(naphthalen-2-yl)azetidine-1-carboxylate **1n** (0.4 mmol, 120 mg), toluene (1.0 mL) sequentially under nitrogen. The tube was sealed and stirred at 130 °C for 12 h. After completion, the reaction mixture was concentrated and purified by silica gel column

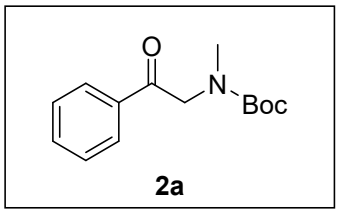
chromatography to provide the product **2n** in 96% yield.

Modified procedure for the synthesis of 2m and 2s



To a 25 ml flame-dried Schlenk tube containing a stirring bar was added IMes^{Me}·HCl (0.08 mmol, 29.4 mg.), NaO*t*-Bu (0.1 mmol, 9.8 mg), **1m** or **1s** (0.4 mmol), toluene (2.0 mL) sequentially under nitrogen. The tube was sealed and stirred at 150 °C for 24 h. After completion, the reaction mixture was concentrated and purified by silica gel column chromatography to provide the product **2m** or **2s**.

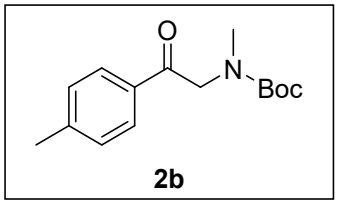
***tert*-butyl methyl(2-oxo-2-phenylethyl)carbamate (2a)[5]**



Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as yellow oil (88 mg, 88% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.01–7.90 (m, 2H), 7.65–7.54 (m, 1H), 7.52–7.41 (m, 2H), 4.64 (d, 2H), 2.96 (d, 3H), 1.44 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 195.1, 194.7, 156.1, 155.6, 135.2, 135.1, 133.4, 133.4, 128.7, 128.6, 127.8, 127.6, 79.9, 79.9, 55.6, 55.0, 35.6, 35.5, 28.3, 28.1.

***tert*-butyl methyl(2-oxo-2-(p-tolyl)ethyl)carbamate (2b)**

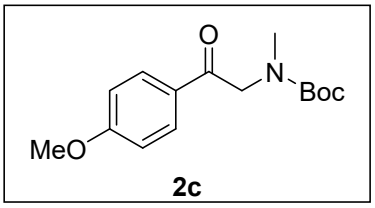


Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as white solid (90 mg, 86% yield). mp: 71-73 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88–7.80 (m, 2H), 7.32–7.23 (m, 2H), 4.61 (d, 2H), 2.95 (d, 3H), 2.41 (d, 3H), 1.44 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 194.7, 194.3, 156.2, 155.7, 144.3, 144.2, 132.7, 129.4, 129.3, 127.9, 127.8, 79.9, 79.8, 55.5, 54.9, 35.6, 35.5, 28.3, 28.2, 21.6. **HRMS(ESI)** Calculated for

$C_{15}H_{21}O_3NNa^+$ ([M+Na]$^+$): 286.1414, found: 286.1411.

***tert*-butyl (2-(4-methoxyphenyl)-2-oxoethyl)(methyl)carbamate (2c)**

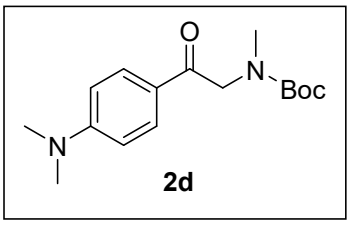


2c

Purified by flash column chromatography (PE/EA = 10:1 to 4:1) as colorless oil (104 mg, 93% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96–7.90 (m, 2H), 6.98–6.90 (m, 2H), 4.59 (d, 2H), 3.87 (d, 3H), 2.95 (d, 3H), 1.44 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 193.5, 193.1, 163.6, 163.6, 156.1, 155.7, 130.0, 129.8, 128.2, 113.8, 113.7, 79.8, 79.7, 55.4, 55.3, 55.1, 54.6, 35.6, 35.5, 28.2, 28.1. **HRMS(ESI)** Calculated for $C_{15}H_{21}O_4NNa^+$ ([M+Na]$^+$): 302.1363, found: 302.1361.

***tert*-butyl (2-(4-(dimethylamino)phenyl)-2-oxoethyl)(methyl)carbamate (2d)**

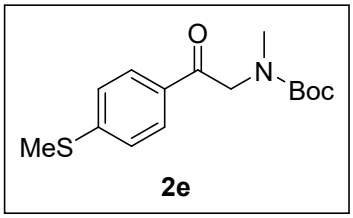


2d

Purified by flash column chromatography (PE/EA = 10:1 to 4:1) as white solid (110 mg, 94% yield). mp: 74-76 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88–7.82 (m, 2H), 6.69–6.60 (m, 2H), 4.56 (d, 2H), 3.05 (d, 6H), 2.94 (d, 3H), 1.44 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 192.7, 192.3, 156.2, 155.9, 153.4, 129.9, 129.7, 123.1, 123.0, 110.6, 110.5, 79.5, 79.5, 54.7, 54.2, 39.8, 35.5, 35.4, 28.3, 28.2. **HRMS(ESI)** Calculated for $C_{16}H_{24}O_3N_2Na^+$ ([M+Na]$^+$): 315.1679, found: 315.1676.

***tert*-butyl methyl(2-(4-(methylthio)phenyl)-2-oxoethyl)carbamate (2e)**



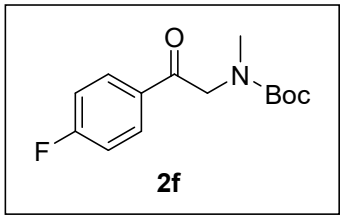
2e

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as yellow solid (112 mg, 93% yield). mp: 48-50 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 – 7.78 (m, 2H), 7.32 – 7.20 (m, 2H), 4.57 (d, 2H), 2.93 (d, 3H), 2.49 (d, 3H), 1.41 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 194.0, 193.7, 156.1, 155.6, 146.4, 146.3, 131.4, 128.2, 128.0, 125.0,

124.9, 79.9, 79.8, 55.3, 54.7, 35.6, 35.5, 28.3, 28.1, 14.6. **HRMS(ESI)** Calculated for $C_{15}H_{21}O_3NNaS^+$ ([M+Na]$^+$): 318.1134, found: 318.1132.

***tert*-butyl (2-(4-fluorophenyl)-2-oxoethyl)(methyl)carbamate (2f)**

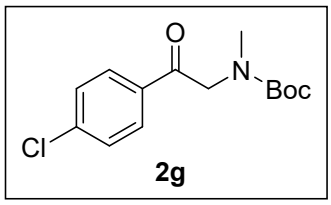


2f

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as white solid (41 mg, 38% yield). mp: 72-74 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.07–7.91 (m, 2H), 7.22–7.07 (m, 2H), 4.60 (d, 2H), 2.96 (d, 3H), 1.44 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 193.7, 193.3, 166.9, 164.9, 156.2, 155.6, 131.7, 130.6, 130.6, 130.4, 130.3, 116.0, 115.9, 115.7, 80.1, 80.1, 55.5, 54.9, 35.7, 35.6, 28.3, 28.2. **HRMS(ESI)** Calculated for $C_{14}H_{18}O_3NFNa^+$ ([M+Na]$^+$): 290.1163, found: 290.1163.

***tert*-butyl (2-(4-chlorophenyl)-2-oxoethyl)(methyl)carbamate (2g)[6]**

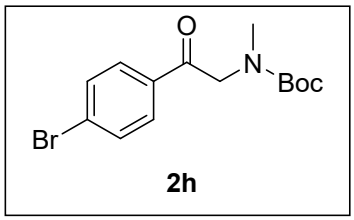


2g

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as colorless oil (84 mg, 74% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89–7.83 (m, 2H), 7.47–7.37 (m, 2H), 4.57 (d, 2H), 2.93 (d, 3H), 1.41 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 194.0, 193.6, 156.1, 155.5, 139.9, 139.8, 133.4, 129.2, 129.0, 128.9, 80.0, 80.0, 55.5, 54.9, 35.6, 35.5, 28.2, 28.1.

***tert*-butyl (2-(4-bromophenyl)-2-oxoethyl)(methyl)carbamate (2h)[6]**



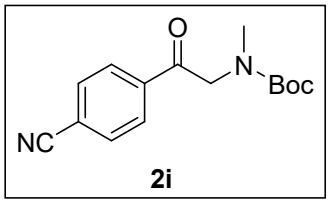
2h

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as yellow oil (108 mg, 83% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87–7.74 (m, 2H), 7.68–7.56 (m, 2H), 4.59 (d, 2H), 2.95 (d, 3H), 1.43 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 194.3, 193.9, 156.2, 155.6, 133.9, 132.1, 132.0, 129.4, 129.2, 128.7, 128.6, 126.4, 80.2,

80.1, 55.6, 55.0, 35.7, 35.6, 28.3, 28.3, 28.2.

***tert*-butyl (2-(4-cyanophenyl)-2-oxoethyl)(methyl)carbamate (2i)**

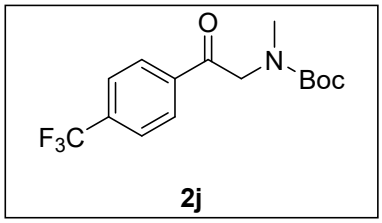


2i

Purified by flash column chromatography (PE/EA = 10:1 to 4:1) as white solid (34 mg, 31% yield). mp: 114-116 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.12–7.99 (m, 2H), 7.92–7.70 (m, 2H), 4.64 (d, 2H), 2.97 (d, 3H), 1.43 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 194.3, 193.8, 156.1, 155.4, 138.1, 132.6, 132.5, 132.2, 132.1), 130.9, 130.3, 128.3, 128.1, 127.9, 125.3, 117.7, 117.6, 116.7, 116.6, 81.6, 80.4, 80.3, 55.9, 55.3, 35.7, 35.6, 28.2, 28.2, 28.1. **HRMS(ESI)** Calculated for $C_{15}H_{17}O_3N_2^-$ ([M-H]$^-$): 273.1245, found: 273.1245.

***tert*-butyl methyl(2-oxo-2-(4-(trifluoromethyl)phenyl)ethyl)carbamate (2j)**

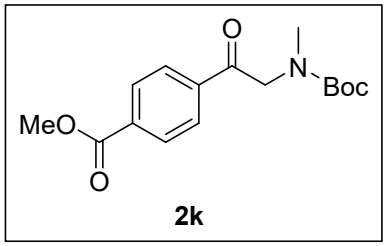


2j

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as yellow solid (33 mg, 26% yield). mp: 72-74 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 9.12–9.00 (m, 2H), 8.81–8.68 (m, 2H), 5.64 (d, 2H), 3.97 (d, 3H), 2.44 (d, 10H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 194.6, 194.1, 156.2, 155.5, 137.9, 128.3, 128.1, 125.9, 125.8, 125.7, 80.3, 80.3, 55.9, 55.3, 35.7, 35.6, 28.3, 28.2. **HRMS(ESI)** Calculated for $C_{15}H_{17}O_3NF_3^-$ ([M-H]$^-$): 316.1166, found: 316.1166.

methyl 4-(N-(*tert*-butoxycarbonyl)-N-methylglycyl)benzoate (2k)



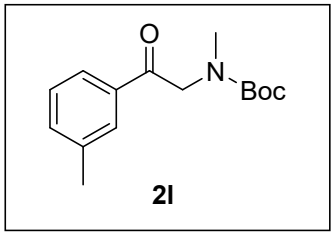
2k

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as yellow oil (25 mg, 20% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.20–8.10 (m, 2H), 8.06–7.94 (m, 2H), 4.64 (d, 2H), 3.95 (d, 3H), 2.97 (d,

3H), 1.43 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 194.9, 194.6, 192.3, 166.1, 156.2, 155.6, 138.4, 134.2, 130.0, 129.9, 129.5, 128.4, 127.8, 127.7, 127.4, 124.6, 81.3, 80.3, 56.0, 55.4, 52.5, 35.7, 35.6, 28.4, 28.3, 28.2. **HRMS(ESI)** Calculated for $C_{16}H_{21}O_5NNa^+$ ([M+Na]$^+$): 330.1312, found: 330.1311.

***tert*-butyl methyl(2-oxo-2-(m-tolyl)ethyl)carbamate (2l)**

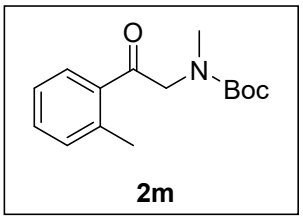


2l

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as colorless oil (88 mg, 84% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.78–7.70 (m, 2H), 7.44–7.31 (m, 2H), 4.63 (d, 2H), 2.95 (d, 3H), 2.41 (d, 3H), 1.44 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 199.3, 198.8, 156.2, 155.7, 138.5, 138.2, 135.9, 135.7, 132.0, 132.0, 131.6, 128.2, 127.7, 125.7, 125.6, 79.9, 57.7, 57.0, 35.7, 35.7, 28.3, 28.2, 21.1, 20.9. **HRMS(ESI)** Calculated for $C_{15}H_{21}ONNa^+$ ([M+Na]$^+$): 286.1414, found: 286.1412.

***tert*-butyl methyl(2-oxo-2-(o-tolyl)ethyl)carbamate (2m)**

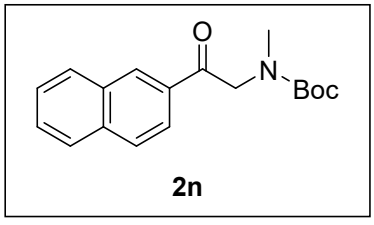


2m

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as colorless oil (45 mg, 43% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.69–7.54 (m, 1H), 7.44–7.34 (m, 1H), 7.30–7.23 (m, 2H), 4.49 (d, 2H), 2.96 (d, 3H), 2.51 (d, 3H), 1.45 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 199.3, 198.8, 156.2, 155.7, 138.5, 138.2, 135.9, 135.7, 132.0, 132.0, 131.6, 128.2, 127.7, 125.7, 125.6, 79.9, 57.7, 57.0, 35.7, 35.7, 28.3, 28.2, 21.1, 20.9. **HRMS(ESI)** Calculated for $C_{15}H_{21}ONNa^+$ ([M+Na]$^+$): 286.1414, found: 286.1411.

***tert*-butyl methyl(2-(naphthalen-2-yl)-2-oxoethyl)carbamate (2n)**



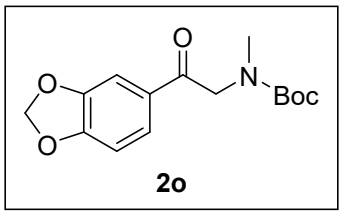
2n

Purified by flash column chromatography (PE/EA =

10:1 to 5:1) as off-white solid (115 mg, 96% yield). mp: 71-73 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.47 (d, 1H), 8.05-7.85 (m, 4H), 7.66-7.54 (m, 2H), 4.78 (d, 2H), 3.01 (d, 3H), 1.46 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 195.2, 194.7, 156.2, 155.7, 135.7, 132.5, 132.4, 129.6, 129.5, 129.4, 129.2, 128.7, 128.6, 128.6, 128.5, 127.8, 127.8, 126.9, 126.8, 123.5, 123.4, 80.0, 80.0, 55.7, 55.1, 35.7, 35.5, 28.3, 28.2. **HRMS(ESI)** Calculated for $C_{18}H_{21}O_3NNa^+$ ([M+Na]$^+$): 322.1414, found: 322.1411.

***tert*-butyl (2-(benzo[d][1,3]dioxol-5-yl)-2-oxoethyl)(methyl)carbamate (2o)**

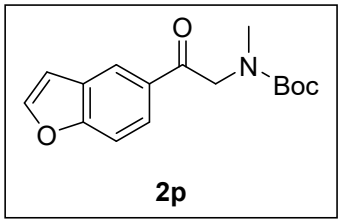


2o

Purified by flash column chromatography (PE/EA = 10:1 to 4:1) as colorless oil (96 mg, 82% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.58–7.49 (m, 1H), 7.44–7.39 (m, 1H), 6.89–6.82 (m, 1H), 6.05 (d, 2H), 4.56 (d, 2H), 2.94 (d, 3H), 1.44 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 193.2, 192.8, 156.2, 155.7, 152.1, 152.0, 148.3, 148.2, 123.0, 124.1, 123.8, 108.0, 108.0, 107.7, 107.6, 101.9, 101.9, 78.0, 79.9, 55.4, 54.8, 35.7, 35.6, 28.4, 28.2. **HRMS(ESI)** Calculated for $C_{15}H_{19}O_5NNa^+$ ([M+Na]$^+$): 316.1155, found: 316.1153.

***tert*-butyl (2-(benzofuran-5-yl)-2-oxoethyl)(methyl)carbamate (2p)**



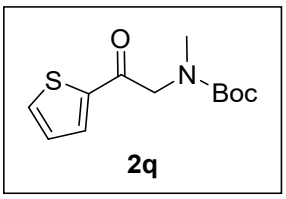
2p

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as white solid (50 mg, 43% yield). mp: 80-82 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.24 (d, *J* = 9.4 Hz, 1H), 7.97–7.91 (m, 1H), 7.75–7.65 (m, 1H), 7.59–7.51 (m, 1H), 6.90–6.79 (m, 1H), 4.69 (d, 2H), 2.97 (d, 3H), 1.44 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 194.6, 194.1, 157.5, 156.2, 155.7, 146.5, 146.4, 130.7, 127.60 (s), 127.5, 124.5, 124.3, 122.1, 121.9, 111.7, 111.6, 107.2, 107.2, 79.9, 79.9, 55.6, 55.0, 35.7, 35.5,

28.3, 28.2. **HRMS(ESI)** Calculated for $C_{16}H_{19}O_4NNa^+$ ([M+Na]$^+$): 312.1206, found: 312.1205.

***tert*-butyl methyl(2-oxo-2-(thiophen-2-yl)ethyl)carbamate (2q)**

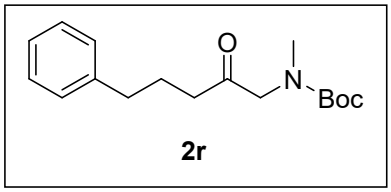


2q

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as yellow oil (75 mg, 73% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.82–7.73 (m, 1H), 7.73–7.62 (m, 1H), 7.20–7.09 (m, 1H), 4.55 (d, 2H), 2.98 (d, 3H), 1.43 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 188.2, 188.0, 156.1, 155.5, 141.5, 141.3, 133.7, 131.9, 131.6, 128.1, 80.1, 80.0, 55.8, 55.1, 35.7, 35.6, 28.3, 28.1. **HRMS(ESI)** Calculated for $C_{12}H_{17}O_3NNaS^+$ ([M+Na]$^+$): 278.0821, found: 278.0820.

***tert*-butyl methyl(2-oxo-5-phenylpentyl)carbamate (2r)**

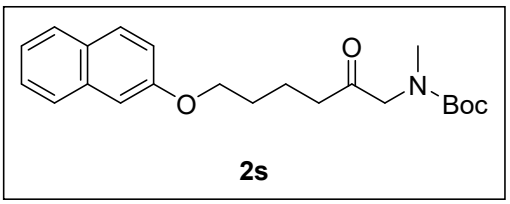


2r

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as yellow oil (47 mg, 41% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32–7.26 (m, 2H), 7.22–7.14 (m, 3H), 3.92 (d, 2H), 2.87 (d, 3H), 2.68–2.58 (m, 2H), 2.44–2.33 (m, 2H), 1.98–1.90 (m, 2H), 1.43 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 206.4, 206.3, 156.1, 155.4, 141.4, 141.2, 128.4, 128.4, 128.3, 126.0, 125.9, 80.0，80.0, 62.2, 58.6, 57.9, 38.7, 38.4, 35.7, 35.0, 34.2, 32.0, 28.3, 28.2, 24.8, 24.8. **HRMS(ESI)** Calculated for $C_{17}H_{25}O_3NNa^+$ ([M+Na]$^+$): 314.1727, found: 314.1725.

***tert*-butyl methyl(6-(naphthalen-2-yloxy)-2-oxohexyl)carbamate (2s)**

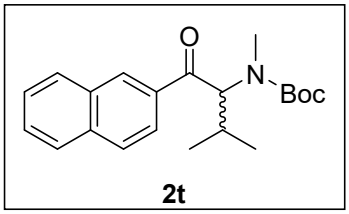


2s

Purified by flash column chromatography (PE/EA = 10:1 to 5:1) as yellow oil (90 mg, 61% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.84–7.63 (m, 3H), 7.47–7.38 (m, 1H), 7.37–7.27 (m, 1H), 7.19–7.06 (m, 2H), 4.05 (d, 2H), 3.95 (d, 2H), 2.88 (d, 3H), 2.55–2.42 (m, 2H), 1.83 (d, 4H), 1.43 (d, 9H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 206.3, 206.2, 156.8, 156.8, 156.0, 155.3, 134.5, 129.3, 129.2, 128.8, 127.5, 126.6, 126.3, 126.2, 123.5, 123.4, 118.8, 118.8, 106.5, 80.0, 80.0, 67.4, 67.3, 58.5, 57.8, 39.0, 38.8, 35.7, 28.6, 28.6, 28.3, 28.2, 20.2, 20.0. **HRMS(ESI)** Calculated for $C_{22}H_{29}O_4NNa^+$ ([M+Na]$^+$): 394.1989, found: 394.1987.

***tert*-butyl methyl(3-methyl-1-(naphthalen-2-yl)-1-oxobutan-2-yl)carbamate (2t)**

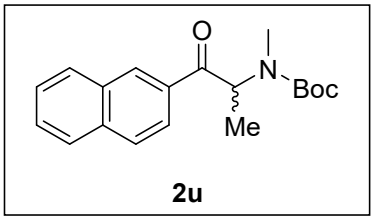


2t

Purified by flash column chromatography (PE/EA = 15:1 to 6:1) as yellow oil (50 mg, 88% yield). NMR data show the presence of rotamers.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.81 (s, 1H), 8.61 (s, 1H), 8.18 – 8.11 (m, 1H), 8.10 – 8.05 (m, 1H), 8.03 – 7.93 (m, 1H), 7.92 – 7.78 (m, 2H), 7.64 – 7.44 (m, 2H), 5.49 (d, 1H), 5.24 (d, 1H), 2.68 (d, 3H), 2.57 – 2.42 (m, 1H), 1.53 (d, 9H), 1.05 – 0.91 (m, 6H). **^{13}C NMR (100 MHz, $CDCl_3$)** δ 197.9, 197.2, 155.9, 155.0, 135.7, 133.6, 133.1, 132.6, 132.,4, 130.9, 130.1, 129.8, 129.3, 128.6, 128.5, 128.4, 128.2, 127.8, 127.5, 126.8, 126.6, 124.1, 80.6, 80.1, 63.8, 62.7, 29.2, 28.9, 28.5, 28.2, 26.1, 25.7, 20.0, 19.9, 18.5, 18.1. **HRMS(ESI)** Calculated for $C_{21}H_{27}O_3NNa^+$ ([M+Na]$^+$): 364.1883, found: 364.1880.

***tert*-butyl methyl(1-(naphthalen-2-yl)-1-oxopropan-2-yl)carbamate (2u)**



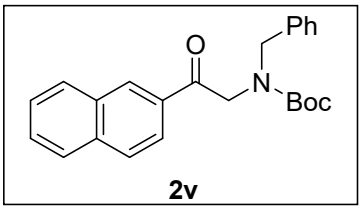
2u

Purified by flash column chromatography (PE/EA = 15:1 to 6:1) as colorless oil (50 mg, 40% yield). NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.61 (s, 0.66H), 8.45 (s, 0.34H), 8.13–7.82 (m, 4H), 7.65–7.47 (m, 2H), 5.97–5.81 (m, 0.66H), 5.46–5.33 (m, 0.32H), 2.73 (d, 3H), 1.46 (s, 9H), 1.42 (d, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 199.7, 198.8, 155.5, 154.6, 135.6, 132.9, 132.6, 130.2, 129.7, 129.6，129.4, 128.4, 128.3,

127.7, 127.6, 126.8, 126.6, 124.1, 80.6, 80.2, 56.8, 54.6, 30.5, 29.4, 28.3, 13.8, 13.3. **HRMS(ESI)** Calculated for $C_{19}H_{23}O_3NNa^+$ ([M+Na]$^+$): 336.1570, found: 336.1568.

***tert*-butyl benzyl(2-(naphthalen-2-yl)-2-oxoethyl)carbamate (2v)**

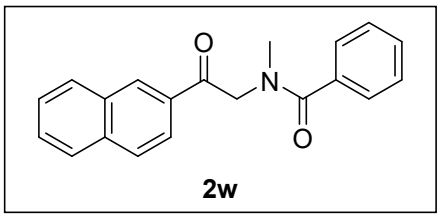


2v

Purified by flash column chromatography (PE/EA = 15:1 to 6:1) as yellow oil (50 mg, 87% yield). NMR data show the presence of rotamers.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, 1H), 8.00–7.93 (m, 1H), 7.93–7.77 (m, 3H), 7.65–7.47 (m, 2H), 7.36–7.23 (m, 5H), 4.76 (s, 1H), 4.66 (s, 1H), 4.60 (d, 2H), 1.47 (d, 9H). **^{13}C NMR (100 MHz, $CDCl_3$)** δ 195.0, 194.6, 156.0, 155.9, 137.8, 137.7, 135.6, 132.4, 132.4, 132.3, 129.6, 129.5, 129.4, 129.2, 128.6, 128.5, 128.5, 128.1, 127.8, 127.7, 127.5, 127.4, 127.3, 126.9, 126.8, 123.5, 123.4, 80.6, 80.3, 52.4, 52.1, 51.3, 51.0, 28.3, 28.2. **HRMS(ESI)** Calculated for $C_{24}H_{25}O_3NNa^+$ ([M+Na]$^+$): 398.1727, found: 398.1726.

N-methyl-N-(2-(naphthalen-2-yl)-2-oxoethyl)benzamide (2w)

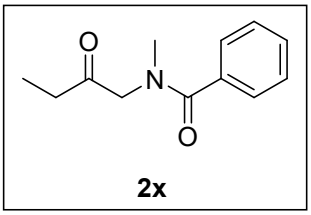


2w

Purified by flash column chromatography (DCM/EA = 10:1 to 4:1) as white solid (107 mg, 88% yield). mp: 136-138 °C. NMR data show the presence of rotamers.

^{1}H NMR (500 MHz, $CDCl_3$) δ 8.37 (d, 1H), 8.09–7.90 (m, 1H), 7.90–7.77 (m, 3H), 7.66–7.47 (m, 3H), 7.46–7.35 (m, 3H), 7.29 (s, 1H), 4.96 (d, 2H), 3.12 (d, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 193.9, 193.8, 172.4 171.9, 135.9, 135.6, 132.3, 132.2, 132.1, 131.7, 129.6, 129.6, 129.4, 129.3, 128.8, 128.6, 128.6, 128.5, 128.4, 128.3, 127.6, 127.0, 126.9, 126.8, 126.4, 123.3, 123.0, 57.8, 53.8, 38.7, 34.6. **HRMS(ESI)** Calculated for $C_{20}H_{17}O_2NNa^+$ ([M+Na]$^+$): 326.1152, found: 326.1149.

N-methyl-N-(2-oxobutyl)benzamide (2x)



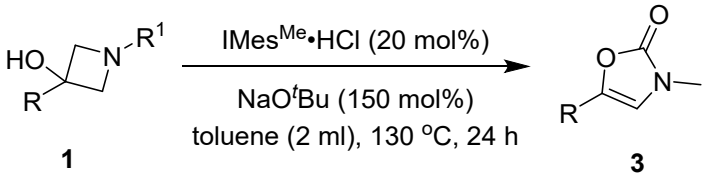
2x

Purified by flash column chromatography (DCM/EA = 10:1

to 4:1) as colorless oil (30 mg, 37% yield). NMR data show the presence of rotamers. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.58–7.28 (m, 5H), 4.19 (d, 2H), 3.04 (d, 3H), 2.39 (q, *J* = 7.3 Hz, 2H), 1.08 (t, *J* = 7.3 Hz, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ δ 205.7, 171.9, 135.6, 129.7, 128.5, 128.4, 127.1, 126.4, 56.4, 38.9, 33.3, 29.7, 7.4. **HRMS(ESI)** Calculated for $C_{12}H_{15}O_2NNa^+$ ([M+Na]$^+$): 228.0994, found: 228.0992.

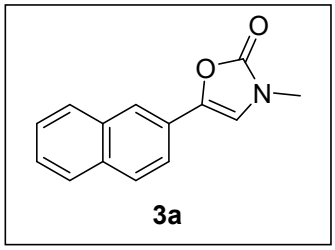
3.3 One-pot synthesis of oxazol-2-ones from azetindinols

General procedure:



One-pot procedure for the synthesis of **3**: To a 25 ml flame-dried Schlenk tube containing a stirring bar was added $IMes^{Me}$·HCl (0.08 mmol, 29.4 mg.), NaO*t*-Bu (0.6 mmol, 58.8 mg), *tert*-butyl 3-hydroxy-3-(naphthalen-2-yl)azetidine-1-carboxylate **1n** (0.4 mmol, 120 mg), toluene (2.0 mL) sequentially under nitrogen. The tube was sealed and stirred at 150 °C for 24 h. After completion, the reaction mixture was concentrated and purified by silica gel column chromatography to provide the product **3a** in 63% yield.

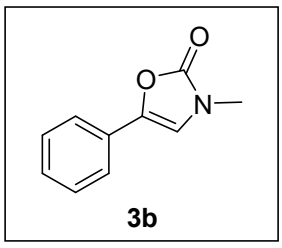
3-methyl-5-(naphthalen-2-yl)oxazol-2(3H)-one (3a)



Purified by flash column chromatography (DCM/EA = 20:1) as off-white solid (57 mg, 63% yield). mp: 181-183 °C. Under modified reaction conditions: **NHC 1** (10 mol%), NaO*t*Bu (15 mol%), Toluene (2 ml), 130 °C, 12 h, **3a** was isolated in 72% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (s, 1H), 7.83 – 7.77 (m, 3H), 7.51 – 7.44 (m, 3H), 6.80 (s, 1H), 3.31 (s, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 155.2, 139.1, 133.3, 132.8, 128.6, 128.1, 127.7, 126.8, 126.4, 124.5, 121.8, 120.4, 111.0, 30.8. **HRMS(ESI)** Calculated for $C_{14}H_{11}O_2NNa^+$ ([M+Na]$^+$): 248.0682, found: 248.0683.

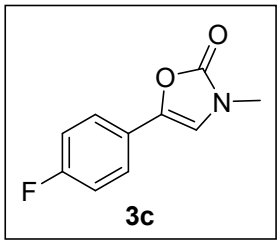
3-methyl-5-phenyloxazol-2(3H)-one (3b)



Under modified reaction conditions: **NHC 1** (10 mol%), NaO^{t}Bu (15 mol%), Toluene (2 ml), 130 ^{o}C, 12 h, **3b** was isolated in 66% yield (46 mg). Purified by flash column chromatography (DCM/EA = 20:1) as white solid. mp: 142-144 °C

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.52 – 7.44 (m, 2H), 7.41 – 7.35 (m, 2H), 7.33 – 7.27 (m, 1H), 6.74 (s, 1H), 3.30 (s, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 155.2, 139.0, 128.8, 128.1, 127.3, 122.8, 110.5, 30.7.

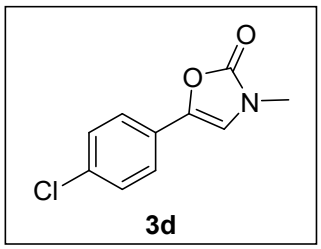
5-(4-fluorophenyl)-3-methyloxazol-2(3H)-one (3c)



Purified by flash column chromatography (DCM/EA = 20:1) as white solid (35 mg, 45% yield). mp: 146-148 °C

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.51–7.39 (m, 2H), 7.15–7.04 (m, 2H), 6.68 (s, 1H), 3.31 (s, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.4 (d, $^1J_{C\text{-}F}$ = 248.5 Hz), 155.1, 138.3, 124.8 (d, $^3J_{C\text{-}F}$ = 8.2 Hz), 123.7, 116.0 (d, $^2J_{C\text{-}F}$ = 22.2 Hz), 110.1, 30.8. **HRMS(ESI)** Calculated for $C_{10}H_8O_2NFNa^+$ ([M+Na]$^+$): 216.0431, found: 216.0432.

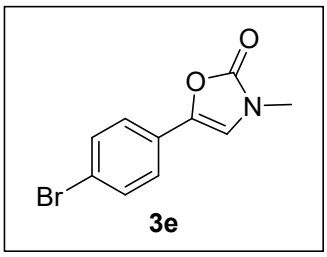
5-(4-chlorophenyl)-3-methyloxazol-2(3H)-one (3d)



Purified by flash column chromatography (DCM/EA = 20:1) as white solid (44 mg, 53% yield). mp: 170-172 °C. Under modified reaction conditions: **NHC 1** (10 mol%), NaO^{t}Bu (15 mol%), Toluene (2 ml), 130 ^{o}C, 12 h, **3d** was isolated in 61% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.43–7.33 (m, 4H), 6.74 (s, 1H), 3.31 (s, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 155.0, 138.1, 133.8, 129.1, 125.9, 124.1, 110.9, 30.8. **HRMS(ESI)** Calculated for $C_{10}H_8O_2NClNa^+$ ([M+Na]$^+$): 232.0136, found: 232.0136.

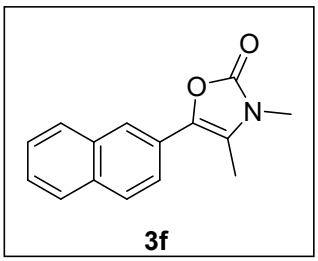
5-(4-bromophenyl)-3-methyloxazol-2(3H)-one (3e)



3e

Purified by flash column chromatography (DCM/EA = 20:1) as yellow solid (42 mg, 41% yield). mp: 168-170 °C **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.59–7.45 (m, 2H), 7.40–7.29 (m, 2H), 6.76 (s, 1H), 3.31 (s, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 155.0, 138.1, 132.0, 126.3, 124.3, 121.9, 111.0, 30.8. **HRMS(ESI)** Calculated for $C_{10}H_9O_2NBr^+$ ($[M+H]^+$): 253.9817, found: 254.0185.

3,4-dimethyl-5-(naphthalen-2-yl)oxazol-2(3H)-one (3f)

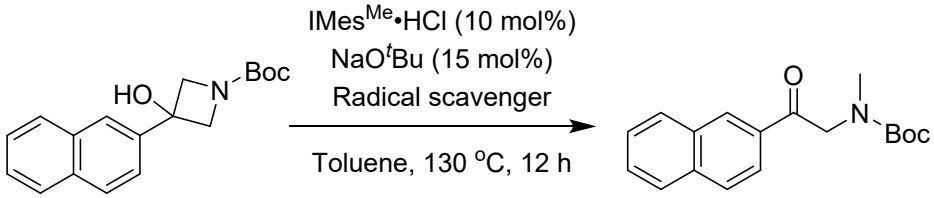


3f

Purified by flash column chromatography (DCM/EA = 20:1) as white solid (46 mg, 48% yield). mp: 103-105 °C **^{1}H NMR (500 MHz, $CDCl_3$)** δ 7.89 (s, 1H), 7.84 – 7.78 (m, 3H), 7.58 – 7.53 (m, 1H), 7.50 – 7.44 (m, 2H), 3.20 (s, 3H), 2.30 (s, 3H). **^{13}C NMR (125 MHz, $CDCl_3$)** δ 155.0, 134.0, 133.2, 132.3, 128.4, 128.0, 127.6, 126.6, 126.2, 125.7, 123.6, 122.5, 119.4, 27.9, 9.4. **HRMS(ESI)** Calculated for $C_{15}H_{14}O_2NNa^+$ ($[M+Na]^+$): 262.0839, found: 262.0839.

4 Mechanistic studies

4.1 Radical trapping experiment



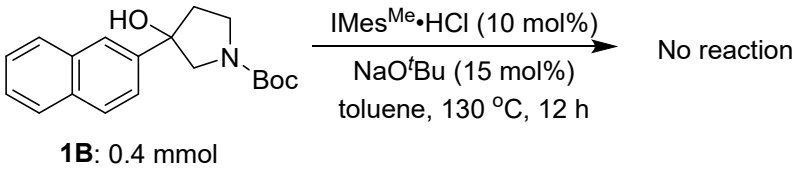
1n **2n**

radical scavenger	yield/**2n**
TEMPO	30%
BHT	88%
1,1'-diphenylethene	85%

Experimental procedure:

To a 25 ml flame-dried Schlenk tube containing a stirring bar was added IMes^{Me}·HCl (0.04 mmol, 14.7 mg.), NaO*t*-Bu (0.06 mmol, 6.0 mg), *tert*-butyl 3-hydroxy-3-(naphthalen-2-yl)azetidine-1-carboxylate **1n** (0.4 mmol, 120 mg), radical scavenger (1 equiv), toluene (1.0 mL) sequentially under nitrogen. The tube was sealed and stirred at 130 °C for 12 h. After completion, the resulting mixture was monitored by TLC and crude ^{1}H NMR analysis.

