Supplementary Information

Synthesis of non-C_2 Symmetrical NOBIN-Type Biaryls Through a Cascade *N*-Arylation and [3,3]-Sigmatropic Rearrangement from *O*-Arylhydroxylamines and Diaryliodonium Salts

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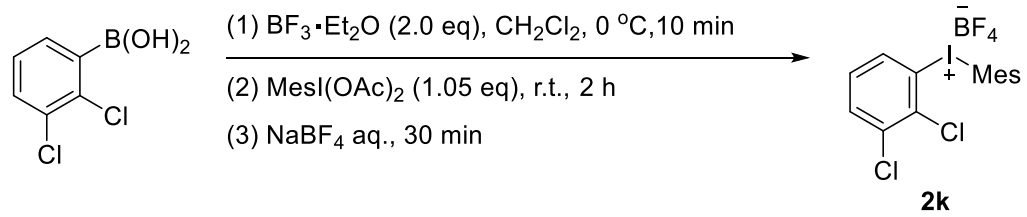
General remarks

All reactions were carried out under an atmosphere of nitrogen with magnetic stirring unless otherwise noted. Solvents were dried following standard procedures under argon. Syringe was used to transfer liquids and solutions. All reactions were monitored by thin-layer chromatography (TLC) with E. Merck silica gel 60 F254 pre-coated plates (0.25 mm). Silica gel (particle size 200-300 mesh) purchased from SiliCycle was used for flash chromatography. For reactions that require heating, oil bath was used.

Proton (^{1}H) and carbon (^{13}C) NMR spectra were taken on a Bruker AV-500 spectrometer operating at 500 MHz or 400 MHz for proton and 126 MHz or 101 MHz for carbon nuclei using $CDCl_3$ or DMSO- d_6 as solvent, respectively. Chemical shifts are expressed as parts per million (δ, ppm) and are referenced to 7.26 ($CDCl_3$) for ^{1}H NMR and 77.00 ($CDCl_3$) for ^{13}C NMR. Proton signal data uses the following abbreviations: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet and *J* = coupling constant. High Resolution Mass Spectrometry was obtained with a Bruker Apex II mass instrument under the conditions of electrospray ionization (ESI) in both positive and negative mode.

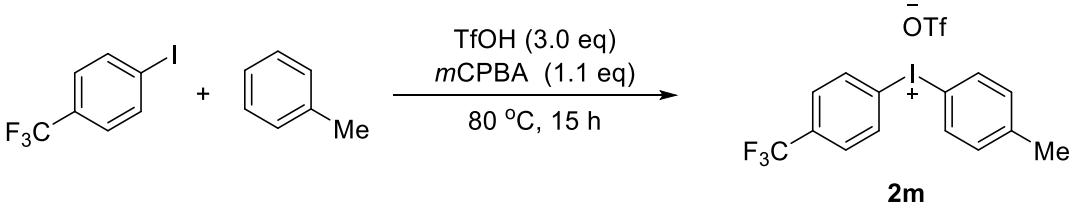
Materials and Methods. Diaryliodonium substrates **2a-d, 2h**[1]**; 2e, 2i, 2j**[2]**; 2f, 2l, 2n**[3]**; 2g**[4]and **2o**[5] were prepared according to literature procedures.

General procedure for the synthesis of Diaryliodonium Substrate



2k

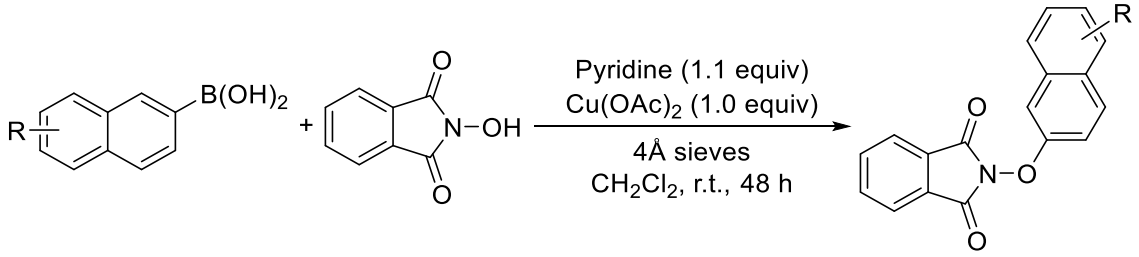
(2,3-dichlorophenyl)boronic acid (5 mmol, 1.0 equiv) and CH_2Cl_2 (50 mL) were combined in an oven-dried round-bottom flask equipped with a stir bar. The mixture was cooled to 0 ℃, BF_3•OEt_2 (2.0 equiv) was added, and the mixture was stirred for 10 min. 2-(Diacetoxyiodo)mesitylene (5.25 mmol, 1.05 equiv) was then added as a solution in CH_2Cl_2 (15 mL), and the mixture was warmed to room temperature and stirred for 2 h. The reaction was quenched by the addition of saturated aqueous $NaBF_4$. After 30 minutes of vigorous stirring, the aqueous layer was extracted with CH_2Cl_2. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under vacuum. The crude residue was then recrystallized or stirred with Et_2O to obtain the desired compound.



2m

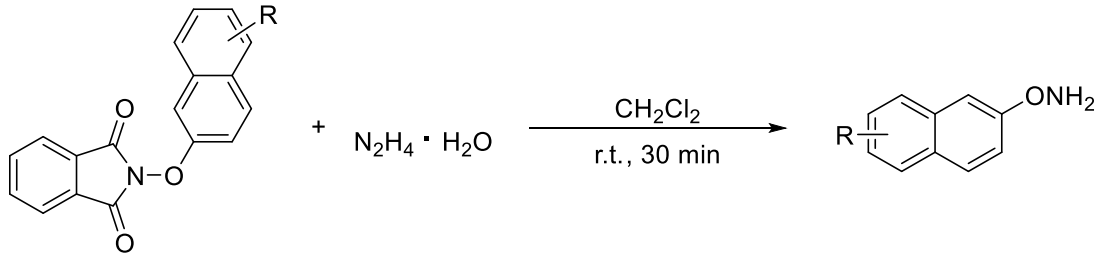
A suspension of (difluoro-λ^3-methyl)(4-iodophenyl)-λ^2-fluorane (5 mmol, 1.0 equiv) and *m*CPBA (1.1 equiv) in CH_2Cl_2 (25 mL) was stirred. Then, PhMe (1.1 equiv) was added, and TfOH (3.0 equiv) was added dropwise to the above mixture at room temperature. The reaction mixture was stirred in 80 ℃ for 15 hours and subsequently concentrated under vacuum. Et_2O (20 mL) was added and the mixture was stirred at room temperature for 10 min to precipitate out a white solid.

General procedure for the synthesis of protected *O*-Arylhydroxyl-amines[7, 8]



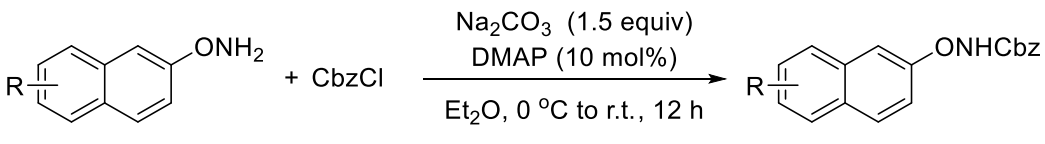
S1 **S2**

A solution of naphthylboronic acid (1.0 equiv), *N*-hydroxyphthalimide (2.0 equiv), copper acetate (1.0 equiv) and freshly activated 4 Å molecular sieves (250 mg/mmol) in anhydrous CH_2Cl_2 (0.25 M). Then pyridine (1.1 equiv) was added to the the suspension. The reaction mixture was stirred at room temperature under air atmosphere for 48 hours. The reaction mixture was filtered and concentrated. The residue was purified by column chromatography to give the desired product **S2**.



S2 **S3**

Hydrazine monohydrate (1.5 equiv) was added to the solution of *N*-aryloxyphthalimide (1.0 equiv) in CH_2Cl_2 (0.25 M). Then, the solution was stirred for 30 minutes at room temperature. The reaction mixture was filtered off and the filtrate was concentrated under reduced pressure. The crude product was purified by column chromatography to obtain the product **S3**.

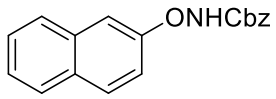


S3 **S4**

Under air atmosphere, a suspension of *N*-aryloxyamine (1.0 equiv), Na_2CO_3 (1.5 equiv) and DMAP (10 mol%) in Et_2O (15 mL) was stirred. Then, benzyl carbonochloridate (1.2 equiv) was added dropwise to the above mixture in 0 ℃. The reaction mixture was stirred at room temperature for 12 hours. Upon completion, the solvent was removed in vacuo, the crude product was purified by flash chromatography to obtain **S4**.

Analysis data of starting materials

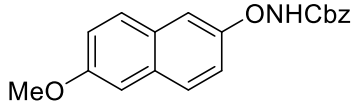
1. benzyl (naphthalen-2-yloxy)carbamate (1a)



1a

81% yield; Pink solid, m.p. = 156-158 °C; R_f = 0.3 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76 (s, 1H), 7.73 – 7.69 (m, 2H), 7.67 – 7.64 (m, 1H), 7.42 – 7.36 (m, 2H), 7.33 – 7.26 (m, 6H), 7.18 (d, *J* = 2.8 Hz, 1H), 5.19 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 157.5, 157.3, 135.2, 134.1, 130.2, 129.6, 128.7, 128.6, 128.4, 127.7, 127.2, 126.6, 124.5, 115.4, 107.9, 68.2; HRMS (ESI) m/z calcd for $[C_{18}H_{16}NO_3]^+$ $[M+H]^+$: 294.1125, found 294.1130.

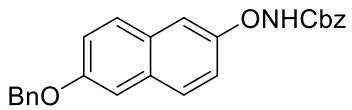
2. benzyl ((6-methoxynaphthalen-2-yl)oxy)carbamate (1b)



1b

63% yield; White solid, m.p. = 151-153 °C; R_f = 0.3 (PE:EA = 5:1); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.33 (s, 1H), 7.84 – 7.74 (m, 2H), 7.42 (dq, *J* = 17.5, 8.0, 6.0 Hz, 6H), 7.31 (t, *J* = 3.4 Hz, 1H), 7.25 (dd, *J* = 8.7, 2.9 Hz, 1H), 7.17 (dd, *J* = 8.6, 2.9 Hz, 1H), 5.22 (d, *J* = 4.6 Hz, 2H), 3.86 (d, *J* = 4.7 Hz, 3H); ^{13}C NMR (101 MHz, DMSO- d_6) δ 157.3, 156.6, 156.5, 136.6, 131.0, 129.4, 128.93, 128.88, 128.8, 128.6, 128.4, 119.7, 116.2, 107.9, 106.6, 67.0, 55.6; HRMS (ESI) m/z calcd for $[C_{19}H_{18}NO_4]^+$ $[M+H]^+$: 324.1230, found 324.1234.

3. benzyl ((6-(benzyloxy)naphthalen-2-yl)oxy)carbamate (1c)

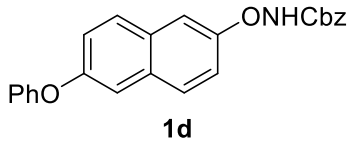


1c

45% yield; Red solid, m.p. = 139-141 °C; R_f = 0.3 (PE:EA = 5:1); ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.30

(s, 1H), 8.03 – 7.87 (m, 1H), 7.78 (d, *J* = 9.0 Hz, 1H), 7.69 – 7.58 (m, 1H), 7.53 – 7.32 (m, 11H), 7.27 – 7.17 (m, 2H), 5.19 (d, *J* = 7.1 Hz, 4H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 157.3, 156.6, 155.7, 137.5, 136.6, 130.9, 129.5, 128.92, 128.89, 128.8, 128.6, 128.4, 128.31, 128.26, 128.2, 119.9, 116.3, 108.0, 107.9, 69.8, 67.0; HRMS (ESI) m/z calcd for $[C_{25}H_{22}NO_4]^+$ $[M+H]^+$: 400.1543, found 400.1535.

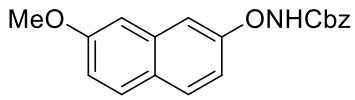
4. benzyl ((6-phenoxynaphthalen-2-yl)oxy)carbamate (1d)



1d

56% yield; White solid, m.p. = 143-145 °C; R_f = 0.3 (PE:EA = 5:1); ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.34 (s, 1H), 7.90 (d, *J* = 8.9 Hz, 1H), 7.81 (d, *J* = 9.0 Hz, 1H), 7.50 (d, *J* = 2.6 Hz, 1H), 7.43 – 7.36 (m, 8H), 7.27 (ddd, *J* = 9.1, 4.1, 2.5 Hz, 2H), 7.18 – 7.13 (m, 1H), 7.07 – 7.04 (m, 2H), 5.20 (s, 2H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 157.44, 157.37, 157.2, 153.6, 136.6, 130.9, 130.7, 130.5, 129.7, 129.3, 128.9, 128.6, 128.4, 123.9, 121.1, 119.0, 116.6, 114.7, 107.8, 67.0; HRMS (ESI) m/z calcd for $[C_{24}H_{20}NO_4]^+$ $[M+H]^+$: 386.1387, found 386.1392.

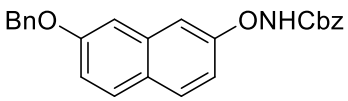
5. benzyl ((7-methoxynaphthalen-2-yl)oxy)carbamate (1e)



1e

76% yield; Brown solid, m.p. = 118-120 °C; R_f = 0.3 (PE:EA = 5:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (s, 1H), 7.71 (dd, *J* = 9.2, 7.9 Hz, 2H), 7.43 – 7.36 (m, 6H), 7.14 (dd, *J* = 9.0, 2.5 Hz, 1H), 7.08 – 7.05 (m, 2H), 5.29 (s, 2H), 3.93 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 163.4, 163.2, 162.0, 141.4, 140.5, 134.5, 134.3, 133.7, 133.4, 133.2, 130.0, 121.9, 117.9, 111.6, 110.8, 71.8, 60.4; HRMS (ESI) m/z calcd for $[C_{19}H_{18}NO_4]^+$ $[M+H]^+$: 324.1230, found 324.1237.

6. benzyl ((7-(benzyloxy)naphthalen-2-yl)oxy)carbamate (1f)

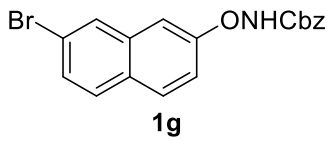


1f

57% yield; Pink solid, m.p. = 154-156 °C; R_f = 0.3 (PE:EA = 5:1); ^{1}H NMR (400 MHz, DMSO-d_6) δ 11.34 (s, 1H), 7.80 (dd, *J* = 9.0, 4.9 Hz, 2H), 7.54 – 7.49 (m, 2H), 7.45 – 7.36 (m, 10H), 7.11 (ddd, *J* = 9.0, 6.6, 2.5 Hz, 2H), 5.21 (d, *J* = 3.8 Hz, 4H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 158.7, 157.5, 157.2, 137.4, 136.6, 135.7,

129.8, 129.7, 128.94, 128.92, 128.6, 128.4, 128.34, 128.26, 125.3, 117.4, 113.3, 107.4, 106.8, 69.7, 67.0; HRMS (ESI) m/z calcd for $[C_{25}H_{22}NO_4]^+$ $[M+H]^+$: 400.1543, found 400.1548.

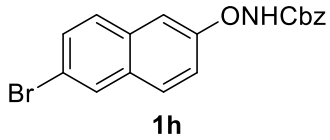
7. benzyl ((7-bromonaphthalen-2-yl)oxy)carbamate (1g)



1g

59% yield; Pink solid, m.p. = 175-177 °C; R_f = 0.3 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91 (d, *J* = 1.9 Hz, 1H), 7.80 – 7.75 (m, 2H), 7.67 (d, *J* = 8.7 Hz, 1H), 7.47 (dd, *J* = 8.7, 2.0 Hz, 1H), 7.39 (s, 4H), 7.30 – 7.27 (m, 3H), 5.29 (s, 2H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 158.8, 157.2, 136.5, 135.6, 130.3, 130.2, 129.2, 128.9, 128.7, 128.5, 128.4, 127.7, 120.6, 116.5, 106.9, 67.1; HRMS (ESI) m/z calcd for $[C_{18}H_{15}BrNO_3]^+$ $[M+H]^+$: 372.0230, found 372.0234.

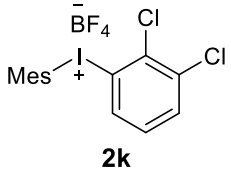
8. benzyl ((6-bromonaphthalen-2-yl)oxy)carbamate (1h)



1h

65% yield; Pink solid, m.p. = 158-160 °C; R_f = 0.3 (PE:EA = 5:1); ^{1}H NMR (500 MHz, DMSO-d_6) δ 11.37 (s, 1H), 8.15 (d, *J* = 2.0 Hz, 1H), 7.88 (d, *J* = 9.0 Hz, 1H), 7.82 (d, *J* = 8.7 Hz, 1H), 7.58 (dd, *J* = 8.8, 2.1 Hz, 1H), 7.50 (d, *J* = 2.5 Hz, 1H), 7.39 – 7.30 (m, 6H), 5.18 (s, 2H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 158.4, 157.2, 136.5, 132.8, 131.0, 130.0, 129.9, 129.7, 129.4, 128.9, 128.7, 128.4, 117.6, 117.1, 107.6, 67.1; HRMS (ESI) m/z calcd for $[C_{18}H_{15}BrNO_3]^+$ $[M+H]^+$: 372.0230, found 372.0214.

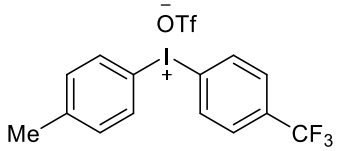
9. ((2,3-dichlorophenyl)(mesityl)-λ^3-iodanyl)tetrafluoro-λ^5-borane (2k)



2k

82% yield; White solid, m.p. = 168-170 °C; R_f = 0.5 (DCM/MeOH = 10/1); ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.18 (dd, *J* = 8.1, 1.3 Hz, 1H), 7.93 (dd, *J* = 8.1, 1.3 Hz, 1H), 7.47 (t, *J* = 8.1 Hz, 1H), 7.22 (s, 2H), 2.61 (s, 6H), 2.29 (s, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 143.8, 142.4, 137.9, 135.0, 134.3, 133.0, 131.8, 130.5, 123.7, 118.5, 26.7, 20.9; ^{19}F NMR (471 MHz, $CDCl_3$) δ -148.3; HRMS (ESI) m/z calcd for $[C_{15}H_{14}Cl_2I]^+$ $[M\text{-}BF_4^-]^+$: 390.9512, found 390.9519.

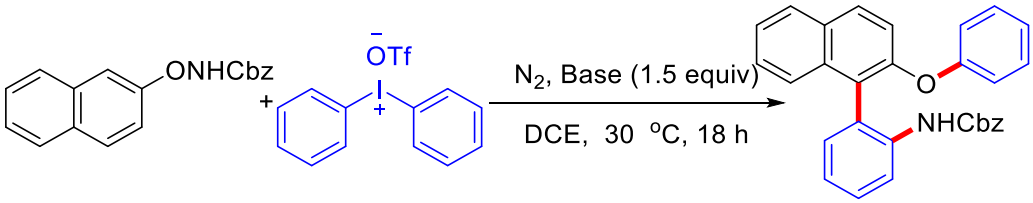
10. *p*-tolyl(4-(trifluoromethyl)phenyl)iodonium trifluoromethanesulfonate (2m)



2m

26% yield; White solid, m.p. = 149-151 °C; R_f = 0.5 (DCM/MeOH = 10/1); ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.42 (d, J = 8.3 Hz, 2H), 8.18 (d, J = 8.4 Hz, 2H), 7.91 (d, J = 8.3 Hz, 2H), 7.36 (d, J = 8.1 Hz, 2H), 2.35 (s, 3H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 143.4, 136.2, 135.9, 133.0, 128.81, 128.78, 128.75, 128.7, 121.3, 113.5, 21.3; ^{19}F NMR (471 MHz, $CDCl_3$) δ -61.7, -77.8; HRMS (ESI) m/z calcd for $[C_{14}H_{11}F_3I]^+$ $[M\text{-}OTf^-]^+$: 362.9852, found 362.9849.

Optimization of reaction conditions[a, b]

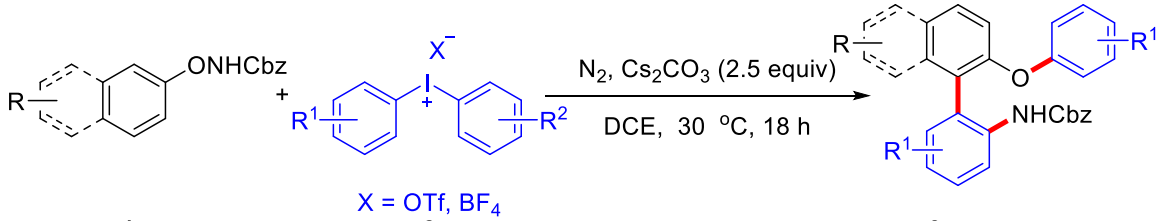


1a **2a** **3a**

Entry	Base	Yield (%)
1	^{t}BuOK	0
2	Et_3N	51
3	^{t}BuONa	55
4	DBU	57
5	DABCO	0
6	pyridine	0
7	K_3PO_4	64
8	KOH	40
9	K_2CO_3	73
10	**Cs_2CO_3**	**74**
11	NaOH	13
12	Na_2CO_3	0
13	NaH	38

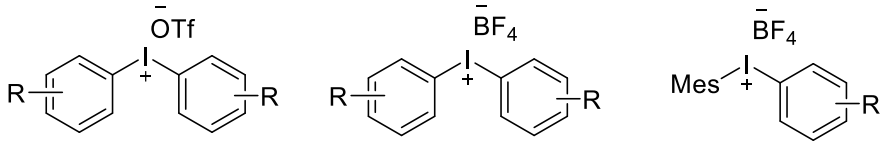
[a]Reaction conditions: **1a** (0.2 mmol), **2a** (2.0 equiv), Base (1.5 equiv), solvent (2 mL) at 30 °C for 18 h. [b]Yields of the isolated products. Cbz = benzyloxycarbonyletyl; DCE = 1,2-dichloroethane; Tf = trifluoromethanesulfonyl.

General procedure for the synthesis of biaryls 3



X = OTf, BF_4

1 **2** **3**

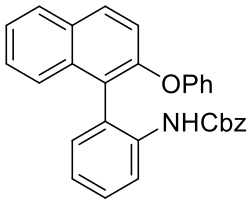


Type A **Type B** **Type C**

A solution of Cs_2CO_3 (0.75 mmol, 2.5 equiv), **1** (0.3 mmol, 1.0 equiv) and **2** (0.66 mmol, 2.2 equiv) in anhydrous DCE (3 mL) under N_2 atmosphere was stirred at 30 °C until the complete consumption of **1** detected by TLC analysis. Reagents **2** of **Type A** were used unless otherwise noted (**Type B: 3e, 3i, 3j; Type C: 3f, 3g, 3k, 3l)**. The reaction mixture was filtered and concentrated. The residue was purified by column chromatography to give the desired product **3**.

Analysis data of biaryl products 3

1. benzyl (2-(2-phenoxynaphthalen-1-yl)phenyl)carbamate (3a)

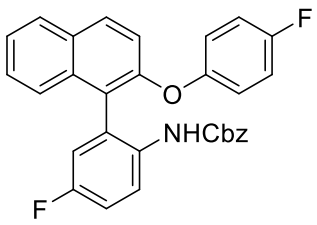


3a

88% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.85 – 7.75 (m, 2H), 7.39 – 7.30 (m, 4H), 7.21 (td, *J* = 5.1, 2.5 Hz, 3H), 7.16 (dd, *J* = 8.3, 3.1 Hz, 3H), 7.13 – 7.06 (m, 3H), 7.03 (td, *J* = 7.4, 1.2 Hz, 1H), 6.94 – 6.88 (m, 1H), 6.77 – 6.71 (m, 2H), 6.36 (s, 1H), 5.02 – 4.91 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 157.5, 153.4, 151.7, 136.4, 136.1, 133.6, 131.4, 130.9, 130.5, 129.6, 129.1, 128.9, 128.7, 128.5, 128.3, 128.24, 128.23, 127.2, 125.4, 125.3, 123.9, 123.4, 123.0, 119.9, 118.2, 66.8; HRMS (ESI) m/z calcd for $[C_{30}H_{24}NO_3]^+$ $[M+H]^+$: 446.1751,found 446.1753.

2. benzyl (4-fluoro-2-(2-(4-fluorophenoxy)naphthalen-1-yl)phenyl)carbamate (3b)

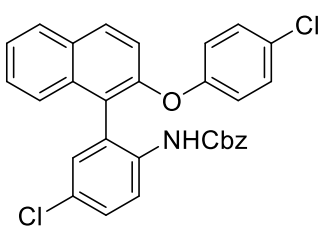
52% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.02 (s, 1H), 7.88 – 7.76 (m, 2H), 7.40 (ddd, *J* = 8.1, 5.3, 2.9 Hz, 1H), 7.36 – 7.29 (m, 2H), 7.23 (dd, *J* = 5.2, 1.9 Hz, 3H), 7.18 – 7.14 (m, 2H), 7.11 (d, *J* = 9.0 Hz, 1H), 7.07 – 6.99 (m, 1H), 6.87 –



3b

6.77 (m, 3H), 6.73 – 6.66 (m, 2H), 6.23 (s, 1H), 5.02 – 4.89 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 159.6, 153.1, 153.0, 151.9, 135.9, 133.2, 131.0, 130.7, 128.7, 128.6, 128.33, 128.27, 127.7, 127.6, 125.5, 124.9, 119.6, 119.5, 119.2, 118.0, 117.8, 116.3, 116.1, 115.7, 115.5, 67.0; ^{19}F NMR (471 MHz, $CDCl_3$) δ -120.1； HRMS (ESI) m/z calcd for $[C_{30}H_{22}F_2NO_3]^+$ $[M+H]^+$: 482.1562, found 482.1563.

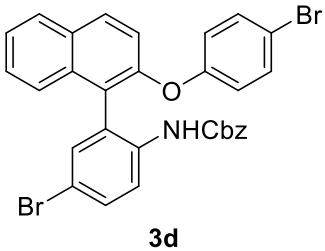
3. benzyl (4-chloro-2-(2-(4-chlorophenoxy)naphthalen-1-yl)phenyl)carbamate (3c)



3c

68% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.05 (s, 1H), 7.84 – 7.78 (m, 2H), 7.41 – 7.32 (m, 3H), 7.28 (dd, *J* = 8.9, 2.5 Hz, 1H), 7.22 (dq, *J* = 4.7, 2.9, 2.2 Hz, 3H), 7.17 – 7.14 (m, 2H), 7.12 (d, *J* = 9.0 Hz, 1H), 7.07 – 7.03 (m, 3H), 6.67 – 6.63 (m, 2H), 6.25 (s, 1H), 5.00 – 4.89 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.9, 153.2, 151.5, 135.8, 135.2, 133.2, 131.2, 131.00, 130.95, 129.7, 129.6, 129.0, 128.7, 128.6, 128.44, 128.41, 128.38, 128.35, 128.3, 127.7, 125.7, 125.0, 122.5, 119.5, 119.4, 67.1; HRMS (ESI) m/z calcd for $[C_{30}H_{22}Cl_2NO_3]^+$ $[M+H]^+$: 514.0971, found 514.0972.

4. benzyl (4-bromo-2-(2-(4-bromophenoxy)naphthalen-1-yl)phenyl)carbamate (3d)

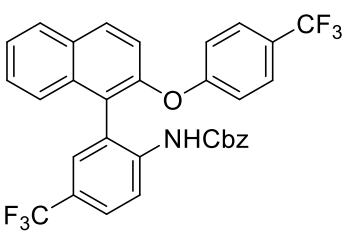


3d

71% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.00 (s, 1H), 7.87 – 7.74 (m, 2H), 7.45 – 7.31 (m, 4H), 7.26 – 7.11 (m, 9H), 6.65 – 6.54 (m, 2H), 6.24 (s, 1H), 5.02 – 4.89 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.4, 151.4, 135.74, 135.69, 133.8, 133.2, 132.60, 132.55, 131.9, 131.6, 131.2, 130.9, 128.6, 128.44, 128.42, 128.38, 128.3, 127.8, 127.7, 125.7, 125.0, 122.4, 119.8, 119.5, 115.7, 67.1； HRMS (ESI) m/z calcd for $[C_{30}H_{22}Br_2NO_3]^+$ $[M+H]^+$: 603.9940, found

603.9953.

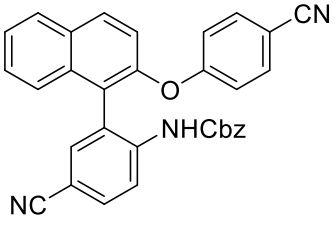
5. benzyl (4-(trifluoromethyl)-2-(2-(4-(trifluoromethyl)phenoxy)naphthalen-1-yl)phenyl)carbamate (3e)



3e

78% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.26 (d, *J* = 8.7 Hz, 1H), 7.90 (d, *J* = 8.9 Hz, 1H), 7.84 (dd, *J* = 8.2, 1.3 Hz, 1H), 7.54 (dd, *J* = 8.9, 2.1 Hz, 1H), 7.43 (ddd, *J* = 8.0, 6.8, 1.3 Hz, 1H), 7.37 (ddd, *J* = 8.3, 6.8, 1.4 Hz, 1H), 7.33 – 7.26 (m, 4H), 7.25 – 7.19 (m, 4H), 7.17 (dd, *J* = 7.1, 2.5 Hz, 2H), 6.73 (d, *J* = 8.5 Hz, 2H), 6.40 (s, 1H), 5.02 – 4.91 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.0, 152.9, 150.9, 139.6, 135.5, 133.2, 131.7, 131.4, 128.7, 128.6, 128.47, 128.45, 128.4, 128.0, 127.09, 127.06, 127.03, 127.00, 126.28, 126.25, 126.1, 125.3, 125.0, 124.9, 123.1, 120.2, 117.4, 67.3； ^{19}F NMR (471 MHz, $CDCl_3$) δ -61.8, -62.0； HRMS (ESI) m/z calcd for $[C_{32}H_{22}F_6NO_3]^+$ $[M+H]^+$: 582.1498, found 582.1496.

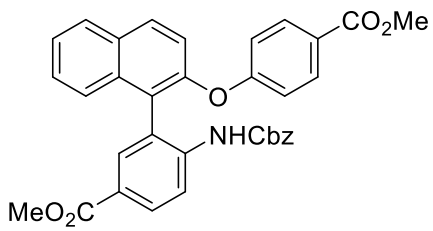
6. benzyl (4-cyano-2-(2-(4-cyanophenoxy)naphthalen-1-yl)phenyl)carbamate (3f)



3f

88% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.44 (d, *J* = 8.7 Hz, 1H), 8.08 (d, *J* = 8.9 Hz, 1H), 8.00 (d, *J* = 8.2 Hz, 1H), 7.71 (d, *J* = 8.7 Hz, 1H), 7.60 (t, *J* = 7.4 Hz, 1H), 7.54 (t, *J* = 7.4 Hz, 1H), 7.45 (d, *J* = 8.6 Hz, 3H), 7.38 (dd, *J* = 8.1, 5.0 Hz, 4H), 7.35 – 7.28 (m, 3H), 6.87 (d, *J* = 8.3 Hz, 2H), 6.59 (s, 1H), 5.18 – 5.03 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 160.6, 152.6, 150.1, 140.7, 135.3, 135.0, 134.2, 133.3, 132.9, 132.2, 131.5, 128.8, 128.7, 128.6, 128.5, 128.3, 126.5, 124.7, 124.5, 122.4, 120.1, 119.6, 118.6, 118.5, 117.7, 106.54, 106.46, 67.6； HRMS (ESI) m/z calcd for $[C_{32}H_{22}N_3O_3]^+$ $[M+H]^+$: 496.1656, found 496.1658.

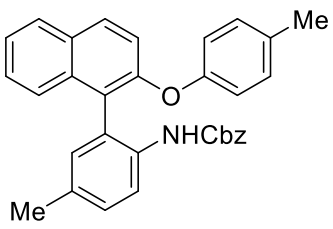
7. methyl 4-(((benzyloxy)carbonyl)amino)-3-(2-(4-(methoxycarbonyl)phenoxy)-naphthalen-1-yl)benzoate (3g)



3g

79% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.36 (d, *J* = 8.8 Hz, 1H), 8.11 (dd, *J* = 8.7, 2.1 Hz, 1H), 8.01 (d, *J* = 8.9 Hz, 1H), 7.96 (d, *J* = 8.2 Hz, 1H), 7.93 – 7.88 (m, 3H), 7.55 (ddd, *J* = 8.1, 6.7, 1.4 Hz, 1H), 7.48 (ddd, *J* = 8.1, 6.7, 1.4 Hz, 1H), 7.45 – 7.41 (m, 1H), 7.37 – 7.30 (m, 6H), 6.85 (d, *J* = 8.9 Hz, 2H), 6.61 (s, 1H), 5.13 – 5.06 (m, 2H), 3.90 (s, 3H), 3.86 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.44, 166.42, 161.3, 152.9, 150.7, 140.7, 135.5, 133.4, 132.9, 131.6, 131.4, 130.8, 128.6, 128.54, 128.50, 128.47, 128.4, 128.3, 127.77, 127.75, 126.0, 125.1, 124.68, 124.65, 123.6, 120.3, 117.0, 67.3, 52.02, 51.98； HRMS (ESI) m/z calcd for $[C_{34}H_{28}NO_7]^+$ $[M+H]^+$: 562.1860, found 562.1857.

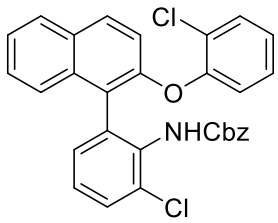
8. benzyl (4-methyl-2-(2-(p-tolyloxy)naphthalen-1-yl)phenyl)carbamate (3h)



3h

66% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.94 (s, 1H), 7.78 – 7.73 (m, 2H), 7.38 – 7.27 (m, 4H), 7.19 (td, *J* = 7.0, 3.9 Hz, 3H), 7.17 – 7.13 (m, 2H), 7.12 – 7.10 (m, 1H), 6.93 – 6.89 (m, 3H), 6.68 – 6.65 (m, 2H), 6.30 (s, 1H), 4.99 – 4.90 (m, 2H), 2.21 (s, 3H), 2.18 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.1, 152.1, 136.2, 133.9, 133.7, 132.6, 131.9, 130.6, 130.3, 130.1, 129.4, 128.6, 128.5, 128.4, 128.21, 128.17, 128.16, 128.0, 127.1, 125.4, 125.1, 124.6, 119.4, 118.5, 115.3, 66.7, 20.8, 20.7; HRMS (ESI) m/z calcd for $[C_{32}H_{28}NO_3]^+$ $[M+H]^+$: 474.2064, found 474.2062.

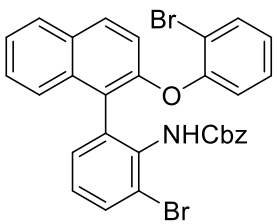
9. benzyl (2-chloro-6-(2-(2-chlorophenoxy)naphthalen-1-yl)phenyl)carbamate (3i)



3i

41% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (dd, *J* = 8.8, 3.3 Hz, 2H), 7.51 – 7.43 (m, 1H), 7.41 – 7.32 (m, 2H), 7.28 (d, *J* = 6.6 Hz, 1H), 7.23 (dd, *J* = 8.0, 1.6 Hz, 1H), 7.17 – 7.08 (m, 5H), 7.04 – 6.95 (m, 2H), 6.88 (ddd, *J* = 15.3, 7.6, 1.7 Hz, 3H), 6.69 (dd, *J* = 8.1, 1.5 Hz, 1H), 6.50 (s, 1H), 4.85 – 4.66 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.0, 152.4, 150.2, 136.3, 135.7, 134.1, 133.7, 133.3, 130.8, 130.6, 130.4, 130.3, 129.8, 128.3, 128.1, 127.82, 127.75, 127.5, 127.2, 125.6, 125.2, 124.9, 124.3, 119.4, 118.1, 66.7; HRMS (ESI) m/z calcd for $[C_{30}H_{22}Cl_2NO_3]^+$ $[M+H]^+$: 514.0971, found 514.0973.

10. benzyl (2-bromo-6-(2-(2-bromophenoxy)naphthalen-1-yl)phenyl)carbamate (3j)

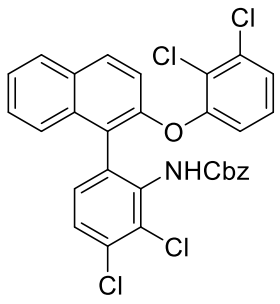


3j

57% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (dd, *J* = 9.0, 2.2 Hz, 2H), 7.57 (dd, *J* = 7.9, 1.6 Hz, 1H), 7.53 – 7.44 (m, 1H), 7.37 (ddd, *J* = 17.3, 8.0, 1.4 Hz, 2H), 7.32 – 7.23 (m, 1H), 7.16 – 7.04 (m, 6H), 7.04 – 7.00 (m, 1H), 6.90 – 6.85 (m, 2H), 6.79 (td, *J* = 7.7, 1.5 Hz, 1H), 6.63 (dd, *J* = 8.2, 1.5 Hz, 2H), 4.79 (d, *J* = 12.1 Hz, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.9, 153.7, 149.9, 136.4, 136.1, 135.2, 133.6, 133.3, 132.9, 131.2, 130.9, 130.3, 128.5, 128.4, 128.24, 128.16, 128.0, 127.7, 127.4, 127.1, 125.7, 125.3, 124.9, 124.5, 118.7, 118.5, 113.7, 66.7; HRMS (ESI) m/z calcd for $[C_{30}H_{22}Br_2NO_3]^+$ $[M+H]^+$: 603.9940, found 603.9923.

11. benzyl (2,3-dichloro-6-(2-(2,3-dichlorophenoxy)naphthalen-1-yl)phenyl)-carbamate (3k)

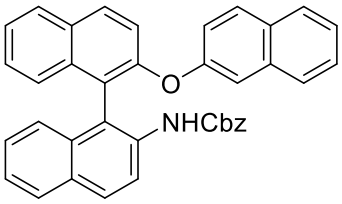
34% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash



3k

chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81 (d, *J* = 8.7 Hz, 2H), 7.45 (s, 1H), 7.42 – 7.37 (m, 2H), 7.33 (s, 1H), 7.19 (s, 1H), 7.15 – 7.12 (m, 2H), 7.09 (dd, *J* = 8.2, 1.3 Hz, 2H), 7.02 (d, *J* = 9.0 Hz, 1H), 6.96 (d, *J* = 8.2 Hz, 1H), 6.94 – 6.89 (m, 2H), 6.61 (dd, *J* = 8.3, 1.4 Hz, 1H), 6.46 (s, 1H), 4.87 – 4.68 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.8, 153.6, 149.9, 136.1, 135.3, 134.3, 133.8, 133.4, 133.0, 132.9, 130.9, 130.7, 130.2, 129.0, 128.6, 128.3, 128.2, 127.9, 127.5, 127.4, 125.5, 125.4, 125.1, 124.0, 123.9, 118.0, 117.1, 66.9；HRMS (ESI) m/z calcd for $[C_{30}H_{20}Cl_4NO_3]^+$ $[M+H]^+$: 584.0162, found 584.0166.

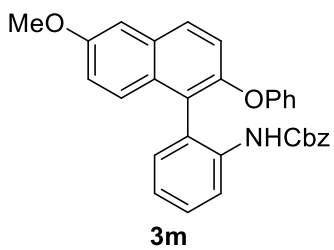
12. benzyl (2'-(naphthalen-2-yloxy)-[1,1'-binaphthalen]-2-yl)carbamate (3l)



3l

44% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (s, 1H), 7.90 (d, *J* = 8.9 Hz, 1H), 7.84 (dd, *J* = 14.4, 8.6 Hz, 2H), 7.73 (d, *J* = 8.1 Hz, 1H), 7.61 (d, *J* = 7.8 Hz, 1H), 7.50 (d, *J* = 8.9 Hz, 1H), 7.43 (d, *J* = 7.9 Hz, 1H), 7.37 (ddd, *J* = 8.0, 6.6, 1.1 Hz, 1H), 7.31 – 7.26 (m, 2H), 7.24 – 7.18 (m, 6H), 7.17 – 7.13 (m, 3H), 7.10 – 7.05 (m, 3H), 6.87 (dd, *J* = 8.9, 2.5 Hz, 1H), 6.47 (s, 1H), 4.91 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 154.8, 153.5, 153.0, 136.0, 134.4, 134.1, 133.9, 133.0, 130.92, 130.88, 130.6, 130.1, 129.7, 129.1, 128.6, 128.43, 128.36, 128.3, 128.1, 127.7, 127.5, 127.0, 126.4, 125.54, 125.45, 124.64, 124.60, 121.2, 119.8, 119.7, 114.0, 66.9；HRMS (ESI) m/z calcd for $[C_{38}H_{28}NO_3]^+$ $[M+H]^+$: 546.2064, found 546.2038.

13. benzyl (2-(6-methoxy-2-phenoxynaphthalen-1-yl)phenyl)carbamate (3m)

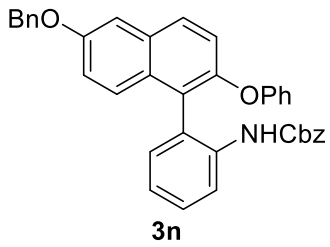


3m

45% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.05 (s, 1H), 7.69 (d, *J* = 9.0 Hz, 1H), 7.24 –

7.19 (m, 3H), 7.18 – 7.04 (m, 9H), 6.98 (ddd, *J* = 9.1, 4.9, 2.0 Hz, 2H), 6.87 (td, *J* = 7.4, 1.3 Hz, 1H), 6.73 – 6.69 (m, 2H), 6.36 (s, 1H), 4.95 (q, *J* = 12.3 Hz, 2H), 3.81 (d, *J* = 3.9 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 157.9, 157.4, 149.9, 136.4, 136.1, 132.2, 131.3, 129.5, 129.2, 128.8, 128.7, 128.5, 128.3, 128.2, 127.7, 127.0, 124.4, 123.3, 122.7, 120.8, 120.6, 119.8, 118.2, 117.8, 106.5, 66.8, 55.4; HRMS (ESI) m/z calcd for $[C_{31}H_{26}NO_4]^+$ $[M+H]^+$: 476.1856, found 476.1857.

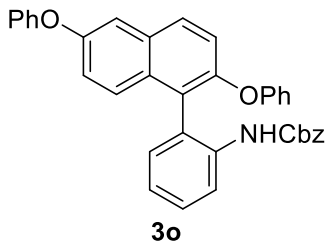
14. benzyl (2-(6-(benzyloxy)-2-phenoxynaphthalen-1-yl)phenyl)carbamate (3n)



3n

30% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.39 (s, 1H), 7.88 (d, *J* = 9.0 Hz, 1H), 7.72 (d, *J* = 8.2 Hz, 1H), 7.55 – 7.50 (m, 3H), 7.40 (dt, *J* = 12.6, 8.0 Hz, 4H), 7.32 – 7.28 (m, 3H), 7.26 – 7.14 (m, 9H), 7.01 (t, *J* = 7.3 Hz, 1H), 6.95 – 6.86 (m, 2H), 5.24 (d, *J* = 3.2 Hz, 2H), 5.05 – 4.87 (m, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 158.0, 156.0, 154.4, 149.8, 137.4, 137.3, 137.2, 132.0, 130.1, 129.2, 129.1, 128.9, 128.8, 128.73, 128.70, 128.6, 128.34, 128.26, 128.2, 127.9, 127.8, 127.2, 125.4, 124.5, 123.0, 120.7, 119.9, 118.3, 108.4, 69.8, 65.8; HRMS (ESI) m/z calcd for $[C_{37}H_{30}NO_4]^+$ $[M+H]^+$: 552.2169, found 552.2175.

15. benzyl (2-(2,6-diphenoxynaphthalen-1-yl)phenyl)carbamate (3o)

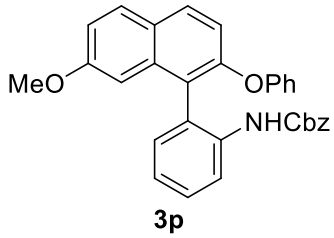


3o

69% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.15 – 7.99 (m, 1H), 7.62 (d, *J* = 8.9 Hz, 1H), 7.34 – 7.23 (m, 7H), 7.22 – 7.16 (m, 5H), 7.08 (dt, *J* = 8.7, 1.9 Hz, 3H), 7.03 – 6.95 (m, 4H), 6.87 (t, *J* = 7.4 Hz, 1H), 6.74 – 6.69 (m, 2H), 6.37 (s, 1H), 5.00 – 4.93 (m, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 157.7, 157.3, 154.5, 154.0, 150.8, 137.4, 137.2, 132.1, 131.8, 130.6, 130.3, 130.1, 129.6, 129.2, 128.9, 128.8, 128.73, 128.70, 128.6, 128.2, 128.0, 125.4, 124.0, 123.2, 120.9, 120.8, 119.0, 118.5, 115.0, 65.9; HRMS (ESI) m/z calcd for $[C_{36}H_{28}NO_4]^+$ $[M+H]^+$: 538.2013,

found 538.2001.

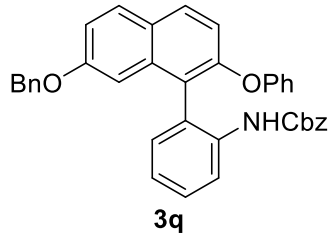
16. benzyl (2-(7-methoxy-2-phenoxynaphthalen-1-yl)phenyl)carbamate (3p)



3p

76% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (d, *J* = 8.2 Hz, 1H), 7.66 (dd, *J* = 12.1, 8.9 Hz, 2H), 7.28 (ddd, *J* = 8.6, 7.4, 1.6 Hz, 1H), 7.20 – 7.16 (m, 3H), 7.13 (d, *J* = 2.5 Hz, 1H), 7.12 (t, *J* = 1.3 Hz, 1H), 7.10 (d, *J* = 1.4 Hz, 1H), 7.07 – 7.04 (m, 2H), 7.02 – 6.96 (m, 3H), 6.87 (ddt, *J* = 8.4, 7.1, 1.1 Hz, 1H), 6.75 – 6.70 (m, 2H), 6.59 (d, *J* = 2.5 Hz, 1H), 6.36 (s, 1H), 4.95 (s, 2H), 3.52 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 158.9, 157.5, 153.6, 152.5, 136.4, 136.2, 135.1, 131.3, 130.2, 129.8, 129.6, 128.9, 128.62, 128.57, 128.30, 128.25, 128.2, 126.3, 123.6, 123.0, 122.8, 118.2, 117.9, 117.3, 103.8, 66.8, 55.2; HRMS (ESI) m/z calcd for $[C_{31}H_{26}NO_4]^+$ $[M+H]^+$: 476.1856, found 476.1859.

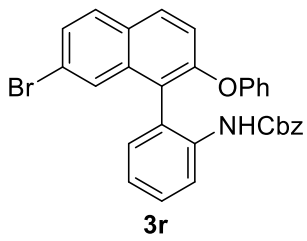
17. benzyl (2-(7-(benzyloxy)-2-phenoxynaphthalen-1-yl)phenyl)carbamate (3q)



3q

82% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 (d, *J* = 7.9 Hz, 1H), 7.64 (dd, *J* = 8.9, 4.9 Hz, 2H), 7.15 (qd, *J* = 7.5, 5.3 Hz, 11H), 7.08 – 7.01 (m, 4H), 6.99 – 6.93 (m, 2H), 6.85 (t, *J* = 7.4 Hz, 1H), 6.71 – 6.68 (m, 2H), 6.66 (d, *J* = 2.5 Hz, 1H), 6.31 (s, 1H), 4.94 (d, *J* = 2.4 Hz, 2H), 4.78 (d, *J* = 2.1 Hz, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.8, 157.6, 153.5, 152.5, 136.6, 136.4, 136.2, 135.0, 131.3, 130.2, 129.9, 129.6, 128.9, 128.69, 128.65, 128.6, 128.33, 128.30, 128.2, 128.0, 127.8, 126.3, 123.6, 123.0, 122.8, 118.4, 118.3, 117.4, 105.4, 70.0, 66.8; HRMS (ESI) m/z calcd for $[C_{37}H_{30}NO_4]^+$ $[M+H]^+$: 552.2169, found 552.2170.

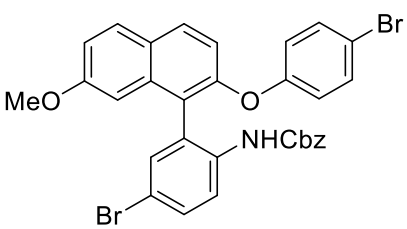
18. benzyl (2-(7-bromo-2-phenoxynaphthalen-1-yl)phenyl)carbamate (3r)



3r

78% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 – 8.01 (m, 1H), 7.69 (d, *J* = 8.9 Hz, 1H), 7.58 (d, *J* = 8.7 Hz, 1H), 7.49 (d, *J* = 1.9 Hz, 1H), 7.39 (dd, *J* = 8.7, 2.0 Hz, 1H), 7.22 – 7.13 (m, 6H), 7.11 – 7.03 (m, 5H), 6.93 – 6.87 (m, 1H), 6.74 – 6.68 (m, 2H), 6.33 (s, 1H), 5.00 – 4.91 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.0, 152.7, 136.5, 136.1, 135.0, 131.4, 130.5, 129.9, 129.7, 129.3, 129.1, 128.8, 128.71, 128.67, 128.6, 128.39, 128.35, 128.3, 127.5, 123.7, 123.4, 123.0, 122.0, 119.9, 118.5, 67.0; HRMS (ESI) m/z calcd for $[C_{30}H_{23}BrNO_3]^+$ $[M+H]^+$: 524.0856, found 524.0863.

19. benzyl (4-bromo-2-(2-(4-bromophenoxy)-7-methoxynaphthalen-1-yl)-phenyl)carbamate (3s)

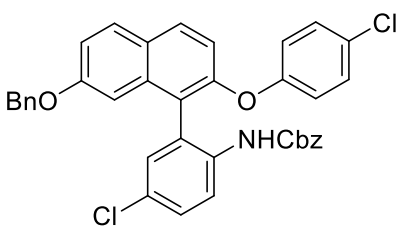


3s

74% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, *J* = 8.9 Hz, 1H), 7.70 (dd, *J* = 18.3, 9.0 Hz, 2H), 7.41 (dd, *J* = 8.9, 2.4 Hz, 1H), 7.24 – 7.12 (m, 8H), 7.04 (dd, *J* = 8.9, 2.5 Hz, 1H), 6.95 (d, *J* = 8.8 Hz, 1H), 6.62 – 6.53 (m, 3H), 6.25 (s, 1H), 4.99 – 4.91 (m, 2H), 3.58 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 159.2, 156.4, 153.2, 152.2, 135.8, 135.6, 134.7, 133.8, 132.6, 131.9, 130.9, 130.0, 128.7, 128.6, 128.44, 128.37, 128.3, 126.3, 121.3, 119.9, 118.2, 116.9, 116.0, 115.7, 103.4, 67.1, 55.3; HRMS (ESI) m/z calcd for $[C_{31}H_{24}Br_2NO_4]^+$ $[M+H]^+$: 634.0046, found 634.0031.

20. benzyl (2-(7-(benzyloxy)-2-(4-chlorophenoxy)naphthalen-1-yl)-4-chlorophenyl)carbamate (3t)

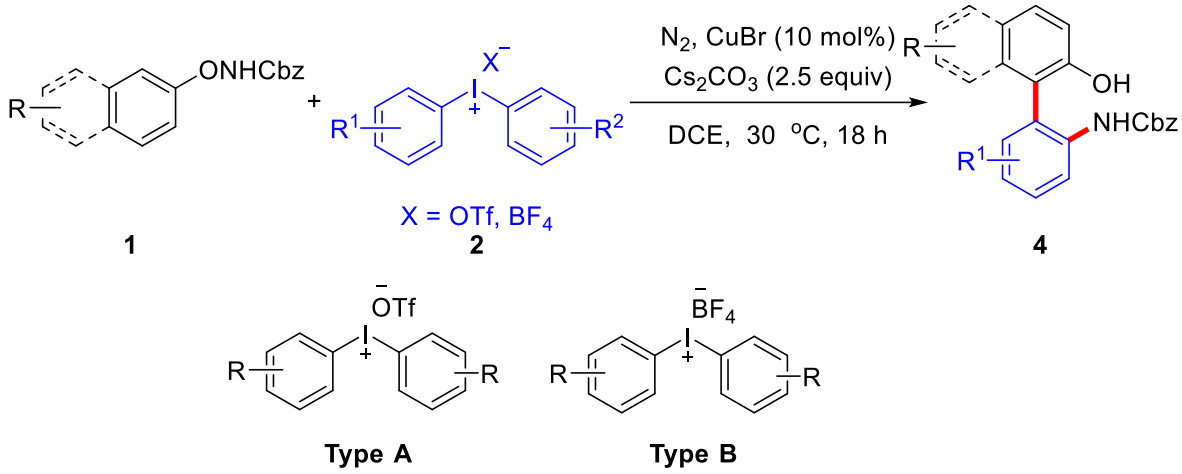
75% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500



3t

MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.71 (dd, *J* = 14.4, 8.9 Hz, 2H), 7.33 – 7.28 (m, 2H), 7.25 – 7.20 (m, 6H), 7.17 (ddd, *J* = 5.3, 4.2, 1.9 Hz, 3H), 7.12 (dd, *J* = 8.9, 2.5 Hz, 1H), 7.07 – 7.01 (m, 3H), 6.96 (d, *J* = 8.9 Hz, 1H), 6.67 – 6.62 (m, 2H), 6.60 (d, *J* = 2.5 Hz, 1H), 6.17 (s, 1H), 4.97 (q, *J* = 12.2 Hz, 2H), 4.87 (s, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 157.6, 156.4, 154.9, 152.3, 137.09, 137.05, 136.3, 134.3, 131.4, 130.6, 130.5, 130.4, 130.0, 129.1, 128.9, 128.8, 128.68, 128.65, 128.6, 128.3, 128.2, 127.7, 127.3, 126.2, 122.7, 120.7, 118.0, 117.1, 105.4, 69.5, 65.9; HRMS (ESI) m/z calcd for $[C_{37}H_{28}Cl_2NO_4]^+$ $[M+H]^+$: 620.1390, found 620.1401.

General procedure for the synthesis of NOBIN-type biaryls 4

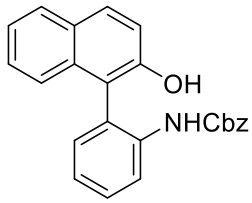


Under N_2 atmosphere, A dried flask was charged with **1** (0.3 mmol, 1.0 equiv), **2** (0.36 mmol, 1.2 equiv), Cs_2CO_3 (0.45 mmol, 1.5 equiv) and CuBr (0.03 mmol, 10 mol%), and the mixture was added anhydrous DCE (3 mL). Reagents **2** of **Type A** were used unless otherwise noted (**Type B: 4f)**.The mixture was stirred at 30 ℃ for 18 hours. The resulting solution was concentrated in vacuo and purified by flash chromatography on silica gel (PE/EtOAc = 10/1) to give **4**.

Analysis data of NOBIN-type biaryls 4

1. benzyl (2-(2-hydroxynaphthalen-1-yl)phenyl)carbamate (4a)

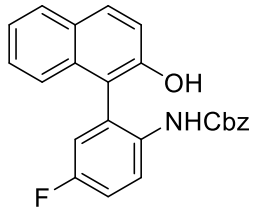
56% yield; White solid, m.p. = 125-127 ℃; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500



4a

MHz, $CDCl_3$) δ 8.24 (d, *J* = 8.2 Hz, 1H), 7.82 – 7.69 (m, 2H), 7.44 (dt, *J* = 8.7, 4.5 Hz, 1H), 7.29 – 7.24 (m, 2H), 7.22 – 7.11 (m, 9H), 6.28 (s, 1H), 5.19 (s, 1H), 4.95 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.5, 151.3, 137.4, 135.8, 132.9, 132.0, 130.8, 130.1, 129.2, 128.5, 128.33, 128.30, 128.26, 127.3, 124.3, 124.0, 123.8, 122.7, 120.5, 117.8, 115.3, 67.0; HRMS (ESI) m/z calcd for $[C_{24}H_{20}NO_3]^+$ $[M+H]^+$: 370.1438, found 370.1442.

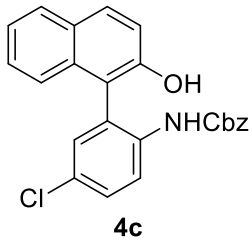
2. benzyl (4-fluoro-2-(2-hydroxynaphthalen-1-yl)phenyl)carbamate (4b)



4b

37% yield; Brown solid, m.p. = 135-137 ℃; R_f = 0.2 (PE:EA = 5:1); ^1H NMR (500 MHz, $CDCl_3$) δ 8.15 (s, 1H), 7.80 – 7.73 (m, 2H), 7.29 (dd, *J* = 6.4, 3.2 Hz, 2H), 7.21 (qd, *J* = 4.7, 1.6 Hz, 3H), 7.18 (s, 1H), 7.16 – 7.12 (m, 4H), 6.93 (dd, *J* = 8.4, 3.0 Hz, 1H), 6.21 (s, 1H), 5.25 – 5.18 (m, 1H), 4.95 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.7, 151.1, 135.7, 133.4, 132.7, 131.2, 129.2, 128.5, 128.4, 128.34, 128.26, 127.6, 127.5, 124.0, 123.8, 118.6, 118.4, 117.9, 116.8, 116.6, 114.6, 67.1; ^{19}F NMR (471 MHz, $CDCl_3$) δ -117.9; HRMS (ESI) m/z calcd for $[C_{24}H_{19}FNO_3]^+$ $[M+H]^+$: 388.1343, found 388.1346.

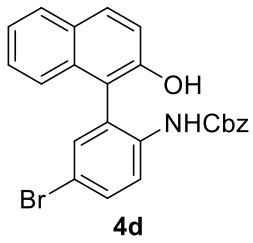
3. benzyl (4-chloro-2-(2-hydroxynaphthalen-1-yl)phenyl)carbamate (4c)



4c

46% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^1H NMR (500 MHz, $CDCl_3$) δ 8.18 (d, *J* = 9.0 Hz, 1H), 7.78 – 7.73 (m, 2H), 7.39 (dd, *J* = 9.0, 2.5 Hz, 1H), 7.30 – 7.27 (m, 2H), 7.20 (dd, *J* = 5.2, 1.8 Hz, 3H), 7.17 (dd, *J* = 4.4, 2.0 Hz, 2H), 7.15 – 7.12 (m, 3H), 6.27 (s, 1H), 5.27 (s, 1H), 4.94 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.4, 151.2, 136.1, 135.6, 132.7, 131.7, 131.3, 130.0, 129.2, 128.6, 128.5, 128.4, 128.3, 127.6, 127.5, 124.8, 124.0, 123.8, 121.6, 117.9, 114.2, 67.3; HRMS (ESI) m/z calcd for $[C_{24}H_{19}ClNO_3]^+$ $[M+H]^+$: 404.1048, found 404.1054.

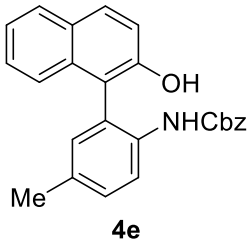
4. benzyl (4-bromo-2-(2-hydroxynaphthalen-1-yl)phenyl)carbamate (4d)



4d

57% yield; Brown solid, m.p. = 128-130 ℃; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.14 (d, *J* = 9.0 Hz, 1H), 7.79 – 7.72 (m, 2H), 7.53 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.32 (d, *J* = 2.4 Hz, 1H), 7.30 – 7.28 (m, 2H), 7.20 (dd, *J* = 5.2, 1.9 Hz, 3H), 7.16 (s, 1H), 7.15 – 7.12 (m, 3H), 6.28 (s, 1H), 5.22 (s, 1H), 4.94 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.3, 151.2, 136.6, 135.5, 134.5, 132.9, 132.7, 131.3, 129.2, 128.6, 128.5, 128.42, 128.36, 127.6, 125.1, 124.1, 123.8, 121.8, 117.8, 116.6, 114.1, 67.3; HRMS (ESI) m/z calcd for $[C_{24}H_{19}BrNO_3]^+$ $[M+H]^+$: 448.0543, found 448.0540.

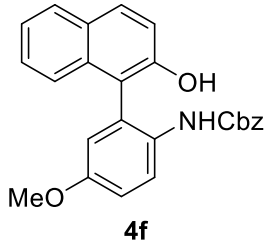
5. benzyl (2-(2-hydroxynaphthalen-1-yl)-4-methylphenyl)carbamate (4e)



4e

60% yield; White solid, m.p. = 165-166 ℃; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.10 – 8.03 (m, 1H), 7.75 – 7.71 (m, 2H), 7.26 – 7.23 (m, 3H), 7.18 (ddd, *J* = 5.2, 3.8, 2.3 Hz, 4H), 7.15 (d, *J* = 1.9 Hz, 1H), 7.12 (dt, *J* = 7.0, 2.2 Hz, 2H), 6.97 (d, *J* = 2.1 Hz, 1H), 6.20 (s, 1H), 5.28 (s, 1H), 4.93 (s, 2H), 2.26 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.7, 151.2, 135.9, 134.8, 134.2, 133.0, 132.3, 130.70, 130.65, 129.1, 128.5, 128.4, 128.31, 128.26, 128.2, 127.2, 124.1, 123.8, 120.8, 117.8, 115.7, 67.0, 20.8; HRMS (ESI) m/z calcd for $[C_{25}H_{22}NO_3]^+$ $[M+H]^+$: 384.1594, found 384.1604.

6. benzyl (2-(2-hydroxynaphthalen-1-yl)-4-methoxyphenyl)carbamate (4f)

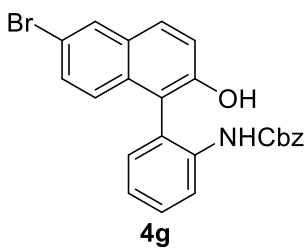


4f

51% yield; Brown solid, m.p. = 115-117 ℃; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (s, 1H), 7.74 – 7.70 (m, 2H), 7.25 (dd, *J* = 6.2, 3.5 Hz, 3H), 7.17 (dt, *J* = 5.4, 2.4 Hz, 5H), 7.09 (dd, *J* = 7.0, 2.8 Hz, 2H), 6.96 (dd, *J* = 9.1, 3.0 Hz, 1H), 6.71 (d, *J* = 3.0 Hz, 1H), 6.13 (s, 1H), 4.91 (s, 2H), 3.67 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 151.2, 135.9, 132.9, 130.7, 130.3, 129.1, 128.7, 128.6, 128.5, 128.4, 128.32, 128.30, 128.22, 128.16, 127.24, 127.22, 124.1, 123.8, 118.0, 116.6, 115.6, 67.0, 55.6; HRMS (ESI) m/z calcd for $[C_{25}H_{22}NO_4]^+$

$[M+H]^+$: 400.1543, found 400.1548.

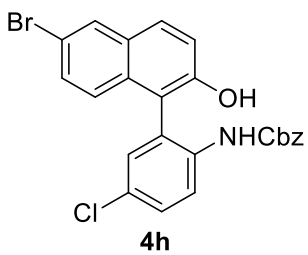
7. benzyl (2-(6-bromo-2-hydroxynaphthalen-1-yl)phenyl)carbamate (4g)



4g

43% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.22 (d, *J* = 8.4 Hz, 1H), 7.90 (d, *J* = 2.0 Hz, 1H), 7.67 (d, *J* = 8.9 Hz, 1H), 7.45 (ddd, *J* = 8.7, 7.2, 1.9 Hz, 1H), 7.31 (dd, *J* = 9.0, 2.1 Hz, 1H), 7.24 – 7.19 (m, 4H), 7.18 – 7.13 (m, 4H), 6.99 (d, *J* = 8.9 Hz, 1H), 6.20 (s, 1H), 5.17 (d, *J* = 12.7 Hz, 1H), 4.96 (d, *J* = 1.3 Hz, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.2, 152.1, 136.6, 135.4, 134.4, 134.0, 133.4, 131.3, 130.0, 128.6, 128.5, 128.4, 127.60, 127.58, 125.8, 124.1, 122.2, 122.1, 118.3, 116.9, 113.5, 67.4; HRMS (ESI) m/z calcd for $[C_{24}H_{19}BrNO_3]^+$ $[M+H]^+$: 448.0543, found 448.0539.

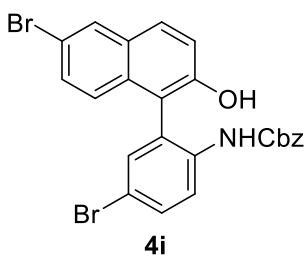
8. benzyl(2-(6-bromo-2-hydroxynaphthalen-1-yl)-4-chlorophenyl)carbamate (4h)



4h

49% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 (d, *J* = 9.0 Hz, 1H), 7.90 (d, *J* = 2.0 Hz, 1H), 7.68 (d, *J* = 8.9 Hz, 1H), 7.41 (dd, *J* = 9.0, 2.5 Hz, 1H), 7.35 (dd, *J* = 8.9, 2.1 Hz, 1H), 7.22 (p, *J* = 2.9, 2.4 Hz, 3H), 7.20 – 7.13 (m, 4H), 6.99 (d, *J* = 8.9 Hz, 1H), 6.18 (s, 1H), 5.22 (d, *J* = 4.5 Hz, 1H), 4.96 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.3, 151.5, 136.0, 135.4, 131.5, 131.2, 130.8, 130.4, 130.31, 130.27, 130.2, 129.4, 128.6, 128.5, 128.4, 125.6, 124.1, 121.9, 119.0, 117.9, 114.5, 67.3; HRMS (ESI) m/z calcd for $[C_{24}H_{18}BrClNO_3]^+$ $[M+H]^+$: 482.0153, found 482.0117.

9. benzyl (4-bromo-2-(6-bromo-2-hydroxynaphthalen-1-yl)phenyl)carbamate (4i)

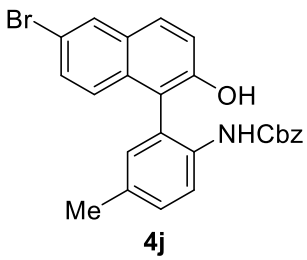


4i

42% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 (d, *J* = 8.9 Hz, 1H), 7.92 (d, *J* = 2.0 Hz, 1H), 7.70 (d, *J* = 8.9 Hz, 1H), 7.57 (dd, *J* = 8.9, 2.4 Hz, 1H), 7.36 (dd, *J* = 8.9, 2.0 Hz, 1H), 7.31 (d, *J* =

2.4 Hz, 1H), 7.25 – 7.20 (m, 3H), 7.19 (d, *J* = 2.0 Hz, 1H), 7.16 (dd, *J* = 7.3, 2.3 Hz, 2H), 7.00 (d, *J* = 9.0 Hz, 1H), 6.18 (s, 1H), 5.09 (s, 1H), 4.97 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.2, 151.5, 136.6, 135.4, 134.3, 133.2, 131.2, 130.8, 130.4, 130.3, 128.6, 128.5, 128.4, 125.6, 122.0, 119.0, 117.9, 116.8, 114.3, 67.3; HRMS (ESI) m/z calcd for $[C_{24}H_{18}Br_2NO_3]^+$ $[M+H]^+$: 527.9627, found 527.9605.

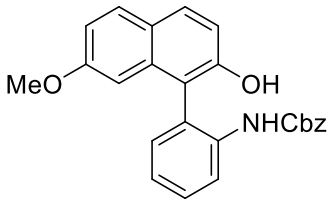
10. benzyl (2-(6-bromo-2-hydroxynaphthalen-1-yl)-4-methylphenyl)carbamate (4j)



4j

56% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.16 (d, *J* = 8.0 Hz, 1H), 8.00 (d, *J* = 2.0 Hz, 1H), 7.76 (d, *J* = 8.9 Hz, 1H), 7.42 (dd, *J* = 9.0, 2.1 Hz, 1H), 7.40 – 7.30 (m, 5H), 7.27 – 7.23 (m, 2H), 7.14 (d, *J* = 9.0 Hz, 1H), 7.07 (d, *J* = 2.1 Hz, 1H), 6.25 (s, 1H), 5.44 (s, 1H), 5.06 (d, *J* = 3.0 Hz, 2H), 2.40 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.6, 151.5, 135.8, 134.7, 134.4, 132.1, 131.5, 130.9, 130.4, 130.2, 129.7, 128.7, 128.6, 128.4, 128.34, 128.25, 122.6, 121.2, 119.0, 117.6, 116.0, 67.1, 20.8; HRMS (ESI) m/z calcd for $[C_{25}H_{21}BrNO_3]^+$ $[M+H]^+$: 462.0699, found 462.0691.

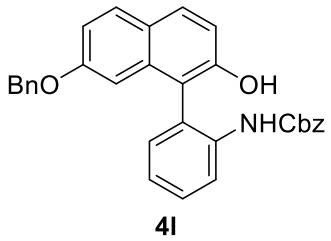
11. benzyl (2-(2-hydroxy-7-methoxynaphthalen-1-yl)phenyl)carbamate (4k)



4k

63% yield; Gray solid, m.p. = 179-181 ℃; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.3 Hz, 1H), 7.63 (dd, *J* = 13.9, 8.9 Hz, 2H), 7.41 (ddd, *J* = 8.7, 6.3, 2.7 Hz, 1H), 7.22 – 7.09 (m, 7H), 7.01 (d, *J* = 8.8 Hz, 1H), 6.91 (dd, *J* = 8.9, 2.5 Hz, 1H), 6.42 – 6.27 (m, 2H), 5.24 (s, 1H), 4.99 – 4.89 (m, 2H), 3.52 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 158.9, 153.6, 151.9, 137.3, 135.8, 134.4, 131.9, 130.5, 130.1, 129.9, 128.6, 128.3, 128.2, 124.50, 124.46, 123.1, 120.7, 116.0, 115.2, 114.6, 102.9, 67.0, 55.2; HRMS (ESI) m/z calcd for $[C_{25}H_{22}NO_4]^+$ $[M+H]^+$: 400.1543, found 400.1535.

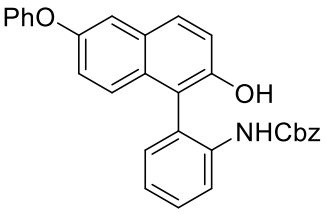
12. benzyl (2-(7-(benzyloxy)-2-hydroxynaphthalen-1-yl)phenyl)carbamate (4l)



4l

51% yield; Brown solid, m.p. = 148-150 ℃; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, *J* = 8.3 Hz, 1H), 7.62 (dd, *J* = 8.8, 7.6 Hz, 2H), 7.43 (ddd, *J* = 8.6, 7.3, 1.8 Hz, 1H), 7.22 – 7.07 (m, 12H), 7.03 – 6.94 (m, 2H), 6.44 (d, *J* = 2.4 Hz, 1H), 6.23 (s, 1H), 5.22 (s, 1H), 4.93 (d, *J* = 3.8 Hz, 2H), 4.79 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.8, 153.6, 151.9, 137.4, 136.7, 135.8, 134.3, 131.9, 130.5, 130.0, 130.0, 128.57, 128.55, 128.33, 128.25, 127.9, 127.6, 124.54, 124.49, 123.1, 120.7, 116.5, 115.3, 114.6, 104.6, 69.9, 67.0; HRMS (ESI) m/z calcd for $[C_{31}H_{26}NO_4]^+$ $[M+H]^+$: 476.1856, found 476.1863.

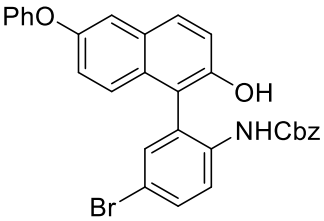
13. benzyl (2-(2-hydroxy-6-phenoxynaphthalen-1-yl)phenyl)carbamate (4m)



4m

55% yield; Yellow solid, m.p. = 162-164 ℃; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.23 (d, *J* = 8.3 Hz, 1H), 7.61 (d, *J* = 8.9 Hz, 1H), 7.44 (ddd, *J* = 8.7, 5.3, 3.6 Hz, 1H), 7.26 – 7.23 (m, 3H), 7.21 (td, *J* = 6.4, 6.0, 2.9 Hz, 3H), 7.16 (dd, *J* = 9.0, 3.0 Hz, 5H), 7.12 (d, *J* = 9.1 Hz, 1H), 7.04 (ddd, *J* = 8.8, 6.5, 4.3 Hz, 2H), 6.98 – 6.94 (m, 2H), 6.30 (s, 1H), 5.11 (s, 1H), 5.01 – 4.93 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 157.3, 153.6, 153.5, 150.5, 137.4, 135.8, 131.9, 130.2, 130.0, 129.9, 129.8, 129.6, 128.58, 128.55, 128.4, 128.3, 126.1, 124.4, 123.3, 121.2, 120.5, 118.9, 118.5, 115.6, 115.1, 67.1; HRMS (ESI) m/z calcd for $[C_{30}H_{24}NO_4]^+$ $[M+H]^+$: 462.1700, found 462.1694.

14. benzyl (4-bromo-2-(2-hydroxy-6-phenoxynaphthalen-1-yl)phenyl)carbamate (4n)

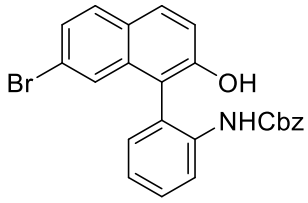


4n

44% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.82 (d, *J* = 6.4 Hz, 1H), 7.96 (s, 1H), 7.81 (dd, *J* = 21.6, 8.7 Hz, 2H), 7.61 (dd, *J* = 8.8, 2.4 Hz, 1H), 7.42 (d, *J* = 2.6 Hz, 1H), 7.39 – 7.34 (m, 3H), 7.32 – 7.26 (m, 4H), 7.23 – 7.18 (m,

3H), 7.14 – 7.10 (m, 2H), 7.03 – 6.99 (m, 2H), 5.05 – 4.96 (m, 2H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 157.7, 154.0, 152.31, 152.27, 136.91, 136.85, 134.7, 131.1, 130.5, 130.4, 130.3, 129.6, 129.2, 128.8, 128.3, 128.1, 126.3, 123.6, 121.0, 119.6, 118.9, 118.6, 116.2, 116.1, 115.6, 66.2; HRMS (ESI) m/z calcd for $[C_{30}H_{23}BrNO_4]^+$ $[M+H]^+$: 540.0805, found 540.0814.

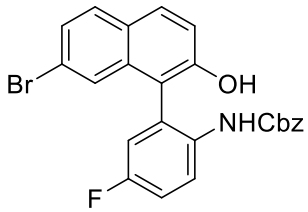
15. benzyl (2-(7-bromo-2-hydroxynaphthalen-1-yl)phenyl)carbamate (4o)



4o

77% yield; Yellow solid, m.p. = 137-139 ℃; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 (d, *J* = 8.4 Hz, 1H), 7.72 (dd, *J* = 9.0, 0.7 Hz, 1H), 7.60 (d, *J* = 8.7 Hz, 1H), 7.47 (ddd, *J* = 8.7, 7.3, 1.8 Hz, 1H), 7.35 (dd, *J* = 8.6, 1.9 Hz, 1H), 7.27 (d, *J* = 1.9 Hz, 1H), 7.23 – 7.13 (m, 8H), 6.22 (s, 1H), 5.28 (s, 1H), 4.98 (s, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 153.5, 152.1, 137.3, 135.7, 134.4, 132.0, 130.8, 130.5, 130.0, 128.6, 128.4, 128.3, 127.6, 127.3, 126.1, 124.6, 122.0, 121.9, 120.8, 118.2, 114.8, 67.2; HRMS (ESI) m/z calcd for $[C_{24}H_{19}BrNO_3]^+$ $[M+H]^+$: 448.0543, found 448.0555.

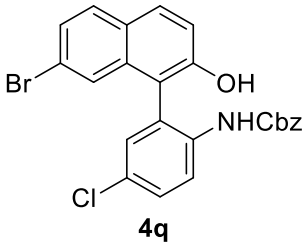
16. benzyl(2-(7-bromo-2-hydroxynaphthalen-1-yl)-4-fluorophenyl)carbamate (4p)



4p

36% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 (s, 1H), 7.75 (d, *J* = 8.9 Hz, 1H), 7.62 (d, *J* = 8.7 Hz, 1H), 7.38 (dd, *J* = 8.6, 1.9 Hz, 1H), 7.27 – 7.20 (m, 4H), 7.18 (dt, *J* = 7.7, 2.9 Hz, 4H), 6.91 (dd, *J* = 8.3, 3.0 Hz, 1H), 6.14 (s, 1H), 5.21 (d, *J* = 17.0 Hz, 1H), 4.99 (s, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 158.3, 153.7, 151.9, 135.6, 134.0, 133.4, 131.1, 130.0, 128.6, 128.4, 128.3, 127.6, 127.5, 125.9, 122.1, 118.6, 118.4, 118.3, 117.3, 117.1, 114.1, 67.3; ^{19}F NMR (471 MHz, $CDCl_3$) δ -117.3; HRMS (ESI) m/z calcd for $[C_{24}H_{18}BrFNO_3]^+$ $[M+H]^+$: 466.0449, found 466.0440.

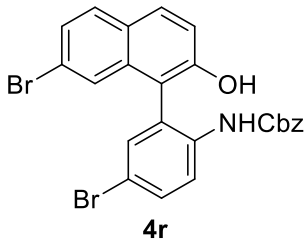
17. benzyl(2-(7-bromo-2-hydroxynaphthalen-1-yl)-4-chlorophenyl)carbamate (4q)



4q

45% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.19 (d, *J* = 8.6 Hz, 1H), 7.73 (d, *J* = 8.9 Hz, 1H), 7.61 (d, *J* = 8.7 Hz, 1H), 7.42 (dd, *J* = 8.9, 2.5 Hz, 1H), 7.37 (dd, *J* = 8.7, 2.0 Hz, 1H), 7.26 – 7.20 (m, 4H), 7.18 – 7.13 (m, 4H), 6.20 (s, 1H), 5.32 (s, 1H), 5.01 – 4.91 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.3, 152.1, 136.0, 135.4, 134.1, 131.6, 131.2, 130.4, 130.0, 129.5, 128.7, 128.6, 128.5, 128.43, 128.39, 127.6, 127.5, 125.9, 122.2, 118.3, 113.6, 67.4; HRMS (ESI) m/z calcd for $[C_{24}H_{18}BrClNO_3]^+$ $[M+H]^+$: 482.0153, found 482.0150.

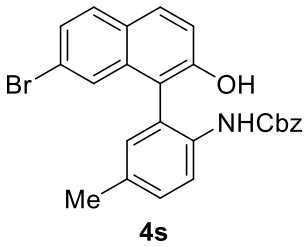
18. benzyl(4-bromo-2-(7-bromo-2-hydroxynaphthalen-1-yl)phenyl)carbamate (4r)



4r

30% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.04 (s, 1H), 8.26 (s, 1H), 7.87 (d, *J* = 8.9 Hz, 1H), 7.82 (d, *J* = 8.7 Hz, 1H), 7.73 (d, *J* = 8.8 Hz, 1H), 7.62 (dd, *J* = 8.7, 2.4 Hz, 1H), 7.41 (dd, *J* = 8.6, 2.0 Hz, 1H), 7.35 (d, *J* = 2.4 Hz, 1H), 7.32 – 7.26 (m, 4H), 7.24 (d, *J* = 1.8 Hz, 1H), 7.18 – 7.14 (m, 2H), 5.08 – 4.90 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.2, 152.1, 136.6, 135.4, 134.4, 134.0, 133.4, 131.3, 130.0, 128.6, 128.5, 128.4, 127.60, 127.58, 125.8, 122.2, 118.3, 116.9, 113.5, 67.4; HRMS (ESI) m/z calcd for $[C_{24}H_{18}Br_2NO_3]^+$ $[M+H]^+$: 527.9627, found 527.9615.

19. benzyl(2-(7-bromo-2-hydroxynaphthalen-1-yl)-4-methylphenyl)carbamate (4s)

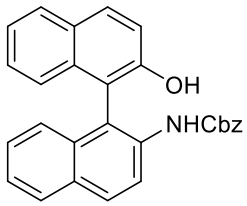


4s

45% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.15 – 8.01 (m, 1H), 7.71 (d, *J* = 8.9 Hz, 1H), 7.60 (d, *J* = 8.6 Hz, 1H), 7.35 (dd, *J* = 8.6, 2.0 Hz, 1H), 7.27 (dd, *J* = 8.3, 2.0 Hz, 2H), 7.25 – 7.14 (m, 6H), 6.95 (d, *J* = 2.1 Hz, 1H), 6.12 (s, 1H), 5.20 (d, *J* = 7.4

Hz, 1H), 4.97 (s, 2H), 2.30 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.6, 152.0, 135.8, 134.7, 134.5, 134.3, 132.2, 131.2, 130.6, 130.0, 128.6, 128.32, 128.27, 127.6, 127.2, 126.2, 121.8, 118.2, 115.1, 67.1, 20.8; HRMS (ESI) m/z calcd for $[C_{25}H_{21}BrNO_3]^+$ $[M+H]^+$: 462.0699, found 462.0672.

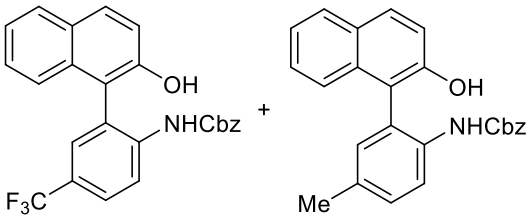
20. benzyl (2'-hydroxy-[1,1'-binaphthalen]-2-yl)carbamate (4t)



4t

48% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); Purified directly by flash chromatography on silica gel (10:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.51 (d, *J* = 9.1 Hz, 1H), 8.02 (d, *J* = 9.1 Hz, 1H), 7.94 (d, *J* = 8.9 Hz, 1H), 7.88 (t, *J* = 7.8 Hz, 2H), 7.40 (t, *J* = 7.5 Hz, 1H), 7.34 (dd, *J* = 8.4, 5.1 Hz, 2H), 7.32 – 7.20 (m, 7H), 7.09 (d, *J* = 8.5 Hz, 1H), 6.99 (d, *J* = 8.4 Hz, 1H), 6.47 (s, 1H), 5.09 (q, *J* = 4.6, 2.7 Hz, 1H), 5.02 (s, 2H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.6, 152.0, 135.9, 135.7, 133.2, 132.9, 131.3, 130.8, 130.4, 129.4, 128.6, 128.4, 128.34, 128.30, 128.27, 127.44, 127.38, 125.2, 125.1, 124.1, 124.0, 119.7, 117.9, 116.7, 112.7, 67.1; HRMS (ESI) m/z calcd for $[C_{28}H_{22}NO_3]^+$ $[M+H]^+$: 420.1594, found 420.1589.

21. benzyl (2-(2-hydroxynaphthalen-1-yl)-4-(trifluoromethyl)phenyl)carbamate (4u)and benzyl (2-(2-hydroxynaphthalen-1-yl)-4-methylphenyl)carbamate (4u')

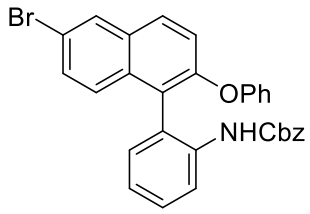


4u/4u'

19% yield and 19% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); Purified directly by flash chromatography on silica gel (10:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.51 (d, *J* = 8.8 Hz, 1H), 8.14 (d, *J* = 8.0 Hz, 1H), 7.89 – 7.80 (m, 4H), 7.76 (dd, *J* = 8.9, 2.1 Hz, 1H), 7.53 (d, *J* = 2.1 Hz, 1H), 7.38 (dd, *J* = 6.3, 3.2 Hz, 2H), 7.36 – 7.32 (m, 3H), 7.30 – 7.26 (m, 6H), 7.26 – 7.19 (m, 7H), 7.16 (dd, *J* = 6.2, 3.4 Hz, 1H), 7.06 (d, *J* = 2.1 Hz, 1H), 6.55 (s, 1H), 6.27 (s, 1H), 5.32 (s, 1H), 5.26 (s, 1H), 5.04 (s, 2H), 5.02 (s, 2H), 2.35 (s, 3H); ^{13}C NMR (126

MHz, $CDCl_3$) δ 153.7, 153.1, 151.3, 151.2, 140.6, 135.8, 135.4, 134.8, 134.2, 132.9, 132.8, 132.2, 131.5, 130.74, 130.66, 129.3, 129.14, 129.11, 128.6, 128.51, 128.48, 128.43, 128.36, 128.31, 128.26, 128.2, 127.7, 127.2, 127.11, 127.08, 126.0, 125.8, 124.14, 124.08, 123.8, 123.7, 123.0, 122.9, 119.6, 117.9, 117.7, 115.6, 113.9, 67.4, 67.0, 20.8; ^{19}F NMR (471 MHz, $CDCl_3$) δ -61.9; HRMS (ESI) m/z calcd for $[C_{25}H_{22}NO_3]^+$ $[M+H]^+$: 384.1594 and $[C_{25}H_{19}F_3NO_3]^+$ $[M+H]^+$: 438.1312, found 384.1595 and 438.1309.

