Synthesis of Optically Active Arylaziridines by Regio and Stereospecific Lithiation of *N*-Bus-Phenylaziridine

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Content

Experimental

General

All reactions involving air-sensitive reagents were performed in oven-dried glassware under an atmosphere of nitrogen using syringe-septum cap technique. Tetrahydrofuran (THF) and diethyl ether (Et_2O) were freshly distilled under a nitrogen atmosphere over sodium / benzophenone.

Column chromatography was performed using the solvent systems indicated. Petroleum ether refers to the fraction that boils at 30–40 °C. The stationary phase used was silica gel 60 unless otherwise indicated.

^{1}H NMR and ^{13}C NMR spectra were recorded at 300, 400, 500, 600 MHz and 75, 100, 125, 200 MHz respectively with $CDCl_3$ or CD_3OD as solvent. Data are expressed as chemical shifts in parts per million (ppm) relative to residual chloroform $CDCl_3$ (^{1}H δ 7.27), (^{13}C δ 77.0). The multiplicity of each signal is designated by the following abbreviations: s, singlet; d, doublet; dd, doublet of doublets; dt, doublet of triplets; ddt, doublet of doublet of triplets; t, triplet; br, broad. Coupling constants *J* are given in Hz. Infra-red spectra of the compounds were recorded neat, as a film, or KBr disc as indicated. High resolution mass spectra were obtained by a double focusing (BE) mass spectrometer using electrospray ionisation techniques ($M+NH_4^+$, $M+H^+$, $M+Na^+$). Low resolution mass spectra were obtained by GC-MS analysis using a gas chromatography with a BPX_5 column-HP 6890 plus (30 m, 0.25 mm i.d.) equipped with a 5973 mass selective detector operating at 70 eV (flow rate (He) = 1 mL/min). HRMS data for Sn-containing compounds are quoted for the most abundant Sn isotope, i.e. ^{120}Sn. Specific rotations $[\alpha]^T_D$ were measured using a polarimeter with a cell of path length 1.0 cm, at T °C and are given in 10^{-1} deg cm^2 g^{-1}. Concentrations (c) are given in g/100 mL. Melting points were uncorrected. TLC was performed on Merck silica gel plates with F-254 indicator; detection was accomplished by UV light (254 nm), by exposing to I_2 vapours and spraying a solution of (5% W/V) ammonium molibdate and 0.2% W/V cerium(III)sulphate in 100 ml 17.6% aq. sulphuric acid and heating to 200 °C for some time until blue spots appear.

N,*N*,*N*',*N*'-tetramethylethylenediamine (TMEDA) was distilled over finely powdered CaH_2. Commercial solutions of *n*-BuLi (2.5 M hexane solution) and *sec*-BuLi (1.3 M cyclohexane solution) were tritated by using *N*-pivaloyl-*o*-toluidine prior use.[1]

[1] Suffert, J. *J. Org. Chem.* **1989**, *54*, 509-510.

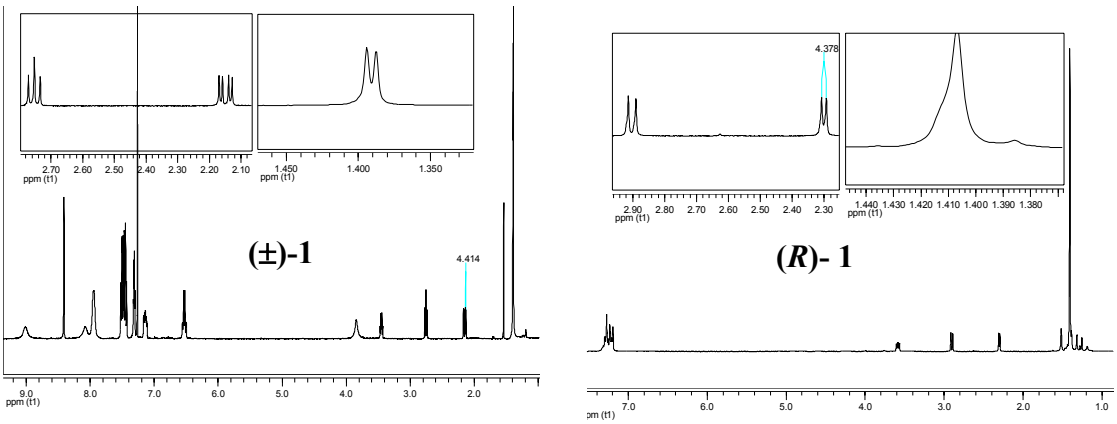
R-(-)- and (±)-*N*-*tert*-butyl-sulphonyl-2-phenylaziridine were prepared following reported procedures.[2] All other chemicals were of commercial grade and used without further purification.

Preparation of aziridine (±)-1.[2a,b]

The aziridination of styrene (104.1 mg, 1.0 mmol) with Bus-NClNa Salt (294 mg, 1.2 mmol) catalyzed by 10% mol of phenyltrimethylammonium tribromide (PTAB)[3] was carried out in acetonitrile (7.0 ml) at room temperature. The mixture was stirred for 12 h, filtered and concentrated under reduced pressure. Purification of the residue by SiO_2 flash chromatography (petroleum ether : Et_2O 9:1) afforded **(±)-1** (208 mg, 87 %).

Preparation of aziridine (*R*)-1.[2c,d]

Aziridine **(*R*)- 1** is readly available from enantiomerically pure (*R*)-(-)-phenylglycinol via activation of the primary alcohol group with in situ aziridine ring closure. The enantiomeric purity of aziridine **(*R*)- 1** ($[\alpha]^{25}_D$ = -184.5, c = 1, $CHCl_3$) was determined by ^{1}H-NMR resolution in presence of the chiral solvating agent (*R*)-(-)-1-(9-Anthryl)-2,2,2-trifluoroethanol and found to be >98 %ee.



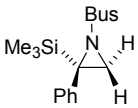
To a solution of (*R*)-(-)-phenylglycinol (500 mg, 3.64 mmol) at 0 °C in CH_2Cl_2 (6.5 mL) and Et_3N (2.5 equiv, 9.1 mmol) was added dropwise *tert*-butylsulfinyl chloride (1 equiv, 3.64 mmol) and the reaction stirred at room temperature for 12 hours. The mixture was then washed with water (3 x 10 mL) and the organic phase was dried ($MgSO_4$) and concentrated *in vacuo* to give the corresponding *N*-sulfinyl-(*R*)-

[2] a) Sharpless, K. B.; Gontcharov, A. V.; Liu, H. Patent **1999**, US6008376. b) Gontcharov, A. V.; Liu, H.; Sharpless, K. B. *Org. Lett.* **1999**, *1*, 5, 783-786. c) Berry, M. B.; Craig, D. *Synlett* **1992**, 41. d) Alonso, D. A.; Andersson, P. G. *J. Org. Chem.* **1998**, *63*, 9455-9461.
[3] Jeong, J. U.; Tao, B.; Sagasser, I.; Henniges, H.; Sharpless, K. B. *J. Am. Chem. Soc.* **1998**, *120*, 6844.

phenylglycinol (99%). To a solution of sulfinamide (880 mg, 3.64 mmol) in CH_2Cl_2 (54 mL) was added *m*-CPBA (1.2 equiv, 751.3 mg, 4.37 mmol) at 0 °C. After 2 hours, the mixture was warmed to room temperature and stirred for a further 1 hour. Then the mixture was diluted with a mixture of saturated aqueous $NaHSO_3$ (25 mL) and $NaHCO_3$ (25 mL) and the aqueous layer extracted with CH_2Cl_2 (2 x 25 mL). The combined organic extracts were dried over $MgSO_4$, and concentrated *in vacuo*. The residue was purified by SiO_2 flash chromatography (Petroleum ether:Et_2O 7:3) to afford the corresponding sulfonamide as a white solid (89%). *p*-Toluenesulfonyl chloride (1 equiv, 615.9 mg, 3.23 mmol)) was added portionwise to a solution of the obtained *N*-protected-(*R*)-phenylglycinol (1 equiv, 833 mg, 3.23 mmol) and Et_3N (2 equiv, 6.46 mmol) in CH_2Cl_2 (40 mL) at 0 °C. The reaction was stirred at room temperature for 12 h then diluted with water and extracted with CH_2Cl_2 (3 x 30 mL). The combined organic phases were dried ($MgSO_4$), filtered and concentrated to give the crude aziridine which was purified by SiO_2 flash chromatography (petroleum ether : Et_2O 7:3) to afford the pure compound as a white solid (486 mg, 63%).

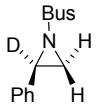
Representative procedure for the lithiation - trapping sequence of aziridines (±)-1 and (*R*)- 1:

n-BuLi (1.6 M in hexane, 525 µL, 0.84 mmol) was added dropwise to a stirred solution of aziridine **(±)-1** (100 mg, 0.42 mmol) and TMEDA (125.8 µL, 0.84 mmol) in Et_2O (8 mL) at -78 °C. After 5 minutes at -78 °C the electrophile (0.84 mmol) was added. After 1 hour at -78 °C, the mixture was allowed to warm slowly to room temperature. After addition of saturated aqueous NH_4Cl (10 mL), the mixture was extracted with Et_2O (3 x 10 mL). The combined organic layers were dried ($MgSO_4$), filtered and evaporated under reduced pressure. Purification by SiO_2 flash chromatography gave the substituted aziridines 5**a-i**.

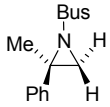


1-(*tert*-Butylsulfonyl)-2-phenyl-2-trimethylsilylaziridine (5a). White solid, mp 110-113 °C, 86%. ^{1}H-NMR (300 MHz, $CDCl_3$) δ 0.00 (s, 9H), 1.33 (s, 9H), 2.60 (br s, 1H), 2.75 (br s, 1H), 7.07-7.18 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 24.2, 39.3, 46.5, 60.6, 126.9, 128.4, 127.9, 129.0; HR-MS (ESI) Calcd for $C_{15}H_{25}NO_2SSi$, $[M+NH_4]^+$: 329.1714. Found: 329.1717. FT-IR cm^{-1}: 2995, 2980,

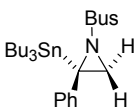
2959, 1302, 1113, 940, 844, 695. Anal calcd for $C_{15}H_{25}NO_2SSi$: C, 57.84; H, 8.09; N, 4.49; S, 10.29%. Found: C, 57.95; H, 8.17; N, 4.21; S, 10.35%.



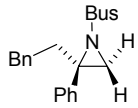
1-(*tert*-Butylsulfonyl)-2-deuterio-2-phenylaziridine (5b). White oil, 88% (97% D). ^{1}H-NMR (300 MHz, $CDCl_3$) δ ^{1}H-NMR (300 MHz, $CDCl_3$) δ 1.47 (s, 9H), 2.36 (s, 1H), 2.96 (s, 1H), 7.26-7.39 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 24.1, 34.6, 59.4, 70.0, 126.3, 128.3, 128.7, 135.1; HR-MS (ESI) Calcd for $C_{12}H_{16}DNO_2S$, $[M+NH_4]^+$: 258.1381. Found: 258.1383. FT-IR cm^{-1}: 2988, 1454, 1298, 1126, 906, 698. Anal calcd for $C_{12}H_{16}DNO_2S$: C, 59.97; H, 7.55; N, 5.83; S, 13.34. Found: C, 59.64; H, 7.56; N, 5.80; S, 12.94. The enantiomeric purity of **(*R*)-5b** ($[\alpha]^{25}_D$ = -164.3, c = 1, $CHCl_3$) was determined by HPLC analysis (AD chiral column; hexane:*i*PrOH 98:2; flow: 0.5 ml/min; for **5b** resulted t_1 = 22.8 min, t_2 = 27.0 min; for **(*R*)-5b** resulted t = 27.0).