4.2 Deconstructive isomerization of 1B

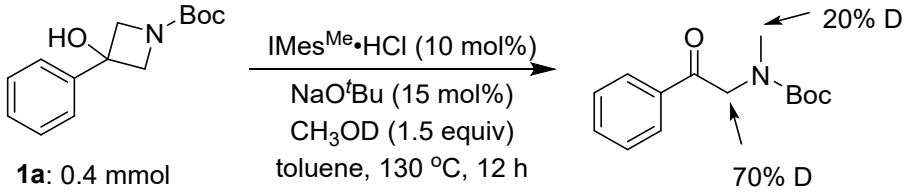


1B: 0.4 mmol

Experimental procedure:

To a 25 ml flame-dried Schlenk tube containing a stirring bar was added IMes^{Me}·HCl (0.04 mmol, 14.7 mg.), NaO*t*-Bu (0.06 mmol, 6.0 mg), *tert*-butyl 3-hydroxy-3-(naphthalen-2-yl)pyrrolidine-1-carboxylate **1B** (0.4 mmol, 120 mg), toluene (1.0 mL) sequentially under nitrogen. The tube was sealed and stirred at 130 °C for 12 h. After completion, the reaction mixture was detected by TLC and crude NMR analysis. Unfortunately, no reaction took place and the starting material was recovered.

4.3 Deuterium experiments



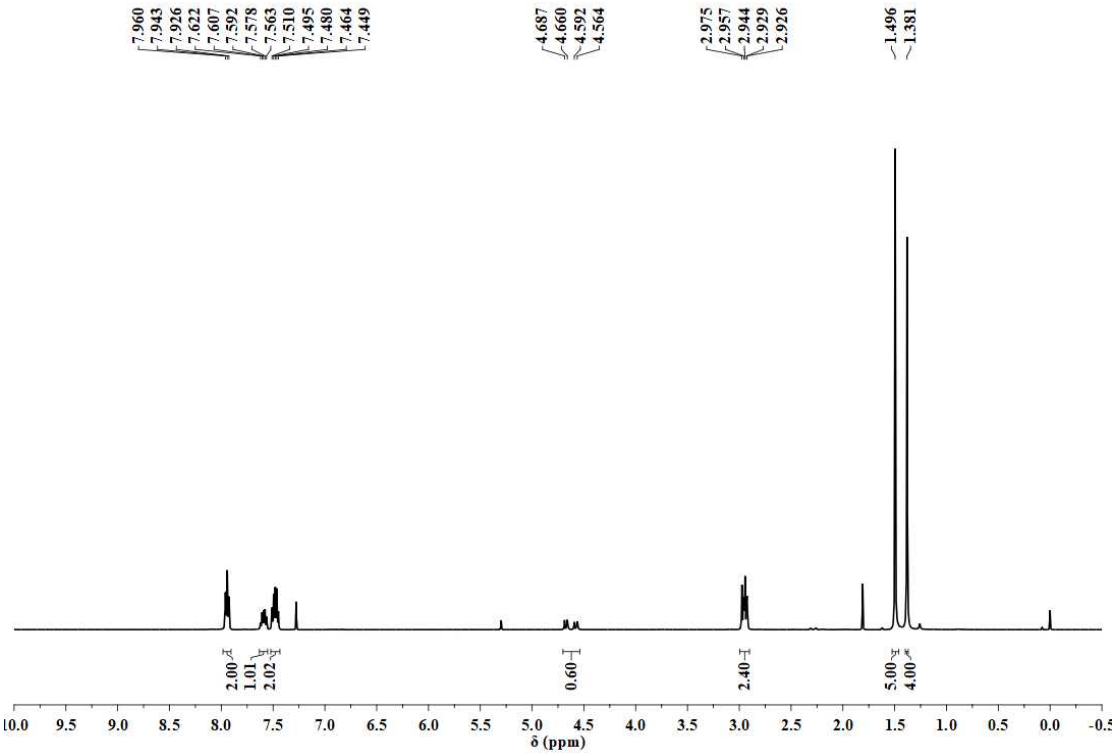
1a: 0.4 mmol

2a-*d*: 31%

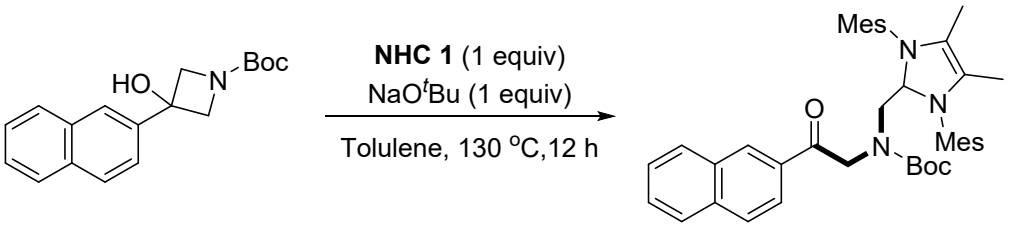
Experimental procedure:

To a 25 ml flame-dried Schlenk tube containing a stirring bar was added IMes^{Me}·HCl (0.04 mmol, 14.7 mg.), NaO*t*-Bu (0.06 mmol, 6.0 mg), *tert*-butyl 3-hydroxy-3-phenylazetidine-1-carboxylate **1a** (0.4 mmol, 120 mg), toluene (1.0 mL) and CH_3OD (1.5 equiv, 19.8 mg) sequentially under nitrogen. The tube was sealed and

stirred at 130 °C for 12 h. After completion, the reaction mixture was concentrated and purified by silica gel column chromatography to provide the product **2a-D** in 31% yield.



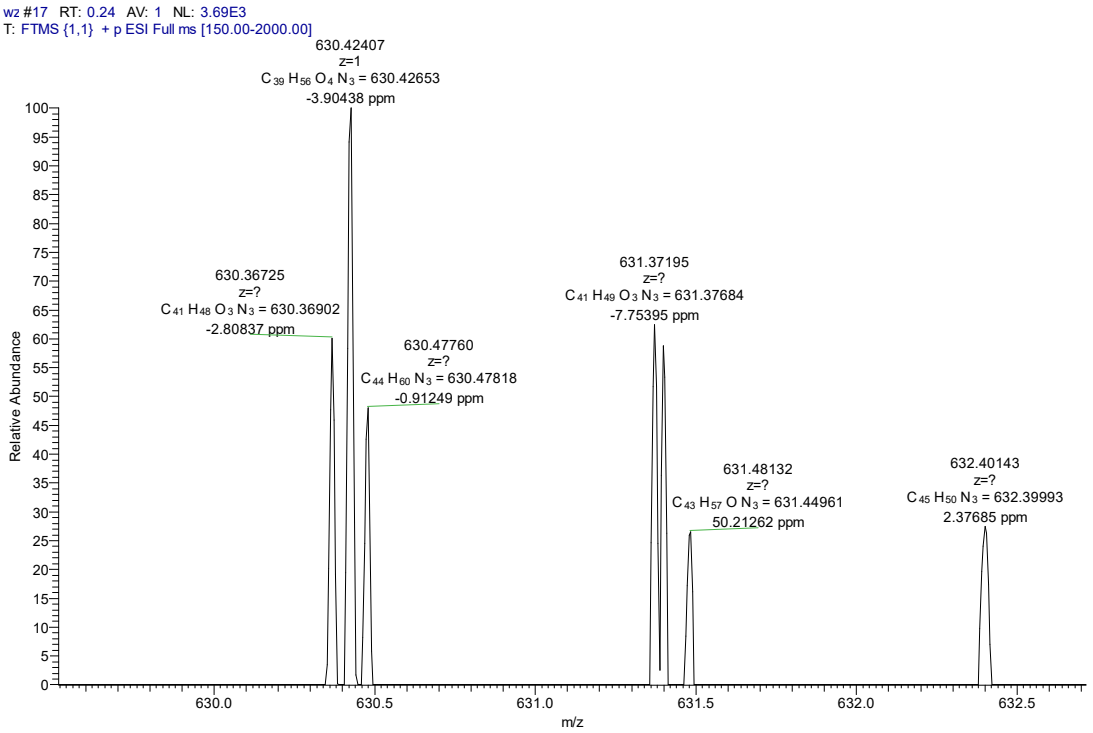
4.4 Stoichiometric experiment

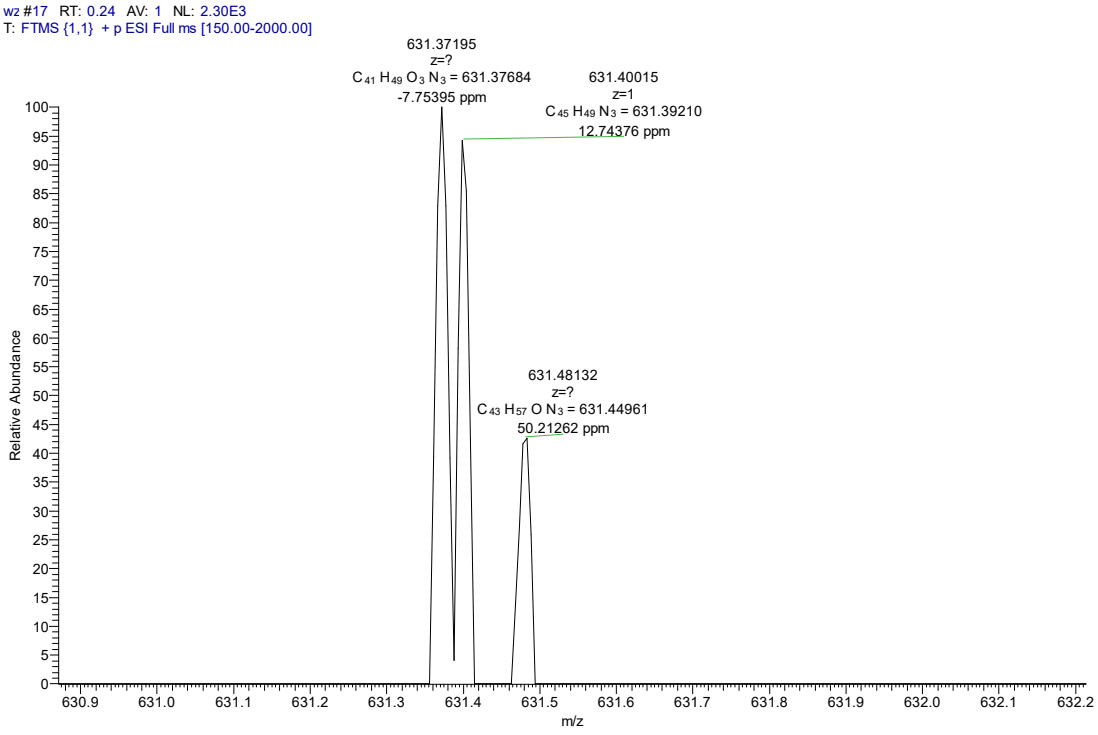


1n **INT**: Detected by HRMS

Experimental procedure:

To a 25 ml flame-dried Schlenk tube containing a stirring bar was added IMes^{Me}·HCl (0.2 mmol, 75 mg.), NaO*t*-Bu (1.05 equiv, 20.6 mg), *tert*-butyl 3-hydroxy-3-phenylazetidine-1-carboxylate **1n** (0.2 mmol, 60 mg) and toluene (1.0 mL) sequentially under nitrogen. The tube was sealed and stirred at 130 °C for 12 h. After completion, the reaction mixture was directly subjected to HRMS analysis and the possible **INT** was detected which might be a key intermediate in the catalytic cycle. **HRMS(ESI)** Calculated for $C_{41}H_{49}O_3N_3^+$ ([M]$^+$):631.37684, found: 631.37195.





4.5 Density functional theory (DFT) calculations

We also conducted the density functional theory (DFT) calculations to support the proposed mechanism of the NHC-catalyzed deconstructive isomerization of azetidinols. The free energy profile of the most favorable pathway for the reaction is

shown in Figure 1. As shown, the reaction started from the catalyst−substrate complex **INT1**, and the key step is the NHC-catalyzed ring opening of azetidinols via **TS1**, which requires an activation energy of 31.8 kcal/mol. Subsequently, the formation of **2a** from **INT2** was studied computationally. For this step, three mechanistic pathways were investigated, concerted alpha-elimination via **TS4**, the NaO^{t}Bu-mediated concerted alpha-elimination via **TS5**, and the NaO^{t}Bu-mediated stepwise elimination pathway via **TS2** and **TS3**. The NaO^{t}Bu-mediated stepwise elimination pathway is the most favorable pathway, which has a barrier of 30.8 kcal/mol.

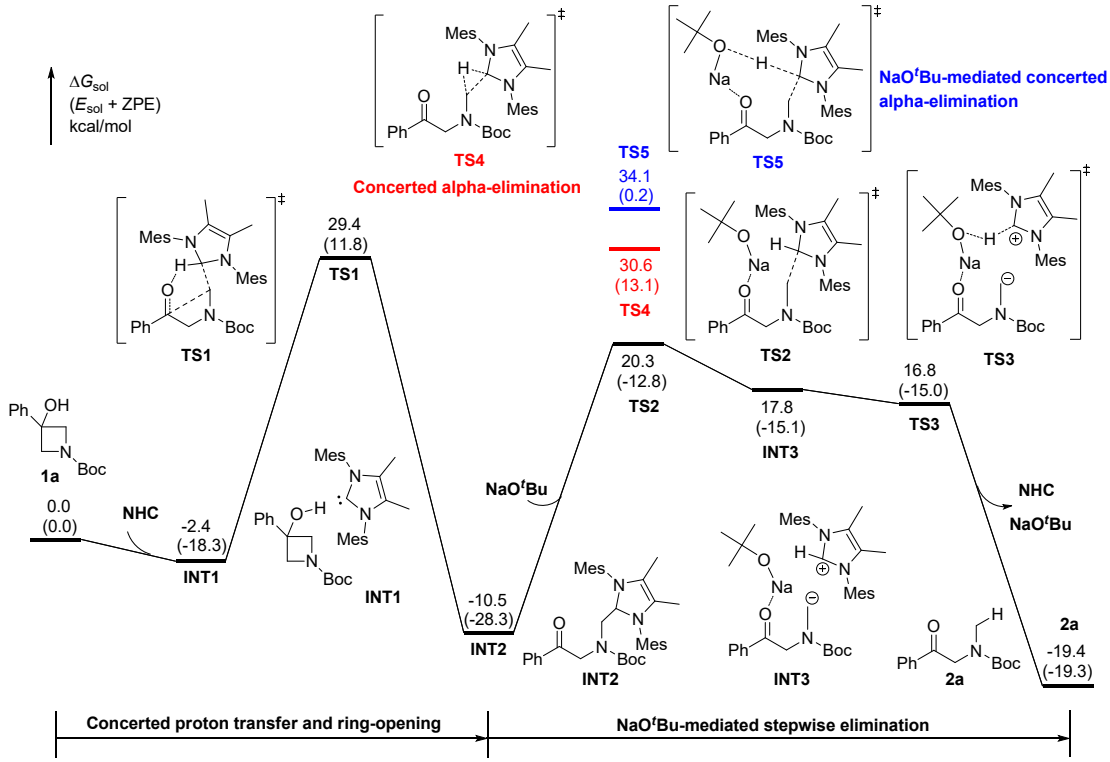
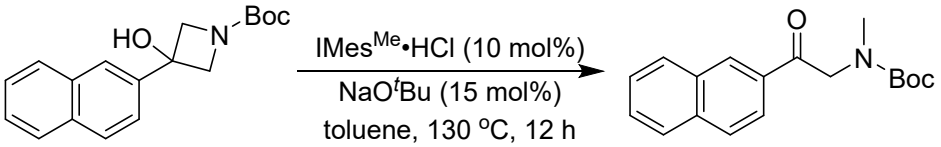


Figure 1. Free energy profiles for the NHC-catalyzed deconstructive isomerization of azetidinols. Calculations were carried out at the M06-2X/6-311++G(2df,2pd)-IEFPCM$_{toluene}$//M06-2X/6-31G(d,p)-IEFPCM$_{toluene}$ level of theory.

5. Synthetic Applications

5.1 Gram-scale reaction

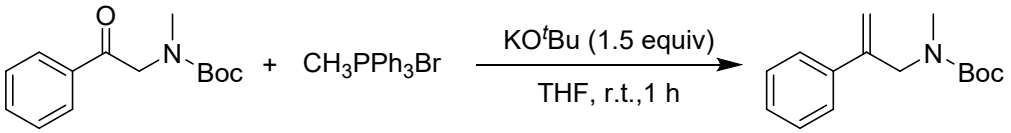


1n: 5 mmol 93%

Experimental procedure:

To a 100 ml flame-dried Schlenk tube containing a stirring bar was added $IMes^{Me}$·HCl (0.5 mmol, 185 mg.), NaO*t*-Bu (0.75 mmol, 73.5 mg), *tert*-butyl 3-hydroxy-3-(naphthalen-2-yl)azetidine-1-carboxylate **1n** (5 mmol, 1495 mg), toluene (12.5 mL) sequentially under nitrogen. The tube was sealed and stirred at 130 °C for 12 h. After completion, the reaction mixture was concentrated and purified by silica gel column chromatography (PE/EA = 20:1 to 8:1) to provide the product **2n** in 93% yield (1.39 g).

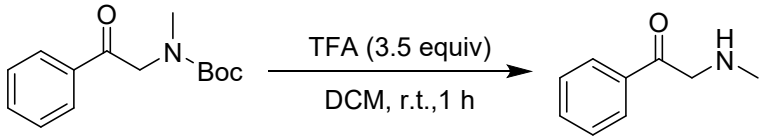
5.2 Transformation of α-amino ketone



0.5 mmol 1.3 equiv **4a**: 84%

Experimental procedure[7]:

Under N_2, to a solution of methyl triphenylphosphonium bromide (0.65 mmol) in anhydrous THF (2 mL) was added KO^{t}Bu (0.75 mmol) and stirred at room temperature for 30 min. A solution of **2a** (0.50 mmol,125 mg) in anhydrous THF (1.0 mL) was added dropwise to the yellow suspension and the mixture was stirred for another 1 h at room temperature. After completion, the reaction mixture was diluted with ethyl acetate (5.0 mL) and filtered through a short pad silica gel washing with ethyl acetate (10 mL). The filtrate was concentrated and purified by silica gel column chromatography to provide the product *tert*-butyl methyl(2-phenylallyl)carbamate (**4a**) as a colorless oil. (104 mg, 84% yield). The NMR data are consistent with previously reported literature.[8]

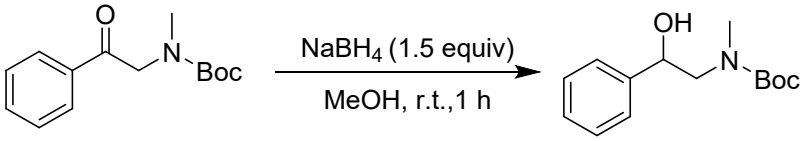


0.5 mmol

5a: 96%

Experimental procedure[5]:

To a solution of **2a** (0.50 mmol, 125 mg) in DCM (2.0 mL) was added TFA (1.75 mmol, 199.5 mg) dropwise. The reaction mixture was stirred for 1 h at room temperature. Then, the mixture was basified with $NaHCO_3$ (aq) to pH≈8 and extracted with DCM (3×5 mL). The combined organic phases were dried over anhydrous Na_2SO_4. Then, the mixture was filtered through a short pad silica gel washing with ethyl acetate (20 mL). Organic phases concentrated in vacuo to afford 2-(methylamino)-1-phenylethan-1-one (**5a**) as a yellow oil (72 mg, 96% yield). The NMR data are consistent with previously reported literature.[9]



2a: 0.5 mmol

6a: 93%

Experimental procedure[5]:

To a solution of **2a** (0.50 mmol, 125 mg) in MeOH (1.0 mL) was added $NaBH_4$ (0.75mmol, 28.4 mg) at 0 °C, and stirred at room temperature for 1 h. The mixture was evaporated to remove MeOH, and diluted with EA. The organic layer was washed with brine, dried over anhydrous Na_2SO_4, filtered, and evaporated. The crude residue was purified by column chromatography on silica gel to afford *tert*-butyl (2-hydroxy-2-phenylethyl)(methyl)carbamate (**4b**) as a colorless oil (117 mg, 93% yield). The NMR data are consistent with previously reported literature.[9]

6. References

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[6] Ruggeri, M.; Dombrowski, A. W.; Djuric, S. W.; Baxendale, I. R. *ChemPhotoChem* **2019**, *3*, 1212.

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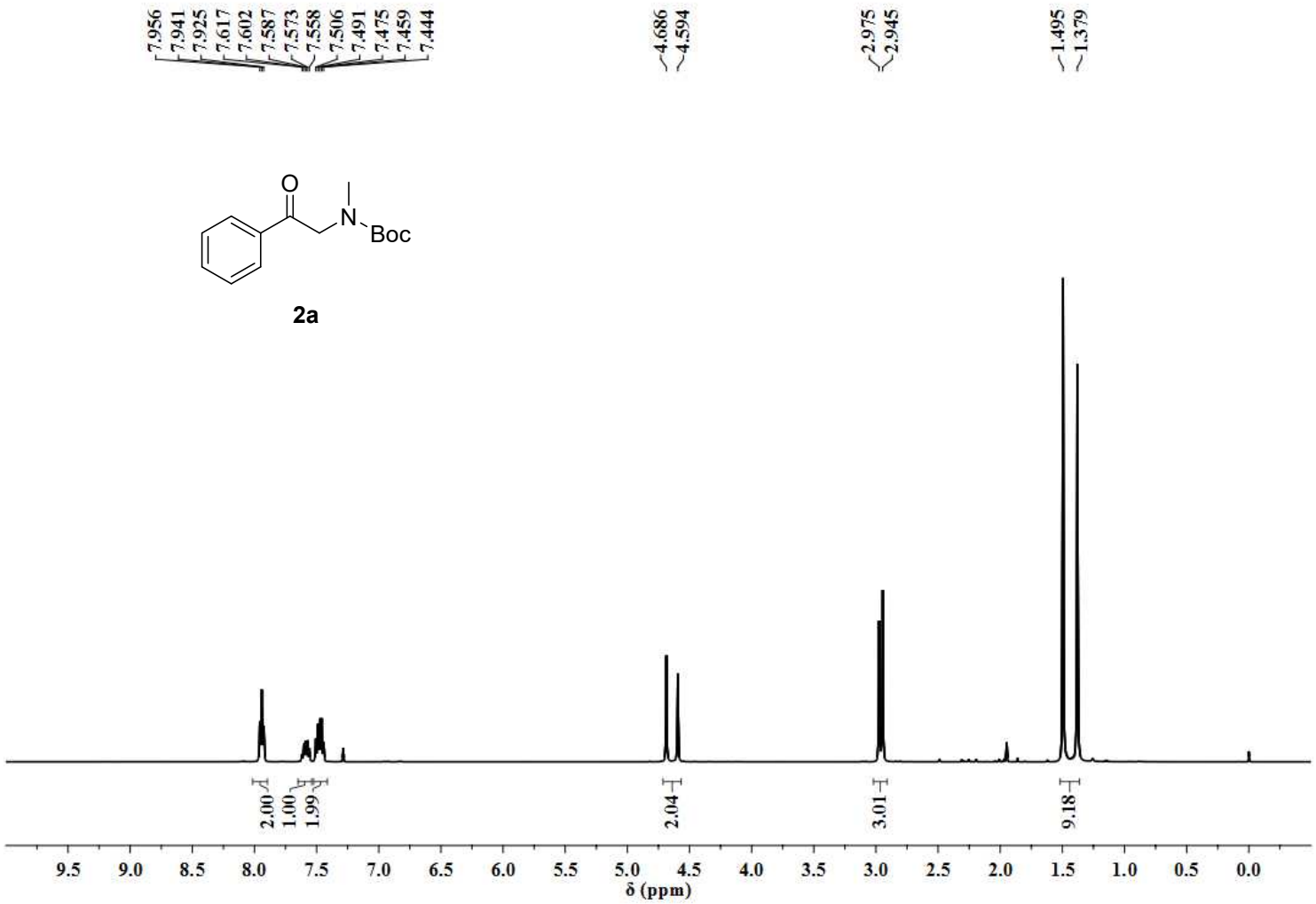
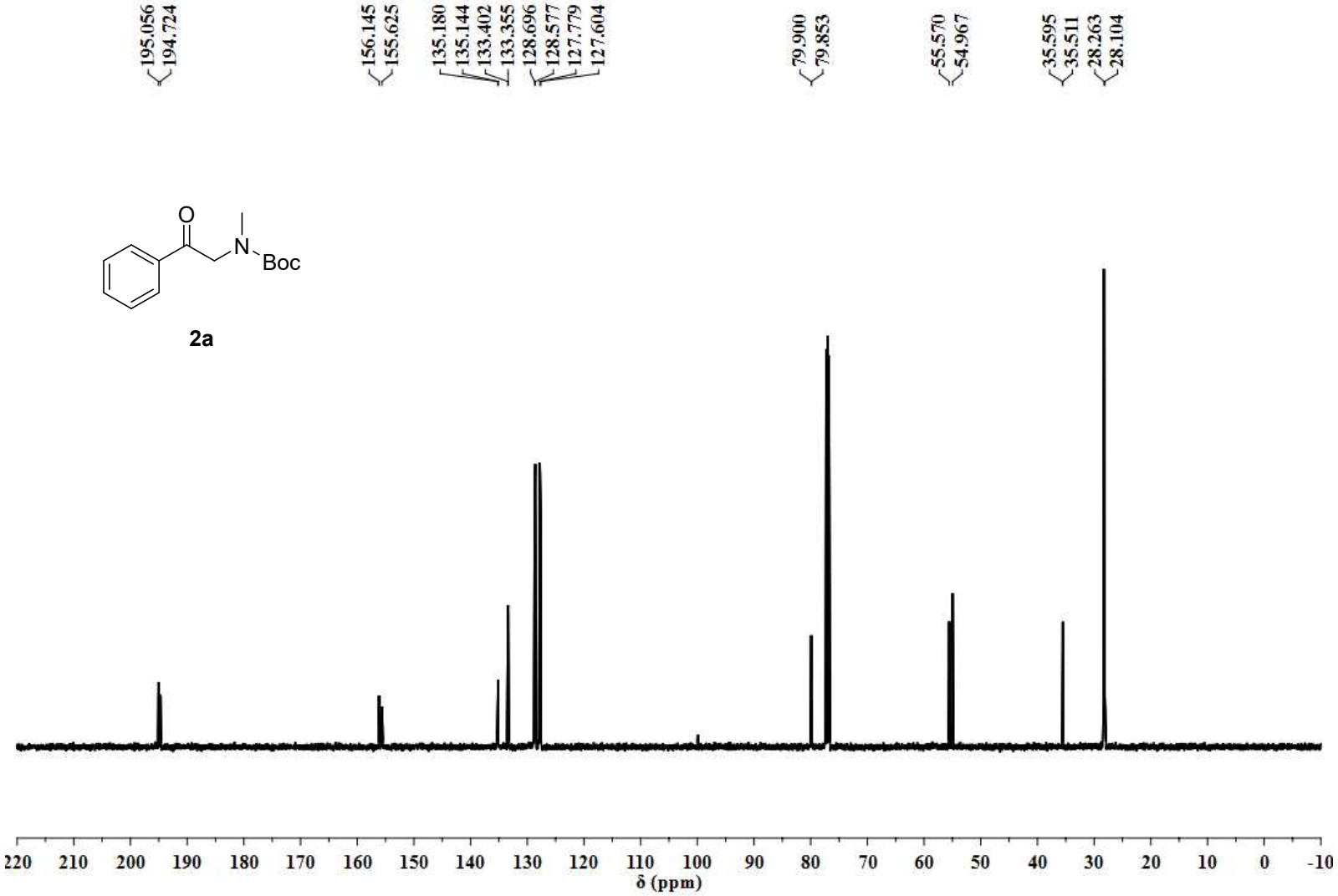
7. ^{1}H and ^{13}C NMR Spectra

