Enantio- and Regioselective CuH-Catalyzed Hydroamination of Alkenes

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Supporting Information

Contents

1. General Information. Commercial reagents were purified prior to use following the guidelines of Perrin and Armarego.[1] All solvents were purified according to the method of Grubbs.[2] Organic solutions were concentrated under reduced pressure on a Büchi rotary evaporator. Chromatographic purification of products was accomplished using force-flow chromatography on Silicycle silica gel according to the method of Still.[3] Thin-layer chromatography (TLC) was performed on Silicycle 250 μm silica gel plates. Compounds were visualized by irradiation with UV light, I_2, or by treatment with a solution of phosphomolybdic acid in ethanol followed by heating. Yields refer to pure compounds, unless otherwise indicated.

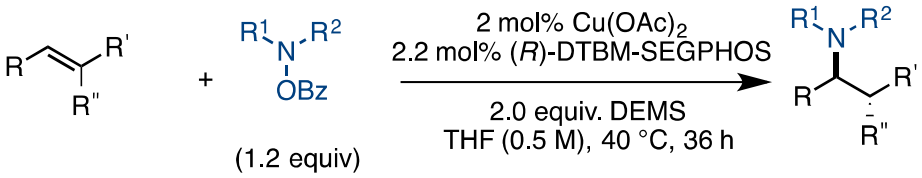
^{1}H NMR spectra were recorded on a Bruker 400 and are referenced relative to residual $CDCl_3$ proton signals at δ 7.26 ppm. ^{19}F NMR spectra were recorded on a Bruker 400 and are referenced relative to $CFCl_3$ (δ 0.0 ppm). Data for ^{1}H and ^{19}F NMR are reported as follows: chemical shift (δ ppm), multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, h = heptet, m = multiplet, ap = apparent), integration, coupling constant (Hz) and assignment. ^{13}C spectra were recorded on a Bruker 400 and are referenced relative to $CDCl_3$ at δ 77.16 ppm. Data for ^{13}C NMR are reported in terms of chemical shift and multiplicity where appropriate. IR spectra were recorded on a Thermo Scientific Nicolet iS5 spectrometer (iD5 ATR, diamond) and are reported in terms of frequency of absorption (cm^{-1}). GC analyses were performed on an Agilent 6890 gas chromatograph with an FID detector using a J & W DB-1 column (10 m, 0.1 mm I.D.). Elemental analyses were performed by Atlantic Microlabs Inc., Norcross, GA. High Resolution Mass spectra were obtained from on a Bruker Daltonics APEXIV 4.7 Tesla Fourier transform ion cyclotron resonance mass spectrometer (FT-ICR-MS). High pressure liquid chromatography (HPLC) was performed on Hewlett-Packard 1100 Series chromatographs using a chiral column (25 cm) and guard column (5 cm) as noted for each compound. Optical rotations were measured on a Jasco P-1010 polarimeter with $[\alpha]_D$ values reported in degrees; concentration (c) is in g/100 mL. For *N*-(1-

(1) Perrin, D. D.; Armarego, W. L. F. *Purification of Laboratory Chemicals.* 3rd ed., Pergamon Press, Oxford, 1988.
(2) Pangborn, A. B.; Giardello, M. A.; Grubbs, R. H.; Rosen, R. K.; Timmers, F. J. *Organometallic.* **1996**, *15*, 1518.
(3) Still, W. C.; Kahn, M.; Mitra, A. J. *J. Org. Chem.* **1978**, *43*, 2923.

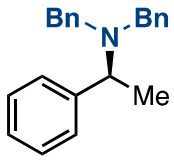
phenylethyl)amine (**3r, u**), the enantiomeric excesses were determined by ^{1}H NMR analysis using our previously published procedure.[4]

2. CuH-Catalyzed Hydroamination of Alkenes

General Procedure for CuH-Catalyzed Hydroamination of Styrenes and Alkenes.



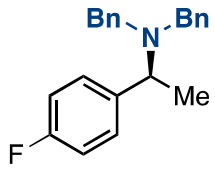
General procedure for the enantioselective CuH catalyzed hydroamination of styrenes: In a glove-box, $Cu(OAc)_2$ (3.6 mg, 2 mol%) and (*R*)-DTBM-SEGPHOS (25.9 mg, 2.2 mol%) were added to a screw-cap test tube. The tube was then sealed and taken out from the glove-box and THF (2.0 mL, 0.5 M) was added. The mixture was stirred for 15 min, then DEMS (diethoxymethylsilane, 270 mg, 320 μL, 2.0 equiv.) was added dropwise and the stirring was continued for another 10 min at rt before being added by a syringe to another screw-cap test tube containing styrene (104 mg, 1.0 mmol, 1.0 equiv.) and *O*-benzoyl-*N*, *N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv.). The reaction tube was stirred at 40°C for 36 h. The reaction mixture was diluted with EtOAc, quenched with 2 mL Na_2CO_3 solution. Dodecane (100 μL) was added as the internal standard for GC yield determination. The product was purified by chromatography on silica gel (5-10% EtOAc/hexane).



(*S*)-*N*,*N*-dibenzyl-1-phenylethan-1-amine (Table 2, entry 3a). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, styrene (104 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol,

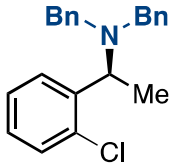
[4] Lee, N. E.; Buchwald, S. L. *J. Am. Chem. Soc.* **1994**, *116*, 5985−5986.

1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a liquid in 95% and 86% yield. IR (thin film) 3028, 2820, 1493, 1452, 1123, 1027, 742, 695 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.46 – 7.18 (m, 15H), 3.94 (q, *J* = 6.9 Hz, 1H), 3.63 (d, *J* = 14.0 Hz, 2H), 3.48 (d, *J* = 13.6 Hz, 2H), 1.46 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 142.86, 140.56, 128.77, 128.31, 128.15, 128.08, 126.85, 126.83, 56.30, 53.71, 13.91. HRMS (DART-TOF) calculated for $C_{22}H_{23}N$ $[M+H]^+$ m/z 302.1903, found 302.1901. Anal. Calcd. for $C_{22}H_{23}N$: C, 87.66; H, 7.69. Found: C, 87.64; H, 7.79. $[\alpha]_D^{25}$ = –97.1 (c = 1.29, $CHCl_3$); HPLC analysis (OD-H, 3% IPA/hexane, 0.8 mL/min, 220 nm) indicated 97% ee: t_R (major) = 4.8 minutes, t_R (minor) = 5.4 minutes.

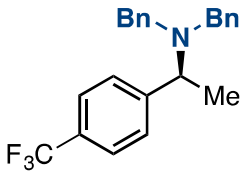


(R)-N,N-dibenzyl-1-(4-fluorophenyl)ethan-1-amine (Table 2, entry 3b). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, 4-fluorostyrene (122.1 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a liquid in 86% and 85% yield. IR (thin film) 1602, 1506, 1453, 1221, 807, 740, 697 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.44 – 7.37 (m, 6H), 7.36 – 7.30 (m, 4H), 7.28 – 7.21 (m, 2H), 7.05 (t, *J* = 8.7 Hz, 2H), 3.93 (q, *J* = 6.9 Hz, 1H), 3.60 (d, *J* = 13.8 Hz, 2H), 3.49 (d, *J* = 13.8 Hz, 2H), 1.45 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 161.84 (d, *J* = 244.6 Hz), 140.37, 138.72 (d, *J* = 3.0 Hz), 129.54 (d, *J* = 7.8 Hz), 128.75, 128.36, 126.95, 114.80 (d, *J* = 20.9 Hz), 55.53, 53.60, 13.49; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -116.43; HRMS (ESI-TOF) calculated for $C_{22}H_{22}FN$ $[M+H]^+$ m/z 320.1809, found 320.1807. Anal. Calcd. for $C_{26}H_{25}N$: C, 82.72; H, 6.94. Found: C, 82.54; H, 6.82. $[\alpha]_D^{25}$ = –79.6 (c = 1.10, $CHCl_3$);

HPLC analysis (OD-H, 5% IPA/hexane, 0.8 mL/min, 220 nm) indicated 97% ee: t_R (major) = 4.8 minutes, t_R (minor) = 5.5 minutes.

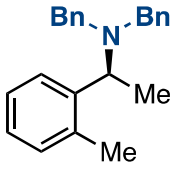


(R)-N,N-dibenzyl-1-(2-chlorophenyl)ethan-1-amine (Table 2, entry 3c). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, 2-chlorostyrene (138.6 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a white solid in 79 % and 92% yield. m.p. 67-68°C. IR (thin film, $CHCl_3$) 3025, 2802, 1493, 1453, 1367, 1035, 746, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.78 (dd, *J* = 7.8, 1.7 Hz, 1H), 7.48 – 7.41 (m, 5H), 7.41 – 7.33 (m, 5H), 7.33 – 7.27 (m, 2H), 7.27 – 7.21 (m, 1H), 4.51 (q, *J* = 6.8 Hz, 1H), 3.84 (d, *J* = 14.1 Hz, 2H), 3.69 (d, *J* = 14.2 Hz, 2H), 1.45 (d, *J* = 6.8 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 142.12, 140.30, 134.17, 129.84, 128.85, 128.14, 127.95, 126.77, 126.76, 56.79, 54.96, 18.15; HRMS (DART-TOF) calculated for $C_{22}H_{22}ClN$ $[M+H]^+$ m/z 336.1514, found 336.1513. Anal. Calcd. for $C_{22}H_{22}ClN$: C, 78.67; H, 6.60. Found: C, 78.64; H, 6.71. $[\alpha]_D^{25}$ = +53.0 (c = 1.13, $CHCl_3$); HPLC analysis (OD-H, 3% IPA/hexane, 0.8 mL/min, 220 nm) indicated 92% ee: t_R (major) = 5.2 minutes, t_R (minor) = 5.8 minutes.



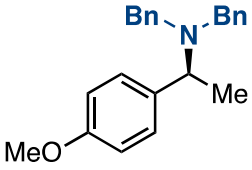
(*R*)-*N*,*N*-dibenzyl-1-(4-(trifluoromethyl)phenyl)ethan-1-amine (Table 2, entry 3d). Prepared following the general procedure using 4 mol% $Cu(OAc)_2$, 4.4% (*R*)-DTBM-

SEGPHOS, 4-(trifluoromethyl)styrene (172.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a liquid in 92% and 84% yield. IR (thin film) 3028, 2973, 2804, 1323, 1162, 1120, 1069, 1016, 737, 696 1453, 1367, 1035, 843, 746, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.72 – 7.64 (m, 2H), 7.64 – 7.58 (m, 2H), 7.50 – 7.43 (m, 4H), 7.42 – 7.35 (m, 4H), 7.35 – 7.29 (m, 2H), 4.05 (q, *J* = 6.8 Hz, 1H), 3.68 (d, *J* = 13.8 Hz, 2H), 3.58 (d, *J* = 13.8 Hz, 2H), 1.53 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 147.45 (q, *J* = 1.3 Hz), 140.08, 129.07 (q, *J* = 32.2 Hz), 128.76, 128.45, 128.33, 127.09, 125.05 (q, *J* = 3.8 Hz), 124.52 (q, *J* = 272.7 Hz), 56.02, 53.76, 13.16; ^{19}F NMR (376 MHz, $CDCl_3$) δ: -62.11; HRMS (ESI-TOF) calculated for $C_{23}H_{22}F_3N$ $[M+H]^+$ m/z 370.1777, found 370.1775. Anal. Calcd. for $C_{23}H_{22}F_3N$: C, 74.78; H, 6.00. Found: C, 74.81; H, 6.14. $[\alpha]_D^{25}$ = –93.8 (c = 1.12, $CHCl_3$); HPLC analysis (OD-H, 3% IPA/hexane, 0.8 mL/min, 220 nm) indicated 95% ee: t_R (major) = 4.8 minutes, t_R (minor) = 6.5 minutes.

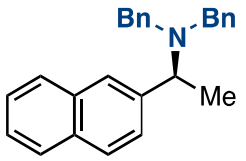


(*S*)-*N*,*N*-dibenzyl-1-(*o*-tolyl)ethan-1-amine (Table 2, entry 3e). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, 2-methylstyrene (118.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a white solid in 85% and 74% yield. m.p.: 83.5-84.0 °C. IR (thin film, $CHCl_3$) 3026, 2970, 2801, 1739, 1494, 1453, 1377, 741, 677 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.54 (d, *J* = 7.5 Hz, 1H), 7.33 – 7.29 (m, 8H), 7.28 – 7.18 (m, 3H), 7.18 – 7.15 (m, 2H), 4.14 (q, *J* = 6.8 Hz, 1H), 3.68 (d, *J* = 13.6 Hz, 2H), 3.63 (d, *J* = 13.7 Hz,

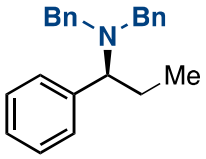
2H), 2.19 (s, 3H), 1.44 (d, J = 6.8 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 142.22, 140.38, 137.27, 130.69, 129.15, 128.11, 127.19, 126.79, 126.68, 125.60, 54.95, 54.50, 19.55, 14.44; HRMS (ESI-TOF) calculated for $C_{23}H_{25}N$ $[M+H]^+$ m/z 316.2060, found 316.2057. Anal. Calcd. for $C_{23}H_{25}N$: C, 87.57; H, 7.99. Found: C, 87.68; H, 7.96. $[\alpha]_D^{25}$ = +34.8 (c = 0.92, $CHCl_3$); HPLC analysis (OJ, 3% IPA/hexane, 0.8 mL/min, 220 nm) indicated 92% ee: t_R (major) = 6.2 minutes, t_R (minor) = 8.7 minutes.



(*S*)-*N*,*N*-dibenzyl-1-(4-methoxyphenyl)ethan-1-amine (Table 2, entry 3f). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, 4-vinylanisole (134.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 5-10% EtOAc in hexane to provide the title compound as a liquid in 89% and 88% yield. IR (thin film) 3025, 2960, 2833, 1510, 1244, 1176, 1028, 832, 739, 697 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.47 – 7.39 (m, 4H), 7.39 – 7.30 (m, 6H), 7.28 – 7.20 (m, 2H), 6.93 (d, J = 8.7 Hz, 2H), 3.92 (q, J = 6.9 Hz, 1H), 3.85 (s, 3H), 3.63 (d, J = 13.8 Hz, 2H), 3.49 (d, J = 13.9 Hz, 2H), 1.45 (d, J = 6.9 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 158.46, 140.64, 134.84, 129.14, 128.74, 128.28, 126.81, 113.39, 55.55, 55.28, 53.58, 13.96; HRMS (DART-TOF) calculated for $C_{23}H_{25}NO$ $[M+H]^+$ m/z 332.2009, found 332.2006. Anal. Calcd. for $C_{23}H_{25}NO$: C, 83.34; H, 7.60. Found: C, 83.28; H, 7.60. $[\alpha]_D^{25}$ = –117.3 (c = 0.93, $CHCl_3$); HPLC analysis (OJ, 10% IPA/hexane, 0.8 mL/min, 220 nm) indicated 99% ee: t_R (major) = 9.0 minutes, t_R (minor) = 17.9 minutes.

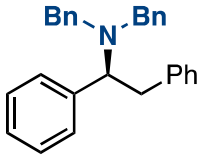


(*S*)-*N*,*N*-dibenzyl-1-(naphthalen-2-yl)ethanamine (Table 3, entry 3g). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, 2-vinylnapthalene (154 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a colorless crystal in 83% and 89% yield. m. p. 123~124 °C. IR (thin film) 3057, 3024, 2968, 1500, 1453, 1379, 1124, 857, 819, 582, 579, 560, 557 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.90 (dd, *J* = 7.6, 3.3 Hz, 3H), 7.85 – 7.80 (m, 1H), 7.72 (dd, *J* = 8.5, 1.7 Hz, 1H), 7.56 – 7.50 (m, 2H), 7.48 (m, 4H), 7.38 (m, 4H), 7.32 – 7.26 (m, 2H), 4.16 (q, *J* = 6.8 Hz, 1H), 3.70 (d, *J* = 13.6 Hz, 2H), 3.63 (d, *J* = 13.6 Hz, 2H), 1.61 (d, *J* = 6.8 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.83, 140.52, 133.28, 132.71, 128.86, 128.34, 128.02, 127.67, 127.31, 126.91, 126.10, 125.94, 125.64, 56.35, 53.76, 13.24. HRMS (DART-TOF) calculated for $C_{26}H_{25}N$ $[M+H]^+$ m/z 352.2060, found 352.2059. Anal. Calcd. for $C_{26}H_{25}N$: C, 87.57; H, 7.99. Found: C, 87.45; H, 8.16. $[\alpha]_D^{25}$ = –149.63 (c = 1.00, $CHCl_3$); HPLC analysis (OJ, 10% IPA/hexane, 0.8 mL/min, 220 nm) indicated 97% ee: t_R (major) = 10.9 minutes, t_R (minor) = 36.2 minutes.



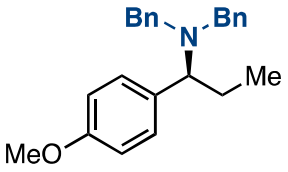
(*S*)-*N*,*N*-dibenzyl-1-phenylpropan-1-amine (Table 2, 3h & 3l). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, trans-β-methylstyrene or cis-*β*–methylstyrene (118.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a liquid. 97% and 98% yields from *trans*-*β*-methylstyrene; 89% and 87% from *cis*-*β*-methylstyrene. IR (thin film) 3025, 2960, 2930, 2800, 1493, 1452, 1027, 739, 695 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.47

– 7.39 (m, 6H), 7.35 (t, *J* = 7.5 Hz, 5H), 7.30 – 7.23 (m, 4H), 3.87 (d, *J* = 13.8 Hz, 2H), 3.64 (t, *J* = 7.5 Hz, 1H), 3.20 (d, *J* = 13.9 Hz, 2H), 2.12 (dt, *J* = 13.7, 7.3 Hz, 1H), 1.96 – 1.75 (m, 1H), 0.97 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.56, 139.08, 129.07, 128.80, 128.25, 127.95, 126.98, 126.75, 63.83, 53.74, 24.31, 11.81; HRMS (DART-TOF) calculated for $C_{23}H_{25}N$ $[M+H]^+$ m/z 316.2060, found 316.2053. Anal. Calcd. for $C_{23}H_{25}N$: C, 87.57; H, 7.99. Found: C, 87.45; H, 8.16. $[\alpha]_D^{25}$ = –112.9 (c = 1.19, $CHCl_3$); HPLC analysis (OD-H, 5% IPA/hexane, 0.8 mL/min, 220 nm) indicated >99% ee (from *trans*-), 96% ee (from *cis*-): t_R (major) = 4.8 minutes, t_R (minor) = 5.6 minutes.

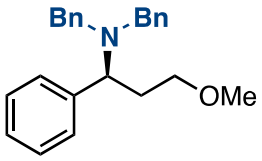


(*S*)-*N*,*N*-dibenzyl-1,2-diphenylethan-1-amine (Table 2, 3i & 3m). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, trans-stilbene or cis-stilbene (180.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a white solid. 95% and 94% yields from *trans*-stilbene; 93% and 93% from *cis*-stilbene. m. p. 73.5-74.0 °C. IR (thin film, $CHCl_3$) 3025, 1493, 1452, 1028, 740, 695 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.43 (t, *J* = 7.7 Hz, 2H), 7.38 – 7.21 (m, 16H), 7.14 (d, *J* = 7.7 Hz, 2H), 4.11 (t, *J* = 7.7 Hz, 1H), 3.94 (d, *J* = 13.9 Hz, 2H), 3.44 (dd, *J* = 14.0, 8.4 Hz, 1H), 3.25 (d, *J* = 14.0 Hz, 2H), 3.13 (dd, *J* = 14.0, 6.9 Hz, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.10, 139.96, 138.57, 129.69, 129.17, 128.76, 128.28, 128.13, 128.07, 127.26, 126.83, 126.04, 63.32, 53.69, 37.75; HRMS (DART-TOF) calculated for $C_{28}H_{27}N$ $[M+H]^+$ m/z 378.2216, found 378.2203. Anal. Calcd. for $C_{28}H_{27}N$: C, 89.08; H, 7.21. Found: C, 89.13; H, 7.29. $[\alpha]_D^{25}$ = –55.7 (c = 0.97, $CHCl_3$); HPLC analysis (OD-H, 5% IPA/hexane, 0.8 mL/min, 220 nm) indicated >99% ee (from trans-), 89% ee (from cis): t_R (major) = 5.2 minutes, t_R (minor)

= 6.5 minutes.

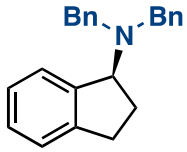


(*S*)-*N*,*N*-dibenzyl-1-(4-methoxyphenyl)propan-1-amine (Table 2, 3j). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, trans-anethole (148.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a colorless liquid in 91% and 92% yield. IR (thin film) 2932, 2832, 1510, 1453, 1247, 1178, 1037, 826, 741, 697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.56 – 7.46 (m, 4H), 7.45 – 7.35 (m, 4H), 7.35 – 7.27 (m, 2H), 7.27 – 7.20 (m, 2H), 7.04 – 6.95 (m, 2H), 3.91 (d, *J* = 13.9 Hz, 2H), 3.91 (s, 3H), 3.66 (t, *J* = 7.5 Hz, 1H), 3.25 (d, *J* = 13.9 Hz, 2H), 2.16 (dt, *J* = 13.7, 7.3 Hz, 1H), 1.95 – 1.78 (m, 1H), 1.02 (t, *J* = 7.3 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 158.60, 140.70, 131.22, 130.09, 128.84, 128.29, 126.78, 113.34, 63.17, 55.29, 53.75, 24.55, 11.91; HRMS (DART-TOF) calculated for $C_{24}H_{27}NO$ $[M+H]^+$ m/z 346.2165, found 346.2171. Anal. Calcd. for $C_{24}H_{27}NO$: C, 83.44; H, 7.88. Found: C, 83.58; H, 7.82. $[\alpha]_D^{25}$ = –137.0 (c = 1.95, $CHCl_3$); HPLC analysis (OJ, 10% EtOH/hexane, 0.8 mL/min, 220 nm) indicated >99% ee: t_R (major) = 8.3 minutes, t_R (minor) = 23.6 minutes.



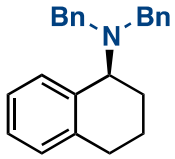
(*S*)-*N*,*N*-dibenzyl-3-methoxy-1-phenylpropan-1-amine (Table 3, entry 3k). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, (E)-(3-methoxyprop-1-en-1-yl)benzene (148.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40

°C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a colorless liquid in 94% and 95% yield. IR (thin film) 2932, 2832, 1493, 1452, 1113, 739, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.50 – 7.42 (m, 6H), 7.42 – 7.35 (m, 5H), 7.34 – 7.26 (m, 4H), 4.00 – 3.85 (m, 3H), 3.56 – 3.47 (m, 2H), 3.33 (d, *J* = 0.9 Hz, 3H), 3.23 (d, *J* = 13.8 Hz, 2H), 2.45 (ddd, *J* = 13.9, 7.6, 6.4 Hz, 1H), 2.21 – 1.96 (m, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.32, 138.49, 129.05, 128.85, 128.33, 128.10, 127.26, 126.90, 70.58, 58.94, 58.59, 53.82, 31.61; HRMS (DART-TOF) calculated for $C_{24}H_{27}NO$ $[M+H]^+$ m/z 346.2165, found 346.2162. Anal. Calcd. for $C_{24}H_{27}NO$: C, 83.44; H, 7.88. Found: C, 83.17; H, 8.02. $[\alpha]_D^{25}$ = –89.9 (c = 0.91, $CHCl_3$); HPLC analysis (OD-H, 3% IPA/hexane, 0.8 mL/min, 220 nm) indicated >99% ee: t_R (major) = 6.0 minutes, t_R (minor) = 6.7 minutes.

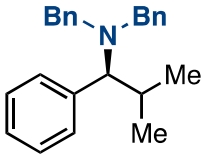


(*S*)-*N*,*N*-dibenzyl-2,3-dihydro-1*H*-inden-1-amine (Table 3, entry 3n). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, s indene (116.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF 2 mL for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a white solid in 95% and 73% yield. m. p. 89-90 °C. IR (thin film) 3024, 2934, 2798, 1493, 1452, 1372, 1117, 1027, 742, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.71 – 7.59 (m, 1H), 7.56 (m, 4H), 7.40 (m, 4H), 7.33 – 7.19 (m, 5H), 4.57 (t, *J* = 7.8 Hz, 1H), 3.67 (d, *J*= 13.6 Hz, 2H), 3.50 (d, *J*= 13.6 Hz, 2H), 3.03 (dt, *J* = 16.1, 6.4 Hz, 1H), 2.86 (dt, *J* = 16.3, 8.5 Hz, 1H), 2.21 (tdd, *J* = 8.3, 6.4, 1.7 Hz, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 144.51, 143.69, 140.47, 128.66, 128.33, 127.39, 126.88, 126.48, 124.72, 124.62, 64.65, 54.31, 30.61, 23.46; HRMS (DART-TOF) calculated for $C_{23}H_{23}N$ $[M+H]^+$ m/z 314.1903, found 314.1902. Anal. Calcd. for $C_{23}H_{23}N$: C, 88.13; H, 7.40. Found: C, 87.84; H, 7.31. $[\alpha]_D^{25}$ = –99.4 (c = 1.35, $CHCl_3$); HPLC analysis (OJ, 5%

IPA/hexane, 0.8 mL/min, 220 nm) indicated 97% ee: t_R (major) = 5.9 minutes, t_R (minor) = 7.6 minutes.

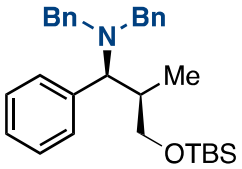


(*S*)-*N*,*N*-dibenzyl-1,2,3,4-tetrahydronaphthalen-1-amine (Table 3, entry 3o). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, 1,2-dihydronaphthalene (130.2 mg, 1.0 mmol, 1.0 equiv), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a colorless liquid in 92% and 82% yield. IR (thin film) 2928, 1493, 1452, 1366, 1121, 1027, 973, 740, 696cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.07 (dt, *J* = 7.8, 1.2 Hz, 1H), 7.53 (d, *J* = 7.3 Hz, 4H), 7.38 (dd, *J* = 8.2, 6.9 Hz, 4H), 7.32 – 7.22 (m, 3H), 7.17 (tt, *J* = 7.3, 1.1 Hz, 1H), 7.09 (d, *J* = 7.9 Hz, 1H), 4.00 (dd, *J* = 10.2, 5.7 Hz, 1H), 3.87 (d, *J* = 13.6 Hz, 2H), 3.54 (d, *J* = 13.6 Hz, 2H), 2.91 – 2.66 (m, 2H), 2.32 – 2.14 (m, 1H), 2.06 (dtt, *J* = 13.7, 5.6, 3.1 Hz, 1H), 1.85 (tdd, *J* = 12.5, 10.1, 2.8 Hz, 1H), 1.76 – 1.58 (m, 1H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.51, 139.20, 138.84, 128.76, 128.69, 128.34, 128.10, 126.88, 126.22, 126.02, 56.45, 53.77, 30.27, 22.37, 20.67; HRMS (DART-TOF) calculated for $C_{24}H_{25}N$ $[M+H]^+$ m/z 328.2060, found 328.2068. Anal. Calcd. for $C_{24}H_{25}N$: C, 88.03; H, 7.70. Found: C, 87.77; H, 7.74. $[\alpha]_D^{25}$ = –77.0 (c = 1.09, $CHCl_3$); HPLC analysis (OJ, 3% IPA/hexane, 0.8 mL/min, 220 nm) indicated 86% ee: t_R (major) = 5.8 minutes, t_R (minor) = 7.7 minutes.



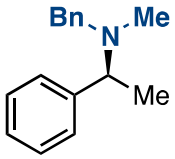
(*S*)-*N*,*N*-dibenzyl-2-methyl-1-phenylpropan-1-amine (Table 2, 3p). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS,

2-methyl-1-phenylpropene (132.2 mg, 1.0 mmol, 1.0 equiv., *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a colorless liquid in 77% and 76% yield. IR (thin film) 3025, 2955, 1493, 1452, 1092, 1069, 1121, 1028, 761, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.47 (d, *J* = 7.6 Hz, 4H), 7.42 (t, *J* = 7.3 Hz, 2H), 7.35 (t, *J* = 7.5 Hz, 5H), 7.29 – 7.22 (m, 2H), 7.15 (d, *J* = 6.9 Hz, 2H), 3.93 (d, *J* = 13.8 Hz, 2H), 3.22 (d, *J* = 10.9 Hz, 1H), 3.00 (d, *J* = 13.9 Hz, 2H), 2.54 – 2.35 (m, 1H), 1.31 (d, *J* = 6.5 Hz, 3H), 0.63 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.45, 137.03, 129.68, 128.89, 128.37, 127.91, 126.97, 126.82, 69.37, 53.68, 28.68, 21.29, 20.92; HRMS (DART-TOF) calculated for $C_{24}H_{27}N$ $[M+H]^+$ m/z 330.2216, found 330.2216. Anal. Calcd. for $C_{24}H_{25}N$: C, 87.49; H, 8.26. Found: C, 87.29; H, 8.43. $[\alpha]_D^{25}$ = –114.5 (c = 1.14, $CHCl_3$); HPLC analysis (OD-H, 5% IPA/hexane, 0.8 mL/min, 220 nm) indicated >99% ee, single isomer: t_R (major) = 4.7 minutes, t_R (minor) = 6.1 minutes.

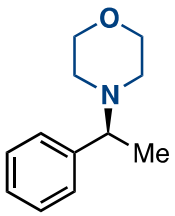


(1*S*,2*R*)-*N*,*N*-dibenzyl-3-((*tert*-butyldimethylsilyl)oxy)-2-methyl-1-phenylpropan-1-amine (Table 2, 3q). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, (E)-*tert*-butyldimethyl((2-methyl-3-phenylallyl)oxy)silane (262.5 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a colorless solid in 84% and 82% yield. m. p. 93~94 °C. IR (thin film) 2955, 2927, 2855, 1494, 1453, 1257, 1084, 834, 763, 698 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.45 – 7.37 (m, 6H), 7.37 – 7.30 (m, 5H), 7.29 – 7.21 (m, 2H), 7.20 – 7.13 (m, 2H), 4.49 (dd, *J* = 9.8, 3.9 Hz, 1H), 3.93 (d, *J* = 13.9 Hz, 2H), 3.54 – 3.33 (m, 2H), 3.01

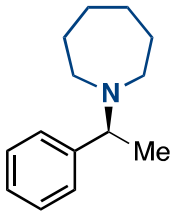
(d, J = 13.9 Hz, 2H), 2.60 – 2.44 (m, 1H), 0.97 (s, 9H), 0.66 (d, J = 6.5 Hz, 3H), 0.12 (d, J = 5.2 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.05, 135.91, 129.73, 128.72, 128.29, 127.87, 127.04, 126.80, 66.74, 65.63, 53.70, 36.07, 26.14, 18.55, 15.68, -5.13, -5.17. HRMS (DART-TOF) calculated for $C_{30}H_{41}NOSi$ $[M+H]^+$ m/z 460.3030, found 460.3026. Anal. Calcd. for $C_{30}H_{41}NOSi$: C, 78.38; H, 8.99. Found: C, 78.54; H, 9.01. $[\alpha]_D^{25}$ = –73.5 (c = 0.86, $CHCl_3$); HPLC analysis (OD-H, 3% IPA/hexane, 0.8 mL/min, 220 nm) indicated >99% ee, single isomer: t_R (major) = 4.3 minutes, t_R (minor) = 4.9 minutes.



(*S*)-*N*-benzyl-*N*-methyl-1-phenylethanamine (Table 3, entry 3r). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (R)-DTBM-SEGPHOS, styrene (104 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*-benzyl-*N*-methylhydroxylamine (290 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a colorless liquid crystal in 90% and 84% yield. IR (thin film) 2971, 2784, 1494, 1451, 1074, 1028, 761, 735, 698 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.44 (m, 2H) 7.42 – 7.22 (m, 8H), 3.69 – 3.64 (q, J = 6.7 Hz, 1H), 3.63 – 3.59 (d, J = 13.3 Hz, 1H), 3.35 – 3.32 (d, J = 13.3 Hz, 1H), 2.16 (s, 3H), 1.46 – 1.44 (d, J = 6.7 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 128.89, 128.31, 128.3, 127.8, 126.9, 126.9, 63.4, 59.0, 38.5, 18.5; HRMS (DART-TOF) calculated for $C_{16}H_{19}N$ $[M+H]^+$ m/z 226.1590, found 226.1582. Anal. Calcd. for $C_{16}H_{19}N$: C, 82.70; H, 11.28. Found: C, 82.64; H, 11.28. $[\alpha]_D^{25}$ = –15.3 (c = 1.02, $CHCl_3$); ^{1}H NMR analysis of the amine and (*R*) and (*S*)-O-acetylmandelic acid indicated 94% ee.



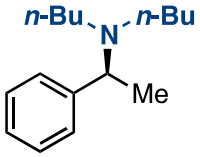
(*S*)-4-(1-phenylethyl)morpholine (Table 3, entry 3s). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (R)-DTBM-SEGPHOS, styrene (104 mg, 1.0 mmol, 1.0 equiv.), morpholino benzoate (207.23 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a liquid in 88% and 85% yield. IR (thin film) 2957, 2851, 2803, 1450, 1116, 946, 865, 759, 700 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.39 – 7.31 (m, 4H), 7.29 – 7.23 (m, 1H), 3.72 (dd, J = 5.3, 4.1 Hz, 4H), 3.33 (q, J = 6.7 Hz, 1H), 2.62 – 2.45 (m, 2H), 2.45 – 2.30 (m, 2H), 1.38 (d, J = 6.7 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 144.05, 128.33, 127.61, 127.00, 67.22, 65.40, 51.37, 19.96; HRMS (DART-TOF) calculated for $C_{12}H_{17}NO$ $[M+H]^+$ m/z 192.1383, found 192.1381. Anal. Calcd. for $C_{12}H_{17}NO$: C, 75.35; H, 8.96. Found: C, 75.09; H, 8.81. $[\square]_D^{24}$ = –36.5 (c = 0.98, $CHCl_3$); $[\square]_D^{25}$ = –41.0 (c = 1.10, EtOH); Literature $[\square]_D^{25}$ = –41.6 (c = 1.10, EtOH)[5]. ee: 98%. GC condition: Varian CP7502 column (25 m×0.25 mm×0.25 μm, chiralsil-DEX CB), H2 2.7 mL/min, programmed from 100 □ to 125 □ at 0.5□/min; t_R (minor) = 28.41 min, and t_R (major) = 29.24 min.



(*S*)-1-(1-phenylethyl)azepane (Table 3, entry 3t). Prepared following the general

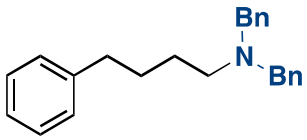
[5] Kawaguchi, M.; Ohashi, J.; Kawakami, Y.; Yamamoto, Y.; Oda, J. Synthesis, 1985, 701.

procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, styrene (104 mg, 1.0 mmol, 1.0 equiv), azepan-1-yl benzoate (219 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 20-50% EtOAc in hexane to provide the title compound as a liquid in 86% yield for both runs. IR (thin film) 2922, 1492, 1451, 1128, 909, 762, 697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.43 – 7.37 (m, 2H), 7.37 – 7.30 (m, 2H), 7.28 – 7.21 (m, 1H), 3.80 (q, *J* = 6.7 Hz, 1H), 2.66 (s, 4H), 1.62 (s, 8H), 1.39 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ: 144.94, 127.95, 127.60, 126.46, 63.21, 52.06, 28.96, 27.07, 18.26; HRMS (DART-TOF) calculated for $C_{14}H_{21}N$ $[M+H]^+$ m/z 204.1747, found 204.1745. Anal. Calcd. for $C_{14}H_{21}N$: C, 82.70; H, 10.41. Found: C, 82.58; H, 10.47. $[\square]_D^{25}$ = +6.5 (c = 1.10, $CHCl_3$); ee~99%. GC condition: Varian CP7502 column (25 m×0.25 mm×0.25 μm, chiralsil-DEX CB), H_2 2.7 mL/min, programmed from 100 □ to 125 □ at 0.5□/min; *t*R＝35.2 min (minor) and *t*R＝35.8 min (major).

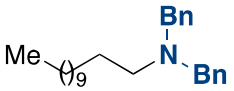


(*S*)-*N*-butyl-*N*-(1-phenylethyl)butan-1-amine (Table 3, entry 3u). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (*R*)-DTBM-SEGPHOS, styrene (104 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibutylhydroxylamine (249 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was quenched with Na_2CO_3 solution, and the crude product extracted with ethyl acetate (x3) (NB: This step is necessary to remove N-OBz compounds). The reaction was then purified by an acid-base treatment, where the amine was first protonated with dilute HCl solution and the aqueous layer washed with ethyl acetate (x1), then treated with 1 M NaOH to deprotonate the amine. The aqueous layer was then extracted with EtOAc (x3), and the organic combined and concentrated to give the pure product as a yellow liquid in 90% yields (for both runs). IR (thin film) 2955, 2929, 2871, 1452, 1367, 1081, 776, 759, 697,

553 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.42 (m, 2H), 7.39 – 7.31 (m, 2H), 7.30 – 7.22 (m, 1H), 3.90 (q, *J* = 6.8 Hz, 1H), 2.58 – 2.47 (m, 2H), 2.42 (m, 2H), 1.54 – 1.41 (m, 4H), 1.38 (m, 3H), 1.36 – 1.18 (m, 4H), 0.92 (t, *J* = 7.3 Hz, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 145.00, 127.89, 127.76, 126.39, 58.96, 49.65, 30.0, 20.62, 16.49, 14.14; HRMS (DART-TOF) calculated for $C_{24}H_{27}N$ $[M+H]^+$ m/z 234.2216, found 234.2209. Anal. Calcd. for $C_{16}H_{27}N$: C, 83.76; H, 11.10. Found: C, 83.63; H, 11.28. $[\alpha]_D^{25}$ = +2.9 (c = 0.57, $CHCl_3$); ^1H NMR analysis of the amine and (*R*) and (*S*)-O-acetylmandelic acid indicated 90% ee.

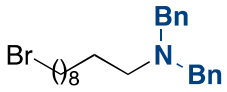


N,N-dibenzyl-4-phenylbutan-1-amine **(Table 4, entry 5a).** Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, but-3-en-1-ylbenzene (132.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% Ether in hexane to provide the title compound as a colorless liquid in 90% and 87% yield. IR (thin film) 2933, 2792, 1494, 1451, 1125, 1027, 732 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.51 – 7.09 (m, 15H), 3.61 (s, 4H), 2.58 (t, *J* = 7.4 Hz, 2H), 2.51 (t, *J* = 6.8 Hz, 2H), 1.74 – 1.58 (m, 4H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 142.74, 140.10, 128.91, 128.52, 128.34, 128.27, 126.87, 125.71, 58.47, 53.20, 35.73, 29.00, 26.65; HRMS (DART-TOF) calculated for $C_{24}H_{27}N$ $[M+H]^+$ m/z 330.2216, found 330.2215. Anal. Calcd. for $C_{24}H_{27}N$: C, 87.49; H, 8.26. Found: C, 87.48; H, 8.27.

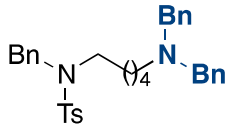


N,N-dibenzyldodecan-1-amine (Table 4, entry 5b). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, dodec-1-ene (168.3

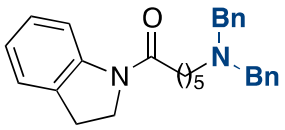
mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound as a colorless liquid in 94% and 95% yield. IR (thin film) 2922, 2852, 1494, 1452, 1028, 734, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.60 – 7.09 (m, 10H), 3.58 (s, 4H), 2.43 (t, J = 7.2 Hz, 2H), 1.67 – 1.42 (m, 2H), 1.41 – 1.09 (m, 18H), 0.92 (t, J = 6.8 Hz, 3H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.11, 128.79, 128.13, 126.71, 58.29, 53.43, 31.97, 29.71, 29.68(3C), 29.54, 29.40, 27.29, 27.00, 22.74, 14.17; HRMS (Dart-TOF) calculated for $C_{26}H_{39}N$ $[M+H]^+$ m/z 366.3155, found 366.3147. Anal. Calcd. for $C_{26}H_{39}N$: C, 85.42; H, 10.75. Found: C, 85.40; H, 10.78.



***N*,*N*-dibenzyl-10-bromodecan-1-amine (Table 4, entry 5c).** Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, 10-bromo-1-decene (219.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 5-10% Ethyl acetate in hexane to provide the title compound as a colorless liquid in 89% and 90% yield. IR (thin film) 2925, 2853, 1494, 1452, 742, 696 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.44 – 7.38 (m, 4H), 7.34 (t, J = 7.4 Hz, 4H), 7.28 (s, 2H), 3.58 (s, 4H), 3.44 (t, J = 6.8 Hz, 2H), 2.43 (t, J = 7.2 Hz, 2H), 1.84 – 1.90 (m, 2H), 1.59 – 1.48 (m, 2H), 1.48 – 1.37 (m, 2H), 1.37 – 1.17 (m, 10H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.10, 128.81, 128.18, 126.76, 58.38, 53.42, 34.06, 32.91, 29.58, 29.50, 29.48, 28.83, 28.25, 27.28, 27.06; HRMS (DART-TOF) calculated for $C_{24}H_{34}NBr$ $[M+H]^+$ m/z 416.1947, found 416.1943. Anal. Calcd. for $C_{24}H_{34}NBr$: C, 69.22; H, 8.23. Found: C, 69.51; H, 8.13.

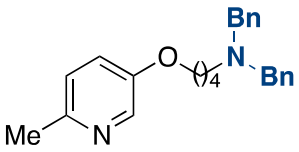


***N*-benzyl-*N*-(5-(dibenzylamino)pentyl)-4-methylbenzenesulfonamide (Table 4, 5d).** Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, *N*-benzyl-4-methyl-*N*-(pent-4-en-1-yl)benzenesulfonamide (329.5 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 10-15% EtOAc in hexane (contain 0.5% TEA) to provide the title compound as a colorless liquid in 95% and 95% yield. IR (thin film) 2932, 1494, 1338, 1155, 1090, 734 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.73 (m, 2H), 7.46 – 7.14 (m, 17H), 4.29 (s, 2H), 3.50 (s, 4H), 3.16 – 2.95 (t, *J* = 7.6 Hz, 2H), 2.45 (s, 3H), 2.29 (t, *J* = 7.2 Hz, 2H), 1.42 – 1.19 (m, 4H), 1.17 – 0.96 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 143.13, 139.93, 137.17, 136.66, 129.69, 128.74, 128.52, 128.25, 128.17, 127.70, 127.19, 126.78, 58.27, 53.18, 51.92, 48.11, 27.87, 26.53, 24.31, 21.55; HRMS (DART-TOF) calculated for $C_{33}H_{38}N_2O_2S$ $[M+H]^+$ m/z 527.2727, found 527.2738.

