Convergent, Asymmetric Synthesis of Vicinal Amino Alcohols via Rh-Catalyzed Addition of α-Amido Trifluoroborates to Carbonyls

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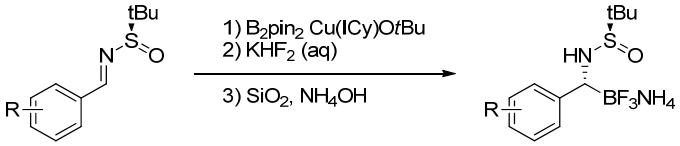
Supporting Information

I. General Methods.

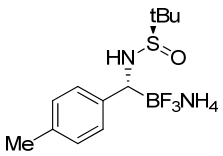
Unless otherwise noted, all reagents were obtained from commercial suppliers and used without further purification. MeOH and EtOH were distilled from Mg turnings, 1,2-Dichloroethane (DCE) was distilled from CaH_2, and iPrOH was stored over 3Å MS prior to use. All solvents and liquid reagents used in the Rh-catalyzed additions including H_2O were sparged with N_2 for at least 30 minutes prior to use. Glassware was dried overnight at 140 ˚C or flame-dried prior to use. Reactions conducted in 1-dram vials were capped with polypropylene caps equipped with PTFE/silicone septa. Chromatography was performed with Silicycle Silia Flash P60 230-400 mesh silica gel. NMR spectra were obtained at room temperature on a Bruker AVB-400 or AVB-500 spectrometer or Agilent MR2 spectrometer (400 MHz). NMR chemical shifts are reported in ppm relative to TMS (0.00 ppm for ^{1}H and 0.00 ppm for ^{13}C) or $CHCl_3$ (7.26 ppm for ^{1}H and 77.16 ppm for ^{13}C). Trifluoroacetic acid (-76.55 ppm for in $CDCl_3$) or C_6F_6 (-162.74 ppm in DMSO-d_6 and -162.90 ppm in $CDCl_3$) were used as external standards for ^{19}F NMR chemical shifts. ^{11}B NMR in DMSO-d_6 are reported uncorrected. IR spectra were recorded on a Nicolet 6700 FT-IR spectrometer, and only partial data are provided. Determinations of enantiomeric ratios were performed using an Agilent 1100 series HPLC equipped with a normal-phase column (Chiracel AS-H or AD-H) and a multiwavelength detector; samples were prepared in 1:1 hexanes/EtOH. HPLC methods were developed using the authentic enantiomers prepared from racemic *tert*-butanesulfinamide. Melting points were acquired using an Electrothermal melting point apparatus, and they are reported uncorrected. Unless otherwise noted, high resolution mass spectra (HRMS) and low resolution mass spectra (LRMS) were obtained using electrospray ionization (ESI) on a Fourier transform ion cyclotron resonance mass spectrometer (9.4T Bruker Qe FT-ICR MS) at the Keck Center (Yale University) or on a time-of-flight (TOF) mass spectrometer (Waters Xevo QTof MS) in the Department of Chemistry (Yale University). GC-MS data were recorded on an Agilent 6890N/5973 instrument.

II. Synthesis of α-Sulfinamido Trifluroborates



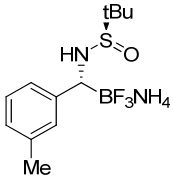
General procedure for the synthesis of α-sulfinamido trifluoroborates. In a nitrogen-filled glovebox, a solution of bis(pinacolato)diboron (2.0 equiv) in toluene was added to a Schlenk tube containing a solution of imine **3** (1.0 equiv) in toluene. Cu(ICy)OtBu (0.10 equiv)[1] in toluene was then added. The total volume of toluene added resulted in the [imine] = 0.2 M. The tube was sealed and removed from the glovebox. The Schlenk tube was placed in a 0 °C bath. The reaction mixture was stirred for 2-3 days until >90% conversion was observed by ^{1}H NMR after filtration of an aliquot of the reaction mixture through a deactivated silica plug (35% w/w H_2O). The entire reaction mixture was then filtered through a deactivated silica plug (35% w/w H_2O, ~15× crude product mass), eluting with EtOAc (70 mL/mmol product) to remove a majority of the copper catalyst. The eluent was then concentrated to provide the crude boronate ester.

The crude boronate ester (dark brown to black oil) was dissolved in MeOH (0.1 M), and the resulting solution was cooled to 0 °C in an ice bath. A concentrated solution of aqueous KHF_2 (~4.5M, 16 equiv) was added dropwise. The reaction flask was removed from the bath, allowed to warm to room temperature, and then heated to 70 °C. The reaction mixture was stirred for 1 h and then cooled to room temperature. The reaction mixture was concentrated by rotary evaporation and then high vacuum overnight. The resulting solid was triturated with acetone (80 mL/mmol product) to remove inorganic salts, and the filtrate was concentrated by rotary evaporation. The ammonium trifluoroborate was isolated by silica gel chromatography using DCM/MeOH/NH_4OH mixtures, visualizing by UV and $KMnO_4$ stain.



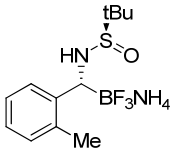
[1] Cu(ICy)OtBu was prepared as described by D. S. Laitar, E. Y. Tsui and J. P. Sadighi, *J. Am. Chem. Soc*. 2006, **128**, 11036.

α-Sulfinamidotrifluoroborate 4a. The general procedure was followed with imine **3a** (1.0 g, 4.5 mmol), bis(pinacolato)diboron (2.3 g, 9.0 mmol), and Cu(ICy)OtBu (175 mg, 0.474 mmol) in toluene (21 mL). To the crude boronate ester in MeOH (40 mL) was added KHF_2 (16 mL). Purification by flash chromatography (silica gel, 99:10:1 to 44:10:1 DCM/MeOH/NH_4OH, product R_f = 0.28 in 44:10:1 DCM/MeOH/NH_4OH) afforded trifluoroborate **4a** (1.1 g, 73%) as a white solid, mp = decomposition >95 °C. IR 3277, 1423, 1181, 998 cm^{-1}. ^1H NMR (400 MHz, DMSO-d_6) δ 7.11 (s, 4H), 7.05 (d, *J* = 7.9 Hz, 2H), 6.92 (d, *J* = 7.9 Hz, 2H), 3.99 (d, *J* = 5.2 Hz, 1H), 3.23 (s, 1H), 2.22 (s, 3H), 1.07 (s, 9H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 144.63, 131.99, 127.39, 126.82, 55.31, 22.04, 20.59 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to boron is not visible]. ^{19}F NMR (376 MHz, DMSO-d_6) δ -145.60. ^{11}B NMR (128 MHz, DMSO-d_6) δ 3.01. HRMS calcd for $C_{12}H_{22}BF_2N_2OS^+$ $[M\text{-}F]^+$, 291.1508; found 291.1494.

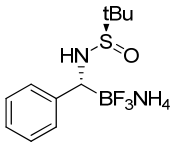


α-Sulfinamidotrifluoroborate 4b. The general procedure was followed with imine **3b** (0.50 g, 2.2 mmol), bis(pinacolato)diboron (1.1 g, 4.4 mmol), and Cu(ICy)OtBu (81 mg, 0.22 mmol) in toluene (10 mL). To the crude boronate ester in MeOH (22 mL) was added KHF_2 (7.8 mL). Purification by flash chromatography (silica gel, 99:10:1 DCM/MeOH/NH_4OH, product R_f = 0.28 in 44:10:1 DCM/MeOH/NH_4OH) afforded trifluoroborate **4b** (0.41 g, 60%) as a white solid, mp = decomposition >75 °C. IR 3279, 1445, 1186, 990 cm^{-1}. ^1H NMR (500 MHz, DMSO-d_6) δ 7.09 (br s,4H), 7.03 – 6.95 (m, 4H), 6.79 (d, *J* = 7.0 Hz, 1H), 3.99 (d, *J* = 5.1 Hz, 1H), 3.24 (br s, 1H), 2.23 (s, 3H), 1.08 (s, 9H). ^{13}C NMR (126 MHz, DMSO) δ 147.68, 135.23, 127.56, 126.67, 124.22, 124.10, 55.36, 22.02, 21.28 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to boron is not visible]. ^{19}F NMR (376 MHz, DMSO-d_6) δ -145.39. ^{11}B NMR (128 MHz, DMSO-d_6) δ 2.99. HRMS calcd for $C_{12}H_{22}BF_2N_2OS^+$ $[M\text{-}F]^+$, 291.1508; found 291.1523.

[2] For selected examples, see: (a) M. Presset, D. Oehlrich, F. Rombouts and G. A. Molander, *Org. Lett.* 2013, **15**, 1528. (b) A. Joliton and E. M. Carreira, *Org. Lett.* 2013, **15**, 5147. (c) G. A. Molander, D. Ryu, M. Hosseini-Sarvari, R. Devulapally and D. G. Seapy, *J. Org. Chem.* 2013, **78**, 6648. (d) G. A. Molander and I. Shin, *Org. Lett.* 2011, **13**, 3956. (e) K. Brak and J. A. Ellman *J. Am. Chem. Soc.* 2009, **131**, 3850.



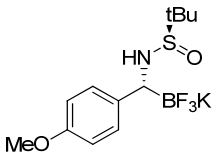
α-Sulfinamidotrifluoroborate 4c. The general procedure was followed with imine **3c** (0.51 g, 2.3 mmol), bis(pinacolato)diboron (1.1 g, 4.4 mmol), and Cu(ICy)OtBu (82 mg, 0.22 mmol) in toluene (10 mL). To the crude boronate ester in MeOH (22 mL) was added KHF_2 (7.8 mL). Purification by flash chromatography (silica gel, 44:10:1 DCM/MeOH/NH_4OH, product R_f = 0.28 in 44:10:1 DCM/MeOH/NH_4OH) afforded trifluoroborate **4c** (0.41 g, 61%, 96% w/w[3]) as a white solid, mp = decomposition >75 °C. IR 3288, 1456, 992, 736 cm^{-1}. ^1H NMR (500 MHz, DMSO-d_6) δ 7.32 (d, *J* = 7.5 Hz, 1H), 7.11 (br s, 4H), 7.00 (t, *J* = 7.5 Hz, 1H), 6.94 (d, *J* = 7.1 Hz, 1H), 6.87 (td, *J* = 7.3, 1.3 Hz, 1H), 4.11 (d, *J* = 5.2 Hz, 1H), 3.56 (s, 1H), 2.20 (s, 3H), 1.07 (s, 9H). ^{13}C NMR (126 MHz, DMSO-d_6) δ 146.17, 134.04, 128.66, 127.24, 124.56, 123.13, 55.31, 22.08, 19.73 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to boron is not visible]. ^{19}F NMR (376 MHz, DMSO-d_6) δ -144.70. ^{11}B NMR (128 MHz, DMSO-d_6) δ 2.96. HRMS calcd for $C_{12}H_{22}BF_2N_2OS^+$ $[M-F]^+$, 291.1508; found 291.1498.



α-Sulfinamidotrifluoroborate 4d. The general procedure was followed with imine **3d** (0.50 g, 2.4 mmol), bis(pinacolato)diboron (1.2 g, 4.8 mmol), and Cu(ICy)OtBu (89 mg, 0.24 mmol) in toluene (12 mL). To the crude boronate ester in MeOH (20 mL) was added KHF_2 (8.5 mL). Purification by flash chromatography (silica gel, 99:10:1 to 44:10:1 DCM/MeOH/NH_4OH, product R_f = 0.25 in 44:10:1 DCM/MeOH/NH_4OH) afforded trifluoroborate **4d** (0.57 g, 80%) as a white solid, mp = decomposition >80 °C. IR 3290, 1450, 1181, 992, 725, 700 cm^{-1}. ^1H NMR (400 MHz, DMSO-d_6) δ 7.22 – 7.08 (m, 8H), 7.01 – 6.94 (m, 1H), 4.03 (d, *J* = 5.1 Hz, 1H), 3.29 (s, 1H), 1.08 (s, 9H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 147.79, 126.84, 126.79, 123.52, 55.43, 22.06 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to

[3] The isolated product contained a small amount of pinacol, which did not affect the subsequent Rh-catalyzed addition.

boron is not visible]. ^{19}F NMR (376 MHz, DMSO-d_6) δ -145.57. ^{11}B NMR (128 MHz, DMSO-d_6) δ 2.87. HRMS calcd for $C_{12}H_{22}BF_2N_2OS^+$ $[M-F]^+$, 277.1352; found 277.1377.

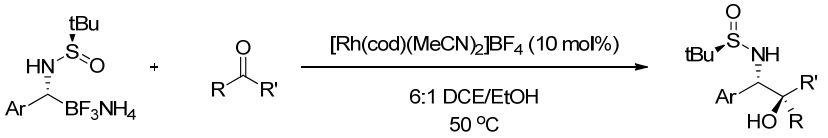


α-Sulfinamidotrifluoroborate 4e. In a nitrogen-filled glovebox, a solution of imine **3e** (1.2 g, 5.0 mmol) in toluene (9 mL) were added to a Schlenk tube containing a solution of bis(pinacolato)diboron (2.5 g, 10 mmol) in toluene (8 mL). Cu(ICy)OtBu (184 mg, 0.500 mmol) in toluene (8 mL) was then added, the tube was sealed and removed from the glovebox. The Schlenk tube was placed in a 0 ^oC bath, and the reaction mixture was stirred for 47 h. The reaction mixture was then filtered through a deactivated silica plug (60 g, 35% w/w H_2O), eluting with EtOAc (~350 mL) to remove a majority of the copper catalyst. The eluent was concentrated to yield the crude boronate ester (dark brown oil).

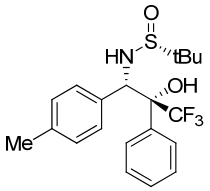
The oil was dissolved in MeOH (50 mL), and reaction mixture was cooled to 0 ^oC. A concentrated solution of KHF_2 (18 mL, ~4.5M, 80 mmol) was added dropwise. The reaction flask was removed from the bath, allowed to warm to room temperature, and then heated to 70 ^oC. The reaction mixture was stirred for 30 min. After cooling to room temperature, the reaction mixture was concentrated by rotary evaporation and then high vacuum overnight. The resulting tan solid was triturated with acetone (~400 mL) to remove inorganic salts, and the filtrate was concentrated by rotary evaporation. The resulting yellow brown oil [Note: do not concentrate to dryness] was dissolved in CPME (55 mL), and pentane (~130 mL) was added resulting in the precipitation of a white solid. The solid was collected via filtration with a fine fritted funnel, washing with pentane (4 x 60 mL). [Note: Until the final wash, the entirety of the solvent was not allowed to pass through the frit; doing so results in the formation of an oily solid, which is difficult to manipulate.] Upon evaporation of trace solvent, the product **4e** was obtained as a powdery, white solid (0.80 g, 47%). Cooling the combined filtrate to -20 ^oC overnight and collection of the resulting solid as described above yielded additional product (0.45 g, 71% overall), mp = decomposition >105 °C. IR (in CH_2Cl_2) 1510, 1244, 1179, 1021 cm^{-1}. ^1H NMR (400 MHz, DMSO-d_6) δ 7.08 (d, J = 8.4 Hz, 2H), 6.71 (d, J = 8.4 Hz, 2H), 3.98 (d, J = 5.0 Hz,

1H), 3.69 (s, 3H), 3.20 (s, 1H), 1.07 (s, 9H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 156.17, 139.69, 127.77, 112.41, 55.30, 54.88, 22.09 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to boron is not visible]. ^{19}F NMR (376 MHz, DMSO-d_6) δ -145.69. ^{11}B NMR (128 MHz, DMSO-d_6) δ 2.86. HRMS calcd for $C_{12}H_{19}BF_2N_2OS^+$ [M-KF+H]$^+$, 290.1192; found 290.1209. LRMS calcd for $C_{12}H_{18}BF_3N_2OS^-$ [M-K]$^-$, 308.11; found 308.13.

III. Additions of α-Sulfinamido Trifluroborates



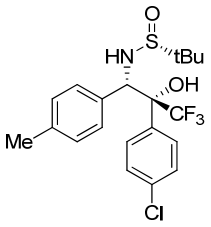
General procedure for the addition of α-Sulfinamidotrifluoroborates to 2,2,2-trifluoromethyl ketones. In a nitrogen-filled glovebox, a 1-dram vial was charged with trifluoroborate **4** (0.200–0.214 mmol) and [Rh(cod)(MeCN)$_2$]BF$_4$ (7.6–7.8 mg, 0.020–0.021 mmol).[4] The appropriate trifluoromethyl ketone (0.40 mmol) in DCE (0.23 mL) and then EtOH (0.040 mL) were added to the vial. The vial was capped, removed from the box, and placed in a heating block at 50 °C. The reaction mixture was then stirred for 22–24h. The reaction mixture was allowed to cool to rt and diluted with EtOAc (6 mL). The organic layer was washed with 50% saturated aqueous NaCl (2 mL), and the aqueous layer was extracted with EtOAc (2 x 3 mL). The combined organic layers were dried over Na_2SO_4 or $MgSO_4$, filtered, and concentrated under reduced pressure. The products were isolated by silica gel chromatography.



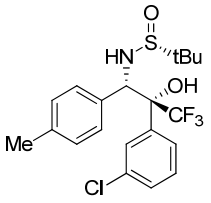
Amino alcohol 2a. The general procedure was followed with ammonium trifluoroborate **4a** (66.4 mg, 0.214 mmol) and 2,2,2-trifluoroacetophenone (56 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 9% EtOAc in DCM, product R_f = 0.31 in 10% EtOAc in DCM) afforded product **2a** (46.4 mg, 54%) as an off-white solid, mp = decomposition >210 °C. IR

[4] [Rh(cod)(MeCN)$_2$]BF$_4$ was prepared as reported by Y. Bolshan and R. A. Batey, *Org. Lett.* 2005, **7**, 1481.

3333, 1157, 930, 720, 705 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) δ 7.49 – 7.39 (m, 2H), 7.24 – 7.18 (m, 3H), 7.13 (d, *J* = 8.0 Hz, 2H), 6.94 (d, *J* = 8.0 Hz, 2H), 5.56 (s, 1H), 5.27 (d, *J* = 4.8 Hz, 1H), 4.26 (d, *J* = 4.5 Hz, 1H), 2.22 (s, 3H), 1.19 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 137.94, 135.56, 132.52, 129.96, 128.92, 128.36, 128.07, 126.75, 125.72 (q, *J* = 290 Hz), 78.35 (q, *J* = 26 Hz), 62.79, 56.52, 22.80, 21.24. ^{19}F NMR (282 MHz, $CDCl_3$) δ -73.21. HRMS calcd for $C_{20}H_{25}F_3NO_2S^+$ $[M+H]^+$, 400.1553; found 400.1552.

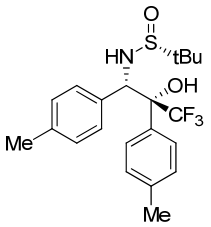


Amino alcohol 2b. The general procedure was followed with ammonium trifluoroborate **4a** (66.3 mg, 0.214 mmol) and 4'-chloro-2,2,2-trifluoroacetophenone (60 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 9% EtOAc in DCM, product R_f = 0.29) afforded product **2b** (62.0 mg, 67%) as a light yellow solid, mp = decomposition over >180 °C. IR (in $CHCl_3$) 3260, 2960, 1161, 1035, 754 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) δ 7.38 (d, *J* = 8.5 Hz, 2H), 7.21 – 7.12 (m, 4H), 6.96 (d, *J* = 8.0 Hz, 2H), 5.85 (s, 1H), 5.25 (d, *J* = 4.2 Hz, 1H), 4.28 (d, *J* = 3.7 Hz, 1H), 2.24 (s, 3H), 1.19 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.20, 134.39, 134.34, 132.10, 126.95,129.09, 128.30, 128.26, 125.54 (q, *J* = 289 Hz), 78.11(q, *J* = 26 Hz), 62.91, 56.51,22.77, 21.24. ^{19}F NMR (376 MHz, $CDCl_3$) δ -74.52. HRMS calcd for $C_{20}H_{24}ClF_3NO_2S^+$ $[M+H]^+$, 434.1163; found 434.1162.

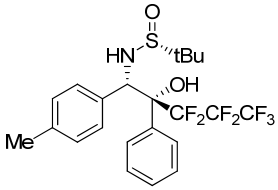


Amino alcohol 2c. The general procedure was followed with ammonium trifluoroborate **4a** (66.3 mg, 0.214 mmol) and 3'-chloro-2,2,2-trifluoroacetophenone (59 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 9% EtOAc in DCM, product R_f = 0.29) afforded product **2c** (54.3 mg, 58%) as a light yellow solid, mp = decomposition >190 °C. IR 3328, 2964, 1157, 1045 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$) δ 7.50 (s, 1H), 7.28 (d, *J* = 7.8 Hz, 1H), 7.20 – 7.09 (m, 4H),

6.96 (d, J = 8.0 Hz, 2H), 5.83 (s, 1H), 5.24 (d, J = 4.4 Hz, 1H), 4.29 (d, J = 4.1 Hz, 1H), 2.23 (s, 3H), 1.20 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.28, 137.75, 134.26, 131.91, 129.96, 129.28, 129.11, 128.59, 127.25, 125.48 (q, J = 289 Hz), 124.33, 78.01 (q, J = 26.1 Hz), 62.83, 56.51, 22.81, 21.25. ^{19}F NMR (376 MHz, $CDCl_3$) δ –74.33. HRMS calcd for $C_{20}H_{24}ClF_3NO_2S^+$ $[M+H]^+$, 434.1163; found 434.1147.

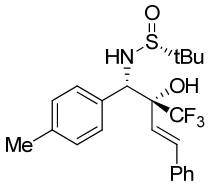


Amino alcohol 2d. The general procedure was followed with ammonium trifluoroborate **4a** (66.3 mg, 0.214 mmol) and 4-(trifluoroacetyl)toluene (51 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 9% EtOAc in DCM, product R_f = 0.29) afforded product **2d** (44.9 mg, 51%, 94:6 dr) as an off-white solid, mp = decomposition >175 °C. IR 3331, 1157, 1035, 929 cm^{-1}. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 (d, J = 8.0 Hz, 2H), 7.13 (d, J = 8.0 Hz, 2H), 7.03 (d, J = 8.0 Hz, 2H), 6.95 (d, J = 8.0 Hz, 2H), 5.49 (s, 1H), 5.24 (d, J = 5.0 Hz, 1H), 4.25 (d, J = 4.8 Hz, 1H), 2.26 (s, 3H), 2.23 (s, 3H), 1.18 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.13, 137.85, 132.72, 132.45, 129.98, 128.89, 128.83, 126.68, 125.74 (q, J = 290 Hz), 78.33 (q, J = 26 Hz), 62.51, 56.55, 22.81, 21.25, 21.16. ^{19}F NMR (376 MHz, $CDCl_3$) δ -74.32. HRMS calcd for $C_{21}H_{27}F_3NO_2S^+$ $[M+H]^+$, 414.1709; found 414.1697.

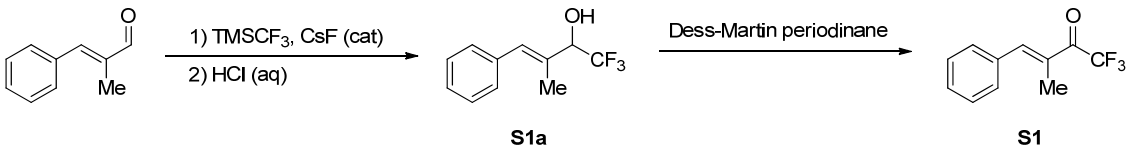


Amino alcohol 2e. The general procedure was followed with ammonium trifluoroborate **4a** (66.4 mg, 0.214 mmol) and heptafluorobutyrophenone (74 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 4.5% EtOAc in DCM, product R_f = 0.30) afforded product **2e** (45.6 mg, 43%) as a light yellow solid, mp = decomposition >170 °C. IR 3327, 2961, 1211, 1135, 1112, 1032, 1013 cm^{-1}. ^{1}H NMR (500 MHz, CD_2Cl_2) δ 7.43 (apparent br s, 2H), 7.22 (apparent br s, 3H), 7.11 (d, J = 8.1 Hz, 2H), 6.97 (d, J = 8.1 Hz, 2H), 6.18 (s, 1H), 5.42 (d, J = 5.0 Hz,

1H), 4.36 (br s, 1H), 2.23 (s, 3H), 1.14 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 137.90, 134.40, 132.64, 130.16, 128.73, 128.42, 127.80, 127.41, 78.34 (t, J = 22 Hz), 62.05, 56.77, 22.90, 21.24 [Note: Due to multiple couplings with ^{19}F, carbons on the perfluoroalkyl chain were not observed]. ^{19}F NMR (376 MHz, $CDCl_3$) δ -77.97 – -83.85 (m, 3F), -111.46 – -112.52 (m, 1F), -113.76 (dp, J = 35, 12 Hz, 1F), -120.89 (ddd, J = 288, 11, 7.3 Hz, 1F), -123.22 (dd, J = 288, 9.9 Hz, 1F). HRMS calcd for $C_{22}H_{25}F_7NO_2S^+$ $[M+H]^+$, 500.1489; found 500.1496.



Amino alcohol 2f. The general procedure was followed with ammonium trifluoroborate **4a** (62.0 mg, 0.200 mmol) and 1,1,1-trifluoro-4-phenyl-but-(E)-3-en-2-one[5] (80.3 mg, 0.401 mmol). Purification by flash chromatography (silica gel, 3% EtOAc in DCM, product R_f = 0.23) afforded product **2f** (55.4 mg, 65%) as a white solid, mp = decomposition >175 °C. IR 3335, 2951, 1175, 1148, 1307, 1020 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.44 – 7.28 (m, 5H), 7.23 – 7.15 (m, 4H), 7.12 (d, J = 15.8 Hz, 1H), 6.07 (d, J = 15.8 Hz, 1H), 5.29 (s, 1H), 4.93 (d, J = 8.4 Hz, 1H), 4.44 (d, J = 8.4 Hz, 1H), 2.36 (s, 3H), 1.12 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.25, 136.06, 135.68, 133.57, 129.15, 129.80, 128.90, 128.73, 127.15, 125.07 (q, J = 287 Hz), 120.88, 77.54 (q, J = 27 Hz), 57.57, 57.54, 23.08, 21.30. ^{19}F NMR (282 MHz, $CDCl_3$) δ -76.25. HRMS calcd for $C_{22}H_{27}F_3NO_2S^+$ $[M+H]^+$, 426.1709; found 426.1722.



S1a **S1**

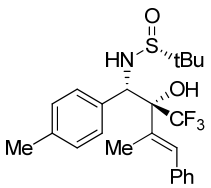
Trifluoromethyl ketone S1. A 10 mL round bottom flask was charged with CsF (36 mg, 0.24 mmol). The flask was placed under vacuum and heated with a heat gun in order to dry the CsF. Upon cooling under vacuum and then N_2, α-methyl-*trans*-cinnamaldehyde (0.70 mL, 5.0 mmol) was added to the flask. Trimethyl(trifluoromethyl)silane (0.77 mL, 5.2 mmol) was added

[5] Prepared as described by C. Zheng, Y. Yan, H. Wang, H. Cui, J. Zhang and G. Zhao, *Adv. Synth Catal.* 2009, **351**, 1685.

dropwise. After stirring for 2h, the reaction mixture was diluted with Et_2O and H_2O. The resulting organic layer was removed, and the aqueous layer extracted twice more with Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated to afford the crude silyl ether.

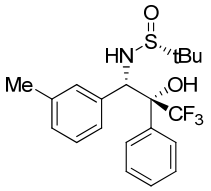
The crude silyl ether was dissolved in THF (15 mL), and aqueous HCl (8.3 mL, 50 mmol, 6.0 M) was added. The reaction mixture was stirred for 1 h. Then the reaction mixture was diluted with Et_2O and H_2O. The resulting organic layer was removed, and the aqueous layer extracted twice more with Et_2O. The combined organic layers were dried over $MgSO_4$, filtered, and concentrated to afford the alcohol **S1a** (0.78 g, 71%) ^{1}H NMR (400 MHz, CDCl3) δ 7.39 – 7.27 (m, 5H), 6.70 (s, 1H), 4.55 (q, J = 7.0 Hz, 1H), 3.79 – 3.66 (m, 1H), 1.98 (s, 3H). Analytical data were consistent with previous literature reports.[6]

Dess-Martin periodinane (2.7 g, 6.4 mmol) was added to a round bottom flask containing a solution of alcohol **S1a** (0.40 g, 2.0 mmol) in DCM (35 mL). The reaction mixture was then stirred at room temperature for 3.5 h. The reaction mixture was then diluted with Et_2O (50 mL) and washed with a solution of Na_2SO_3 (7 g) in sat. $NaHCO_3$ (150 mL), sat. $NaHCO_3$, and then H_2O. The combined aqueous layers were subsequently extracted with Et_2O. Then the combined organic layers were dried over $MgSO_4$, filtered, and concentrated. Purification by flash chromatography (silica gel, 98:2 hexanes/Et_2O) afforded trifluoromethyl ketone **S1** (0.20 g, 49%) as a clear liquid, IR 1693, 1615, 1135, 1024, 688 cm^{-1}. ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.75 (s, 1H), 7.51 – 7.40 (m, 5H), 2.18 (d, J = 0.5 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 182.50 (q, J = 33 Hz), 145.92 (q, J = 3.5 Hz), 134.77, 131.08, 130.45, 130.09, 128.84, 116.99 (q, J = 292 Hz), 13.42. ^{19}F NMR (376 MHz, $CDCl_3$) δ -68.93. GCMS (EI) calcd for $C_{11}H_9F_3O^+$ $[M]^+$, 214.1; found 214.1.

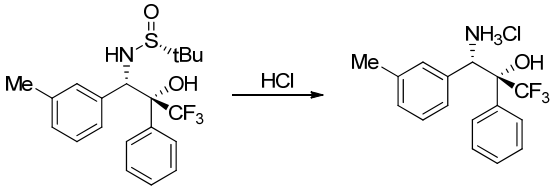


[6] Y. Shen, Y. Zhang and Y. Zhou, *J. Chem. Soc., Perkin Trans. 1.* 1999, 1759.

Amino alcohol 2g. The general procedure was followed with ammonium trifluoroborate **4a** (62.0 mg, 0.200 mmol) and trifluoromethyl ketone **S1** (86.1 mg, 0.402 mmol). Purification by flash chromatography (silica gel, 5% to 10% EtOAc in DCM, product R_f = 0.17 in 5% EtOAc in DCM) afforded product **2g** (44.8 mg, 51%) as a light yellow solid, mp = decomposition >155 °C. IR 3170, 2963, 1162, 1150, 1049 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$) δ 7.39 (d, *J* = 8.1 Hz, 2H), 7.24 (t, *J* = 7.5 Hz, 2H), 7.16 (t, *J* = 7.4 Hz, 1H), 7.10 (d, *J* = 8.0 Hz, 2H), 6.91 (d, *J* = 7.4 Hz, 2H), 6.85 (s, 1H), 5.03 (d, *J* = 4.8 Hz, 1H), 5.02 (s, 1H), 4.15 (d, *J* = 4.8 Hz, 1H), 2.31 (s, 3H), 1.65 (s, 3H), 1.22 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.36, 137.37, 133.18, 132.15, 130.62, 129.60, 129.16, 128.89, 128.11, 126.76, 125.73 (q, *J* = 290 Hz), 79.79 (q, *J* = 25 Hz), 62.21, 56.36, 22.70, 23.31, 14.70. ^{19}F NMR (282 MHz, $CDCl_3$) δ -72.95. HRMS calcd for $C_{23}H_{29}F_3NO_2S^+$ $[M+H]^+$, 440.1866; found 440.1906.

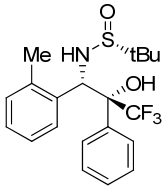


Amino alcohol 2h. The general procedure was followed with ammonium trifluoroborate **4b** (62.0 mg, 0.200 mmol) and 2,2,2-trifluoroacetophenone (56 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 5% to 7.5% EtOAc in DCM, product R_f = 0.28 in 7.5% EtOAc in DCM) afforded product **2h** (50.5 mg, 63%) as a white solid, mp = decomposition >200 °C. IR 3324, 1163, 1030, 715, 699 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$) δ 7.42 (d, *J* = 6.7 Hz, 2H), 7.24 – 7.17 (m, 3H), 7.08 – 6.99 (m, 3H), 6.94 (d, *J* = 7.2 Hz, 1H), 5.47 (s, 1H), 5.23 (d, *J* = 5.1 Hz, 1H), 4.26 (d, *J* = 4.9 Hz, 1H), 2.19 (s, 3H), 1.20 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) 137.70, 135.58, 135.49, 130.75, 128.97, 128.39, 128.01, 127.02, 126.73, 125.71 (q, *J* = 289 Hz), 78.39 (q, *J* = 26 Hz), 62.94, 56.60, 22.80, 21.46. ^{19}F NMR (376 MHz, $CDCl_3$) δ -73.29. HRMS calcd for $C_{20}H_{25}F_3NO_2S^+$ $[M+H]^+$, 400.1553; found 400.1570.

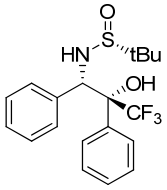


Amine hydrochloride 5 from the deprotection of amino alcohol 2h. A 20 mL scintillation vial was charged with amino alcohol **2h** (60.2 mg, 0.151 mmol), which was then dissolved in MeOH

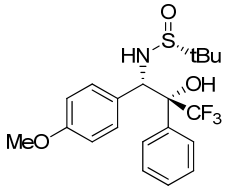
(7.5 mL). The vial was placed in a water bath at rt, and HCl in CPME (0.20 mL, 3.0 M, 0.60 mmol) was added dropwise via syringe. The water bath was removed, and the reaction mixture was stirred for 25h at rt. The vial was again placed in water bath at rt, and HCl in CPME (0.20 mL, 3.0 M, 0.60 mmol) was added dropwise via syringe. The water bath was removed, and the reaction mixture was stirred for an additional 23 h at rt. The reaction mixture was then concentrated. The resulting solid was re-dissolved in MeOH (~0.1 mL), and a minimal amount of DCM, and then Et_2O (~10 mL) was added, leading to precipitation of a white solid. The solid was collected via filtration and washed with Et_2O (3x). A second batch of product could be recovered by concentrating the filtrate, dissolving in a minimal amount of DCM, and precipitating with Et_2O. Together the two batches provided purified amine hydrochloride **5** as a white solid (41.9 mg, 84%), mp = decomposition > 170 ^oC. IR 3263, 2921, 1197, 1157, 713 cm^{-1}. ^1H NMR (400 MHz, DMSO-d_6) δ 8.90 (s, 3H), 7.90 (s, 1H), 7.46 – 7.35 (m, 2H), 7.30 – 7.18 (m, 3H), 7.12 – 6.92 (m, 4H), 5.14 (s, 1H), 2.12 (s, 3H). ^{13}C NMR (151 MHz, DMSO-d_6) δ 136.52, 134.80, 133.36, 130.14, 129.06, 128.57, 127.86, 127.48, 126.70, 126.40, 125.35 (q, J = 289 Hz), 77.68 (q, J = 27 Hz), 56.85, 20.97. ^{19}F NMR (376 MHz, DMSO-d_6) δ -72.38. HRMS calcd for $C_{16}H_{17}F_3NO^+$ $[M\text{-}Cl]^+$, 296.1257; found 296.1269.



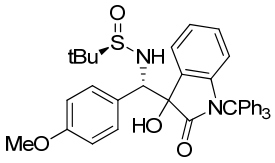
Amino alcohol 2i. The general procedure was followed with ammonium trifluoroborate **4c** (64.7 mg, 96% w/w, 0.200 mmol) and 2,2,2-trifluoroacetophenone (56 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 2.5% EtOAc in DCM, product R_f = 0.25) afforded product **2i** (38.1 mg, 48%) as a white solid, mp = decomposition >140 °C. IR 3317, 1248, 1154, 1044, 940, 706 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$) δ 7.67 (d, J = 7.8 Hz, 1H), 7.45 (d, J = 7.5 Hz, 2H), 7.20 – 7.10 (m, 3H), 7.02 (d, J = 4.1 Hz, 2H), 6.94 – 6.87 (m, 1H), 6.19 (s, 1H), 5.59 (d, J = 2.8 Hz, 1H), 4.42 (s, 1H), 2.38 (s, 3H), 1.22 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 136.56, 136.21, 133.27, 130.58, 130.36, 128.30, 128.19, 128.04, 126.28, 125.91 (q, J = 290 Hz), 125.79, 78.09 (q, J = 25 Hz), 59.17, 55.83, 22.76, 19.61. ^{19}F NMR (376 MHz, $CDCl_3$) δ -74.18. HRMS calcd for $C_{20}H_{25}F_3NO_2S^+$ $[M+H]^+$, 400.1553; found 400.1568.



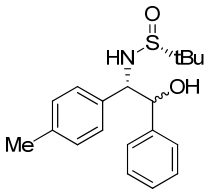
Amino alcohol 2j. The general procedure was followed with ammonium trifluoroborate **4d** (63.4 mg, 0.214 mmol) and 2,2,2-trifluoroacetophenone (56 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 9% EtOAc in DCM, product $R_f = 0.21$) afforded product **2j** (45.6 mg, 55%) as a white solid, mp = decomposition >235 °C. IR 3255, 1165, 1135, 1030, 713 cm^{-1}. ^1H NMR (500 MHz, d_6-DMSO) δ 7.42 – 7.33 (m, 2H), 7.22 – 7.18 (m, 3H), 7.08 – 6.95 (m, 5H), 6.88 (s, 1H), 5.36 (d, J = 11.3 Hz, 1H), 4.98 (d, J = 11.3 Hz, 1H), 1.17 (s, 9H). ^{13}C NMR (126 MHz, DMSO) δ 138.12, 136.69, 129.03, 127.84, 127.67, 126.86, 126.81, 125.85, 79.66 (q, J = 26 Hz), 65.09, 55.86, 22.17 [Note: While peaks corresponding to the CF_3 quartet were observed, overlap with the aryl carbons made precise analysis impossible]. ^{19}F NMR (376 MHz, d_6-DMSO) δ -70.37. HRMS calcd for $C_{19}H_{22}F_3NO_2S^+$ $[M+H]^+$, 386.1397; found 386.1416.



Amino alcohol 2k. The general procedure was followed with potassium trifluoroborate **4e** (69.6 mg, 0.200 mmol) and 2,2,2-trifluoroacetophenone (56 μL, 0.40 mmol). Purification by flash chromatography (silica gel, 10% EtOAc in DCM, product $R_f = 0.20$) afforded product **2k** (44.8 mg, 54%) as an off-white solid, mp = decomposition >165 °C. IR 3331, 2960, 1516, 1257, 1031, 939 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$) δ 7.43 (d, J = 7.0 Hz, 2H), 7.25 – 7.16 (m, 5H), 6.66 (d, J = 8.9 Hz, 2H), 5.61 (s, 1H), 5.25 (d, J = 4.7 Hz, 1H), 4.30 (d, J = 4.5 Hz, 1H), 3.70 (s, 3H), 1.20 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 159.48, 135.91, 131.64, 128.62, 128.37, 127.82, 126.95, 126.00 (q, J = 290 Hz), 113.79, 78.62 (q, J = 26 Hz), 62.91, 56.70, 55.43, 23.07. ^{19}F NMR (376 MHz, $CDCl_3$) δ -73.08. HRMS calcd for $C_{20}H_{26}F_3NO_3S^+$ $[M+H]^+$, 416.1502; found 416.1516.



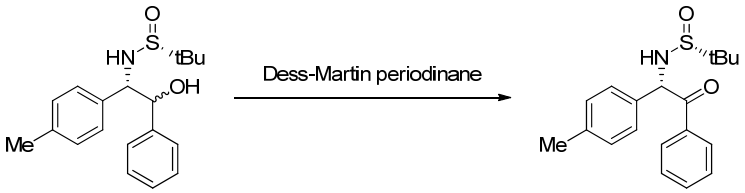
Amino alcohol 6. In a nitrogen-filled glovebox, a 1-dram vial was charged with potassium trifluoroborate **4e** (69.5 mg, 0.200 mmol), 1-tritylisatin[7] (156 mg, 0.40 mmol), and $[Rh(cod)(MeCN)_2]BF_4$ (7.6 mg, 0.020 mmol). DCE (0.92 mL) and then EtOH (0.16 mL) were added to the vial. [Note: Reactions were conducted at 0.19M due to solubility of the isatin.] The vial was capped, removed from the box, and placed in a heating block at 50 ^oC. The reaction mixture was then stirred for 22 h. The reaction mixture was allowed to cool to rt and diluted with EtOAc (15 mL). The organic layer was washed with 50% saturated aqueous NaCl (2 mL), and the aqueous layer was extracted with EtOAc (2 x 3 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash chromatography (silica gel, 3:1 to 1:1 DCM/Et_2O, product R_f = 0.17 in 3:1 DCM/Et_2O) afforded product **6** (63.6 mg, 50%) as an off-white solid, mp = decomposition >125 °C. IR 3017, 1722, 1611, 1215, 743 cm^{-1}. ^1H NMR (500 MHz, $CDCl_3$) δ 7.38 (d, *J* = 6.8 Hz, 1H), 7.20 – 7.10 (m, 9H), 7.08 – 6.99 (m, 8H), 6.96 – 6.91 (m, 1H), 6.86 (td, *J* = 8.0, 1.5 Hz, 1H), 6.83 (d, *J* = 8.8 Hz, 2H), 6.12 (d, *J* = 8.0 Hz, 1H), 4.70 (d, *J* = 5.1 Hz, 1H), 4.33 (d, *J* = 5.0 Hz, 1H), 3.79 (s, 3H), 3.67 (s, 1H), 1.27 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 178.77, 160.25, 143.93, 141.49, 130.29, 129.54, 128.58, 128.36, 127.59, 127.20, 127.07, 124.78, 122.54, 116.62, 113.98, 78.40, 74.88, 65.47, 57.09, 55.37, 23.01. HRMS calcd for $C_{39}H_{39}N_2O_4S^+$ $[M+H]^+$, 631.2625; found 631.2653.



Amino alcohol 7. In a nitrogen filled glovebox, a 1-dram vial was charged with trifluoroborate **4a** (62.0 mg, 0.200 mmol) and $[Rh(cod)(MeCN)_2]BF_4$ (7.6 mg, 0.020 mmol). To the vial was added iPrOH (0.43 mL), benzaldehyde (41 μL, 0.40 mmol), and then H_2O (0.65 mL). The vial was capped, removed from the box, and placed in a heating block at 50 ^oC. The reaction mixture

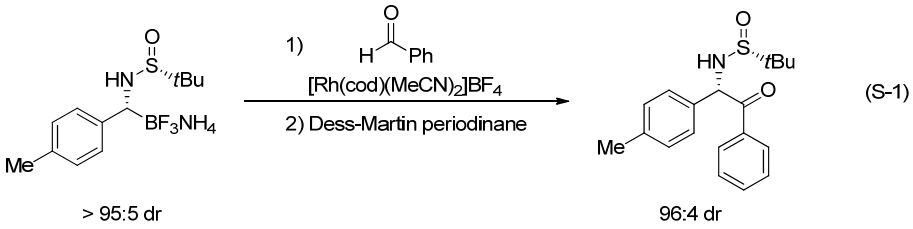
[7] Prepared as described by R. Shintani, K. Takatsu and T. Hayashi, *Chem. Commun.* 2010, **46**, 6822.

was then stirred for 22 h. The reaction mixture was allowed to cool to rt and diluted with EtOAc (6 mL). The organic layer was washed with 50% saturated aqueous NaCl (2 mL), and the aqueous layer was extracted with EtOAc (2 x 3 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by flash chromatography (silica gel, 3:1 MTBE/hexanes, product $R_f = 0.21$) afforded product **7** (41.0 mg, 62%, 1.8:1 dr) as a clear, viscous oil. IR 3348, 2960, 1453, 1217, 1037, 747 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) *Major diastereomer* δ 7.44 – 7.16 (m, 5H), 7.14 – 6.95 (m, 4H), 5.08 – 4.92 (m, 1H), 4.71 (dd, *J* = 6.8, 5.1 Hz, 1H), 3.81 (d, *J* = 6.8 Hz, 1H), 3.27 (d, *J* = 3.8 Hz, 1H), 2.33 (s, 3H), 1.10 (s, 9H); *Minor diastereomer* δ 7.44 – 7.16 (m, 5H), 7.14 – 6.95 (m, 4H), 5.08 – 4.92 (m, 1H), 4.48 (apparent t, *J* = 6.1 Hz, 1H), 4.21 (d, *J* = 6.3 Hz, 1H), 3.65 (d, *J* = 4.6 Hz, 1H), 2.31 (s, 3H), 1.11 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 141.13, 139.64, 137.78, 137.71, 135.86, 135.26, 129.30, 129.26, 128.30, 128.21, 128.02, 127.73, 127.14, 126.73, 66.07, 62.94, 56.83, 56.54, 22.88, 22.65, 21.26, 21.25. HRMS calcd for $C_{19}H_{26}NO_2S^+$ $[M+H]^+$, 332.1679; found 332.1656.



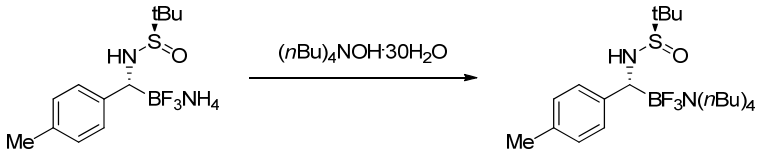
α-Amino ketone S3 via oxidation of amino alcohol 6. This reaction was not performed in dry glassware or under inert atmosphere. To a solution of amino alcohol **6** (21.9 mg, 0.0661 mmol) in CH_2Cl_2 (1.3 mL) was added Dess-Martin periodinane (43.5 mg, 0.103 mmol). The reaction mixture was stirred at room temperature for 1.25 h, and then the reaction was quenched by the addition of sat. aqueous $NaHCO_3$ (2.4 mL) and sat. aqueous$Na_2S_2O_3$ (2.4 mL). After stirring for 15 min, the organic layer was removed, and the aqueous layer was extracted with CH_2Cl_2 (2 x 4 mL). The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. [Note: A 96:4 dr was observed by ^1H NMR of the crude material.] Purification by flash chromatography (silica gel, 10% EtOAc in DCM, product $R_f = 0.22$) afforded product **S3** as a single diastereomer (12.0 mg, 55%) as a white solid, mp = decomposition >90 °C. IR 3280, 1683, 1060, 690 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) δ 8.00 – 7.85 (m, 2H), 7.55 – 7.48 (m, 1H), 7.44 – 7.36 (m, 2H), 7.26 (d, *J* = 8.0 Hz, 2H), 7.12 (d, *J* = 8.0 Hz, 2H), 5.98 (d, *J* = 7.4 Hz, 1H), 4.77 (d, *J* = 7.3 Hz,

1H), 2.27 (s, 3H), 1.21 (s, 9H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 196.54, 138.56, 134.78, 134.34, 133.67, 130.11, 129.06, 128.79, 128.31, 61.27, 56.87, 22.70, 21.29. HRMS calcd for $C_{19}H_{24}NO_2S^+$ $[M+H]^+$, 330.1522; found 330.1545. This experiment established that excellent stereochemical retention is observed for the carbinamine stereocenter and that the poor diastereoselectivity observed in the Rh-catalyzed addition results from poor selectivity in the formation of the carbinol stereocenter (eqn S-1).



(S-1)

IV. Synthesis of Protected α-Amino Trifluoroborates

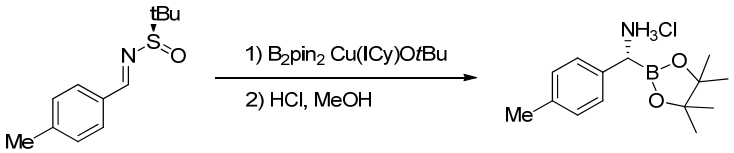


α-Sulfinamidotrifluoroborate 4a'. A 50 mL round bottom flask was charged with $(n\text{Bu})_4\text{OH}\cdot 30\text{H}_2\text{O}$ (645 mg, 0.806 mmol). Water (5.0 mL) was added to the flask, and the aqueous solution was stirred vigorously. Upon dissolution of the salt, the flask was placed in 0 ^{o}C bath. Ammonium trifluoroborate **4a** was added in a single portion. The reaction mixture was stirred for 5 min at 0 ^{o}C, at which time DCM (15 mL) was added. The biphasic reaction mixture was then warmed to room temperature. The organic layer was removed, dried over $MgSO_4$, filtered, and concentrated to afford tetrabutylammonium trifluoroborate **4a'** (392 mg, 87%)[8] as a yellow oil. IR (in CH_2Cl_2) 2963, 2786, 1025, 976, 731 cm^{-1}. ^{1}H NMR (400 MHz, CD_2Cl_2) δ 7.18 (d, J = 8.0 Hz, 2H), 7.01 (d, J = 8.0 Hz, 2H), 4.00 (d, J = 5.6 Hz, 1H), 3.41 (br s, 1H), 3.13 – 2.78 (m, 8H), 2.28 (s, 3H), 1.57 – 1.46 (m, 8H), 1.43 – 1.31 (m, 8H), 1.15 (s, 9H), 0.99 (t, J = 7.3 Hz, 12H). ^{13}C NMR (126 MHz, CD_2Cl_2) δ 145.39, 133.42, 128.26, 127.63, 58.89, 56.13, 24.15, 22.63, 21.13, 20.04, 13.76 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to boron is not visible]. ^{19}F NMR (376 MHz, CD_2Cl_2) δ -148.26. ^{11}B NMR (128

[8] The isolated trifluoroborate contained a small amount of DCM (4% w/w), which did not affect reactivity.

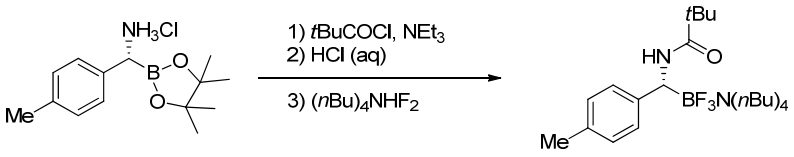
MHz, CD_2Cl_2) δ 3.34. HRMS calcd for $C_{12}H_{19}BF_2NOS^+$ $[M\text{-}nBu_4NF+H]^+$, 274.1243; found 274.1236. LRMS calcd for $C_{13}H_{18}BF_3NOS^-$ $[M\text{-}nBu_4N]^-$, 292.12; found 292.14.