1-(*tert*-Butylsulfonyl)-2-methyl-2-phenylaziridine (5c). Colourless oil, 80%. ^{1}H-NMR (300 MHz, $CDCl_3$) δ 1.43 (s, 9H), 1.92 (s, 3H), 2.42 (s, 1H), 2.84 (s, 1H), 7.18-7.34 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 20.9, 24.2, 43.5, 49.2, 61.0, 126.4, 127.7, 128.4, 141.6; HR-MS (ESI) Calcd for $C_{13}H_{19}NO_2S$, $[M+NH_4]^+$: 271.1475. Found: 271.1477. FT-IR cm^{-1}: 2985, 1303, 1114, 724. Anal calcd for $C_{13}H_{19}NO_2S$: C, 61.63; H, 7.56; N, 5.53; S, 12.65. Found: C, 61.79; H, 7.87; N, 5.33; S, 12.67. The enantiomeric purity of **(*R*)-5c** ($[\alpha]^{25}_D$ = -142.5, c = 1.3, $CHCl_3$) was determined by ^{1}H-NMR resolution in presence of the chiral solvating agent (*R*)-(-)-1-(9-Anthryl)-2,2,2-trifluoroethanol and found to be >98 %ee.

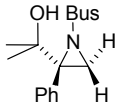


1-(*tert*-Butylsulfonyl)-2-phenyl-2-tributylstannylaziridine (5d). Yellow oil, 90%. ^{1}H-NMR (300 MHz, $CDCl_3$) δ 0.71-0.92 (m, 9H), 1.15-1.25 (m, 18H), 1.42 (s, 9H), 2.58 (s, 1H), 2.74 (s, 1H), 7.07-7.21 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 8.7, 13.6, 13.7, 24.3, 27.3, 27.4, 27.7, 28.8, 29.3, 40.0, 59.8, 126.1, 127.2, 128.1, 144.7; HR-MS (ESI) Calcd for $C_{24}H_{43}NO_2SSn$, $[M+Na]^+$: 552.1929. Found: 552.1929. FT-IR cm^{-1}: 2956, 2923, 1306, 1129, 930, 698.



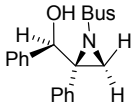
1-(*tert*-Butylsulfonyl)-2-benzyl-2-phenylaziridine (5e). Colourless oil,

36%. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 1.42 (s, 9H), 2.67 (br s, 1H), 2.98 (br s, 1H), 3.38 (d, *J* = 13.8 Hz, 1H), 3.52 (d, *J* = 13.8 Hz, 1H), 6.86-6.88 (m, 2H), 7.06-7.18 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.1, 41.1, 41.9, 54.1, 61.0, 126.7, 127.8, 127.8$_4$, 128.1, 128.6, 129.8, 137.0; HR-MS (ESI) Calcd for $C_{19}H_{23}NO_2S$, $[M+NH_4]^+$: 347.1788. Found: 347.1786. FT-IR cm^{-1}: 2962, 2905, 1412, 1260, 1096, 798, 467.

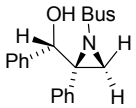


2-[1-(*tert*-Butylsulfonyl)-2-phenylaziridin-2-yl]-propan-2-ol (5f). White solid, mp 122 – 124 °C, 56%. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 1.039 (s, 3H), 1.39 (s, 3H), 1.41 (s, 9H), 2.84 (s, 1H), 2.97 (s, 1H), 7.24 – 7.28 (m, 3H), 7.54 – 7.56 (m, 2); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 24.9, 27.2, 39.2, 61.3, 71.3, 127.5, 128.7, 131.3, 133.7; HR-MS (ESI) Calcd for $C_{15}H_{23}NO_3S$, $[M+H]^+$: 298.1471. Found: 298.1473. FT-IR cm^{-1}: 3525, 2975, 1308, 1122, 947, 760, 705. The enantiomeric purity of **(*R*)-5f** ($[\alpha]^{25}_D$ = +139.2, c = 1, $CHCl_3$) was determined by ^{1}H-NMR resolution in presence of the chiral solvating agent (*R*)-(-)-1-(9-Anthryl)-2,2,2-trifluoroethanol and found to be >98 %ee.

[1-(*tert*-Butylsulfonyl)-2-phenylaziridin-2-yl]-phenylmethanol (5g). Diastereomers (dr = 70:30) were separated by SiO_2 flash chromatography (petroleum ether : Et_2O 7:3).

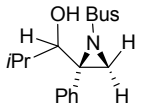


Major diastereomer (1*R,2'*R**)-5g:** White solid, mp 120 – 122 °C, 56%. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 1.55 (s, 9H), 2.64 (s, 1H), 3.32 (s, 1H), 4.25 (br s, 1H), 5.25 (d, *J* = 2.87 Hz, 1H), 6.90 – 6.93 (m, 2H), 7.07 – 7.25 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.0, 40.4, 59.4, 61.4, 75.5, 126.6, 127.2, 128.8, 129.9,135.0, 139.2; HR-MS (ESI) Calcd for $C_{19}H_{23}NO_3S$, $[M+NH_4]^+$: 363.1737. Found: 363.1738. FT-IR cm^{-1}: 3472, 2982, 2934, 1451, 1286, 1112, 962, 749, 692. **(1*R*, 2'*R*)-5g** ($[\alpha]^{25}_D$ = -141.5, c = 1.0, $CHCl_3$). The enantiomeric purity was determined by HPLC analysis (AD chiral column; hexane:*i*PrOH 98:2; flow: 0.5 ml/min; for **(1*S*, 2'*S*)-5g** resulted t_1 = 29.88 min, **(1*R*, 2'*R*)-5g** resulted t_2 = 35.5 min; for enantioenriched sample **(1*R*, 2'*R*)-5g** resulted t = 35.5 min, er > 98:2). Single crystals suitable for X-ray diffraction grown from hexane/Et_2O.



Minor diastereomer (1*R,2'*S**)-5g:** Colourless oil, 24%. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 1.42 (s, 9H), 2.99 (s, 1H), 3.09 (s, 1H), 5.24 (s, 1H), 6.88

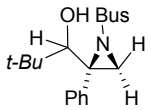
– 6.90 (m, 2H), 7.05 – 7.21 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.3, 35.9, 61.5, 74.0, 126.9, 127.8, 127.9, 120.0, 128.9, 130.4, 138.2; HR-MS (ESI) Calcd for $C_{19}H_{23}NO_3S$, $[M+H]^+$: 346.1471. Found: 346.1470. FT-IR cm^{-1}: 3500, 2986, 1453, 1304, 1119, 696. **(1*S*, 2'*R*)-5g** ($[\alpha]^{25}_D$ = +15.2, c = 1.1, $CHCl_3$).



1-[*N*-(*tert*-Butylsulfonyl)-2-phenylaziridin-2-yl]-2-methylpropan-1-ol (5h). Diastereomers (dr = 80:20) were separated by SiO_2 flash chromatography (petroleum ether : Et_2O 7:3).

Major diastereomer: white solid, mp 115 – 117 °C, 44%. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 0.91 (d, *J* = 6.5 Hz, 3H), 0.99 (d, *J* = 6.7 H, 3H), 1.42 (s, 9H), 1.47 (m, 1H), 2.73 (s, 1H), 2.99 (s, 1H), 3.49 (dd, *J* = 3.1, 9.7 Hz, 1H), 3.84 (bs, 1H), 7.24 – 7.30 (m, 3H), 7.36 – 7.38 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.4, 19.9, 23.9, 31.7, 40.6, 57.7, 61.3, 79.3, 127.8, 128.1, 129.3, 136.1; HR-MS (ESI) Calcd for $C_{16}H_{25}NO_3S$, $[M+NH_4]^+$: 329.1893. Found: 329.1895. FT-IR cm^{-1}: 3510, 2957, 1285, 1107, 701.

Minor diastereomer: white solid, mp 105 – 107 °C, 11%. ^{1}H-NMR (300 MHz, $CDCl_3$) δ 0.74 (d, *J* = 6.8 Hz, 3H), 0.88 (d, *J* = 6.9 H, 3H), 1.14-1.21 (m, 1H), 1.37 (s, 9H), 2.40 (br s, 1H), 2.95 (s, 1H), 3.13 (s, 1H), 4.18 (t, *J* = 2.1 Hz, 1H), 7.28 – 7.32 (m, 3H), 7.42 – 7.46 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.5, 20.7, 24.2, 29.0, 36.3, 61.5, 74.6, 128.2, 129.0, 129.7; HR-MS (ESI) Calcd for $C_{16}H_{25}NO_3S$, $[M+H]^+$: 312.1628. Found: 312.1626. FT-IR cm^{-1}: 3339, 3295, 3245, 2967, 2929, 1302, 1128.

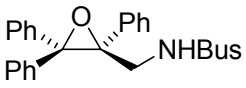


1-[1-(*tert*-Butylsulfonyl)-2-phenylaziridin-2-yl]-2,2-dimethyl-propan-1-ol (5i). Diastereomers (dr = 80:20) were separated by SiO_2 flash chromatography (petroleum ether : Et_2O 7:3) but only the major isomer was analitically pure.

Major diastereomer: white solid, mp 132 °C, 48%. ^{1}H-NMR (300 MHz, $CDCl_3$) δ 0.72 (s, 9H), 1.37 (s, 9H), 2.89 (s, 1H), 3.02 (s, 1H), 3.57 (d, *J* = 3.5 Hz, 1H), 3.98 (bs, 1H), 7.24 – 7.27 (m, 3H), 7.43 – 7.47 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.8, 26.7, 36.0, 40.7, 57.7, 61.2, 81.4, 127.8, 128.1, 130.3, 137.0; HR-MS (ESI) Calcd for $C_{17}H_{27}NO_3S$, $[M+NH_4]^+$: 343.2050. Found: 343.2050. FT-IR cm^{-1}: 3501, 2979, 1281, 1110, 735.

Procedure for the preparation of epoxide 7:

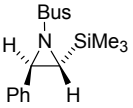
n-BuLi (1.6 M in hexane, 525 μL, 0.84 mmol) was added dropwise to a stirred solution of aziridine **1** (100 mg, 0.42 mmol) and TMEDA (125.8 μL, 0.84 mmol) in Et_2O (8 mL) at -78 °C. After 5 minutes at -78 °C benzophenone (0.84 mmol in 2 mL of Et_2O) was added. After 1 hour at -78 °C, the mixture was allowed to warm slowly to room temperature. After addition of saturated aqueous NH_4Cl (10 mL), the mixture was extracted with Et_2O (3 x 10 mL). The combined organic layers were dried ($MgSO_4$), filtered and evaporated under reduced pressure. Purification by SiO_2 flash chromatography gave **7** (283 mg) as a white solid.



2-(tert-Butylsulfonamido)methyl-2,3,3-triphenyloxirane (7). White solid, mp 173 – 176 °C, 80%. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 1.13 (s, 9H), 3.12 (dd, *J* = 6.5, 13.7 Hz, 1H), 3.71 (t, *J* = 6.2 H, 1H), 3.85 (dd, *J* = 6.0, 13.7 Hz, 1H), 6.91-7.48 (m, 15H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.1, 29.7, 48.8, 60.2, 70.5, 126.8, 127.2, 127.4, 127.7, 127.9, 128.1, 128.2, 128.8, 135.5, 138.0, 138.4; HR-MS (ESI) Calcd for $C_{25}H_{27}NO_3S$, $[M+NH_4]^+$: 439.2050. Found: 439.2054. FT-IR cm^{-1}: 3421, 1448, 1293, 1125, 891, 697.