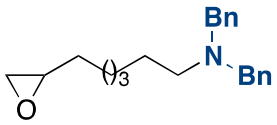


6-(dibenzylamino)-1-(indolin-1-yl)hexan-1-one (Table 4, 5e). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, 1-(indolin-1-yl)hex-5-en-1-one (215.3 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 15-20% EtOAc in hexane (contain 0.5% TEA) to provide the title compound as a colorless liquid in 85% and 91% yield. IR (thin film) 2932, 1658, 1598, 1481, 1404, 1262, 747, 697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 8.29 (d, *J* = 8.1 Hz, 1H), 7.41 (d, *J* = 7.3 Hz, 4H), 7.34 (t, *J* = 7.5 Hz, 4H), 7.30 – 7.17 (m, 4H), 7.09 – 6.99 (m, 1H), 4.01 (t, *J* = 8.5 Hz, 1.78 H) &

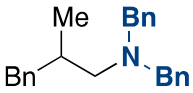
4.17 (m, 0.22 H) due to rotamer, 3.61 (s, 4H), 3.20 (t, J = 8.5 Hz, 1.78 H) & 3.07 (m, 0.22H) due to rotamer, 2.49 (t, J = 7.2 Hz, 2H), 2.38 (t, J = 7.5 Hz, 1.78H) & 2.65 (m, 0.22H) due to rotamer, 1.79 – 1.66 (m, 2H), 1.66 – 1.53 (m, 2H), 1.47 – 1.35 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 171.40, 143.20, 140.02, 131.09, 128.87, 128.23, 127.60, 126.84, 124.55, 123.51, 117.06, 58.44, 53.43, 48.03, 35.97, 28.10, 27.12, 27.04, 24.55; HRMS (DART-TOF) calculated for $C_{28}H_{32}N_2O$ $[M+H]^+$ m/z 413.2587, found 413.2595. Anal. Calcd. for $C_{28}H_{32}N_2O$: C, 81.28; H, 7.83. Found: C, 81.28; H, 7.83.



***N*,*N*-dibenzyl-4-((6-methylpyridin-3-yl)oxy)butan-1-amine (Table 4, entry 5f).** Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, 5-(but-3-en-1-yloxy)-2-methylpyridine (163.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 20-50% EtOAc in hexane (contain 0.5% TEA) to provide the title compound as a colorless liquid in 92% yield for both runs. IR (thin film) 2942, 2793, 1494, 1262, 825 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.15 (dd, J = 2.6, 1.0 Hz, 1H), 7.42 – 7.35 (m, 4H), 7.35 – 7.29 (m, 4H), 7.28 – 7.22 (m, 2H), 7.08 – 6.99 (m, 2H), 3.85 (t, J = 6.3 Hz, 2H), 3.59 (s, 4H), 2.51 (s, 3H), 2.50 (t, J = 6.9 Hz, 2H), 1.86 – 1.76 (m, 2H), 1.73 – 1.66 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 153.20, 150.10, 139.85, 136.79, 128.86, 128.45, 128.22, 126.88, 123.24, 121.96, 67.99, 58.43, 52.56, 26.73, 23.42, 23.36; HRMS (DART-TOF) calculated for $C_{24}H_{28}N_2O$ $[M+H]^+$ m/z 361.2274, found 361.2270. Anal. Calcd. for $C_{24}H_{28}N_2O$: C, 79.96; H, 7.83. Found: C, 79.83; H, 7.75.

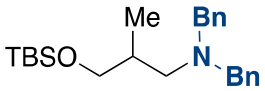


***N,N*-dibenzyl-6-(oxiran-2-yl)hexan-1-amine (Table 4, 5g).** Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, 1,2-epoxy-7-octene (126.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 5-10% EtOAc in hexane (contain 0.5% TEA) to provide the title compound as a colorless liquid in 90% and 91% yield. IR (thin film) 2928, 2855, 2790, 1494, 1128, 1028, 743, 697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.40 (d, *J* = 6.7 Hz, 4H), 7.34 (t, *J* = 7.4 Hz, 4H), 7.26 (t, *J* = 7.2 Hz, 2H), 3.58 (s, 4H), 2.96 – 2.87 (m, 1H), 2.77 (dd, *J* = 5.0, 4.0 Hz, 1H), 2.48 (dd, *J* = 5.0, 2.7 Hz, 1H), 2.44 (t, *J* = 7.2 Hz, 2H), 1.62 – 1.37 (m, 6H), 1.37 – 1.22 (m, 4H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.03, 128.77, 128.14, 126.74, 58.36, 53.25, 52.31, 47.07, 32.47, 29.24, 27.12, 26.91, 25.96; HRMS (DART-TOF) calculated for $C_{22}H_{29}NO$ $[M+H]^+$ m/z 324.2322, found 324.2314.

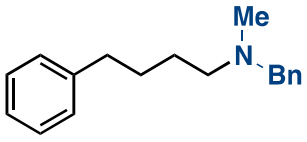


***N, N*-dibenzyl-2-methyl-3-phenylpropan-1-amine (Table 4, 5h).** Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, (2-methylallyl)benzene (132.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (1 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 5-10% EtOAc in hexane to provide the title compound as a colorless liquid in 87% and 90% yields. IR (thin film) 3025, 2795, 1494, 1452, 1066, 1028, 735, 697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.46 – 7.40 (m, 4H), 7.36 (t, *J* = 7.4 Hz, 4H), 7.28 (s, 4H), 7.22 (d, *J* = 7.3 Hz, 1H), 7.15 – 7.08 (m, 2H), 3.62 (d, *J* = 13.6 Hz, 2H), 3.58 (d, *J* = 13.6 Hz, 2H), 2.97 (dd, *J* = 13.1, 4.6 Hz, 1H), 2.38 (dd, *J* = 12.5, 7.3 Hz, 1H), 2.29 (dd, *J* = 12.4, 6.9

Hz, 1H), 2.15 (dd, *J* = 13.1, 9.1 Hz, 1H), 2.11 – 1.99 (m, 1H), 0.86 (d, *J* = 6.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ: 141.64, 139.96, 129.26, 129.04, 128.28, 128.22, 126.91, 125.70, 60.72, 59.08, 41.50, 33.68, 18.09; HRMS (DART-TOF) calculated for $C_{24}H_{27}N$ $[M+H]^+$ m/z 330.2216, found 330.2203. Anal. Calcd. for $C_{24}H_{27}N$: C, 87.49; H, 8.26 Found: C, 87.59; H, 8.24.

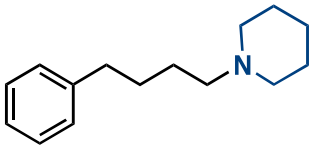


***N,N*-dibenzyl-3-((tert-butyldimethylsilyl)oxy)-2-methylpropan-1-amine (Table 4, 5i).** Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, *tert*-butyldimethyl((2-methylallyl)oxy)silane (132.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-dibenzylhydroxylamine (381 mg, 1.2 mmol, 1.2 equiv), THF (1 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 5-10% EtOAc in hexane to provide the title compound as a colorless liquid in 88% an 87% yield. IR (thin film) 2927, 1452, 1250, 1086, 834, 773, 743, 696 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.39 – 7.27 (m, 8H), 7.25 – 7.19 (m, 2H), 3.63 – 3.54 (m, 3H), 3.47 (d, *J* = 13.6 Hz, 2H), 3.28 (dd, *J* = 9.8, 6.7 Hz, 1H), 2.37 (dd, *J* = 12.6, 6.7 Hz, 1H), 2.18 (dd, *J* = 12.5, 7.6 Hz, 1H), 1.99 – 1.85 (m, 1H), 0.87 (m, 3H), 0.87 (s, 9H), 0.01 (s, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 140.01, 128.99, 128.23, 126.86, 67.12, 58.99, 57.51, 34.43, 26.12, 18.49, 15.80, -5.19; HRMS (DART-TOF) calculated for $C_{24}H_{37}NOSi$ $[M+H]^+$ m/z 384.2717, found 384.2718.

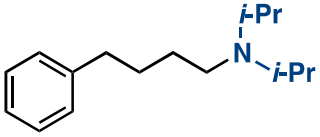


N-benzyl-N-methyl-4-phenylbutan-1-amine (Table 5, 5j). Prepared following the general procedure using 2 mol% $Cu(OAc)_2$, 2.2% (±)-DTBM-SEGPHOS, *but-3-en-1-ylbenzene* (132.2 mg, 1.0 mmol, 1.0 equiv.), O-benzoyl-N-benzyl-N-methylhydroxylamine (290 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C.

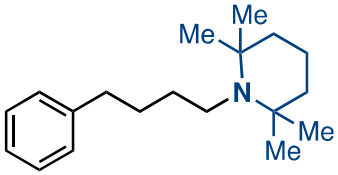
The reaction mixture was purified by flash chromatography on silica gel using 20-50% EtOAc in hexane (contain 0.5% TEA) to provide the title compound as a colorless liquid in 91% and 92% yield. IR (thin film) 2937, 2785, 1495, 1452, 1027, 736, 697 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.37 – 7.25 (m, 7H), 7.24 – 7.17 (m, 3H), 3.51 (s, 2H), 2.64 (t, J = 7.6 Hz, 2H), 2.42 (t, J = 7.6 Hz, 2H), 2.21 (s, 3H), 1.74 – 1.64 (m, 2H), 1.64 – 1.54 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 142.67, 139.32, 129.14, 128.50, 128.34, 128.27, 126.97, 125.73, 62.50, 57.35, 42.34, 35.90, 29.30, 27.10; HRMS (DART-TOF) calculated for $C_{18}H_{23}N$ $[M+H]^+$ m/z 254.1903, found 254.1897. Anal. Calcd. for $C_{18}H_{23}N$: C, 85.32; H, 9.15 Found: C, 85.06; H, 9.14.



1-(4-phenylbutyl)piperidine (Table 5, 5k). Prepared following the general procedure using 4 mol% $Cu(OAc)_2$, 4.4% (±)-DTBM-SEGPHOS, but-3-en-1-ylbenzene (132.2 mg, 1.0 mmol, 1.0 equiv.), piperidin-1-yl benzoate (246.3 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 10-20% EtOAc in hexane (contain 1% TEA) to provide the title compound as a colorless liquid in 99% yield for both runs. IR (thin film) 2931, 1738, 1453, 1350, 1122, 1039, 745 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.35 – 7.25 (m, 2H), 7.25 – 7.15 (m, 3H), 2.65 (t, J = 7.5 Hz, 2H), 2.40 – 2.33 (m, 4H), 2.33 (t, J = 7.5 Hz, 2H), 1.73 – 1.51 (m, 8H), 1.51 – 1.39 (m, 2H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 142.52, 128.39, 128.23, 125.63, 59.44, 54.68, 35.91, 29.63, 26.67, 26.02, 24.53; HRMS (DART-TOF) calculated for $C_{15}H_{23}N$ $[M+H]^+$ m/z 218.1903, found 218.1895. Anal. Calcd. for $C_{15}H_{23}N$: C, 82.89; H, 10.67 Found: C, 82.76; H, 10.69.



***N*,*N*-diisopropyl-4-phenylbutan-1-amine (Table 5, 5l).** Prepared following the general procedure using 4 mol% $Cu(OAc)_2$, 4.4% (±)-DTBM-SEGPHOS, *but-3-en-1-ylbenzene* (132.2 mg, 1.0 mmol, 1.0 equiv.), *O*-benzoyl-*N*,*N*-diisopropylhydroxylamine (246.3 mg, 1.2 mmol, 1.2 equiv), THF (1 mL) for 36 h at 40 °C. The reaction mixture was purified by flash chromatography on silica gel using 20-50% EtOAc in hexane (contain 1% TEA) to provide the title compound as a colorless liquid in 97% yield for both runs. IR (thin film) 2961, 2933, 1453, 1384, 1360, 1206, 1158, 742, 698 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ: 7.33 – 7.26 (m, 2H), 7.24 – 7.16 (m, 3H), 3.13 – 2.89 (m, 2H), 2.64 (t, J = 7.6 Hz, 2H), 2.43 (t, J = 7.6 Hz, 2H), 1.69 –1.57 (m, 2H), 1.55 – 1.40 (m, 2H), 1.02 (d, J = 6.6 Hz, 12H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 142.91, 128.40, 128.23, 125.57, 48.40, 45.10, 35.99, 31.13, 29.33, 20.71; HRMS (DART-TOF) calculated for $C_{16}H_{27}N$ $[M+H]^+$ m/z 234.2216, found 234.2213. Anal. Calcd. for $C_{16}H_{27}N$: C, 82.34; H, 11.66 Found: C, 82.086; H, 11.66.

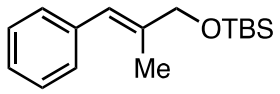


2,2,6,6-Tetramethyl-1-(4-phenylbutyl)piperidine (Table 5, 5m). Prepared following the general procedure using 4 mol% $Cu(OAc)_2$, 4.4% (±)-DTBM-SEGPHOS, but-3-en-1-ylbenzene (132.2 mg, 1.0 mmol, 1.0 equiv.), 2,2,6,6-tetramethylpiperidin-1-yl benzoate (314 mg, 1.2 mmol, 1.2 equiv), THF (2 mL) for 36 h at 40 °C. The reaction mixture was quenched with Na_2CO_3 solution, and the crude product extracted with EtOAc (x3) (NB: This step is necessary to remove N-OBz compounds). The reaction was then purified by an acid-base treatment, where the amine was first protonated with dilute HCl solution and the aqueous layer washed with EtOAc (x1), then treated with 1 M NaOH to deprotonate

the amine. The aqueous layer was then extracted with EtOAc (x3), and the organic combined and concentrated to give the pure product as a yellow liquid in 83% and 76% yields. IR (thin film) 2963, 2925, 2868, 1453, 1377, 1359, 1350, 1261, 1175, 1129, 1108, 1025, 746, 697 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.38 – 7.26 (m, 2H), 7.24 – 7.18 (m, 3H), 2.65 (t, *J* = 7.5 Hz, 2H), 2.47 – 2.35 (m, 2H), 1.60 – 1.50 (m, 6H), 1.47 – 1.39 (m, 4H), 1.05 (s, 12H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 143.05, 128.44, 128.33, 125.67, 54.58, 45.12, 41.28, 36.12, 35.87, 29.55, 27.63, 17.92; HRMS (DART-TOF) calculated for $C_{19}H_{31}N$ $[M+H]^+$ m/z 274.2529, found 274.2519.

3. Substrate Preparation

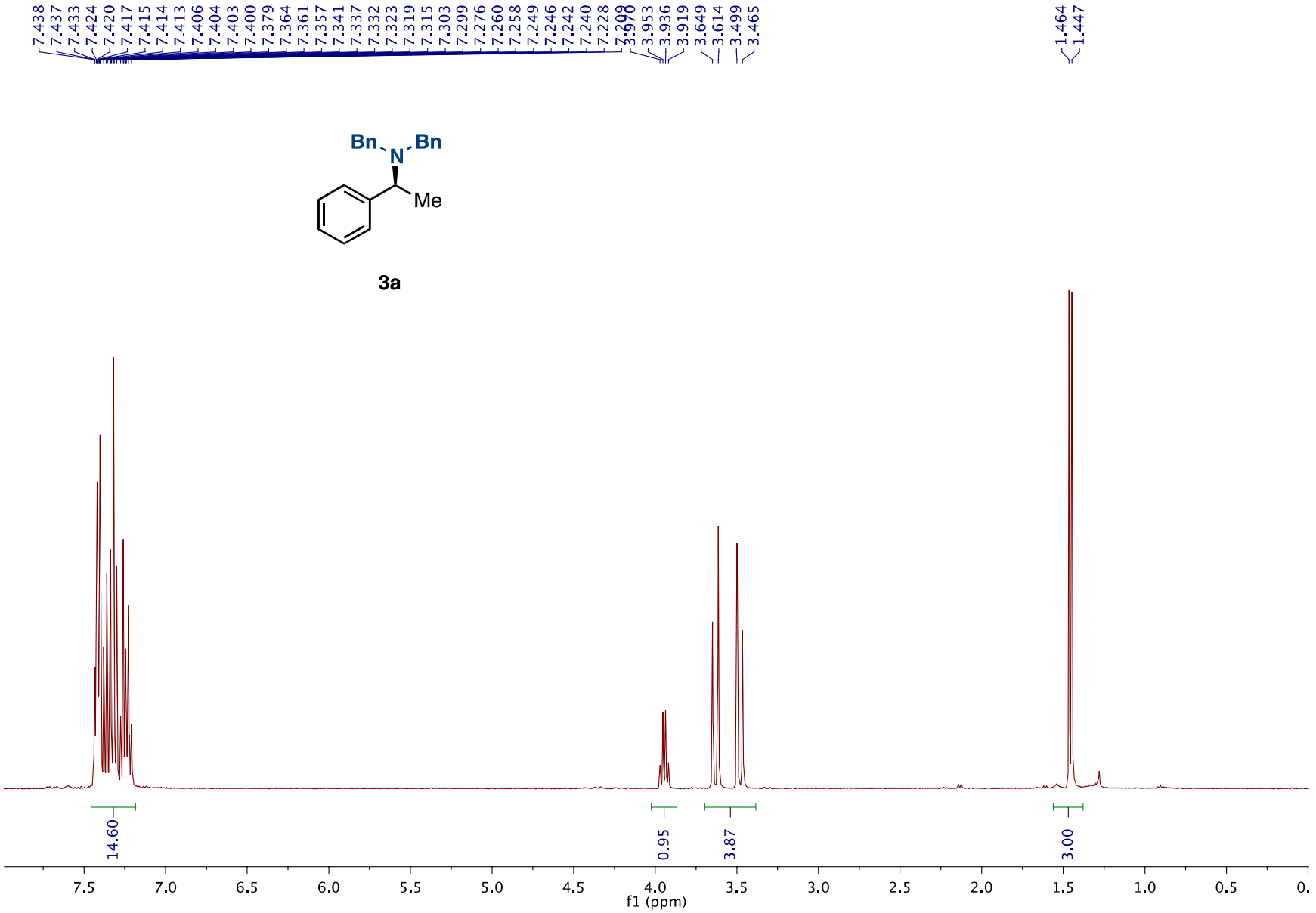
Synthesis of substrates **1q**:



(*E*)-*tert*-butyldimethyl((2-methyl-3-phenylallyl)oxy)silane (Table 2, 1q) To a 50 mL round-bottom flask containing trans-2-Methyl-3-phenyl-2-propen-1-ol (2.964 g, 20 mmol, 1.00 equiv), imidazole (26 mmol, 1.3 equiv.) was added DMF (20 mL). Then TBSCl (3.62 g, 24 mmol, 1.2 equiv.) was added in one portion. The mixture was allowed to stir overnight. It was then diluted with ethyl acetate and washed with water, extracted 2 times with ethyl acetate and the combined organic layers were washed with brine and dried over NaSO4. The mixture was purified by flash chromatography on silica gel using 0-5% EtOAc in hexane to provide the title compound in 90% yield as a colorless oil. IR (thin film) 2957, 2928, 2855, 1257, 1110, 1076, 835, 776 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.40 – 7.29 (m, 4H), 7.23 (t, *J* = 7.1 Hz, 1H), 6.56 (s, 1H), 4.26 – 4.14 (m, 2H), 1.86 (d, *J* = 1.3 Hz, 3H), 0.98 (s, 9H), 0.15 (s, 6H); ^{13}C NMR (101 MHz, $CDCl_3$) δ: 138.17, 137.62, 129.03, 128.19, 126.25, 123.83, 68.64, 26.12, 18.61, 15.15, -5.09; HRMS (DART-TOF) calculated for $C_{16}H_{26}OSi$ $[M+H]^+$ m/z 263.1826, found 263.1889.