Trifluoroborate 4l. A 250 mL round bottom flask was charged with ammonium trifluoroborate **4a** (202 mg, 0.650 mmol). DCM (33 mL) was added to the flask, and then dry *m*-chloroperoxybenzoic acid (151 mg, 0.726 mmol, 83.4% w/w) was added in a single portion. The reaction mixture was stirred at room temperature for 2 h. The reaction mixture was then concentrated *in vacuo*. Purification by flash chromatography (silica gel, 62:10:1 to 44:10:1 DCM/MeOH/NH_4OH, product R_f = 0.32 in 44:10:1 DCM/MeOH/NH_4OH) afforded ammonium trifluoroborate **4l** (108 mg, 51%) as a white solid, mp = decomposition >100 °C. IR 3271, 1427, 1280, 1117, 1014 cm^{-1}. ^1H NMR (400 MHz, DMSO-d_6) δ 7.11 (s, 4H), 7.05 (d, J = 7.9 Hz, 2H), 6.92 (d, J = 7.9 Hz, 2H), 3.99 (d, J = 5.2 Hz, 1H), 3.23 (br s, 1H), 2.22 (s, 3H), 1.07 (s, 9H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 145.28, 131.81, 127.35, 126.30, 58.39, 24.10, 20.64 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to boron is not visible]. ^{19}F NMR (376 MHz, DMSO-d_6) δ -144.85. ^{11}B NMR (128 MHz, DMSO-d_6) δ 2.84. HRMS calcd for $C_{12}H_{22}BF_2N_2O_2S^+$ $[M\text{-}F]^+$, 307.1458; found 307.1432.



α-Amino pinacol boronate ester hydrochloride S2. In a nitrogen-filled glovebox, a solution of imine **3a** (1.1 g, 5.0 mmol) in toluene (9 mL) were added to a Schlenk tube containing a solution of bis(pinacolato)diboron (2.5 g, 10 mmol) in toluene (8 mL). Cu(ICy)OtBu (180 mg, 0.50 mmol, 10 mol%)[1] in toluene (8 mL) was then added, the tube was sealed, and removed from the glovebox. The Schlenk tube was placed in a 0 °C bath. The reaction mixture was stirred for 45 h at 0 °C, and then at room temperature for 5 h. The reaction mixture was then filtered through a deactivated silica plug (60g, 35% w/w H_2O), eluting with EtOAc (350 mL) to remove a majority of the copper catalyst. The eluent was then concentrated to provide the crude boronate ester.

The crude product was then dissolved in a mixture of dioxane (25 mL) and MeOH (2.0 mL). The reaction mixture was cooled to 0 °C, and HCl (1.3 mL, 5.2 mmol, 4.0 N in dioxane) was added dropwise via syringe pump over 15 min. The reaction mixture was stirred an additional 10 min, and the 0 °C bath was removed. The reaction mixture was stirred for 1.5 h with warming to room temperature. Concentration of the reaction mixture resulted in a white solid, which was triturated with 2:1 hexanes/Et_2O to afford the desired product **S2** (1.2 g) as an off-white solid. While not analytically pure, the compound was sufficiently pure for further elaboration. ^{1}H NMR (400 MHz, 8:1 CD_3OD/D_2O) δ 7.28 (d, J = 7.8 Hz, 2H), 7.22 (d, J = 7.8 Hz, 2H), 3.81 (s, 1H), 2.33 (s, 3H), 1.24 (s, 12H). LRMS calcd for $C_{14}H_{23}BNO_2^+$ $[M\text{-}Cl]^+$, 248.18; found 248.19.

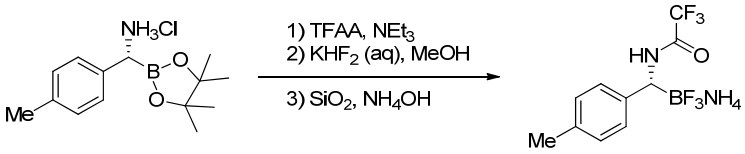


Trifluoroborate 4m. A 50 mL round bottom flask was charged with **S2** (500 mg, 1.76 mmol). DCM (8.8 mL) was added to the flask, and the solution was cooled to 0 °C. NEt_3 (0.98 mL, 7.05 mmol) and then pivaloyl chloride (0.44 mL, 3.53 mmol) were added dropwise. The reaction mixture was stirred at 0 °C for 20 min and then at room temperature for 1.5 h. The reaction mixture was diluted with EtOAc and poured into 1N $NaHSO_4$. The aqueous layer was removed. The remaining organic layer was washed first with 1M $NaHCO_3$ and then brine. The organic layer was dried over Na_2SO_4, filtered, and concentrated to afford the crude boronate ester.

To a 250 mL round bottom flask containing the crude boronate ester was added degassed, aqueous HCl (35 mL, 3 M). The reaction mixture was heated to 100 °C for 1 h. After cooling to room temperature, the aqueous reaction mixture was washed with EtOAc (85 mL). The remaining aqueous layer was concentrated first by rotary evaporation at 40 °C and then under high vacuum overnight to afford the crude boronic acid.

To a 100 mL round bottom flask containing the crude boronic acid in $CHCl_3$ (25 mL) was added H_2O (5.0 mL). Open to air, a solution of tetrabutylammonium bifluoride (1.5 g, 5.28 mmol) in H_2O (7.4 mL) was added dropwise via addition funnel. Upon addition, the flask was capped, and

the reaction mixture was stirred rapidly for 2 h. The organic layer was then removed, and the aqueous layer extracted with $CHCl_3$ (3 × 10 mL). The combined organic layers were washed with H_2O (3 × 20 mL) and brine (2 × 15 mL). The organic layer was then dried over $MgSO_4$, filtered, and concentrated to afford tetrabutylammonium trifluoroborate **4m** (388 mg, 43%) as a white solid, mp = decomposition >110 °C. IR 2961, 2874, 1651, 1510, 1165, 1038, 978. ^{1}H NMR (400 MHz, CD_2Cl_2) δ 7.01 (d, *J* = 8.1 Hz, 2H), 6.97 (d, *J* = 8.1 Hz, 2H), 6.35 (d, *J* = 6.3 Hz, 1H), 3.76 (br s, 1H), 3.05 – 2.88 (m, 8H), 2.26 (s, 3H), 1.58 – 1.44 (m, 8H), 1.41 – 1.29 (m, 8H), 1.17 (s, 9H), 0.99 (t, *J* = 7.3 Hz, 12H). ^{13}C NMR (126 MHz, CD_2Cl_2) δ 178.16, 145.37, 132.80, 128.27, 126.16, 58.82, 38.70, 28.00, 24.15, 21.05, 20.05, 13.77 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to boron is not visible]. ^{19}F NMR (376 MHz, CD_2Cl_2) δ -148.56. ^{11}B NMR (128 MHz, CD_2Cl_2) δ 3.37. HRMS calcd for $C_{13}H_{18}BFNO^+$ $[M\text{-}nBu_4NF_2]^+$, 234.1460; found 234.1454. LRMS calcd for $C_{13}H_{18}BF_3NO^-$ $[M\text{-}nBu_4N]^-$, 272.14; found 272.13.

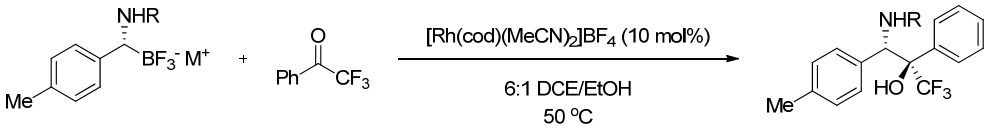


Trifluoroborate 4n. A 20 mL scintillation was charged with **S2** (0.28 g, 1.0 mmol). DCM (5 mL) was added to the flask, and the reaction mixture was cooled to 0 °C. NEt_3 (0.60 mL, 4.3 mmol) and then trifluoroacetic anhydride (0.28 mL, 2.0 mmol) were added dropwise. The reaction mixture was stirred at 0 °C for 20 min and then at room temperature for 1.5 h. The reaction mixture was diluted with EtOAc and poured into 1N $NaHSO_4$. The aqueous layer was removed. The remaining organic layer was washed first with 1M $NaHCO_3$ and then brine. The organic layer was dried over Na_2SO_4, filtered, and concentrated to afford the crude boronate ester.

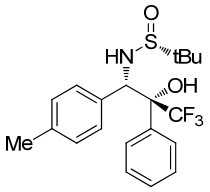
The crude boronate ester was dissolved in MeOH (3.3 mL), and reaction mixture was cooled to 0 °C. A concentrated solution of KHF_2 (1.4 mL, 6.2 mmol, ~4.5M) was added dropwise. The reaction flask was removed from the bath and allowed to warm to room temperature. The reaction mixture was stirred for 3 h at room temperature. Subsequently, the reaction mixture was concentrated by rotary evaporation and then high vacuum overnight. The resulting tan solid was

triturated with acetone (~80 mL) to remove inorganic salts, and the filtrate was concentrated by rotary evaporation. Purification by flash chromatography (silica gel, 44:10:1 DCM/MeOH/NH_4OH, product R_f = 0.26) afforded ammonium trifluoroborate **4n** (91 mg, 30%) as a white solid, mp = 148-151 °C. IR 3291, 1668, 1420, 1158, 998, 970. ^{1}H NMR (400 MHz, DMSO-d_6) δ 8.21 (d, *J* = 7.8 Hz, 1H), 7.08 (s, 4H), 7.01 (d, *J* = 8.0 Hz, 2H), 6.95 (d, *J* = 8.0 Hz, 2H), 3.85 (br s, 1H), 2.22 (s, 3H). ^{13}C NMR (101 MHz, DMSO-d_6) δ 156.02 (q, *J* = 35 Hz), 142.21, 132.62 127.78, 126.20, 116.46 (q, *J* = 289 Hz), 20.64 [Note: As with other trifluoroborates reported in the literature,[2] the carbon attached to boron is not visible]. ^{19}F NMR (376 MHz, DMSO-d_6) δ -73.93 (s, 3F), -144.47 (br s, 3F). ^{11}B NMR (128 MHz, DMSO-d_6) δ 2.85. HRMS calcd for $C_{10}H_9BF_5NONa^+$ $[M\text{-}NH_4F+Na]^+$, 288.0590; found 288.0629. LRMS calcd for $C_{10}H_9BF_6NO^-$ $[M\text{-}NH_4]^-$, 284.07; found 284.10.

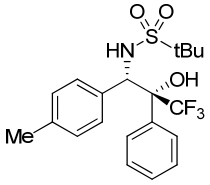
V. Additions of Protected α-Amino Trifluoroborates



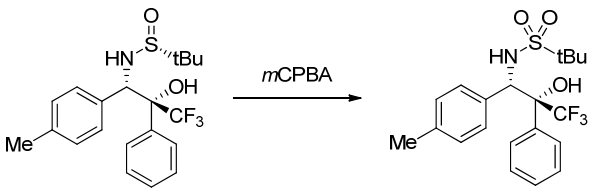
General procedure for the addition of protected α-aminotrifluoroborates to 2,2,2-trifluoroacetophenone. In a nitrogen filled glovebox, a 1-dram vial was charged with trifluoroborate **4** (0.200–0.214 mmol) and $[Rh(cod)(MeCN)_2]BF_4$ (7.5–7.8 mg, 0.020–0.021 mmol).[4] 2,2,2-Trifluoroacetophenone (56 μL, 0.40 mmol) in DCE (0.23 mL) and then EtOH (0.040 mL) were added to the vial. The vial was capped, removed from the box, and placed in a heating block at 50 °C. The reaction mixture was then stirred for 22-24 h. The reaction mixture was allowed to cool to rt and diluted with EtOAc (6 mL). The organic layer was washed with 50% saturated aqueous NaCl (2 mL), and the aqueous layer was extracted with EtOAc (2 x 3 mL). The combined organic layers were dried over Na_2SO_4 or $MgSO_4$, filtered, and concentrated under reduced pressure. The products were isolated by silica gel chromatography.



Amino alcohol 2a from tetrabutylammonium trifluoroborate 4a'. The general procedure was followed with tetrabutylammonium trifluoroborate **4a'** (111 mg, 0.208 mmol). Purification by flash chromatography (silica gel, 9% ethyl acetate in DCM, product $R_f = 0.31$ in 10% ethyl acetate in DCM) afforded product **2a** (47.7 mg, 57%) as an off-white solid. Analytical data were consistent with the product produced in the reaction of the ammonium trifluoroborate **4a** with 2,2,2-trifluoroacetophenone. This result demonstrated that comparable yields were achieved whether employing the ammonium or tetrabutylammonium trifluoroborate starting materials.

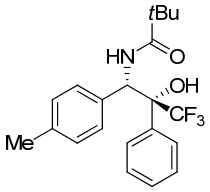


Amino alcohol 2l. The general procedure was followed with ammonium trifluoroborate **4l** (64.4 mg, 0.200 mmol). Purification by flash chromatography (silica gel, 5% ethyl acetate in DCM, product $R_f = 0.31$) afforded product **2l** (59.9 mg, 73%, 97:3 er) as a white solid, mp = decomposition >65 °C. HPLC (AS-H, hexanes/*i*PrOH; 95:5 for 5 min, 95:5 to 70:30 over 20 min, 70:30 for 5 min; 1.0 mL/min; $\lambda = 250$ nm): $t_{major} = 13.1$ min, $t_{minor} = 14.5$ min. IR 3396, 1308, 1131, 1161 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.27 (m, 5H), 6.98 (d, $J = 8.0$ Hz, 2H), 6.74 (d, $J = 8.0$ Hz, 2H), 5.01 (d, $J = 10.2$ Hz, 1H), 4.75 (d, $J = 10.2$ Hz, 1H), 3.72 (s, 1H), 2.28 (s, 3H), 1.21 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.18, 134.22, 133.27, 129.11, 128.79, 128.63, 128.31, 126.95, 125.34 (q, $J = 288$ Hz), 79.91 (q, $J = 27$ Hz), 62.41, 60.45, 24.13, 21.23. ^{19}F NMR (376 MHz, $CDCl_3$) δ -73.14. HRMS calcd for $C_{20}H_{24}F_3NO_3SNa^+$ $[M+Na]^+$, 438.1321; found 438.1281.

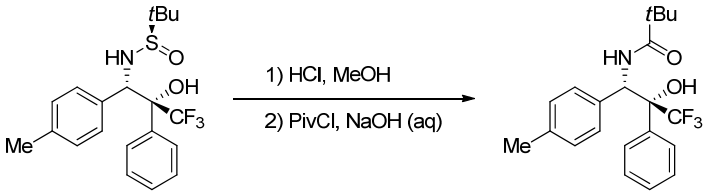


Oxidation of amino alcohol 2a to amino alcohol 2l. A 1-dram vial was charged with amino alcohol **2a** (8.4 mg, 0.021 mmol). DCM (0.5 mL) was added, and the vial was placed in a 0 ^{o}C bath. Dry *m*-chloroperoxybenzoic acid (6.5 mg, 0.031 mmol, 83.4% w/w) was then added in a single portion. The reaction mixture was stirred at 0 ^{o}C for 2 h before quenching with a 1:1 mixture of sat. $NaHCO_3$ and sat. $NaHSO_3$. The organic layer was removed, and the aqueous layer was extracted twice more with DCM. The combined organic layers were passed through a plug of Na_2SO_4 and concentrated. Purification by flash chromatography (silica gel, 5% ethyl acetate in DCM, product $R_f = 0.31$) afforded amino alcohol **2l** (7.5mg, 94% w/w) as a clear oil. The remaining *m*-chlorobenzoic acid was removed by dissolution of the product in DCM and washing with sat. $NaHCO_3$ (3x) to afford pure amino alcohol **2l** (7.1 mg, 82%, >99:1 er) as a white film. Analytical data were consistent with the product produced in the Rh-catalyzed addition of the ammonium trifluoroborate **4l** to 2,2,2-trifluoroacetophenone. HPLC (AS-H, hexanes/*i*PrOH; 95:5 for 5 min, 95:5 to 70:30 over 20 min, 70:30 for 5 min; 1.0 mL/min; $\lambda = 250$ nm): $t_{major} = 12.7$ min.

As determined by NMR, the same diastereomer of **2l** is obtained in the Rh-catalyzed addition of trifluoroborate **4l** to 2,2,2-trifluoroacetophenone and in the oxidation of **2a**. In addition, chiral HPLC demonstrated that the same enantiomer of **2l** is produced in both cases (See Section VIII, pg. S-28). Together, these results rigorously demonstrate that the same relative and absolute configuration is observed for the carbinamine and tertiary alcohol stereocenters of the *N*-*tert*-butanesulfinyl and *N*-Bus amino alcohol products **2a** and **2l**, respectively.



Amino alcohol 2m. The general procedure was followed with tetrabutylammonium trifluoroborate **4m** (104 mg, 0.202 mmol). Purification by flash chromatography (silica gel, 0% to 2% EtOAc in DCM, product R_f = 0.30 in 2% EtOAc in DCM) afforded product **2m** (66.7 mg, 87%, 90:10 dr, 96:4 er [major diastereomer]) as a white solid, mp = decomposition >200 °C. HPLC (AD-H, hexanes/*i*PrOH; 95:5 for 5 min, 95:5 to 70:30 over 20 min, 70:30 for 5 min; 1.0 mL/min; λ = 250 nm): t_{major} = 16.2 min, t_{minor} = 17.0 min. IR 3422, 1630, 1528, 1154 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) δ 7.43 – 7.24 (m, 5H), 6.92 (d, *J* = 8.0 Hz, 2H), 6.81 (d, *J* = 8.0 Hz, 2H), 6.54 (d, *J* = 8.0 Hz, 1H), 5.60 (d, *J* = 8.0 Hz, 1H), 4.73 (br s, 1H), 2.23 (s, 3H), 1.21 (s, 9H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 179.33, 137.87, 135.65, 133.32, 128.87, 128.79, 128.52, 128.18, 126.56 (apparent d, *J* = 1.5 Hz), 125.54, (q, *J* = 289 Hz), 80.64 (q, *J* = 27 Hz), 58.17, 39.01, 27.48, 21.17. ^{19}F NMR (376 MHz, $CDCl_3$) *Major diastereomer* δ -73.19; *Minor diastereomer* δ -73.50. HRMS calcd for $C_{21}H_{25}F_3NO_2^+$ $[M+H]^+$, 380.1832; found 380.1829.

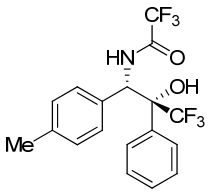


Conversion of amino alcohol 2a to amino alcohol 2m. A 1-dram vial was charged with amino alcohol **2a** (21 mg, 0.053 mmol), and MeOH (1.3 mL) was added. The vial was placed in a water bath at rt, and HCl in dioxane (0.10 mL, 4.0 M, 0.40 mmol) was added dropwise via syringe. The water bath was removed, and the reaction mixture was stirred for 15 h at rt. The reaction mixture was diluted with DCM, and washed with 1M NaOH (aq). The organic layer was removed, and the aqueous layer was extracted twice more with DCM. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated to afford the crude deprotected amino alcohol.

In a round bottom flask, the crude amino alcohol was dissolved in DCM (0.3 mL). To the solution was added aq. NaOH (40 μL, 0.11 mmol, 3.0 M). The flask was placed in a water bath

at rt, and pivaloyl chloride (7 μL, 0.058 mmol) was added, resulting in formation of a white solid. The flask was removed from the water bath, and additional DCM (0.5 mL) was added to improve solubility. The reaction mixture was diluted with DCM, and washed with sat. $NaHCO_3$. The organic layer was removed, and the aqueous layer was extracted twice more with DCM. The combined organic layers were dried over Na_2SO_4, filtered, and concentrated. Purification by flash chromatography (silica gel, 2% EtOAc in DCM) afforded product **2m** (16 mg, 84%, >99:1 er) as a white solid. Analytical data were consistent with the product produced in the Rh-catalyzed addition of the ammonium trifluoroborate **4m** to 2,2,2-trifluoroacetophenone. HPLC (AD-H, hexanes/*i*PrOH; 95:5 for 5 min, 95:5 to 70:30 over 20 min, 70:30 for 5 min; 1.0 mL/min; λ = 250 nm): t_{major} = 16.1 min.

As determined by NMR, the same diastereomer of **2m** is obtained in the Rh-catalyzed addition of *N*-pivaloyl trifluoroborate **4m** to 2,2,2-trifluoroacetophenone and in the deprotection and subsequent pivaloylation of **2a**. In addition, chiral HPLC demonstrated that the same enantiomer of **2m** is produced in both cases (See Section VIII, pg. S-28). Together, these results rigorously demonstrate that the same relative and absolute configuration is observed for the carbinamine and tertiary alcohol stereocenters of the *N*-*tert*-butanesulfinyl and *N*-pivaloyl amino alcohol products **2a** and **2m**, respectively.

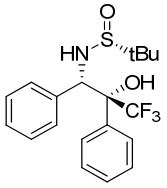


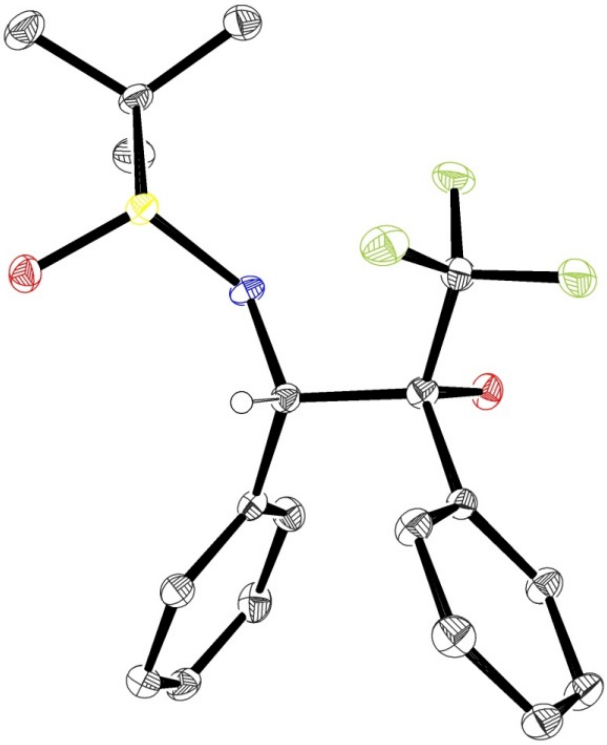
Amino alcohol 2n. The general procedure was followed with ammonium trifluoroborate **4n** (61.4 mg, 0.203 mmol). Purification by two sequential flash chromatography steps (*first:* silica gel, DCM, product R_f = 0.30; *second:* silica gel, 2:1 to 4:1 DCM/hexanes, product R_f = 0.18 in 2:1 DCM/hexanes) afforded product **2n** (32.8 mg, 41%, 88:12 er) as a white solid, mp = 144-147 °C. HPLC (AD-H, hexanes/*i*PrOH; 95:5 for 5 min, 95:5 to 70:30 over 20 min, 70:30 for 5 min; 1.0 mL/min; λ = 254 nm): t_{major} = 12.2 min, t_{minor} = 13.0 min. IR 3380, 1696, 1559, 1212, 1175, 1158 cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) δ 7.34 (d, *J* = 9.0 Hz, 1H), 7.21 – 7.06 (m, 5H), 6.74 (apparent s, 4H), 5.54 (d, *J* = 9.1 Hz, 1H), 3.22 (s, 1H), 2.04 (s, 3H). ^{13}C NMR (101 MHz,

$CDCl_3$) δ 156.45 (q, *J* = 38 Hz), 138.38, 134.89, 131.63, 129.19, 129.04, 128.60, 128.42, 125.66 (q, *J* = 1.6 Hz), 125.16 (q, *J* = 289 Hz), 115.90 (q, *J* = 289 Hz), 79.84 (q, *J* = 27 Hz), 56.84, 21.16. ^{19}F NMR (376 MHz, $CDCl_3$) δ -73.83 (s, 3F), -76.02 (s, 3F). HRMS calcd for $C_{18}H_{15}F_6NO_2Na^+$ $[M+Na]^+$, 414.0899; found 414.0867.

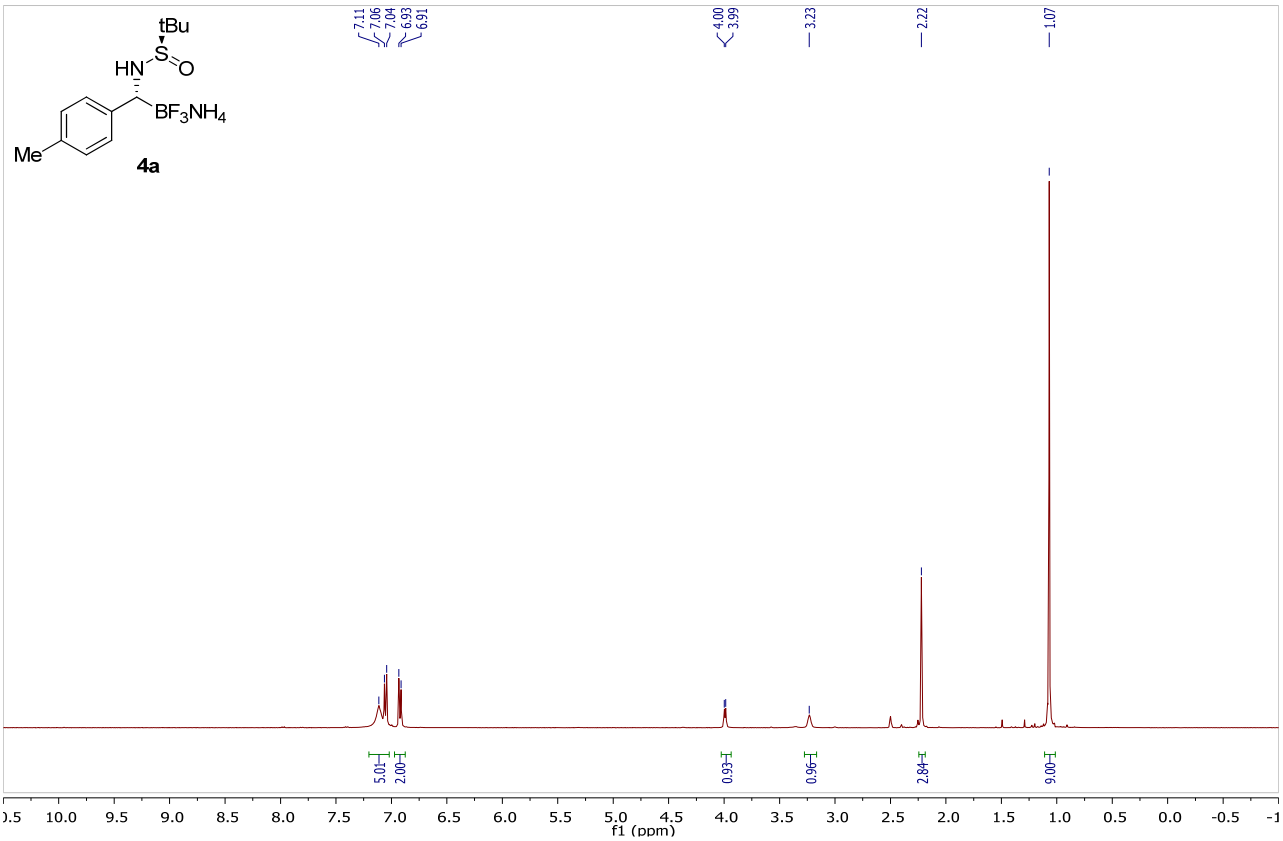
VI. Crystal structure

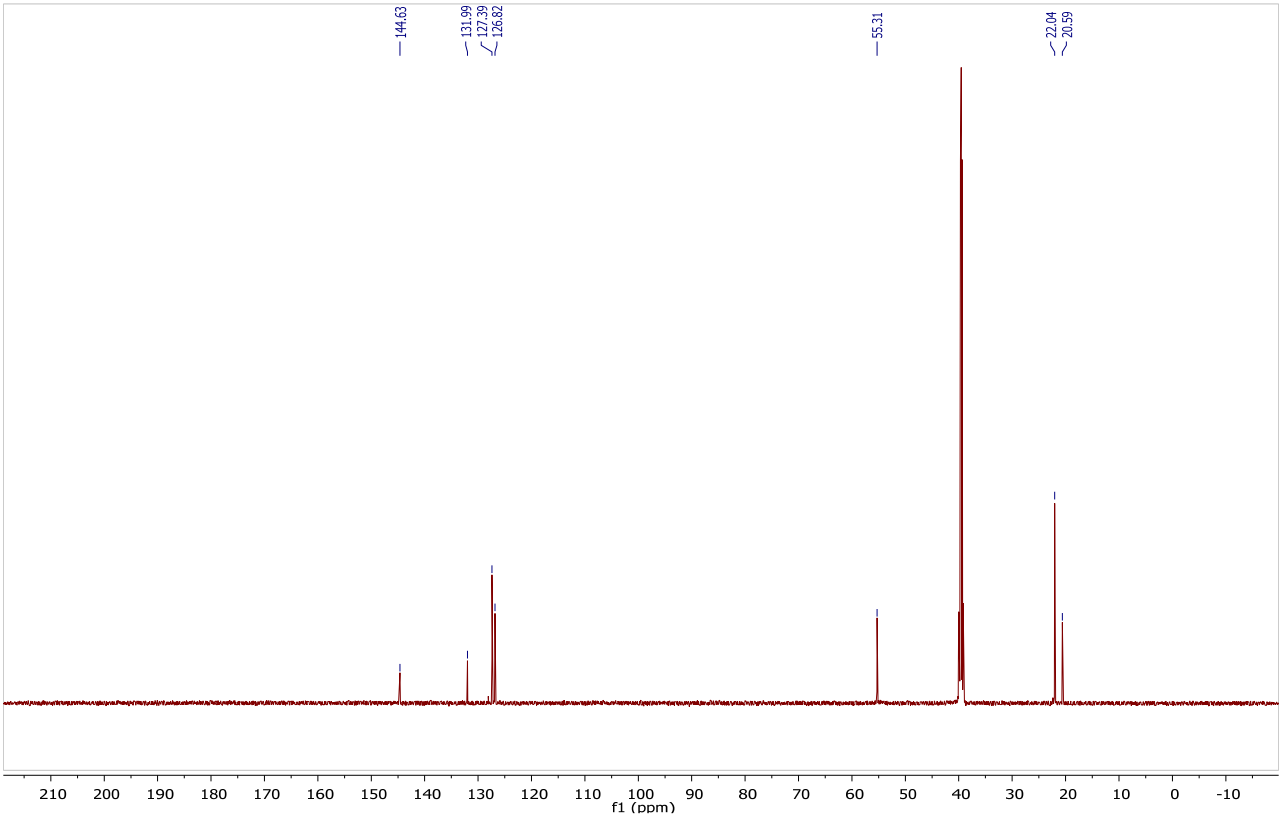
ORTEP Diagram of Amino Alcohol **2j**

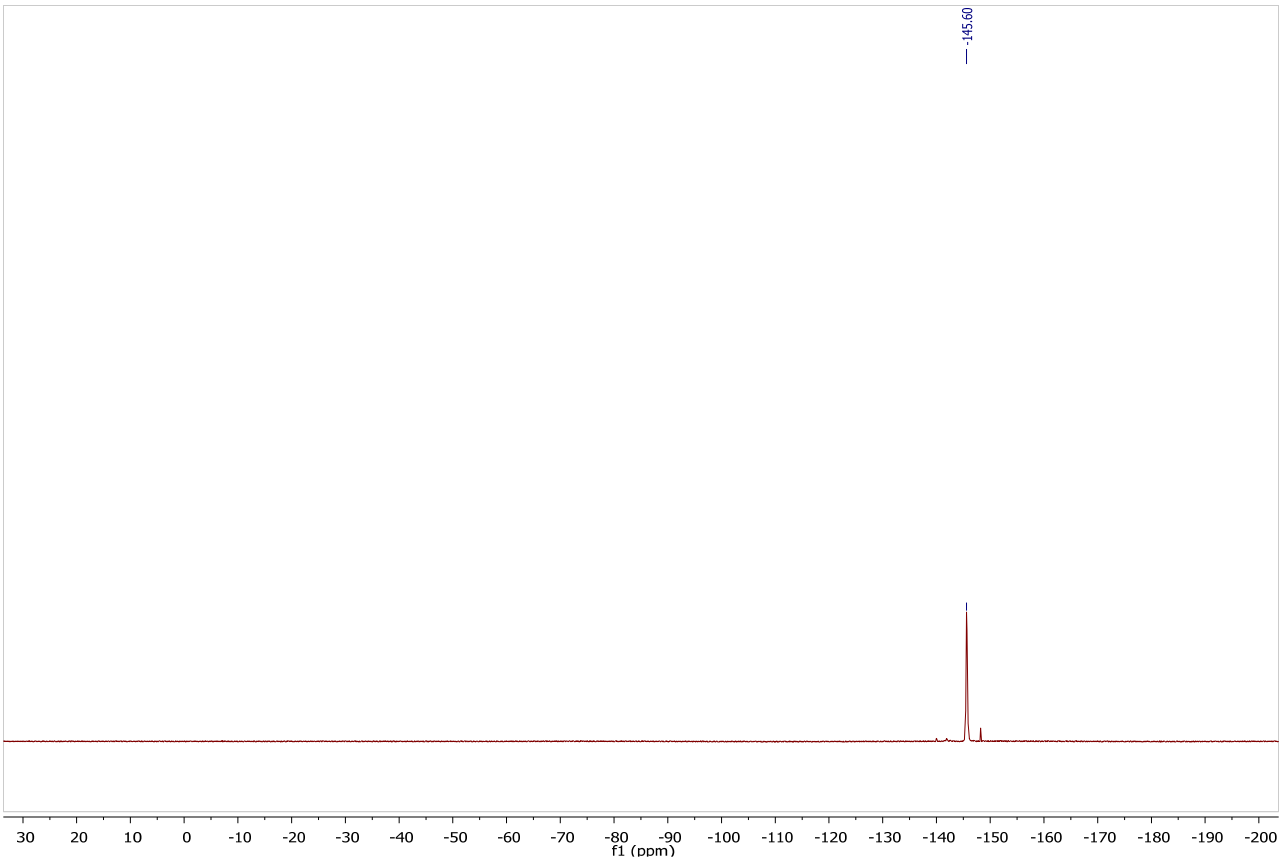


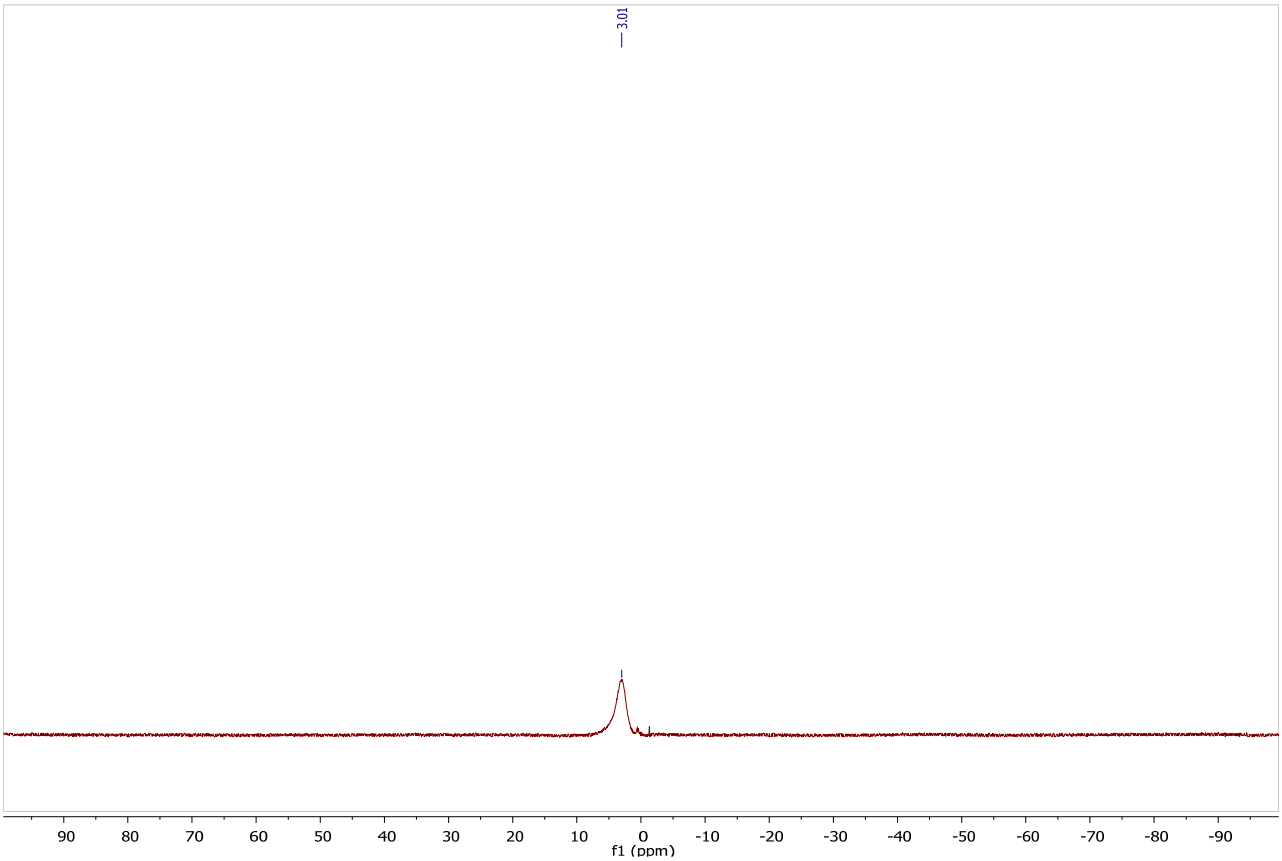


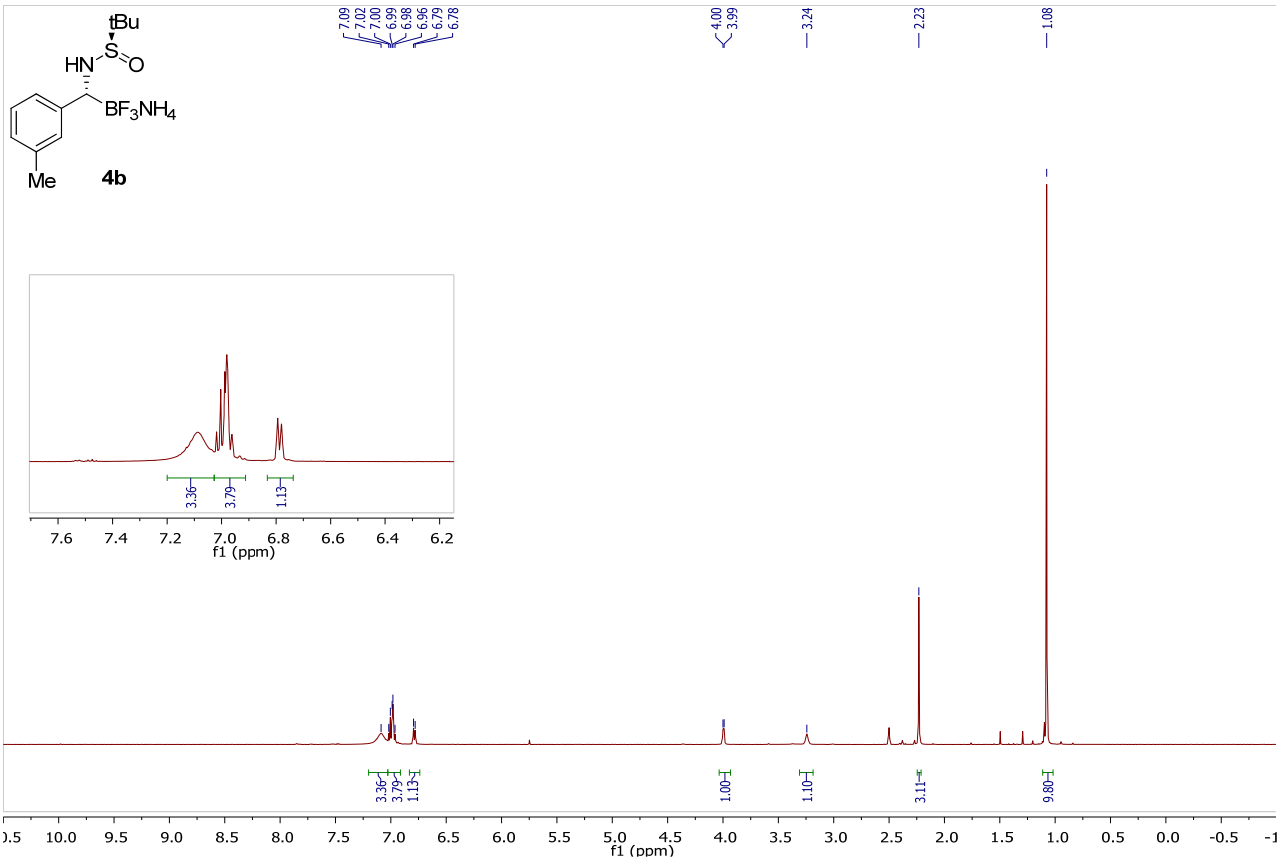
VII. NMR data

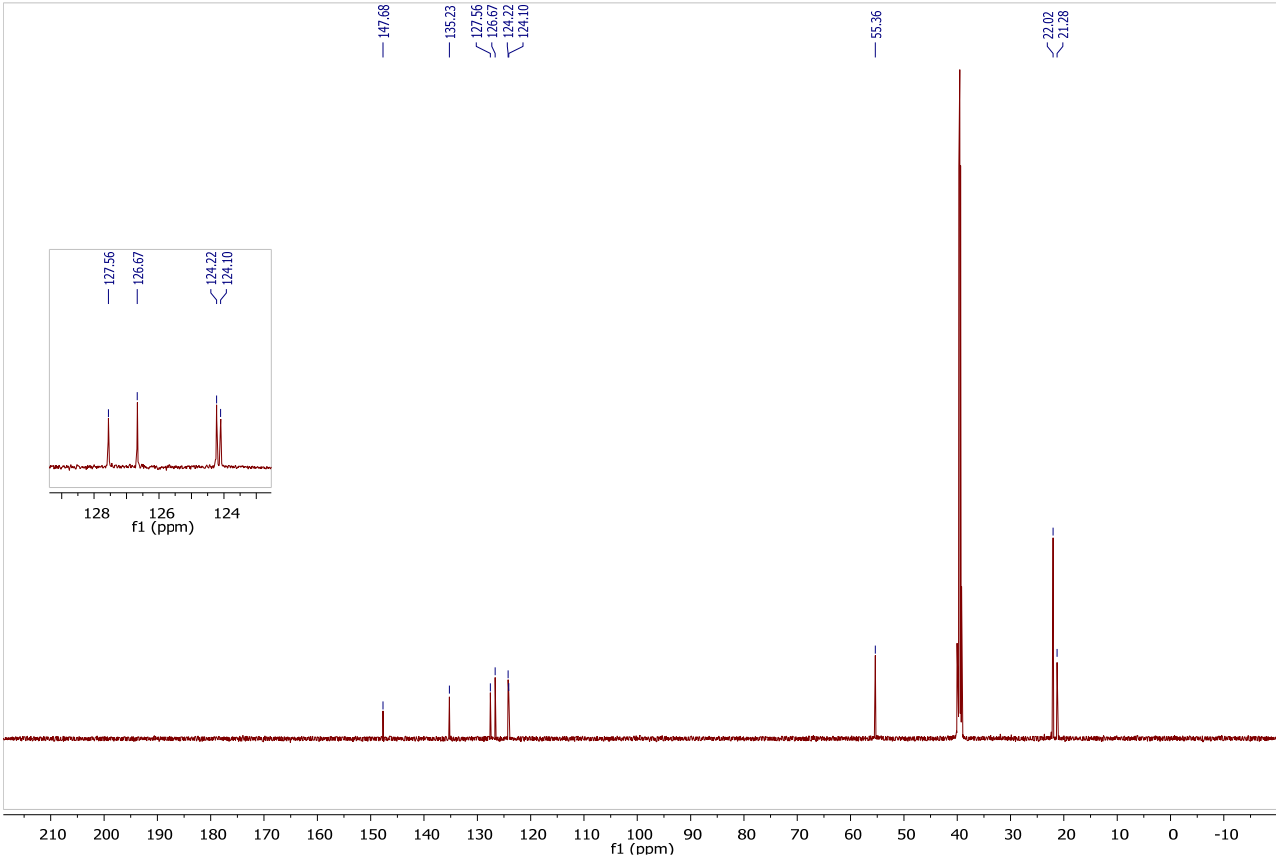

tBu
HN
S
O
BF3NH4
Me
4a
7.11
7.06
7.04
6.93
6.91
4.00
3.99
3.23
2.22
1.07
5.01
2.00
0.93
0.96
2.84
9.00
f1 (ppm)


144.63
131.99
127.39
126.82
55.31
22.04
20.59
f1 (ppm)


-145.60
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


3.01
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)


tBu
HN
S
O
BF3NH4
Me
4b
7.09
7.02
7.00
6.99
6.98
6.96
6.79
6.78
4.00
3.99
3.24
2.23
1.08
3.36
3.79
1.13
1.00
1.10
3.11
9.80
f1 (ppm)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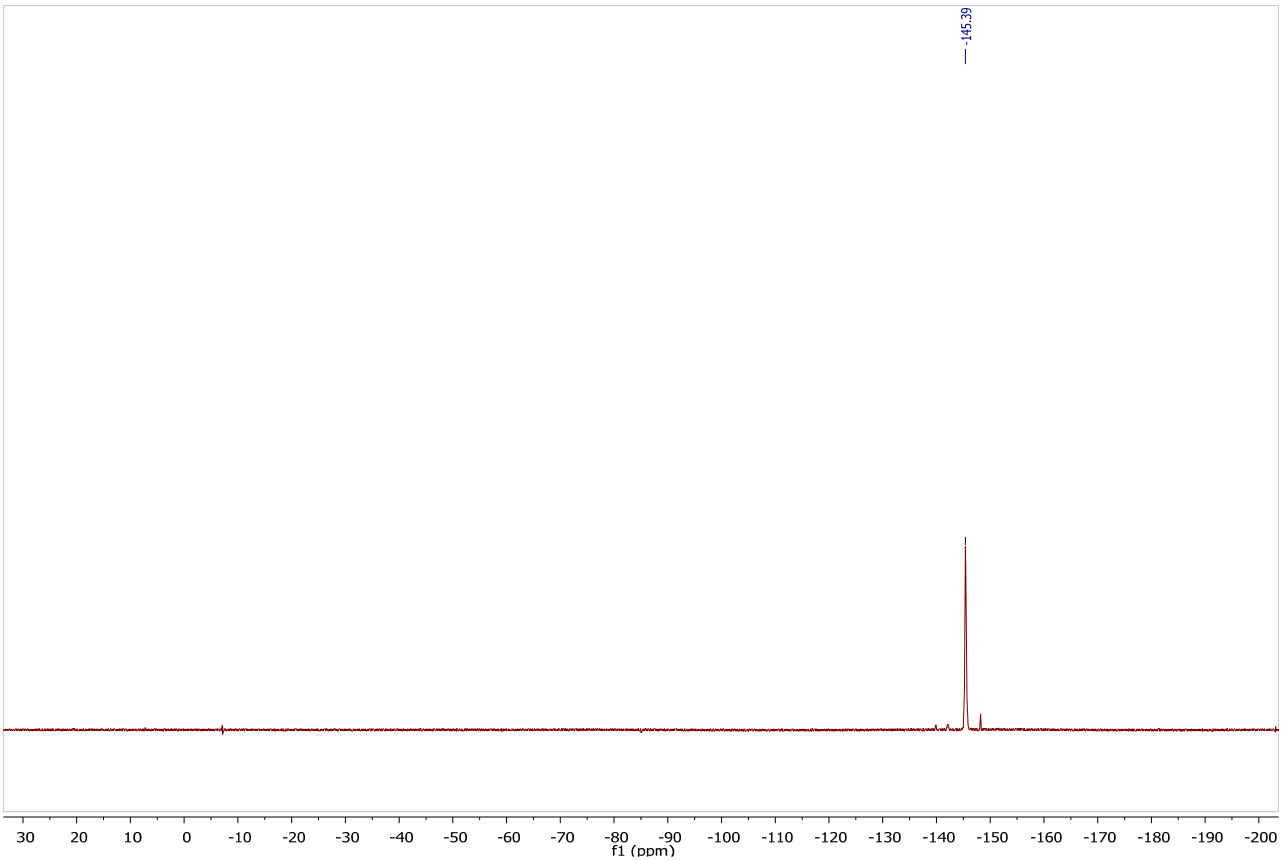
135.23
127.56
126.67
124.22
124.10
55.36
22.02
21.28
f1 (ppm)