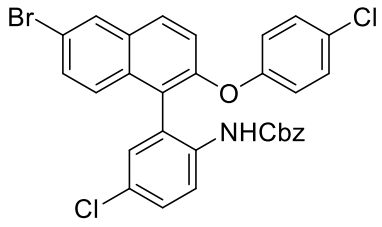
22. benzyl (2-(6-bromo-2-phenoxynaphthalen-1-yl)phenyl)carbamate (4g')



4g'

27% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^1H NMR (400 MHz, $CDCl_3$) δ 8.13 – 7.99 (m, 1H), 7.94 (d, *J* = 2.0 Hz, 1H), 7.69 (d, *J* = 8.9 Hz, 1H), 7.34 (qd, *J* = 8.8, 2.1 Hz, 2H), 7.24 – 7.20 (m, 3H), 7.19 – 7.08 (m, 6H), 7.08 – 7.01 (m, 2H), 6.96 – 6.90 (m, 1H), 6.77 – 6.71 (m, 2H), 6.29 (s, 1H), 5.02 – 4.92 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.1, 153.4, 152.1, 136.4, 136.0, 132.1, 131.9, 131.3, 130.5, 130.2, 129.7, 129.5, 129.1, 128.62, 128.57, 128.31, 128.28, 127.7, 127.2, 124.0, 123.6, 123.3, 120.8, 119.3, 118.3, 66.9; HRMS (ESI) m/z calcd for $[C_{30}H_{23}BrNO_3]^+$ $[M+H]^+$: 524.0856, found 524.0867.

23. benzyl (2-(6-bromo-2-(4-chlorophenoxy)naphthalen-1-yl)-4-chlorophenyl)-carbamate (4h')

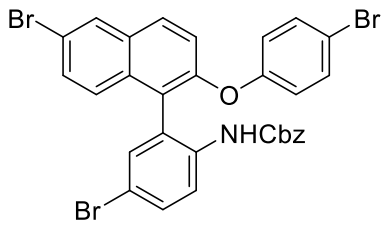


4h'

23% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^1H NMR (500 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.97 (d, *J* = 2.0 Hz, 1H), 7.74 (d, *J* = 9.0 Hz, 1H), 7.42 (dd, *J* = 9.0, 2.0 Hz, 1H), 7.31 (dd, *J* = 8.9, 2.5 Hz, 1H), 7.25 (dd, *J* = 5.4, 1.9 Hz, 3H), 7.21 – 7.17 (m, 3H), 7.15 (d, *J* = 9.0 Hz, 1H), 7.10 – 7.06 (m, 2H), 7.06 (d, *J* = 2.6 Hz, 1H), 6.72 – 6.62 (m, 2H), 6.18 (s, 1H), 5.03 – 4.92 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ

155.4, 153.1, 151.8, 135.7, 135.1, 131.9, 131.7, 131.0, 130.9, 130.3, 130.2, 129.8, 129.2, 128.63, 128.57, 128.5, 128.4, 126.8, 124.0, 122.6, 120.4, 119.7, 119.6, 67.2; HRMS (ESI) m/z calcd for $[C_{30}H_{21}BrCl_2NO_3]^+$ $[M+H]^+$: 592.0076, found 592.0069.

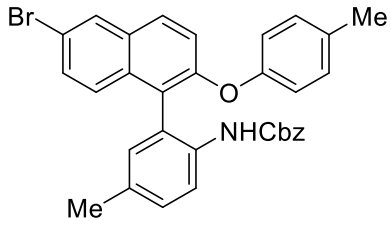
24. benzyl (4-bromo-2-(6-bromo-2-(4-bromophenoxy)naphthalen-1-yl)phenyl)-carbamate (4i')



4i'

30% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, *J* = 2.0 Hz, 2H), 7.73 (d, *J* = 9.0 Hz, 1H), 7.43 (ddd, *J* = 13.9, 9.0, 2.2 Hz, 2H), 7.27 – 7.22 (m, 4H), 7.22 – 7.16 (m, 5H), 7.14 (d, *J* = 9.0 Hz, 1H), 6.61 (d, *J* = 8.9 Hz, 2H), 6.17 (s, 1H), 5.02 – 4.90 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 156.0, 153.0, 151.7, 135.7, 135.6, 133.7, 132.71, 132.66, 132.1, 131.9, 131.8, 131.7, 131.0, 130.3, 130.2, 128.6, 128.5, 128.4, 126.8, 122.6, 121.8, 120.4, 120.0, 119.8, 116.1, 67.2; HRMS (ESI) m/z calcd for $[C_{30}H_{21}Br_3NO_3]^+$ $[M+H]^+$: 681.9046, found 681.9051.

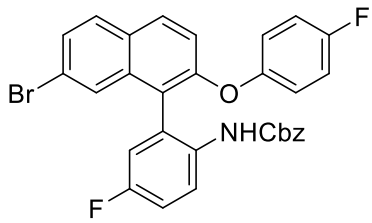
25. benzyl (2-(6-bromo-2-(*p*-tolyloxy)naphthalen-1-yl)-4-methylphenyl)carba-mate (4j')



4j'

13% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 2.0 Hz, 1H), 7.65 (d, *J* = 9.0 Hz, 1H), 7.35 (dd, *J* = 9.1, 2.1 Hz, 1H), 7.27 – 7.20 (m, 4H), 7.18 – 7.10 (m, 4H), 6.97 – 6.88 (m, 3H), 6.67 (d, *J* = 8.5 Hz, 2H), 6.23 (s, 1H), 5.04 – 4.88 (m, 2H), 2.22 (s, 3H), 2.20 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.8, 153.5, 152.5, 136.1, 133.8, 132.9, 132.2, 131.8, 131.6, 130.4, 130.2, 130.1, 129.7, 129.2, 128.7, 128.5, 128.4, 128.23, 128.21, 127.7, 127.3, 123.7, 120.3, 119.0, 118.6, 66.8, 20.8, 20.7; HRMS (ESI) m/z calcd for $[C_{32}H_{27}BrNO_3]^+$ $[M+H]^+$: 552.1169, found 552.1161.

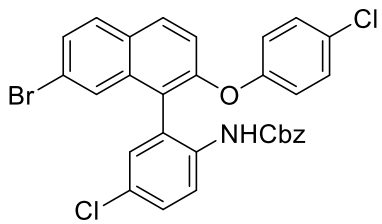
26. benzyl (2-(7-bromo-2-(4-fluorophenoxy)naphthalen-1-yl)-4-fluorophenyl)-carbamate (4l')



4l'

31% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.03 (s, 1H), 7.77 (d, *J* = 9.0 Hz, 1H), 7.66 (d, *J* = 8.5 Hz, 1H), 7.47 (d, *J* = 9.3 Hz, 2H), 7.24 (dd, *J* = 5.3, 1.8 Hz, 3H), 7.21 – 7.16 (m, 2H), 7.07 (dd, *J* = 14.5, 8.8 Hz, 2H), 6.82 (t, *J* = 8.8 Hz, 3H), 6.70 (dd, *J* = 9.1, 4.3 Hz, 2H), 6.18 (s, 1H), 4.99 (q, *J* = 12.2 Hz, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 160.1, 157.7, 153.5, 152.8, 135.8, 134.5, 132.6, 130.9, 129.9, 129.02, 128.94, 128.6, 128.4, 128.3, 127.0, 122.3, 120.00, 119.92, 119.1, 118.0, 117.7, 116.5, 116.2, 116.1, 115.9, 67.1; ^{19}F NMR (471 MHz, $CDCl_3$) δ -119.1, -119.5; HRMS (ESI) m/z calcd for $[C_{30}H_{21}BrF_2NO_3]^+$ $[M+H]^+$: 560.0667, found 560.0669.

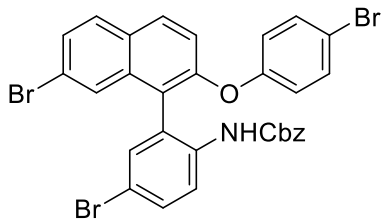
27. benzyl (2-(7-bromo-2-(4-chlorophenoxy)naphthalen-1-yl)-4-chlorophenyl)-carbamate (4m')



4m'

19% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.06 (s, 1H), 7.78 (d, *J* = 9.0 Hz, 1H), 7.66 (d, *J* = 8.6 Hz, 1H), 7.52 – 7.43 (m, 2H), 7.31 (dd, *J* = 8.8, 2.5 Hz, 1H), 7.24 (dd, *J* = 5.5, 1.8 Hz, 3H), 7.21 – 7.16 (m, 2H), 7.11 (d, *J* = 9.0 Hz, 1H), 7.08 (s, 1H), 7.07 – 7.03 (m, 2H), 6.70 – 6.63 (m, 2H), 6.19 (s, 1H), 4.98 (q, *J* = 12.1 Hz, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 155.4, 153.1, 152.5, 135.7, 135.2, 134.5, 131.1, 130.9, 130.0, 129.8, 129.3, 129.23, 129.18, 129.1, 128.71, 128.65, 128.5, 128.42, 128.37, 127.0, 125.7, 122.5, 121.5, 119.7, 119.5, 67.2; HRMS (ESI) m/z calcd for $[C_{30}H_{21}BrCl_2NO_3]^+$ $[M+H]^+$: 592.0076, found 592.0064.

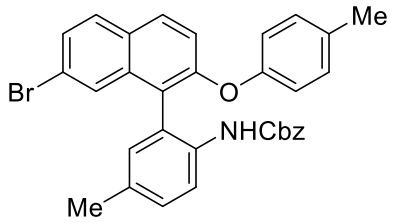
28. benzyl (4-bromo-2-(7-bromo-2-(4-bromophenoxy)naphthalen-1-yl)phenyl)-carbamate, hydrogen salt (4n')



4n'

30% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.02 (s, 1H), 7.79 (d, *J* = 9.0 Hz, 1H), 7.67 (d, *J* = 8.7 Hz, 1H), 7.51 – 7.43 (m, 3H), 7.25 (d, *J* = 6.9 Hz, 2H), 7.22 (d, *J* = 2.1 Hz, 1H), 7.22 – 7.17 (m, 4H), 7.12 (d, *J* = 9.0 Hz, 1H), 6.66 – 6.56 (m, 2H), 6.18 (s, 1H), 5.05 – 4.92 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 155.9, 153.0, 152.4, 135.67, 135.66, 134.54, 133.66, 132.71, 132.26, 131.12, 129.98, 129.24, 129.22, 128.7, 128.5, 128.4, 127.0, 122.5, 121.5, 120.1, 119.6, 116.2, 116.1, 67.2; HRMS (ESI) m/z calcd for $[C_{30}H_{21}Br_3NO_3]^+$ $[M+H]^+$: 681.9046, found 681.9054.

29. benzyl (2-(7-bromo-2-(*p*-tolyloxy)naphthalen-1-yl)-4-methylphenyl)carbamate (4o')

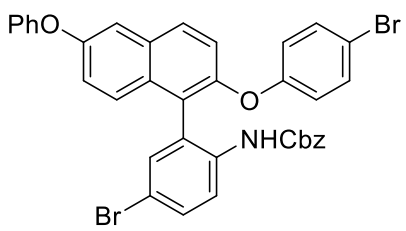


4o'

15% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (s, 1H), 7.71 (d, *J* = 9.0 Hz, 1H), 7.62 (d, *J* = 8.7 Hz, 1H), 7.51 (d, *J* = 1.8 Hz, 1H), 7.42 (dd, *J* = 8.7, 1.9 Hz, 1H), 7.25 – 7.13 (m, 6H), 7.10 (d, *J* = 9.0 Hz, 1H), 6.97 – 6.86 (m, 3H), 6.67 (d, *J* = 8.5 Hz, 2H), 6.25 (s, 1H), 5.03 – 4.93 (m, 2H), 2.24 (s, 3H), 2.20 (s, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 154.7, 153.5, 153.1, 136.1, 135.0, 133.9, 133.0, 131.7, 130.2, 130.1, 129.79, 129.77, 129.6, 128.9, 128.6, 128.54, 128.49, 128.24, 128.22, 127.4, 122.6, 121.8, 119.4, 118.8, 66.9, 20.9, 20.7; HRMS (ESI) m/z calcd for $[C_{32}H_{27}BrNO_3]^+$ $[M+H]^+$: 552.1169, found 552.1156.

30. benzyl (4-bromo-2-(2-(4-bromophenoxy)-6-phenoxynaphthalen-1-yl)phenyl)-carbamate (4s')

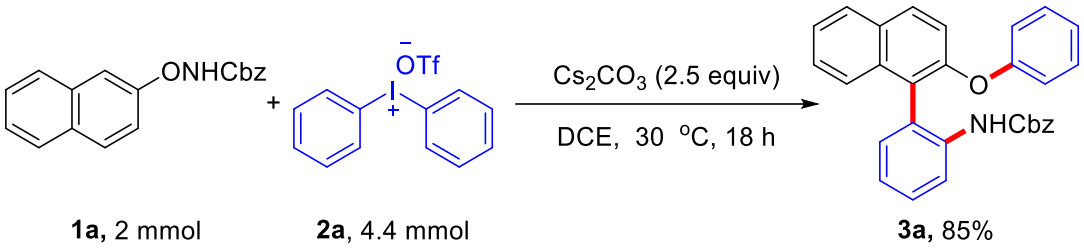
22% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash



4s'

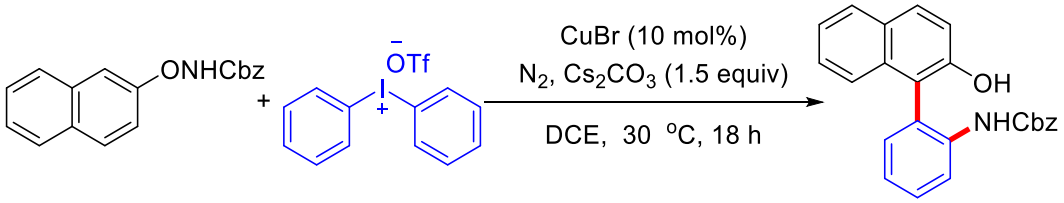
chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.76 (d, *J* = 9.0 Hz, 1H), 7.51 (dd, *J* = 9.0, 2.4 Hz, 1H), 7.41 – 7.37 (m, 2H), 7.37 (d, *J* = 2.0 Hz, 1H), 7.35 – 7.32 (m, 3H), 7.29 – 7.26 (m, 4H), 7.26 (s, 3H), 7.22 (d, *J* = 4.3 Hz, 1H), 7.18 (d, *J* = 8.0 Hz, 1H), 7.08 (dt, *J* = 7.8, 1.1 Hz, 2H), 6.73 – 6.62 (m, 2H), 6.32 (s, 1H), 5.11 – 5.01 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 157.6, 157.0, 154.9, 150.7, 136.4, 136.1, 131.9, 131.3, 130.1, 129.9, 129.6, 129.5, 129.1, 128.9, 128.7, 128.6, 128.29, 128.27, 127.5, 124.3, 123.7, 123.4, 122.9, 121.1, 120.8, 119.23, 119.21, 117.9, 114.3, 66.9; HRMS (ESI) m/z calcd for $[C_{36}H_{26}Br_2NO_4]^+$ $[M+H]^+$: 696.0203, found 696.0200.

Experimental procedure for large scale reaction



1a, 2 mmol **2a**, 4.4 mmol **3a,** 85%

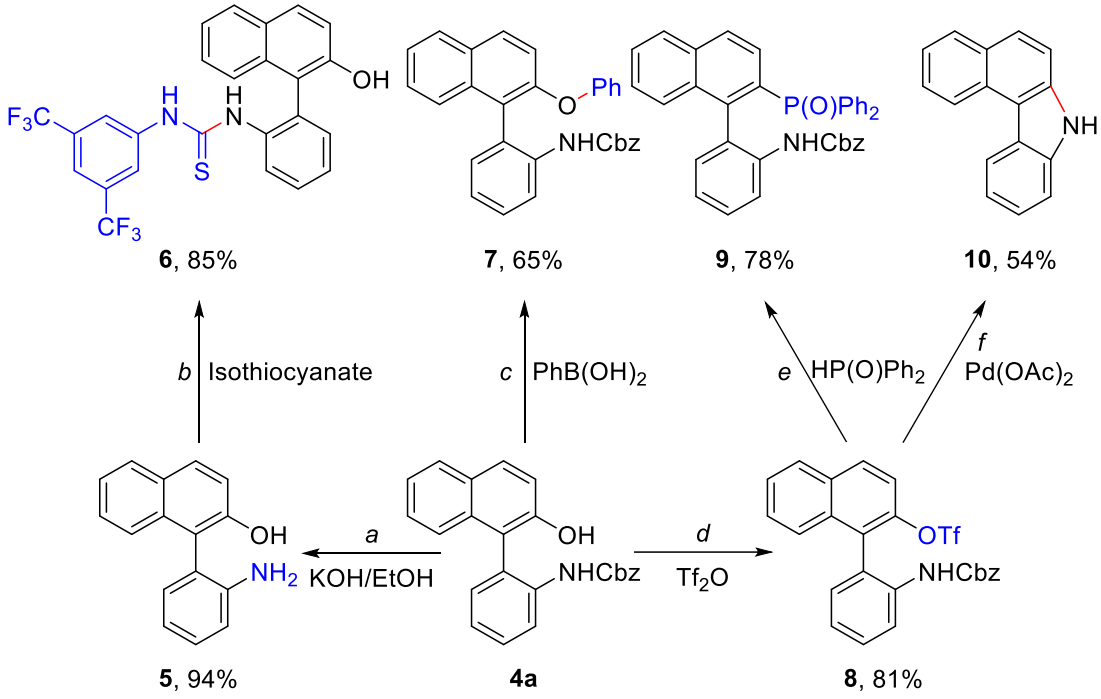
Benzyl(naphthalen-2-yloxy)carbamate (0.59 g, 2 mmol, 1.0 equiv) and diphenyl-λ^3-iodanyl trifluoromethanesulfonate (4.4 mmol, 2.2 equiv) were dissolved in anhydrous DCE (20 mL) under air atmosphere and Cs_2CO_3 (5 mmol, 2.5 equiv) was added. The resulting mixture was stirred at 30 ℃ for 18 hours. After the solvent was removed in vacuum, the residue was purified by flash chromatography (PE/EtOAc = 20/1) to obtain **3a** (0.77 g, 85 %).



1a, 2 mmol **2a**, 2.4 mmol **4a,** 54%

Under N_2 atmosphere, A dried flask was charged with Benzyl(naphthalen-2-yloxy)carbamate (0.59 g, 2 mmol, 1.0 equiv), diphenyl-λ^3-iodanyl trifluoromethanesulfonate (2.4 mmol, 1.2 equiv), Cs_2CO_3 (3 mmol, 1.5 equiv) and CuBr (0.2 mmol, 10 mol%), and the mixture was added anhydrous DCE (20 mL). The mixture was stirred at 30 ℃ for 18 hours. The resulting solution was concentrated in vacuo and purified by flash chromatography on silica gel (PE/EtOAc = 10/1) to give **4a** (0.4 g, 54 %)..

Synthetic applications of the biaryl products



General Procedure for the Synthesis of 5[8].

KOH (2 mmol, 0.132 g, 20 equiv) was added to a solution of **4a** (0.1 mmol, 1.0 equiv) in EtOH (2 mL) in a sealed-tube. The resulting mixture was stirred at 100 ℃ for 12 hours. After completion of the reaction, the mixture was cooled to room temperature. The solvent was removed in vacuum, and the resulting residue was purified on a silica gel column (PE/EtOAc = 5/1) to provide the desired products **5** (22 mg, 94%).

(a) General Procedure for the Synthesis of 6[9].

Compound **5** (0.2 mmol, 1.0 equiv), 3,5-bis(tri-fluoromethyl)phenyl isothiocyanate (1.0 equiv) was dissolved in dry THF (6.0 mL). The reaction mixture was stirred in 30 ℃ for 12 hours. After completion of the reaction, the solvent was removed in vacuum and was purified by silica gel column chromatography (PE/EtOAc = 5/1) to obtain the desired product **6** (86 mg, 85%).

(b) General Procedure for the Synthesis of 7[10].

A solution of **4a** (0.2 mmol, 1.00 equiv), phenylboronic acid (50 mg, 0.4 mmol, 2.0

equiv), copper acetate (37.5 mg, 0.2 mmol, 1.0 equiv) and freshly activated 4 Å molecular sieves (250 mg/mmol) in ethyl acetate (2.0 mL). Then triethylamine (56 μL, 0.4 mmol., 2.0 equiv) was added to the the suspension. The reaction mixture was stirred at 30 ℃ for 12 hours. The residue was purified by column chromatography to give the desired product **7**.

(c) General Procedure for the Synthesis of 8[11].

To a solution of **4a** (0.2 mmol, 73.8 mg) in anhydrous CH_2Cl_2 (2.0 mL) was added triethylamine (34 μL, 0.24 mmol) at 0 ℃ under nitrogen atmosphere, and then triflic anhydride (0.24 mmol, 1.2 equiv) was slowly added to the mixture. After being stirred 0 ℃ for 5 minutes, the mixture was concentrated in vacuo. And purified by silica gel column chromatography (PE/EtOAc = 20/1) to obtain product **8** (162 mg, 81%).

(d) General Procedure for the Synthesis of 9[12].

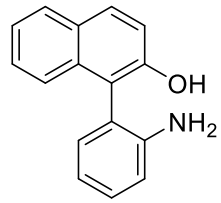
diphenylphosphine oxide (0.2 mmol, 2.0 equiv) was added to a solution of **4a** (0.1 mmol, 1.0 equiv), $Pd(OAc)_2$ (2.3 mg, 0.1 equiv), 1,3-bis(diphenylphosphino)propane (6.3 mg, 0.10 equiv), and *N*,*N*-diisopropylethylamine (86 μL, 0.15 equiv) in DMSO (1 mL). The mixture was stirred at 100 ℃ for 24 hours. After being cooled to room temperature, the mixture was diluted by ethyl acetate and washed with H_2O, the organic layer was washed with brine and dried over sodium sulfate. After the solvent was removed in vacuum, the crude product was purified by flash chromatography (PE/EtOAc = 5/1) to obtain desired product **9** (43 mg, 78%).

(e) General Procedure for the Synthesis of 10[13].

8 (0.22 g, 0.43 mmol), $Pd(OAc)_2$ (13 mg, 10 mol%) and Cs_2CO_3 (315 mg, 1.5 equiv) were combined in a toluene solution (6 mL) and stirred for 12 hours under a refluxing condition. After being cooled to room temperature, after the solvent was removed in vacuum, the crude product was purified by flash chromatography (PE/EtOAc = 10/1) to obtain desired product **10** (50 mg, 54%).

Analysis data of synthetic application products

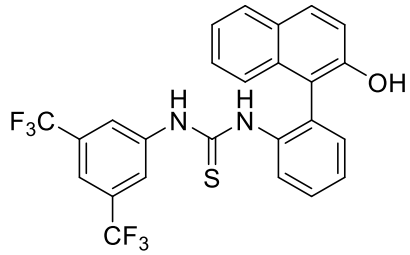
1. 1-(2-aminophenyl)naphthalen-2-ol (5)



5

94% yield; White solid, m.p. = 167-169 ℃; R_f = 0.2 (PE:EA =5:1); Purified directly by flash chromatography on silica gel (5:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.76 – 7.73 (m, 2H), 7.38 – 7.34 (m, 1H), 7.31 – 7.20 (m, 4H), 7.10 (dd, *J* = 7.5, 1.6 Hz, 1H), 6.88 – 6.81 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 151.2, 145.1, 133.0, 132.5, 130.0, 129.9, 129.3, 128.2, 126.7, 124.6, 123.5, 119.5, 118.8, 118.1, 117.2, 116.2; HRMS (ESI) m/z calcd for $[C_{16}H_{14}NO]^+$ $[M+H]^+$: 236.1070, found 236.1060.

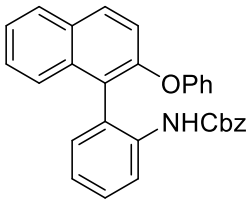
2. 1-(3,5-bis(trifluoromethyl)phenyl)-3-(2-(2-hydroxynaphthalen-1-yl)phenyl)thiourea (6)



6

85% yield; Viscous oily liquid; R_f = 0.2 (PE:EA = 5:1); Purified directly by flash chromatography on silica gel (5:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.88 – 9.77 (m, 1H), 9.70 (s, 1H), 9.34 (s, 1H), 7.81 – 7.73 (m, 3H), 7.73 – 7.67 (m, 2H), 7.59 (s, 1H), 7.50 (td, *J* = 7.7, 1.6 Hz, 1H), 7.42 – 7.35 (m, 2H), 7.30 – 7.24 (m, 2H), 7.14 (pd, *J* = 6.8, 1.6 Hz, 2H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 179.9, 152.3, 142.0, 137.9, 133.7, 133.0, 132.9, 130.0, 129.8, 129.6, 128.4, 128.3, 128.2, 128.0, 126.7, 126.4, 124.8, 124.7, 123.44, 123.41, 122.8, 122.6, 118.6, 117.9, 116.6; ^{19}F NMR (471 MHz, $CDCl_3$) δ -62.9; HRMS (ESI) m/z calcd for $[C_{25}H_{17}F_6N_2OS]^+$ $[M+H]^+$: 507.0960, found 507.0957.

3. benzyl (2-(2-phenoxynaphthalen-1-yl)phenyl)carbamate (7)

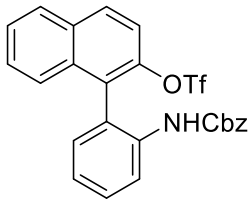


7

65% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 (s, 1H), 7.85 – 7.75 (m, 2H), 7.39 – 7.30 (m, 4H), 7.21 (td,

J = 5.1, 2.5 Hz, 3H), 7.16 (dd, *J* = 8.3, 3.1 Hz, 3H), 7.13 – 7.06 (m, 3H), 7.03 (td, *J* = 7.4, 1.2 Hz, 1H), 6.94 – 6.88 (m, 1H), 6.77 – 6.71 (m, 2H), 6.36 (s, 1H), 5.02 – 4.91 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 157.5, 153.4, 151.7, 136.4, 136.1, 133.6, 131.4, 130.9, 130.5, 129.6, 129.1, 128.9, 128.7, 128.5, 128.3, 128.24, 128.23, 127.2, 125.4, 125.3, 123.9, 123.4, 123.0, 119.9, 118.2, 66.8; HRMS (ESI) m/z calcd for $[C_{30}H_{24}NO_3]^+$ $[M+H]^+$: 446.1751,found 446.1753.

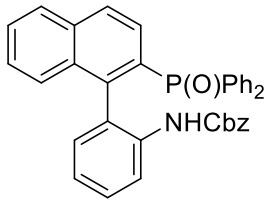
4. 1-(2-(((benzyloxy)carbonyl)amino)phenyl)naphthalen-2-yl trifluoromethanesulfonate (8)



8

81% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 15:1); Purified directly by flash chromatography on silica gel (20:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.27 (s, 1H), 8.04 (dd, *J* = 29.2, 8.6 Hz, 2H), 7.63 (dd, *J* = 9.7, 4.8 Hz, 2H), 7.57 (dt, *J* = 8.9, 3.1 Hz, 2H), 7.52 (t, *J* = 7.6 Hz, 1H), 7.37 – 7.31 (m, 5H), 7.26 (dd, *J* = 6.3, 2.9 Hz, 2H), 6.27 (d, *J* = 5.0 Hz, 1H), 5.18 – 5.05 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 153.5, 144.9, 136.6, 136.0, 132.74, 132.68, 131.5, 131.4, 130.2, 128.52, 128.49, 128.4, 128.3, 128.2, 128.1, 127.5, 126.3, 124.2, 121.8, 119.7, 119.6, 117.2, 66.9; ^{19}F NMR (471 MHz, $CDCl_3$) δ -74.1; HRMS (ESI) m/z calcd for $[C_{25}H_{19}F_3NO_5S]^+$ $[M+H]^+$: 502.0931, found 502.0942.

5. benzyl (2-(2-(diphenylphosphoryl)naphthalen-1-yl)phenyl)carbamate (9)

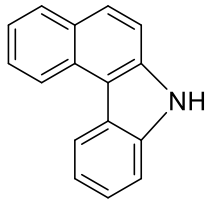


9

78% yield; Viscous oily liquid; R_f = 0.3 (PE:EA = 2:1); Purified directly by flash chromatography on silica gel (5:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, DMSO-d_6) δ 8.44 (s, 1H), 8.05 (dd, *J* = 13.0, 8.4 Hz, 2H), 7.78 (dd, *J* = 11.6, 7.6 Hz, 2H), 7.64 (t, *J* = 7.6 Hz, 1H), 7.54 (dt, *J* = 15.5, 7.7 Hz, 3H), 7.44 (dq, *J* = 18.6, 9.5, 8.5 Hz, 5H), 7.33 (ddd, *J* = 20.6, 11.0, 8.0 Hz, 3H), 7.27 – 7.23 (m, 3H), 7.20 (t, *J* = 7.8 Hz, 1H), 7.14 – 7.07 (m, 3H), 6.75 (t, *J* = 7.5 Hz, 1H), 6.65 (d, *J* = 7.7 Hz, 1H), 4.93 (s, 2H); ^{13}C NMR (126 MHz, DMSO- d_6) δ 154.3, 142.7, 137.1, 137.0, 135.0, 133.0, 132.8, 132.7, 132.5, 132.1, 132.0, 131.9, 131.8, 131.3, 131.2, 130.1, 129.0, 128.9, 128.8, 128.72, 128.70, 128.6, 128.5, 128.4,

128.2, 127.8, 127.7, 126.5, 124.0, 65.8; ^{31}P NMR (202 MHz, $CDCl_3$): δ 27.1; HRMS (ESI) m/z calcd for $[C_{36}H_{29}NO_3P]^+$ $[M+H]^+$: 554.1880, found 554.1881.

6. 7*H*-benzo[c]carbazole (10)



10

54% yield; Brown solid, m.p. = 166-169 ℃; R_f = 0.2 (PE:EA = 5:1); Purified directly by flash chromatography on silica gel (10:1, petroleum ether: ethyl acetate); ^{1}H NMR (500 MHz, DMSO-d_6) δ 9.43 (s, 1H), 7.80 (t, *J* = 8.8 Hz, 2H), 7.32 – 7.23 (m, 4H), 7.12 (td, *J* = 7.7, 1.7 Hz, 1H), 6.91 (dd, *J* = 7.5, 1.7 Hz, 1H), 6.85 – 6.77 (m, 1H), 6.69 (td, *J* = 7.3, 1.2 Hz, 1H); ^{13}C NMR (126 MHz, DMSO-d_6) δ 152.7, 146.7, 133.9, 132.0, 129.2, 128.7, 128.42, 128.36, 126.5, 124.7, 122.9, 121.3, 119.0, 118.4, 116.8, 115.3; HRMS (ESI) m/z calcd for $[C_{16}H_{12}N]^+$ $[M+H]^+$: 218.0964, found 218.0971.

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X-ray crystal structure data for compound 3a and 4a

Single crystal was chosen under an optical microscope and quickly coated with high vacuum grease (Dow Corning Corporation) to prevent decomposition. Intensity data and cell parameters were recorded at 173 K on a Bruker Apex II single crystal diffractometer, employing a Mo K_α radiation (λ = 0.71073 Å) and a CCD area detector. The raw frame data were processed using SAINT and SADABS to yield the reflection data file.[1] The structure was solved using the charge-flipping algorithm, as implemented in the program *SUPERFLIP*[2] and refined by full-matrix least-squares techniques against F_o^2 using the SHELXL program[3] through the OLEX2 interface.[4] Hydrogen atoms at carbon were placed in calculated positions and refined isotropically by using a riding model. Appropriate restraints or constraints were applied to the geometry and the atomic displacement parameters of the atoms in the cluster. All structures were examined using the Addsym subroutine of PLATON[5] to ensure that no additional symmetry could be applied to the models. CCDC **2049890** (**3a**) and CCDC **2049893** (**4a**) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from the Cambridge Crystallographic Data Centre.

References

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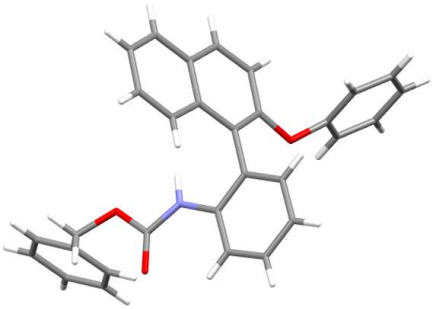

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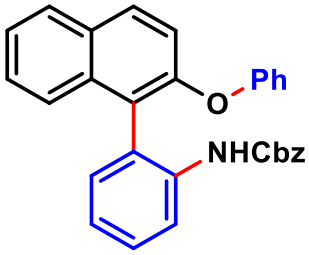
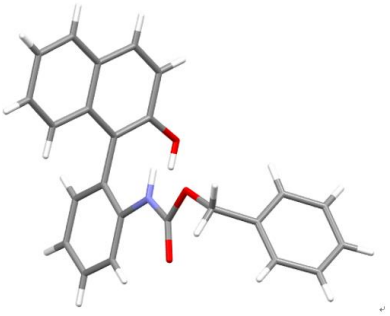


3a



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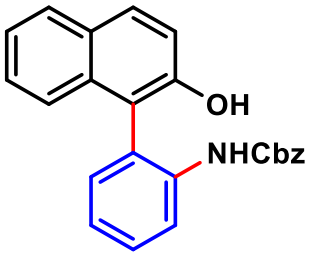
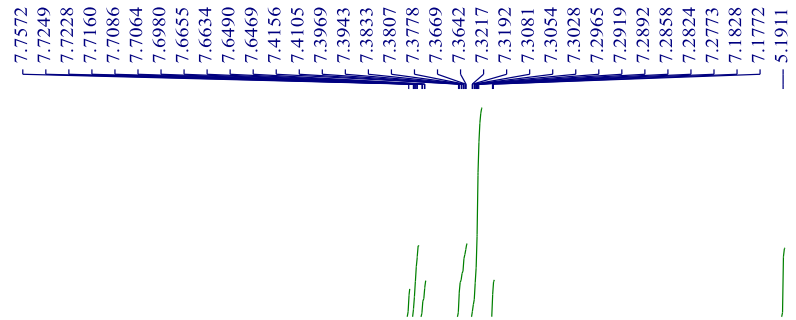


4a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7.3778
7.3669
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7.3192
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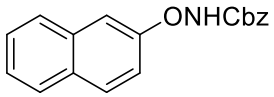
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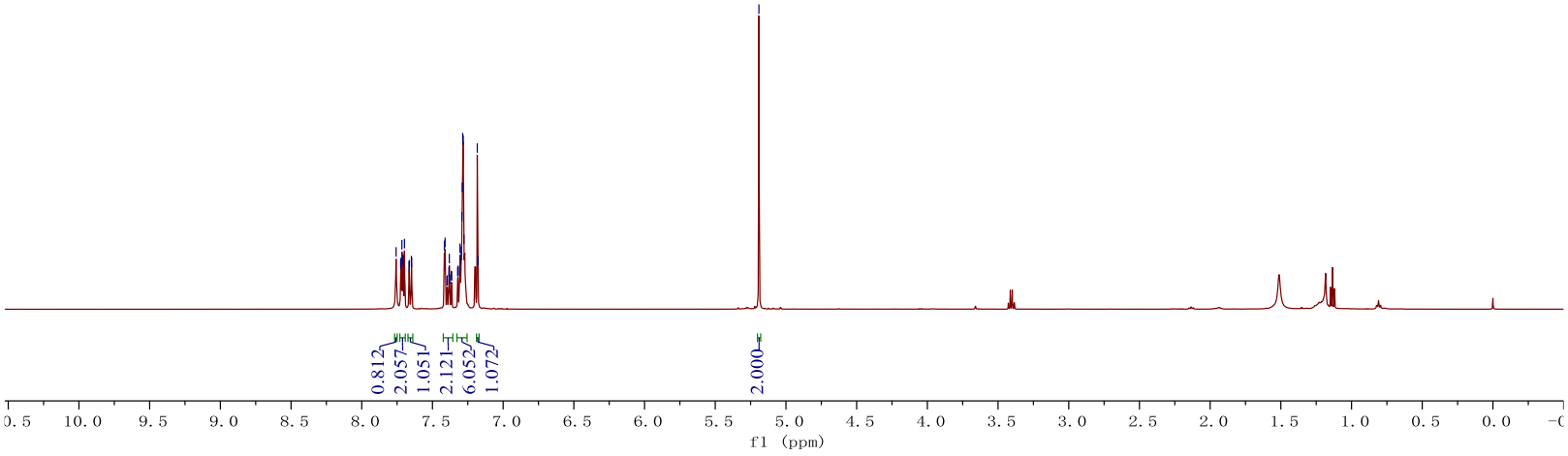
1a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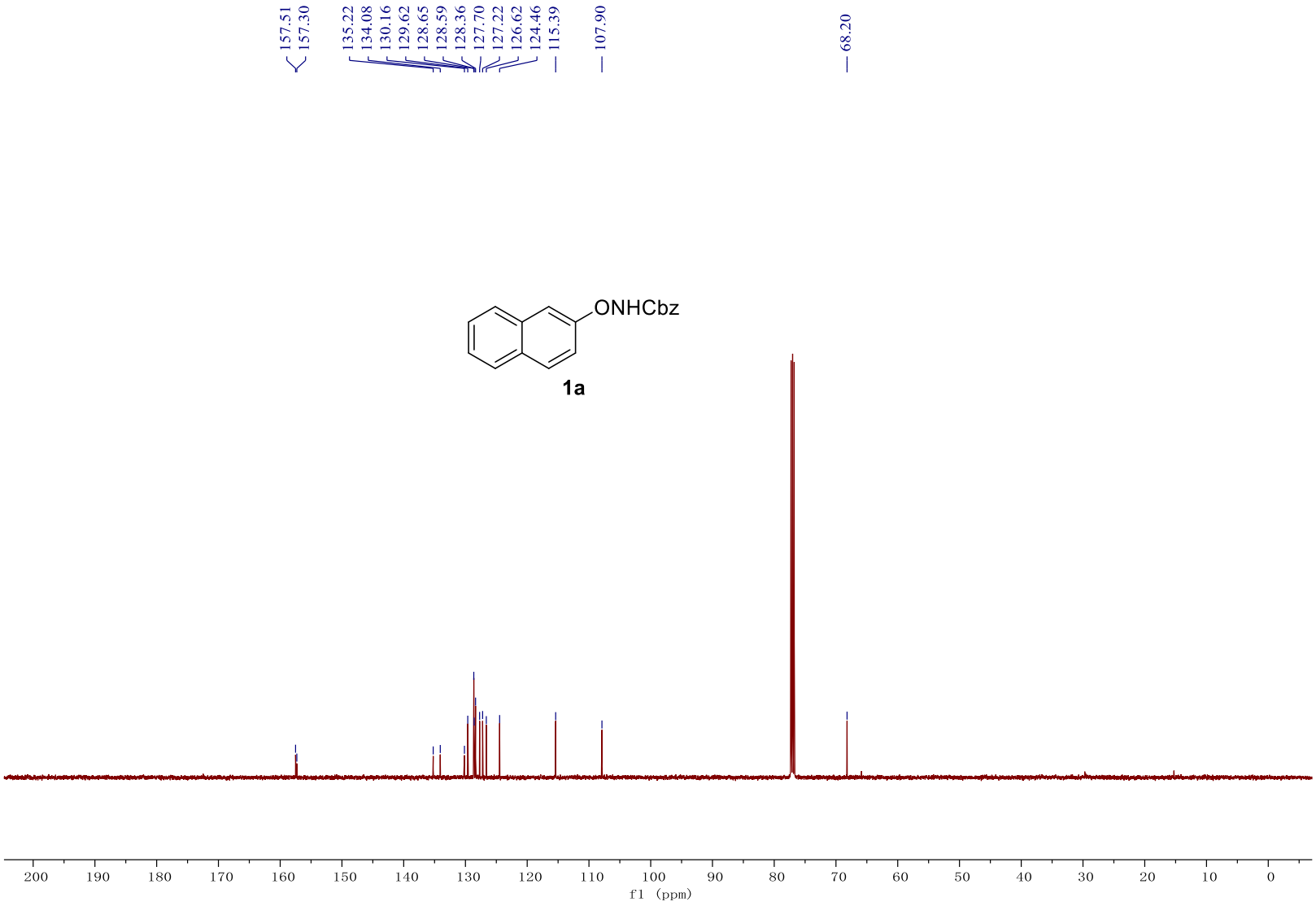
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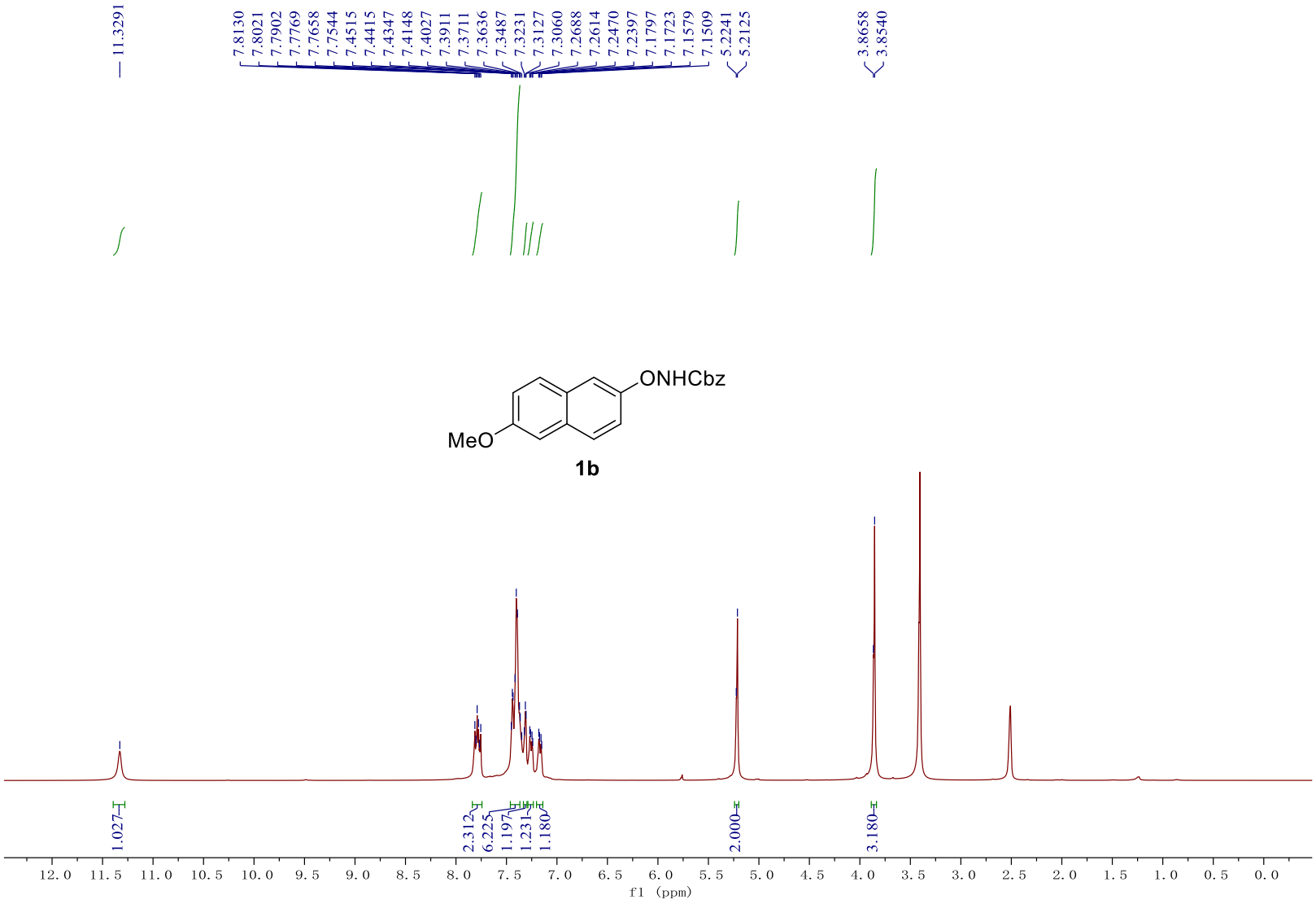
f1 (ppm)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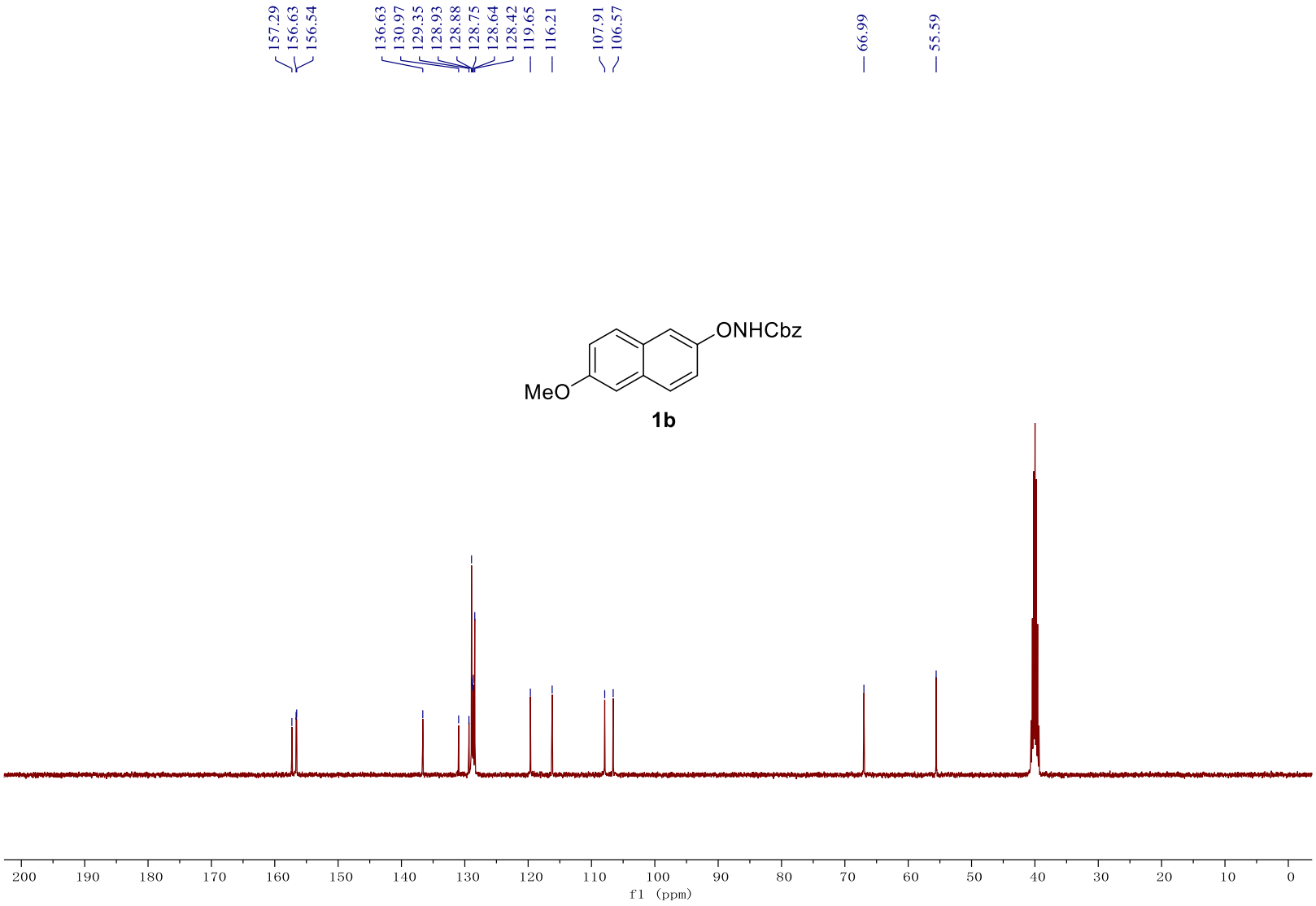
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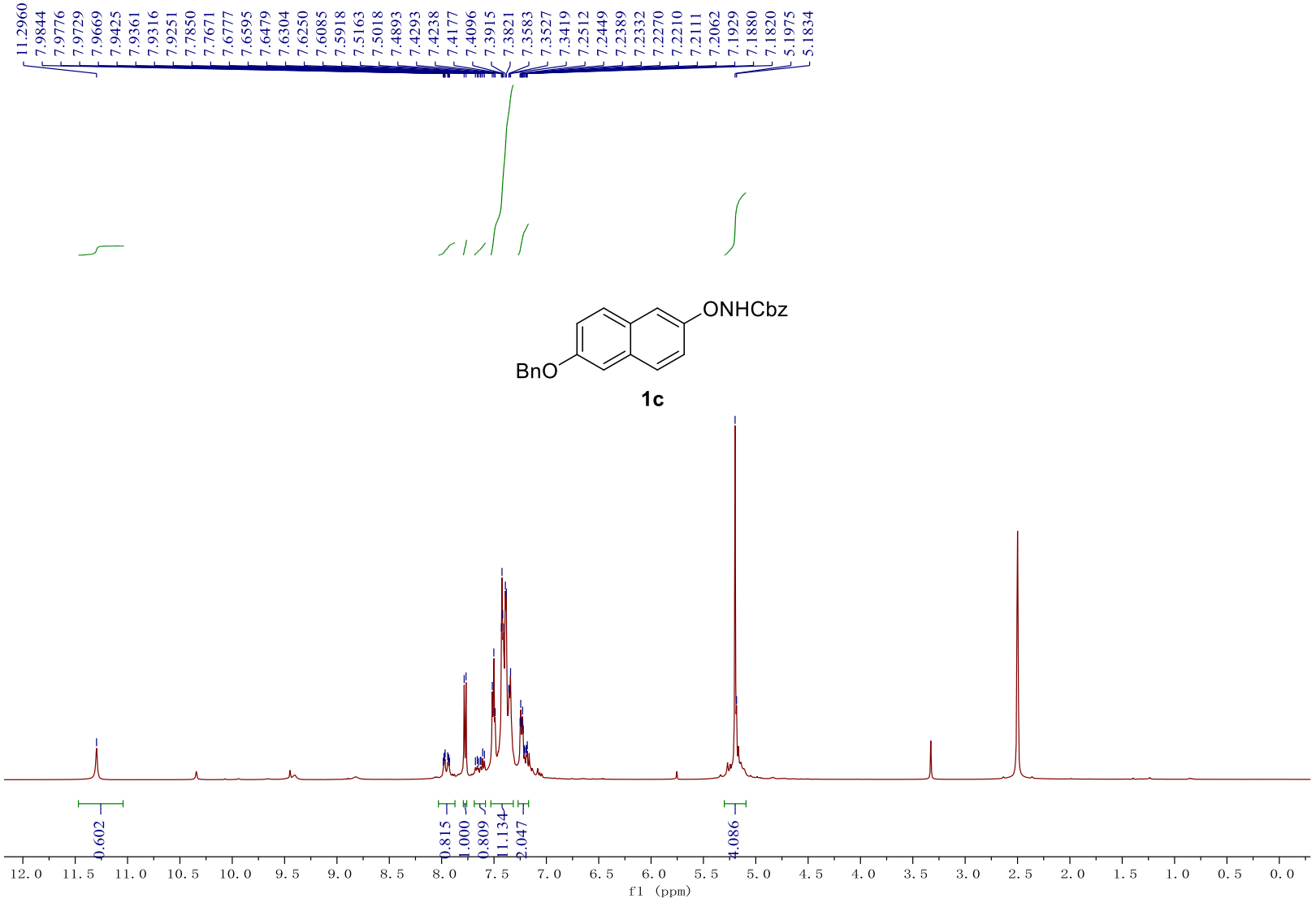
f1 (ppm)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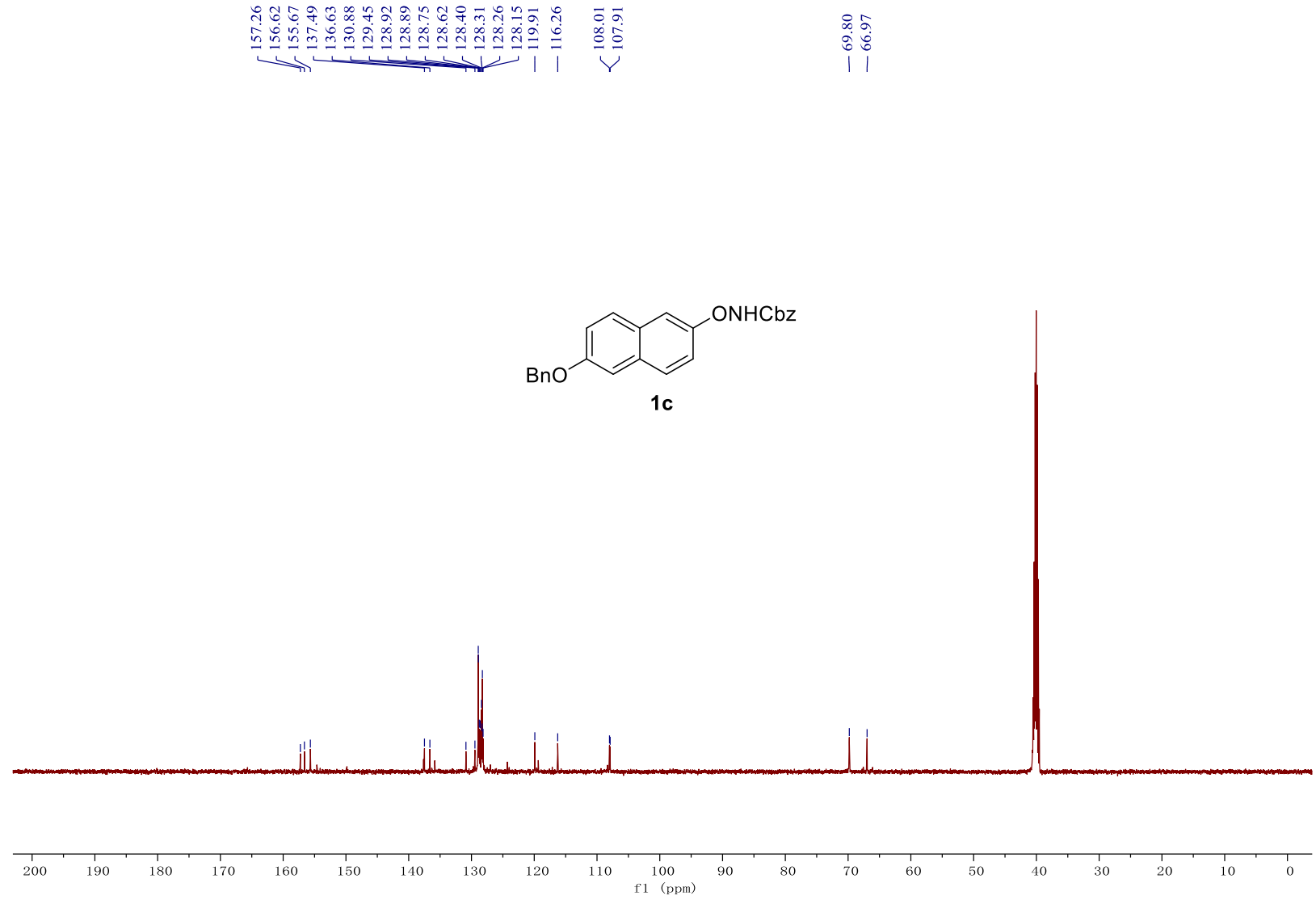
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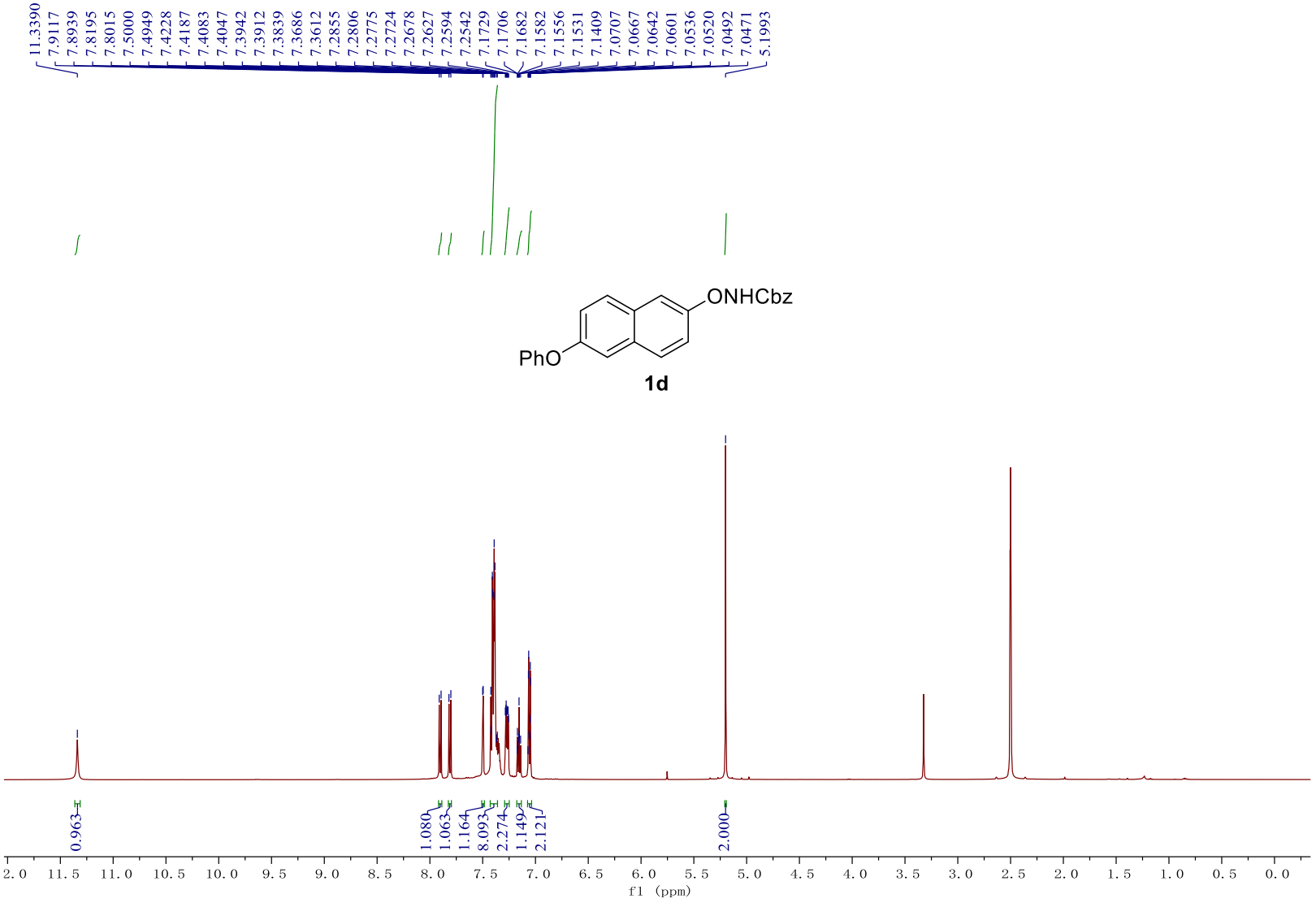
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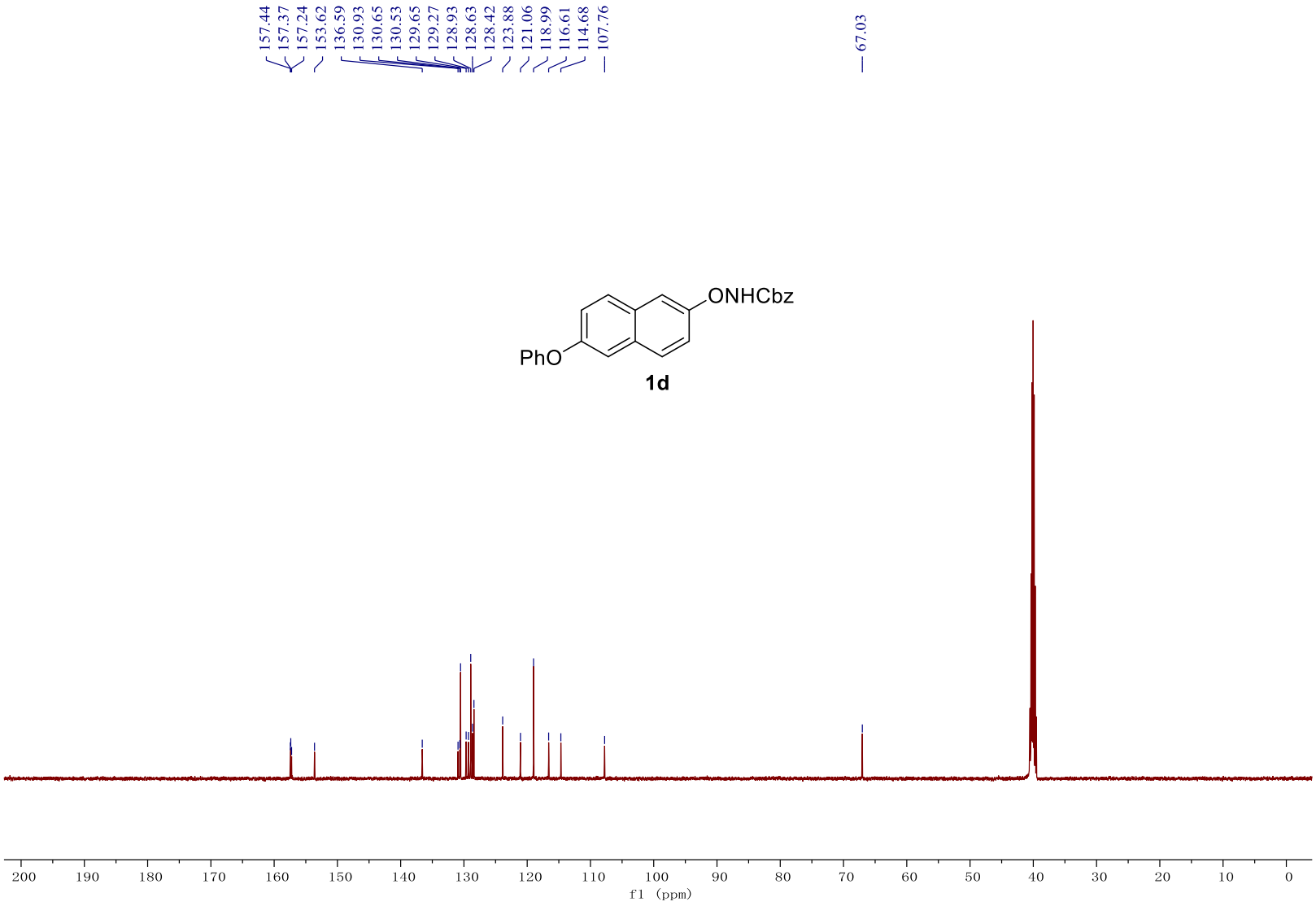
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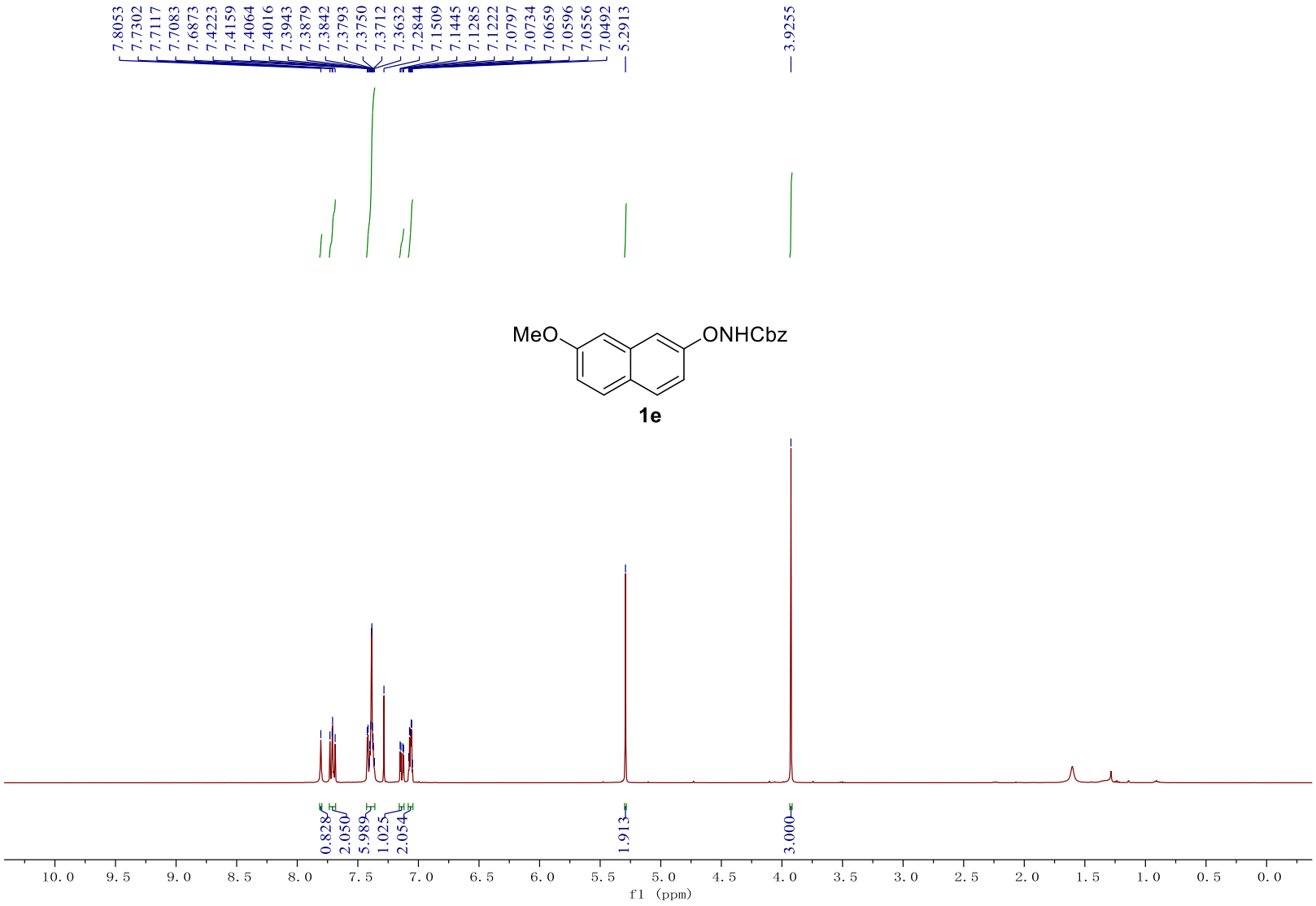
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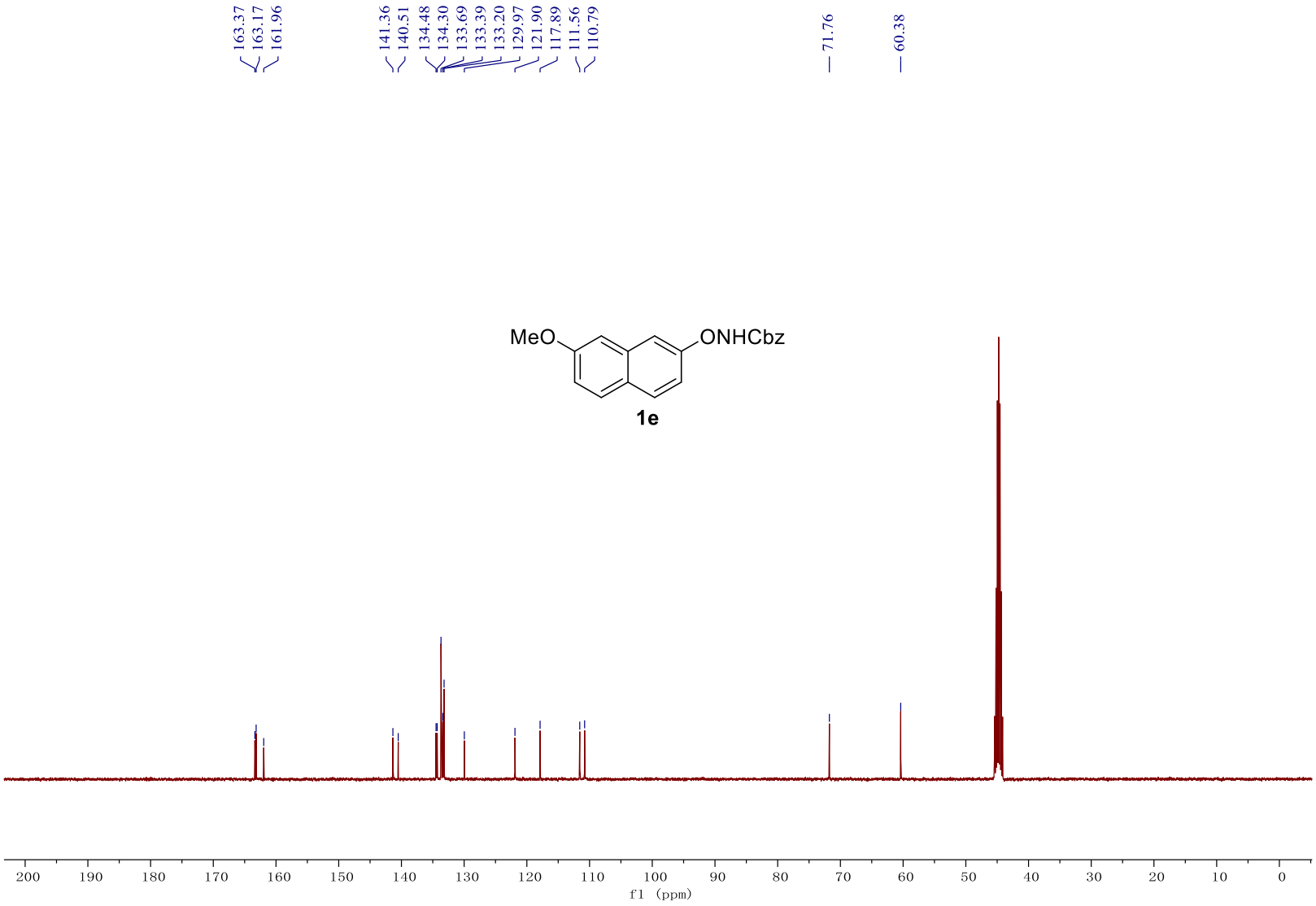
f1 (ppm)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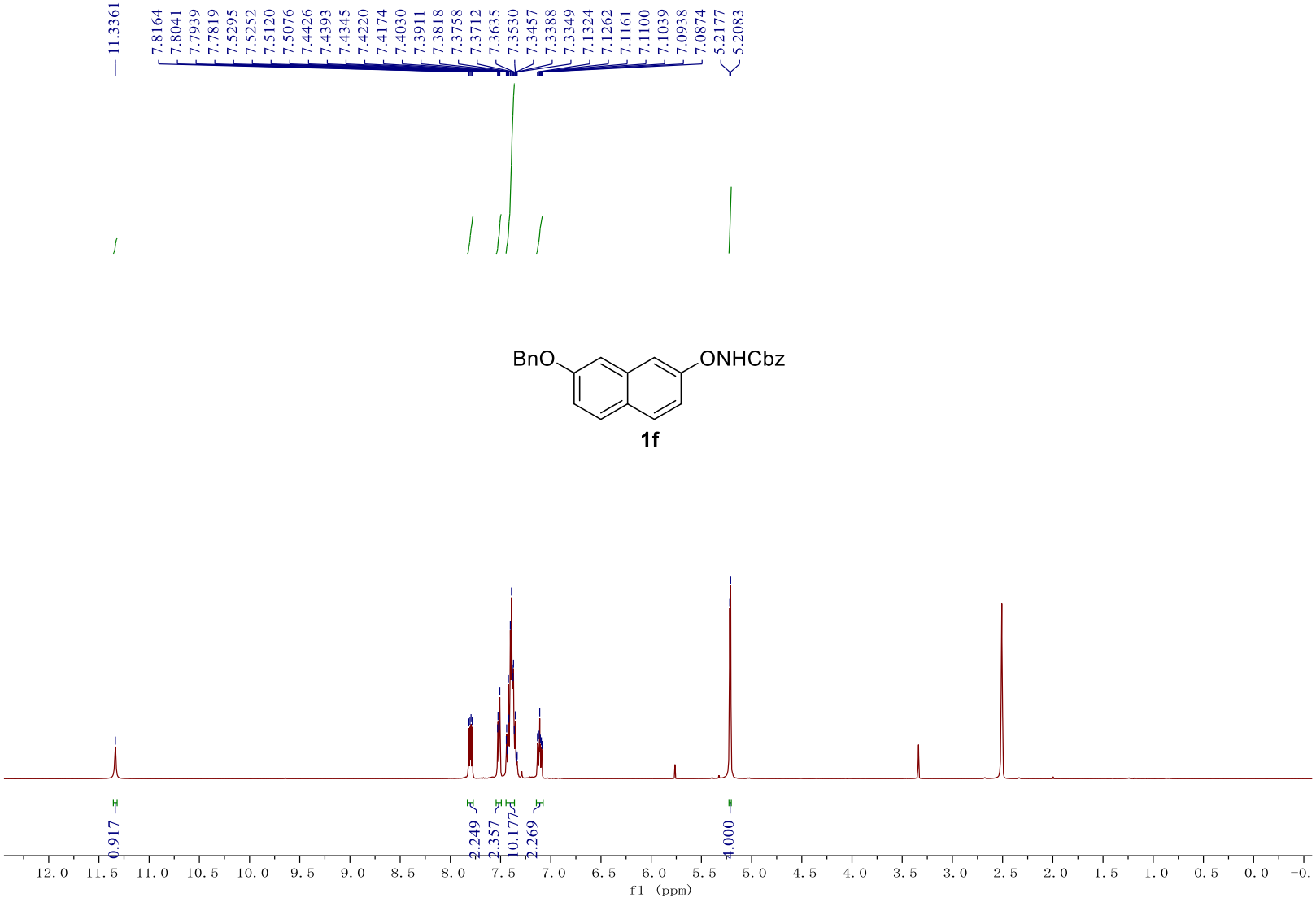
163.17
161.96
141.36
140.51
134.48
134.30
133.69
133.39
133.20
129.97
121.90
117.89
111.56
110.79
71.76
60.38
MeO
ONHCbz
1e
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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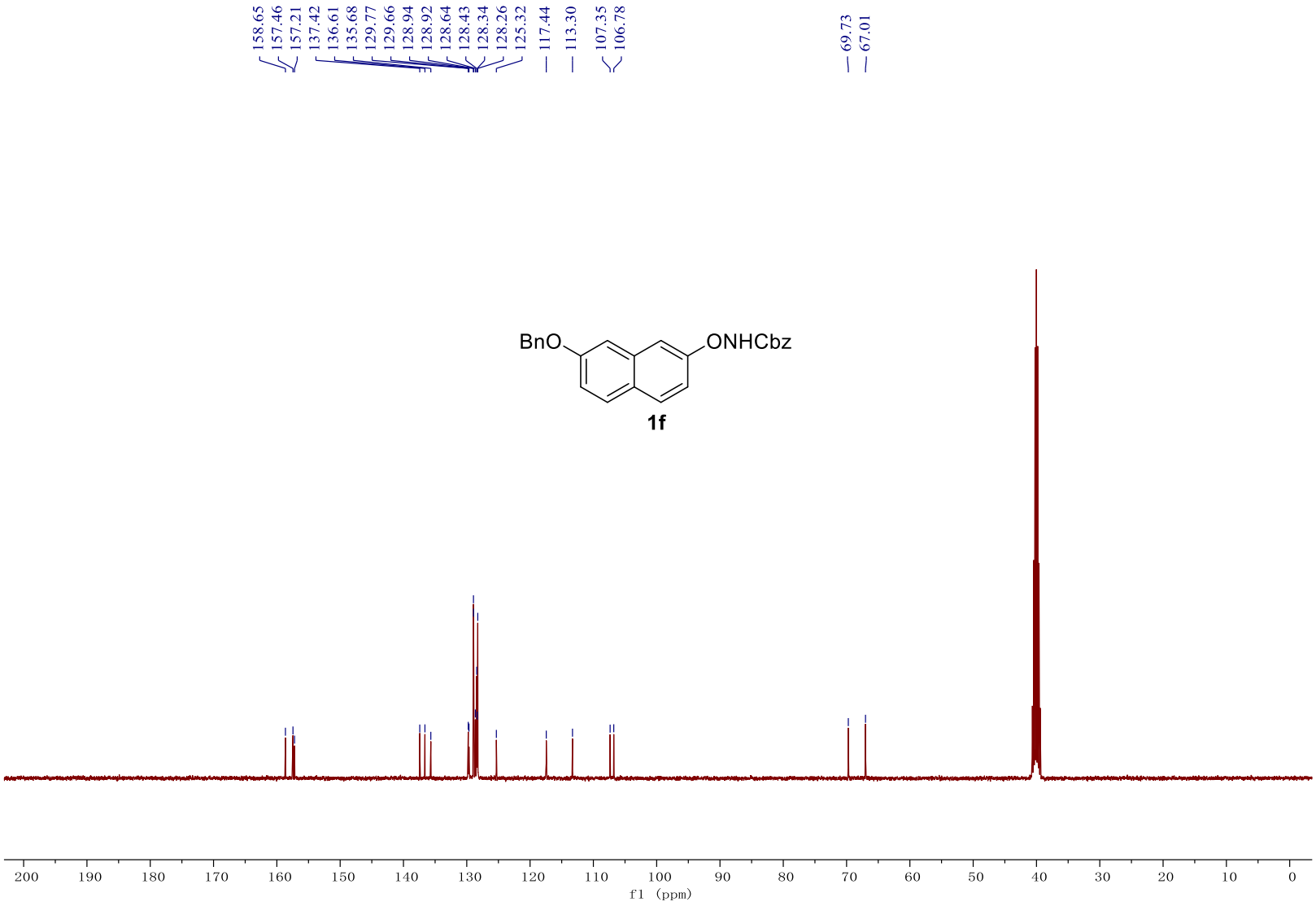
7.8164
7.8041
7.7939
7.7819
7.5295
7.5252
7.5120
7.5076
7.4426
7.4393
7.4345
7.4220
7.4174
7.4030
7.3911
7.3818
7.3758
7.3712
7.3635
7.3530
7.3457
7.3388
7.3349
7.1324
7.1262
7.1161
7.1100
7.1039
7.0938
7.0874
5.2177
5.2083
BnO
ONHCbz
1f
0.917
2.249
2.357
10.177
2.269
4.000
12.0 11.5 11.0 10.5 10.0 9.5 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.
f1 (ppm)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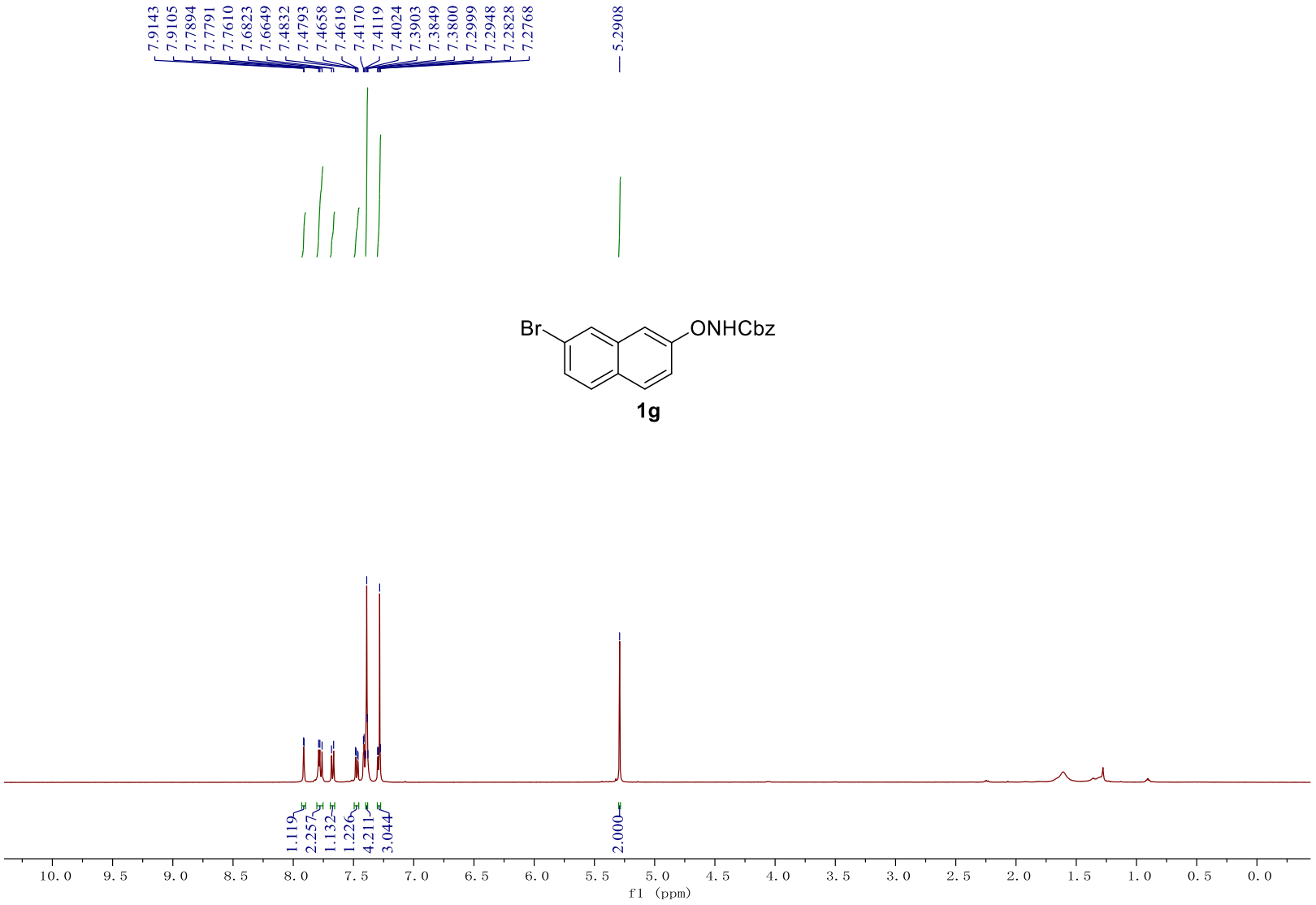
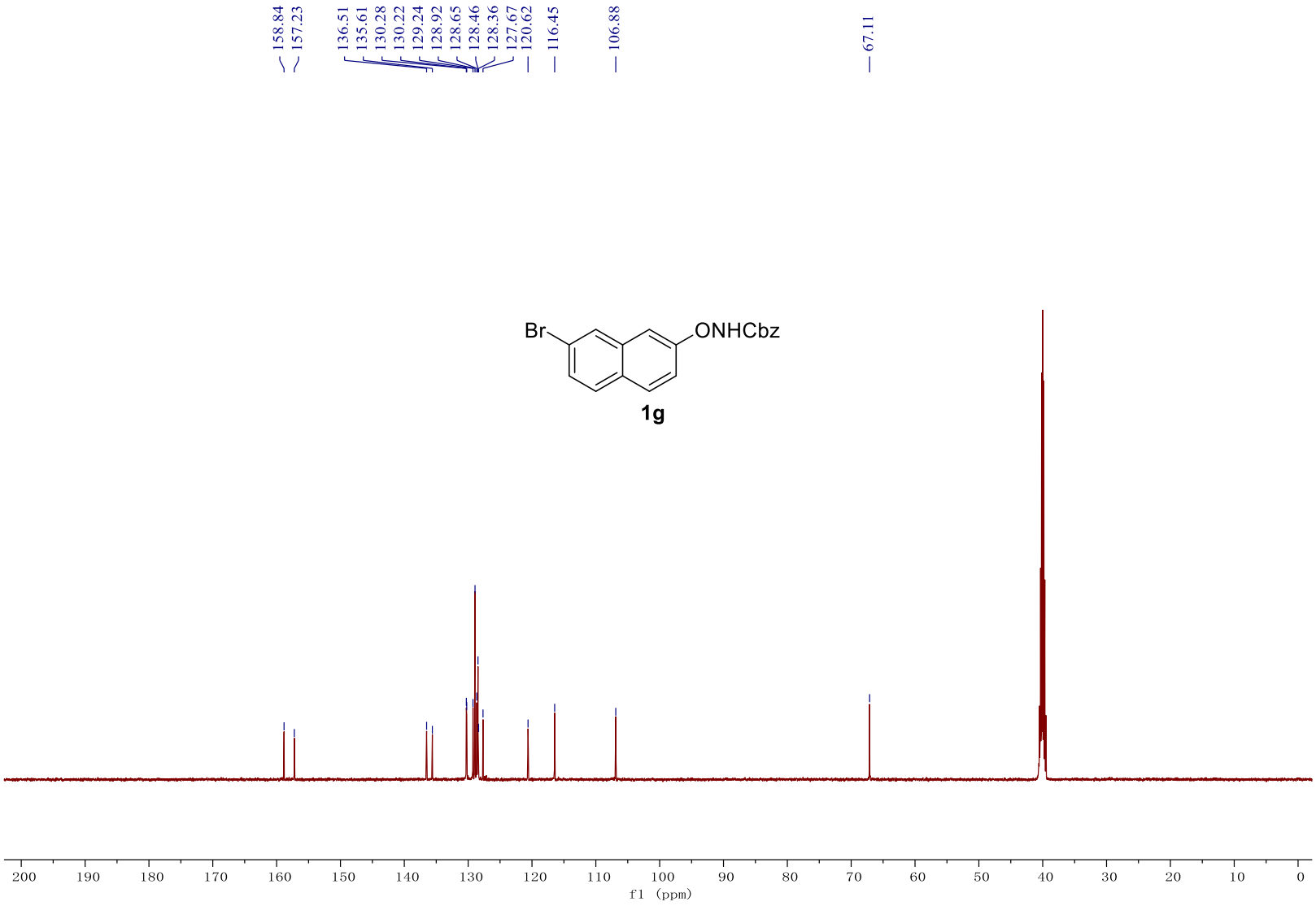
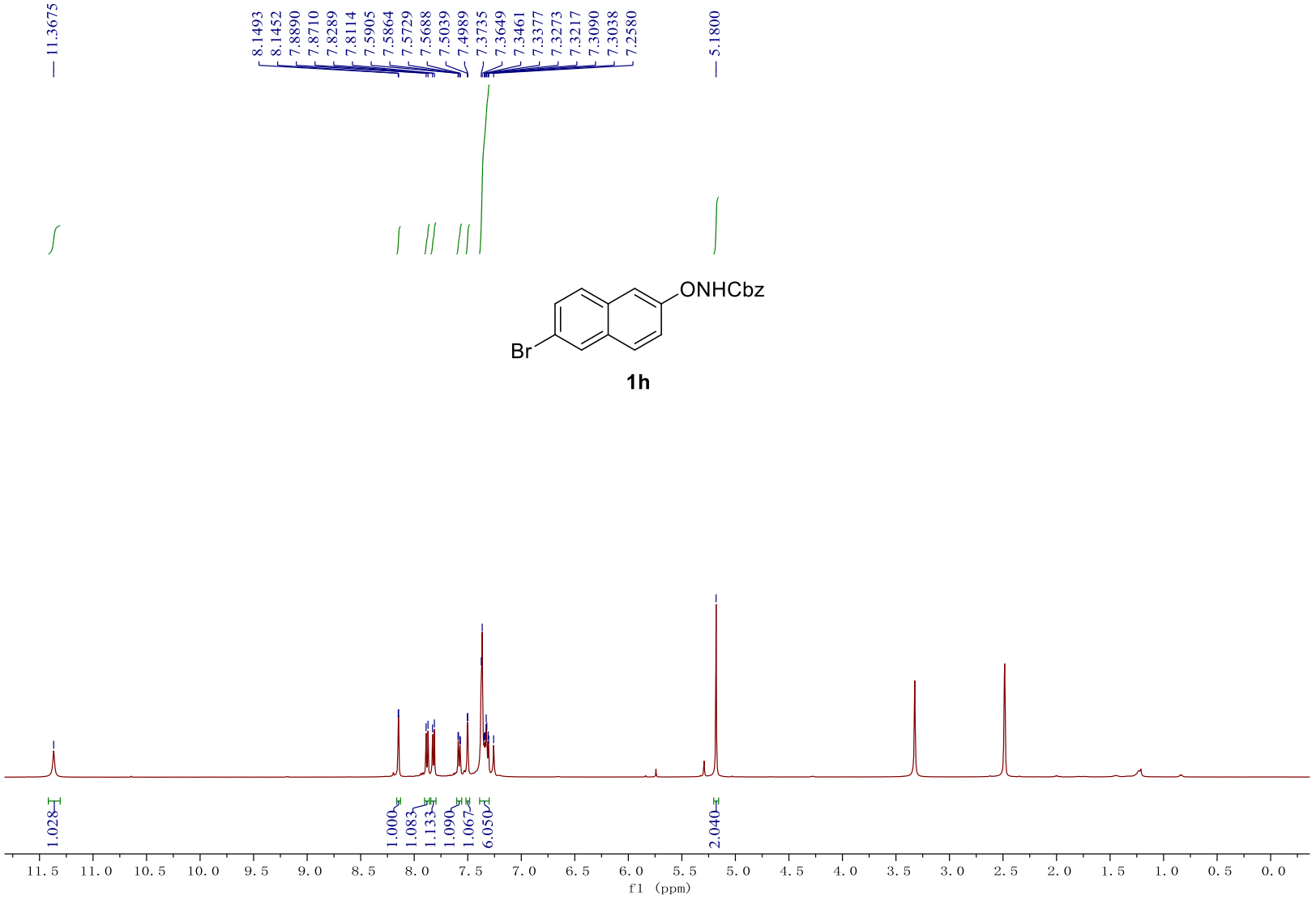
157.46
157.21
137.42
136.61
135.68
129.77
129.66
128.94
128.92
128.64
128.43
128.34
128.26
125.32
117.44
113.30
107.35
106.78
69.73
67.01
BnO
ONHCbz
1f
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.9143
7.9105
7.7894
7.7791
7.7610
7.6823
7.6649
7.4832
7.4793
7.4658
7.4619
7.4170
7.4119
7.4024
7.3903
7.3849
7.3800
7.2999
7.2948
7.2828
7.2768
5.2908
Br
ONHCbz
1g
1.119
2.257
1.132
1.226
4.211
3.044
2.000
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
f1 (ppm)