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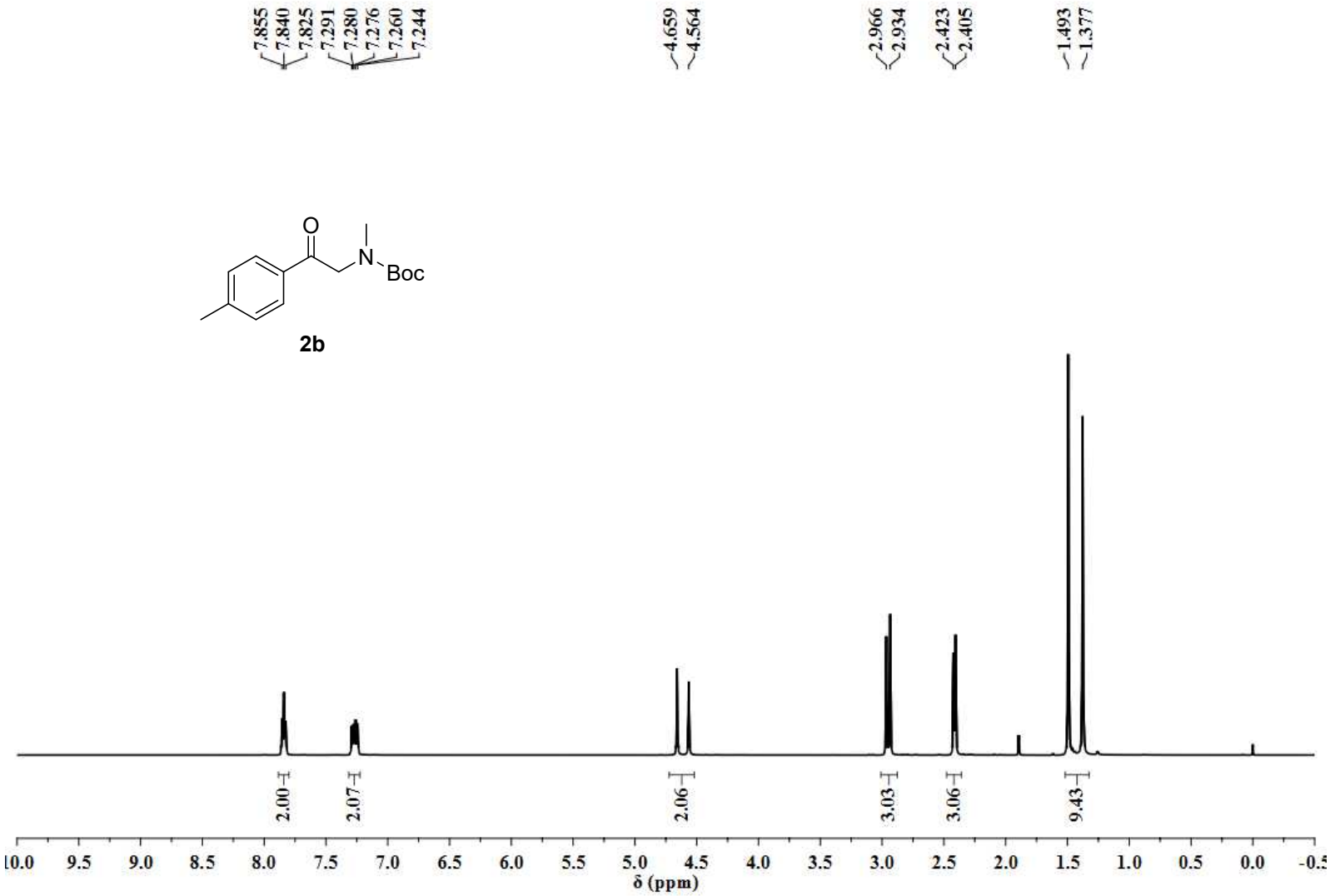
194.724
156.145
155.625
135.180
135.144
133.402
133.355
128.696
128.577
127.779
127.604
79.900
79.853
55.570
54.967
35.595
35.511
28.263
28.104
O
N
Boc
2a
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)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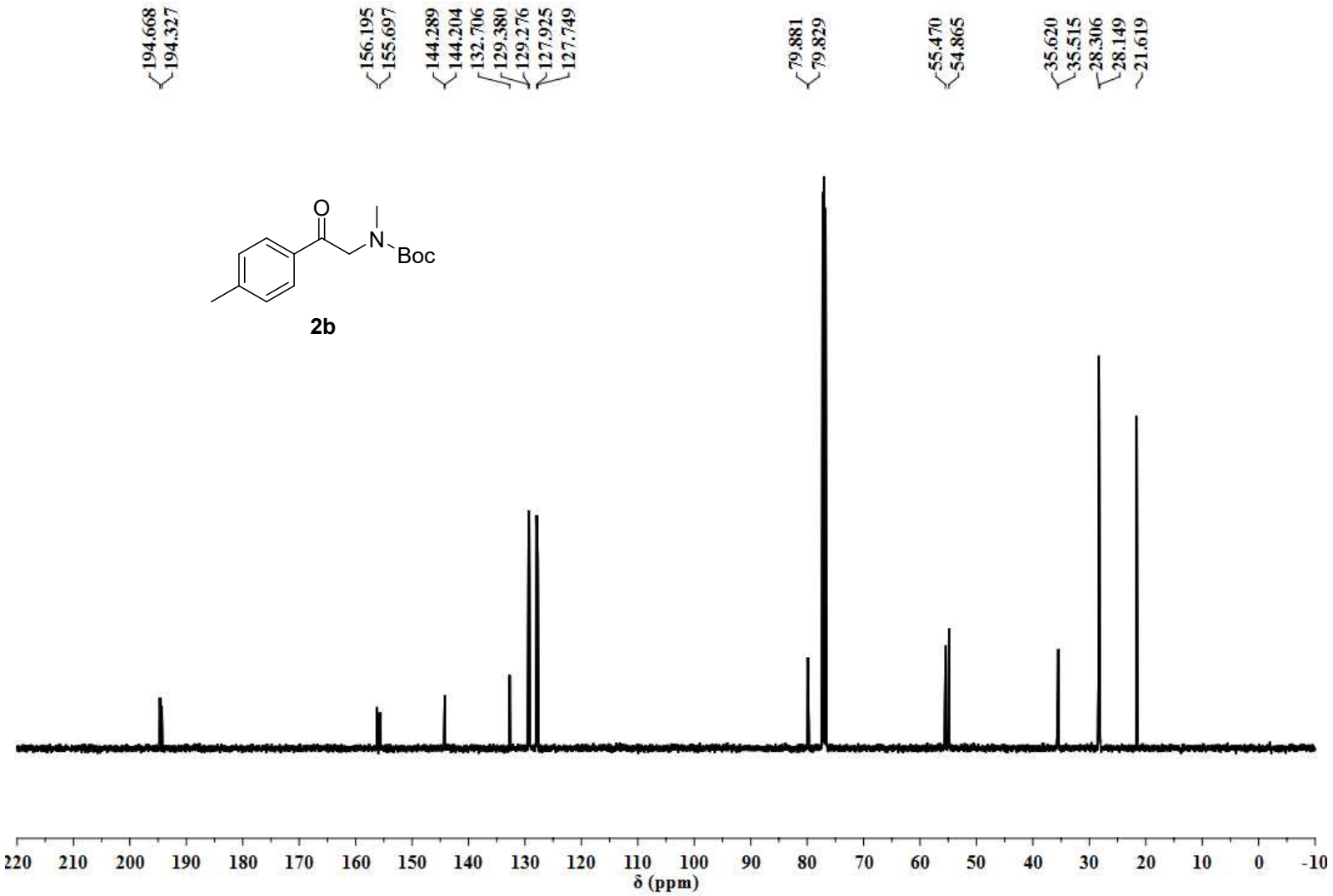
7.840
7.825
7.291
7.280
7.276
7.260
7.244
4.659
4.564
2.966
2.934
2.423
2.405
1.493
1.377
O
N
Boc
2b
2.00
2.07
2.06
3.03
3.06
9.43
δ (ppm)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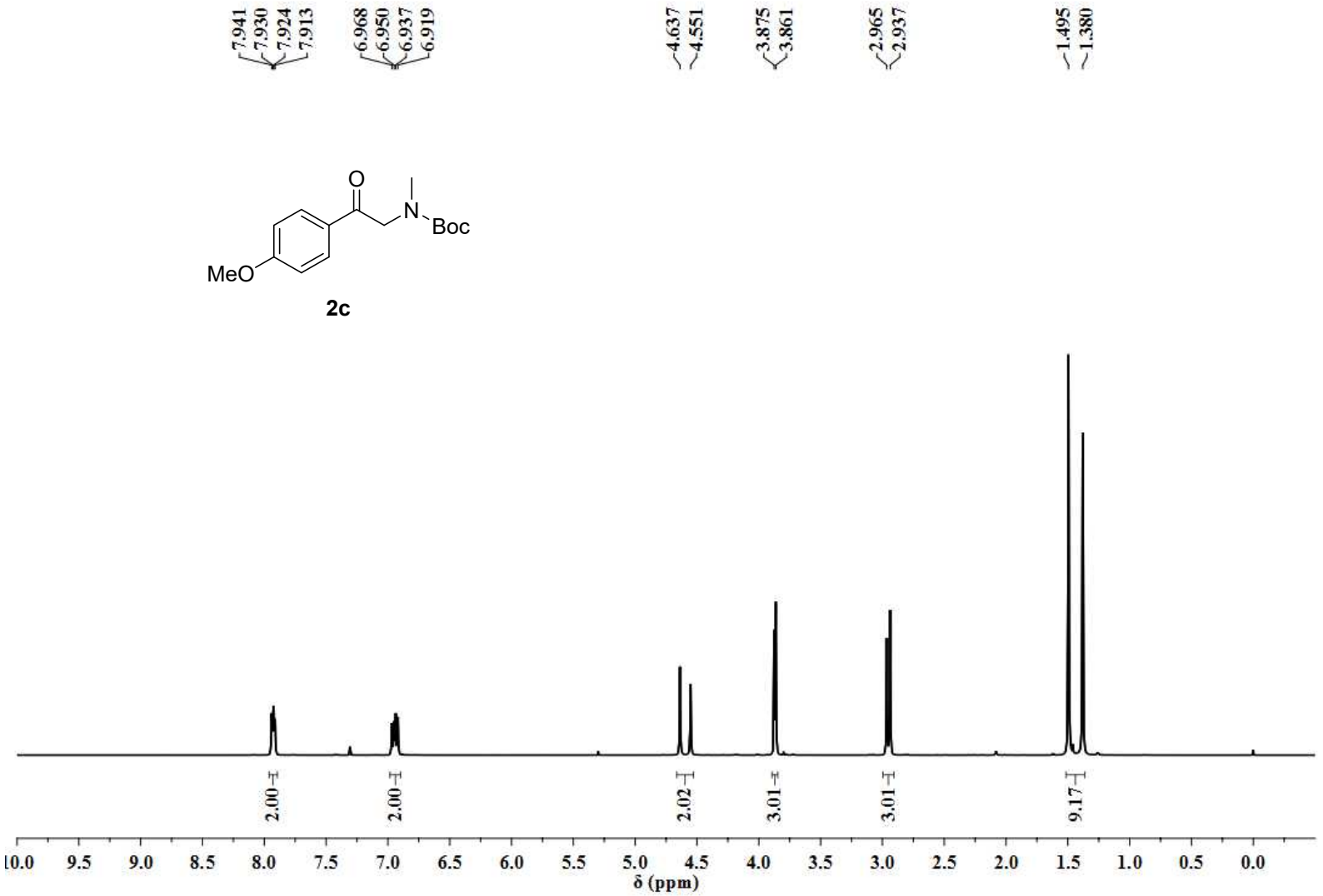
194.327
156.195
155.697
144.289
144.204
132.706
129.380
129.276
127.925
127.749
79.881
79.829
55.470
54.865
35.620
35.515
28.306
28.149
21.619
O
N
Boc
2b
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)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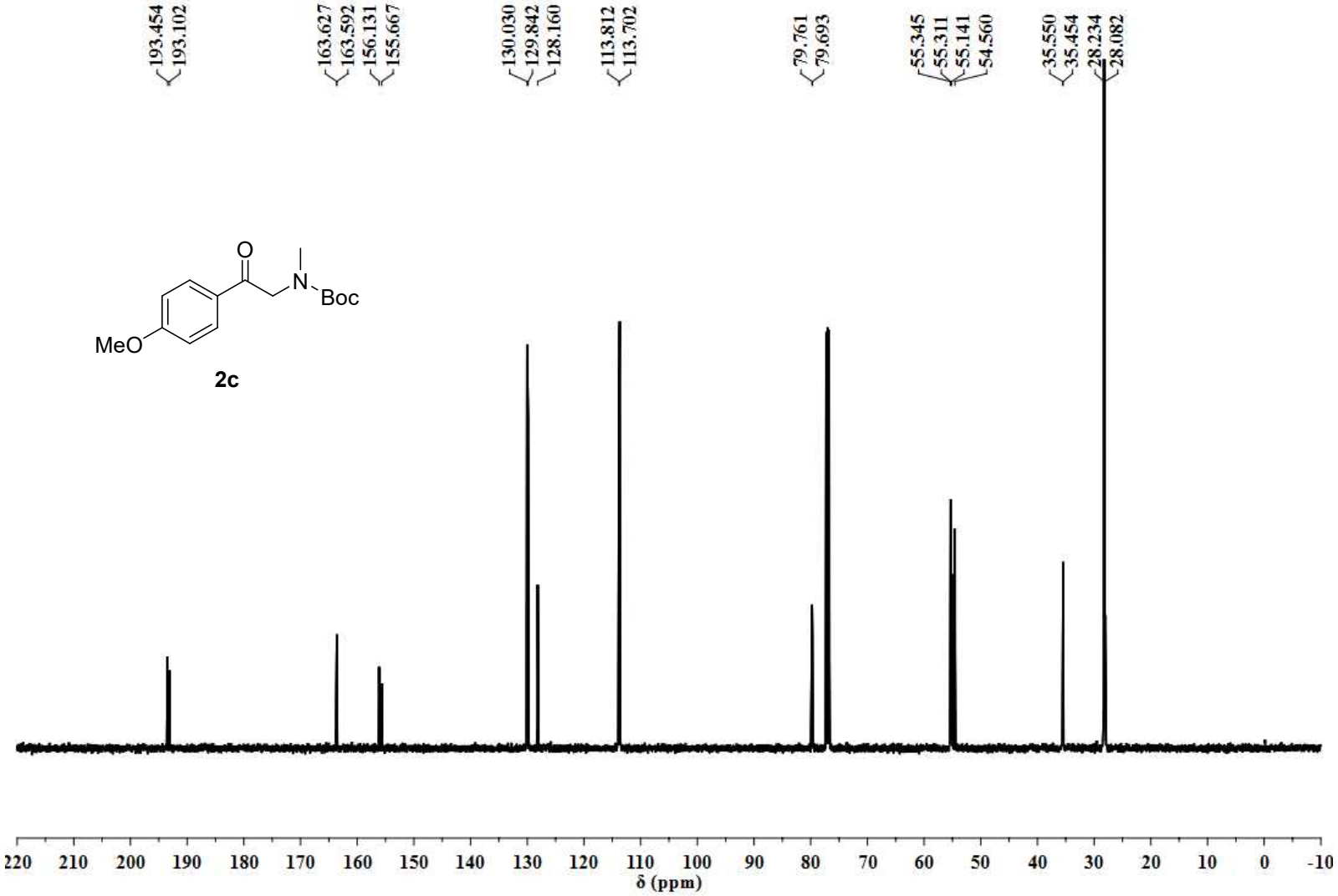
7.930
7.924
7.913
6.968
6.950
6.937
6.919
4.637
4.551
3.875
3.861
2.965
2.937
1.495
1.380
O
N
Boc
MeO
2c
2.00
2.00
2.02
3.01
3.01
9.17
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
δ (ppm)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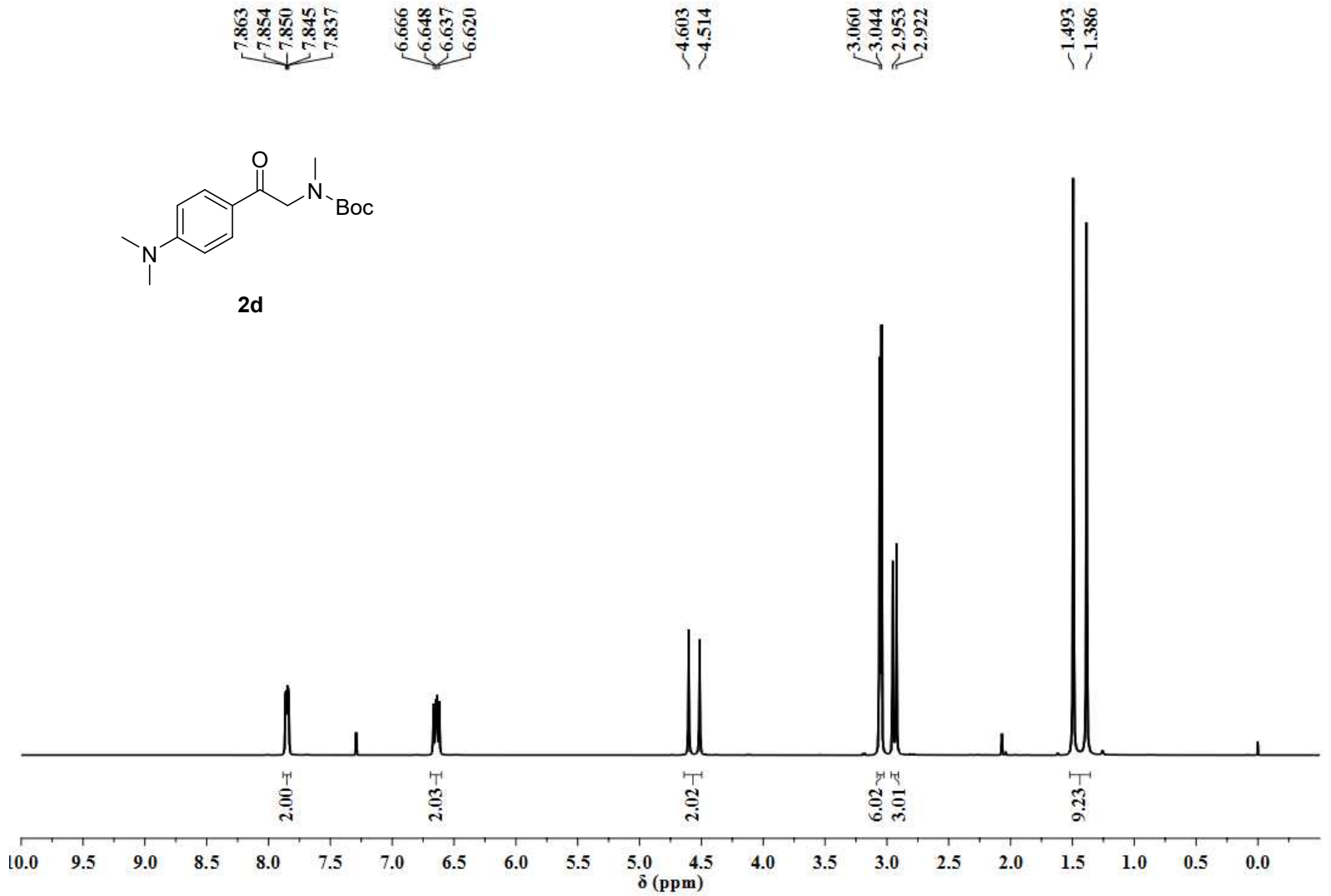
193.102
163.627
163.592
156.131
155.667
130.030
129.842
128.160
113.812
113.702
79.761
79.693
55.345
55.311
55.141
54.560
35.550
35.454
28.234
28.082
O
N
Boc
MeO
2c
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)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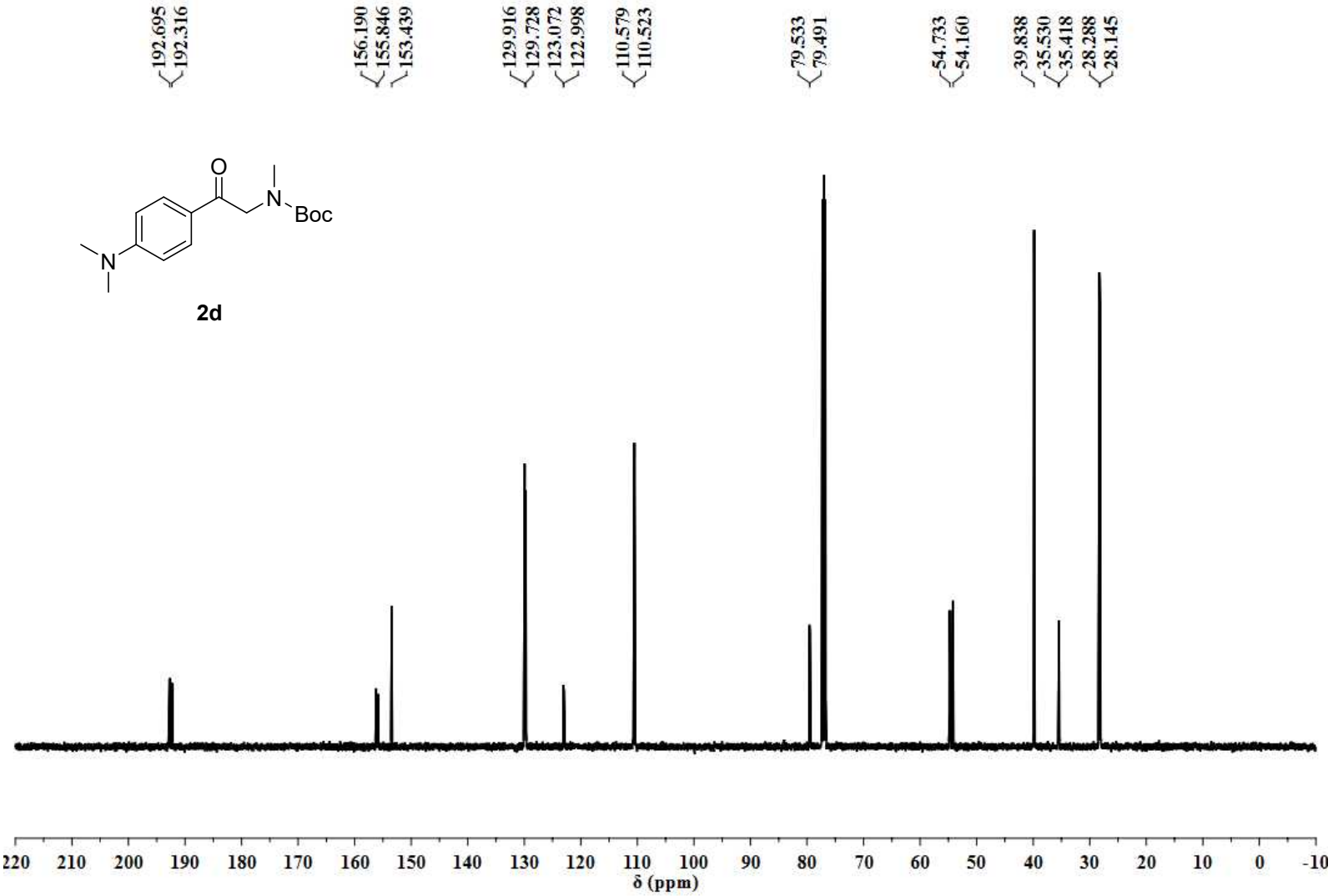
7.854
7.850
7.845
7.837
6.666
6.648
6.637
6.620
4.603
4.514
3.060
3.044
2.953
2.922
1.493
1.386
O
N
Boc
N
2d
2.00
2.03
2.02
6.02
3.01
9.23
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
δ (ppm)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156.190
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129.916
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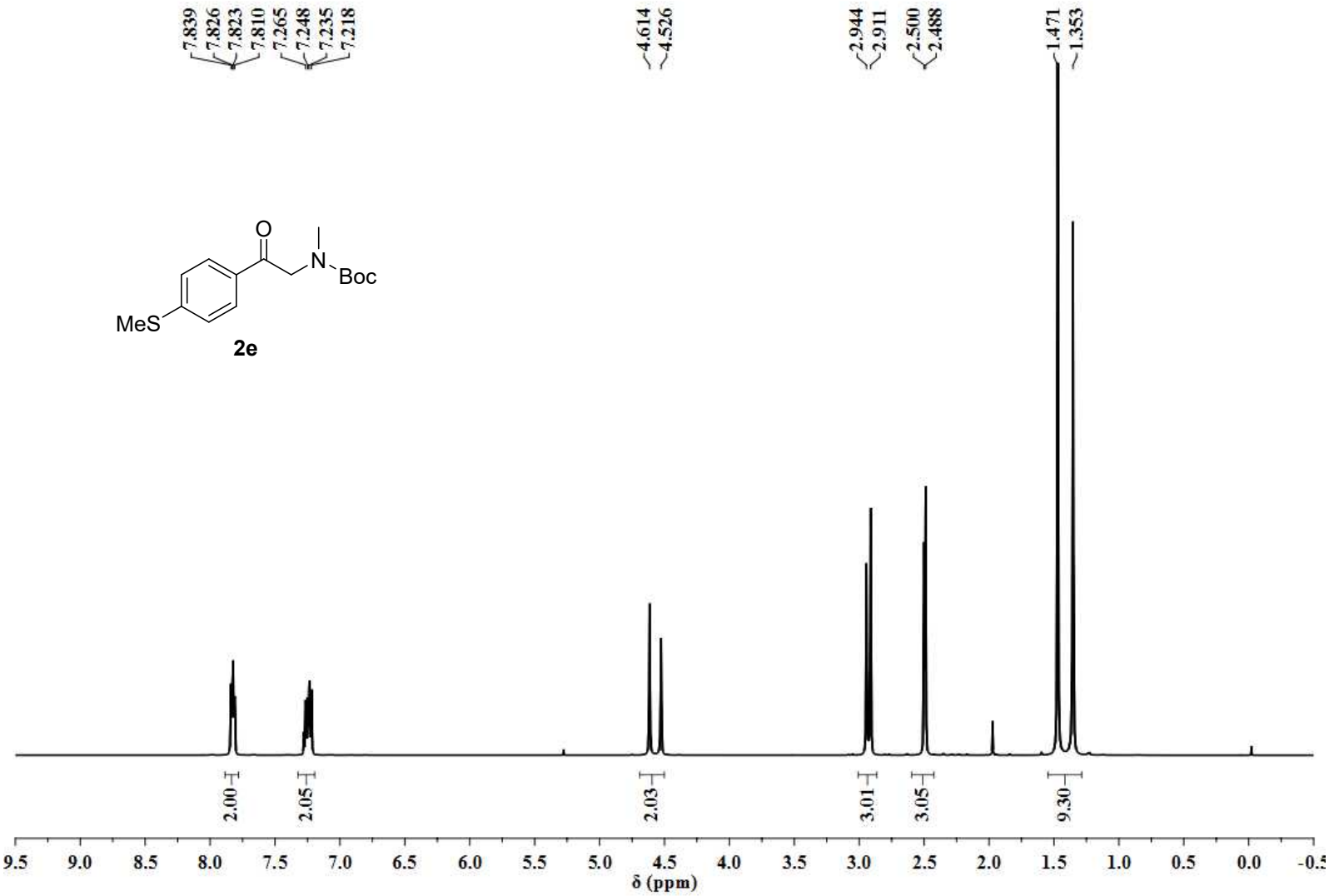
110.579
110.523
79.533
79.491
54.733
54.160
39.838
35.530
35.418
28.288
28.145
O
N
Boc
N
2d
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)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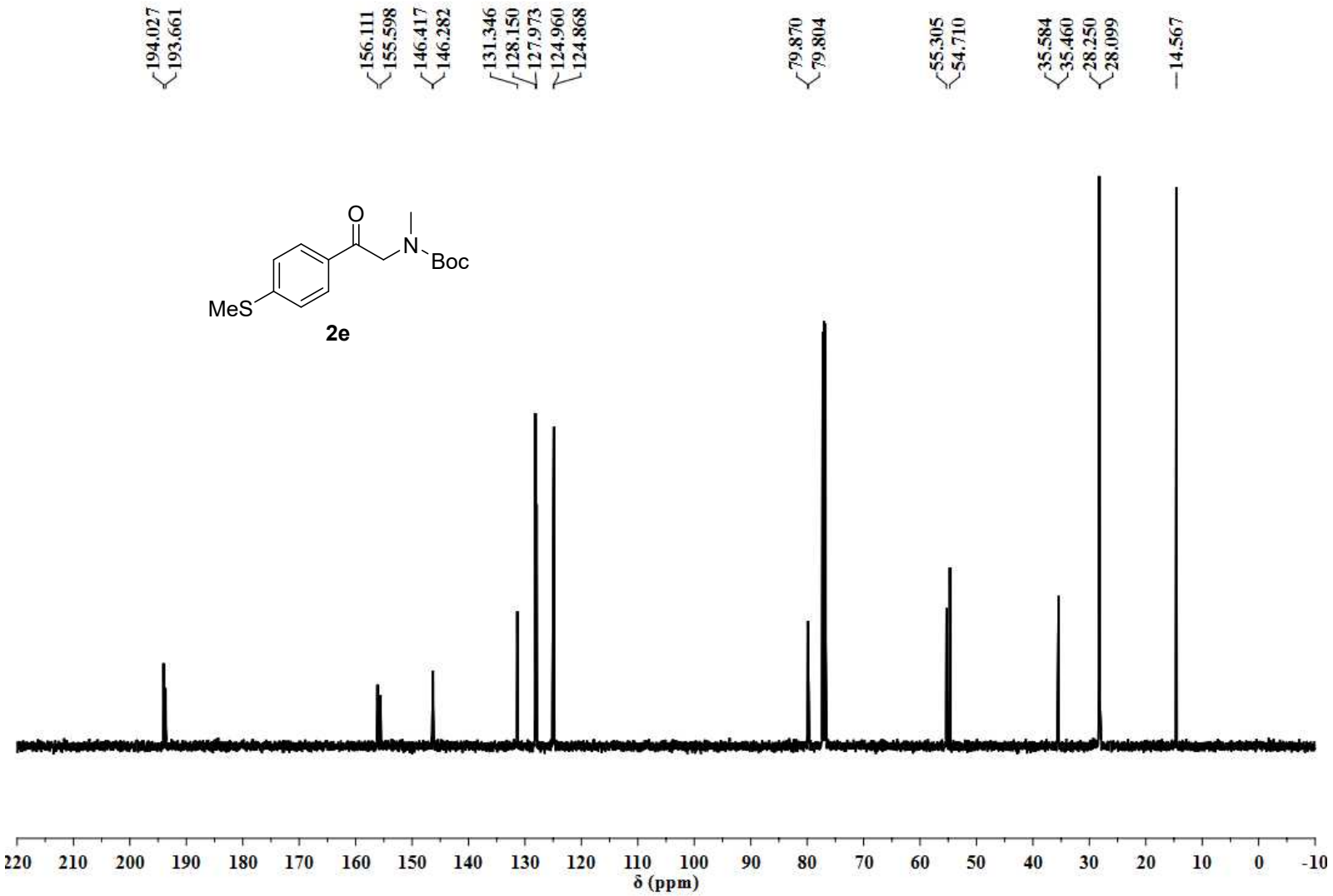
7.826
7.823
7.810
7.265
7.248
7.235
7.218
4.614
4.526
2.944
2.911
2.500
2.488
1.471
1.353
O
N
Boc
MeS
2e
2.00
2.05
2.03
3.01
3.05
9.30
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)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193.661
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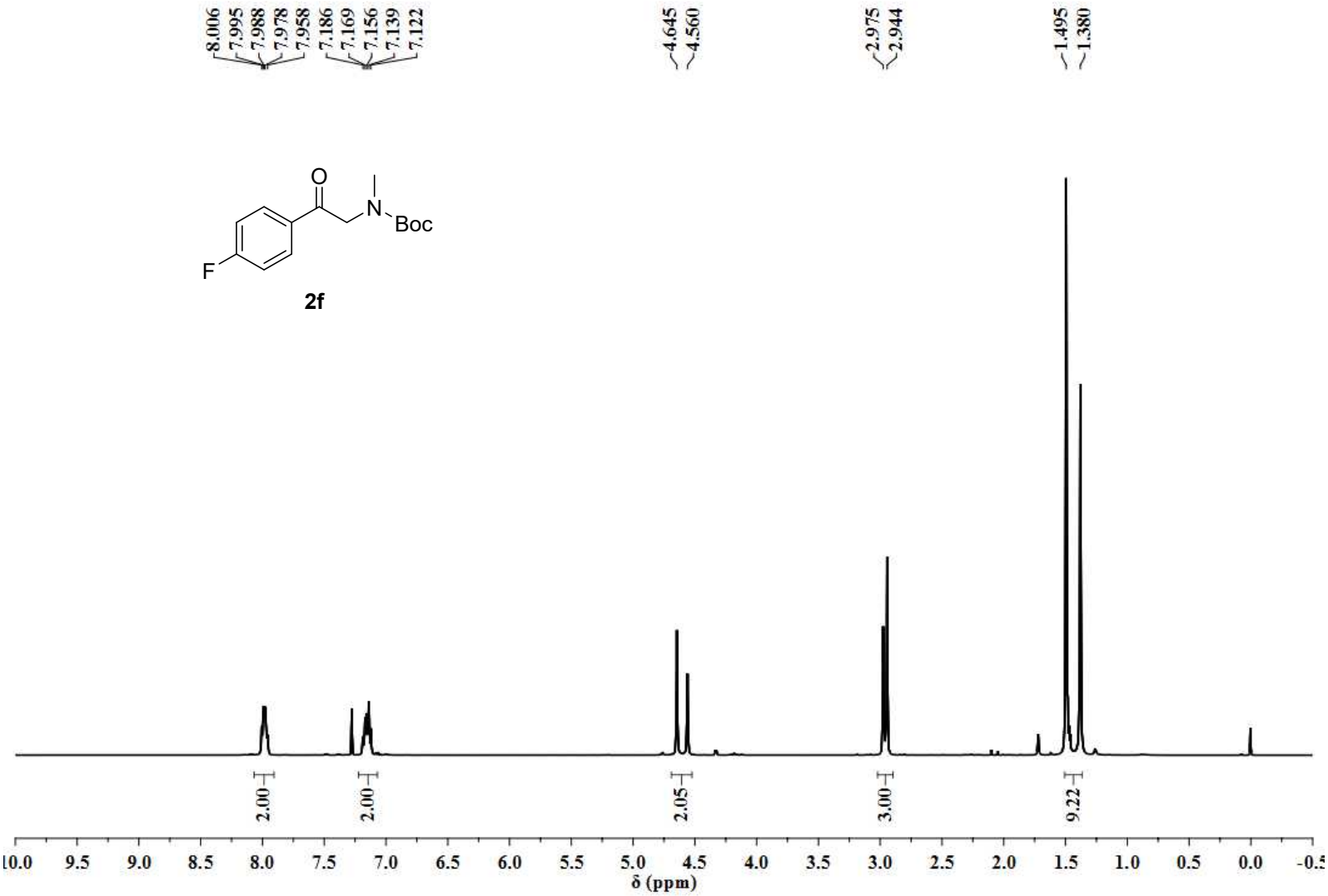
131.346
128.150
127.973
124.960
124.868
79.870
79.804
55.305
54.710
35.584
35.460
28.250
28.099
14.567
O
N
Boc
MeS
2e
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)