4. Spectroscopic Data.

^{1}H, ^{13}C, ^{19}F NMR and HPLC spectra are included below.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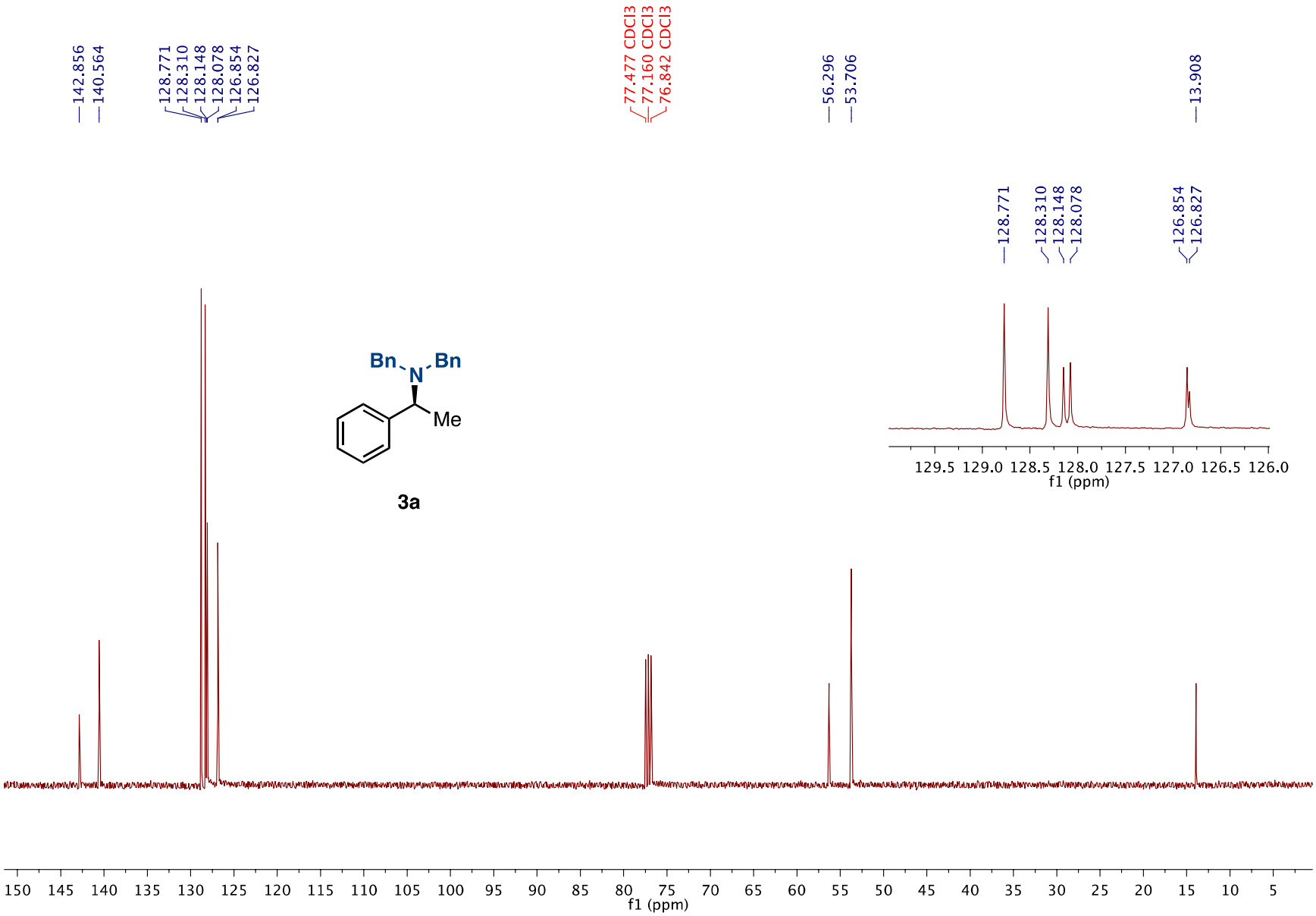
7.400
7.379
7.364
7.361
7.357
7.341
7.337
7.332
7.323
7.319
7.315
7.303
7.299
7.276
7.260
7.258
7.249
7.246
7.242
7.240
7.228
7.209
3.970
3.953
3.936
3.919
3.649
3.614
3.499
3.465
1.464
1.447
Bn
N
Bn
Me
3a
14.60
0.95
3.87
3.00
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.
f1 (ppm)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126.827
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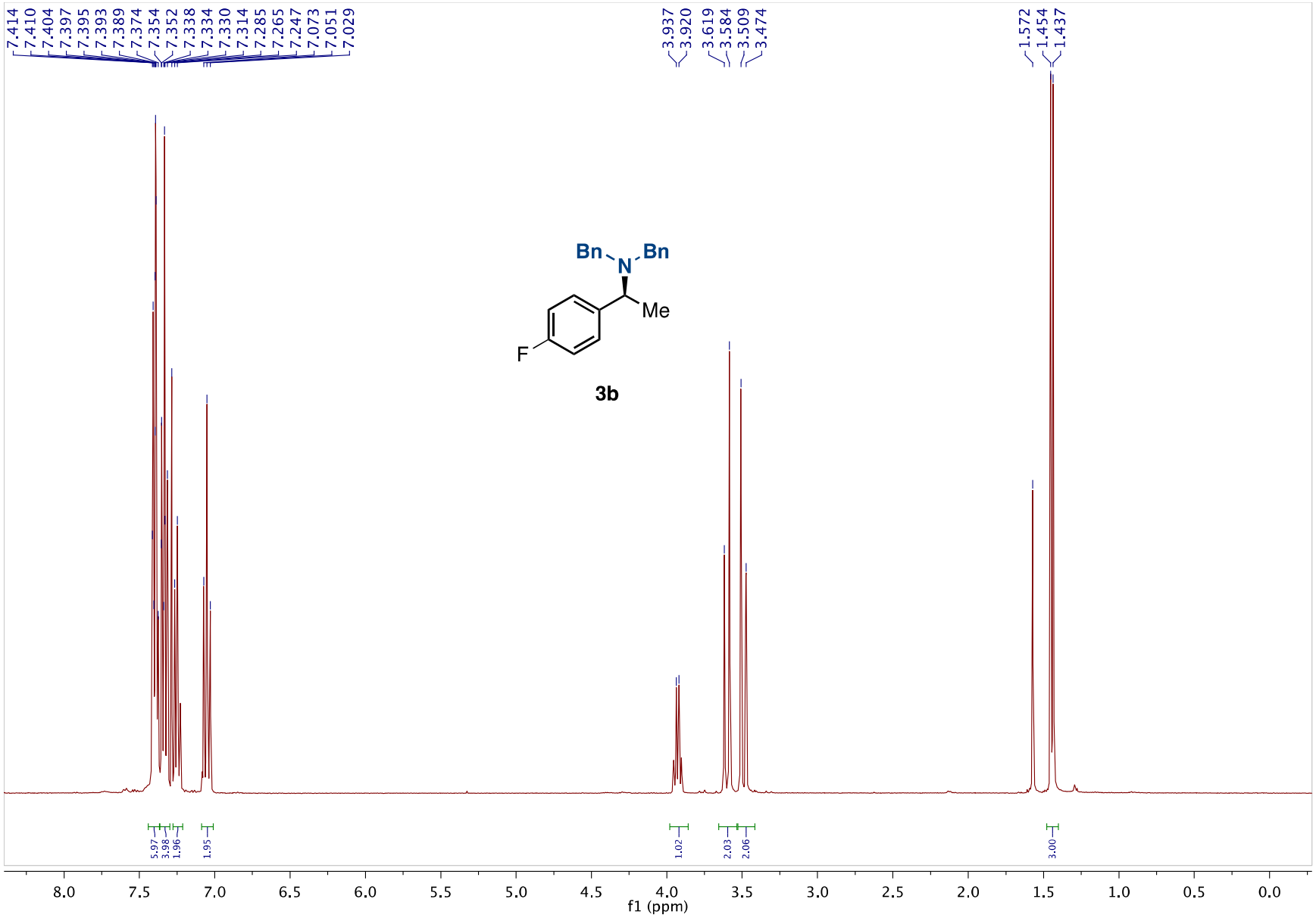
77.160 CDCl3
76.842 CDCl3
56.296
53.706
13.908
Bn
N
Bn
Me
3a
128.771
128.310
128.148
128.078
126.854
126.827
129.5 129.0 128.5 128.0 127.5 127.0 126.5 126.0
f1 (ppm)
150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
f1 (ppm)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7.314
7.285
7.265
7.247
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7.051
7.029
3.937
3.920
3.619
3.584
3.509
3.474
1.572
1.454
1.437
Bn
N
Bn
Me
F
3b
5.97
3.98
1.96
1.95
1.02
2.03
2.06
3.00
8.0
7.5
7.0
6.5
6.0
5.5
5.0
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3.0
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2.0
1.5
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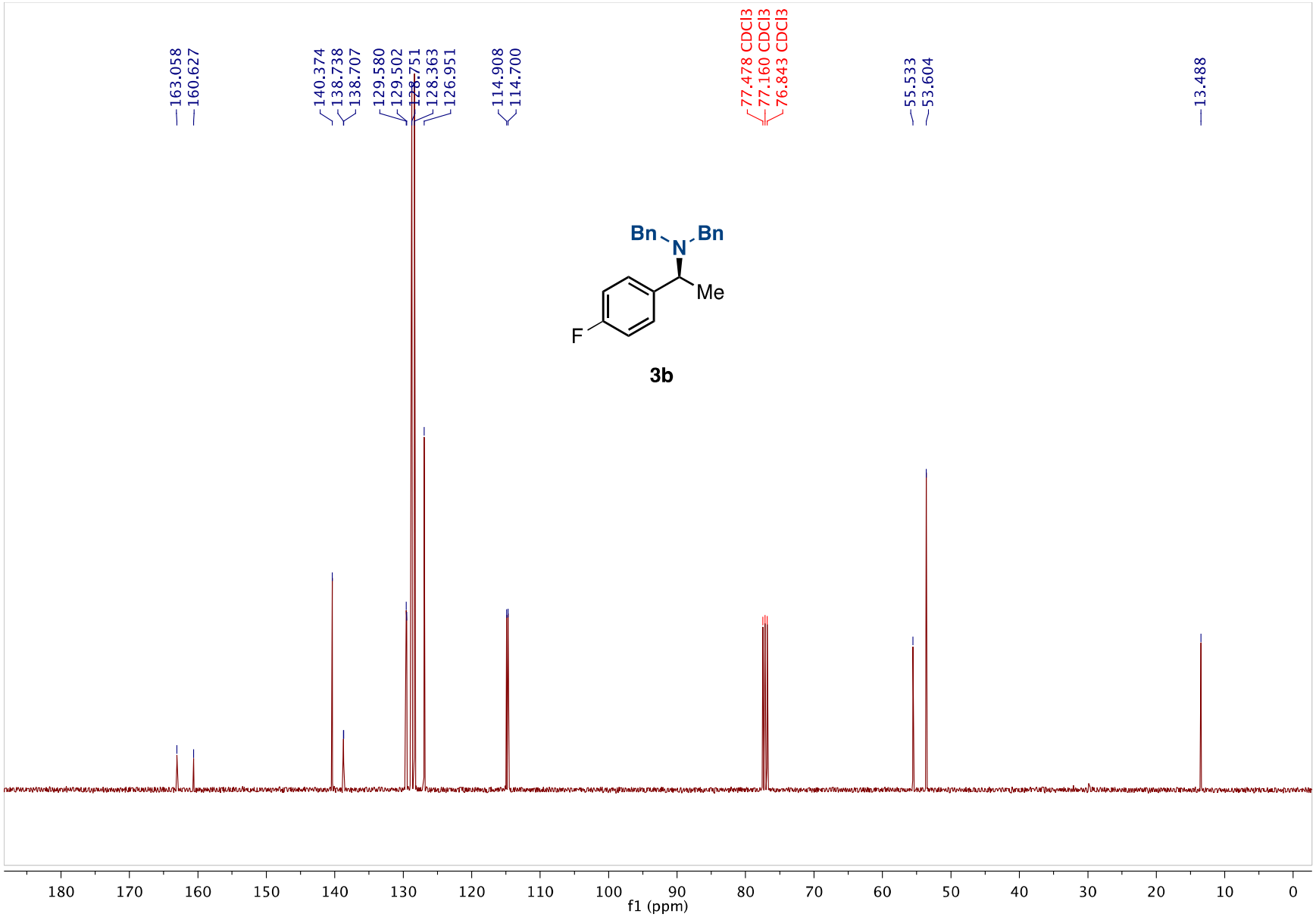
0.0
f1 (ppm)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114.700
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77.160 CDCl3
76.843 CDCl3
55.533
53.604
13.488
Bn
N
Bn
Me
F
3b
180
170
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120
110
100
90
80
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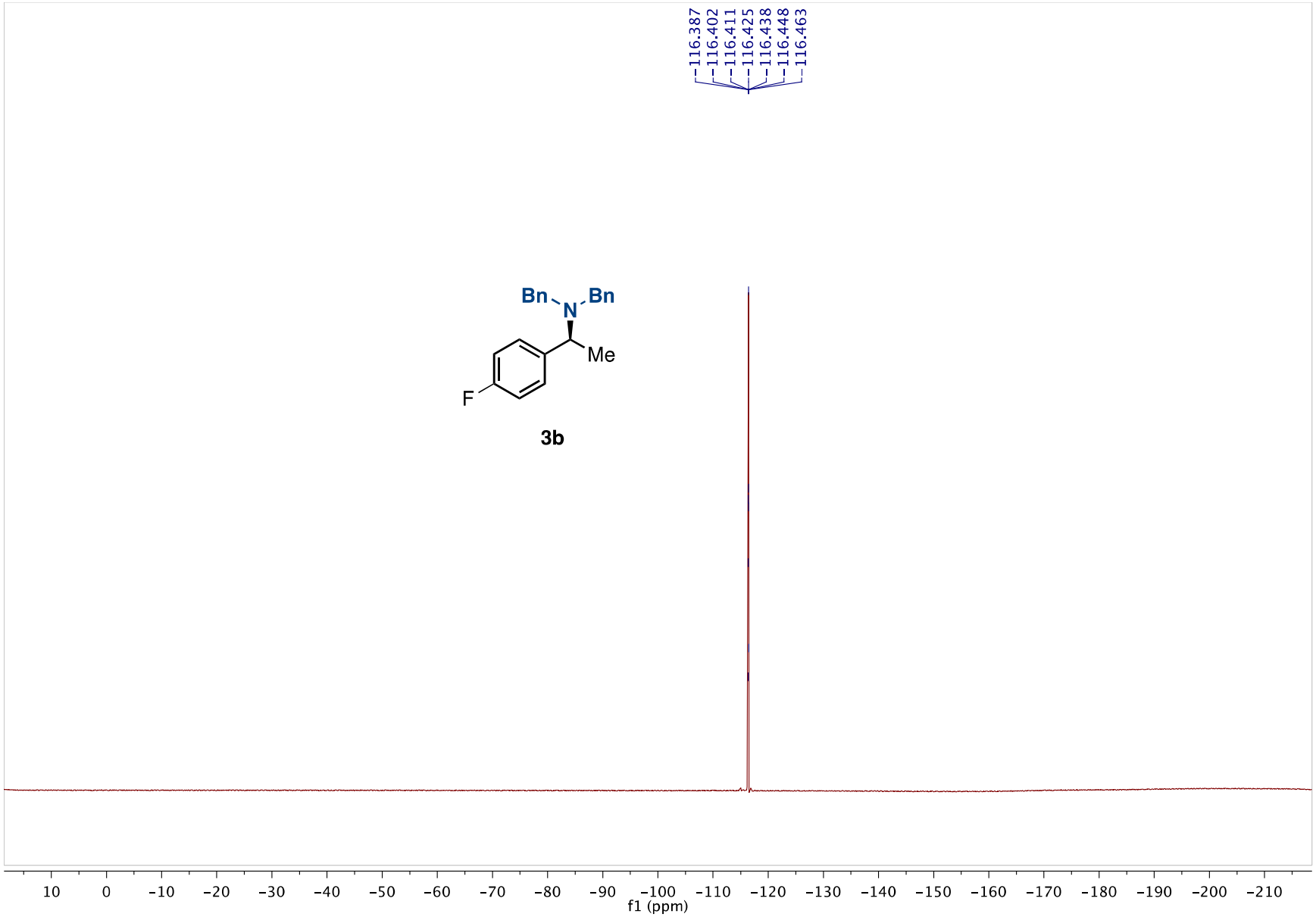
60
50
40
30
20
10
0
f1 (ppm)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Me
F
3b
10
0
-10
-20
-30
-40
-50
-60
-70
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-130
-140
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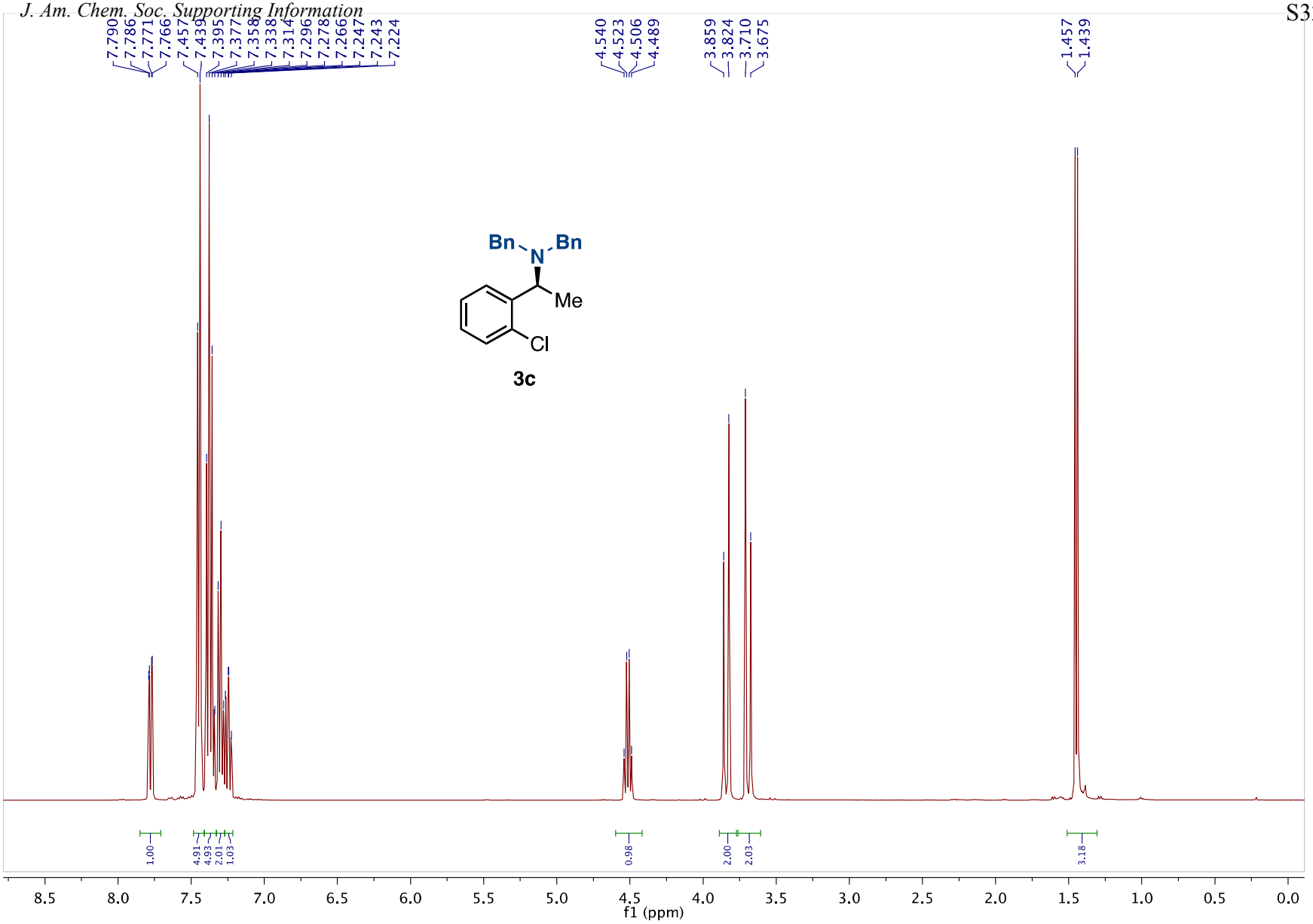
-160
-170
-180
-190
-200
-210
f1 (ppm)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7.278
7.266
7.247
7.243
7.224
4.540
4.523
4.506
4.489
3.859
3.824
3.710
3.675
1.457
1.439
Bn
N
Bn
Me
Cl
3c
1.00
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4.93
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1.03
0.98
2.00
2.03
3.18
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7.5
7.0
6.5
6.0
5.5
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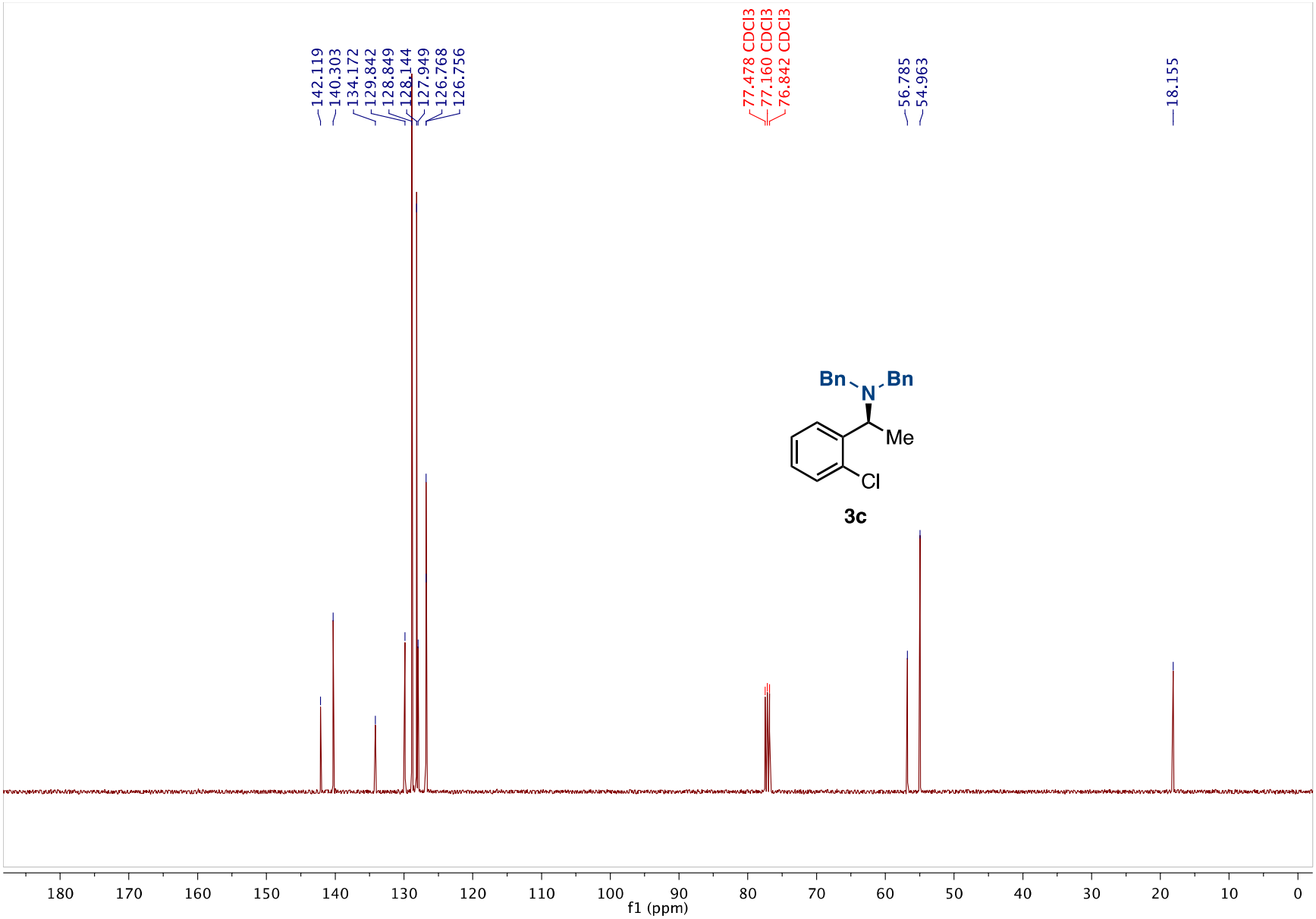
f1 (ppm)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54.963
18.155
Bn
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Bn
Me
Cl
3c
180
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130
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100
90
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50
40
30
20
10
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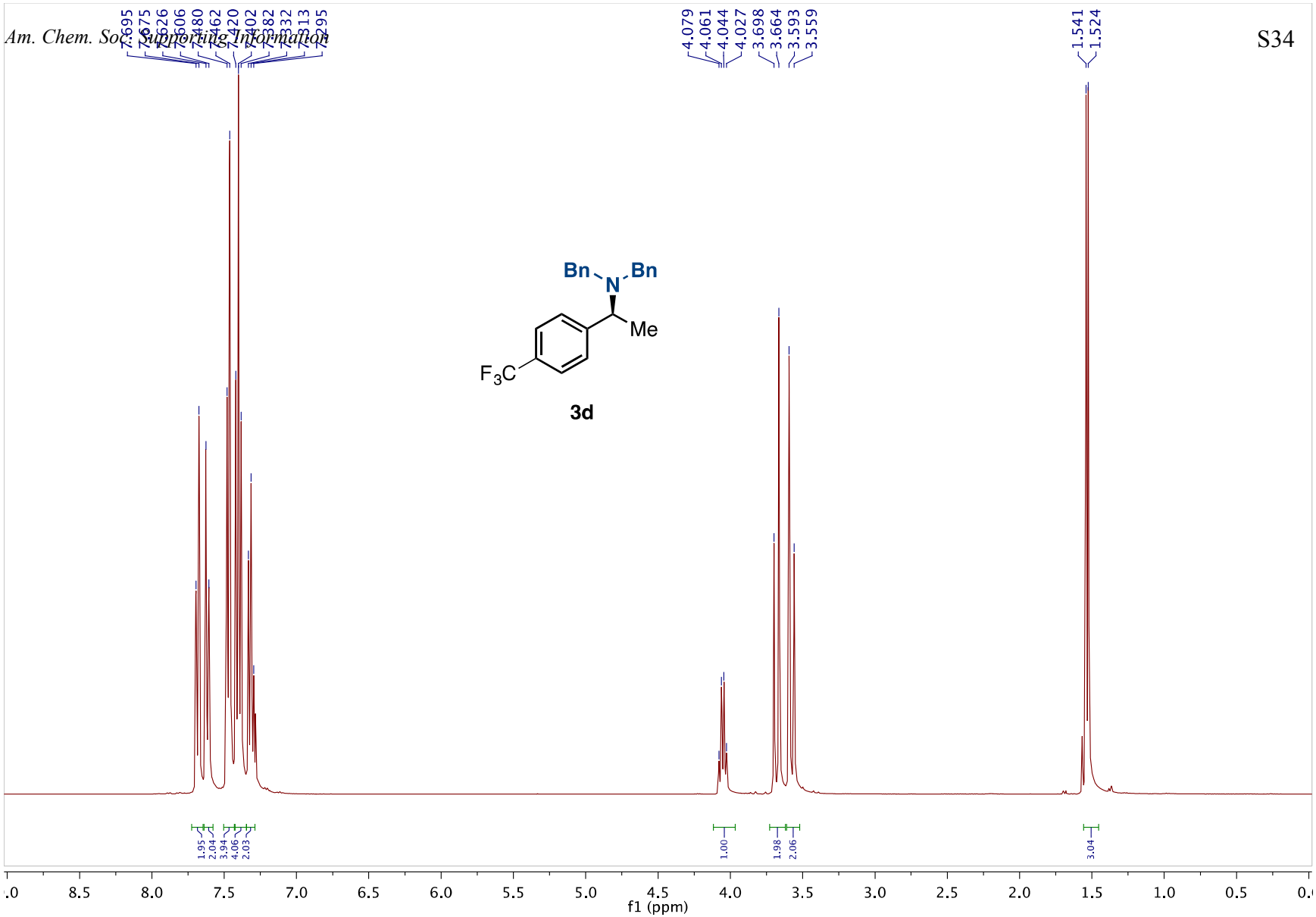
f1 (ppm)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4.061
4.044
4.027
3.698
3.664
3.593
3.559
1.541
1.524
Bn
N
Bn
Me
F3C
3d
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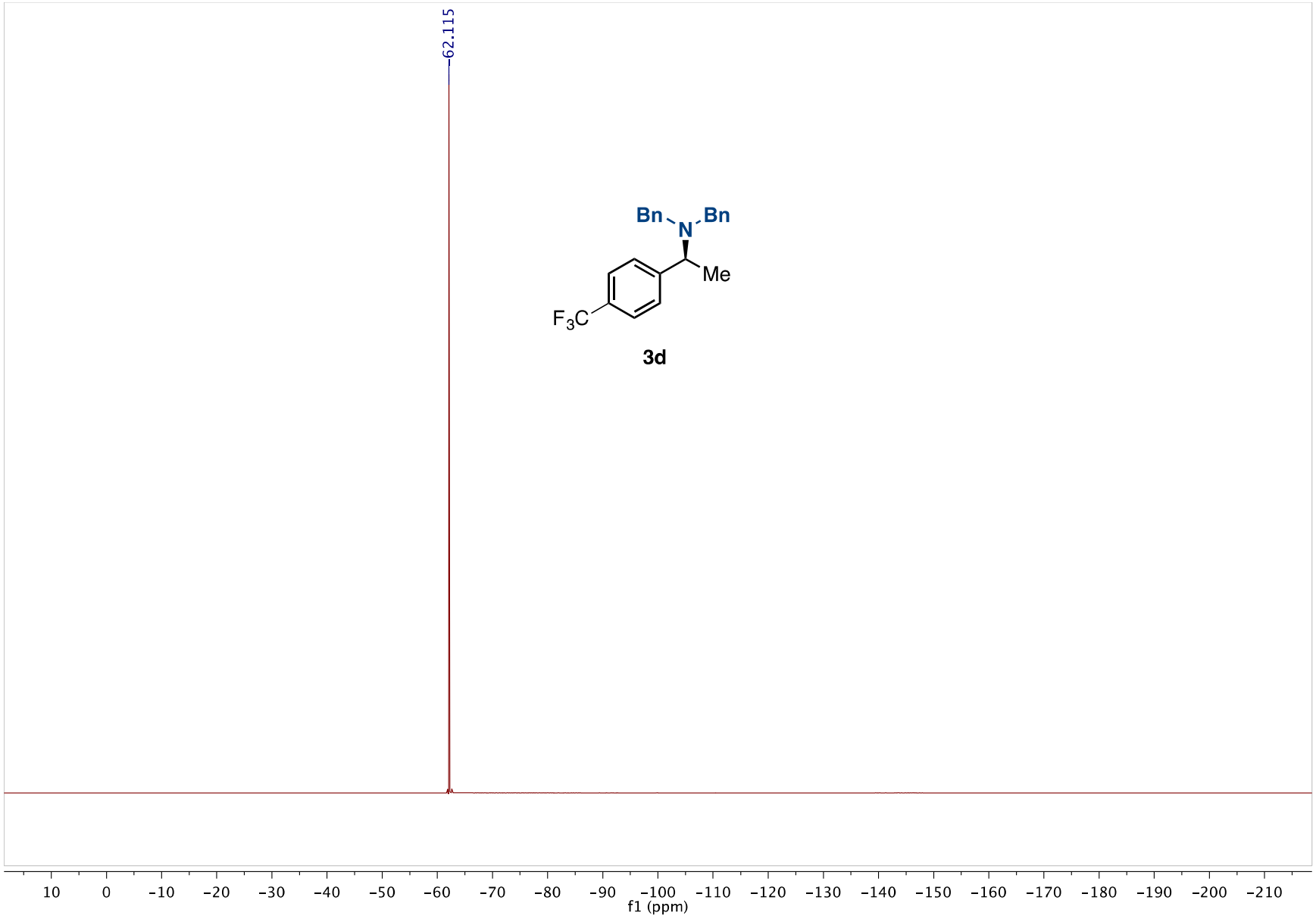
4.06
2.03
1.00
1.98
2.06
3.04
f1 (ppm)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-140
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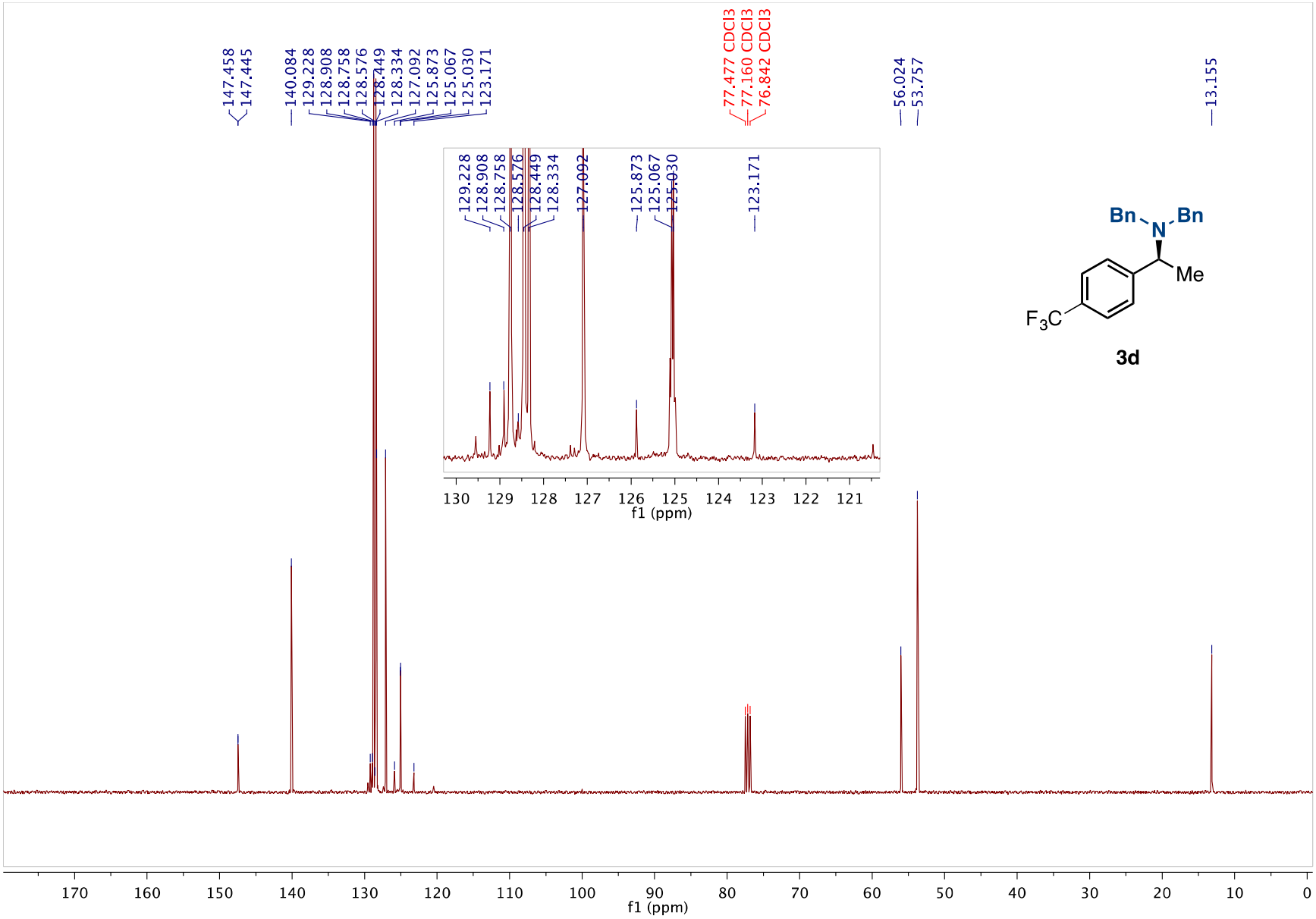
-210
f1 (ppm)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125.030
123.171
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13.155
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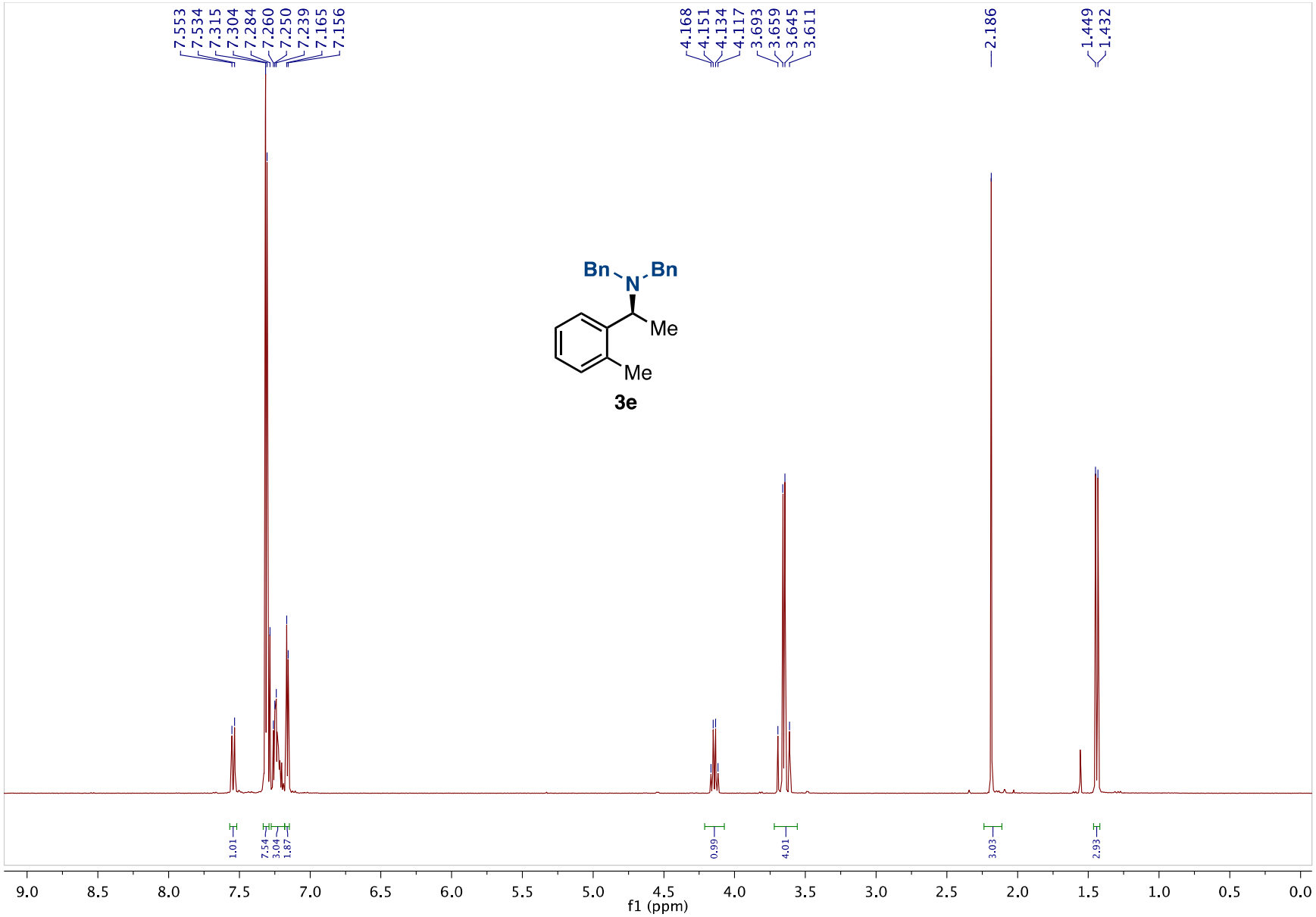
N
Bn
Me
F3C
3d
f1 (ppm)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4.134
4.117
3.693
3.659
3.645
3.611
2.186
1.449
1.432
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Bn
Me
Me
3e
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3.04
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0.99
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3.03
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9.0
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7.5
7.0
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6.0
5.5
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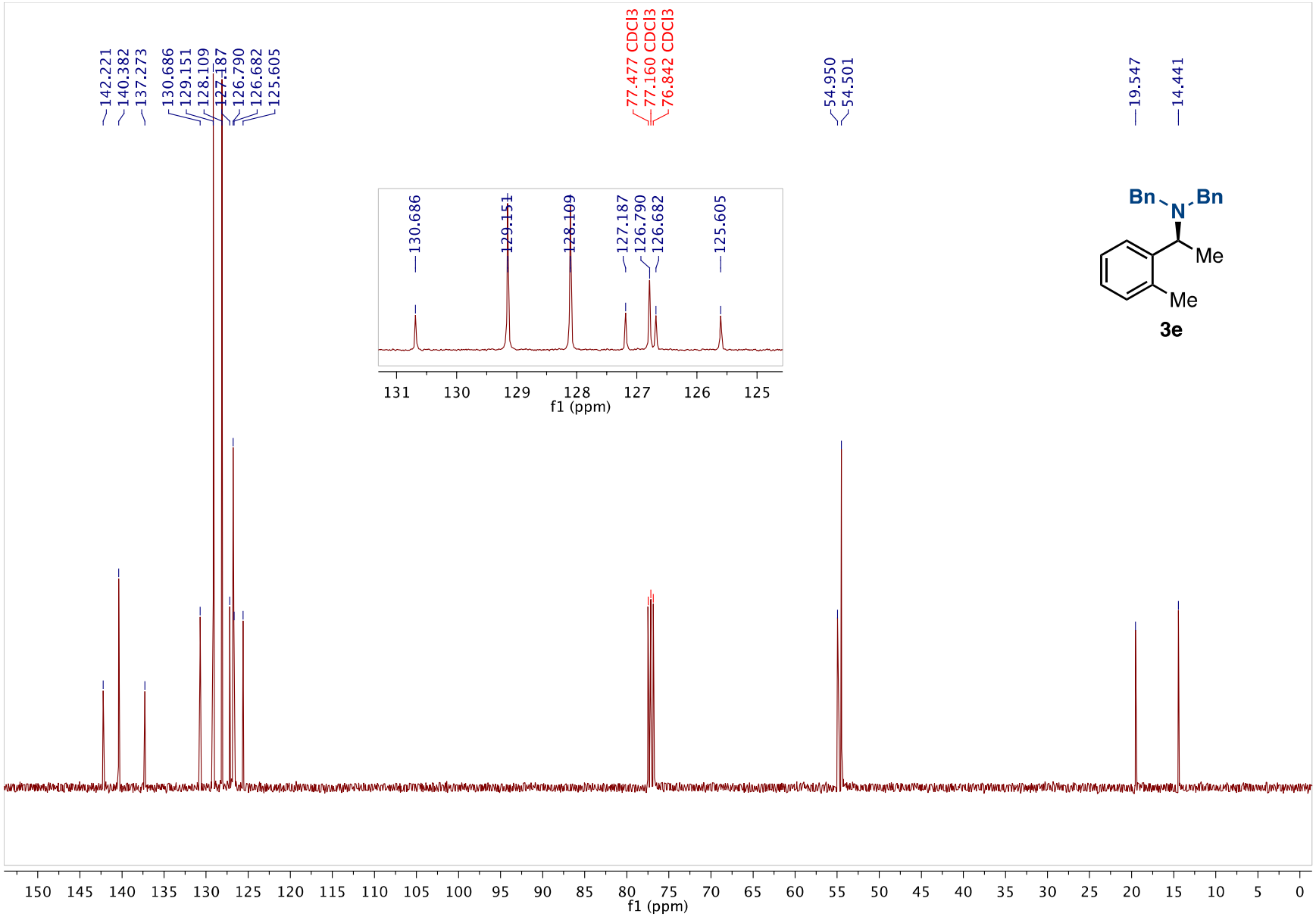
f1 (ppm)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77.160 CDCl3
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Me
Me
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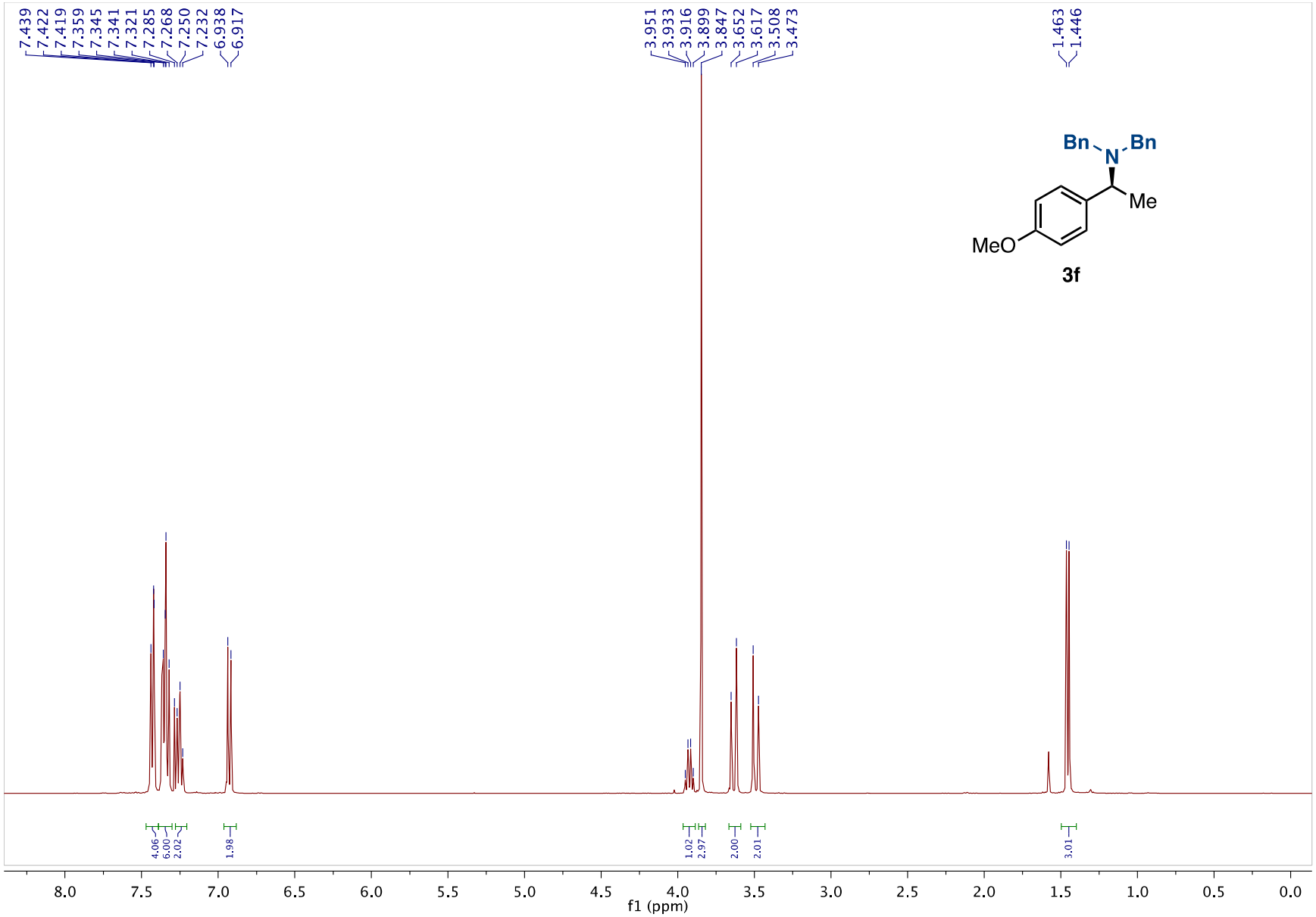
f1 (ppm)
f1 (ppm)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3.916
3.899
3.847
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Me
MeO
3f
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1.98
1.02
2.97
2.00
2.01
3.01
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7.5
7.0
6.5
6.0
5.5
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3.0
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1.0
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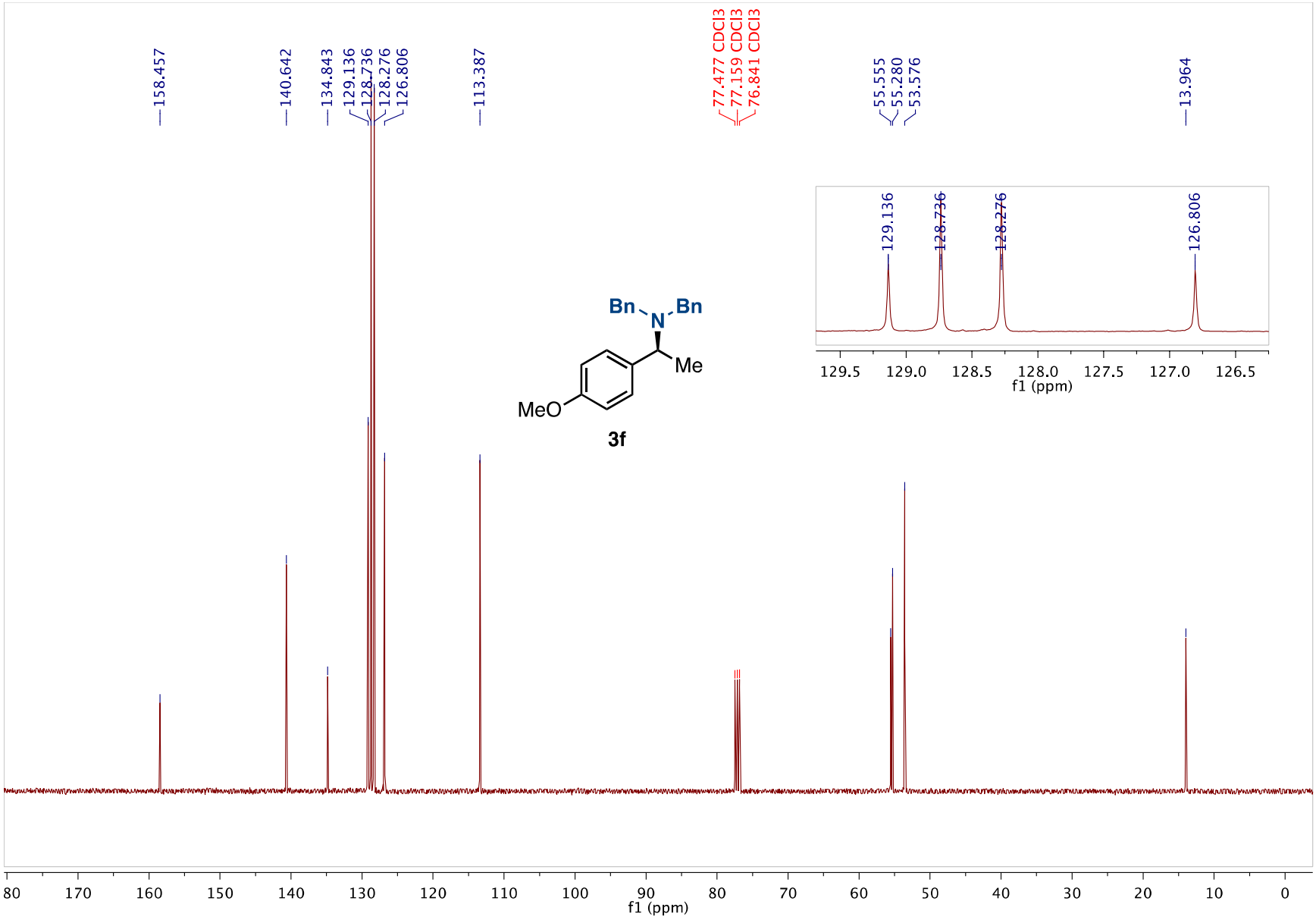
0.0
f1 (ppm)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128.276
126.806
113.387
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77.159 CDCl3
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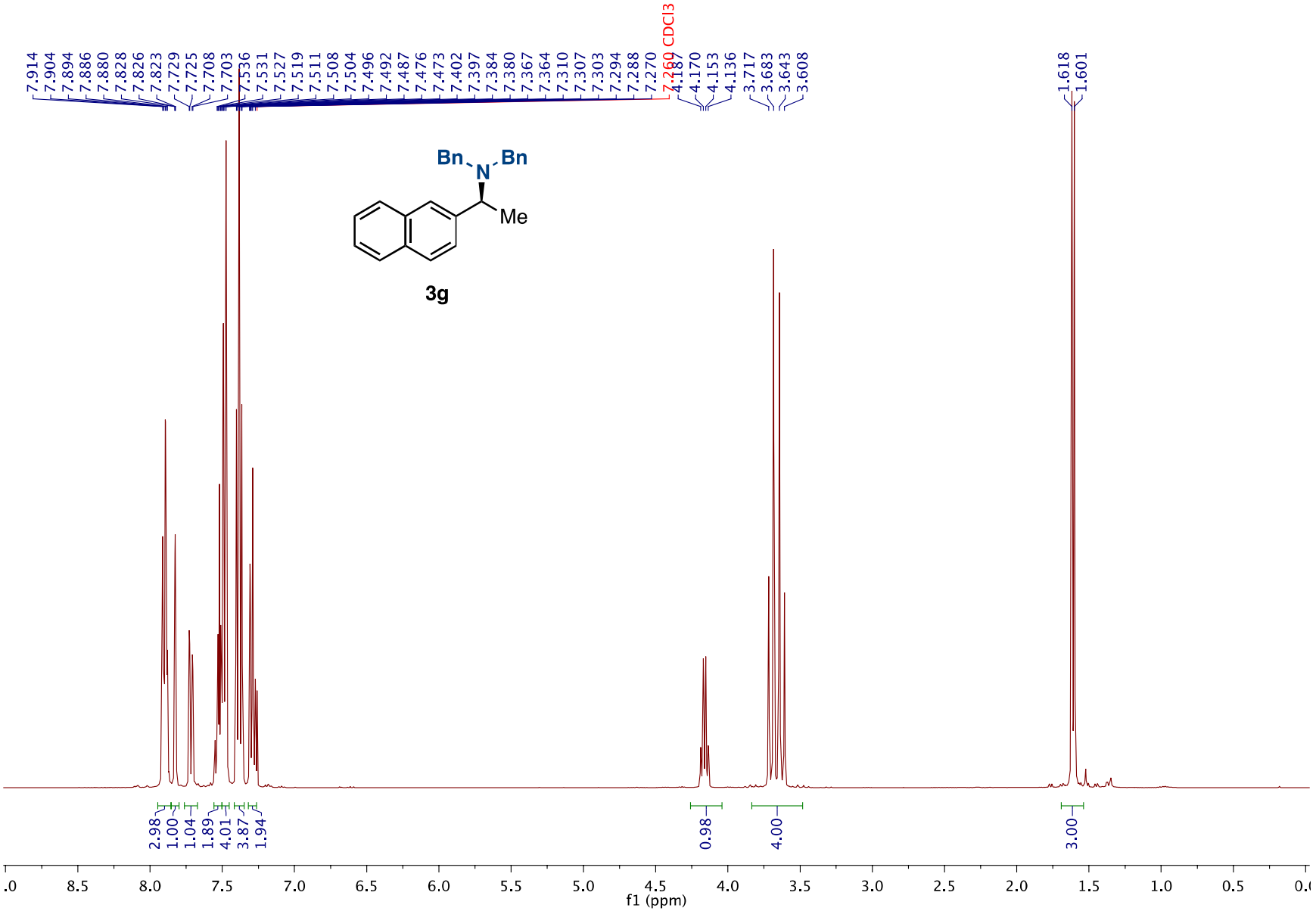
55.555
55.280
53.576
13.964
Bn
N
Bn
Me
MeO
3f
129.136
128.736
128.276
126.806
129.5
129.0
128.5
128.0
127.5
127.0
126.5
f1 (ppm)
80
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.492
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7.476
7.473
7.402
7.397
7.384
7.380
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Bn
Me
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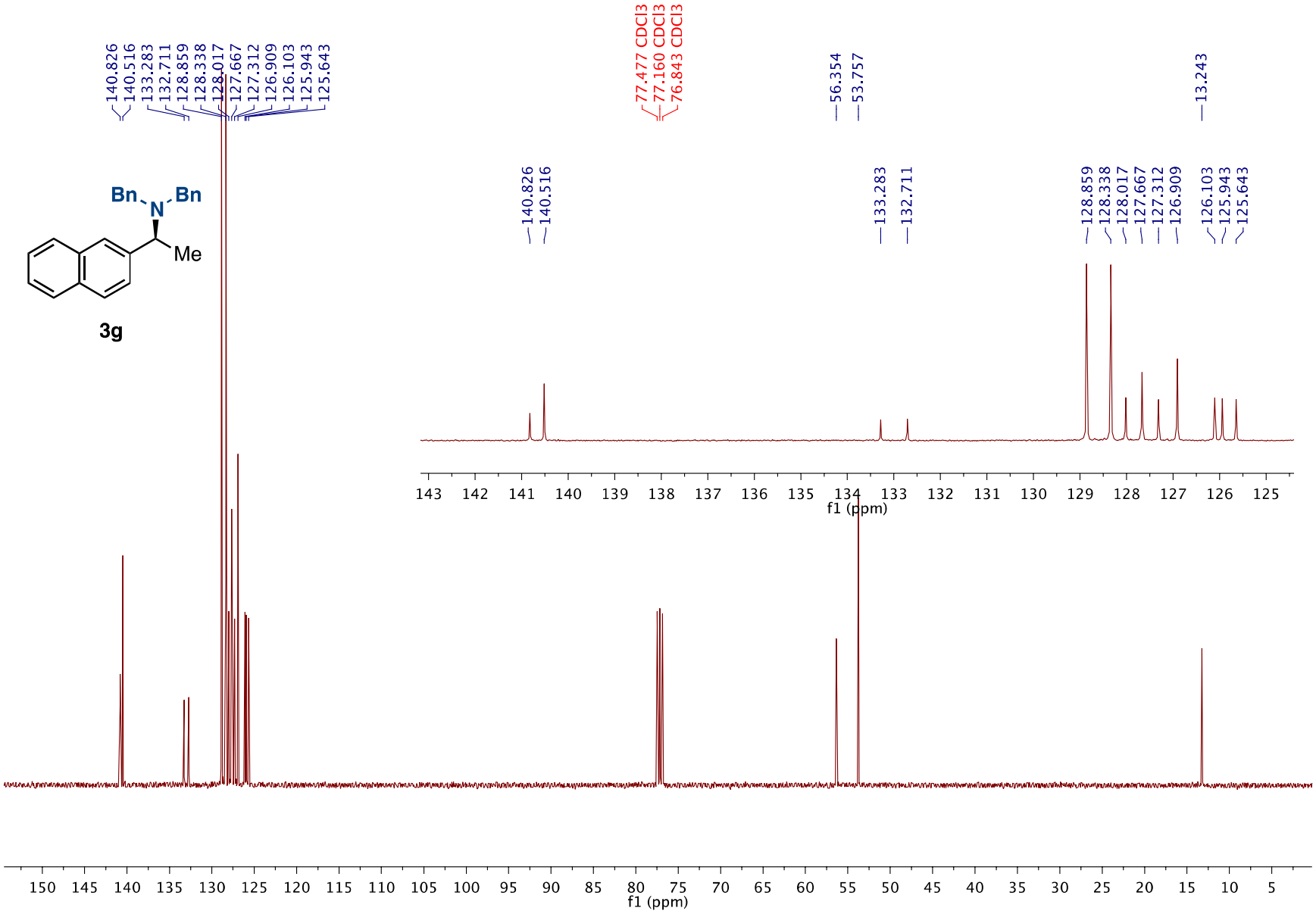
3.00
f1 (ppm)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125.643
77.477 CDCl3
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76.843 CDCl3
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53.757
13.243
Bn
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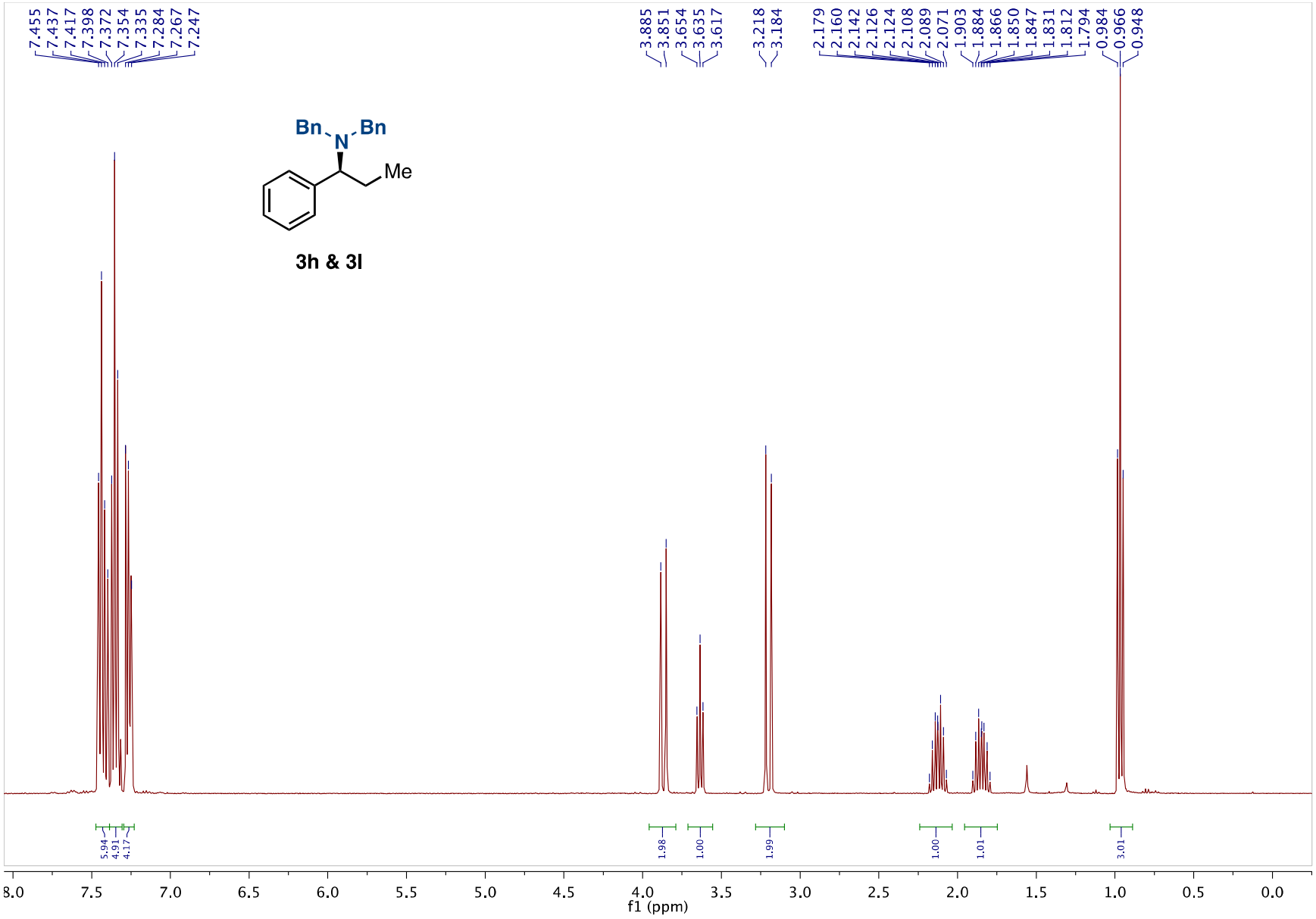
Bn
Me
3g
f1 (ppm)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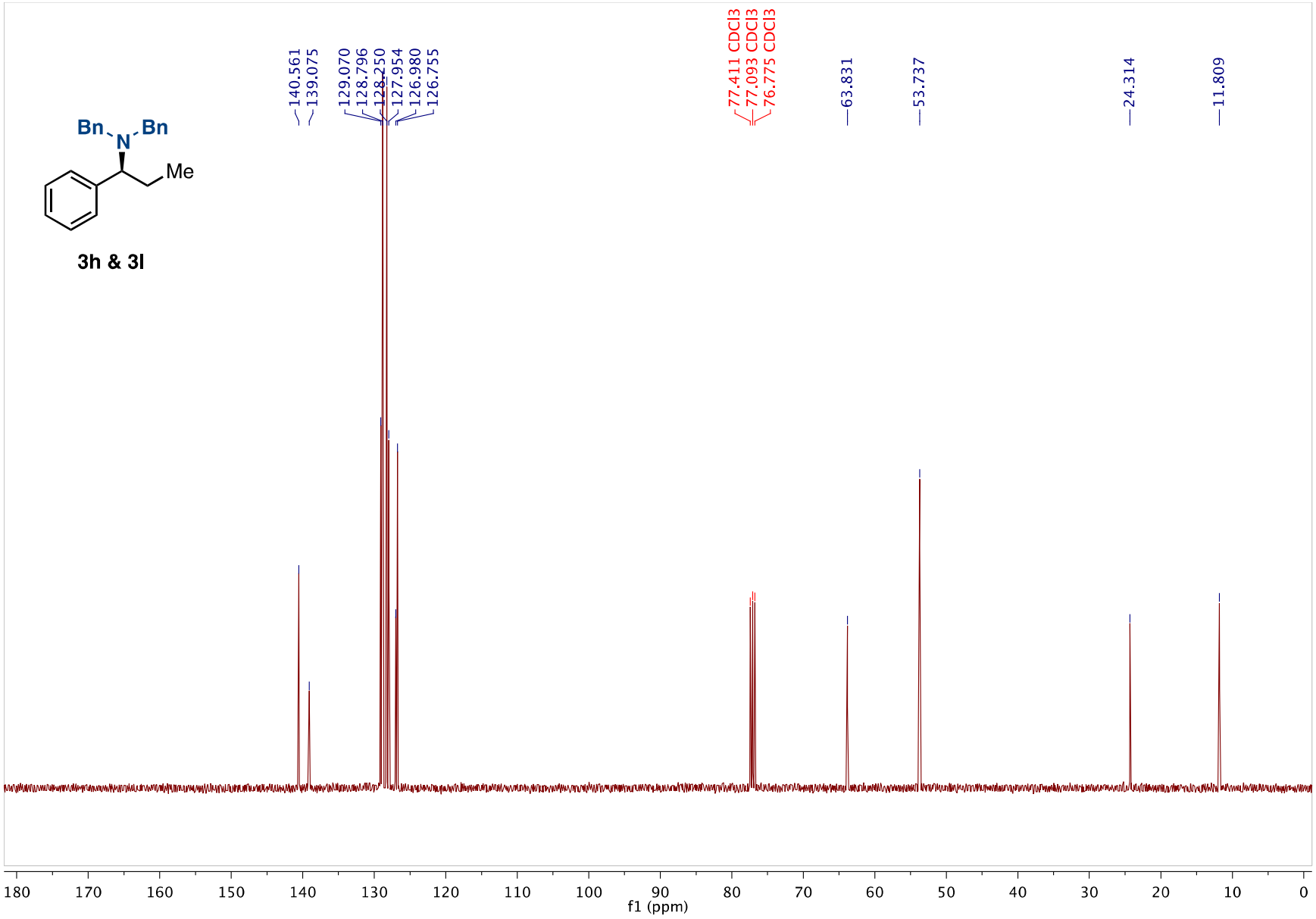
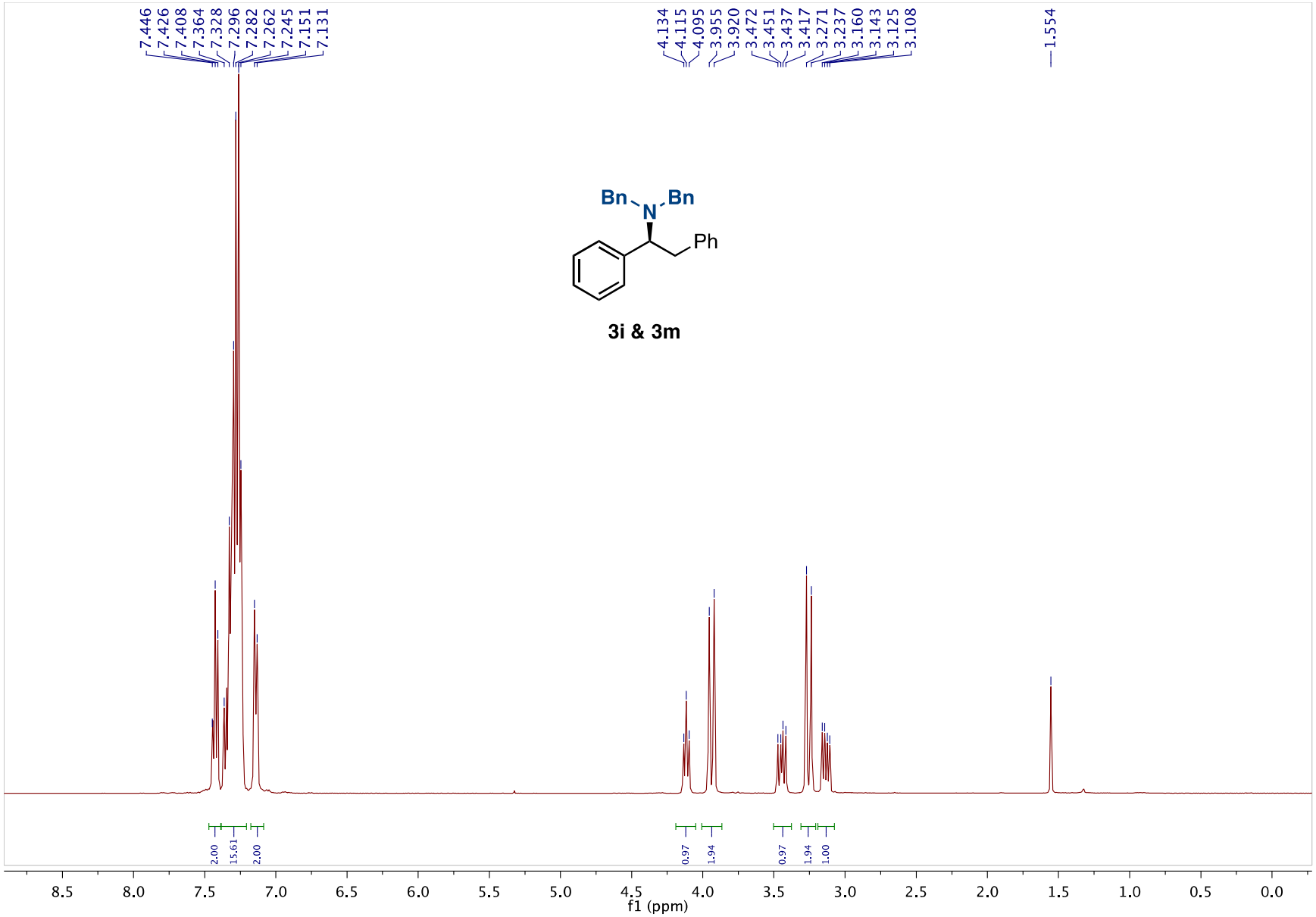
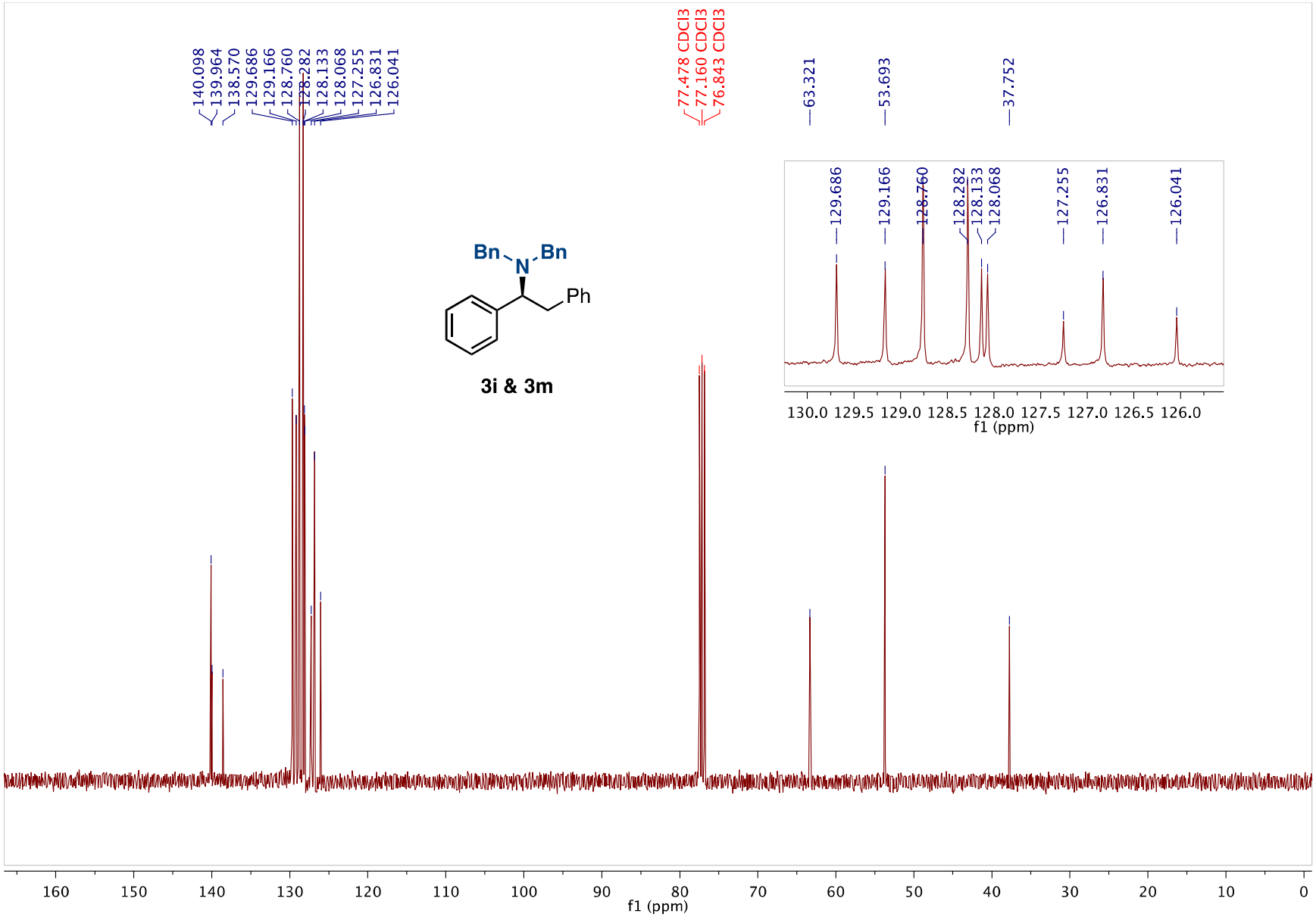
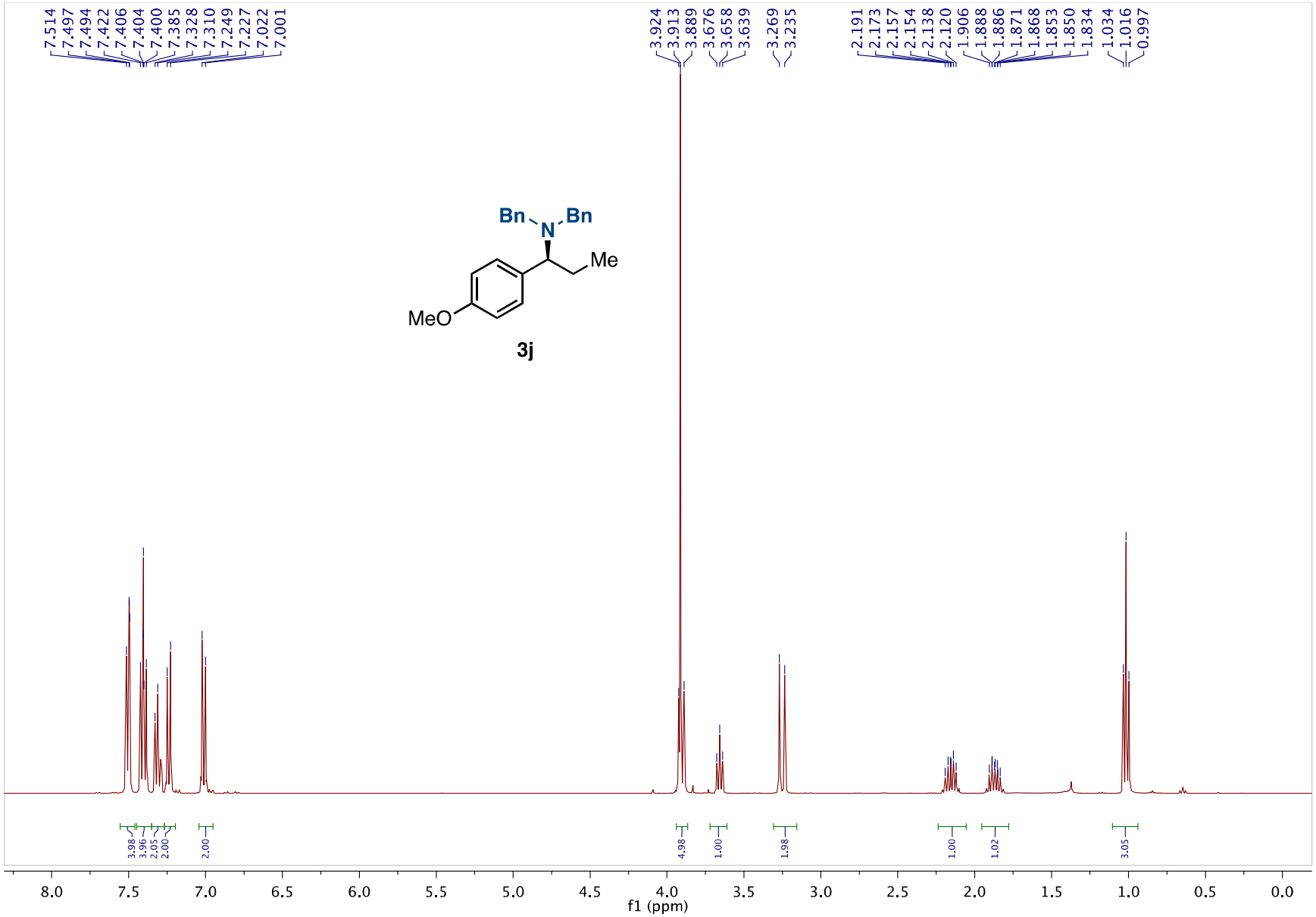
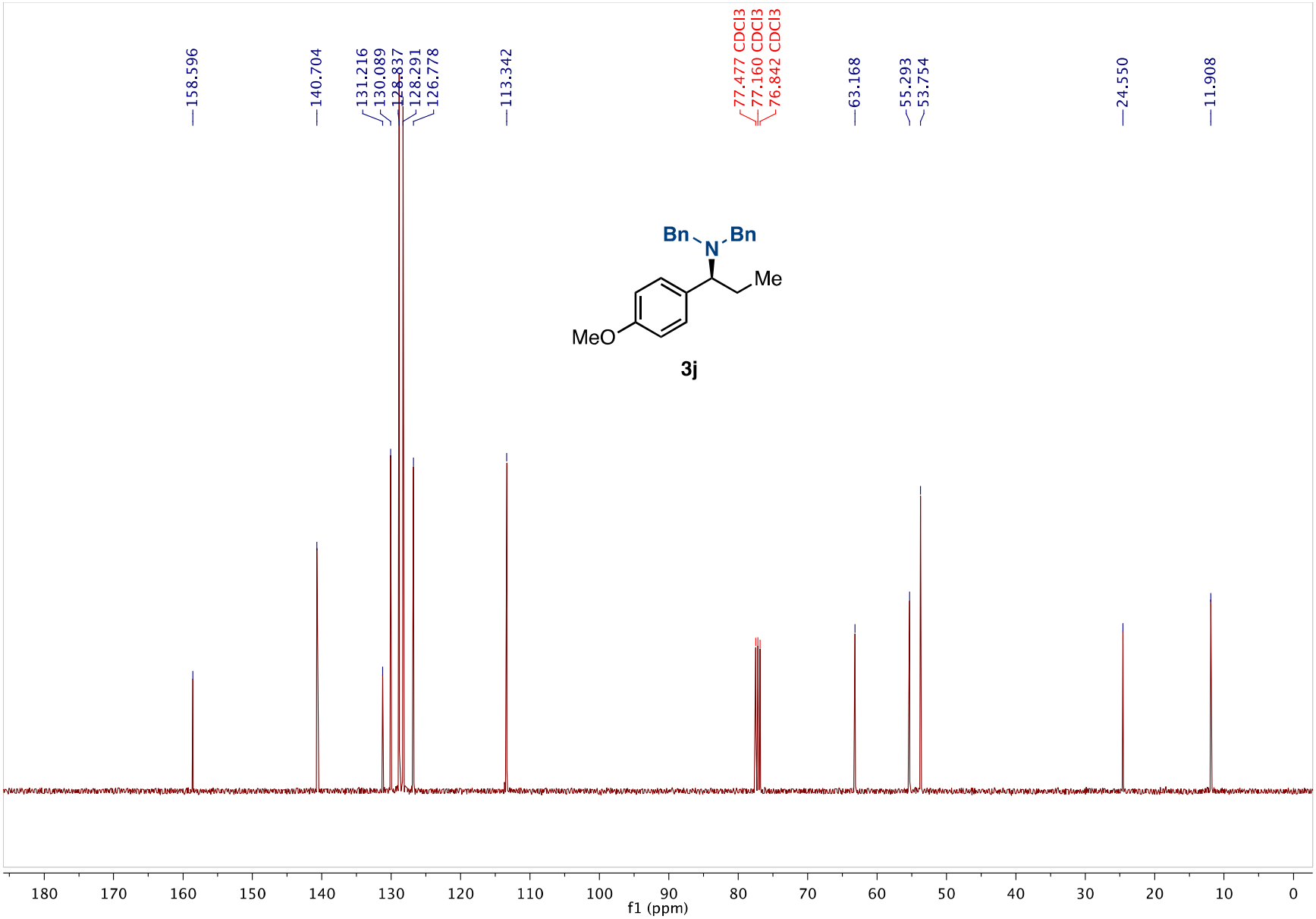
3.635
3.617
3.218
3.184
2.179
2.160
2.142
2.126
2.124
2.108
2.089
2.071
1.903
1.884
1.866
1.850
1.847
1.831
1.812
1.794
0.984
0.966
0.948
Bn
N
Bn
Me
3h & 3l
5.94
4.91
4.17
1.98
1.00
1.99
1.00
1.01
3.01
f1 (ppm)