158.84
157.23
136.51
135.61
130.28
130.22
129.24
128.92
128.65
128.46
128.36
127.67
120.62
116.45
106.88
67.11
Br
ONHCbz
1g
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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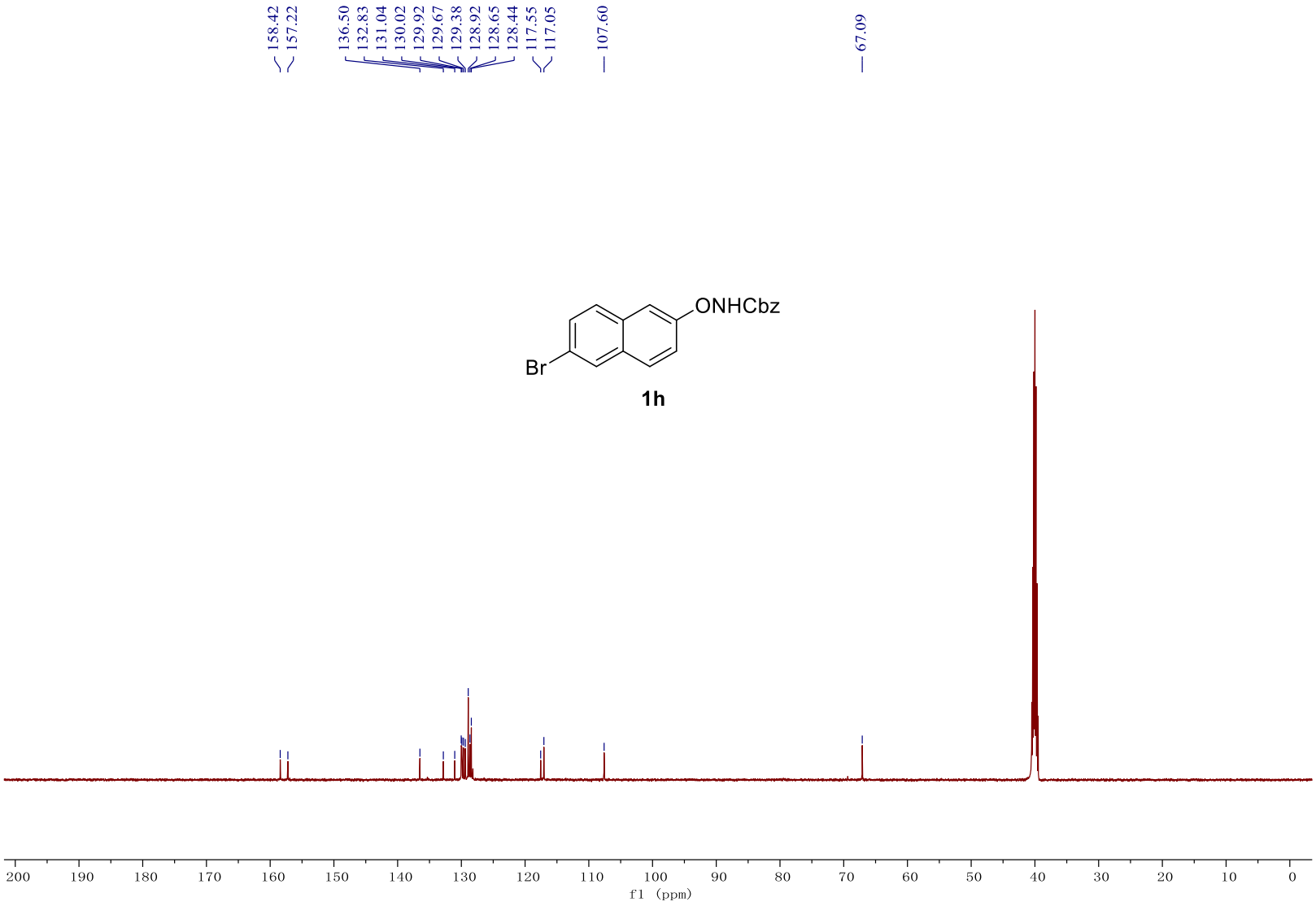
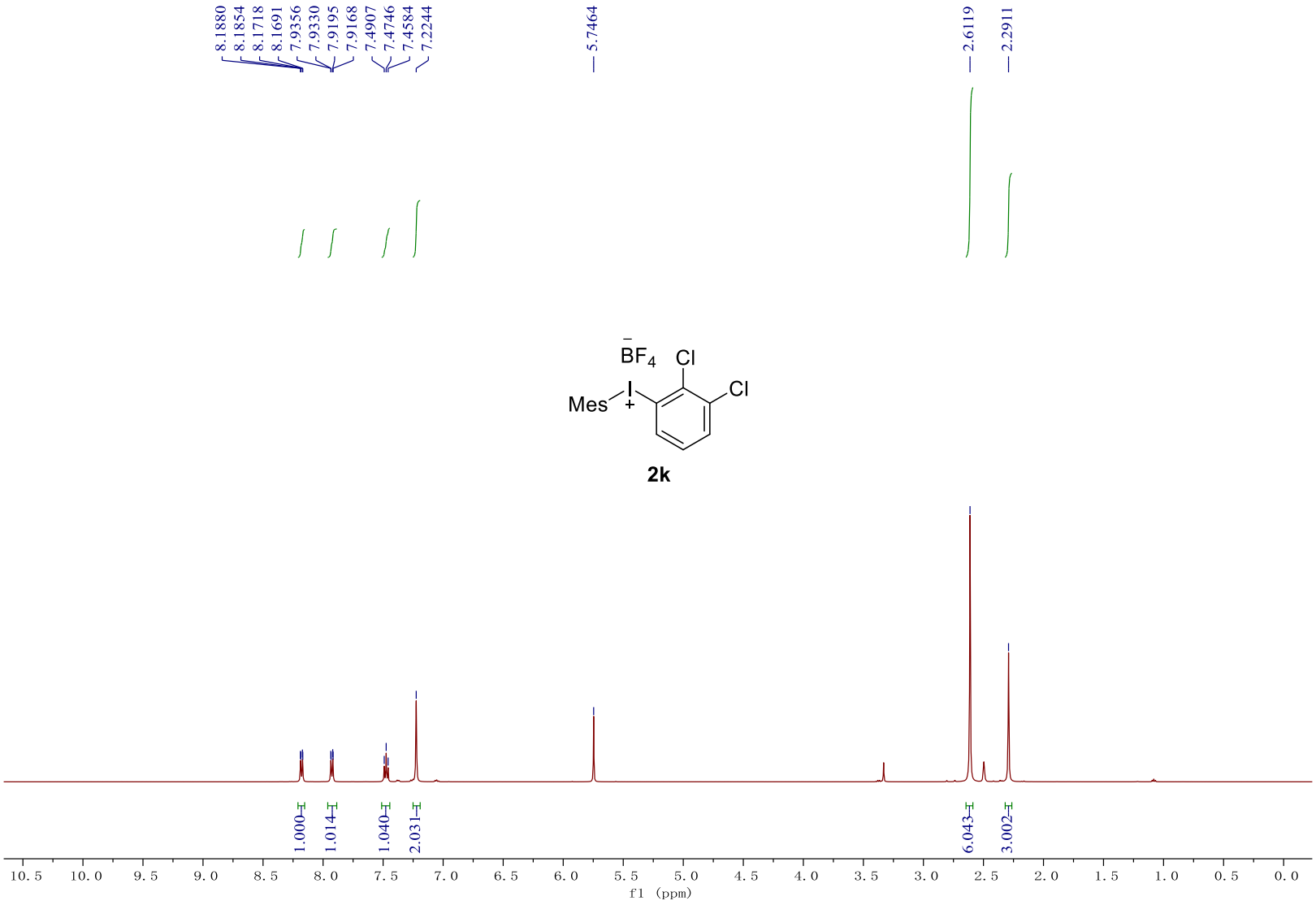
8.1452
7.8890
7.8710
7.8289
7.8114
7.5905
7.5864
7.5729
7.5688
7.5039
7.4989
7.3735
7.3649
7.3461
7.3377
7.3273
7.3217
7.3090
7.3038
7.2580
5.1800
ONHCbz
Br
1h
1.028
1.000
1.083
1.133
1.090
1.067
6.050
2.040
f1 (ppm)


158.42
157.22
136.50
132.83
131.04
130.02
129.92
129.67
129.38
128.92
128.65
128.44
117.55
117.05
107.60
67.09
ONHCbz
Br
1h
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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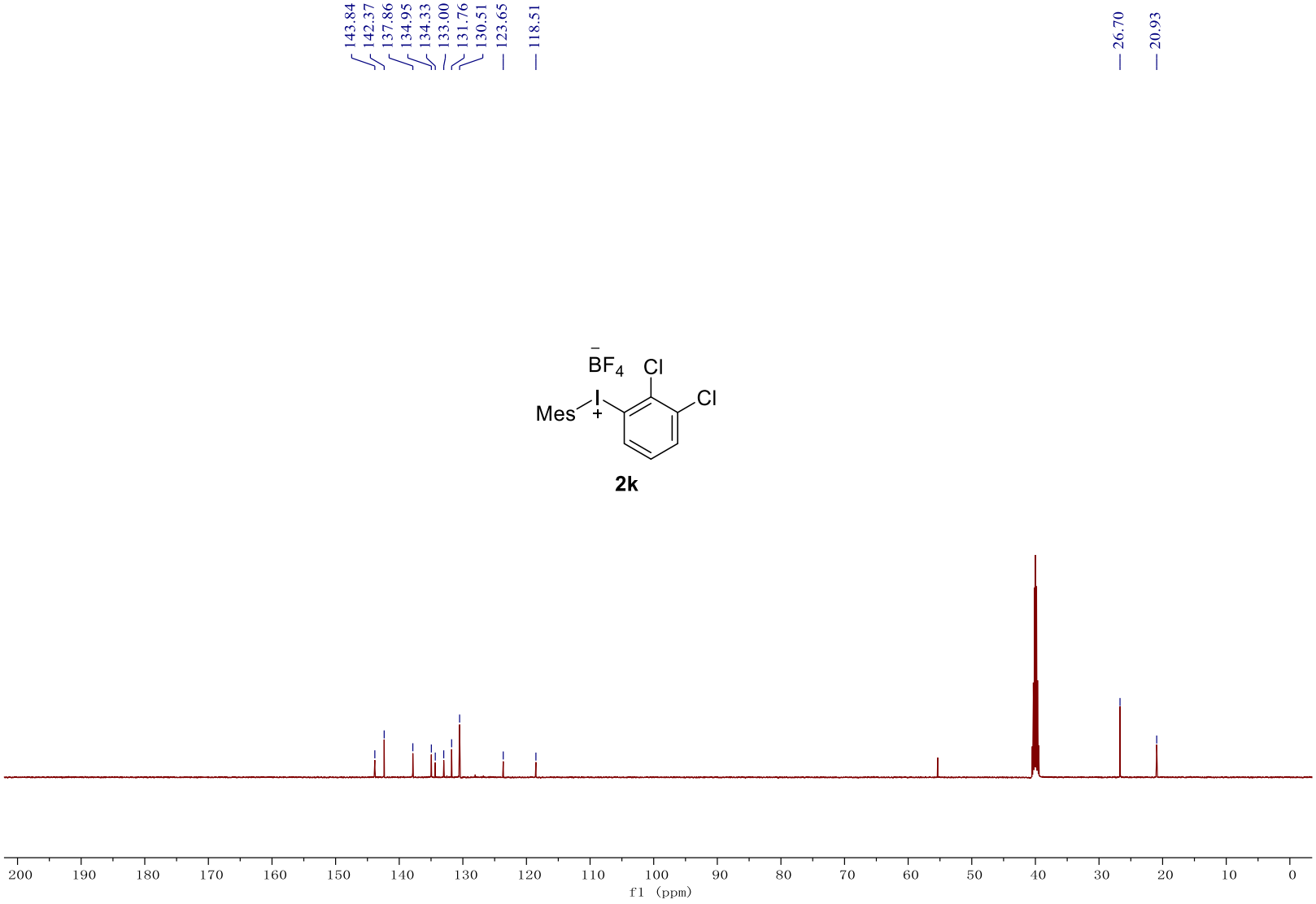
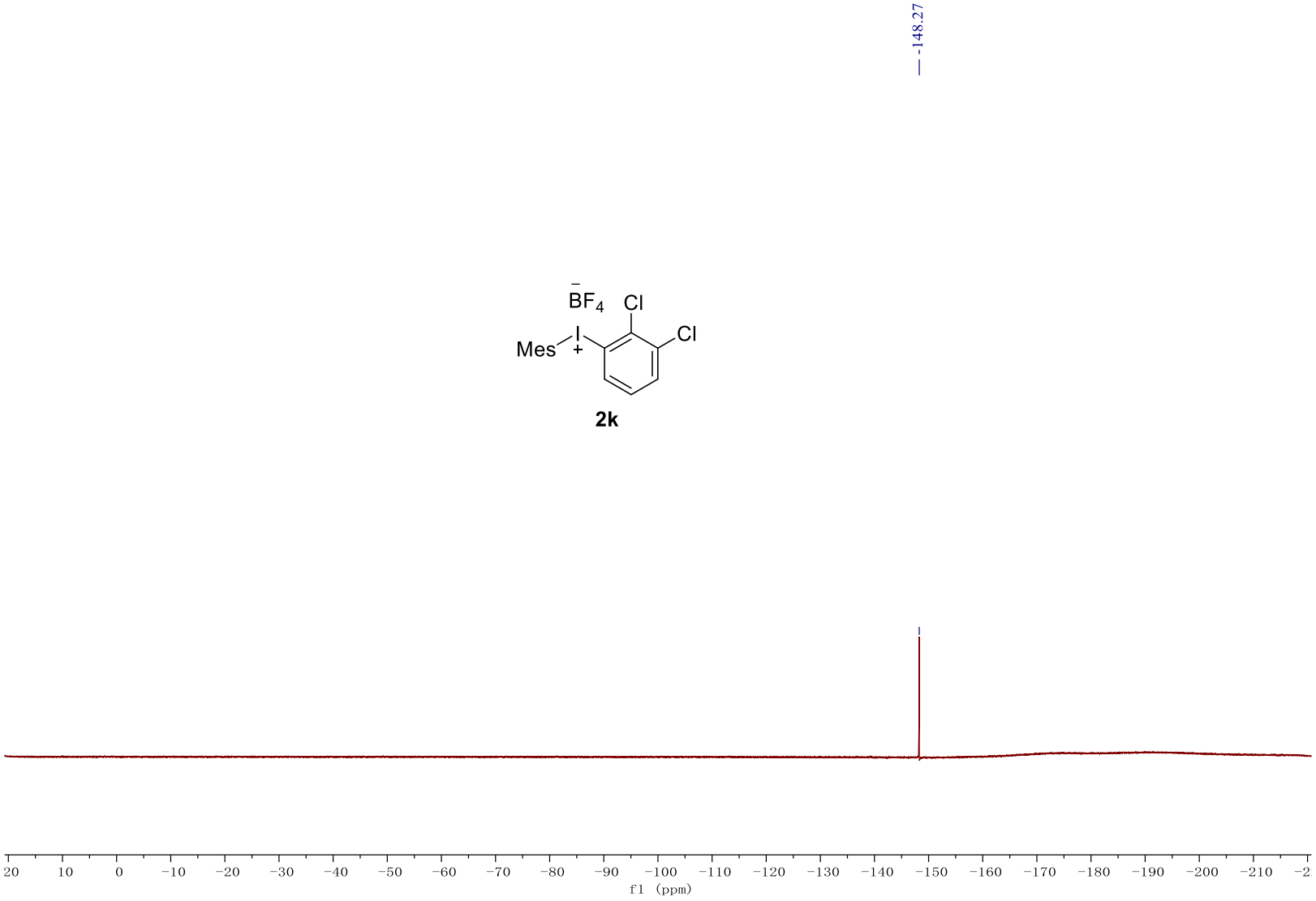
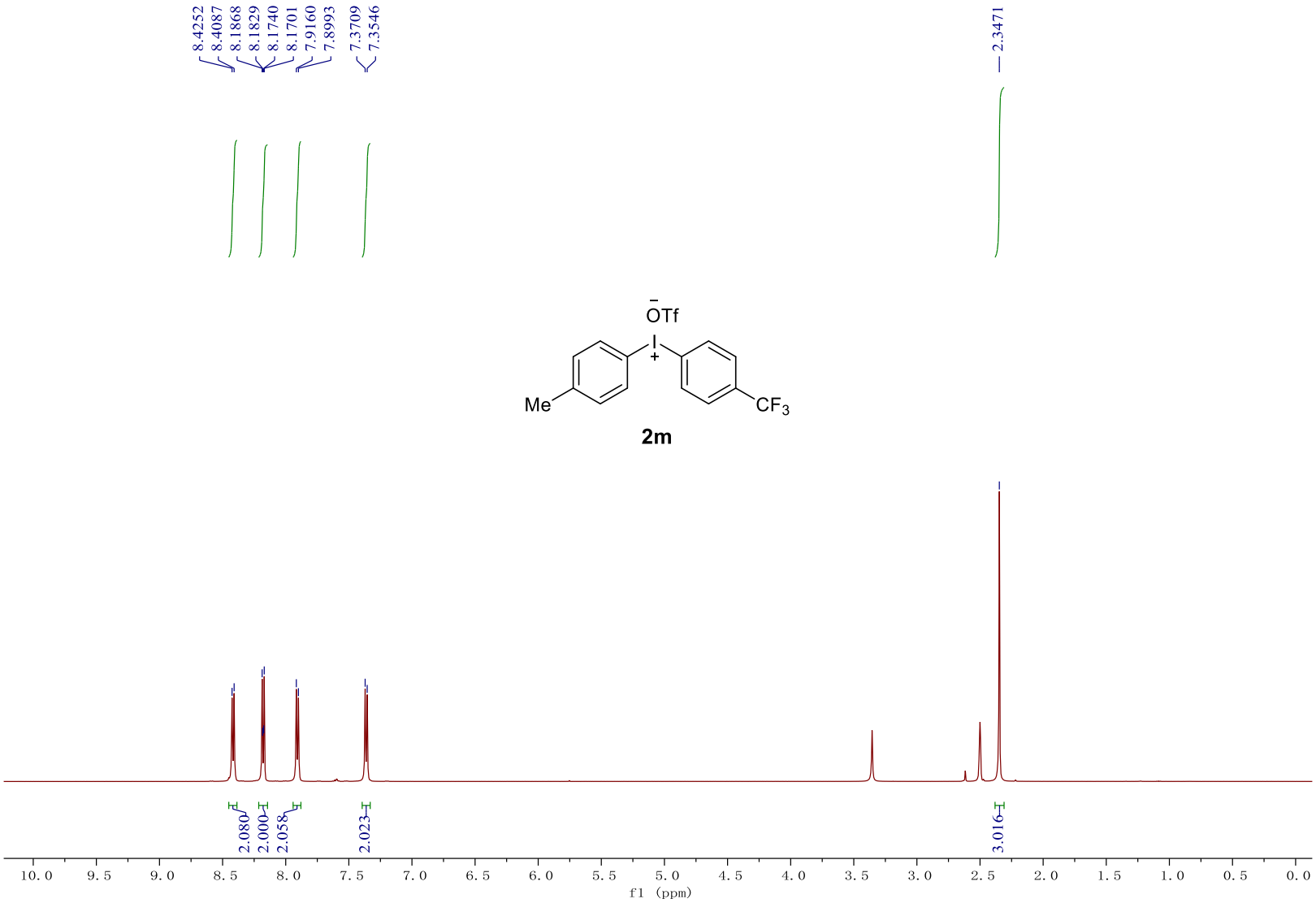
8.1854
8.1718
8.1691
7.9356
7.9330
7.9195
7.9168
7.4907
7.4746
7.4584
7.2244
5.7464
2.6119
2.2911
BF4
Cl
Cl
Mes
I
+
2k
1.000
1.014
1.040
2.031
6.043
3.002
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


143.84
142.37
137.86
134.95
134.33
133.00
131.76
130.51
123.65
118.51
26.70
20.93
BF4
Cl
Cl
I
+
Mes
2k
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-148.27
BF4
Cl
Cl
Mes
I
+
2k
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)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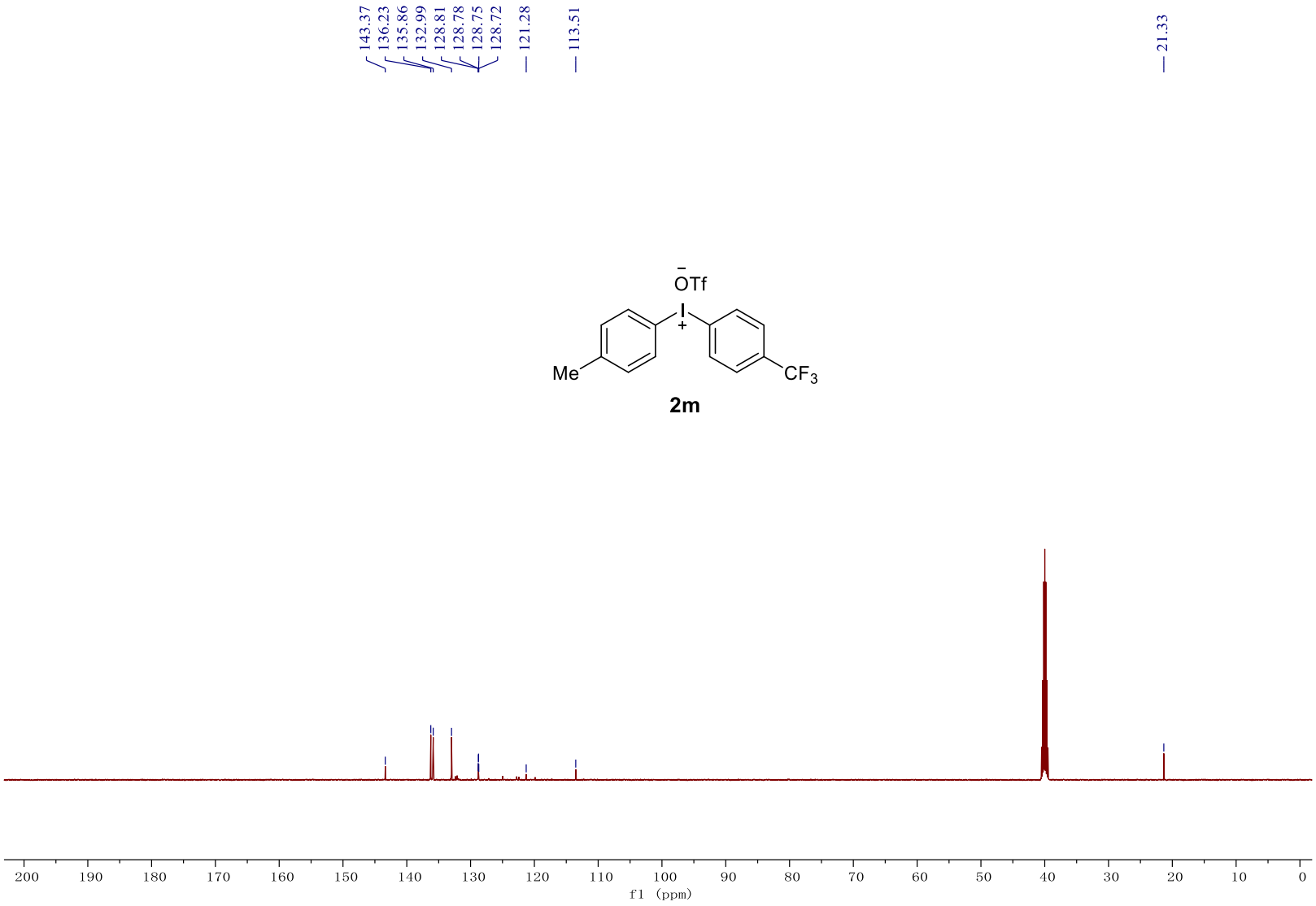
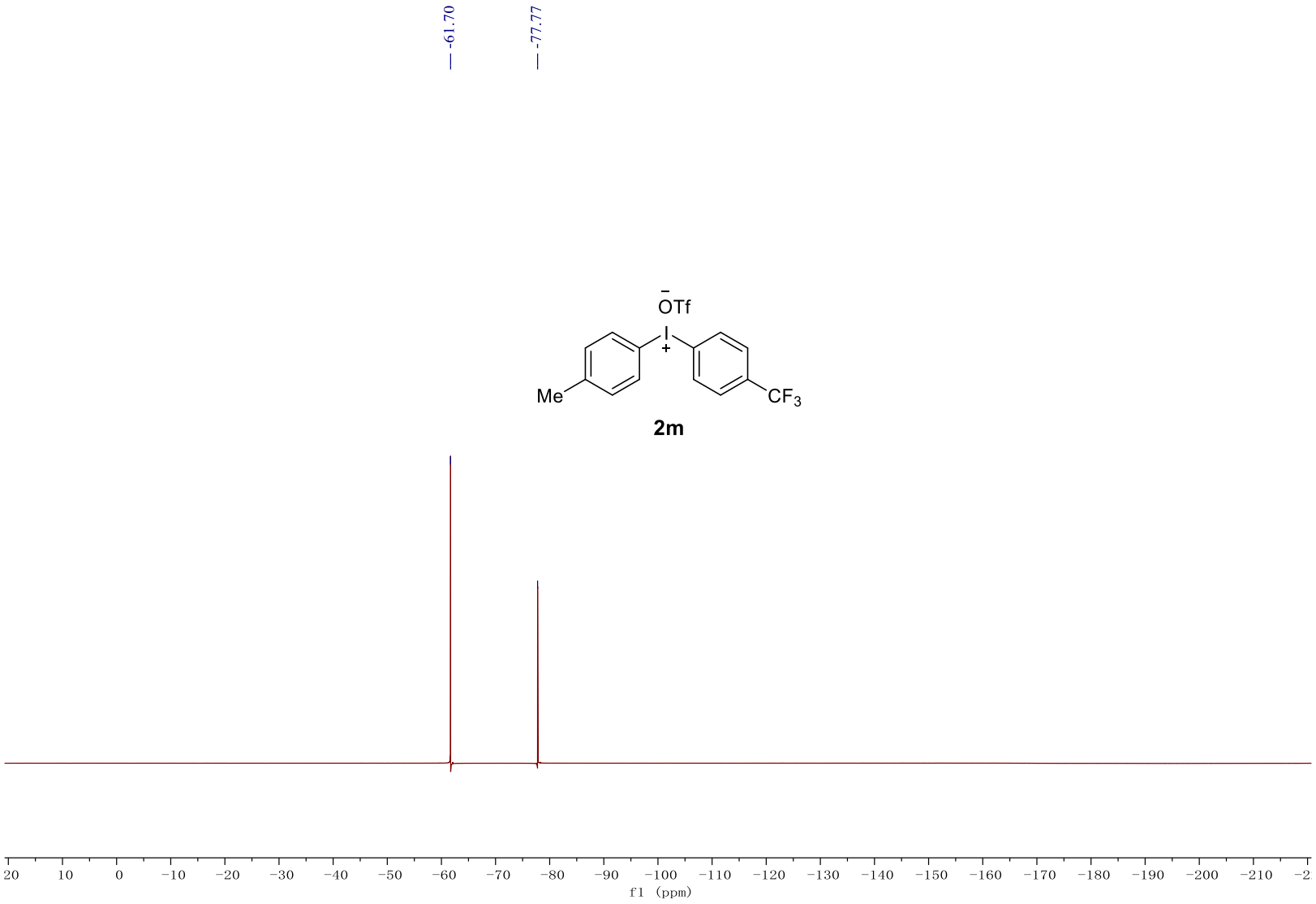
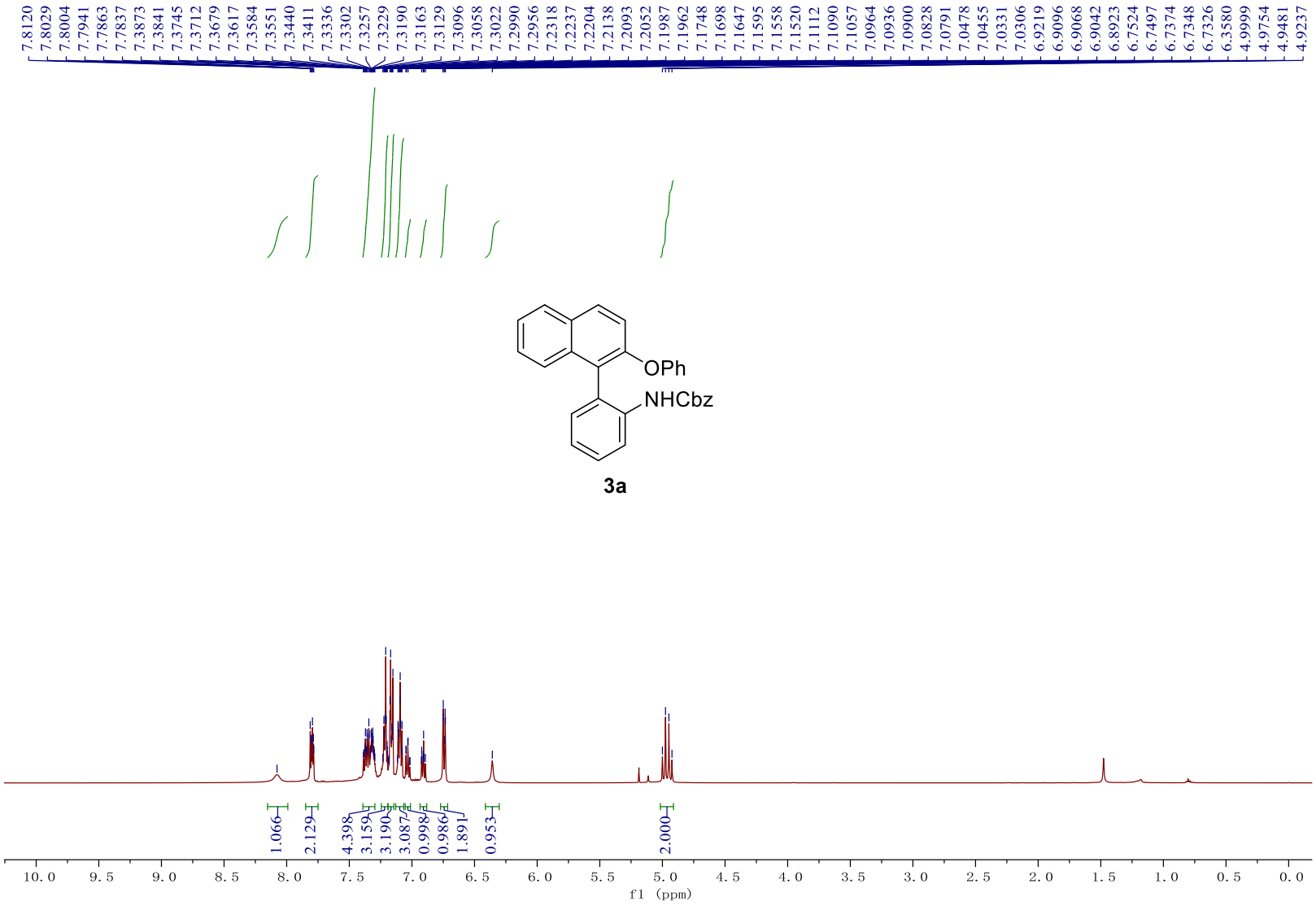
8.1868
8.1829
8.1740
8.1701
7.9160
7.8993
7.3709
7.3546
2.3471
OTf
Me
CF3
2m
2.080
2.000
2.058
2.023
3.016
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


143.37
136.23
135.86
132.99
128.81
128.78
128.75
128.72
121.28
113.51
21.33
OTf
Me
CF3
2m
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-61.70
-77.77
OTf
Me
CF3
2m
20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210 -2
f1 (ppm)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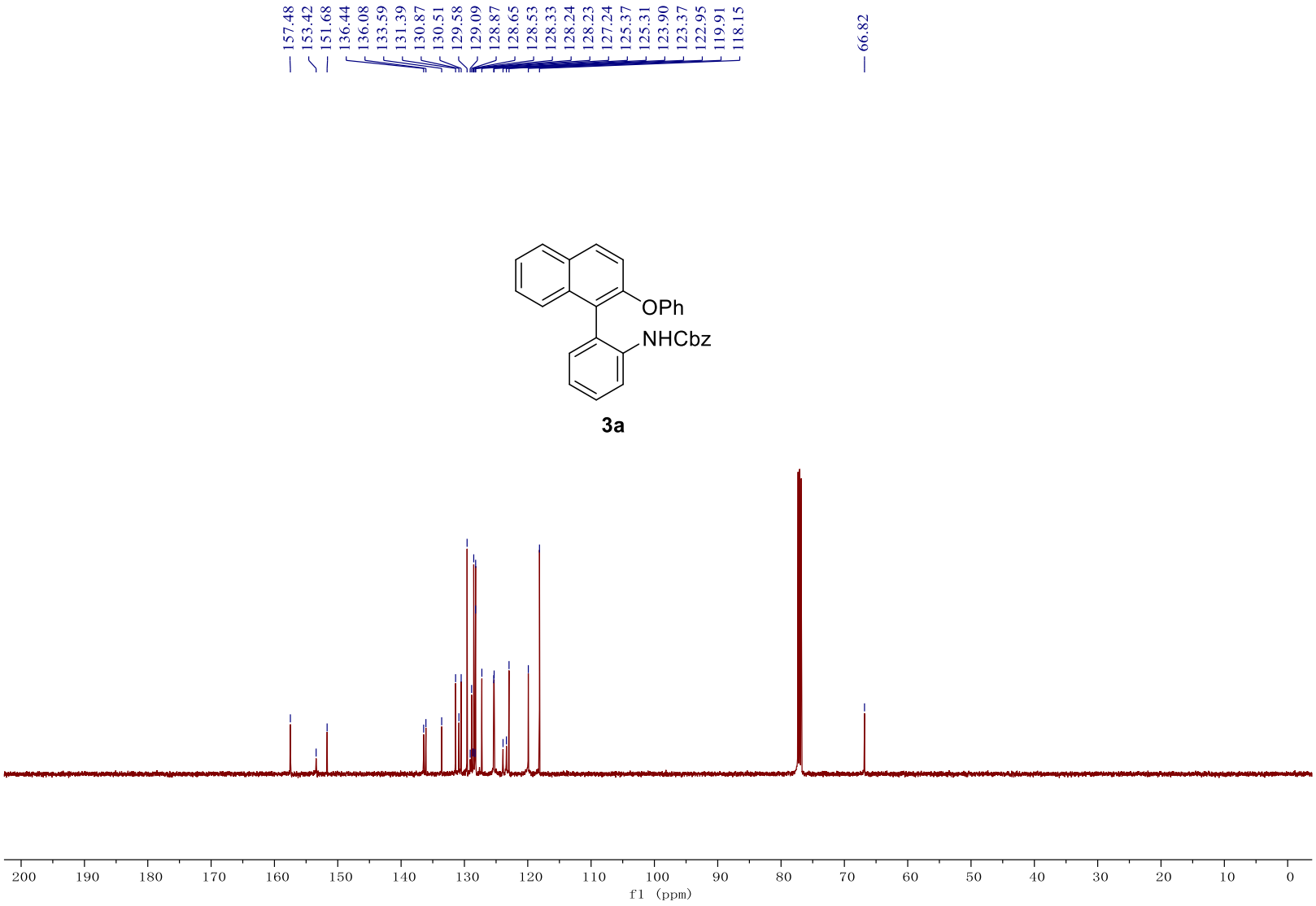
7.7863
7.7837
7.3873
7.3841
7.3745
7.3712
7.3679
7.3617
7.3584
7.3551
7.3440
7.3411
7.3336
7.3302
7.3257
7.3229
7.3190
7.3163
7.3129
7.3096
7.3058
7.3022
7.2990
7.2956
7.2318
7.2237
7.2204
7.2138
7.2093
7.2052
7.1987
7.1962
7.1748
7.1698
7.1647
7.1595
7.1558
7.1520
7.1112
7.1090
7.1057
7.0964
7.0936
7.0900
7.0828
7.0791
7.0478
7.0455
7.0331
7.0306
6.9219
6.9096
6.9068
6.9042
6.8923
6.7524
6.7497
6.7374
6.7348
6.7326
6.3580
4.9999
4.9754
4.9481
4.9237
OPh
NHCbz
3a
1.066
2.129
4.398
3.159
3.190
3.087
0.998
0.986
1.891
0.953
2.000
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
f1 (ppm)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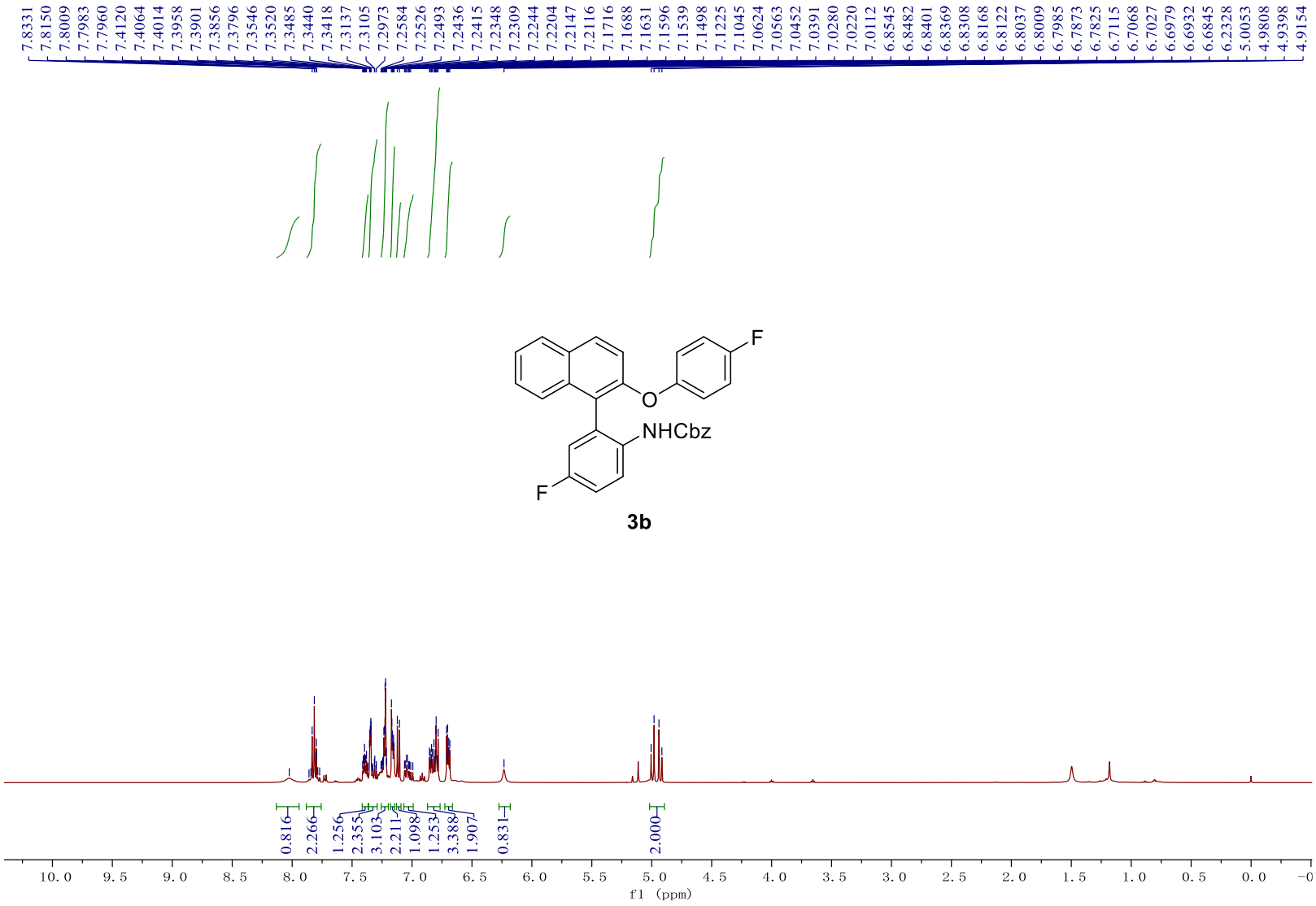
151.68
136.44
136.08
133.59
131.39
130.87
130.51
129.58
129.09
128.87
128.65
128.53
128.33
128.24
128.23
127.24
125.37
125.31
123.90
123.37
122.95
119.91
118.15
66.82
OPh
NHCbz
3a
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.8009
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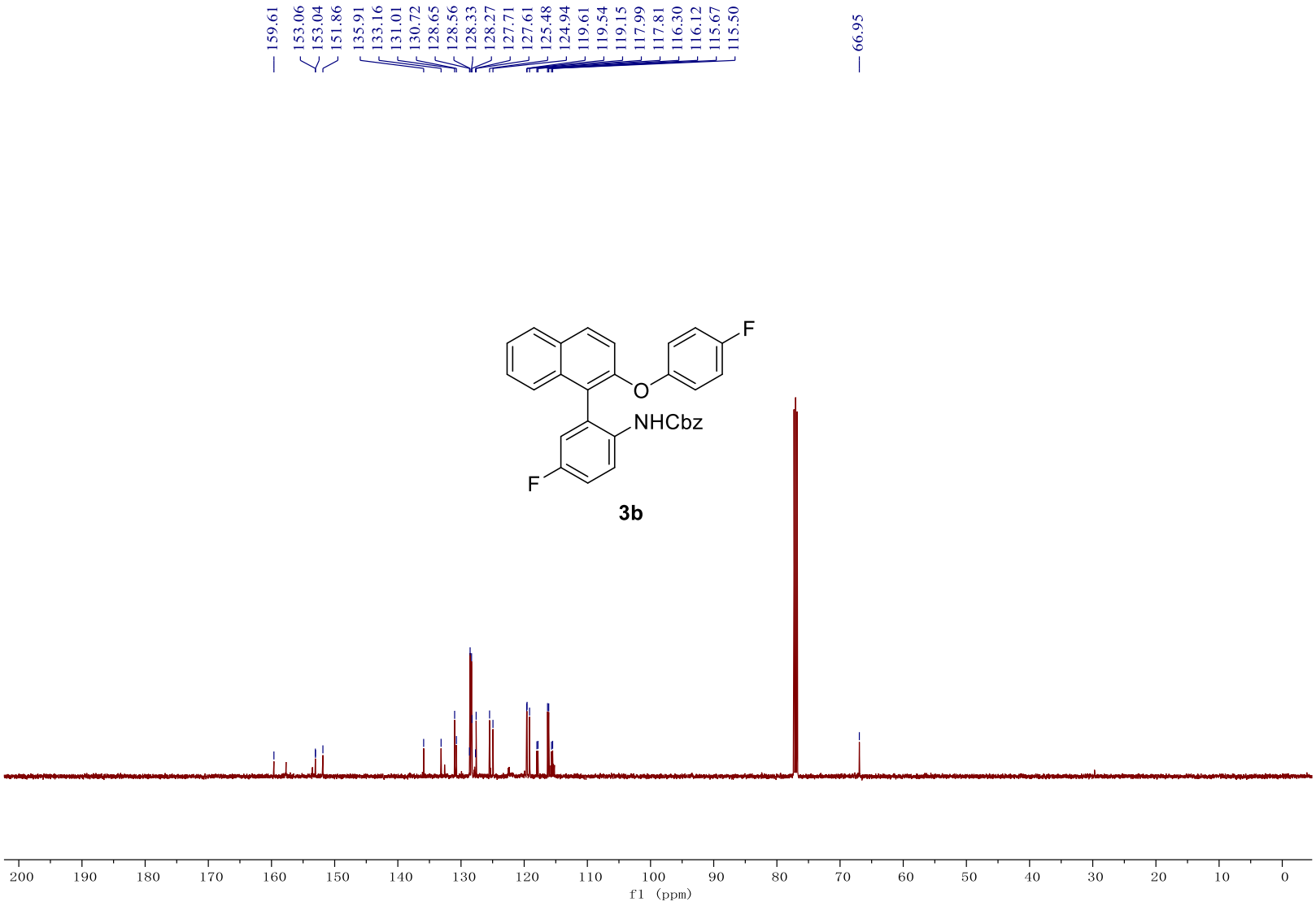
7.7960
7.4120
7.4064
7.4014
7.3958
7.3901
7.3856
7.3796
7.3546
7.3520
7.3485
7.3440
7.3418
7.3137
7.3105
7.2973
7.2584
7.2526
7.2493
7.2436
7.2415
7.2348
7.2309
7.2244
7.2204
7.2147
7.2116
7.1716
7.1688
7.1631
7.1596
7.1539
7.1498
7.1225
7.1045
7.0624
7.0563
7.0452
7.0391
7.0280
7.0220
7.0112
6.8545
6.8482
6.8401
6.8369
6.8308
6.8168
6.8122
6.8037
6.8009
6.7985
6.7873
6.7825
6.7115
6.7068
6.7027
6.6979
6.6932
6.6845
6.2328
5.0053
4.9808
4.9398
4.9154
F
O
NHCbz
F
0.816
2.266
1.256
2.355
3.103
2.211
1.098
1.253
3.388
1.907
0.831
2.000
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
f1 (ppm)

3b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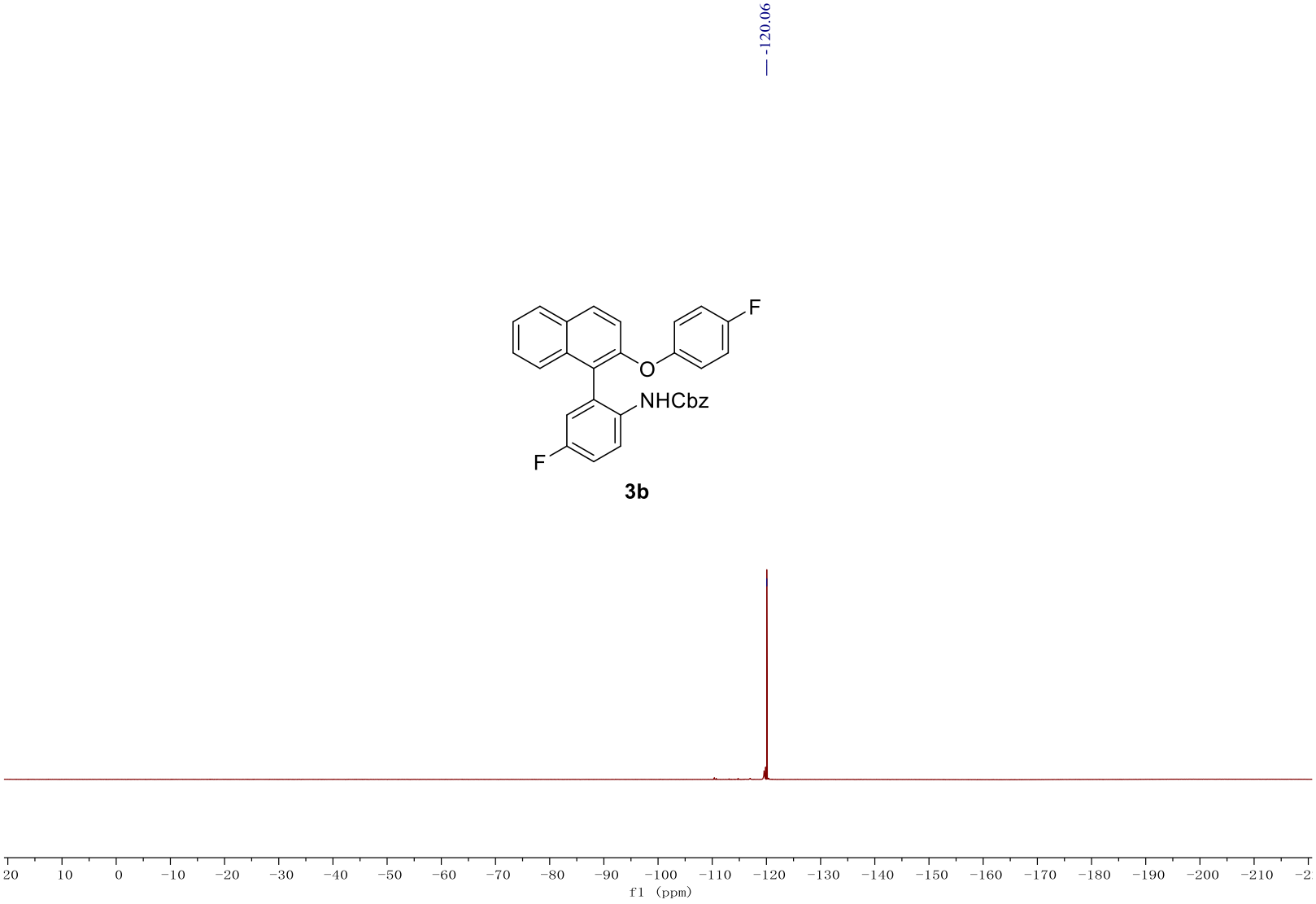
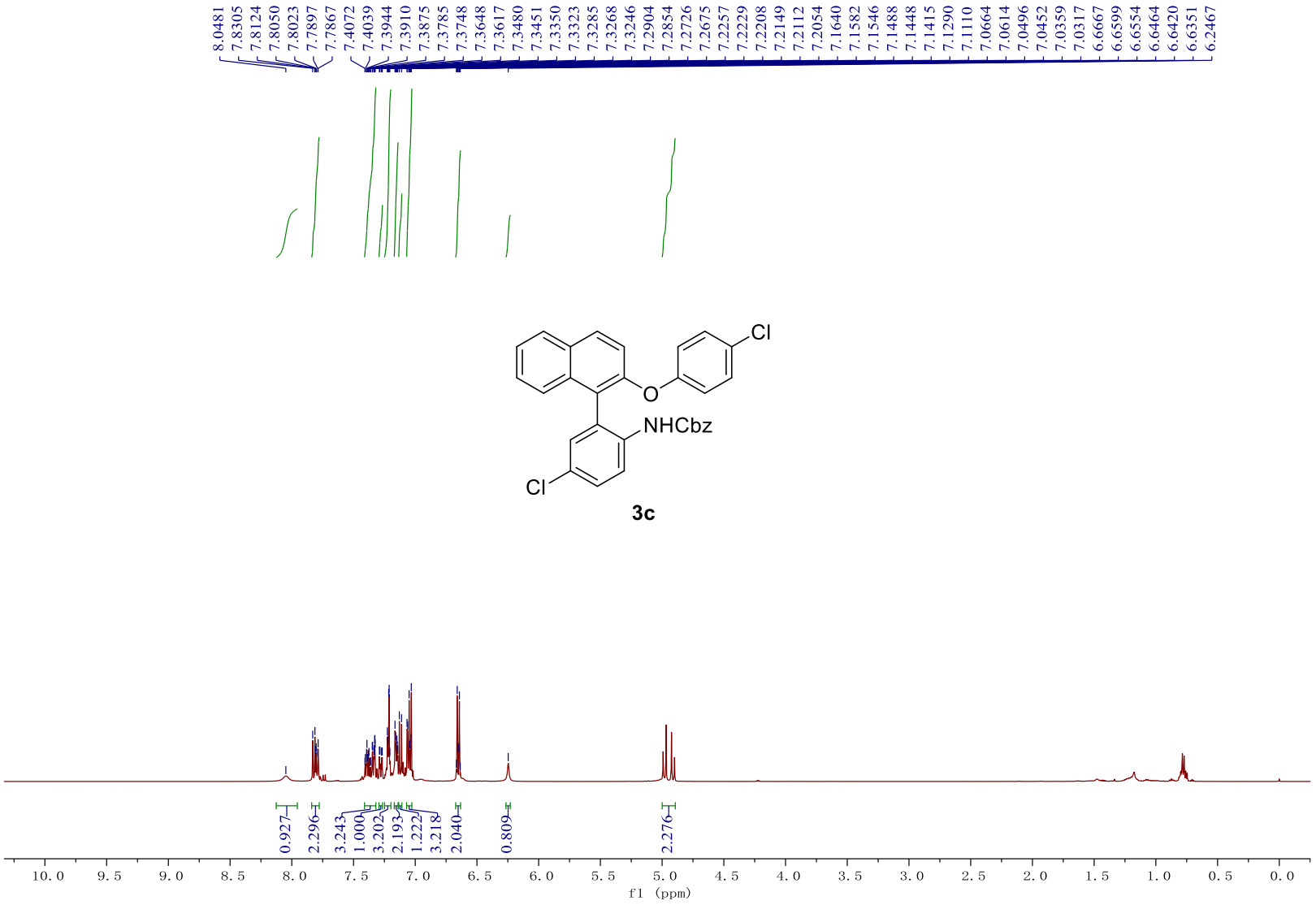
151.86
135.91
133.16
131.01
130.72
128.65
128.56
128.33
128.27
127.71
127.61
125.48
124.94
119.61
119.54
119.15
117.99
117.81
116.30
116.12
115.67
115.50
66.95
F
O
NHCbz
F
3b
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-120.06
F
O
NHCbz
F
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

3b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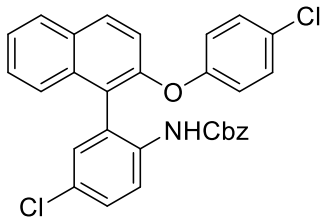
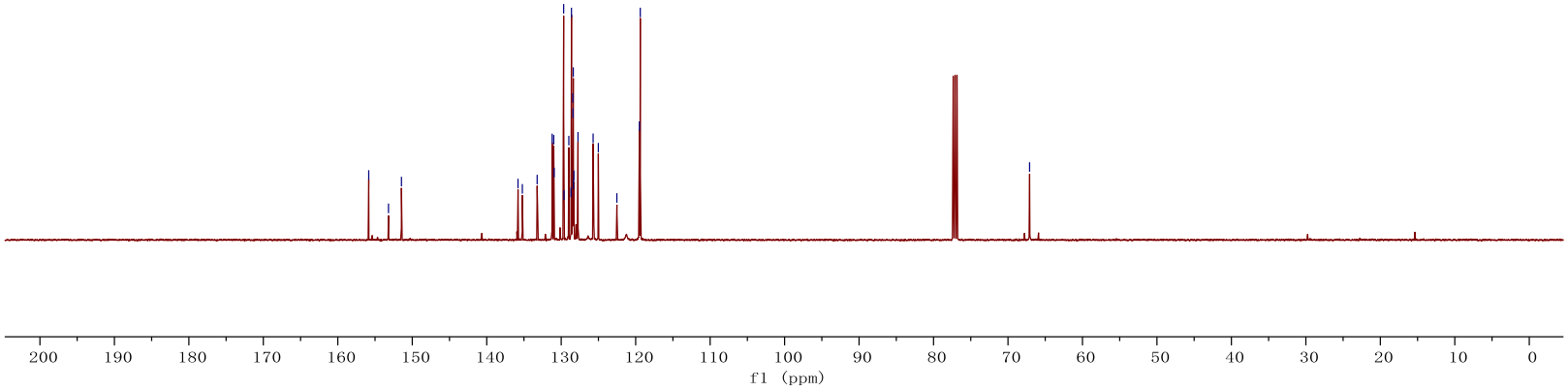
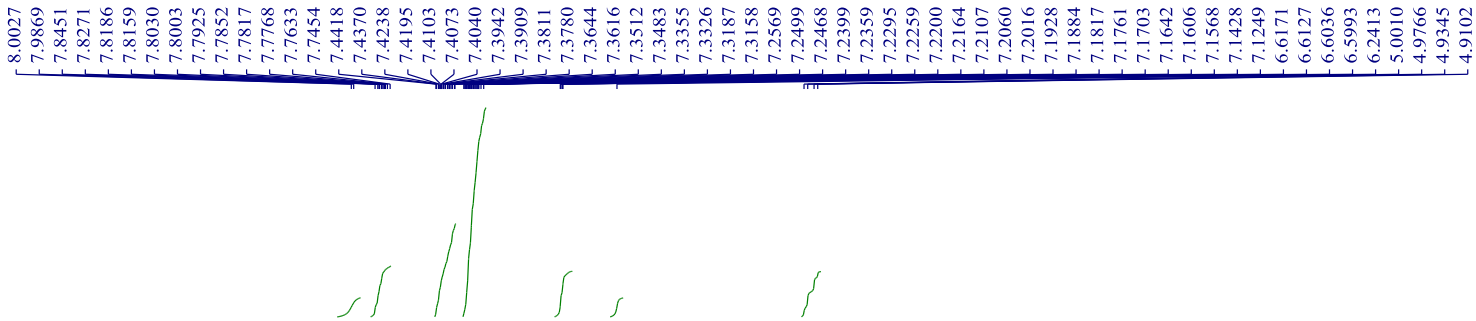
7.4039
7.3944
7.3910
7.3875
7.3785
7.3748
7.3648
7.3617
7.3480
7.3451
7.3350
7.3323
7.3285
7.3268
7.3246
7.2904
7.2854
7.2726
7.2675
7.2257
7.2229
7.2208
7.2149
7.2112
7.2054
7.1640
7.1582
7.1546
7.1488
7.1448
7.1415
7.1290
7.1110
7.0664
7.0614
7.0496
7.0452
7.0359
7.0317
6.6667
6.6599
6.6554
6.6464
6.6420
6.6351
6.2467
Cl
O
NHCbz
Cl
3c
0.927
2.296
3.243
1.000
3.202
2.193
1.222
3.218
2.040
0.809
2.276
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
f1 (ppm)


155.85
153.19
151.45
135.80
135.22
133.23
131.22
131.00
130.95
129.67
129.62
128.98
128.68
128.62
128.44
128.41
128.38
128.35
128.30
127.74
125.72
125.01
122.53
119.50
119.38
67.10


Cl
O
NHCbz
Cl

3c


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.8186
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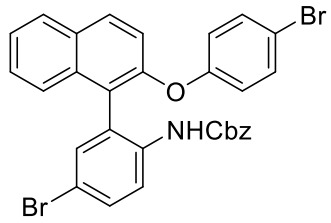
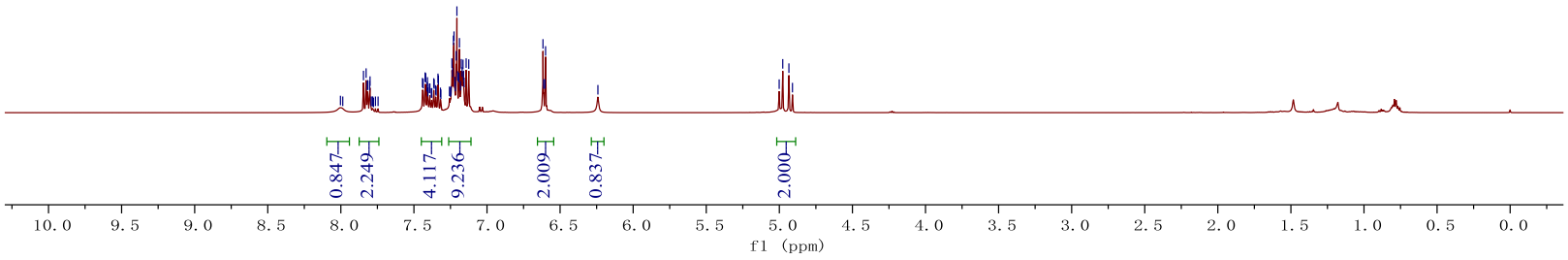
7.8030
7.8003
7.7925
7.7852
7.7817
7.7768
7.7633
7.7454
7.4418
7.4370
7.4238
7.4195
7.4103
7.4073
7.4040
7.3942
7.3909
7.3811
7.3780
7.3644
7.3616
7.3512
7.3483
7.3355
7.3326
7.3187
7.3158
7.2569
7.2499
7.2468
7.2399
7.2359
7.2295
7.2259
7.2200
7.2164
7.2107
7.2060
7.2016
7.1928
7.1884
7.1817
7.1761
7.1703
7.1642
7.1606
7.1568
7.1428
7.1249
6.6171
6.6127
6.6036
6.5993
6.2413
5.0010
4.9766
4.9345
4.9102


Br
O
NHCbz
Br

3d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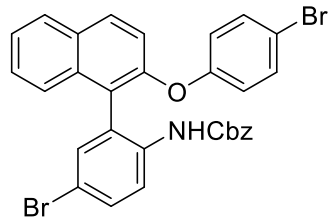
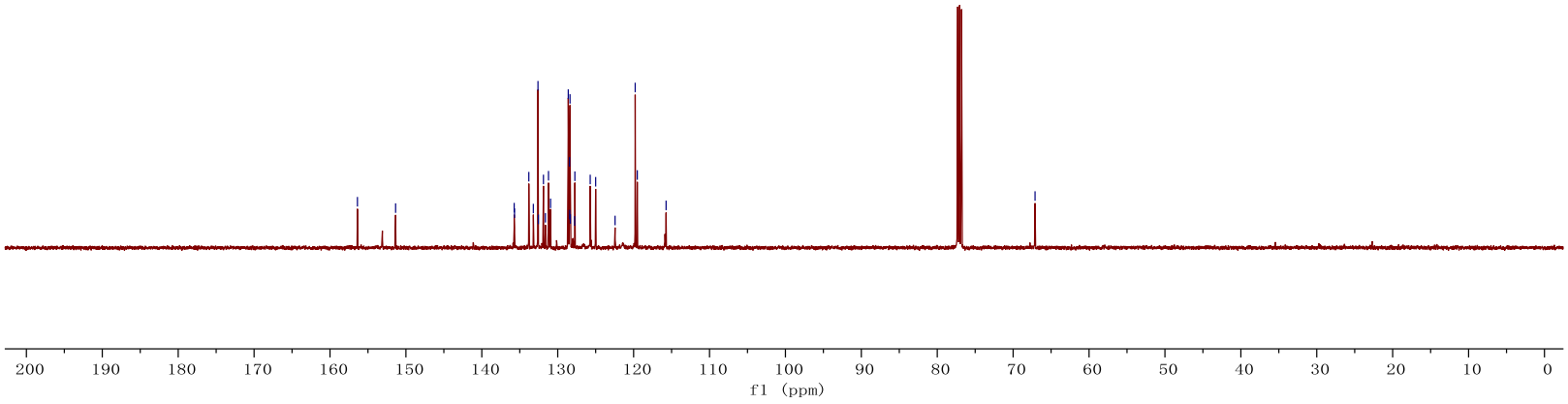
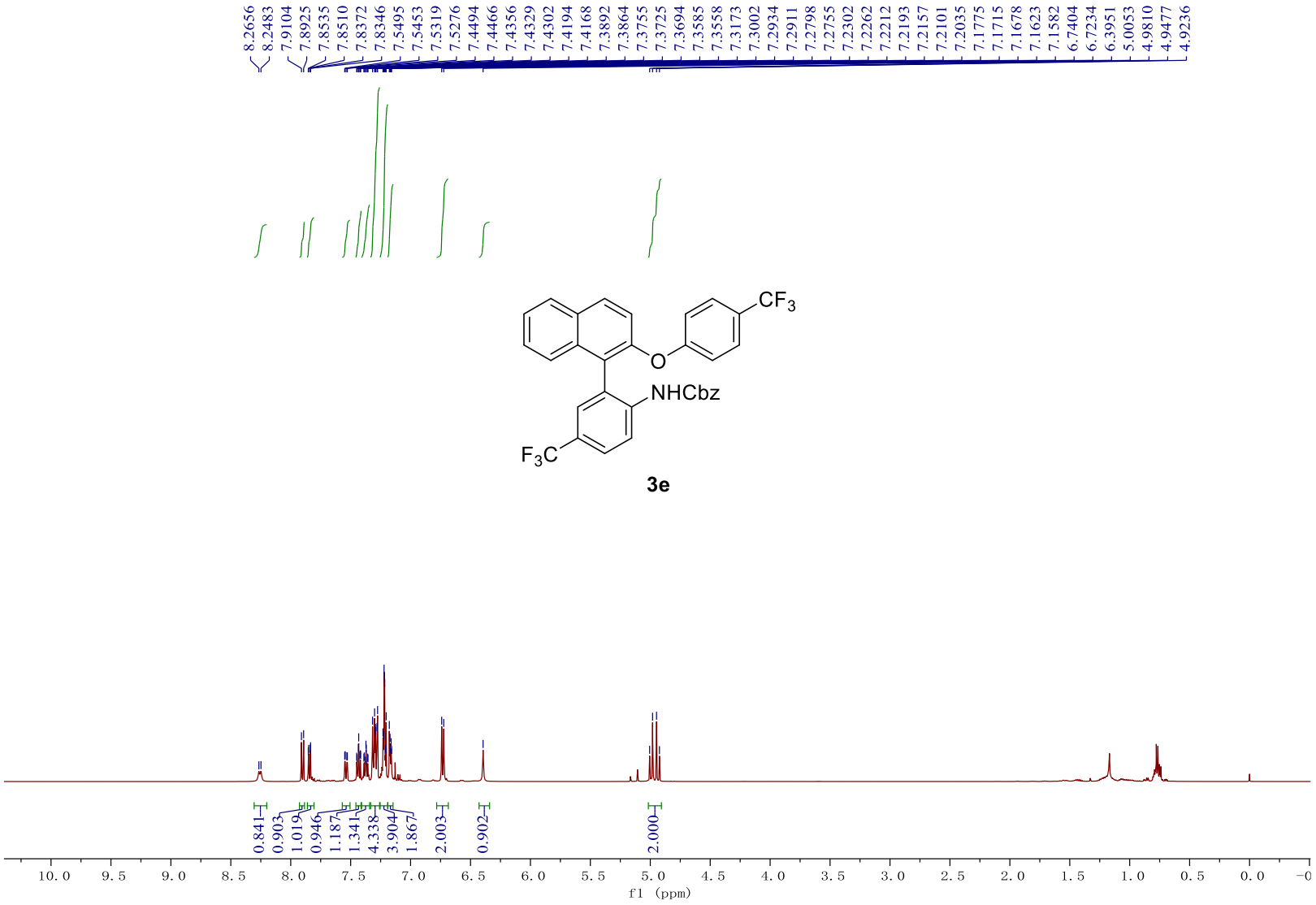
2.249
4.117
9.236
2.009
0.837
2.000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


156.39
151.36
135.74
135.69
133.81
133.21
132.60
132.55
131.88
131.62
131.22
130.94
128.61
128.44
128.42
128.38
128.33
127.77
127.74
125.72
125.00
122.44
119.79
119.52
115.72
67.11


Br
O
NHCbz
Br

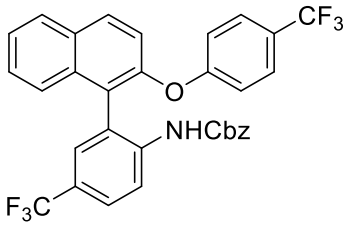
3d


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

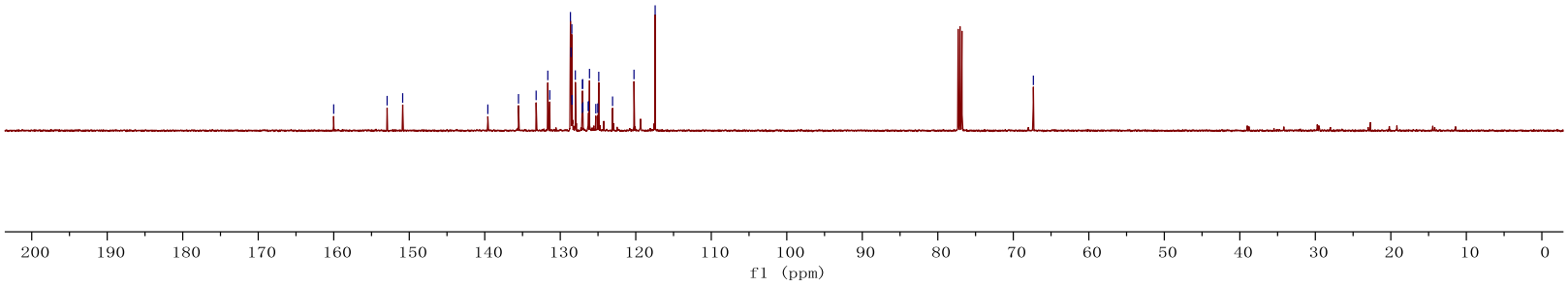

8.2656
8.2483
7.9104
7.8925
7.8535
7.8510
7.8372
7.8346
7.5495
7.5453
7.5319
7.5276
7.4494
7.4466
7.4356
7.4329
7.4302
7.4194
7.4168
7.3892
7.3864
7.3755
7.3725
7.3694
7.3585
7.3558
7.3173
7.3002
7.2934
7.2911
7.2798
7.2755
7.2302
7.2262
7.2212
7.2193
7.2157
7.2101
7.2035
7.1775
7.1715
7.1678
7.1623
7.1582
6.7404
6.7234
6.3951
5.0053
4.9810
4.9477
4.9236
CF3
O
NHCbz
F3C
0.841
0.903
1.019
0.946
1.187
1.341
4.338
3.904
1.867
2.003
0.902
2.000
f1 (ppm)

3e


160.00
152.93
150.87
139.59
135.53
133.19
131.65
131.39
128.65
128.57
128.47
128.45
128.42
128.00
127.09
127.06
127.03
127.00
126.28
126.25
126.13
125.29
125.03
124.90
123.07
120.23
117.43
67.34


CF3
O
NHCbz
F3C

3e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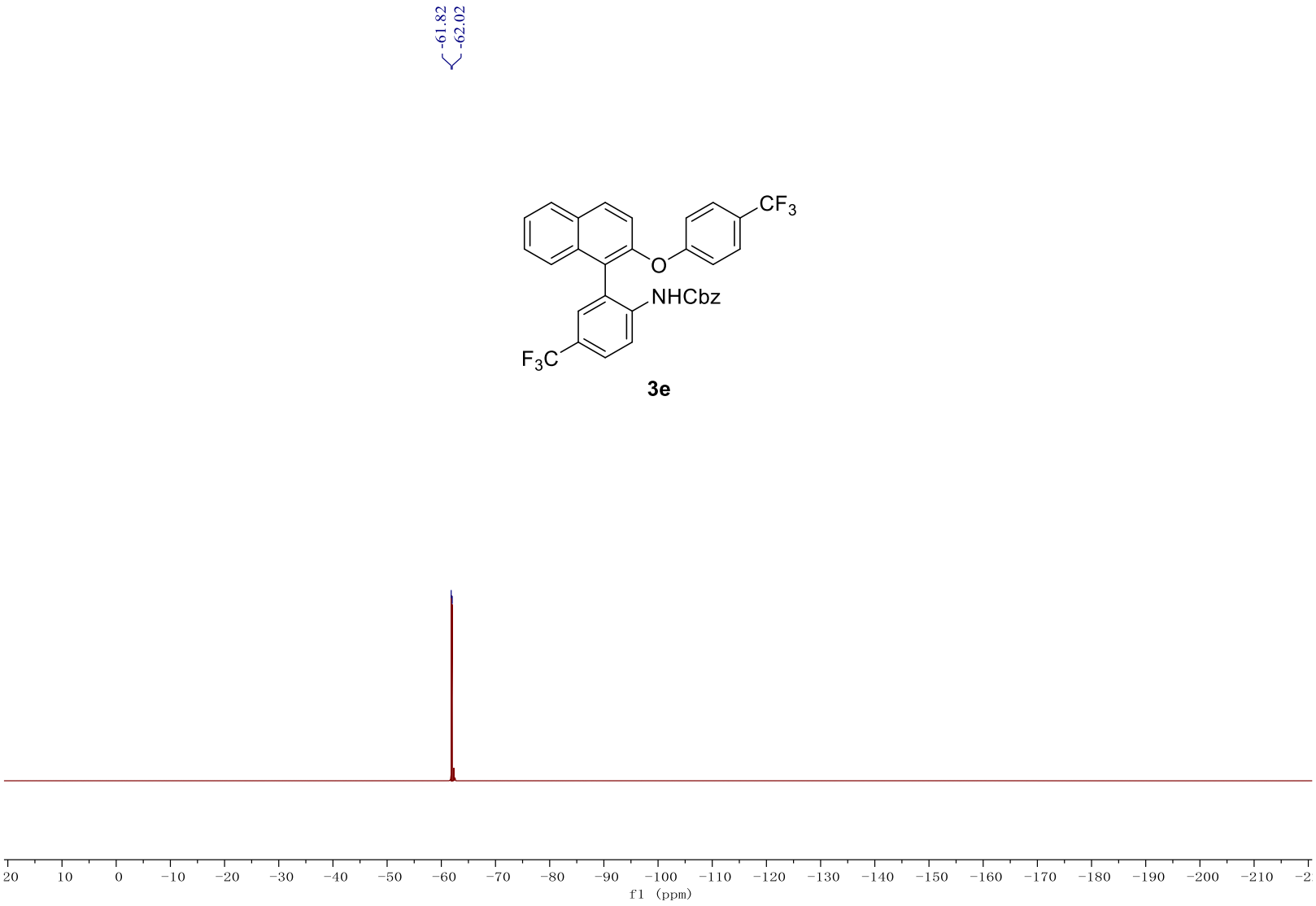
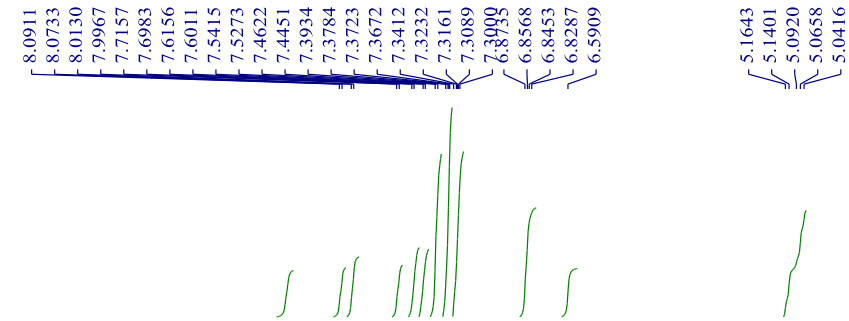
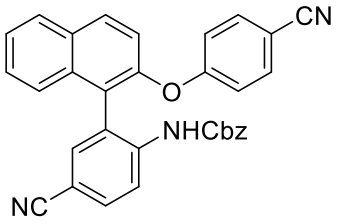
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

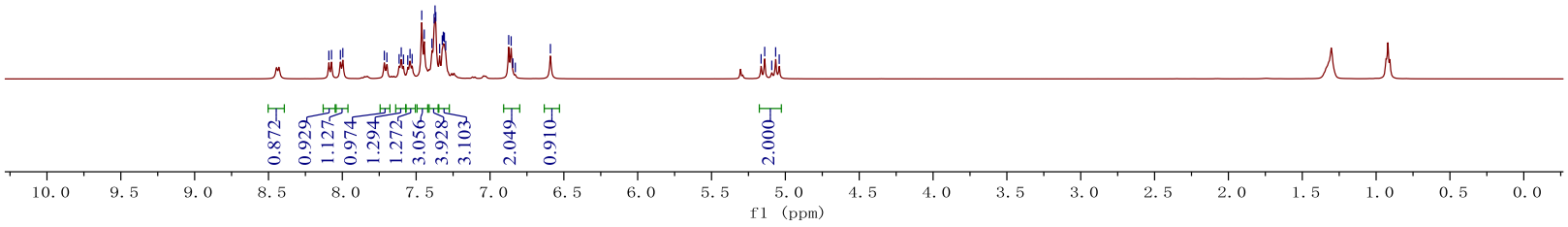

-61.82
-62.02
CF3
O
NHCbz
F3C
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
−110
−120
−130
−140
−150
−160
−170
−180
−190
−200
−210
f1 (ppm)

3e


8.0911
8.0733
8.0130
7.9967
7.7157
7.6983
7.6156
7.6011
7.5415
7.5273
7.4622
7.4451
7.3934
7.3784
7.3723
7.3672
7.3412
7.3232
7.3161
7.3089
7.3000
6.8735
6.8568
6.8453
6.8287
6.5909
5.1643
5.1401
5.0920
5.0658
5.0416