-145.39
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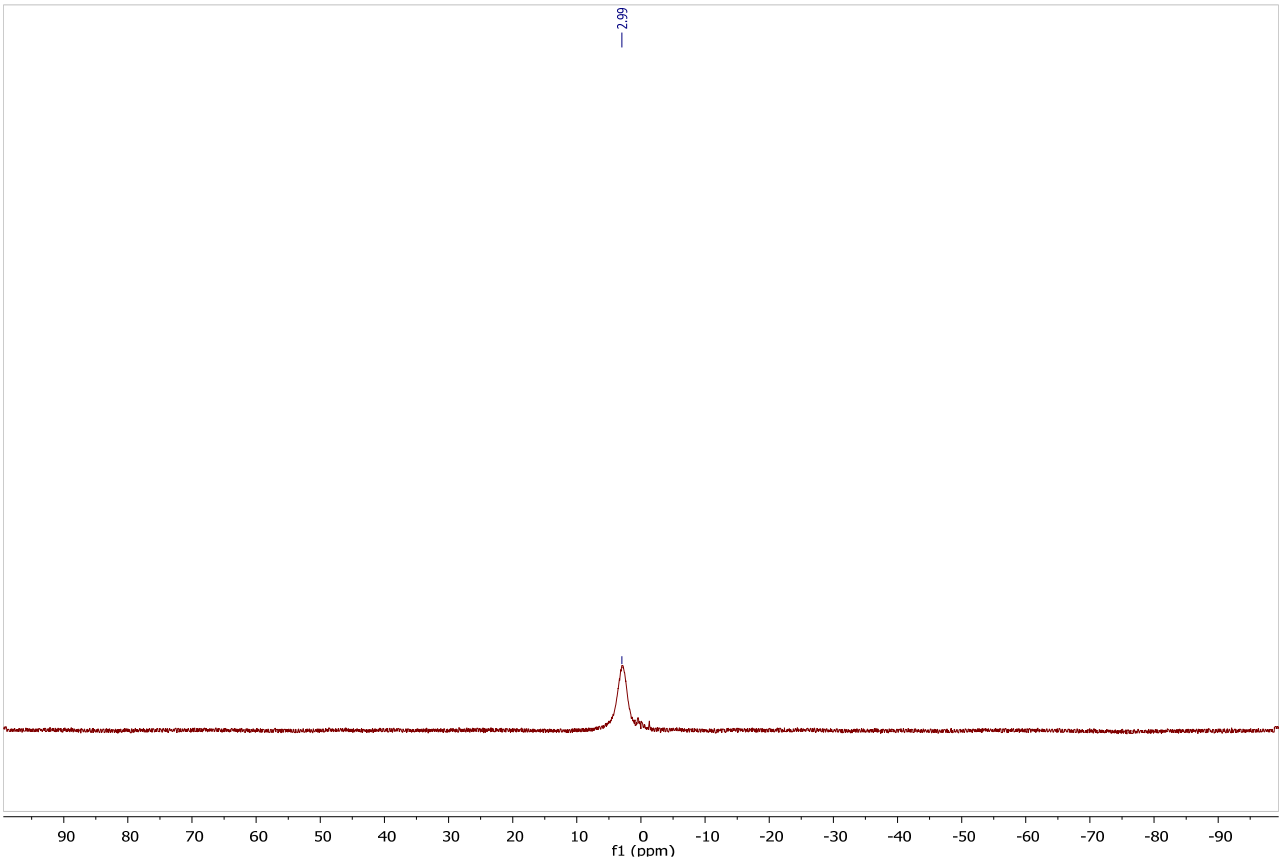
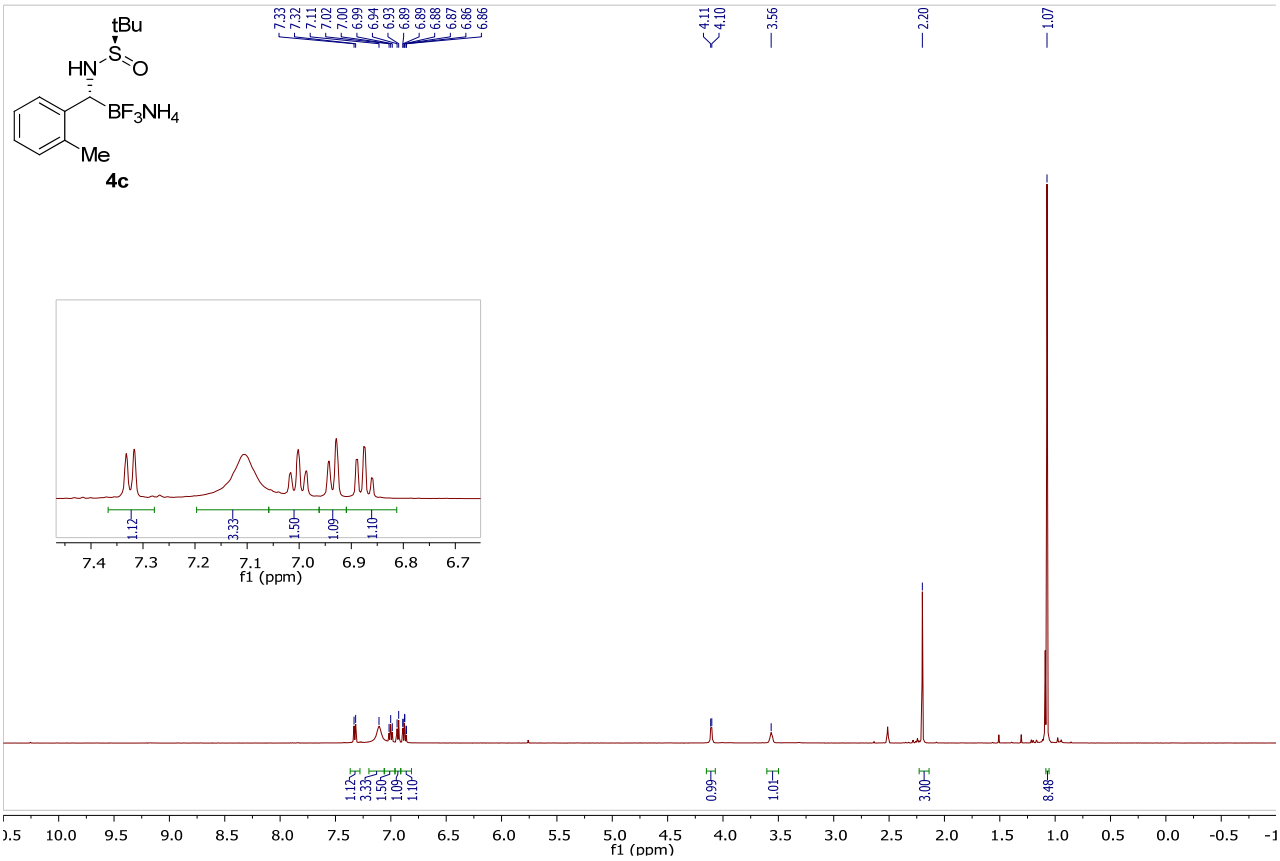
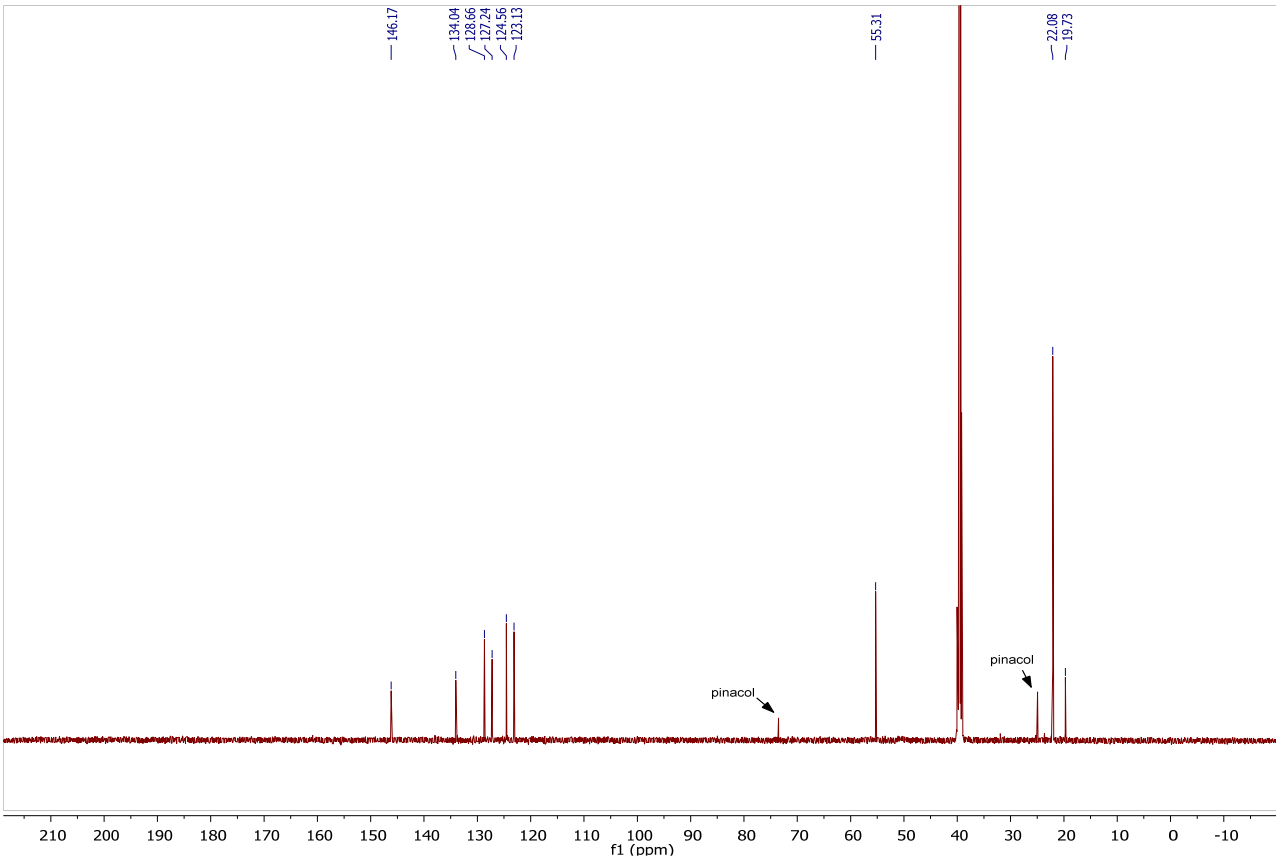
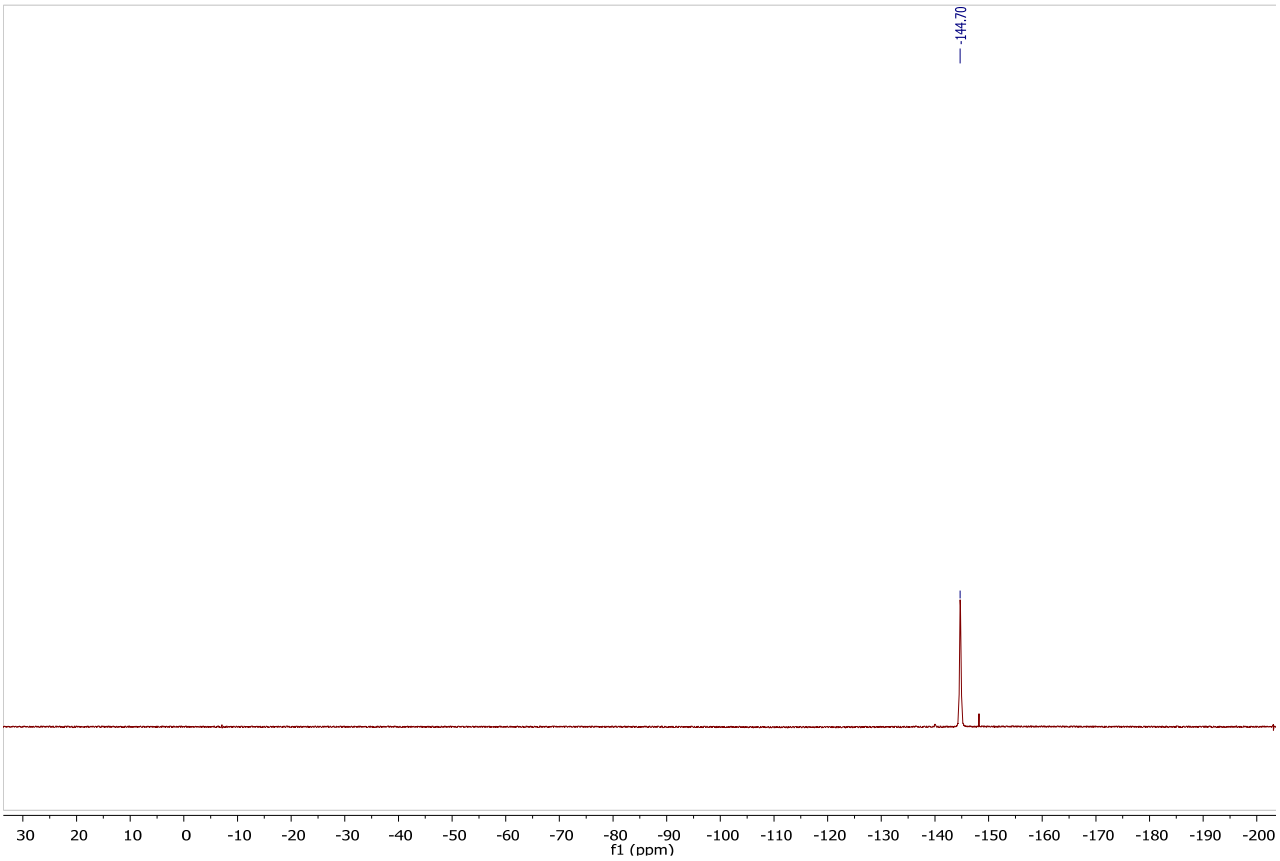
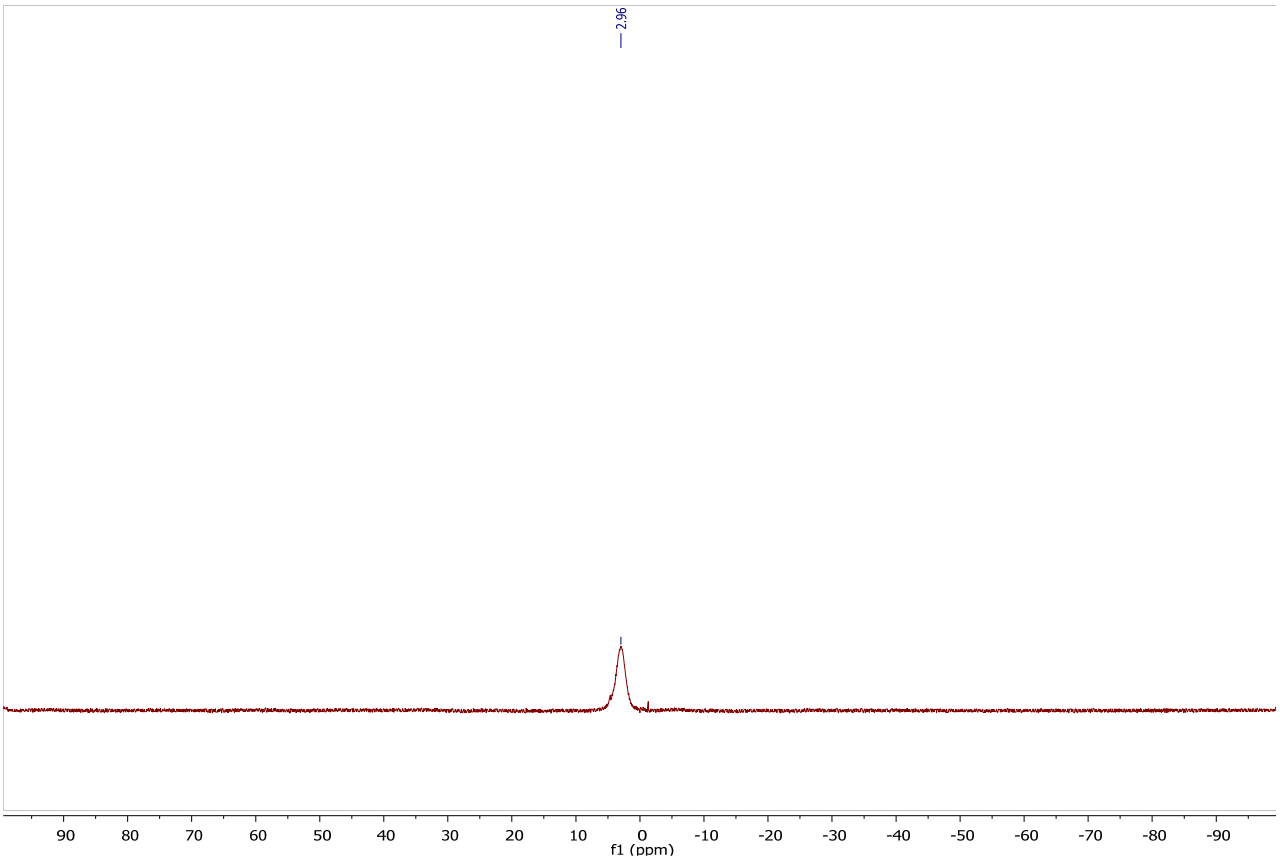
f1 (ppm)


2.99
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)


tBu
HN
S
O
BF3NH4
Me
4c
7.33
7.32
7.11
7.02
7.00
6.99
6.94
6.93
6.89
6.89
6.88
6.87
6.86
6.86
4.11
4.10
3.56
2.20
1.07
1.12
3.33
1.50
1.09
1.10
0.99
1.01
3.00
8.48
f1 (ppm)


146.17
134.04
128.66
127.24
124.56
123.13
55.31
22.08
19.73
pinacol
pinacol
f1 (ppm)


-144.70
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


2.96
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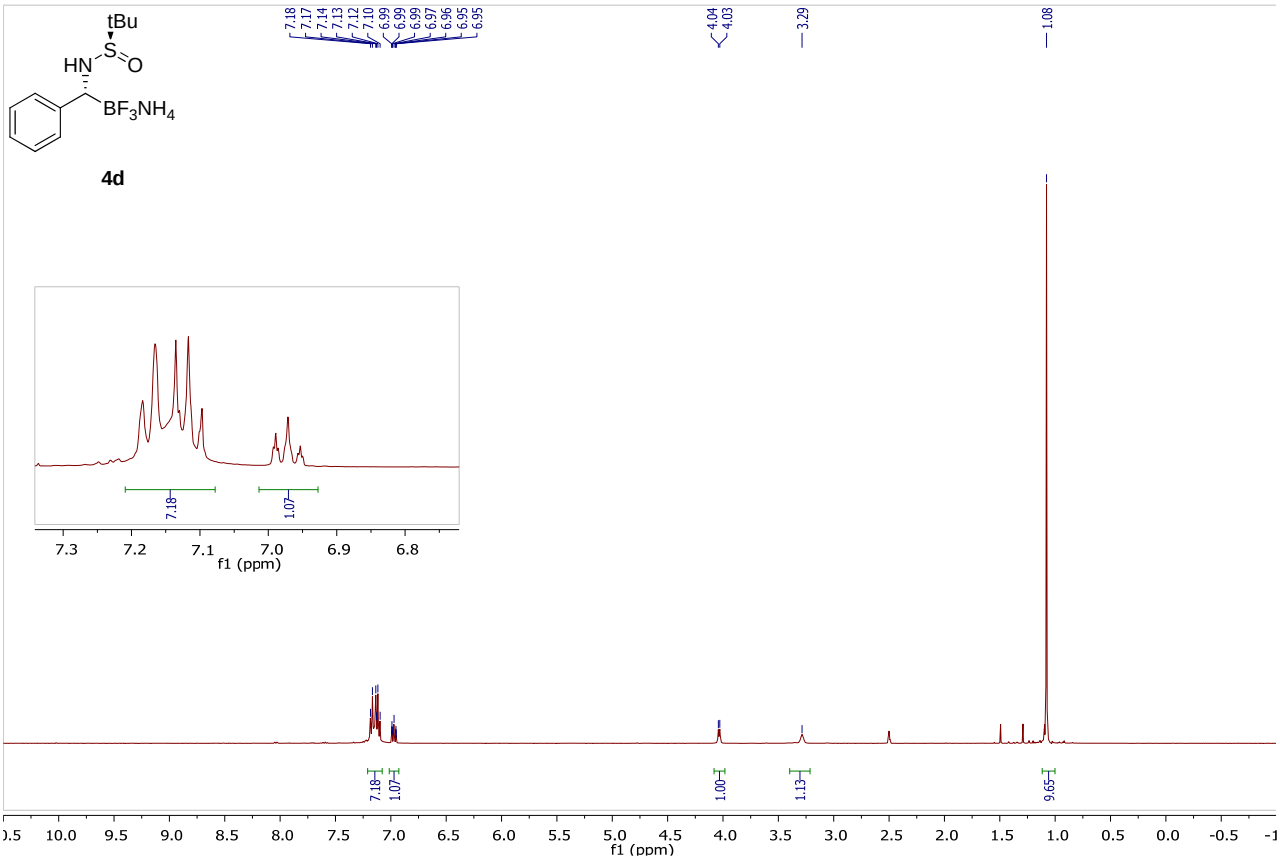
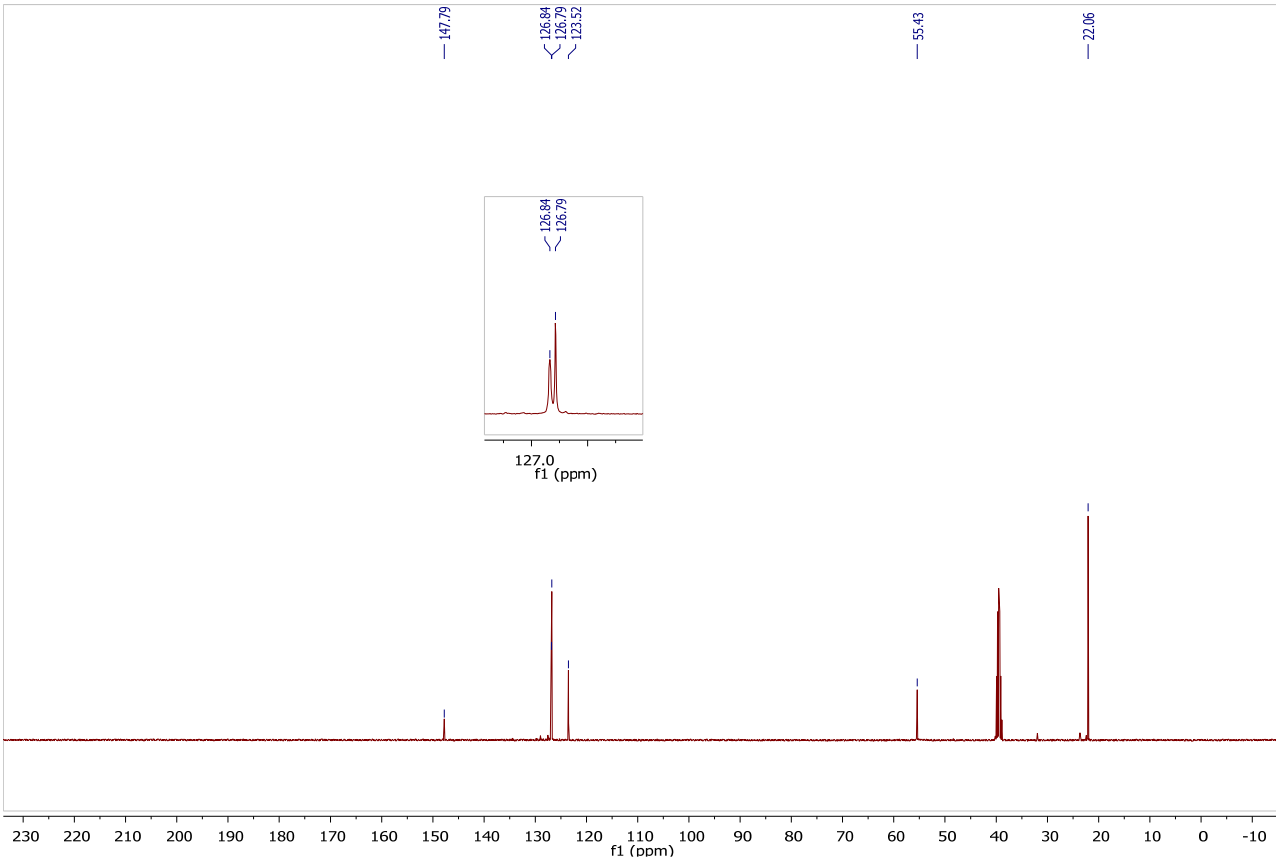
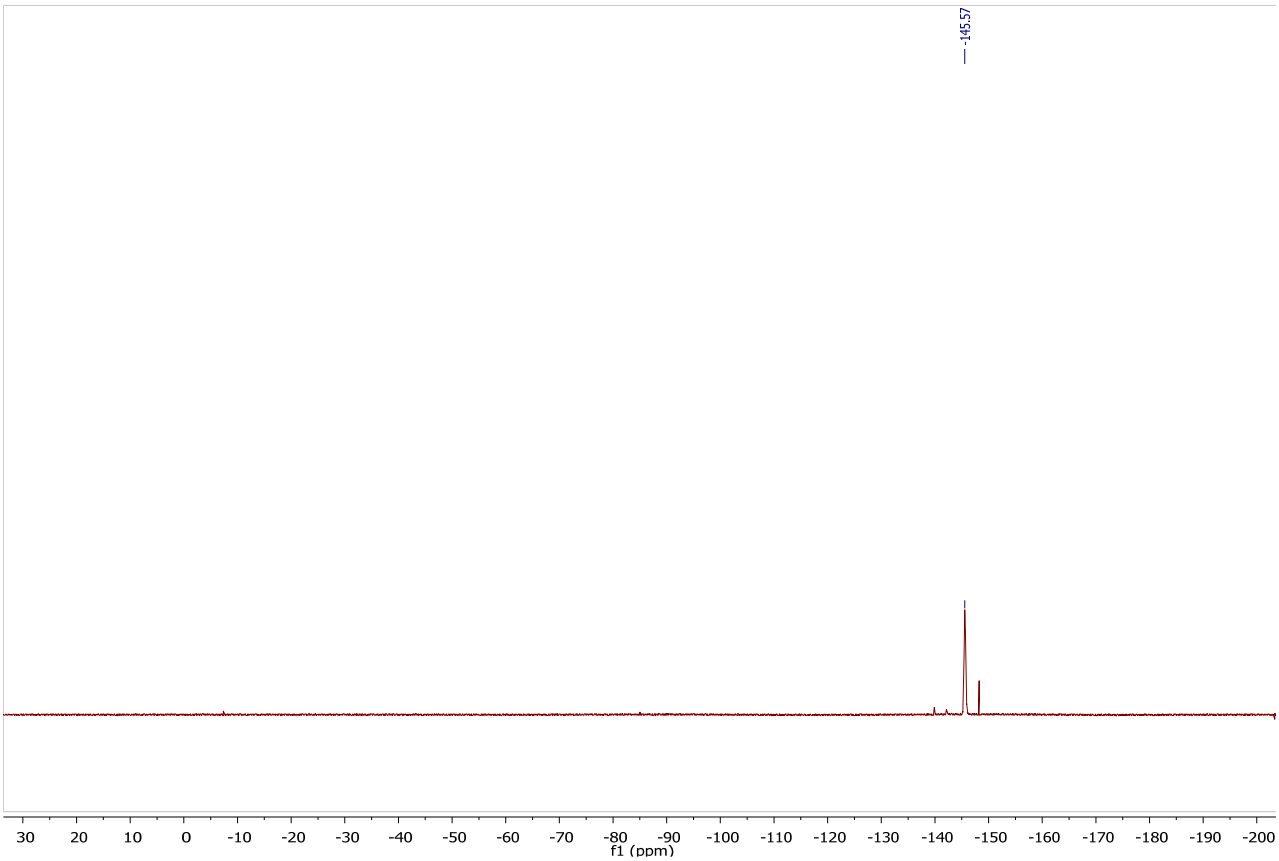
f1 (ppm)


tBu
HN
S
O
BF3NH4
4d
7.18
7.17
7.14
7.13
7.12
7.10
6.99
6.99
6.99
6.97
6.96
6.95
6.95
4.04
4.03
3.29
1.08
7.18
1.07
7.3
7.2
7.1
7.0
6.9
6.8
f1 (ppm)
7.18
1.07
1.00
1.13
9.65
f1 (ppm)


147.79
126.84
126.79
123.52
55.43
22.06
126.84
126.79
127.0
f1 (ppm)
f1 (ppm)


-145.57
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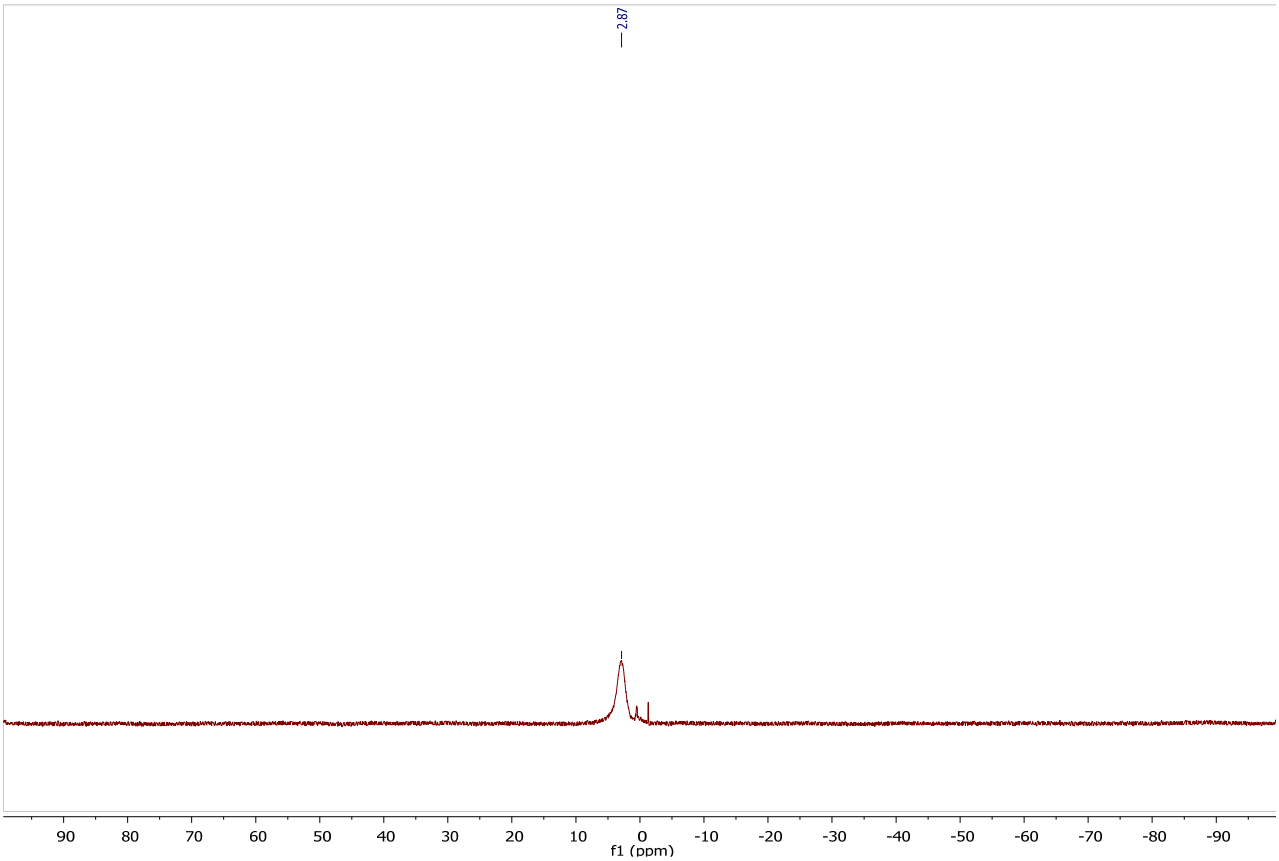
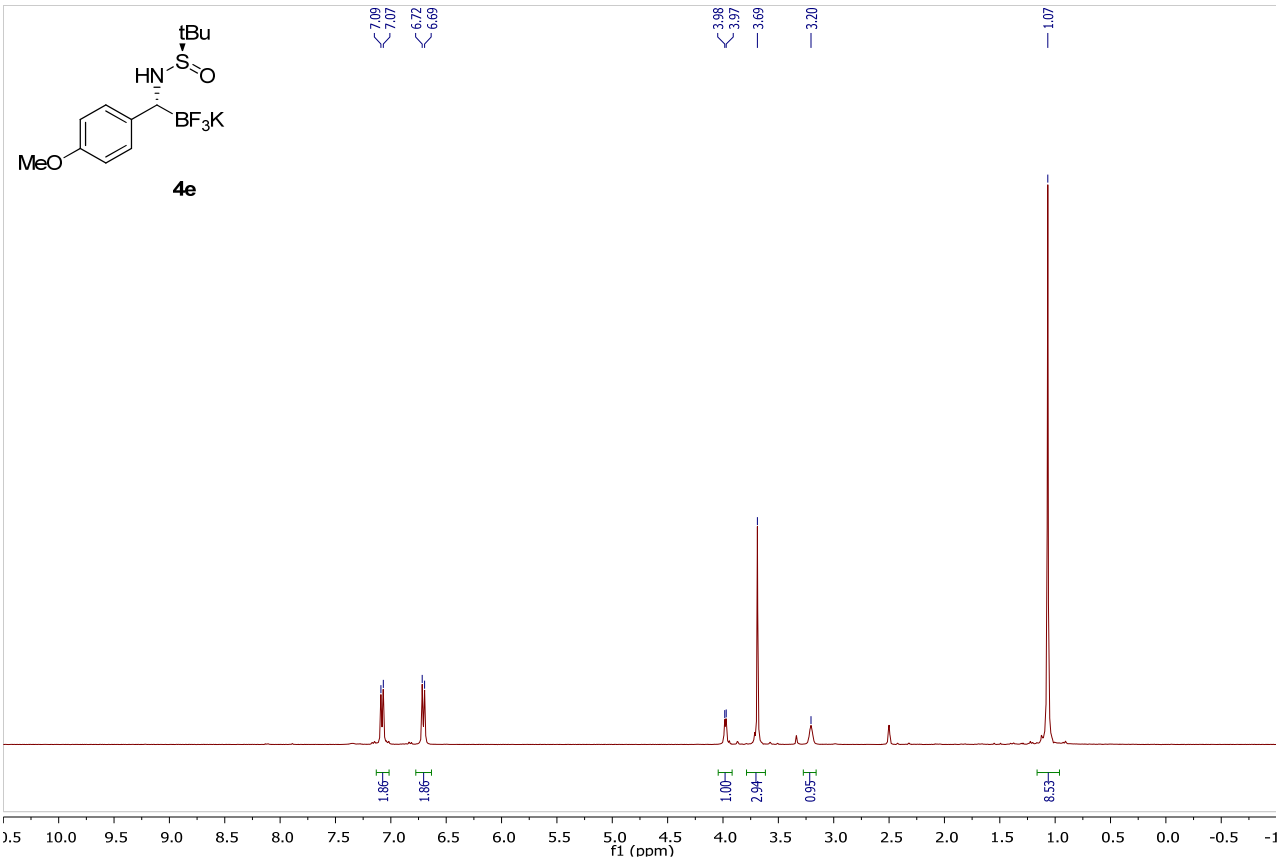
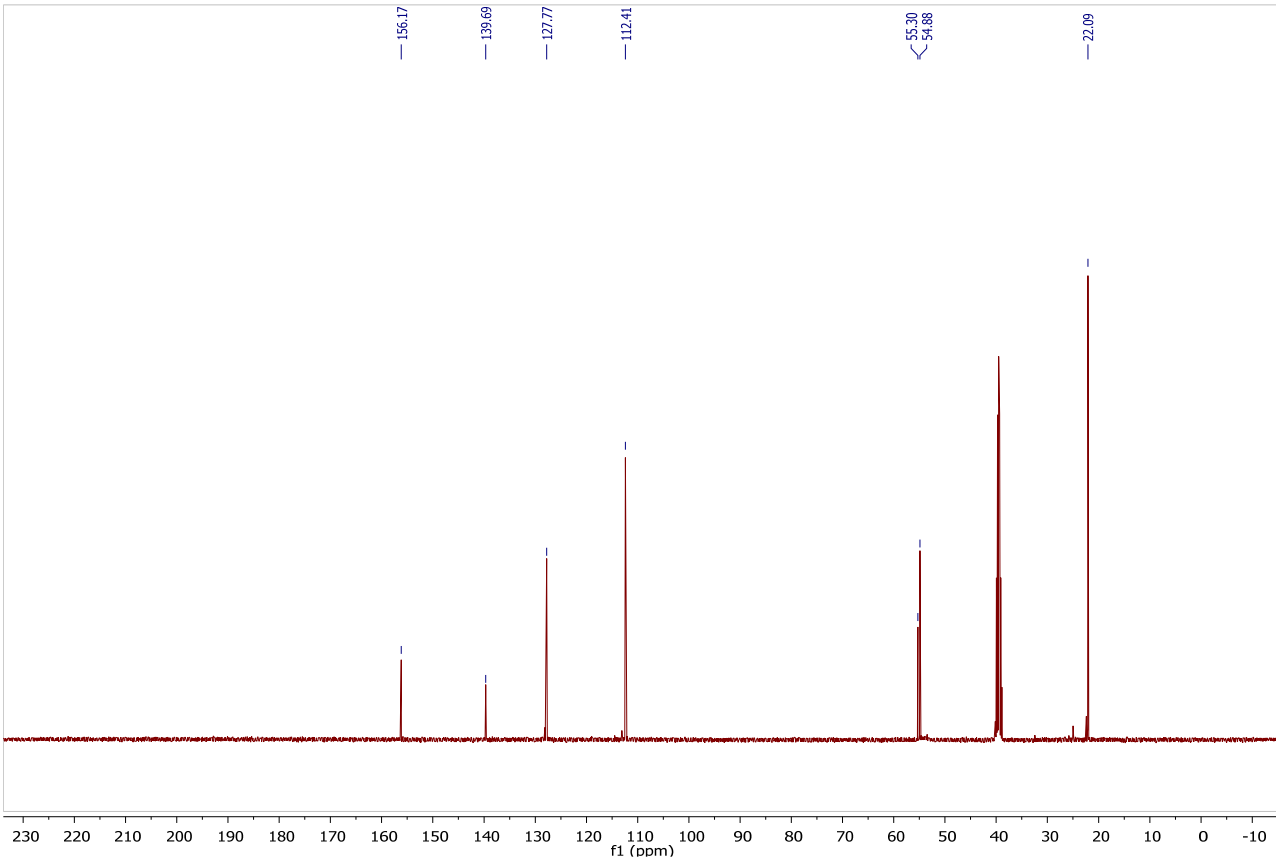
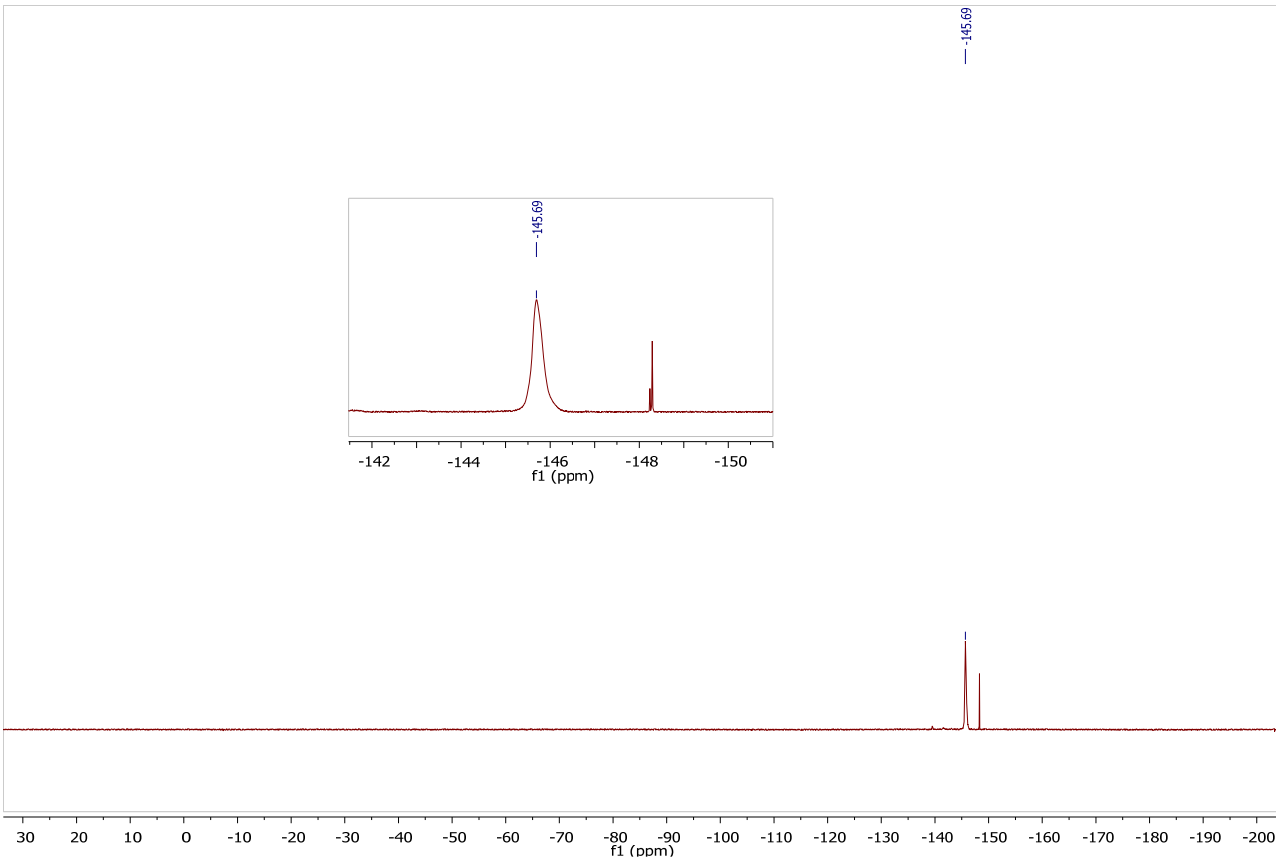
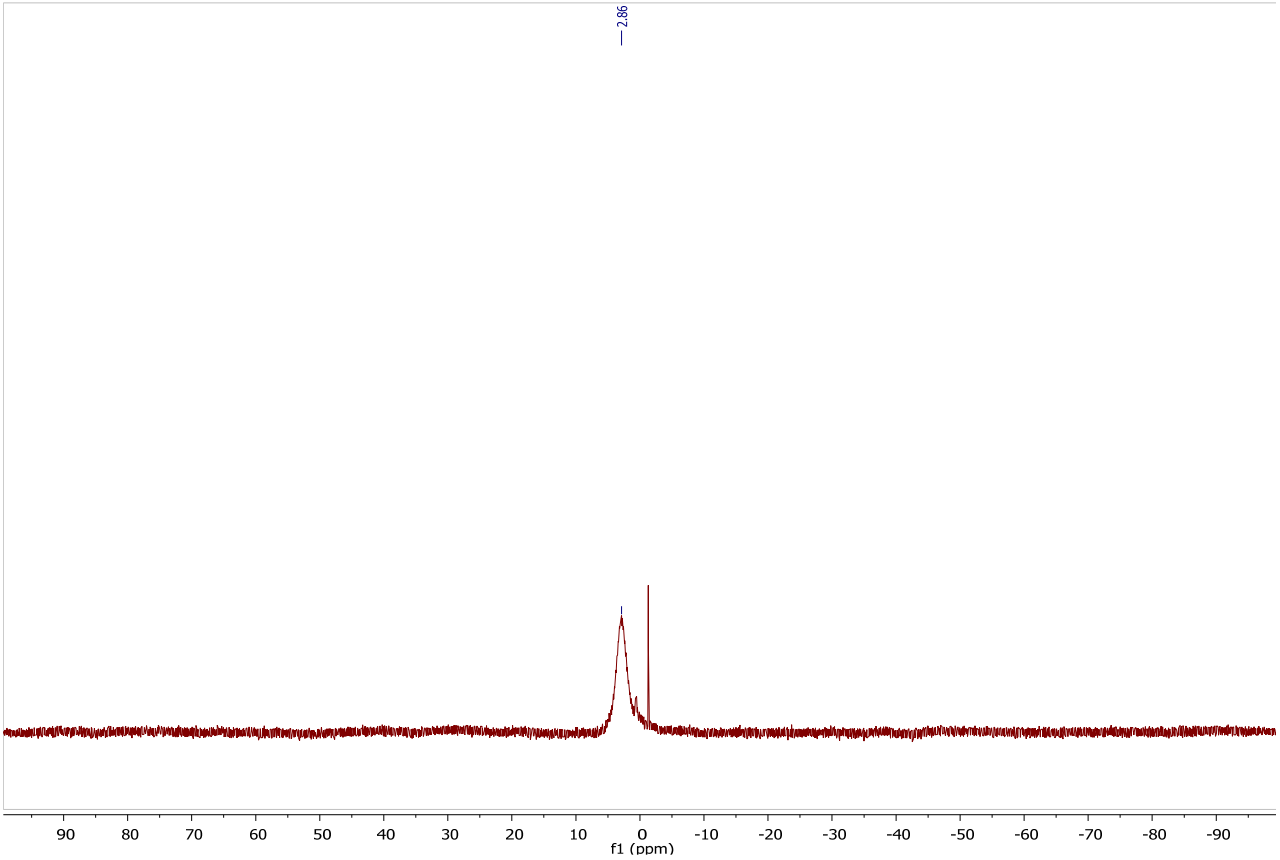
f1 (ppm)


2.87
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)


tBu
HN
S
O
BF3K
MeO
4e
7.09
7.07
6.72
6.69
3.98
3.97
3.69
3.20
1.07
1.86
1.86
1.00
2.94
0.95
8.53
f1 (ppm)


156.17
139.69
127.77
112.41
55.30
54.88
22.09
f1 (ppm)


-145.69
-145.69
-142
-144
-146
-148
-150
f1 (ppm)
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