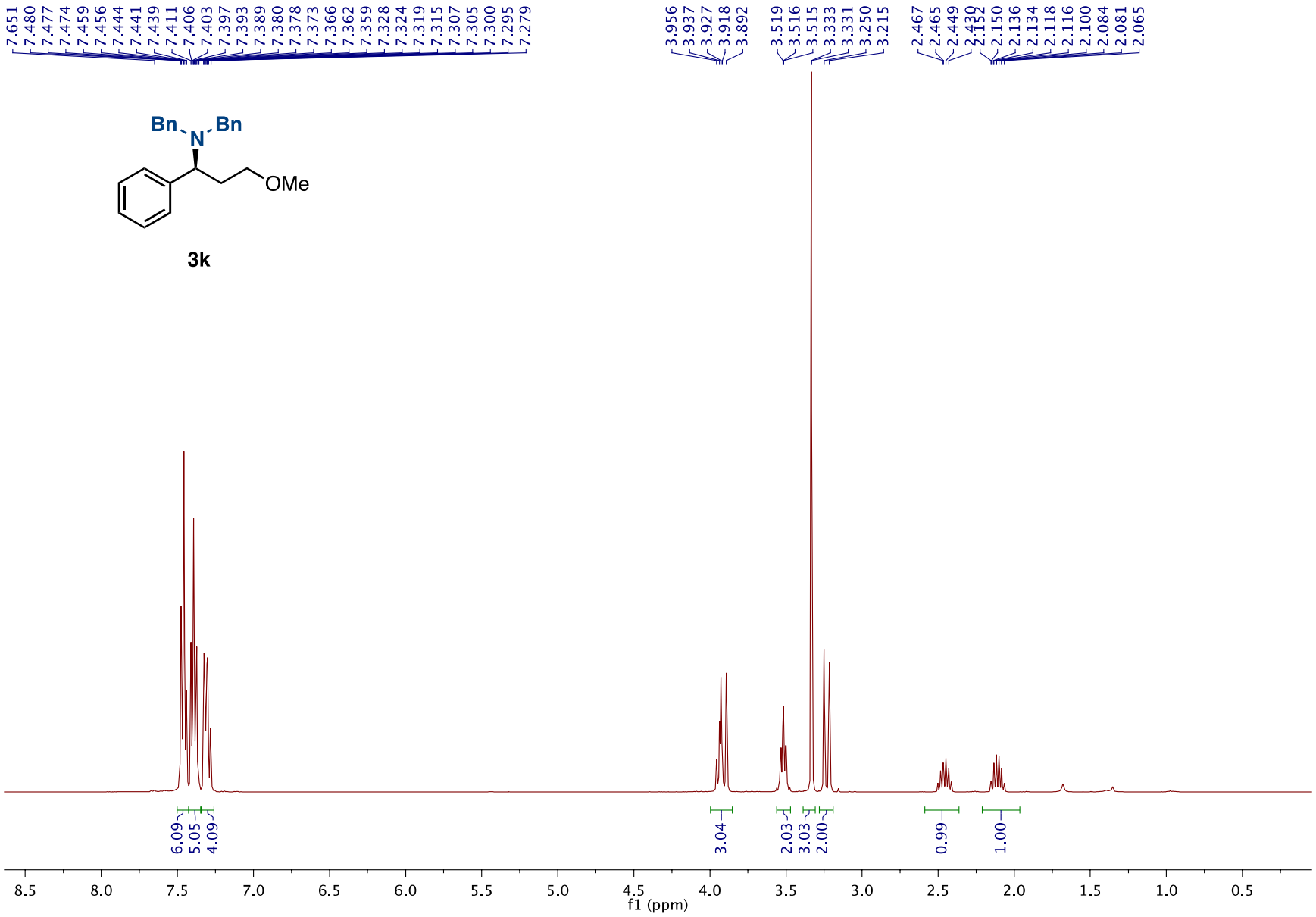

Bn
N
Bn
Me
3h & 3l
140.561
139.075
129.070
128.796
128.250
127.954
126.980
126.755
77.411 CDCl3
77.093 CDCl3
76.775 CDCl3
63.831
53.737
24.314
11.809
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

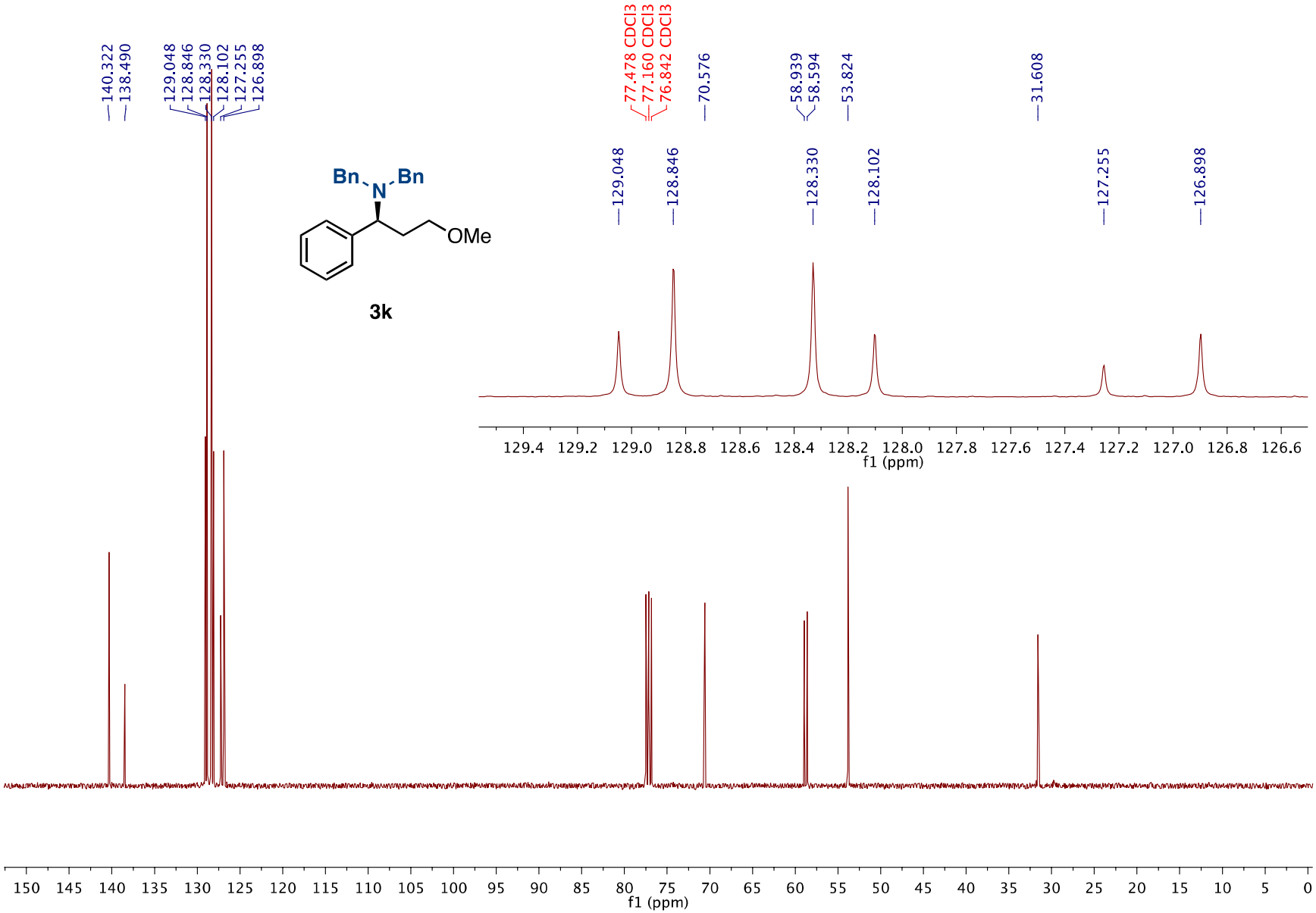

7.446
7.426
7.408
7.364
7.328
7.296
7.282
7.262
7.245
7.151
7.131
4.134
4.115
4.095
3.955
3.920
3.472
3.451
3.437
3.417
3.271
3.237
3.160
3.143
3.125
3.108
1.554
Bn
N
Bn
Ph
3i & 3m
2.00
15.61
2.00
0.97
1.94
0.97
1.94
1.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

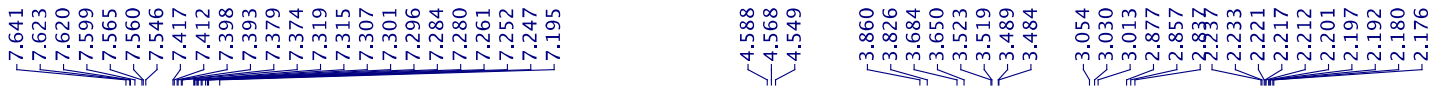

140.098
139.964
138.570
129.686
129.166
128.760
128.282
128.133
128.068
127.255
126.831
126.041
77.478 CDCl3
77.160 CDCl3
76.843 CDCl3
63.321
53.693
37.752
Bn
N
Bn
Ph
3i & 3m
130.0 129.5 129.0 128.5 128.0 127.5 127.0 126.5 126.0
f1 (ppm)
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

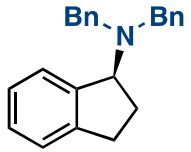

7.514
7.497
7.494
7.422
7.406
7.404
7.400
7.385
7.328
7.310
7.249
7.227
7.022
7.001
3.924
3.913
3.889
3.676
3.658
3.639
3.269
3.235
2.191
2.173
2.157
2.154
2.138
2.120
1.906
1.888
1.886
1.871
1.868
1.853
1.850
1.834
1.034
1.016
0.997
Bn
N
Bn
Me
MeO
3j
3.98
3.96
2.05
2.00
2.00
4.98
1.00
1.98
1.00
1.02
3.05
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)


158.596
140.704
131.216
130.089
128.837
128.291
126.778
113.342
77.477 CDCl3
77.160 CDCl3
76.842 CDCl3
63.168
55.293
53.754
24.550
11.908
Bn
N
Bn
Me
MeO
3j
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

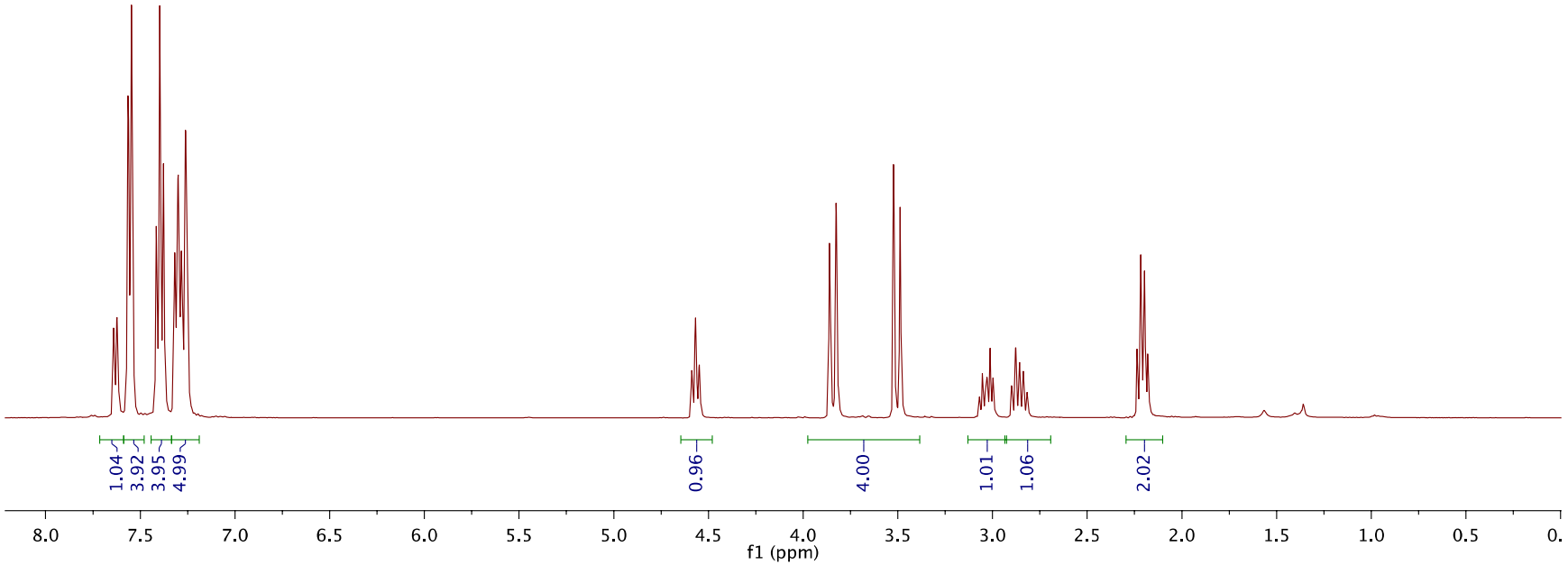

7.651
7.480
7.477
7.474
7.459
7.456
7.444
7.441
7.439
7.411
7.406
7.403
7.397
7.393
7.389
7.380
7.378
7.373
7.366
7.362
7.359
7.328
7.324
7.319
7.315
7.307
7.305
7.300
7.295
7.279
3.956
3.937
3.927
3.918
3.892
3.519
3.516
3.515
3.333
3.331
3.250
3.215
2.467
2.465
2.449
2.430
2.152
2.150
2.136
2.134
2.118
2.116
2.100
2.084
2.081
2.065
Bn
N
Bn
OMe
3k
6.09
5.05
4.09
3.04
2.03
3.03
2.00
0.99
1.00
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
f1 (ppm)

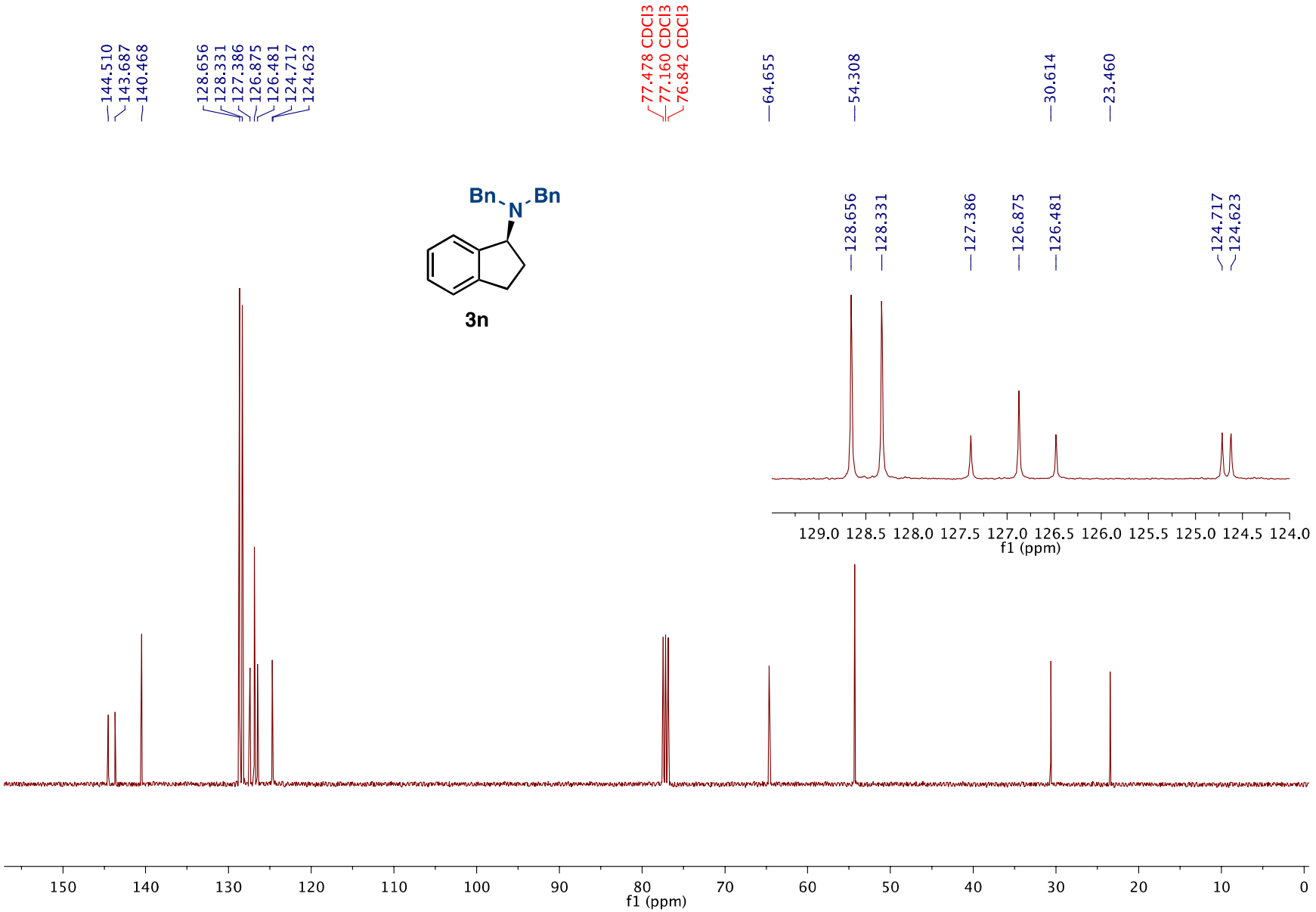

140.322
138.490
129.048
128.846
128.330
128.102
127.255
126.898
77.478 CDCl3
77.160 CDCl3
76.842 CDCl3
70.576
58.939
58.594
53.824
31.608
Bn
N
Bn
OMe
3k
f1 (ppm)

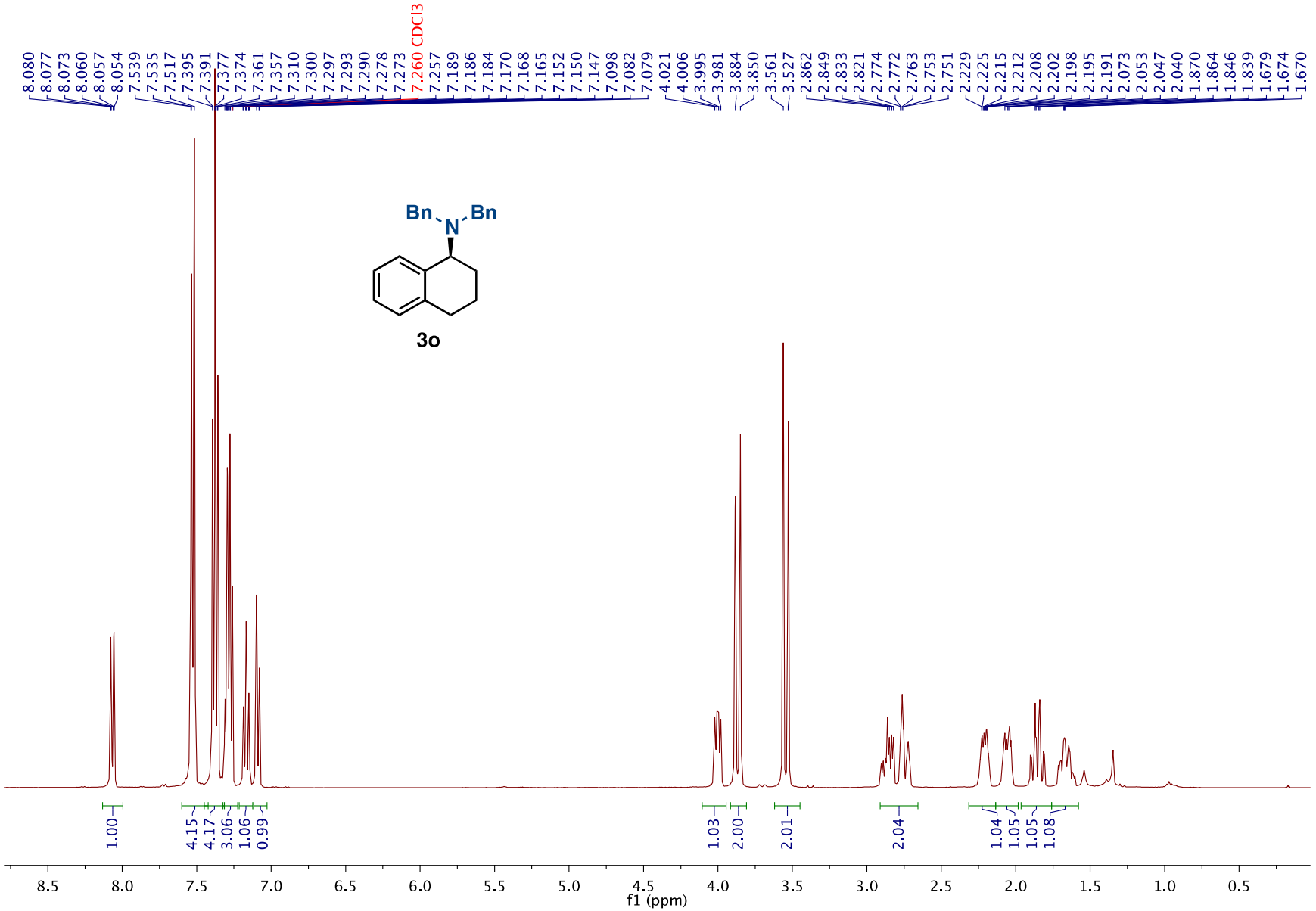

7.641
7.623
7.620
7.599
7.565
7.560
7.546
7.417
7.412
7.398
7.393
7.379
7.374
7.319
7.315
7.307
7.301
7.296
7.284
7.280
7.261
7.252
7.247
7.195
4.588
4.568
4.549
3.860
3.826
3.684
3.650
3.523
3.519
3.489
3.484
3.054
3.030
3.013
2.877
2.857
2.837
2.233
2.221
2.217
2.212
2.201
2.197
2.192
2.180
2.176