CN
O
NHCbz
NC

3f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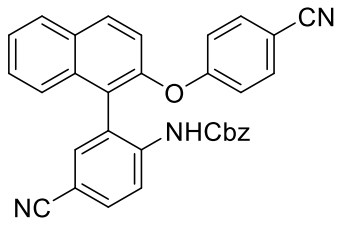
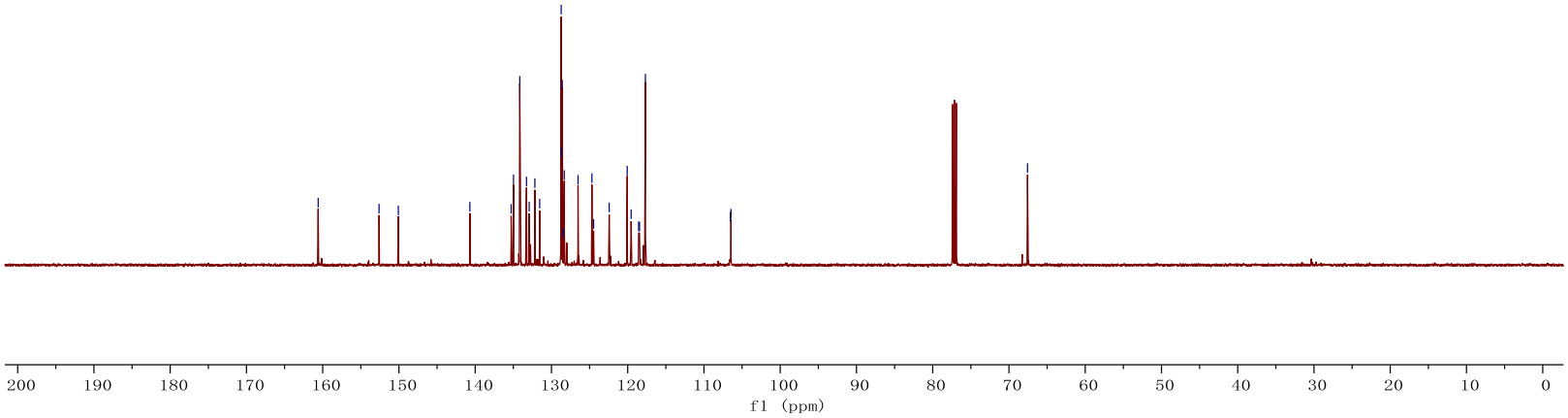
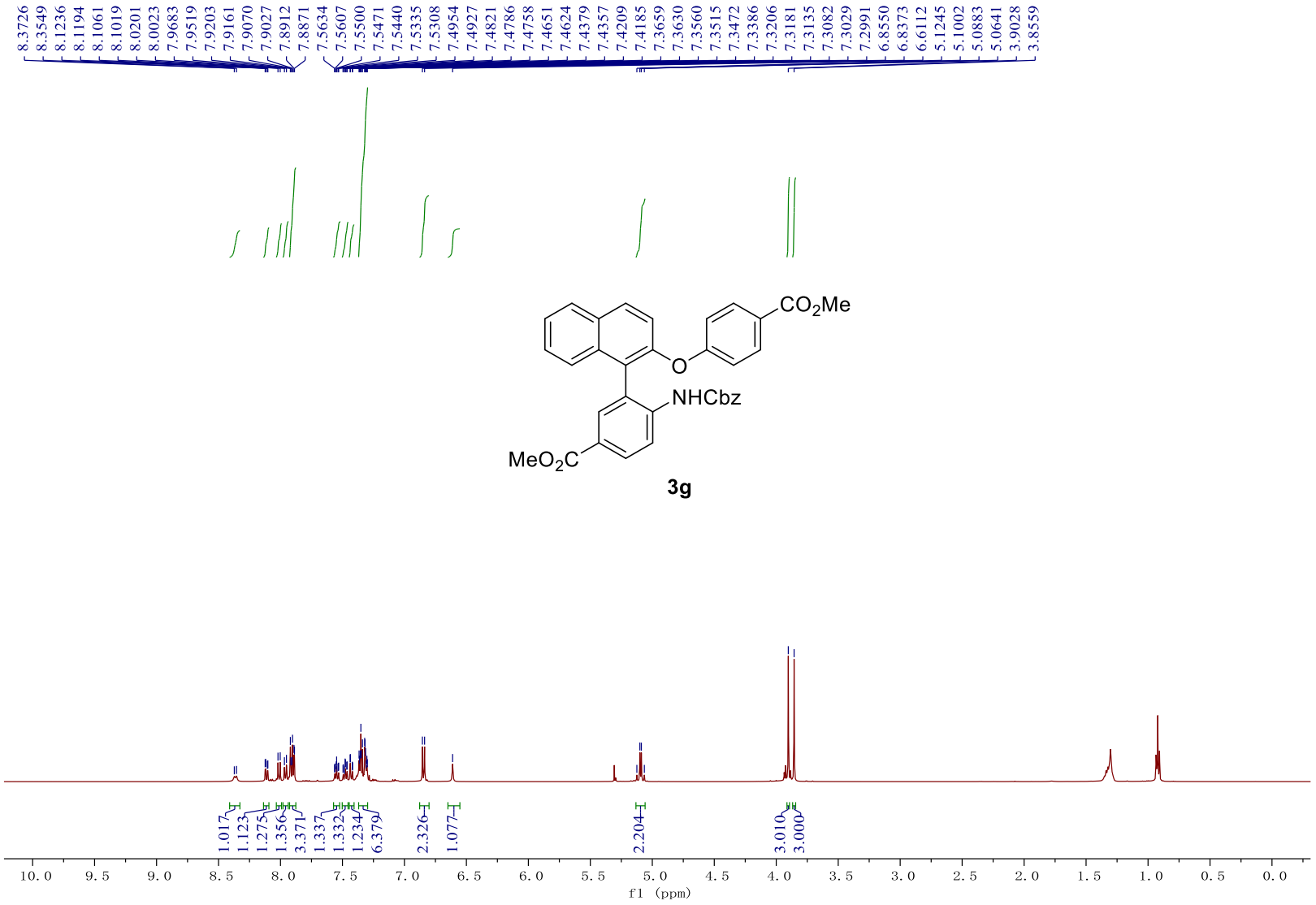
0.929
1.127
0.974
1.294
1.272
3.056
3.928
3.103
2.049
0.910
2.000
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


160.59
152.61
150.08
140.70
135.28
134.98
134.16
133.28
132.92
132.18
131.54
128.76
128.72
128.58
128.46
128.32
126.52
124.69
124.47
122.43
120.07
119.55
118.57
118.45
117.68
106.54
106.46
67.57


CN
O
NHCbz
NC

3f


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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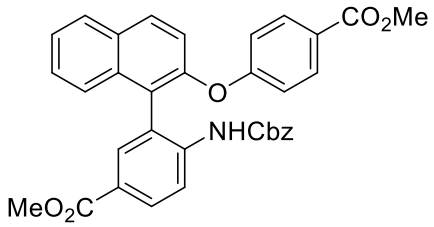
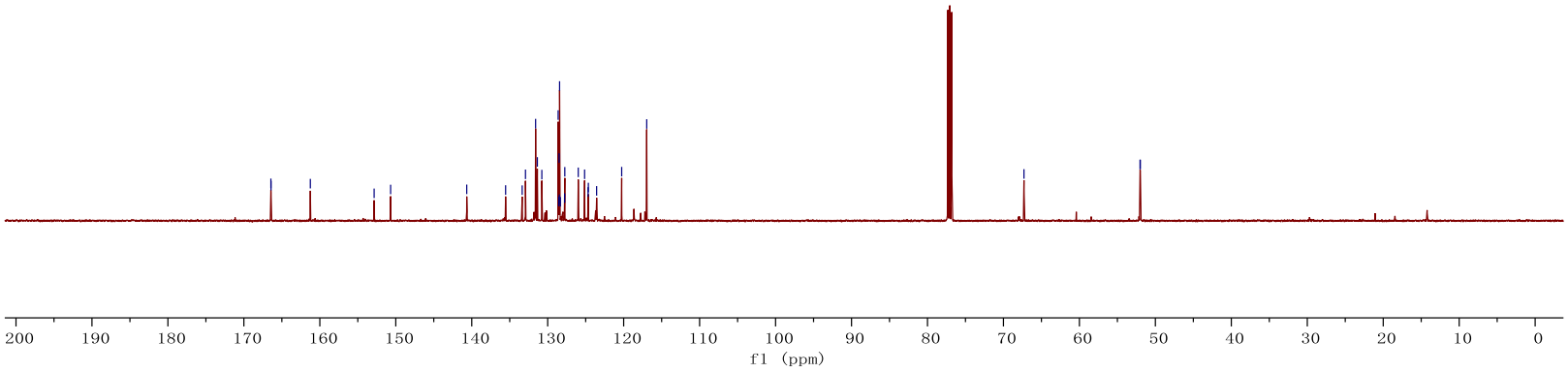
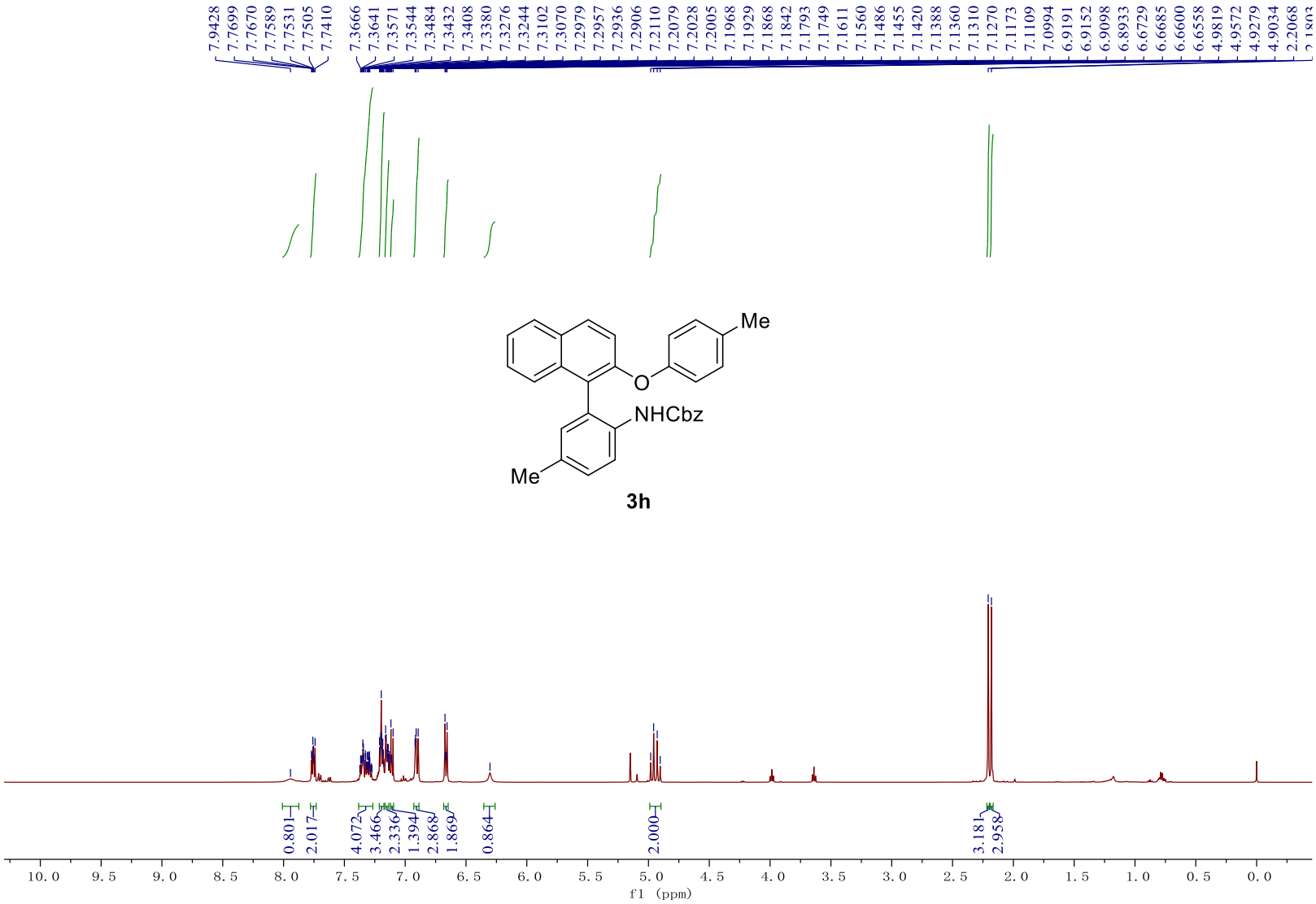
8.3549
8.1236
8.1194
8.1061
8.1019
8.0201
8.0023
7.9683
7.9519
7.9203
7.9161
7.9070
7.9027
7.8912
7.8871
7.5634
7.5607
7.5500
7.5471
7.5440
7.5335
7.5308
7.4954
7.4927
7.4821
7.4786
7.4758
7.4651
7.4624
7.4379
7.4357
7.4209
7.4185
7.3659
7.3630
7.3560
7.3515
7.3472
7.3386
7.3206
7.3181
7.3135
7.3082
7.3029
7.2991
6.8550
6.8373
6.6112
5.1245
5.1002
5.0883
5.0641
3.9028
3.8559
CO2Me
O
NHCbz
MeO2C
3g
1.017
1.123
1.275
1.356
3.371
1.337
1.332
1.234
6.379
2.326
1.077
2.204
3.010
3.000
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
f1 (ppm)


166.44
166.42
161.25
152.85
150.68
140.66
135.54
133.36
132.93
131.59
131.36
130.77
128.62
128.54
128.50
128.47
128.44
128.33
127.77
127.75
125.98
125.14
124.68
124.65
123.56
120.26
116.96
67.30
52.02
51.98


CO2Me
O
NHCbz
MeO2C

3g


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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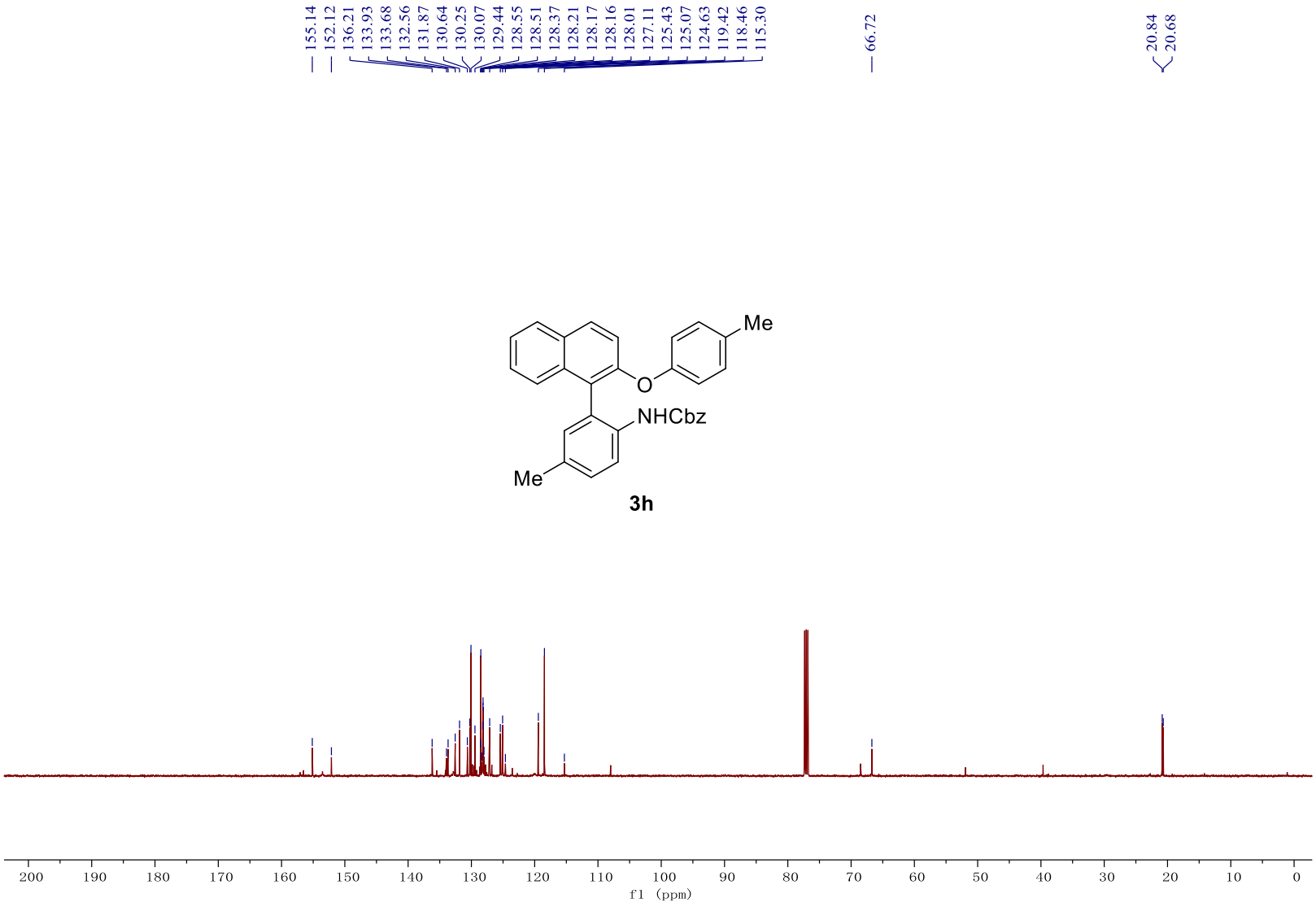
7.7699
7.7670
7.7589
7.7531
7.7505
7.7410
7.3666
7.3641
7.3571
7.3544
7.3484
7.3432
7.3408
7.3380
7.3276
7.3244
7.3102
7.3070
7.2979
7.2957
7.2936
7.2906
7.2110
7.2079
7.2028
7.2005
7.1968
7.1929
7.1868
7.1842
7.1793
7.1749
7.1611
7.1560
7.1486
7.1455
7.1420
7.1388
7.1360
7.1310
7.1270
7.1173
7.1109
7.0994
6.9191
6.9152
6.9098
6.8933
6.6729
6.6685
6.6600
6.6558
4.9819
4.9572
4.9279
4.9034
2.2068
Me
O
NHCbz
Me
3h
0.801
2.017
4.072
3.466
2.336
1.394
2.868
1.869
0.864
2.000
3.181
2.958
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
f1 (ppm)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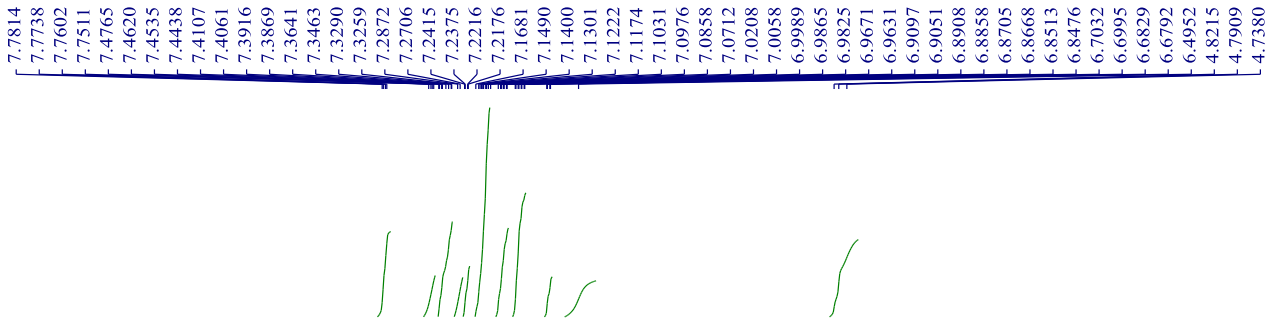
136.21
133.93
133.68
132.56
131.87
130.64
130.25
130.07
129.44
128.55
128.51
128.37
128.21
128.17
128.16
128.01
127.11
125.43
125.07
124.63
119.42
118.46
115.30
66.72
20.84
20.68
Me
O
NHCbz
Me
3h
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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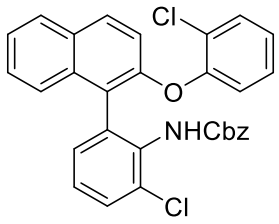
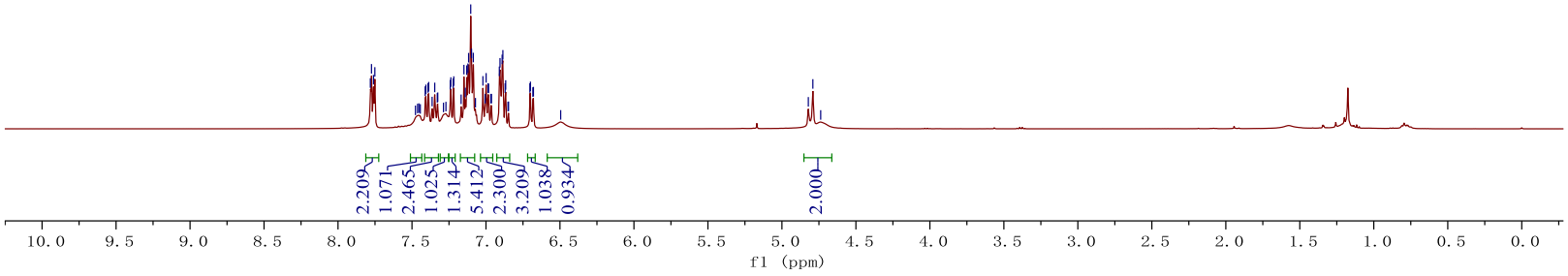
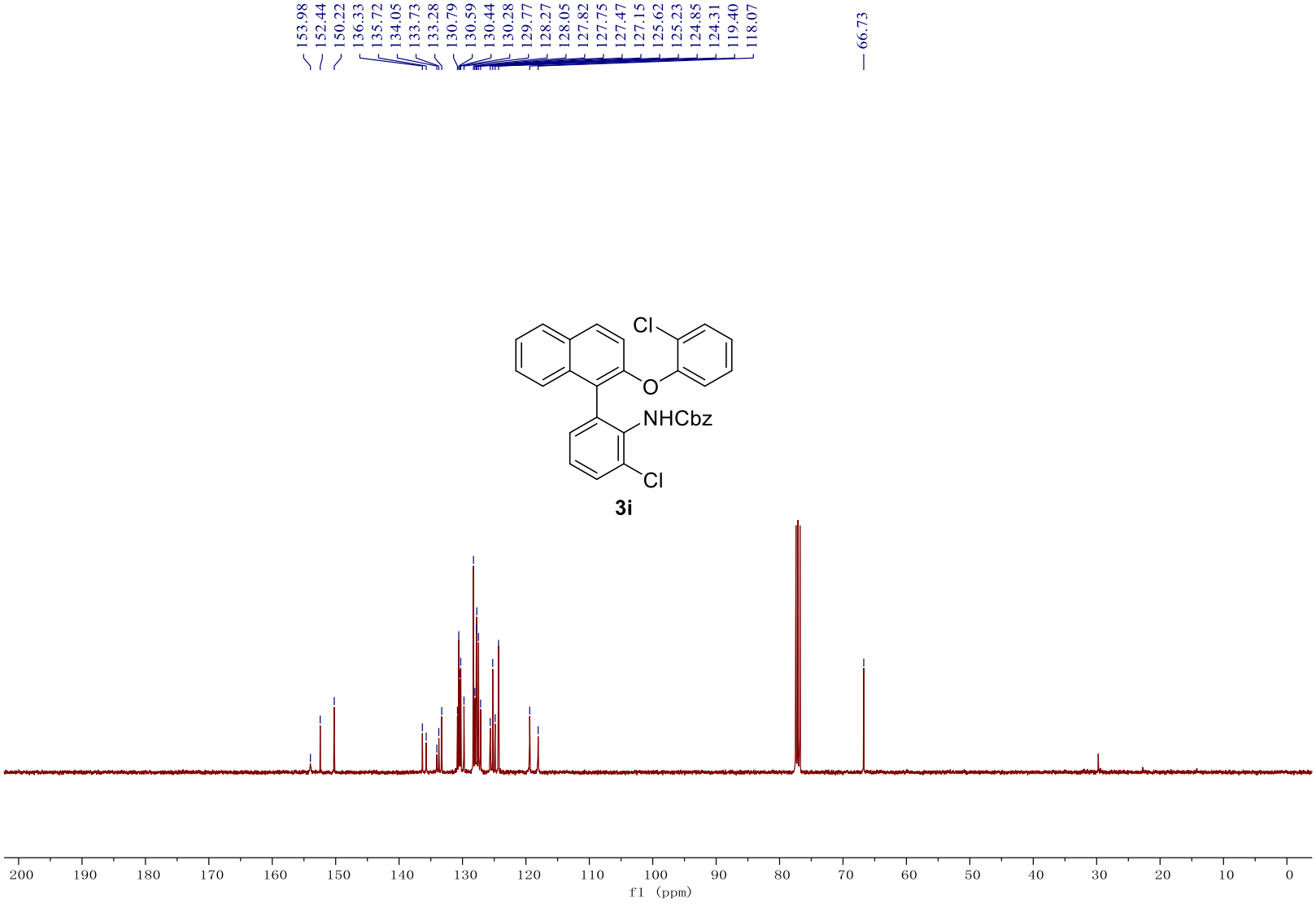
7.7511
7.4765
7.4620
7.4535
7.4438
7.4107
7.4061
7.3916
7.3869
7.3641
7.3463
7.3290
7.3259
7.2872
7.2706
7.2415
7.2375
7.2216
7.2176
7.1681
7.1490
7.1400
7.1301
7.1222
7.1174
7.1031
7.0976
7.0858
7.0712
7.0208
7.0058
6.9989
6.9865
6.9825
6.9671
6.9631
6.9097
6.9051
6.8908
6.8858
6.8705
6.8668
6.8513
6.8476
6.7032
6.6995
6.6829
6.6792
6.4952
4.8215
4.7909
4.7380


Cl
O
NHCbz
Cl

3i


2.209
1.071
2.465
1.025
1.314
5.412
2.300
3.209
1.038
0.934
2.000
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
f1 (ppm)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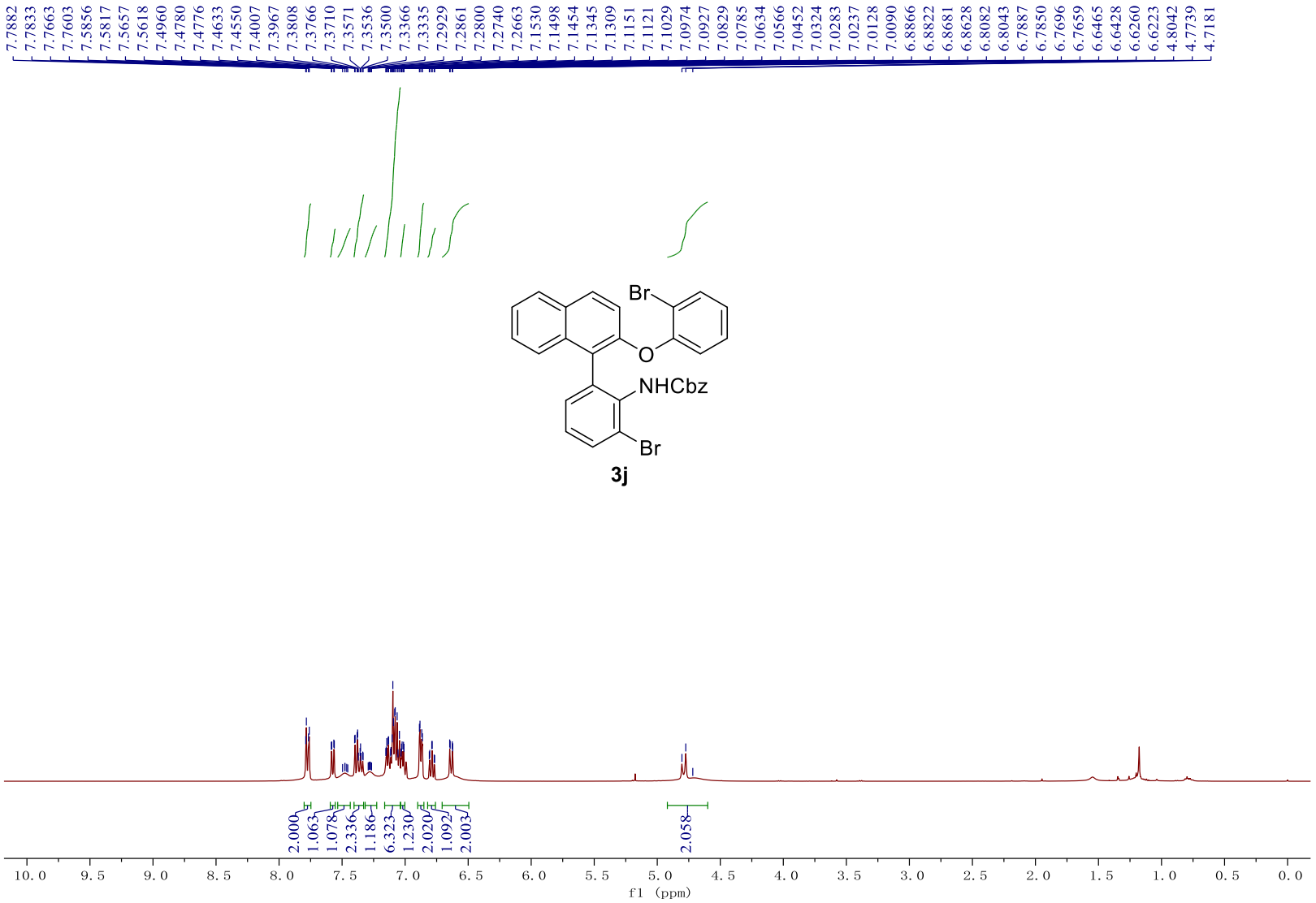
150.22
136.33
135.72
134.05
133.73
133.28
130.79
130.59
130.44
130.28
129.77
128.27
128.05
127.82
127.75
127.47
127.15
125.62
125.23
124.85
124.31
119.40
118.07
66.73
Cl
O
NHCbz
Cl
3i
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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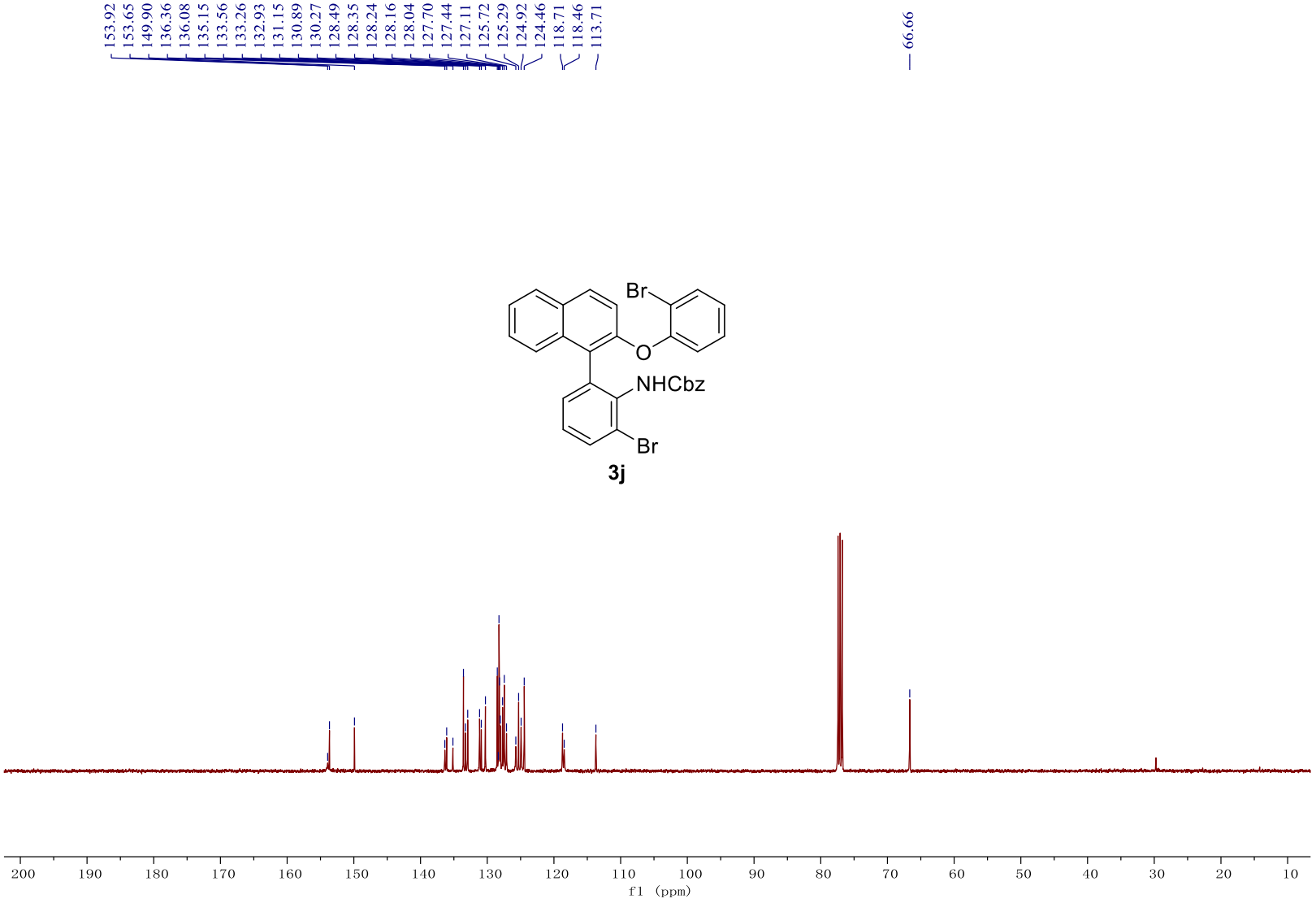
7.7603
7.5856
7.5817
7.5657
7.5618
7.4960
7.4780
7.4776
7.4633
7.4550
7.4007
7.3967
7.3808
7.3766
7.3710
7.3571
7.3536
7.3500
7.3366
7.3335
7.2929
7.2861
7.2800
7.2740
7.2663
7.1530
7.1498
7.1454
7.1345
7.1309
7.1151
7.1121
7.1029
7.0974
7.0927
7.0829
7.0785
7.0634
7.0566
7.0452
7.0324
7.0283
7.0237
7.0128
7.0090
6.8866
6.8822
6.8681
6.8628
6.8082
6.8043
6.7887
6.7850
6.7696
6.7659
6.6465
6.6428
6.6260
6.6223
4.8042
4.7739
4.7181
Br
O
NHCbz
Br
3j
2.000
1.063
1.078
2.336
1.186
6.323
1.230
2.020
1.092
2.003
2.058
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
f1 (ppm)


153.92
153.65
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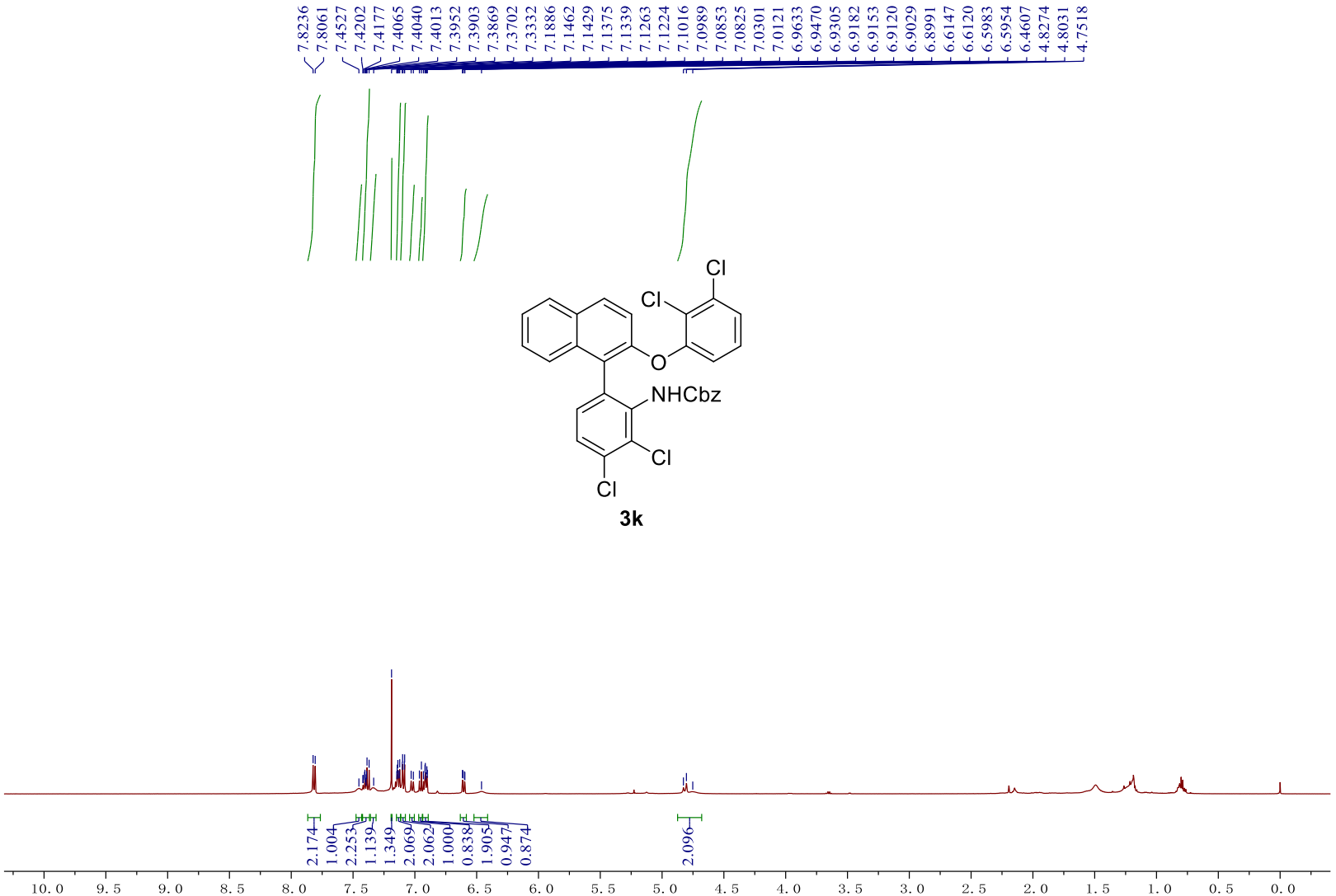
136.36
136.08
135.15
133.56
133.26
132.93
131.15
130.89
130.27
128.49
128.35
128.24
128.16
128.04
127.70
127.44
127.11
125.72
125.29
124.92
124.46
118.71
118.46
113.71
66.66
Br
O
NHCbz
Br
3j
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
f1 (ppm)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7.4527
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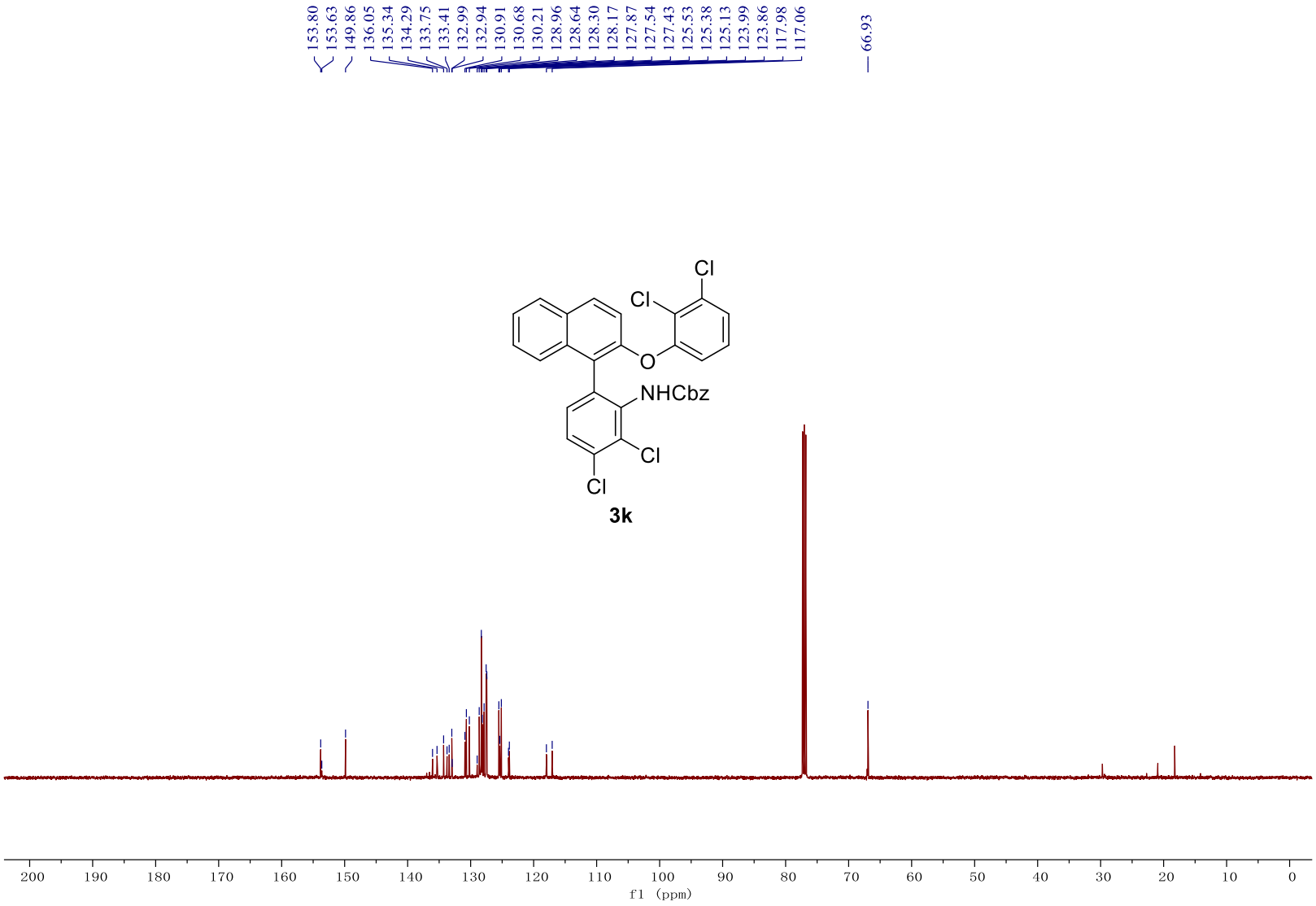
7.4177
7.4065
7.4040
7.4013
7.3952
7.3903
7.3869
7.3702
7.3332
7.1886
7.1462
7.1429
7.1375
7.1339
7.1263
7.1224
7.1016
7.0989
7.0853
7.0825
7.0301
7.0121
6.9633
6.9470
6.9305
6.9182
6.9153
6.9120
6.9029
6.8991
6.6147
6.6120
6.5983
6.5954
6.4607
4.8274
4.8031
4.7518
Cl
Cl
O
NHCbz
Cl
Cl
3k
2.174
1.004
2.253
1.139
1.349
2.069
2.062
1.000
0.838
1.905
0.947
0.874
2.096
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
f1 (ppm)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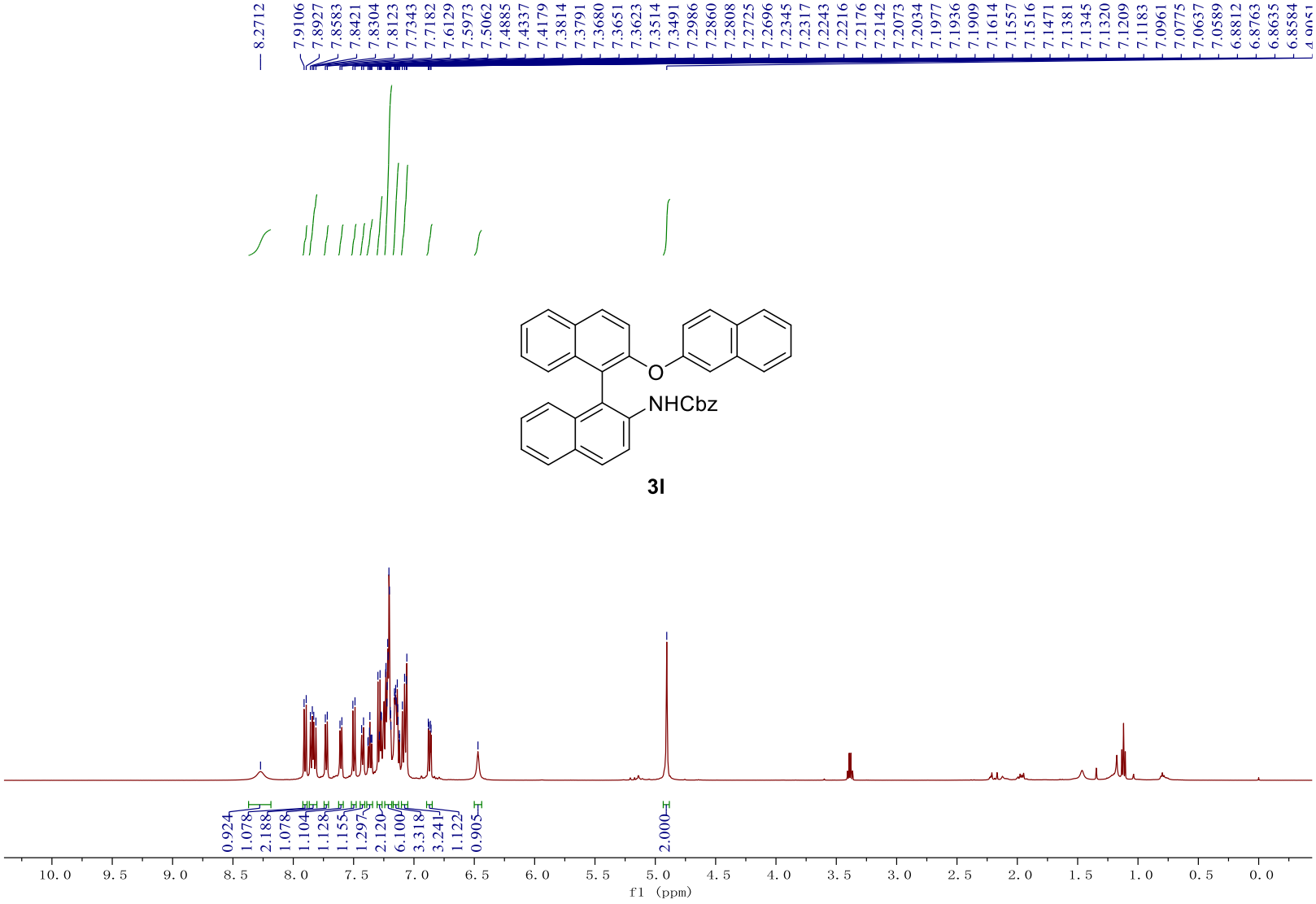
153.63
149.86
136.05
135.34
134.29
133.75
133.41
132.99
132.94
130.91
130.68
130.21
128.96
128.64
128.30
128.17
127.87
127.54
127.43
125.53
125.38
125.13
123.99
123.86
117.98
117.06
66.93
Cl
Cl
O
NHCbz
Cl
Cl
3k
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.8927
7.8583
7.8421
7.8304
7.8123
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7.7182
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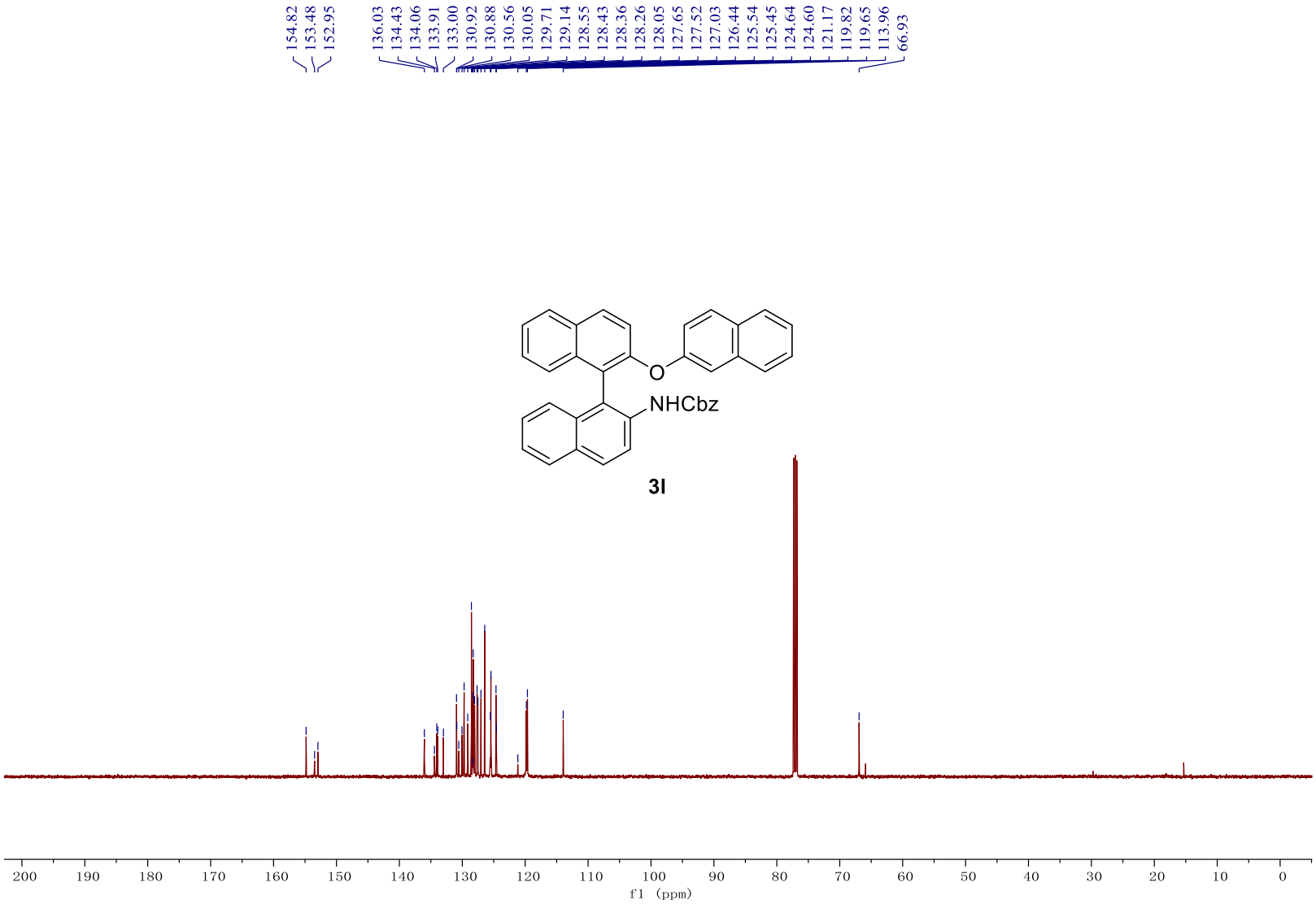
7.5973
7.5062
7.4885
7.4337
7.4179
7.3814
7.3791
7.3680
7.3651
7.3623
7.3514
7.3491
7.2986
7.2860
7.2808
7.2725
7.2696
7.2345
7.2317
7.2243
7.2216
7.2176
7.2142
7.2073
7.2034
7.1977
7.1936
7.1909
7.1614
7.1557
7.1516
7.1471
7.1381
7.1345
7.1320
7.1209
7.1183
7.0961
7.0775
7.0637
7.0589
6.8812
6.8763
6.8635
6.8584
O
NHCbz
0.924
1.078
2.188
1.078
1.104
1.128
1.155
1.297
2.120
6.100
3.318
3.241
1.122
0.905
2.000
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
f1 (ppm)

3l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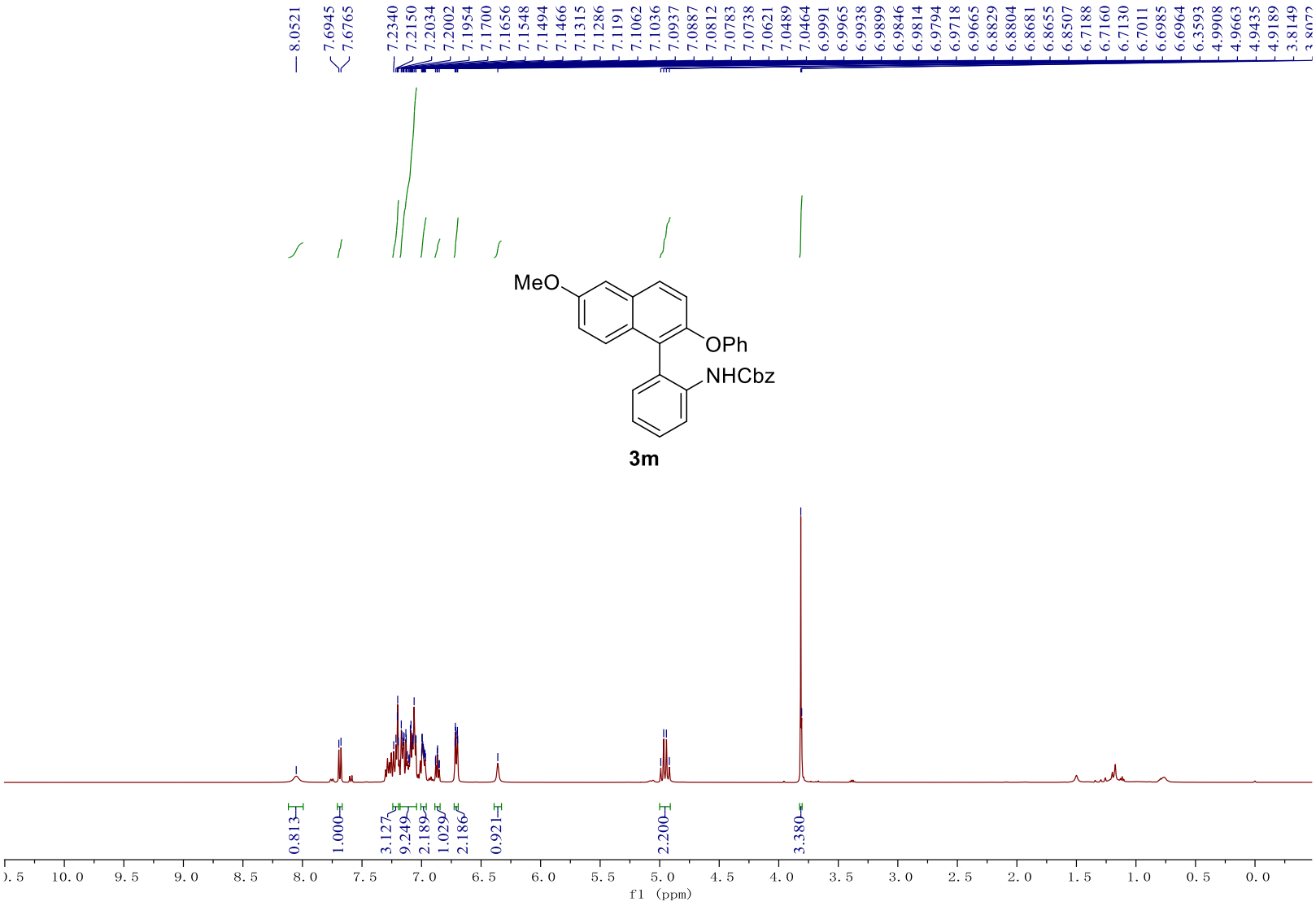
153.48
152.95
136.03
134.43
134.06
133.91
133.00
130.92
130.88
130.56
130.05
129.71
129.14
128.55
128.43
128.36
128.26
128.05
127.65
127.52
127.03
126.44
125.54
125.45
124.64
124.60
121.17
119.82
119.65
113.96
66.93
O
NHCbz
3l
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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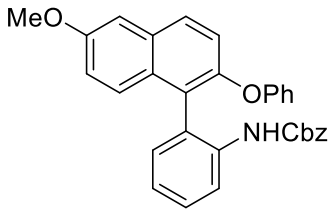
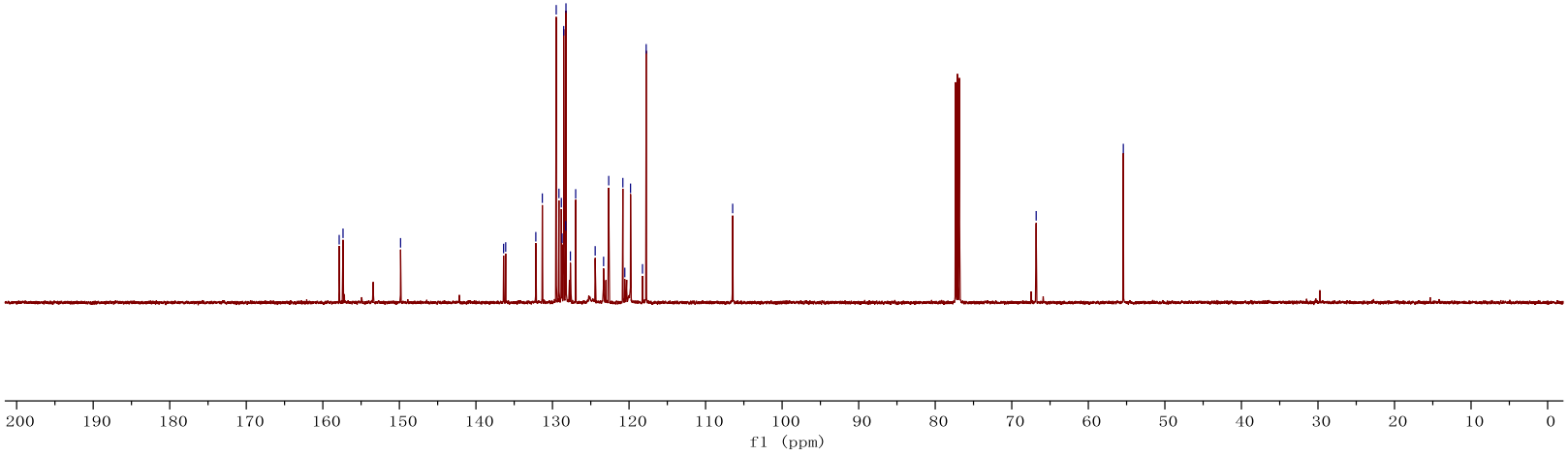
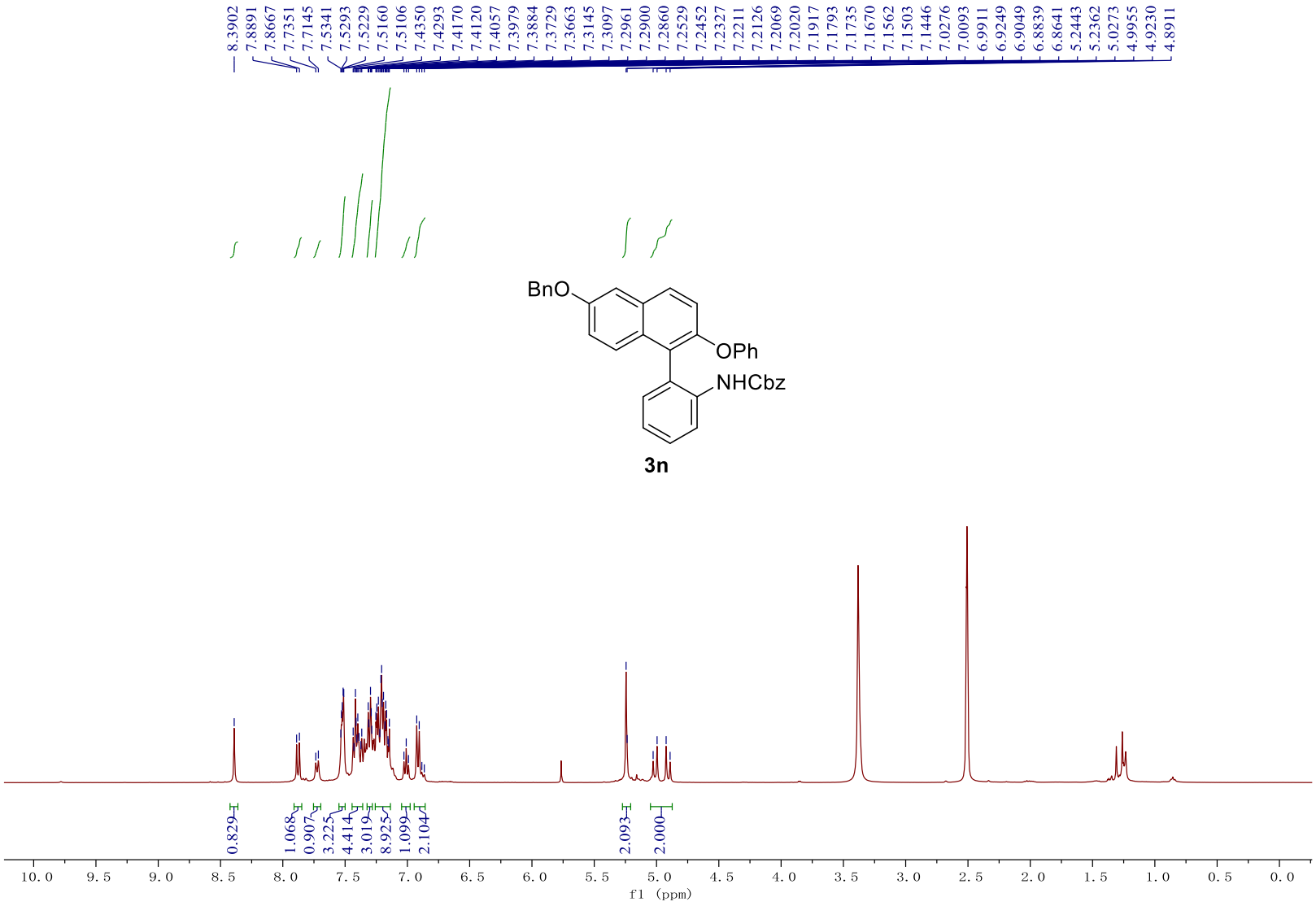
7.6945
7.6765
7.2340
7.2150
7.2034
7.2002
7.1954
7.1700
7.1656
7.1548
7.1494
7.1466
7.1315
7.1286
7.1191
7.1062
7.1036
7.0937
7.0887
7.0812
7.0783
7.0738
7.0621
7.0489
7.0464
6.9991
6.9965
6.9938
6.9899
6.9846
6.9814
6.9794
6.9718
6.9665
6.8829
6.8804
6.8681
6.8655
6.8507
6.7188
6.7160
6.7130
6.7011
6.6985
6.6964
6.3593
4.9908
4.9663
4.9435
4.9189
3.8149
MeO
OPh
NHCbz
3m
0.813
1.000
3.127
9.249
2.189
1.029
2.186
0.921
2.200
3.380
f1 (ppm)


157.86
157.36
149.85
136.39
136.11
132.18
131.33
129.51
129.15
128.84
128.74
128.53
128.27
128.24
127.66
126.97
124.42
123.32
122.65
120.80
120.55
119.80
118.24
117.76
106.46
66.81
55.43

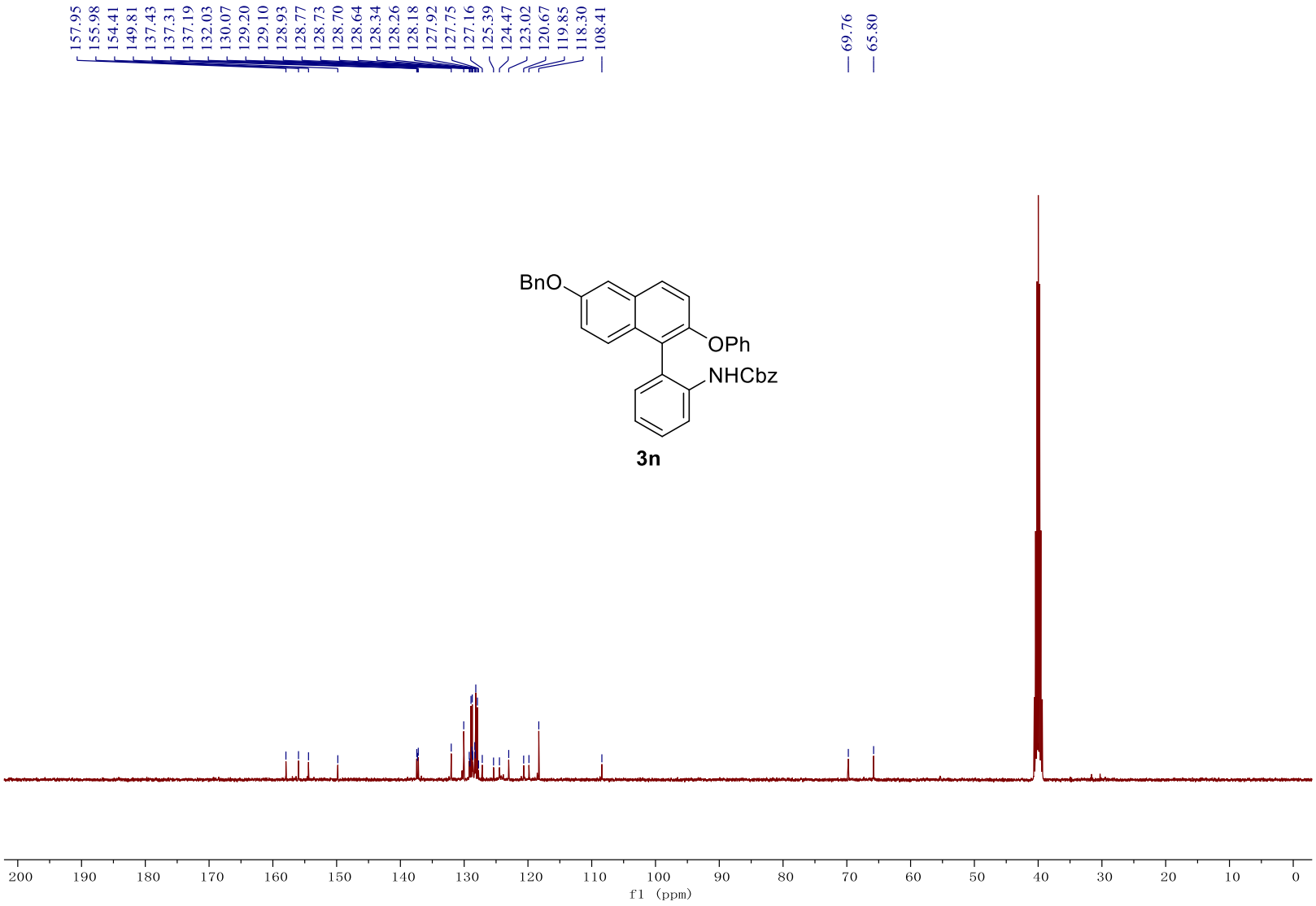

MeO
OPh
NHCbz

3m


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.3902
7.8891
7.8667
7.7351
7.7145
7.5341
7.5293
7.5229
7.5160
7.5106
7.4350
7.4293
7.4170
7.4120
7.4057
7.3979
7.3884
7.3729
7.3663
7.3145
7.3097
7.2961
7.2900
7.2860
7.2529
7.2452
7.2327
7.2211
7.2126
7.2069
7.2020
7.1917
7.1793
7.1735
7.1670
7.1562
7.1503
7.1446
7.0276
7.0093
6.9911
6.9249
6.9049
6.8839
6.8641
5.2443
5.2362
5.0273
4.9955
4.9230
4.8911
BnO
OPh
NHCbz
0.829
1.068
0.907
3.225
4.414
3.019
8.925
1.099
2.104
2.093
2.000
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
f1 (ppm)

3n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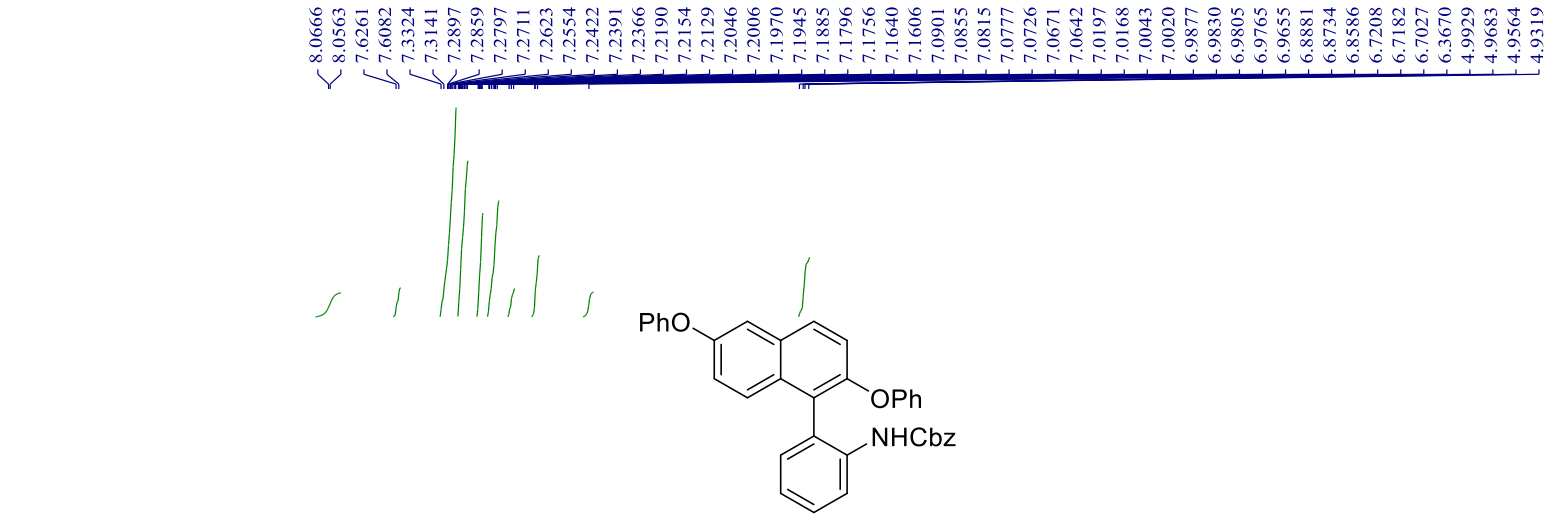
155.98
154.41
149.81
137.43
137.31
137.19
132.03
130.07
129.20
129.10
128.93
128.77
128.73
128.70
128.64
128.34
128.26
128.18
127.92
127.75
127.16
125.39
124.47
123.02
120.67
119.85
118.30
108.41
69.76
65.80
BnO
OPh
NHCbz
3n
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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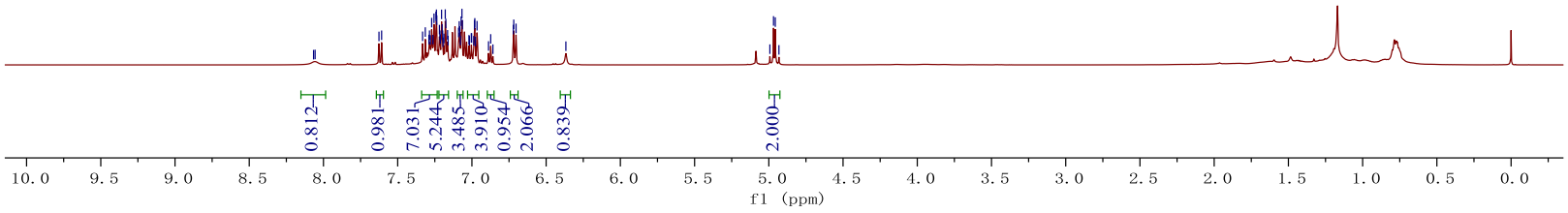
7.6261
7.6082
7.3324
7.3141
7.2897
7.2859
7.2797
7.2711
7.2623
7.2554
7.2422
7.2391
7.2366
7.2190
7.2154
7.2129
7.2046
7.2006
7.1970
7.1945
7.1885
7.1796
7.1756
7.1640
7.1606
7.0901
7.0855
7.0815
7.0777
7.0726
7.0671
7.0642
7.0197
7.0168
7.0043
7.0020
6.9877
6.9830
6.9805
6.9765
6.9655
6.8881
6.8734
6.8586
6.7208
6.7182
6.7027
6.3670
4.9929
4.9683
4.9564
4.9319
PhO
OPh
NHCbz

3o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0.981
7.031
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3.485
3.910
0.954
2.066
0.839
2.000
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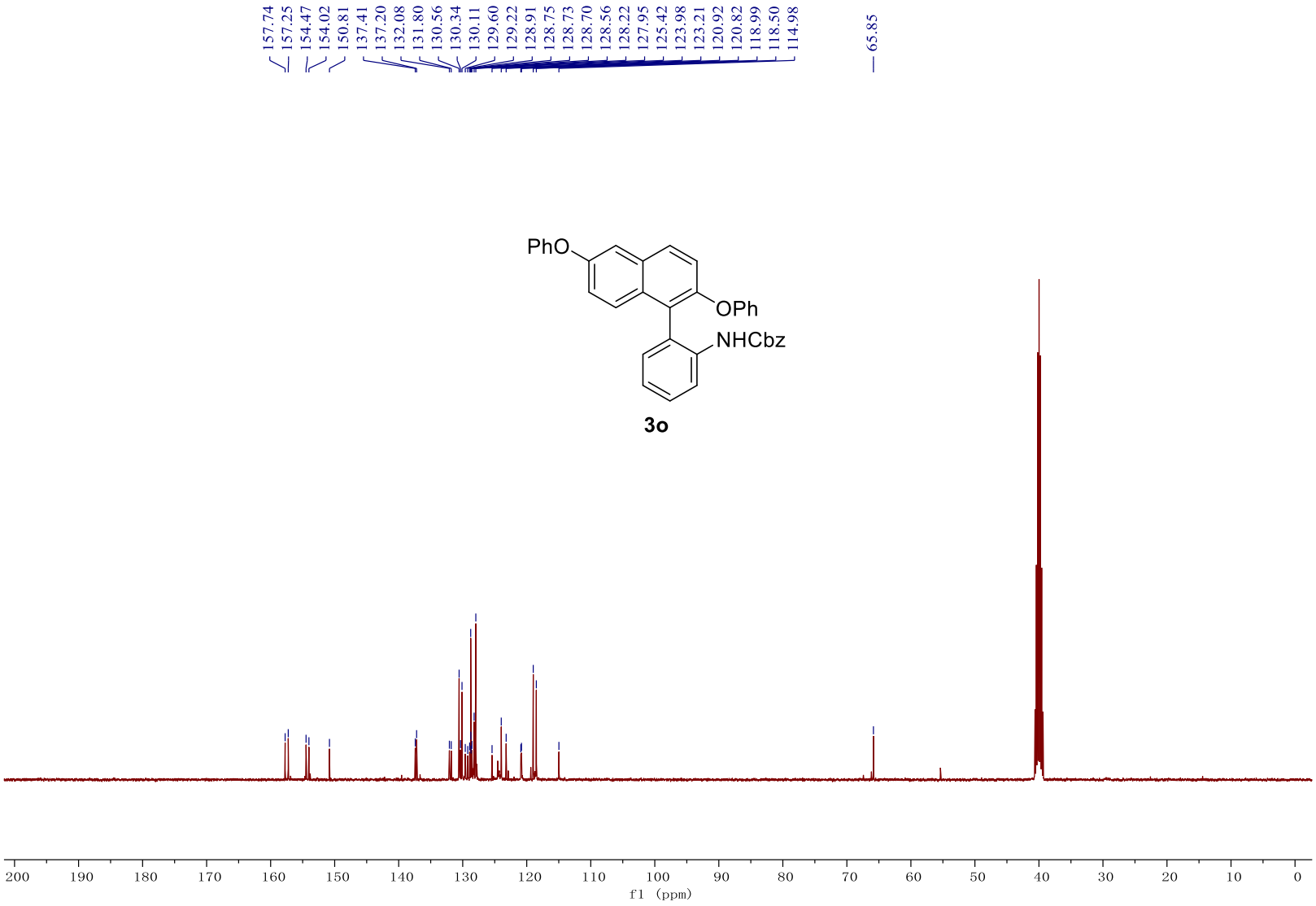
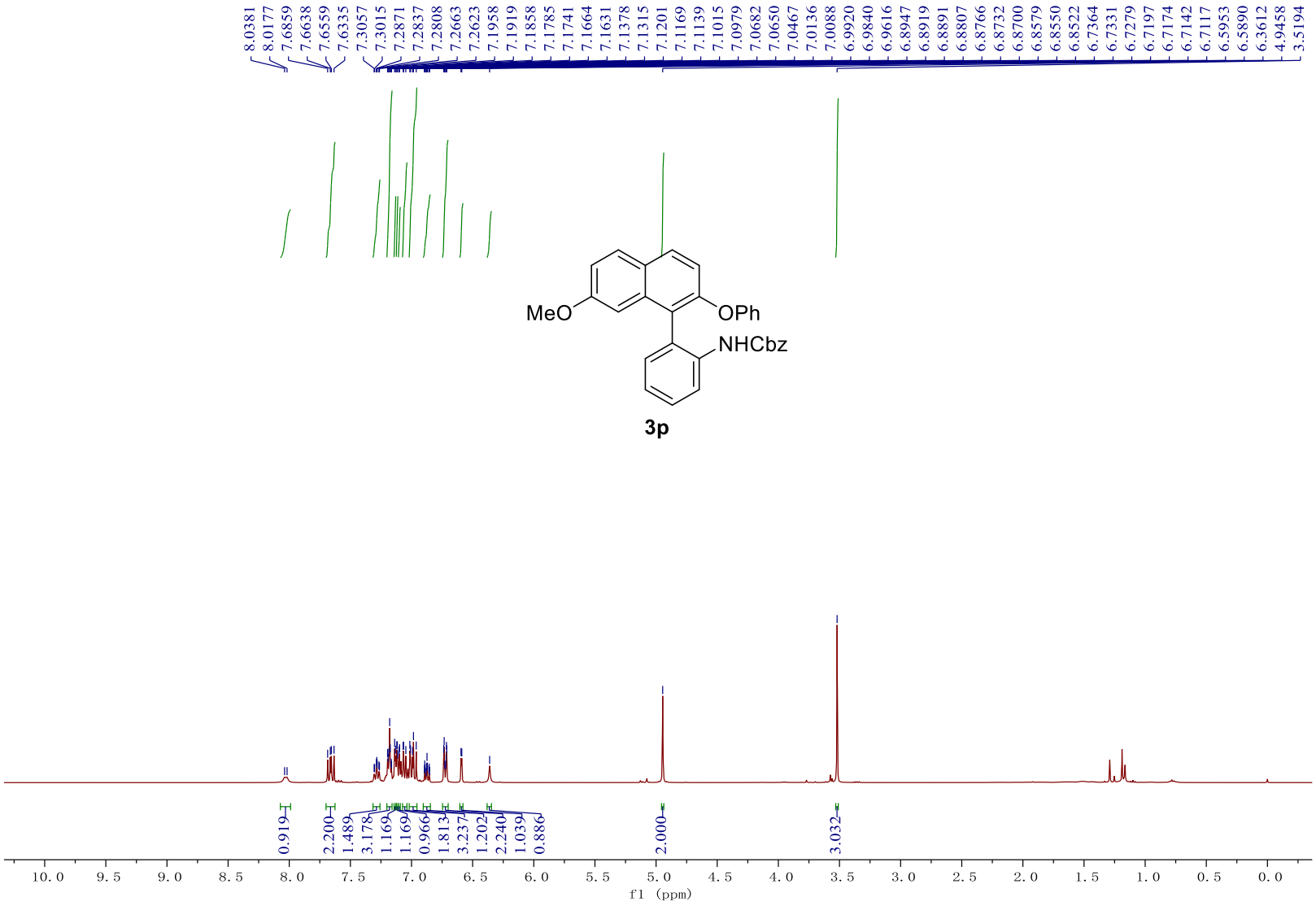
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


157.74
157.25
154.47
154.02
150.81
137.41
137.20
132.08
131.80
130.56
130.34
130.11
129.60
129.22
128.91
128.75
128.73
128.70
128.56
128.22
127.95
125.42
123.98
123.21
120.92
120.82
118.99
118.50
114.98
65.85
PhO
OPh
NHCbz
3o
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.6638
7.6559
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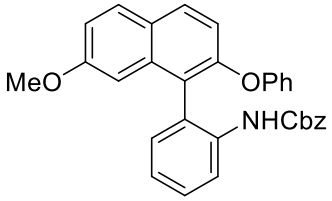
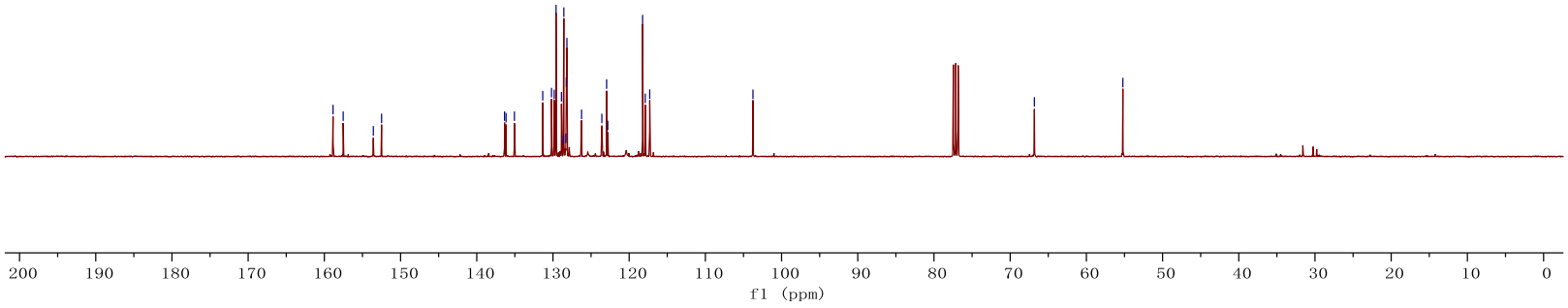
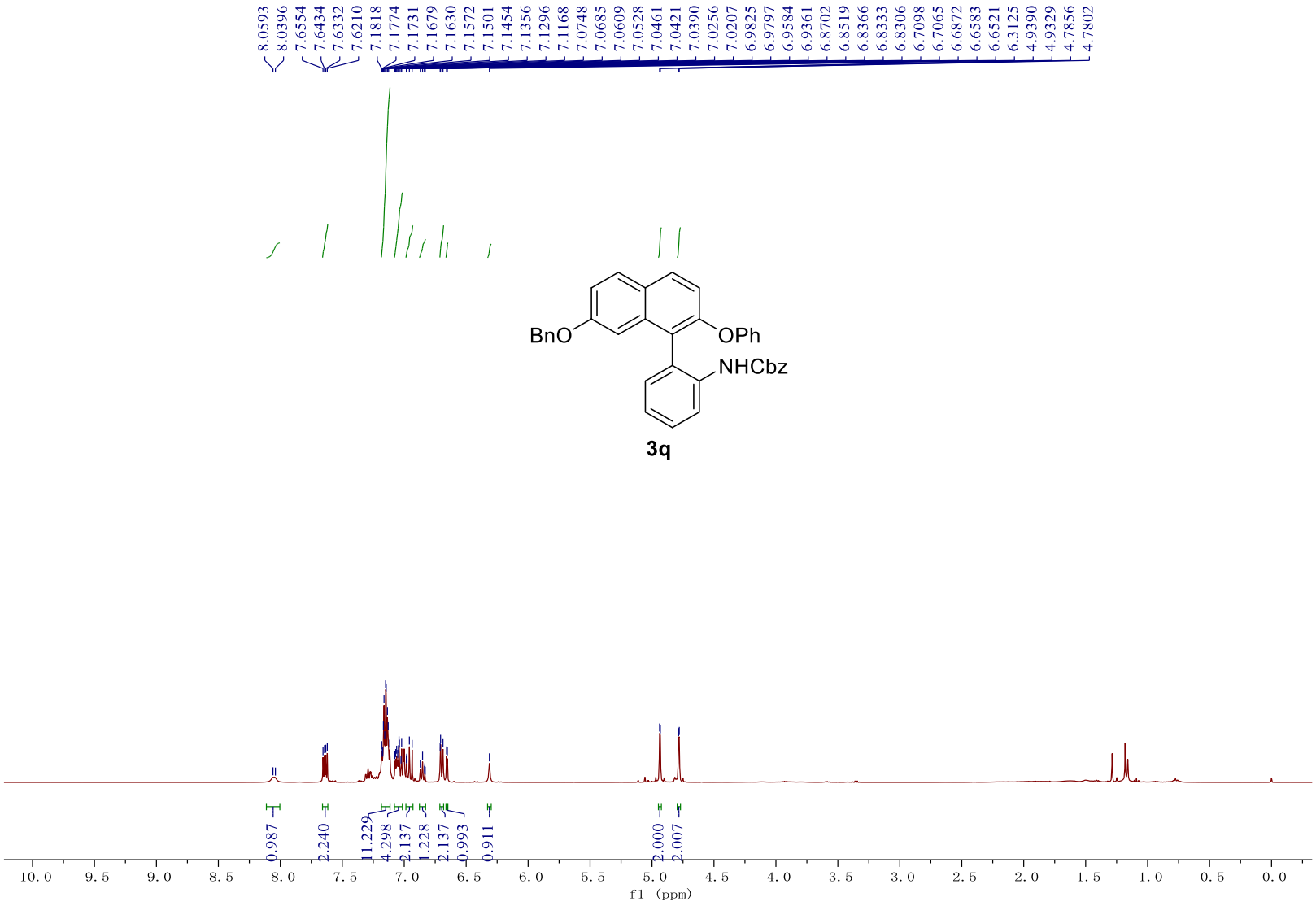
7.3057
7.3015
7.2871
7.2837
7.2808
7.2663
7.2623
7.1958
7.1919
7.1858
7.1785
7.1741
7.1664
7.1631
7.1378
7.1315
7.1201
7.1169
7.1139
7.1015
7.0979
7.0682
7.0650
7.0467
7.0136
7.0088
6.9920
6.9840
6.9616
6.8947
6.8919
6.8891
6.8807
6.8766
6.8732
6.8700
6.8579
6.8550
6.8522
6.7364
6.7331
6.7279
6.7197
6.7174
6.7142
6.7117
6.5953
6.5890
6.3612
4.9458
3.5194
MeO
OPh
NHCbz
3p
0.919
2.200
1.489
3.178
1.169
1.169
0.966
1.813
3.237
1.202
2.240
1.039
0.886
2.000
3.032
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
f1 (ppm)