8.006
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7.169
7.156
7.139
7.122
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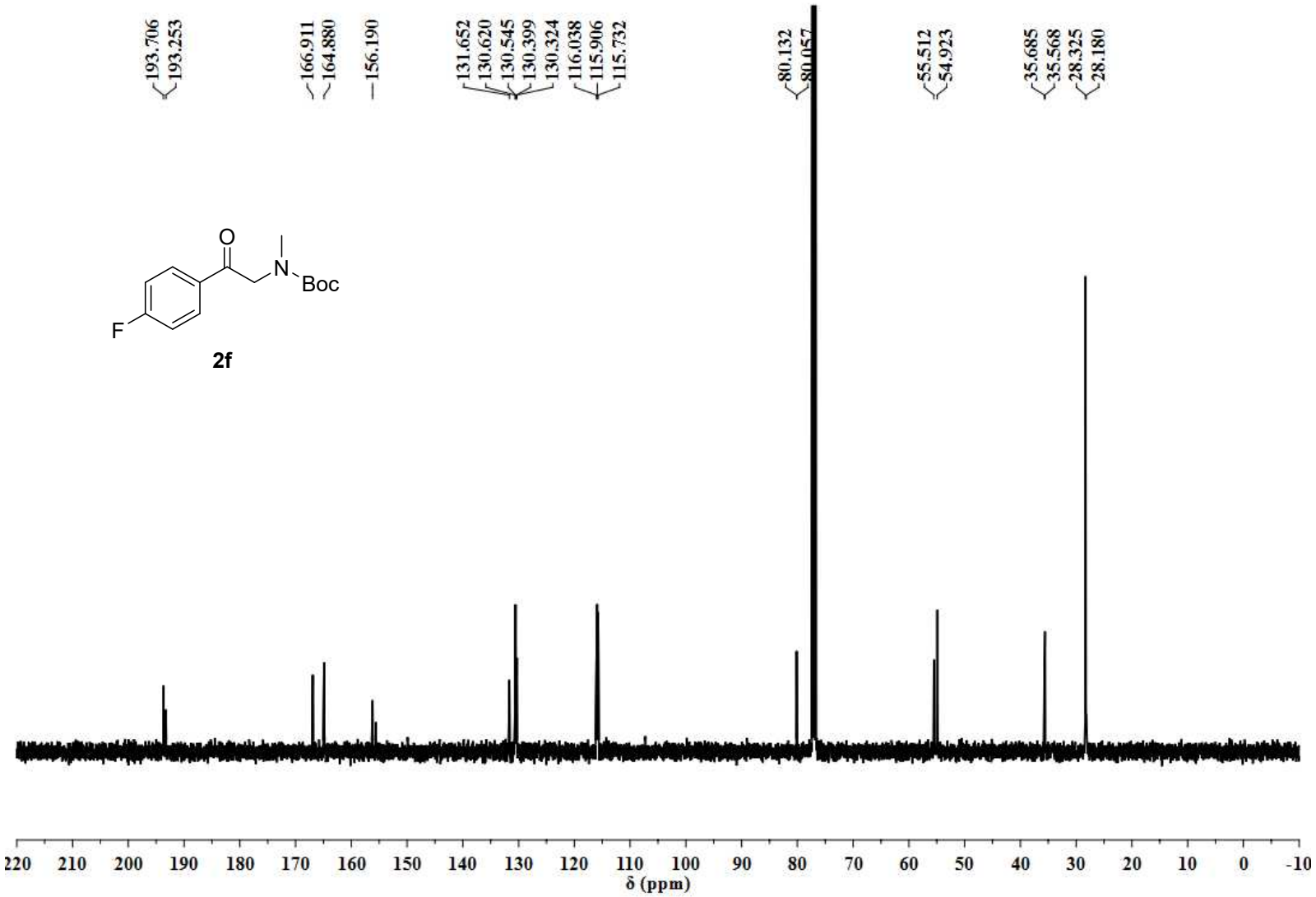
2.975
2.944
1.495
1.380
O
N
Boc
F
2f
2.00
2.00
2.05
3.00
9.22
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)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130.545
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130.324
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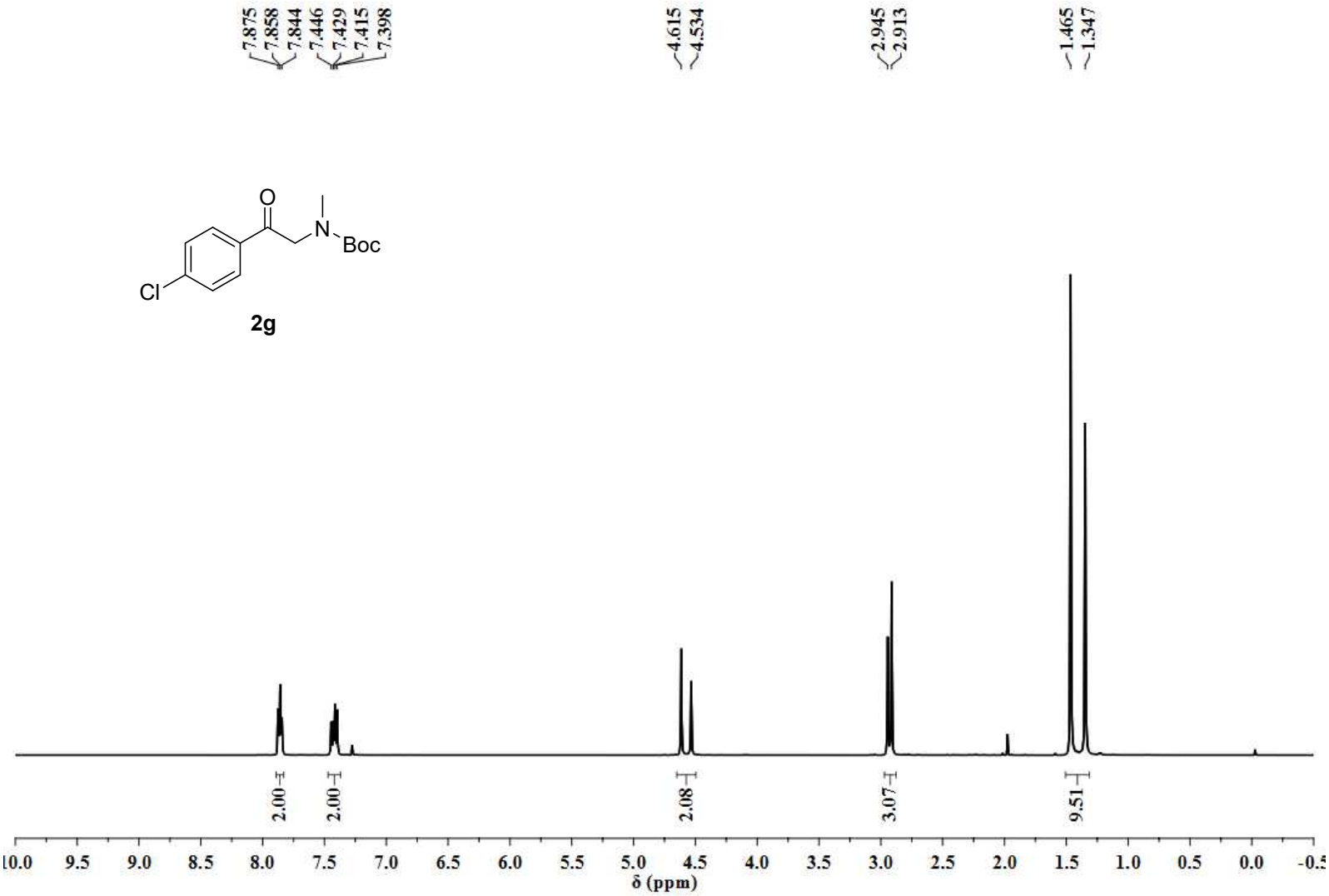
115.732
80.132
80.057
55.512
54.923
35.685
35.568
28.325
28.180
O
N
Boc
F
2f
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)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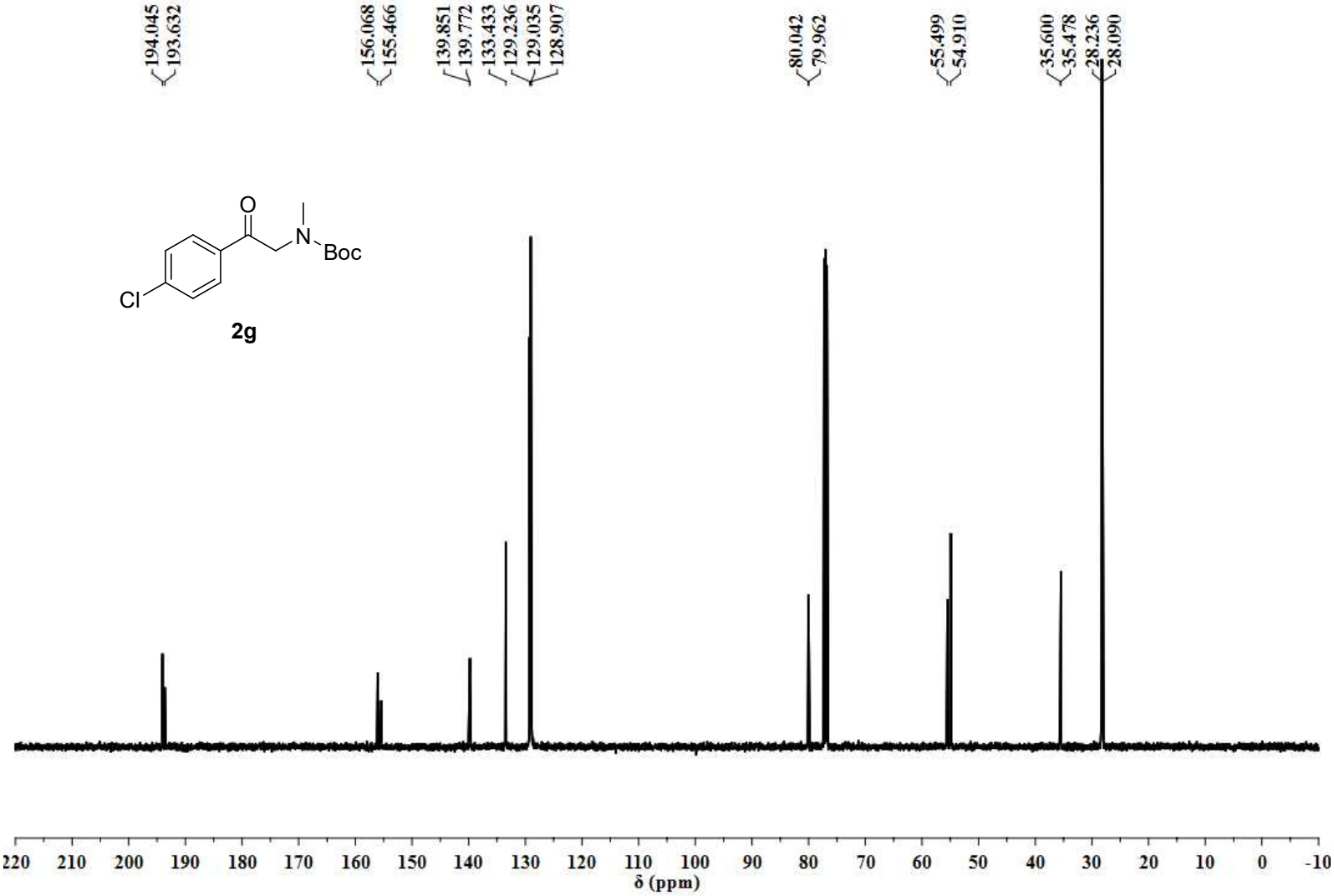
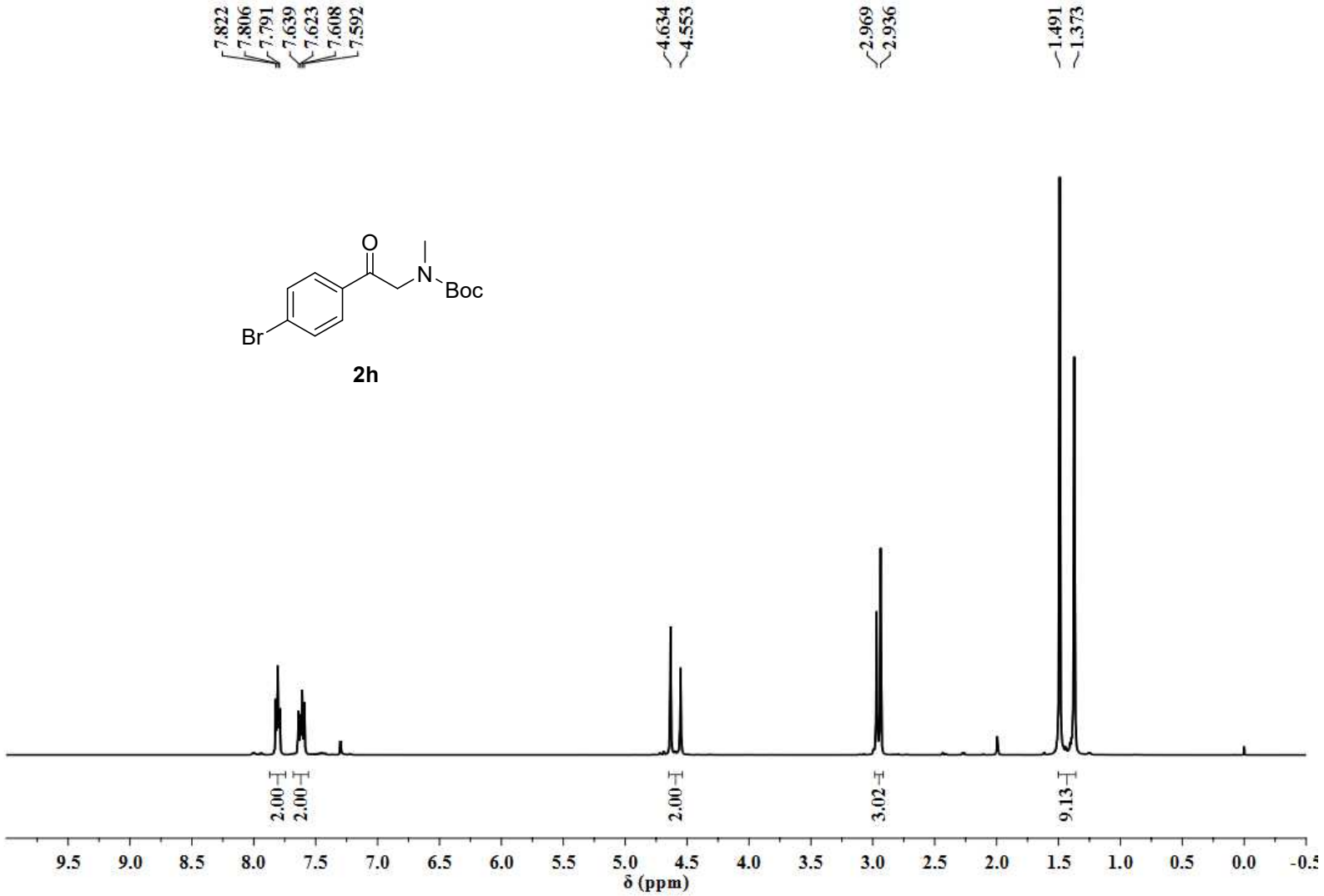
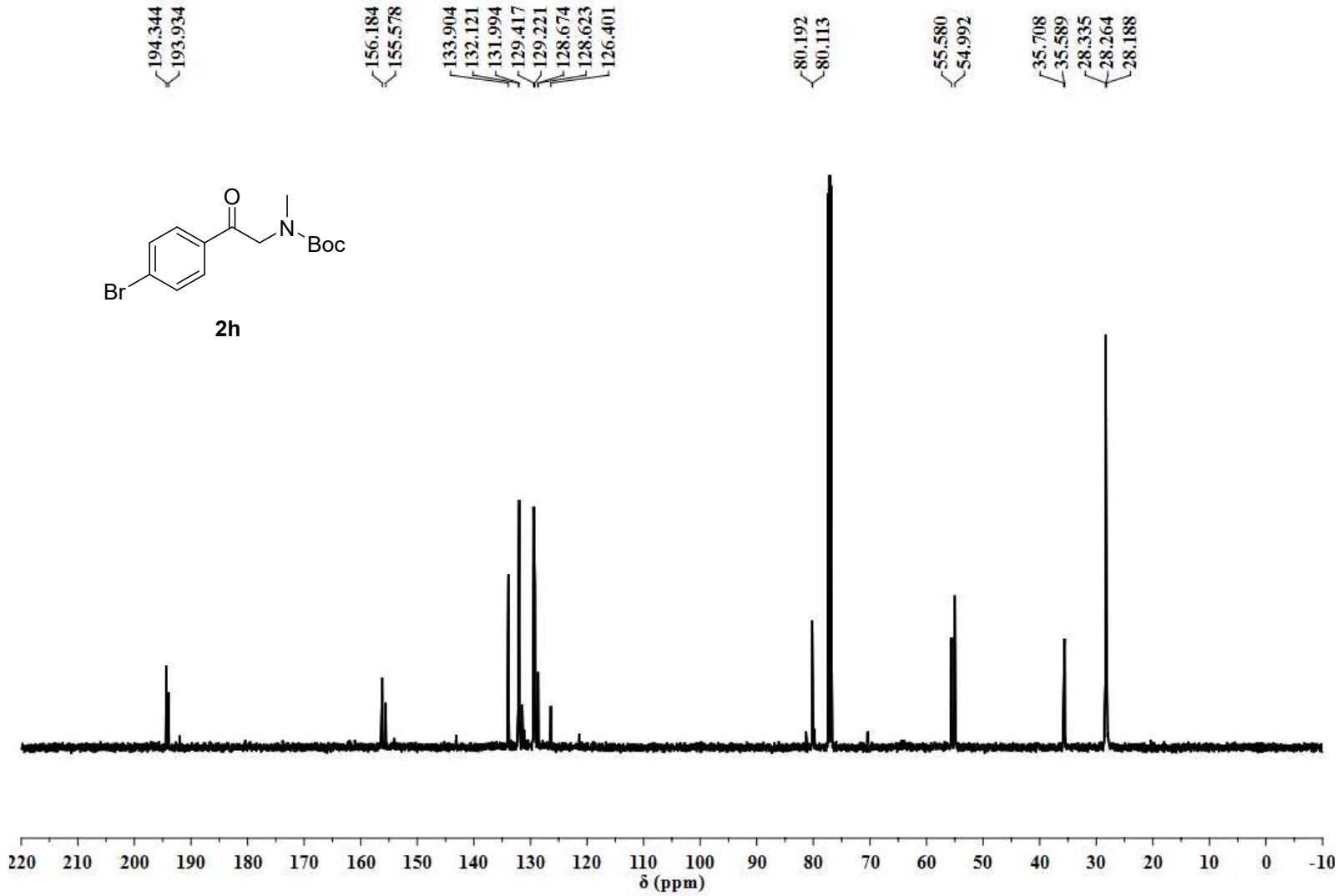
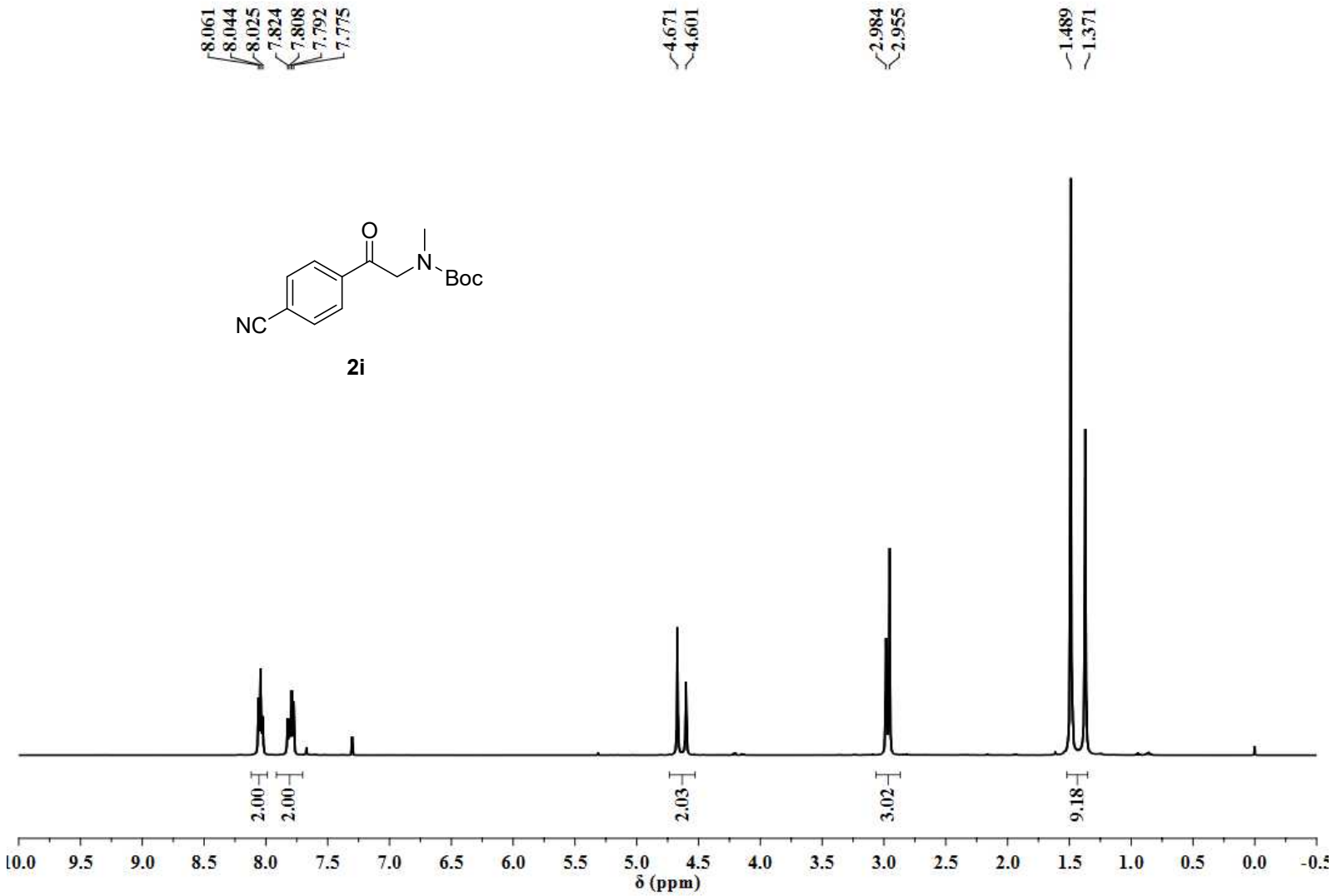
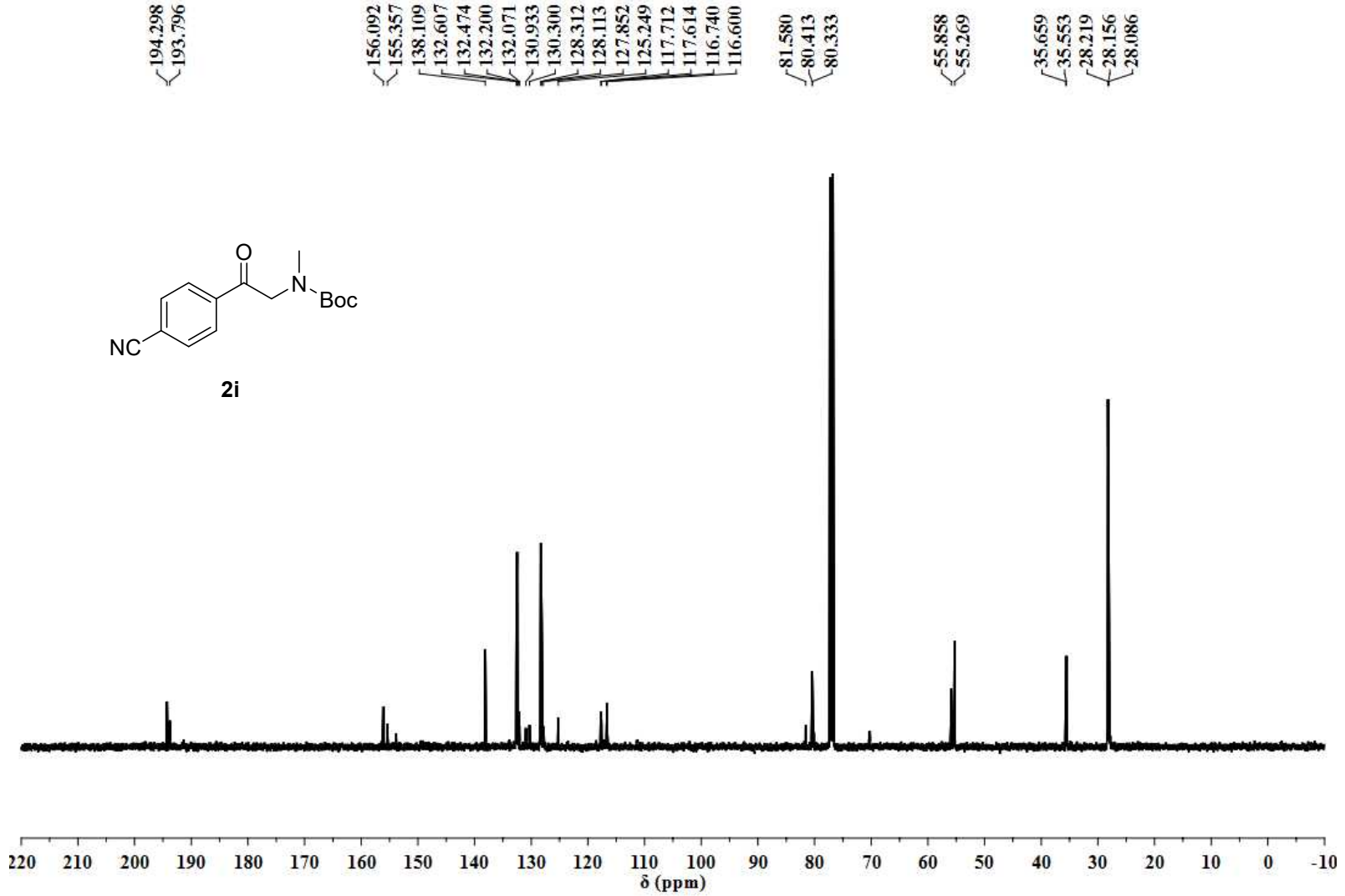
7.415
7.398
4.615
4.534
2.945
2.913
1.465
1.347
O
N
Boc
Cl
2g
2.00
2.00
2.08
3.07
9.51
δ (ppm)

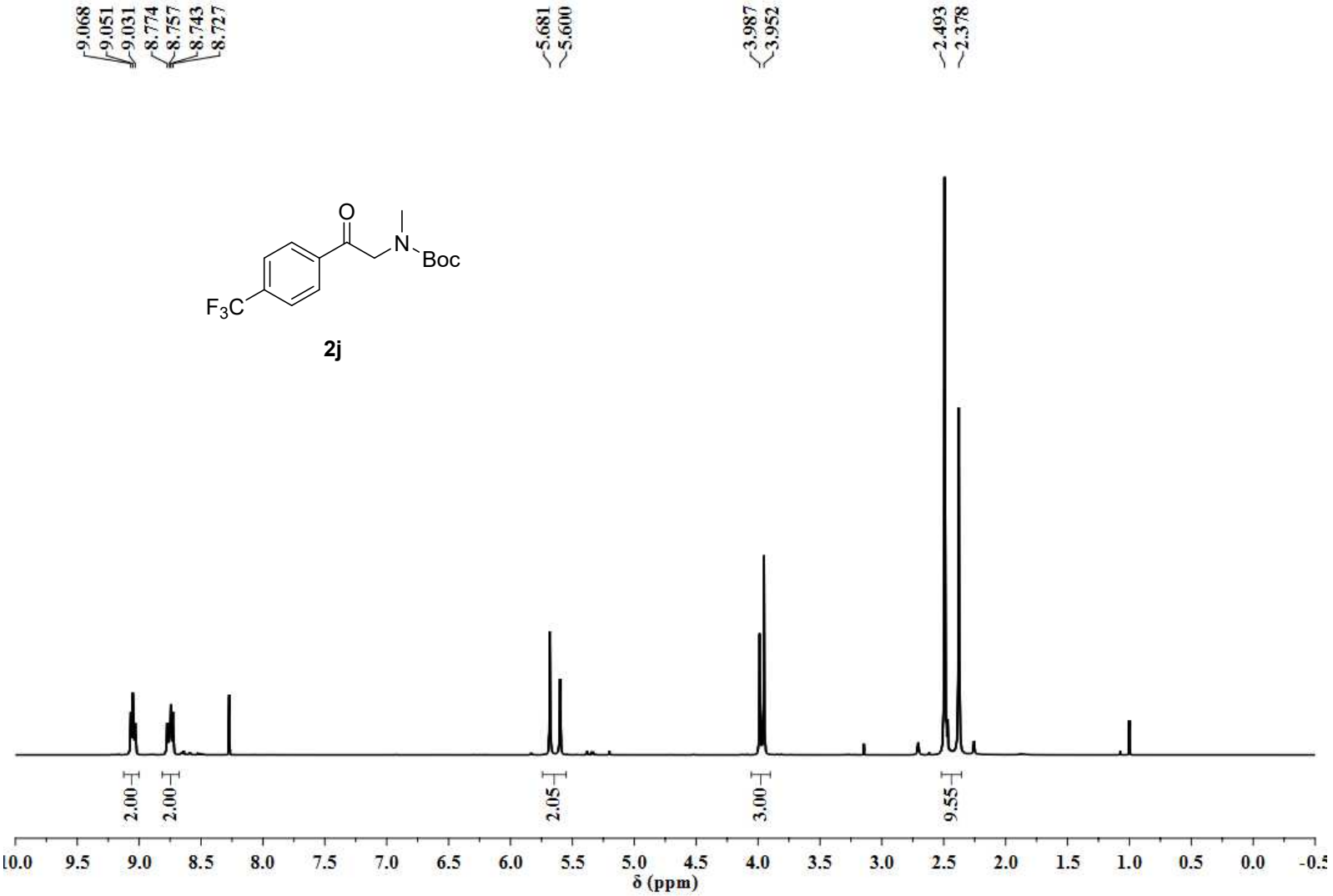

194.045
193.632
156.068
155.466
139.851
139.772
133.433
129.236
129.035
128.907
80.042
79.962
55.499
54.910
35.600
35.478
28.236
28.090
O
N
Boc
Cl
2g
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

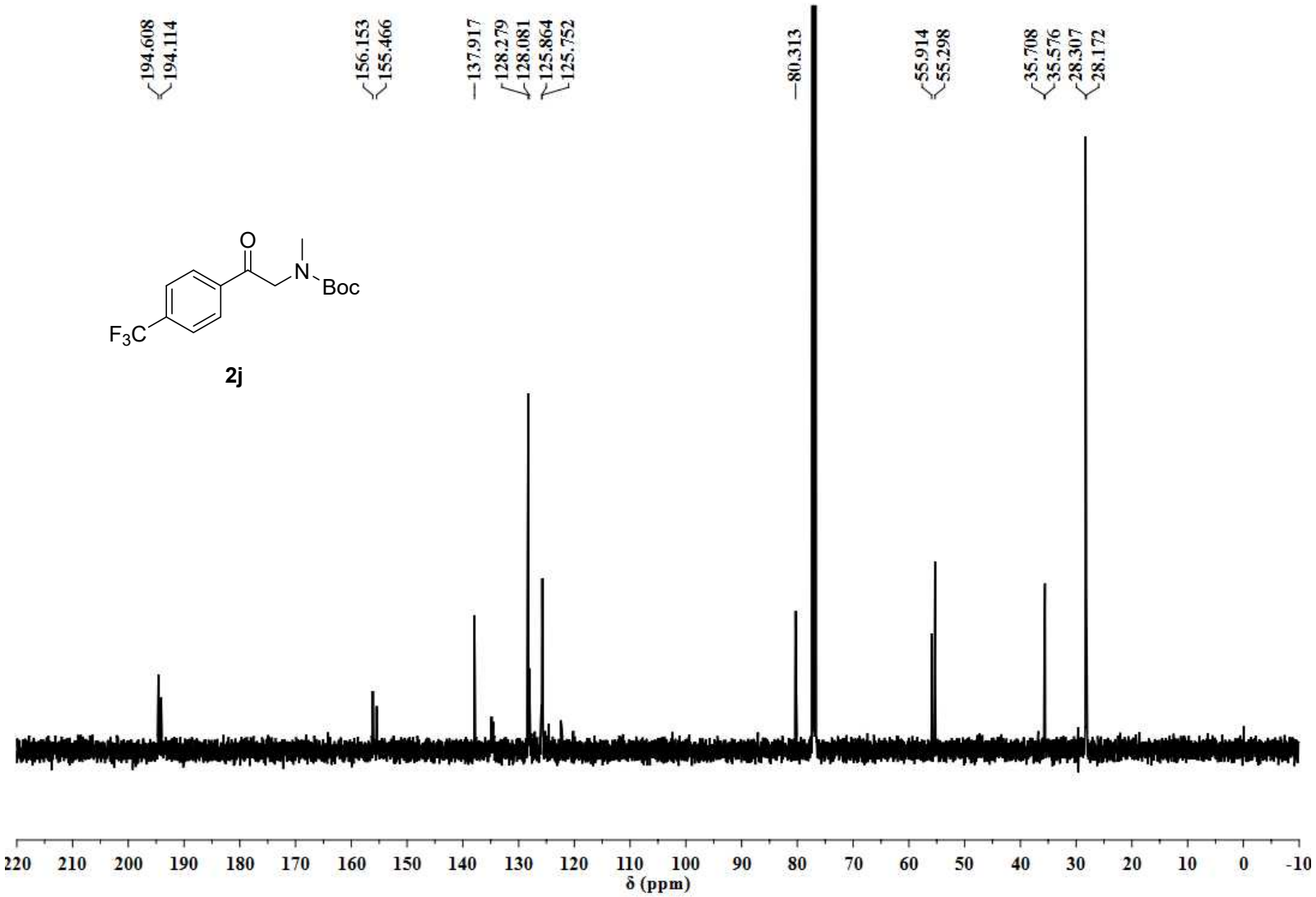

7.822
7.806
7.791
7.639
7.623
7.608
7.592
4.634
4.553
2.969
2.936
1.491
1.373
O
N
Boc
Br
2h
2.00
2.00
2.00
3.02
9.13
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
δ (ppm)

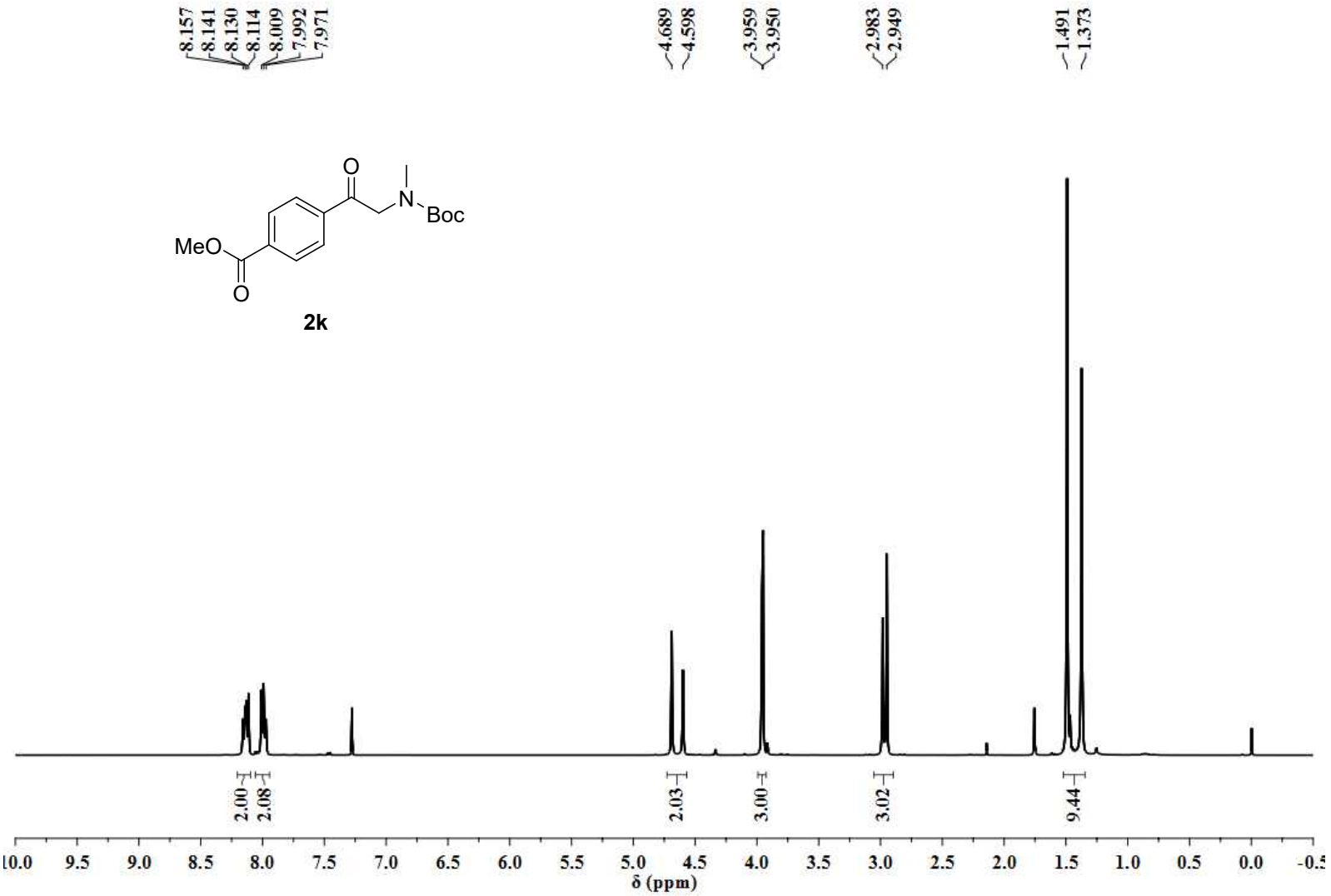

194.344
193.934
156.184
155.578
133.904
132.121
131.994
129.417
129.221
128.674
128.623
126.401
80.192
80.113
55.580
54.992
35.708
35.589
28.335
28.264
28.188
O
N
Boc
Br
2h
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

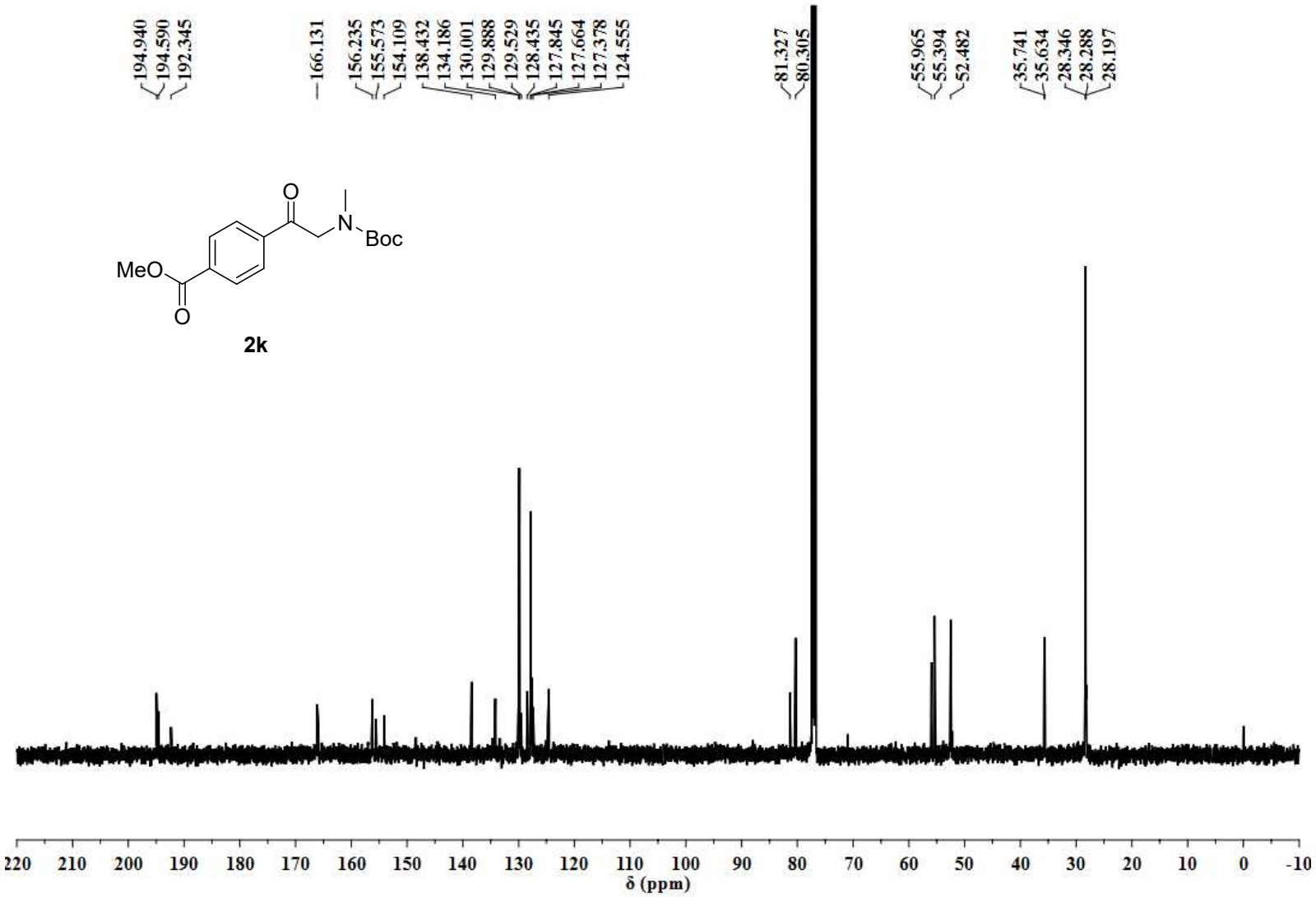

8.061
8.044
8.025
7.824
7.808
7.792
7.775
4.671
4.601
2.984
2.955
1.489
1.371
O
N
Boc
NC
2i
2.00
2.00
2.03
3.02
9.18
δ (ppm)

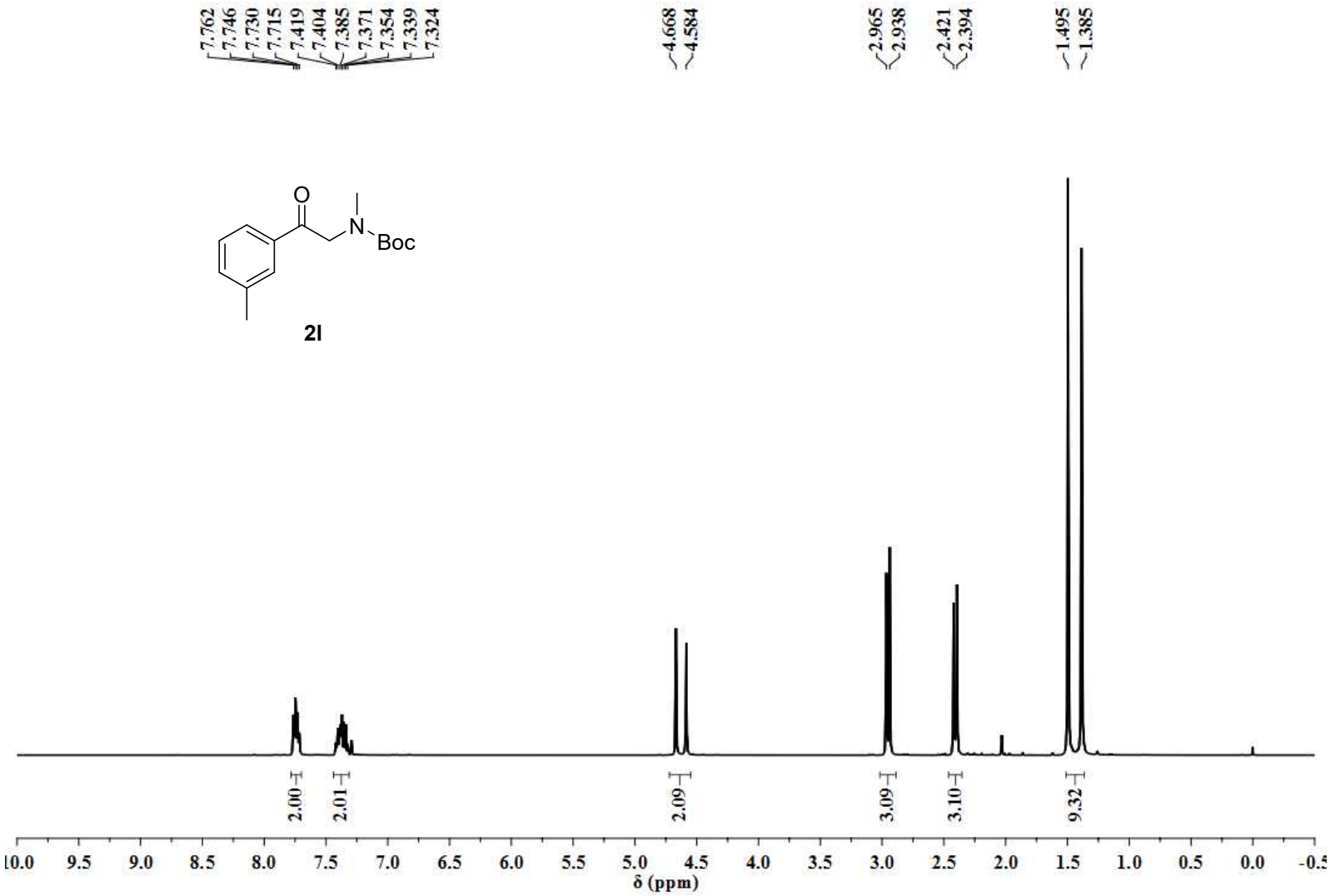

194.298
193.796
156.092
155.357
138.109
132.607
132.474
132.200
132.071
130.933
130.300
128.312
128.113
127.852
125.249
117.712
117.614
116.740
116.600
81.580
80.413
80.333
55.858
55.269
35.659
35.553
28.219
28.156
28.086
O
N
Boc
NC
2i
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)


9.068
9.051
9.031
8.774
8.757
8.743
8.727
5.681
5.600
3.987
3.952
2.493
2.378
O
N
Boc
F3C
2j
2.00
2.00
2.05
3.00
9.55
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
δ (ppm)