2.86
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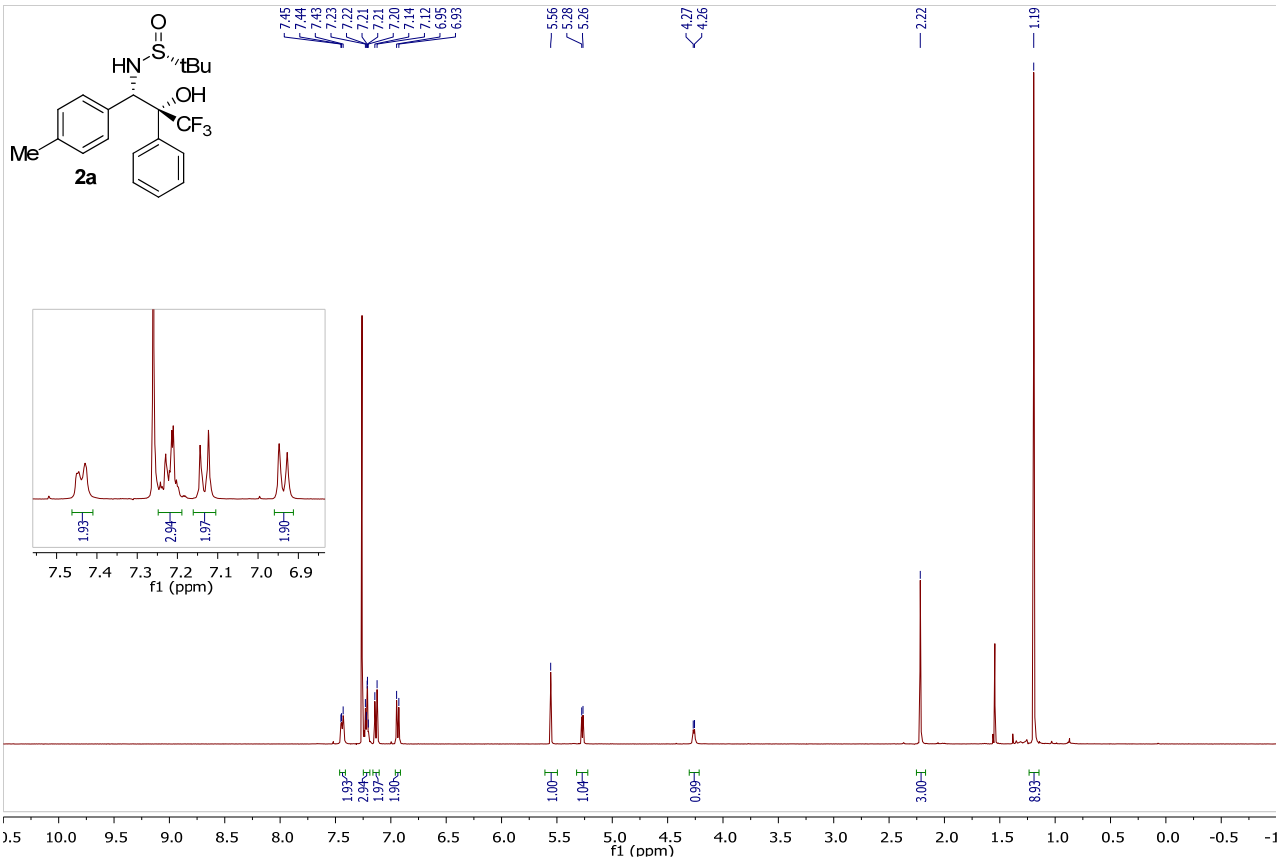
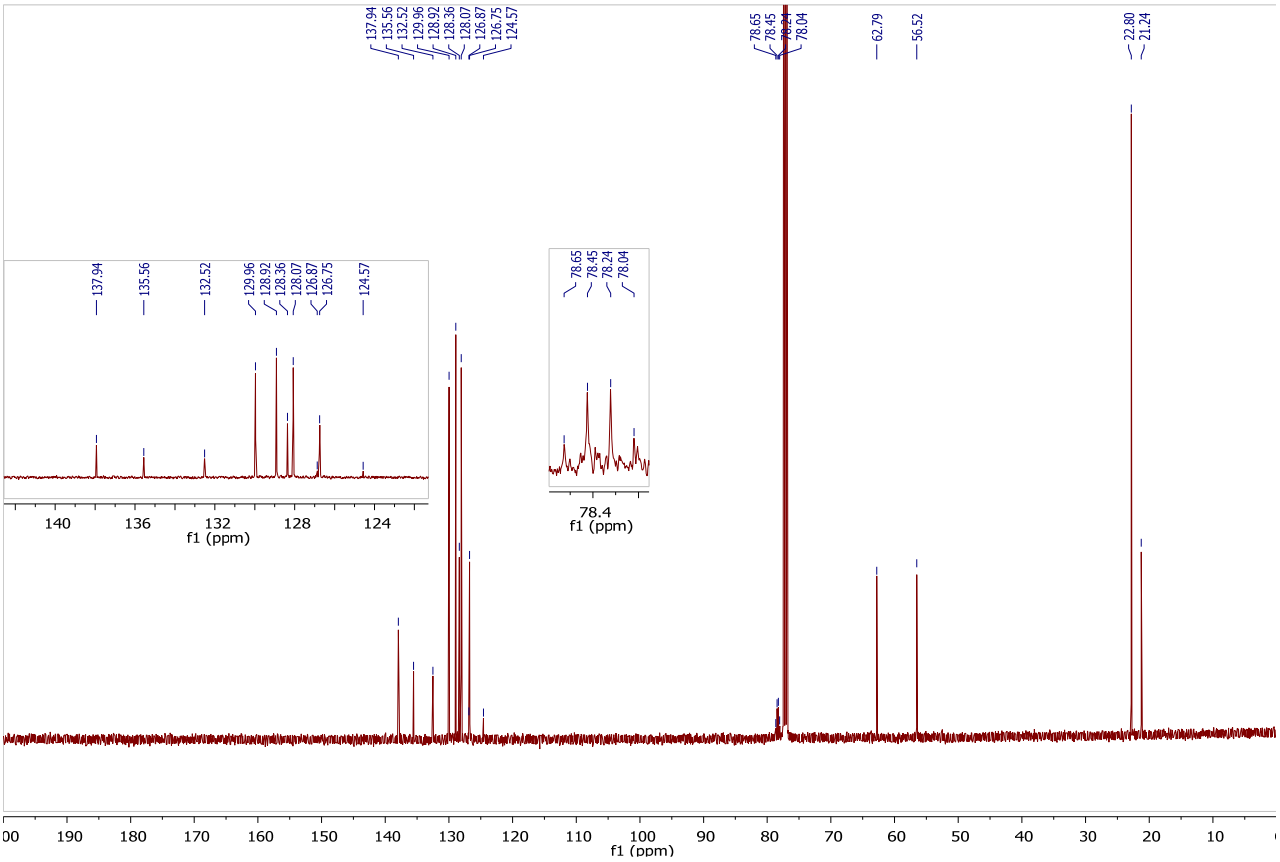
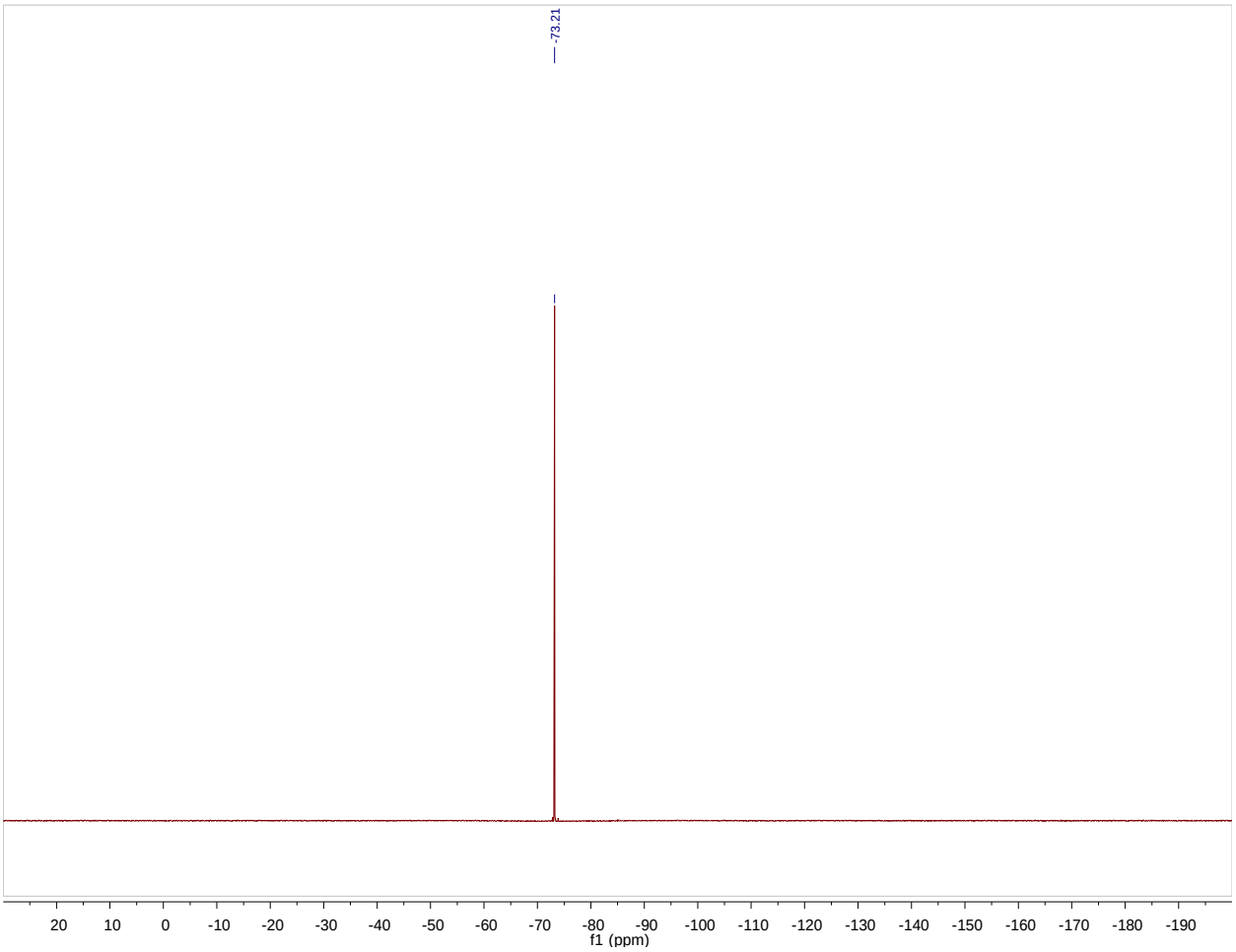
f1 (ppm)


Me
2a
7.45
7.44
7.43
7.23
7.22
7.21
7.21
7.20
7.14
7.12
6.95
6.93
5.56
5.28
5.26
4.27
4.26
2.22
1.19
1.93
2.94
1.97
1.90
1.00
1.04
0.99
3.00
8.93
f1 (ppm)


137.94
135.56
132.52
129.96
128.92
128.36
128.07
126.87
126.75
124.57
78.65
78.45
78.24
78.04
62.79
56.52
22.80
21.24
f1 (ppm)


-73.21
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
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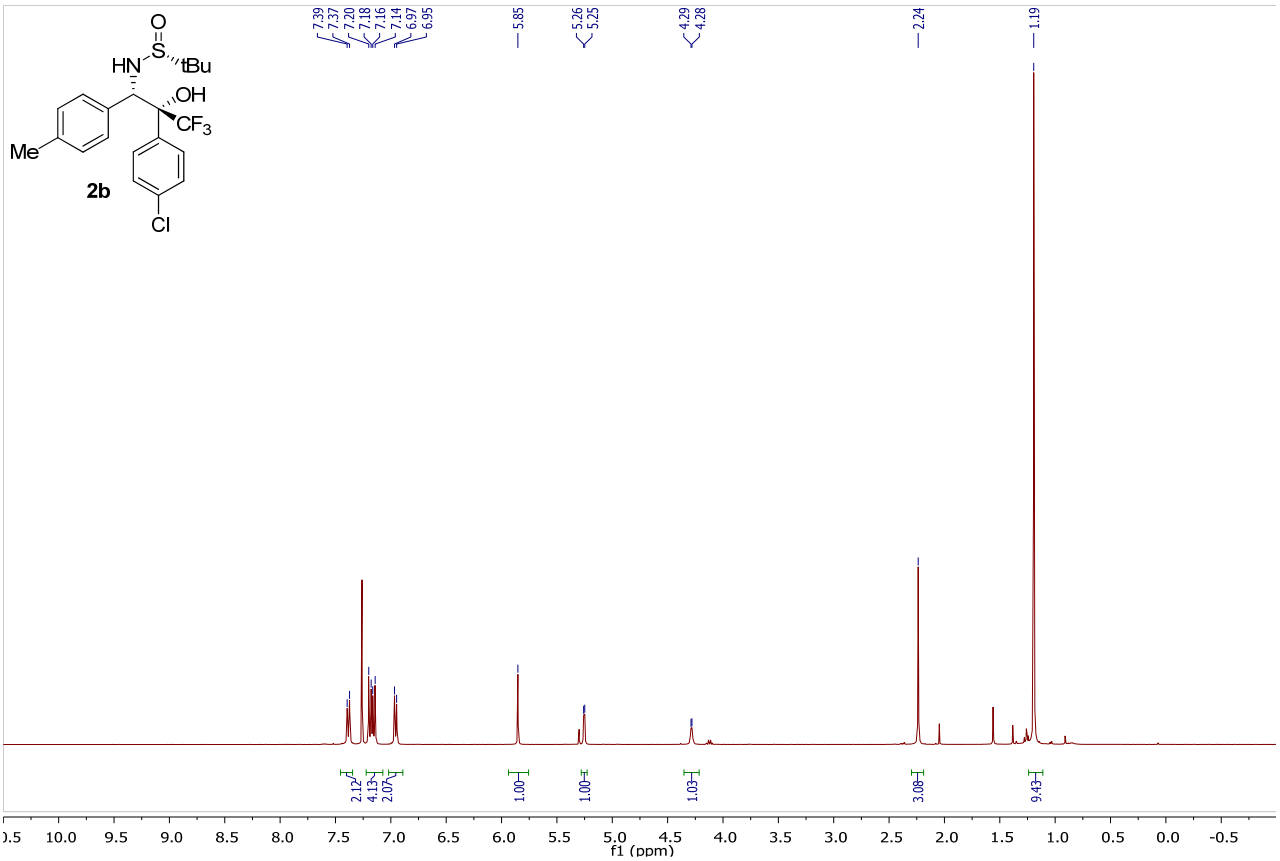
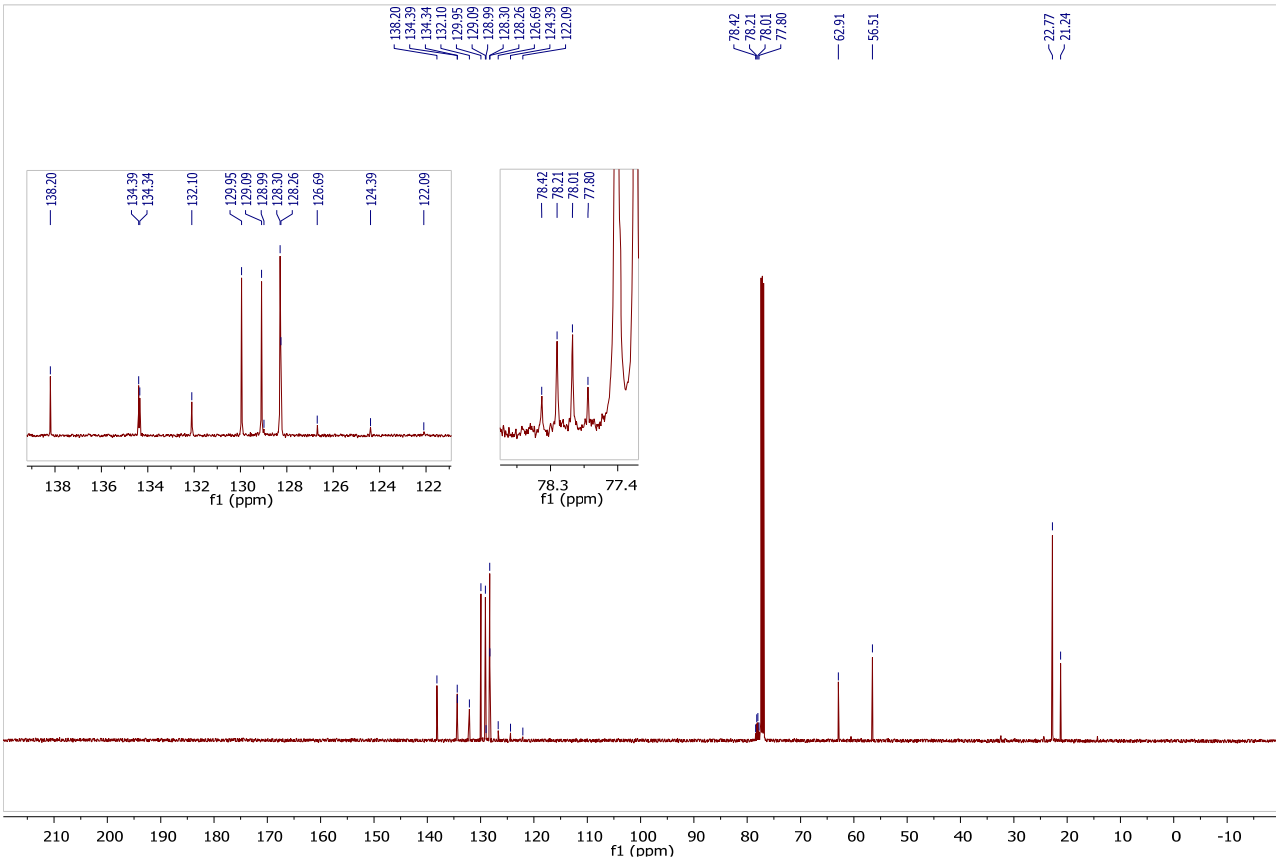
-140
-150
-160
-170
-180
-190
f1 (ppm)


2b
Me
HN
tBu
OH
CF3
Cl
f1 (ppm)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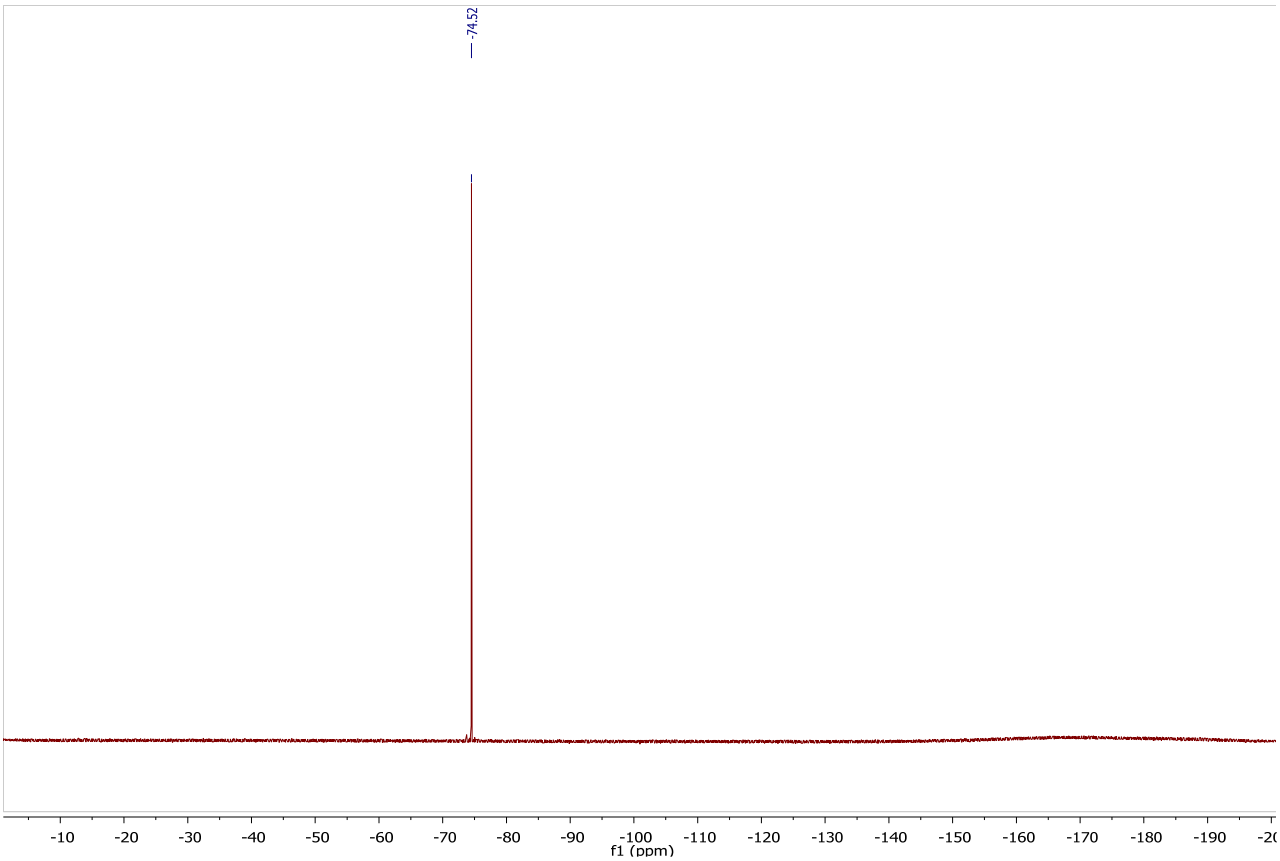
-74.52
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
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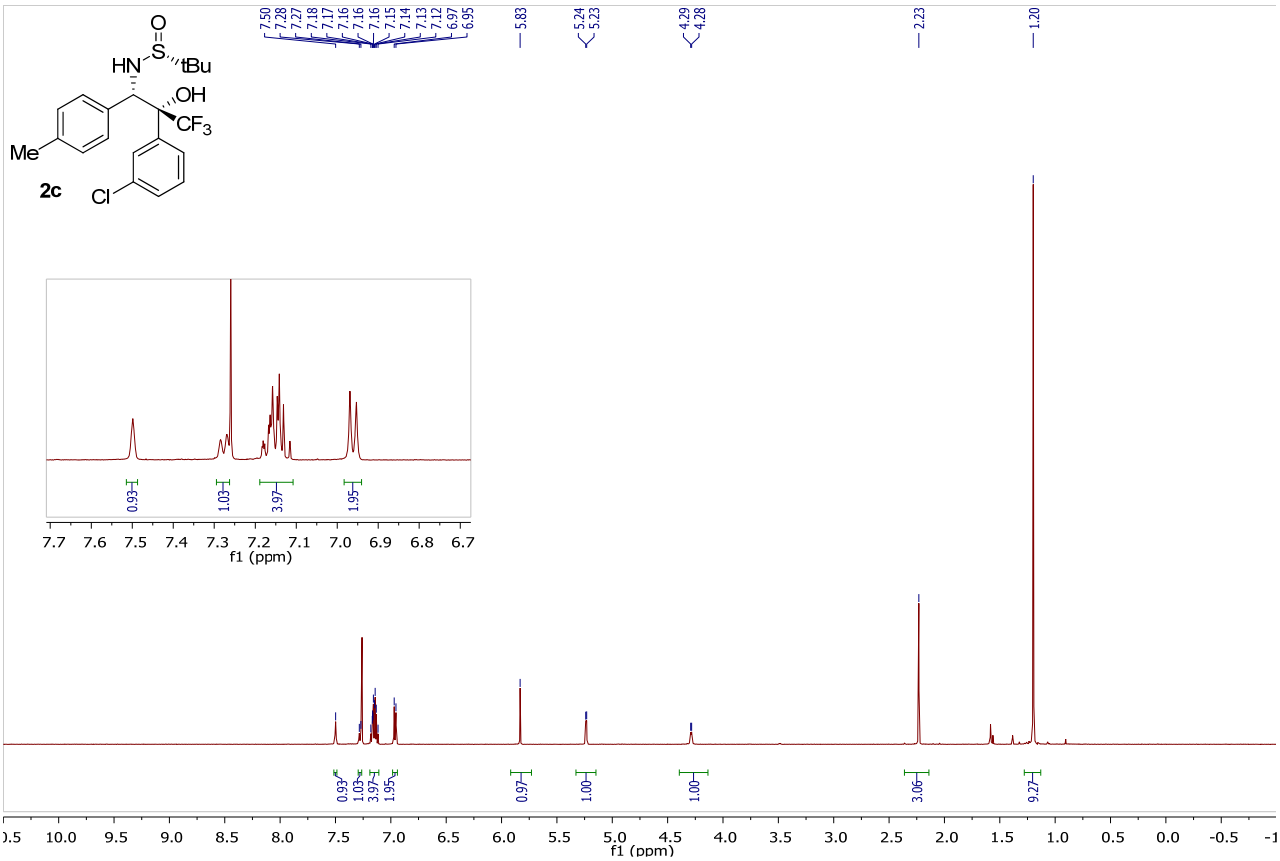
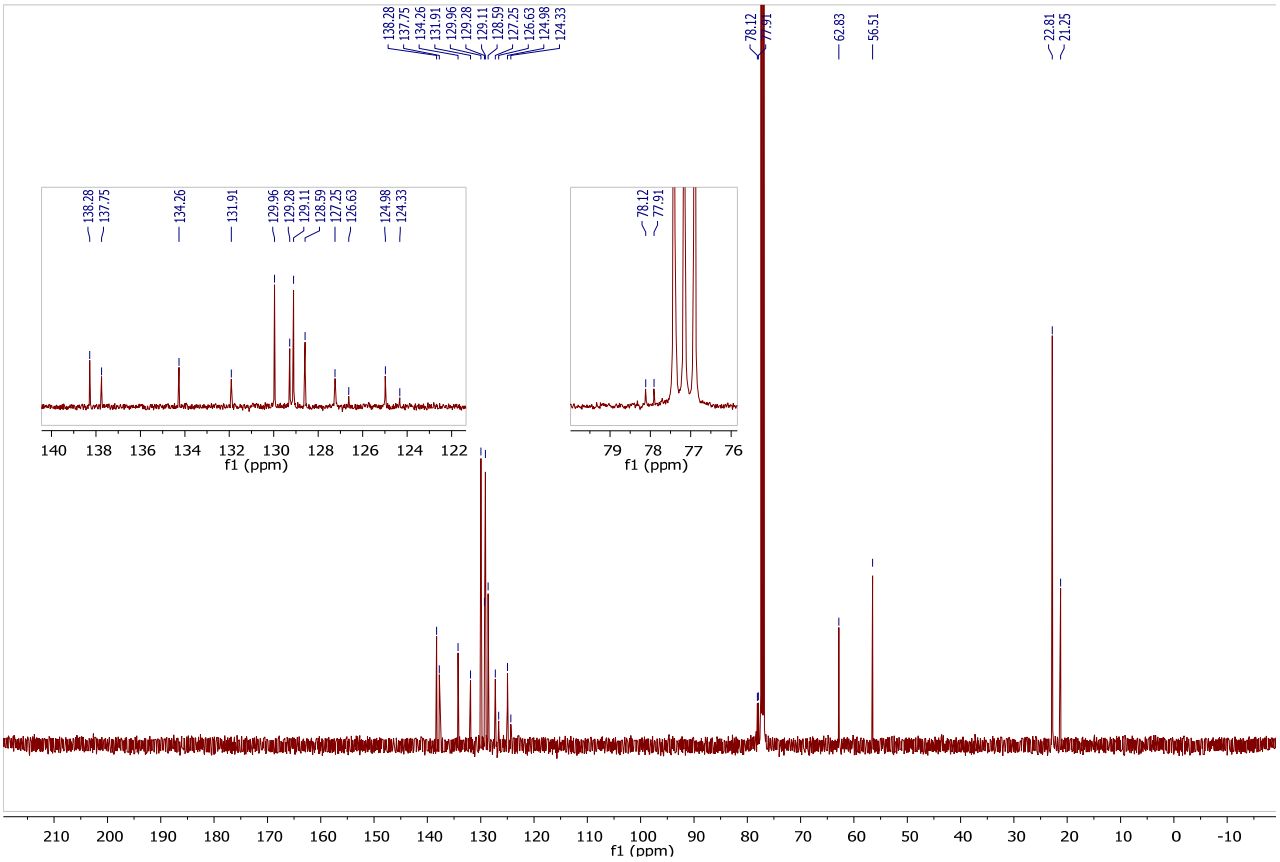
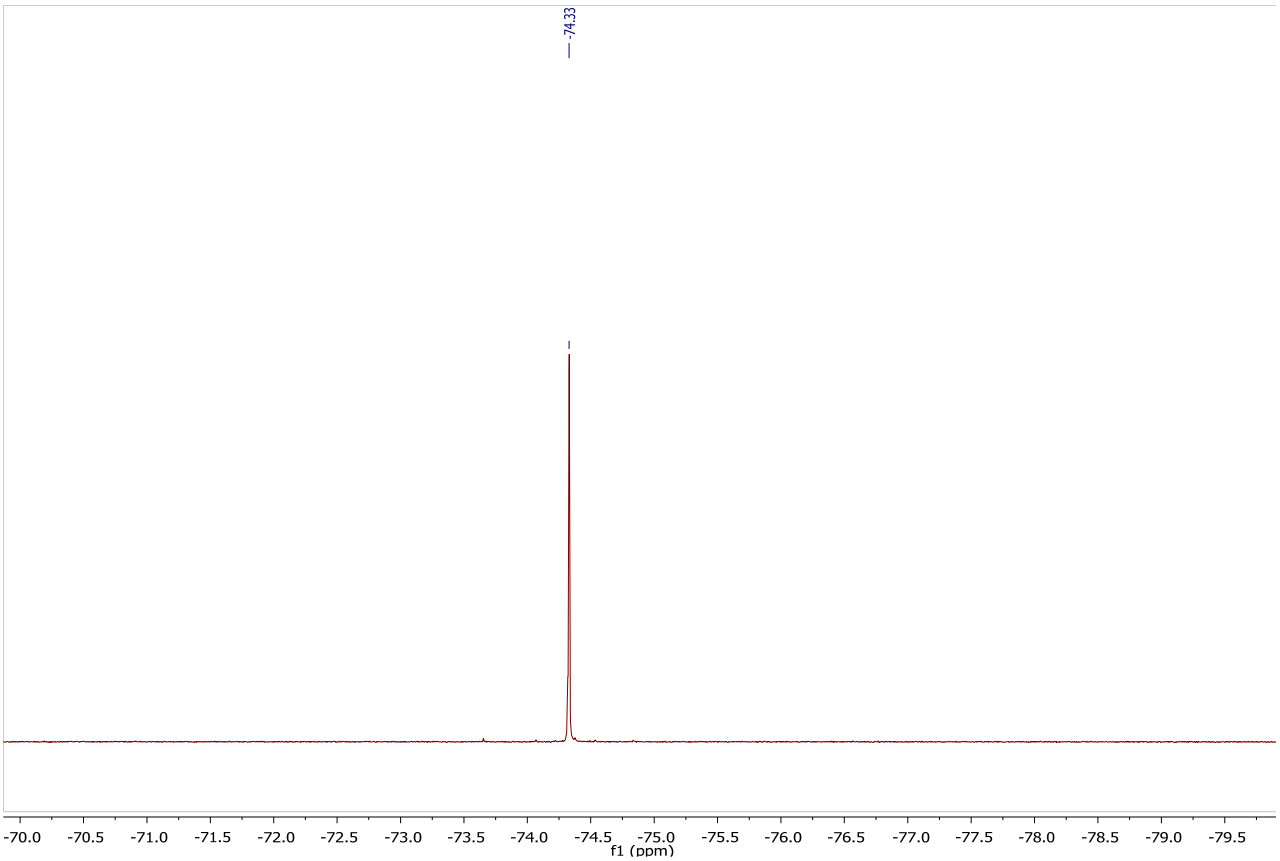
-150
-160
-170
-180
-190
f1 (ppm)


2c
Me
Cl
OH
CF3
tBu
HN
f1 (ppm)


f1 (ppm)


-74.33
-70.0
-70.5
-71.0
-71.5
-72.0
-72.5
-73.0
-73.5
-74.0
-74.5
-75.0
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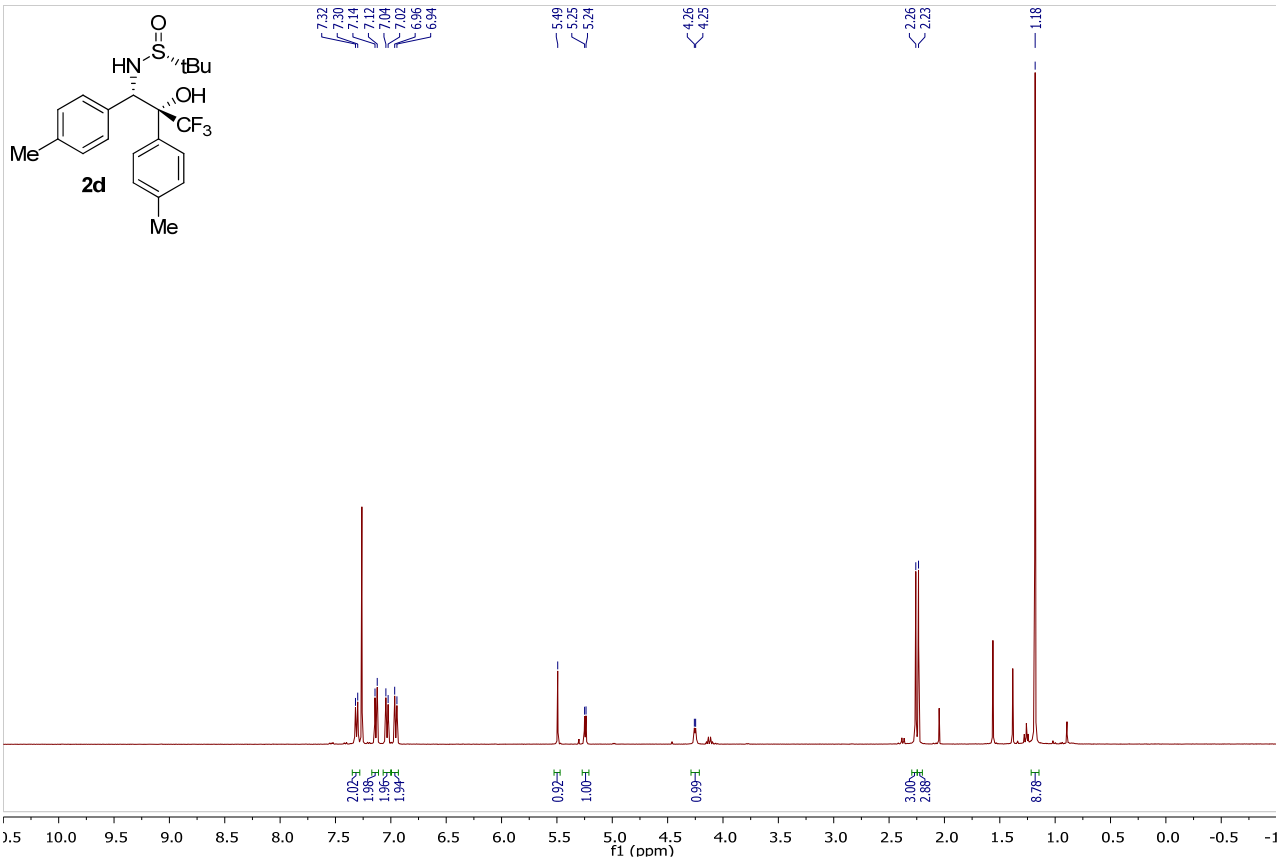
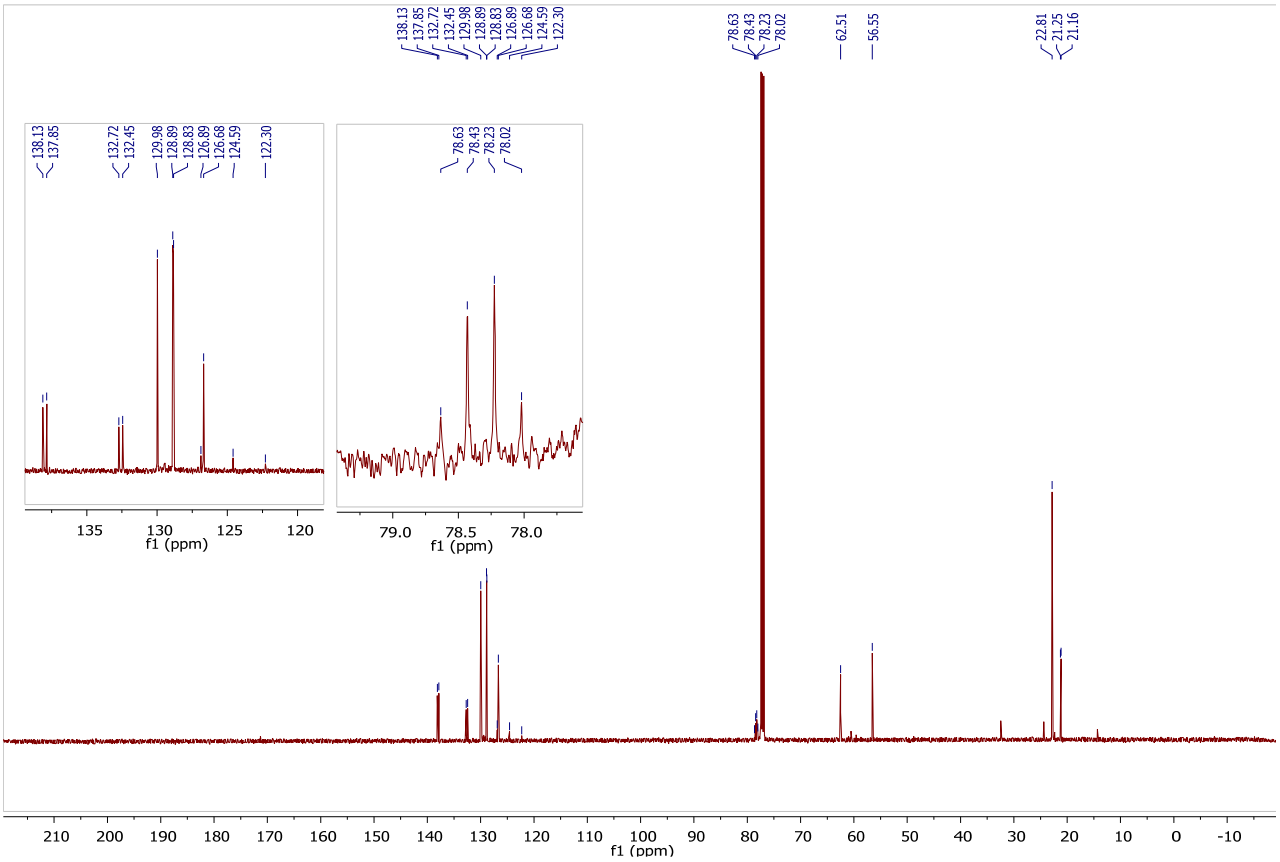
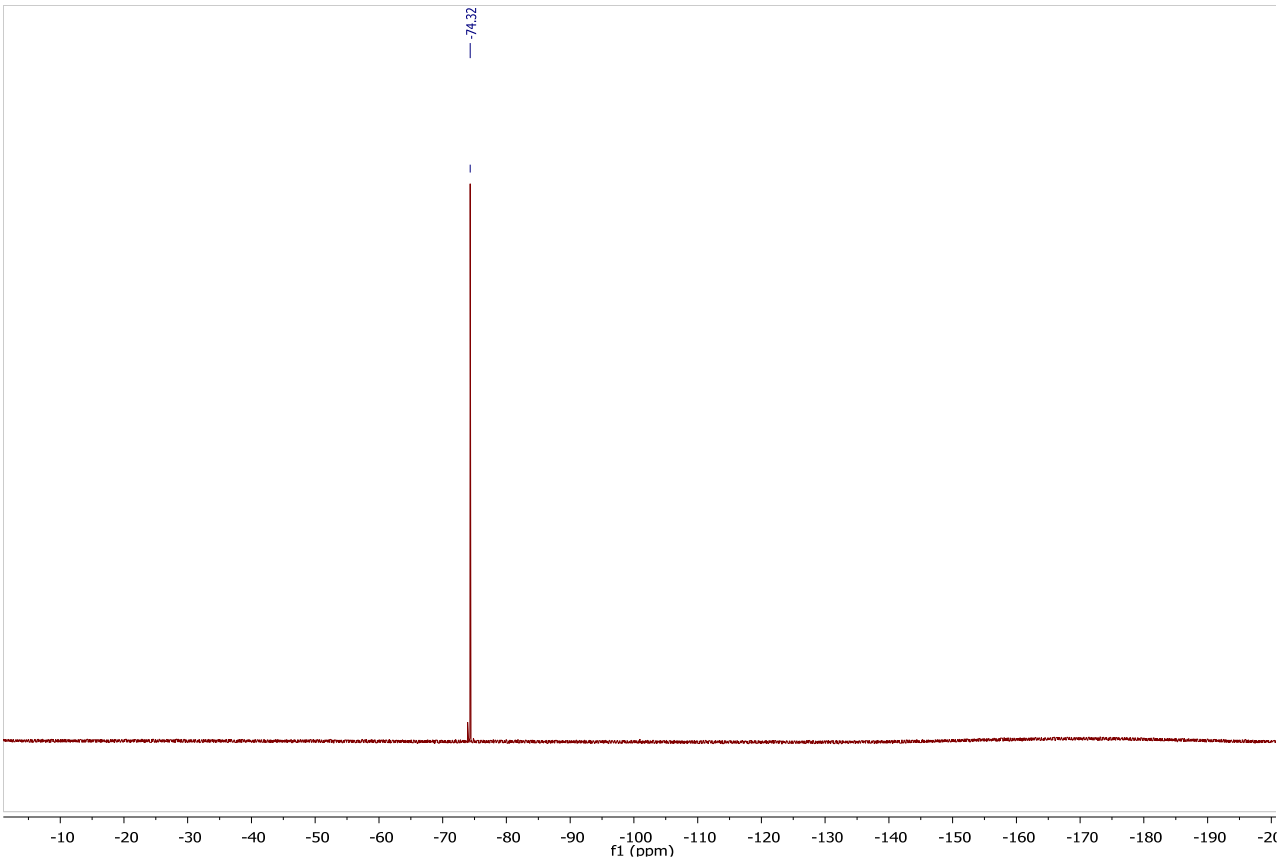
-78.5
-79.0
-79.5
f1 (ppm)


2d
Me
Me
HN
tBu
OH
CF3
f1 (ppm)


f1 (ppm)
f1 (ppm)
f1 (ppm)


-74.32
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
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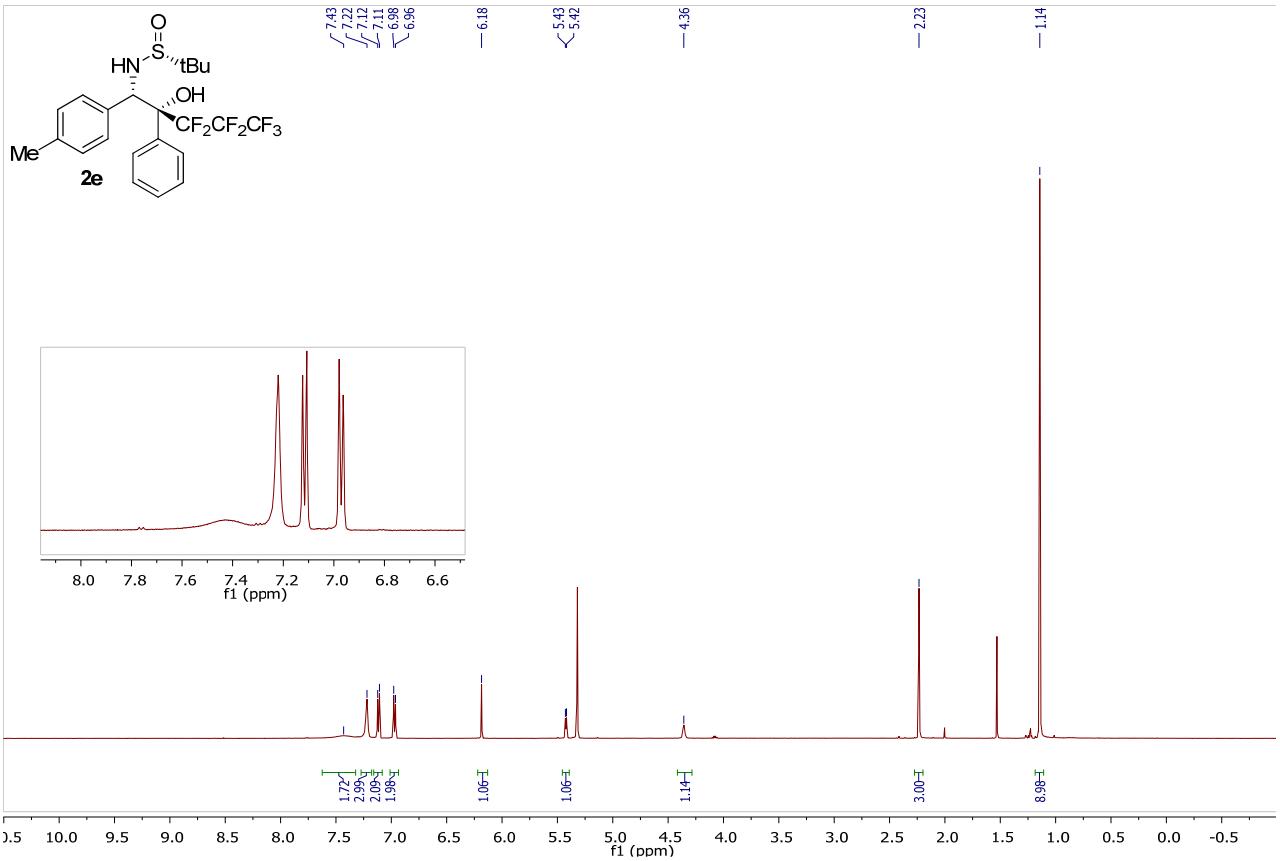
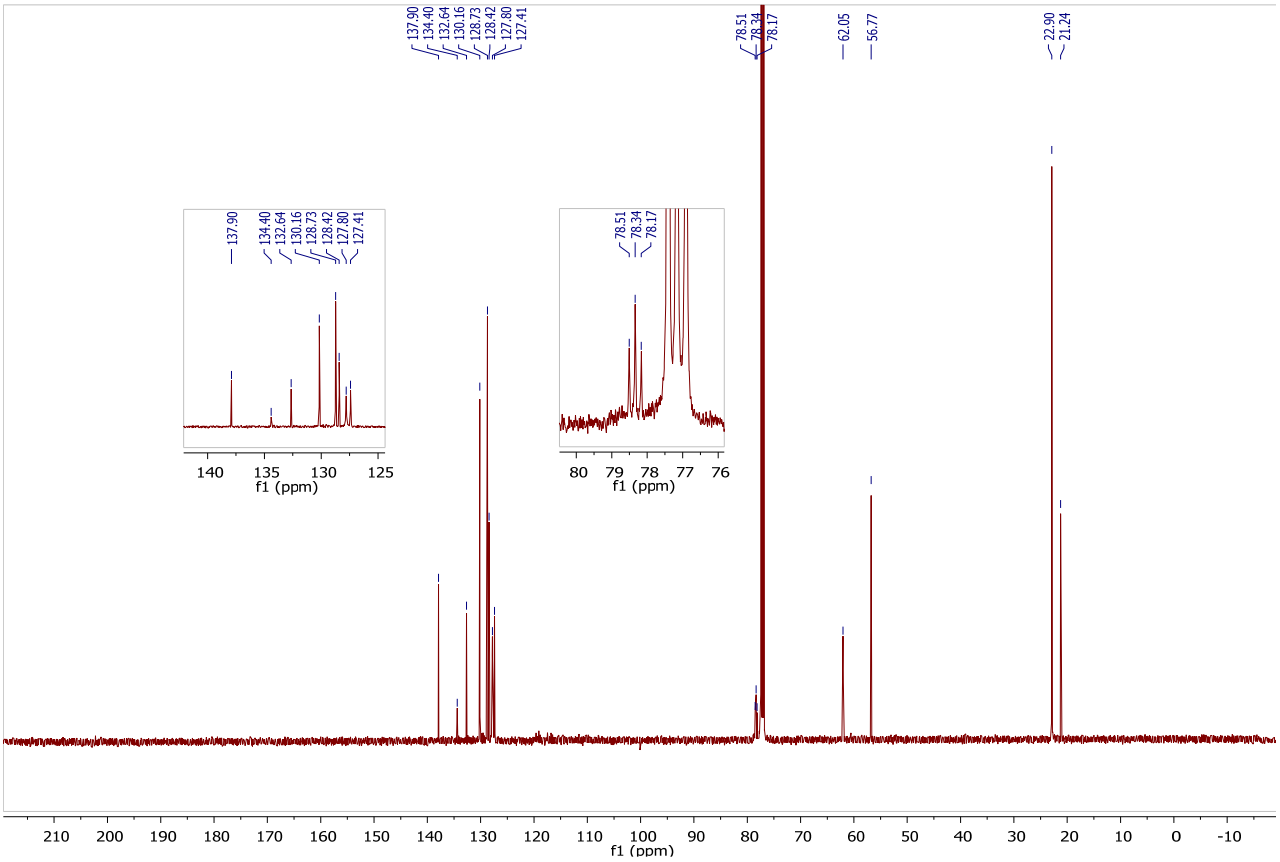
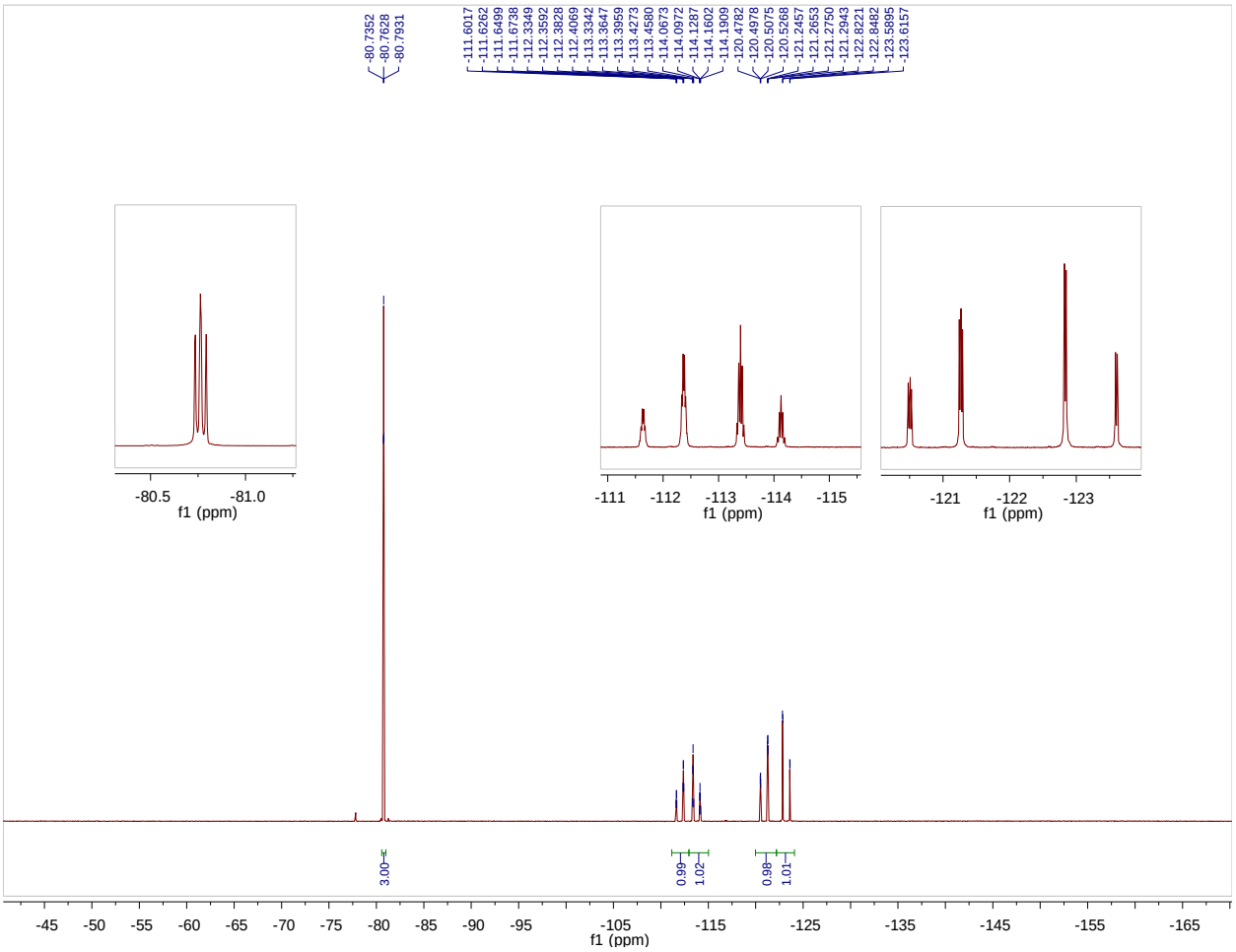
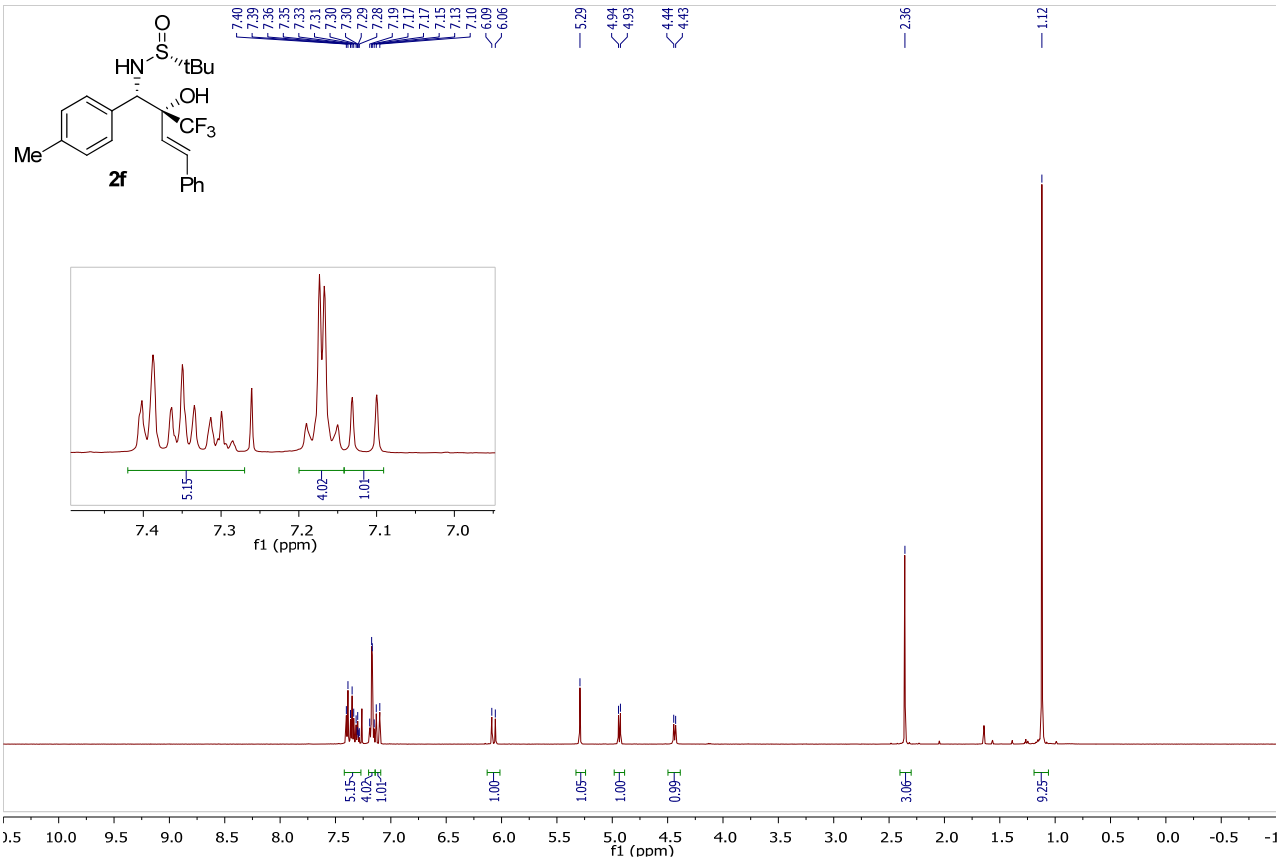
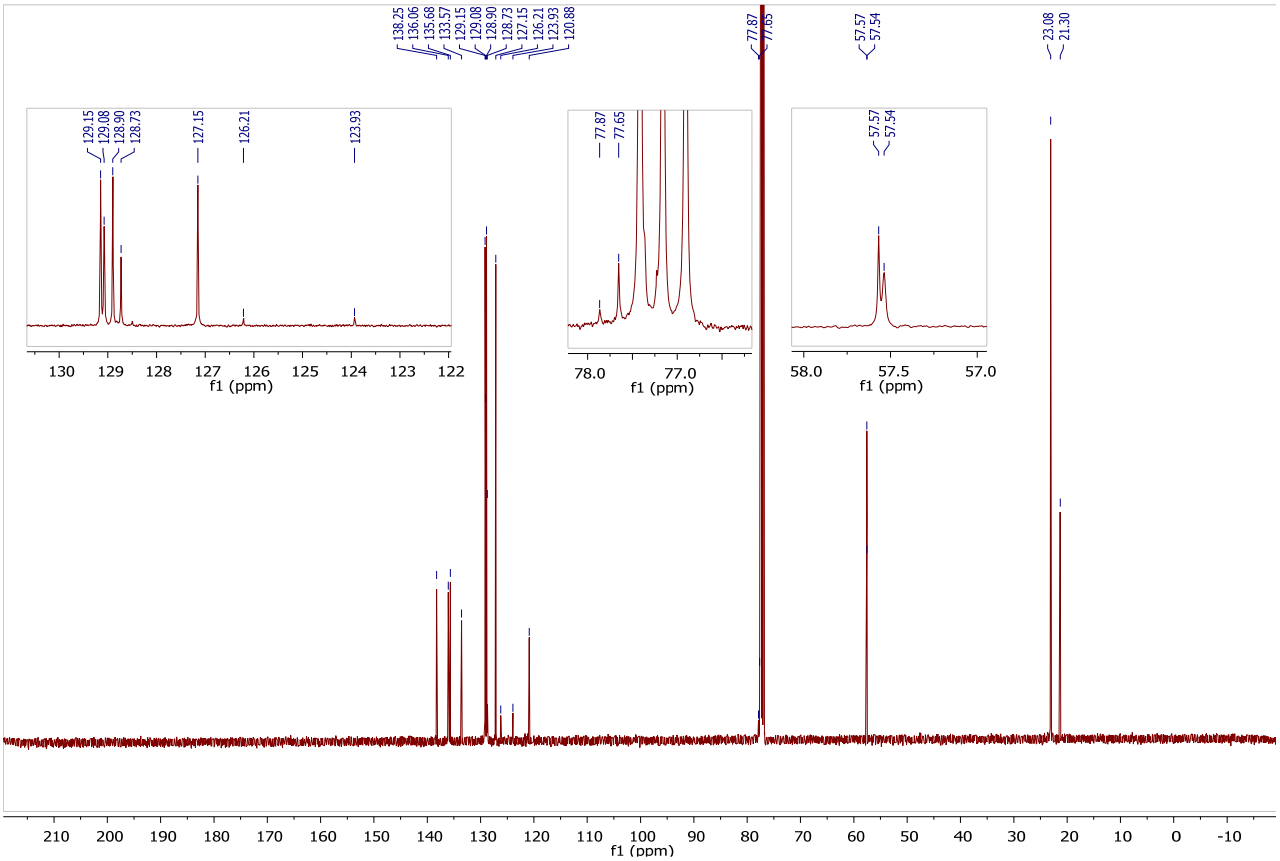
-150
-160
-170
-180
-190
f1 (ppm)