158.86
157.53
153.57
152.49
136.35
136.15
135.05
131.34
130.19
129.84
129.59
128.89
128.62
128.57
128.30
128.25
128.17
126.25
123.58
122.96
122.80
118.24
117.89
117.30
103.75
66.83
55.21


MeO
OPh
NHCbz

3p


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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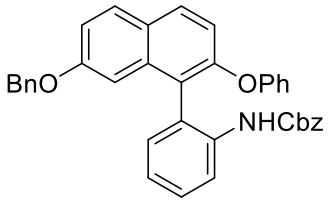
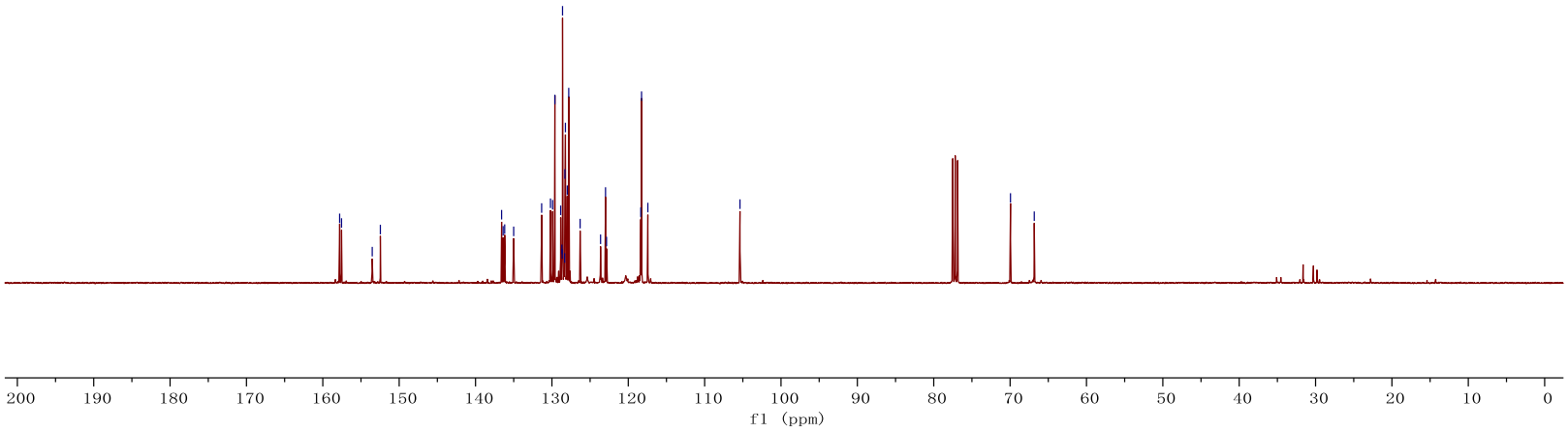
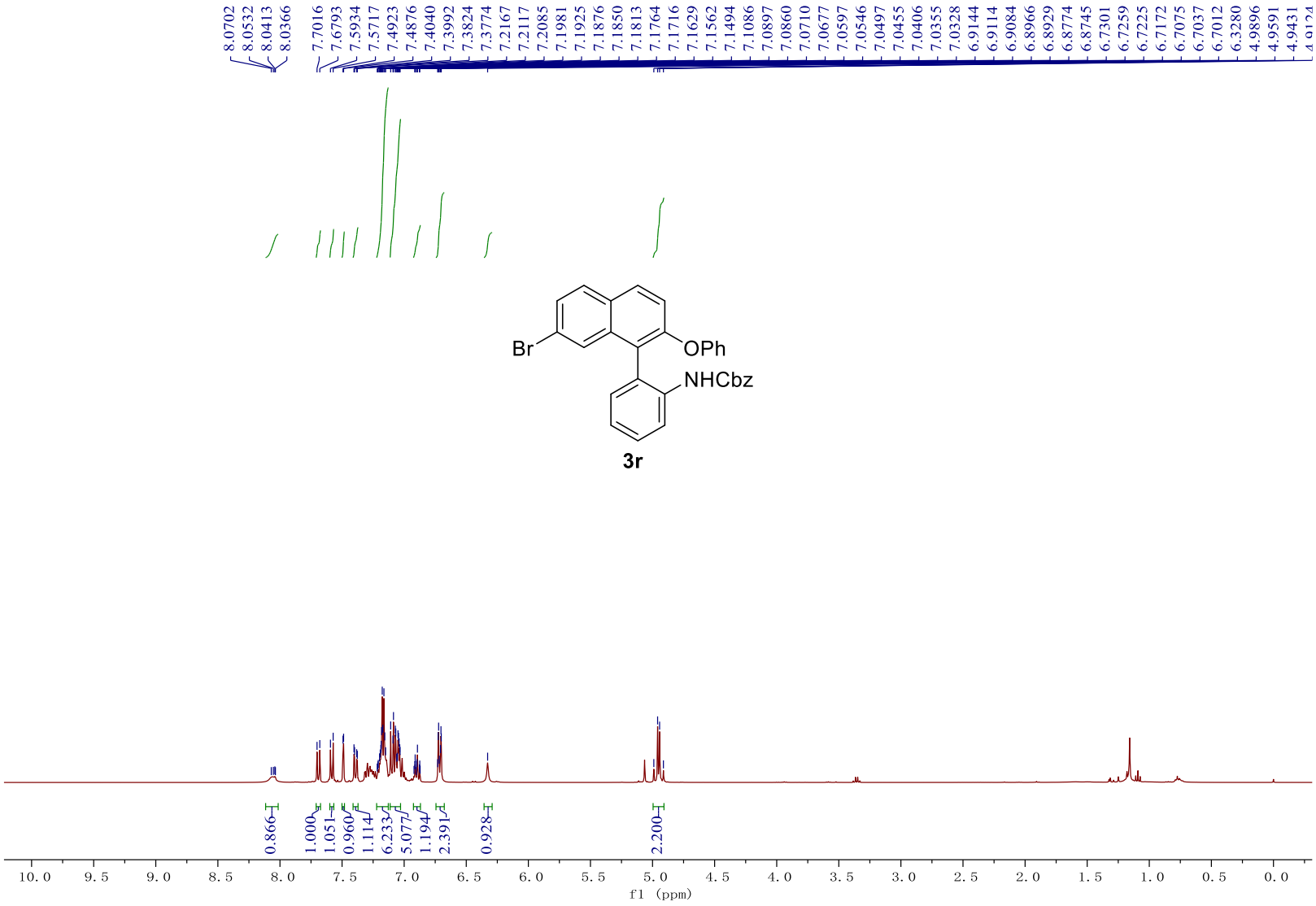
8.0396
7.6554
7.6434
7.6332
7.6210
7.1818
7.1774
7.1731
7.1679
7.1630
7.1572
7.1501
7.1454
7.1356
7.1296
7.1168
7.0748
7.0685
7.0609
7.0528
7.0461
7.0421
7.0390
7.0256
7.0207
6.9825
6.9797
6.9584
6.9361
6.8702
6.8519
6.8366
6.8333
6.8306
6.7098
6.7065
6.6872
6.6583
6.6521
6.3125
4.9390
4.9329
4.7856
4.7802
BnO
OPh
NHCbz
3q
0.987
2.240
11.229
4.298
2.137
1.228
2.137
0.993
0.911
2.000
2.007
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
f1 (ppm)


157.80
157.55
153.53
152.46
136.59
136.39
136.18
135.01
131.34
130.19
129.91
129.61
128.85
128.69
128.65
128.61
128.33
128.30
128.23
127.99
127.79
126.31
123.63
122.98
122.84
118.36
118.26
117.44
105.37
69.95
66.84


BnO
OPh
NHCbz

3q


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.0413
8.0366
7.7016
7.6793
7.5934
7.5717
7.4923
7.4876
7.4040
7.3992
7.3824
7.3774
7.2167
7.2117
7.2085
7.1981
7.1925
7.1876
7.1850
7.1813
7.1764
7.1716
7.1629
7.1562
7.1494
7.1086
7.0897
7.0860
7.0710
7.0677
7.0597
7.0546
7.0497
7.0455
7.0406
7.0355
7.0328
6.9144
6.9114
6.9084
6.8966
6.8929
6.8774
6.8745
6.7301
6.7259
6.7225
6.7172
6.7075
6.7037
6.7012
6.3280
4.9896
4.9591
4.9431
Br
OPh
NHCbz
3r
0.866
1.000
1.051
0.960
1.114
6.233
5.077
1.194
2.391
0.928
2.200
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
f1 (ppm)


157.04
152.71
136.49
136.07
135.01
131.40
130.48
129.92
129.74
129.25
129.10
128.79
128.71
128.67
128.62
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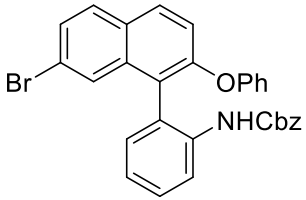
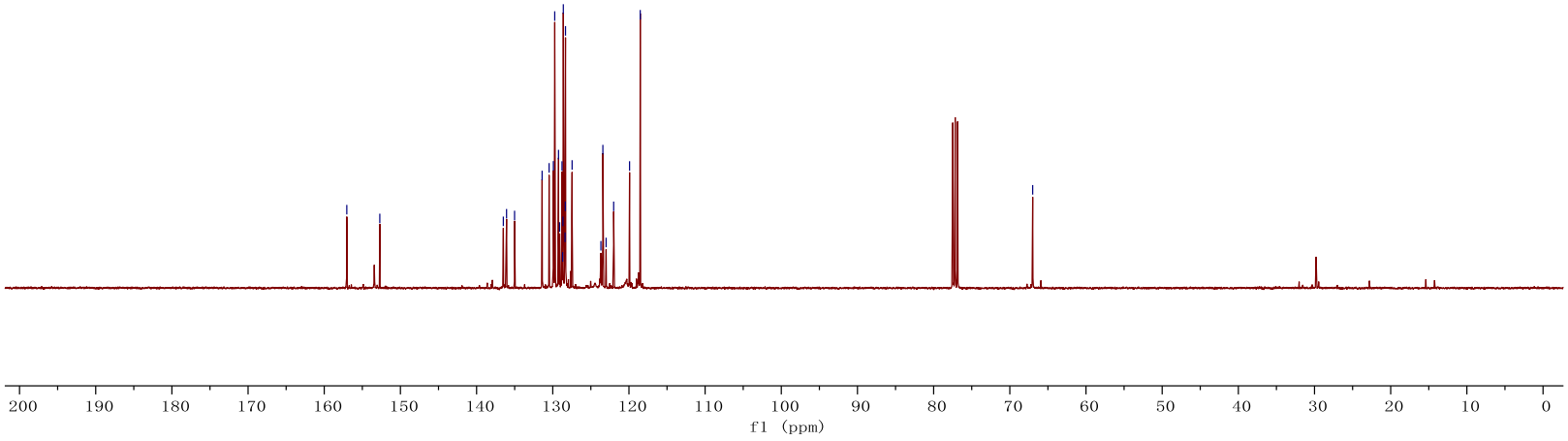
128.35
128.33
127.46
123.68
123.42
123.00
122.01
119.92
118.52
67.00


Br
OPh
NHCbz

3r


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
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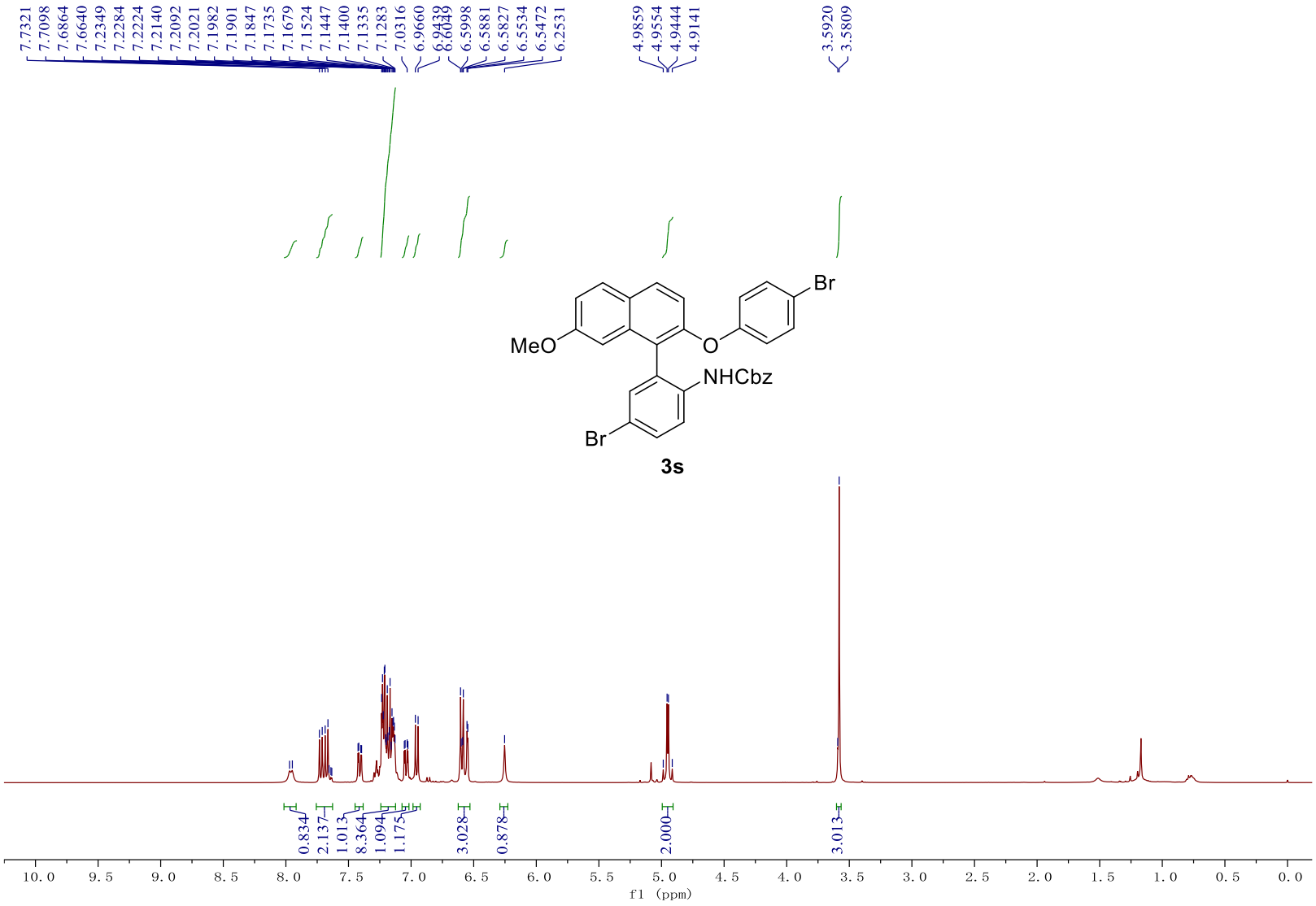
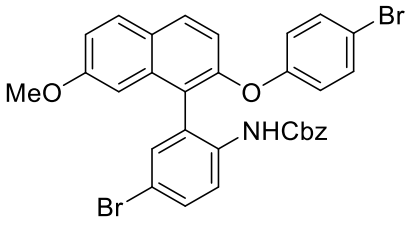
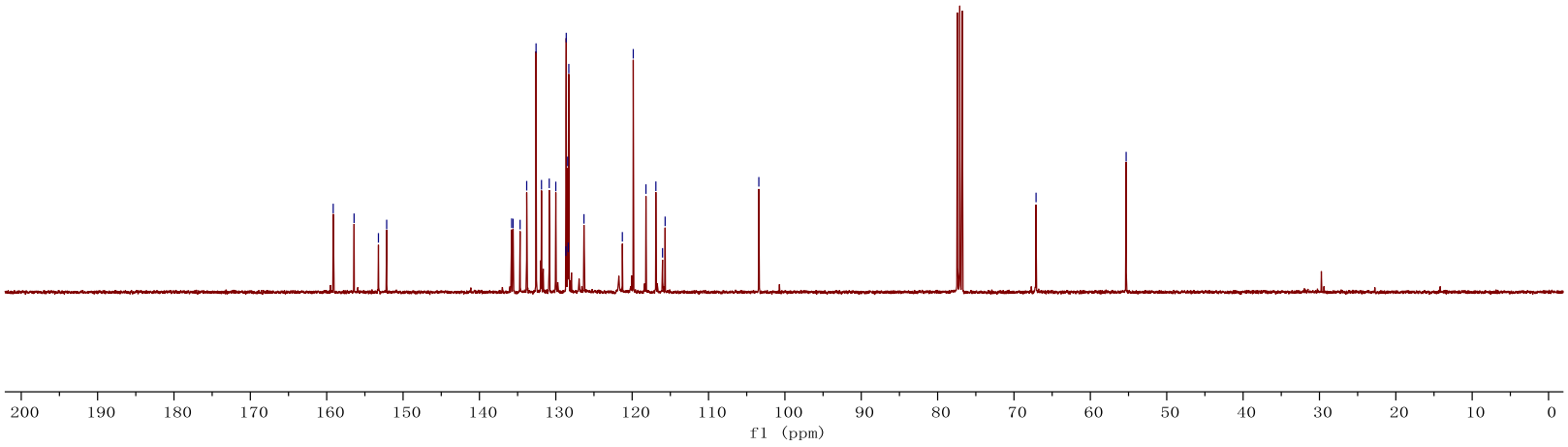
f1 (ppm)

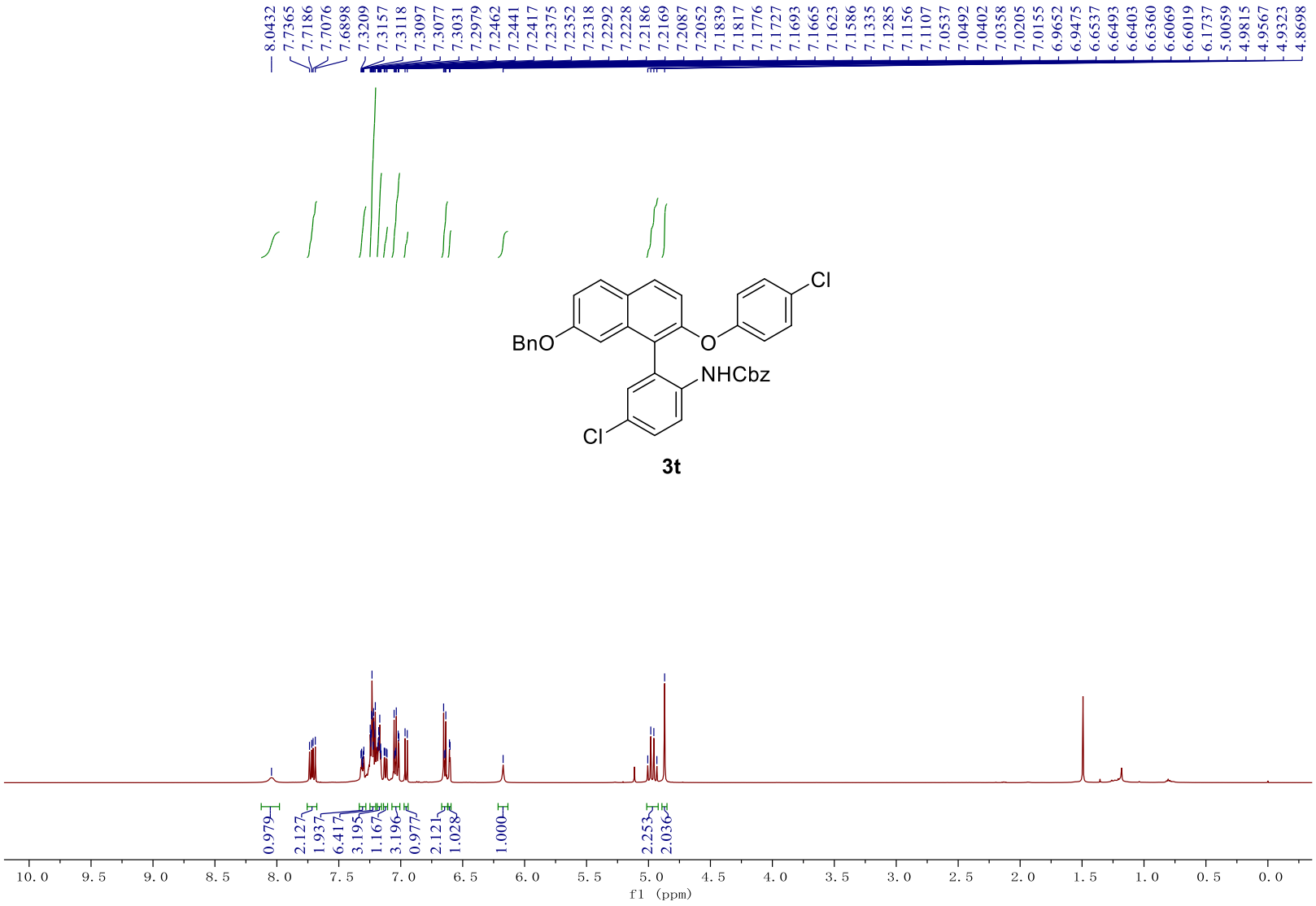

7.7321
7.7098
7.6864
7.6640
7.2349
7.2284
7.2224
7.2140
7.2092
7.2021
7.1982
7.1901
7.1847
7.1735
7.1679
7.1524
7.1447
7.1400
7.1335
7.1283
7.0316
6.9660
6.9439
6.9049
6.5998
6.5881
6.5827
6.5534
6.5472
6.2531
4.9859
4.9554
4.9444
4.9141
3.5920
3.5809
MeO
O
NHCbz
Br
Br
3s
0.834
2.137
1.013
8.364
1.094
1.175
3.028
0.878
2.000
3.013
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
f1 (ppm)


159.15
156.41
153.23
152.15
135.78
135.59
134.67
133.81
132.59
131.87
130.86
130.00
128.68
128.63
128.44
128.37
128.30
126.31
121.28
119.86
118.19
116.90
116.02
115.68
103.41
67.11
55.31


MeO
O
Br
NHCbz
Br

3s


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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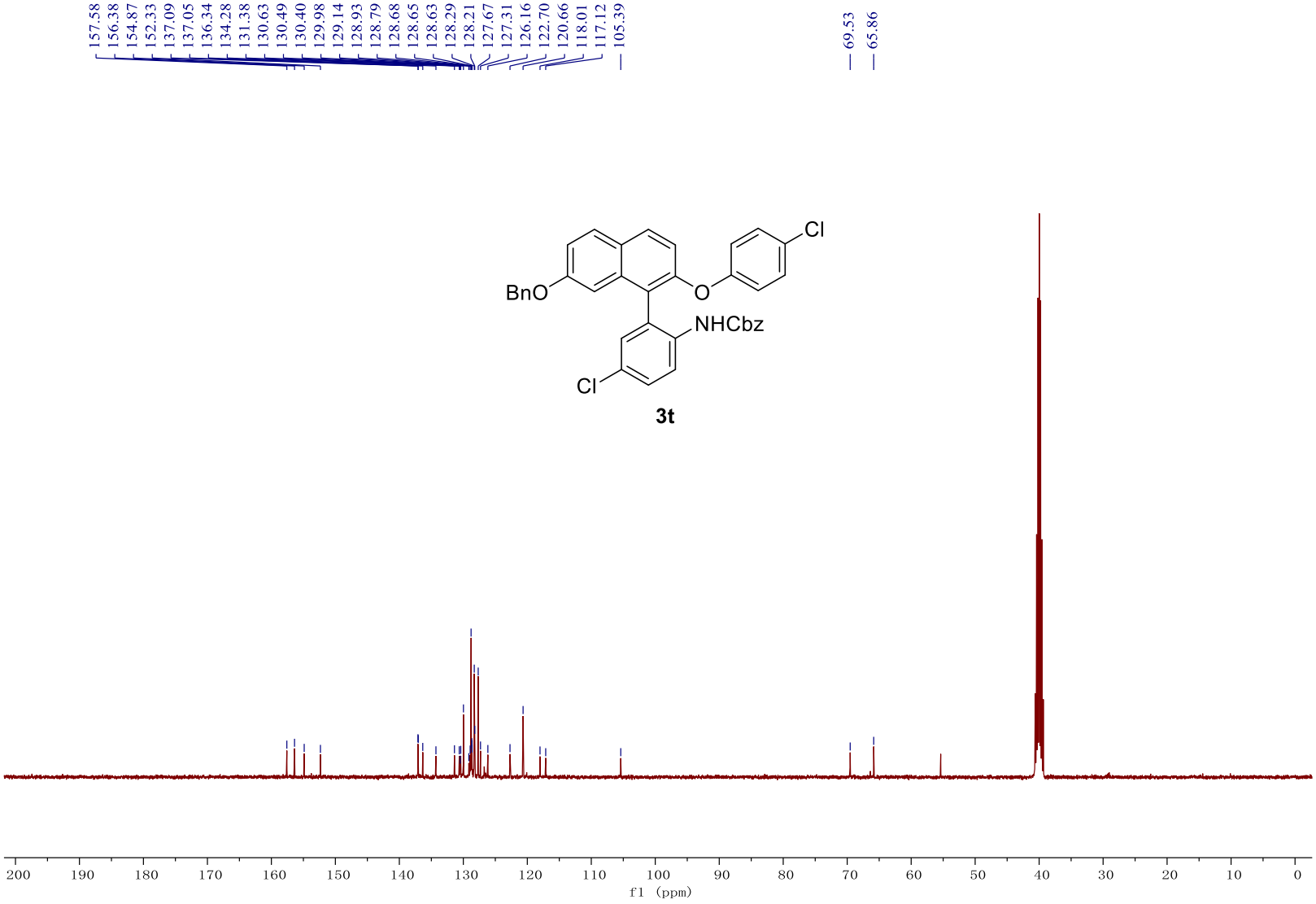
7.7365
7.7186
7.7076
7.6898
7.3209
7.3157
7.3118
7.3097
7.3077
7.3031
7.2979
7.2462
7.2441
7.2417
7.2375
7.2352
7.2318
7.2292
7.2228
7.2186
7.2169
7.2087
7.2052
7.1839
7.1817
7.1776
7.1727
7.1693
7.1665
7.1623
7.1586
7.1335
7.1285
7.1156
7.1107
7.0537
7.0492
7.0402
7.0358
7.0205
7.0155
6.9652
6.9475
6.6537
6.6493
6.6403
6.6360
6.6069
6.6019
6.1737
5.0059
4.9815
4.9567
4.9323
4.8698
BnO
O
Cl
NHCbz
Cl
3t
0.979
2.127
1.937
6.417
3.195
1.167
3.196
0.977
2.121
1.028
1.000
2.253
2.036
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
f1 (ppm)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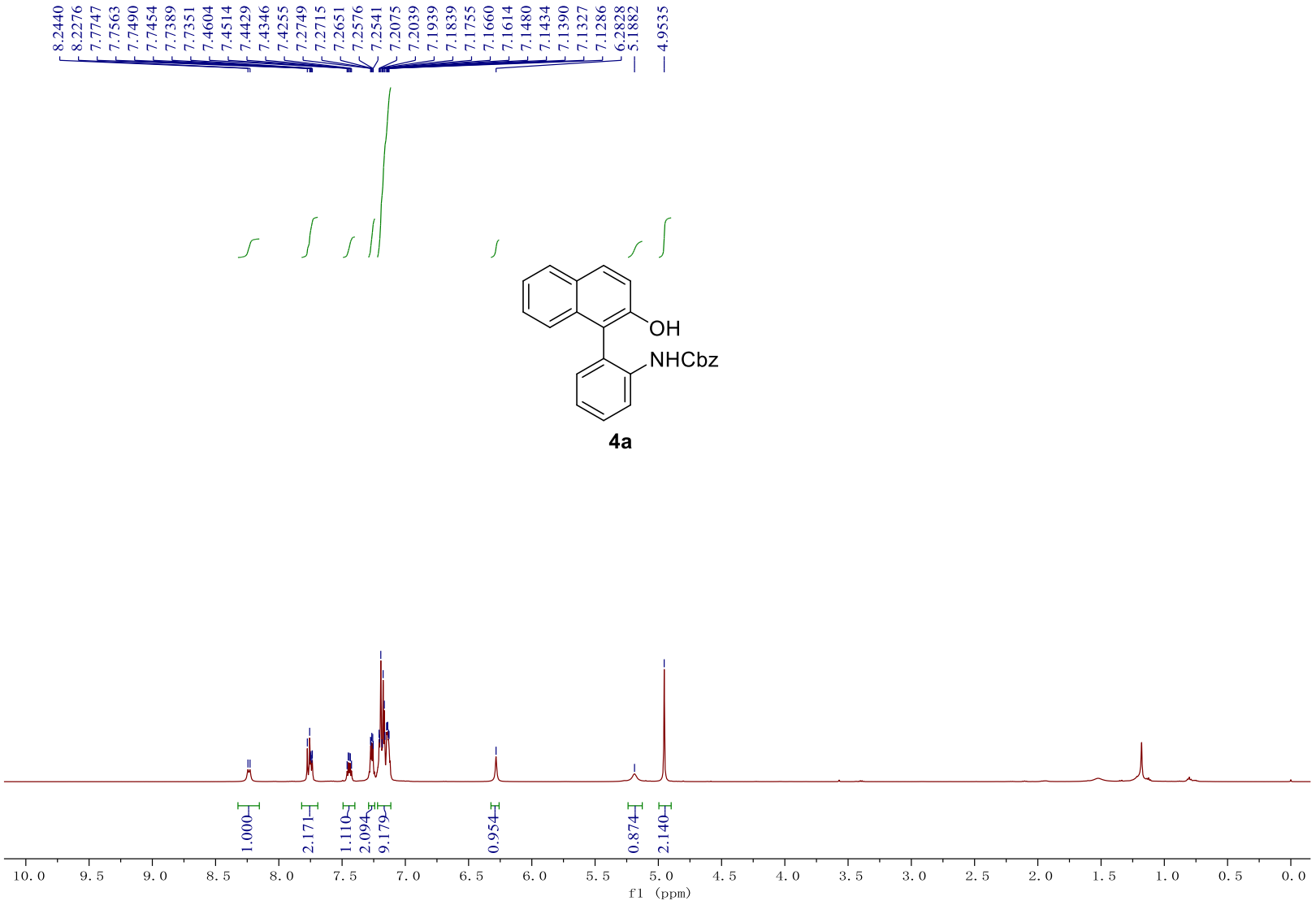
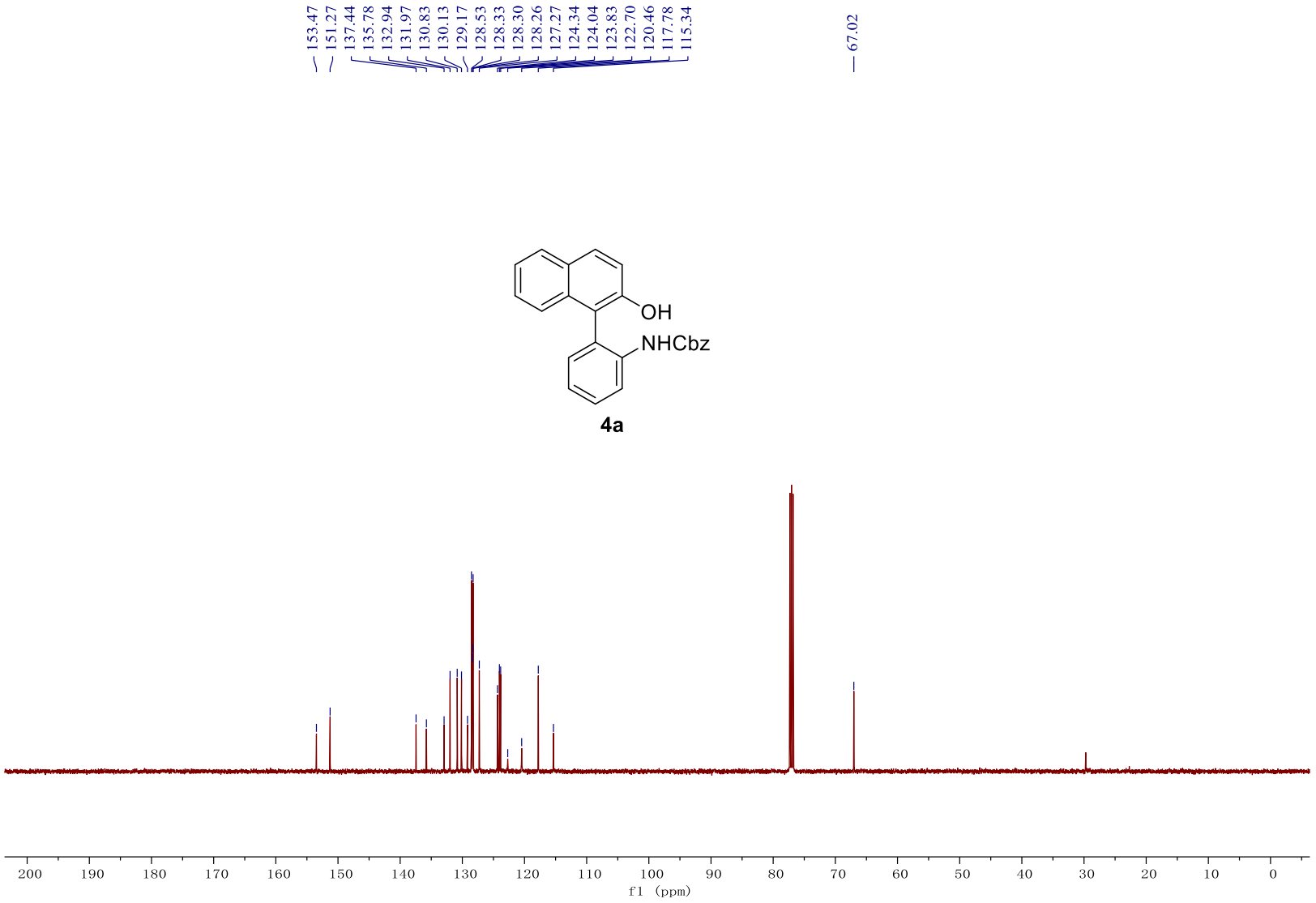
156.38
154.87
152.33
137.09
137.05
136.34
134.28
131.38
130.63
130.49
130.40
129.98
129.14
128.93
128.79
128.68
128.65
128.63
128.29
128.21
127.67
127.31
126.16
122.70
120.66
118.01
117.12
105.39
69.53
65.86
BnO
O
Cl
NHCbz
Cl
3t
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.2440
8.2276
7.7747
7.7563
7.7490
7.7454
7.7389
7.7351
7.4604
7.4514
7.4429
7.4346
7.4255
7.2749
7.2715
7.2651
7.2576
7.2541
7.2075
7.2039
7.1939
7.1839
7.1755
7.1660
7.1614
7.1480
7.1434
7.1390
7.1327
7.1286
6.2828
5.1882
4.9535
OH
NHCbz
4a
1.000
2.171
1.110
2.094
9.179
0.954
0.874
2.140
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
f1 (ppm)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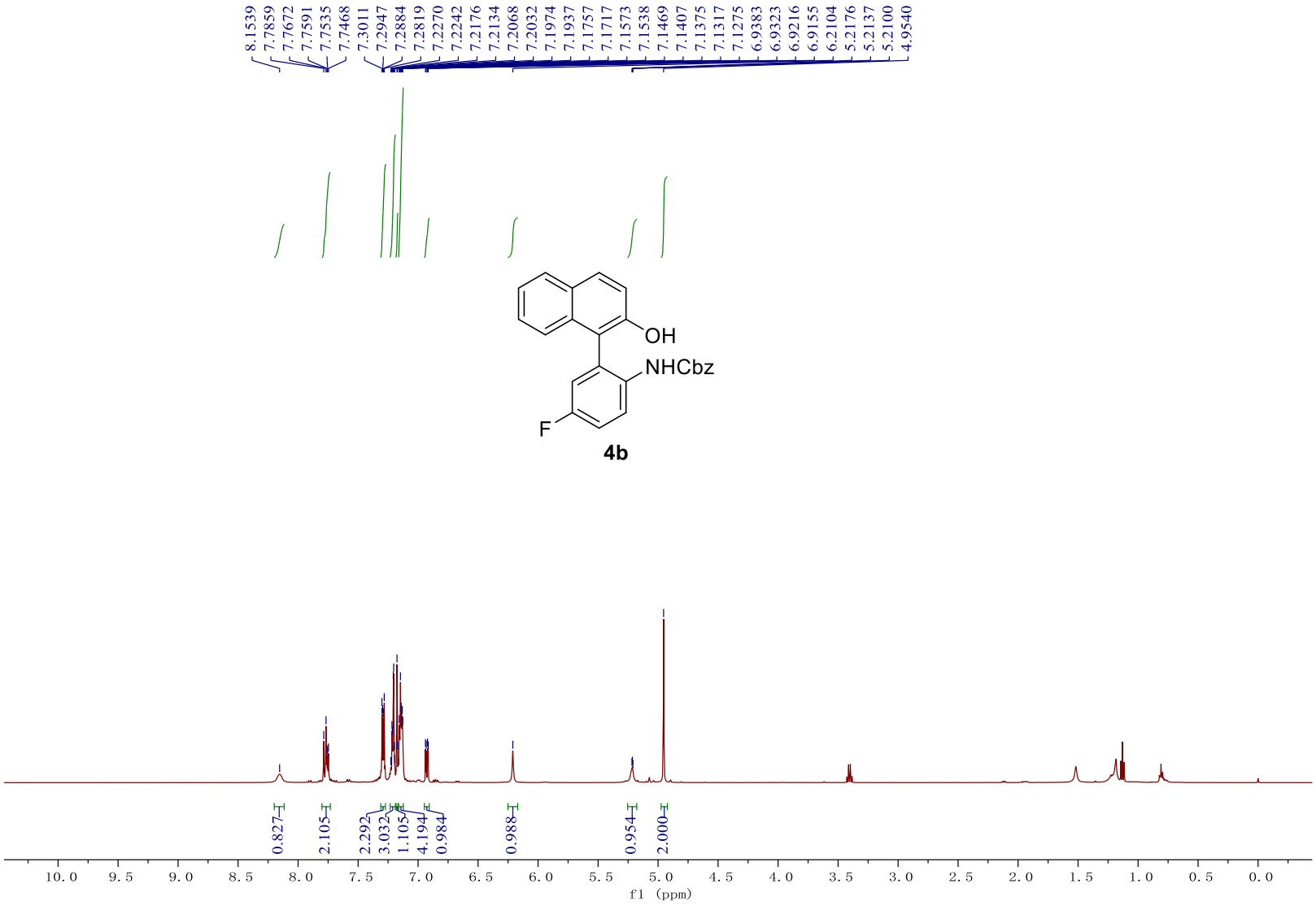
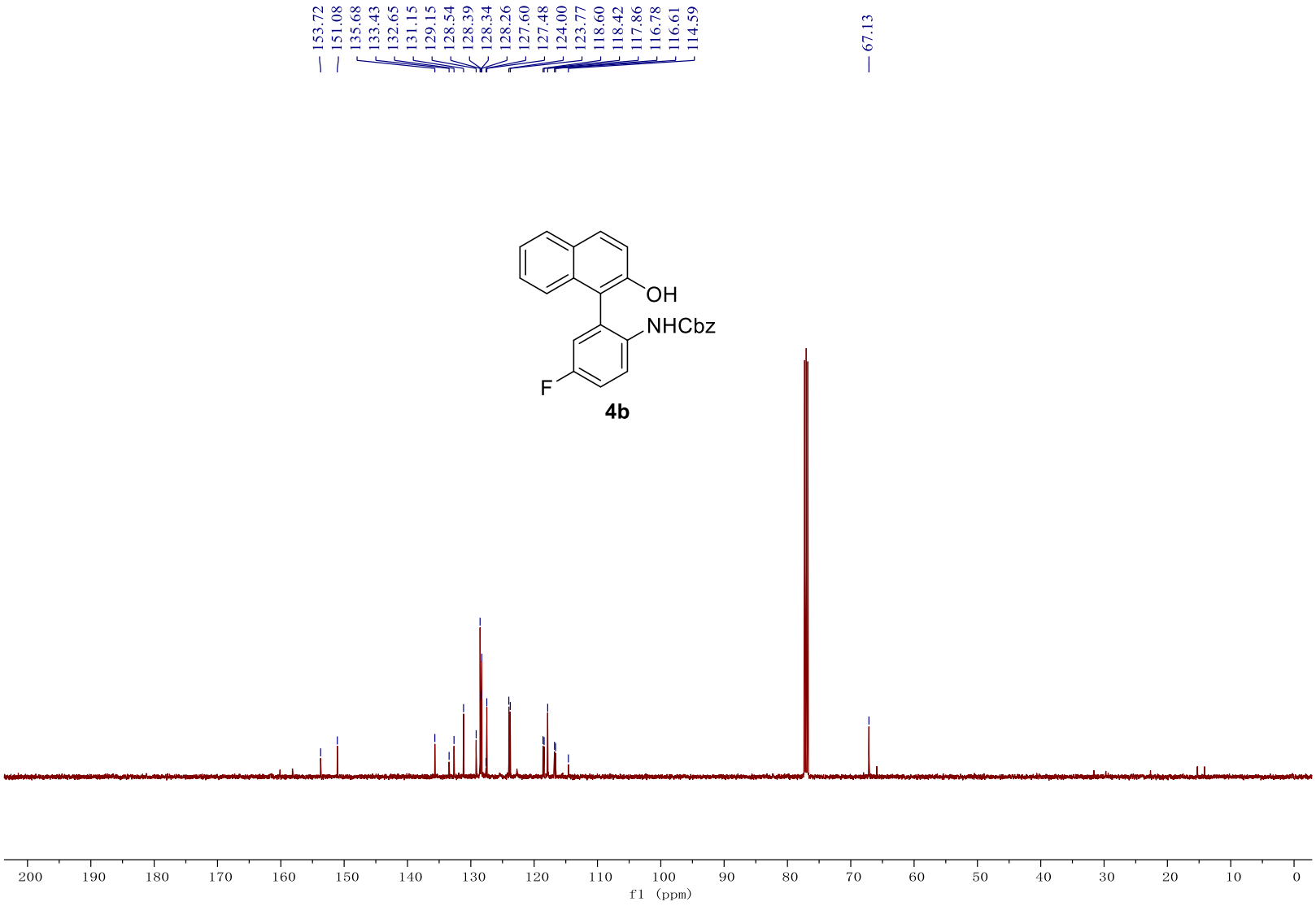
151.27
137.44
135.78
132.94
131.97
130.83
130.13
129.17
128.53
128.33
128.30
128.26
127.27
124.34
124.04
123.83
122.70
120.46
117.78
115.34
67.02
OH
NHCbz
4a
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.1539
7.7859
7.7672
7.7591
7.7535
7.7468
7.3011
7.2947
7.2884
7.2819
7.2270
7.2242
7.2176
7.2134
7.2068
7.2032
7.1974
7.1937
7.1757
7.1717
7.1573
7.1538
7.1469
7.1407
7.1375
7.1317
7.1275
6.9383
6.9323
6.9216
6.9155
6.2104
5.2176
5.2137
5.2100
4.9540
OH
NHCbz
F
4b
0.827
2.105
2.292
3.032
1.105
4.194
0.984
0.988
0.954
2.000
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
f1 (ppm)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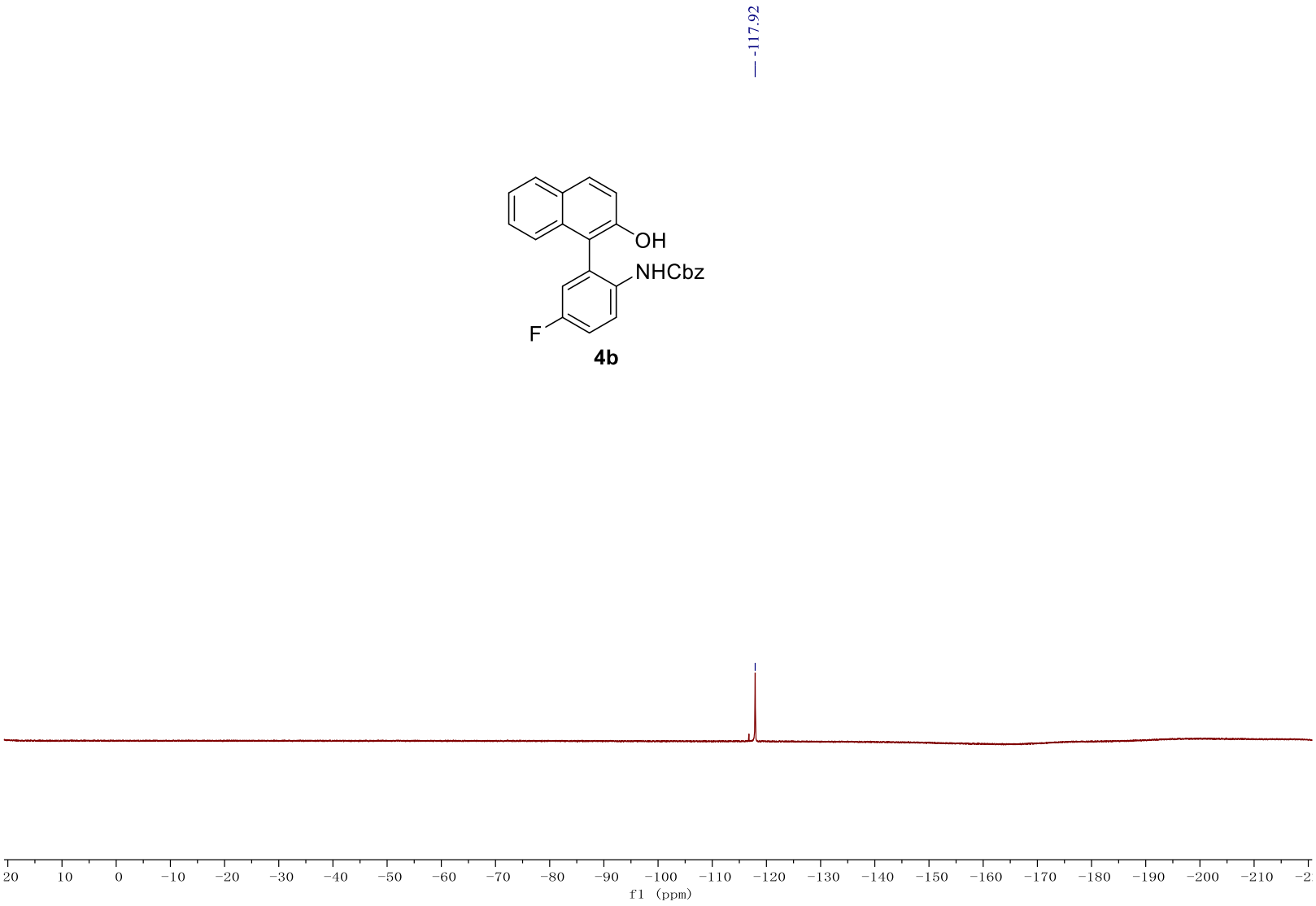
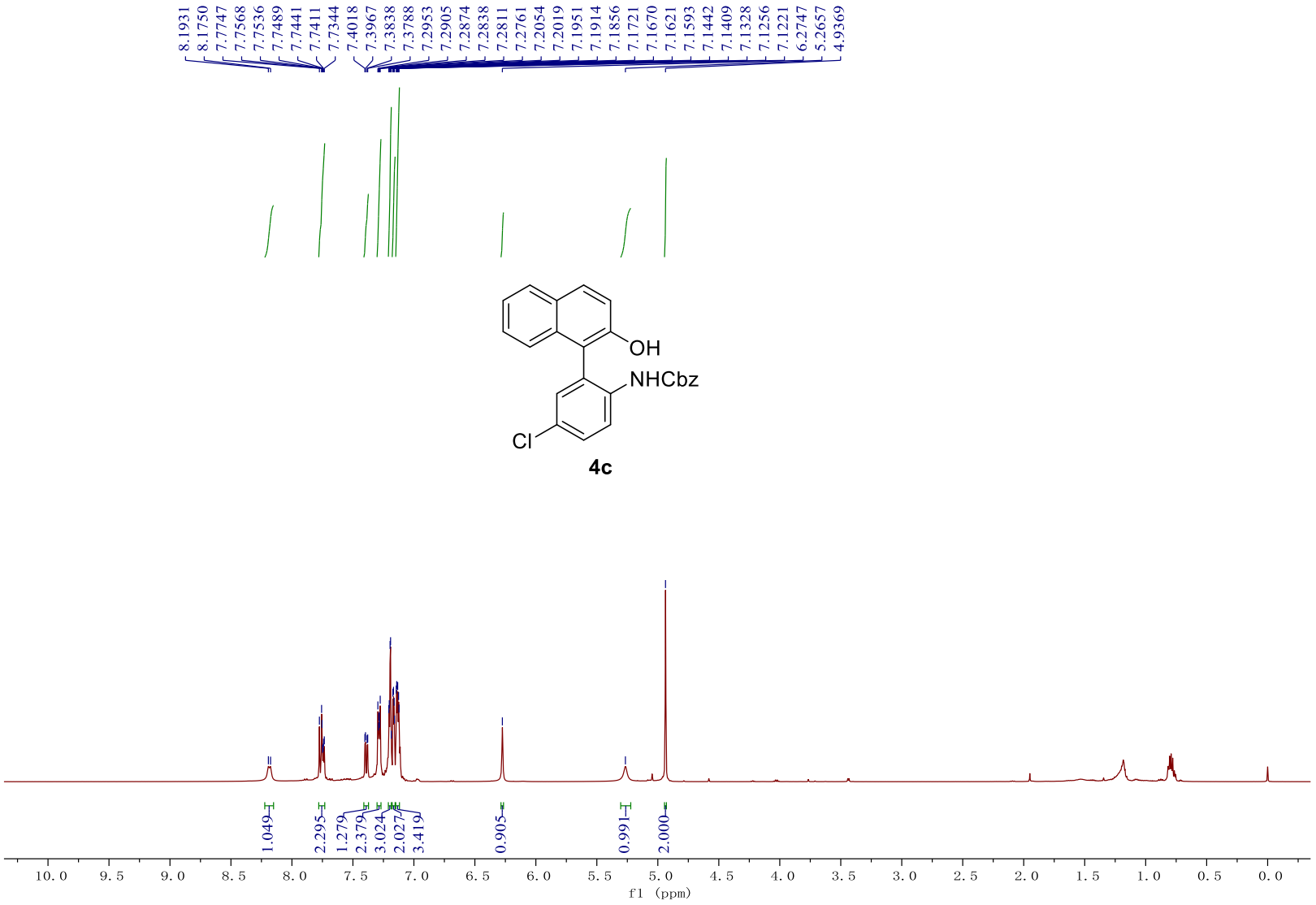
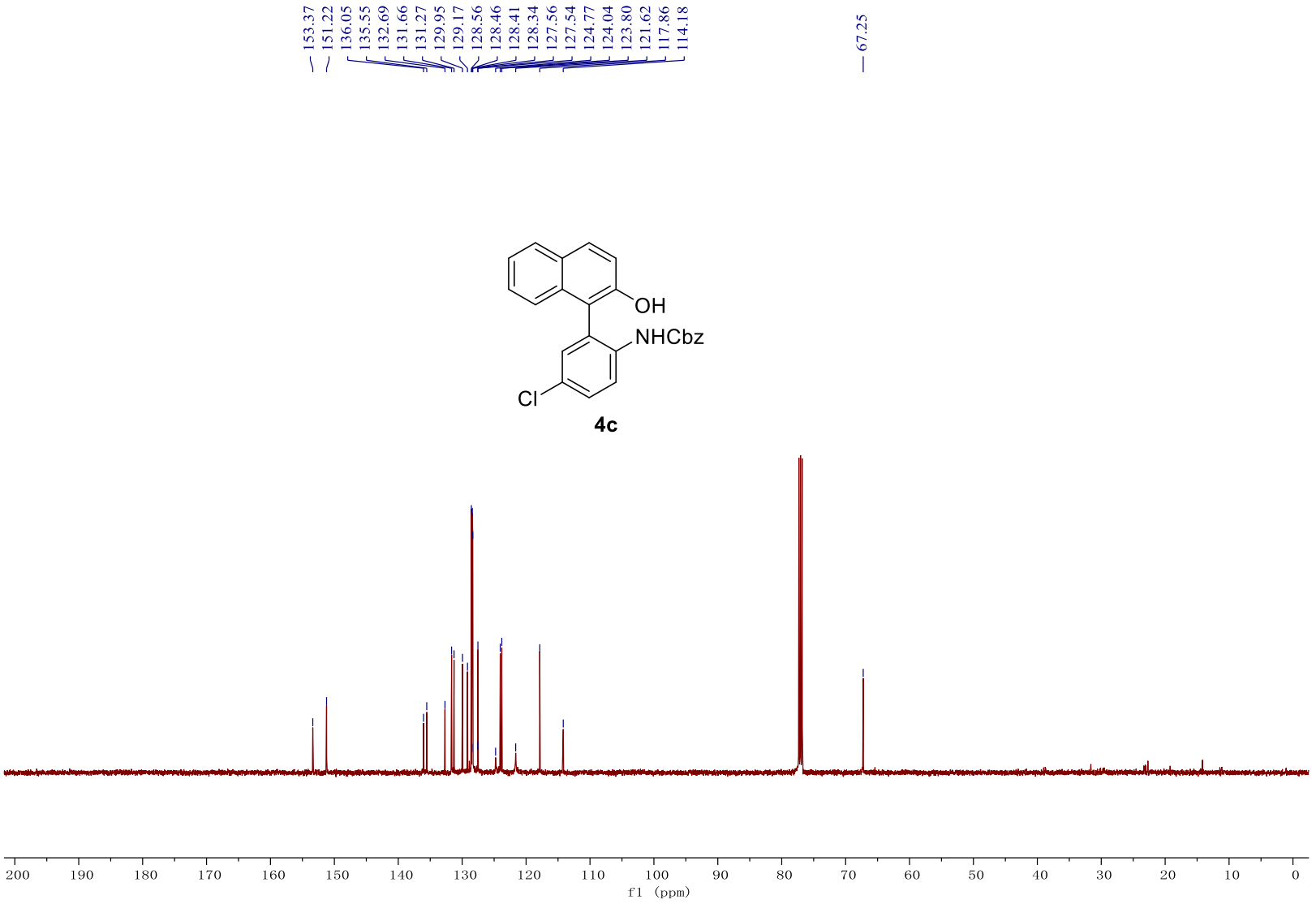
151.08
135.68
133.43
132.65
131.15
129.15
128.54
128.39
128.34
128.26
127.60
127.48
124.00
123.77
118.60
118.42
117.86
116.78
116.61
114.59
67.13
OH
NHCbz
F
4b
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-117.92
OH
NHCbz
F
4b
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)


8.1931
8.1750
7.7747
7.7568
7.7536
7.7489
7.7441
7.7411
7.7344
7.4018
7.3967
7.3838
7.3788
7.2953
7.2905
7.2874
7.2838
7.2811
7.2761
7.2054
7.2019
7.1951
7.1914
7.1856
7.1721
7.1670
7.1621
7.1593
7.1442
7.1409
7.1328
7.1256
7.1221
6.2747
5.2657
4.9369
OH
NHCbz
Cl
4c
1.049
2.295
1.279
2.379
3.024
2.027
3.419
0.905
0.991
2.000
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
f1 (ppm)


153.37
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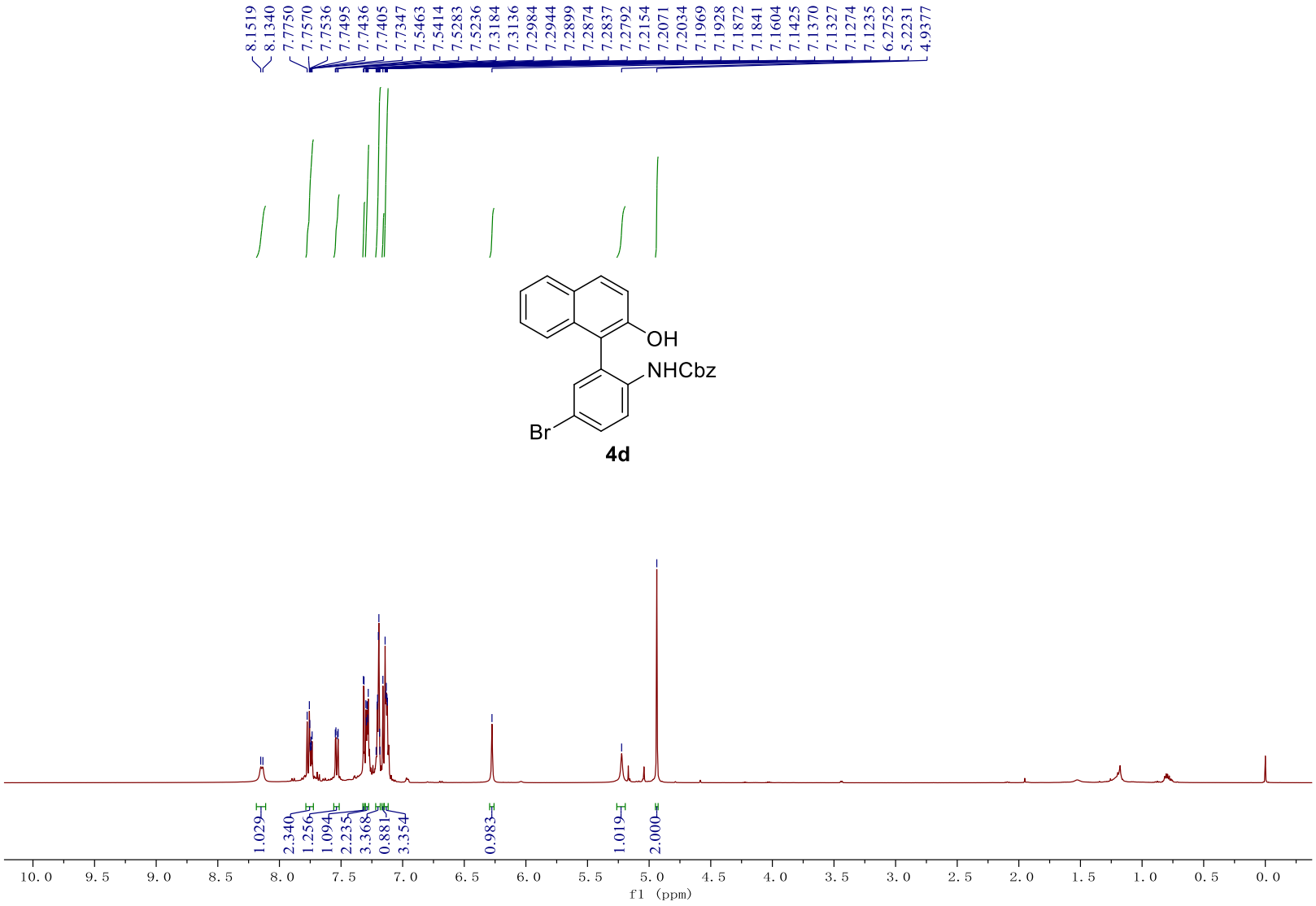
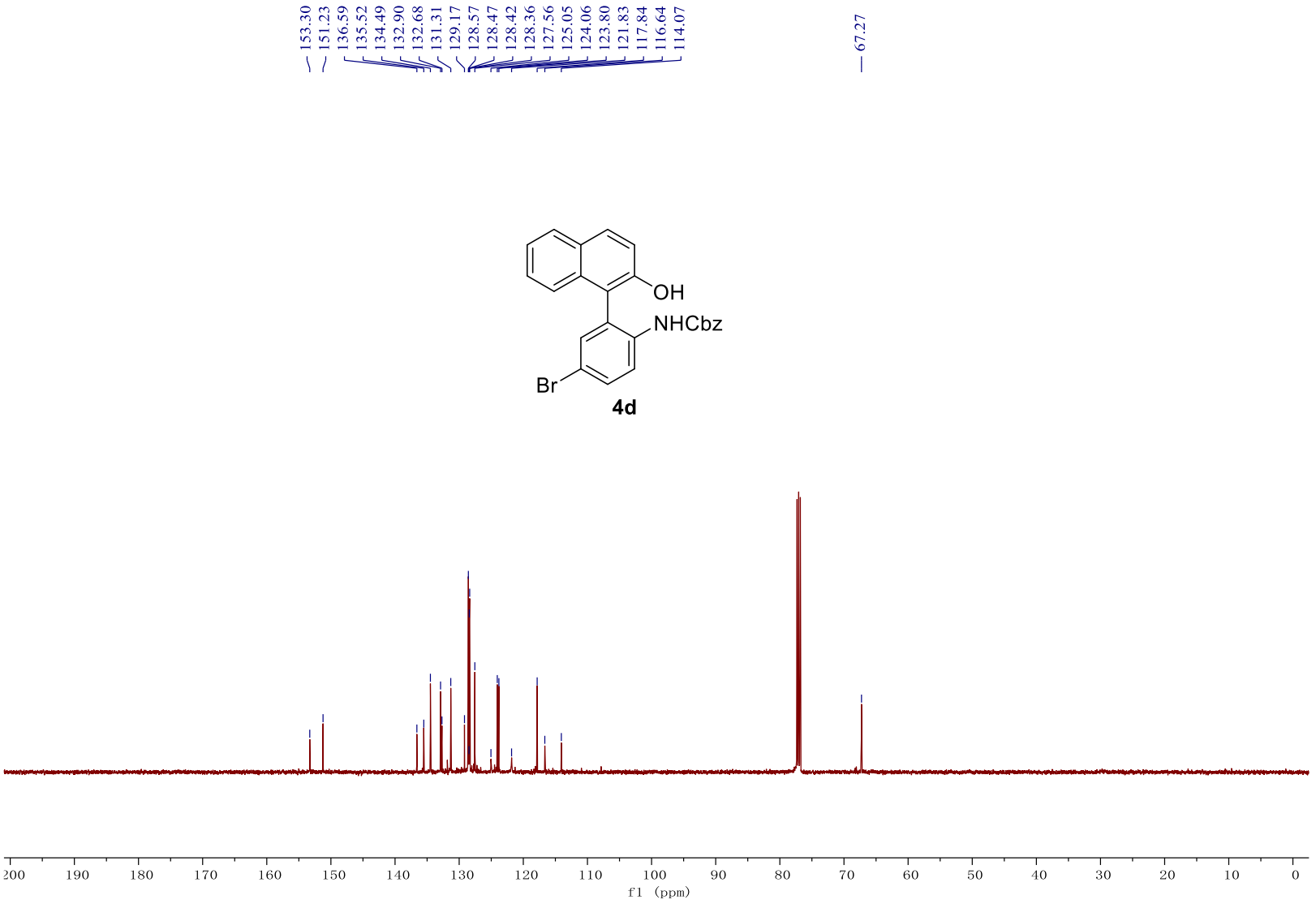
136.05
135.55
132.69
131.66
131.27
129.95
129.17
128.56
128.46
128.41
128.34
127.56
127.54
124.77
124.04
123.80
121.62
117.86
114.18
67.25
OH
NHCbz
Cl
4c
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.1519
8.1340
7.7750
7.7570
7.7536
7.7495
7.7436
7.7405
7.7347
7.5463
7.5414
7.5283
7.5236
7.3184
7.3136
7.2984
7.2944
7.2899
7.2874
7.2837
7.2792
7.2154
7.2071
7.2034
7.1969
7.1928
7.1872
7.1841
7.1604
7.1425
7.1370
7.1327
7.1274
7.1235
6.2752
5.2231
4.9377
OH
NHCbz
Br
4d
1.029
2.340
1.256
1.094
2.235
3.368
0.881
3.354
0.983
1.019
2.000
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
f1 (ppm)


153.30
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135.52
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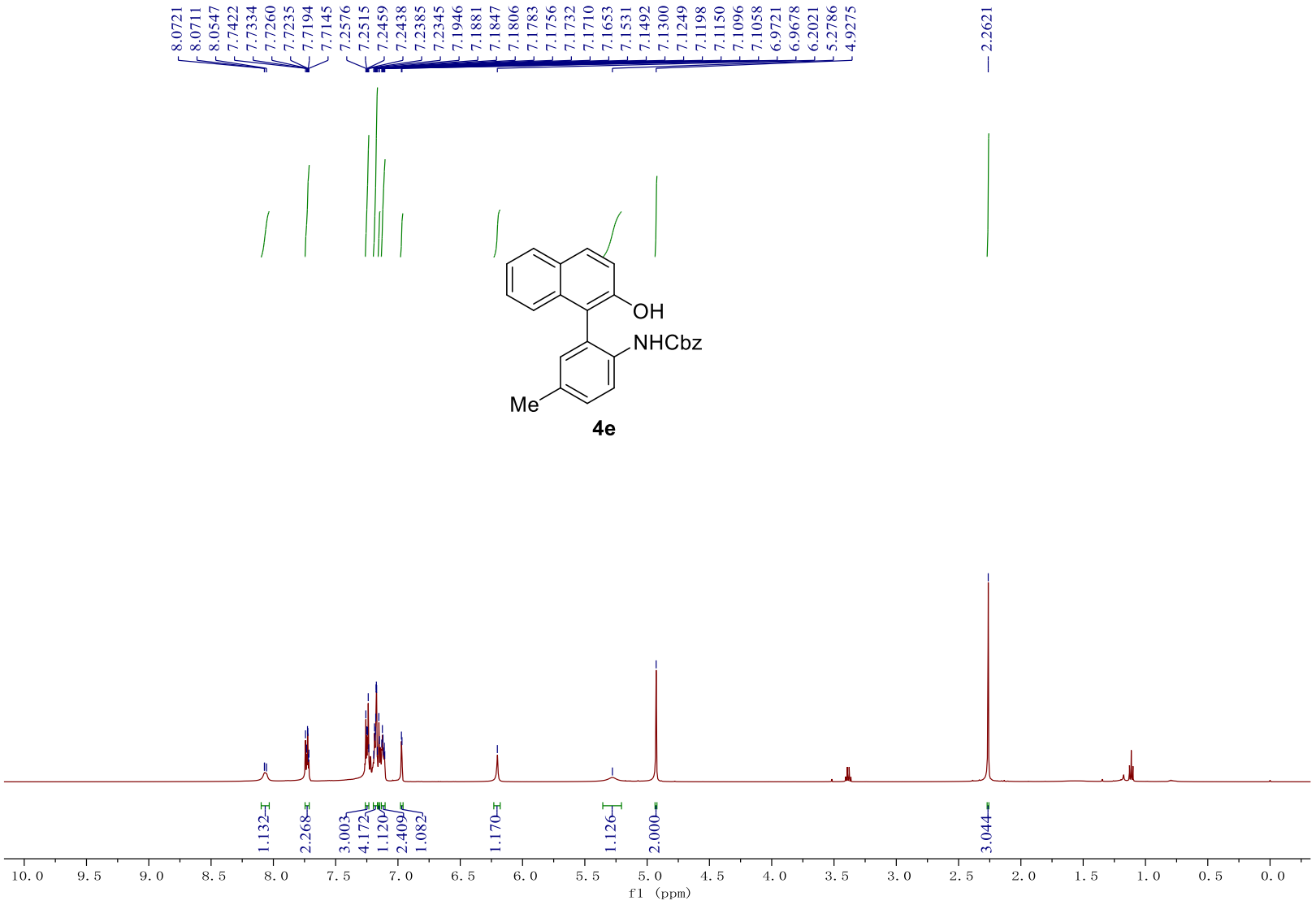
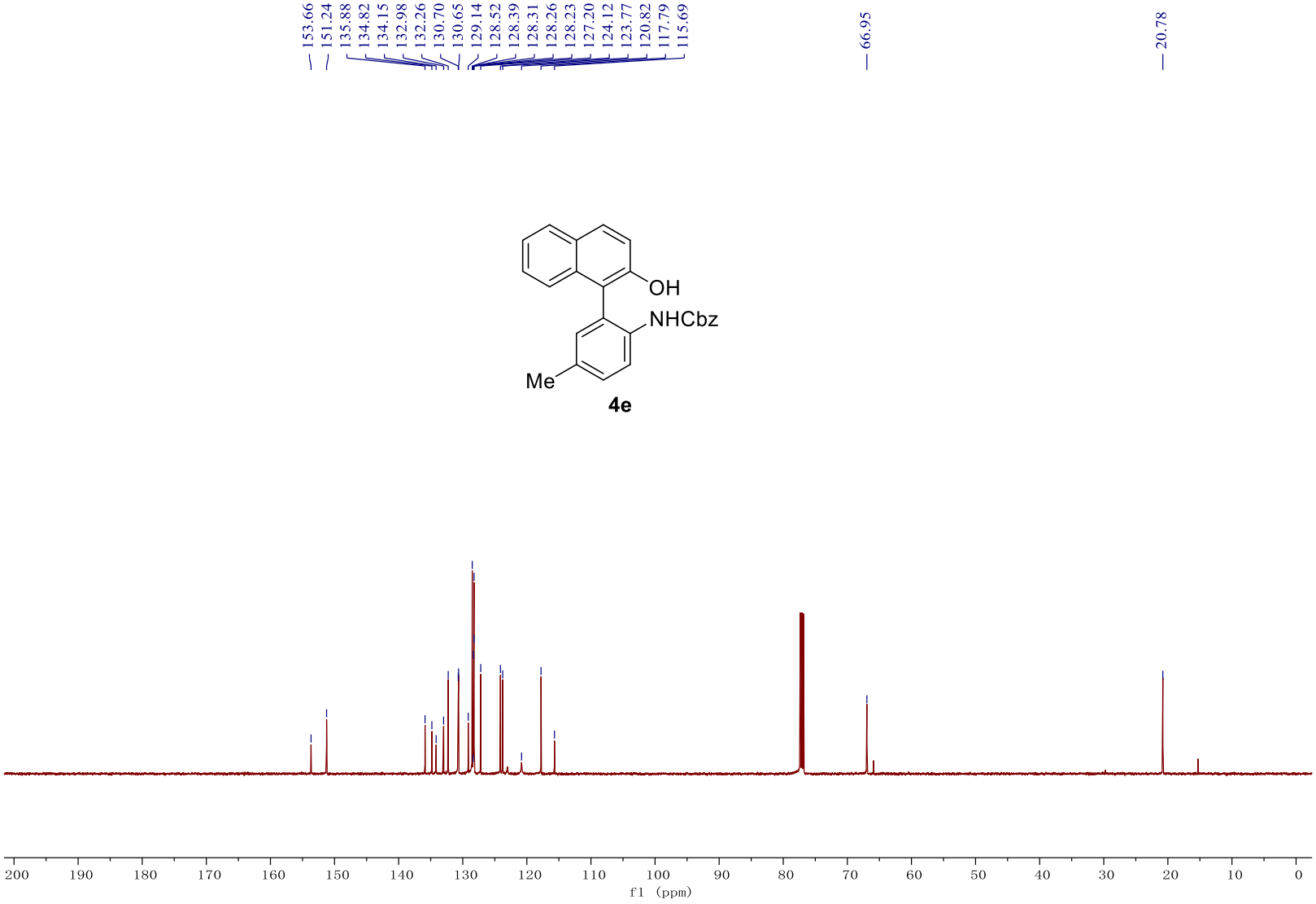
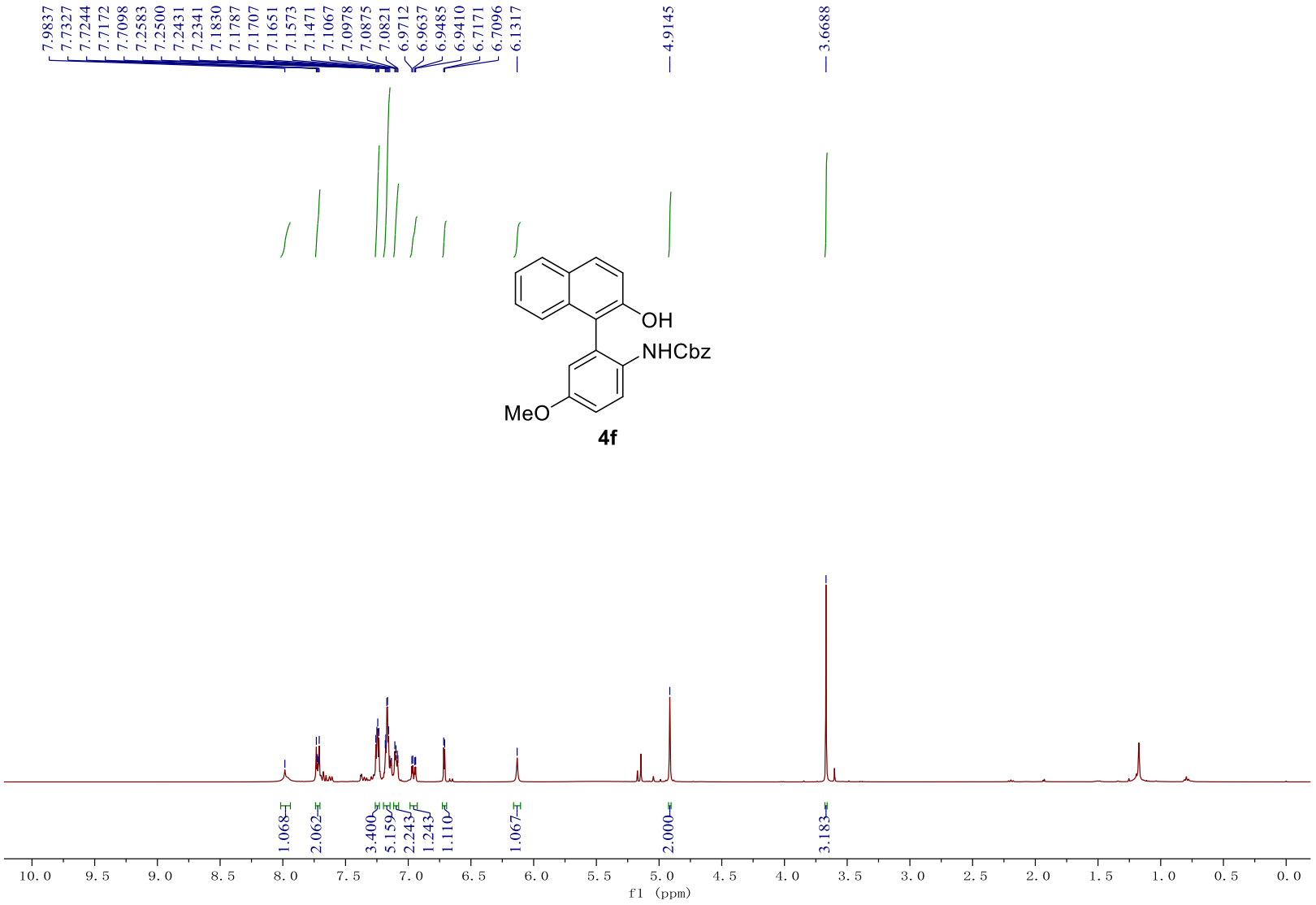
132.90
132.68
131.31
129.17
128.57
128.47
128.42
128.36
127.56
125.05
124.06
123.80
121.83
117.84
116.64
114.07
67.27
OH
NHCbz
Br
4d
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.0721
8.0711
8.0547
7.7422
7.7334
7.7260
7.7235
7.7194
7.7145
7.2576
7.2515
7.2459
7.2438
7.2385
7.2345
7.1946
7.1881
7.1847
7.1806
7.1783
7.1756
7.1732
7.1710
7.1653
7.1531
7.1492
7.1300
7.1249
7.1198
7.1150
7.1096
7.1058
6.9721
6.9678
6.2021
5.2786
4.9275
2.2621
OH
NHCbz
Me
4e
1.132
2.268
3.003
4.172
1.120
2.409
1.082
1.170
1.126
2.000
3.044
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
f1 (ppm)


153.66
151.24
135.88
134.82
134.15
132.98
132.26
130.70
130.65
129.14
128.52
128.39
128.31
128.26
128.23
127.20
124.12
123.77
120.82
117.79
115.69
66.95
20.78
OH
NHCbz
Me
4e
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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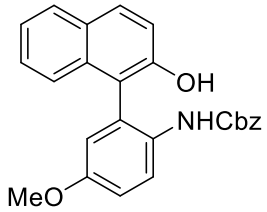
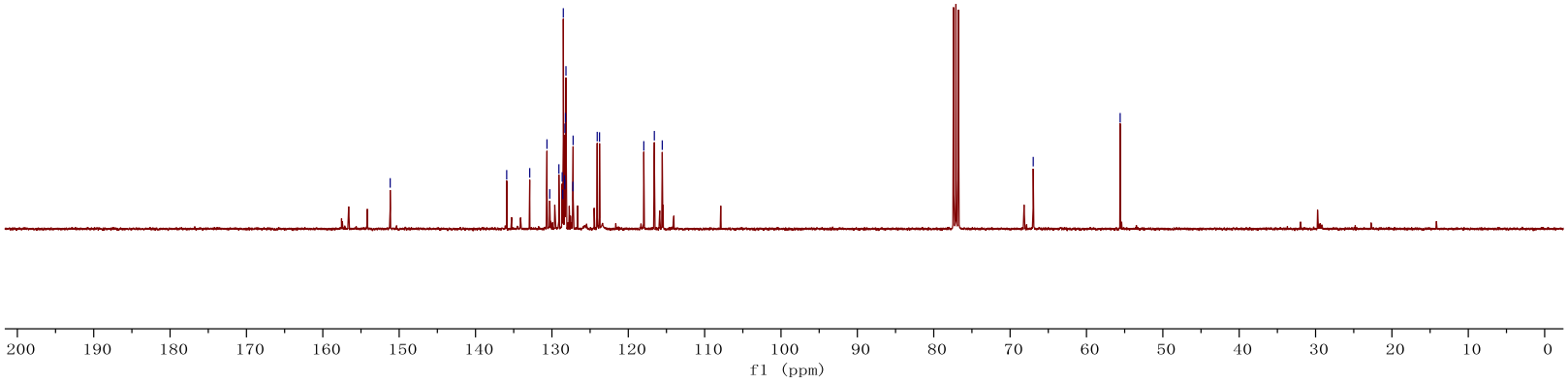
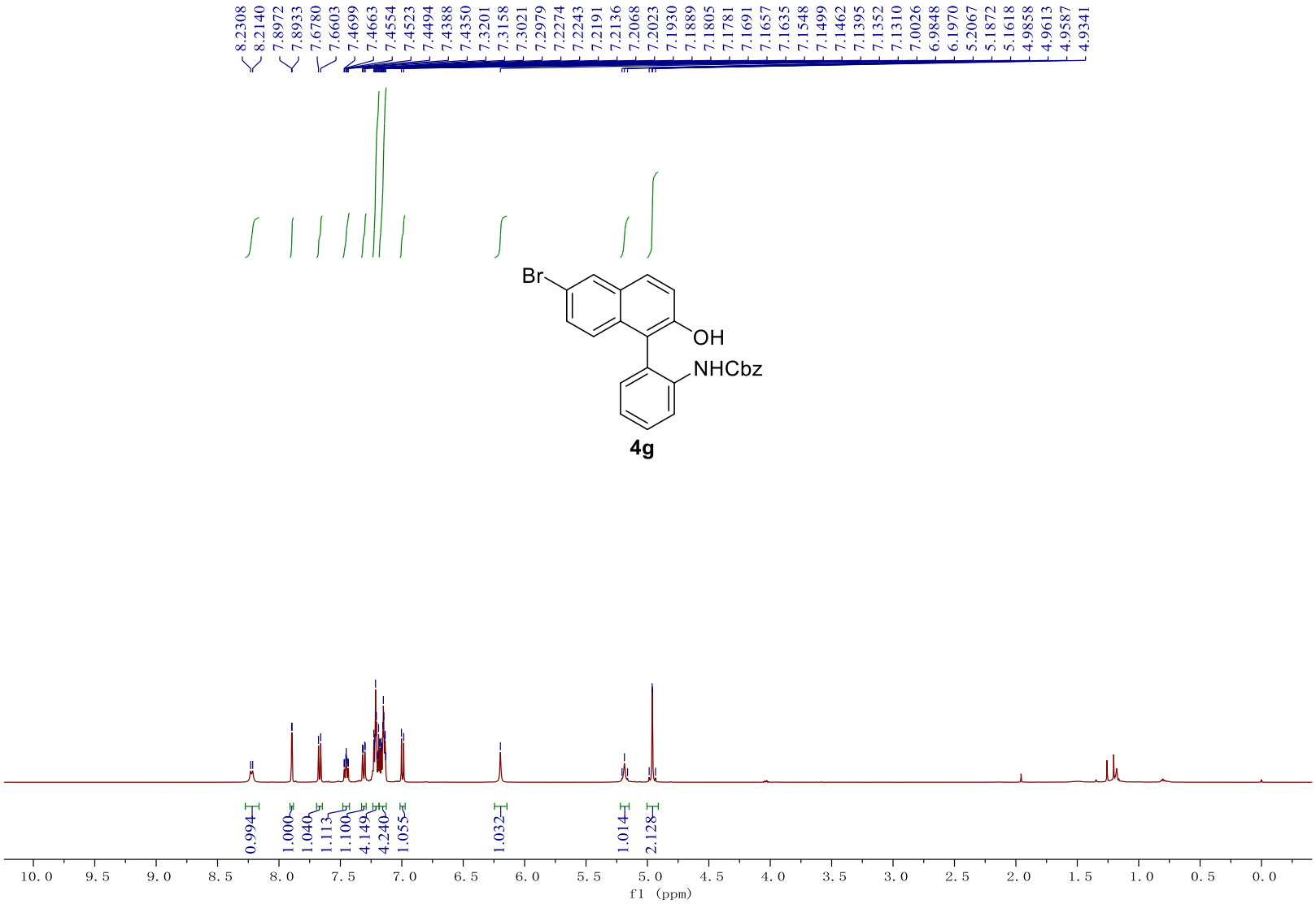
7.7327
7.7244
7.7172
7.7098
7.2583
7.2500
7.2431
7.2341
7.1830
7.1787
7.1707
7.1651
7.1573
7.1471
7.1067
7.0978
7.0875
7.0821
6.9712
6.9637
6.9485
6.9410
6.7171
6.7096
6.1317
4.9145
3.6688
OH
NHCbz
MeO
4f
1.068
2.062
3.400
5.159
2.243
1.243
1.110
1.067
2.000
3.183
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


151.17
135.92
132.91
130.65
130.28
129.09
128.65
128.58
128.51
128.35
128.32
128.30
128.22
128.16
127.24
127.22
124.07
123.76
117.97
116.59
115.55
66.97
55.59