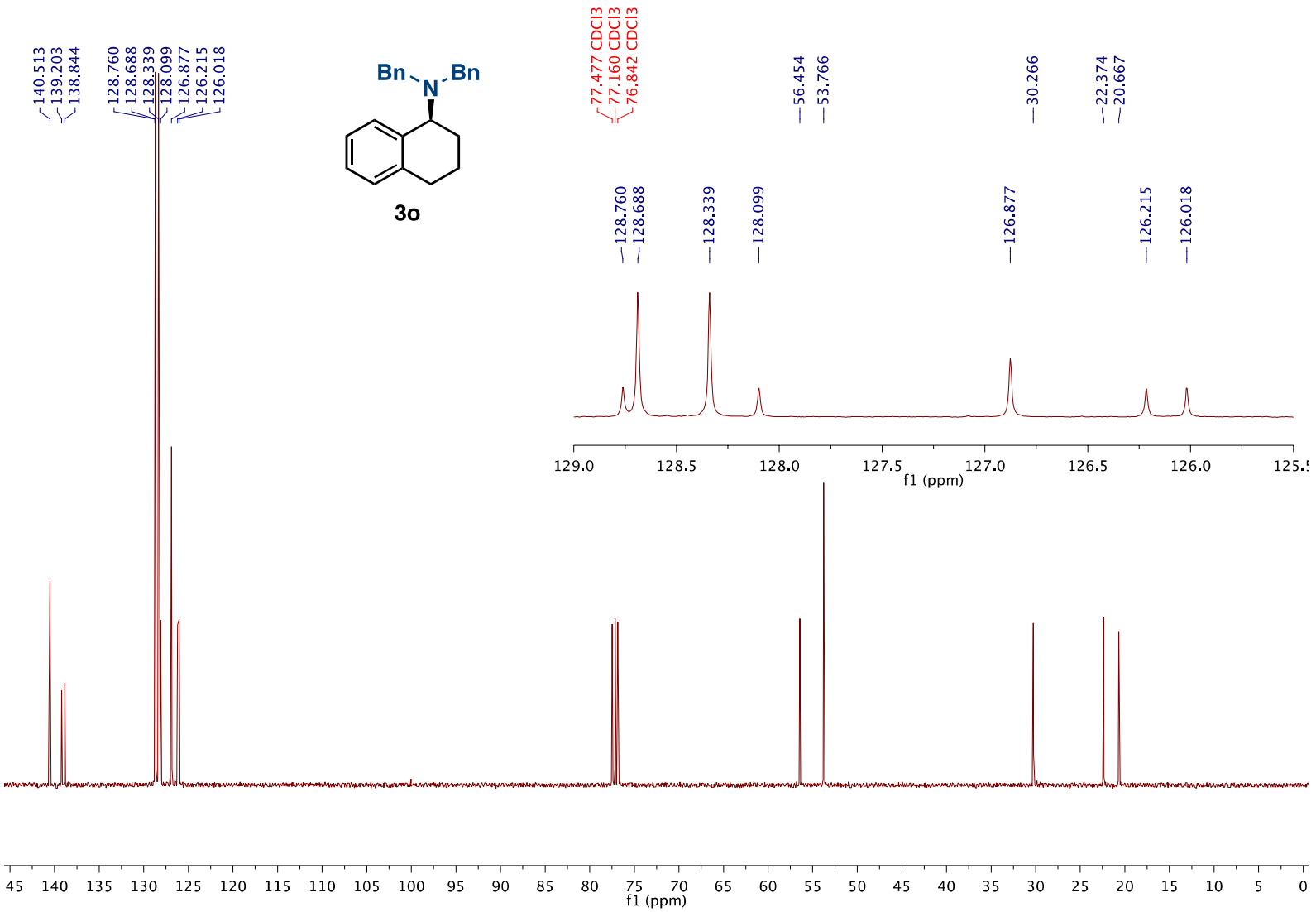

Bn
N
Bn

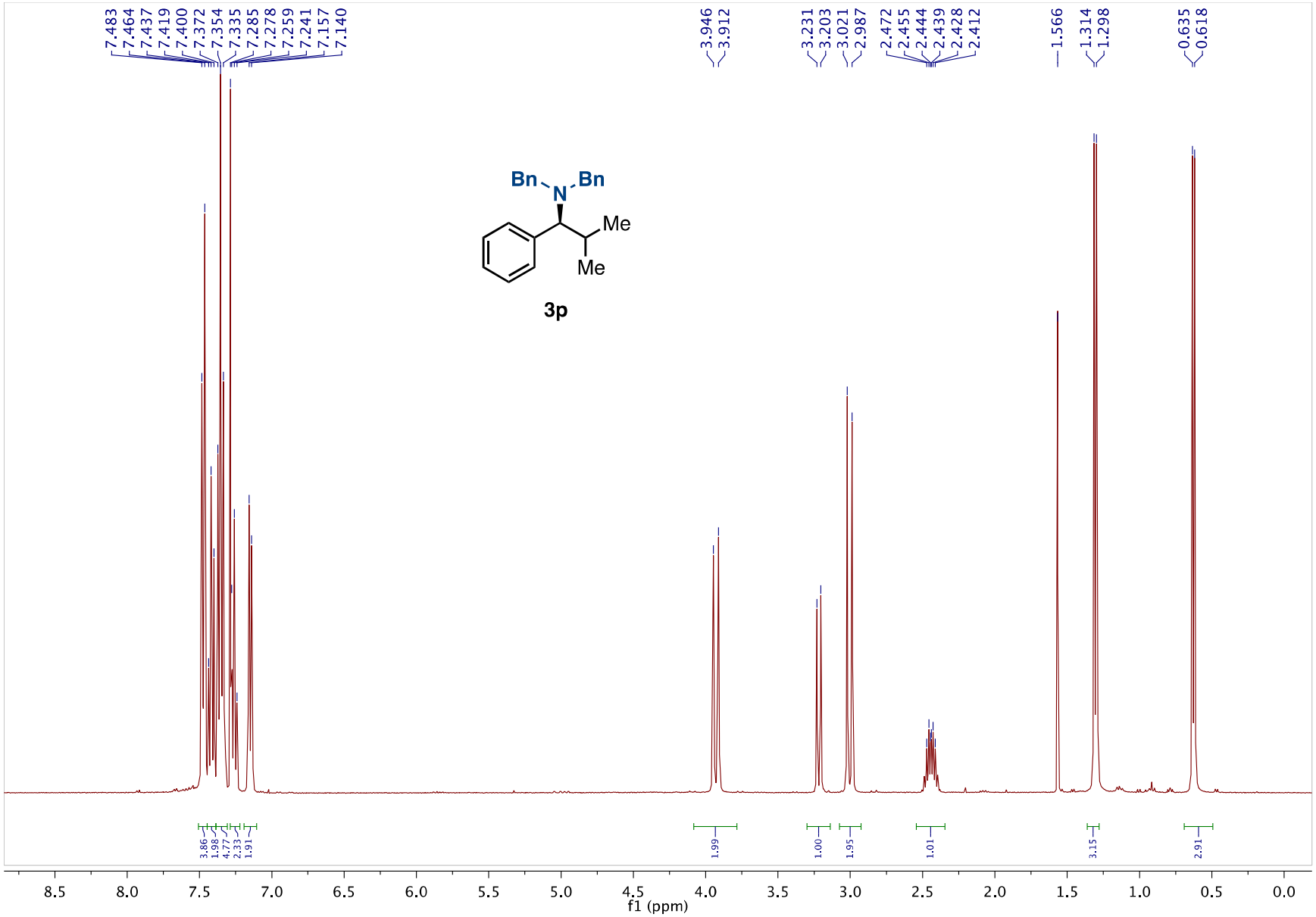
3n

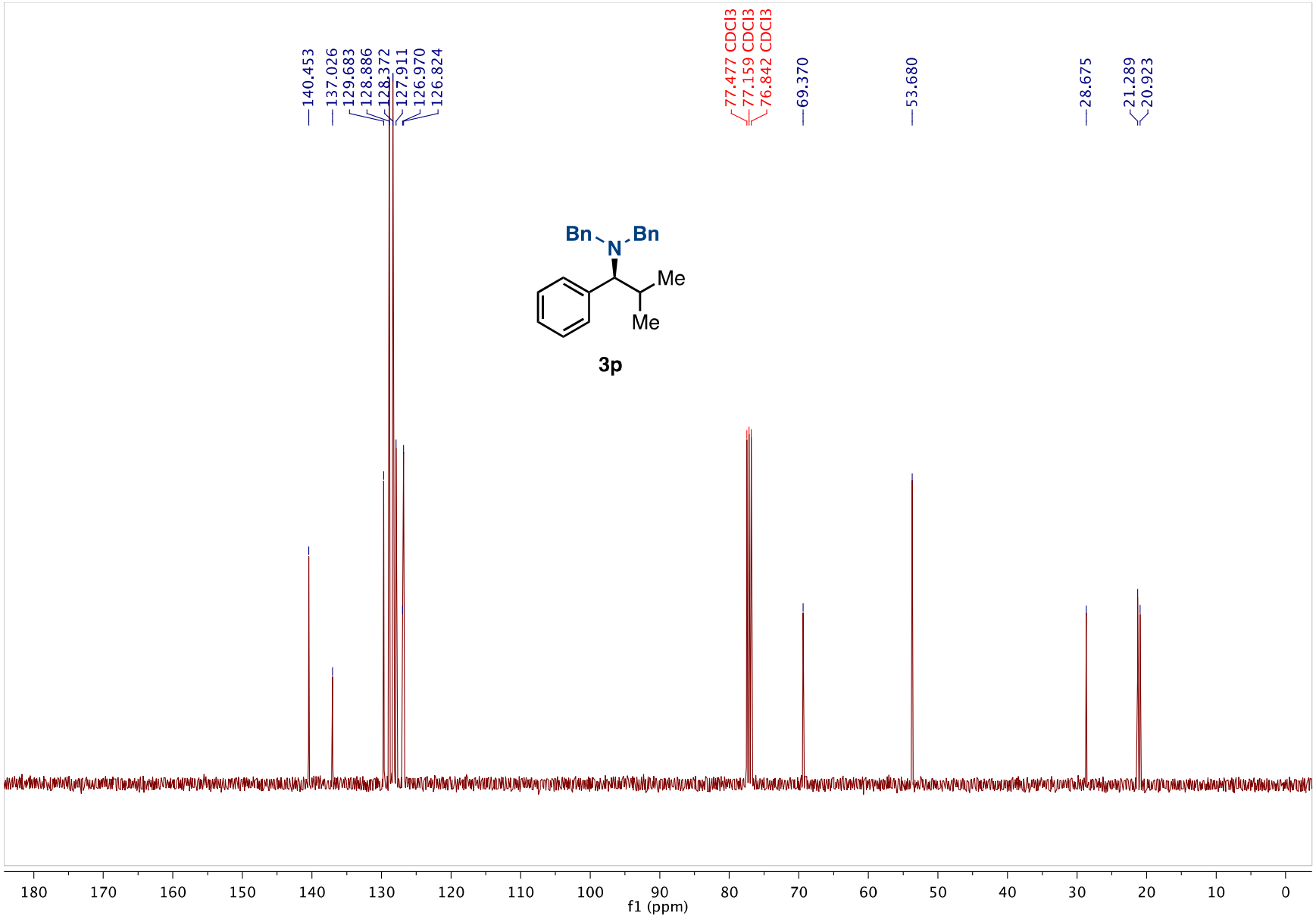

1.04
3.92
3.95
4.99
0.96
4.00
1.01
1.06
2.02
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.
f1 (ppm)

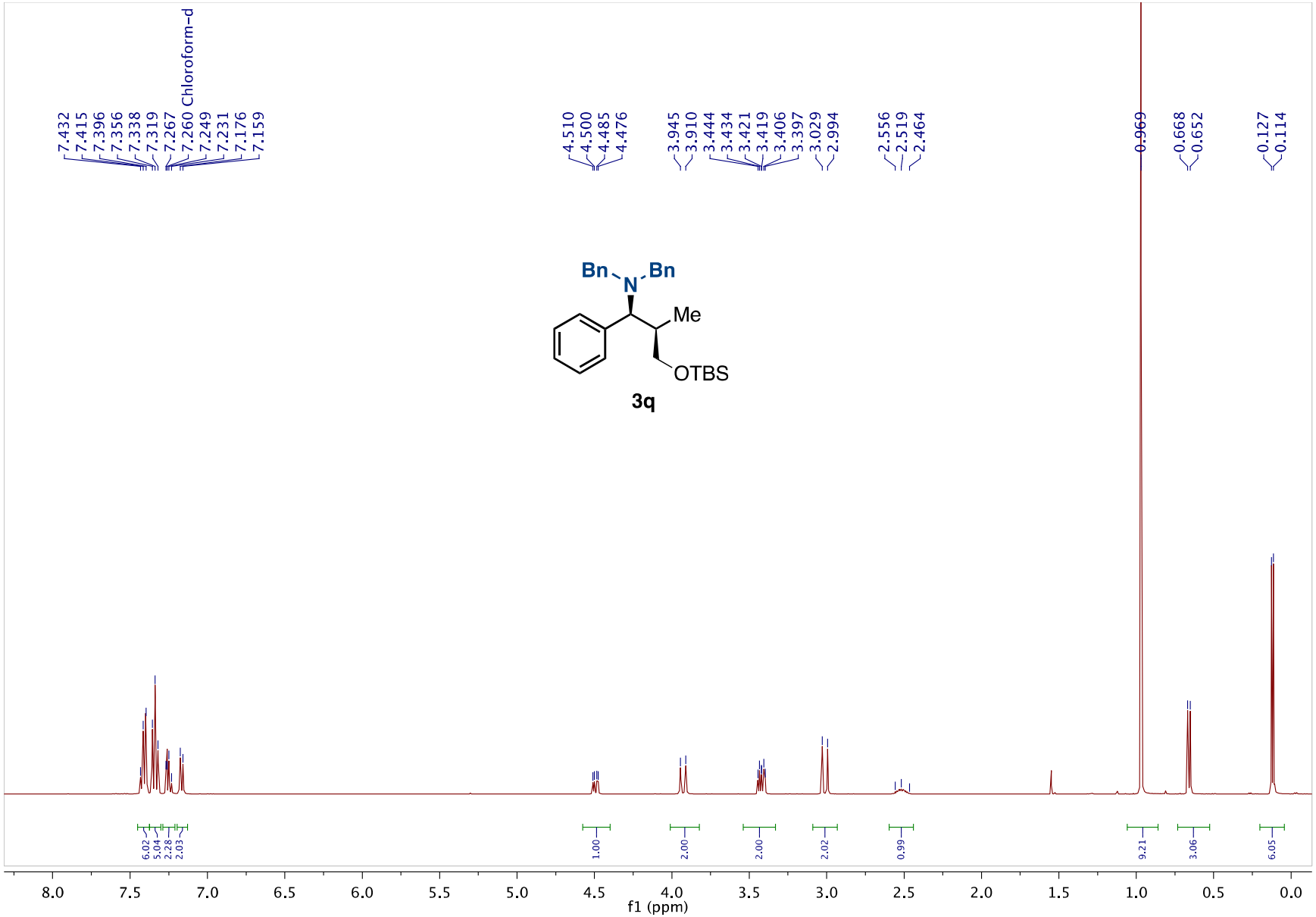

144.510
143.687
140.468
128.656
128.331
127.386
126.875
126.481
124.717
124.623
77.478 CDCl3
77.160 CDCl3
76.842 CDCl3
64.655
54.308
30.614
23.460
Bn
N
Bn
3n
128.656
128.331
127.386
126.875
126.481
124.717
124.623
129.0 128.5 128.0 127.5 127.0 126.5 126.0 125.5 125.0 124.5 124.0
f1 (ppm)
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

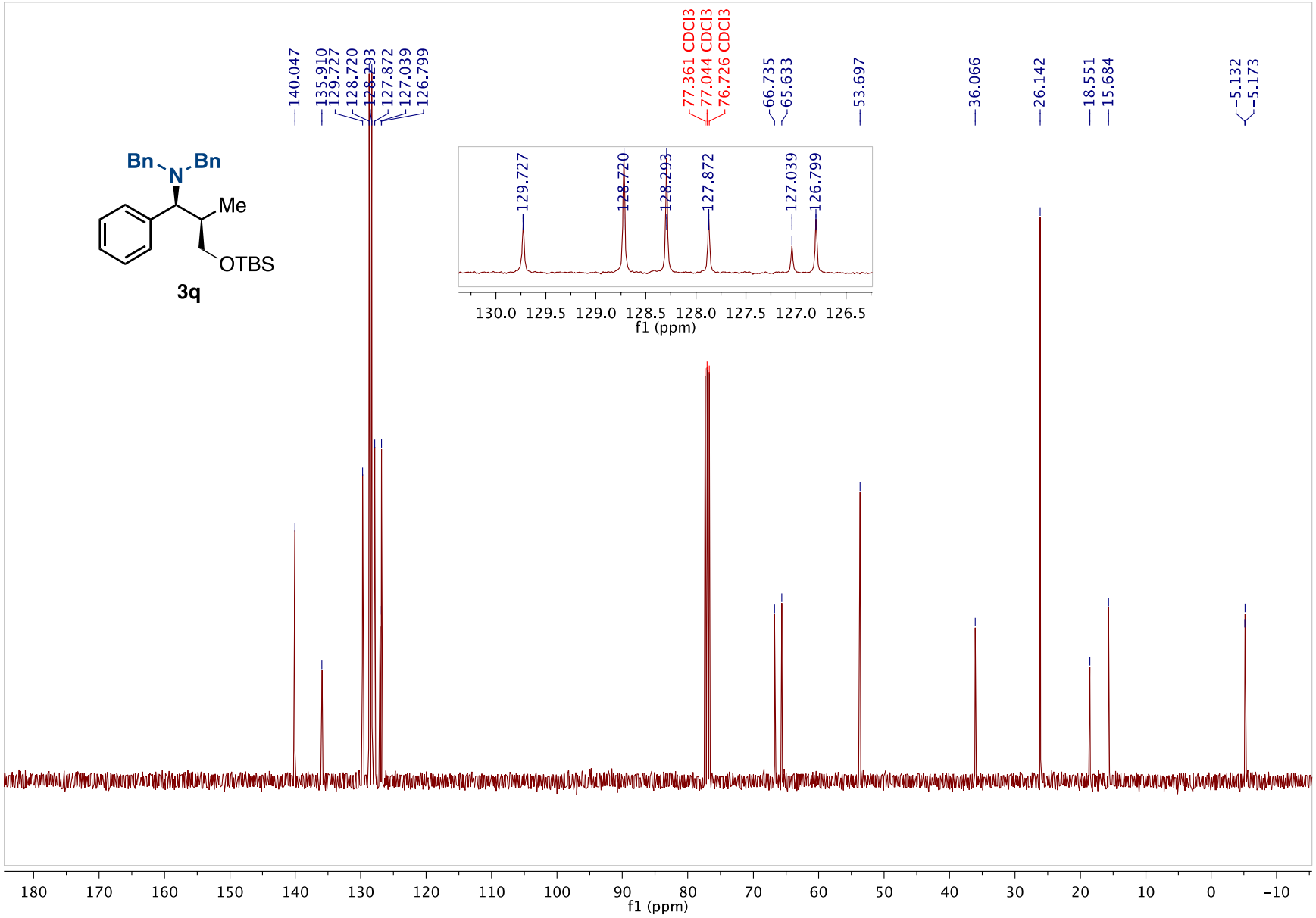

8.080
8.077
8.073
8.060
8.057
8.054
7.539
7.535
7.517
7.395
7.391
7.377
7.374
7.361
7.357
7.310
7.300
7.297
7.293
7.290
7.278
7.273
7.260 CDCl3
7.257
7.189
7.186
7.184
7.170
7.168
7.165
7.152
7.150
7.147
7.098
7.082
7.079
4.021
4.006
3.995
3.981
3.884
3.850
3.561
3.527
2.862
2.849
2.833
2.821
2.774
2.772
2.763
2.753
2.751
2.229
2.225
2.215
2.212
2.208
2.202
2.198
2.195
2.191
2.073
2.053
2.047
2.040
1.870
1.864
1.846
1.839
1.679
1.674
1.670
Bn
N
Bn
3o
1.00
4.15
4.17
3.06
1.06
0.99
1.03
2.00
2.01
2.04
1.04
1.05
1.05
1.08
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
f1 (ppm)

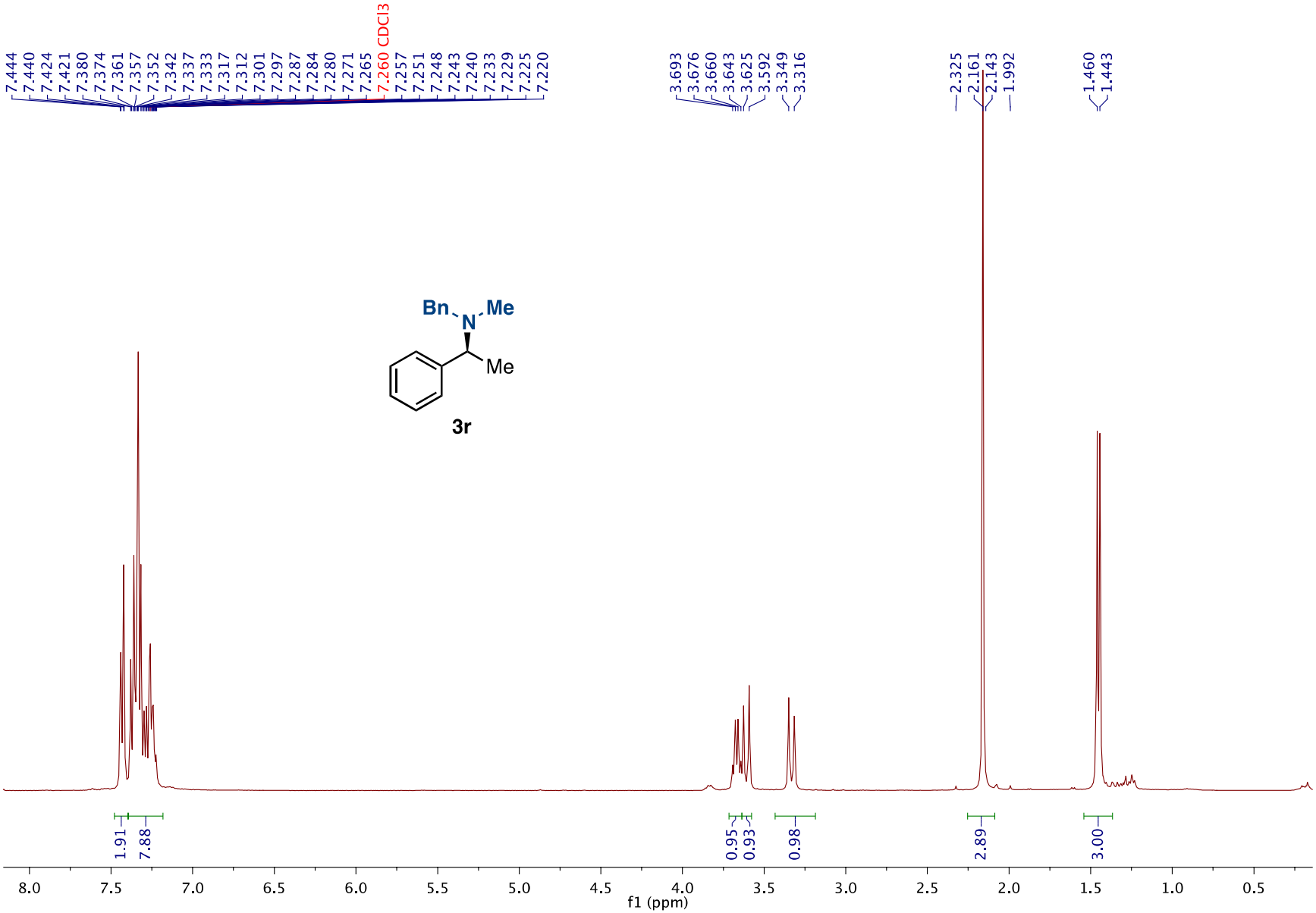

140.513
139.203
138.844
128.760
128.688
128.339
128.099
126.877
126.215
126.018
Bn
N
Bn
3o
77.477 CDCl3
77.160 CDCl3
76.842 CDCl3
56.454
53.766
30.266
22.374
20.667
f1 (ppm)
f1 (ppm)

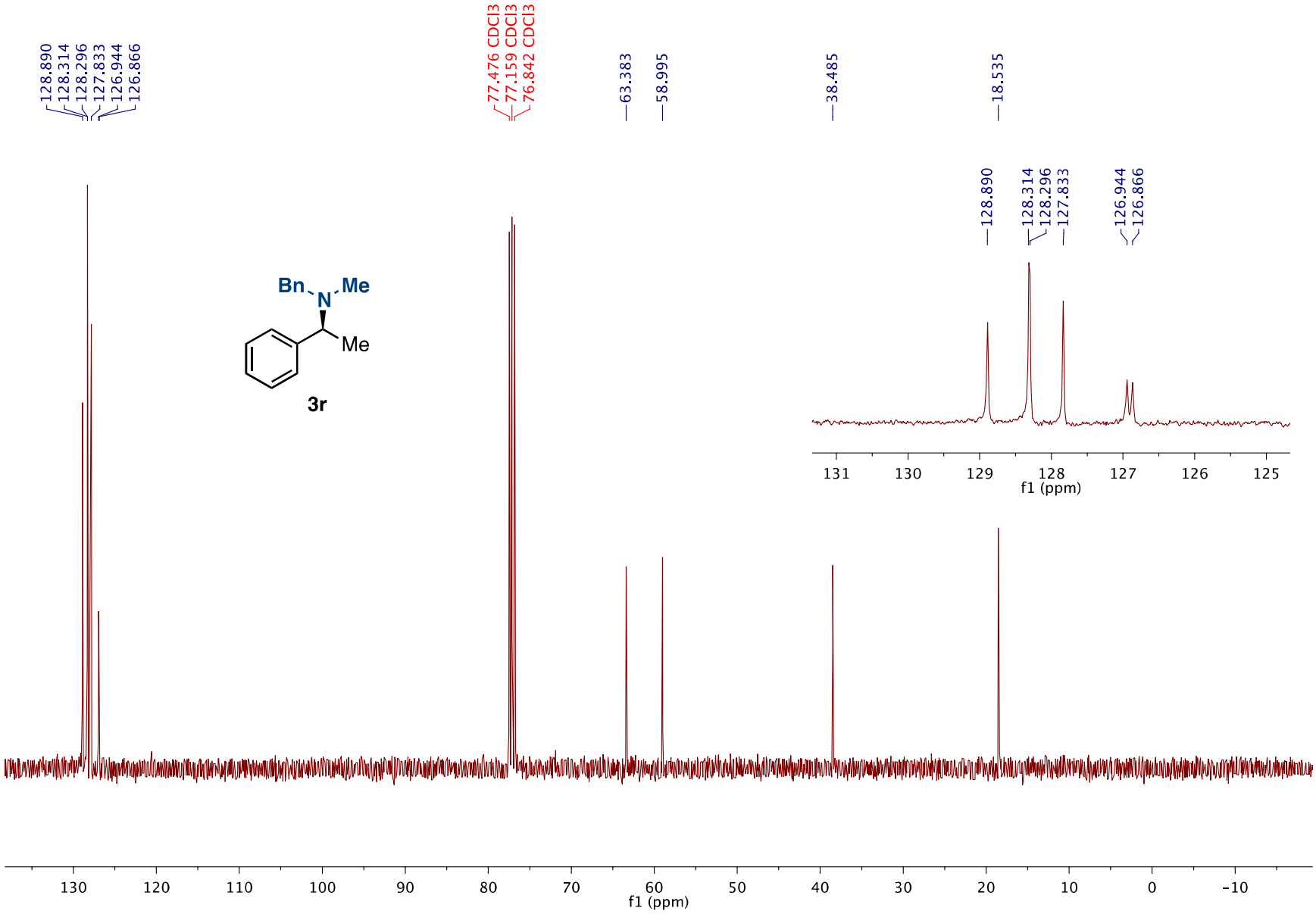

7.483
7.464
7.437
7.419
7.400
7.372
7.354
7.335
7.285
7.278
7.259
7.241
7.157
7.140
3.946
3.912
3.231
3.203
3.021
2.987
2.472
2.455
2.444
2.439
2.428
2.412
1.566
1.314
1.298
0.635
0.618
Bn
N
Bn
Me
Me
3p
3.86
1.98
4.77
2.33
1.91
1.99
1.00
1.95
1.01
3.15
2.91
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


140.453
137.026
129.683
128.886
128.372
127.911
126.970
126.824
77.477 CDCl3
77.159 CDCl3
76.842 CDCl3
69.370
53.680
28.675
21.289
20.923
Bn
N
Bn
Me
Me
3p
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

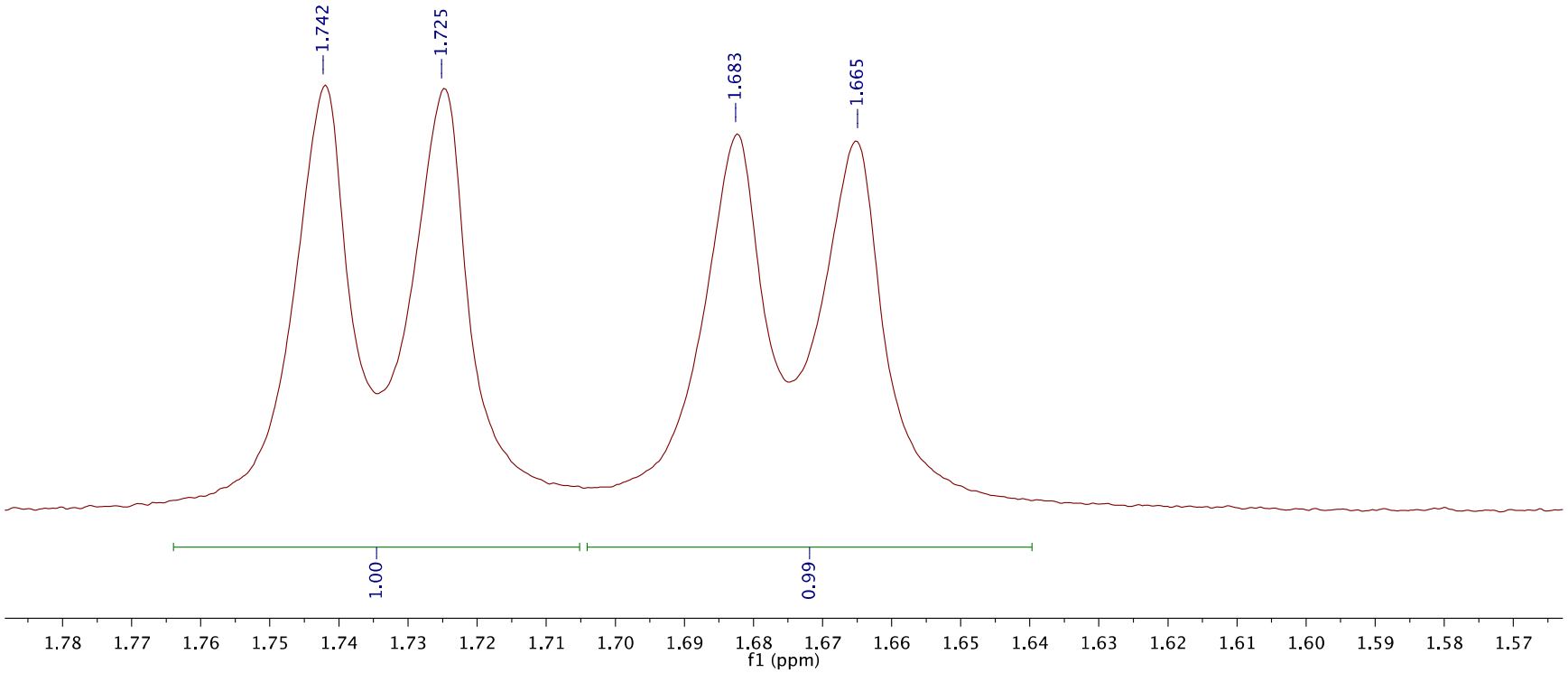

7.432
7.415
7.396
7.356
7.338
7.319
7.267
7.260 Chloroform-d
7.249
7.231
7.176
7.159
4.510
4.500
4.485
4.476
3.945
3.910
3.444
3.434
3.421
3.419
3.406
3.397
3.029
2.994
2.556
2.519
2.464
0.969
0.668
0.652
0.127
0.114
Bn
N
Bn
Me
OTBS
3q
6.02
5.04
2.28
2.03
1.00
2.00
2.00
2.02
0.99
9.21
3.06
6.05
8.0
7.5
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)


140.047
135.910
129.727
128.720
128.293
127.872
127.039
126.799
77.361 CDCl3
77.044 CDCl3
76.726 CDCl3
66.735
65.633
53.697
36.066
26.142
18.551
15.684
-5.132
-5.173
Bn
N
Bn
Me
OTBS
3q
129.727
128.720
128.293
127.872
127.039
126.799
130.0 129.5 129.0 128.5 128.0 127.5 127.0 126.5
f1 (ppm)
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

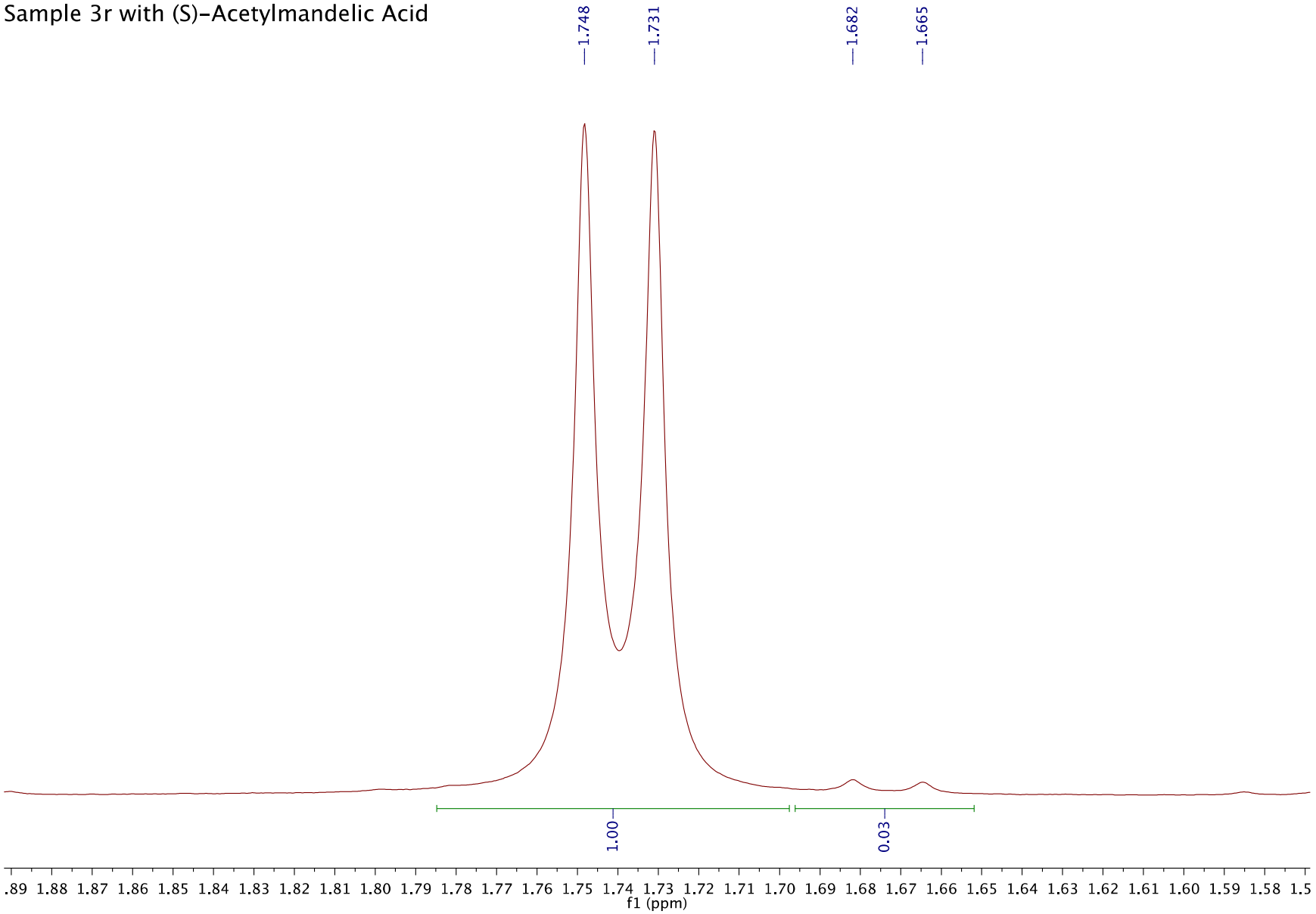

7.444
7.440
7.424
7.421
7.380
7.374
7.361
7.357
7.352
7.342
7.337
7.333
7.317
7.312
7.301
7.297
7.287
7.284
7.280
7.271
7.265
7.260 CDCl3
7.257
7.251
7.248
7.243
7.240
7.233
7.229
7.225
7.220
3.693
3.676
3.660
3.643
3.625
3.592
3.349
3.316
2.325
2.161
2.143
1.992
1.460
1.443
Bn
N
Me
Me
3r
1.91
7.88
0.95
0.93
0.98
2.89
3.00
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
f1 (ppm)

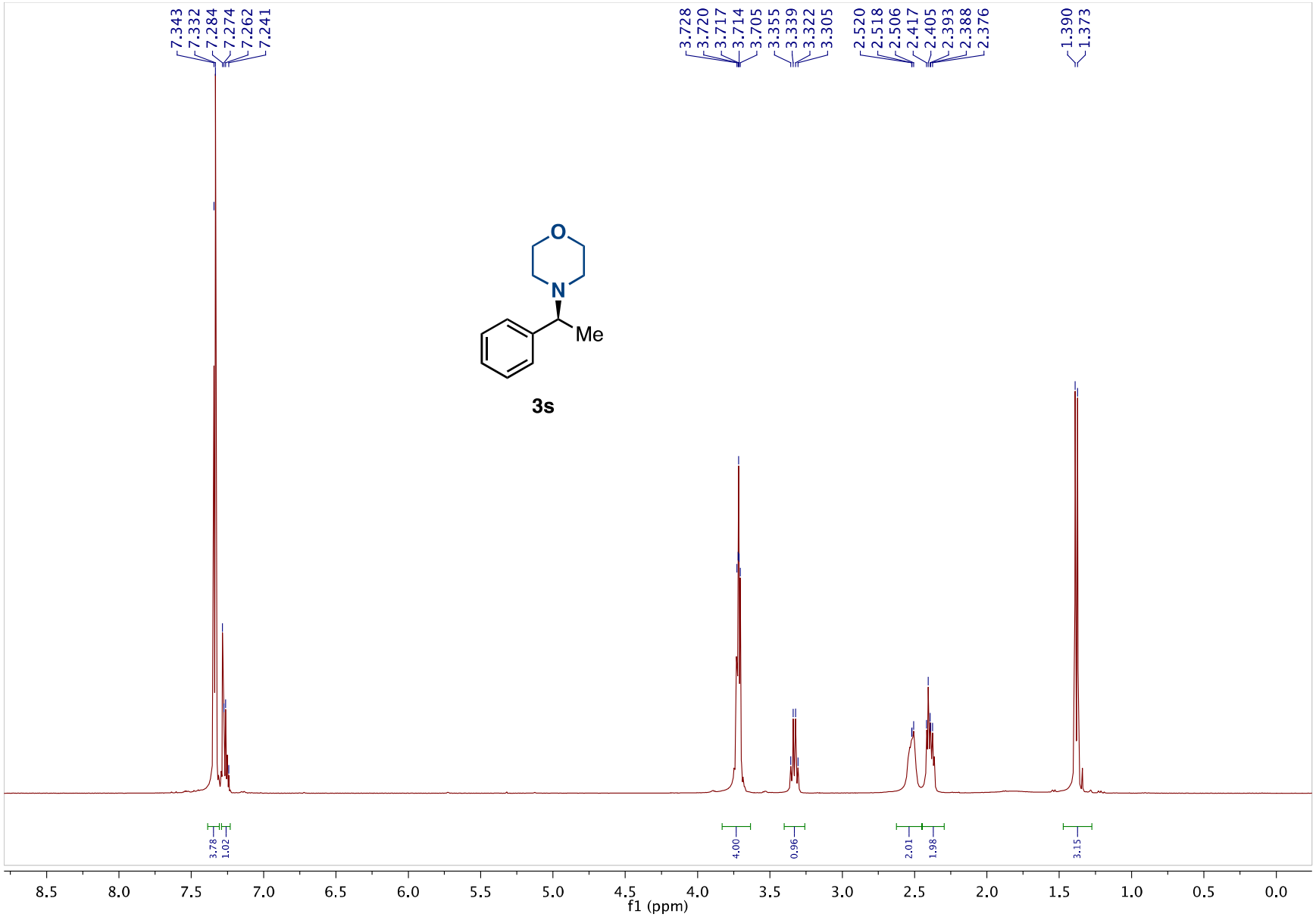

128.890
128.314
128.296
127.833
126.944
126.866
77.476 CDCl3
77.159 CDCl3
76.842 CDCl3
63.383
58.995
38.485
18.535
Bn
N
Me
Me
3r
f1 (ppm)
f1 (ppm)

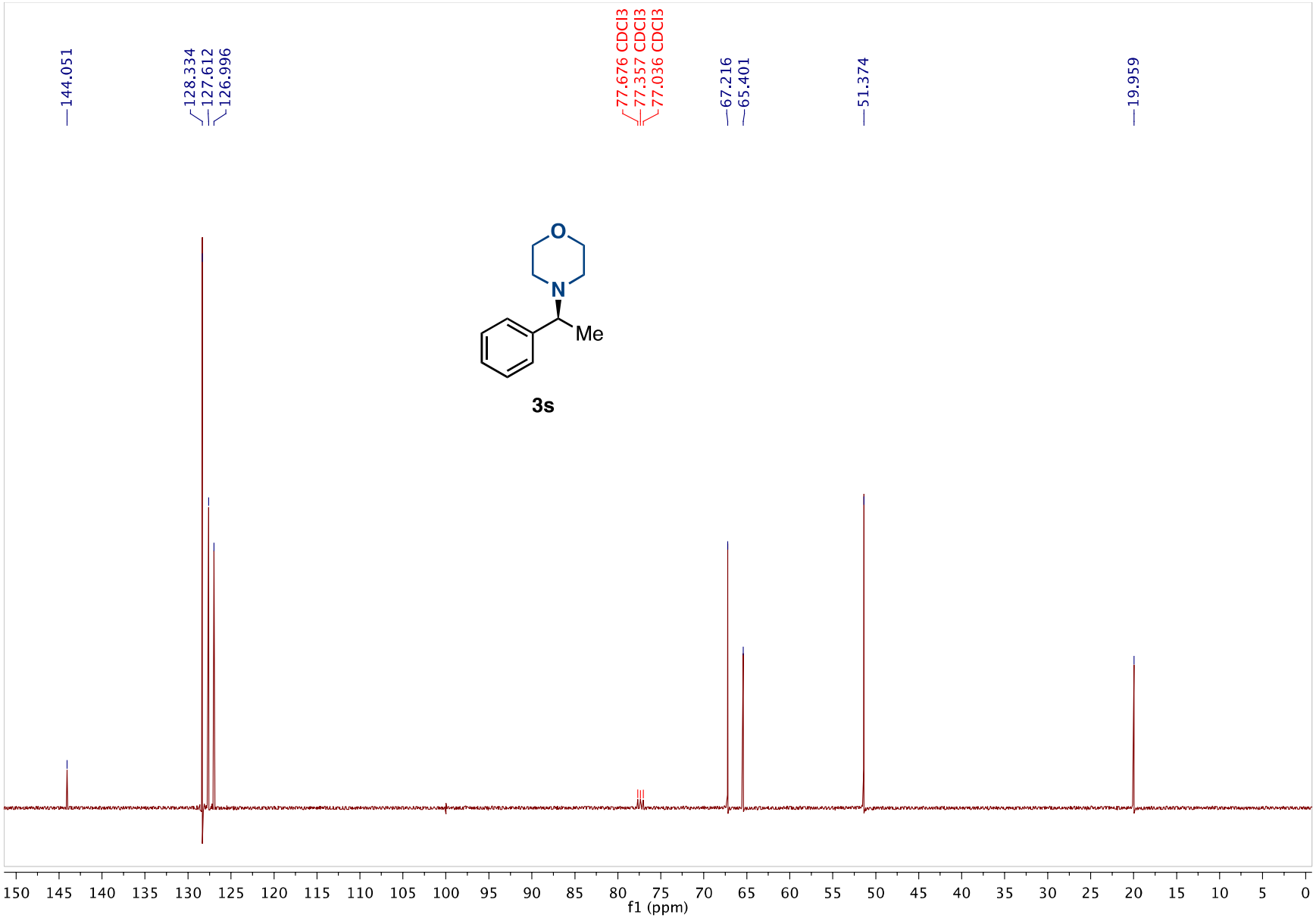
Racemic 3r with (R)-Acetylmandelic Acid

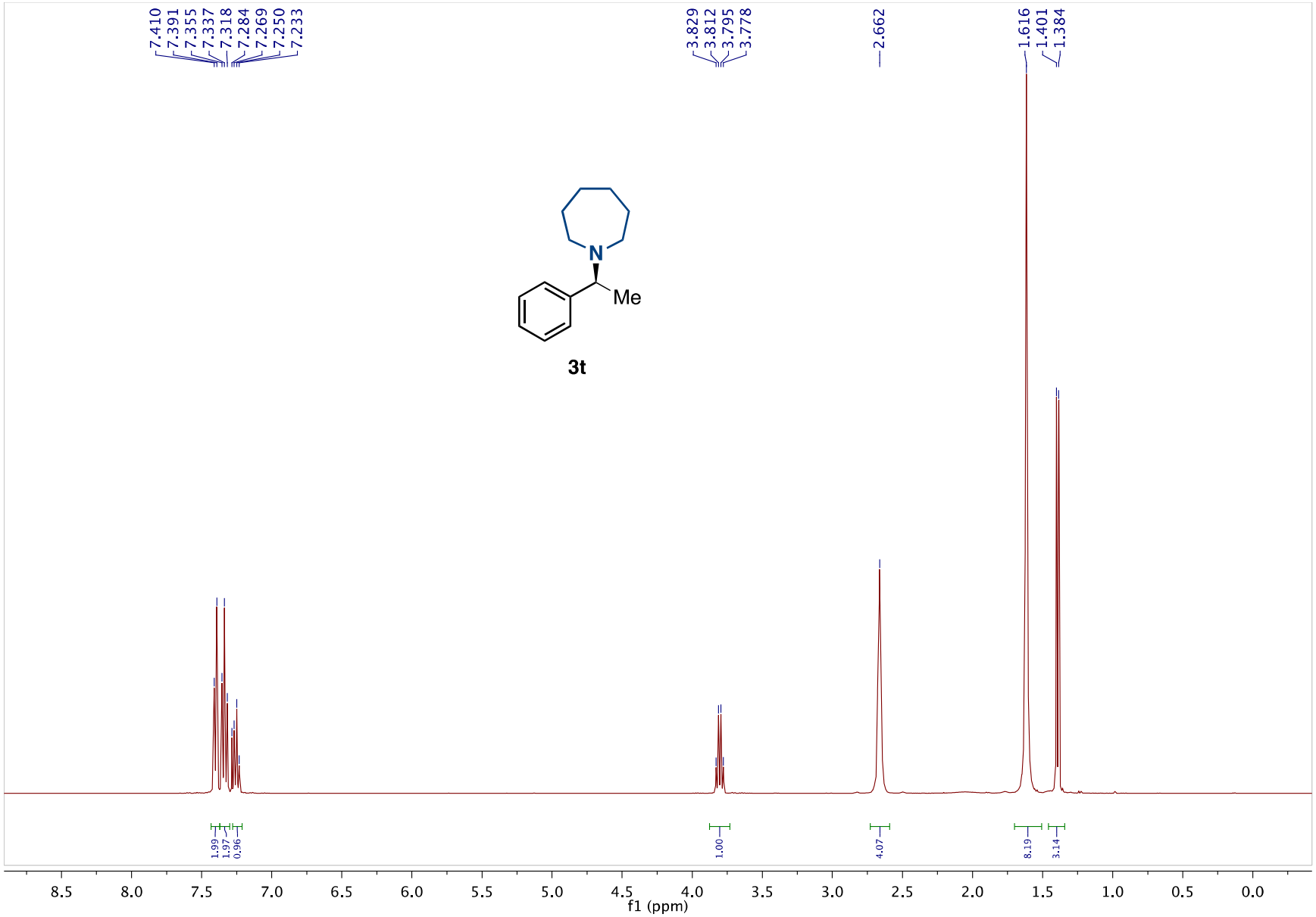


Sample 3r with (S)-Acetylmandelic Acid




7.343
7.332
7.284
7.274
7.262
7.241
3.728
3.720
3.717
3.714
3.705
3.355
3.339
3.322
3.305
2.520
2.518
2.506
2.417
2.405
2.393
2.388
2.376
1.390
1.373
O
N
Me
3s
3.78
1.02
4.00
0.96
2.01
1.98
3.15
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)