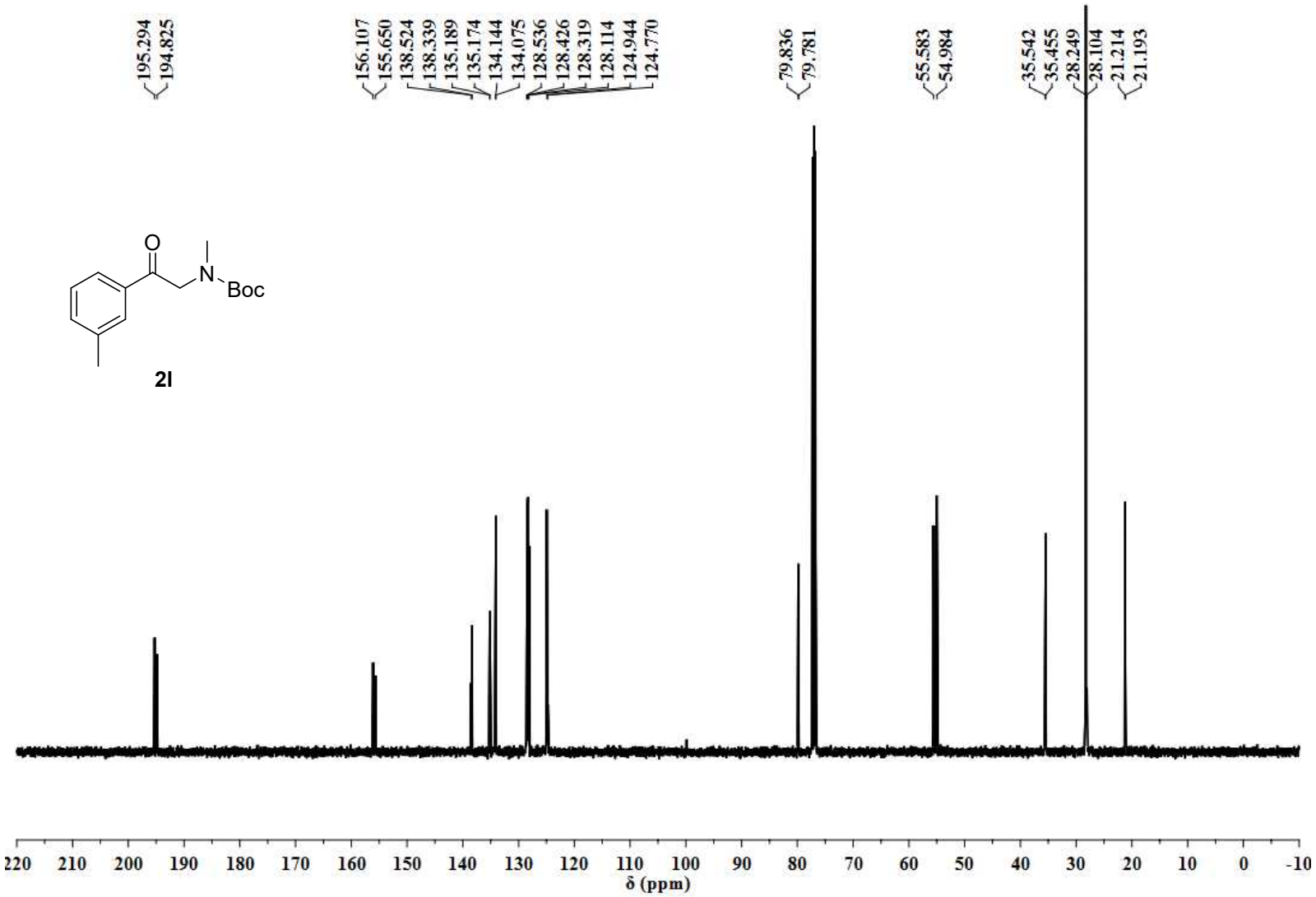

194.608
194.114
156.153
155.466
137.917
128.279
128.081
125.864
125.752
80.313
55.914
55.298
35.708
35.576
28.307
28.172
O
N
Boc
F3C
2j
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)


8.157
8.141
8.130
8.114
8.009
7.992
7.971
4.689
4.598
3.959
3.950
2.983
2.949
1.491
1.373
O
N
Boc
MeO
O
2k
2.00
2.08
2.03
3.00
3.02
9.44
δ (ppm)

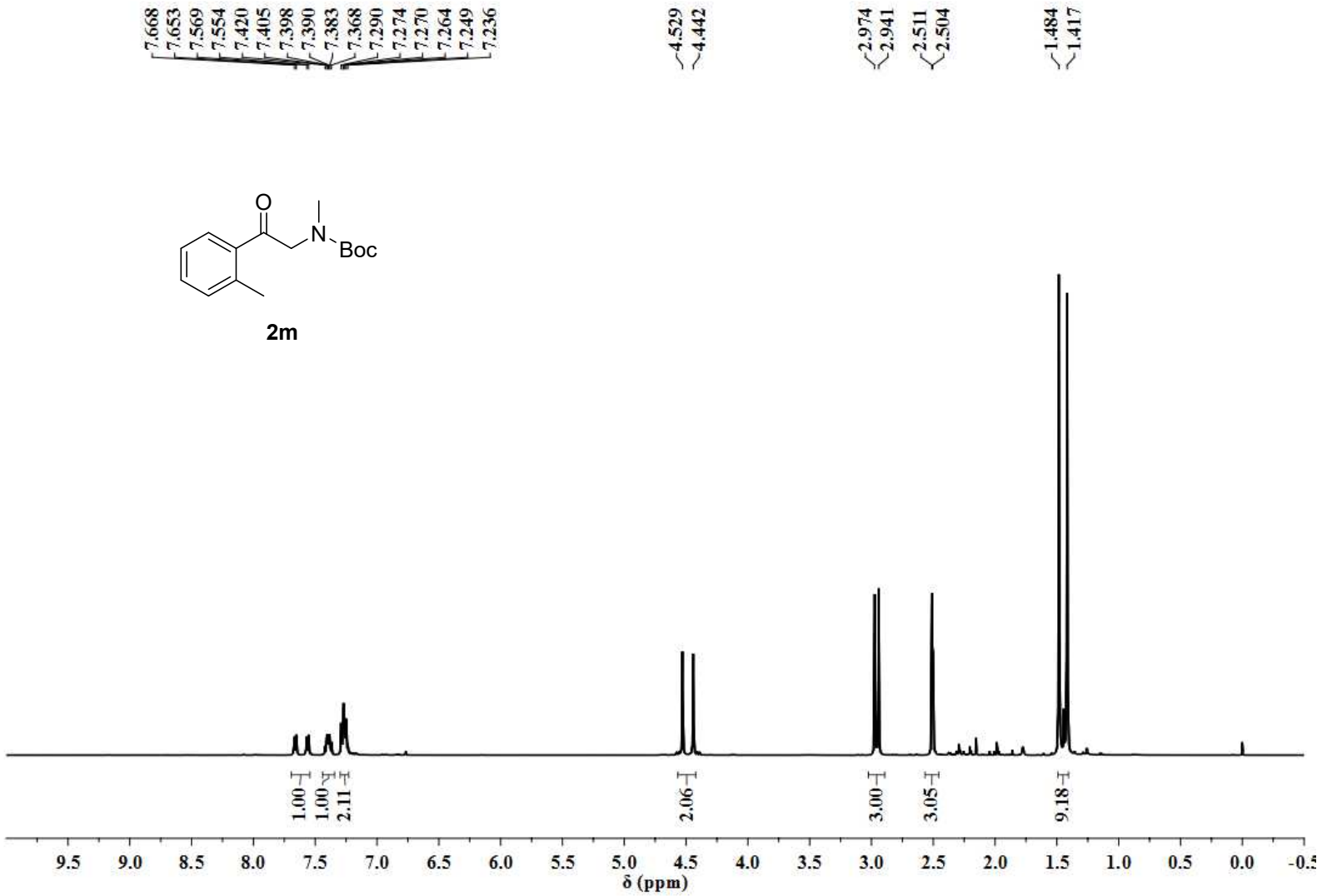

194.940
194.590
192.345
166.131
156.235
155.573
154.109
138.432
134.186
130.001
129.888
129.529
128.435
127.845
127.664
127.378
124.555
81.327
80.305
55.965
55.394
52.482
35.741
35.634
28.346
28.288
28.197
MeO
O
O
N
Boc
2k
δ (ppm)


7.762
7.746
7.730
7.715
7.419
7.404
7.385
7.371
7.354
7.339
7.324
4.668
4.584
2.965
2.938
2.421
2.394
1.495
1.385
O
N
Boc
2.00
2.01
2.09
3.09
3.10
9.32
δ (ppm)

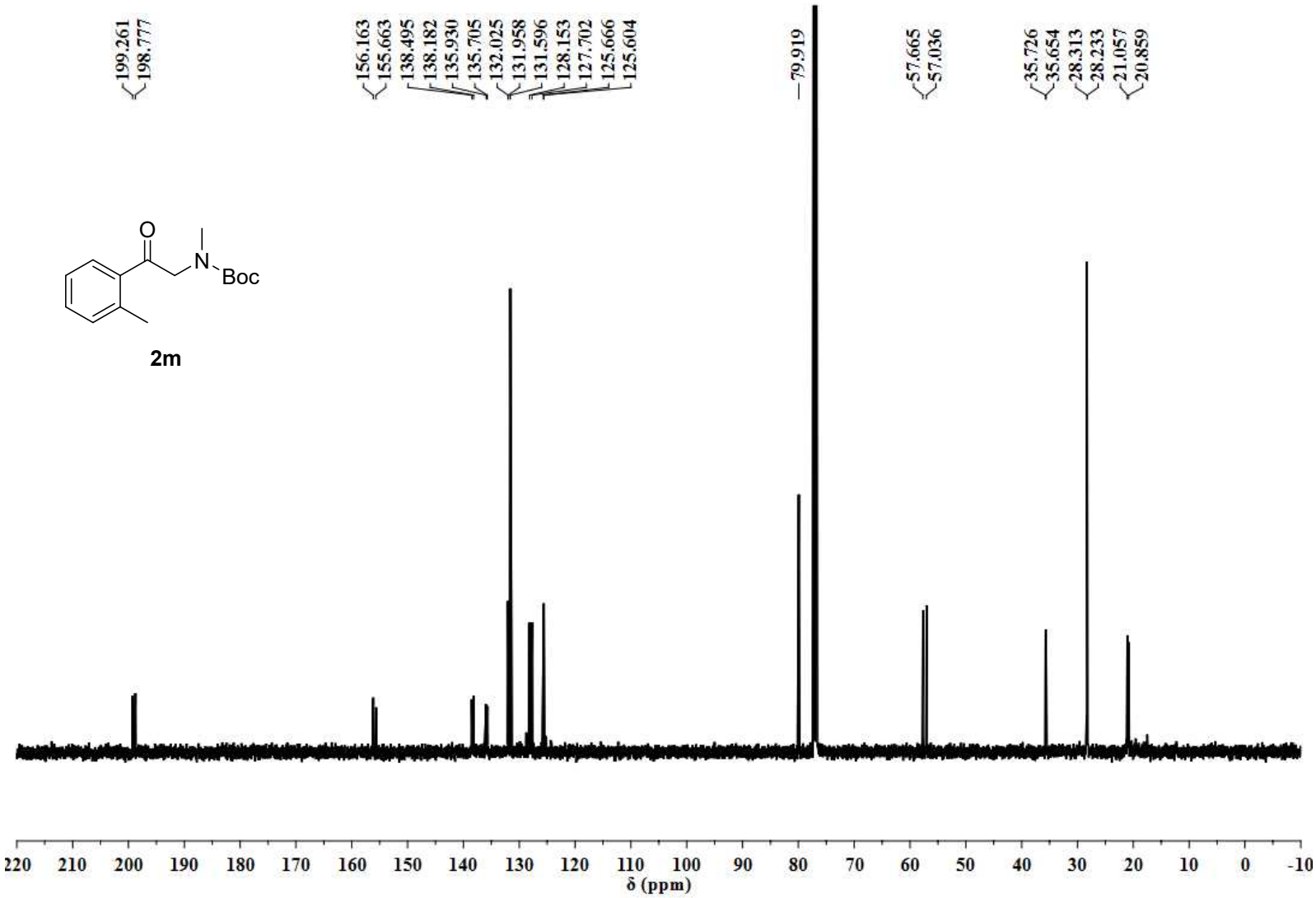
2l

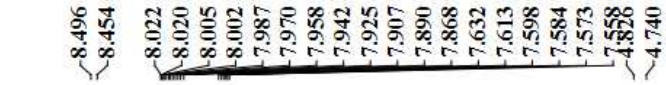

195.294
194.825
156.107
155.650
138.524
138.339
135.189
135.174
134.144
134.075
128.536
128.426
128.319
128.114
124.944
124.770
79.836
79.781
55.583
54.984
35.542
35.455
28.249
28.104
21.214
21.193
O
N
Boc
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

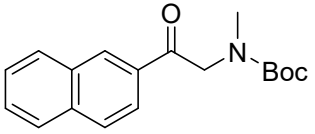
2l


7.668
7.653
7.569
7.554
7.420
7.405
7.398
7.390
7.383
7.368
7.290
7.274
7.270
7.264
7.249
7.236
4.529
4.442
2.974
2.941
2.511
2.504
1.484
1.417
O
N
Boc
1.00
1.00
2.11
2.06
3.00
3.05
9.18
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
δ (ppm)

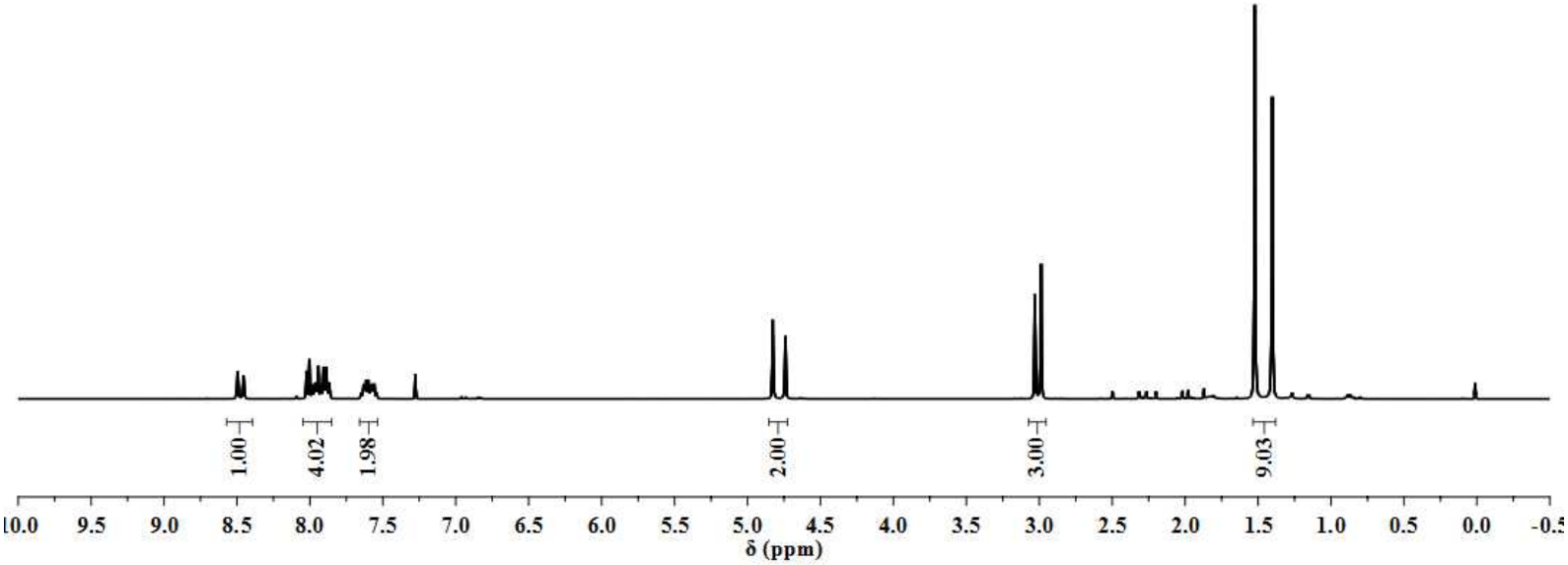
2m

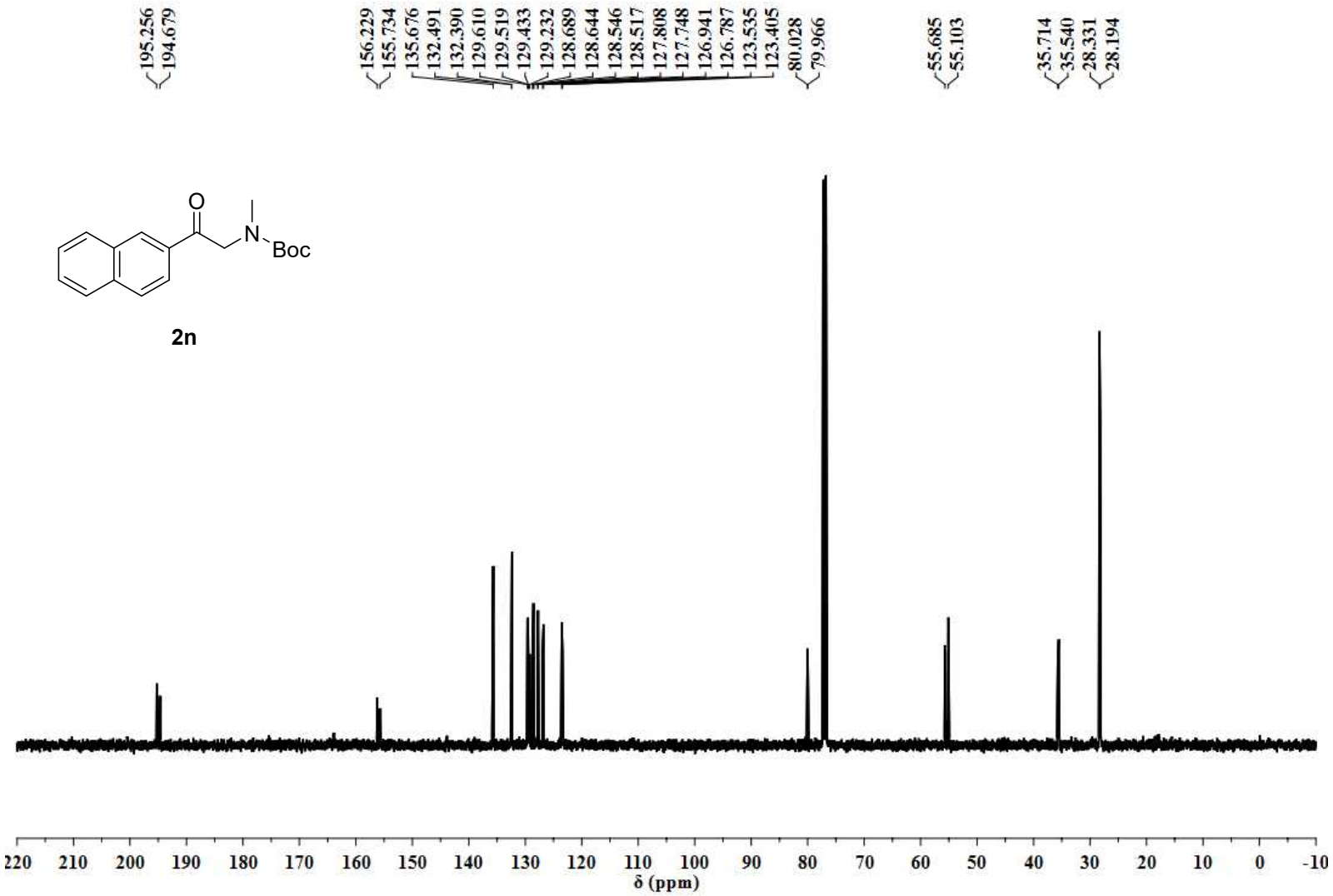

199.261
198.777
156.163
155.663
138.495
138.182
135.930
135.705
132.025
131.958
131.596
128.153
127.702
125.666
125.604
79.919
57.665
57.036
35.726
35.654
28.313
28.233
21.057
20.859
O
N
Boc
2m
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

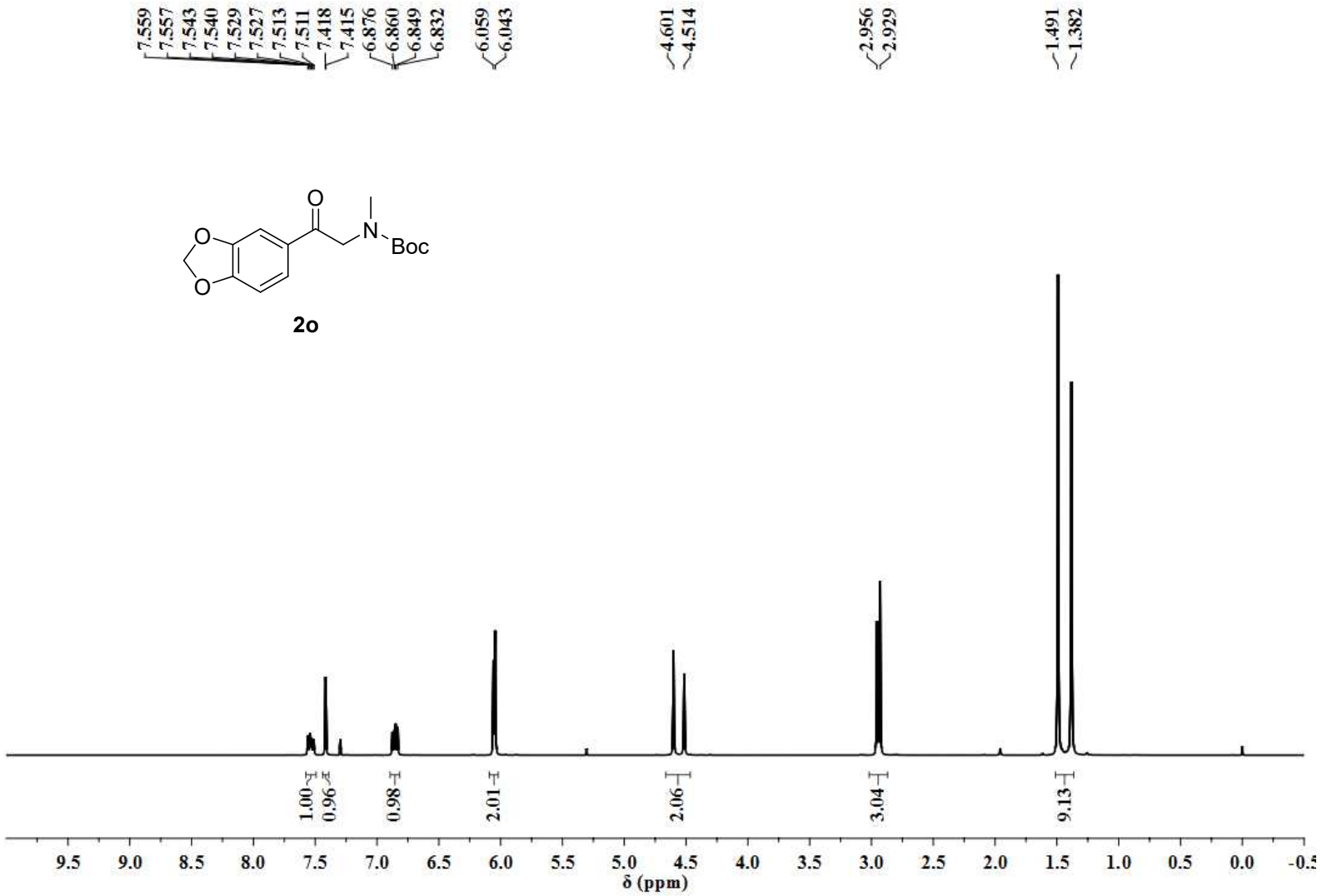

8.496
8.454
8.022
8.020
8.005
8.002
7.987
7.970
7.958
7.942
7.925
7.907
7.890
7.868
7.632
7.613
7.598
7.584
7.573
7.558
4.826
4.740
3.030
2.987
1.522
1.402


O
N
Boc

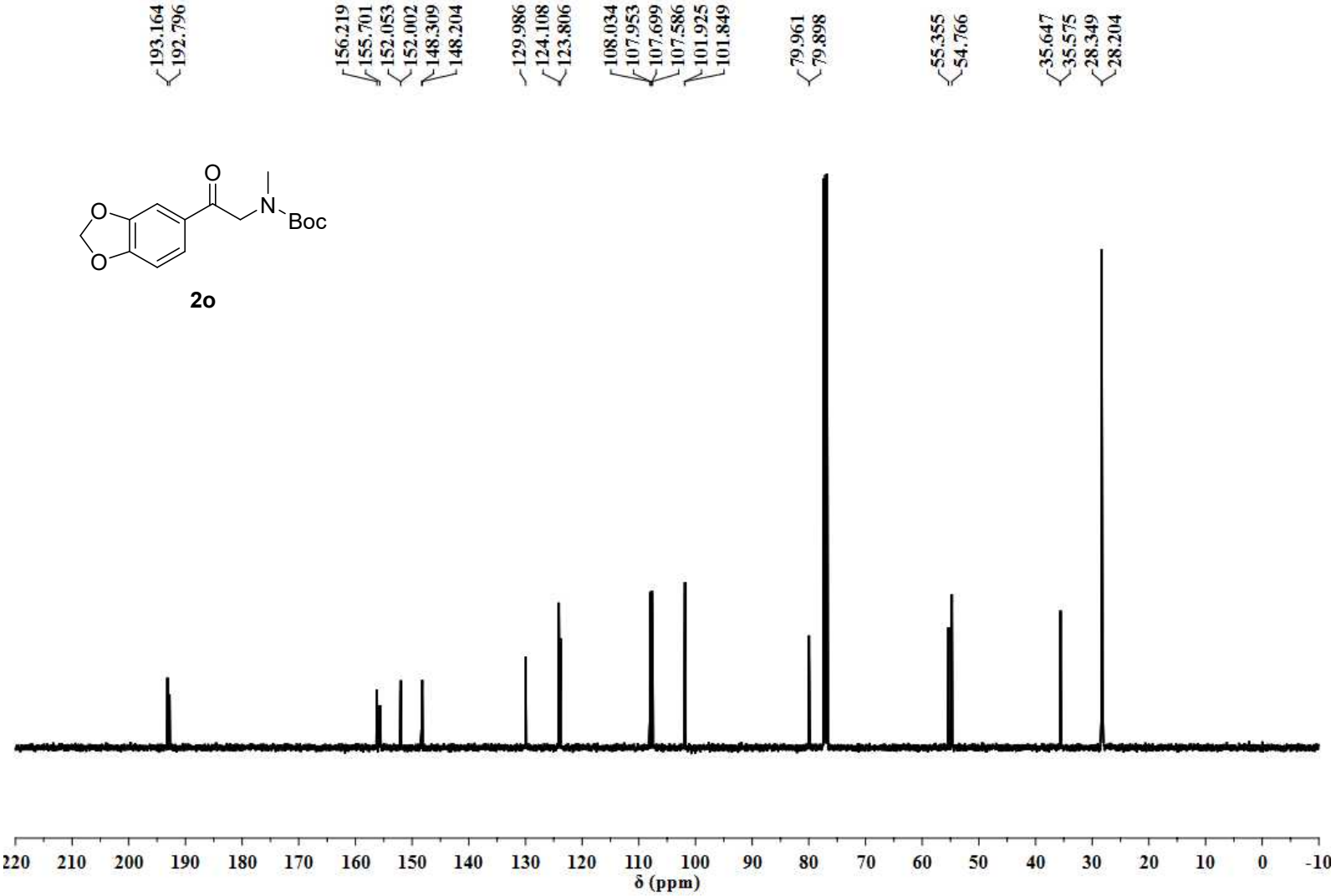
2n


1.00
4.02
1.98
2.00
3.00
9.03
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
δ (ppm)

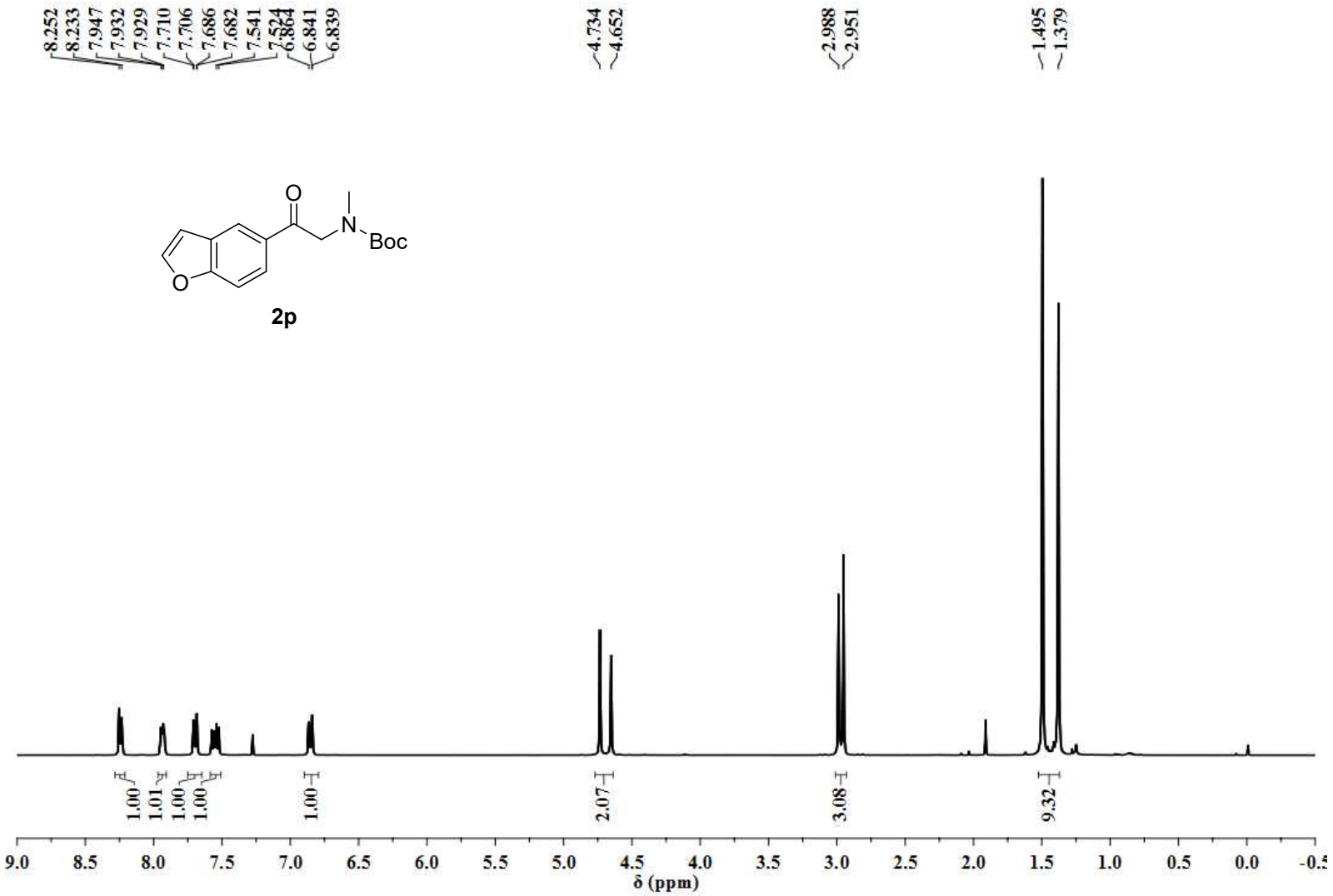

195.256
194.679
156.229
155.734
135.676
132.491
132.390
129.610
129.519
129.433
129.232
128.689
128.644
128.546
128.517
127.808
127.748
126.941
126.787
123.535
123.405
80.028
79.966
55.685
55.103
35.714
35.540
28.331
28.194
O
N
Boc
2n
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)


7.559
7.557
7.543
7.540
7.529
7.527
7.513
7.511
7.418
7.415
6.876
6.860
6.849
6.832
6.059
6.043
4.601
4.514
2.956
2.929
1.491
1.382
O
O
O
N
Boc
1.00
0.96
0.98
2.01
2.06
3.04
9.13
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
δ (ppm)

2o


193.164
192.796
156.219
155.701
152.053
152.002
148.309
148.204
129.986
124.108
123.806
108.034
107.953
107.699
107.586
101.925
101.849
79.961
79.898
55.355
54.766
35.647
35.575
28.349
28.204
O
O
O
N
Boc
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