OH
NHCbz
MeO

4f


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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8.2140
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7.6780
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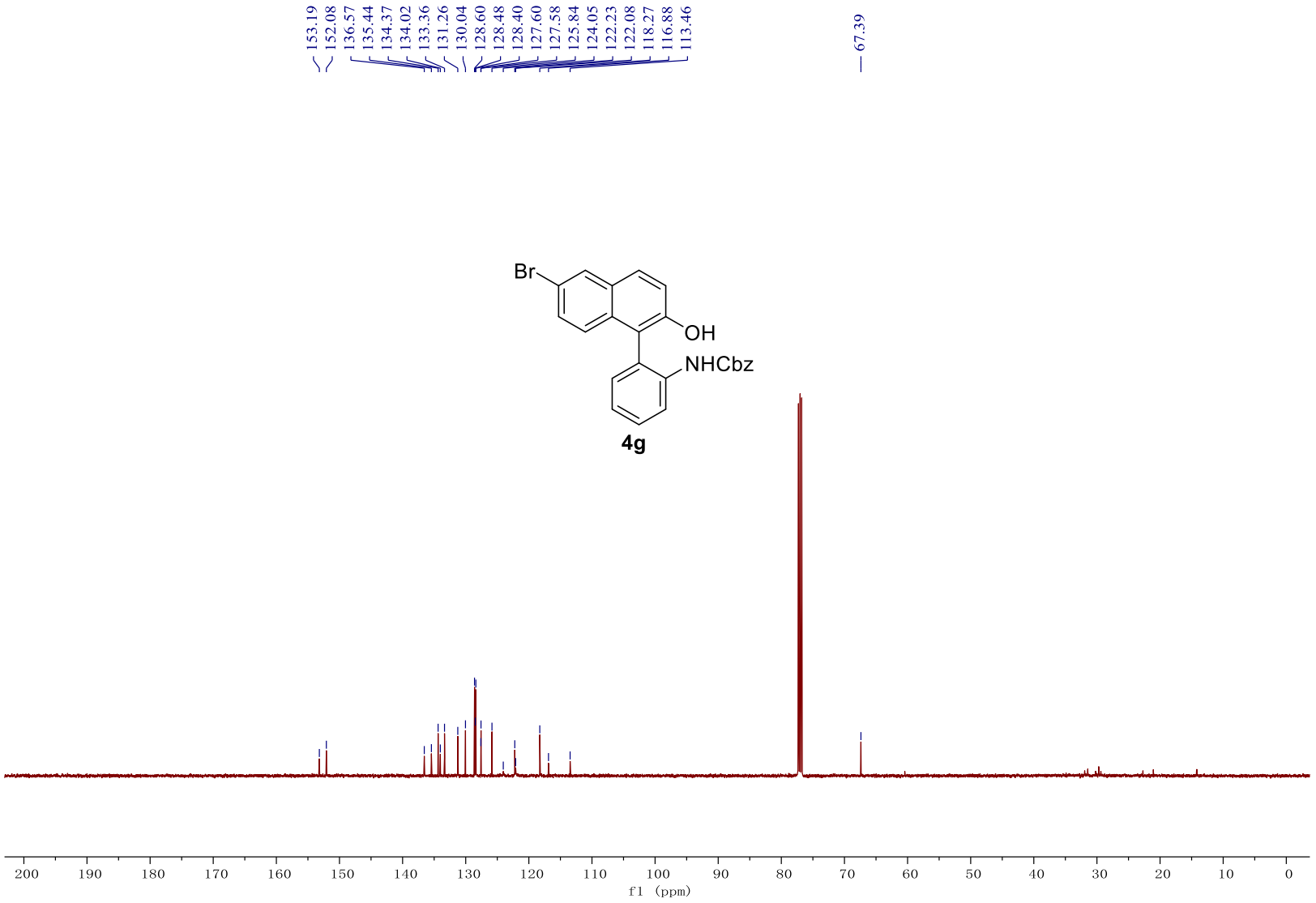
7.4699
7.4663
7.4554
7.4523
7.4494
7.4388
7.4350
7.3201
7.3158
7.3021
7.2979
7.2274
7.2243
7.2191
7.2136
7.2068
7.2023
7.1930
7.1889
7.1805
7.1781
7.1691
7.1657
7.1635
7.1548
7.1499
7.1462
7.1395
7.1352
7.1310
7.0026
6.9848
6.1970
5.2067
5.1872
5.1618
4.9858
4.9613
4.9587
4.9341
Br
OH
NHCbz
4g
0.994
1.000
1.040
1.113
1.100
4.149
4.240
1.055
1.032
1.014
2.128
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
f1 (ppm)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128.48
128.40
127.60
127.58
125.84
124.05
122.23
122.08
118.27
116.88
113.46
67.39
Br
OH
NHCbz
4g
200
190
180
170
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150
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130
120
110
100
90
80
70
60
50
40
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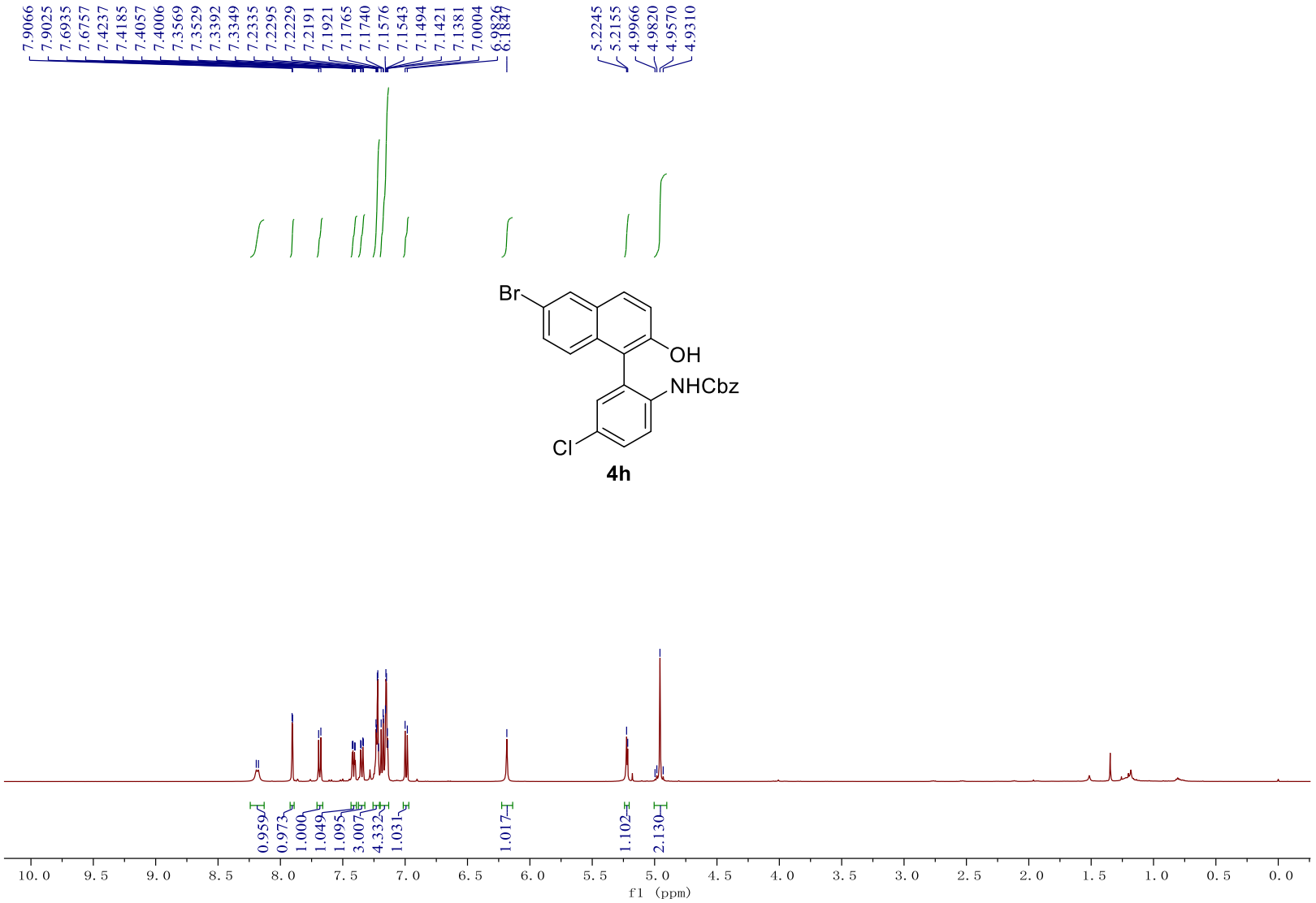
10
0
f1 (ppm)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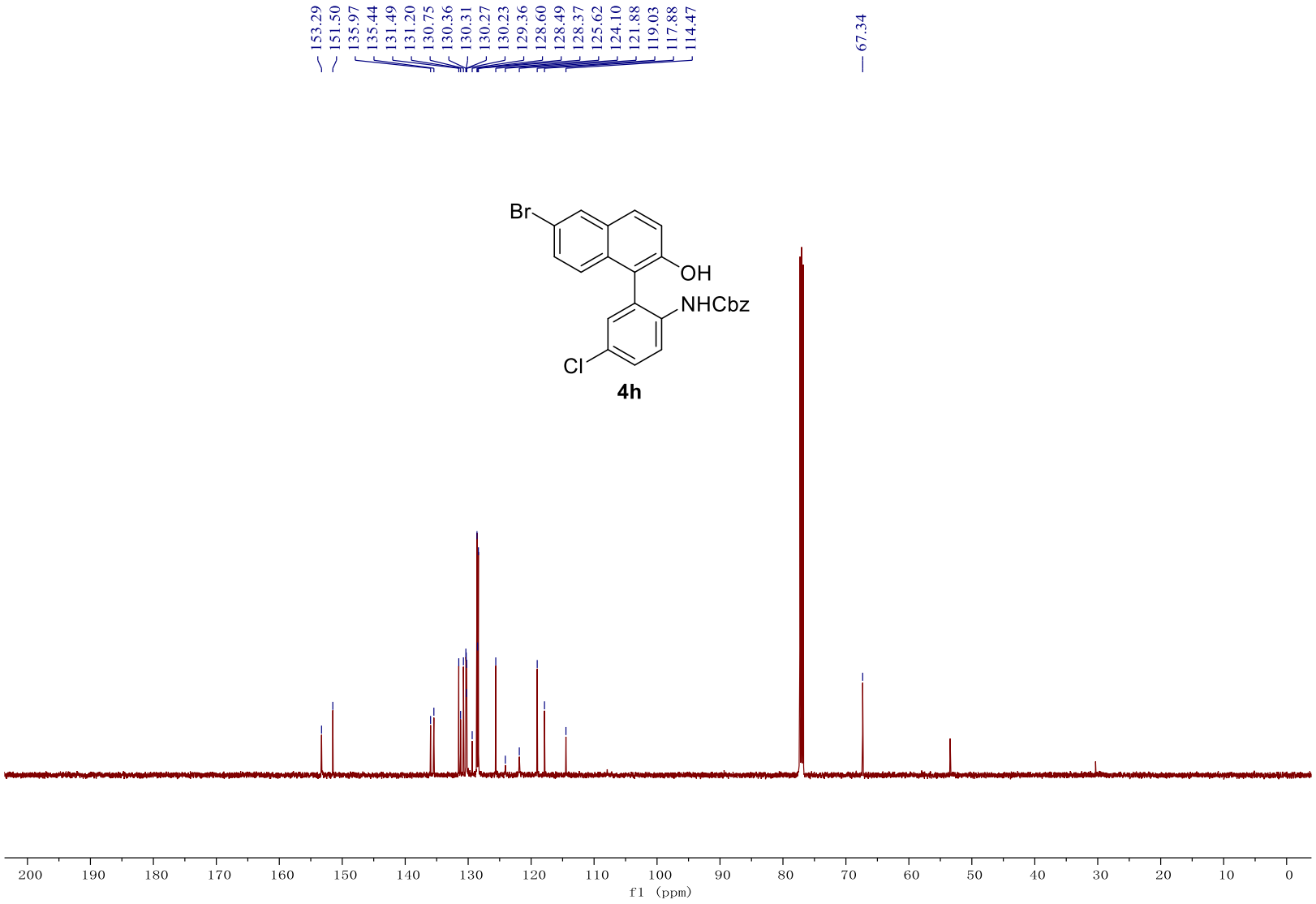
7.3349
7.2335
7.2295
7.2229
7.2191
7.1921
7.1765
7.1740
7.1576
7.1543
7.1494
7.1421
7.1381
7.0004
6.9826
6.9847
5.2245
5.2155
4.9966
4.9820
4.9570
4.9310
Br
OH
NHCbz
Cl
4h
0.959
0.973
1.000
1.049
1.095
3.007
4.332
1.031
1.017
1.102
2.130
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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128.49
128.37
125.62
124.10
121.88
119.03
117.88
114.47
67.34
Br
OH
NHCbz
Cl
4h
200
190
180
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140
130
120
110
100
90
80
70
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50
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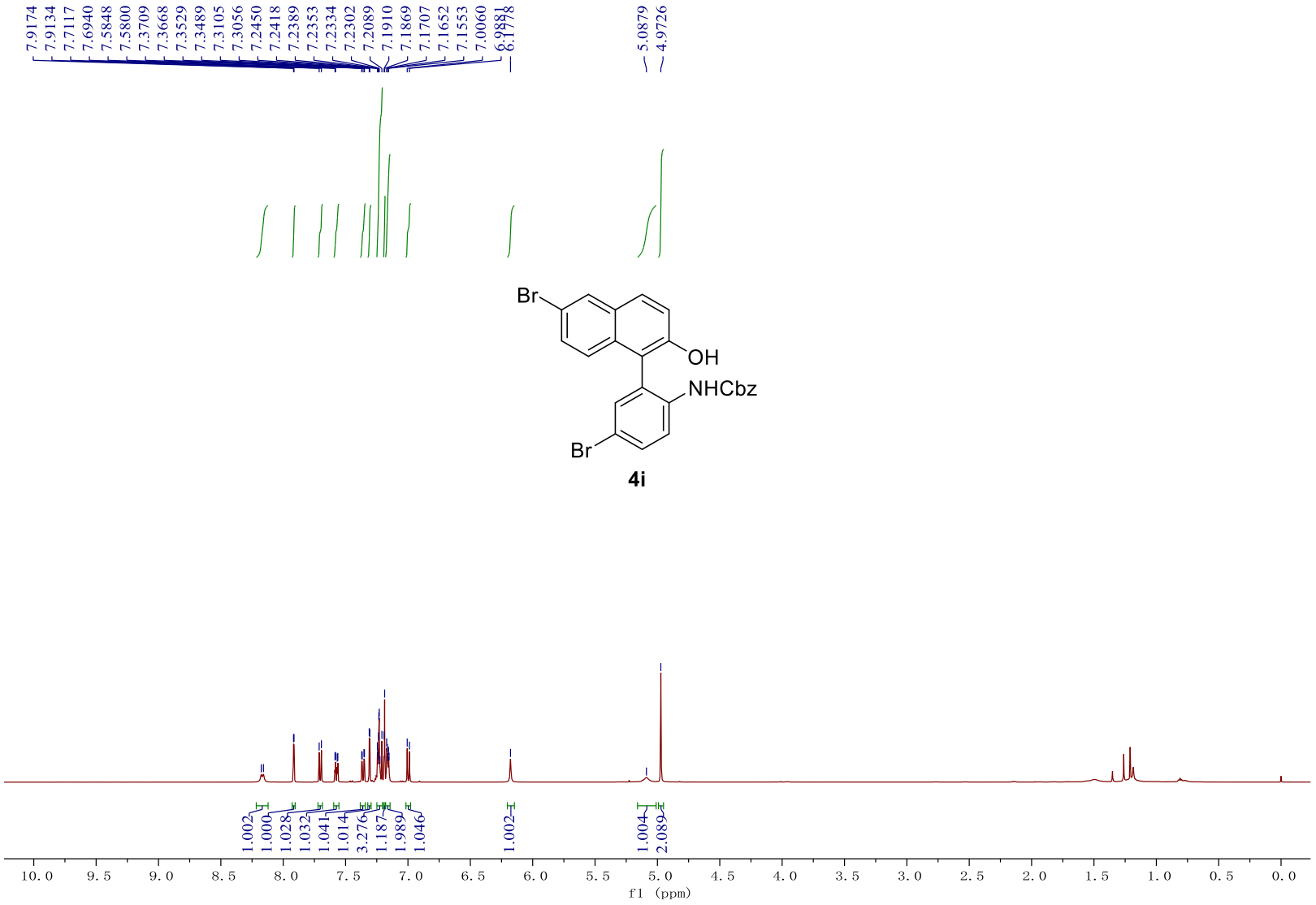
10
0
f1 (ppm)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7.3105
7.3056
7.2450
7.2418
7.2389
7.2353
7.2334
7.2302
7.2089
7.1910
7.1869
7.1707
7.1652
7.1553
7.0060
6.9881
6.9778
5.0879
4.9726
Br
OH
NHCbz
Br
4i
1.002
1.000
1.028
1.032
1.041
1.014
3.276
1.187
1.989
1.046
1.002
1.004
2.089
10.0
9.5
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
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1.0
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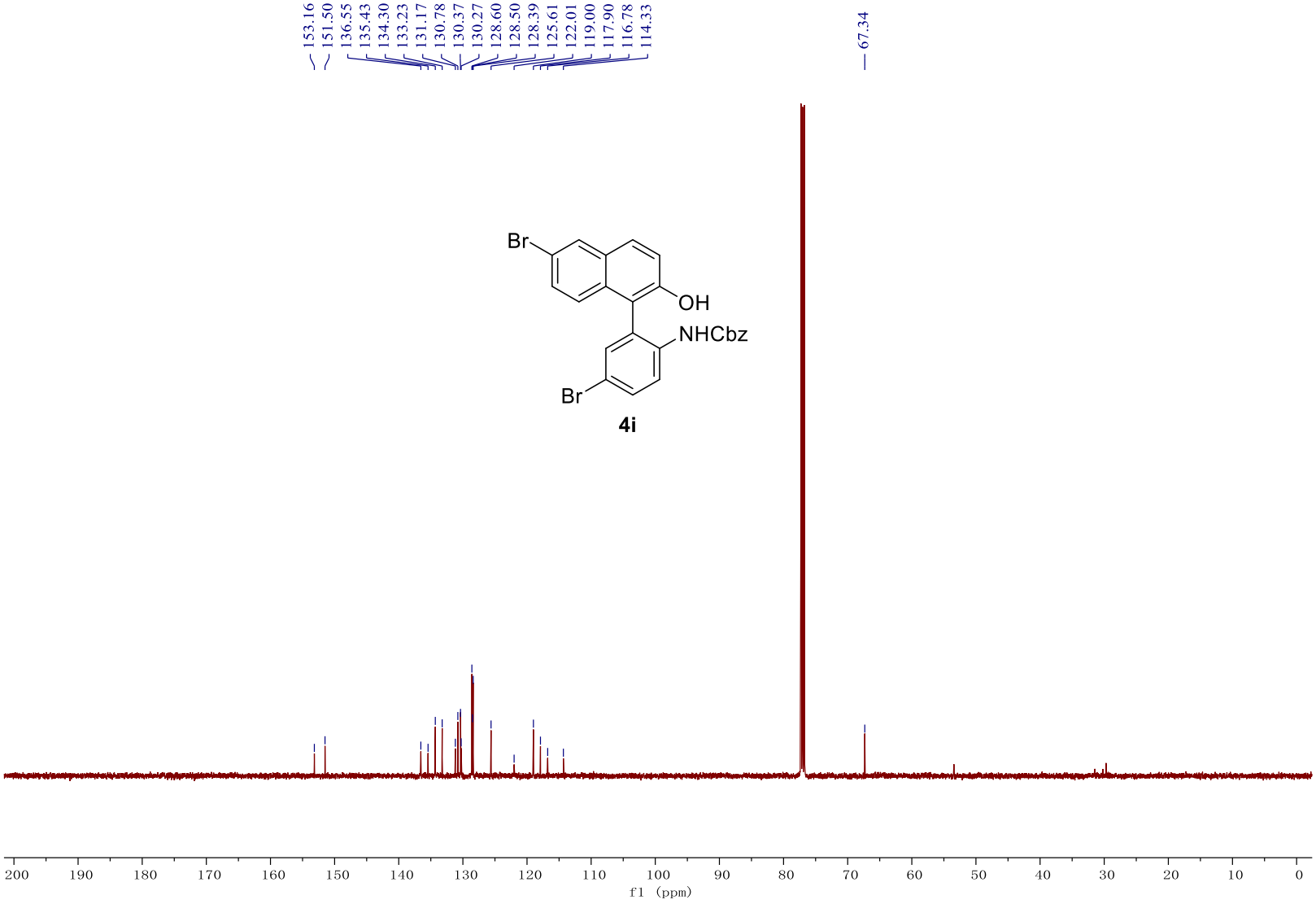
0.0
f1 (ppm)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130.27
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128.50
128.39
125.61
122.01
119.00
117.90
116.78
114.33
67.34
Br
OH
NHCbz
Br
4i
200
190
180
170
160
150
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130
120
110
100
90
80
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50
40
30
20
10
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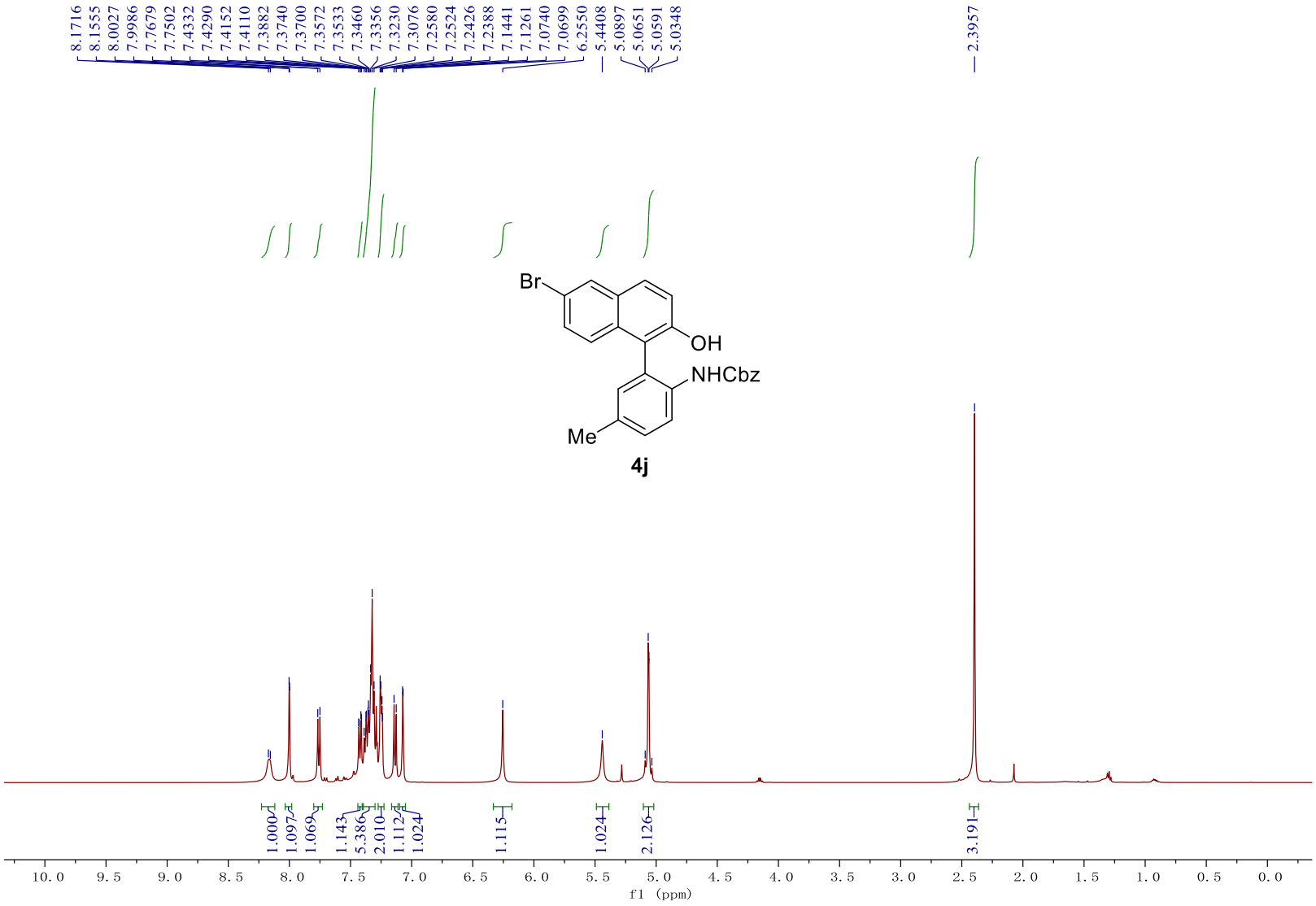
f1 (ppm)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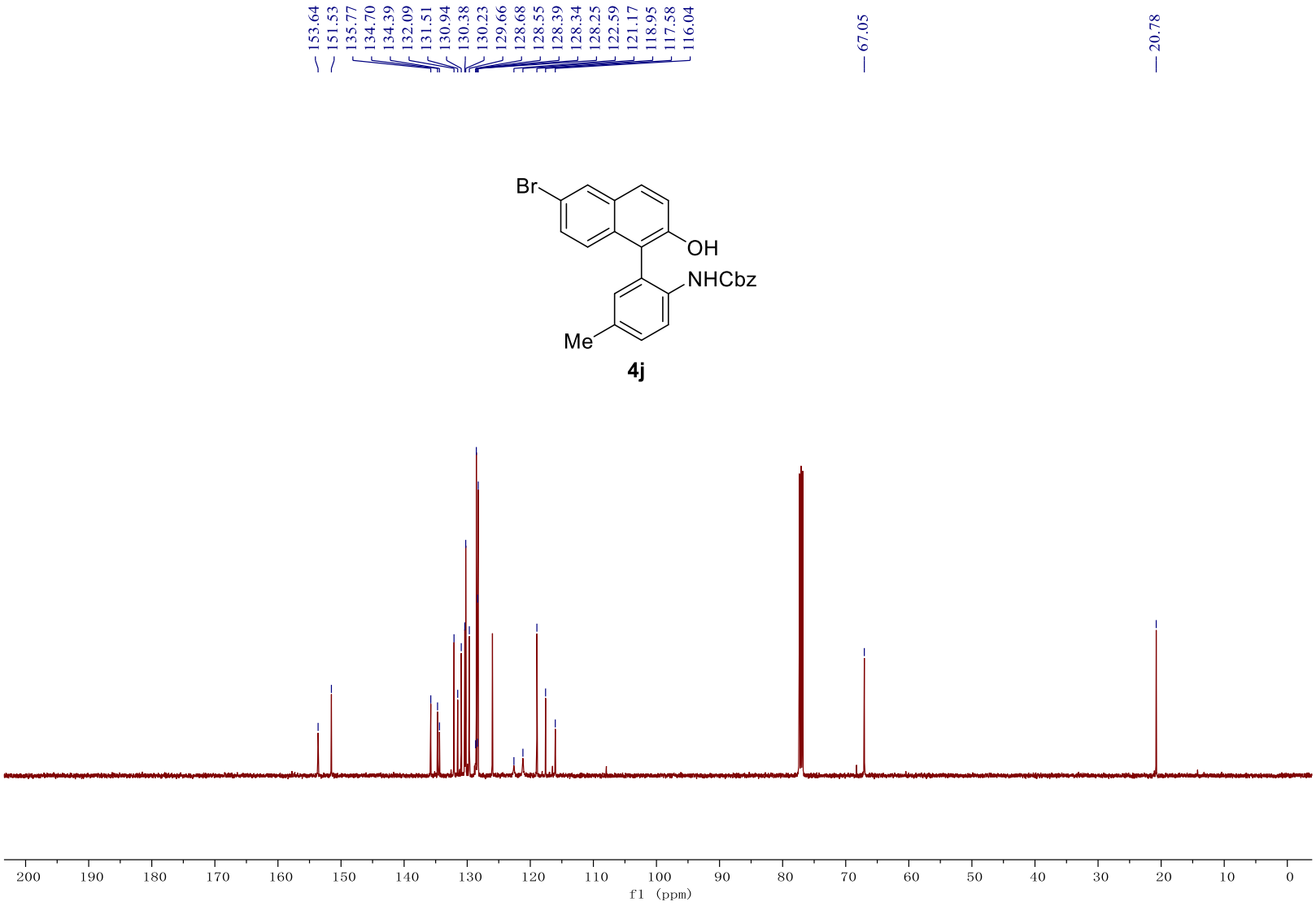
7.4110
7.3882
7.3740
7.3700
7.3572
7.3533
7.3460
7.3356
7.3230
7.3076
7.2580
7.2524
7.2426
7.2388
7.1441
7.1261
7.0740
7.0699
6.2550
5.4408
5.0897
5.0651
5.0591
5.0348
2.3957
Br
OH
NHCbz
Me
4j
1.000
1.097
1.069
1.143
5.386
2.010
1.112
1.024
1.115
1.024
2.126
3.191
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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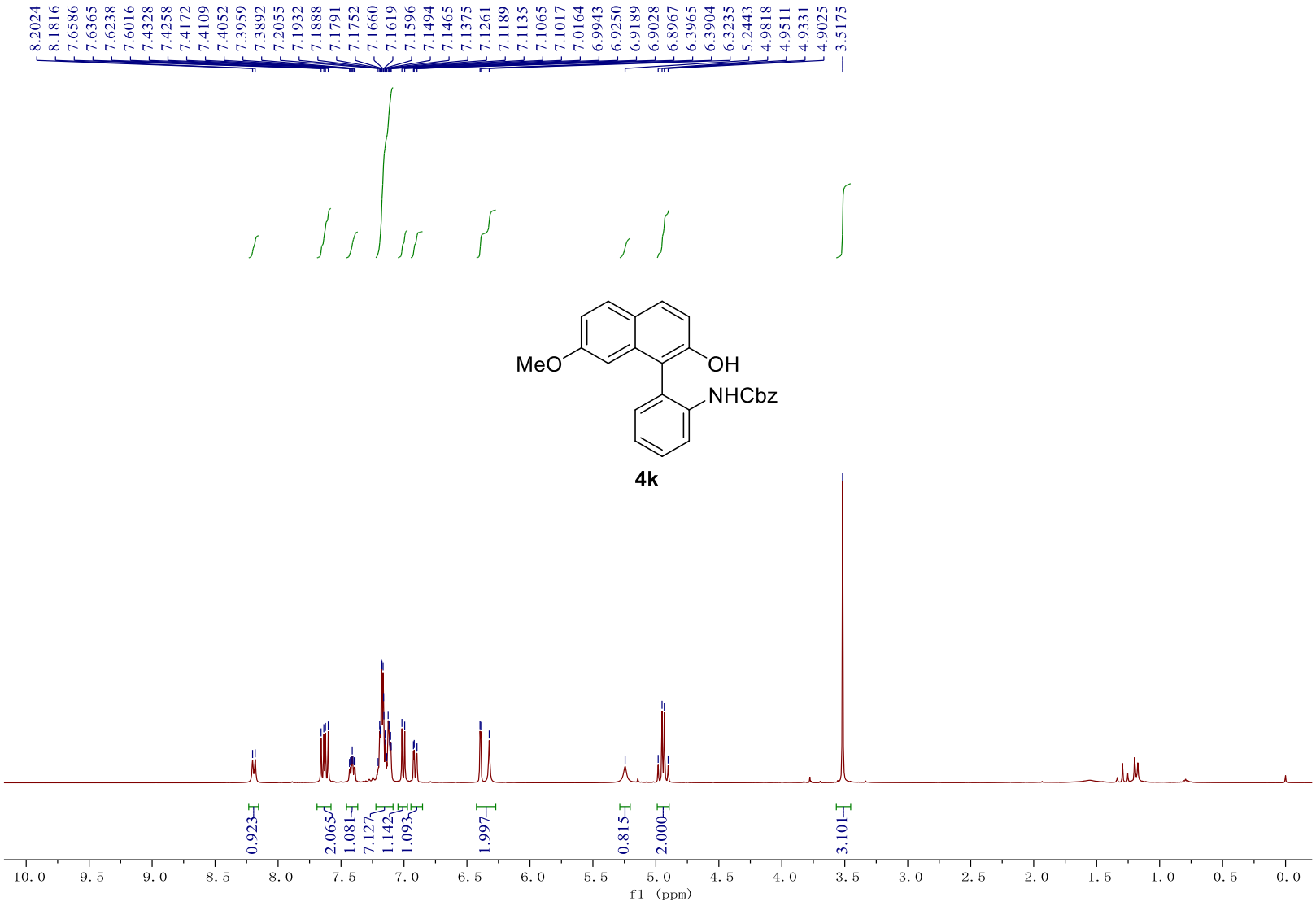
130.94
130.38
130.23
129.66
128.68
128.55
128.39
128.34
128.25
122.59
121.17
118.95
117.58
116.04
67.05
20.78
Br
OH
NHCbz
Me
4j
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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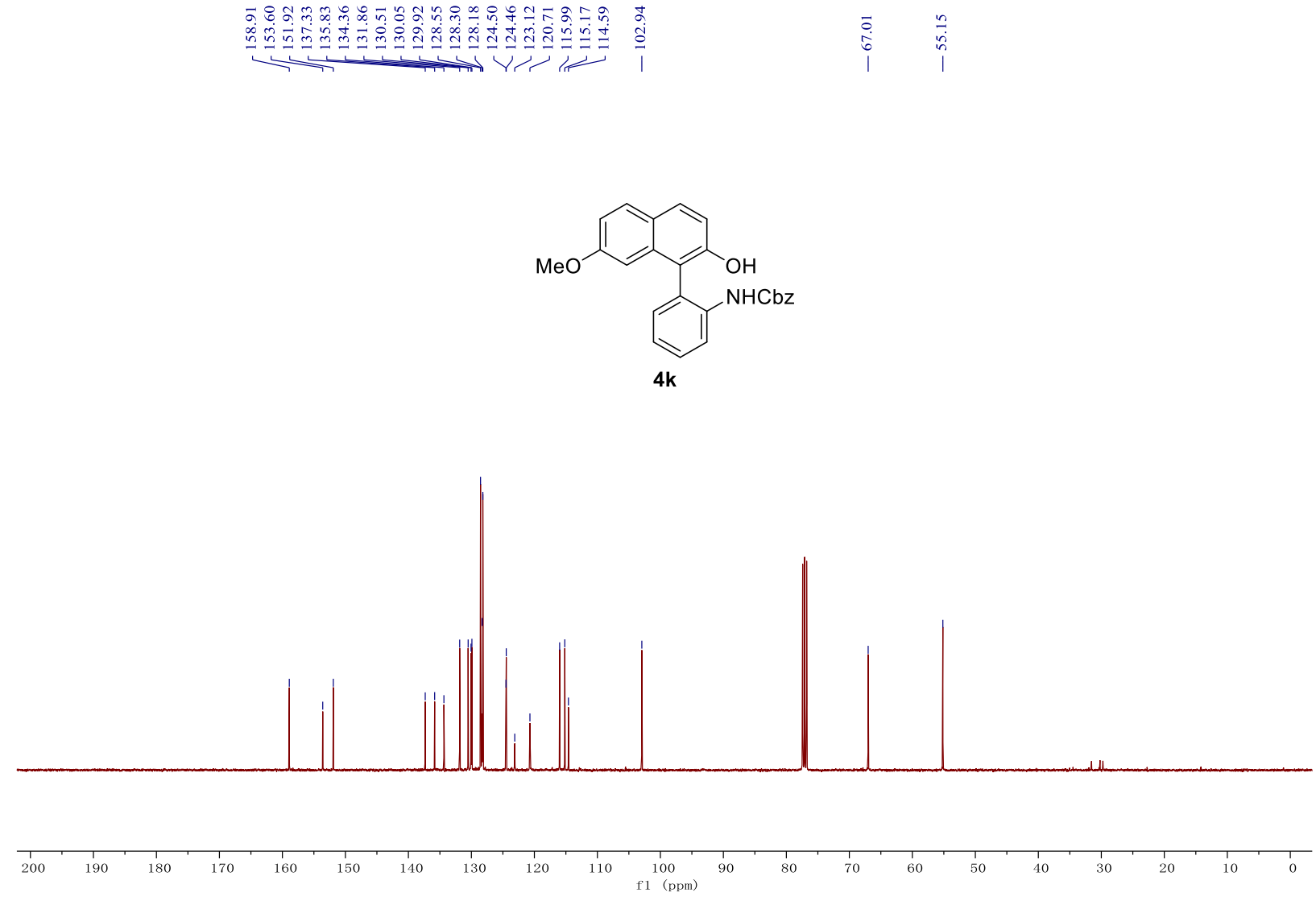
7.3959
7.3892
7.2055
7.1932
7.1888
7.1791
7.1752
7.1660
7.1619
7.1596
7.1494
7.1465
7.1375
7.1261
7.1189
7.1135
7.1065
7.1017
7.0164
6.9943
6.9250
6.9189
6.9028
6.8967
6.3965
6.3904
6.3235
5.2443
4.9818
4.9511
4.9331
4.9025
3.5175
MeO
OH
NHCbz
4k
0.923
2.065
1.081
7.127
1.142
1.093
1.997
0.815
2.000
3.101
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
f1 (ppm)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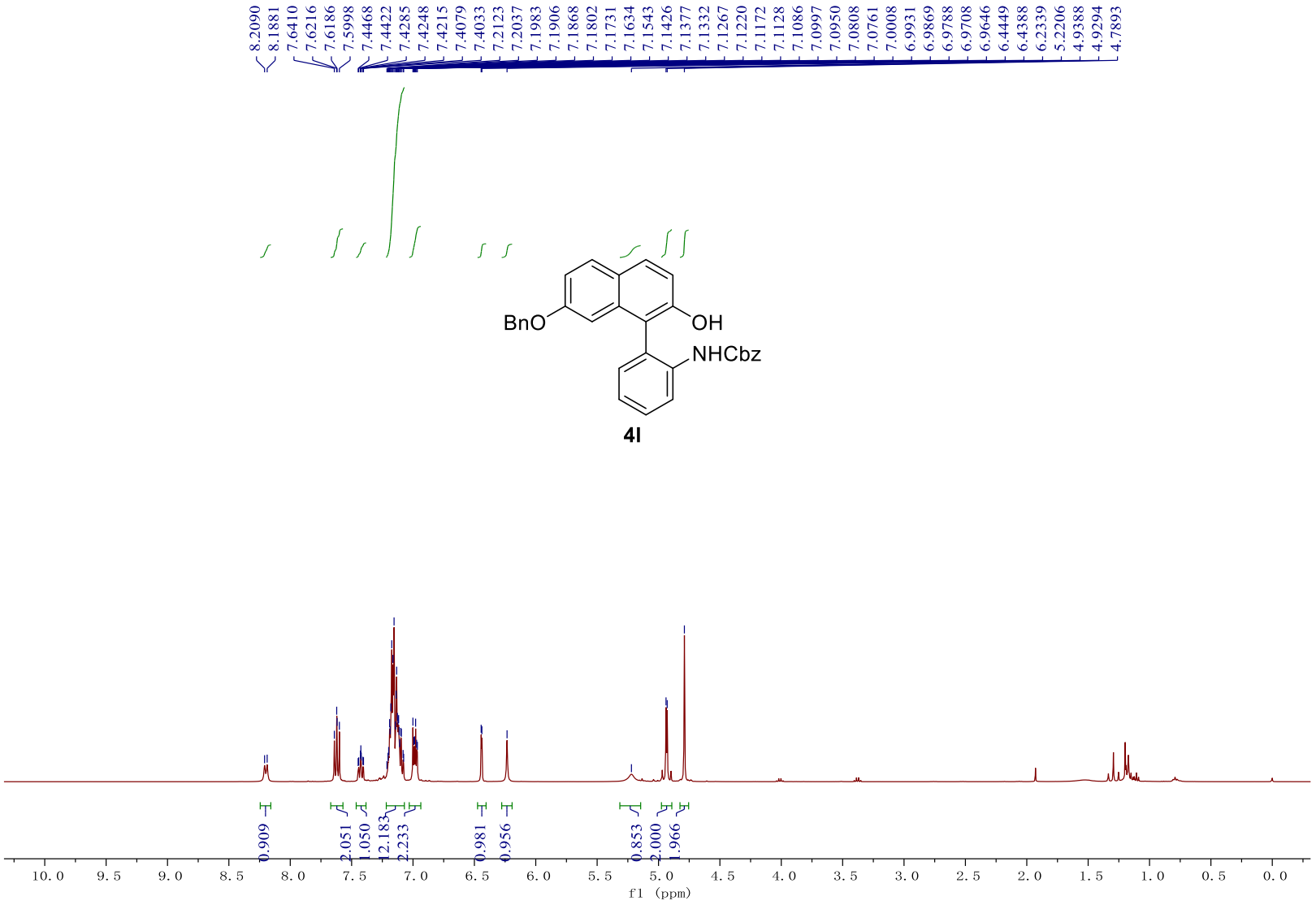
134.36
131.86
130.51
130.05
129.92
128.55
128.30
128.18
124.50
124.46
123.12
120.71
115.99
115.17
114.59
102.94
67.01
55.15
MeO
OH
NHCbz
4k
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.4079
7.4033
7.2123
7.2037
7.1983
7.1906
7.1868
7.1802
7.1731
7.1634
7.1543
7.1426
7.1377
7.1332
7.1267
7.1220
7.1172
7.1128
7.1086
7.0997
7.0950
7.0808
7.0761
7.0008
6.9931
6.9869
6.9788
6.9708
6.9646
6.4449
6.4388
6.2339
5.2206
4.9388
4.9294
4.7893
BnO
OH
NHCbz
4l
0.909
2.051
1.050
2.183
2.233
0.981
0.956
0.853
2.000
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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
f1 (ppm)


157.84
153.55
151.88
137.35
136.66
135.83
134.30
131.92
130.46
130.01
129.95
128.57
128.55
128.33
128.25
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124.49
123.12
120.68
116.48
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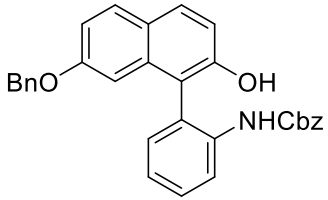
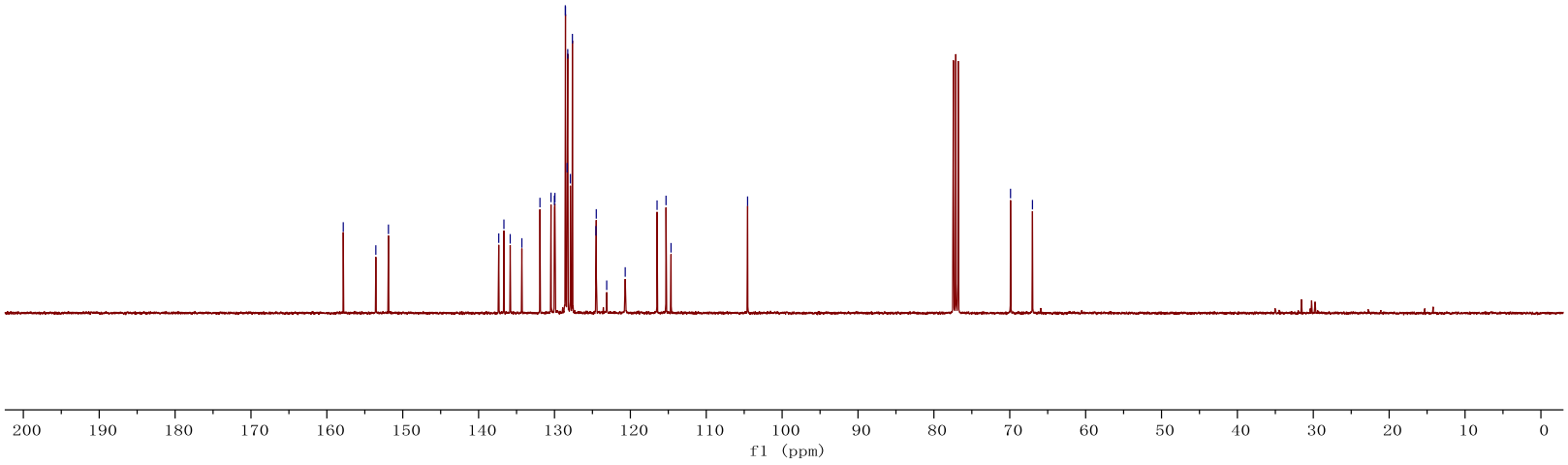
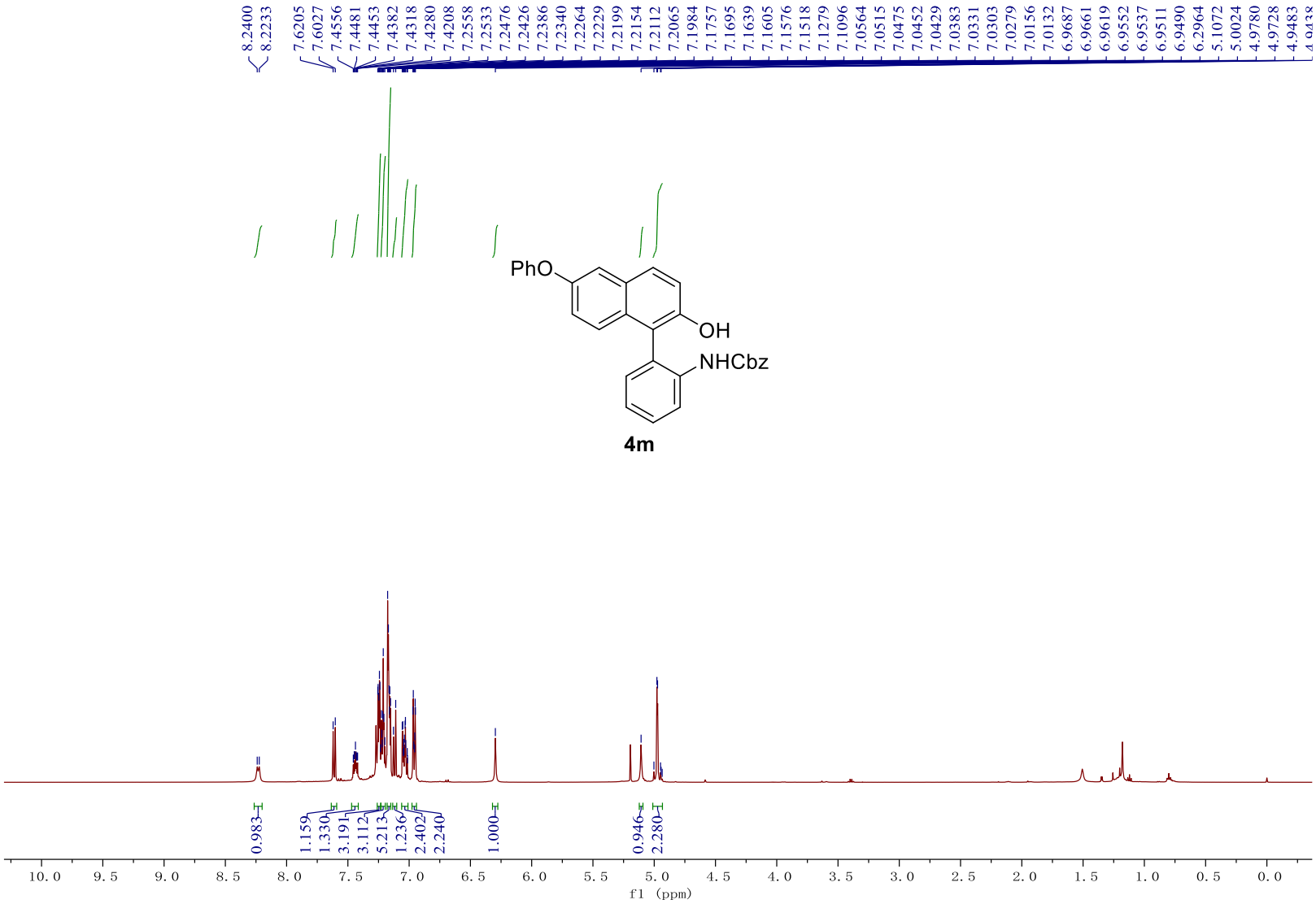
114.64
104.55
69.90
67.01


BnO
OH
NHCbz

4l


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.4208
7.2558
7.2533
7.2476
7.2426
7.2386
7.2340
7.2264
7.2229
7.2199
7.2154
7.2112
7.2065
7.1984
7.1757
7.1695
7.1639
7.1605
7.1576
7.1518
7.1279
7.1096
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7.0515
7.0475
7.0452
7.0429
7.0383
7.0331
7.0303
7.0279
7.0156
7.0132
6.9687
6.9661
6.9619
6.9552
6.9537
6.9511
6.9490
6.2964
5.1072
5.0024
4.9780
4.9728
4.9483
PhO
OH
NHCbz
4m
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3.191
3.112
5.213
1.236
2.402
2.240
1.000
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2.280
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9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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4.5
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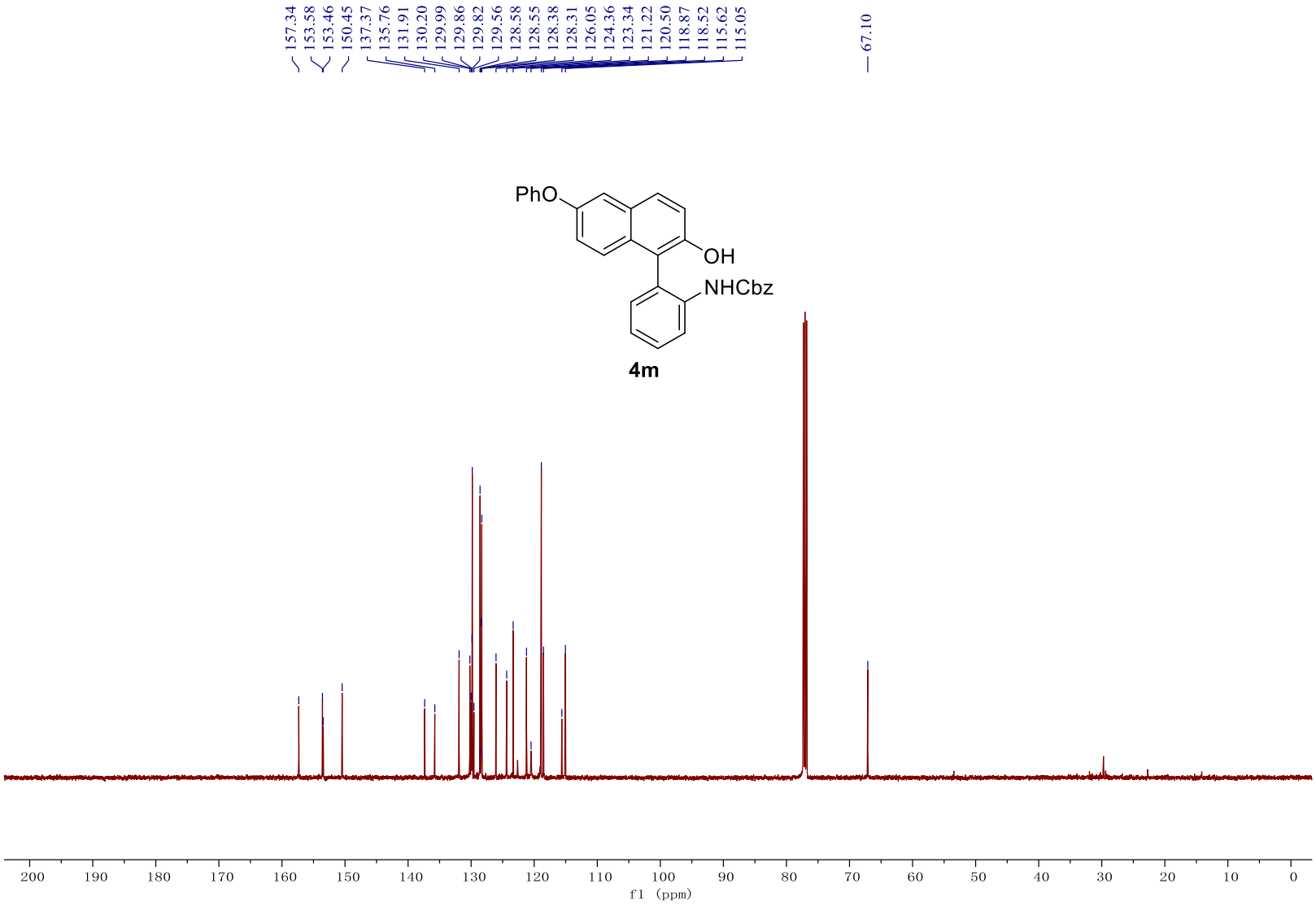
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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129.82
129.56
128.58
128.55
128.38
128.31
126.05
124.36
123.34
121.22
120.50
118.87
118.52
115.62
115.05
67.10
PhO
OH
NHCbz
4m
200
190
180
170
160
150
140
130
120
110
100
90
80
70
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50
40
30
20
10
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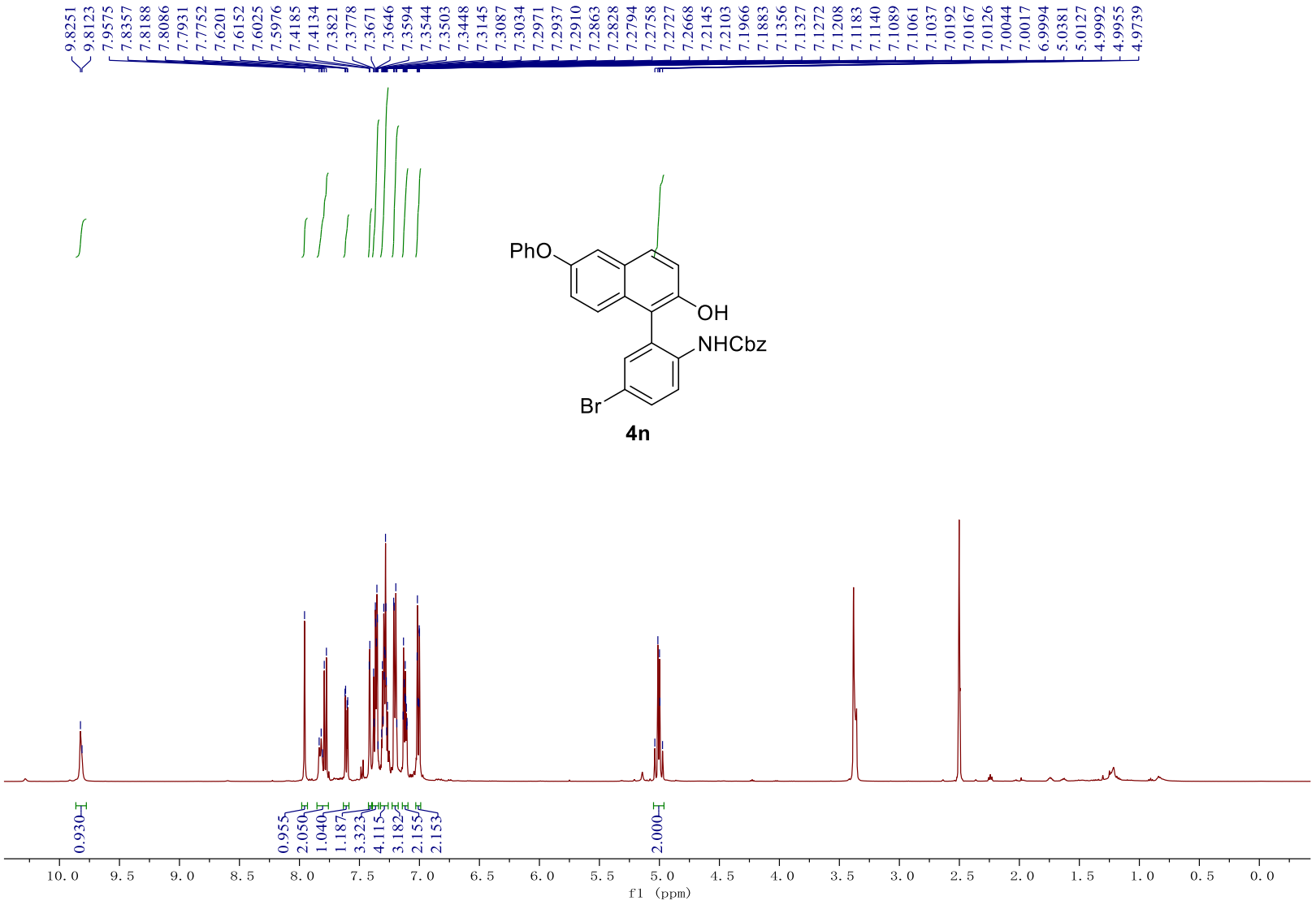
f1 (ppm)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7.4134
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7.3778
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7.3646
7.3594
7.3544
7.3503
7.3448
7.3145
7.3087
7.3034
7.2971
7.2937
7.2910
7.2863
7.2828
7.2794
7.2758
7.2727
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7.2145
7.2103
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7.1883
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7.1327
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7.1208
7.1183
7.1140
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7.1061
7.1037
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7.0167
7.0126
7.0044
7.0017
6.9994
5.0381
5.0127
4.9992
4.9955
4.9739
PhO
OH
NHCbz
Br
4n
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0.955
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1.040
1.187
3.323
4.115
3.182
2.155
2.153
2.000
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9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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3.5
3.0
2.5
2.0
1.5
1.0
0.5
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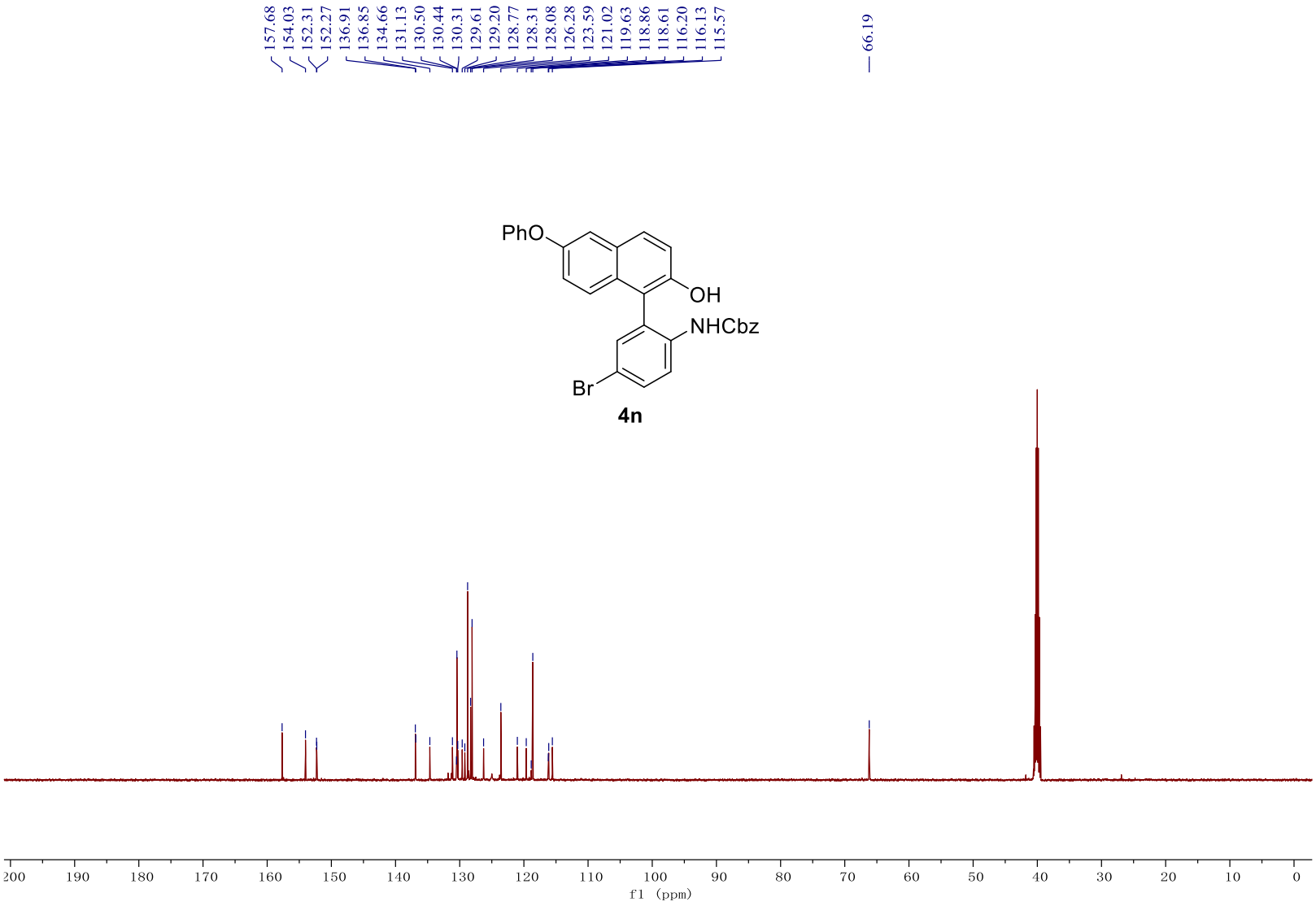
f1 (ppm)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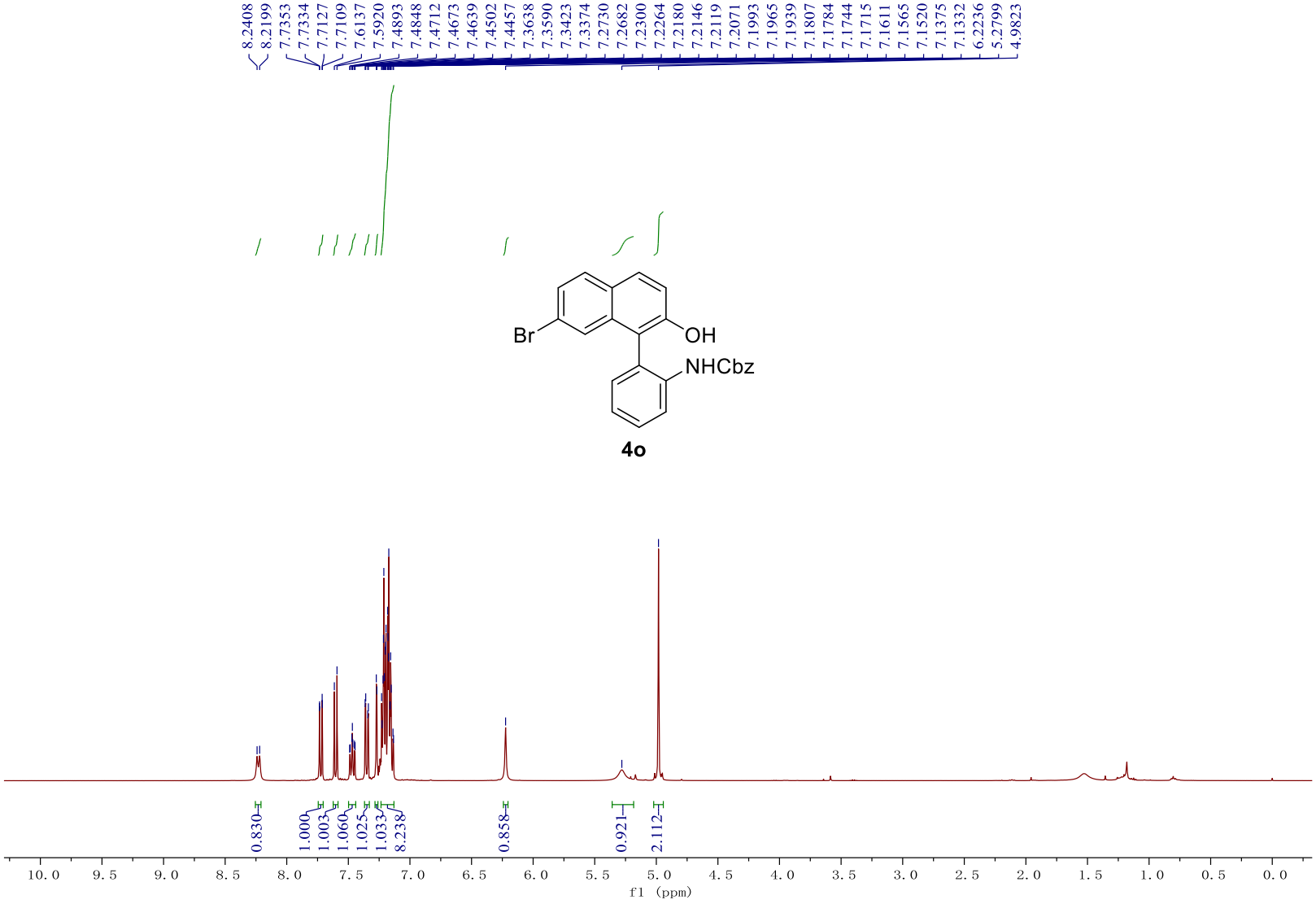
130.31
129.61
129.20
128.77
128.31
128.08
126.28
123.59
121.02
119.63
118.86
118.61
116.20
116.13
115.57
66.19
PhO
OH
NHCbz
Br
4n
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.4673
7.4639
7.4502
7.4457
7.3638
7.3590
7.3423
7.3374
7.2730
7.2682
7.2300
7.2264
7.2180
7.2146
7.2119
7.2071
7.1993
7.1965
7.1939
7.1807
7.1784
7.1744
7.1715
7.1611
7.1565
7.1520
7.1375
7.1332
6.2236
5.2799
4.9823
Br
OH
NHCbz
4o
0.830
1.000
1.003
1.060
1.025
1.033
8.238
0.858
0.921
2.112
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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4.5
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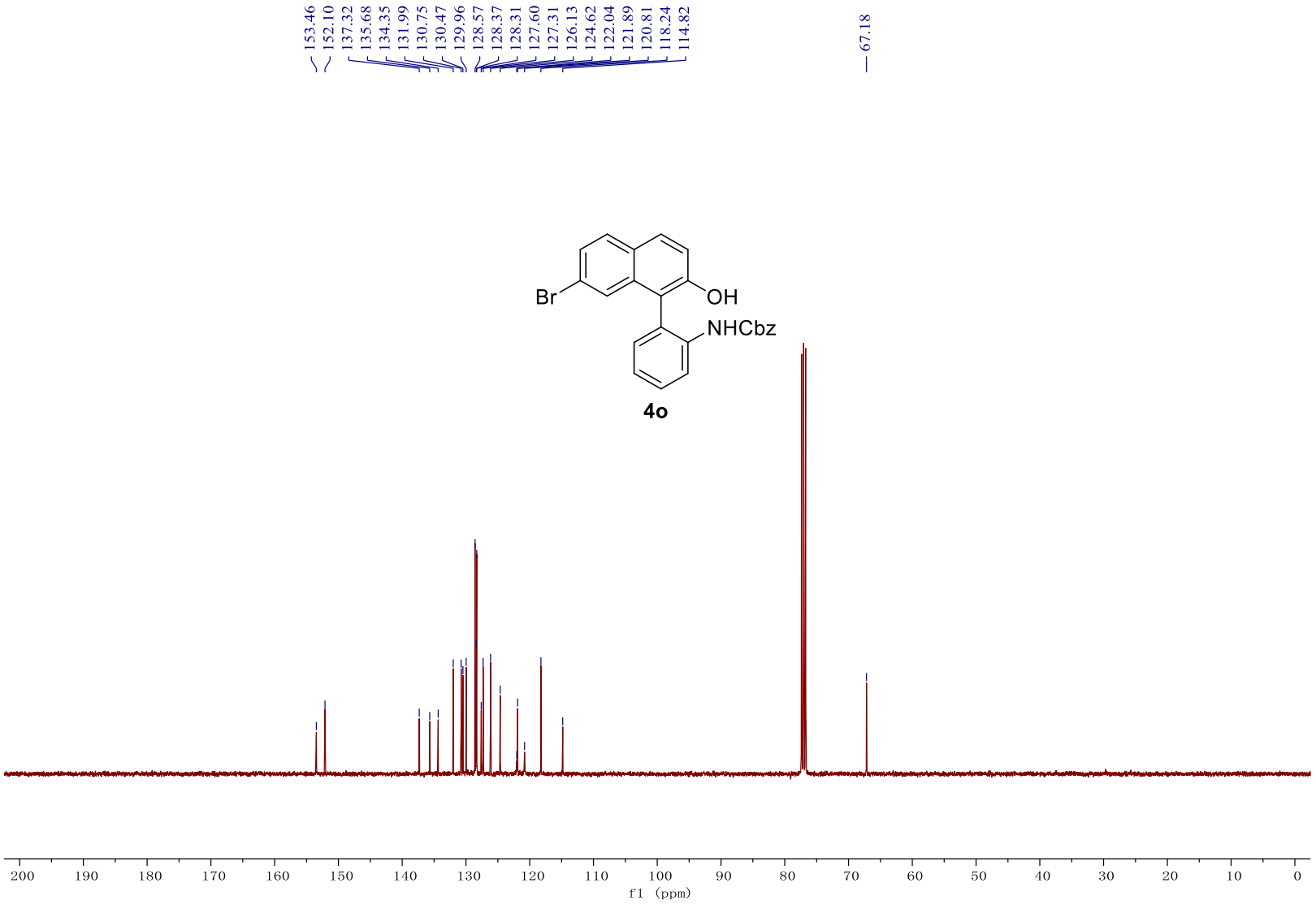
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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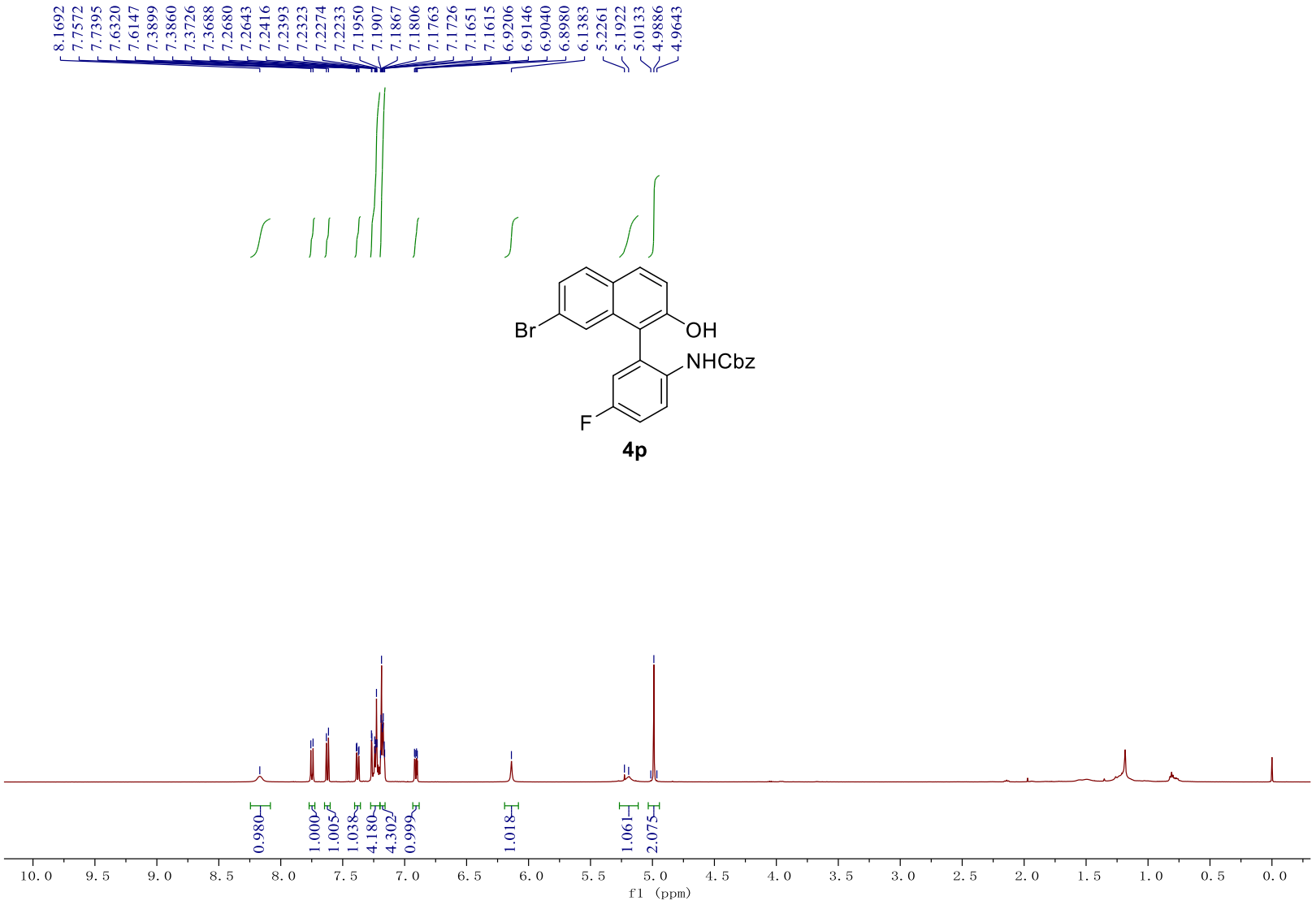
128.31
127.60
127.31
126.13
124.62
122.04
121.89
120.81
118.24
114.82
67.18
Br
OH
NHCbz
4o
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.2233
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7.1907
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7.1763
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7.1651
7.1615
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6.8980
6.1383
5.2261
5.1922
5.0133
4.9886
4.9643
Br
OH
NHCbz
F
4p
0.980
1.000
1.005
1.038
4.180
4.302
0.999
1.018
1.061
2.075
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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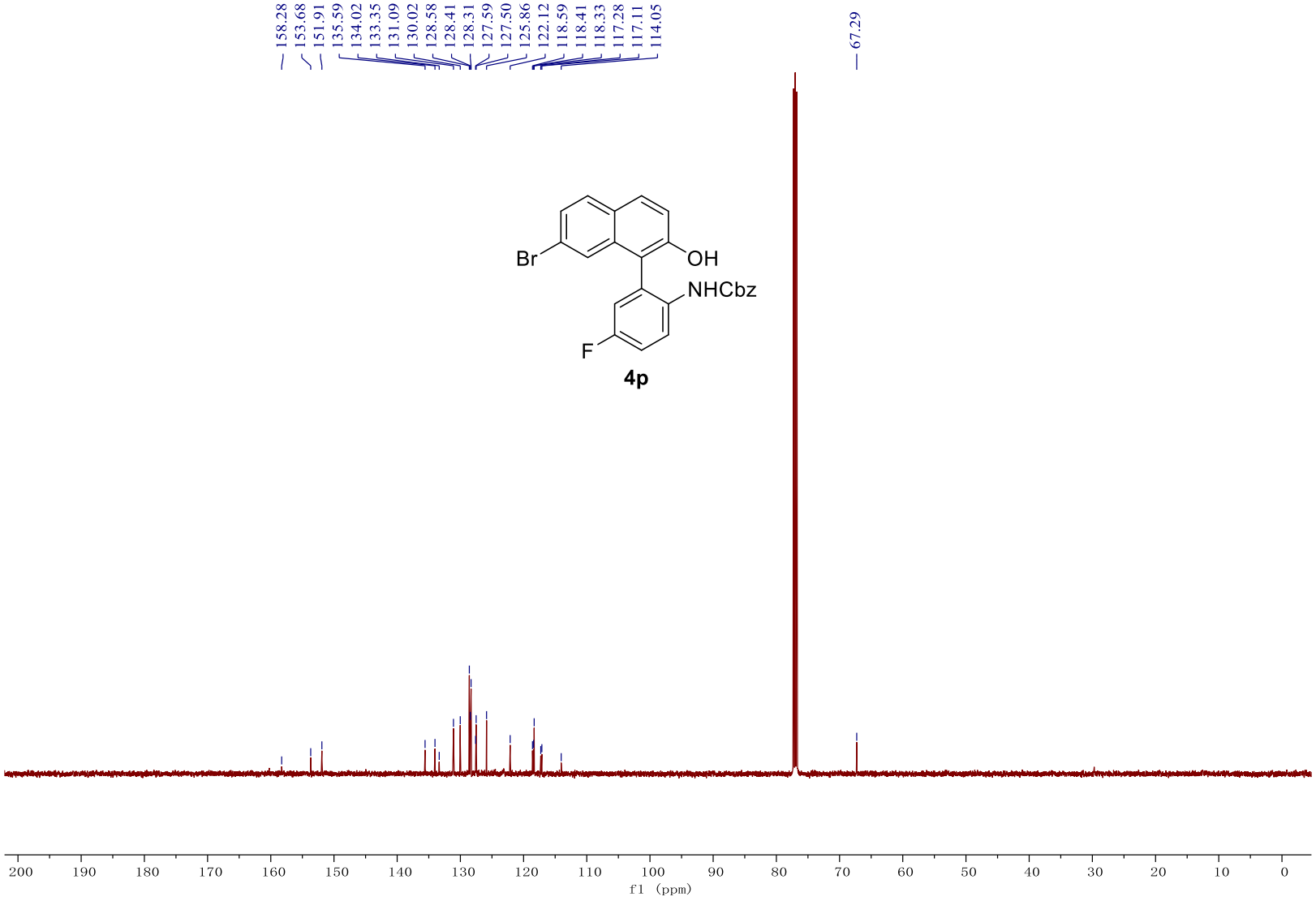
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130.02
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128.41
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127.59
127.50
125.86
122.12
118.59
118.41
118.33
117.28
117.11
114.05
67.29
Br
OH
NHCbz
F
4p
200
190
180
170
160
150
140
130
120
110
100
90
80
70
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50
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30
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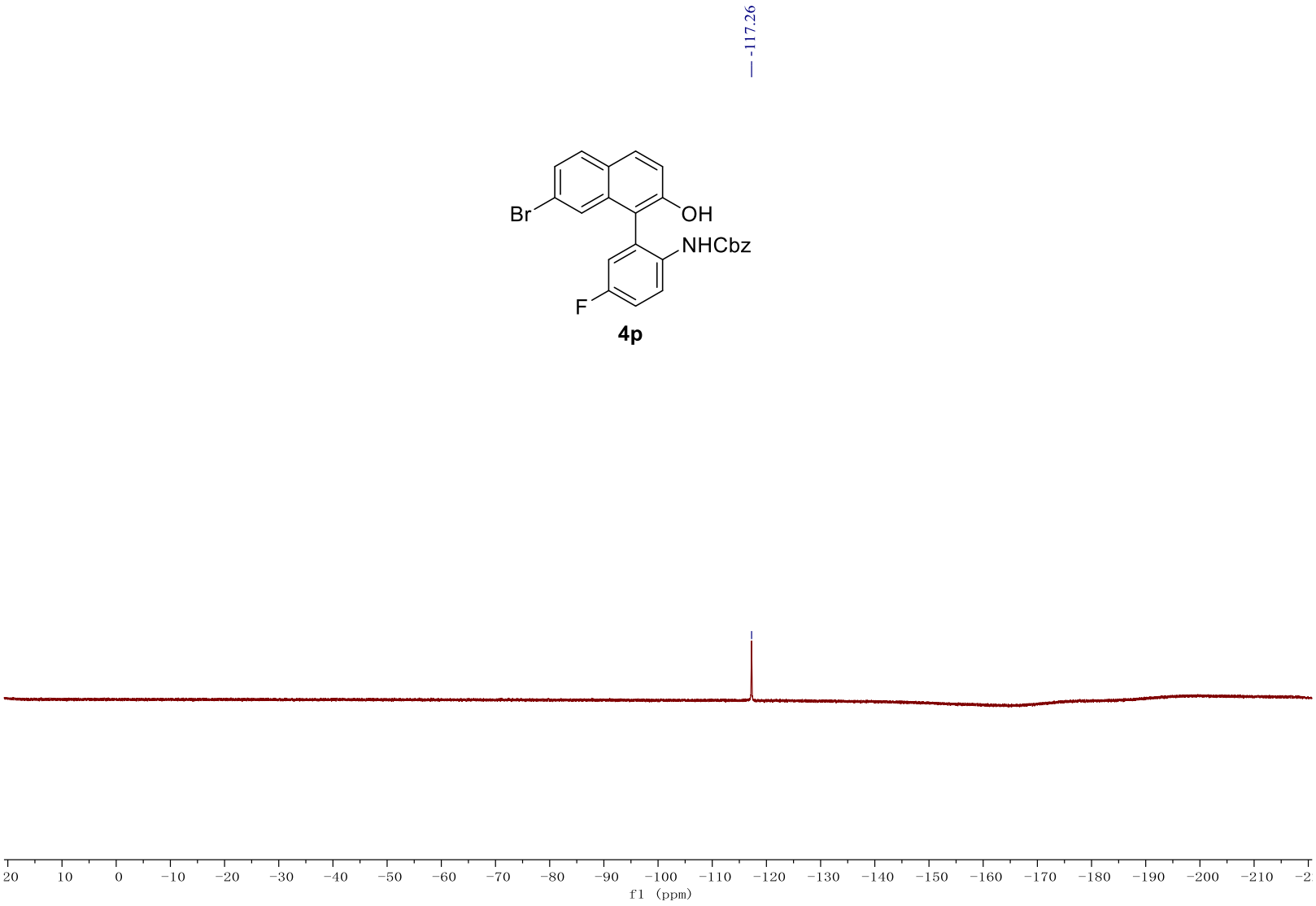
f1 (ppm)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NHCbz
F
4p
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-20
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-50
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-70
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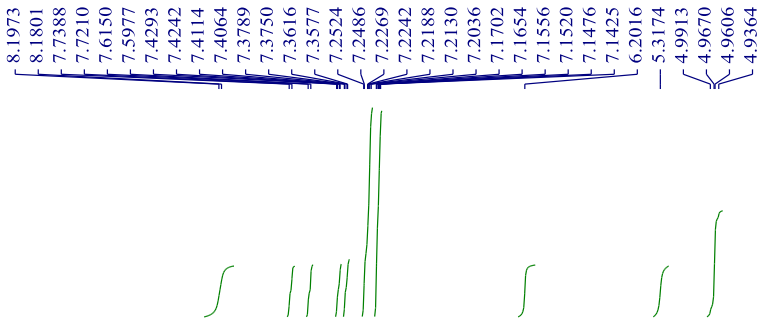
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)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7.4114
7.4064
7.3789
7.3750
7.3616
7.3577
7.2524
7.2486
7.2269
7.2242
7.2188
7.2130
7.2036
7.1702
7.1654
7.1556
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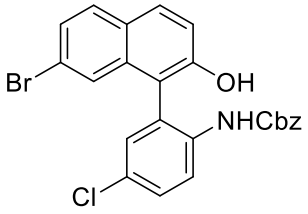
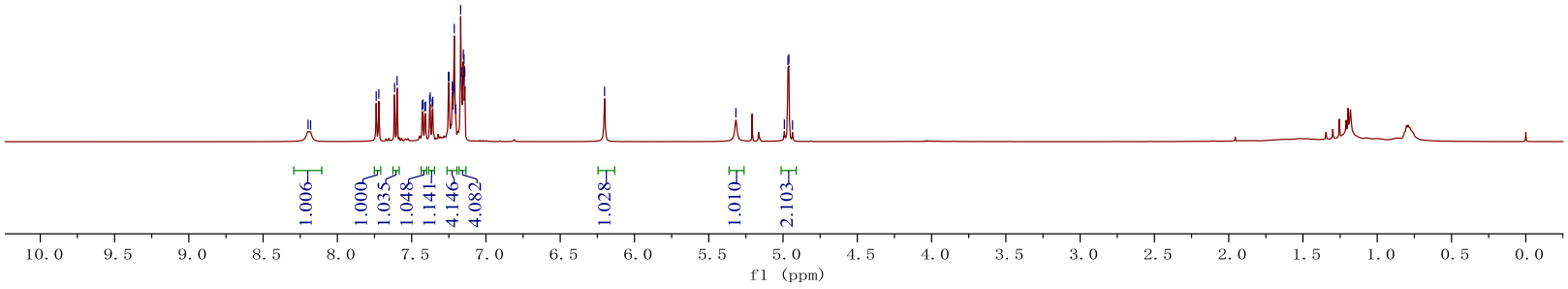
7.1476
7.1425
6.2016
5.3174
4.9913
4.9670
4.9606
4.9364