144.051
128.334
127.612
126.996
77.676 CDCl3
77.357 CDCl3
77.036 CDCl3
67.216
65.401
51.374
19.959
O
N
Me
3s
150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)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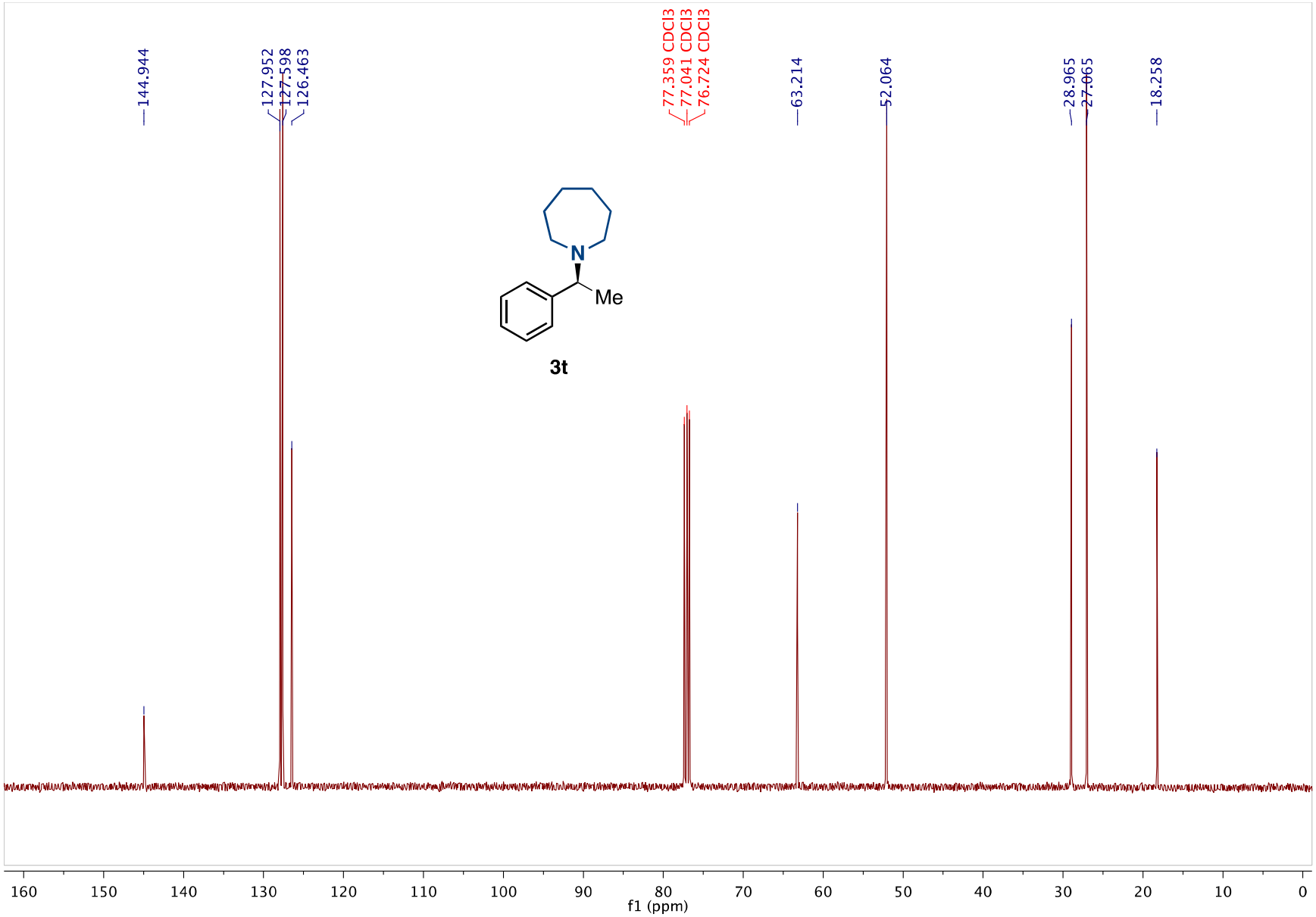
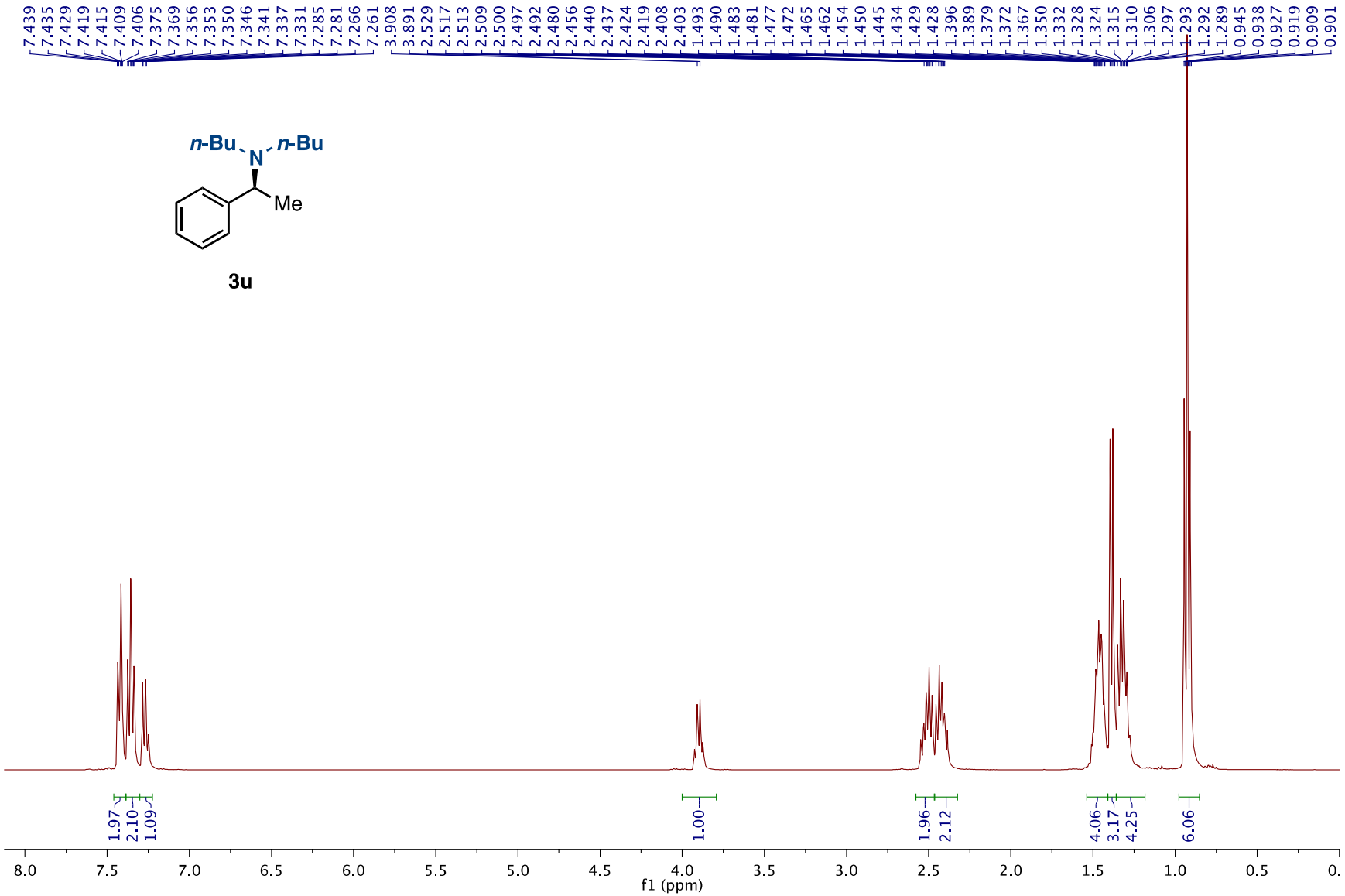
7.391
7.355
7.337
7.318
7.284
7.269
7.250
7.233
3.829
3.812
3.795
3.778
2.662
1.616
1.401
1.384
N
Me
3t
1.99
1.97
0.96
1.00
4.07
8.19
3.14
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


144.944
127.952
127.598
126.463
77.359 CDCl3
77.041 CDCl3
76.724 CDCl3
63.214
52.064
28.965
27.065
18.258
N
Me
3t
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.435
7.429
7.419
7.415
7.409
7.406
7.375
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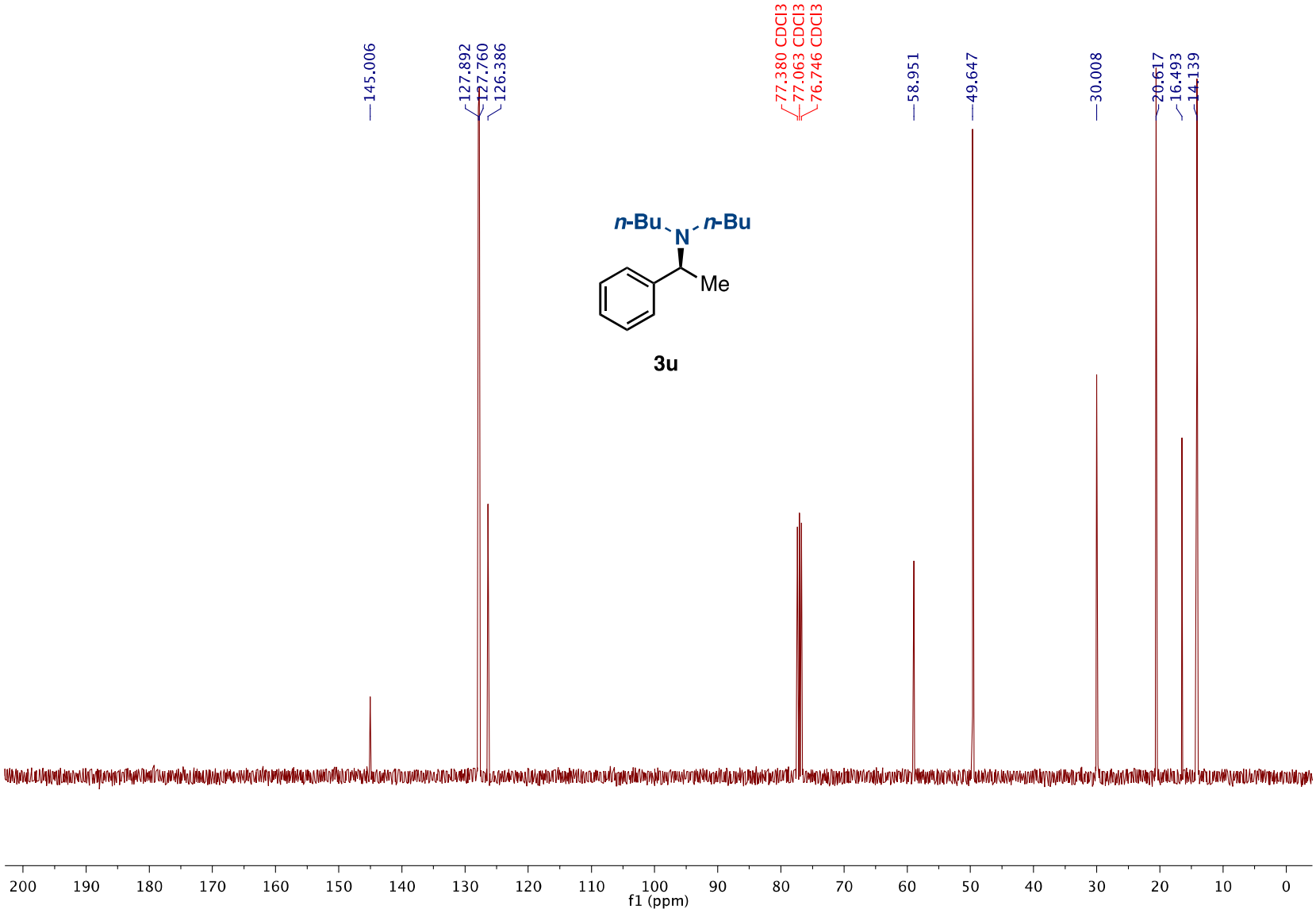
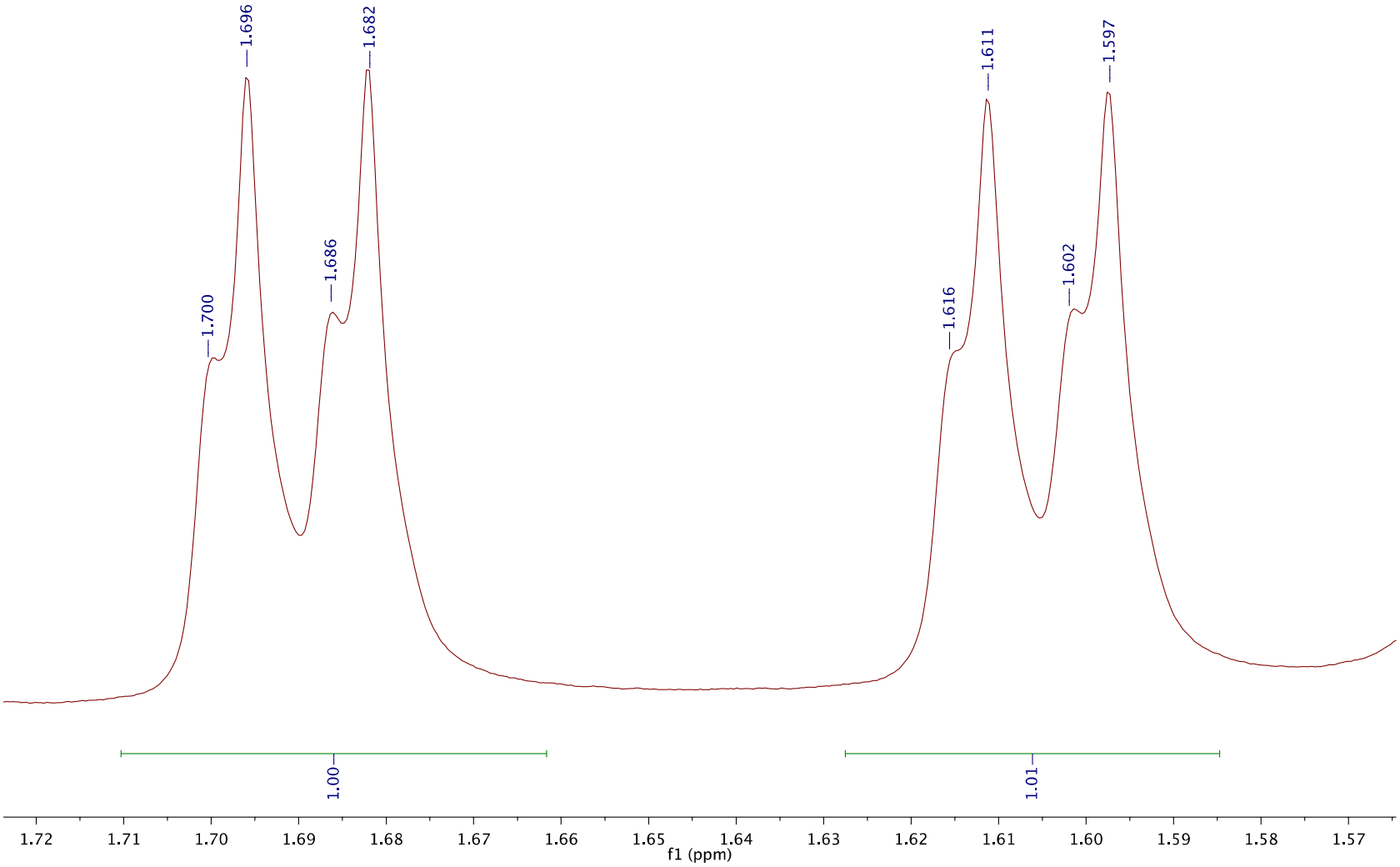
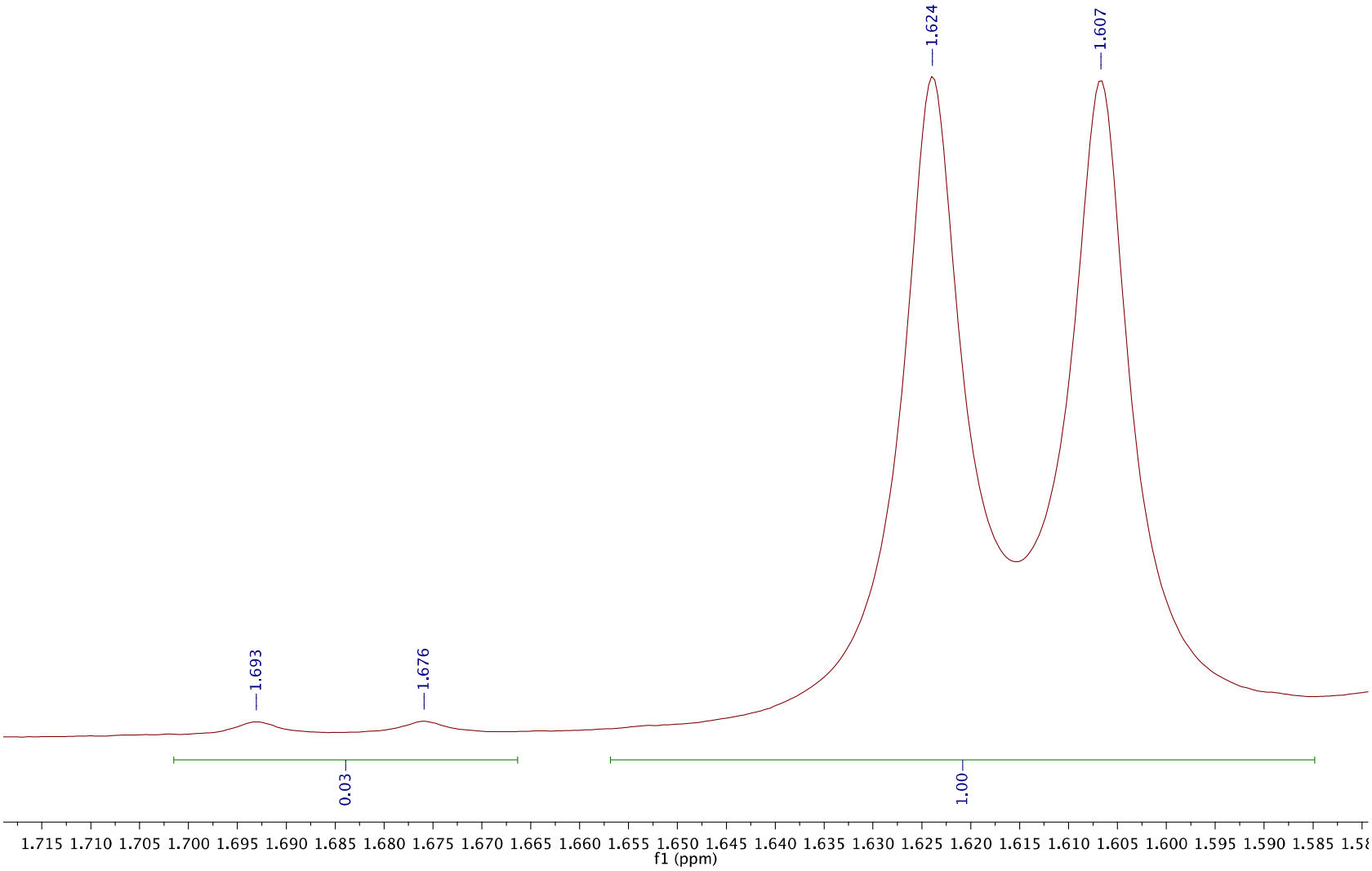
7.356
7.353
7.350
7.346
7.341
7.337
7.331
7.285
7.281
7.266
7.261
3.908
3.891
2.529
2.517
2.513
2.509
2.500
2.497
2.492
2.480
2.456
2.440
2.437
2.424
2.419
2.408
2.403
1.493
1.490
1.483
1.481
1.477
1.472
1.465
1.462
1.454
1.450
1.445
1.434
1.429
1.428
1.396
1.389
1.379
1.372
1.367
1.350
1.332
1.328
1.324
1.315
1.310
1.306
1.297
1.293
1.292
1.289
0.945
0.938
0.927
0.919
0.909
0.901
n-Bu
N
n-Bu
Me
3u
1.97
2.10
1.09
1.00
1.96
2.12
4.06
3.17
4.25
6.06
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.
f1 (ppm)

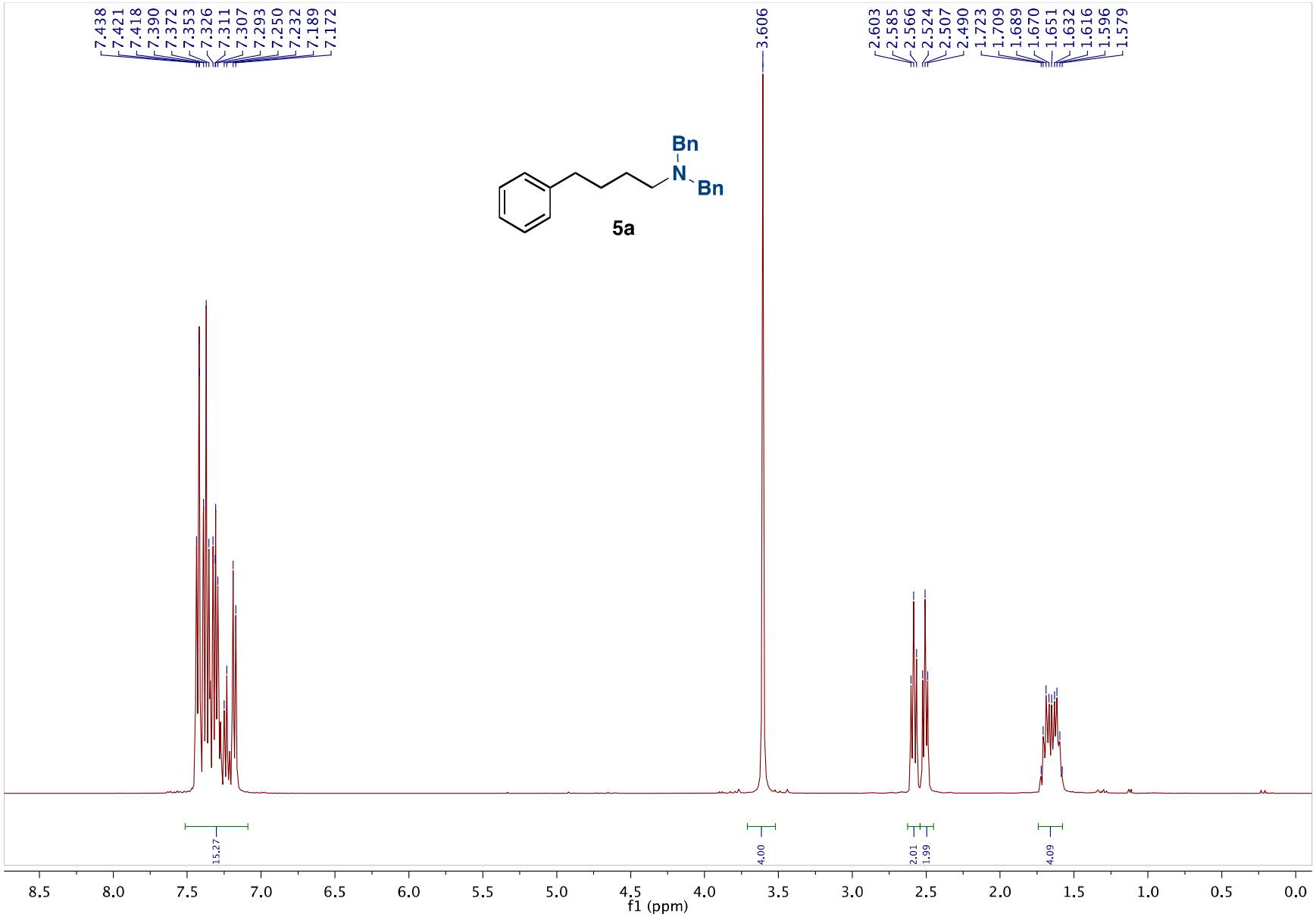

145.006
127.892
127.760
126.386
77.380 CDCl3
77.063 CDCl3
76.746 CDCl3
58.951
49.647
30.008
20.617
16.493
14.139
n-Bu
N
n-Bu
Me
3u
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

Racemic 3u with (R)-Acetylmandelic Acid



Sample of 3u with (R)-Acetylmandelic Acid

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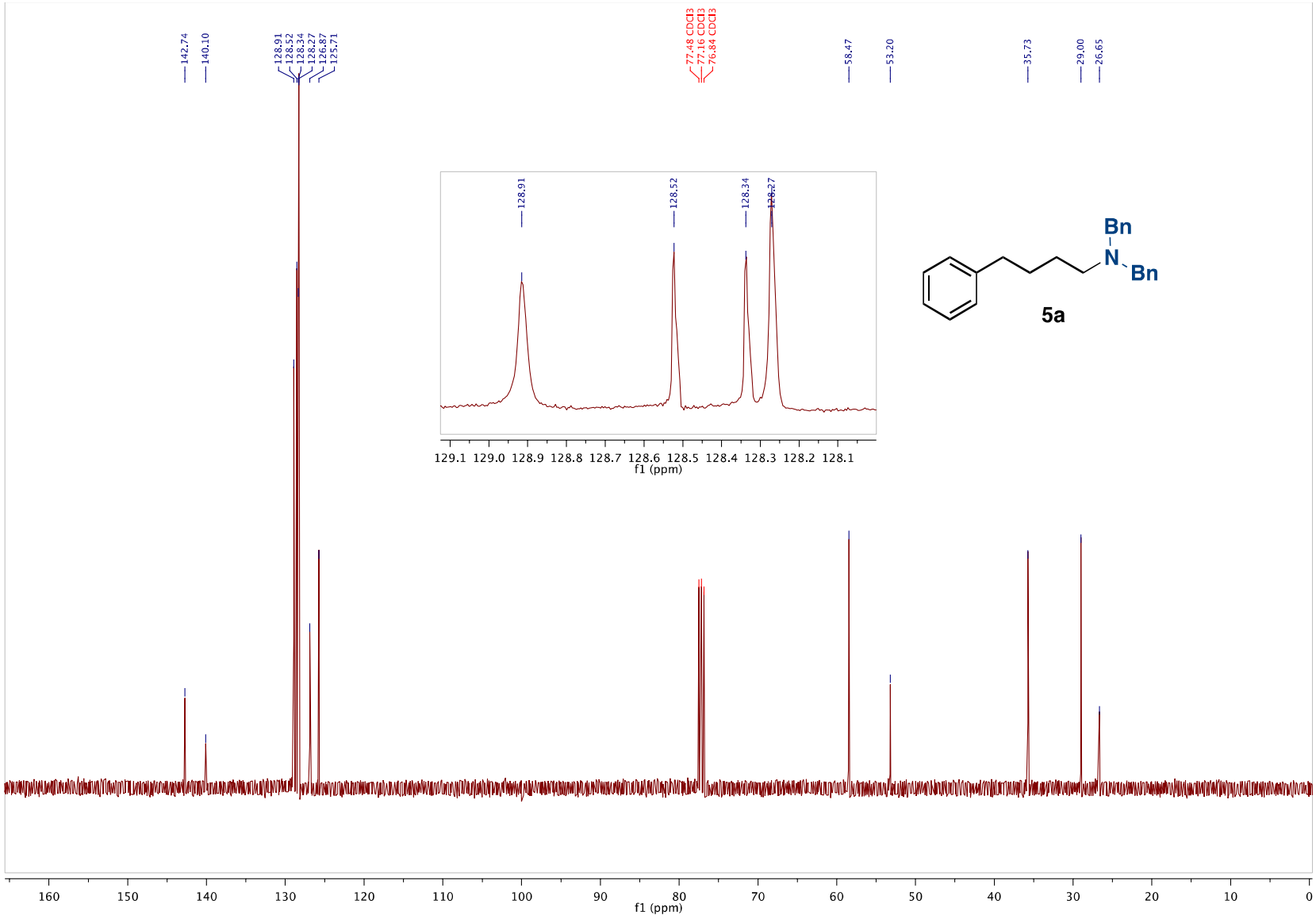
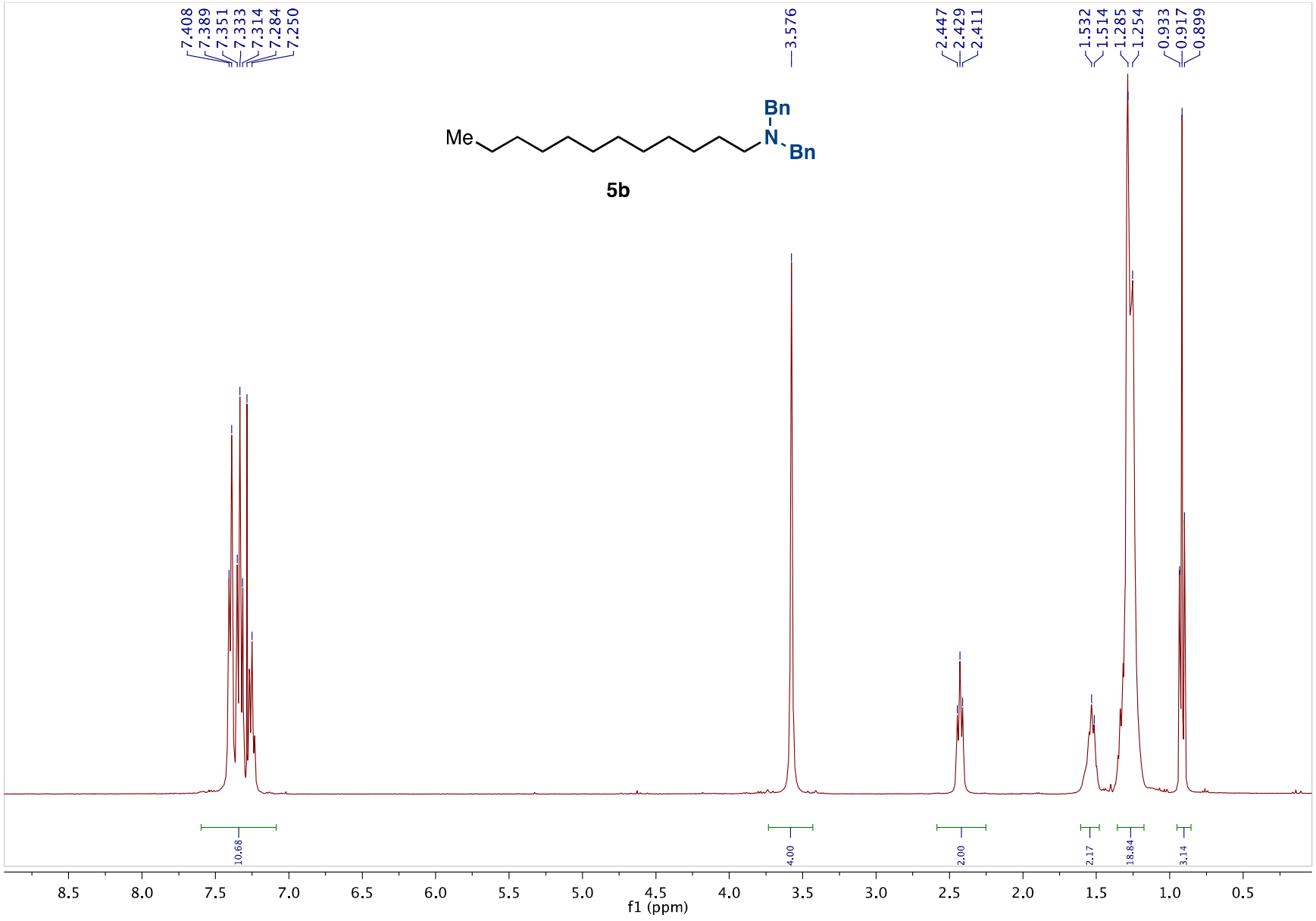
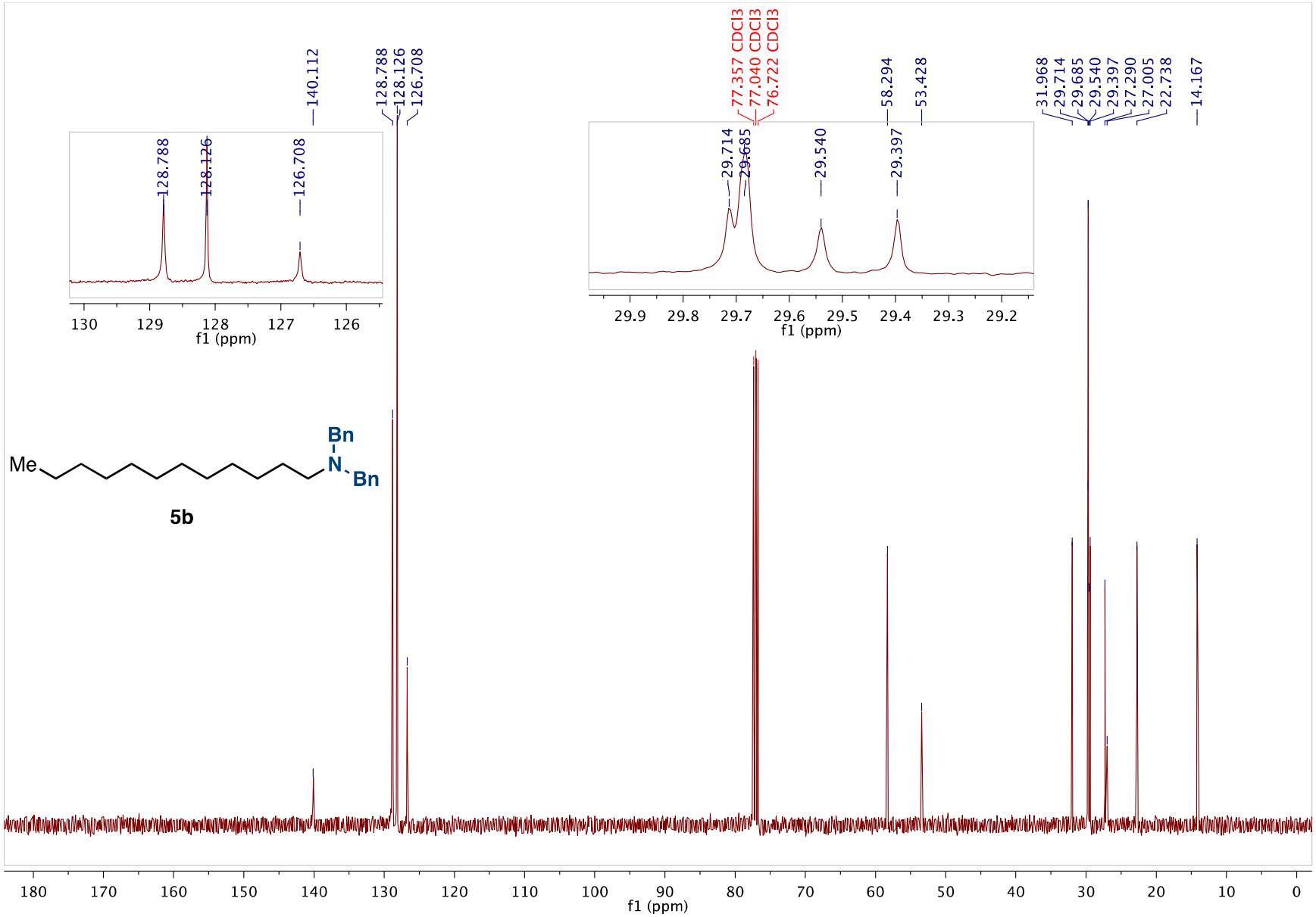
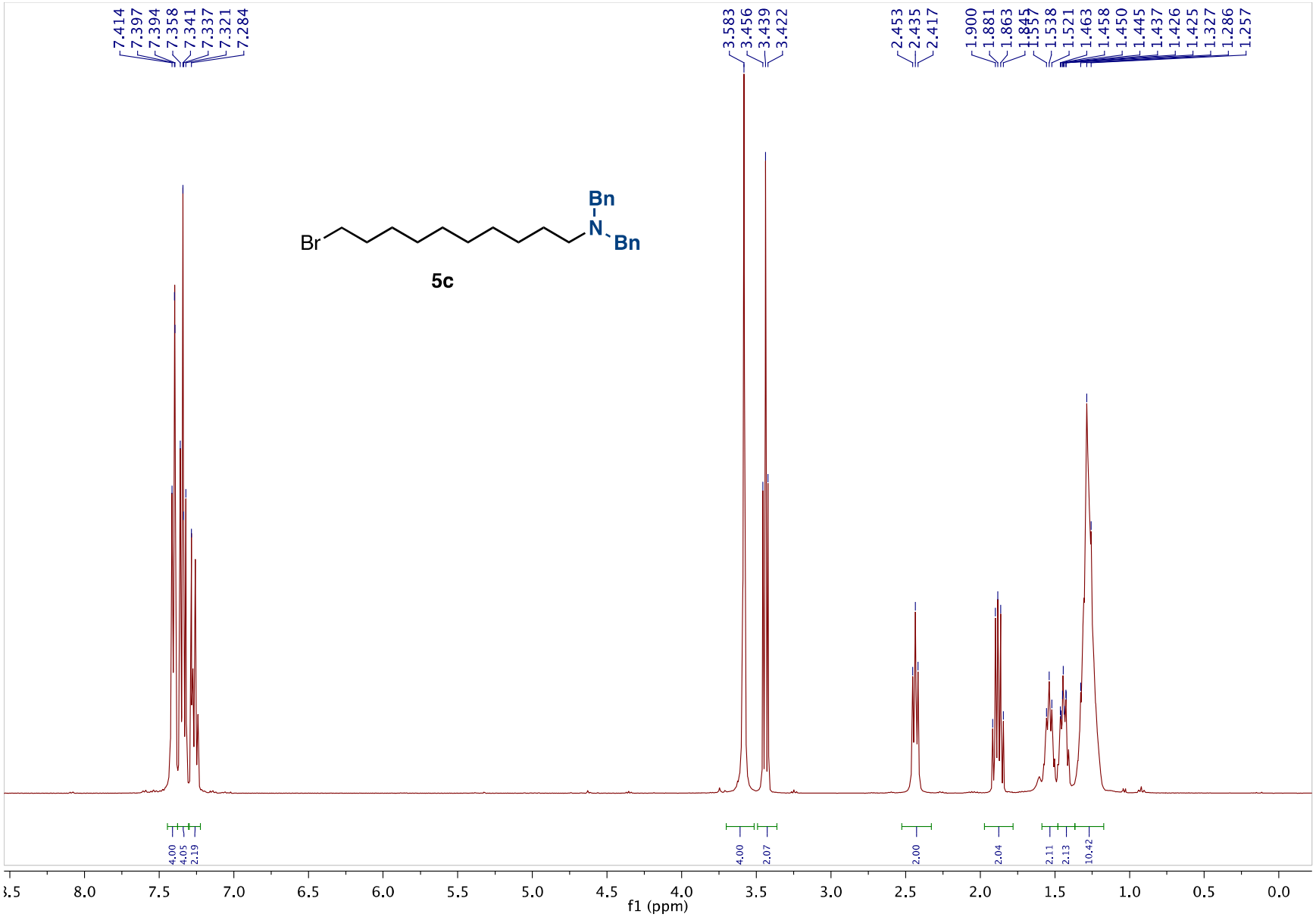
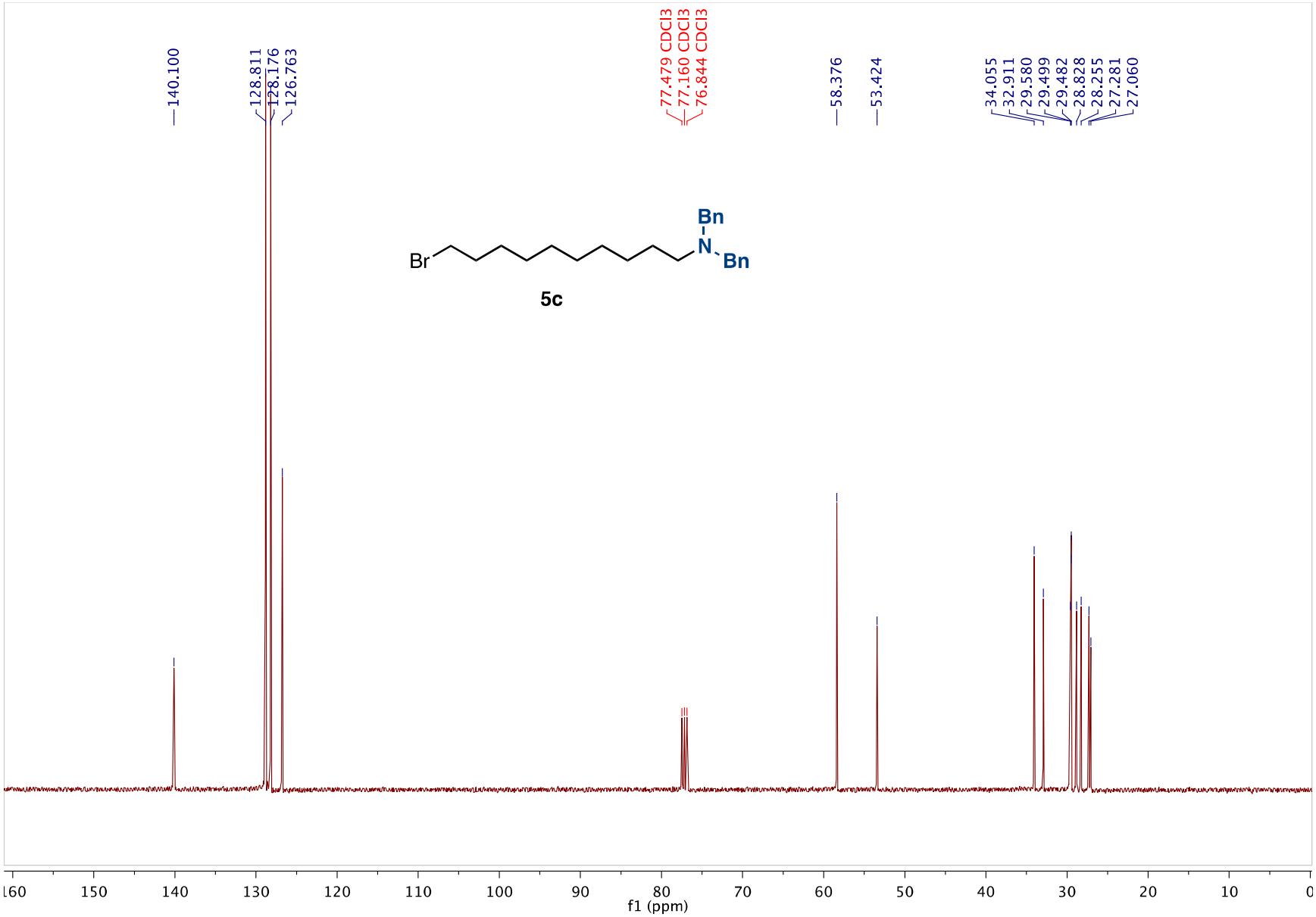
7.421
7.418
7.390
7.372
7.353
7.326
7.311
7.307
7.293
7.250
7.232
7.189
7.172
3.606
2.603
2.585
2.566
2.524
2.507
2.490
1.723
1.709
1.689
1.670
1.651
1.632
1.616
1.596
1.579
Bn
N
Bn
5a
15.27
4.00
2.01
1.99
4.09
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