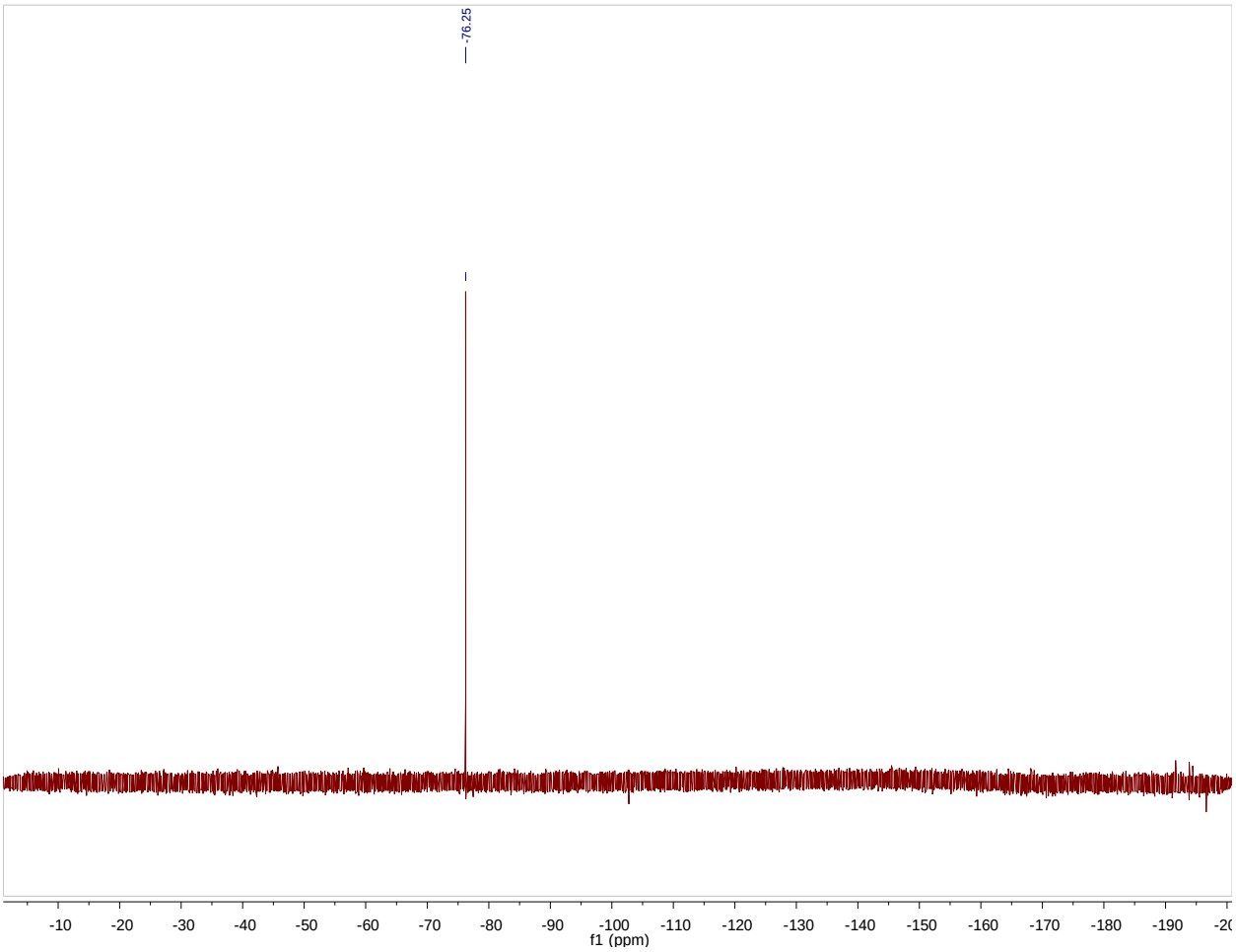

7.43
7.22
7.12
7.11
6.98
6.96
6.18
5.43
5.42
4.36
2.23
1.14
HN
S
O
tBu
OH
CF2CF2CF3
Me
2e
1.72
2.99
2.09
1.98
1.06
1.06
1.14
3.00
8.98
f1 (ppm)

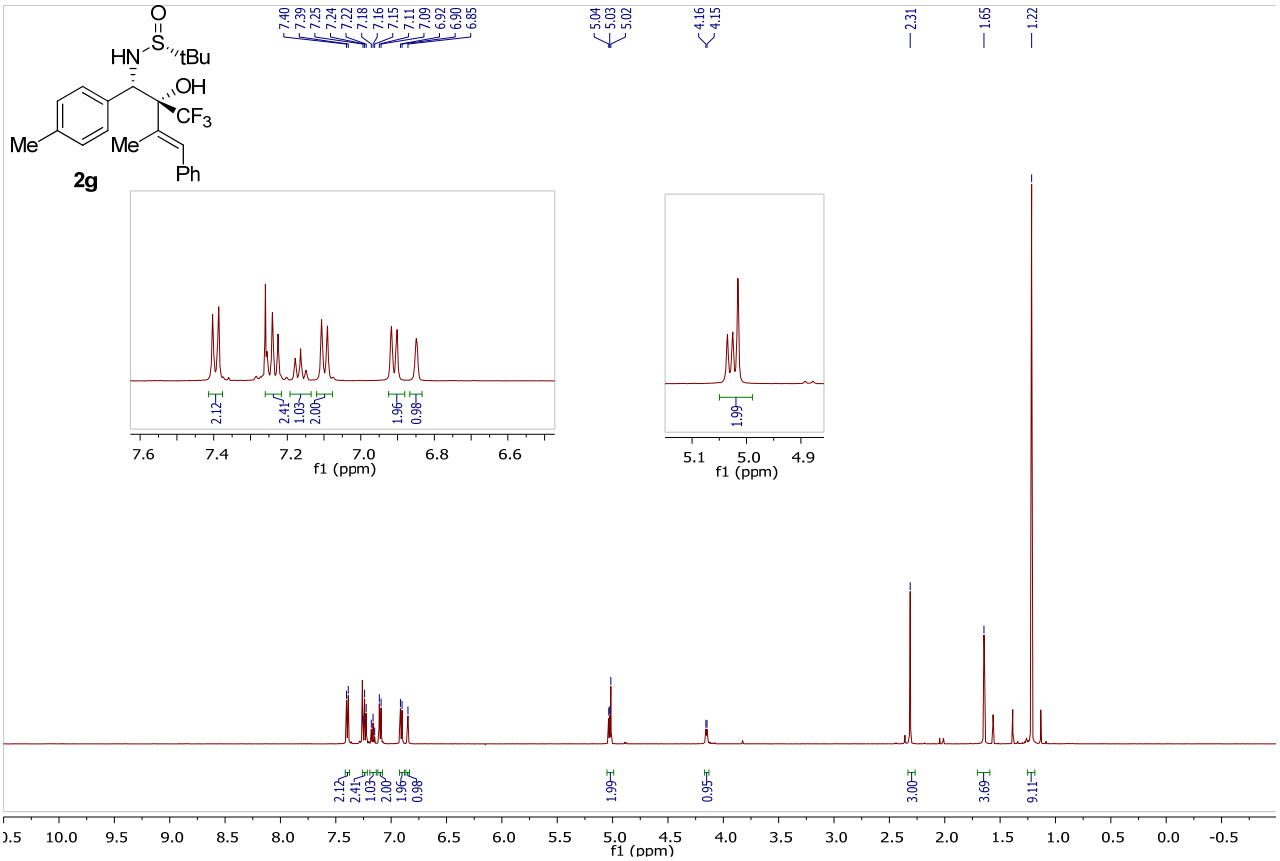

137.90
134.40
132.64
130.16
128.73
128.42
127.80
127.41
78.51
78.34
78.17
62.05
56.77
22.90
21.24
f1 (ppm)

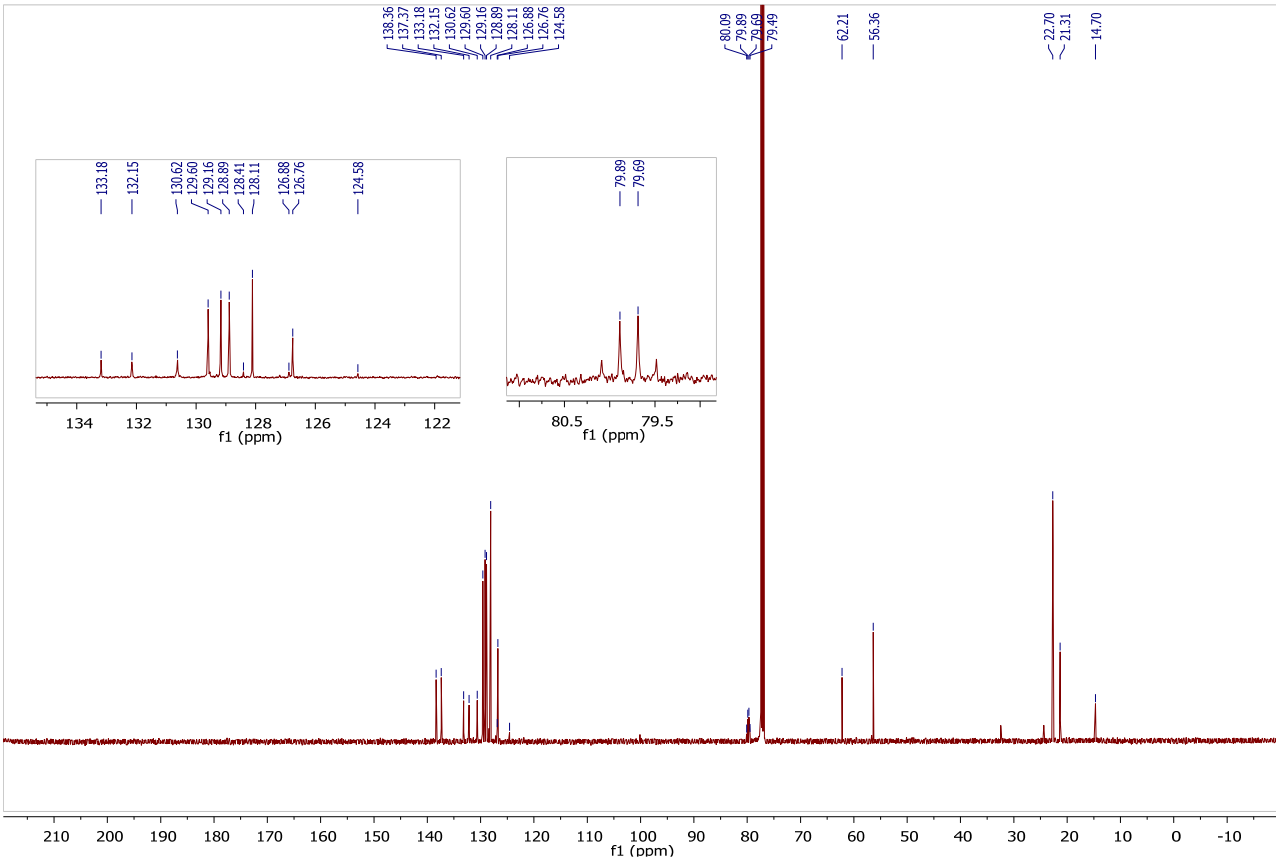

-80.7352
-80.7628
-80.7931
-111.6017
-111.6262
-111.6499
-111.6738
-112.3349
-112.3592
-112.3828
-112.4069
-113.3342
-113.3647
-113.3959
-113.4273
-113.4580
-114.0673
-114.0972
-114.1287
-114.1602
-114.1909
-120.4782
-120.4978
-120.5075
-120.5268
-121.2457
-121.2653
-121.2750
-121.2943
-122.8221
-122.8482
-123.5895
-123.6157
-80.5
-81.0
f1 (ppm)
-111
-112
-113
-114
-115
f1 (ppm)
-121
-122
-123
f1 (ppm)
3.00
0.99
1.02
0.98
1.01
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
-95
-105
-115
-125
-135
-145
-155
-165
f1 (ppm)

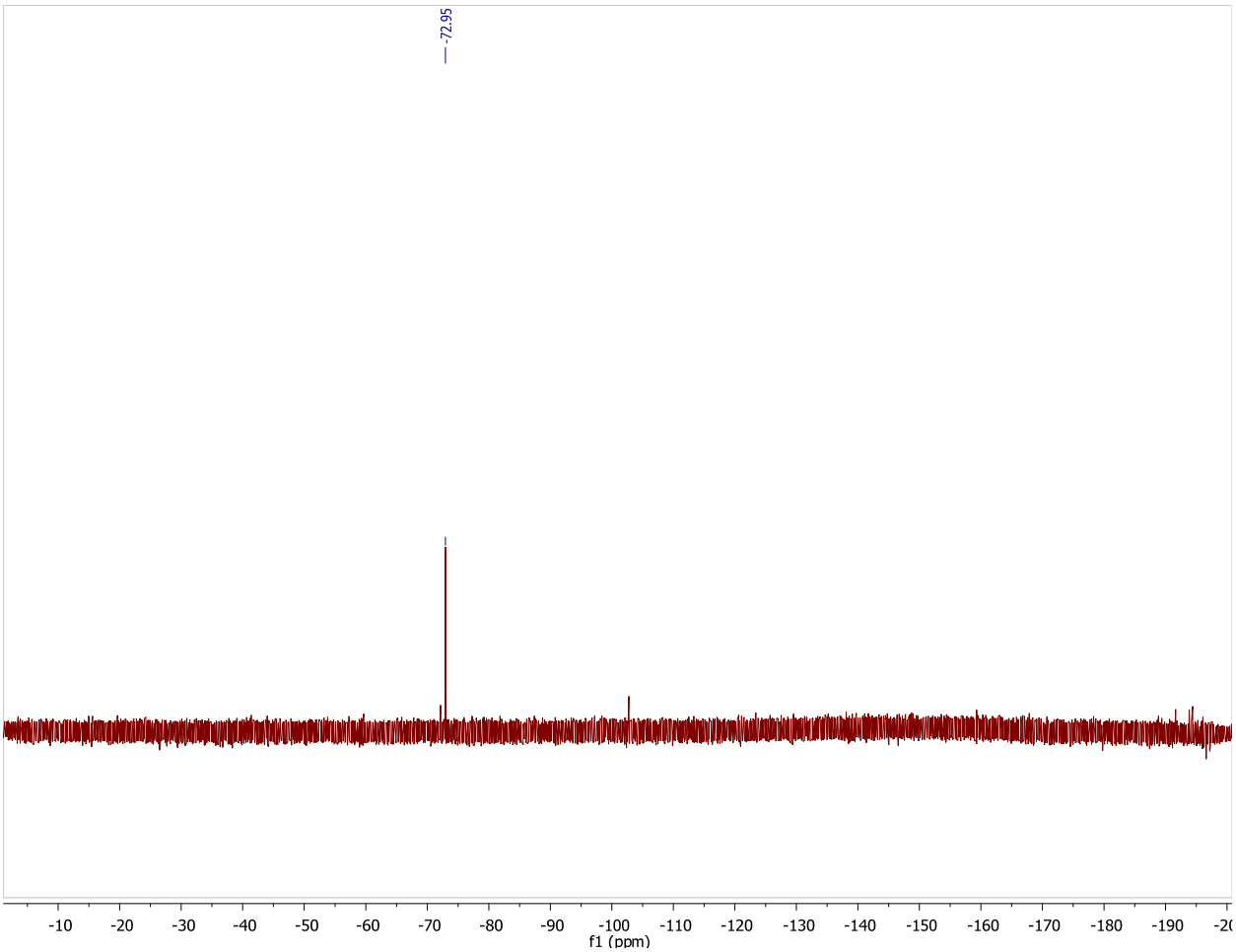

2f
Me
Ph
OH
CF3
tBu
HN
S
O
f1 (ppm)

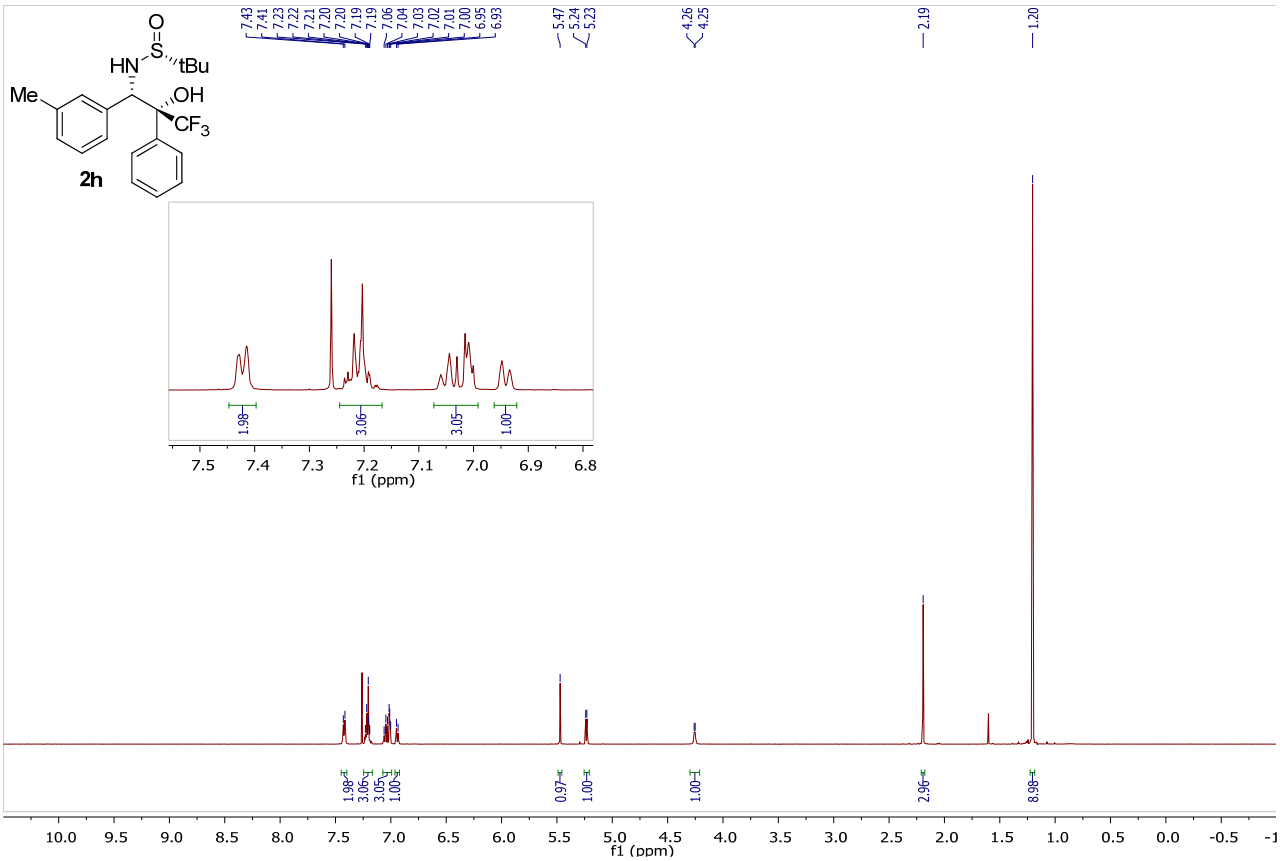

f1 (ppm)

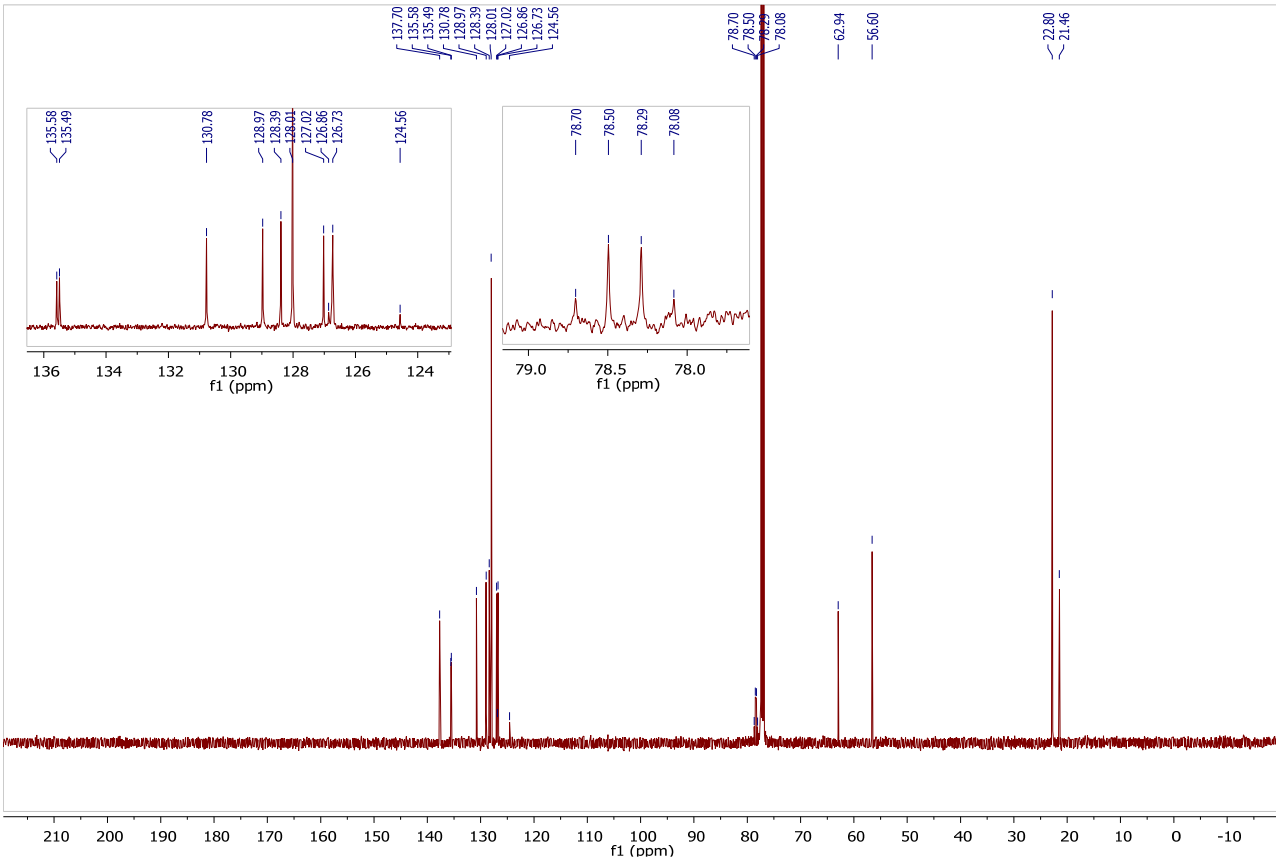

-76.25
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)

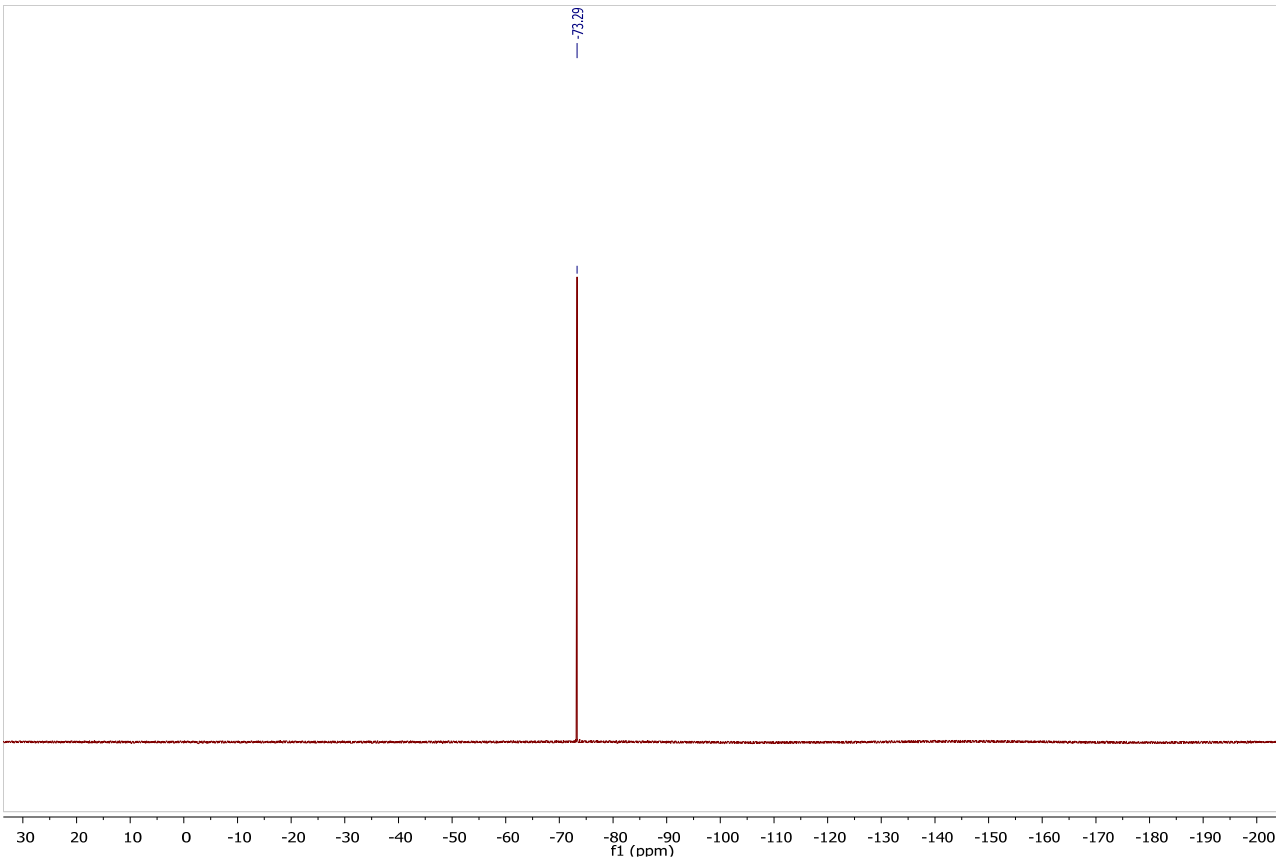

HN
tBu
OH
CF3
Me
Me
Ph
2g
f1 (ppm)

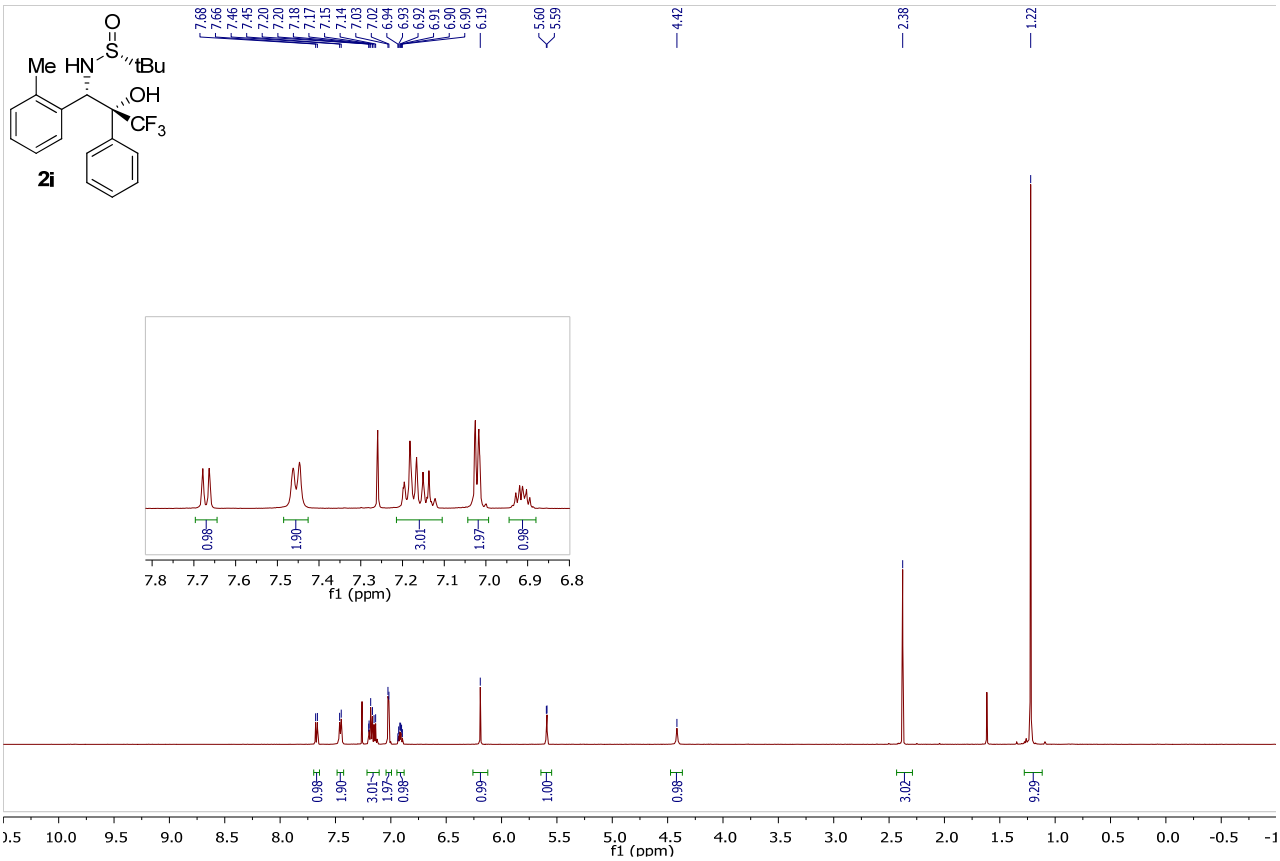

f1 (ppm)

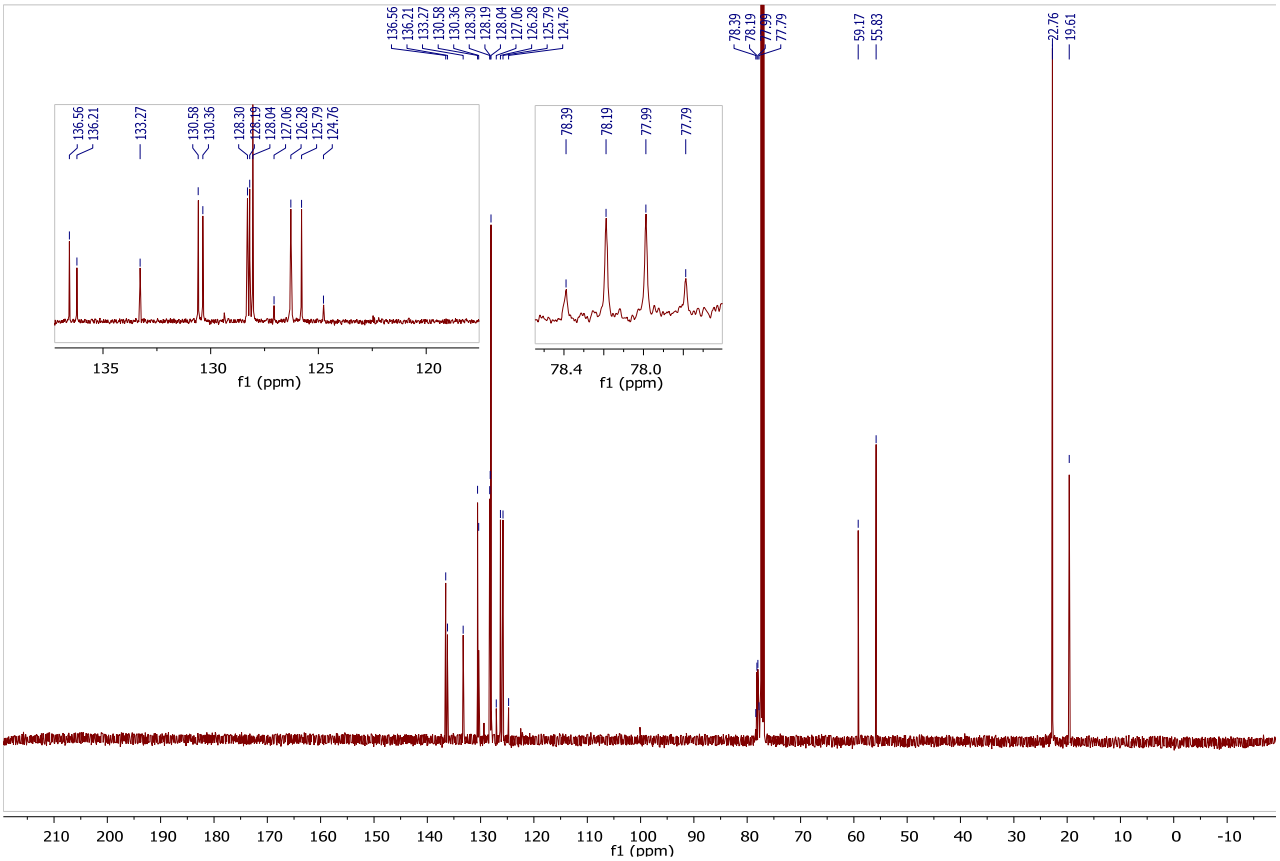

-72.95
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)

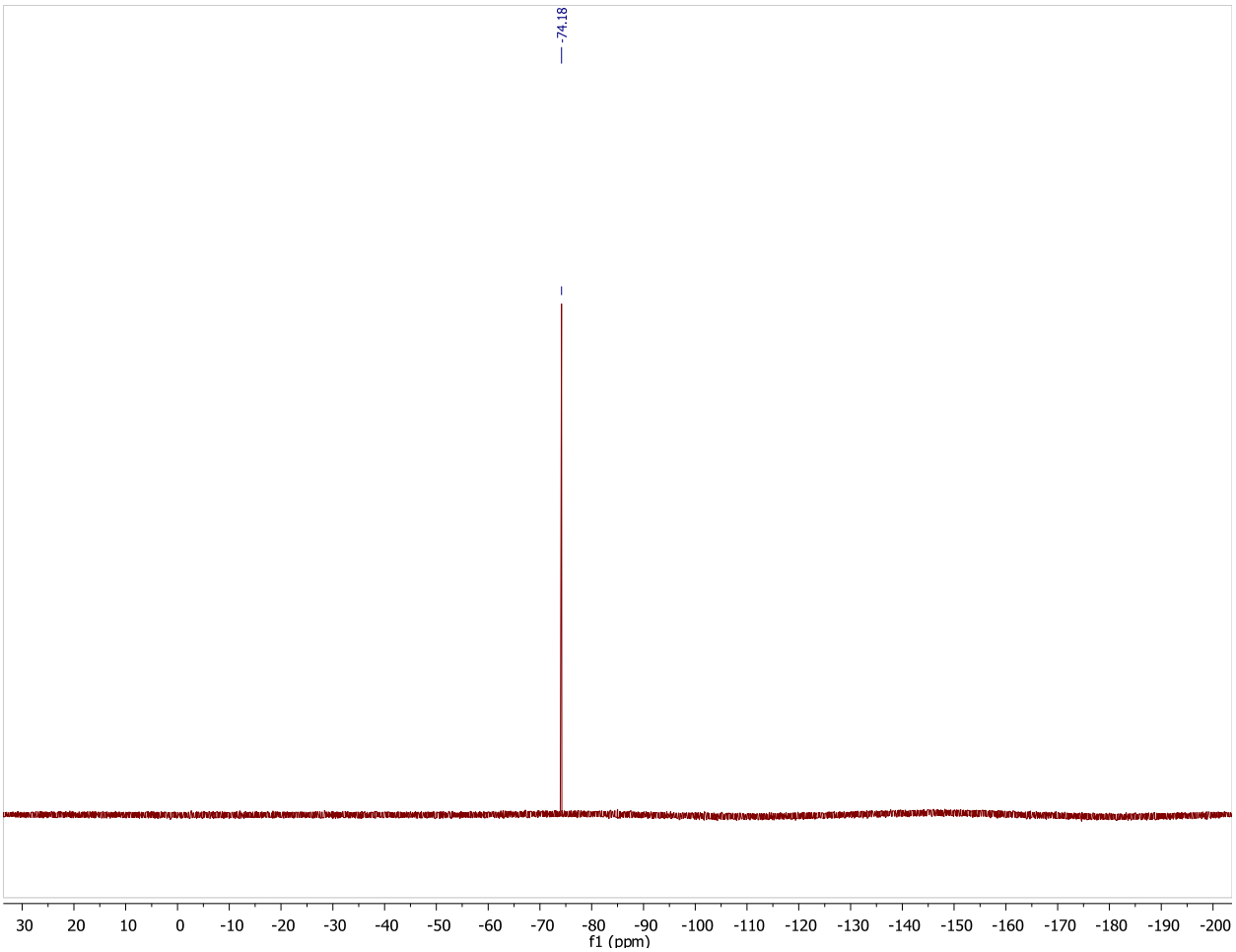

2h
Me
HN
tBu
OH
CF3
f1 (ppm)

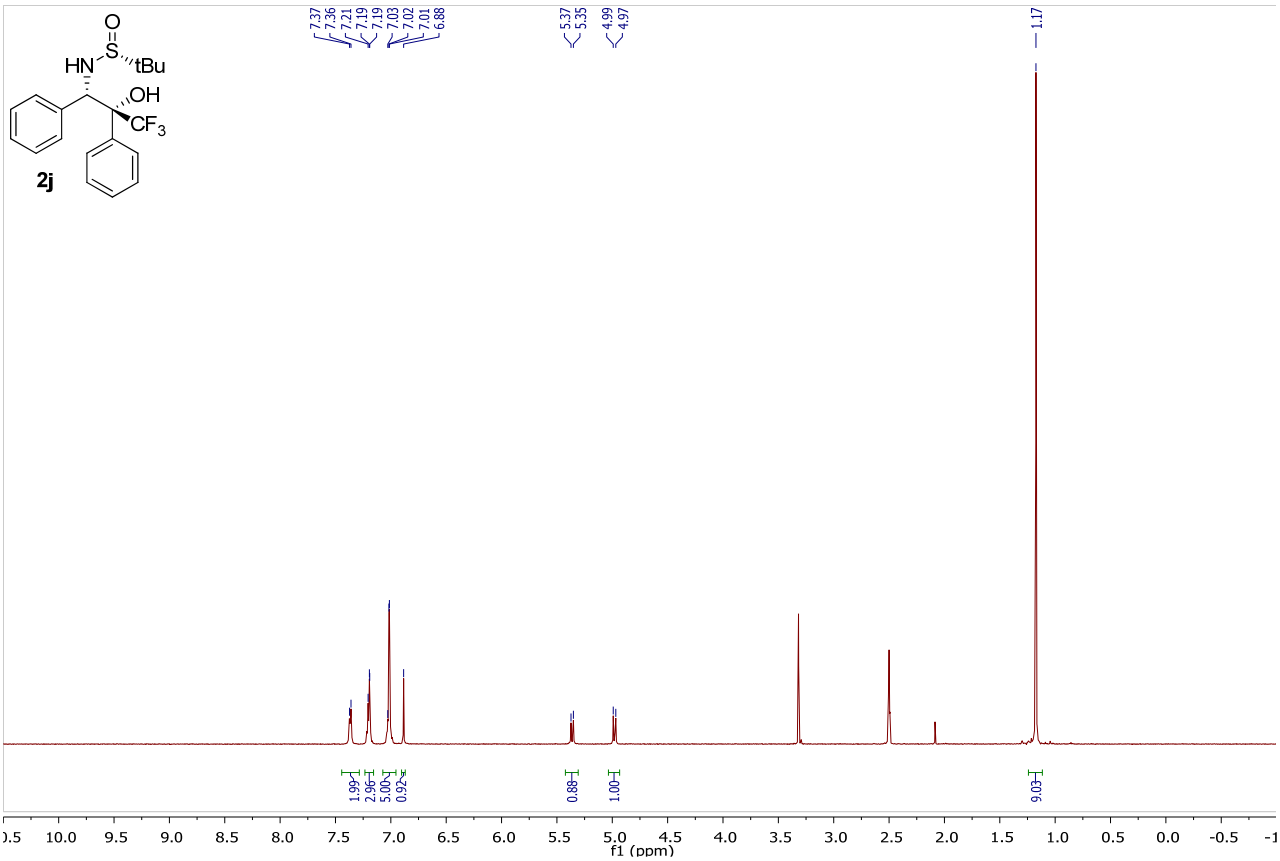

f1 (ppm)

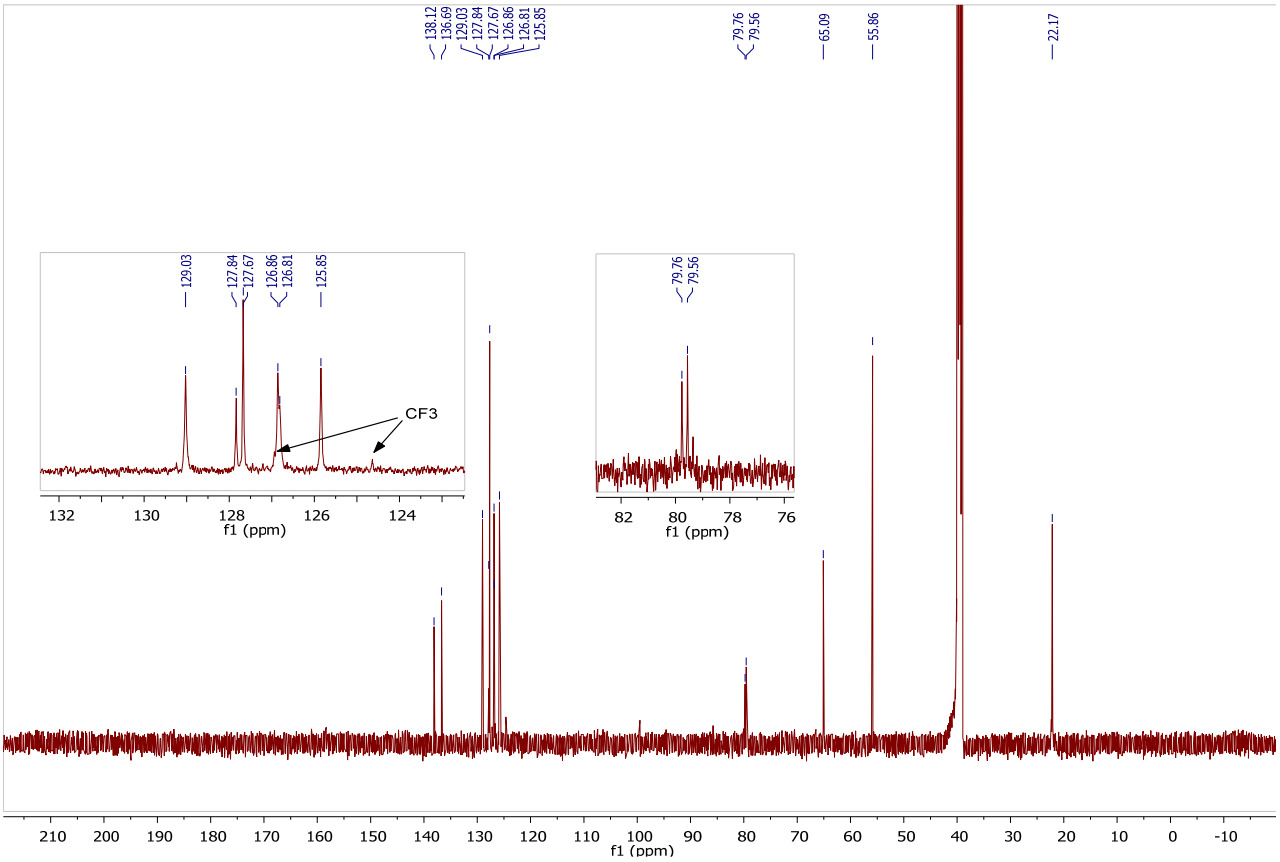

-73.29
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

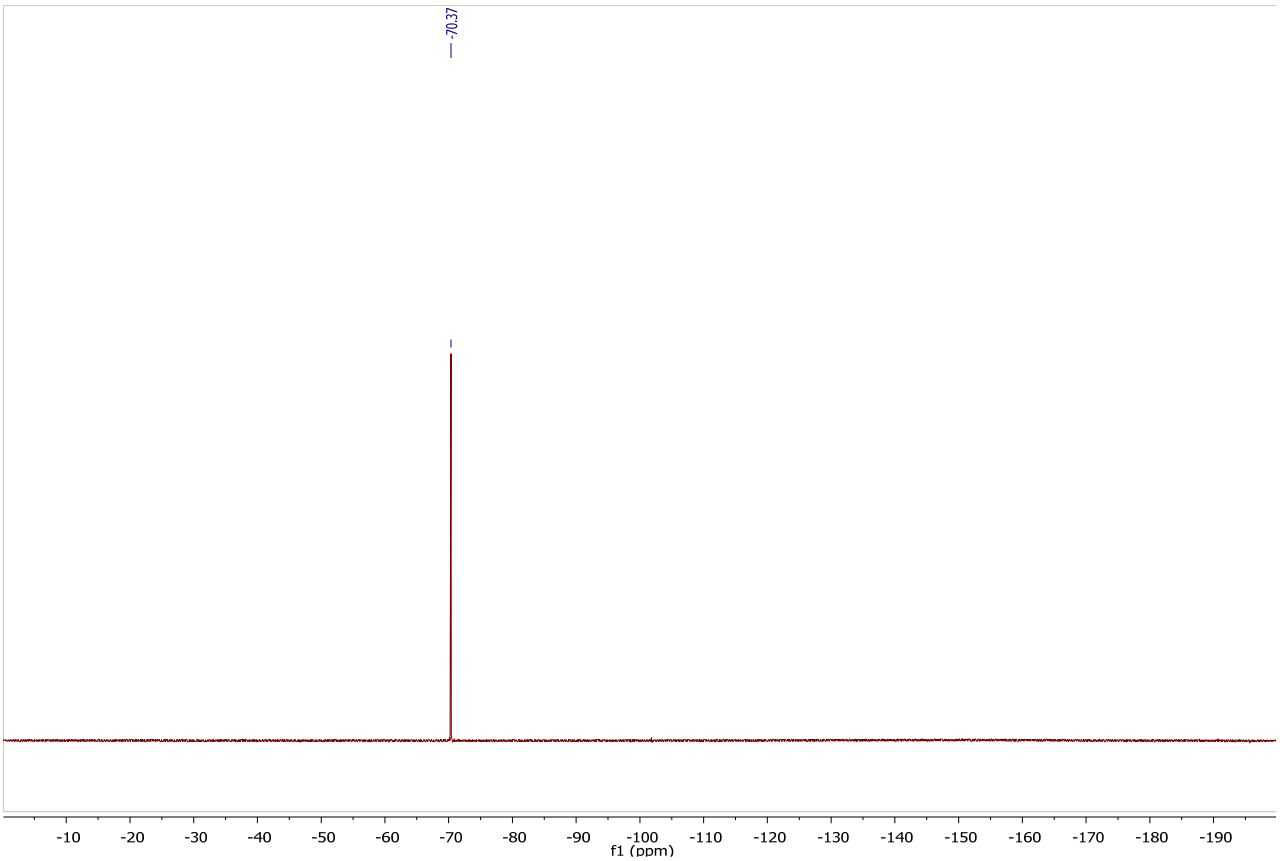

Me HN
O
S
tBu
OH
CF3
2i
7.68
7.66
7.46
7.45
7.20
7.20
7.18
7.17
7.15
7.14
7.03
7.02
6.94
6.93
6.92
6.91
6.90
6.90
6.19
5.60
5.59
4.42
2.38
1.22
0.98
1.90
3.01
1.97
0.98
0.99
1.00
0.98
3.02
9.29
f1 (ppm)