Procedure for the preparation of aziridine 4:

n-BuLi (1.6M in hexanes, 1.88 mL, 3.0 mmol) was added dropwise to a stirred solution of 2,2,6,6-tetramethylpiperidine (0.51 mL, 3.0 mmol) in THF (15 mL) at –78 °C. The mixture was warmed to room temperature over 30 min, then re-cooled to –78 °C before dropwise addition of the aziridine (239 mg, 1.0 mmol) in THF (8 mL). The mixture was stirred at –78 °C for 5 min before the addition of chlorotrimethylsylane (3.0 mmol), sat. aq. NH_4Cl (8 mL) and Et_2O (16 mL). After 1 hour at -78 °C, the mixture was allowed to warm to room temperature. After addition of saturated aqueous NH_4Cl (10 mL), the mixture was extracted with Et_2O (3 x 10 mL). The combined organic layers were dried ($MgSO_4$), filtered and evaporated under reduced pressure. Purification by SiO_2 flash chromatography gave **4** (133 mg).



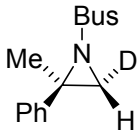
1-(*tert*-Butylsulfonyl)-2-phenyl-3-trimethylsilylaziridine (4). Colourless oil, 43%. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 0.21 (s, 9H), 1.35 (s, 9H), 1.84

(d, J = 6 Hz, 1H), 3.54 (d, J = 6 Hz, 1H), 7.19-7.30 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ -1.1, 24.2, 43.8, 46.1, 59.5, 126.0, 128.1, 128.7, 137.5. Single crystals suitable for X-ray diffraction grown from hexane/Et_2O.

Procedure for the lithiation - trapping of aziridine (±)-5c:

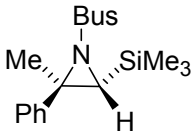
n-BuLi (1.6 M in hexane, 787 μL, 1.26 mmol) was added dropwise to a stirred solution of aziridine **(±)-5c** (100 mg, 0.42 mmol) and TMEDA (188.7 μL, 1.26 mmol) in Et_2O (8 mL) at -78 °C. After 15 minutes at -78 °C the electrophile (1.26 mmol) was added. After 1 hour at -78 °C, the mixture was allowed to warm slowly to room temperature. Saturated aqueous NH_4Cl (10 mL) was added and the mixture extracted with Et_2O (3 x 10 mL). The combined organic layers were dried ($MgSO_4$), filtered and evaporated under reduced pressure. Purification by SiO_2 flash chromatography (petroleum ether:Et_2O 8:2) gave the substituted aziridines **9a**, **9b**.

***(2R*,3R*)*-1-(*tert*-Butylsulfonyl)-2-methyl-2-phenyl-3-deuterioaziridine (9a).**



Colourless oil, 87% (95%D). ^{1}H-NMR (400 MHz, $CDCl_3$) δ 1.47 (s, 9H), 1.96 (s, 3H), 2.45 (s, 1H), 7.22-7.39 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 20.8, 24.1, 43.1 (t, J = 26 Hz), 49.0, 60.8, 126.3, 127.6, 128.4, 141.5; ESI-MS *m/z*: 277 $[M+Na]^+$ (100). GC-MS (70 eV) *m/z* (%): 254 (1), 134 (13), 133 (65), 92 (100), 77 (11), 57 (29). FT-IR cm^{-1}: 2984, 1297, 1110, 719.

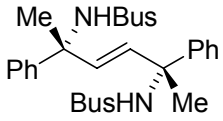
***(2R*,3R*)*-1-(*tert*-Butylsulfonyl)-2-methyl-2-phenyl-3-trimetylsylylaziridine (9b).**



White solid, mp 105 – 106 °C, 84 %. ^{1}H-NMR (600 MHz, CD_3OD, 210 K) a mixture of invertomers is detectible (ratio 2:1) δ 0.32 (s, 9H major + 9H minor), 1.41 (s, 9H major), 1.48 (s, 9H minor), 1.66 (s, 3H major), 1.94 (s, 3H minor), 2.01 (s, 1H minor), 2.85 (s, 1H major), 7.33 -7.59 (m, 5H major + 5H minor); ^{13}C NMR (125 MHz, CD_3OD, 210 K) δ -1.6, -0.5, 20.9, 23.9, 26.3, 43.6, 50.0, 52.5, 54.1, 60.5, 61.1, 126.3, 128.0, 128.3, 128.8, 129.0, 130.5, 139.3, 145.0; GC-MS (70 eV) *m/z* (%): 325 (8), 190 (12), 132 (100), 73 (32), 57 (26). FT-IR cm^{-1}: 3000, 2979, 1304, 1125, 886, 848, 763, 695.

Procedure for the eliminative dimerization of aziridine (*R*)-5c. *n*-BuLi (1.6M in hexanes, 1.88 mL, 3.0 mmol) was added dropwise to a stirred solution of 2,2,6,6-tetramethylpiperidine (0.51 mL, 3.0 mmol) in THF (0.4 mL) at –78 °C. The mixture was warmed to 0 °C over 15 min, then re-cooled to –78 °C before dropwise addition of the aziridine (1.0 mmol) in THF (0.8 mL). The mixture was stirred at –78 °C for 20 min, then at 0 °C for 1 h, before the addition of MeOH (0.8 mL), sat. aq. NH_4Cl (8 mL) and Et_2O (16 mL). The layers were separated, and the aqueous phase was extracted with Et_2O (16 mL). The combined organic phase was dried ($MgSO_4$) and concentrated, giving the corresponding ene-2,5-diamine.

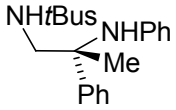
(3*E*)-*N*,*N'*-bis(*tert*-Butylsulfonyl)-2,5-diphenylhexan-3-ene-2,5-diamine (13).



White solid, mp 135-136 °C, 90%. ^{1}H-NMR (600 MHz, $CDCl_3$) δ 1.42 (s, 9H), 1.89 (s, 3H), 4.20 (s, 1H), 6.05 (s, 1H), 7.22-7.35 (m, 3H), 7.45-7.48 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 24.4, 27.1, 60.1, 63.2, 126.1, 127.5, 128.5, 135.5, 145.3; ESI-MS *m/z*: 277 [M-H] (100). FT-IR cm^{-1}: 3272, 2964, 2921, 1601, 1446, 1305, 1261, 1094, 1020, 798. Anal calcd for $C_{26}H_{38}N_2O_4S_2$: C, 61.63; H, 7.56; N, 5.53. Found: C, 61,45; H, 7.54; N, 5.91. The enantiomeric purity of **13** ($[\alpha]^{25}_D$ = +8.55, c = 0.9, $CHCl_3$) was determined by HPLC analysis (AD chiral column; hexane:*i*PrOH 98:2; flow: 0.5 ml/min; for **(±)-13** resulted t_1 = 35.7 min, t_2 = 39.5 min; for **(+)-13** resulted t = 39.5 min, er >98:2).

General procedure for the ring-opening reaction with amines:

A mixture of aziridine **(*R*)-5c** (100 mg, 0.42 mmol), aniline (1.2 equiv, 45.6 μL, 0.50 mmol) and EtOH (420 μL) was charged in a round-bottom glass flask containing a magnetic stirring bar. The flask was placed in a CEM Discover Focused Microwave Synthesis System. The flask was subjected to MW irradiation at 100 °C (300 W) for 30 min. After the reaction is completed, the flask was removed from the MW cavity and cooled to room temperature. The reaction mixture was concentrated *in vacuo*, followed by distillation in a Kugelrohr apparatus at 85 °C/0.1 mbar to remove excess aniline. The enantiomeric purity of the corresponding chiral products was established by ^{1}H NMR analysis using Mosher's acid.



[2-Phenyl-(2-phenylamino)]propyl-*tert*-butylsulfonamide (10). White solid, mp 119 – 121 °C, 98%. ^{1}H-NMR (300 MHz, $CDCl_3$) δ 1.26 (s, 9H), 1.63 (s, 3H), 3.44 (ddd, *J* = 17.5, 13.3, 5.9 Hz, 1H), 4.14 (dd, *J* = 7.5, 4.7 Hz, 1H), 6.29 (d, *J* = 7.8 Hz, 1H), 6.94 (t, *J* = 7.9 Hz, 1H), 7.08 (t, *J* = 7.9 Hz, 1H), 7.17-7.39 (m, 5H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 22.7, 54.2, 58.7, 115.5, 117.0, 126.3, 128.5, 128.7, 145.0, 146.1; HR-MS (ESI) Calcd for $C_{19}H_{26}N_2O_2S$, $[M+H]^+$: 347.1788. Found: 347.1789. FT-IR cm^{-1}: 3398, 3267, 2976, 1600, 1501, 1305, 1122, 743, 698, 691. Anal calcd for $C_{19}H_{26}N_2O_2S$: C, 65.86; H, 7.56; N, 8.08; S, 9.25. Found: C, 66.70; H, 7.63; N, 8.48; S, 8.75.

Cleavage of the Bus group:[4]

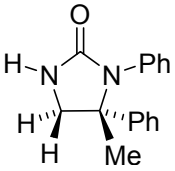
To a solution of sulfonamide (73 mg, 0.21 mmol) and anisole (19.7 equiv, 462 μL, 4.25 mmol) in CH_2Cl_2 (6.2 mL) at 0 °C was slowly added trifluoromethanesulfonic acid (0.2 N in CH_2Cl_2, 6.2 mL) (the final concentration of the triflic acid is 0.1 N). The resultant mixture was stirred at room temperature until reaction was complete according to TLC analysis (usually overnight). The reaction mixture was poured into 10 % aqueous NaOH (20 mL) and extracted with CH_2Cl_2 (2 x 20 mL). The organic phases were combined, dried over $MgSO_4$, filtered and concentrated under reduced pressure. The residue was purified by SiO_2 flash chromatography (Dichloromethane:MeOH 95:5) to afford **11**.

2-phenylamino-2-phenyl-propanamine (11). Colourless oil, 98 %. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 1.64 (s, 3H), 2.89 (s, 2H), 6.36 (d, *J* = 7.8 Hz, 2H), 6.59 (t, *J* = 7.3 Hz, 1H), 6.99 (t, *J* = 7.9 Hz, 2H), 7.21-7.24 (m, 1H), 7.30-7.34 (m, 2H), 7.43-7.45 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 24.4, 24.6, 55.0, 58.4, 60.2, 115.3, 117.4, 126.2, 127.2, 128.7, 128.9, 143.1, 145.0; ESI-MS *m/z*: 257 [M-H] (100). FT-IR cm^{-1}: 3337, 2919, 1601, 1499, 1316, 1262, 751, 700. The enantiomeric purity of **11** ($[\alpha]^{25}_D$ = +11.5, c 0.2, $CHCl_3$) was determined by ^{1}H-NMR resolution in presence of the Mosher's acid and found to be >98 %ee.

[4] Sun, P.; Weinreb, S. M. *J. Org. Chem.* **1997**, *62*, 8604-8608.