2o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8.233
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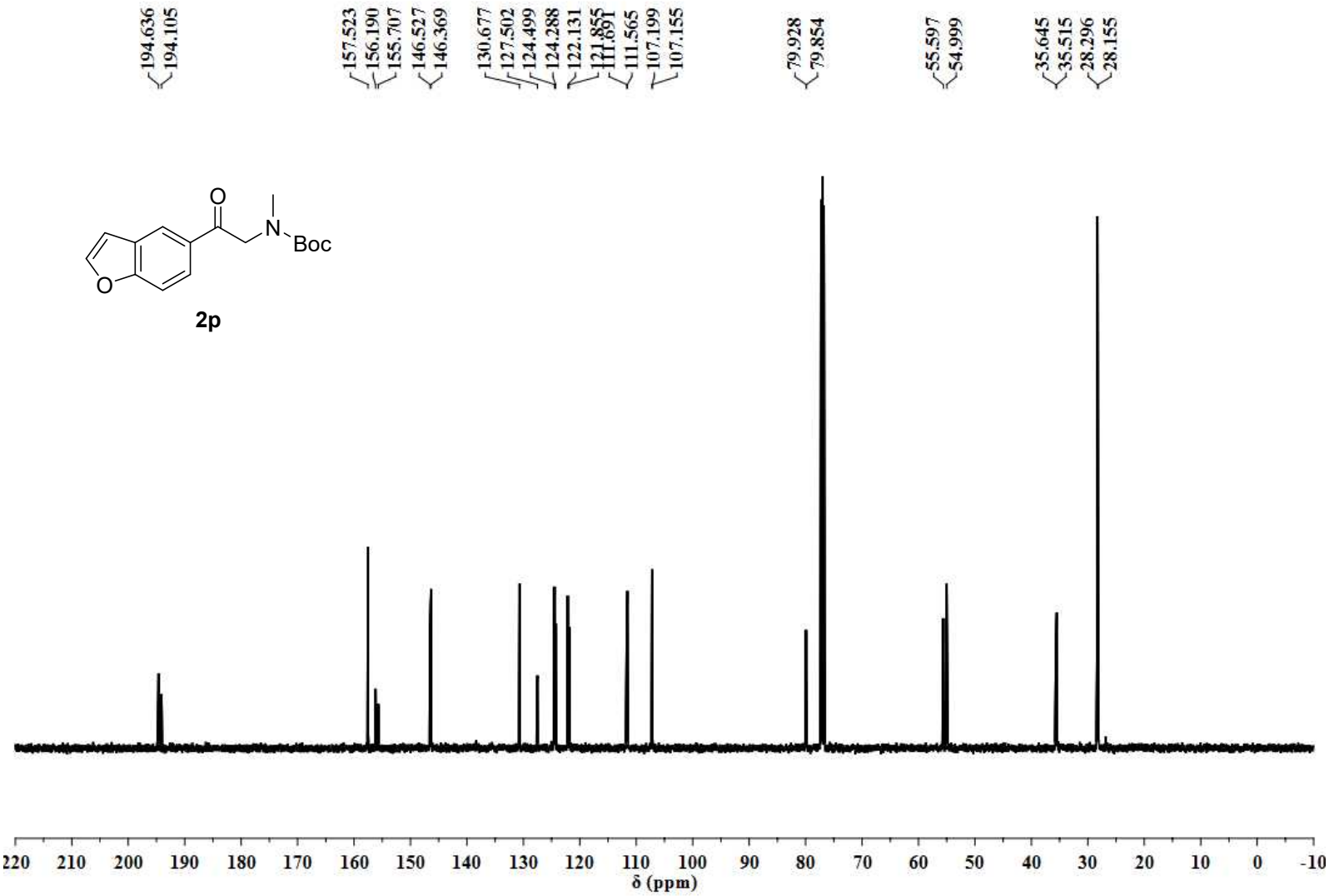
7.932
7.929
7.710
7.706
7.686
7.682
7.541
7.524
6.864
6.841
6.839
4.734
4.652
2.988
2.951
1.495
1.379
O
N
Boc
O
2p
1.00
1.01
1.00
1.00
1.00
2.07
3.08
9.32
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
δ (ppm)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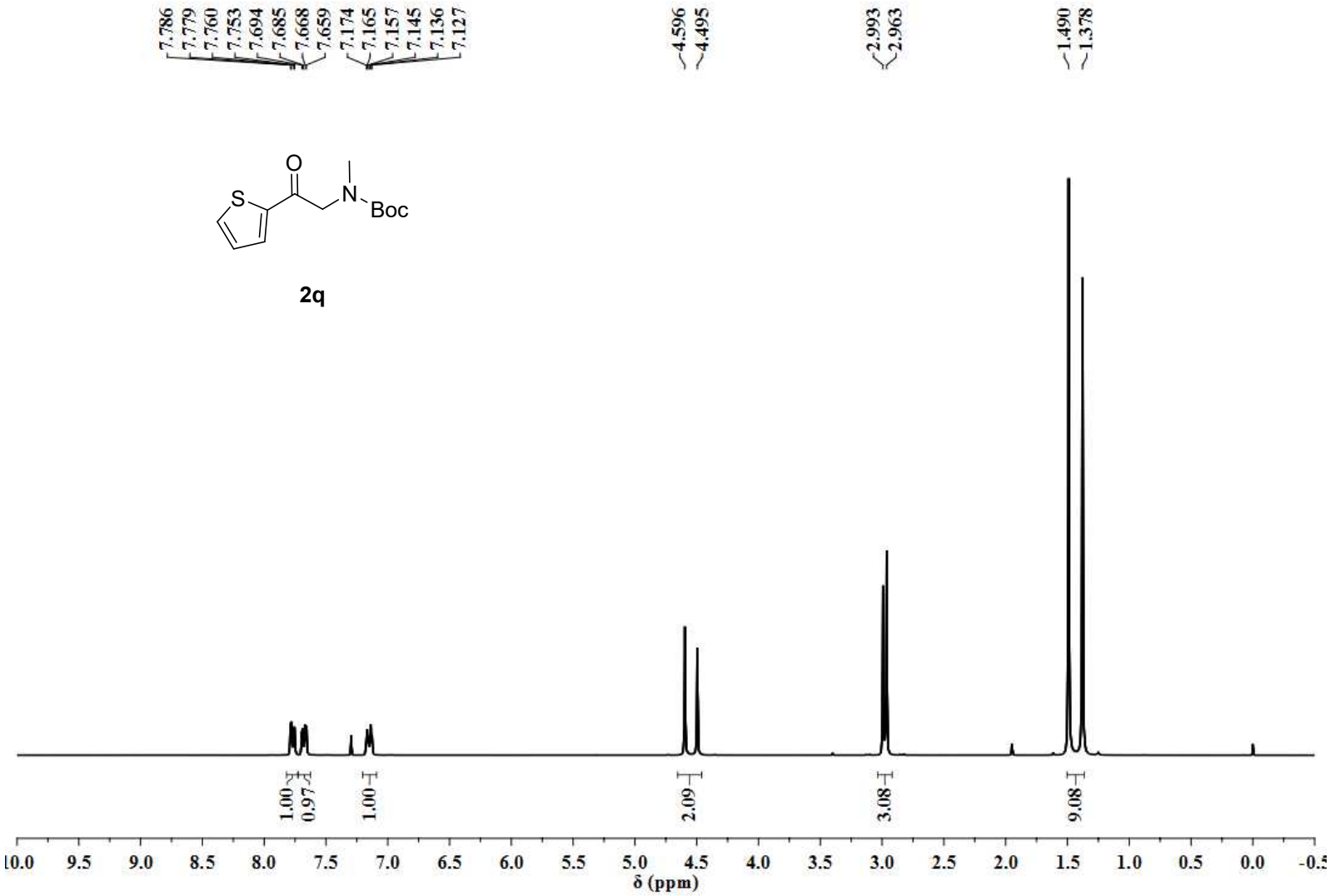
194.105
157.523
156.190
155.707
146.527
146.369
130.677
127.502
124.499
124.288
122.131
121.855
111.691
111.565
107.199
107.155
79.928
79.854
55.597
54.999
35.645
35.515
28.296
28.155
O
N
Boc
O
2p
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)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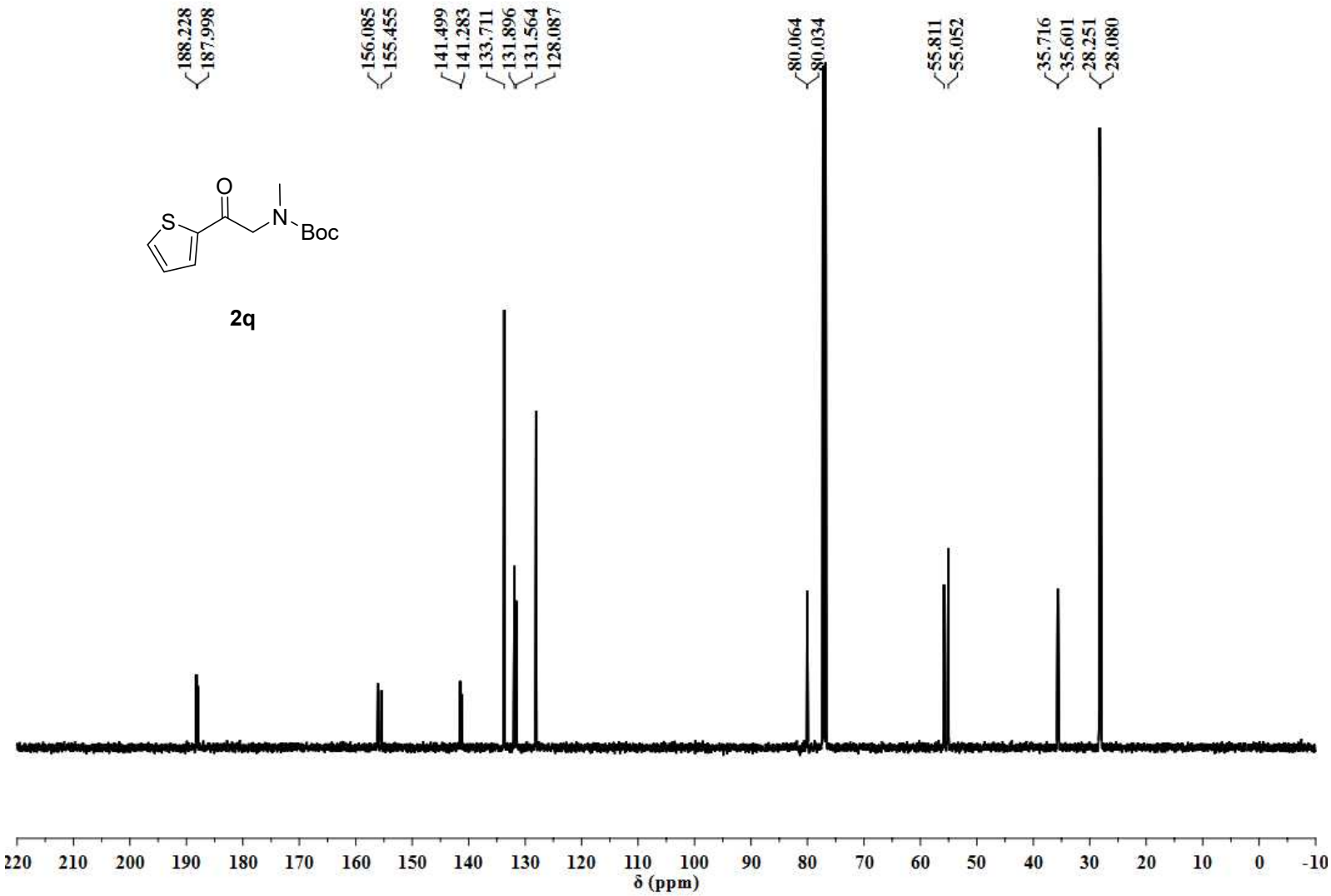
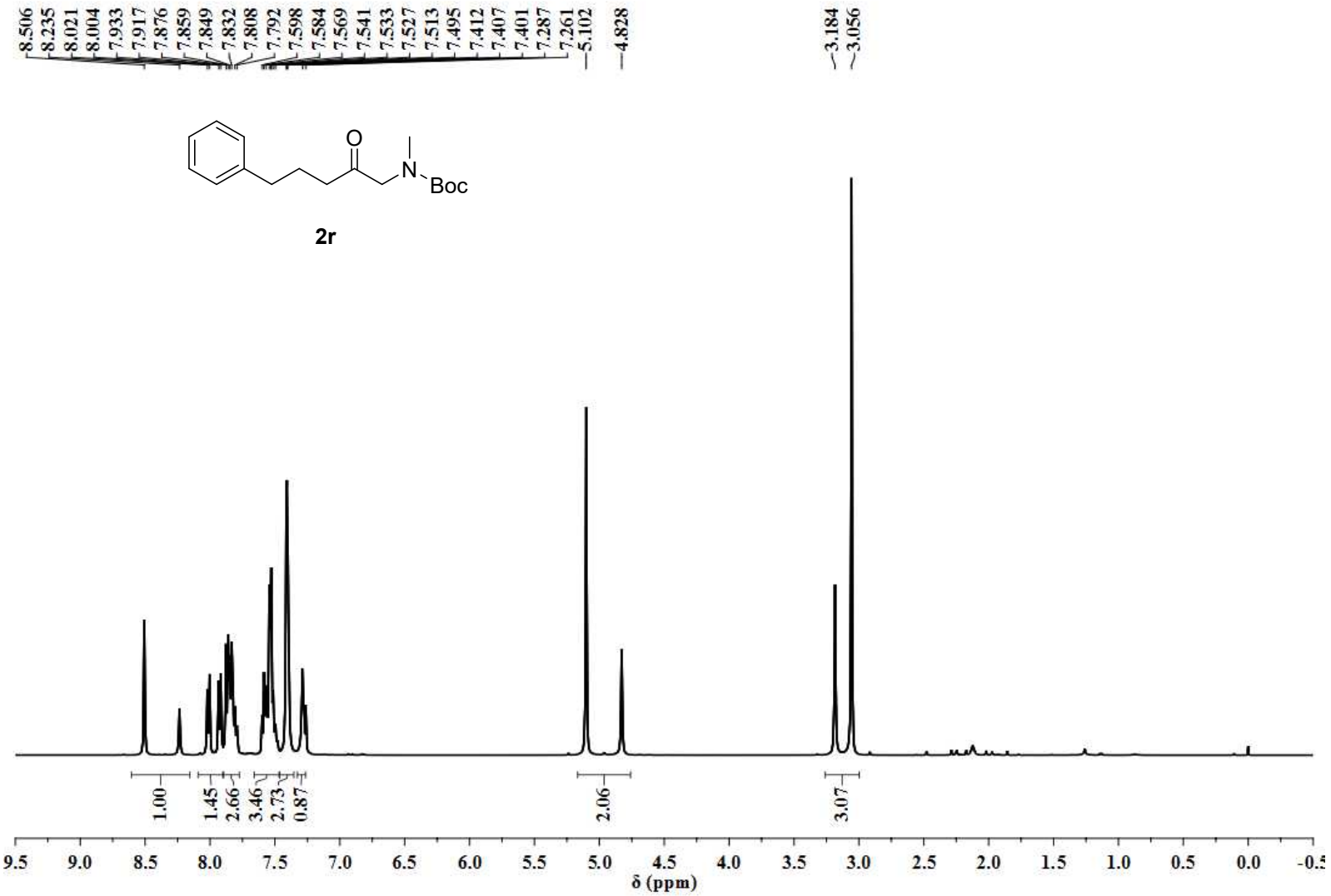
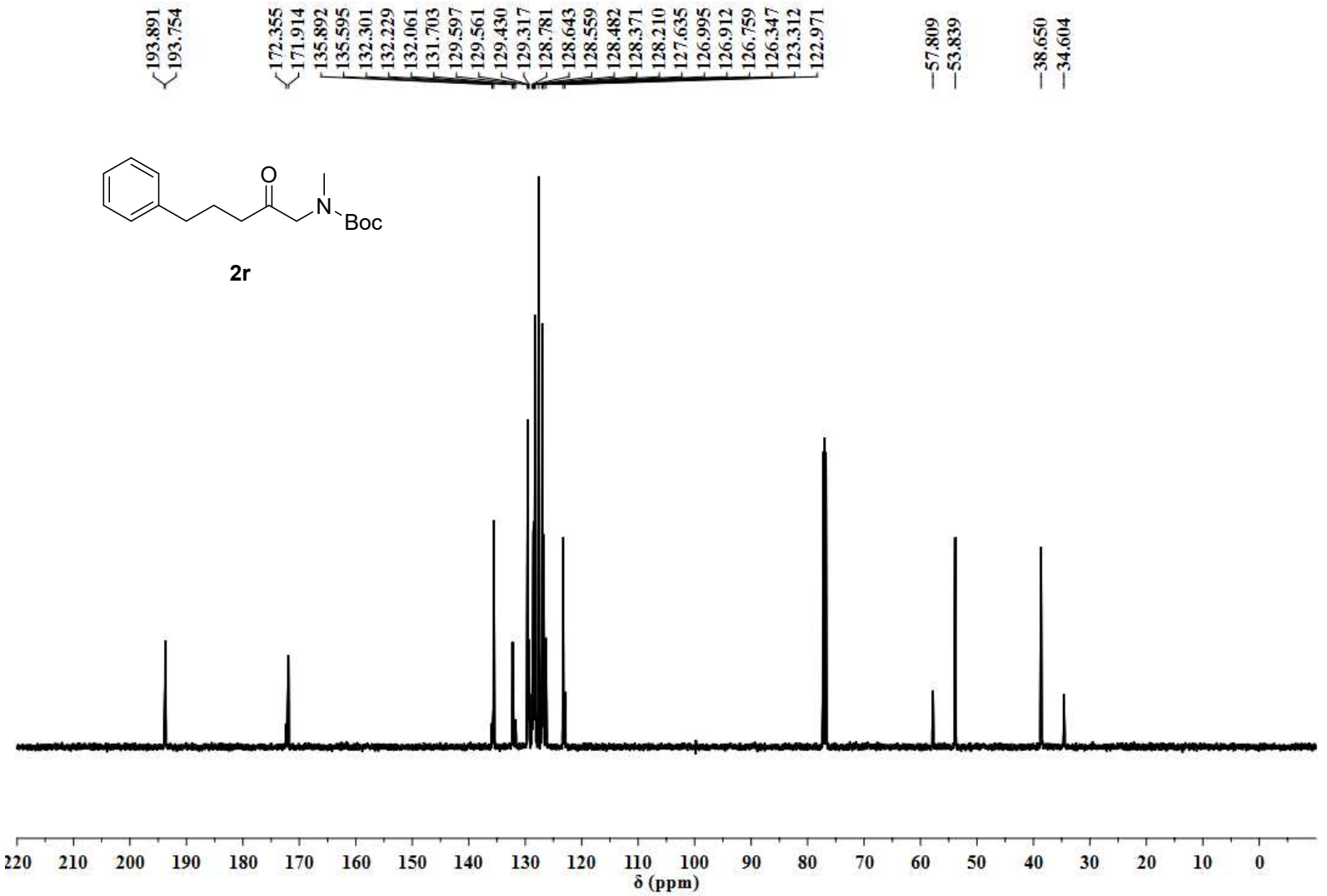
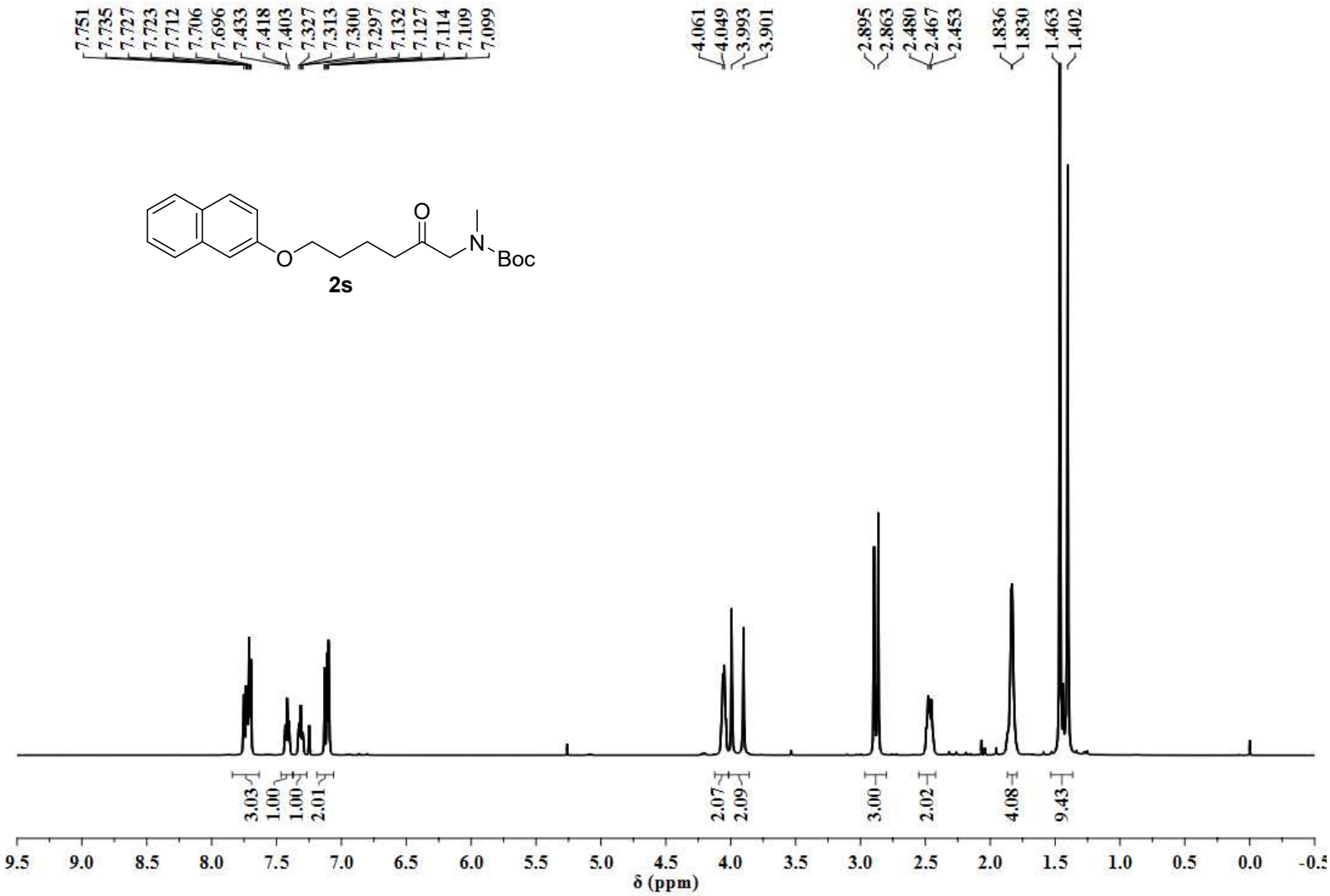
7.760
7.753
7.694
7.685
7.668
7.659
7.174
7.165
7.157
7.145
7.136
7.127
4.596
4.495
2.993
2.963
1.490
1.378
O
S
N
Boc
1.00
0.97
1.00
2.09
3.08
9.08
δ (ppm)

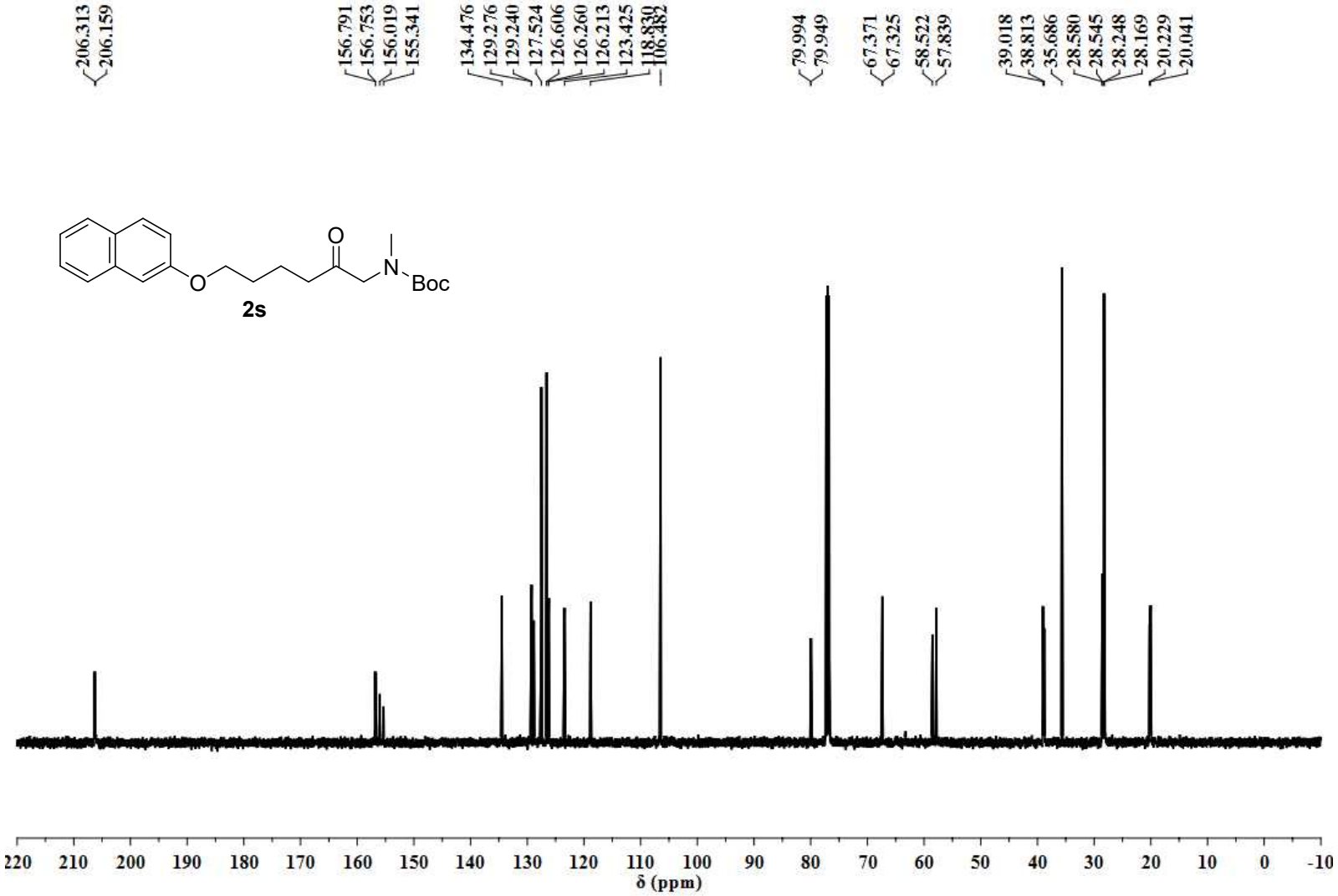
2q

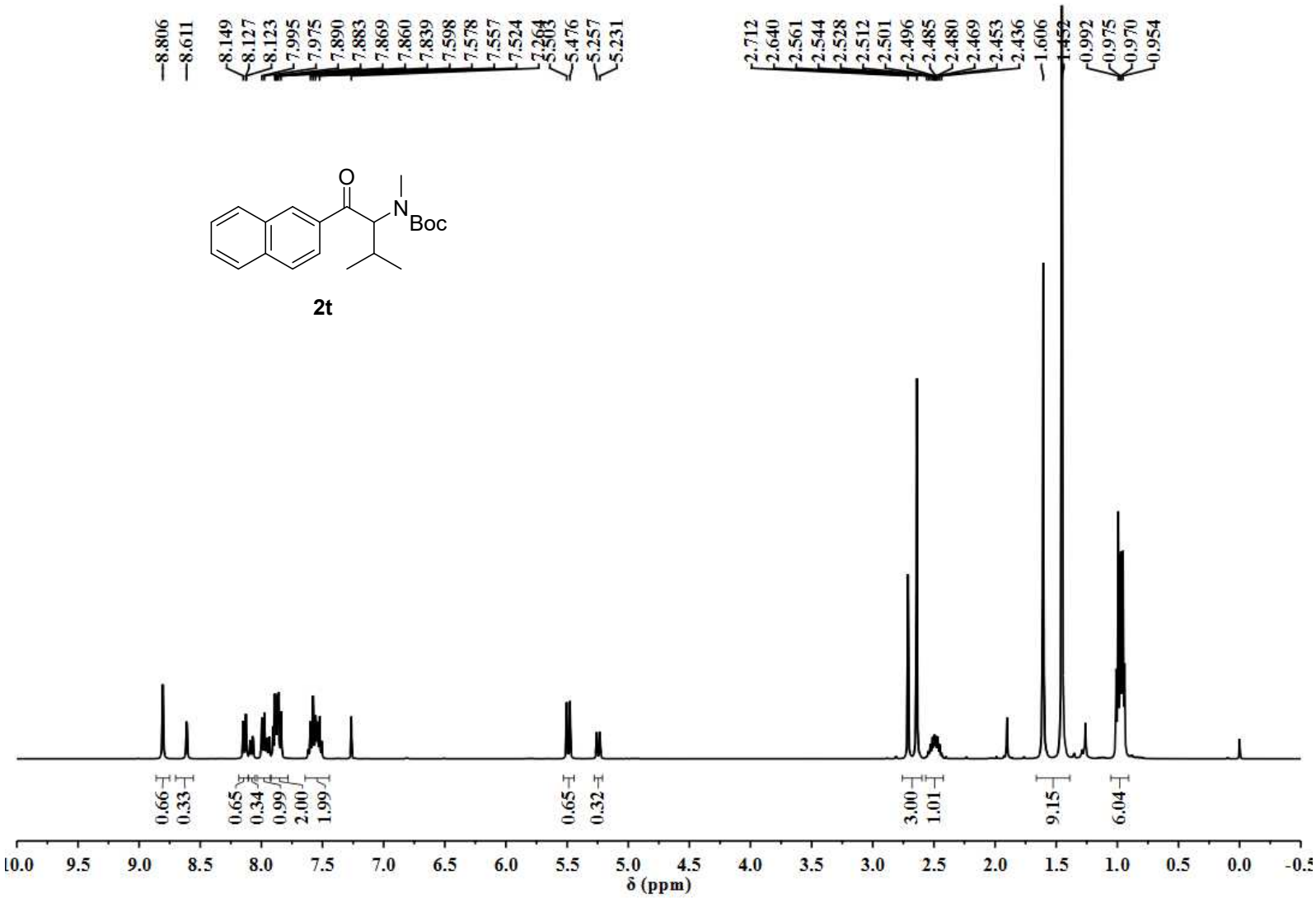

188.228
187.998
156.085
155.455
141.499
141.283
133.711
131.896
131.564
128.087
80.064
80.034
55.811
55.052
35.716
35.601
28.251
28.080
O
S
N
Boc
2q
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

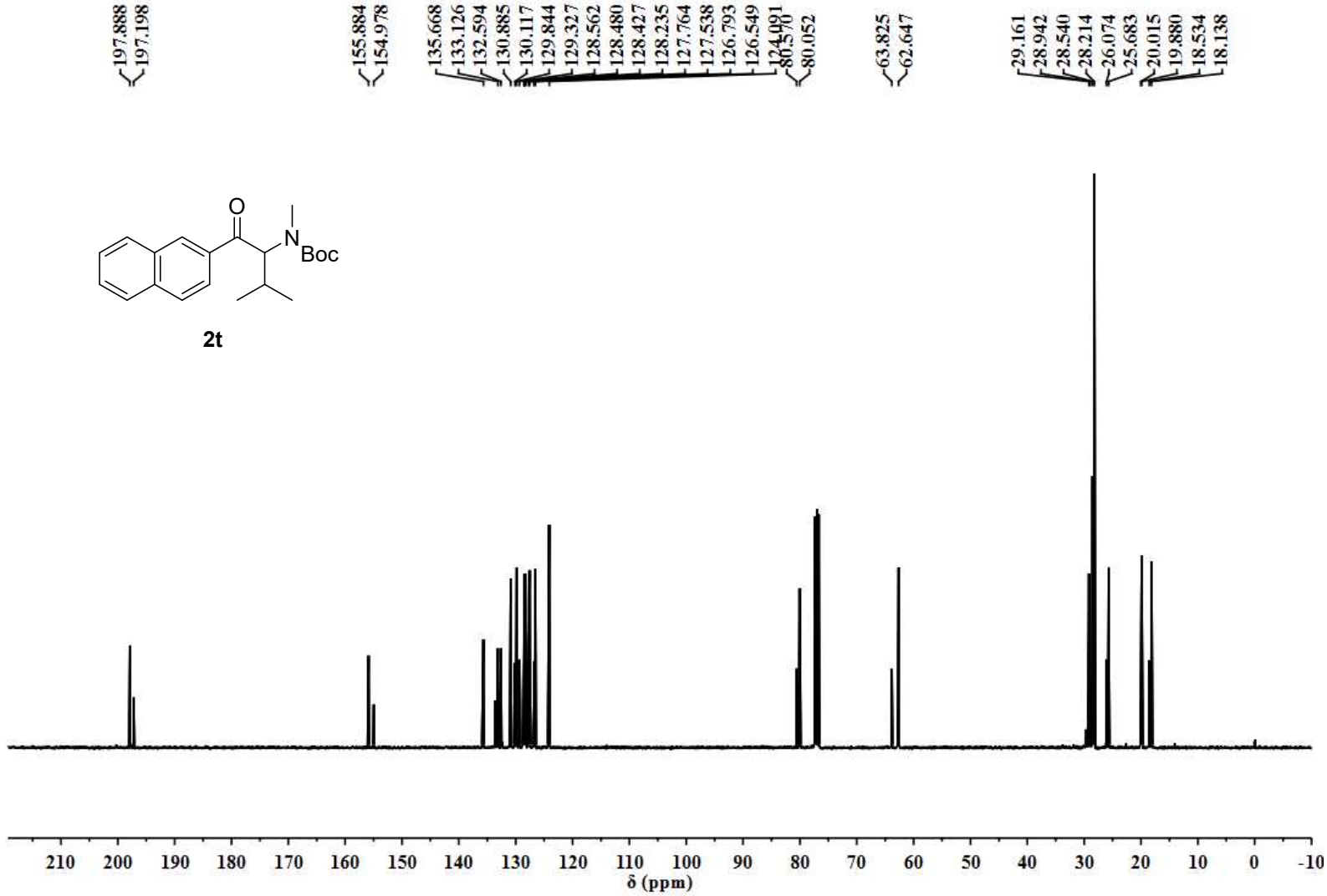

8.506
8.235
8.021
8.004
7.933
7.917
7.876
7.859
7.849
7.832
7.808
7.792
7.598
7.584
7.569
7.541
7.533
7.527
7.513
7.495
7.412
7.407
7.401
7.287
7.261
5.102
4.828
3.184
3.056
O
N
Boc
2r
1.00
1.45
2.66
3.46
2.73
0.87
2.06
3.07
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
δ (ppm)

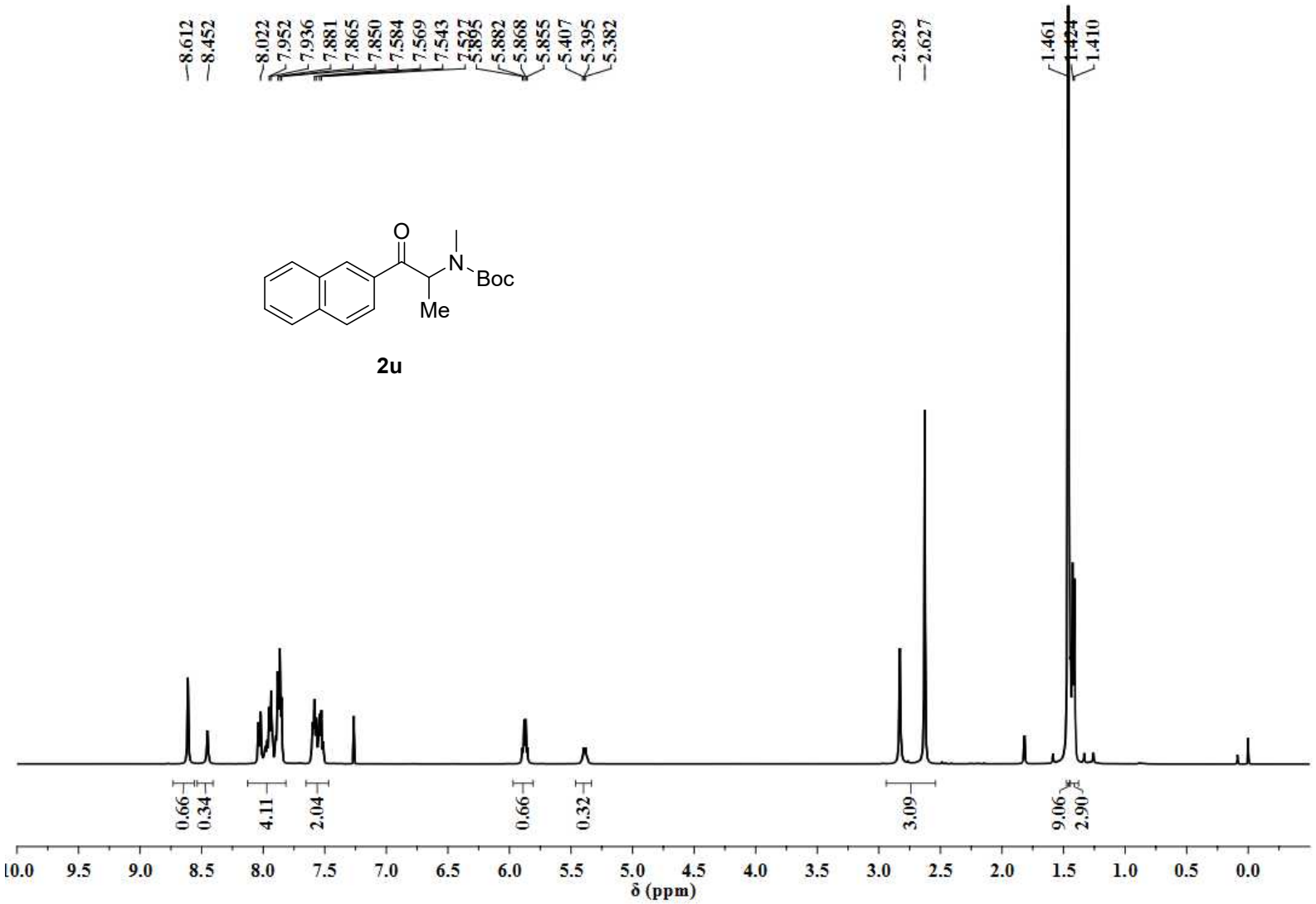

193.891
193.754
172.355
171.914
135.892
135.595
132.301
132.229
132.061
131.703
129.597
129.561
129.430
129.317
128.781
128.643
128.559
128.482
128.371
128.210
127.635
126.995
126.912
126.759
126.347
123.312
122.971
57.809
53.839
38.650
34.604
O
N
Boc
2r
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
δ (ppm)

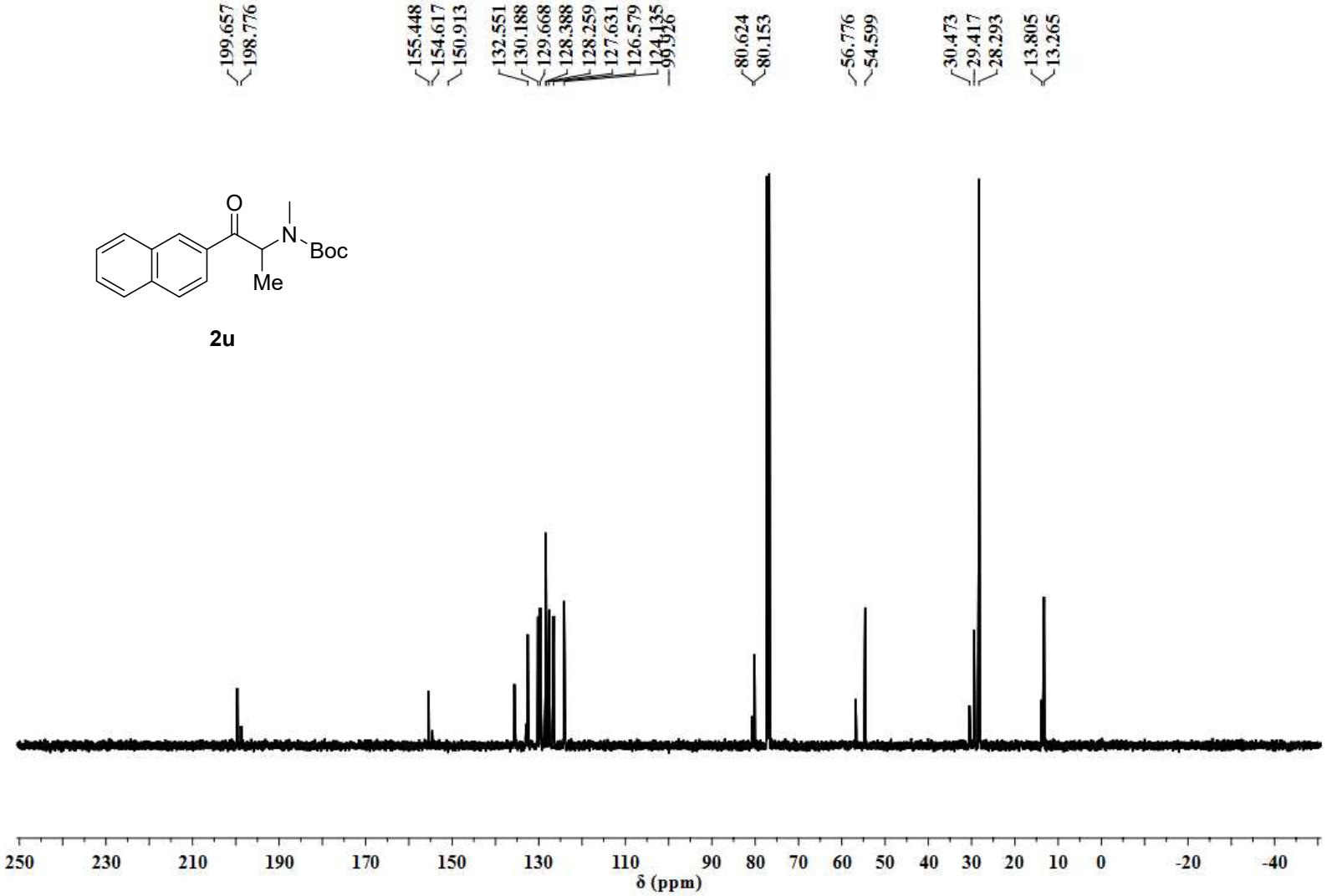

7.751
7.735
7.727
7.723
7.712
7.706
7.696
7.433
7.418
7.403
7.327
7.313
7.300
7.297
7.132
7.127
7.114
7.109
7.099
4.061
4.049
3.993
3.901
2.895
2.863
2.480
2.467
2.453
1.836
1.830
1.463
1.402
O
O
N
Boc
2s
3.03
1.00
1.00
2.01
2.07
2.09
3.00
2.02
4.08
9.43
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
δ (ppm)