Br
OH
NHCbz
Cl

4q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1.035
1.048
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4.082
1.028
1.010
2.103
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
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4.5
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3.0
2.5
2.0
1.5
1.0
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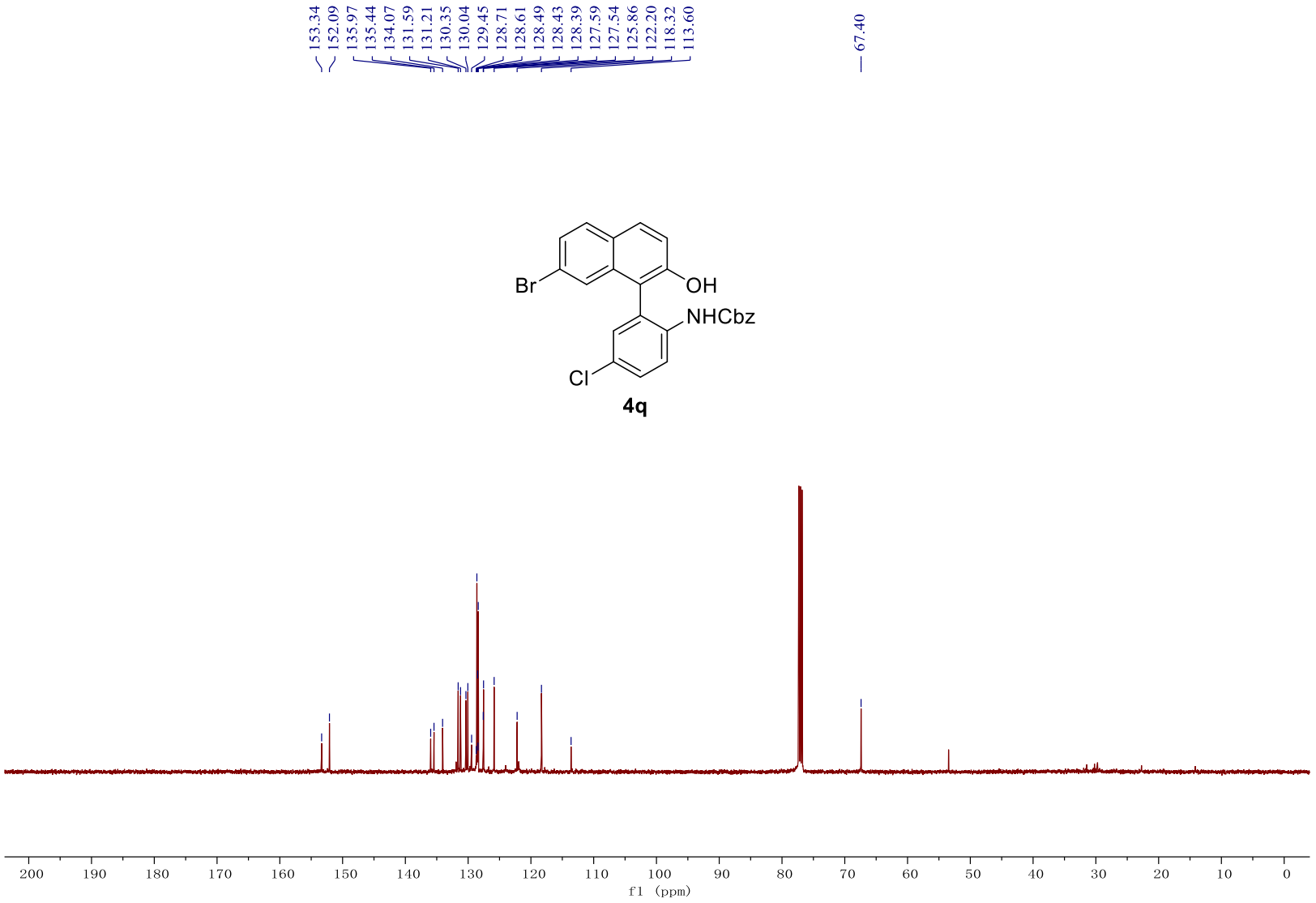
0.0
f1 (ppm)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129.45
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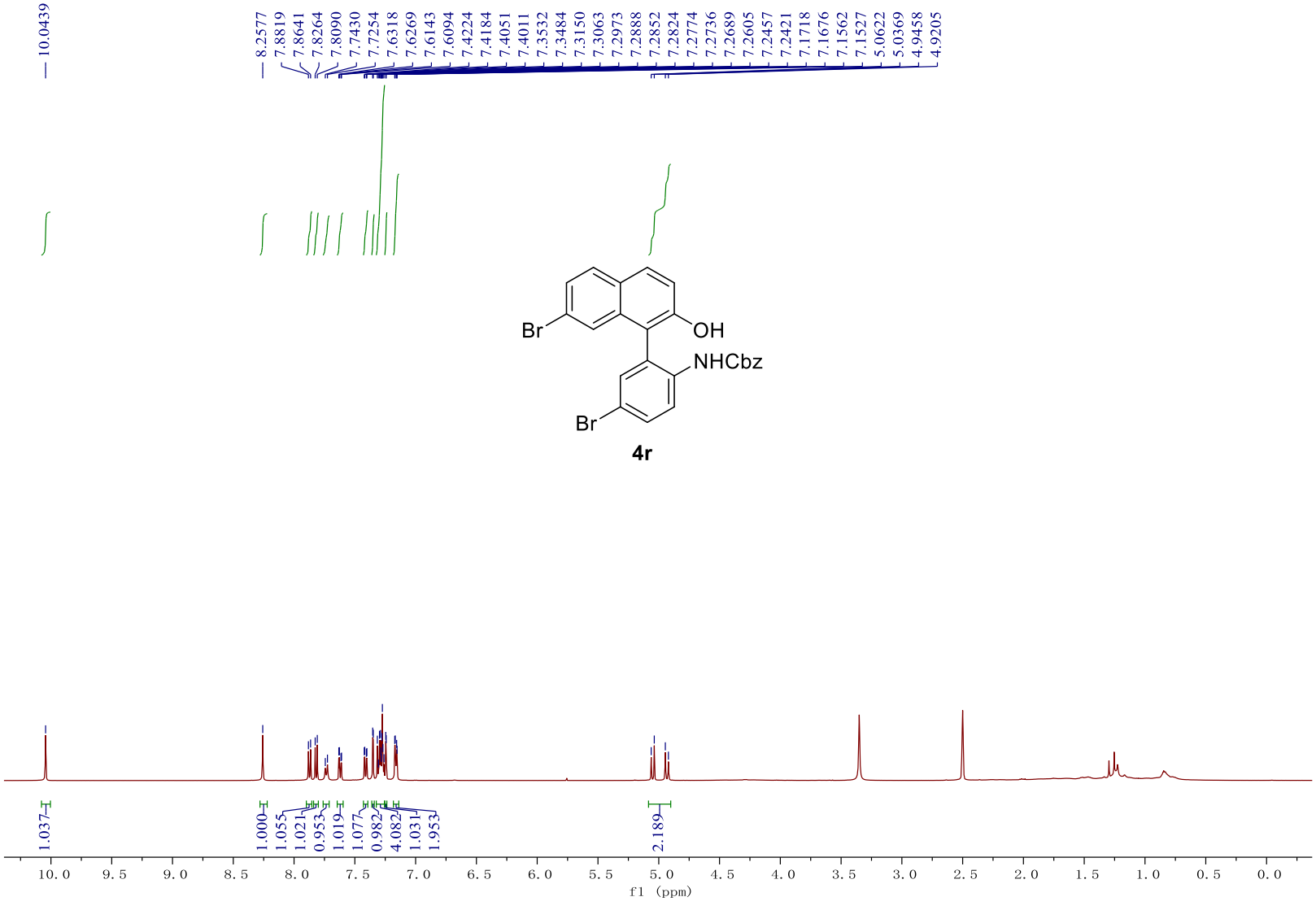
128.49
128.43
128.39
127.59
127.54
125.86
122.20
118.32
113.60
67.40
Br
OH
NHCbz
Cl
4q
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.8264
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7.7254
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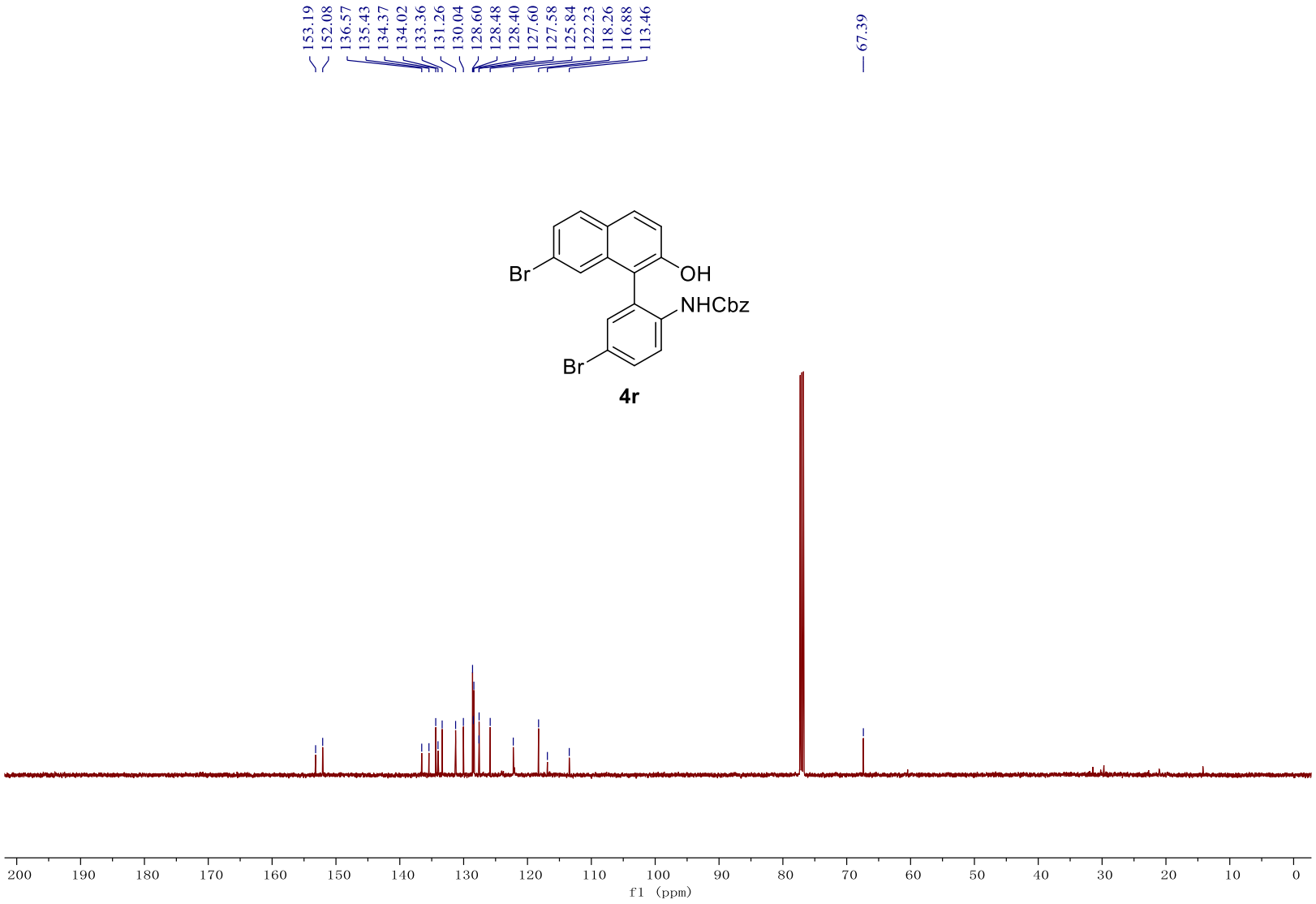
7.6143
7.6094
7.4224
7.4184
7.4051
7.4011
7.3532
7.3484
7.3150
7.3063
7.2973
7.2888
7.2852
7.2824
7.2774
7.2736
7.2689
7.2605
7.2457
7.2421
7.1718
7.1676
7.1562
7.1527
5.0622
5.0369
4.9458
4.9205
Br
OH
NHCbz
Br
4r
1.037
1.000
1.055
1.021
0.953
1.019
1.077
0.982
4.082
1.031
1.953
2.189
10.0
9.5
9.0
8.5
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
f1 (ppm)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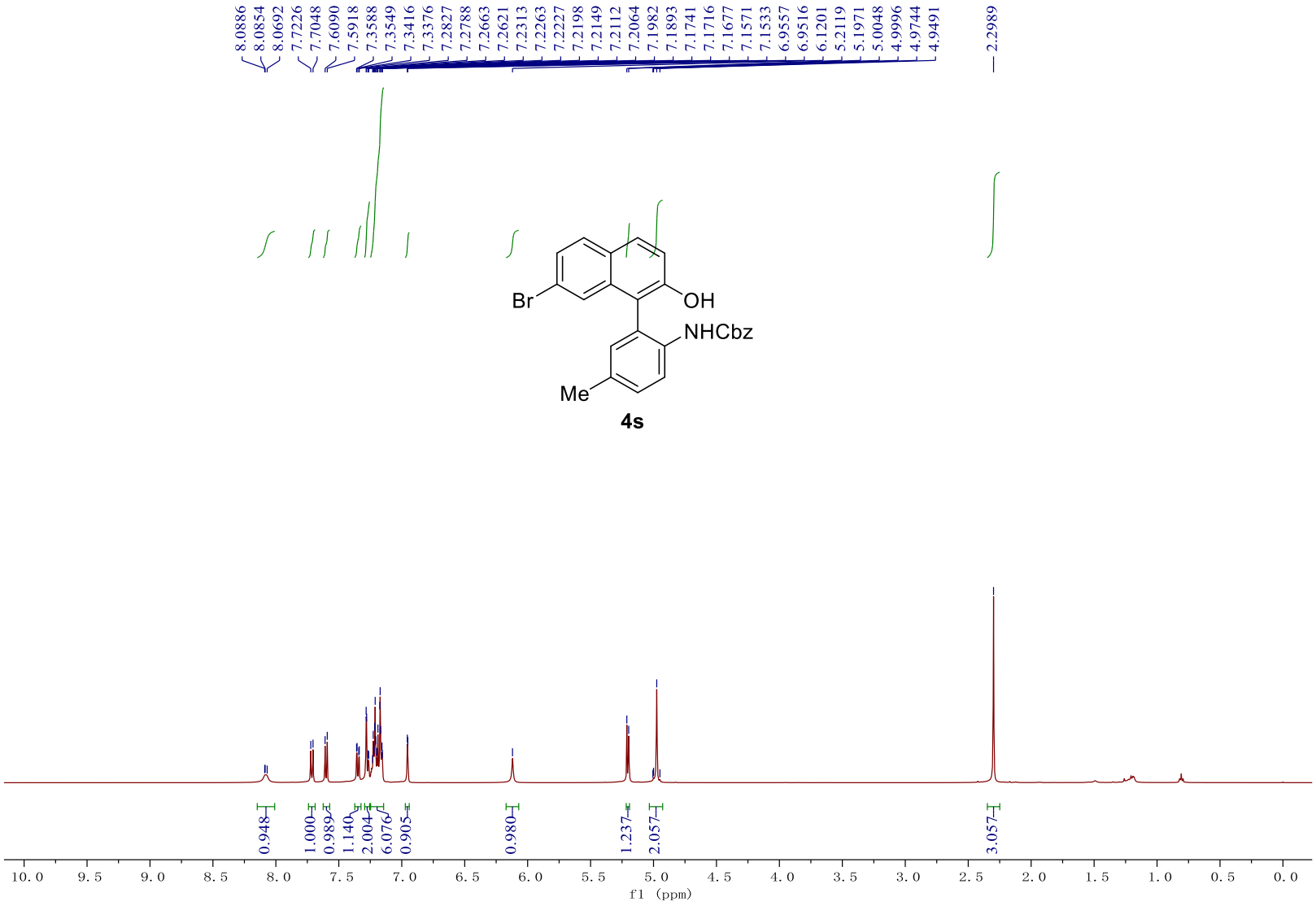
136.57
135.43
134.37
134.02
133.36
131.26
130.04
128.60
128.48
128.40
127.60
127.58
125.84
122.23
118.26
116.88
113.46
67.39
Br
OH
NHCbz
Br
4r
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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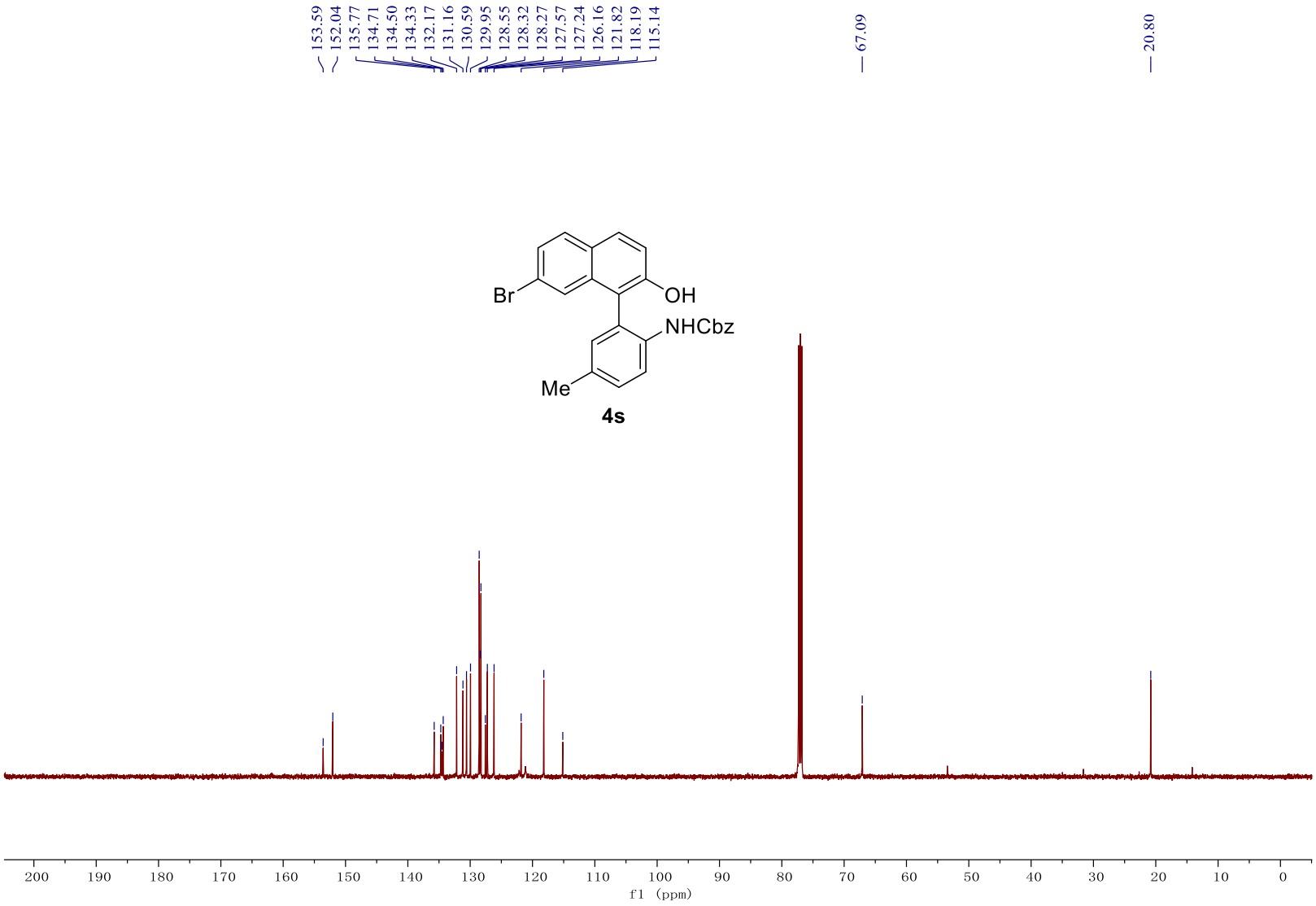
8.0854
8.0692
7.7226
7.7048
7.6090
7.5918
7.3588
7.3549
7.3416
7.3376
7.2827
7.2788
7.2663
7.2621
7.2313
7.2263
7.2227
7.2198
7.2149
7.2112
7.2064
7.1982
7.1893
7.1741
7.1716
7.1677
7.1571
7.1533
6.9557
6.9516
6.1201
5.2119
5.1971
5.0048
4.9996
4.9744
4.9491
2.2989
Br
OH
NHCbz
Me
4s
0.948
1.000
0.989
1.140
2.004
6.076
0.905
0.980
1.237
2.057
3.057
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
f1 (ppm)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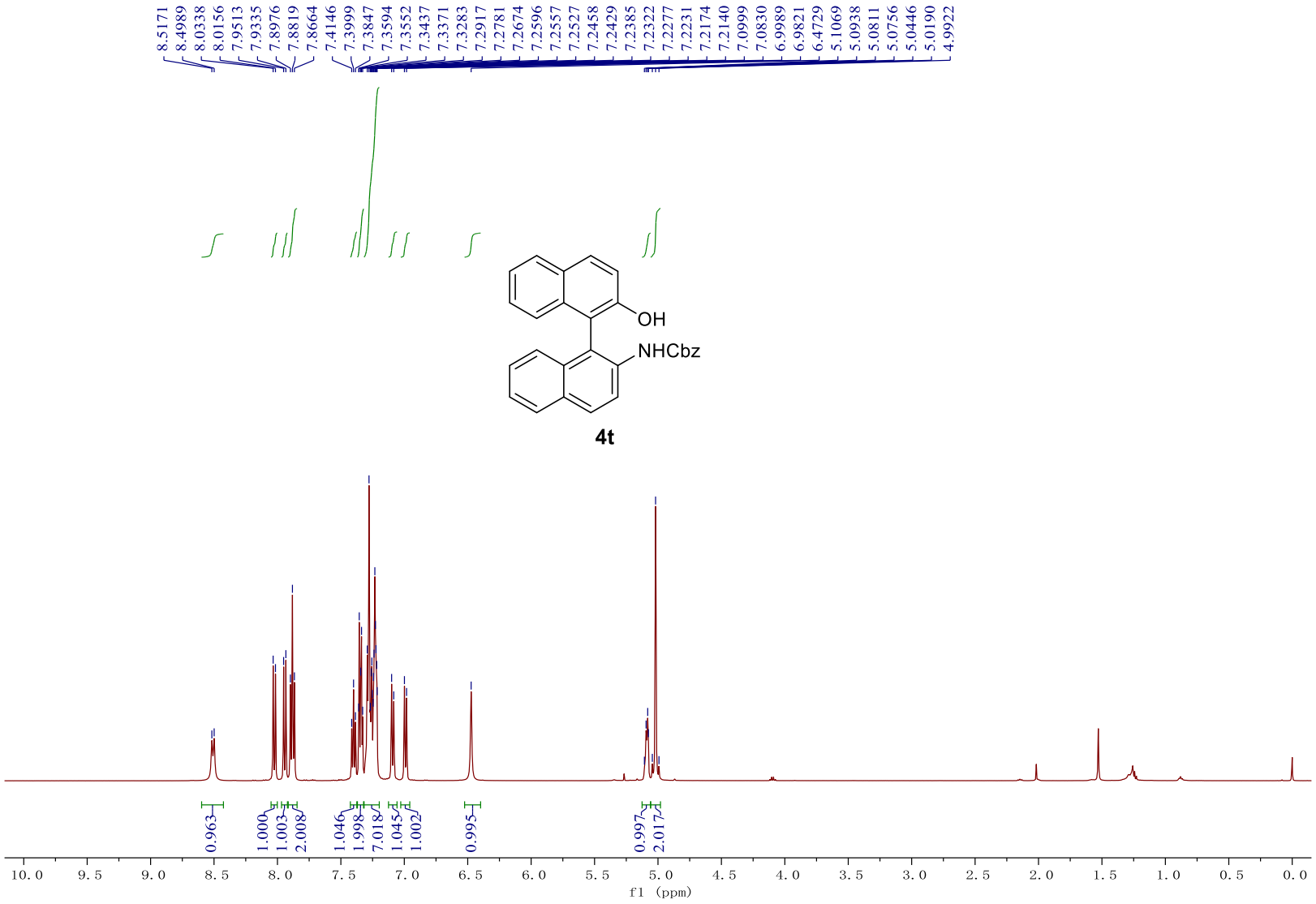
134.33
132.17
131.16
130.59
129.95
128.55
128.32
128.27
127.57
127.24
126.16
121.82
118.19
115.14
67.09
20.80
Br
OH
NHCbz
Me
4s
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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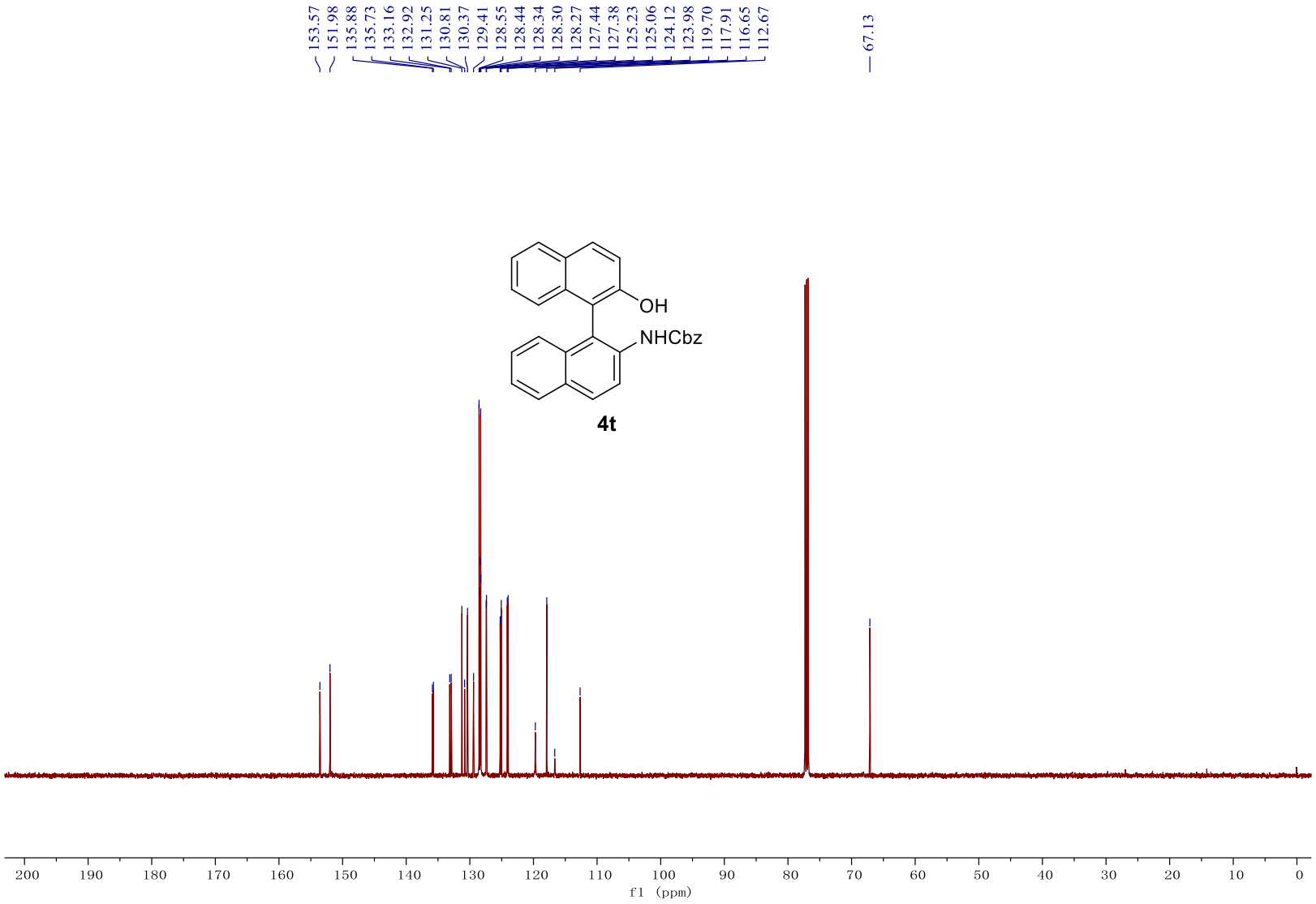
7.3999
7.3847
7.3594
7.3552
7.3437
7.3371
7.3283
7.2917
7.2781
7.2674
7.2596
7.2557
7.2527
7.2458
7.2429
7.2385
7.2322
7.2277
7.2231
7.2174
7.2140
7.0999
7.0830
6.9989
6.9821
6.4729
5.1069
5.0938
5.0811
5.0756
5.0446
5.0190
4.9922
OH
NHCbz
4t
0.963
1.000
1.003
2.008
1.046
1.998
7.018
1.045
1.002
0.995
0.997
2.017
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
f1 (ppm)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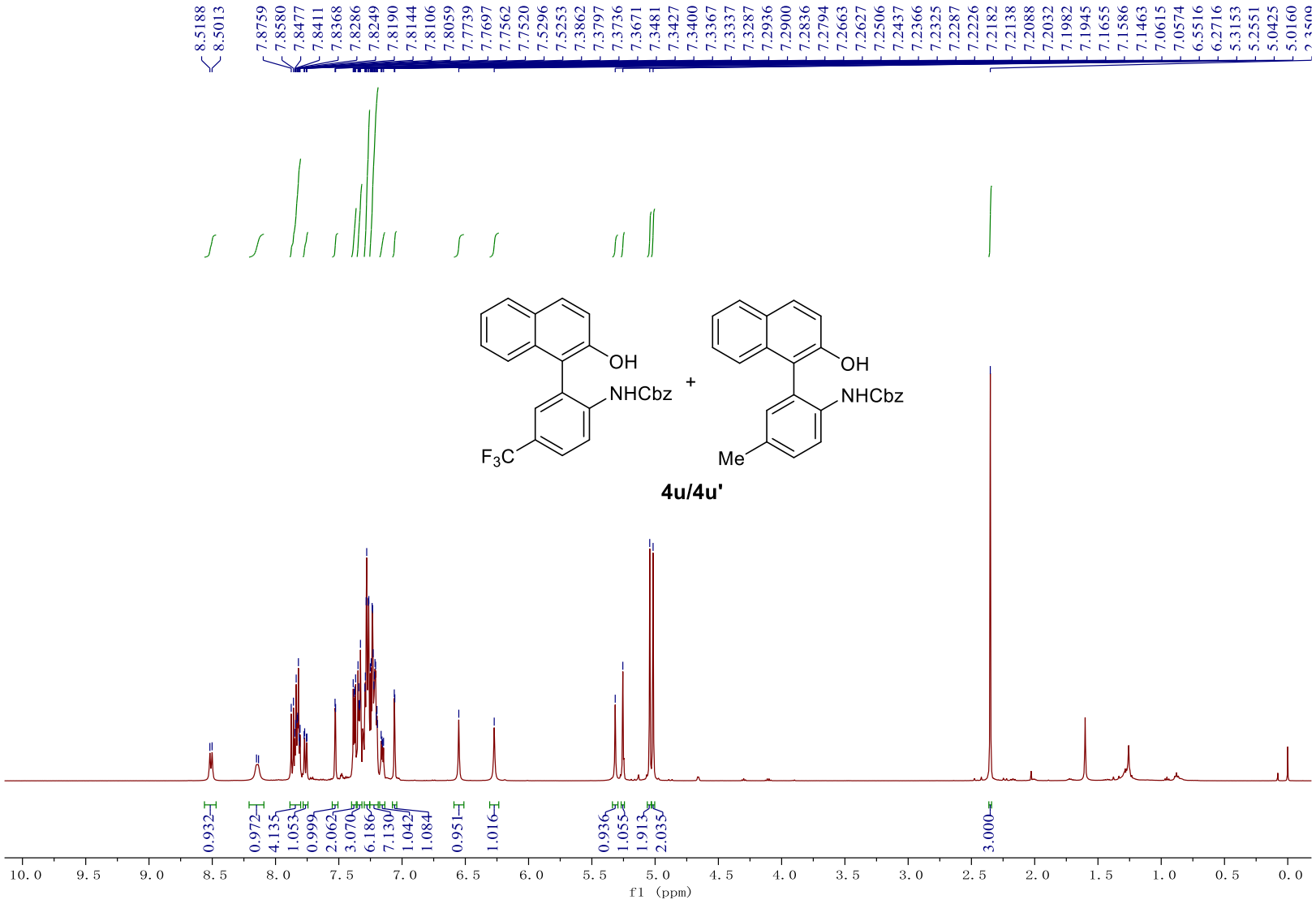
128.34
128.30
128.27
127.44
127.38
125.23
125.06
124.12
123.98
119.70
117.91
116.65
112.67
67.13
OH
NHCbz
4t
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.8411
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7.8249
7.8190
7.8144
7.8106
7.8059
7.7739
7.7697
7.7562
7.7520
7.5296
7.5253
7.3862
7.3797
7.3736
7.3671
7.3481
7.3427
7.3400
7.3367
7.3337
7.3287
7.2936
7.2900
7.2836
7.2794
7.2663
7.2627
7.2506
7.2437
7.2366
7.2325
7.2287
7.2226
7.2182
7.2138
7.2088
7.2032
7.1982
7.1945
7.1655
7.1586
7.1463
7.0615
7.0574
6.5516
6.2716
5.3153
5.2551
5.0425
5.0160
OH
NHCbz
F3C
+
OH
NHCbz
Me
4u/4u'
0.932
0.972
4.135
1.053
0.999
2.062
3.070
6.186
7.130
1.042
1.084
0.951
1.016
0.936
1.055
1.913
2.035
3.000
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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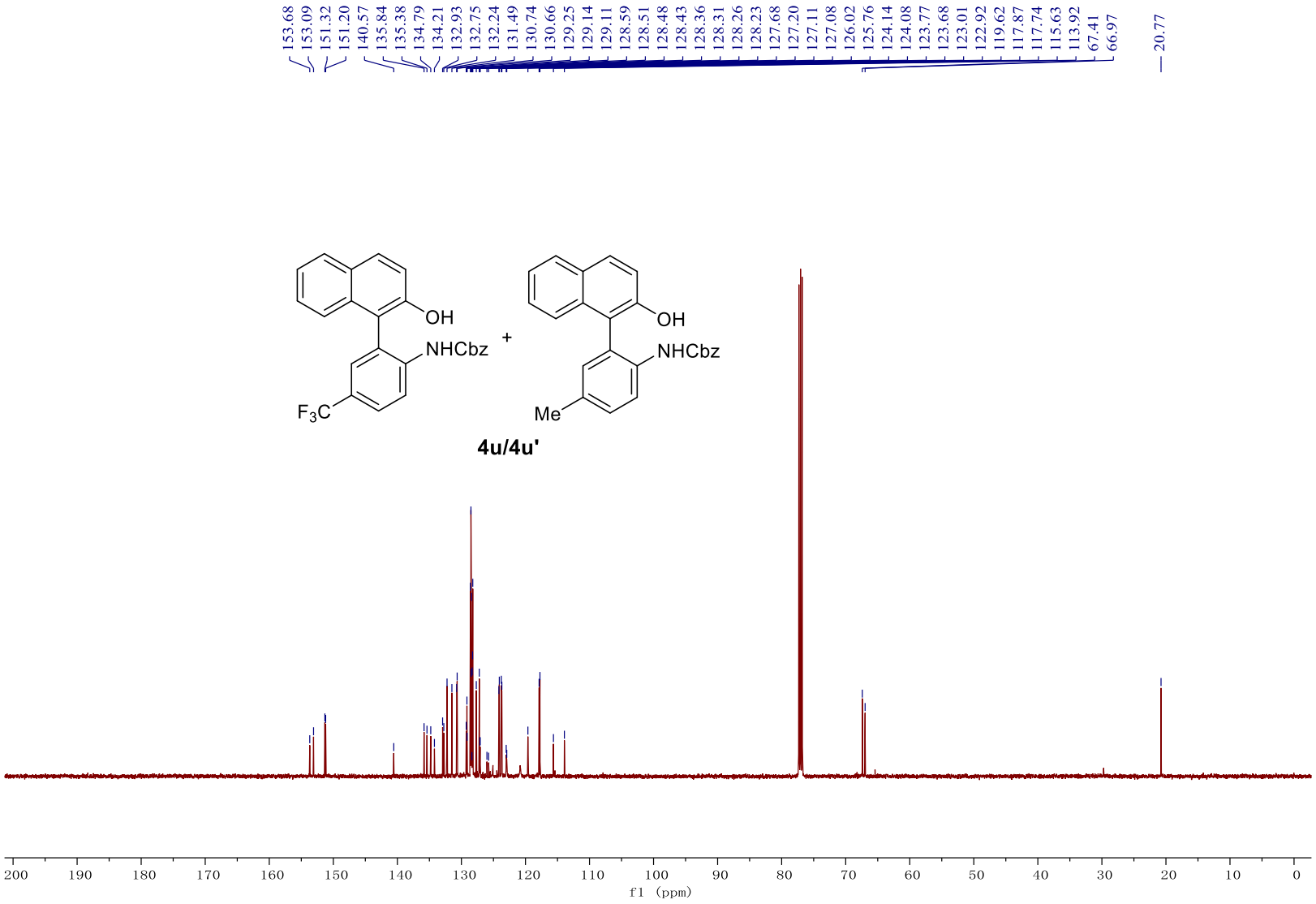
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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132.24
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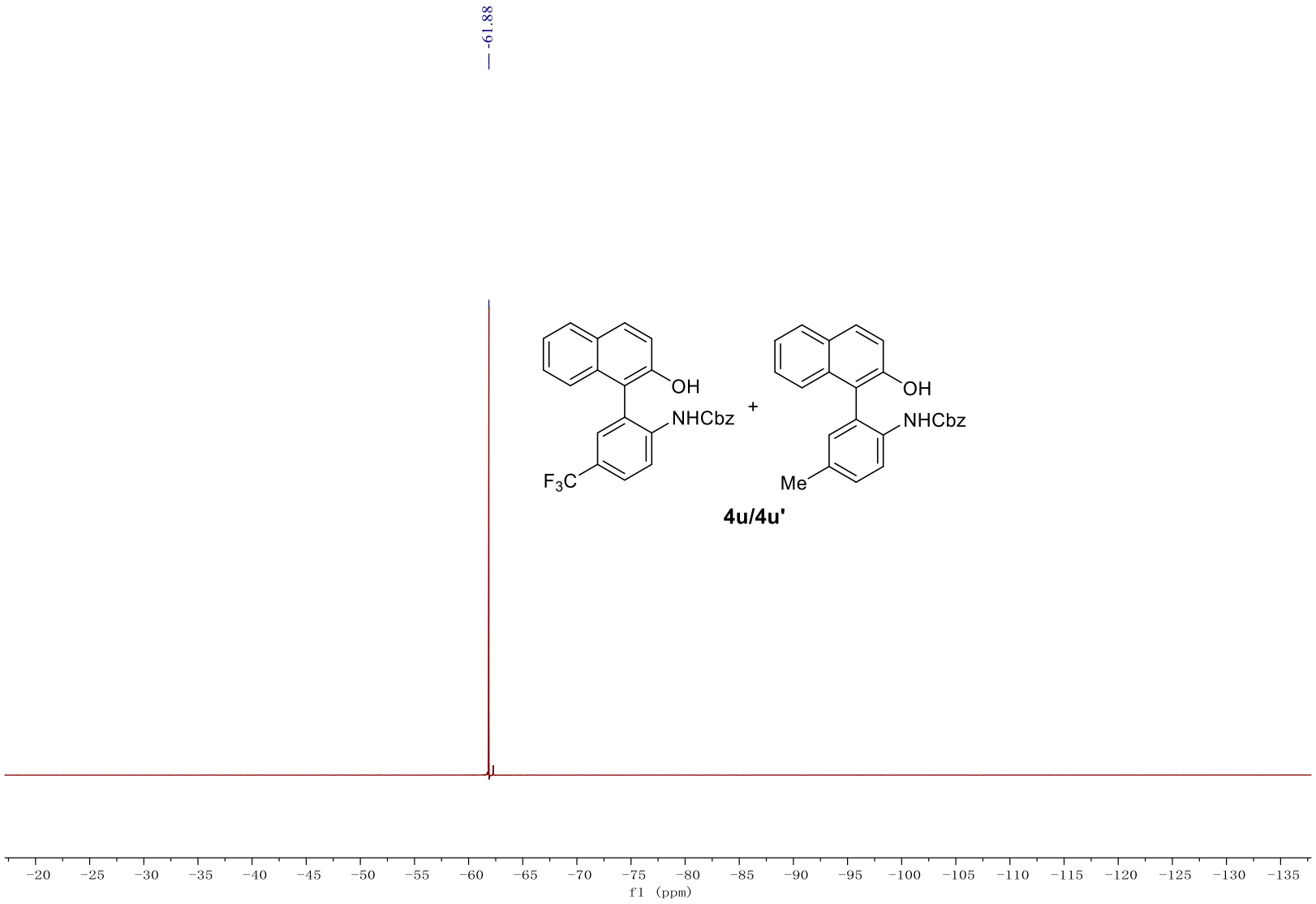
129.25
129.14
129.11
128.59
128.51
128.48
128.43
128.36
128.31
128.26
128.23
127.68
127.20
127.11
127.08
126.02
125.76
124.14
124.08
123.77
123.68
123.01
122.92
119.62
117.87
117.74
115.63
113.92
67.41
66.97
20.77
OH
NHCbz
F3C
+
OH
NHCbz
Me
4u/4u'
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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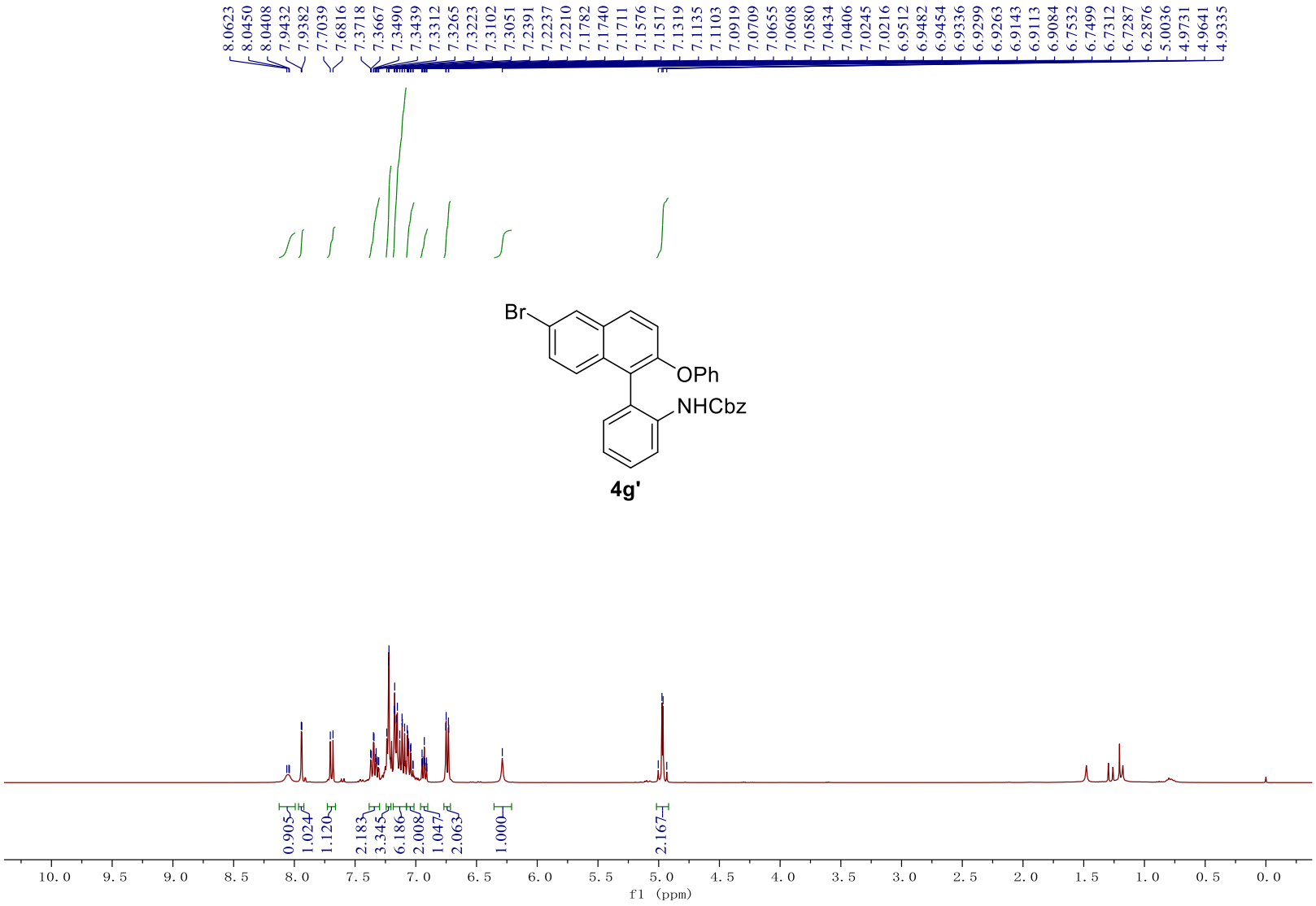
OH
NHCbz
F3C
+
OH
NHCbz
Me
4u/4u'
−20 −25 −30 −35 −40 −45 −50 −55 −60 −65 −70 −75 −80 −85 −90 −95 −100 −105 −110 −115 −120 −125 −130 −135
f1 (ppm)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7.3439
7.3312
7.3265
7.3223
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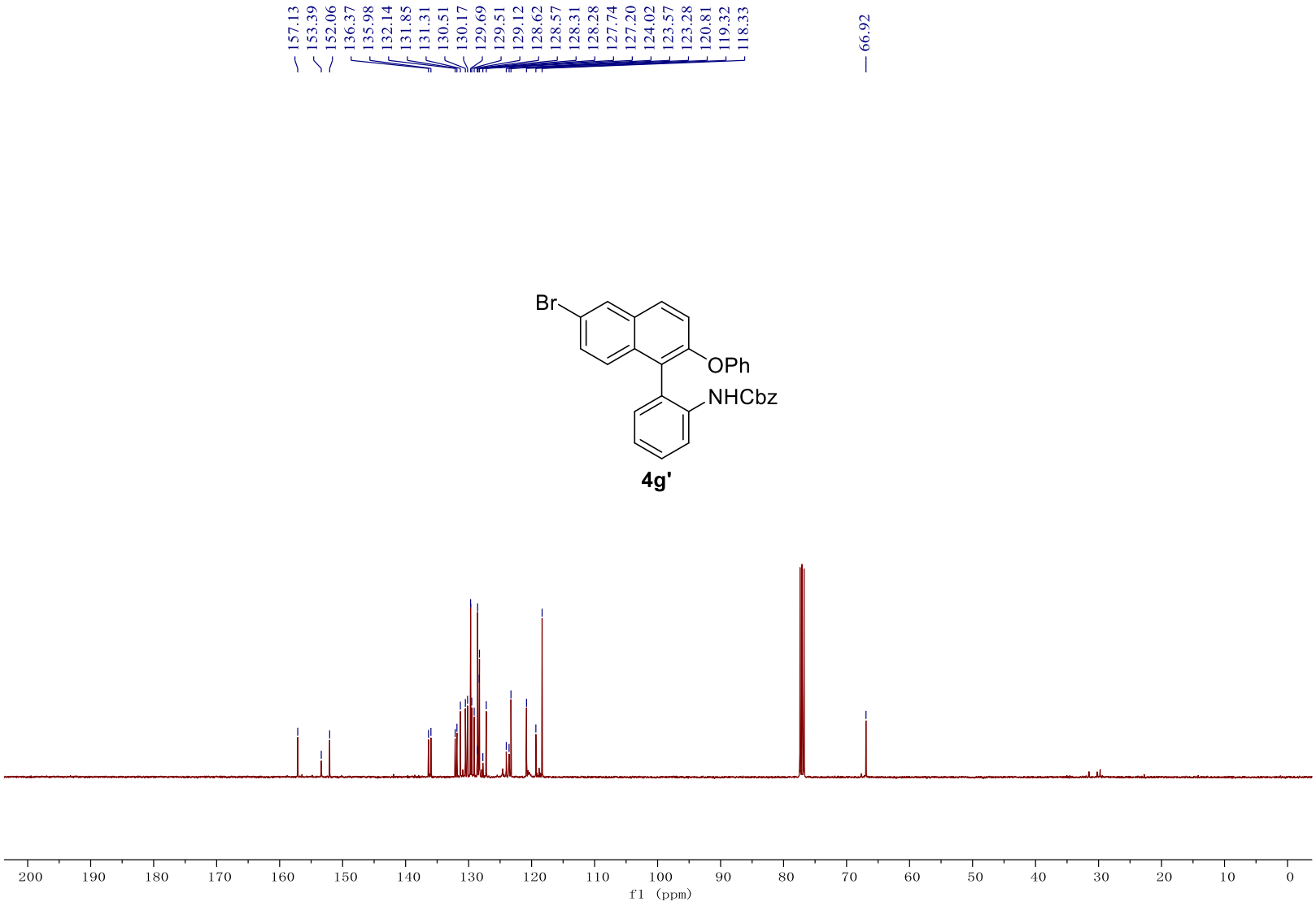
7.3051
7.2391
7.2237
7.2210
7.1782
7.1740
7.1711
7.1576
7.1517
7.1319
7.1135
7.1103
7.0919
7.0709
7.0655
7.0608
7.0580
7.0434
7.0406
7.0245
7.0216
6.9512
6.9482
6.9454
6.9336
6.9299
6.9263
6.9143
6.9113
6.9084
6.7532
6.7499
6.7312
6.7287
6.2876
5.0036
4.9731
4.9641
4.9335
Br
OPh
NHCbz
4g'
0.905
1.024
1.120
2.183
3.345
6.186
2.008
1.047
2.063
1.000
2.167
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
f1 (ppm)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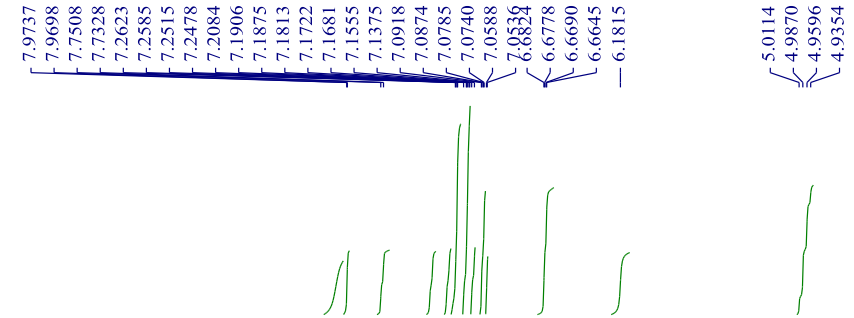
131.31
130.51
130.17
129.69
129.51
129.12
128.62
128.57
128.31
128.28
127.74
127.20
124.02
123.57
123.28
120.81
119.32
118.33
66.92
Br
OPh
NHCbz
4g'
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.7328
7.2623
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7.2515
7.2478
7.2084
7.1906
7.1875
7.1813
7.1722
7.1681
7.1555
7.1375
7.0918
7.0874
7.0785
7.0740
7.0588
7.0536
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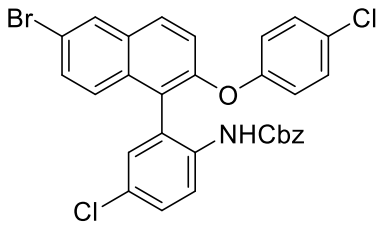
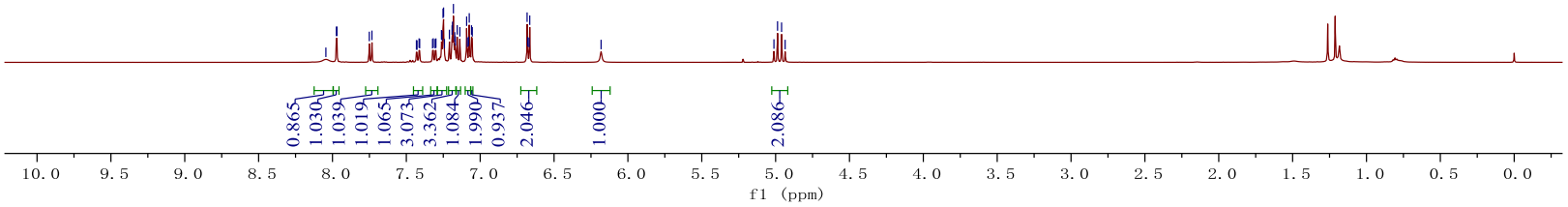
6.6778
6.6690
6.6645
6.1815
5.0114
4.9870
4.9596
4.9354


Br
Cl
O
NHCbz
Cl

4h'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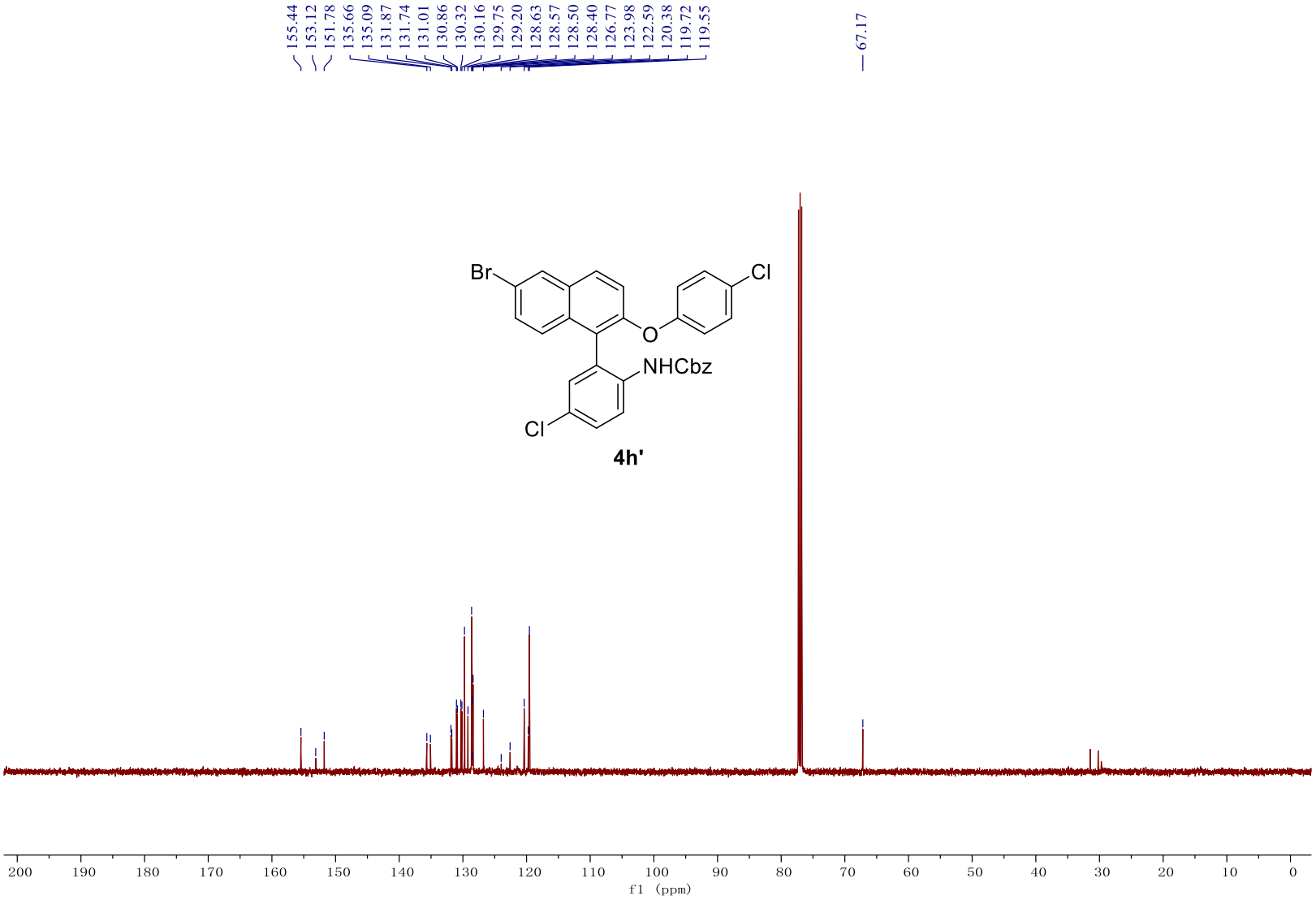
1.039
1.019
1.065
3.073
3.362
1.084
1.990
0.937
2.046
1.000
2.086
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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131.74
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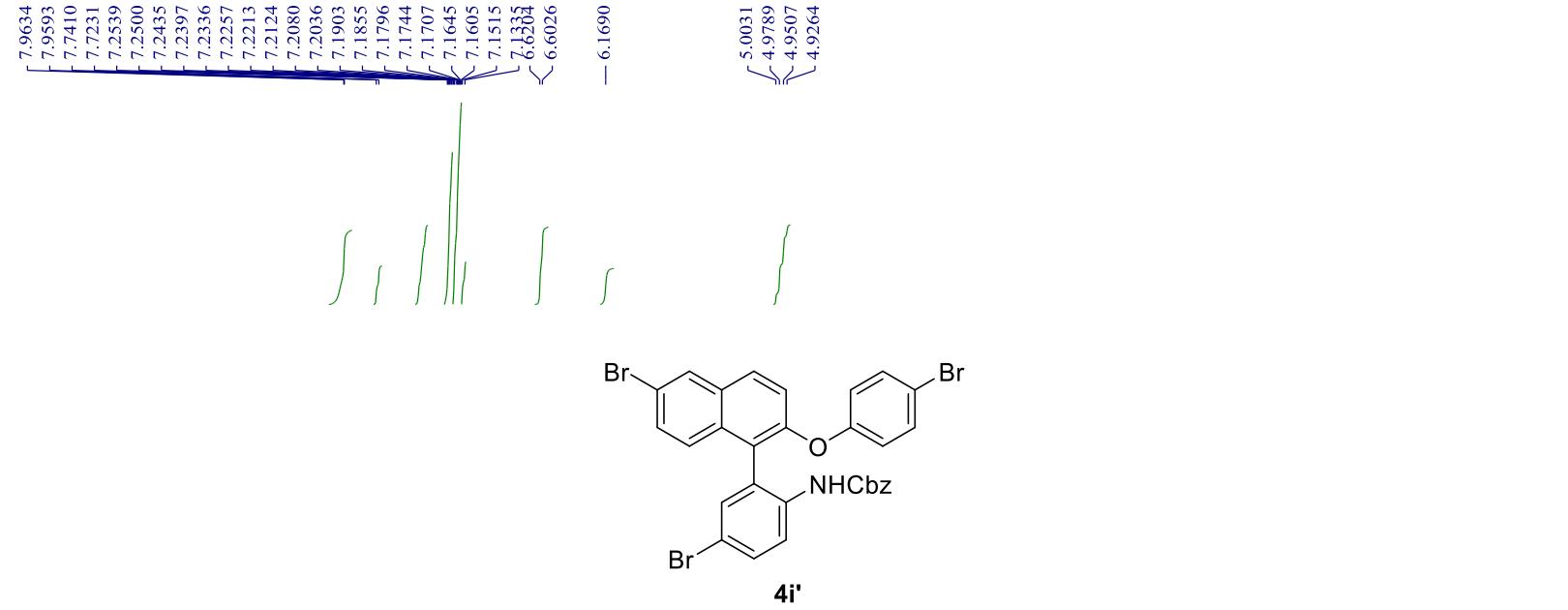
130.86
130.32
130.16
129.75
129.20
128.63
128.57
128.50
128.40
126.77
123.98
122.59
120.38
119.72
119.55
67.17
Br
Cl
O
NHCbz
Cl
4h'
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.7410
7.7231
7.2539
7.2500
7.2435
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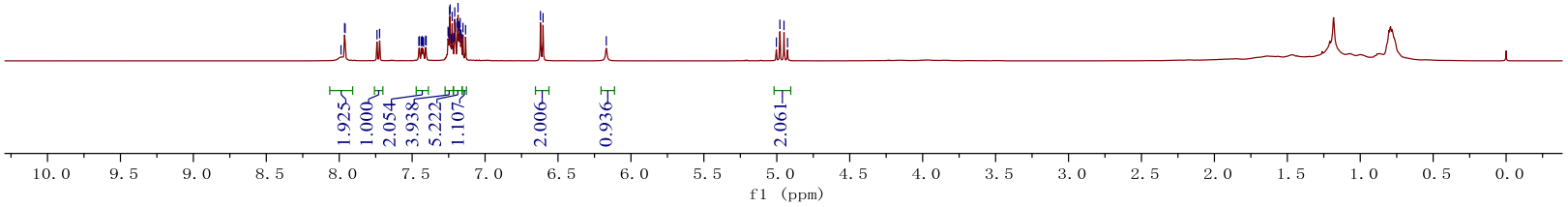
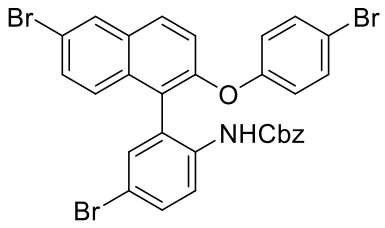
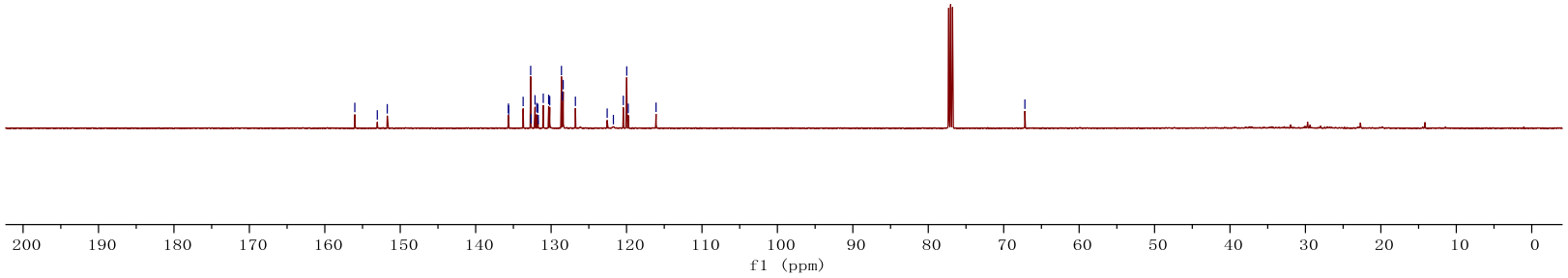
7.2336
7.2257
7.2213
7.2124
7.2080
7.2036
7.1903
7.1855
7.1796
7.1744
7.1707
7.1645
7.1605
7.1515
7.1335
6.6204
6.6026
6.1690
5.0031
4.9789
4.9507
4.9264
Br
Br
O
NHCbz
Br
4i'

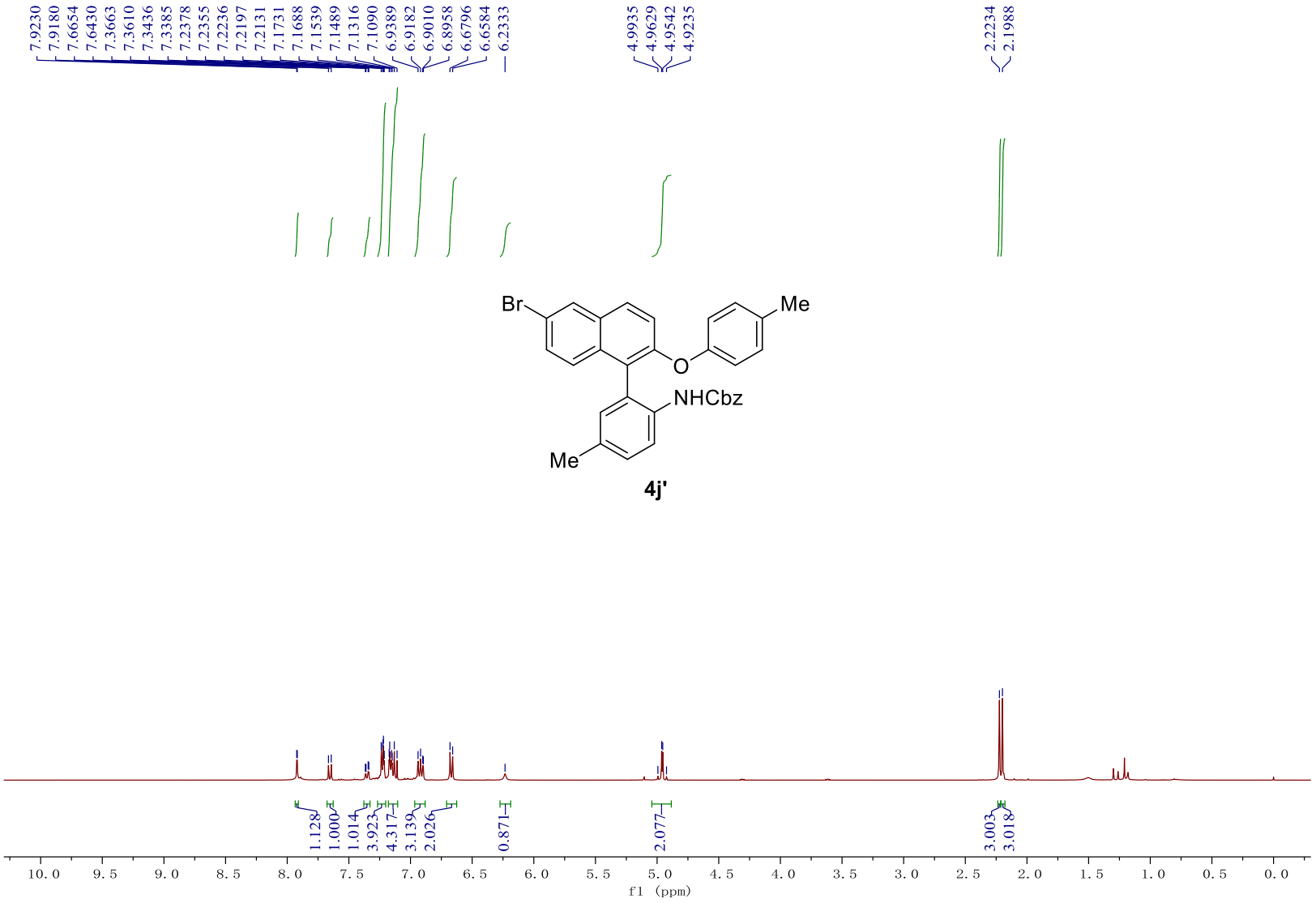

1.925
1.000
2.054
3.938
5.222
1.107
2.006
0.936
2.061
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


156.02
153.04
151.72
135.66
135.63
133.71
132.71
132.66
132.13
131.91
131.76
131.70
131.04
130.33
130.18
128.63
128.50
128.40
126.78
122.57
121.75
120.43
119.98
119.78
116.09
67.19

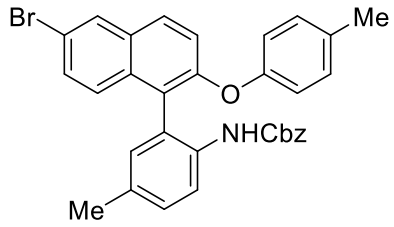

Br
Br
O
NHCbz
Br

4i'

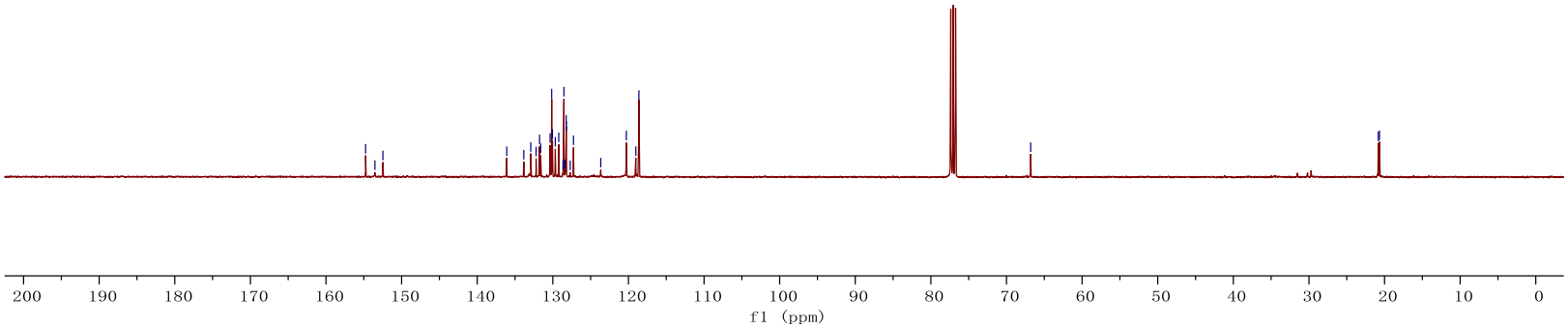

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

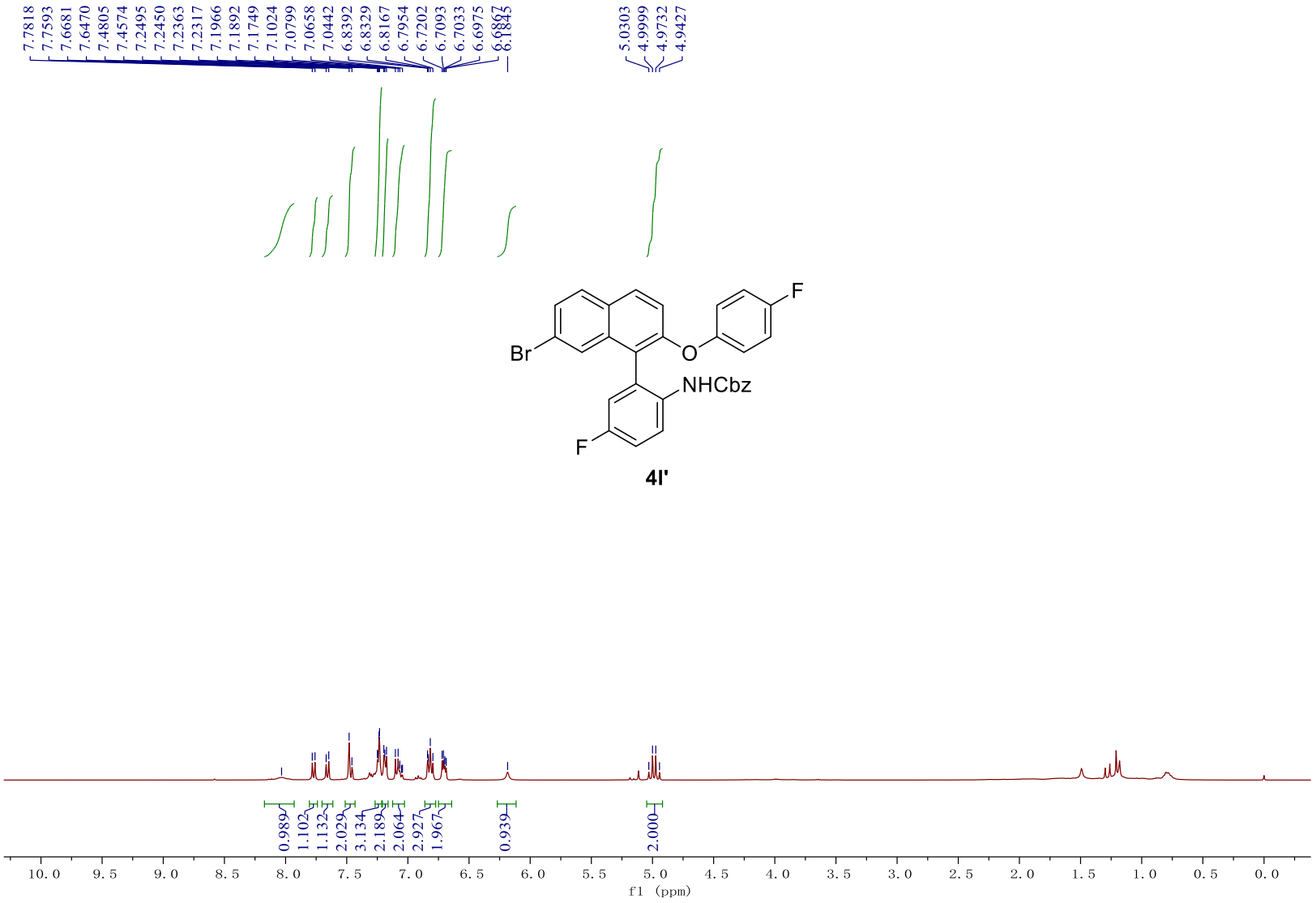

7.9230
7.9180
7.6654
7.6430
7.3663
7.3610
7.3436
7.3385
7.2378
7.2355
7.2236
7.2197
7.2131
7.1731
7.1688
7.1539
7.1489
7.1316
7.1090
6.9389
6.9182
6.9010
6.8958
6.6796
6.6584
6.2333
4.9935
4.9629
4.9542
4.9235
2.2234
2.1988
Br
Me
O
NHCbz
Me
4j'
1.128
1.000
1.014
3.923
4.317
3.139
2.026
0.871
2.077
3.003
3.018
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
f1 (ppm)

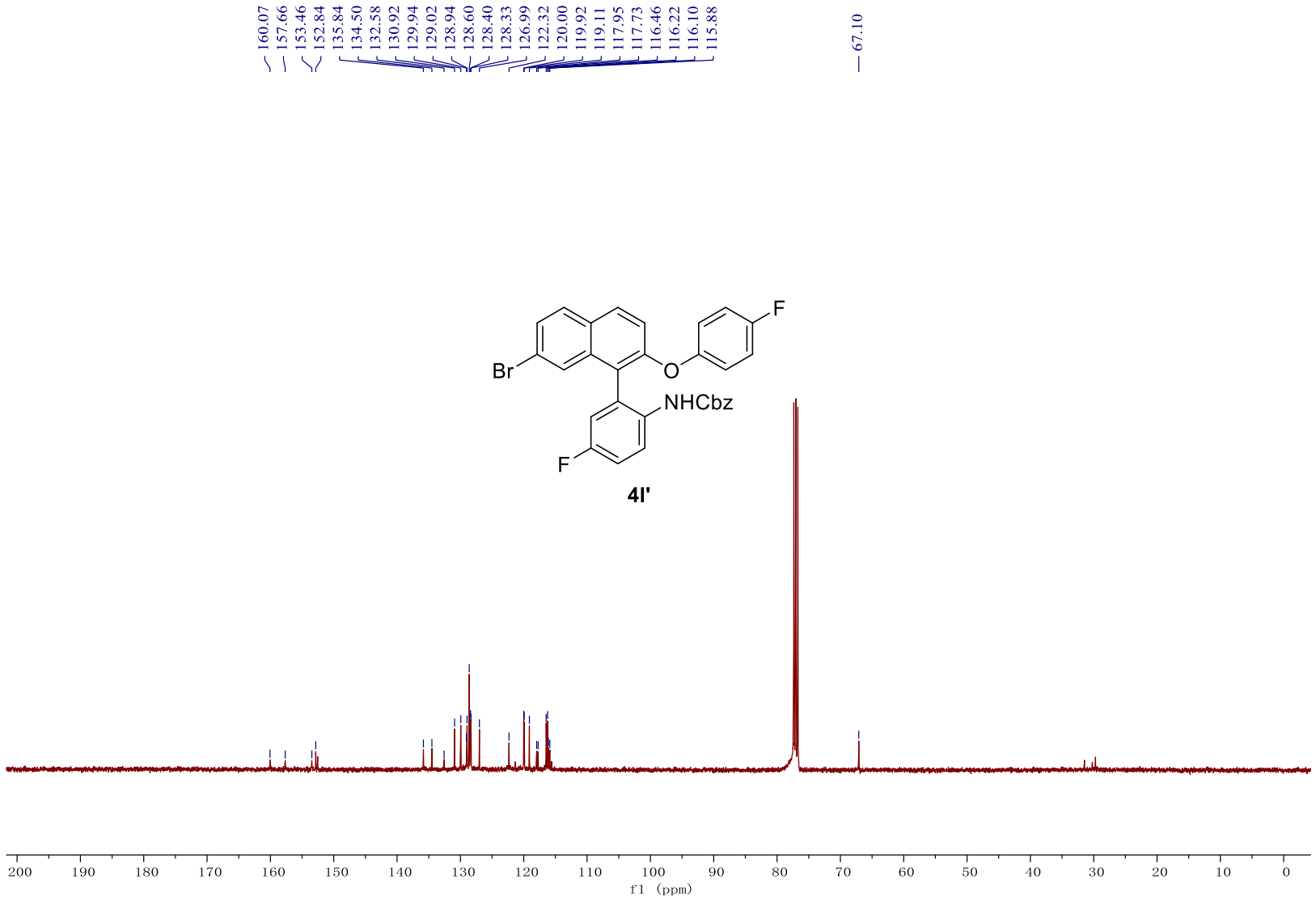

154.76
153.53
152.47
136.09
133.84
132.92
132.21
131.75
131.61
130.36
130.15
130.05
129.67
129.21
128.65
128.53
128.40
128.23
128.21
127.70
127.27
123.66
120.28
119.02
118.62
66.80
20.82
20.67

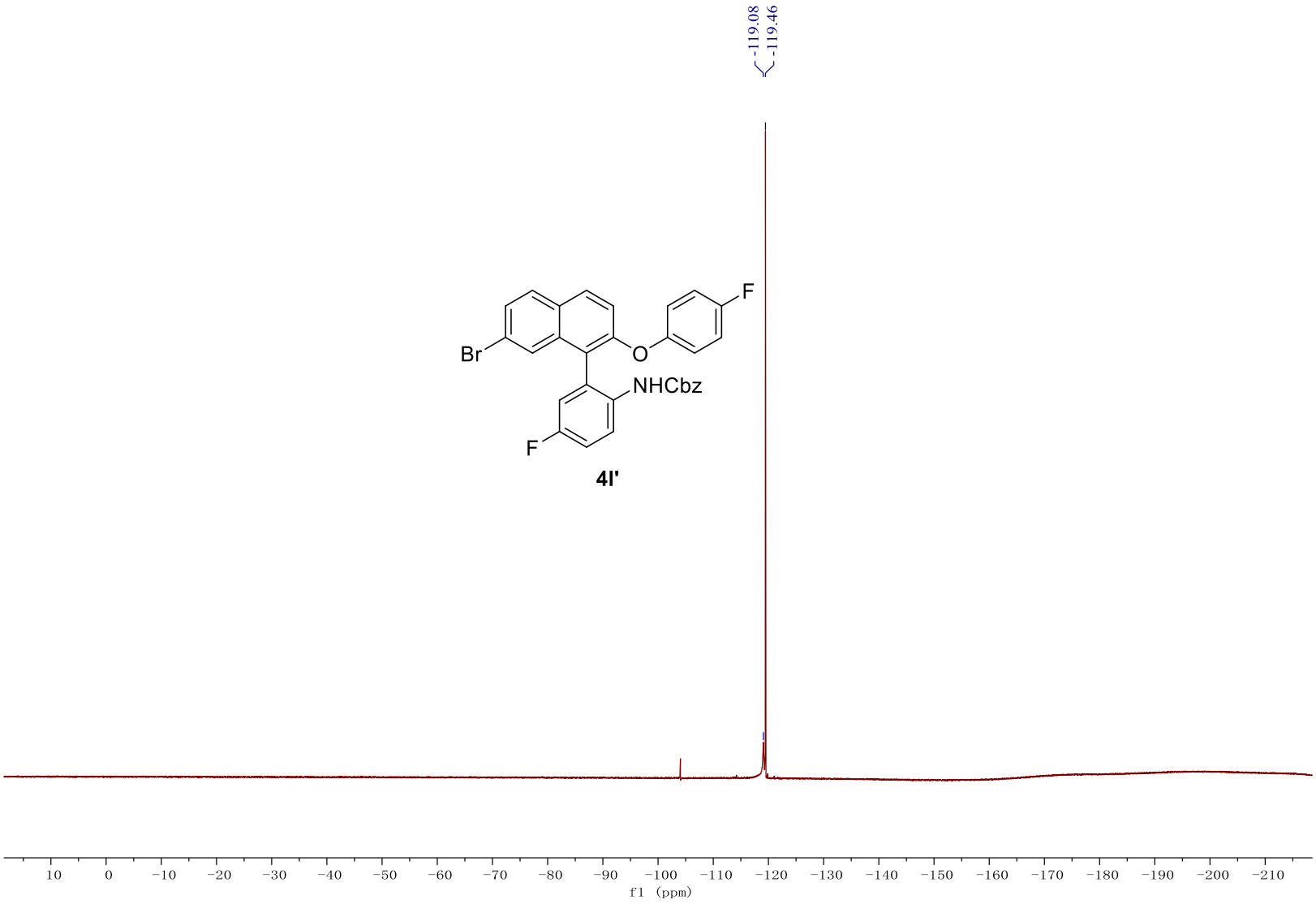

Br
Me
O
NHCbz
Me

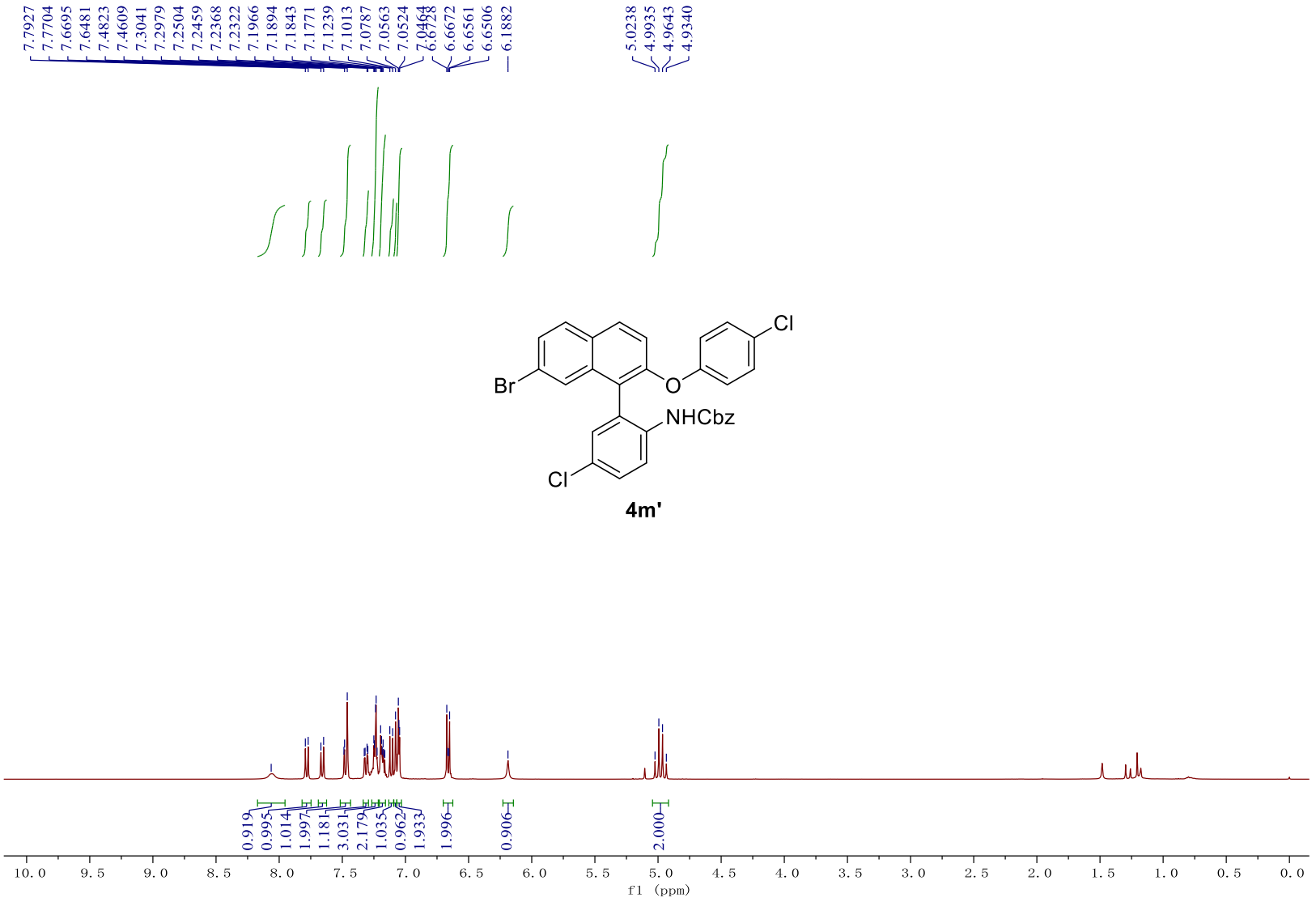
4j'


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

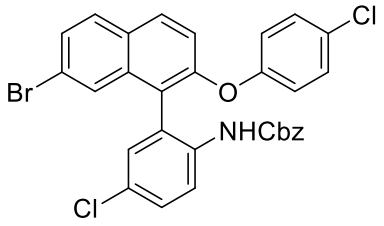

7.7818
7.7593
7.6681
7.6470
7.4805
7.4574
7.2495
7.2450
7.2363
7.2317
7.1966
7.1892
7.1749
7.1024
7.0799
7.0658
7.0442
6.8392
6.8329
6.8167
6.7954
6.7202
6.7093
6.7033
6.6975
6.6867
6.6845
5.0303
4.9999
4.9732
4.9427
Br
O
F
NHCbz
F
4l'
0.989
1.102
1.132
2.029
3.134
2.189
2.064
2.927
1.967
0.939
2.000
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
f1 (ppm)


160.07
157.66
153.46
152.84
135.84
134.50
132.58
130.92
129.94
129.02
128.94
128.60
128.40
128.33
126.99
122.32
120.00
119.92
119.11
117.95
117.73
116.46
116.22
116.10
115.88
67.10
Br
O
F
NHCbz
F
4l'
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