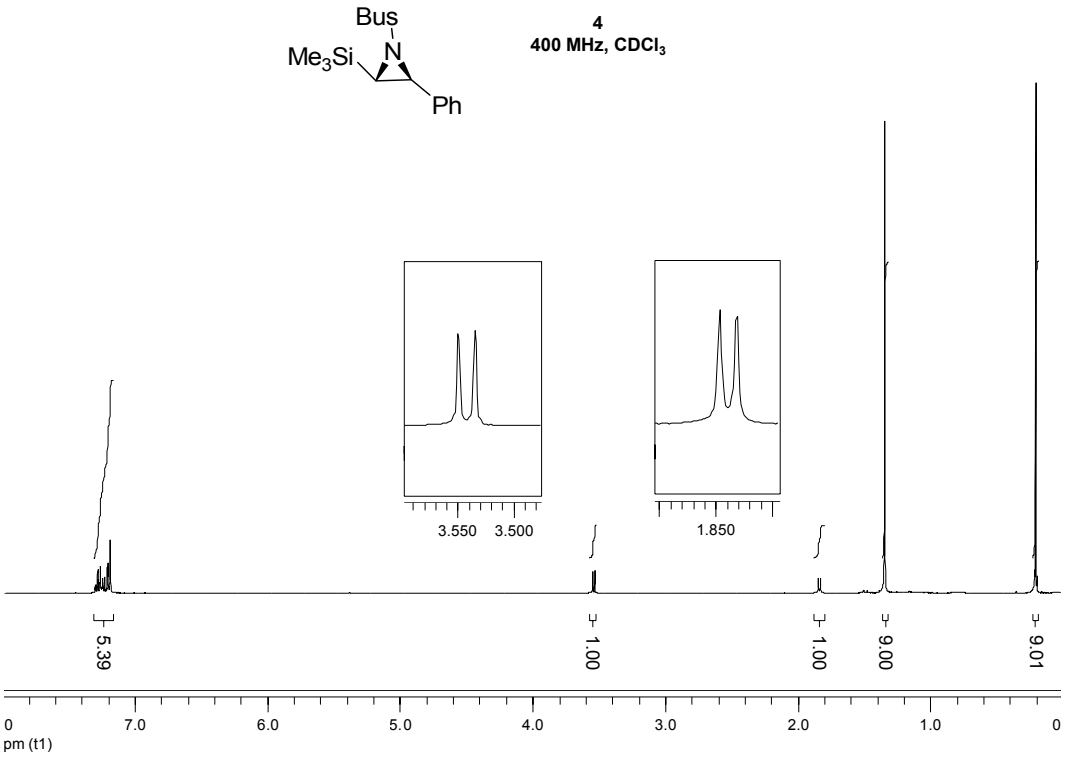
Procedure for the preparation of imidazolidinone derivative 12.[5]

To a solution of diamine (25 mg, 0.11 mmol) in THF (250 μl) was slowly added a solution of N,N'-carbonyldiimidazole (18.53 mg, 0.11 mmol) in THF (250 μl) at 0 °C. The resultant mixture was stirred at room temperature until reaction was complete according to TLC analysis (usually overnight). The reaction mixture was poured into brine and the acqueous layer was extracted with Et_2O (3 x 20 mL). The organic phases were combined, dried over $MgSO_4$ and concentrated under reduced pressure. The residue was purified by SiO_2 flash chromatography (Dichloromethane:MeOH 95:5) to afford the corresponding imidazolidinone **12**.



4-Methyl-3,4-diphenyl-imidazolidin-2-one (12). Colourless oil. 41 % . ^{1}H-NMR (400 MHz, $CDCl_3$) δ 1.74 (s, 3H), 3.57 (s, 2H), 5.25(br s, 1H), 6.98-7.18 (m, 5H), 7.28-7.47 (m, 5H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 23.7, 55.4, 64.7, 125.4, 125.6, 125.8, 127.8, 128.5, 128.7, 136.8, 144.4, 160.4; GC-MS (70 eV) *m/z* (%): 253 (13), 252 (76), 237 (100), 194 (31), 180 (31), 77 (34).FT-IR cm^{-1}: 3215, 2921, 1687, 700.