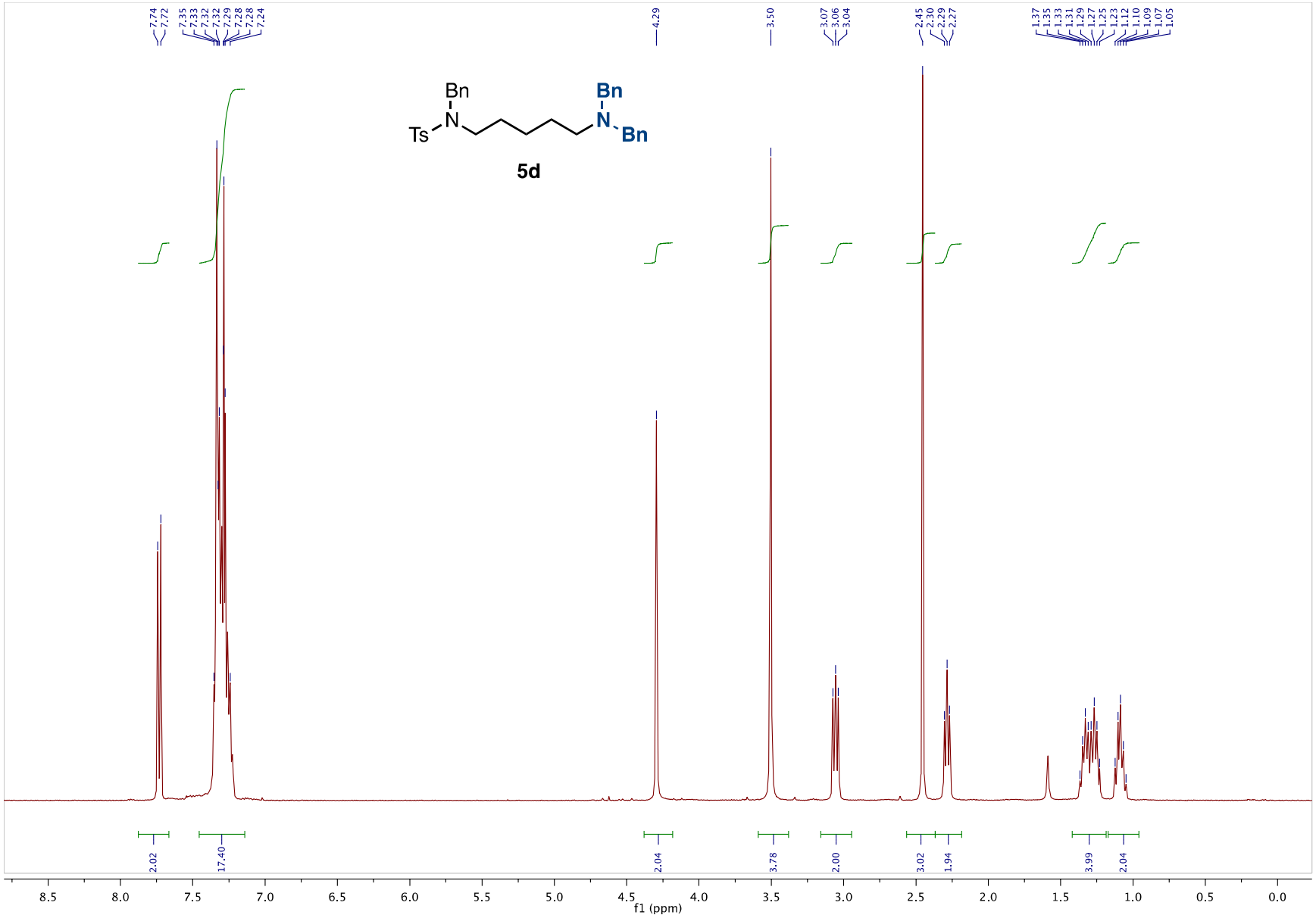

142.74
140.10
128.91
128.52
128.34
128.27
126.87
125.71
77.48 CDCl3
77.16 CDCl3
76.84 CDCl3
58.47
53.20
35.73
29.00
26.65
128.91
128.52
128.34
128.27
129.1 129.0 128.9 128.8 128.7 128.6 128.5 128.4 128.3 128.2 128.1
f1 (ppm)
Bn
N
Bn
5a
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

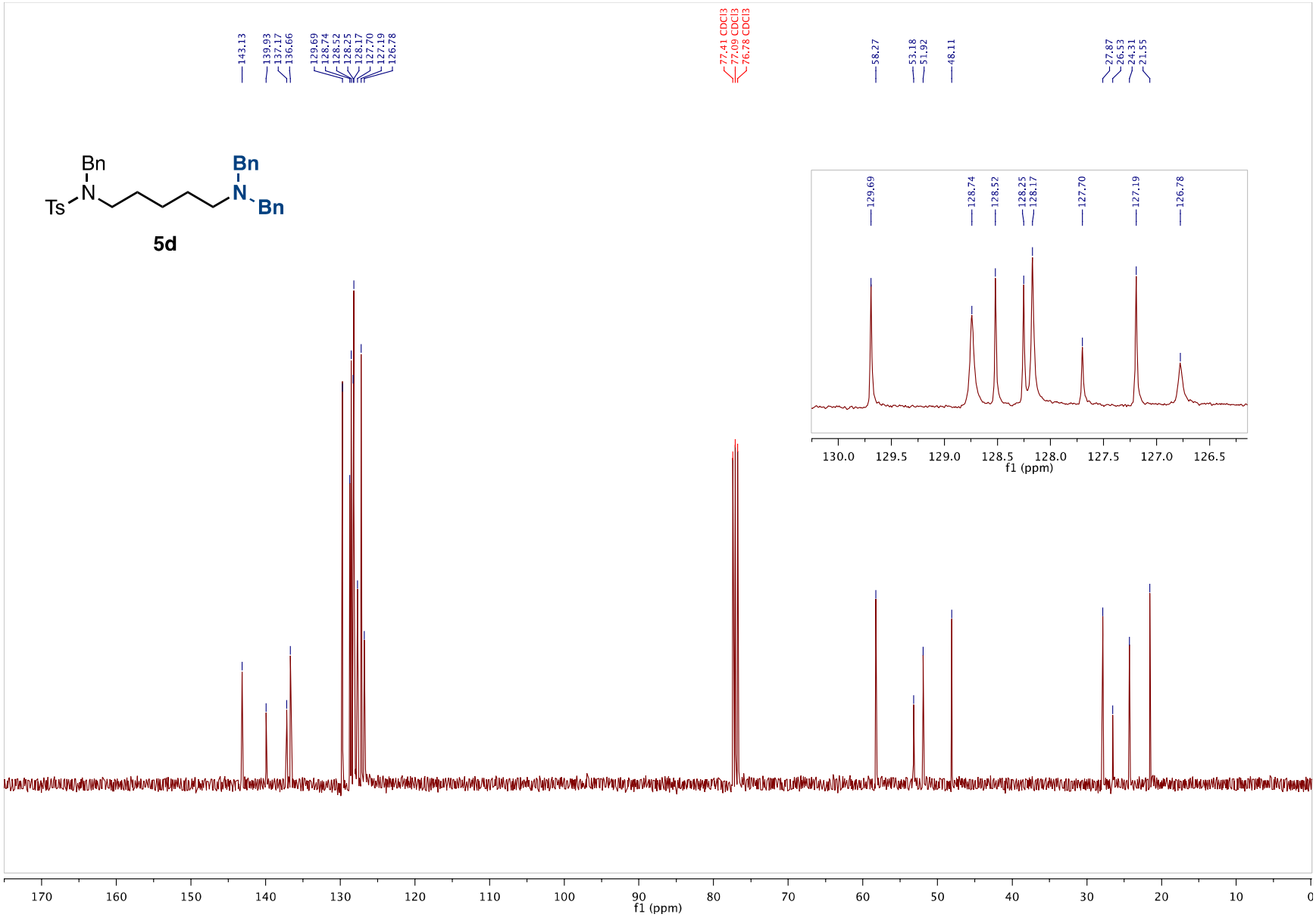

7.408
7.389
7.351
7.333
7.314
7.284
7.250
3.576
2.447
2.429
2.411
1.532
1.514
1.285
1.254
0.933
0.917
0.899
Me
Bn
N
Bn
5b
10.68
4.00
2.00
2.17
18.84
3.14
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

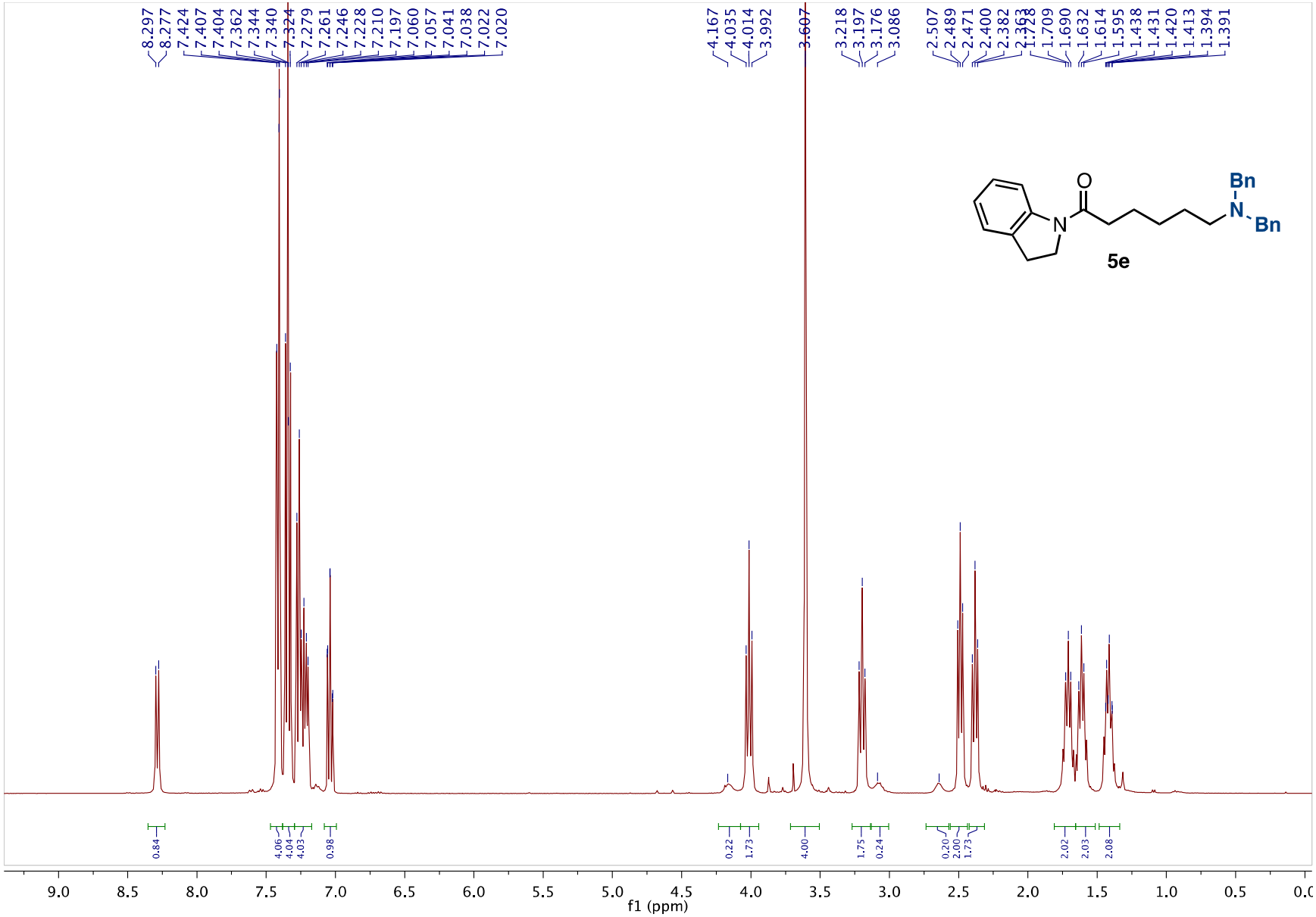

140.112
128.788
128.126
126.708
77.357 CDCl3
77.040 CDCl3
76.722 CDCl3
58.294
53.428
31.968
29.714
29.685
29.540
29.397
27.290
27.005
22.738
14.167
Me
Bn
N
Bn
5b
f1 (ppm)


7.414
7.397
7.394
7.358
7.341
7.337
7.321
7.284
3.583
3.456
3.439
3.422
2.453
2.435
2.417
1.900
1.881
1.863
1.845
1.557
1.538
1.521
1.463
1.458
1.450
1.445
1.437
1.426
1.425
1.327
1.286
1.257
Br
Bn
N
Bn
5c
4.00
4.05
2.19
4.00
2.07
2.00
2.04
2.11
2.13
10.42
f1 (ppm)


140.100
128.811
128.176
126.763
77.479 CDCl3
77.160 CDCl3
76.844 CDCl3
58.376
53.424
34.055
32.911
29.580
29.499
29.482
28.828
28.255
27.281
27.060
Br
N
Bn
Bn
5c
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.74
7.72
7.35
7.33
7.32
7.32
7.29
7.28
7.28
7.24
4.29
3.50
3.07
3.06
3.04
2.45
2.30
2.29
2.27
1.37
1.35
1.33
1.31
1.29
1.27
1.25
1.23
1.12
1.10
1.09
1.07
1.05
Bn
N
Ts
Bn
N
Bn
5d
2.02
17.40
2.04
3.78
2.00
3.02
1.94
3.99
2.04
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)


143.13
139.93
137.17
136.66
129.69
128.74
128.52
128.25
128.17
127.70
127.19
126.78
77.41 CDCl3
77.09 CDCl3
76.78 CDCl3
58.27
53.18
51.92
48.11
27.87
26.53
24.31
21.55
Bn
N
Ts
Bn
N
Bn
5d
f1 (ppm)


8.297
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7.424
7.407
7.404
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7.340
7.324
7.279
7.261
7.246
7.228
7.210
7.197
7.060
7.057
7.041
7.038
7.022
7.020
4.167
4.035
4.014
3.992
3.607
3.218
3.197
3.176
3.086
2.507
2.489
2.471
2.400
2.382
2.363
1.728
1.709
1.690
1.632
1.614
1.595
1.438
1.431
1.420
1.413
1.394
1.391
O
N
Bn
N
Bn
5e
0.84
4.06
4.04
4.03
0.98
0.22
1.73
4.00
1.75
0.24
0.20
2.00
1.73
2.02
2.03
2.08
9.0
8.5
8.0
7.5
7.0
6.5
6.0
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5.0
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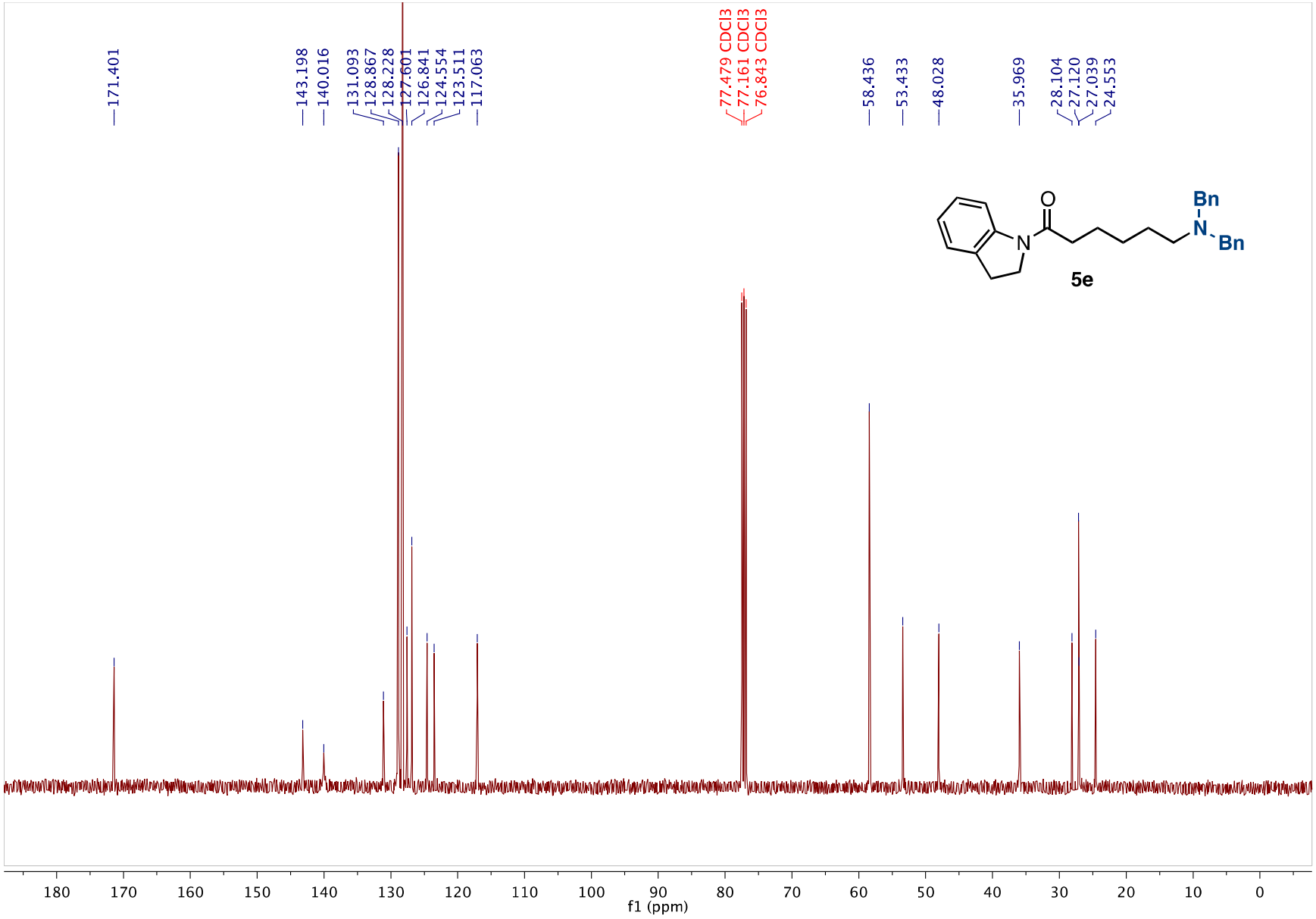
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)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131.093
128.867
128.228
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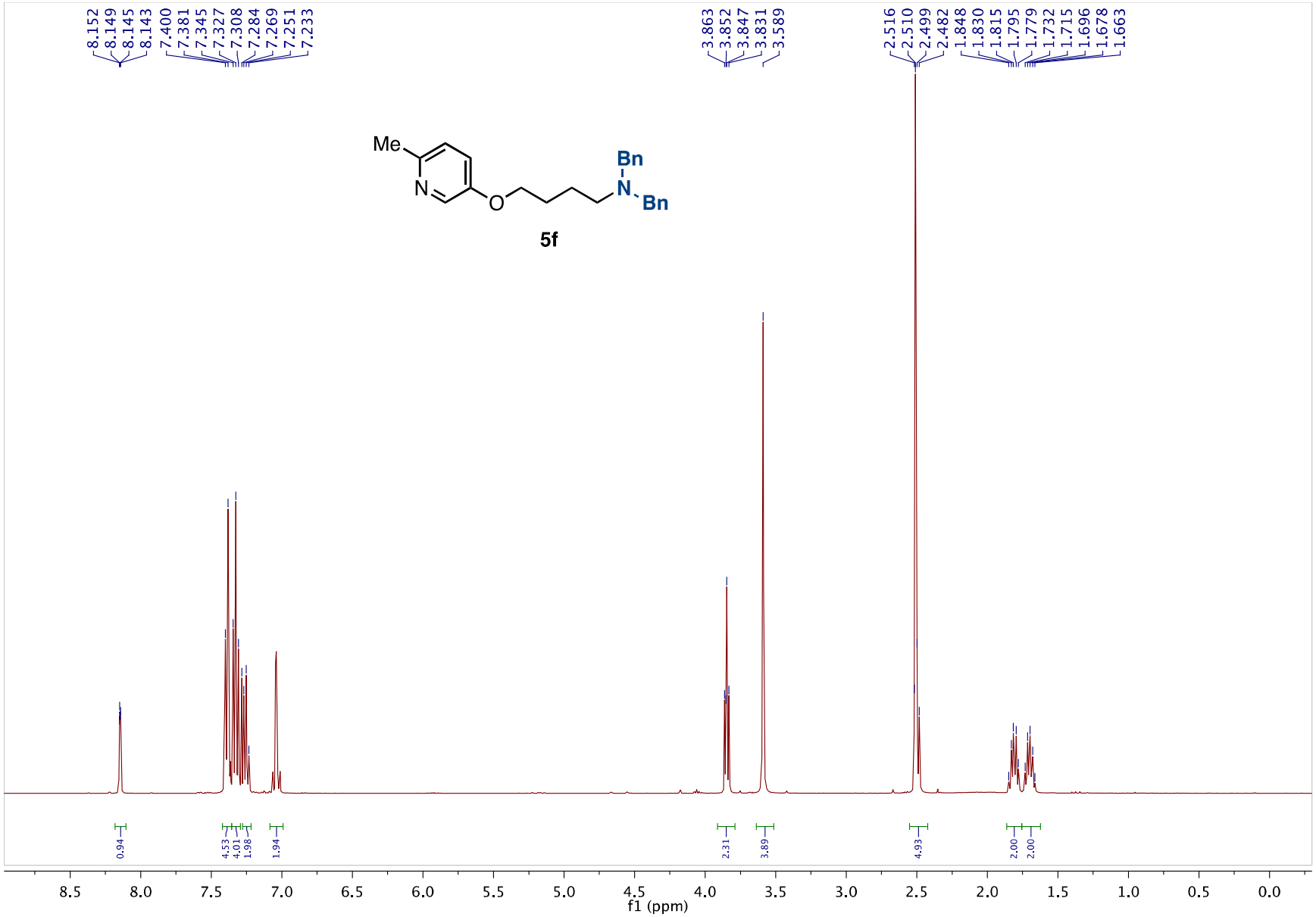
126.841
124.554
123.511
117.063
77.479 CDCl3
77.161 CDCl3
76.843 CDCl3
58.436
53.433
48.028
35.969
28.104
27.120
27.039
24.553
O
N
Bn
N
Bn
5e
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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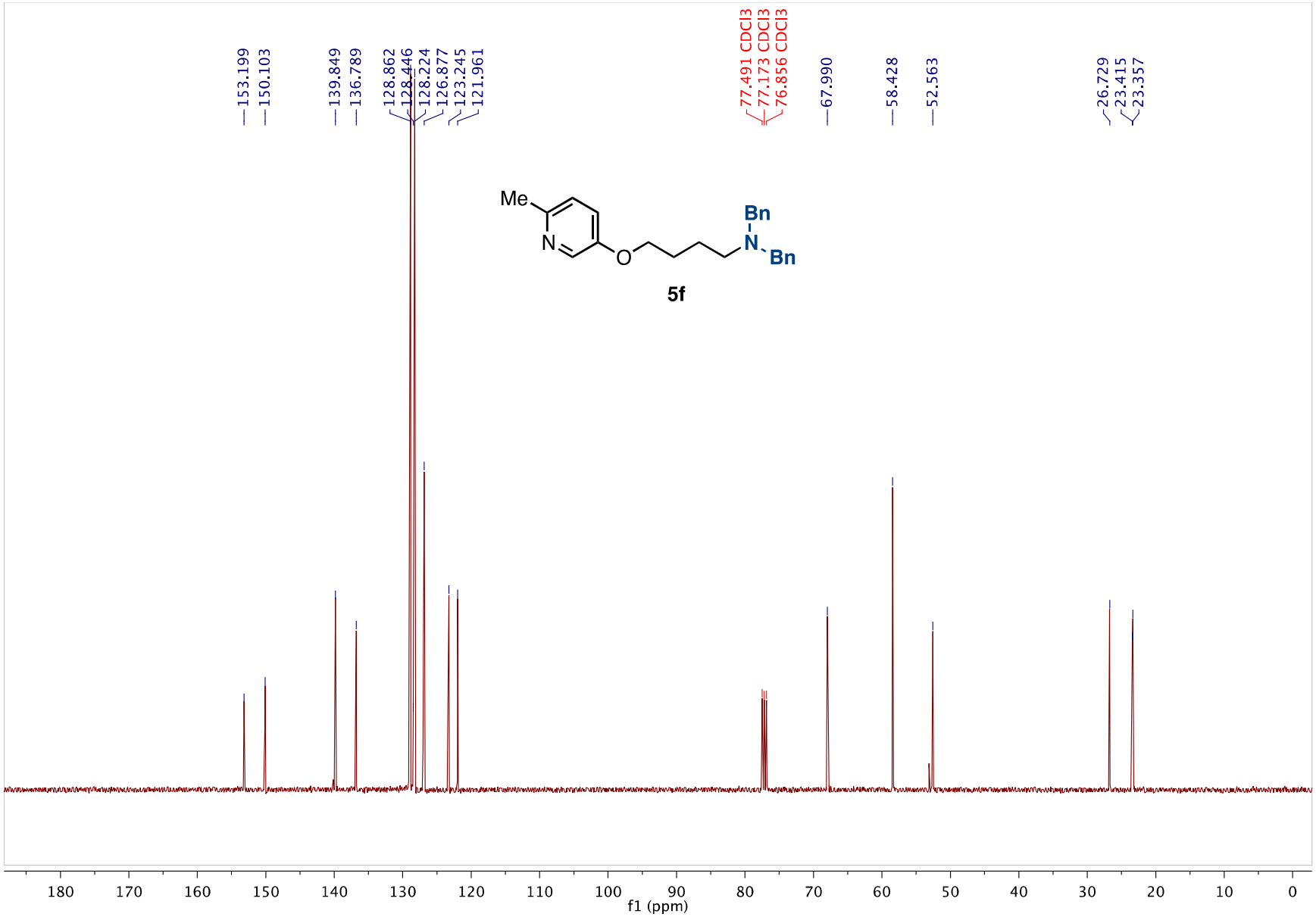
7.327
7.308
7.284
7.269
7.251
7.233
3.863
3.852
3.847
3.831
3.589
2.516
2.510
2.499
2.482
1.848
1.830
1.815
1.795
1.779
1.732
1.715
1.696
1.678
1.663
Me
N
O
Bn
N
Bn
5f
0.94
4.53
4.01
1.98
1.94
2.31
3.89
4.93
2.00
2.00
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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150.103
139.849
136.789
128.862
128.446
128.224
126.877
123.245
121.961
77.491 CDCl3
77.173 CDCl3
76.856 CDCl3
67.990
58.428
52.563
26.729
23.415
23.357
Me
N
O
Bn
N
Bn
5f
180
170
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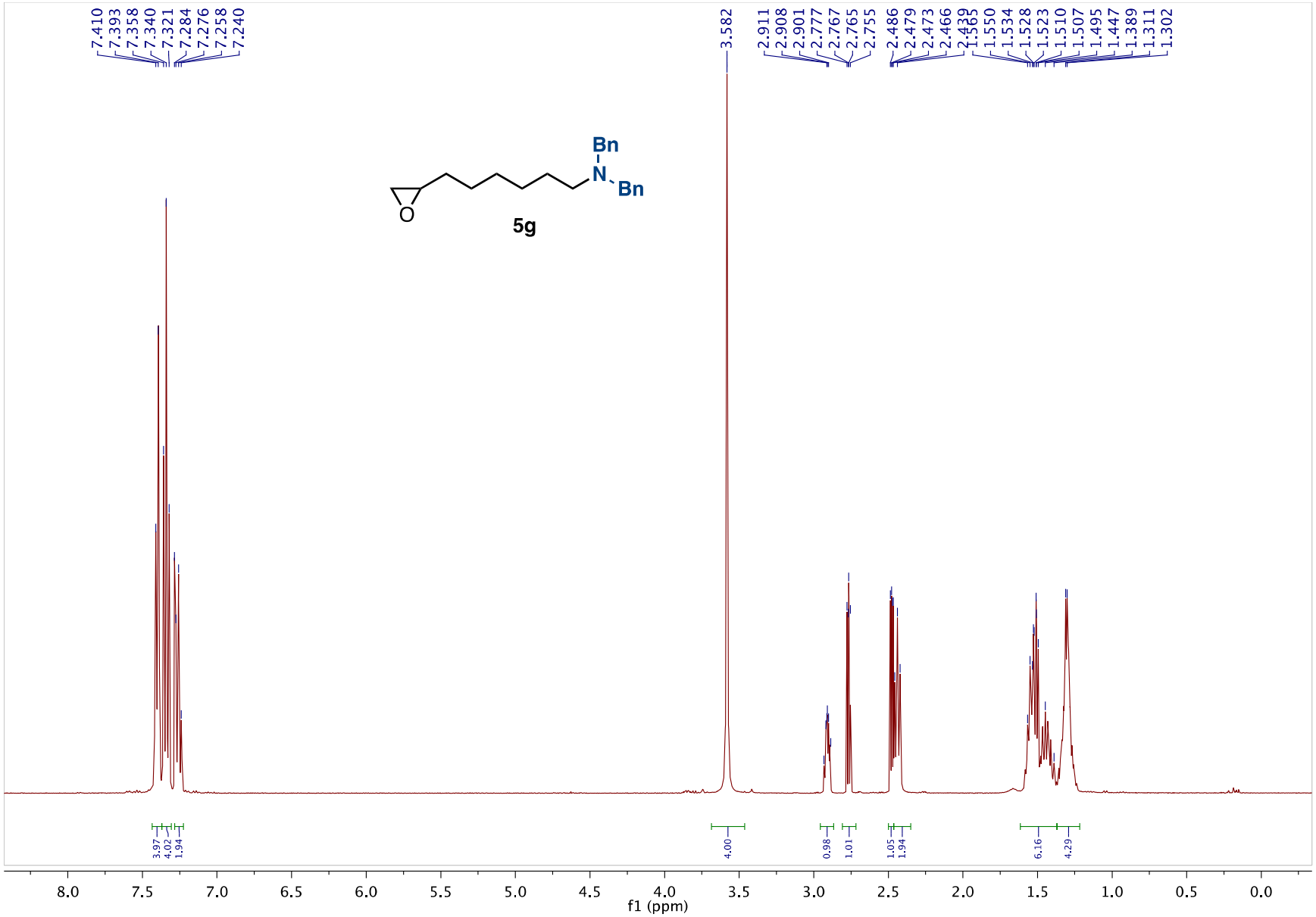
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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7.321
7.284
7.276
7.258
7.240
3.582
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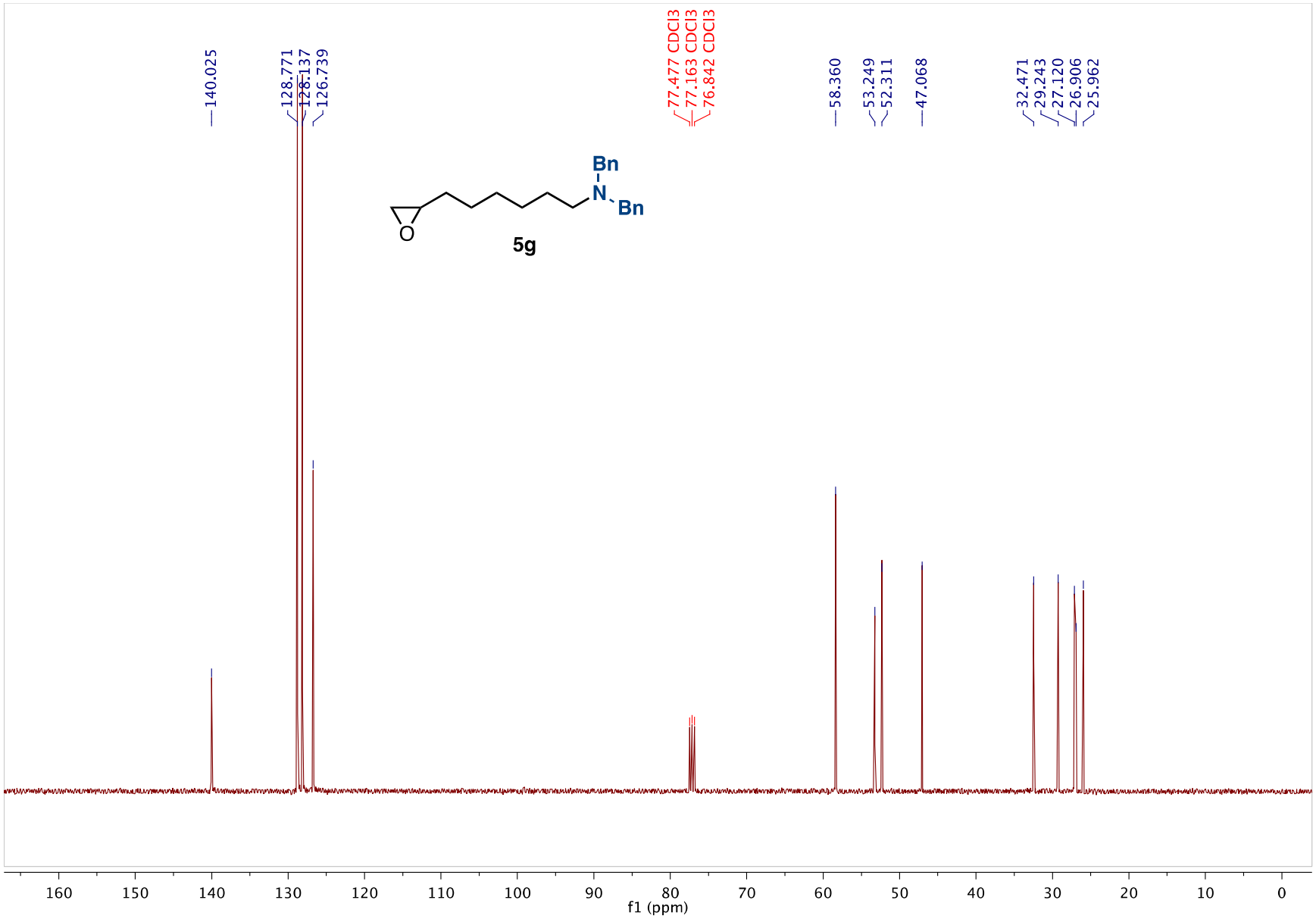
2.908
2.901
2.777
2.767
2.765
2.755
2.486
2.479
2.473
2.466
1.565
1.550
1.534
1.528
1.523
1.510
1.507
1.495
1.447
1.389
1.311
1.302
Bn
N
Bn
O
5g
3.97
4.02
1.94
4.00
0.98
1.01
1.05
1.94
6.16
4.29
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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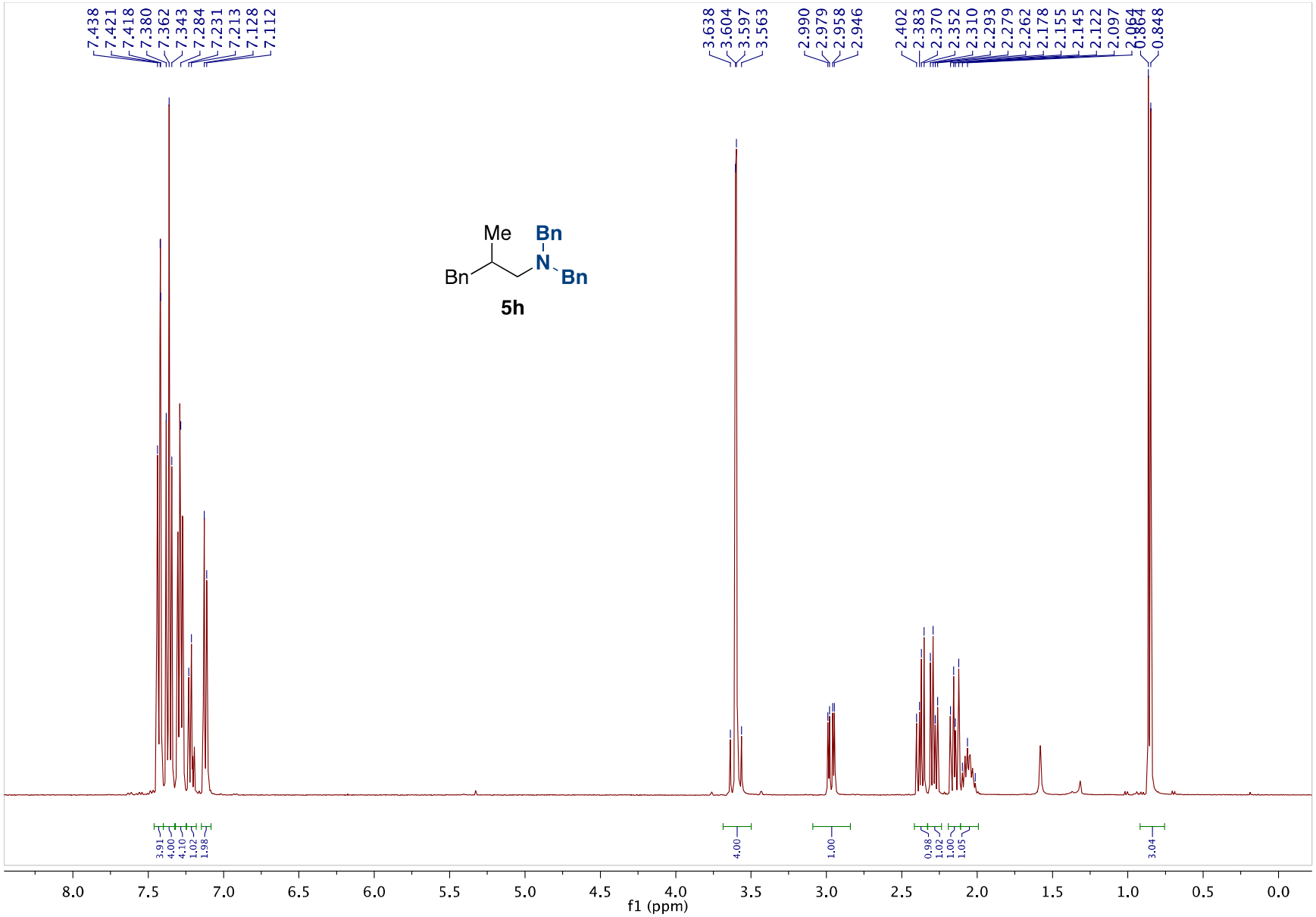
128.137
126.739
77.477 CDCl3
77.163 CDCl3
76.842 CDCl3
58.360
53.249
52.311
47.068
32.471
29.243
27.120
26.906
25.962
Bn
N
Bn
O
5g
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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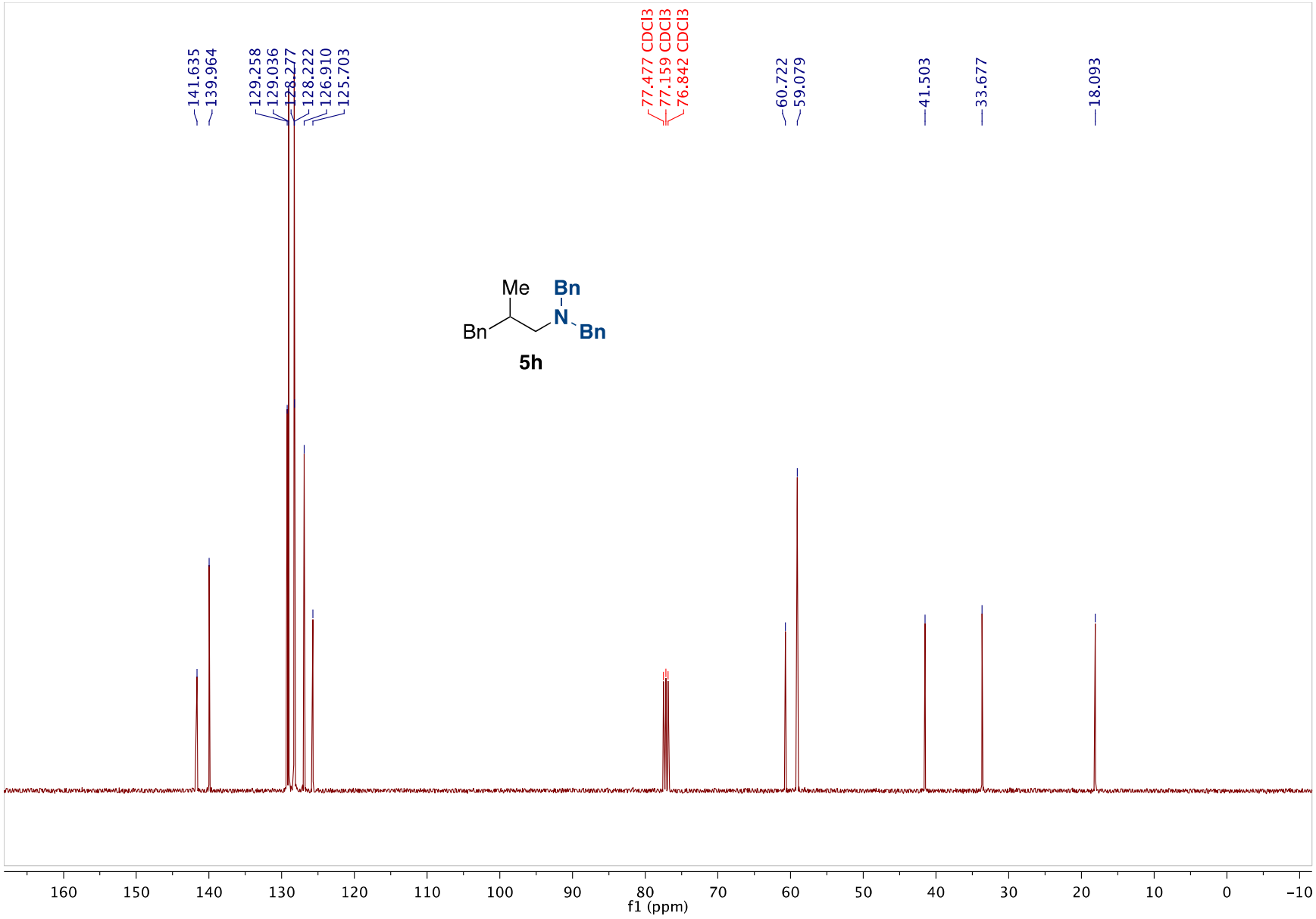
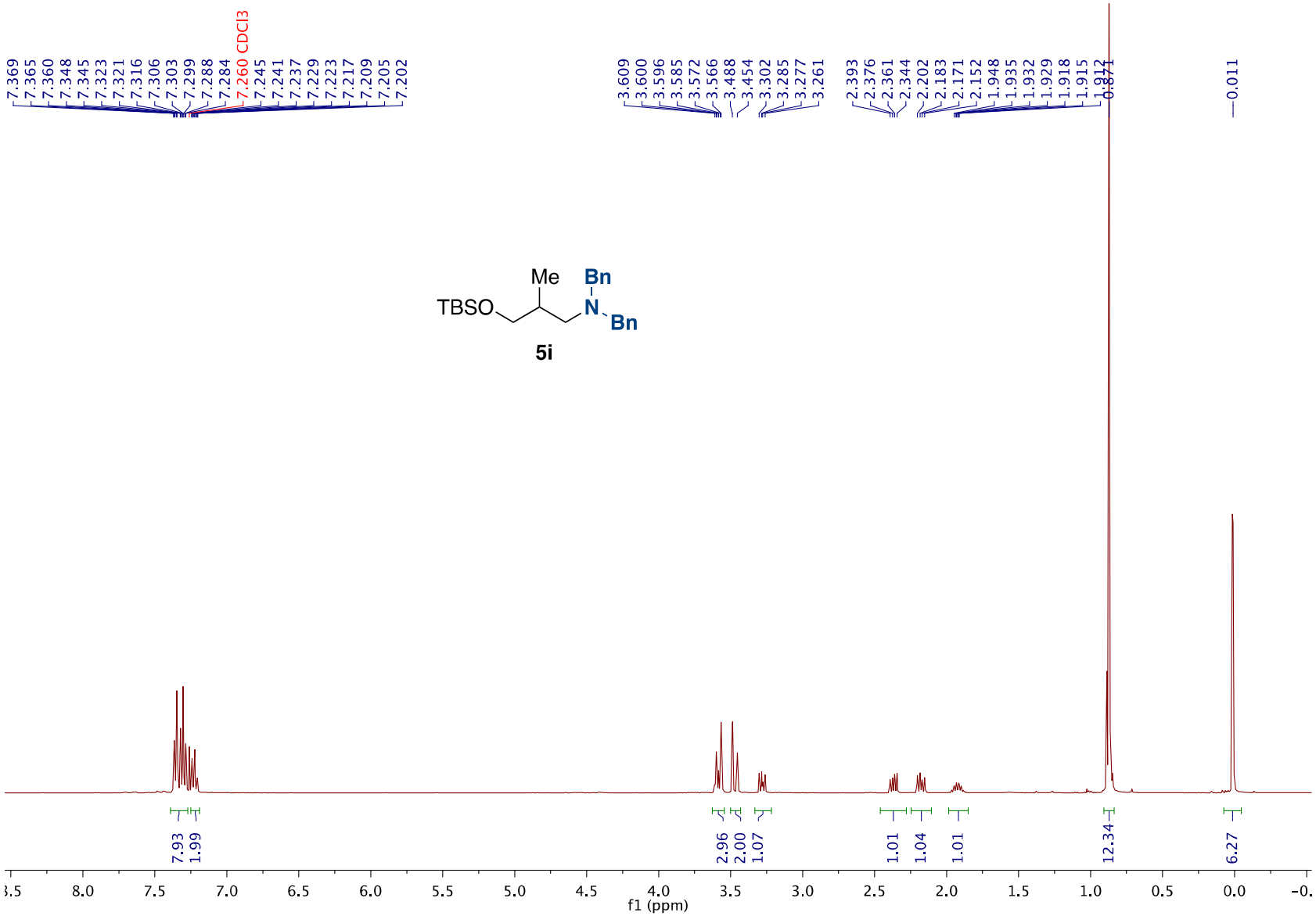
7.421
7.418
7.380
7.362
7.343
7.284
7.231
7.213
7.128
7.112
3.638
3.604
3.597
3.563
2.990
2.979
2.958
2.946
2.402
2.383
2.370
2.352
2.310
2.293
2.279
2.262
2.178
2.155
2.145
2.122
2.097
2.064
0.864
0.848
Me
Bn
N
Bn
Bn
5h
3.91
4.00
4.10
1.02
1.98
4.00
1.00
0.98
1.02
1.00
1.05
3.04
8.0
7.5
7.0
6.5
6.0
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)