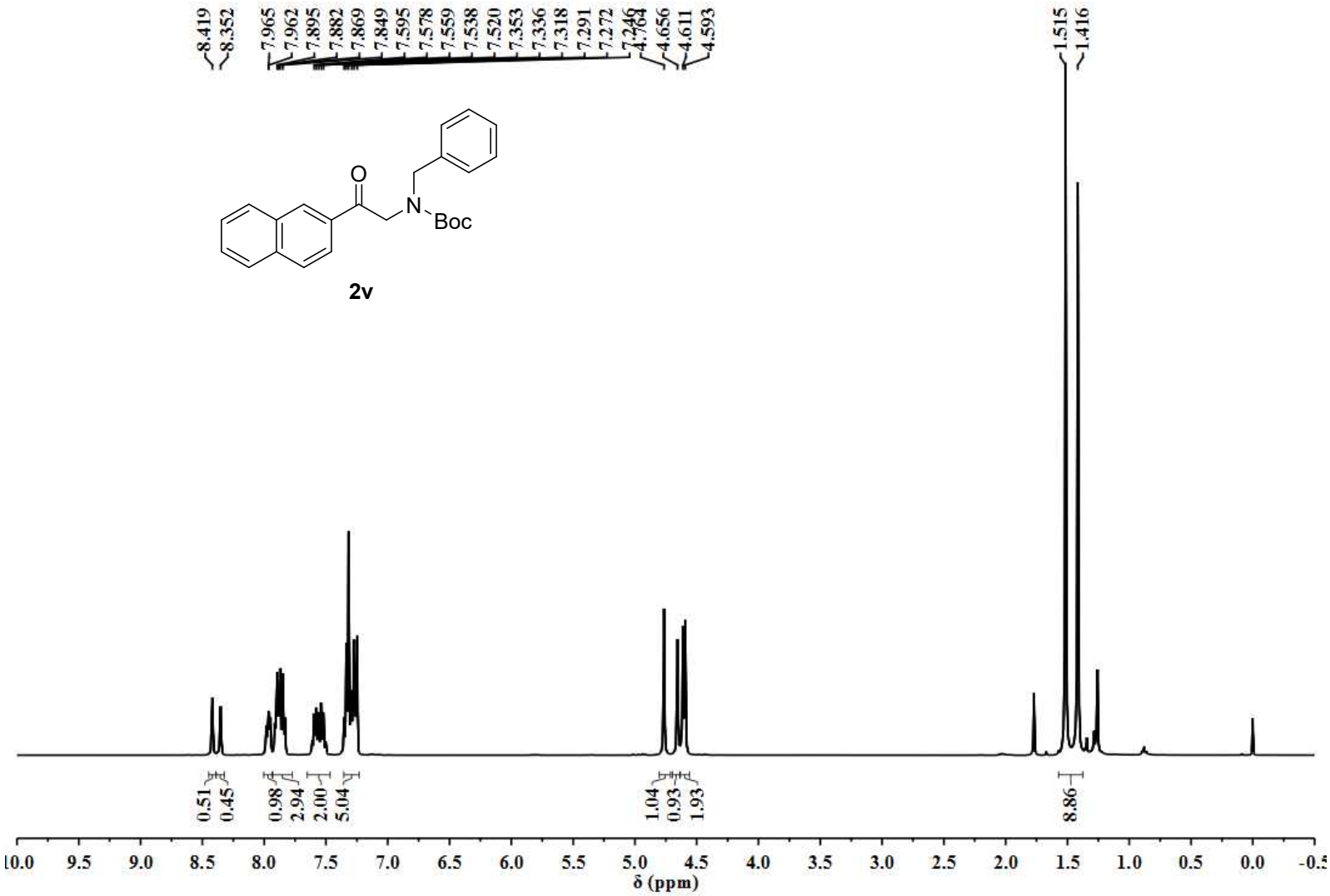

206.313
206.159
156.791
156.753
156.019
155.341
134.476
129.276
129.240
127.524
126.606
126.260
126.213
123.425
118.830
106.482
79.994
79.949
67.371
67.325
58.522
57.839
39.018
38.813
35.686
28.580
28.545
28.248
28.169
20.229
20.041
O
N
Boc
O
2s
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

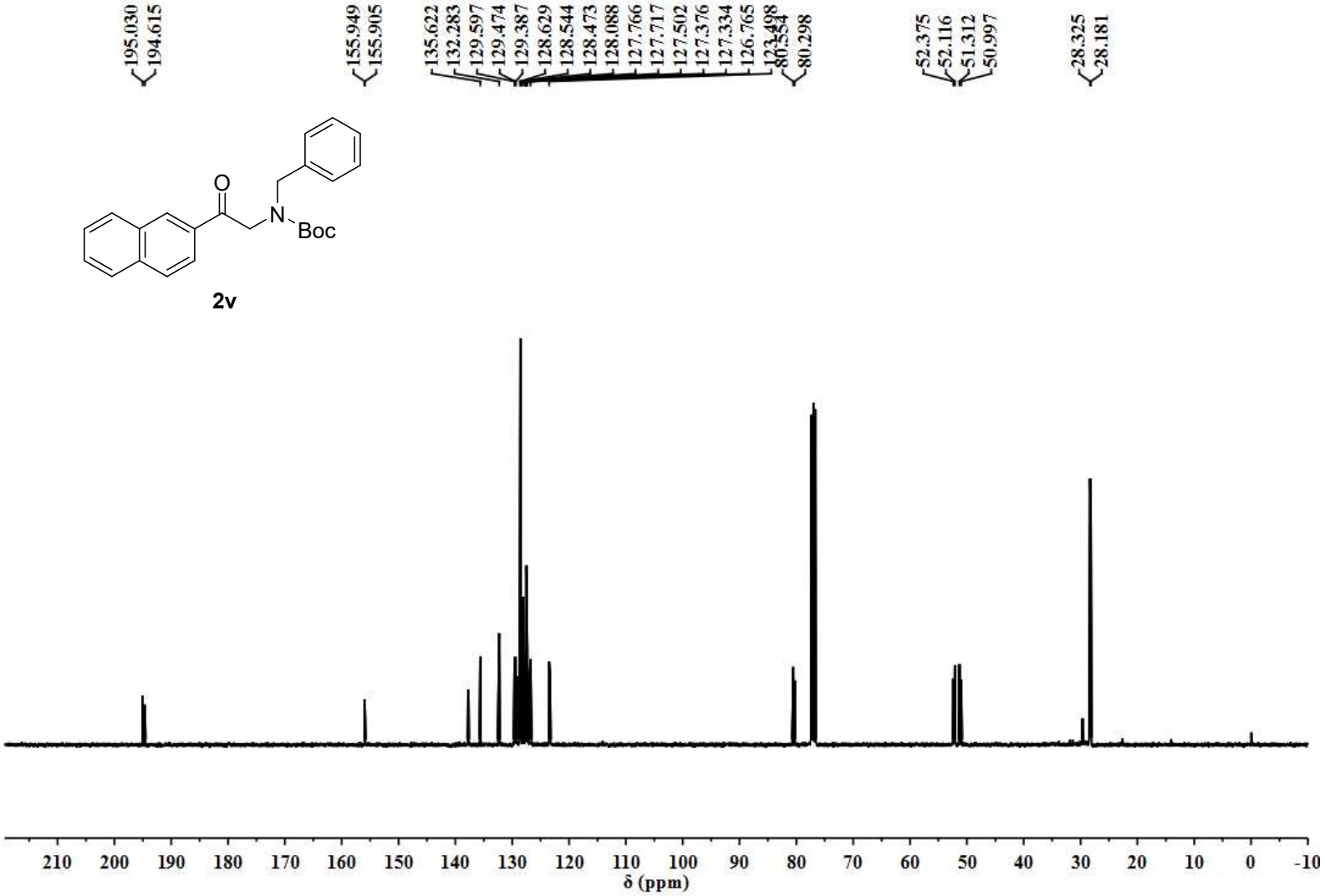

8.806
8.611
8.149
8.127
8.123
7.995
7.975
7.890
7.883
7.869
7.860
7.839
7.598
7.578
7.557
7.524
5.476
5.257
5.231
2.712
2.640
2.561
2.544
2.528
2.512
2.501
2.496
2.485
2.480
2.469
2.453
2.436
1.606
1.452
0.992
0.975
0.970
0.954
O
N
Boc
2t
0.66
0.33
0.65
0.34
0.99
2.00
1.99
0.65
0.32
3.00
1.01
9.15
6.04
δ (ppm)

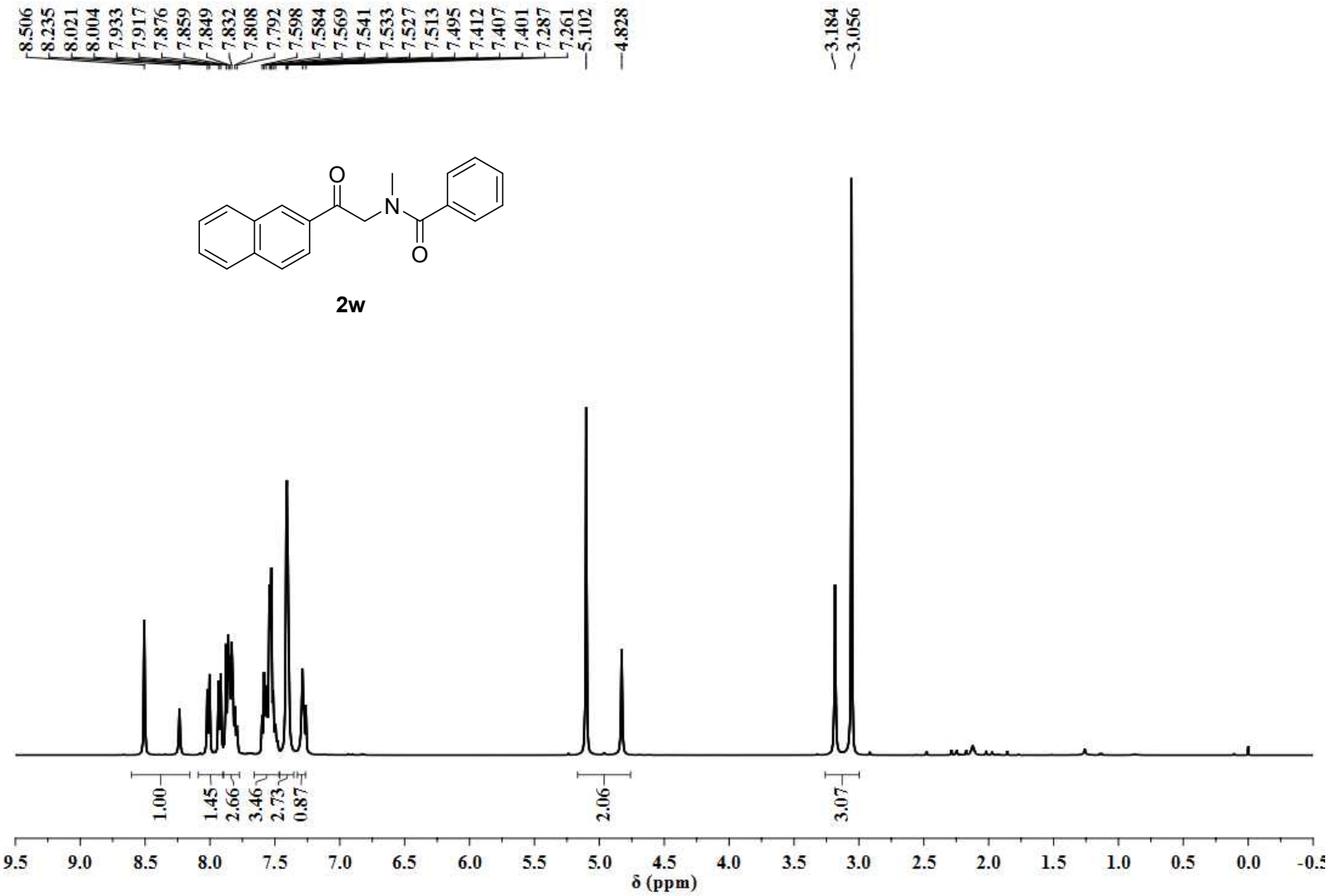

197.888
197.198
155.884
154.978
135.668
133.126
132.594
130.885
130.117
129.844
129.327
128.562
128.480
128.427
128.235
127.764
127.538
126.793
126.549
124.091
80.570
80.052
63.825
62.647
29.161
28.942
28.540
28.214
26.074
25.683
20.015
19.880
18.534
18.138
O
N
Boc
2t
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

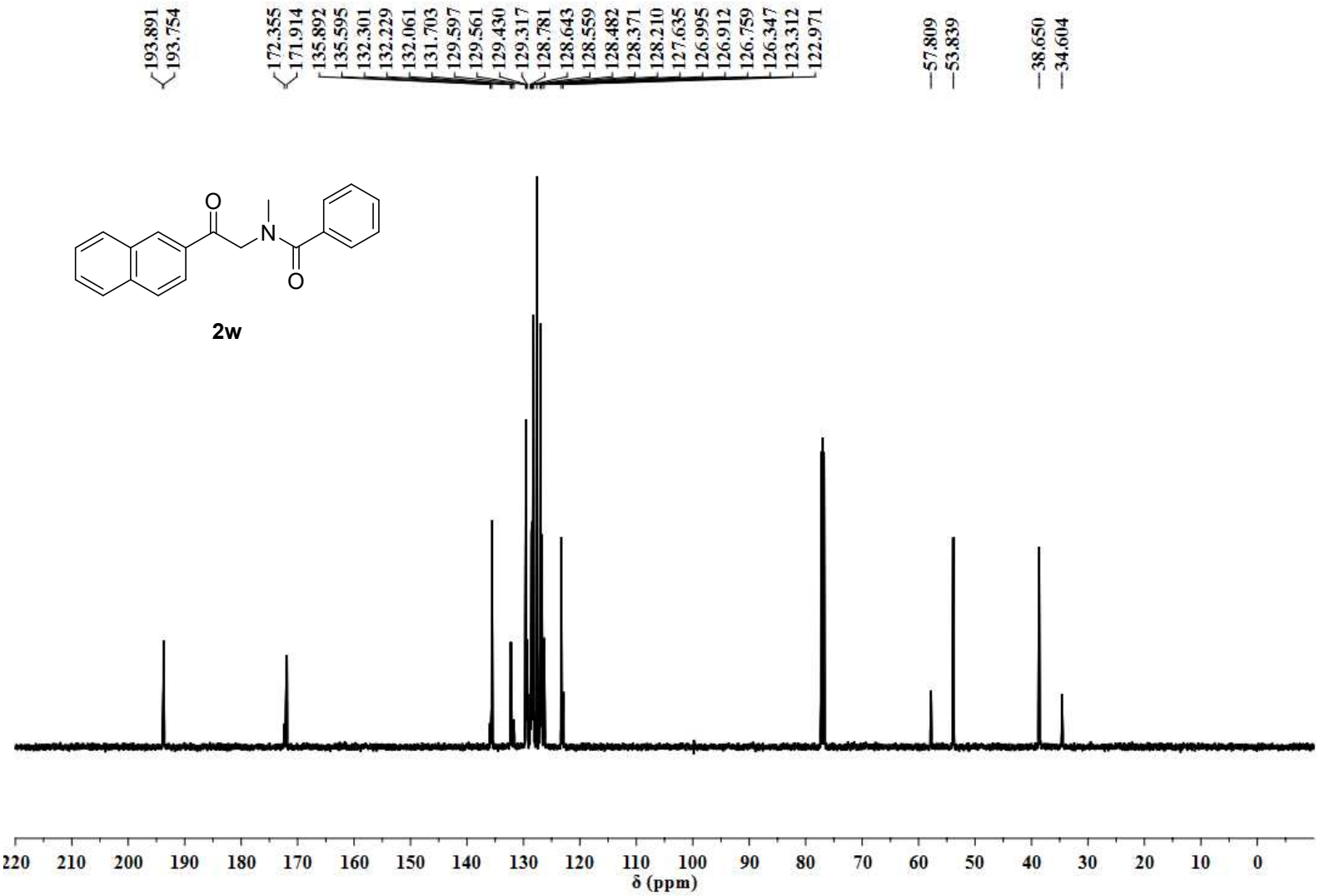

8.612
8.452
8.022
7.952
7.936
7.881
7.865
7.850
7.584
7.569
7.543
7.527
5.895
5.882
5.868
5.855
5.407
5.395
5.382
2.829
2.627
1.461
1.424
1.410
O
N
Boc
Me
2u
0.66
0.34
4.11
2.04
0.66
0.32
3.09
9.06
2.90
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
δ (ppm)

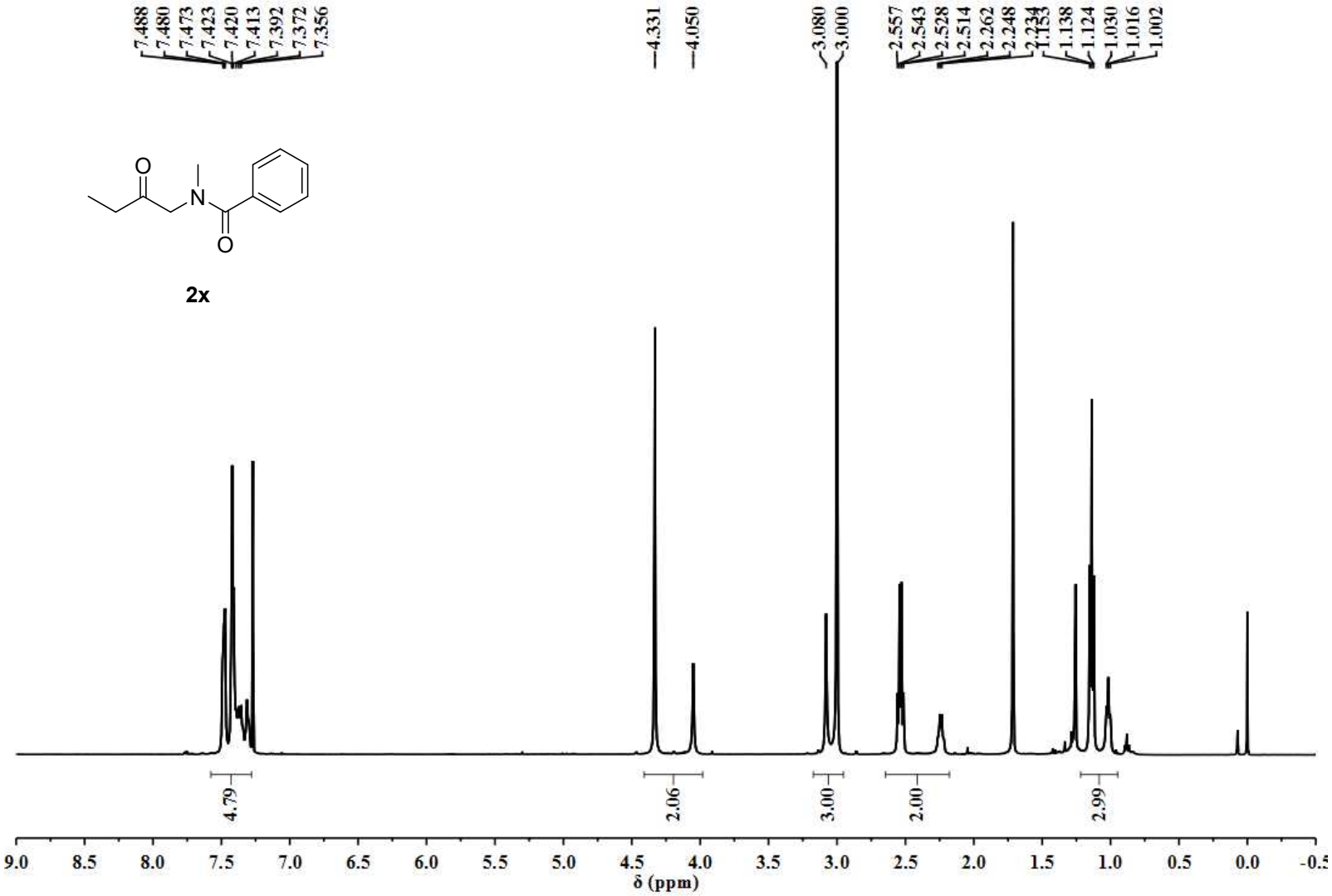

199.657
198.776
155.448
154.617
150.913
132.551
130.188
129.668
128.388
128.259
127.631
126.579
124.135
99.926
80.624
80.153
56.776
54.599
30.473
29.417
28.293
13.805
13.265
O
N
Boc
Me
2u
250
230
210
190
170
150
130
110
90
80
70
60
50
40
30
20
10
0
-20
-40
δ (ppm)

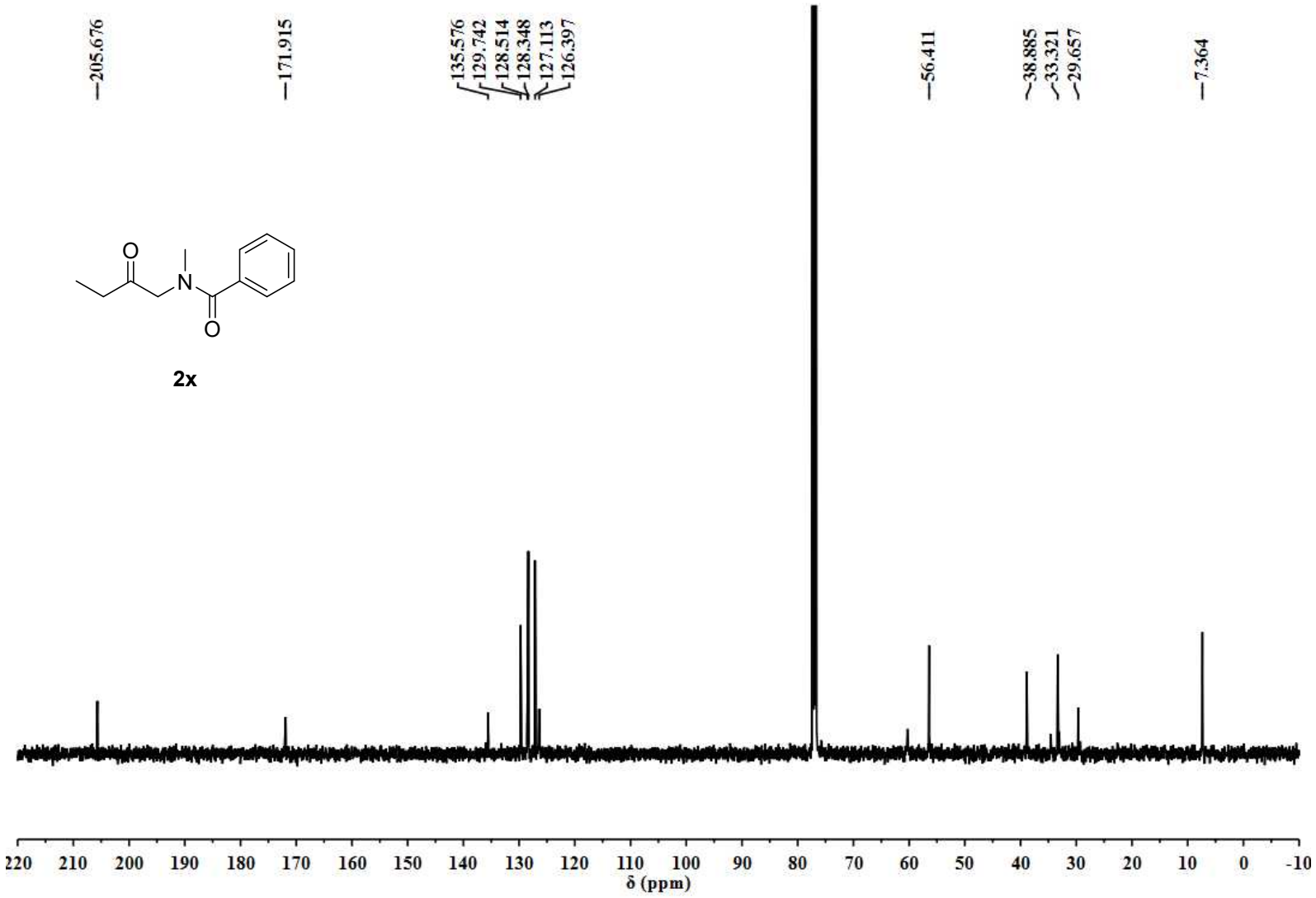

8.419
8.352
7.965
7.962
7.895
7.882
7.869
7.849
7.595
7.578
7.559
7.538
7.520
7.353
7.336
7.318
7.291
7.272
7.246
4.764
4.656
4.611
4.593
1.515
1.416
O
N
Boc
2v
0.51
0.45
0.98
2.94
2.00
5.04
1.04
0.93
1.93
8.86
δ (ppm)

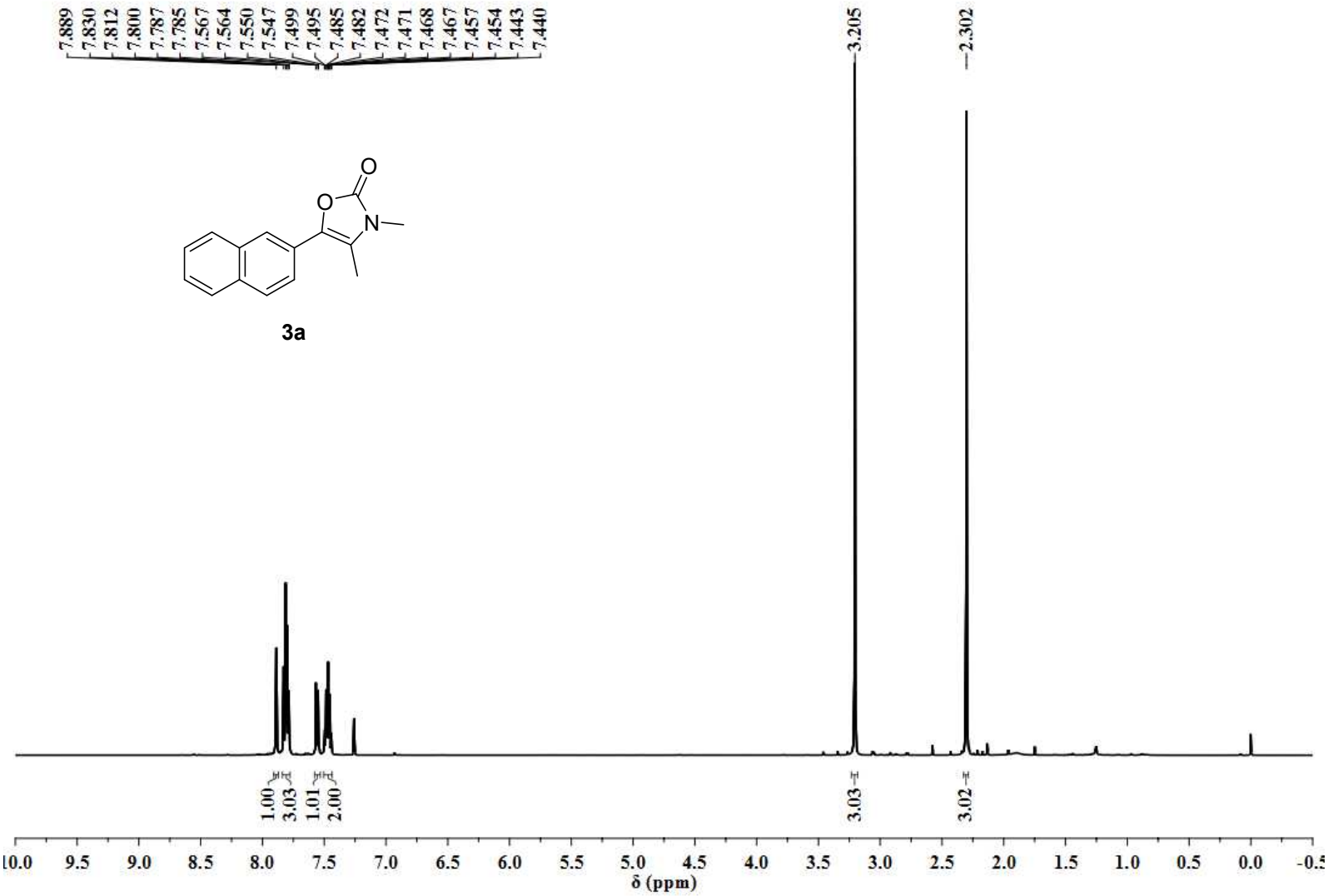

195.030
194.615
155.949
155.905
135.622
132.283
129.597
129.474
129.387
128.629
128.544
128.473
128.088
127.766
127.717
127.502
127.376
127.334
126.765
123.498
80.534
80.298
52.375
52.116
51.312
50.997
28.325
28.181
O
N
Boc
2v
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)


8.506
8.235
8.021
8.004
7.933
7.917
7.876
7.859
7.849
7.832
7.808
7.792
7.598
7.584
7.569
7.541
7.533
7.527
7.513
7.495
7.412
7.407
7.401
7.287
7.261
5.102
4.828
3.184
3.056
O
N
O
2w
1.00
1.45
2.66
3.46
2.73
0.87
2.06
3.07
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
δ (ppm)

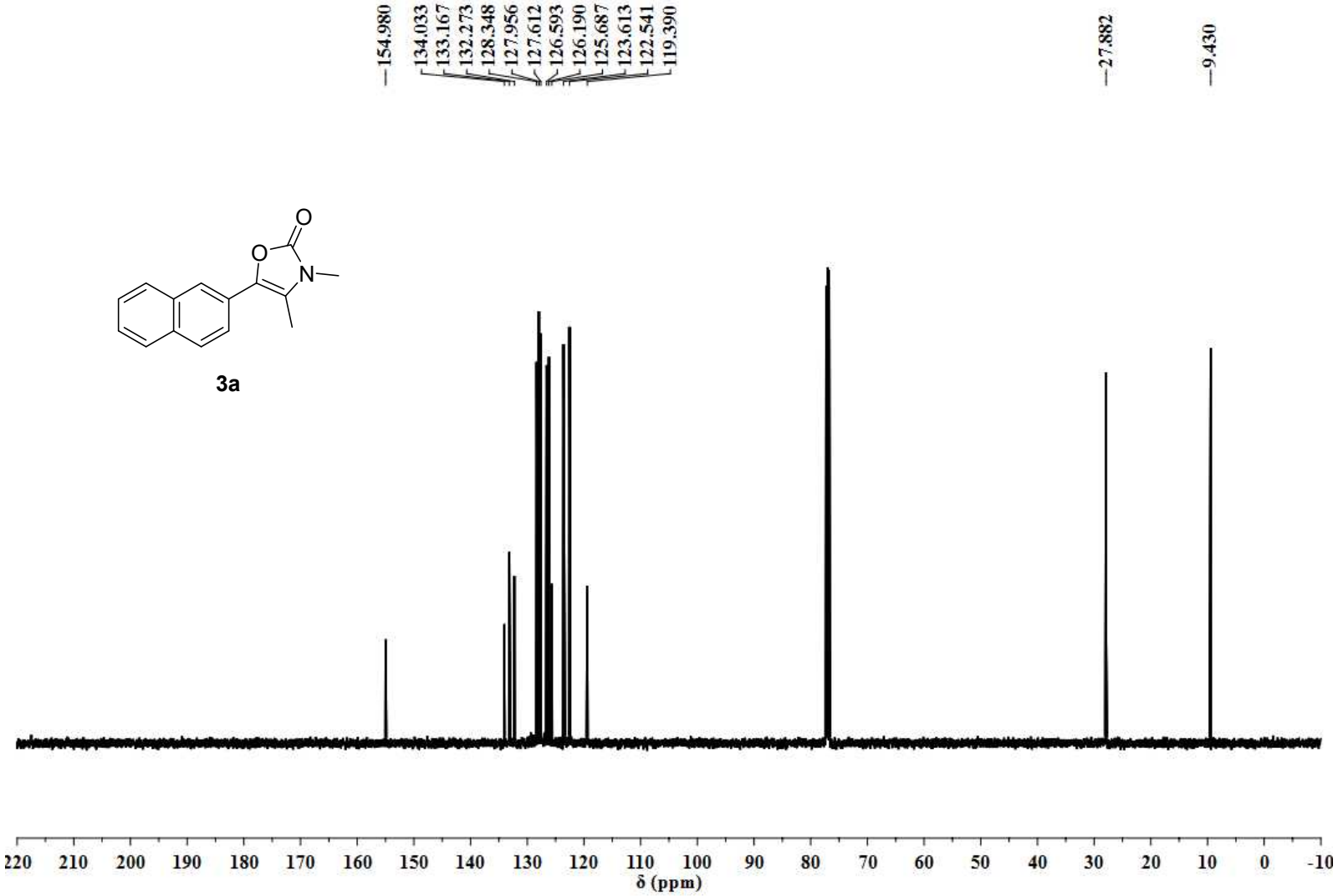

193.891
193.754
172.355
171.914
135.892
135.595
132.301
132.229
132.061
131.703
129.597
129.561
129.430
129.317
128.781
128.643
128.559
128.482
128.371
128.210
127.635
126.995
126.912
126.759
126.347
123.312
122.971
57.809
53.839
38.650
34.604
O
N
O
2w
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
δ (ppm)

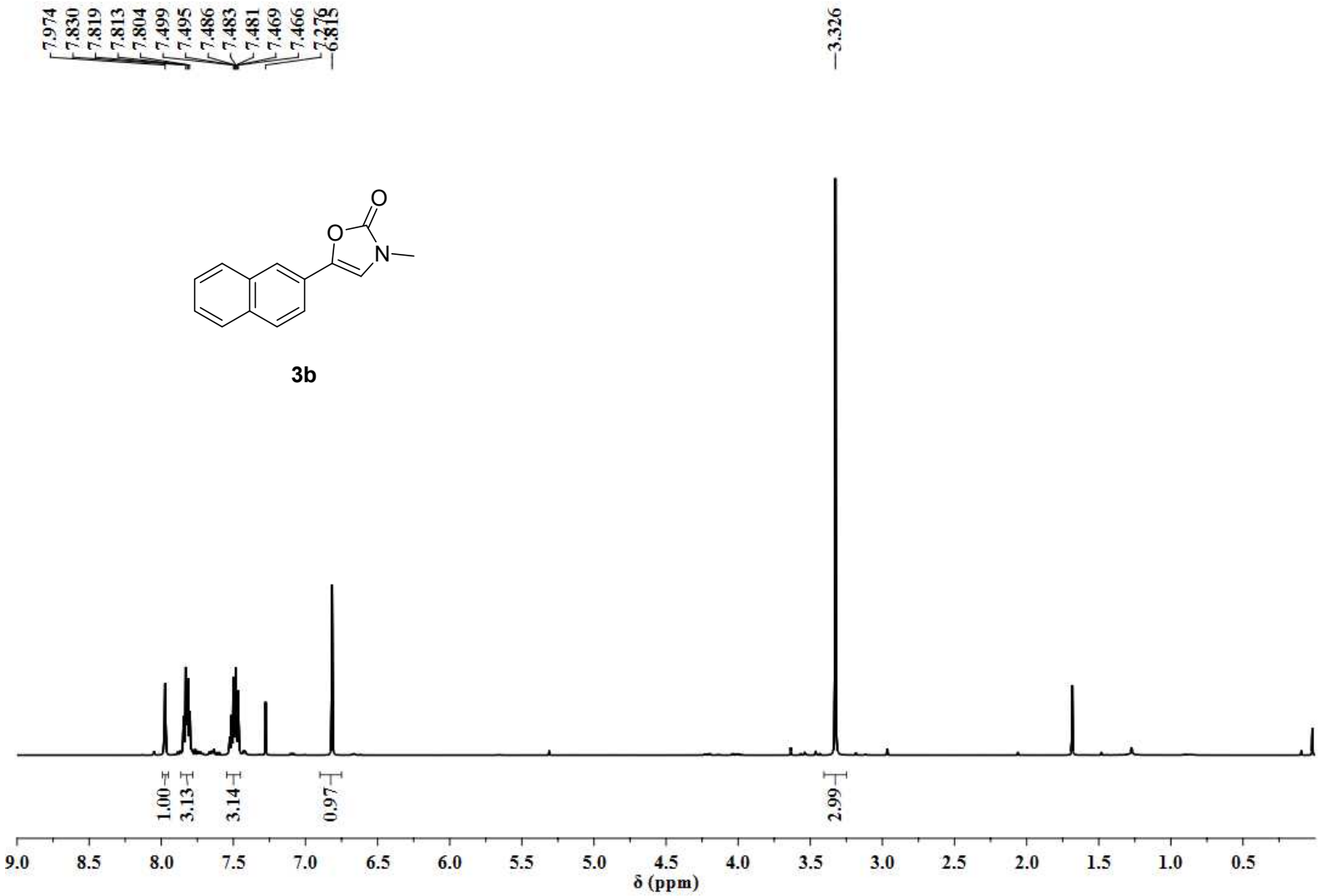

7.488
7.480
7.473
7.423
7.420
7.413
7.392
7.372
7.356
4.331
4.050
3.080
3.000
2.557
2.543
2.528
2.514
2.262
2.248
2.234
1.153
1.138
1.124
1.030
1.016
1.002
O
N
O
2x
4.79
2.06
3.00
2.00
2.99
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
δ (ppm)