[5] Wright, W. B. Jr. *J. Heter. Chem.* **1965**, 41-43.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N
Ph
4
400 MHz, CDCl3
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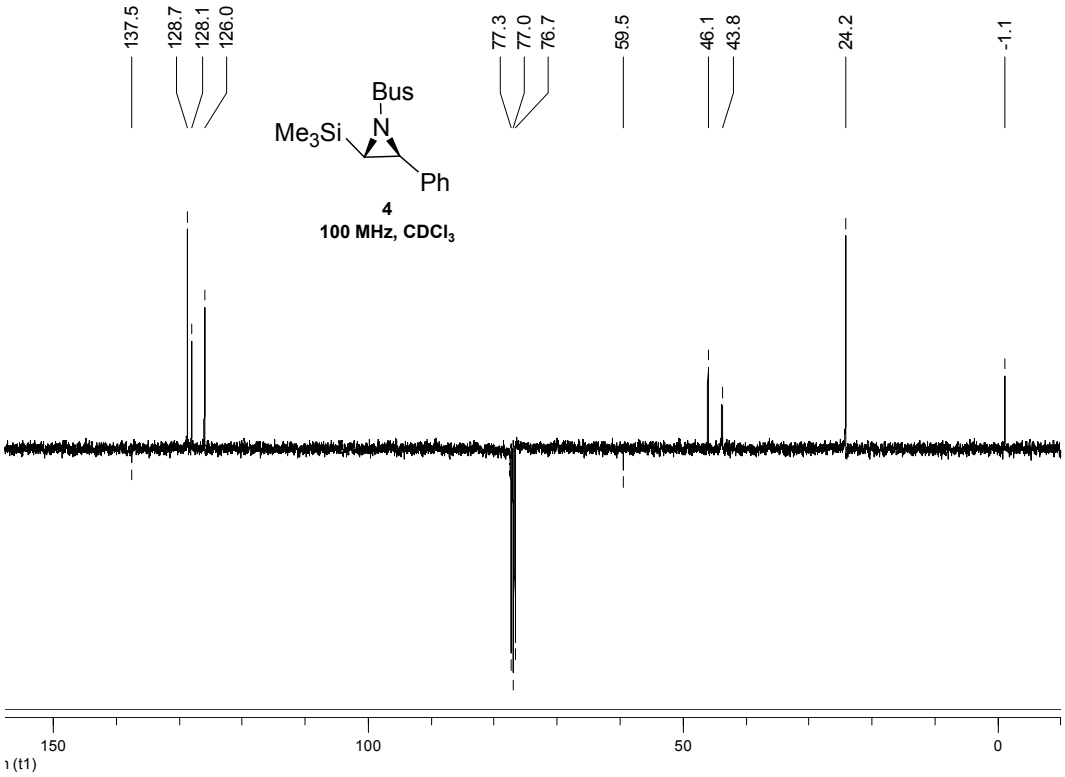
3.500
1.850
5.39
1.00
1.00
9.00
9.01
0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
pm (t1)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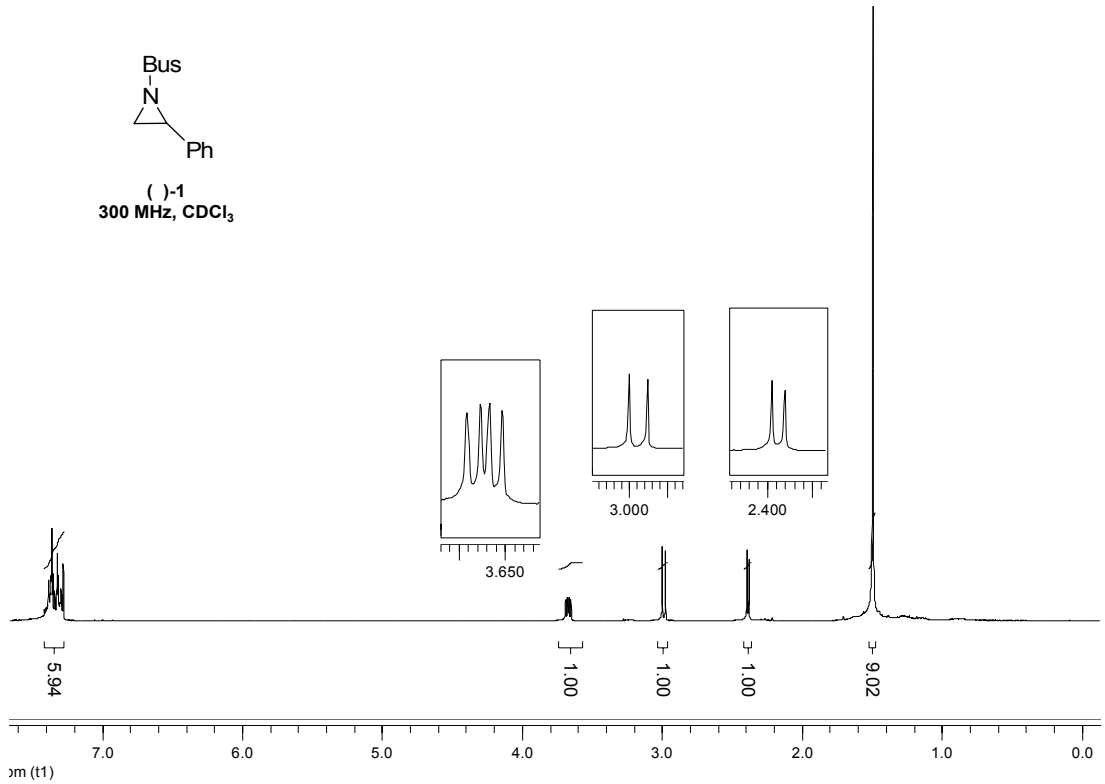
128.7
128.1
126.0
77.3
77.0
76.7
59.5
46.1
43.8
24.2
-1.1
Bus
Me3Si
N
Ph
4
100 MHz, CDCl3
150
100
50
0
(t1)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Ph
( )-1
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3.000
2.400
5.94
1.00
1.00
1.00
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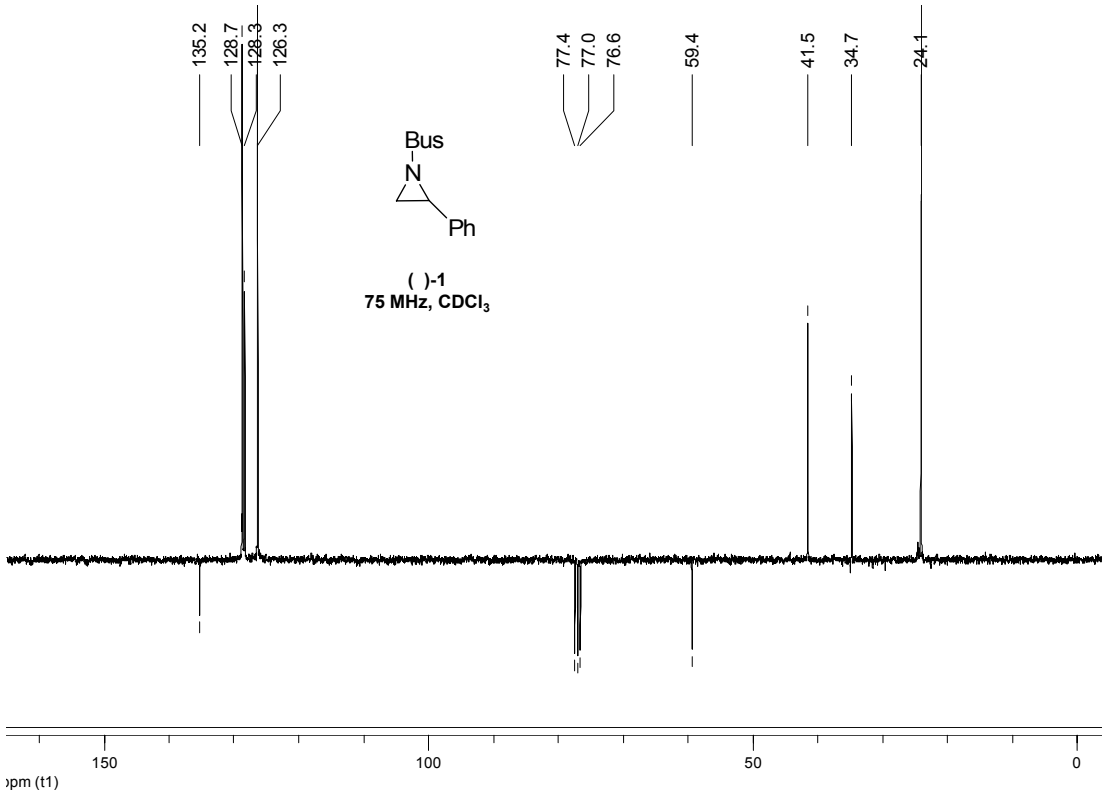
6.0
5.0
4.0
3.0
2.0
1.0
0.0
pm (t1)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128.3
126.3
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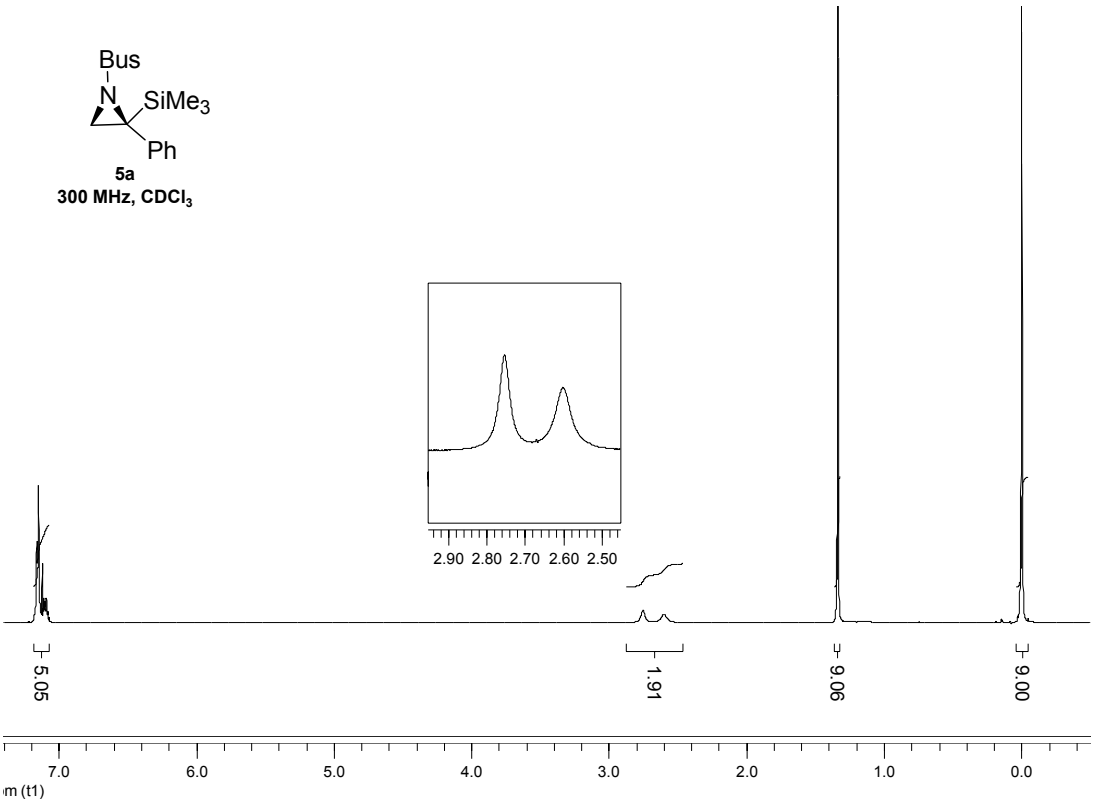
77.0