141.635
139.964
129.258
129.036
128.277
128.222
126.910
125.703
77.477 CDCl3
77.159 CDCl3
76.842 CDCl3
60.722
59.079
41.503
33.677
18.093
Me
Bn
Bn
N
Bn
5h
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
f1 (ppm)


7.369
7.365
7.360
7.348
7.345
7.323
7.321
7.316
7.306
7.303
7.299
7.288
7.284
7.260 CDCl3
7.245
7.241
7.237
7.229
7.223
7.217
7.209
7.205
7.202
3.609
3.600
3.596
3.585
3.572
3.566
3.488
3.454
3.302
3.285
3.277
3.261
2.393
2.376
2.361
2.344
2.202
2.183
2.171
2.152
1.948
1.935
1.932
1.929
1.918
1.915
1.912
0.871
0.011
Me
Bn
TBSO
N
Bn
5i
7.93
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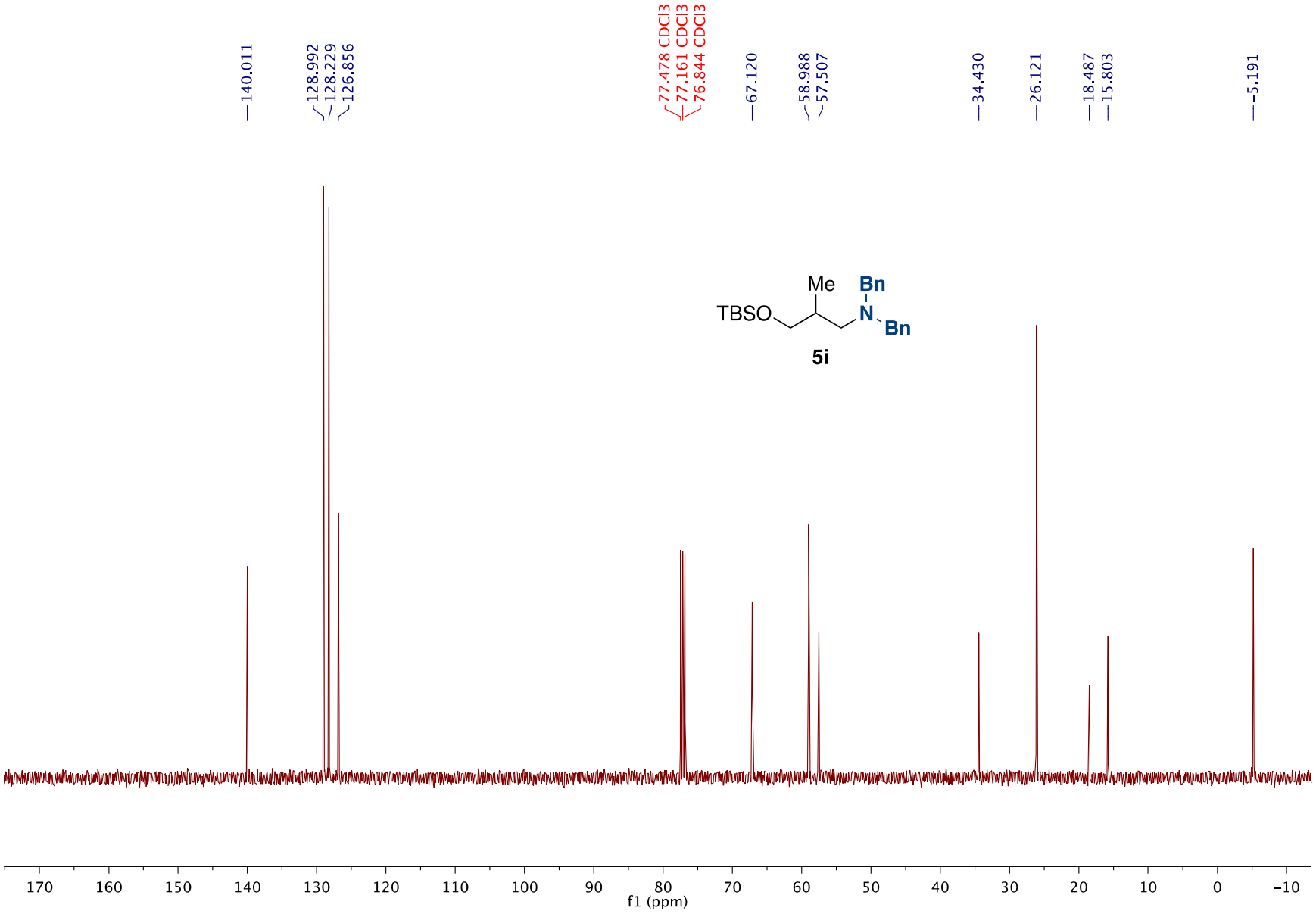
2.96
2.00
1.07
1.01
1.04
1.01
12.34
6.27
f1 (ppm)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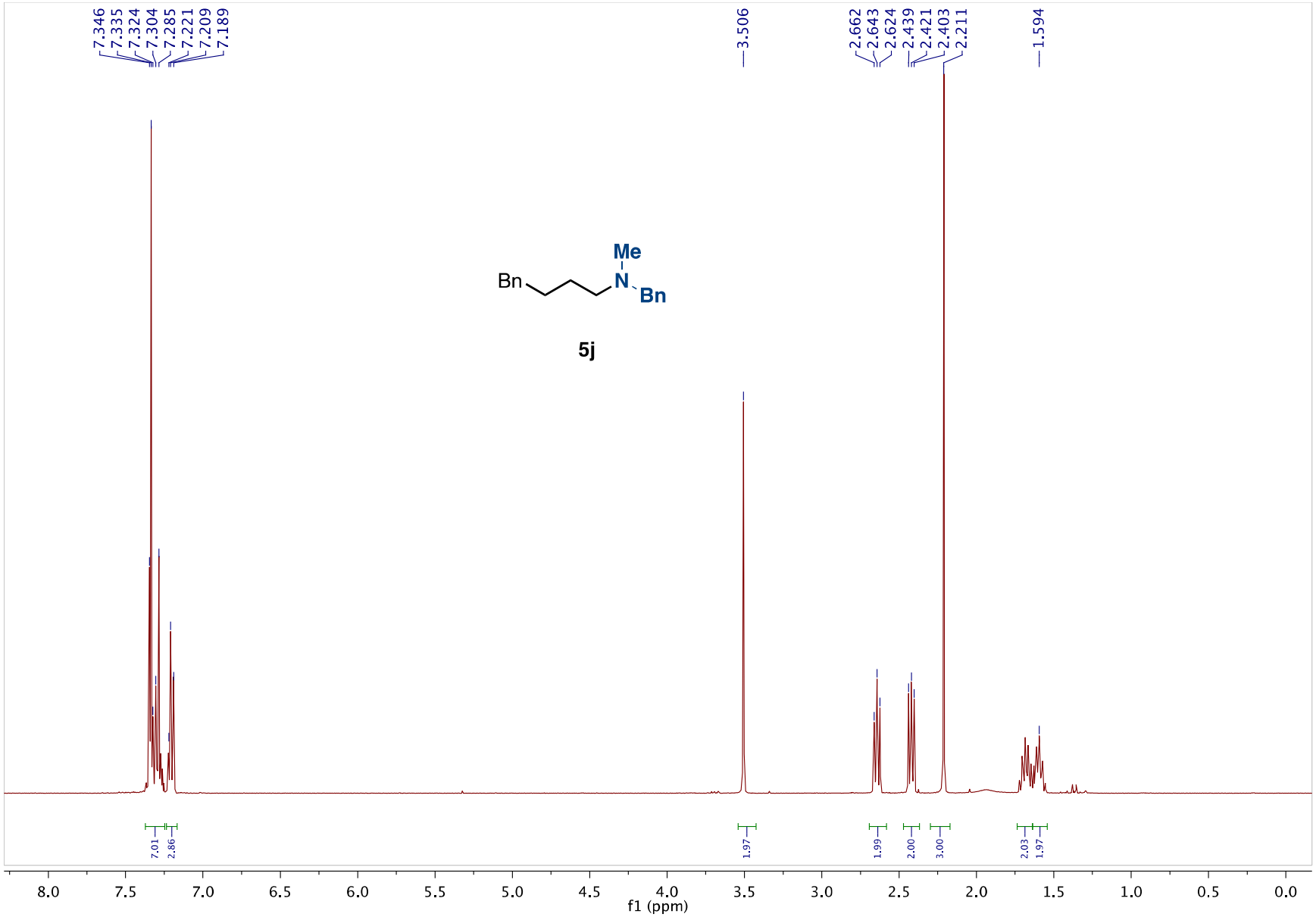
128.229
126.856
77.478 CDCl3
77.161 CDCl3
76.844 CDCl3
67.120
58.988
57.507
34.430
26.121
18.487
15.803
-5.191
Me
Bn
TBSO
N
Bn
5i
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)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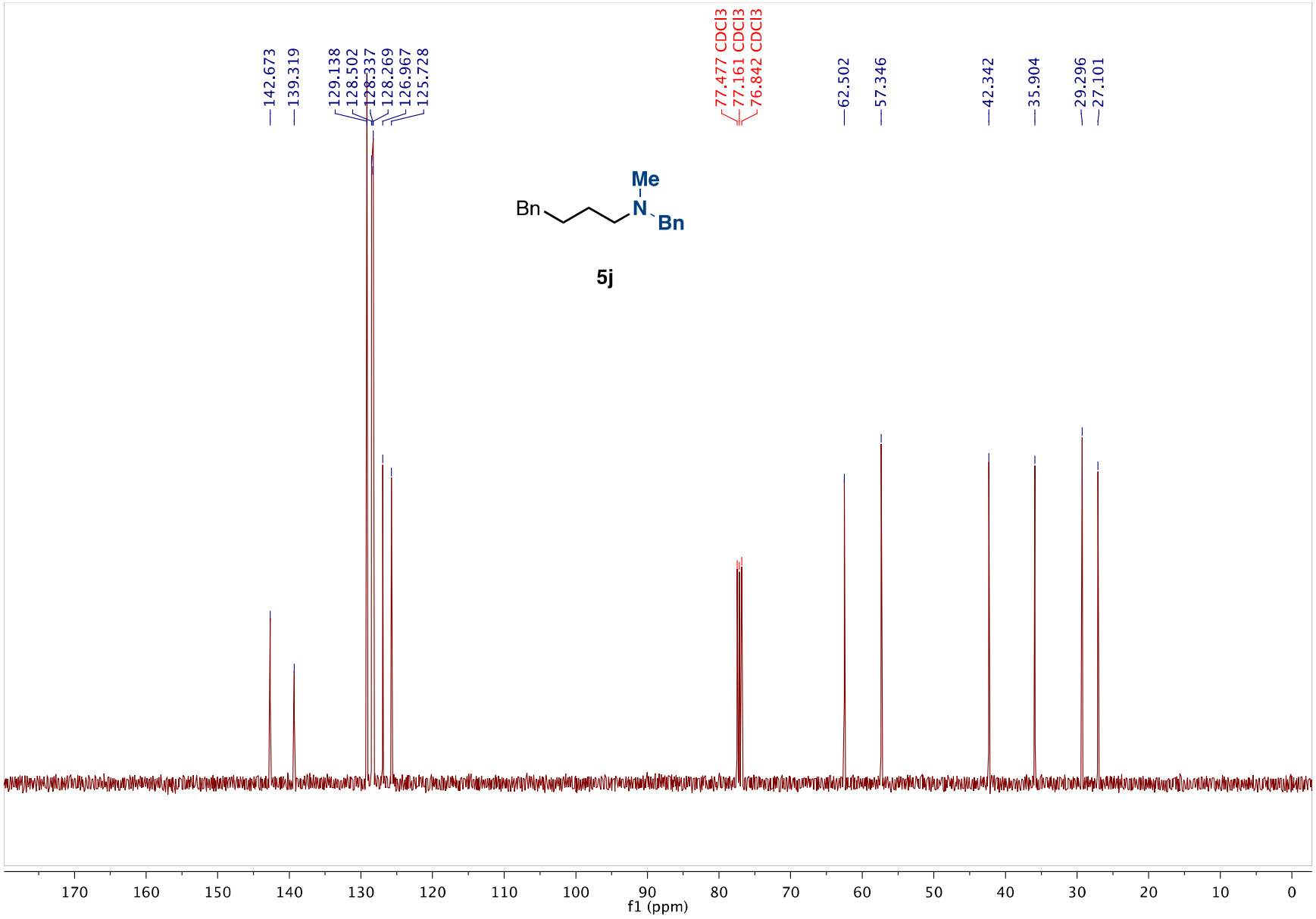
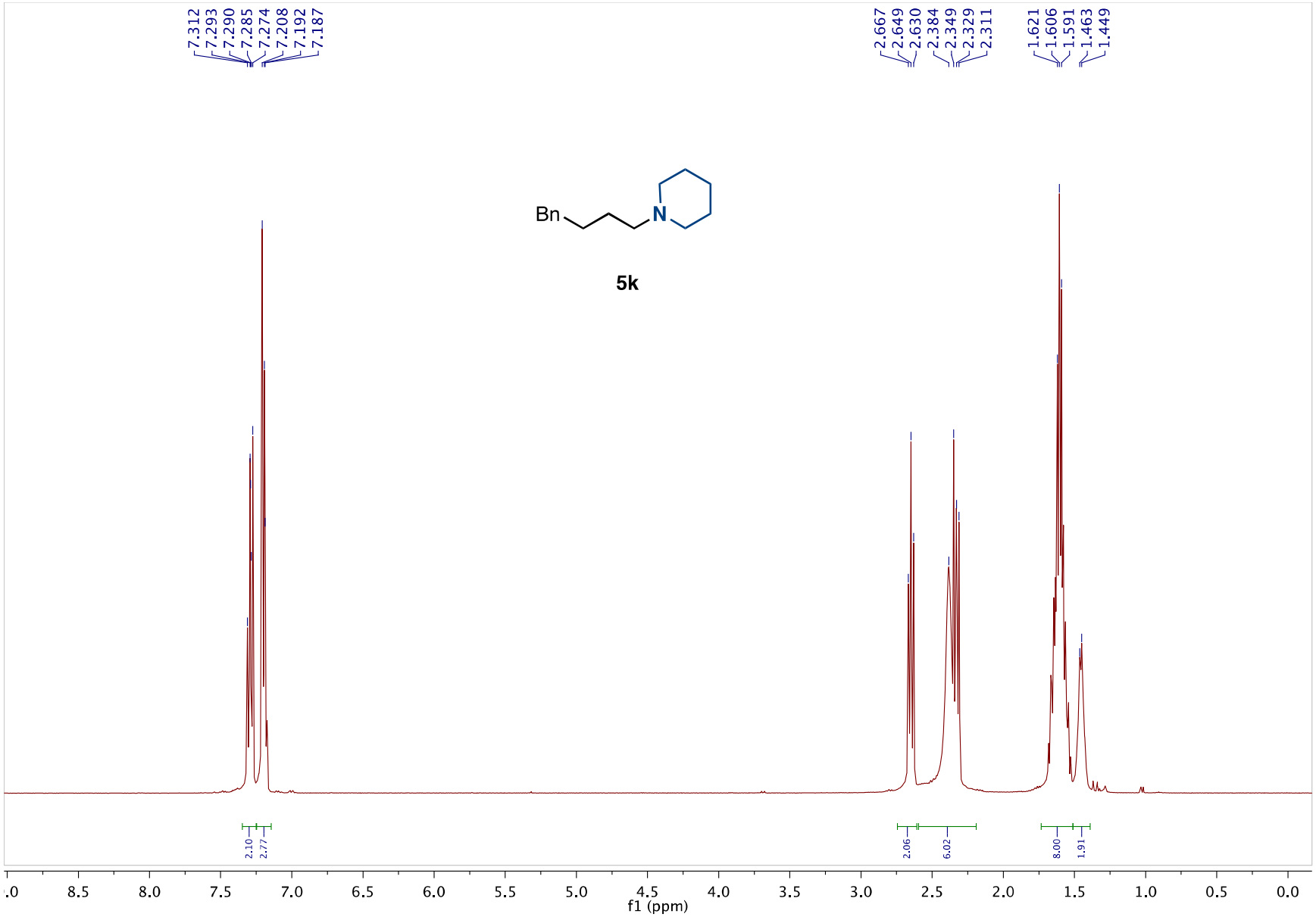
7.324
7.304
7.285
7.221
7.209
7.189
3.506
2.662
2.643
2.624
2.439
2.421
2.403
2.211
1.594
Me
N
Bn
Bn
5j
7.01
2.86
1.97
1.99
2.00
3.00
2.03
1.97
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


142.673
139.319
129.138
128.502
128.337
128.269
126.967
125.728
77.477 CDCl3
77.161 CDCl3
76.842 CDCl3
62.502
57.346
42.342
35.904
29.296
27.101
Me
N
Bn
Bn
5j
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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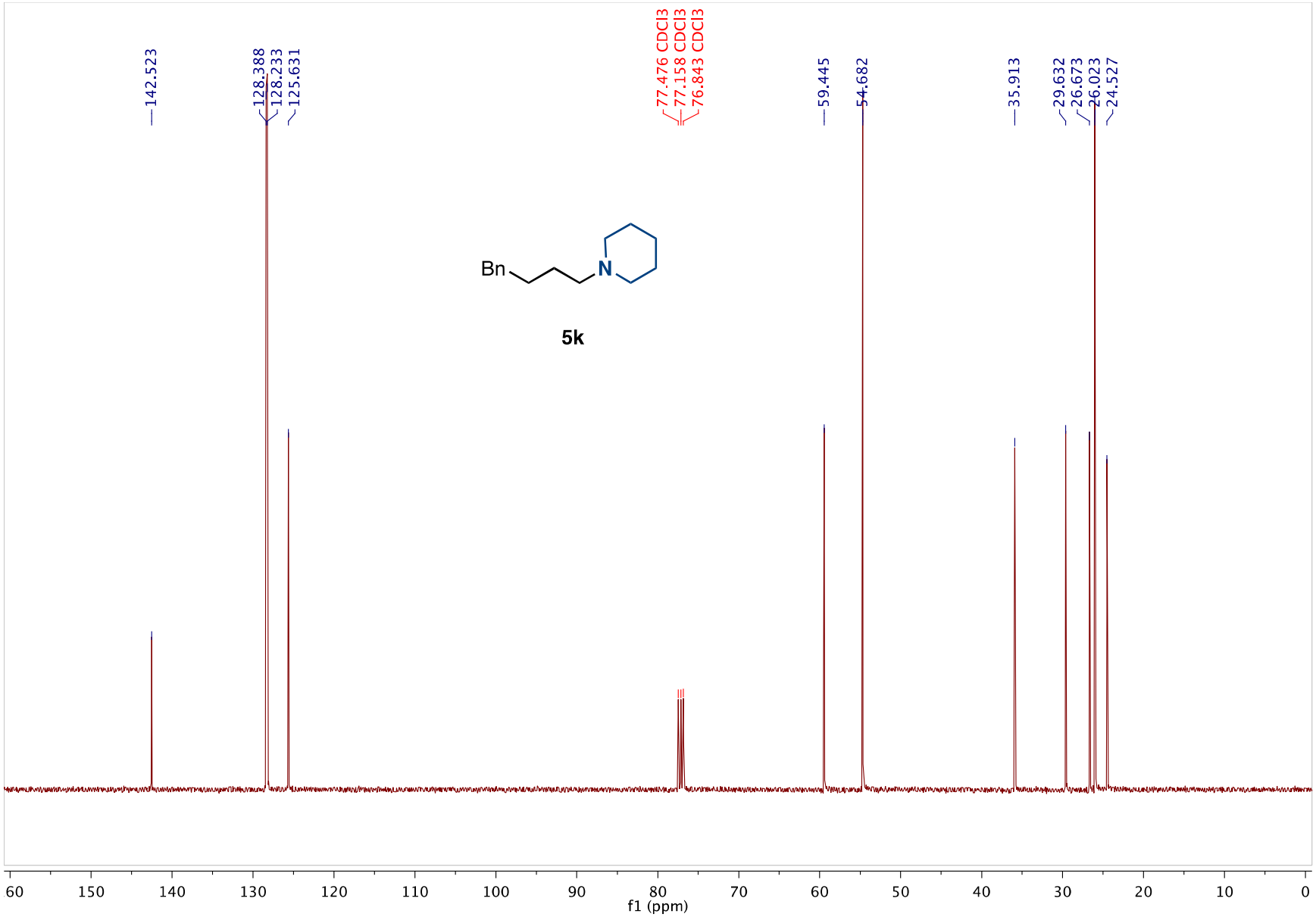
7.290
7.285
7.274
7.208
7.192
7.187
2.667
2.649
2.630
2.384
2.349
2.329
2.311
1.621
1.606
1.591
1.463
1.449
Bn
N
5k
2.10
2.77
2.06
6.02
8.00
1.91
f1 (ppm)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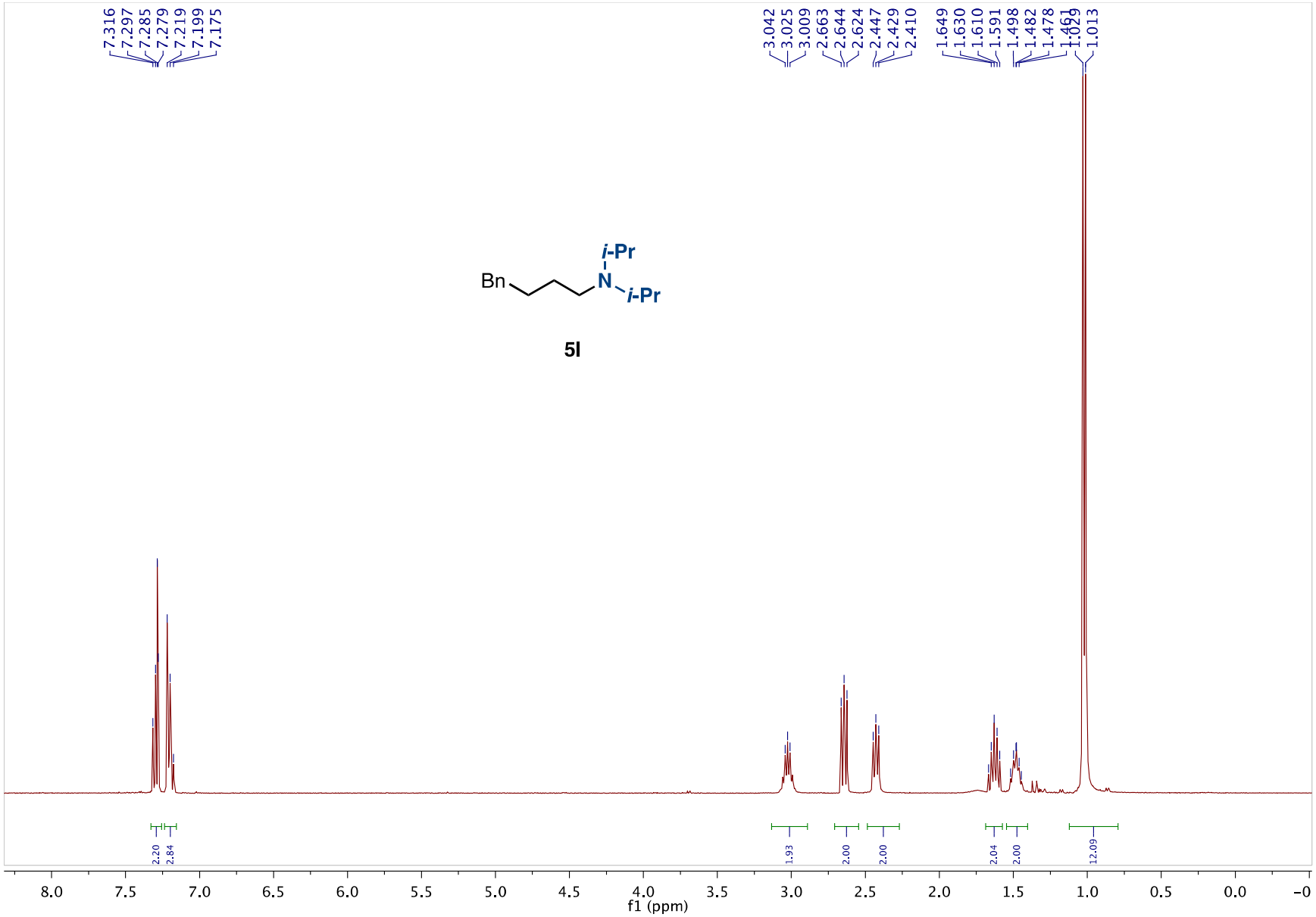
128.233
125.631
77.476 CDCl3
77.158 CDCl3
76.843 CDCl3
59.445
54.682
35.913
29.632
26.673
26.023
24.527
Bn
N
5k
60
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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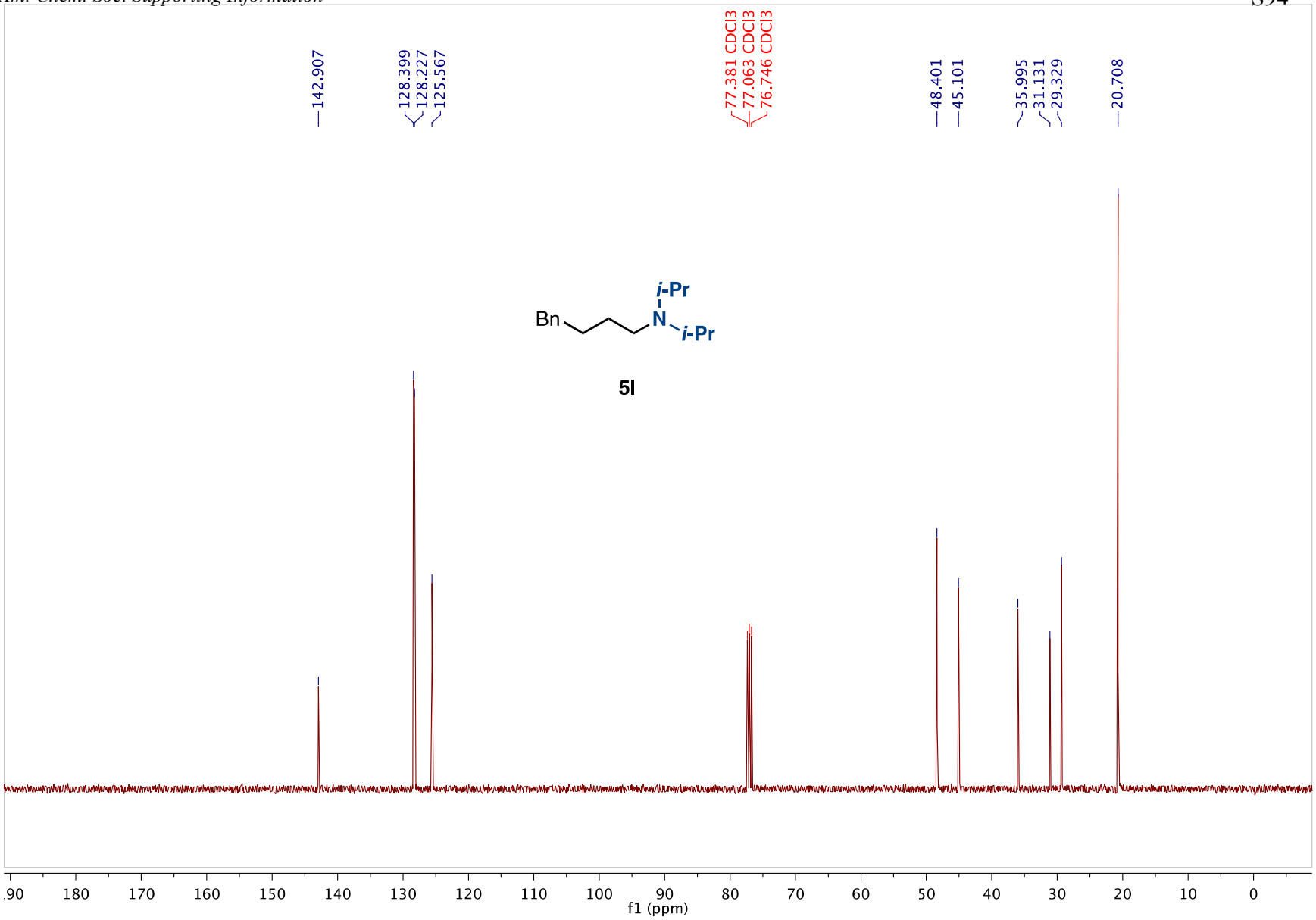
7.297
7.285
7.279
7.219
7.199
7.175
3.042
3.025
3.009
2.663
2.644
2.624
2.447
2.429
2.410
1.649
1.630
1.610
1.591
1.498
1.482
1.478
1.461
1.029
1.013
Bn
N
i-Pr
i-Pr
5l
2.20
2.84
1.93
2.00
2.00
2.04
2.00
12.09
f1 (ppm)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128.399
128.227
125.567
77.381 CDCl3
77.063 CDCl3
76.746 CDCl3
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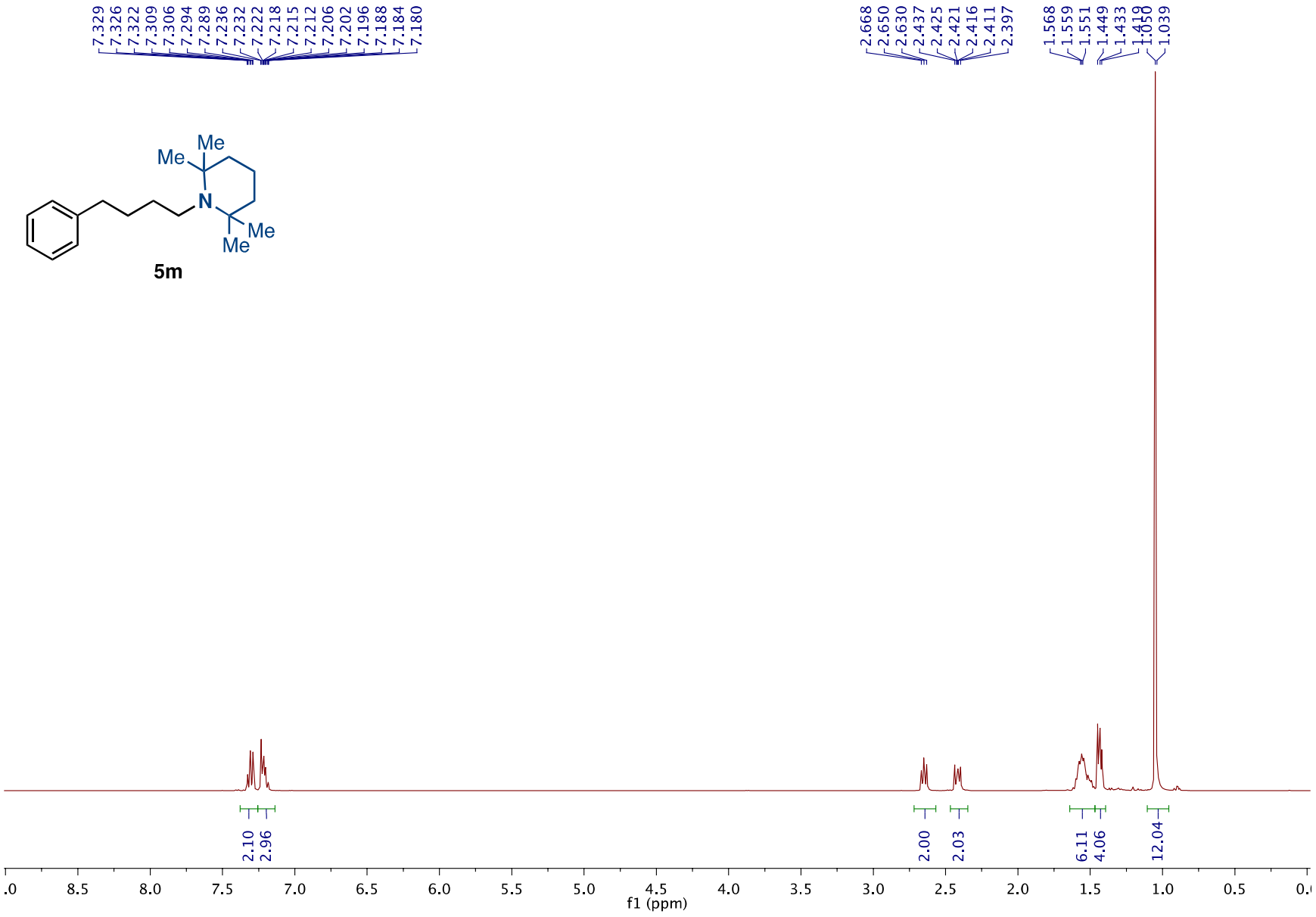
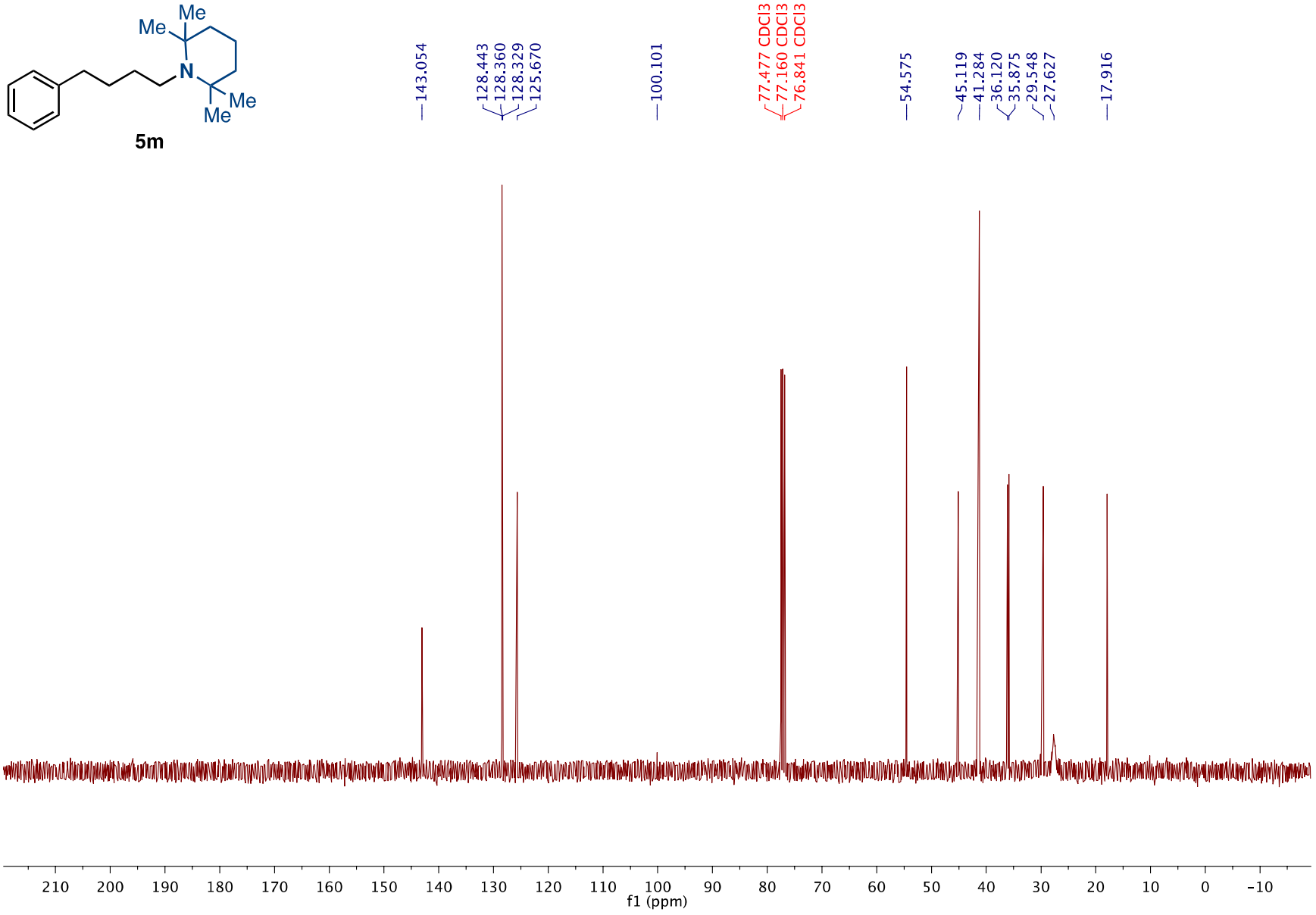
35.995
31.131
29.329
20.708
i-Pr
Bn
N
i-Pr
5l
f1 (ppm)


7.329
7.326
7.322
7.309
7.306
7.294
7.289
7.236
7.232
7.222
7.218
7.215
7.212
7.206
7.202
7.196
7.188
7.184
7.180
2.668
2.650
2.630
2.437
2.425
2.421
2.416
2.411
2.397
1.568
1.559
1.551
1.449
1.433
1.419
1.050
1.039
Me
Me
N
Me
Me
5m
2.10
2.96
2.00
2.03
6.11
4.06
12.04
f1 (ppm)


Me
Me
N
Me
Me
5m
143.054
128.443
128.360
128.329
125.670
100.101
77.477 CDCl3
77.160 CDCl3
76.841 CDCl3
54.575
45.119
41.284
36.120
35.875
29.548
27.627
17.916
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)