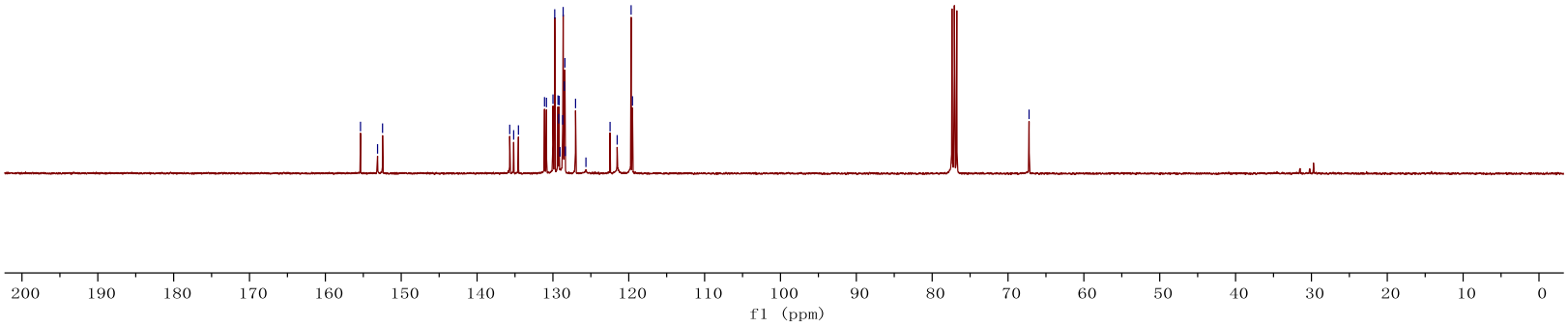

-119.08
-119.46
Br
O
F
NHCbz
F
4l'
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

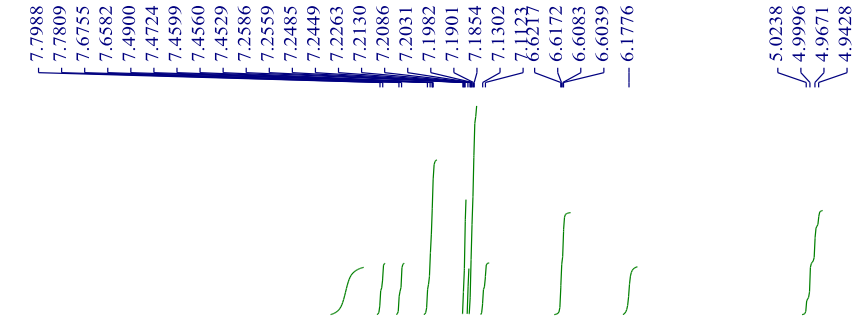

7.7927
7.7704
7.6695
7.6481
7.4823
7.4609
7.3041
7.2979
7.2504
7.2459
7.2368
7.2322
7.1966
7.1894
7.1843
7.1771
7.1239
7.1013
7.0787
7.0563
7.0524
7.0464
6.6728
6.6672
6.6561
6.6506
6.1882
5.0238
4.9935
4.9643
4.9340
Br
O
Cl
NHCbz
Cl
4m'
0.919
0.995
1.014
1.997
1.181
3.031
2.179
1.035
0.962
1.933
1.996
0.906
2.000
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
f1 (ppm)

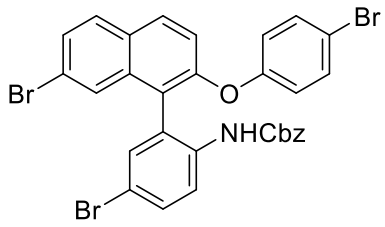

155.37
153.12
152.46
135.70
135.17
134.54
131.11
130.85
129.99
129.76
129.33
129.23
129.18
129.07
128.71
128.65
128.50
128.42
128.37
127.02
125.65
122.46
121.53
119.69
119.51
67.23


Cl
Br
O
NHCbz
Cl

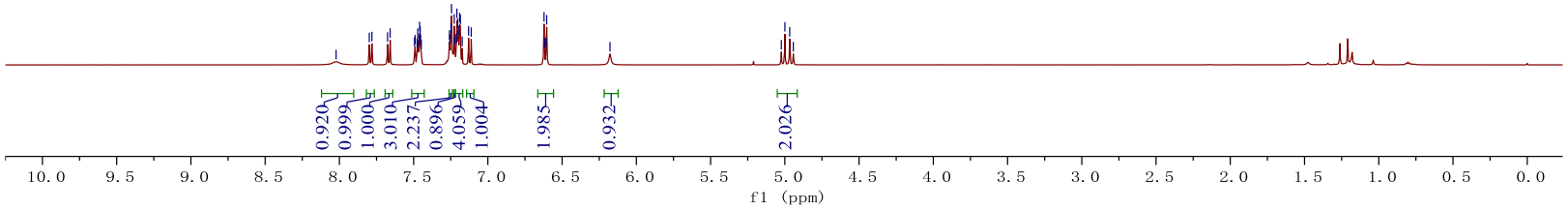
4m'

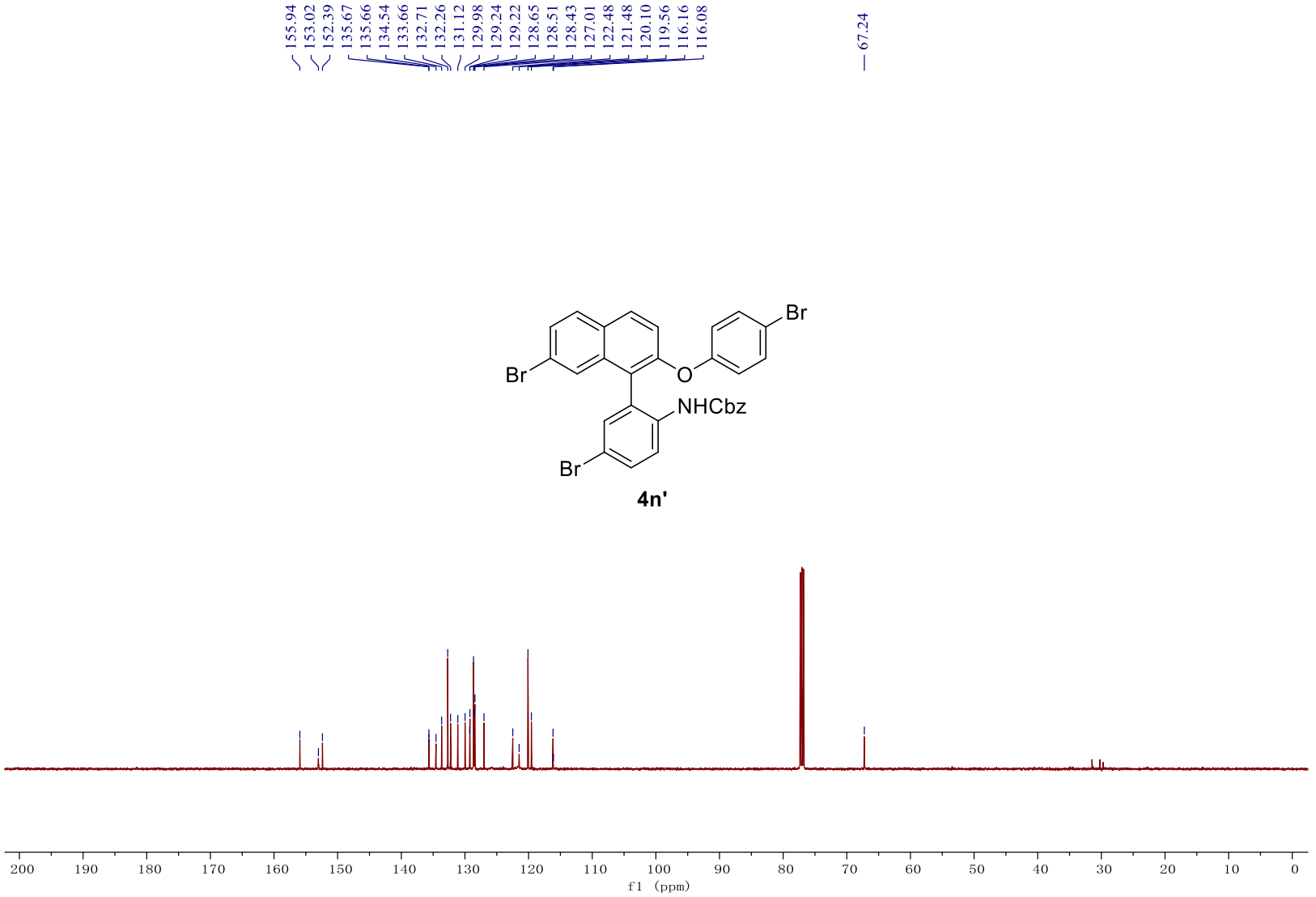

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

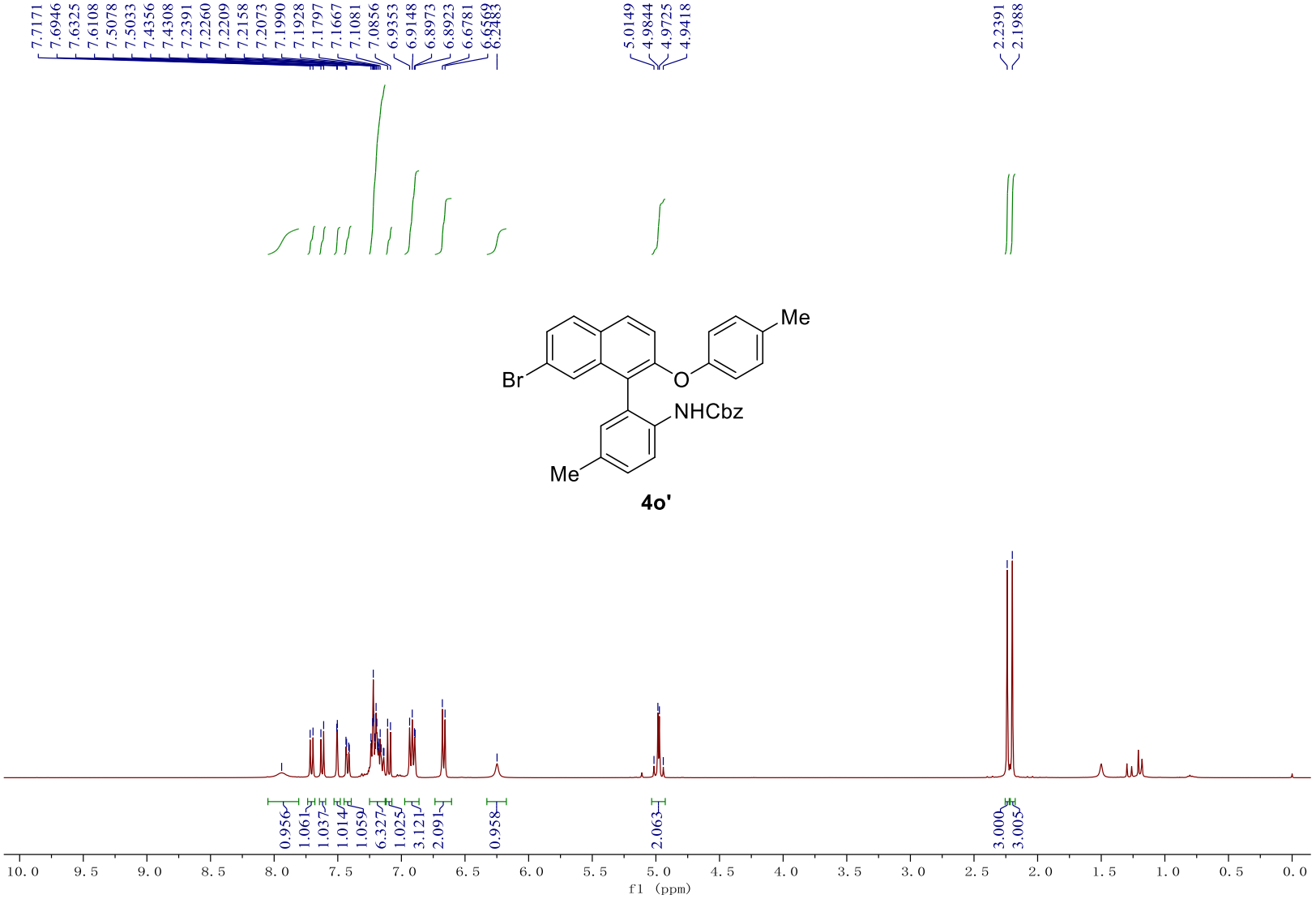

7.7988
7.7809
7.6755
7.6582
7.4900
7.4724
7.4599
7.4560
7.4529
7.2586
7.2559
7.2485
7.2449
7.2263
7.2130
7.2086
7.2031
7.1982
7.1901
7.1854
7.1302
7.1123
6.6217
6.6172
6.6083
6.6039
6.1776
5.0238
4.9996
4.9671
4.9428

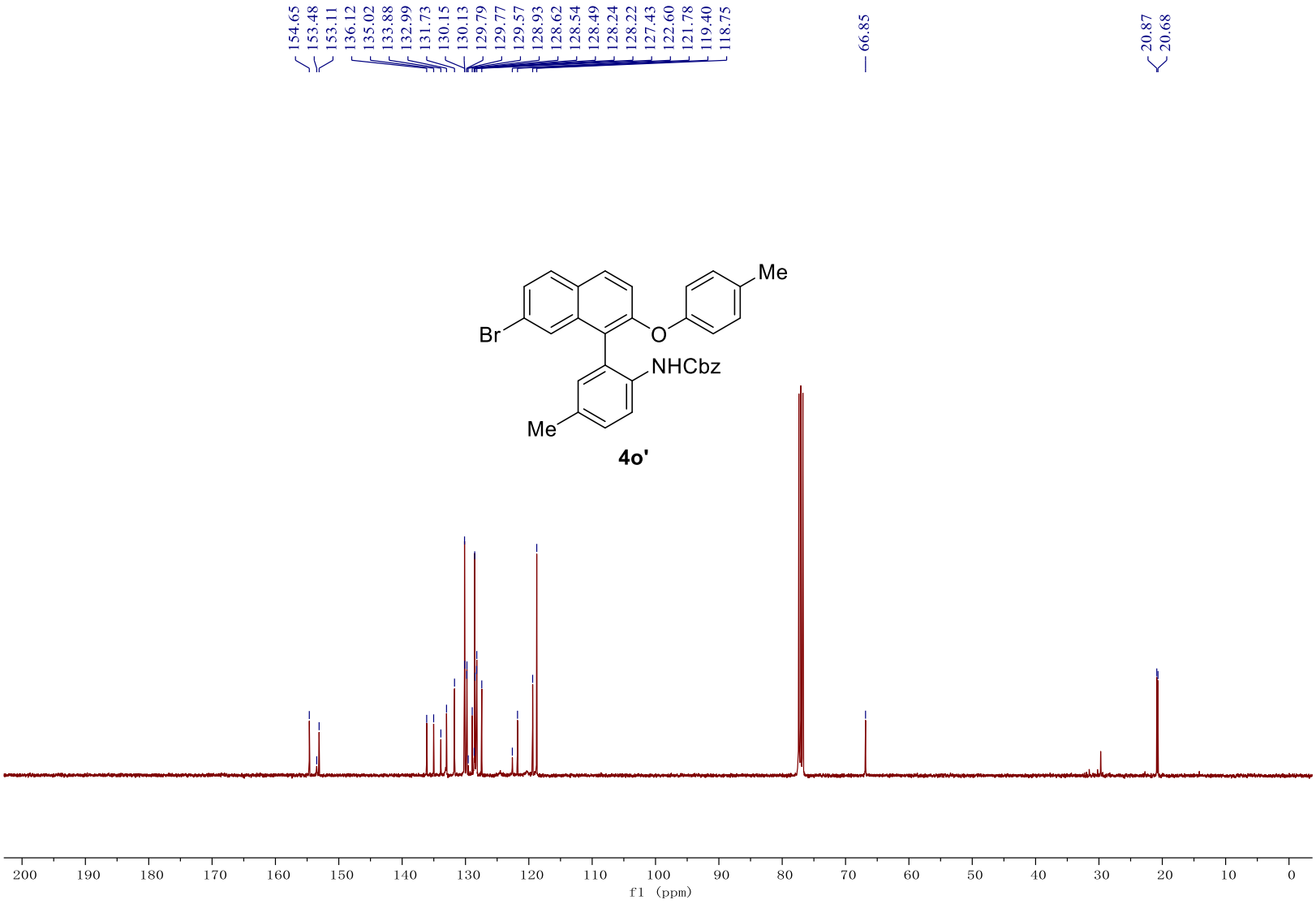

Br
Br
O
NHCbz
Br

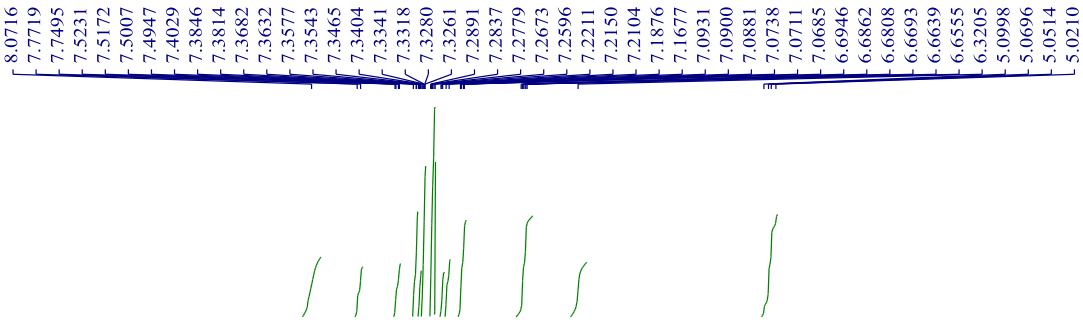
4n'


0.920
0.999
1.000
3.010
2.237
0.896
4.059
1.004
1.985
0.932
2.026
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
f1 (ppm)


155.94
153.02
152.39
135.67
135.66
134.54
133.66
132.71
132.26
131.12
129.98
129.24
129.22
128.65
128.51
128.43
127.01
122.48
121.48
120.10
119.56
116.16
116.08
67.24
Br
Br
O
NHCbz
Br
4n'
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.7171
7.6946
7.6325
7.6108
7.5078
7.5033
7.4356
7.4308
7.2391
7.2260
7.2209
7.2158
7.2073
7.1990
7.1928
7.1797
7.1667
7.1081
7.0856
6.9353
6.9148
6.8973
6.8923
6.6781
6.6562
6.6483
5.0149
4.9844
4.9725
4.9418
2.2391
2.1988
Br
O
Me
NHCbz
Me
4o'
0.956
1.061
1.037
1.014
1.059
6.327
1.025
3.121
2.091
0.958
2.063
3.000
3.005
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
f1 (ppm)


154.65
153.48
153.11
136.12
135.02
133.88
132.99
131.73
130.15
130.13
129.79
129.77
129.57
128.93
128.62
128.54
128.49
128.24
128.22
127.43
122.60
121.78
119.40
118.75
66.85
20.87
20.68
Br
O
NHCbz
Me
Me
4o'
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


8.0716
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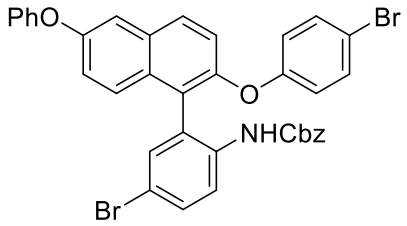
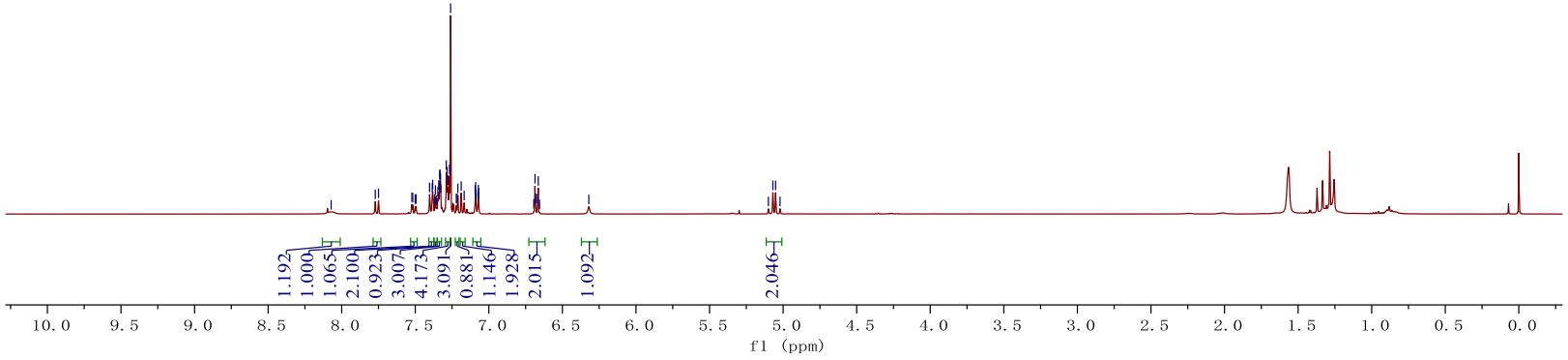
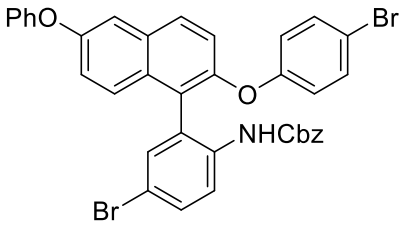
7.7495
7.5231
7.5172
7.5007
7.4947
7.4029
7.3846
7.3814
7.3682
7.3632
7.3577
7.3543
7.3465
7.3404
7.3341
7.3318
7.3280
7.3261
7.2891
7.2837
7.2779
7.2673
7.2596
7.2211
7.2150
7.2104
7.1876
7.1677
7.0931
7.0900
7.0881
7.0738
7.0711
7.0685
6.6946
6.6862
6.6808
6.6693
6.6639
6.6555
6.3205
5.0998
5.0696
5.0514
5.0210


PhO
Br
O
NHCbz
Br

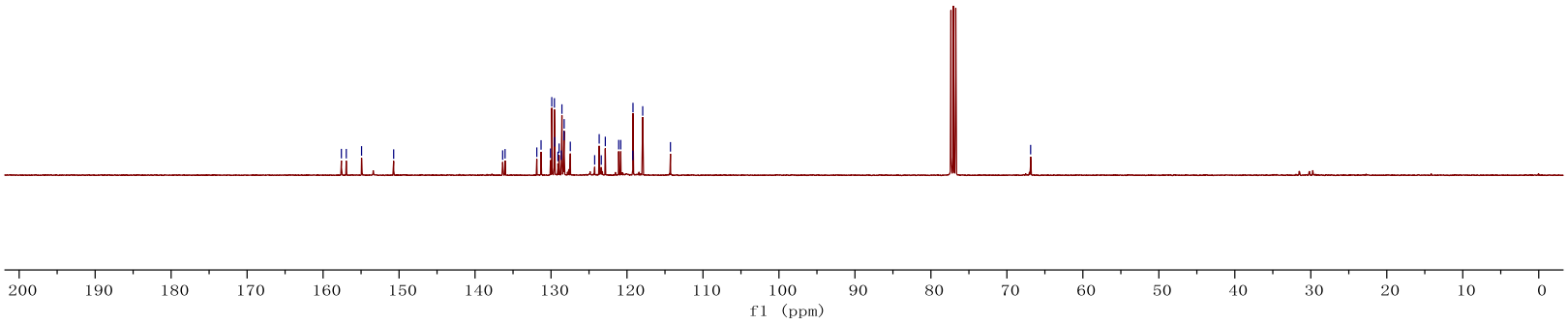
4s'

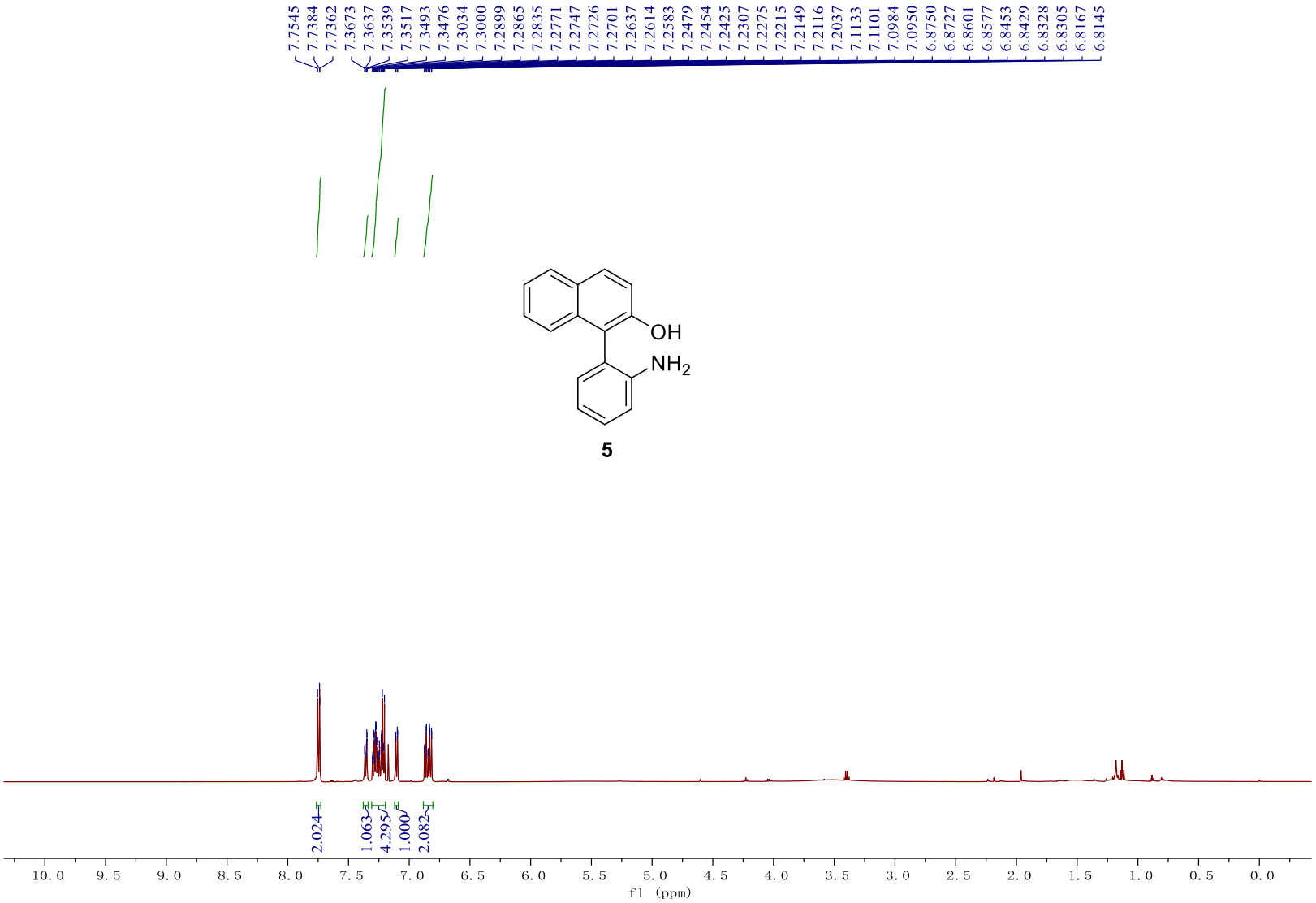

1.192
1.000
1.065
2.100
0.923
3.007
4.173
3.091
0.881
1.146
1.928
2.015
1.092
2.046
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


157.59
156.95
154.94
150.71
136.37
136.05
131.87
131.31
130.07
129.90
129.55
129.52
129.09
128.94
128.65
128.57
128.29
128.27
127.46
124.25
123.66
123.39
122.86
121.09
120.82
119.23
119.21
117.93
114.28
66.88

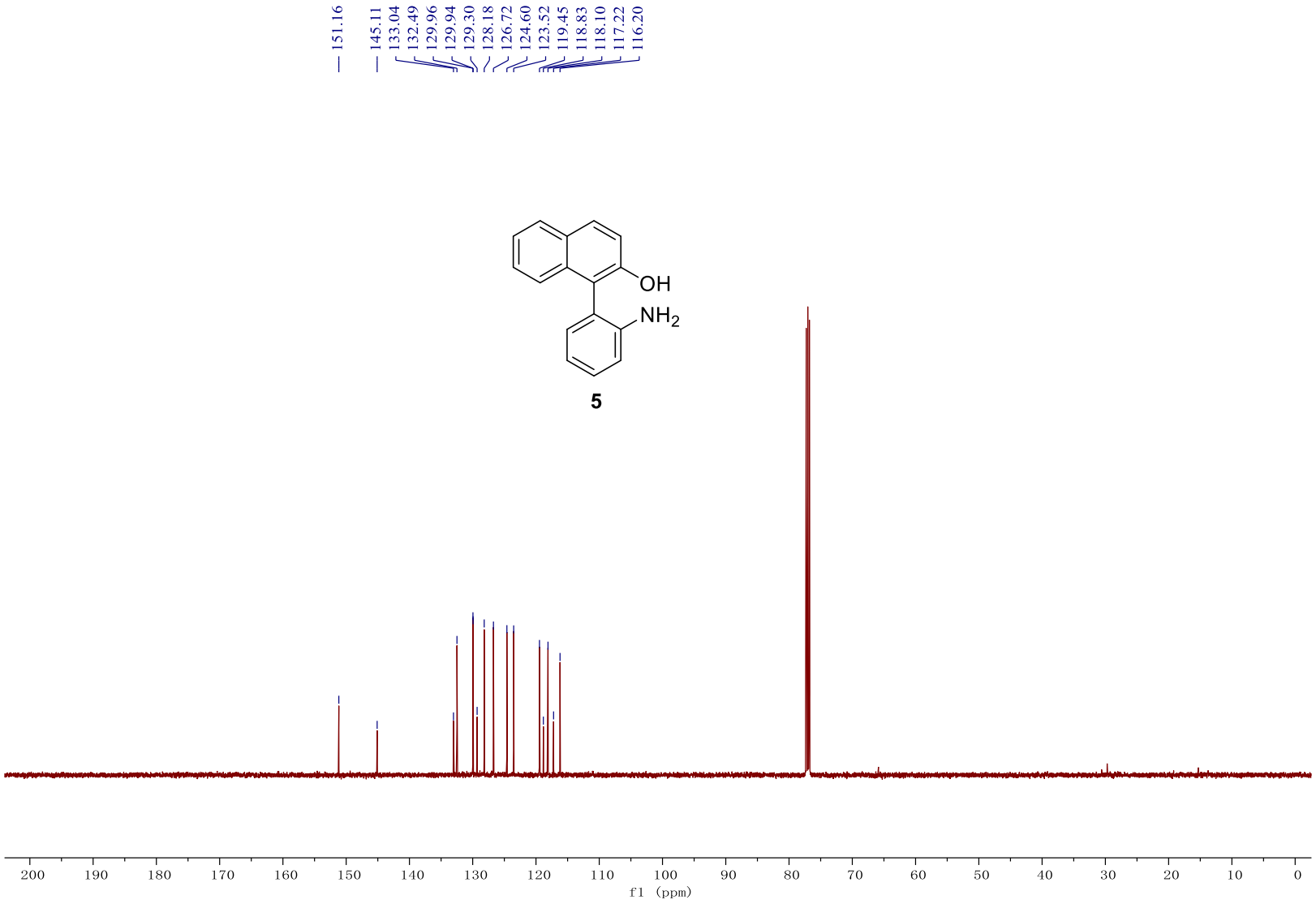

PhO
Br
O
NHCbz
Br

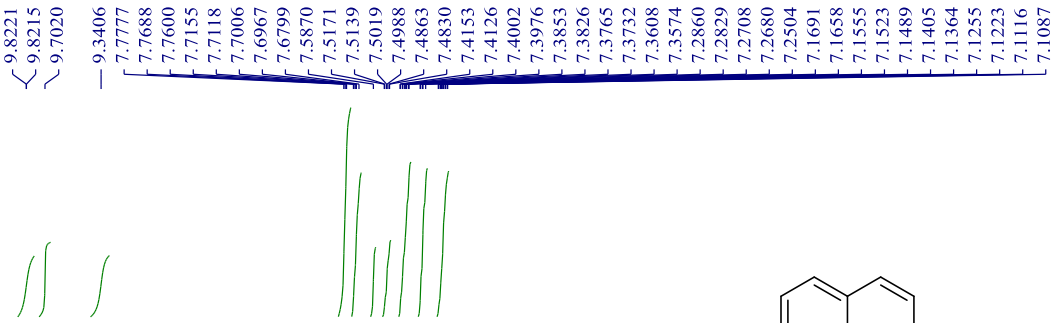
4s'


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.7545
7.7384
7.7362
7.3673
7.3637
7.3539
7.3517
7.3493
7.3476
7.3034
7.3000
7.2899
7.2865
7.2835
7.2771
7.2747
7.2726
7.2701
7.2637
7.2614
7.2583
7.2479
7.2454
7.2425
7.2307
7.2275
7.2215
7.2149
7.2116
7.2037
7.1133
7.1101
7.0984
7.0950
6.8750
6.8727
6.8601
6.8577
6.8453
6.8429
6.8328
6.8305
6.8167
6.8145
OH
NH2
2.024
1.063
4.295
1.000
2.082
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
f1 (ppm)

5


151.16
145.11
133.04
132.49
129.96
129.94
129.30
128.18
126.72
124.60
123.52
119.45
118.83
118.10
117.22
116.20
OH
NH2
5
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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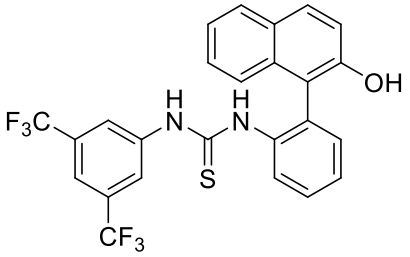
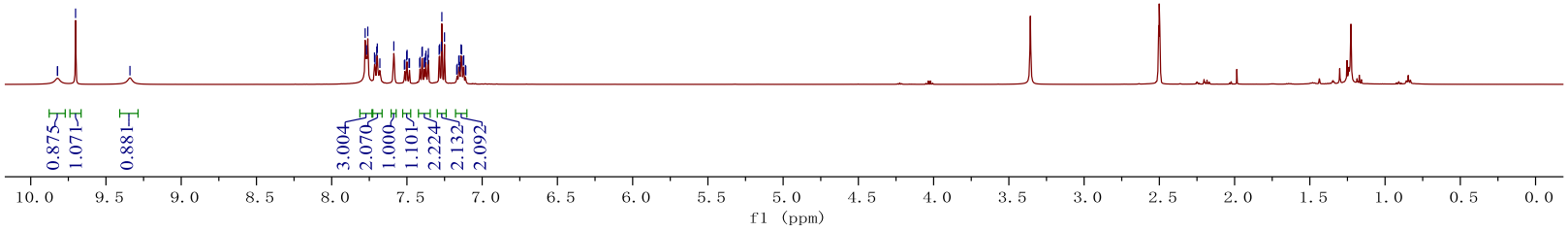
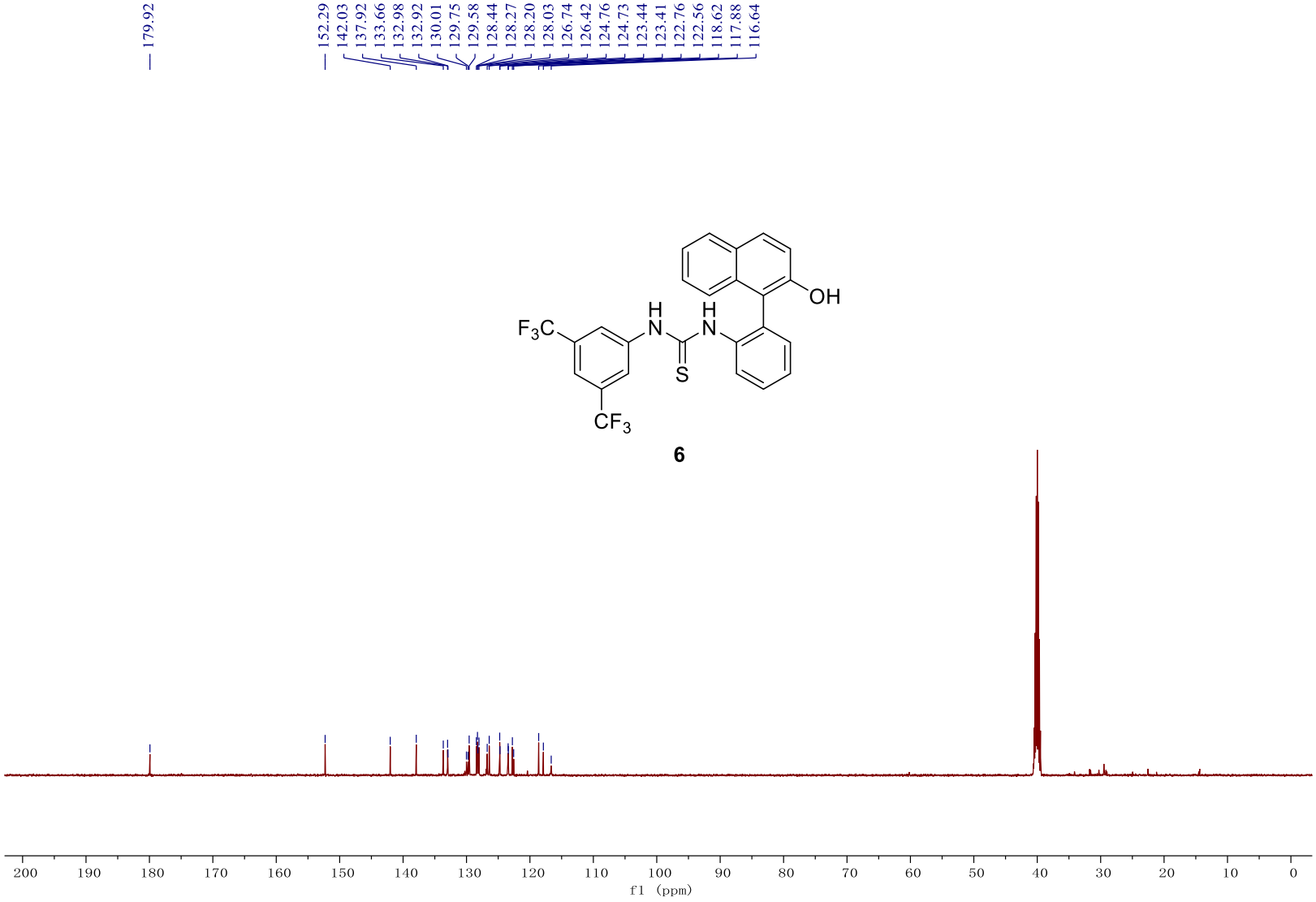
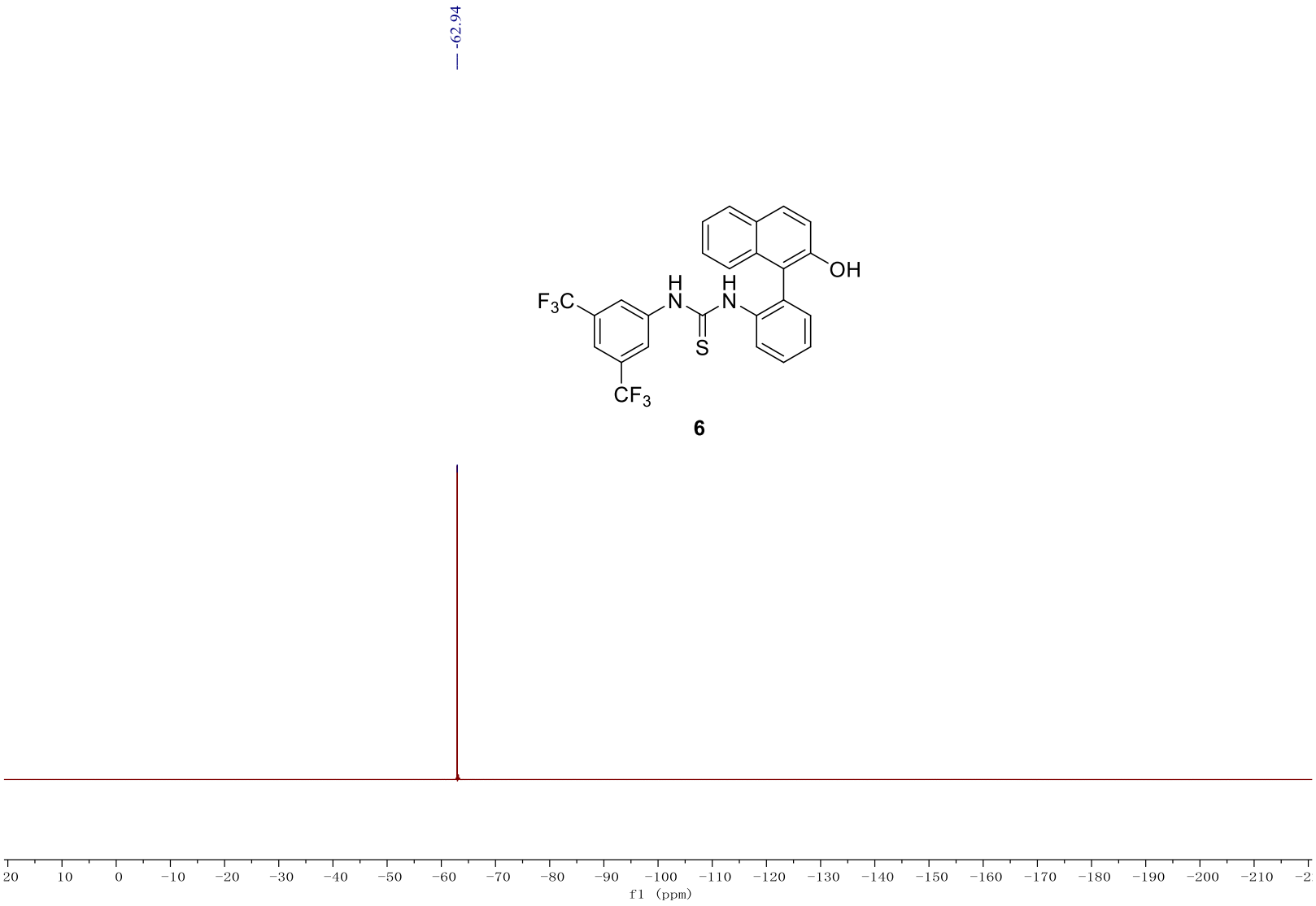
9.8215
9.7020
9.3406
7.7777
7.7688
7.7600
7.7155
7.7118
7.7006
7.6967
7.6799
7.5870
7.5171
7.5139
7.5019
7.4988
7.4863
7.4830
7.4153
7.4126
7.4002
7.3976
7.3853
7.3826
7.3765
7.3732
7.3608
7.3574
7.2860
7.2829
7.2708
7.2680
7.2504
7.1691
7.1658
7.1555
7.1523
7.1489
7.1405
7.1364
7.1255
7.1223
7.1116
7.1087

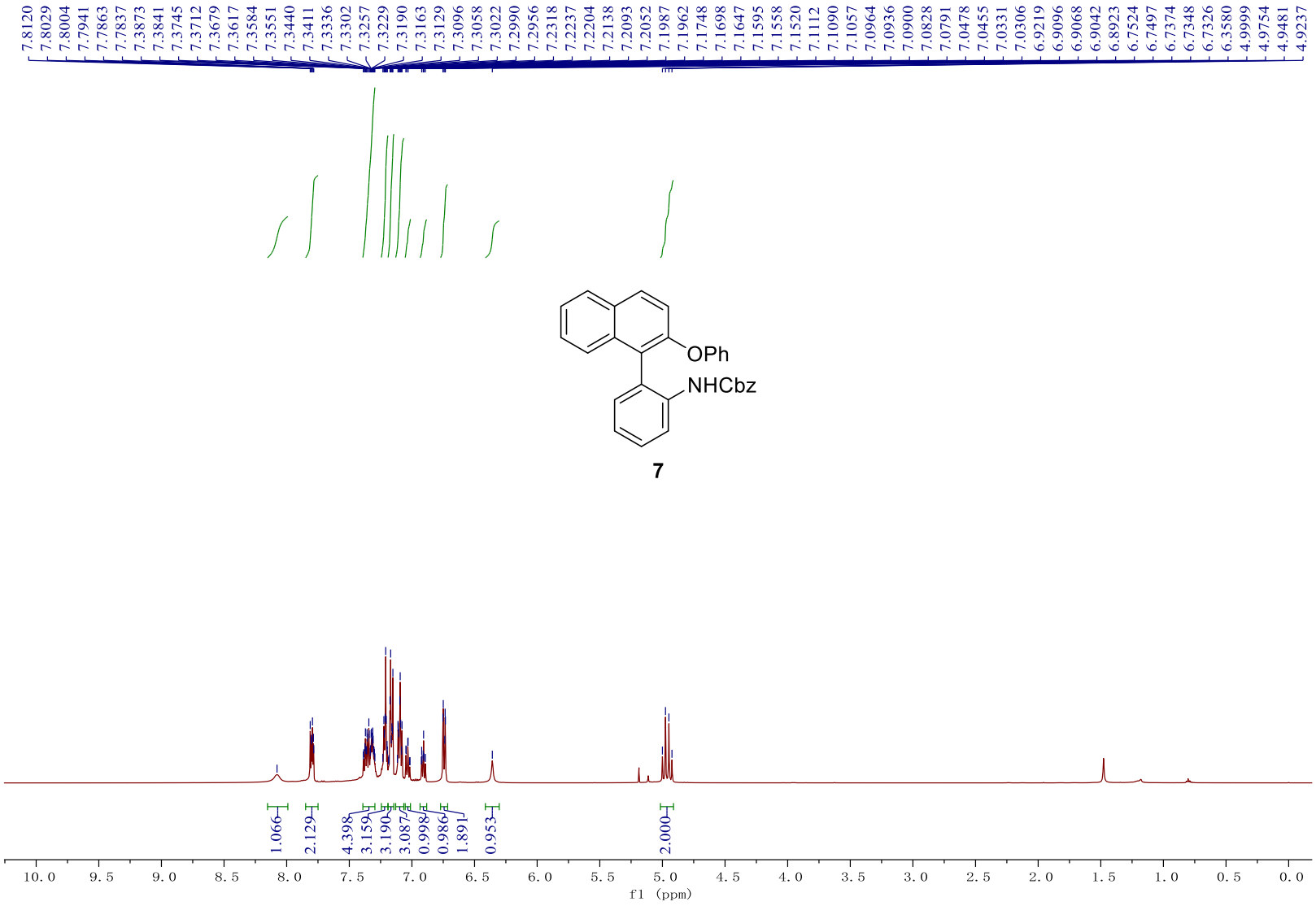

OH
H
N
H
N
S
F3C
CF3

6


0.875
1.071
0.881
3.004
2.070
1.000
1.101
2.224
2.132
2.092
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
f1 (ppm)


179.92
152.29
142.03
137.92
133.66
132.98
132.92
130.01
129.75
129.58
128.44
128.27
128.20
128.03
126.74
126.42
124.76
124.73
123.44
123.41
122.76
122.56
118.62
117.88
116.64
OH
H
N
H
N
S
F3C
CF3
6
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


-62.94
F3C
H
N
H
N
S
OH
CF3
6
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)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7.8029
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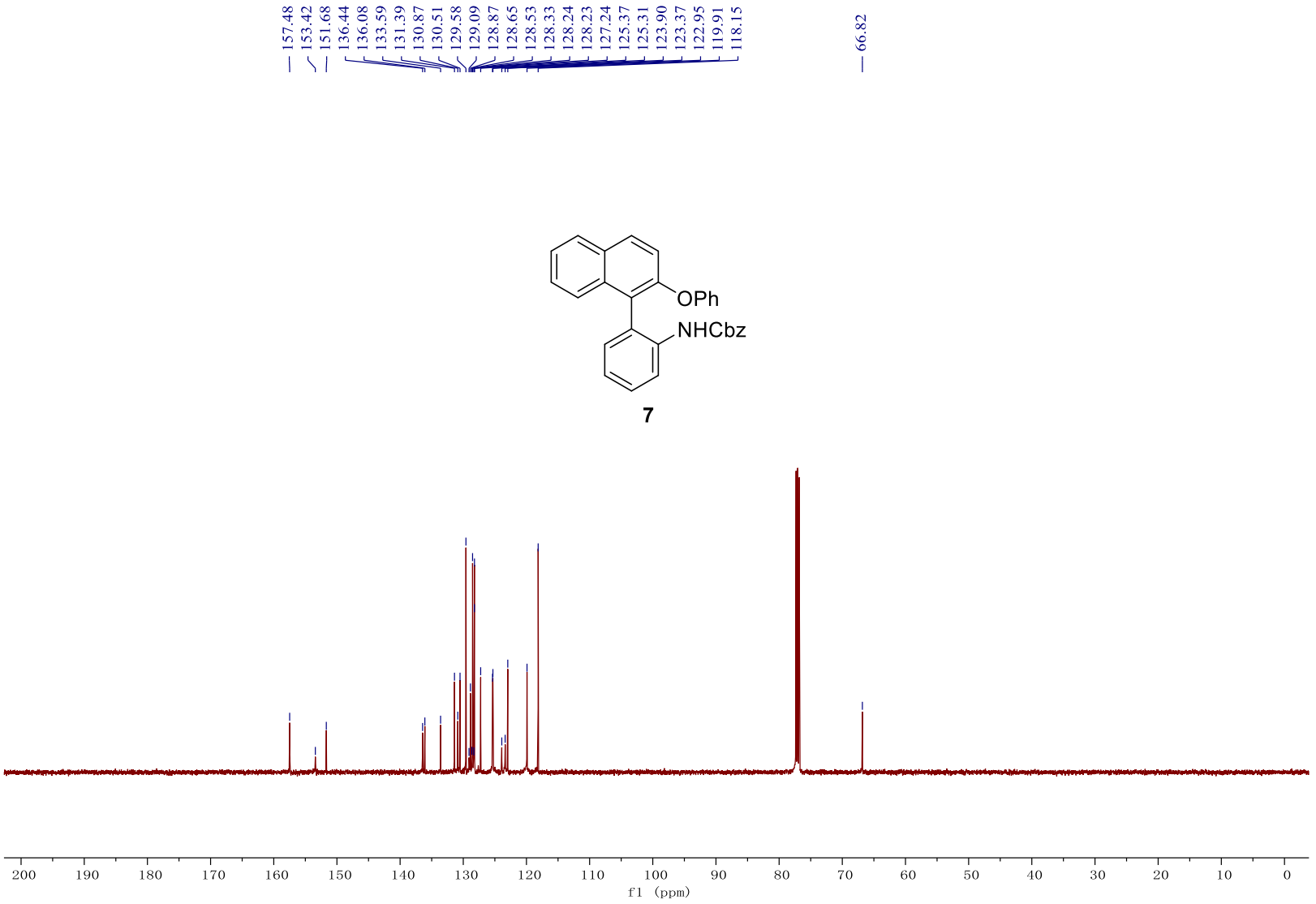
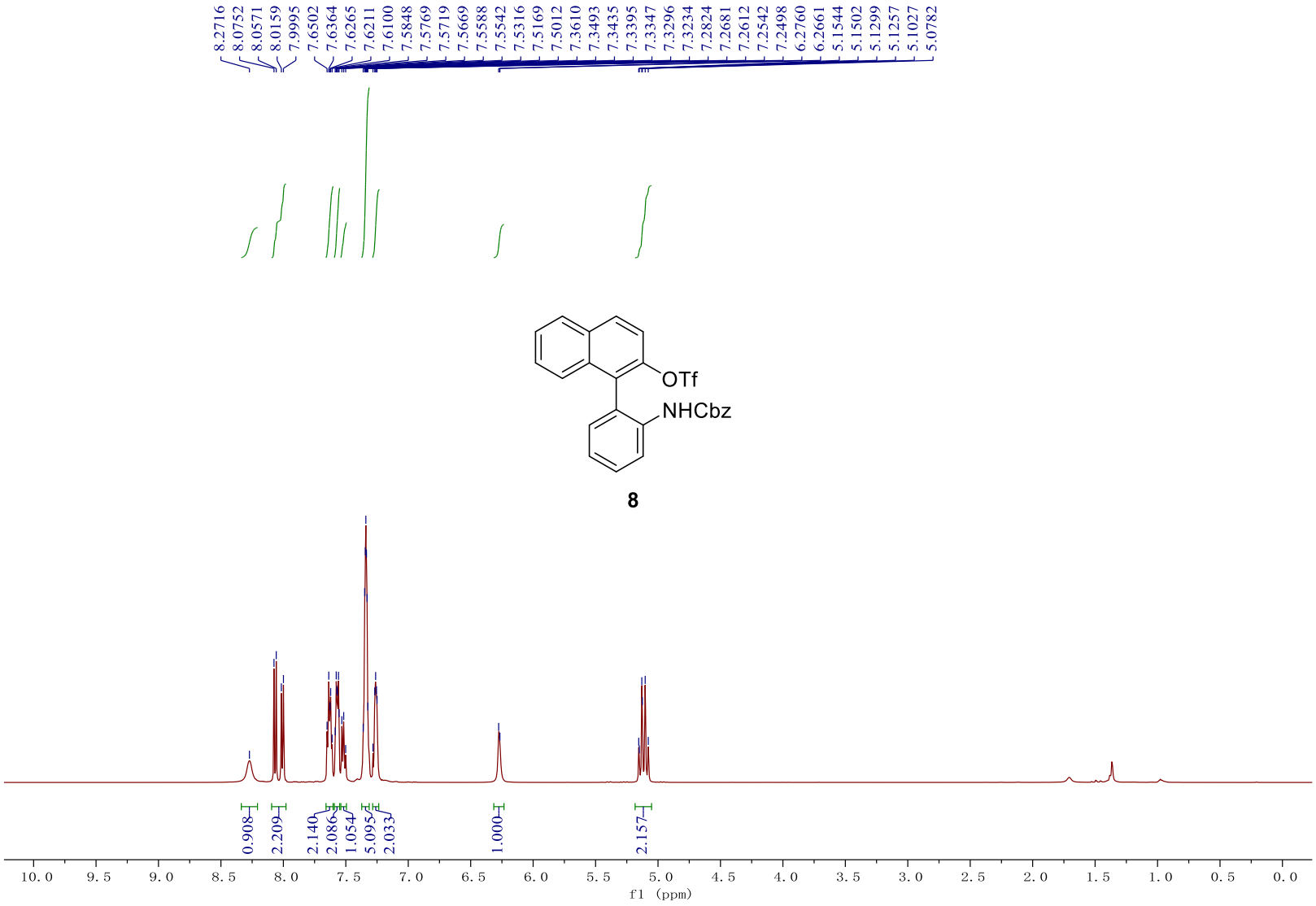
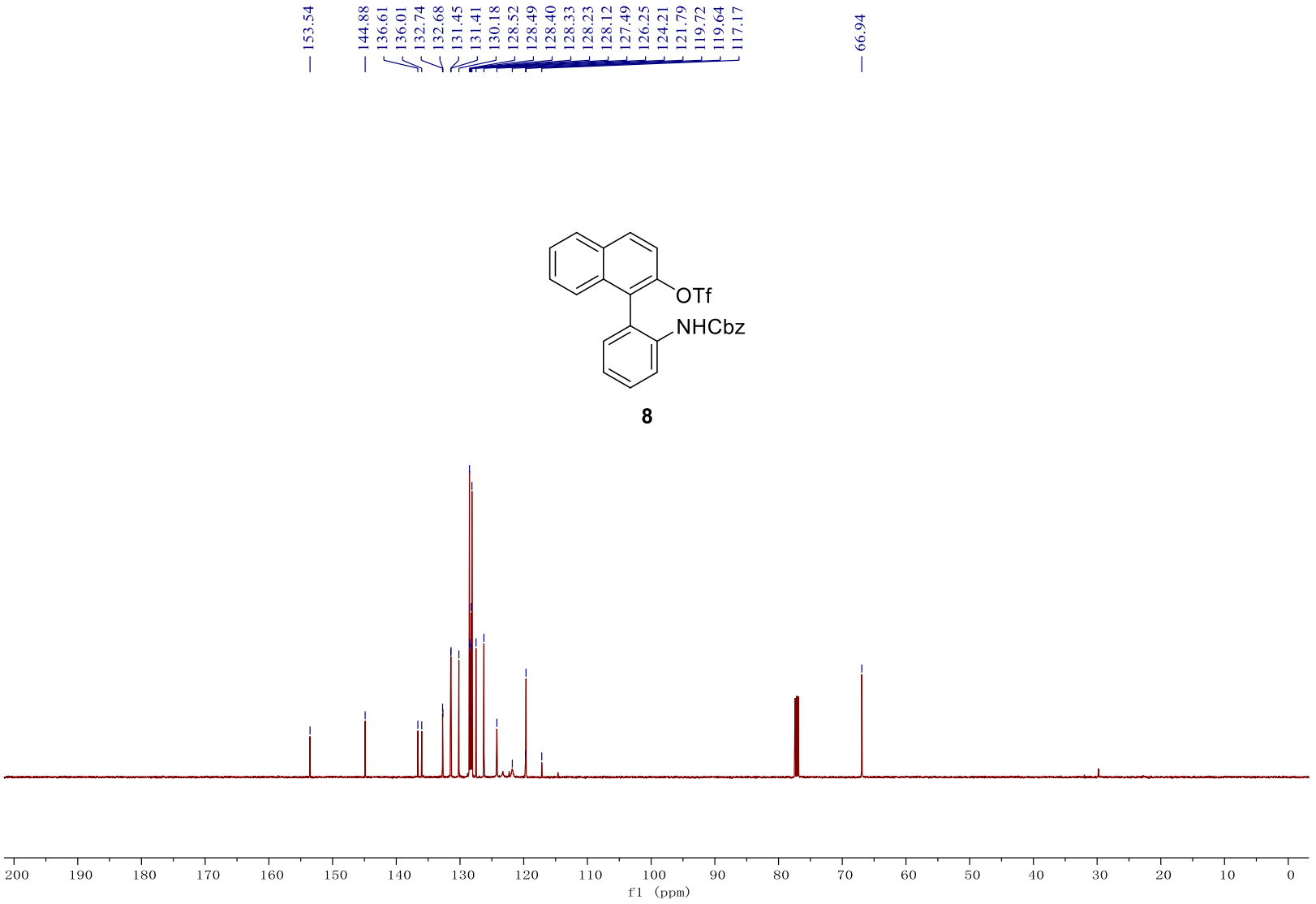
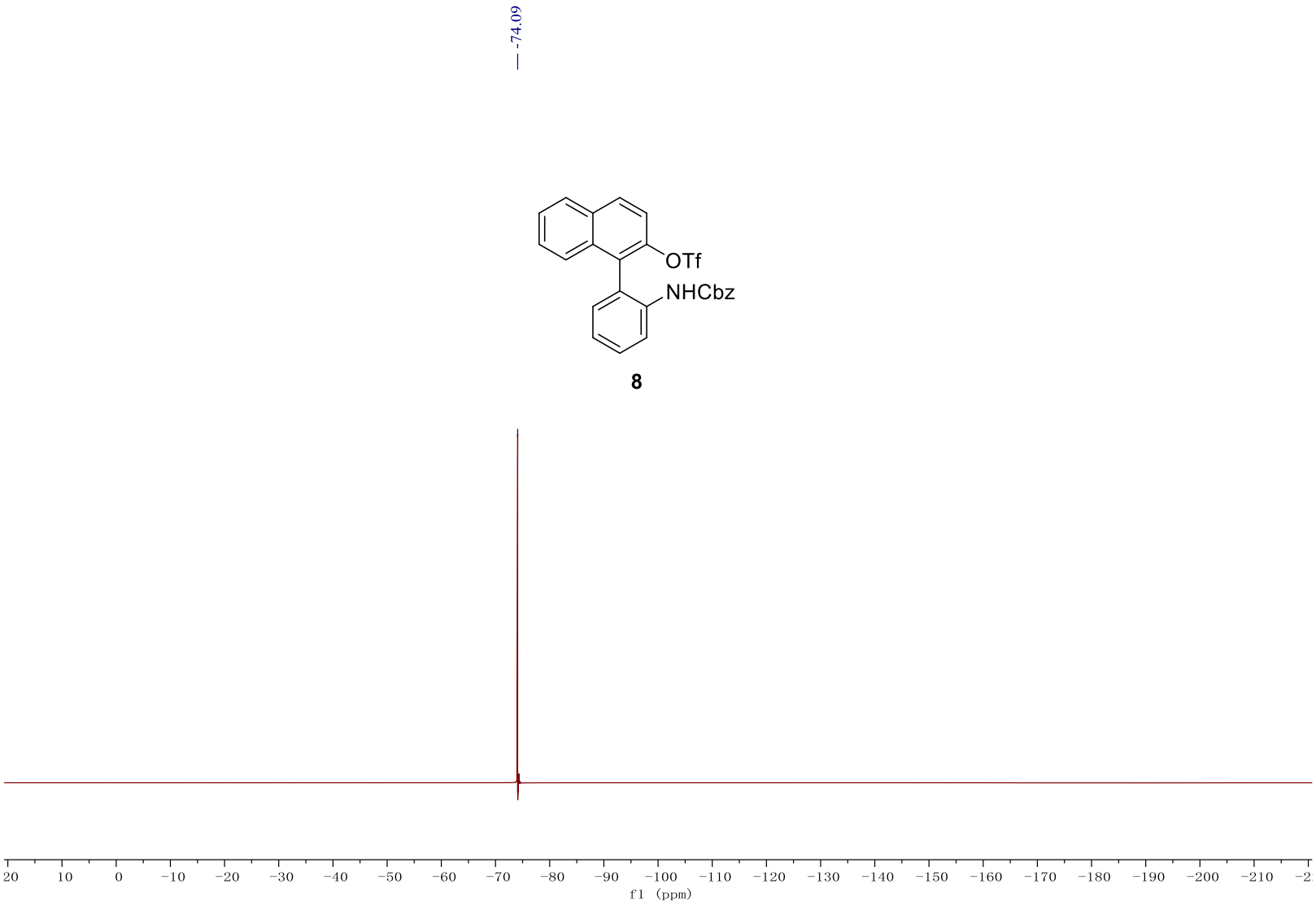
7.3873
7.3841
7.3745
7.3712
7.3679
7.3617
7.3584
7.3551
7.3440
7.3411
7.3336
7.3302
7.3257
7.3229
7.3190
7.3163
7.3129
7.3096
7.3058
7.3022
7.2990
7.2956
7.2318
7.2237
7.2204
7.2138
7.2093
7.2052
7.1987
7.1962
7.1748
7.1698
7.1647
7.1595
7.1558
7.1520
7.1112
7.1090
7.1057
7.0964
7.0936
7.0900
7.0828
7.0791
7.0478
7.0455
7.0331
7.0306
6.9219
6.9096
6.9068
6.9042
6.8923
6.7524
6.7497
6.7374
6.7348
6.7326
6.3580
4.9999
4.9754
4.9481
4.9237
OPh
NHCbz
7
1.066
2.129
4.398
3.159
3.190
3.087
0.998
0.986
1.891
0.953
2.000
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
f1 (ppm)


157.48
153.42
151.68
136.44
136.08
133.59
131.39
130.87
130.51
129.58
129.09
128.87
128.65
128.53
128.33
128.24
128.23
127.24
125.37
125.31
123.90
123.37
122.95
119.91
118.15
66.82
OPh
NHCbz
7
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

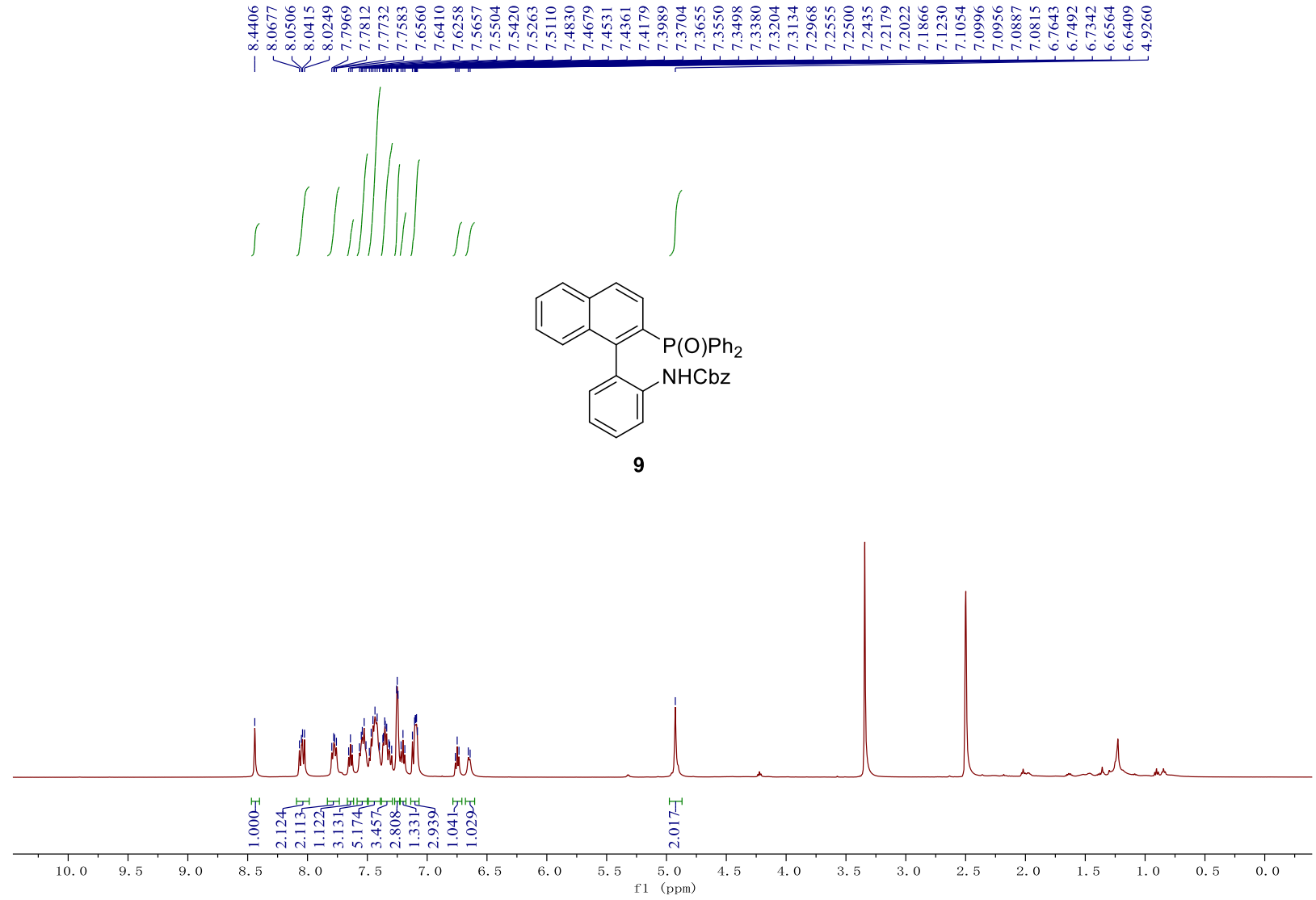

8.2716
8.0752
8.0571
8.0159
7.9995
7.6502
7.6364
7.6265
7.6211
7.6100
7.5848
7.5769
7.5719
7.5669
7.5588
7.5542
7.5316
7.5169
7.5012
7.3610
7.3493
7.3435
7.3395
7.3347
7.3296
7.3234
7.2824
7.2681
7.2612
7.2542
7.2498
6.2760
6.2661
5.1544
5.1502
5.1299
5.1257
5.1027
5.0782
OTf
NHCbz
0.908
2.209
2.140
2.086
1.054
5.095
2.033
1.000
2.157
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
f1 (ppm)

8

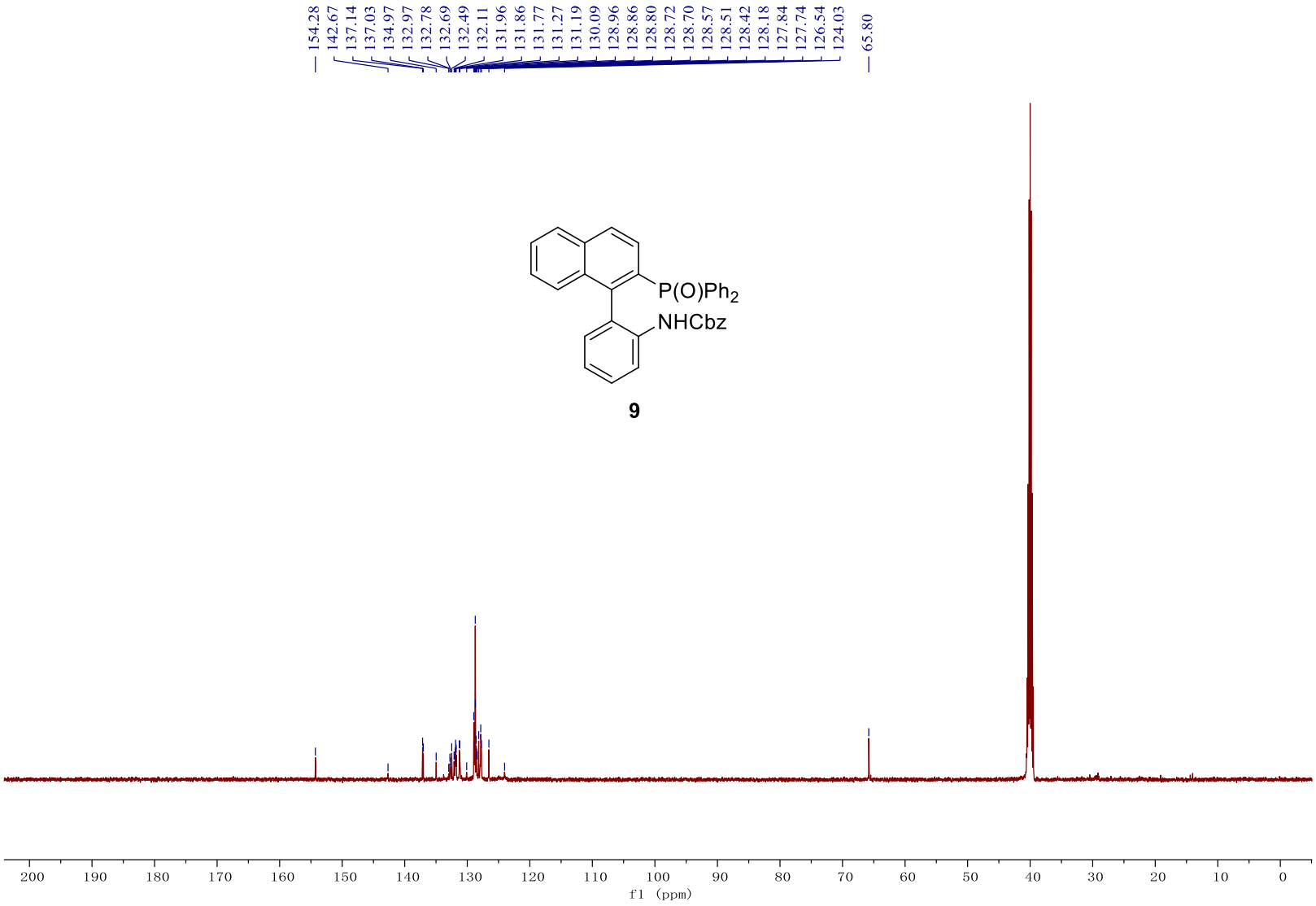

153.54
144.88
136.61
136.01
132.74
132.68
131.45
131.41
130.18
128.52
128.49
128.40
128.33
128.23
128.12
127.49
126.25
124.21
121.79
119.72
119.64
117.17
66.94
OTf
NHCbz
8
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

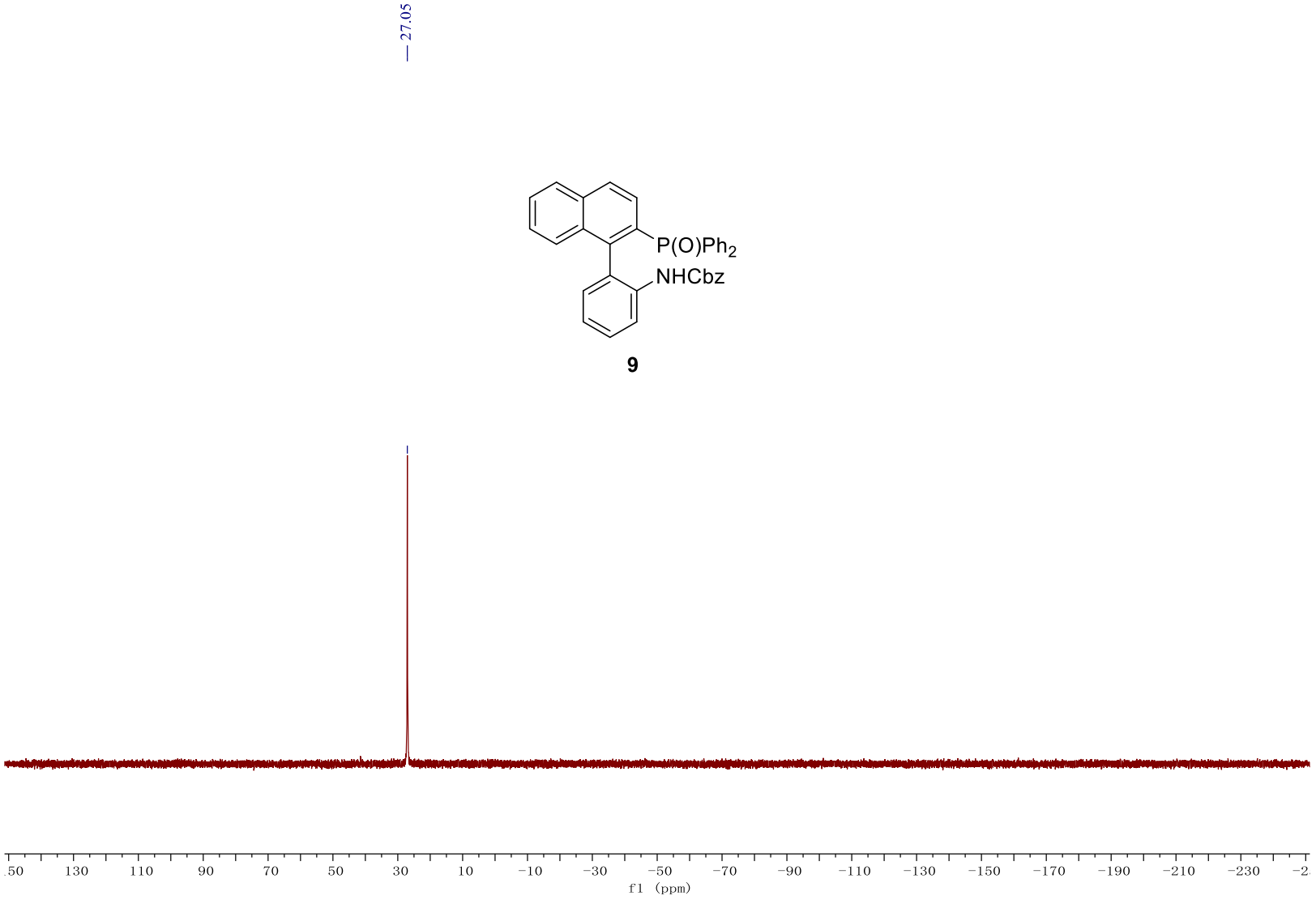

-74.09
OTf
NHCbz
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

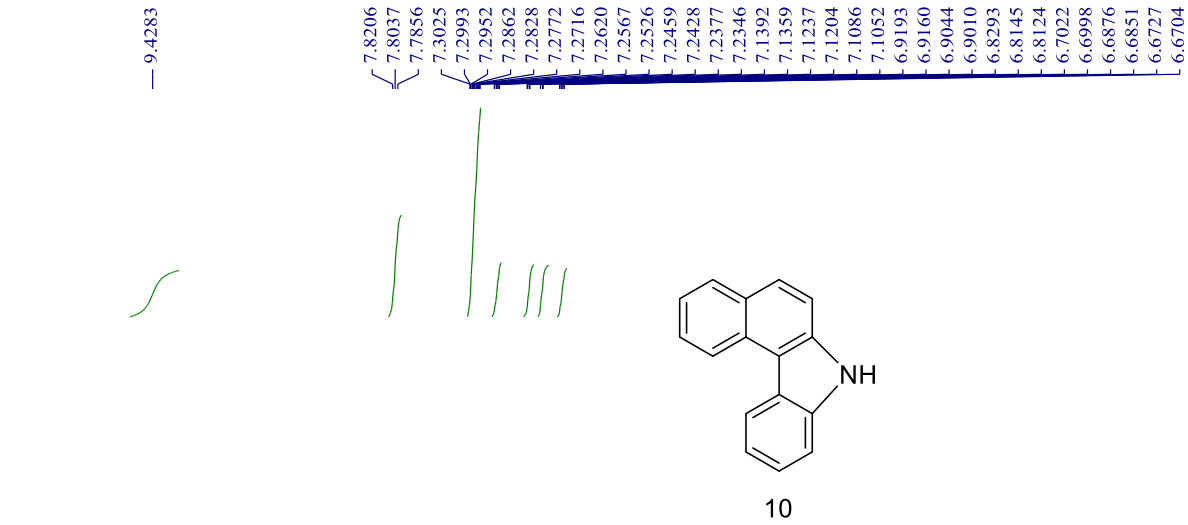
8


8.4406
8.0677
8.0506
8.0415
8.0249
7.7969
7.7812
7.7732
7.7583
7.6560
7.6410
7.6258
7.5657
7.5504
7.5420
7.5263
7.5110
7.4830
7.4679
7.4531
7.4361
7.4179
7.3989
7.3704
7.3655
7.3550
7.3498
7.3380
7.3204
7.3134
7.2968
7.2555
7.2500
7.2435
7.2179
7.2022
7.1866
7.1230
7.1054
7.0996
7.0956
7.0887
7.0815
6.7643
6.7492
6.7342
6.6564
6.6409
4.9260
P(O)Ph2
NHCbz
1.000
2.124
2.113
1.122
3.131
5.174
3.457
2.808
1.331
2.939
1.041
1.029
2.017
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
f1 (ppm)

9


154.28
142.67
137.14
137.03
134.97
132.97
132.78
132.69
132.49
132.11
131.96
131.86
131.77
131.27
131.19
130.09
128.96
128.86
128.80
128.72
128.70
128.57
128.51
128.42
128.18
127.84
127.74
126.54
124.03
65.80
P(O)Ph2
NHCbz
9
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


27.05
P(O)Ph2
NHCbz
9
.50
130
110
90
70
50
30
10
−10
−30
−50
−70
−90
−110
−130
−150
−170
−190
−210
−230
f1 (ppm)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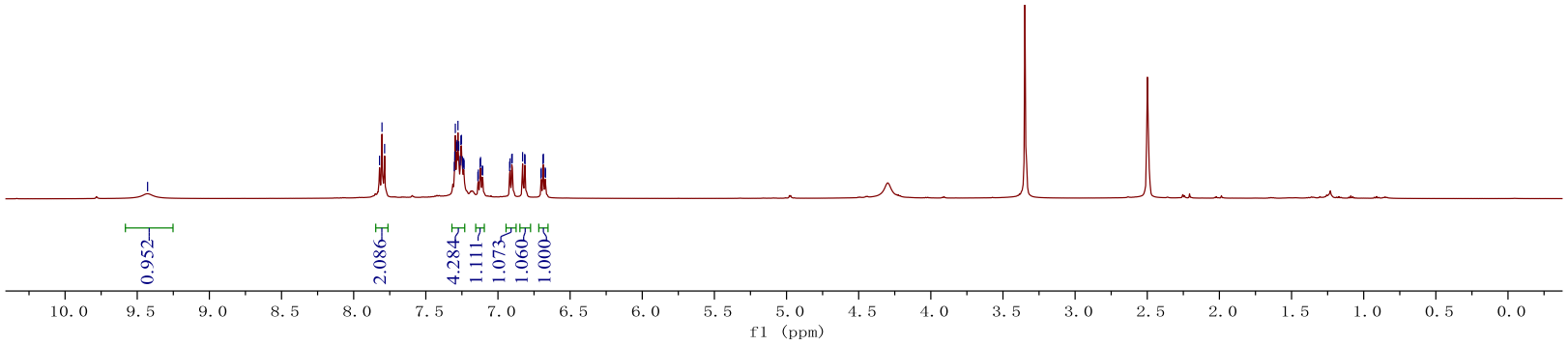
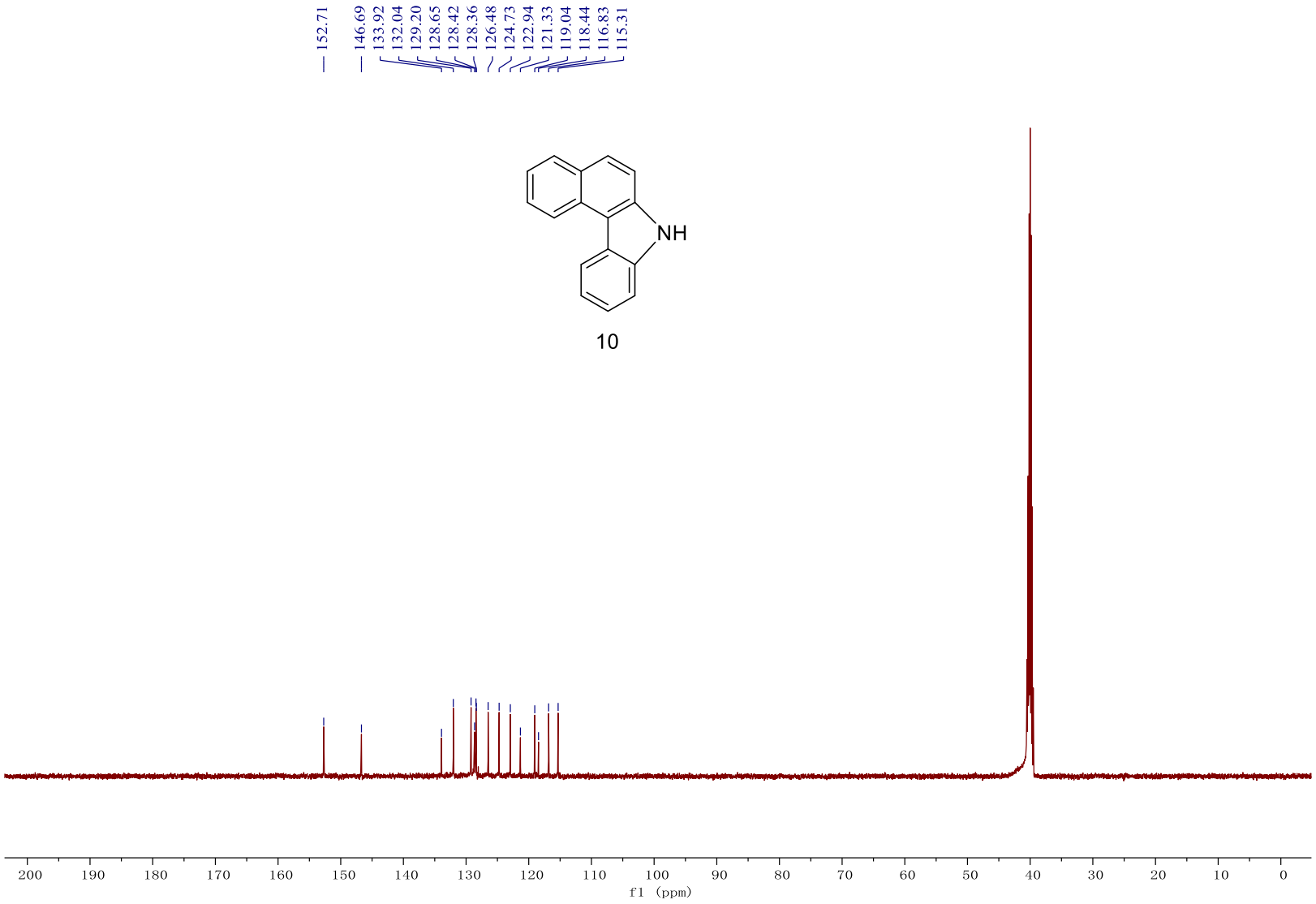
7.8037
7.7856
7.3025
7.2993
7.2952
7.2862
7.2828
7.2772
7.2716
7.2620
7.2567
7.2526
7.2459
7.2428
7.2377
7.2346
7.1392
7.1359
7.1237
7.1204
7.1086
7.1052
6.9193
6.9160
6.9044
6.9010
6.8293
6.8145
6.8124
6.7022
6.6998
6.6876
6.6851
6.6727
6.6704
NH

10


0.952
2.086
4.284
1.111
1.073
1.060
1.000
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
f1 (ppm)


152.71
146.69
133.92
132.04
129.20
128.65
128.42
128.36
126.48
124.73
122.94
121.33
119.04
118.44
116.83
115.31
NH
10
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)