76.6
59.4
41.5
34.7
24.1
Bus
N
Ph
( )-1
75 MHz, CDCl3
150
100
50
0
ppm (t1)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9.00
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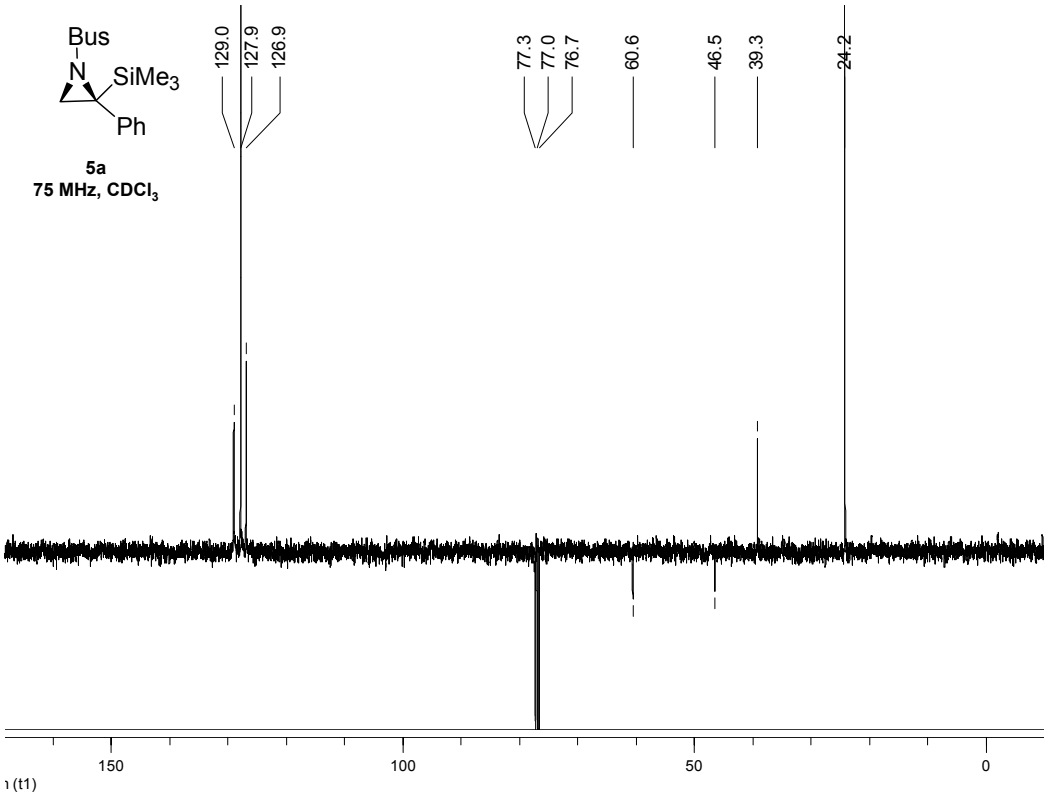
5.0
4.0
3.0
2.0
1.0
0.0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50
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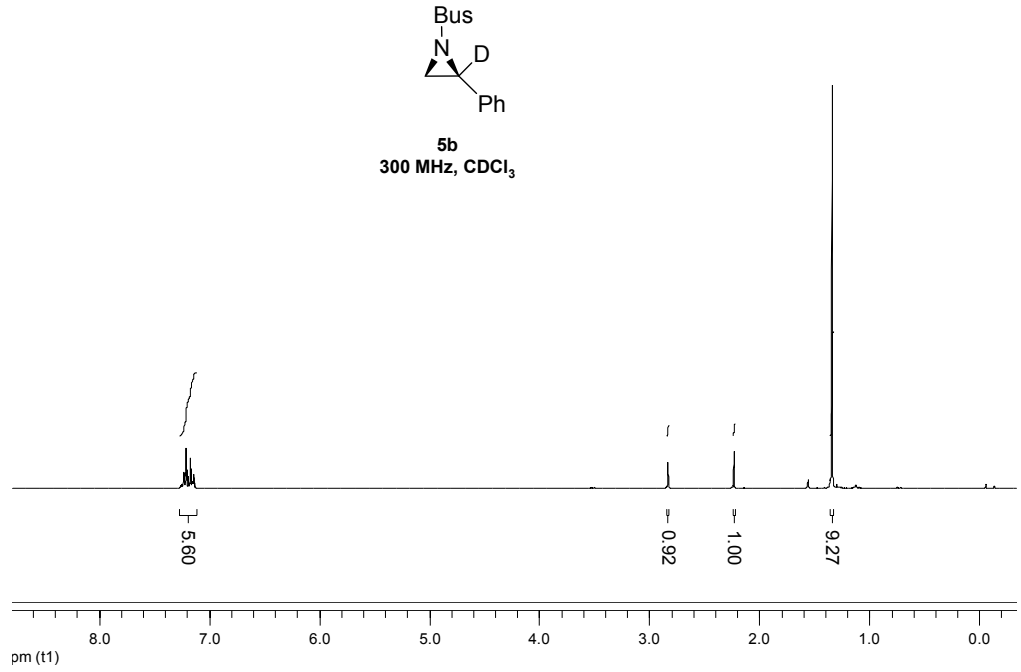
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D
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3.0
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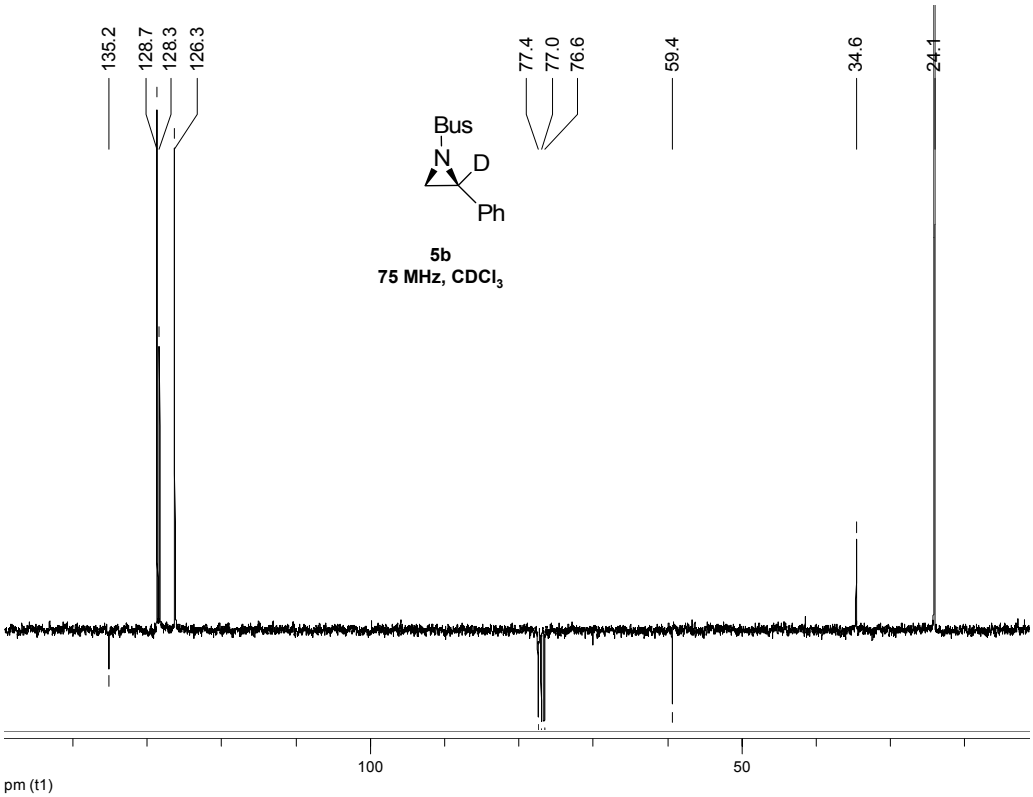
0.0
pm (t1)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128.3
126.3
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77.0
76.6
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34.6
24.1
Bus
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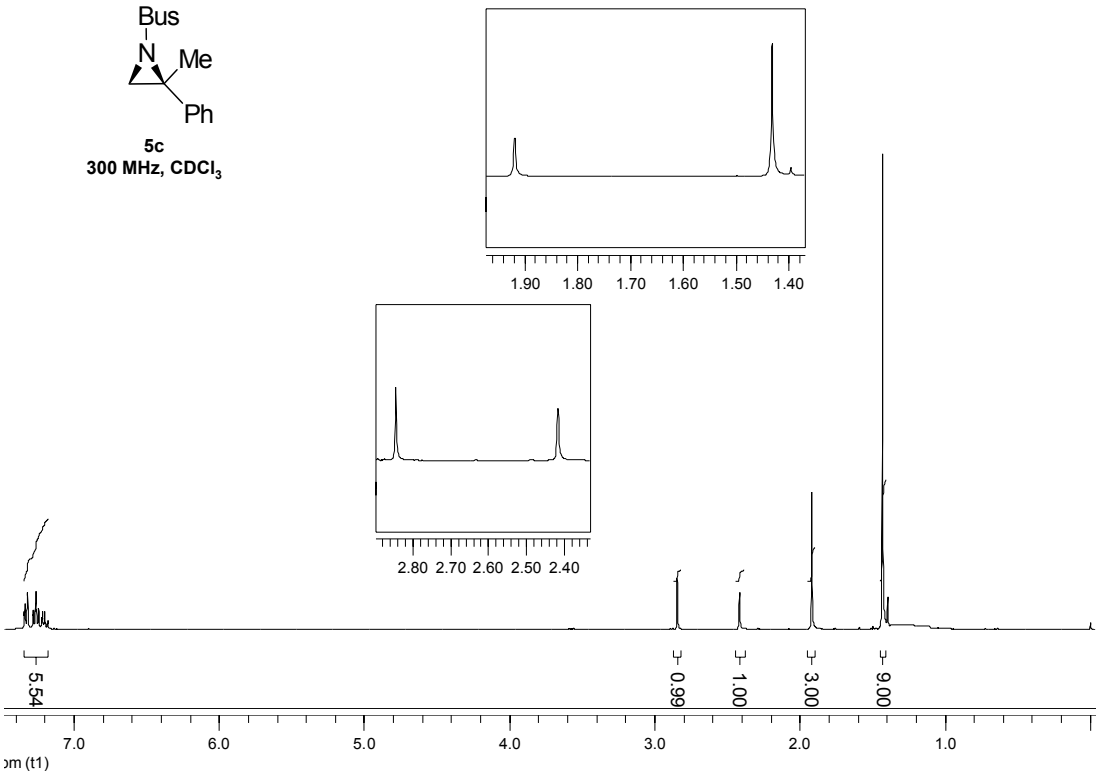
Ph
5b
75 MHz, CDCl3
100
50