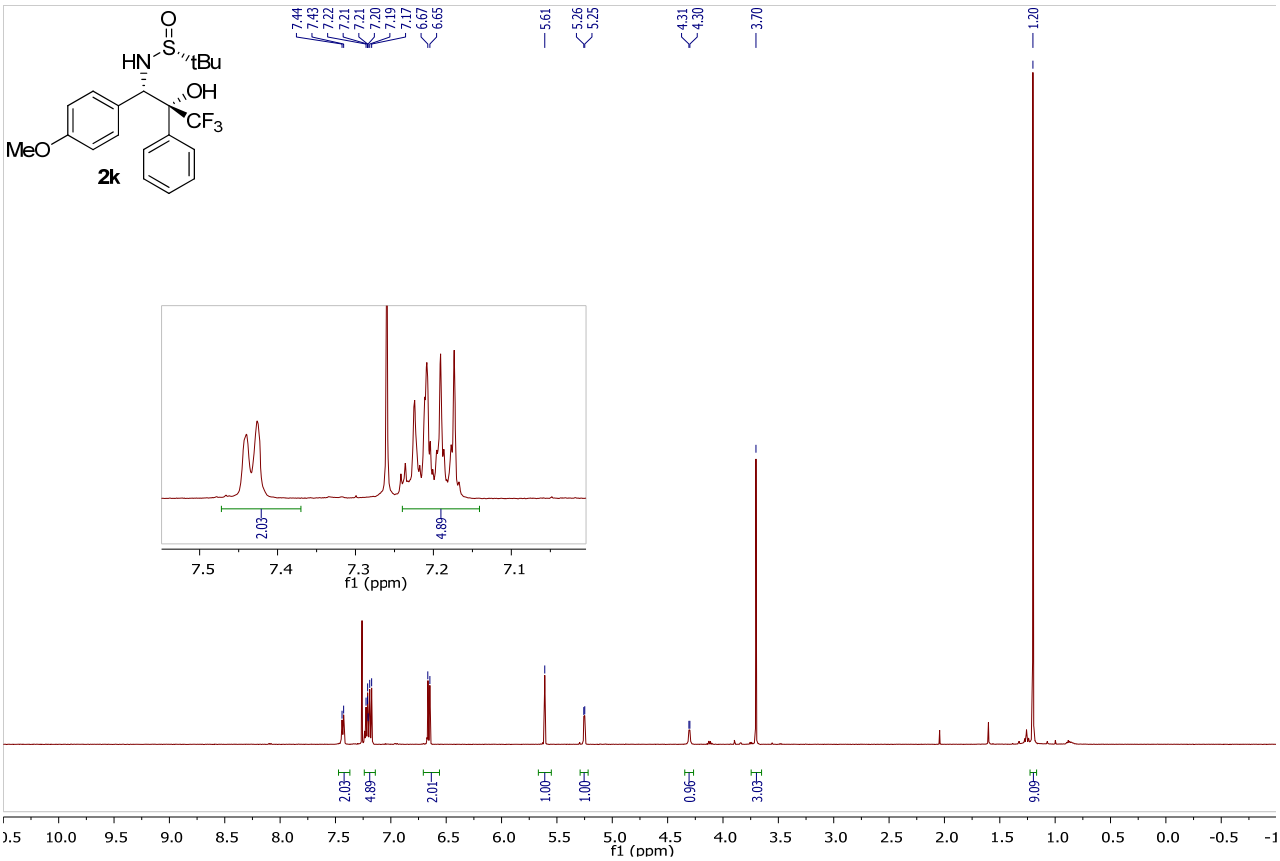

136.56
136.21
133.27
130.58
130.36
128.30
128.19
128.04
127.06
126.28
125.79
124.76
78.39
78.19
77.99
77.79
59.17
55.83
22.76
19.61
f1 (ppm)

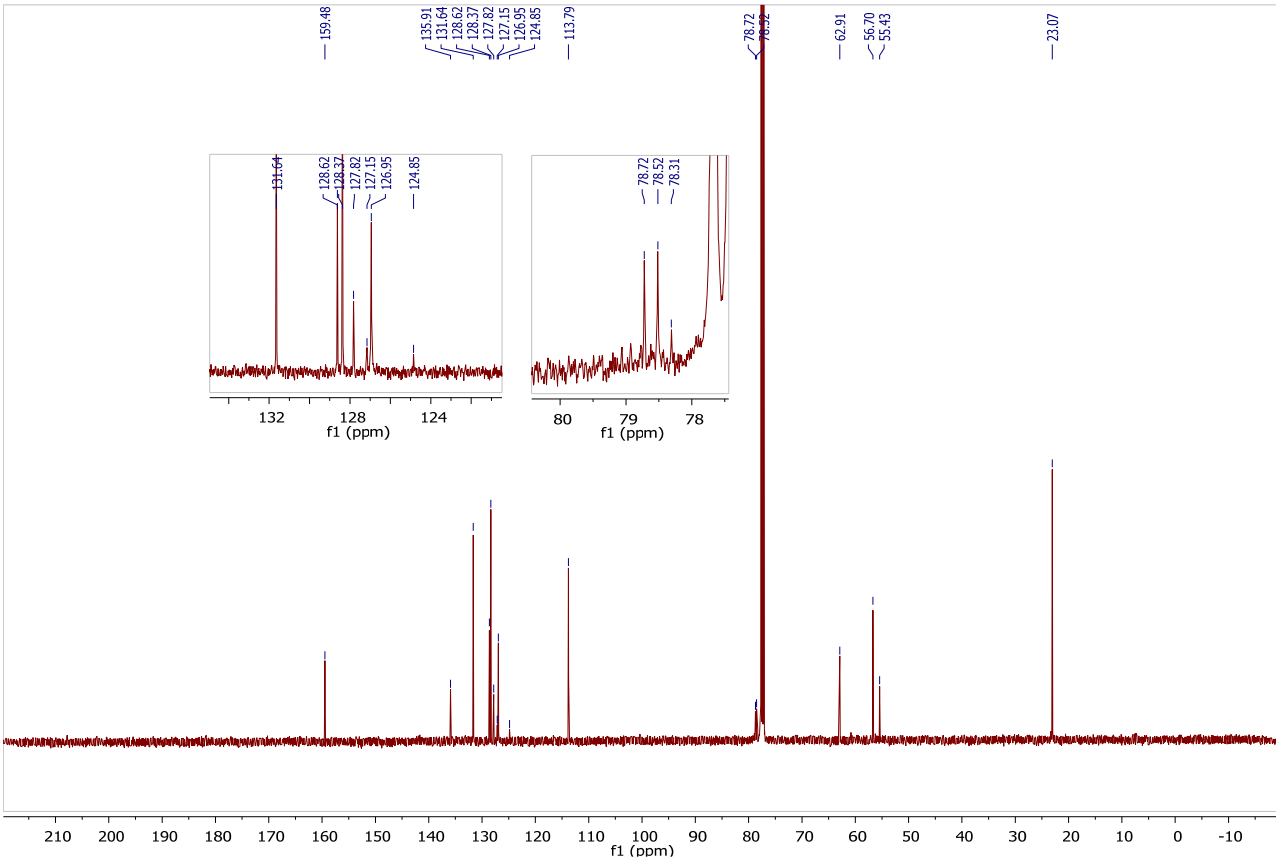

-74.18
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
f1 (ppm)

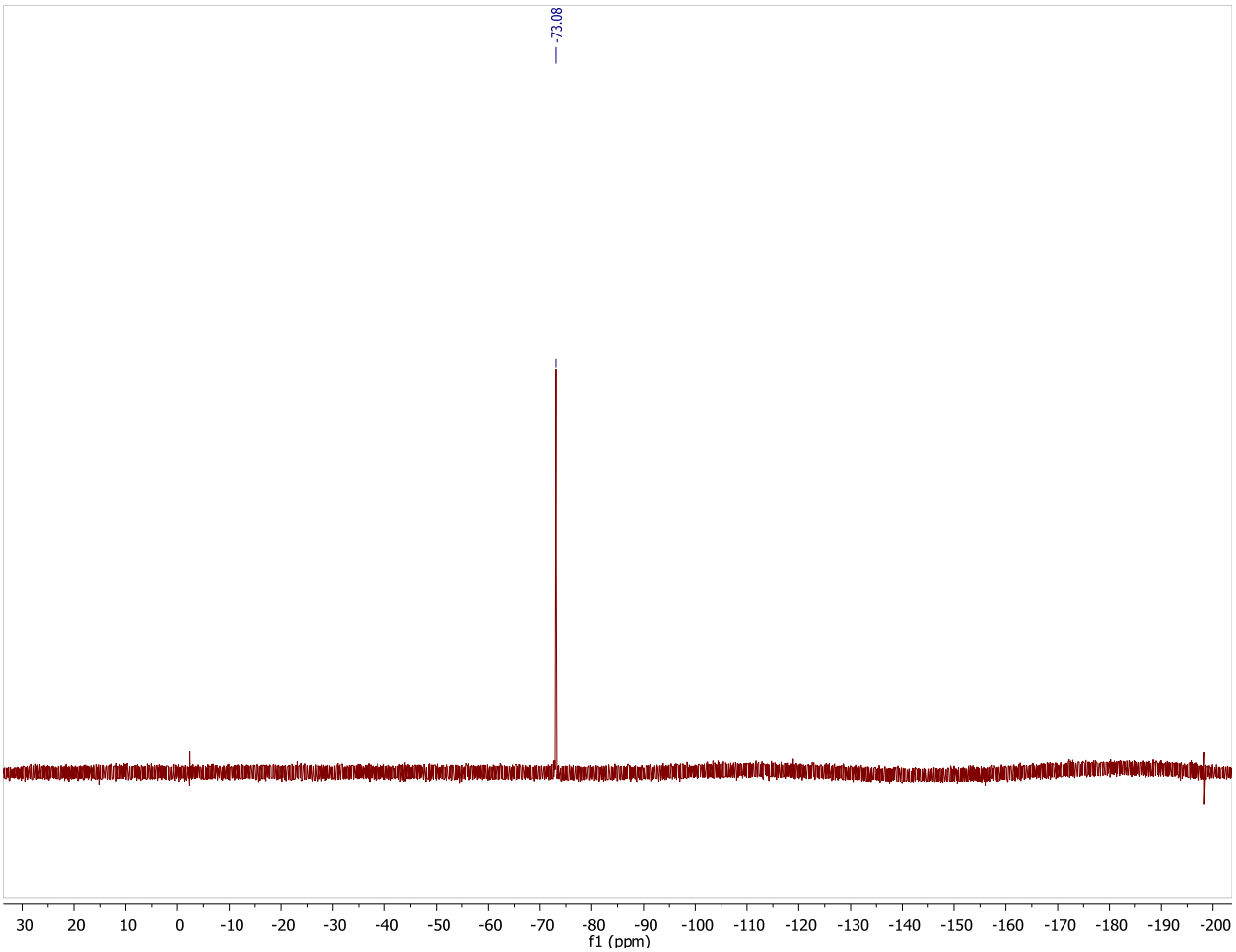

2j
7.37
7.36
7.21
7.19
7.19
7.03
7.02
7.01
6.88
5.37
5.35
4.99
4.97
1.17
1.99
2.96
5.00
0.92
0.88
1.00
9.03
f1 (ppm)


138.12
136.69
129.03
127.84
127.67
126.86
126.81
125.85
79.76
79.56
65.09
55.86
22.17
CF3
f1 (ppm)
f1 (ppm)
f1 (ppm)


-70.37
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
f1 (ppm)


HN
S
O
tBu
OH
CF3
MeO
2k
7.44
7.43
7.22
7.21
7.21
7.20
7.19
7.17
6.67
6.65
5.61
5.26
5.25
4.31
4.30
3.70
1.20
2.03
4.89
7.5
7.4
7.3
7.2
7.1
f1 (ppm)
2.03
4.89
2.01
1.00
1.00
0.96
3.03
9.09
f1 (ppm)


159.48
135.91
131.64
128.62
128.37
127.82
127.15
126.95
124.85
113.79
78.72
78.52
62.91
56.70
55.43
23.07
131.64
128.62
128.37
127.82
127.15
126.95
124.85
132
128
124
f1 (ppm)
78.72
78.52
78.31
80
79
78
f1 (ppm)
f1 (ppm)


-73.08
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
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-120
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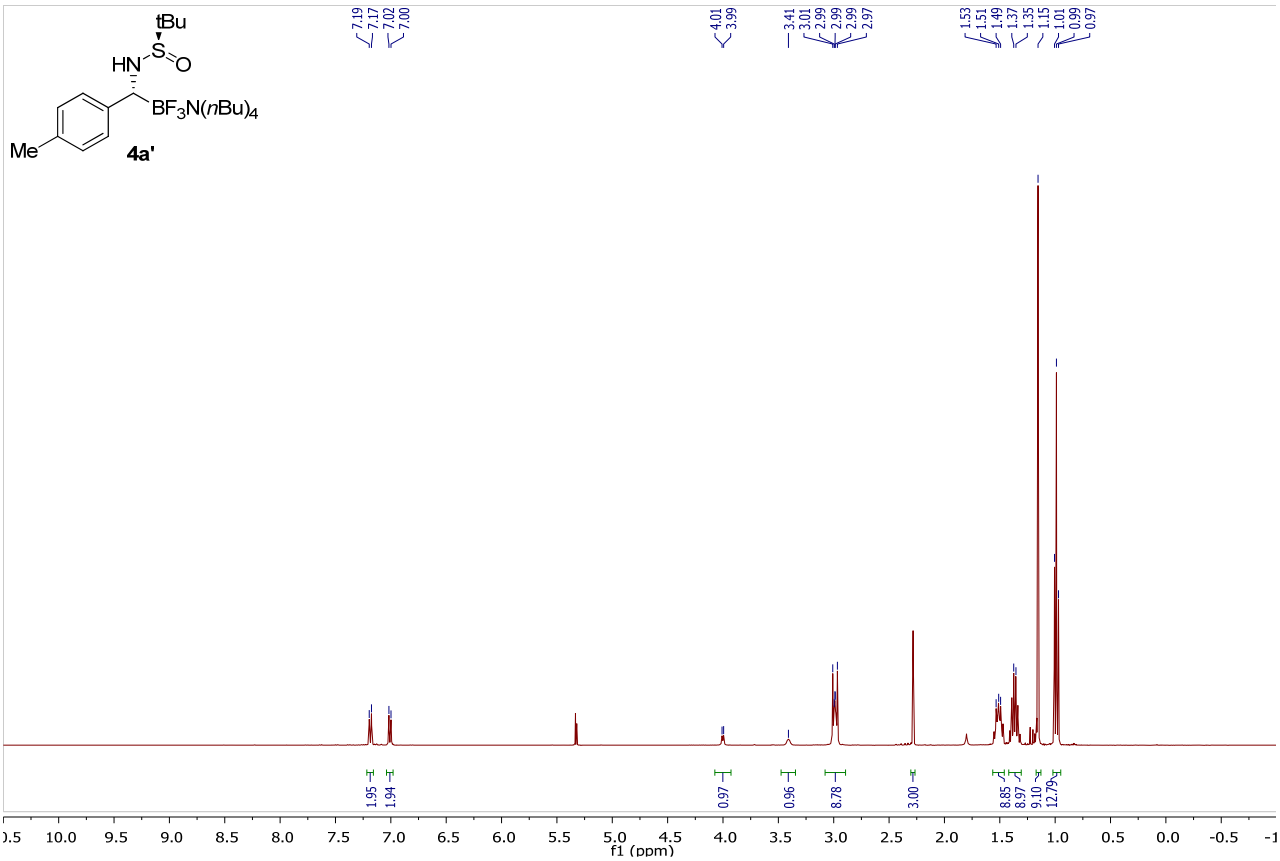
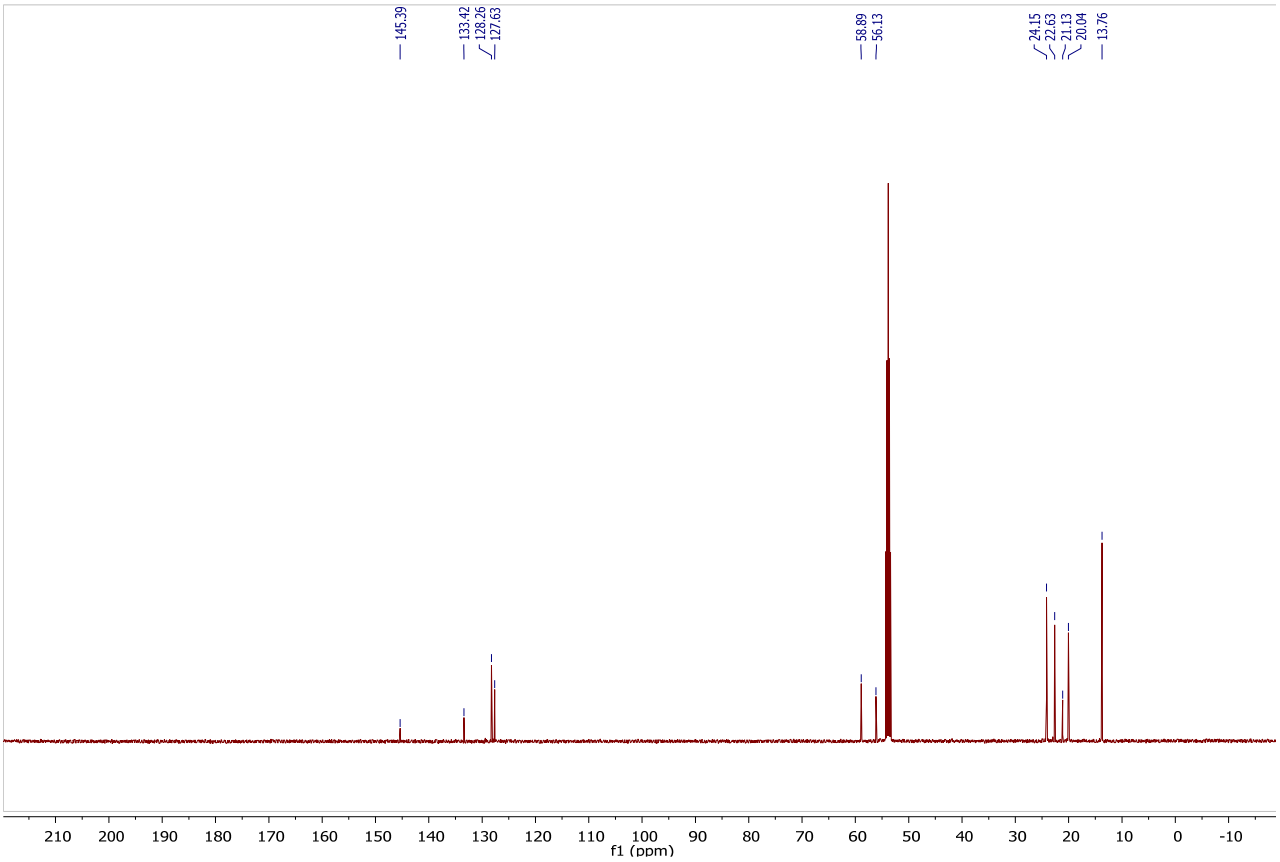
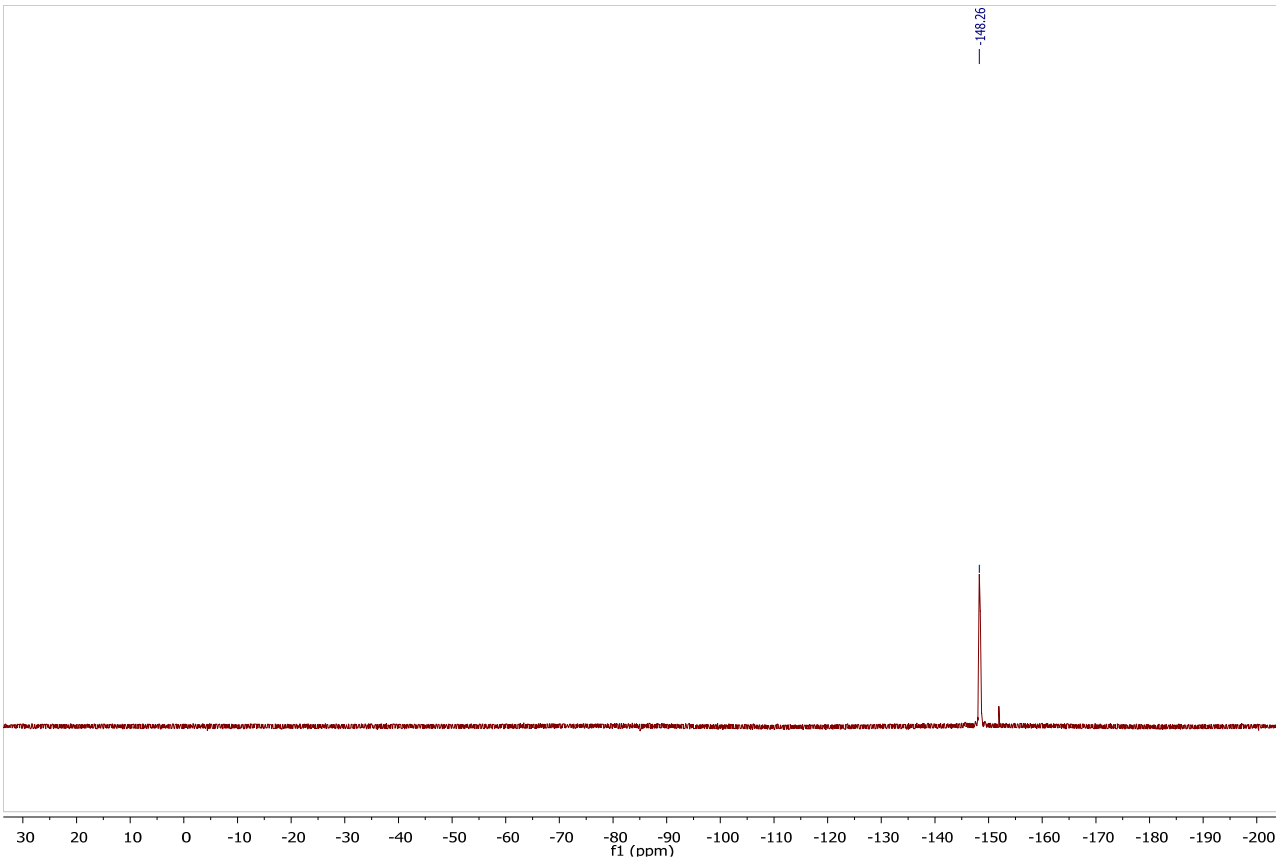
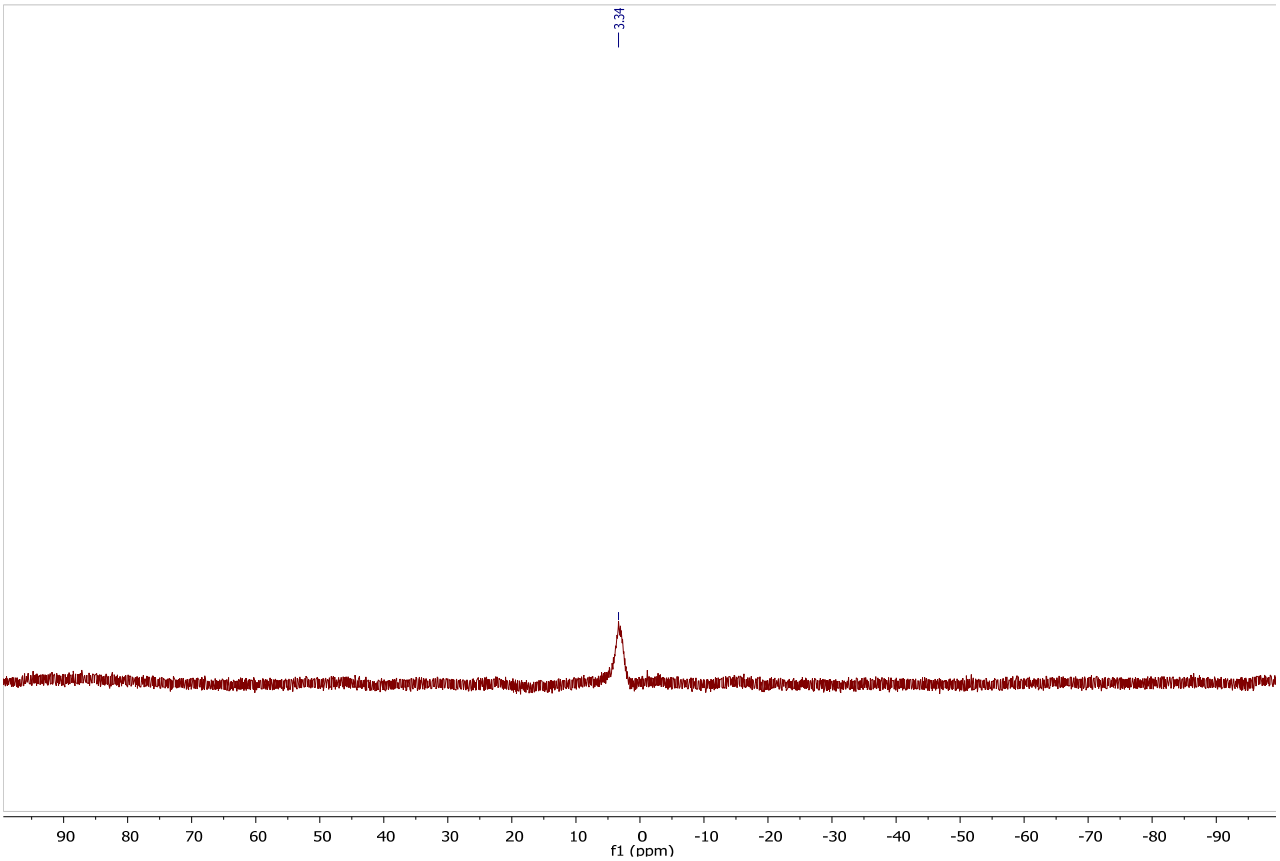
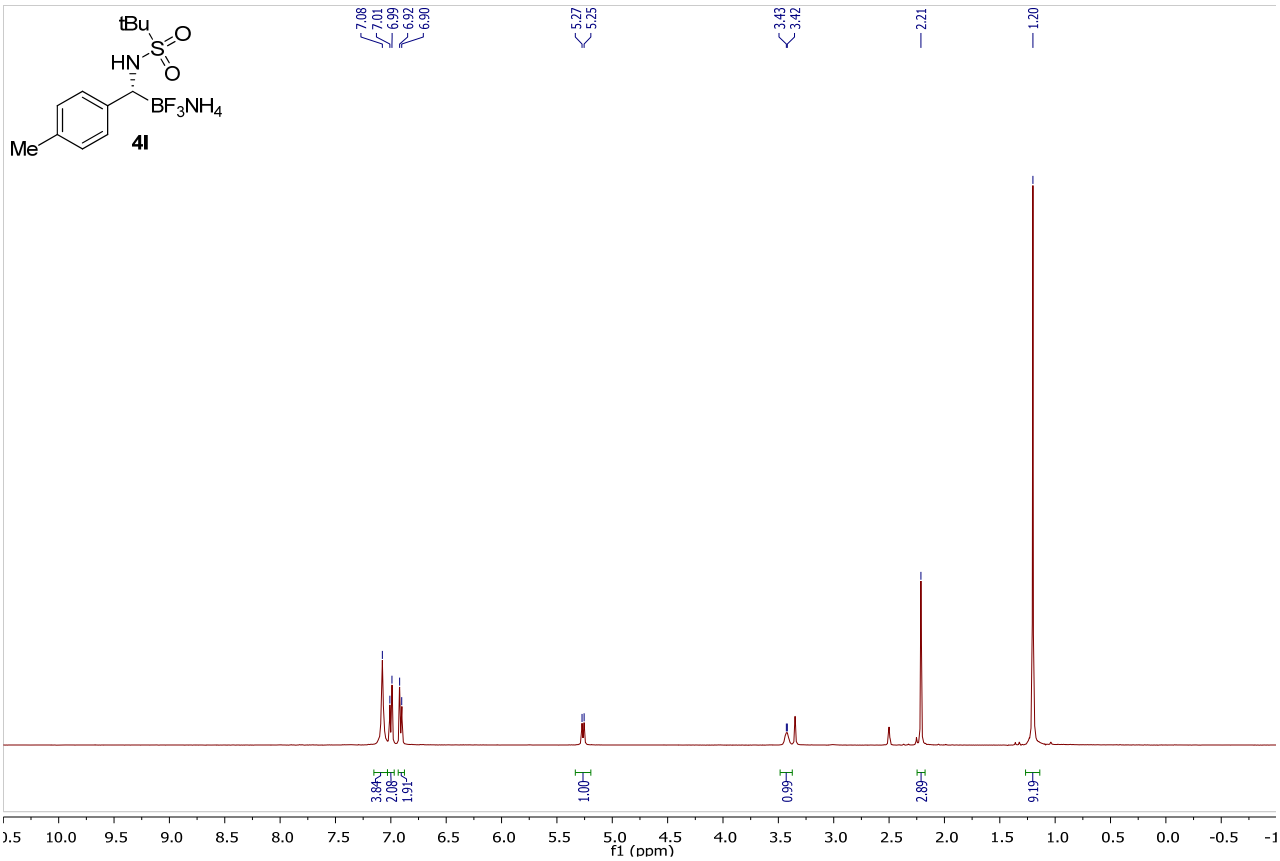
-140
-150
-160
-170
-180
-190
-200
f1 (ppm)

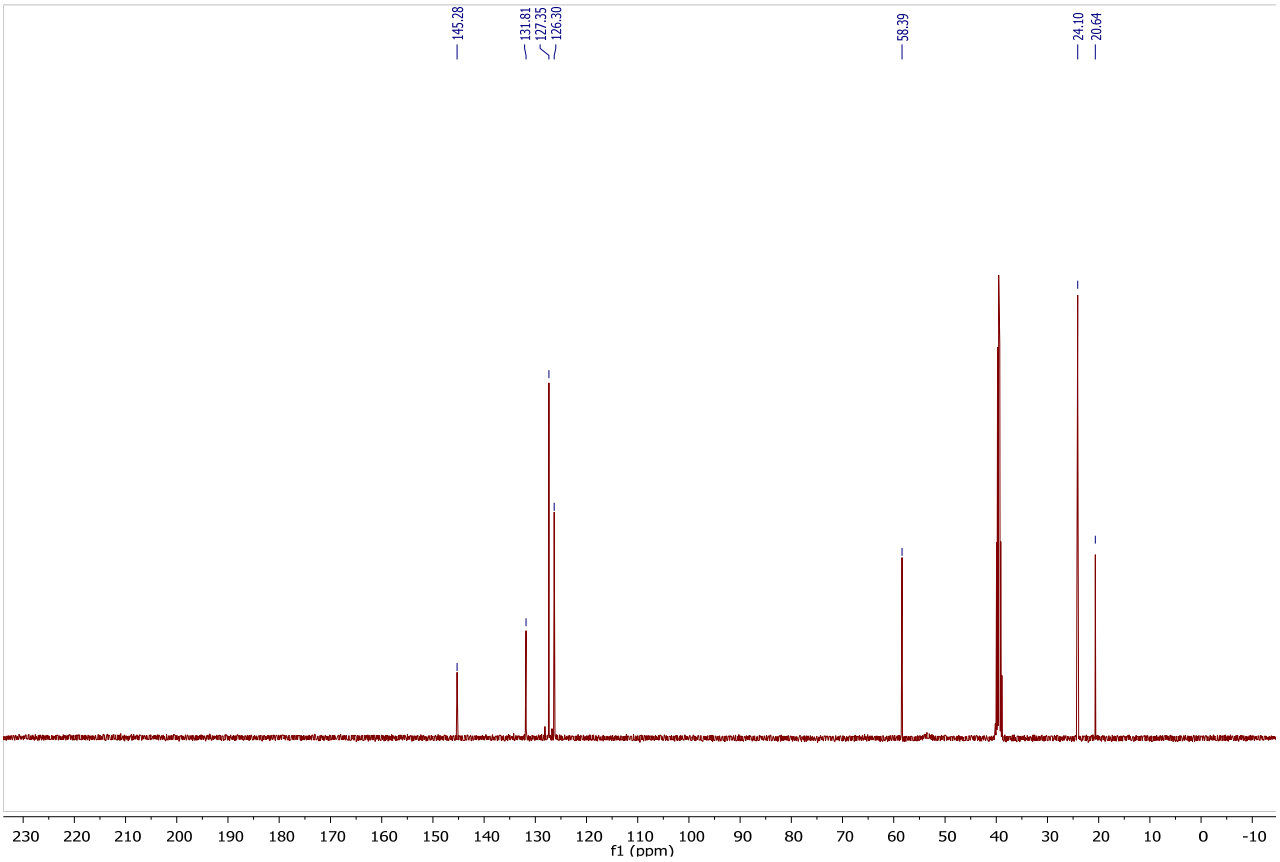

tBu
HN
S
O
BF3N(nBu)4
Me
4a'
7.19
7.17
7.02
7.00
4.01
3.99
3.41
3.01
2.99
2.99
2.99
2.97
1.53
1.51
1.49
1.37
1.35
1.15
1.01
0.99
0.97
1.95
1.94
0.97
0.96
8.78
3.00
8.85
8.97
9.10
12.79
f1 (ppm)

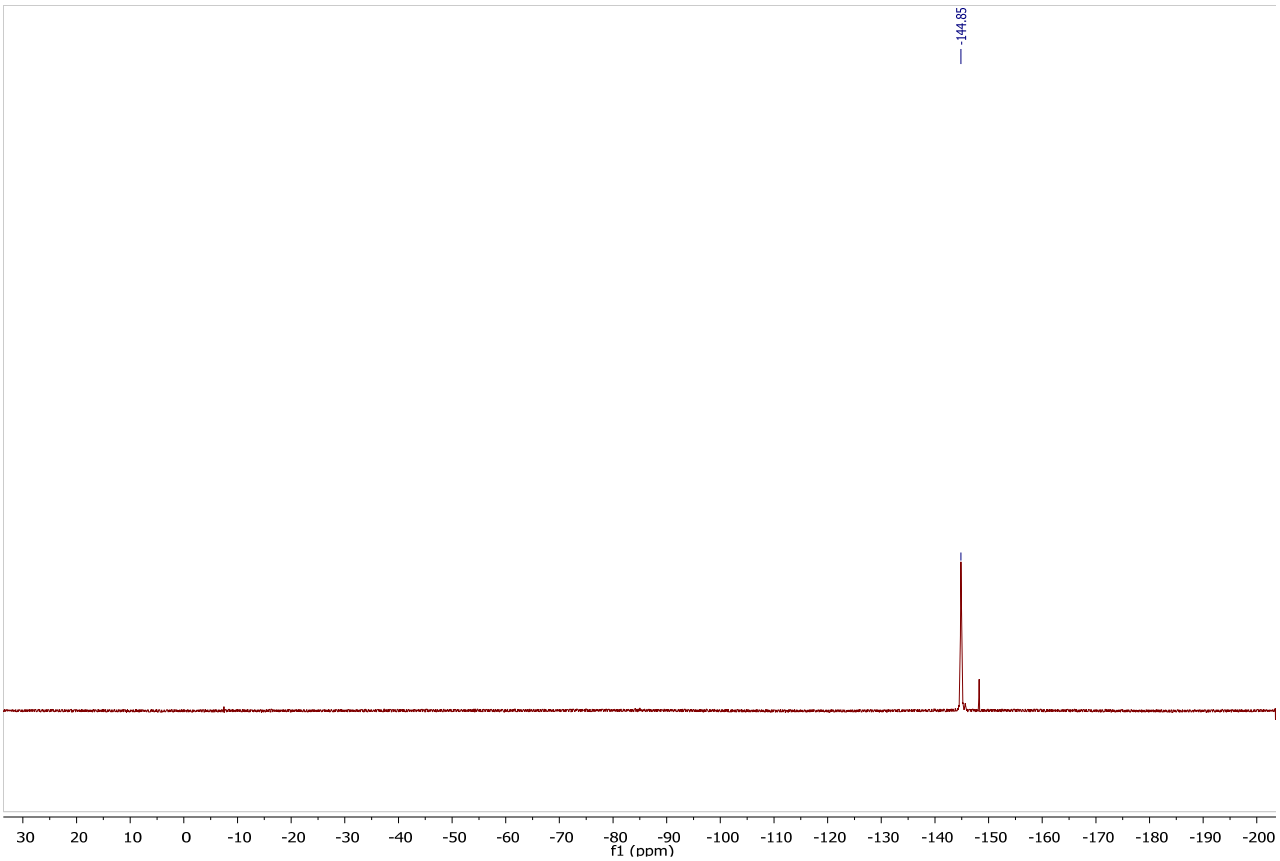

145.39
133.42
128.26
127.63
58.89
56.13
24.15
22.63
21.13
20.04
13.76
f1 (ppm)

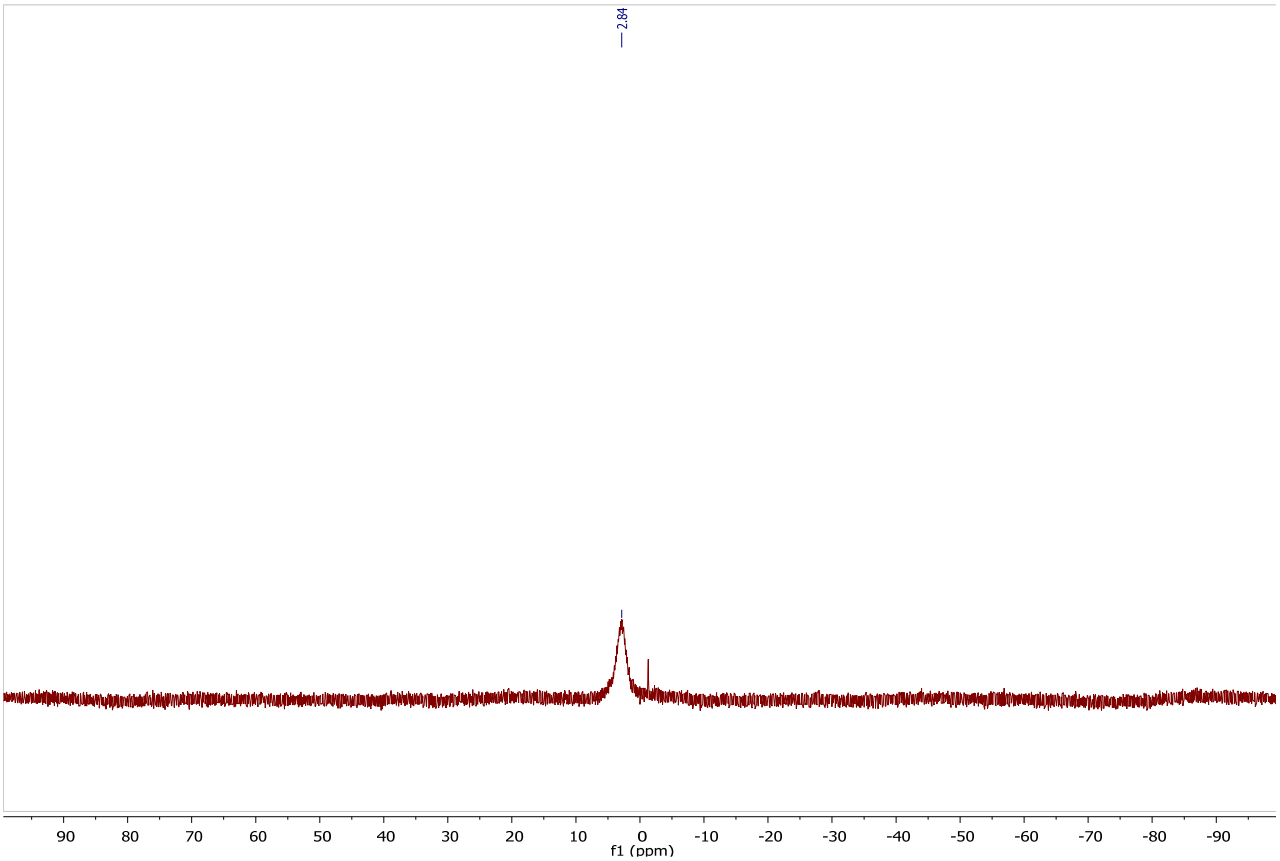

-148.26
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

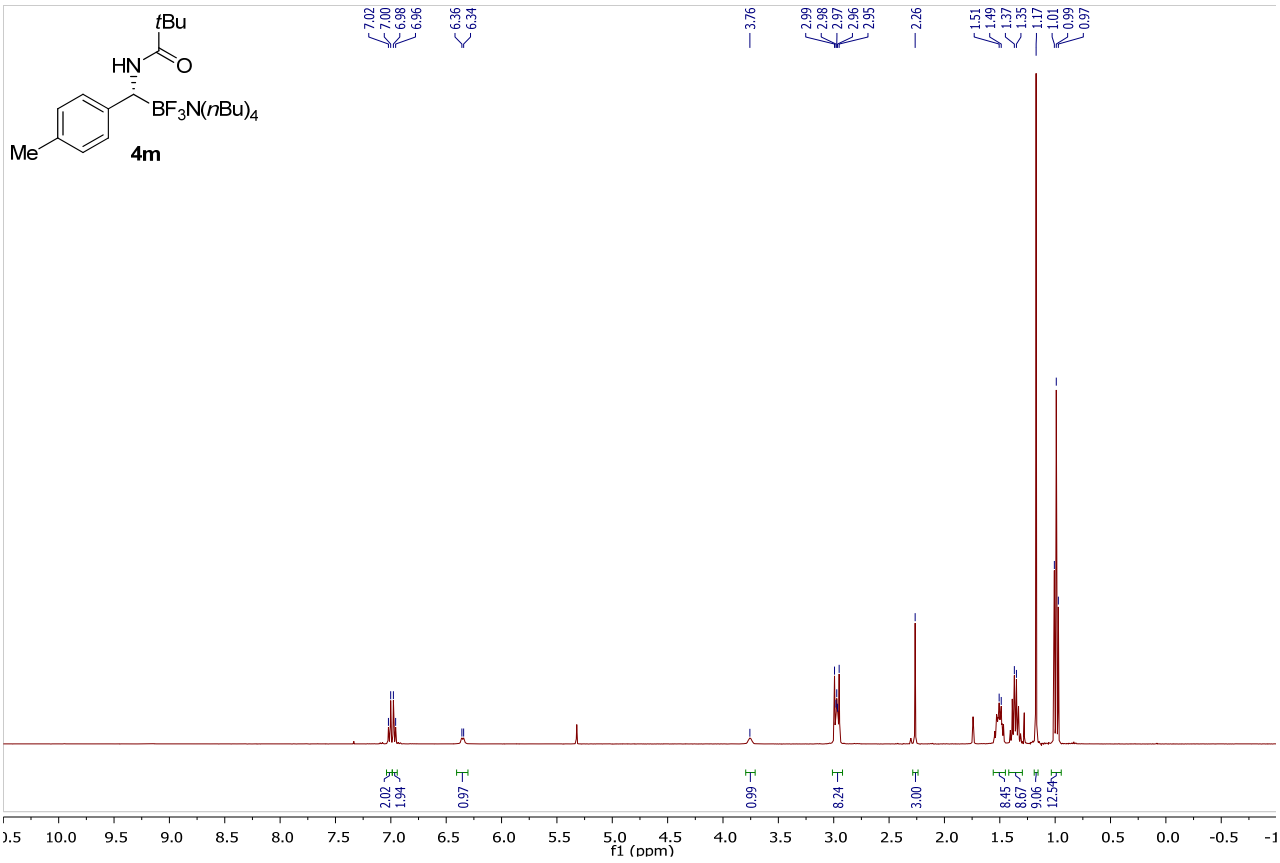

3.34
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)

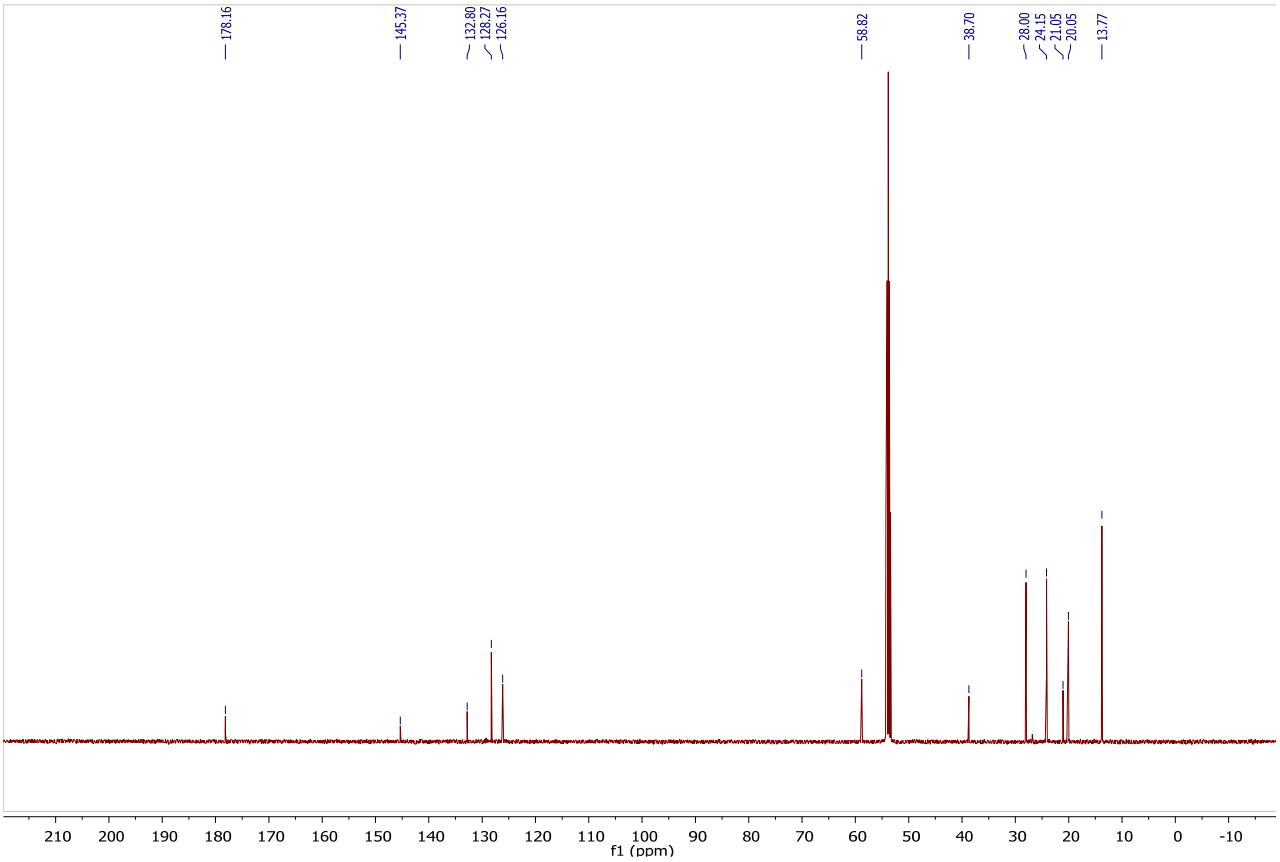

tBu
HN
S
O
O
BF3NH4
Me
4l
7.08
7.01
6.99
6.92
6.90
5.27
5.25
3.43
3.42
2.21
1.20
3.84
2.08
1.91
1.00
0.99
2.89
9.19
f1 (ppm)