205.676
171.915
135.576
129.742
128.514
128.348
127.113
126.397
56.411
38.885
33.321
29.657
7.364
O
N
O
2x
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

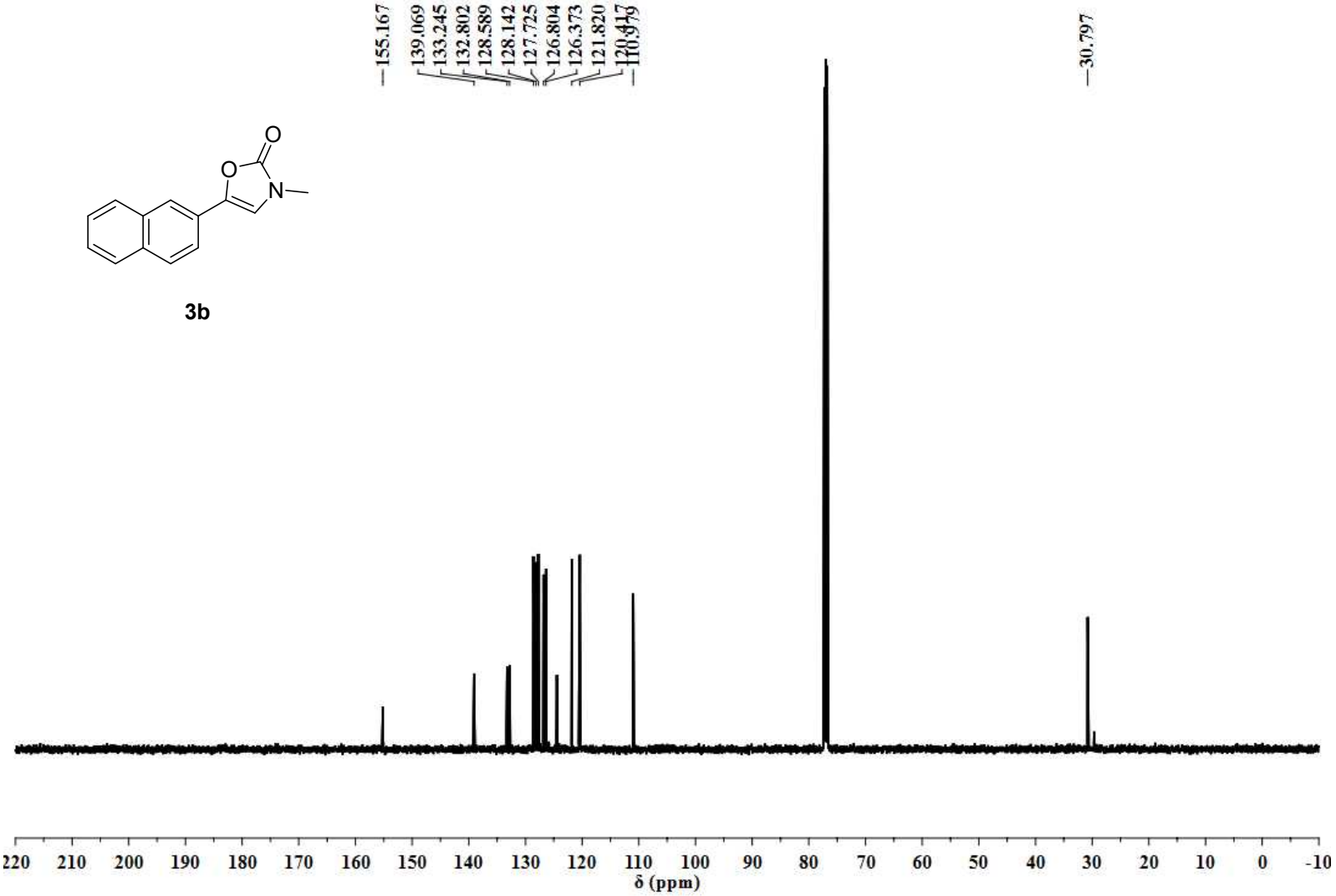

7.889
7.830
7.812
7.800
7.787
7.785
7.567
7.564
7.550
7.547
7.499
7.495
7.485
7.482
7.472
7.471
7.468
7.467
7.457
7.454
7.443
7.440
3.205
2.302
O
O
N
1.00
3.03
1.01
2.00
3.03
3.02
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
δ (ppm)

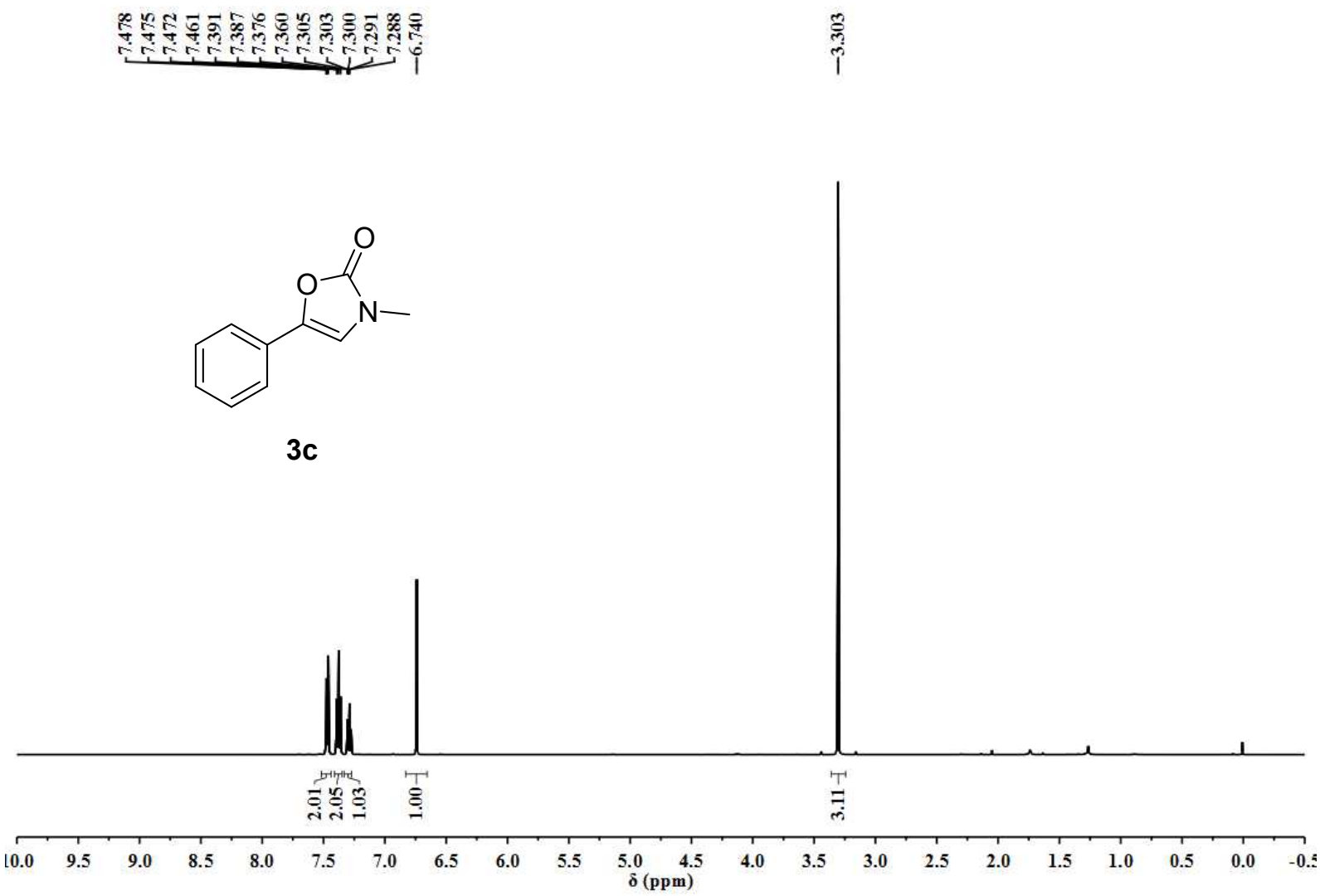
3a


154.980
134.033
133.167
132.273
128.348
127.956
127.612
126.593
126.190
125.687
123.613
122.541
119.390
27.882
9.430
O
O
N
3a
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

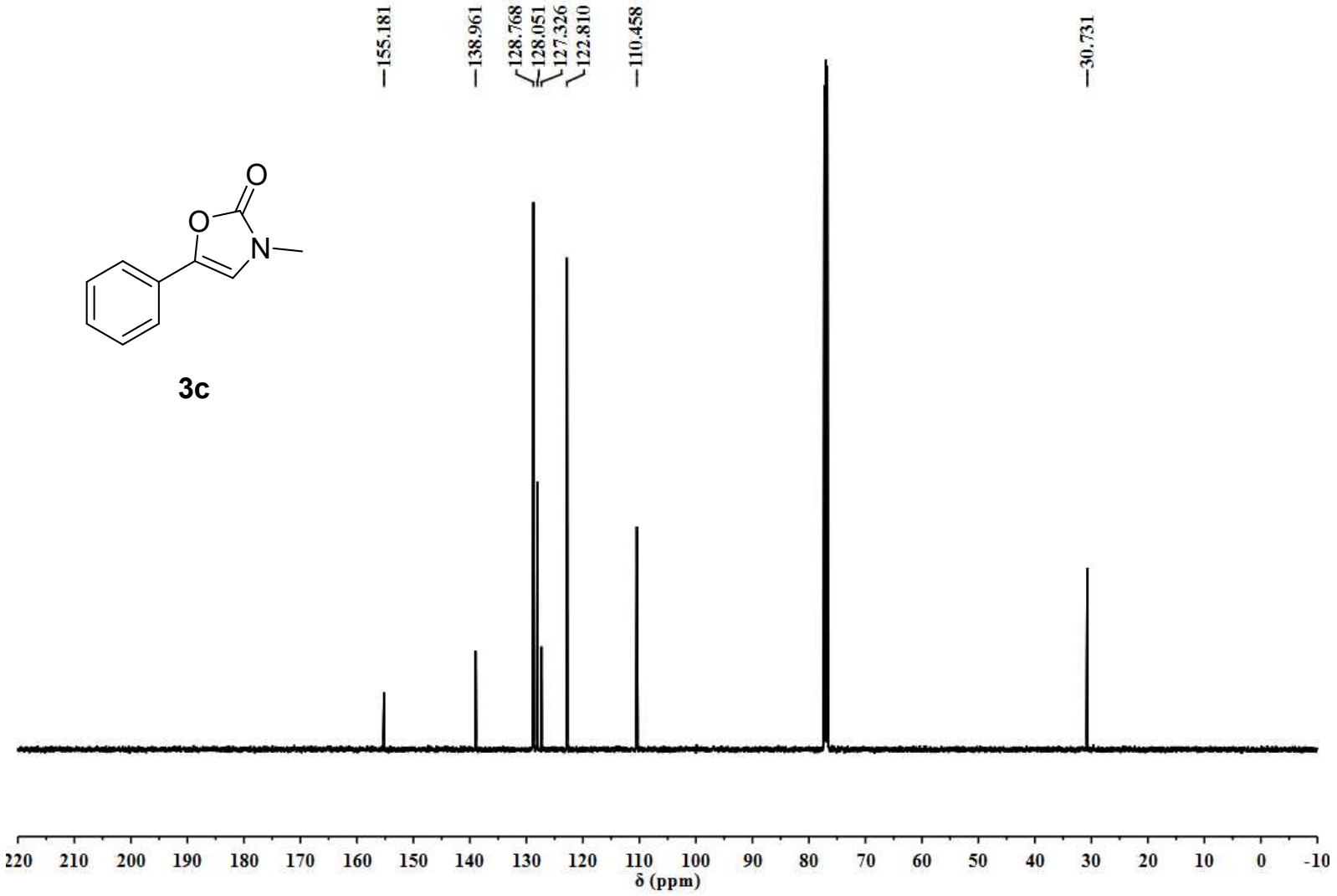

7.974
7.830
7.819
7.813
7.804
7.499
7.495
7.486
7.483
7.481
7.469
7.466
7.276
6.815
3.326
O
O
N
1.00
3.13
3.14
0.97
2.99
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
δ (ppm)

3b

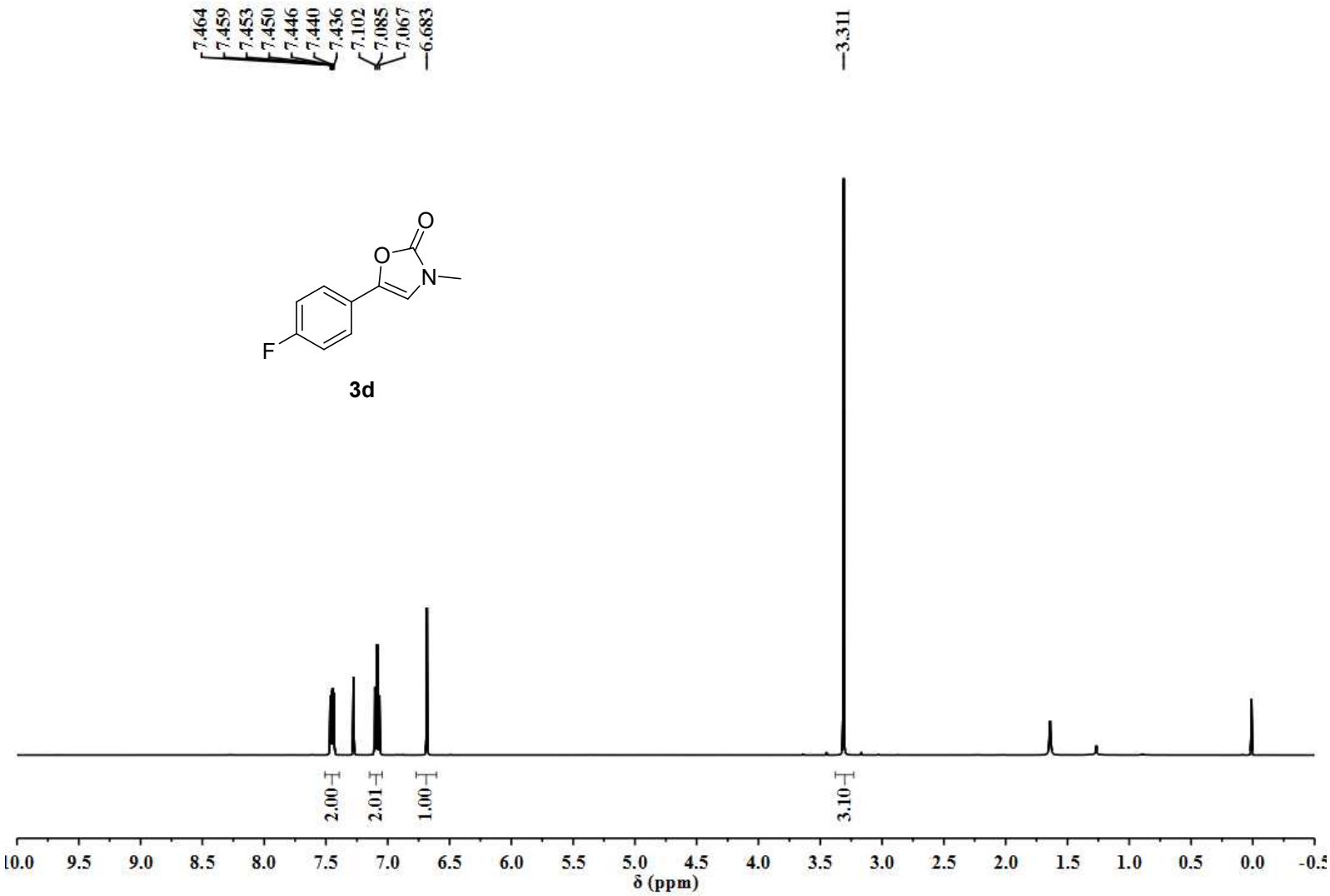

155.167
139.069
133.245
132.802
128.589
128.142
127.725
126.804
126.373
121.820
30.797
O
O
N
3b
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

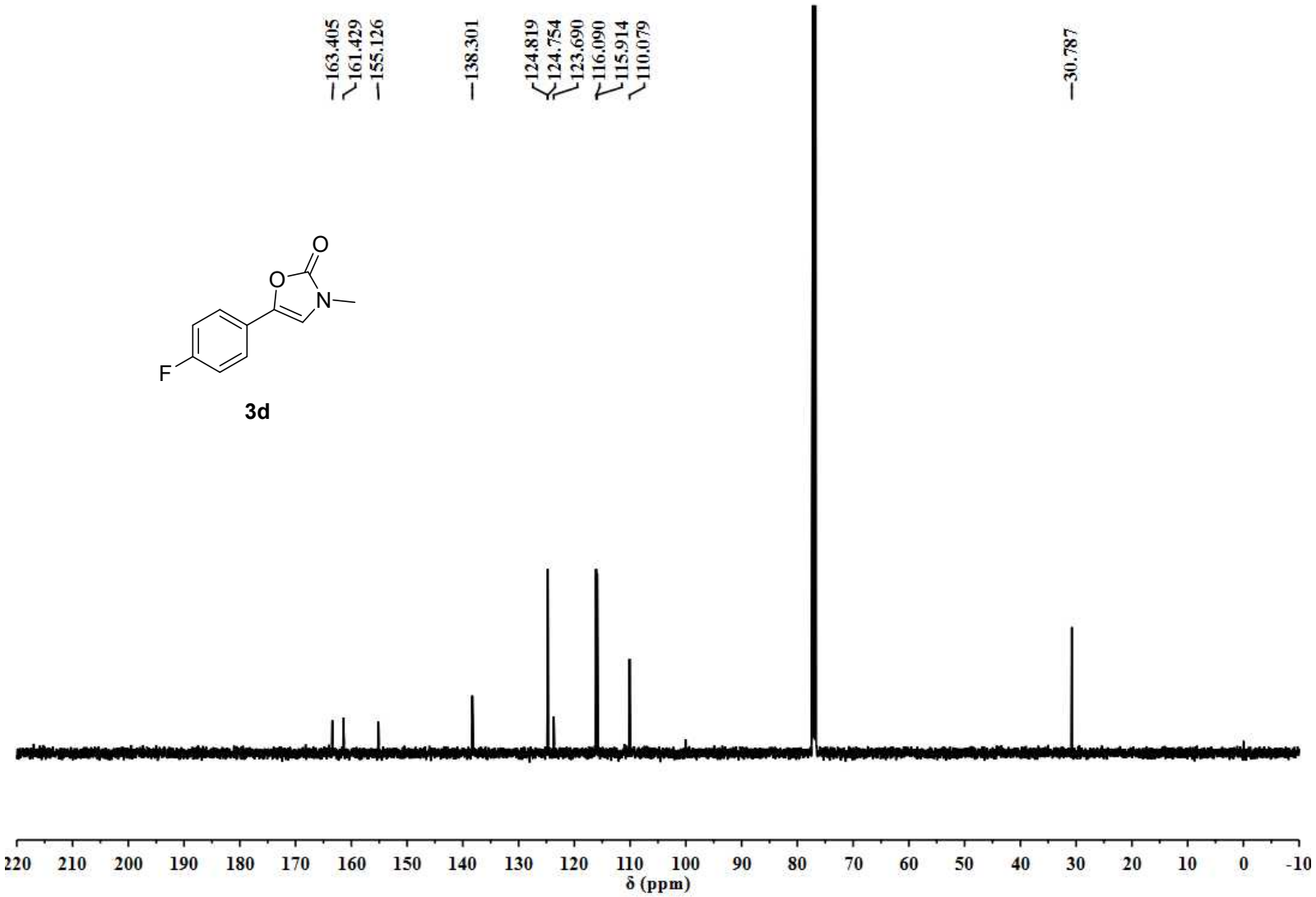

7.478
7.475
7.472
7.461
7.391
7.387
7.376
7.360
7.305
7.303
7.300
7.291
7.288
6.740
3.303
O
O
N
2.01
2.05
1.03
1.00
3.11
δ (ppm)

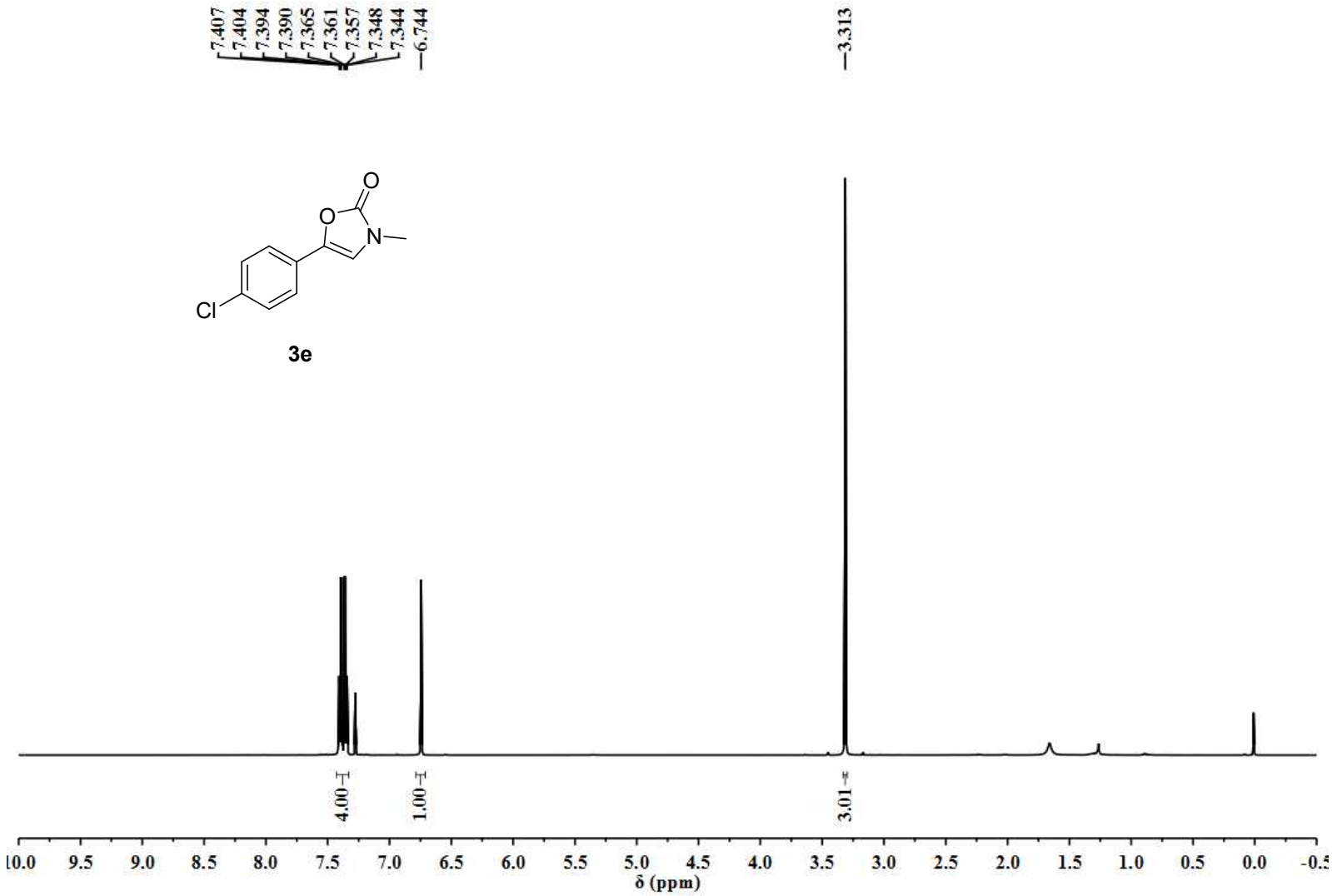
3c


155.181
138.961
128.768
128.051
127.326
122.810
110.458
30.731
O
O
N
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

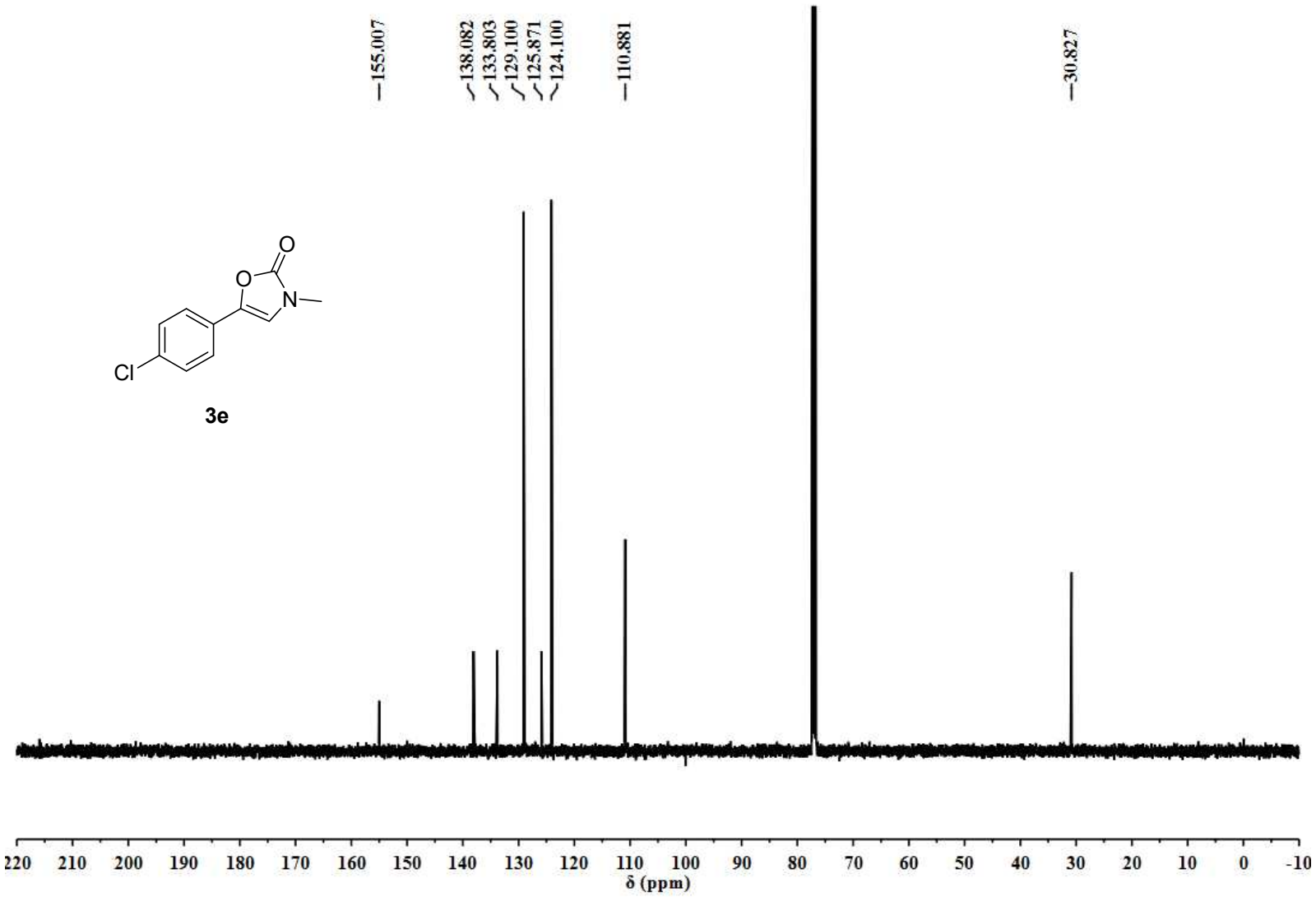
3c

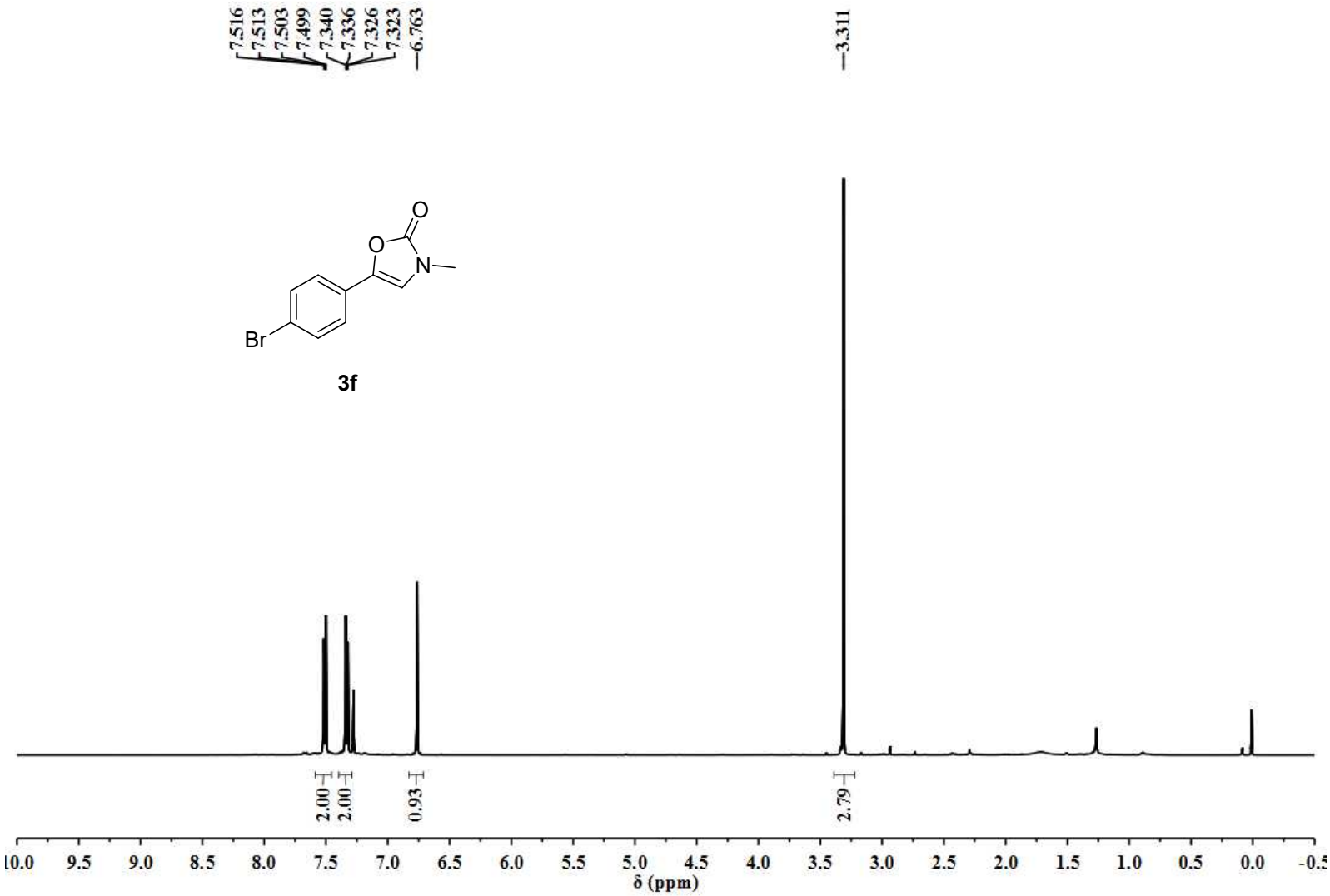

7.464
7.459
7.453
7.450
7.446
7.440
7.436
7.102
7.085
7.067
6.683
3.311
O
O
N
F
3d
2.00
2.01
1.00
3.10
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
δ (ppm)

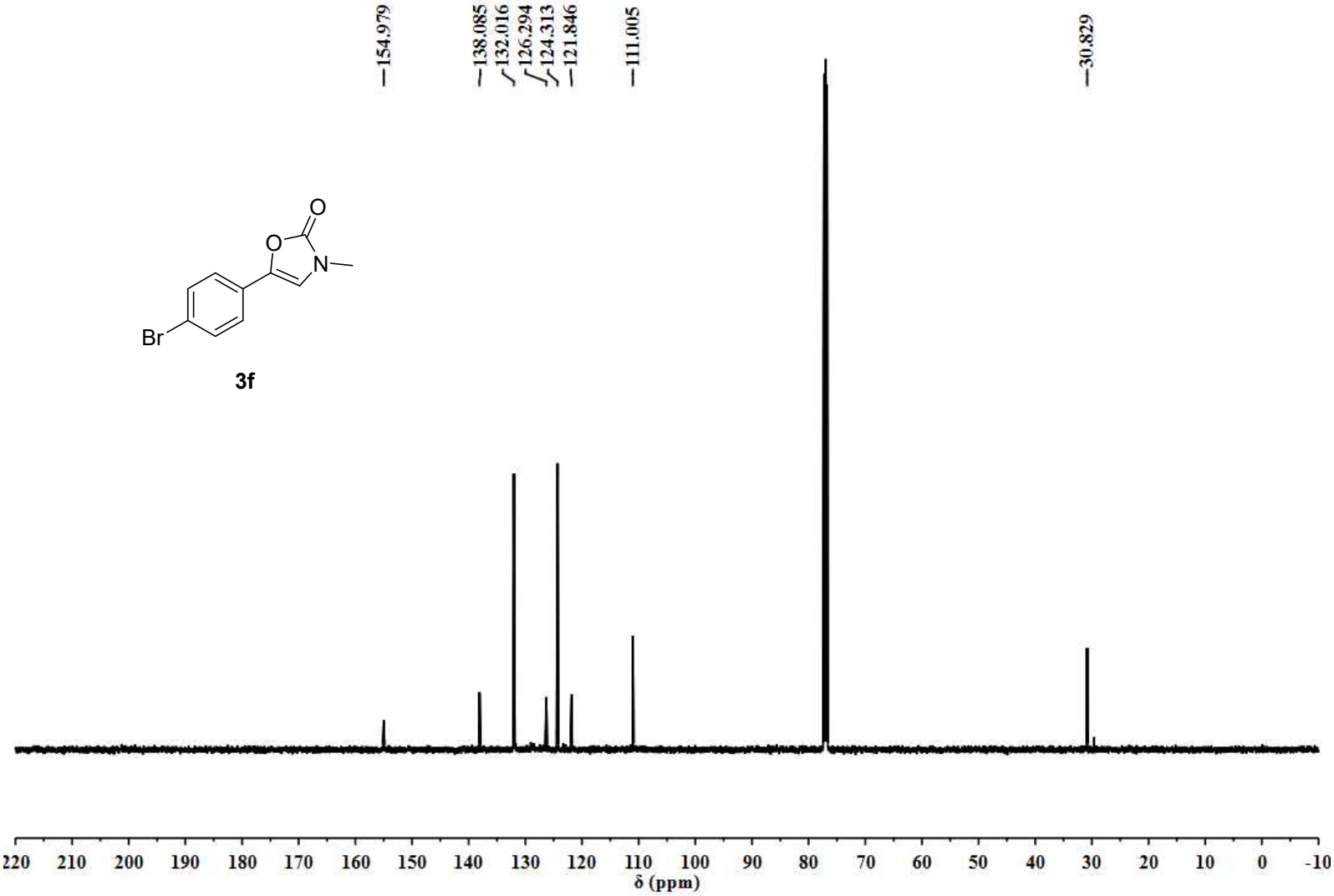

163.405
161.429
155.126
138.301
124.819
124.754
123.690
116.090
115.914
110.079
30.787
O
O
N
F
3d
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)


7.407
7.404
7.394
7.390
7.365
7.361
7.357
7.348
7.344
6.744
3.313
O
O
N
Cl
4.00
1.00
3.01
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
δ (ppm)

3e


155.007
138.082
133.803
129.100
125.871
124.100
110.881
30.827
O
O
N
Cl
3e
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)


7.516
7.513
7.503
7.499
7.340
7.336
7.326
7.323
6.763
3.311
O
O
N
Br
3f
2.00
2.00
0.93
2.79
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
δ (ppm)


154.979
138.085
132.016
126.294
124.313
121.846
111.005
30.829
O
O
N
Br
3f
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)