pm (t1)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Me
Ph
5c
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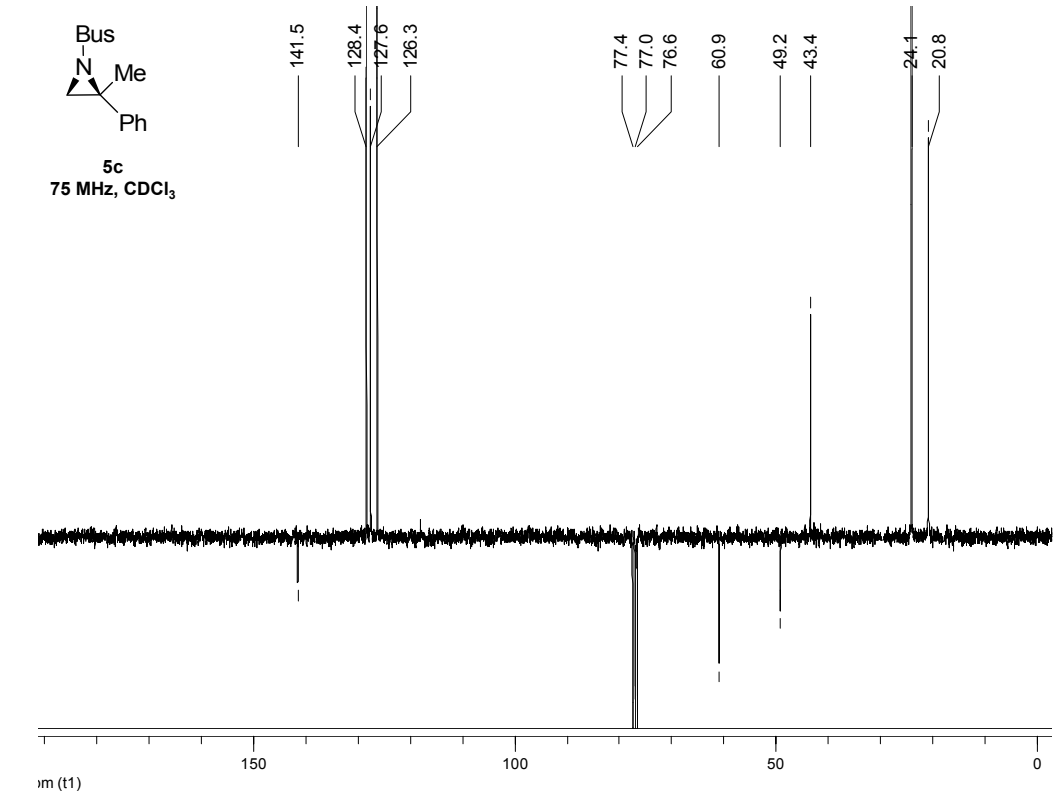
2.80 2.70 2.60 2.50 2.40
5.54
0.99
1.00
3.00
9.00
7.0 6.0 5.0 4.0 3.0 2.0 1.0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Me
Ph
5c
75 MHz, CDCl3
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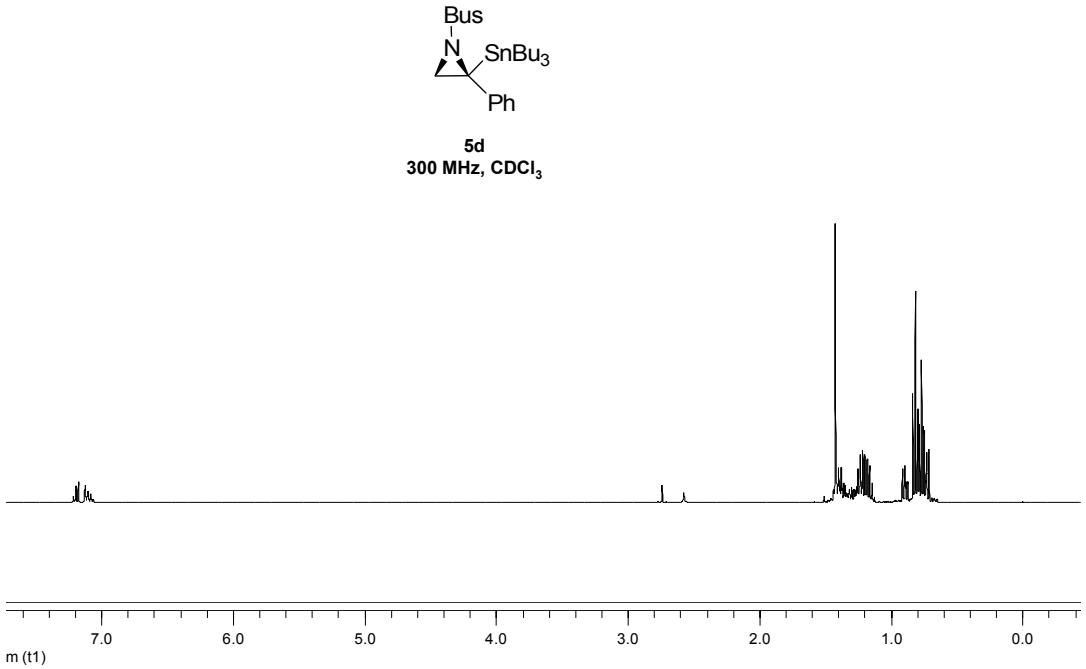
49.2
43.4
24.1
20.8
150 100 50 0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SnBu3
Ph
5d
300 MHz, CDCl3
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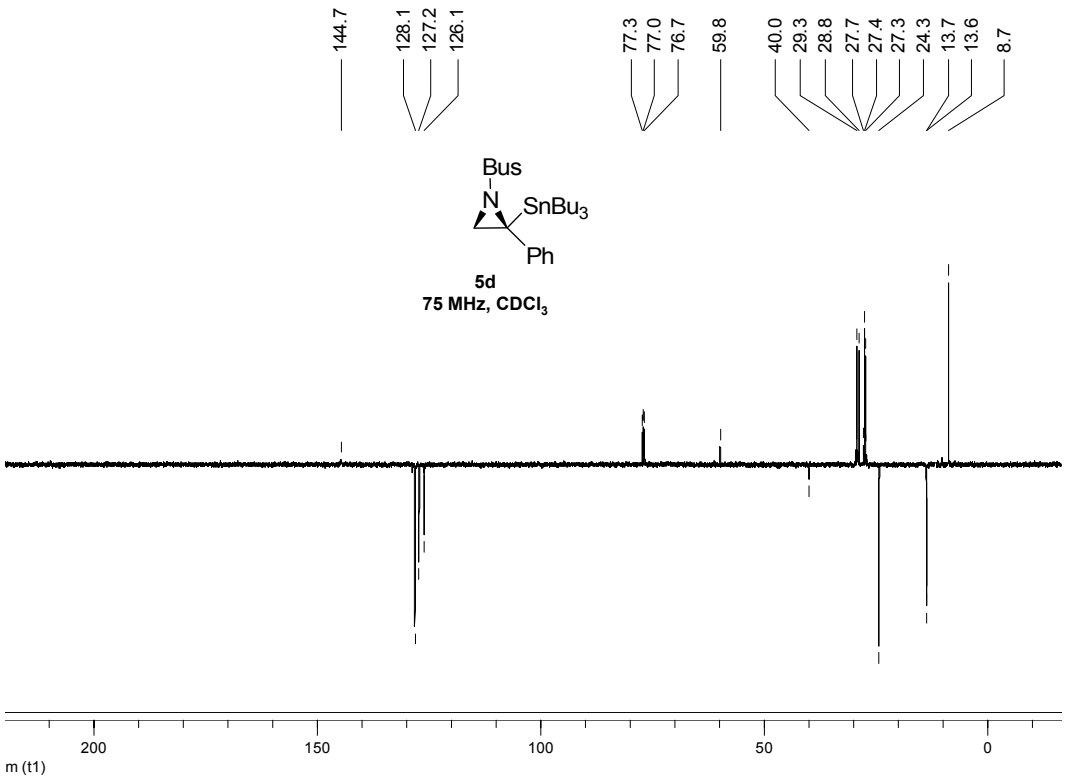
5.0
4.0
3.0
2.0
1.0
0.0
m (t1)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128.1
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77.3
77.0
76.7
59.8
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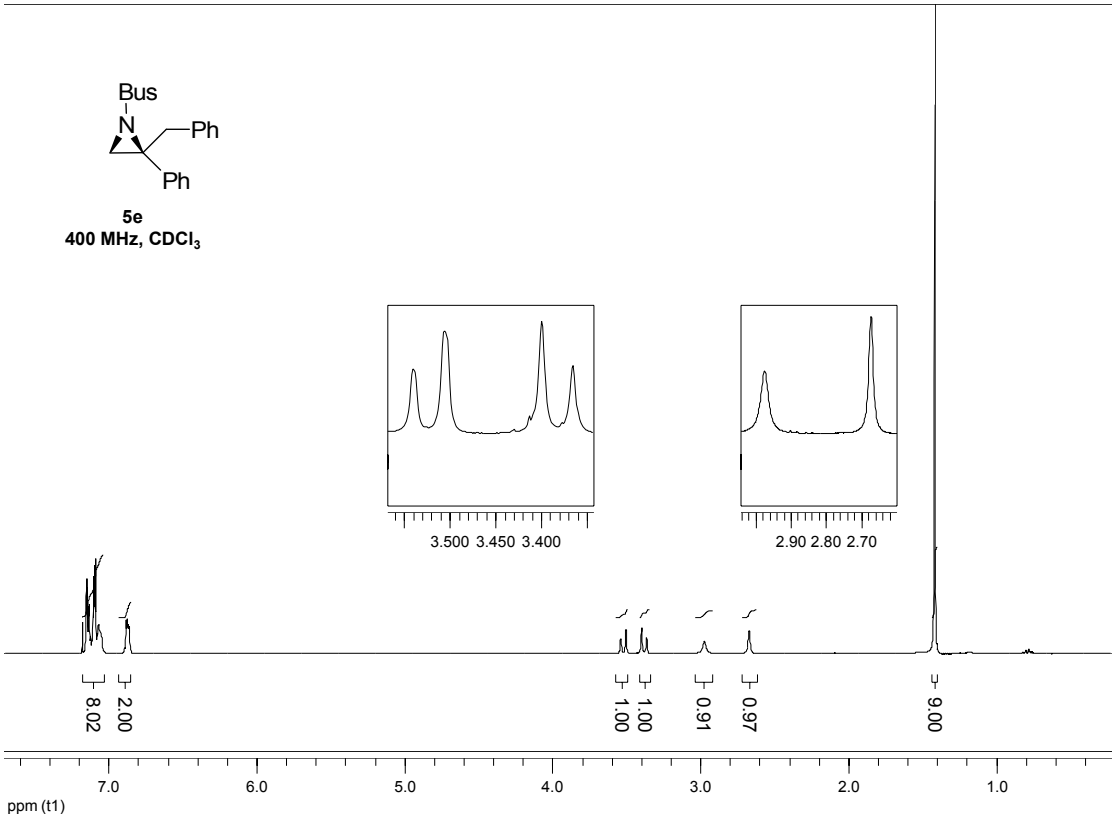
28.8
27.7
27.4
27.3
24.3
13.7
13.6
8.7
Bus
N
SnBu3
Ph
5d
75 MHz, CDCl3
200
150
100
50
0