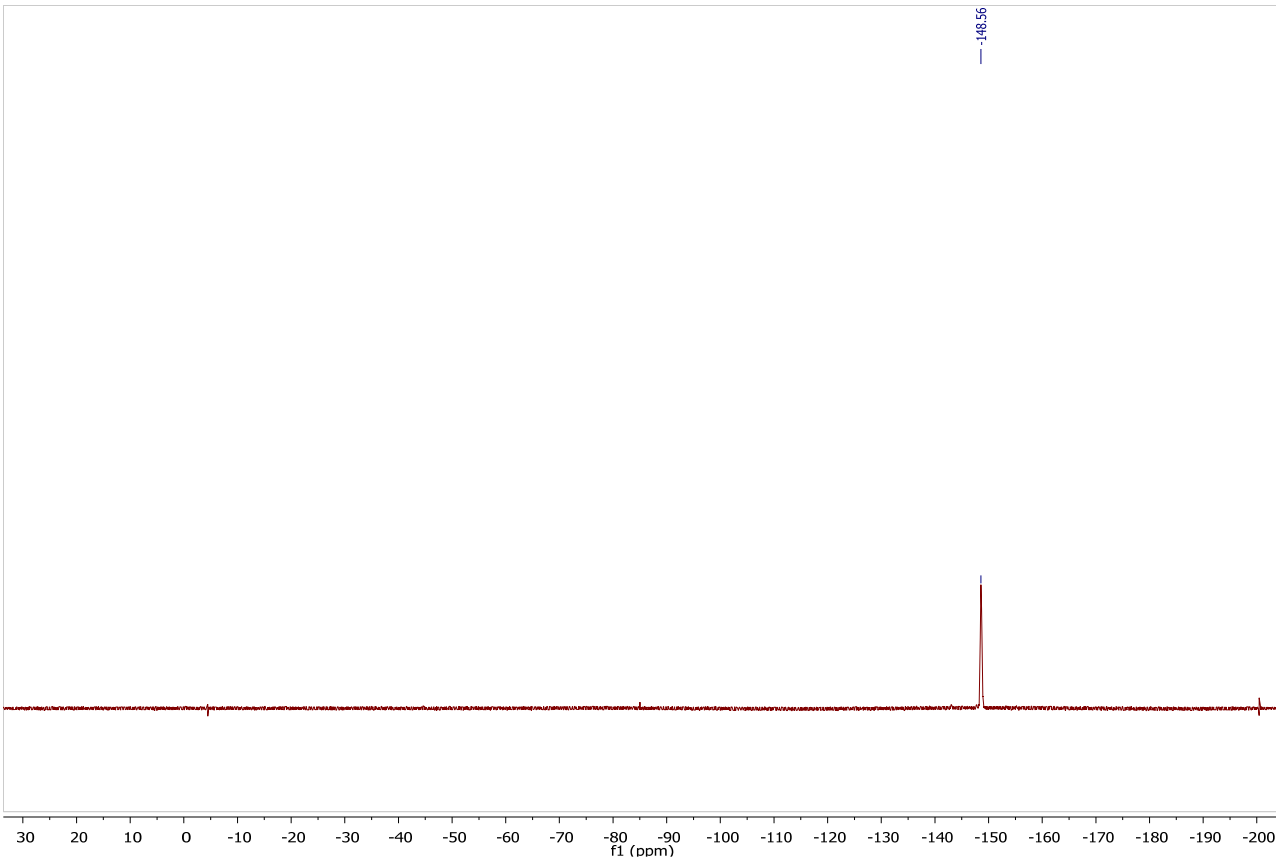

145.28
131.81
127.35
126.30
58.39
24.10
20.64
f1 (ppm)


-144.85
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


2.84
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)


tBu
HN
O
BF3N(nBu)4
Me
4m
7.02
7.00
6.98
6.96
6.36
6.34
3.76
2.99
2.98
2.97
2.96
2.95
2.26
1.51
1.49
1.37
1.35
1.17
1.01
0.99
0.97
2.02
1.94
0.97
0.99
8.24
3.00
8.45
8.67
9.06
12.54
f1 (ppm)


178.16
145.37
132.80
128.27
126.16
58.82
38.70
28.00
24.15
21.05
20.05
13.77
f1 (ppm)


-148.56
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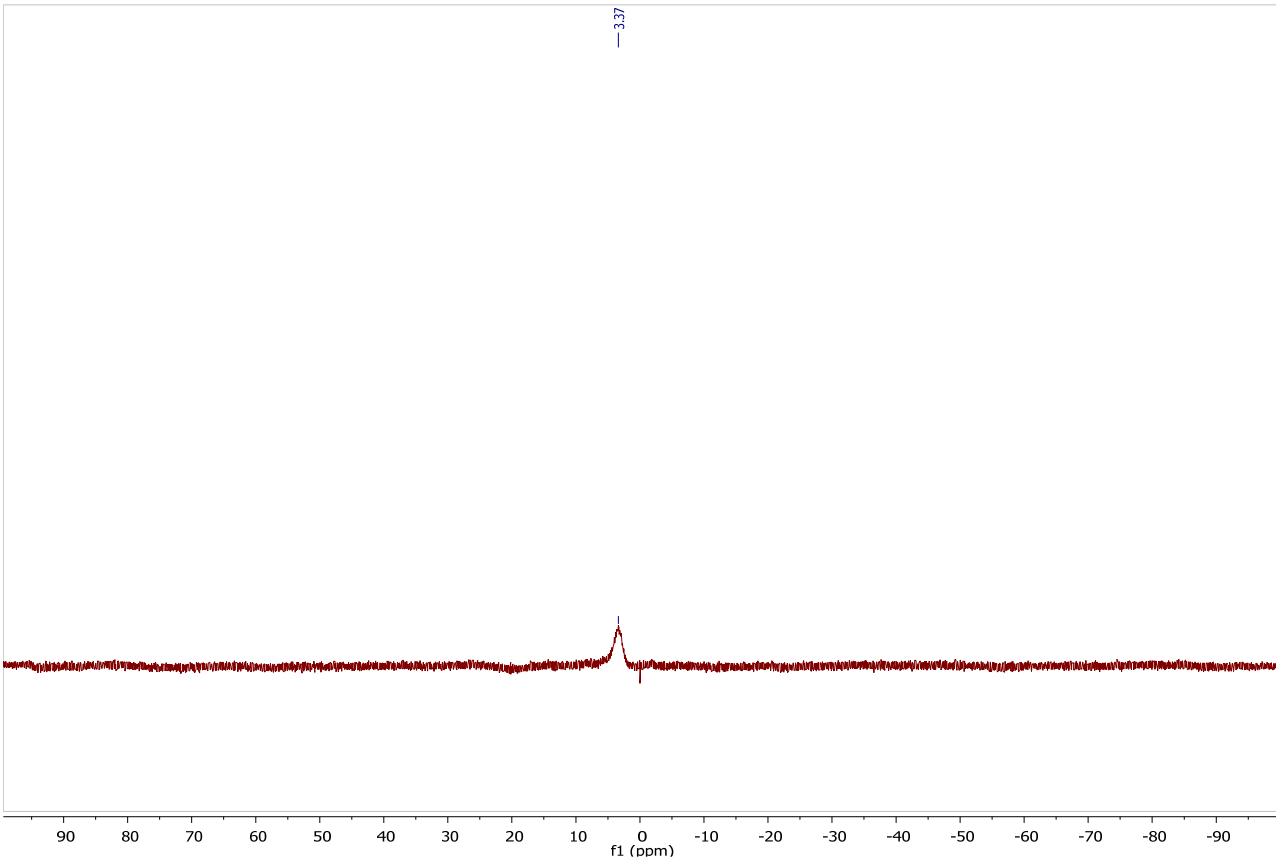
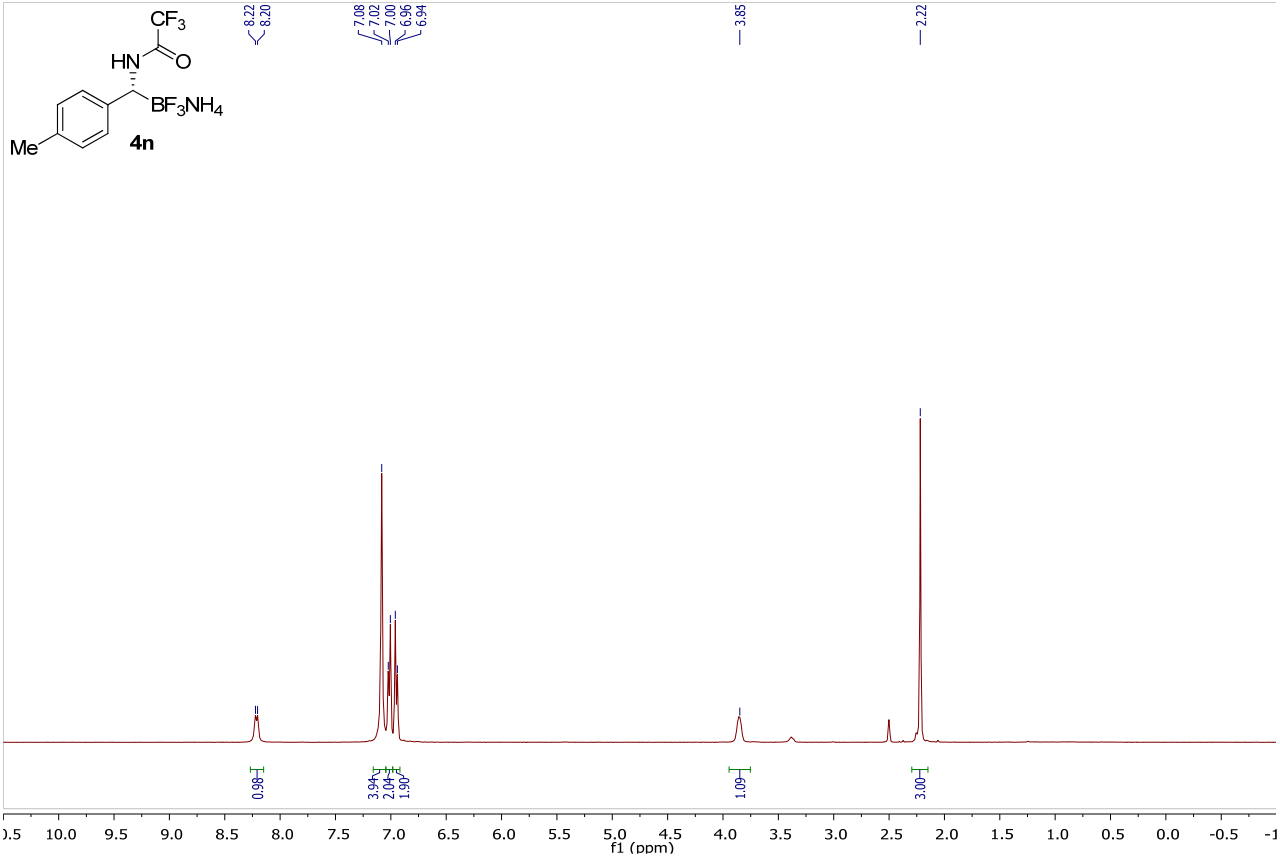
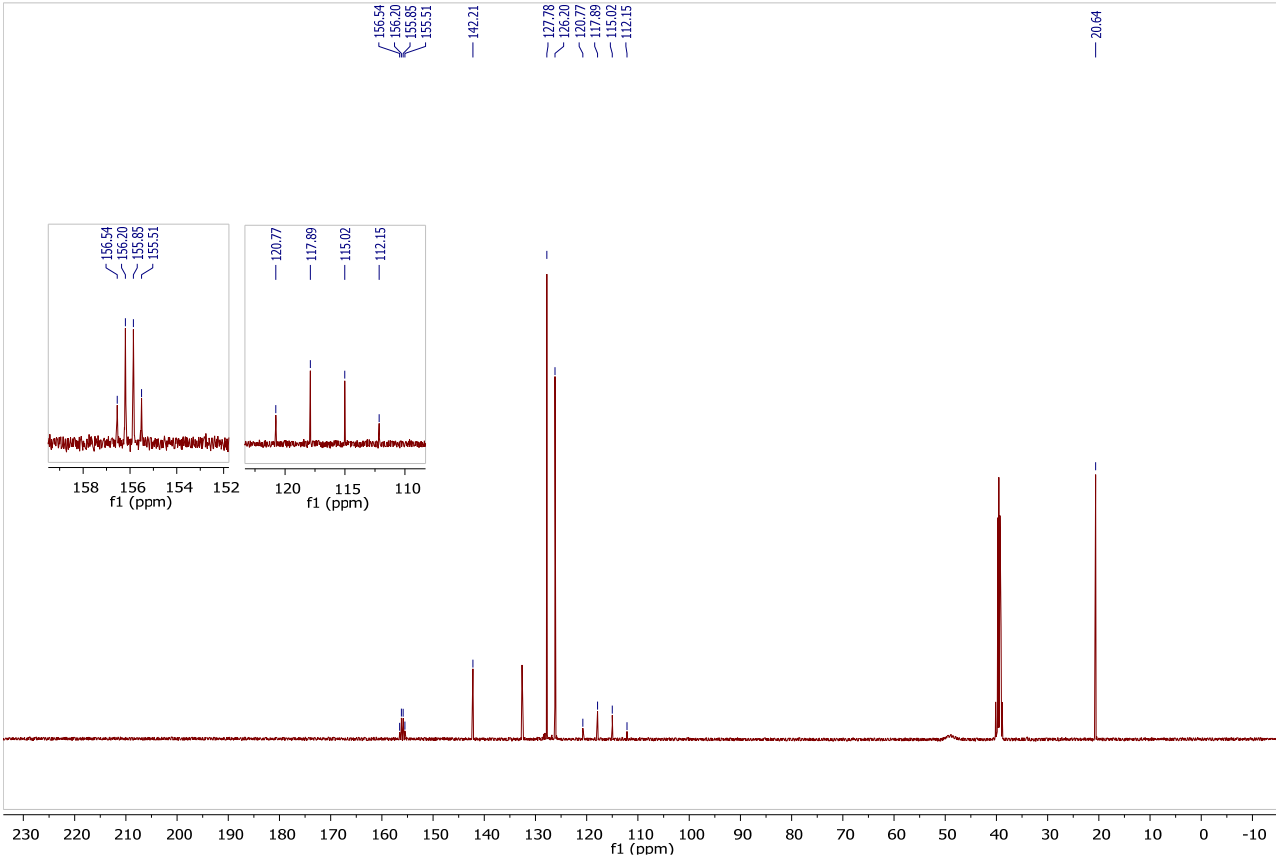
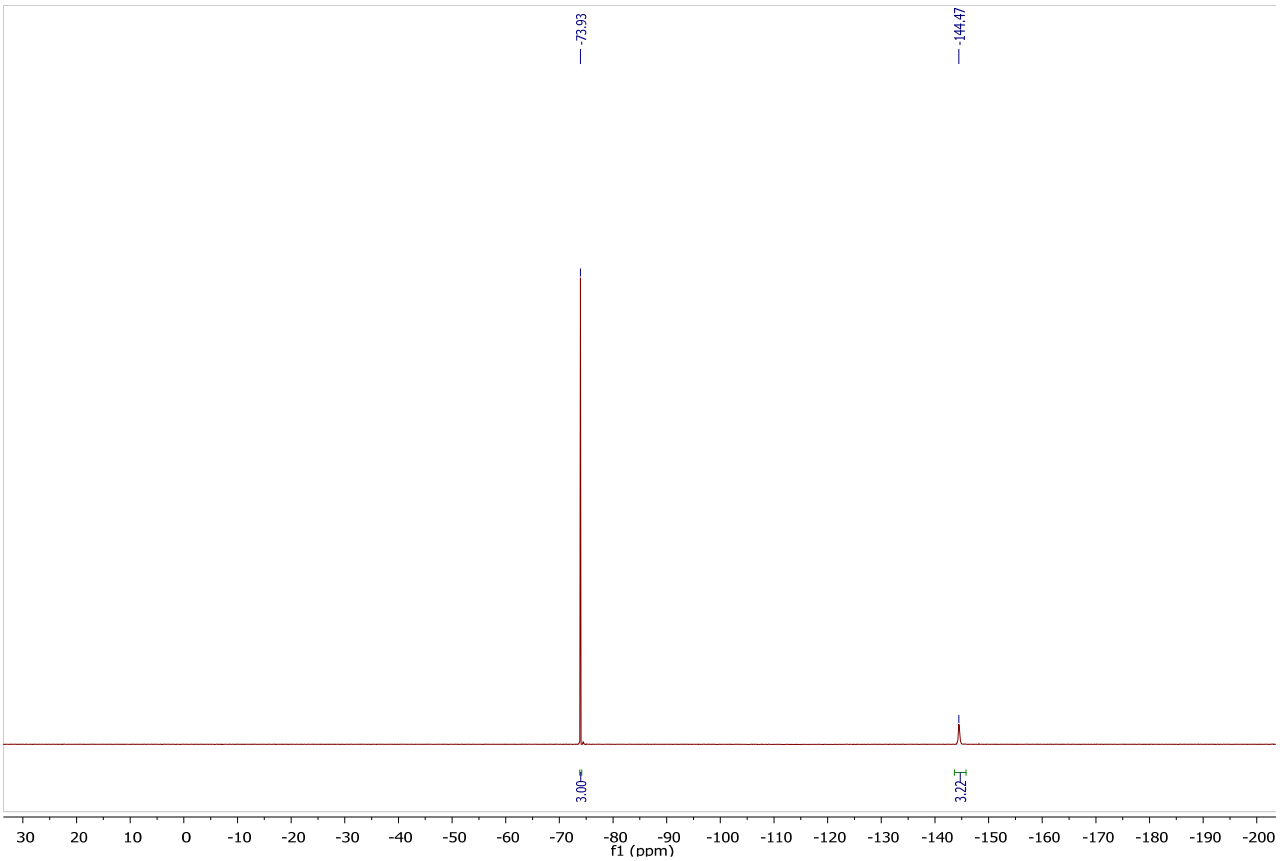
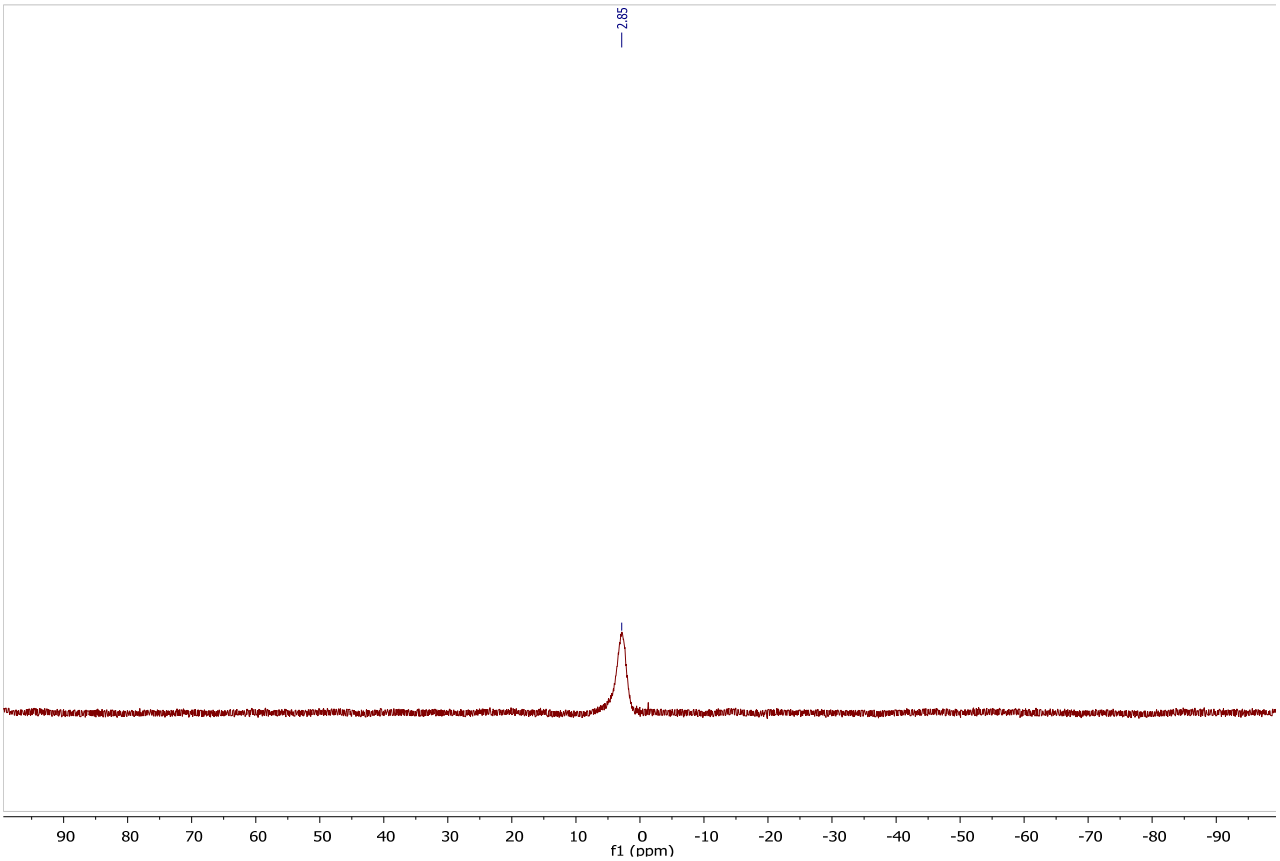
f1 (ppm)

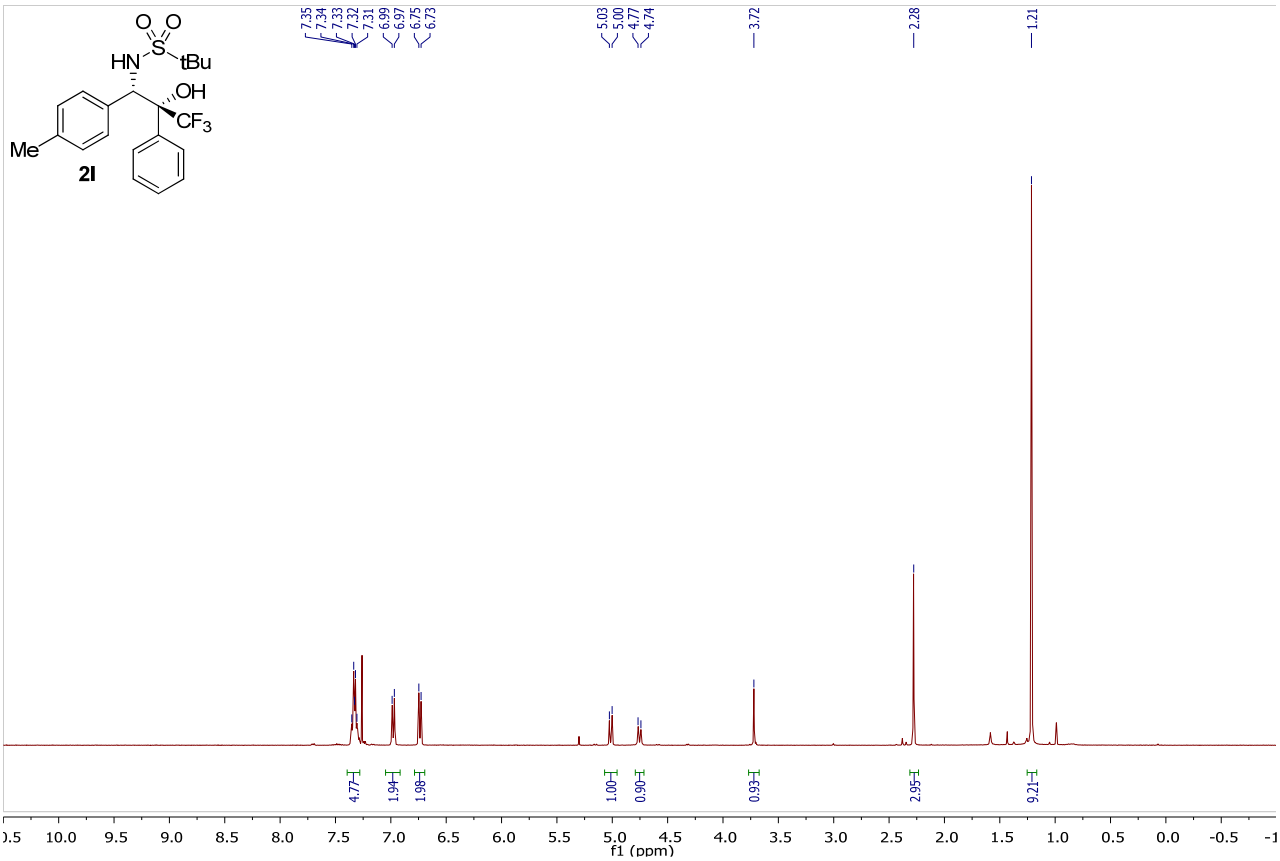

3.37
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)

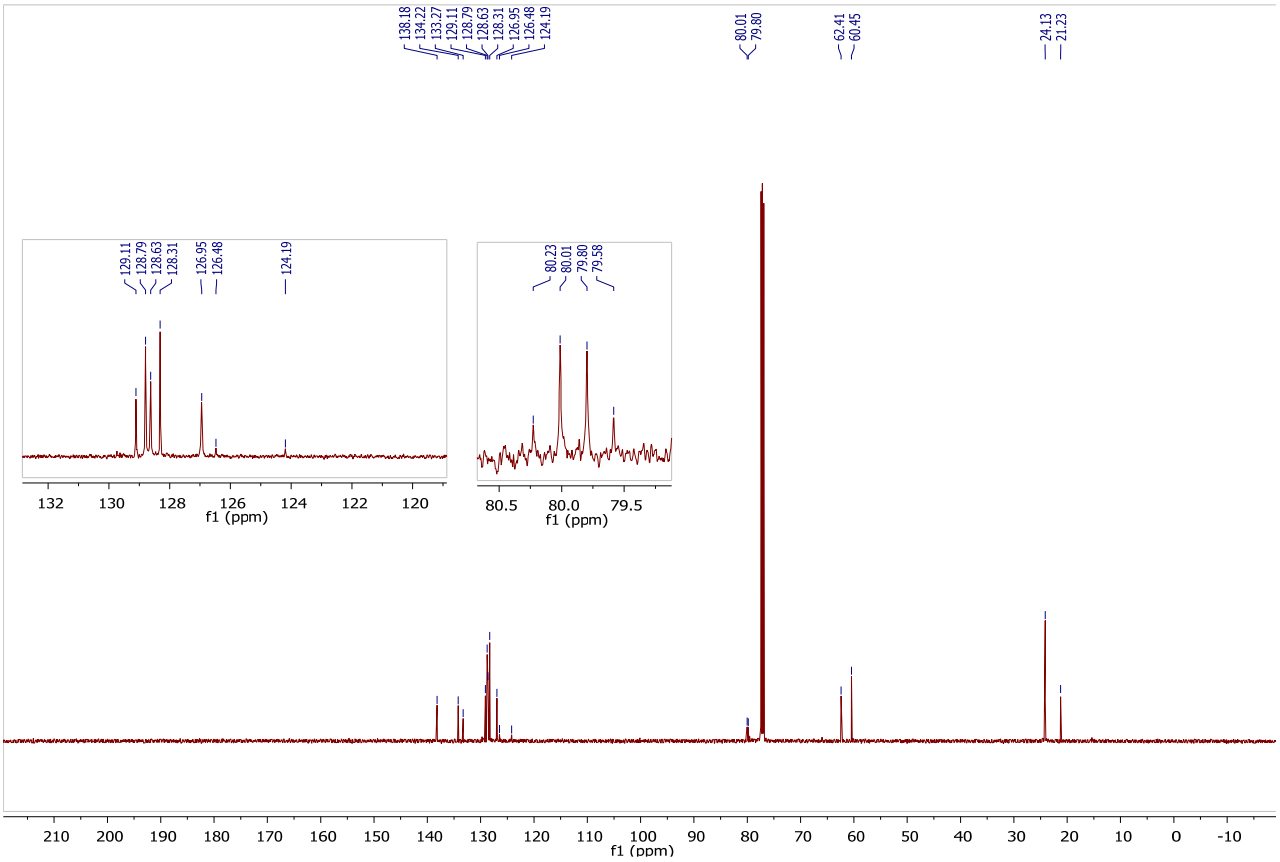

CF3
HN
O
BF3NH4
Me
4n
8.22
8.20
7.08
7.02
7.00
6.96
6.94
3.85
2.22
0.98
3.94
2.04
1.90
1.09
3.00
f1 (ppm)

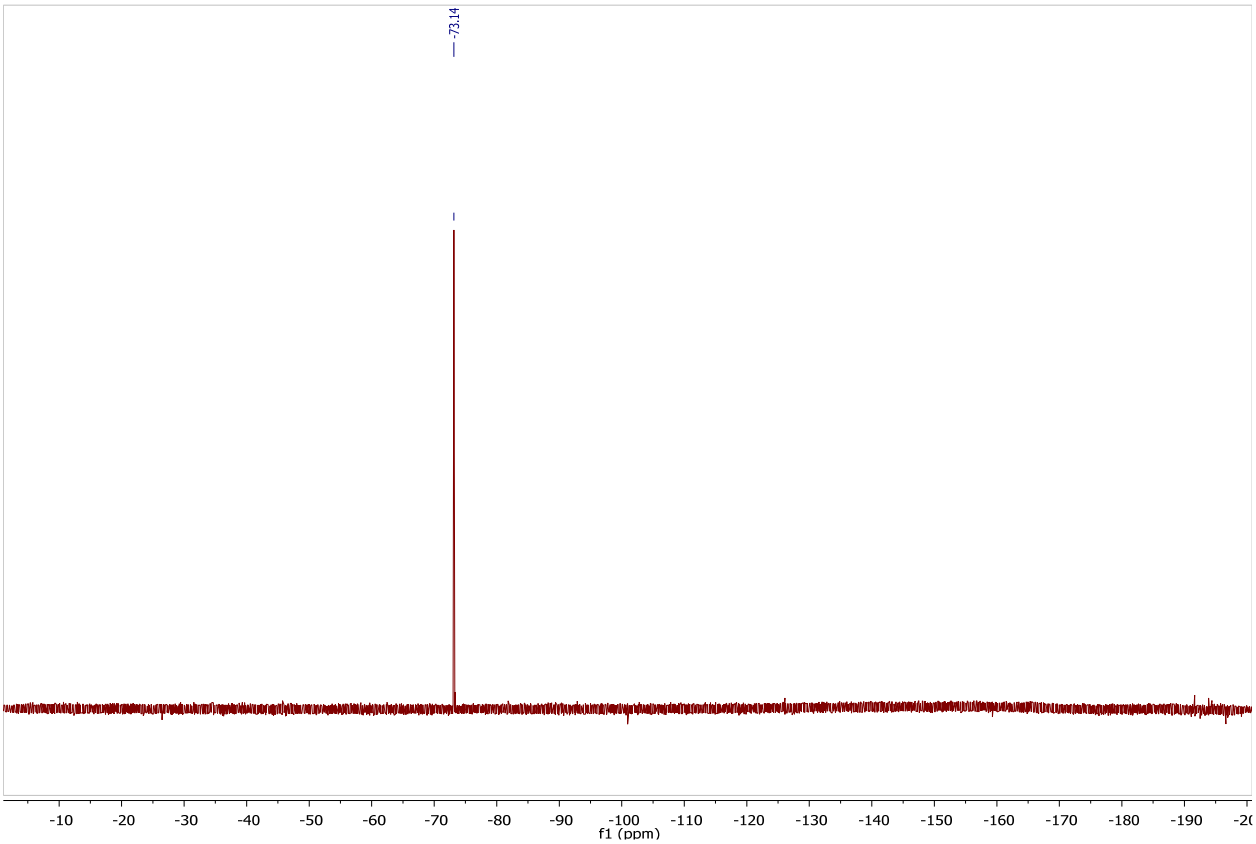

156.54
156.20
155.85
155.51
142.21
127.78
126.20
120.77
117.89
115.02
112.15
20.64
f1 (ppm)
f1 (ppm)
f1 (ppm)


-73.93
-144.47
3.00
3.22
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


2.85
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)


7.35
7.34
7.33
7.32
7.31
6.99
6.97
6.75
6.73
5.03
5.00
4.77
4.74
3.72
2.28
1.21
4.77
1.94
1.98
1.00
0.90
0.93
2.95
9.21
f1 (ppm)


138.18
134.22
133.27
129.11
128.79
128.63
128.31
126.95
126.48
124.19
80.01
79.80
62.41
60.45
24.13
21.23
129.11
128.79
128.63
128.31
126.95
126.48
124.19
80.23
80.01
79.80
79.58
f1 (ppm)
f1 (ppm)


-73.14
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
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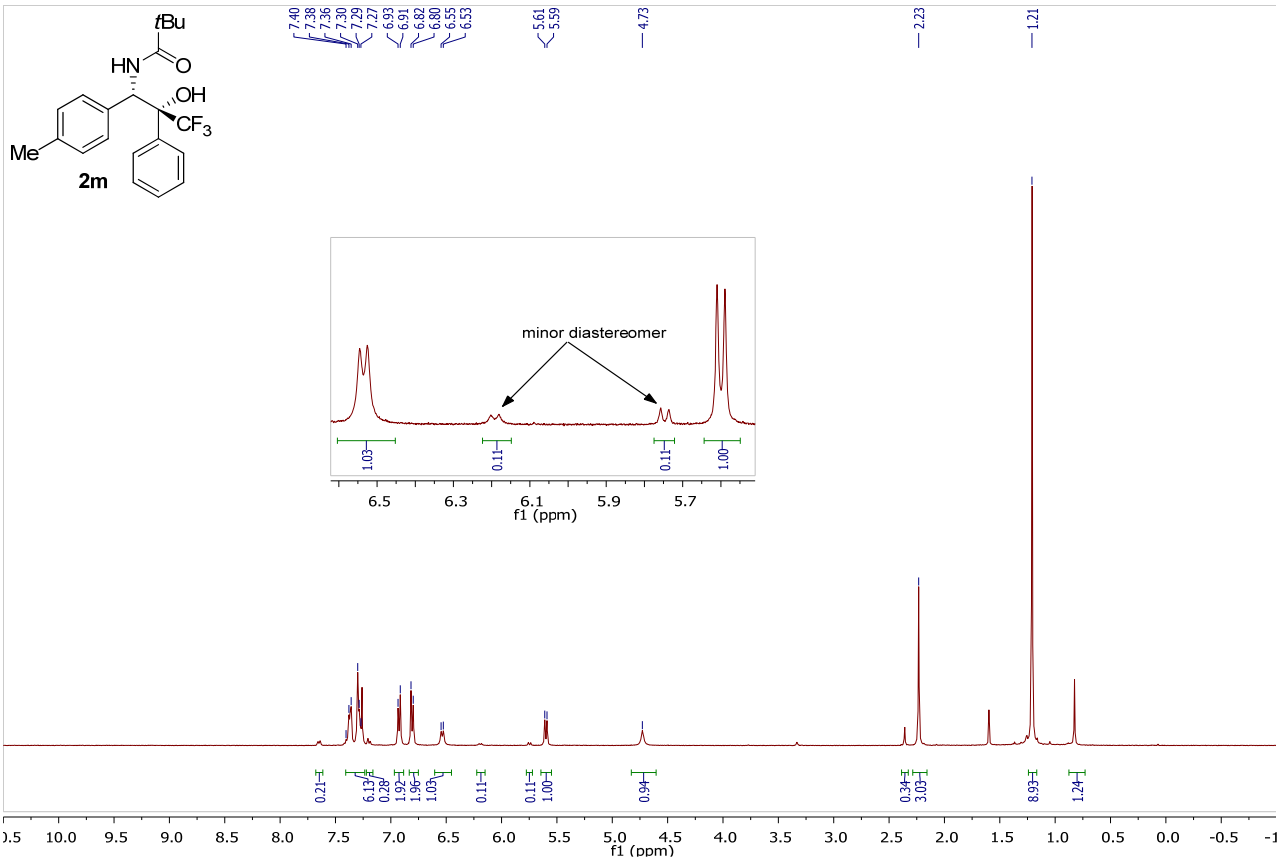
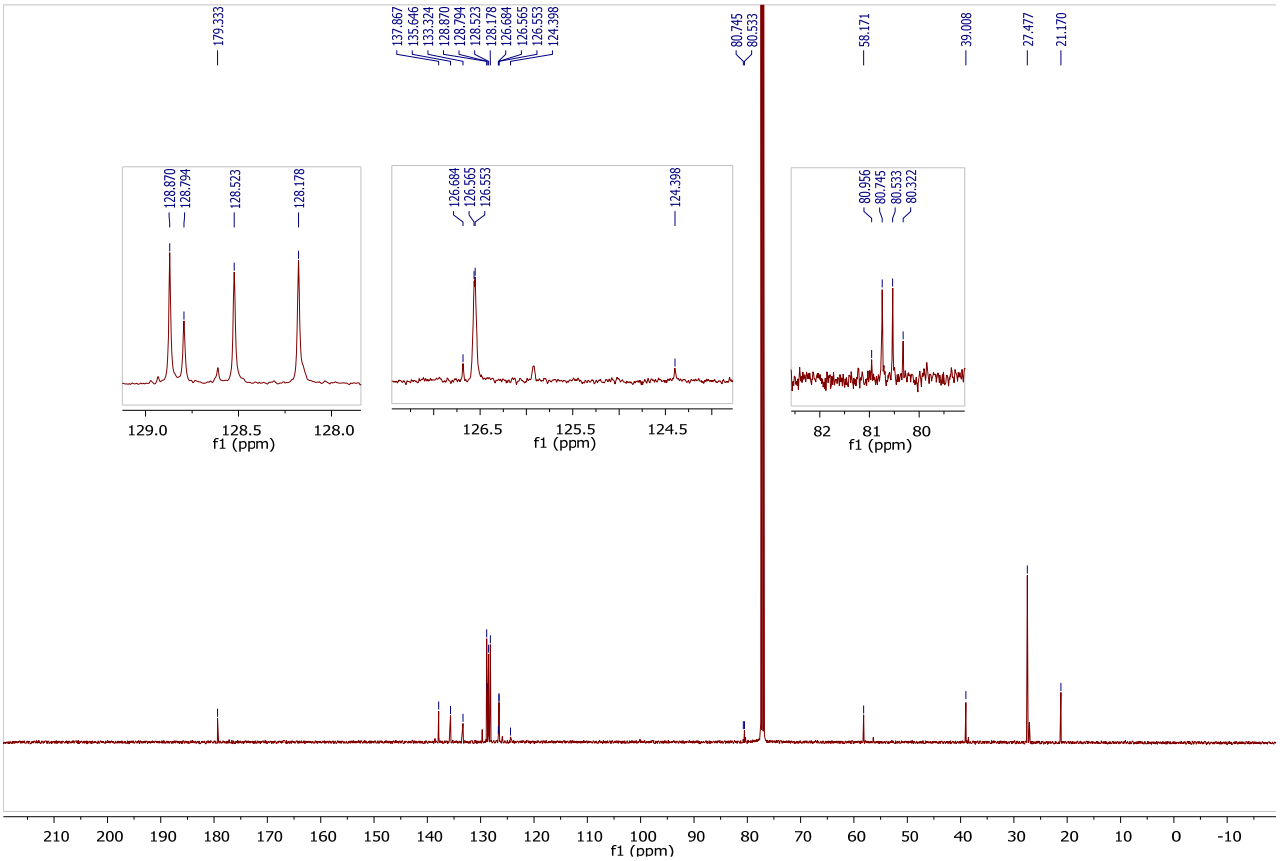
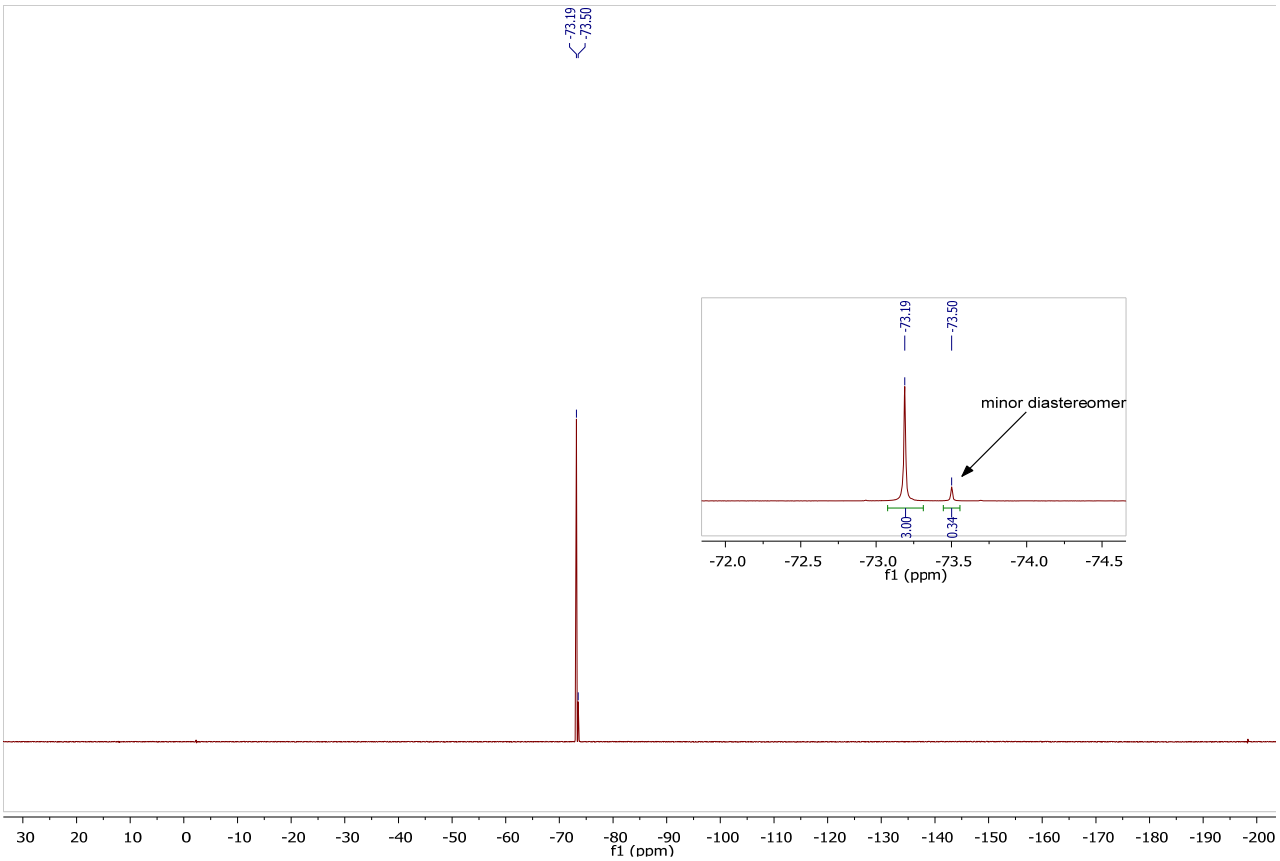
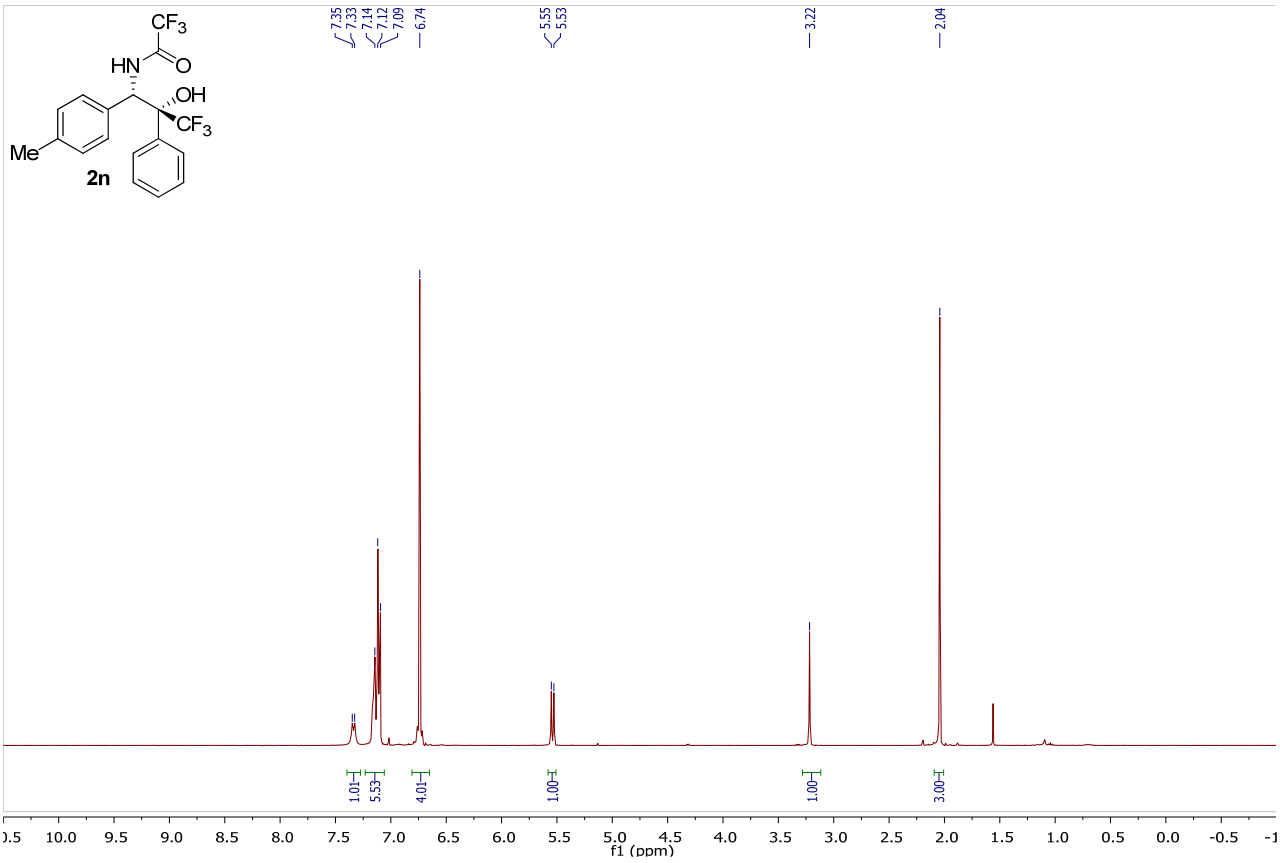
-150
-160
-170
-180
-190
f1 (ppm)


tBu
HN
O
OH
CF3
Me
2m
minor diastereomer
f1 (ppm)


f1 (ppm)


-73.19
-73.50
-73.19
-73.50
minor diastereomer
3.00
0.34
-72.0
-72.5
-73.0
-73.5
-74.0
-74.5
f1 (ppm)
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
f1 (ppm)


CF3
HN
O
OH
CF3
Me
2n
7.35
7.33
7.14
7.12
7.09
6.74
5.55
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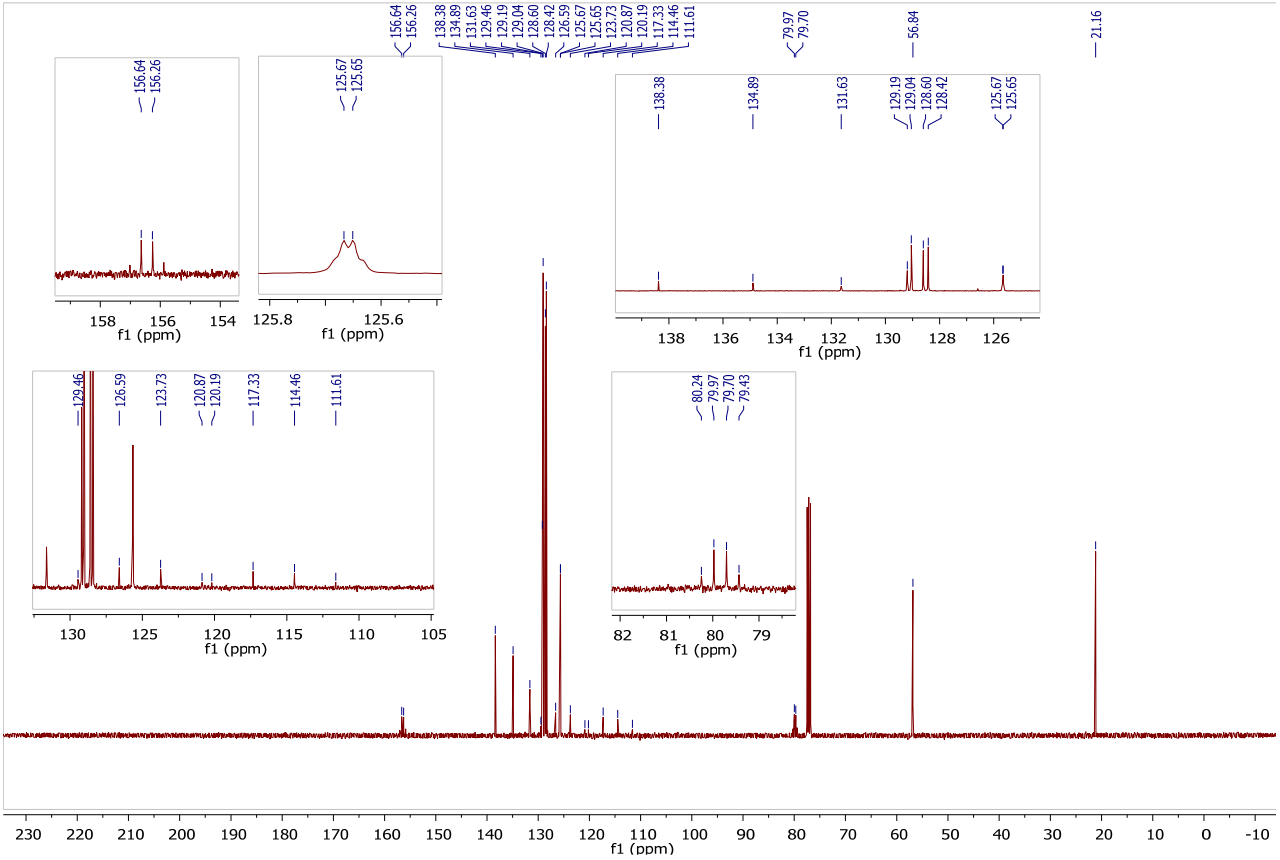
3.22
2.04
1.01
5.53
4.01
1.00
1.00
3.00
f1 (ppm)


156.64
156.26
138.38
134.89
131.63
129.46
129.19
129.04
128.60
128.42
126.59
125.67
125.65
123.73
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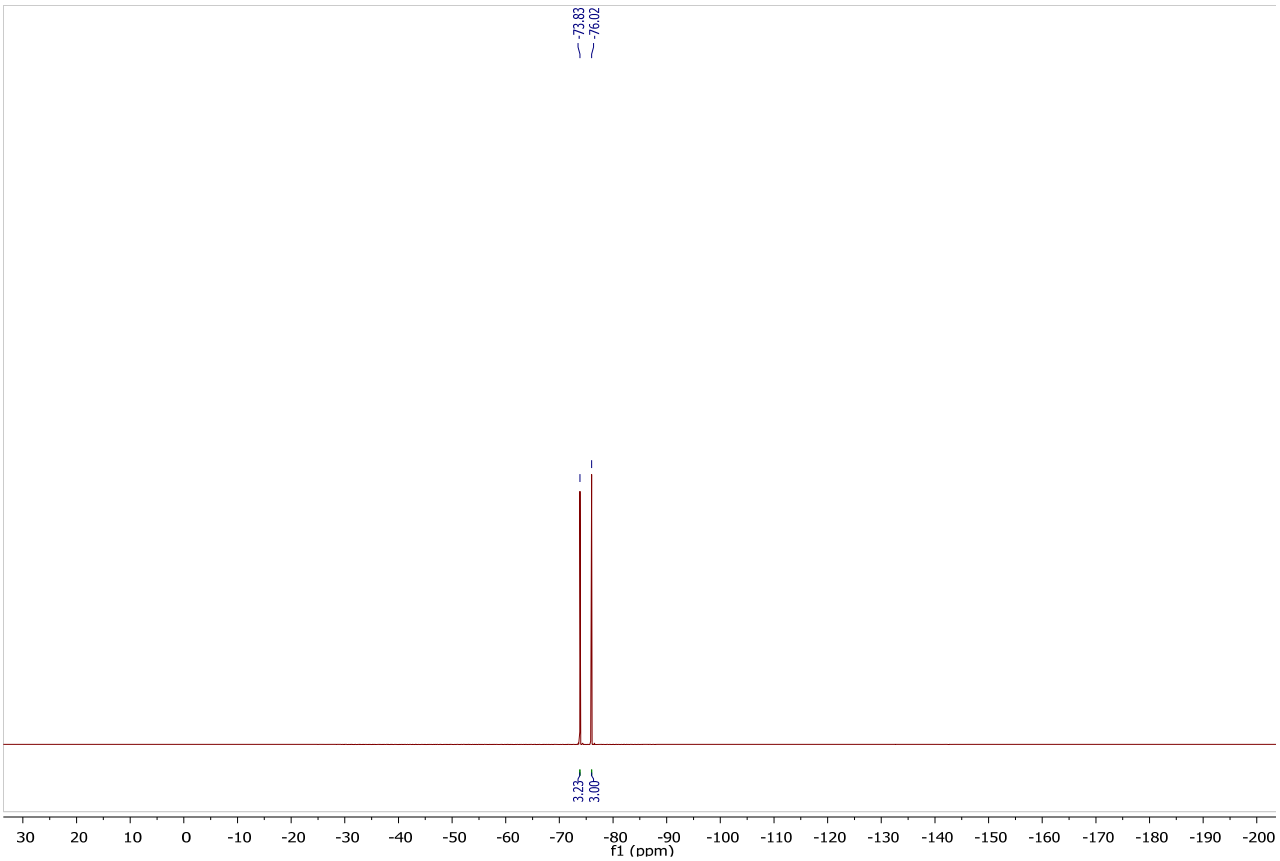
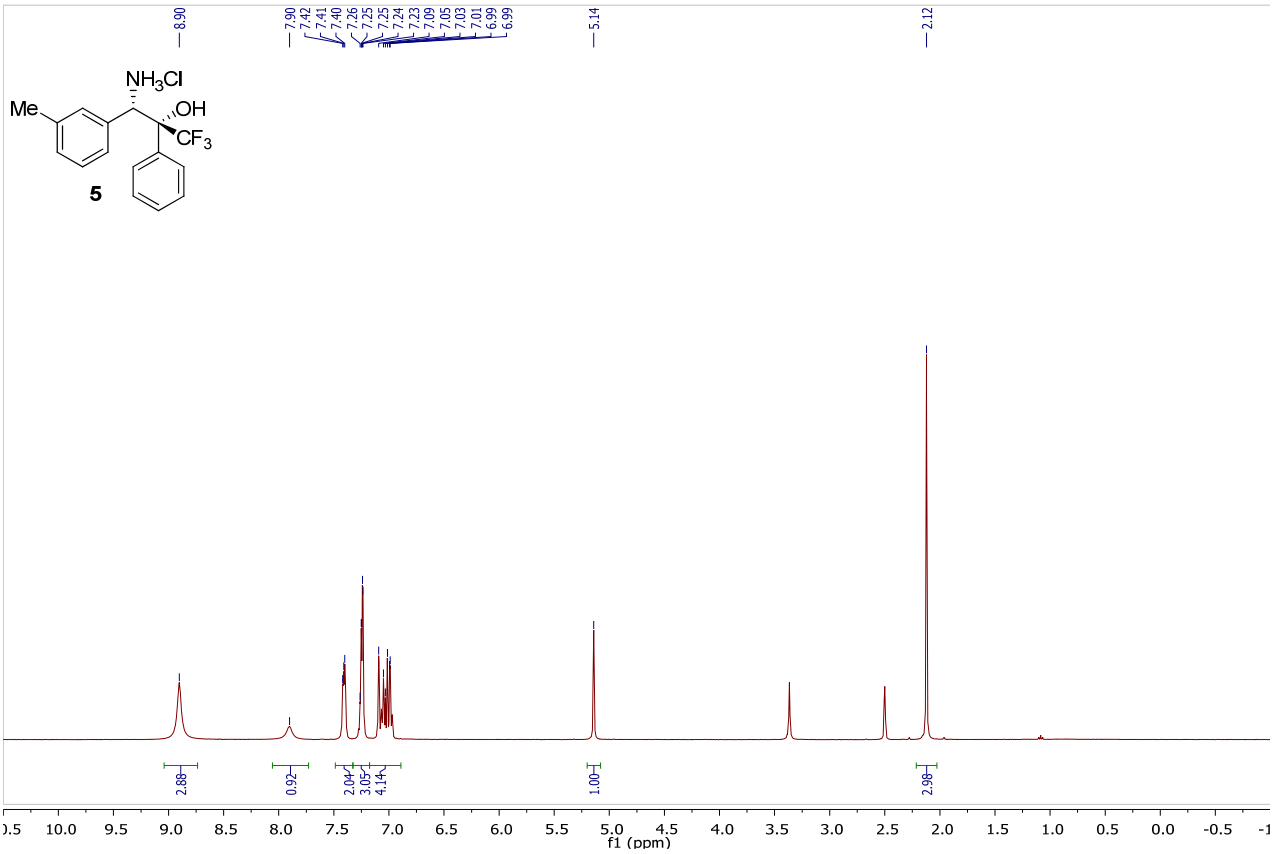
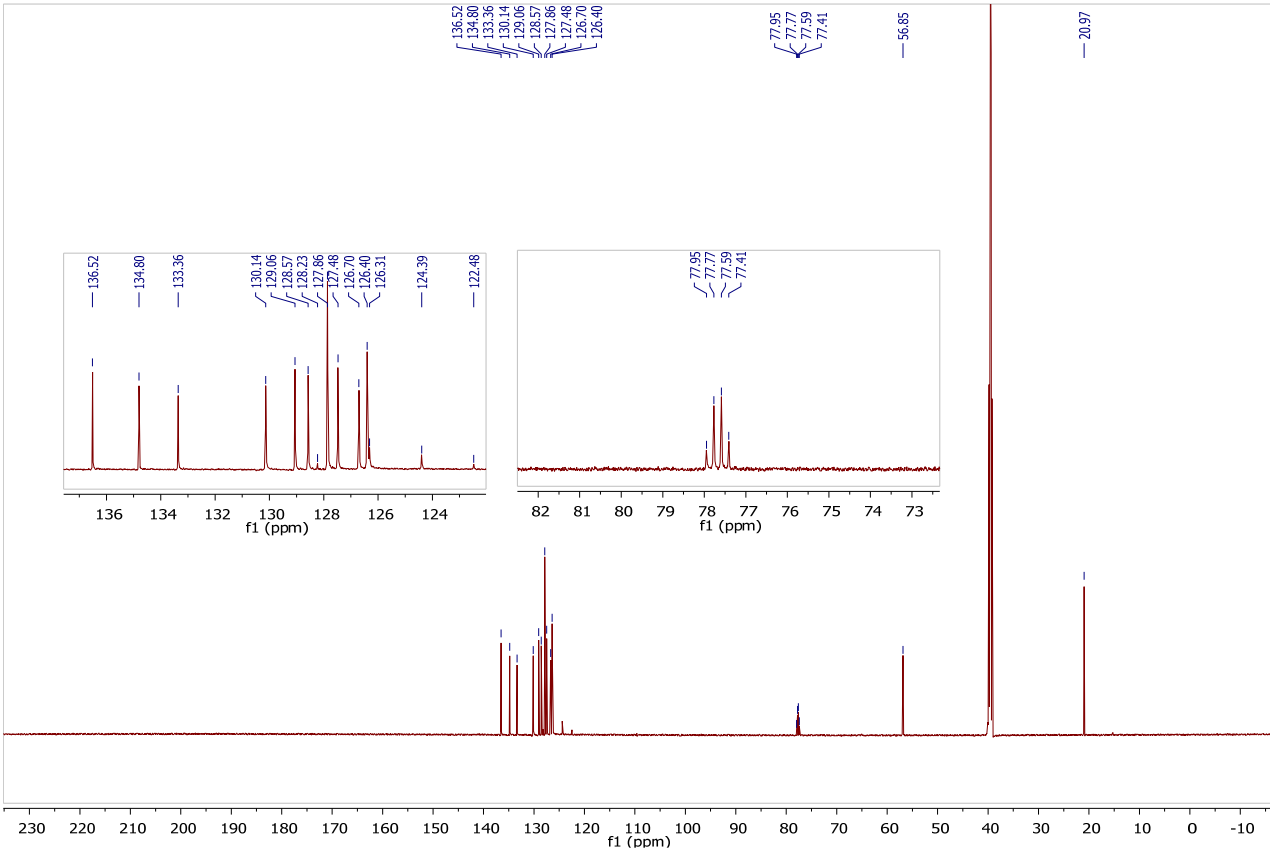
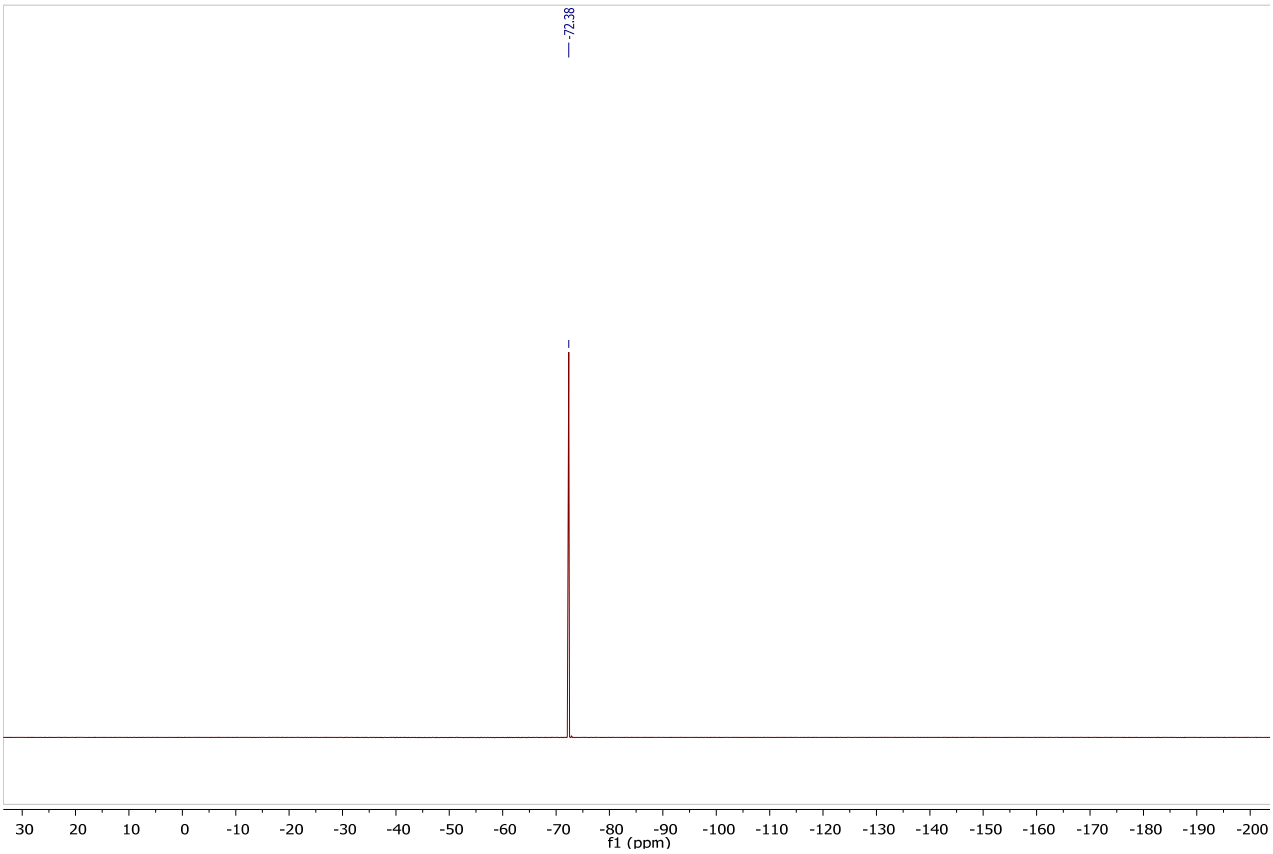
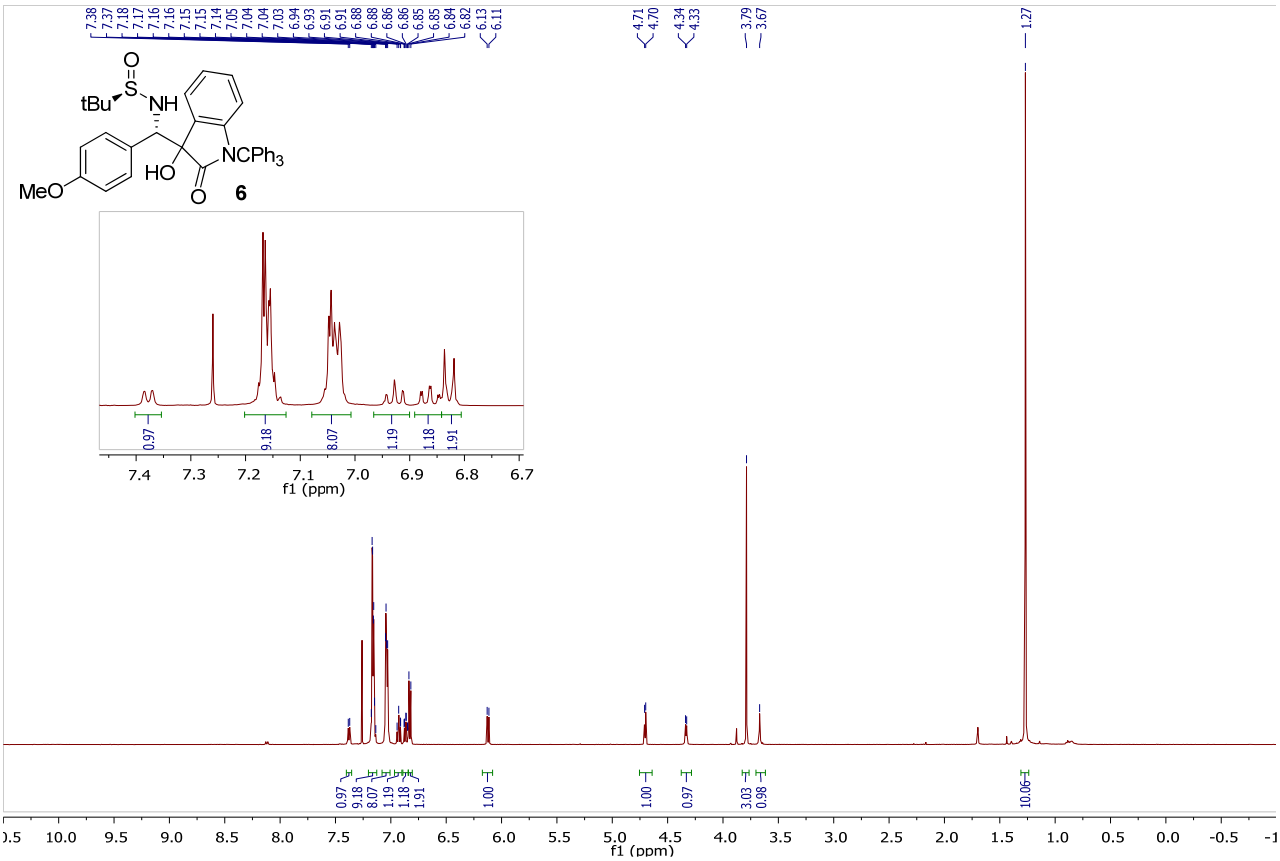
120.19
117.33
114.46
111.61
79.97
79.70
56.84
21.16
f1 (ppm)

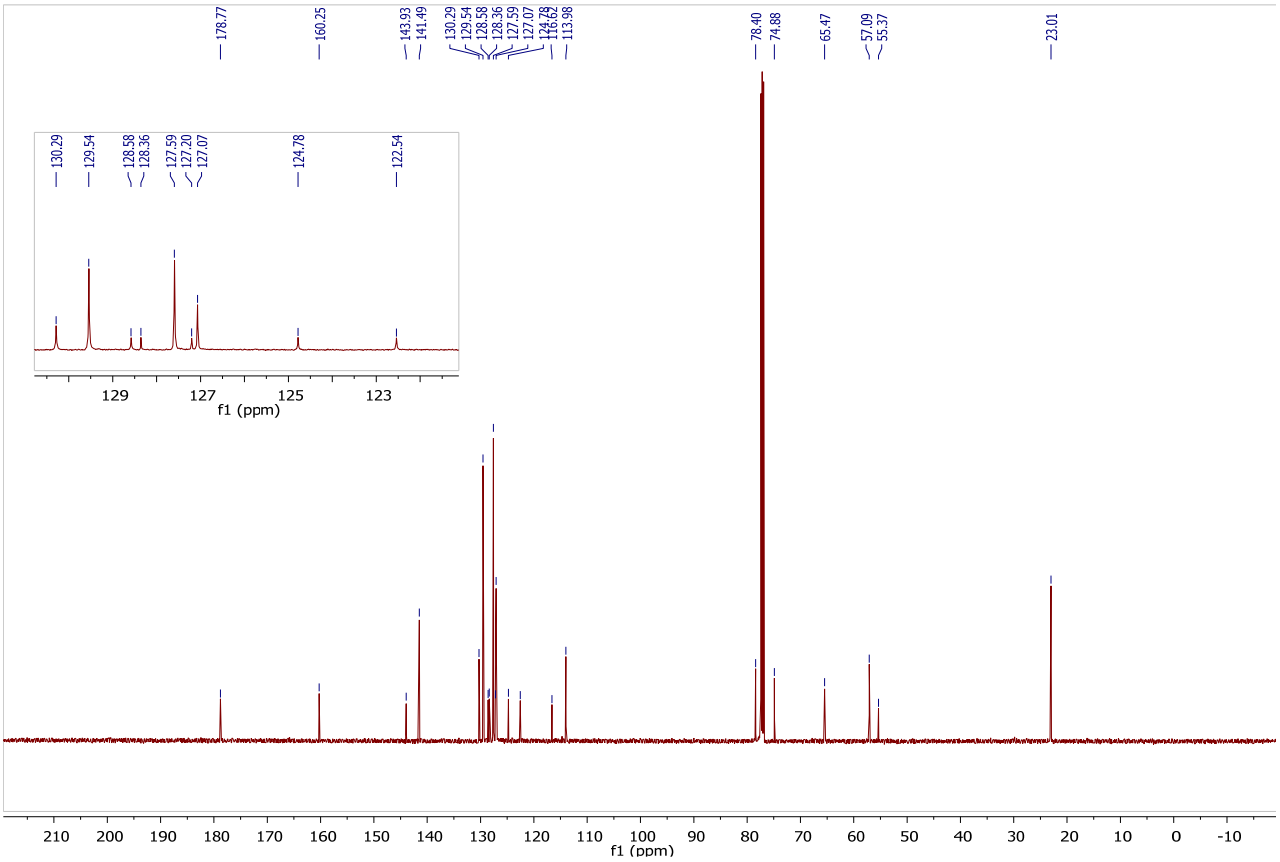

-73.83
-76.02
3.23
3.00
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

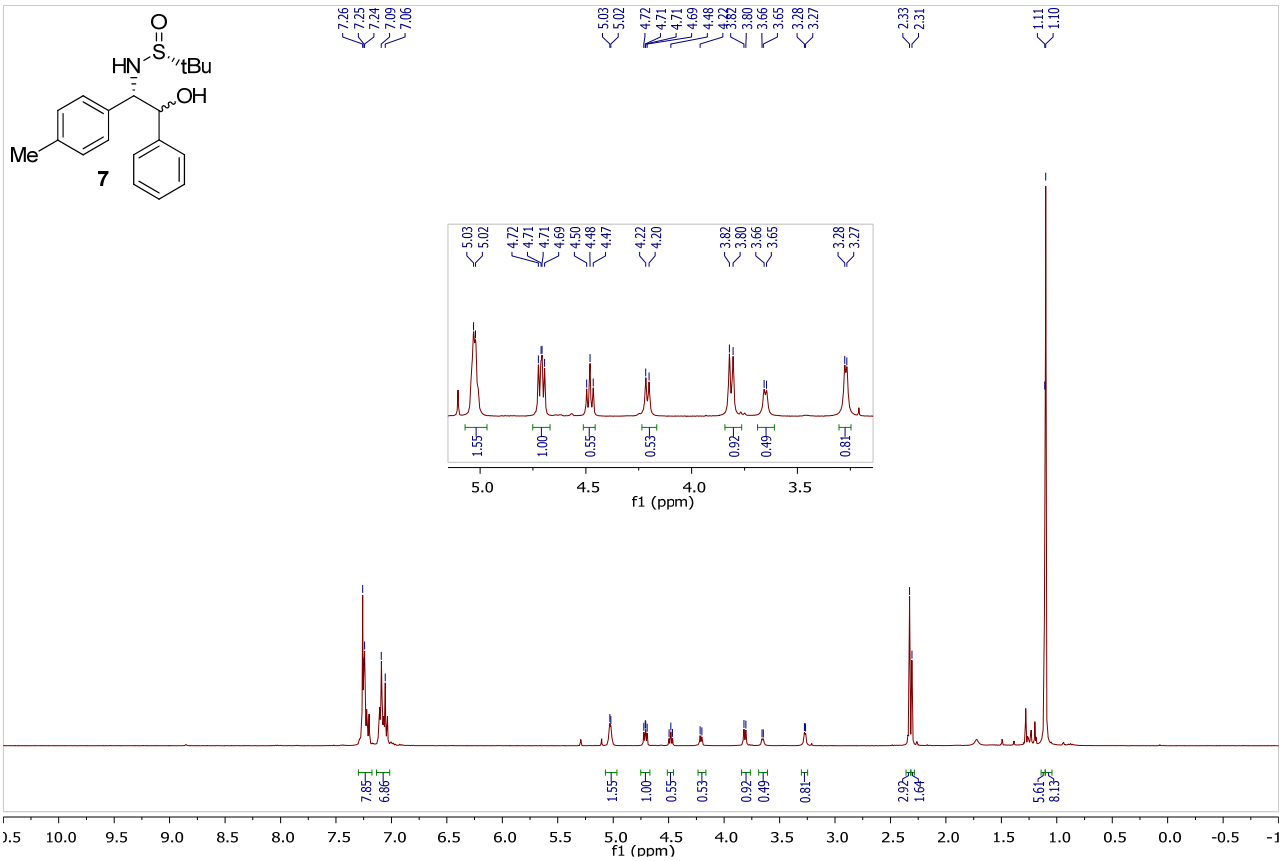

8.90
7.90
7.42
7.41
7.40
7.26
7.25
7.25
7.24
7.23
7.09
7.05
7.03
7.01
6.99
6.99
5.14
2.12
NH3Cl
Me
OH
CF3
5
2.88
0.92
2.04
3.05
4.14
1.00
2.98
f1 (ppm)

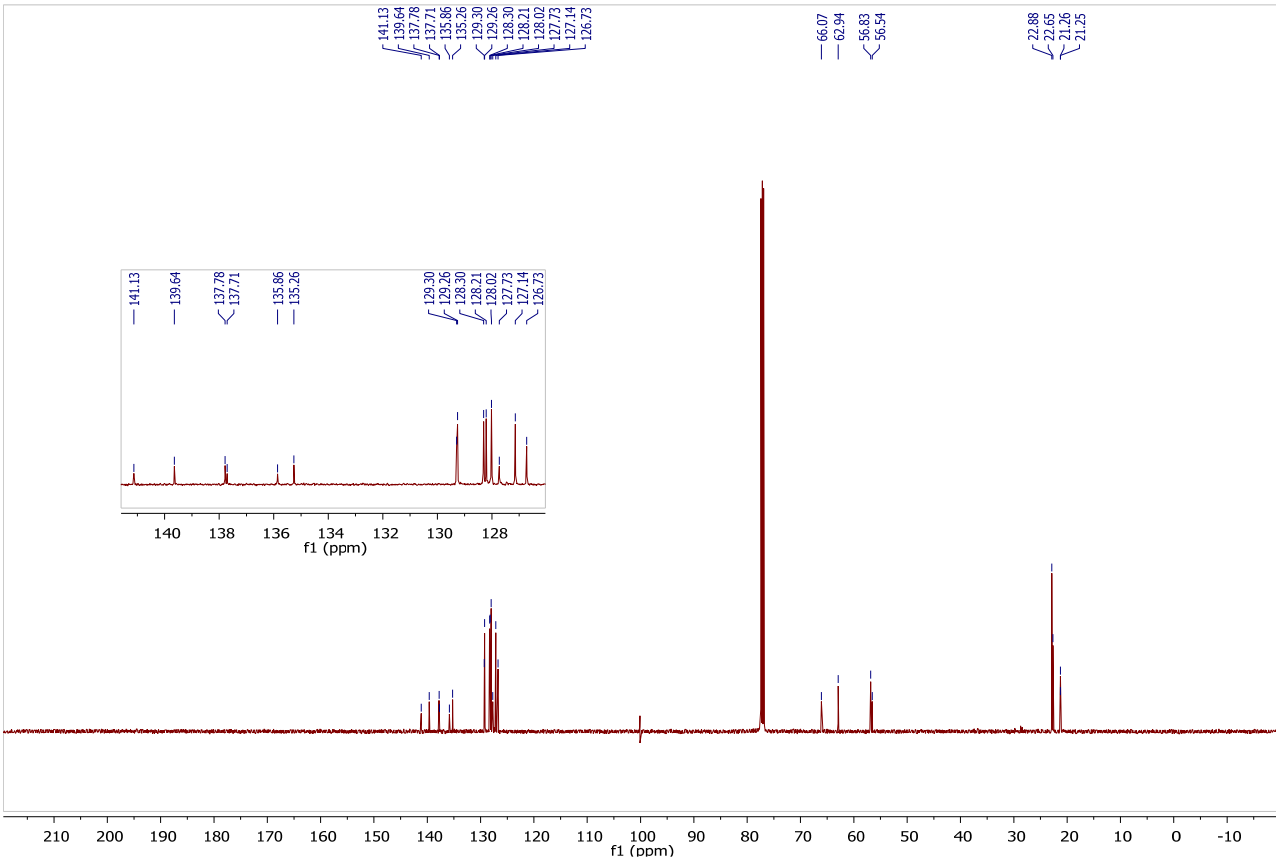

136.52
134.80
133.36
130.14
129.06
128.57
127.86
127.48
126.70
126.40
77.95
77.77
77.59
77.41
56.85
20.97
f1 (ppm)

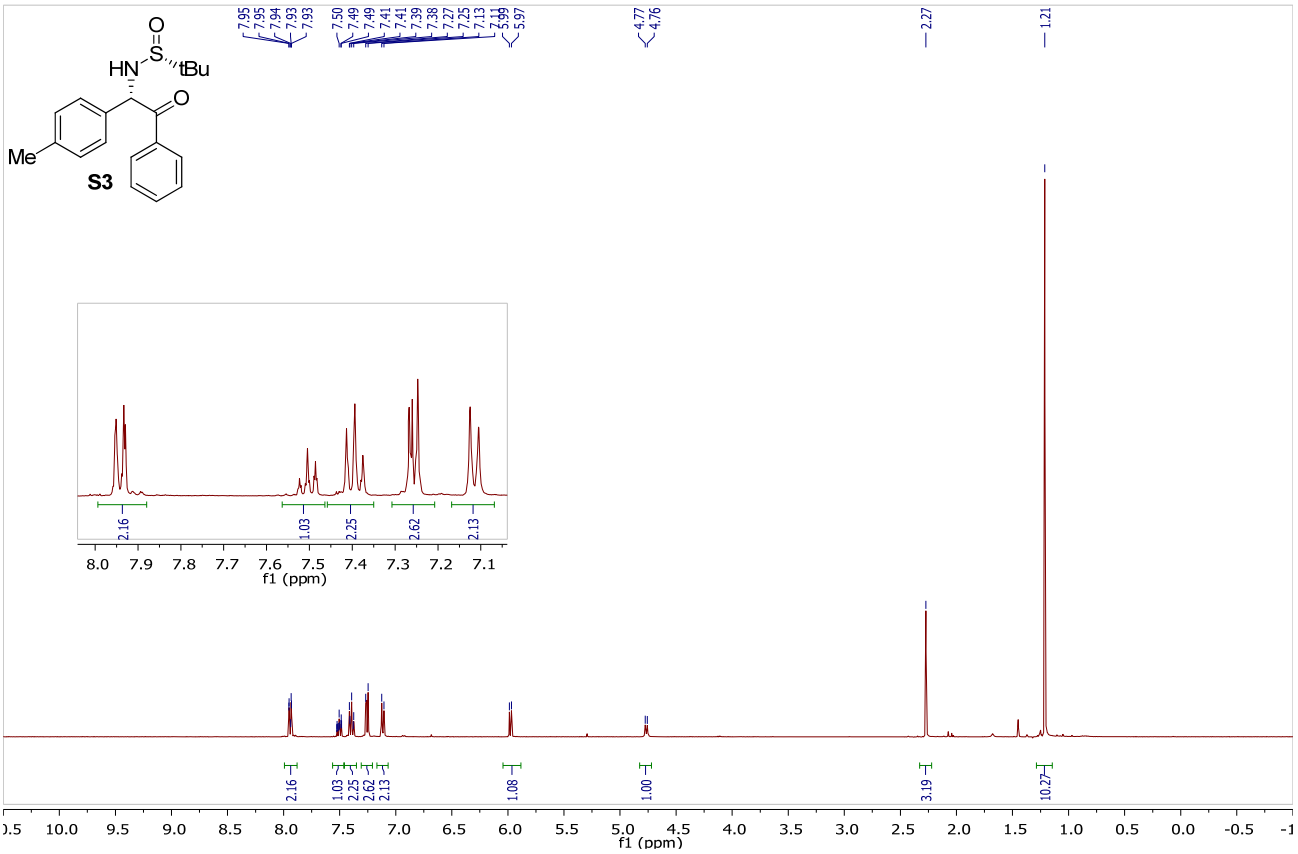

-72.38
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)

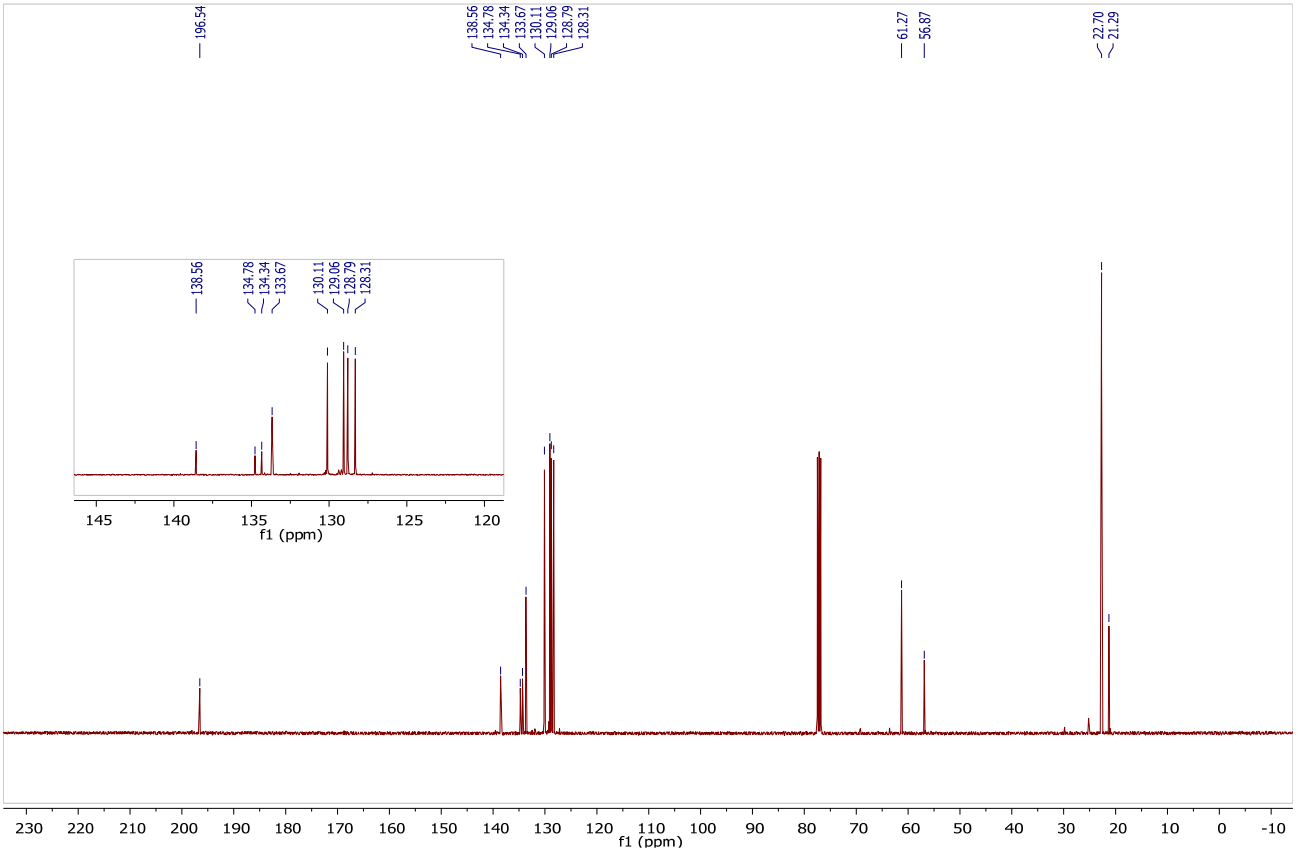

tBu
S
O
NH
HO
NCPh3
O
MeO
6
f1 (ppm)


f1 (ppm)


HN
S
O
tBu
OH
Me
7
f1 (ppm)

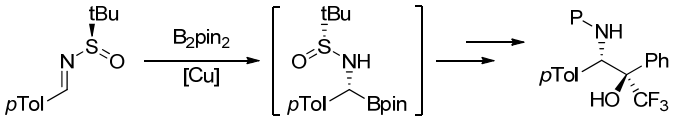

f1 (ppm)


HN
tBu
O
O
Me
S3
f1 (ppm)


f1 (ppm)

VIII. Stereochemical Purity and HPLC Data

Table S1 Assessment of Stereochemical Purity for Amino Alcohol Products



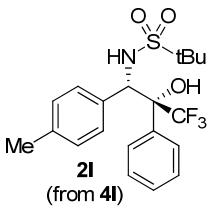
1a **2**

entry	P =	**1a** (dr[a])	**2** (er[b])
1	Bus	>95:5	**2l**, 97:3
2	Piv	94:6	**2m**, 96:4
3	$COCF_3$	>95:5	**2n**, 88:12

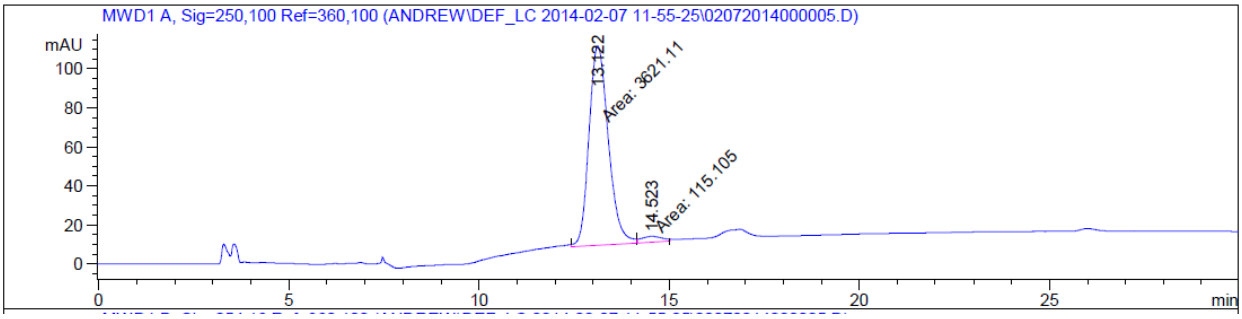
[a] Based on the inherent selectivity of conditions used to synthesize crude boronate ester **1a**. [b] Determined by chiral HPLC (*vida infra*).

Little to no loss of stereochemical purity is observed in the synthesis of Bus- or pivaloyl-protected amino alcohol products **2l** and **2m,** respectively (entries 1 and 2). Synthesis of trifluoroacetyl-protected amino alcohol **2n**, however, resulted in a small but appreciable loss of stereochemical purity (entry 3). While most likely arising during Rh-catalyzed addition,[9] we cannot rule out epimerization during the acylation and trifluoroborate formation steps. Given the low yield and diastereoselectivity observed for **2n** (see Table 4), we did not pursue further investigation of this loss of stereochemical purity.

[9] For similar observations in the Pd-catalyzed cross-coupling of α-amido boronate esters, see: (a) T. Ohmura, T. Awano and M. Suginome, *J. Am. Chem. Soc.*, 2010, **132**, 13191; (b) T. Awano, T. Ohmura and M. Suginome, *J. Am. Chem. Soc.*, 2011, **133**, 20738.

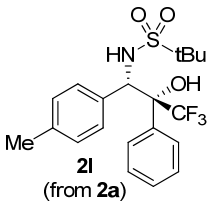


2l
(from **4l**)

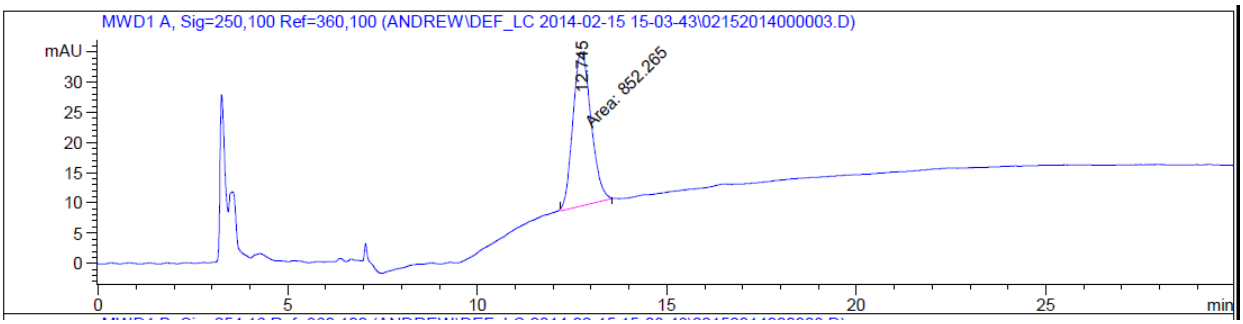


Signal 1: MWD1 A, Sig=250,100 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.122	MF	0.5900	3621.10840	102.28318	96.9192
2	14.523	FM	0.6516	115.10455	2.94434	3.0808
Totals :				3736.21295	105.22752	

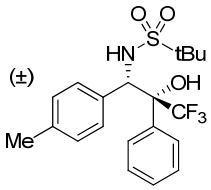


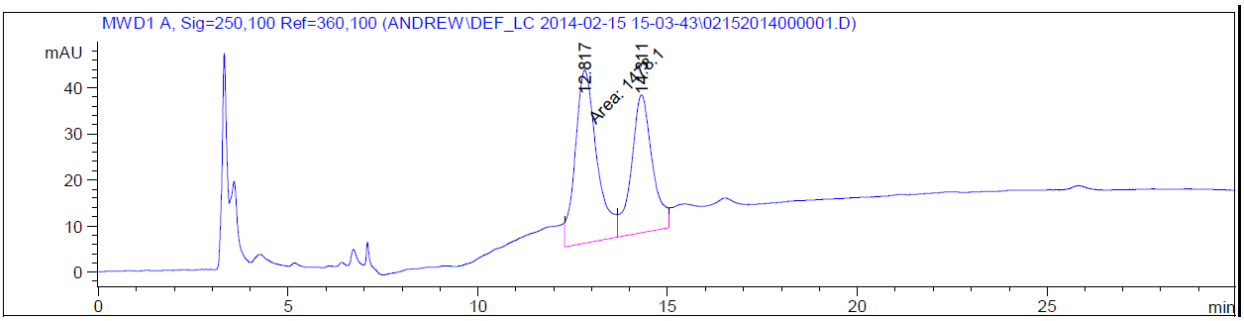
2l
(from **2a**)



Signal 1: MWD1 A, Sig=250,100 Ref=360,100

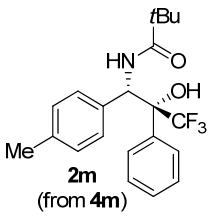
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.745	MM	0.5558	852.26483	25.55837	100.0000
Totals :				852.26483	25.55837	



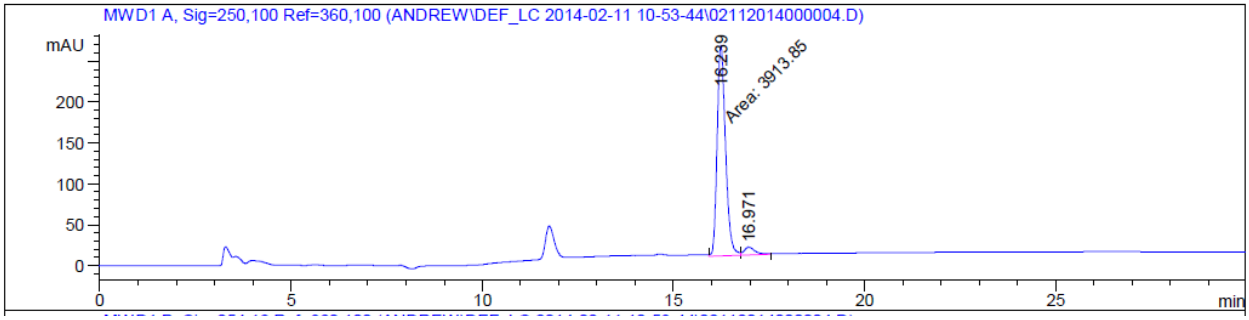


Signal 1: MWD1 A, Sig=250,100 Ref=360,100

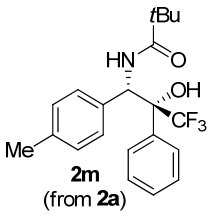
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.817	FM	0.6559	1478.09729	37.55735	56.2208
2	14.311	VV	0.5670	1150.99805	29.90731	43.7792
Totals :				2629.09534	67.46466	



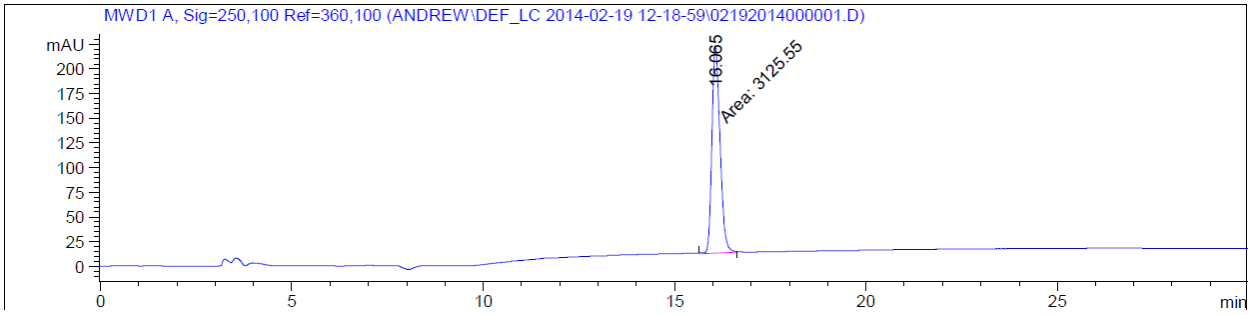
2m
(from **4m**)



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.239	FM	0.2534	3913.84741	257.37787	95.5189
2	16.971	VV	0.2905	183.61046	9.37631	4.4811
Totals :				4097.45787	266.75418	

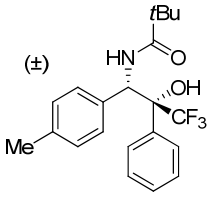


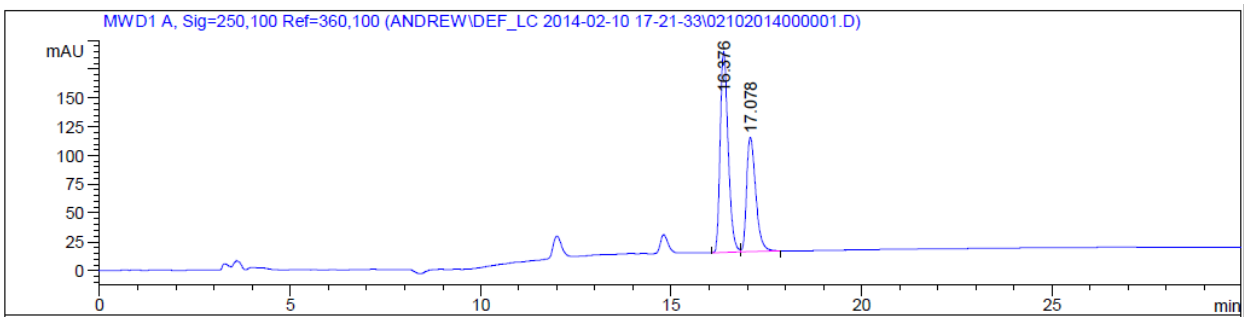
2m
(from **2a**)



Signal 1: MWD1 A, Sig=250,100 Ref=360,100

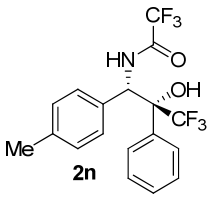
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.065	MM	0.2476	3125.55225	210.37517	100.0000
Totals :				3125.55225	210.37517	

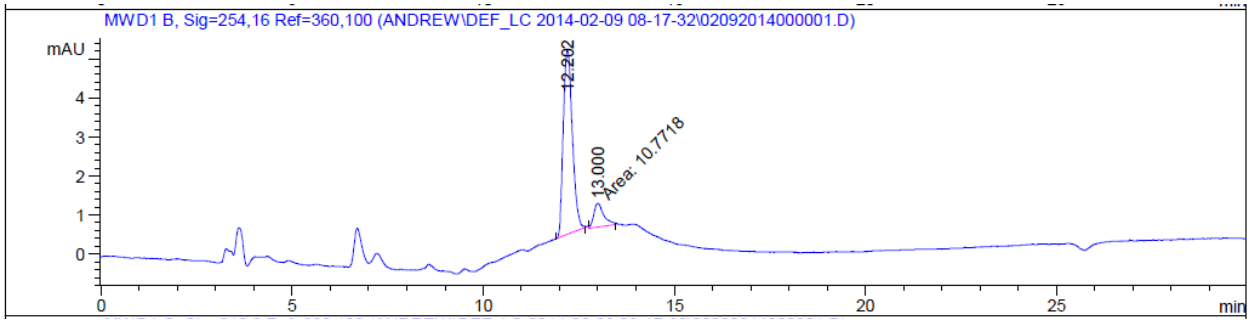




Signal 1: MWD1 A, Sig=250,100 Ref=360,100

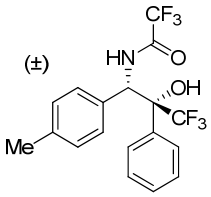
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.376	BV	0.2259	2544.65771	174.73396	60.6200
2	17.078	VB	0.2578	1653.06030	99.51825	39.3800
Totals :				4197.71802	274.25221	

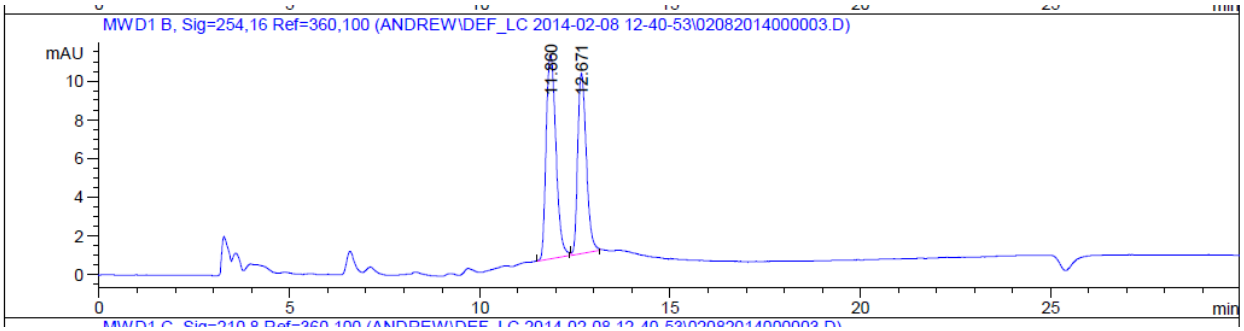




Signal 2: MWD1 B, Sig=254,16 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.202	BB	0.2626	78.05830	4.72738	87.8737
2	13.000	MM	0.2984	10.77180	6.01670e-1	12.1263
Totals :				88.83010	5.32905	





Signal 2: MWD1 B, Sig=254,16 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.860	BB	0.2817	188.41757	10.58352	56.3142
2	12.671	BB	0.2465	146.16495	9.34148	43.6858
Totals :				334.58252	19.92499	