m (t1)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Ph
Ph
5e
400 MHz, CDCl3
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2.90 2.80 2.70
8.02
2.00
1.00
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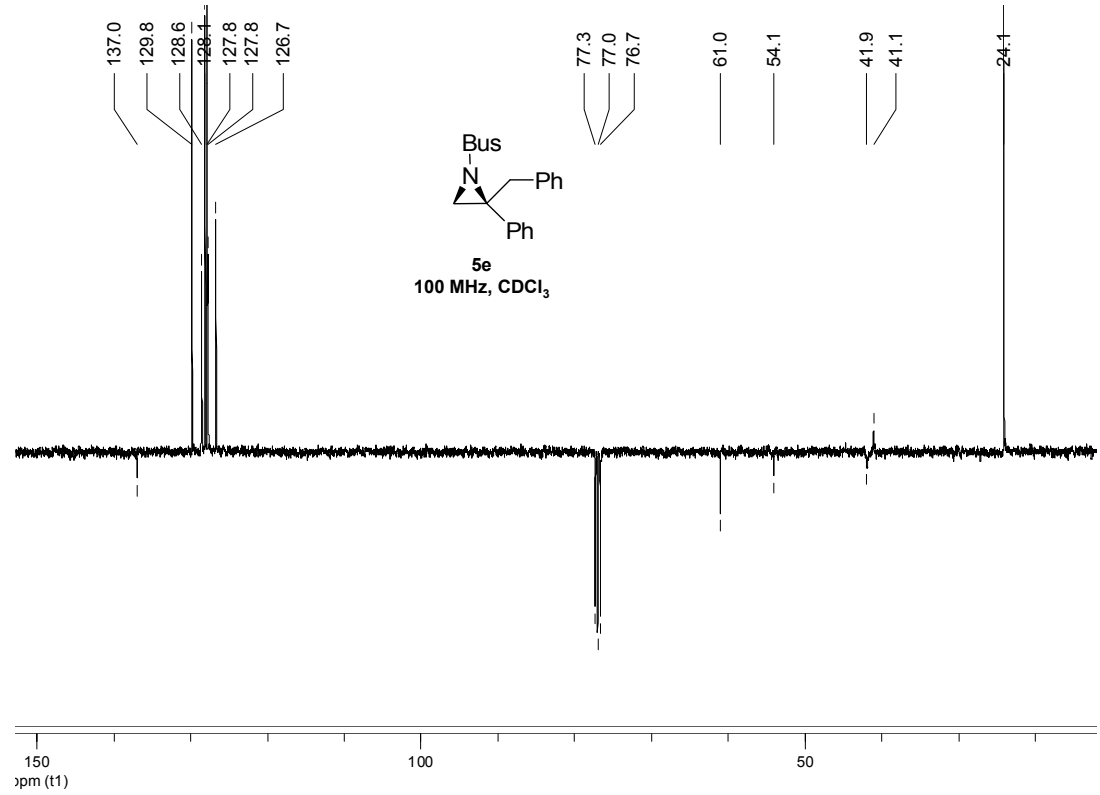
3.0
2.0
1.0
ppm (t1)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76.7
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Bus
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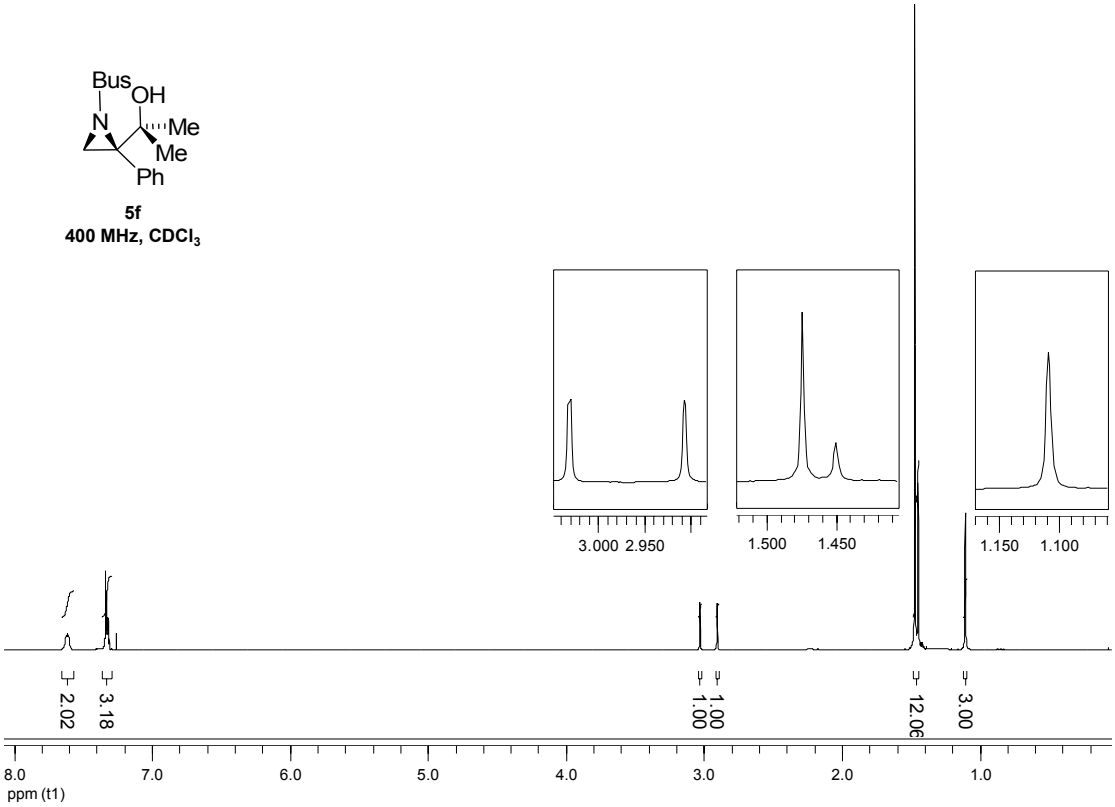
Ph
Ph
5e
100 MHz, CDCl3
150
100
50
ppm (t1)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N
Me
Me
Ph
5f
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1.150 1.100
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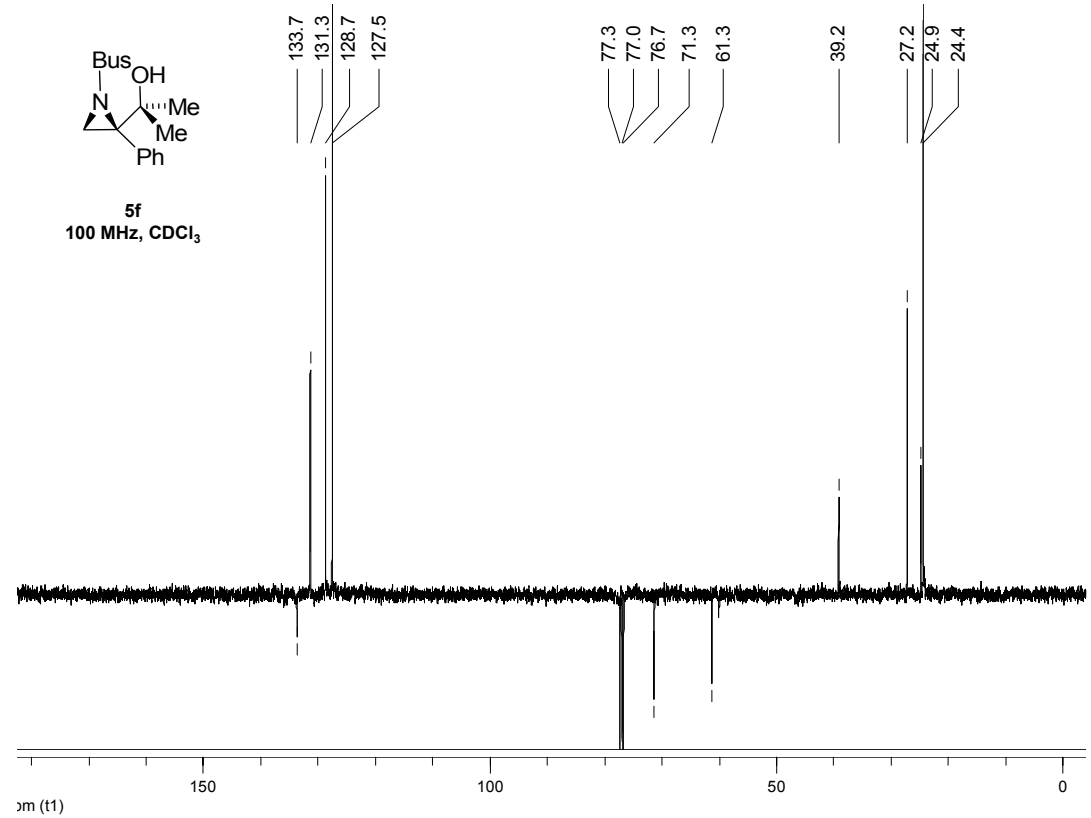
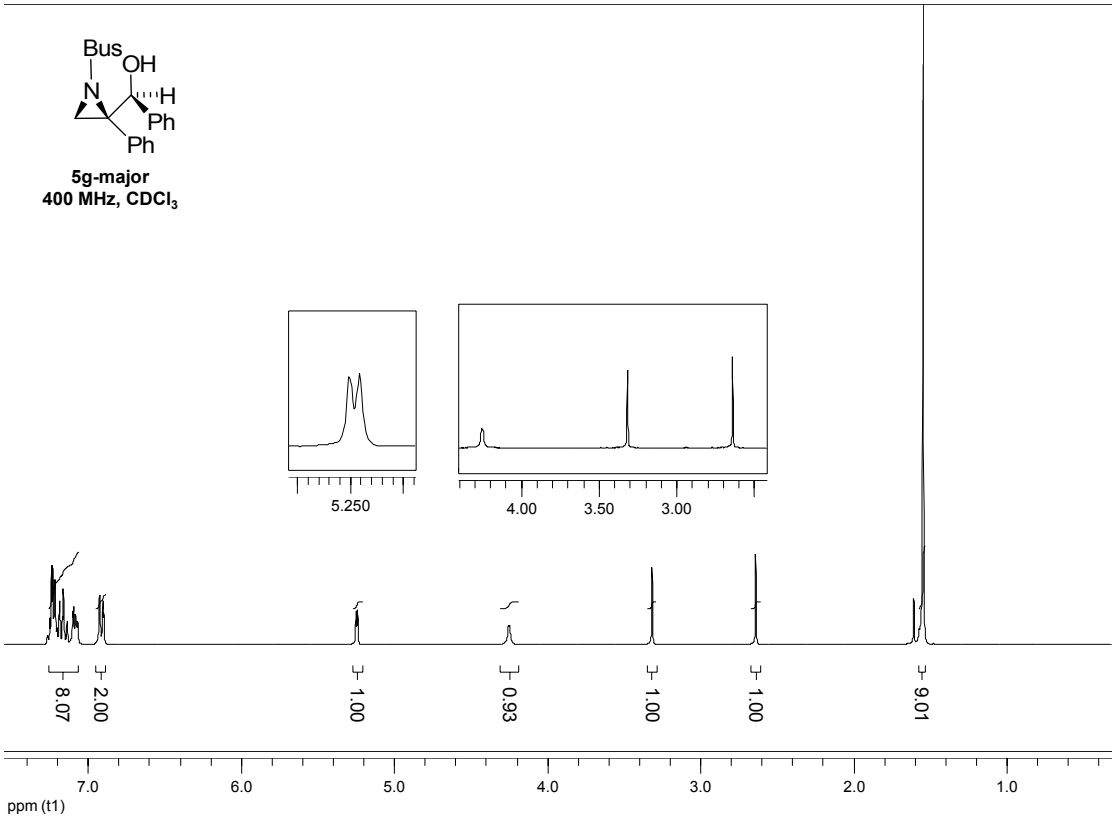
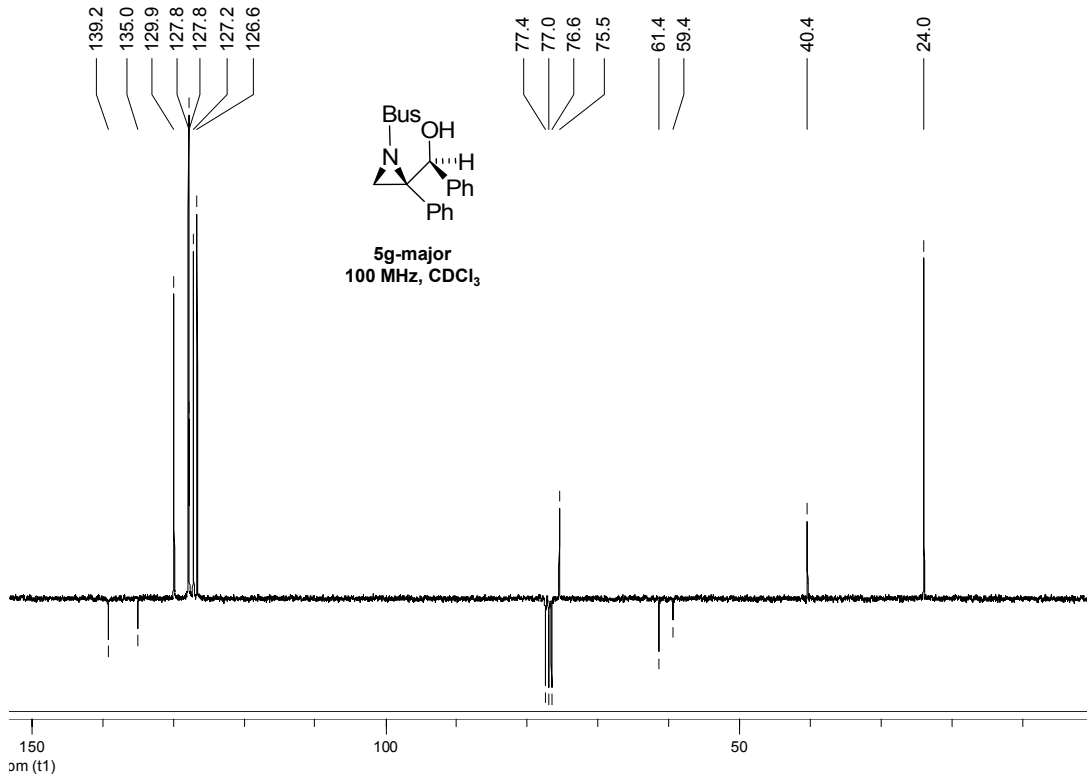
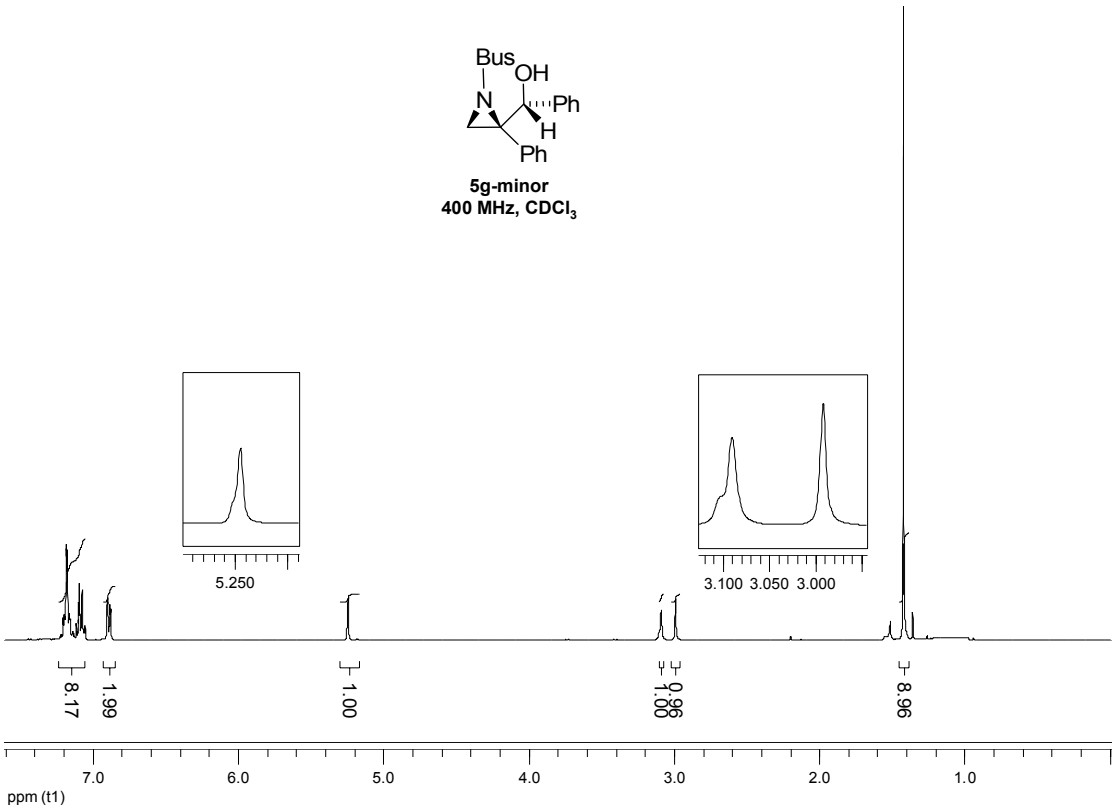
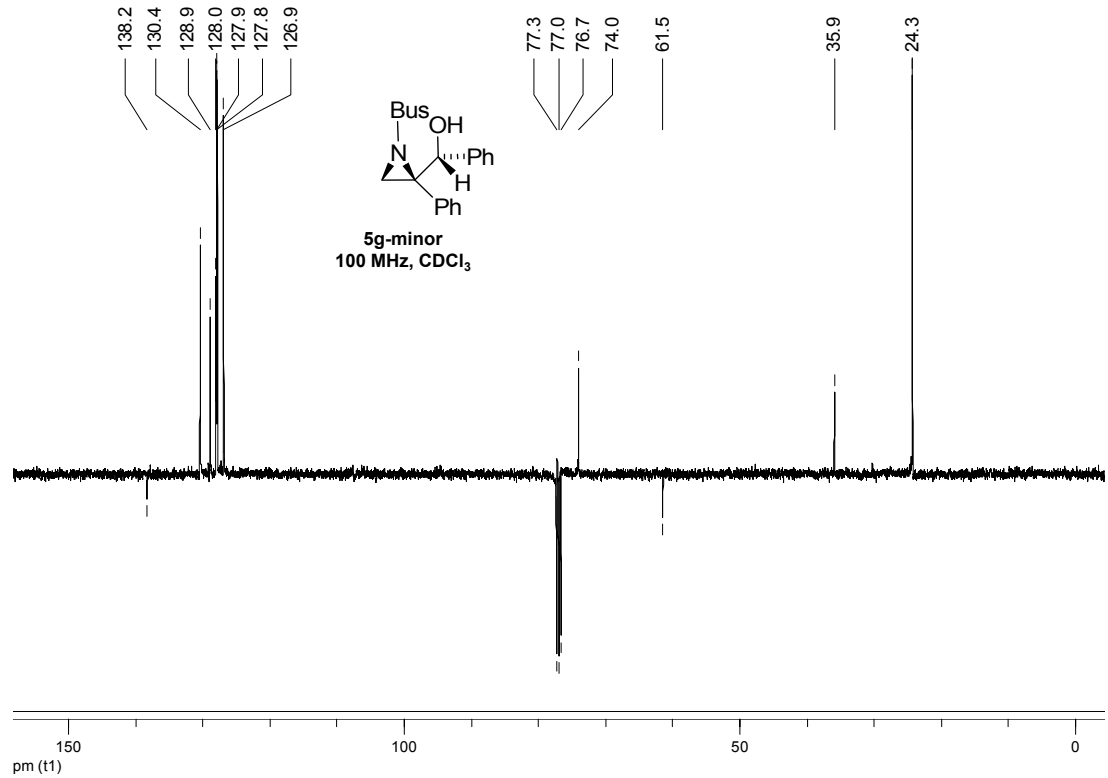
1.00
12.06
3.00
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

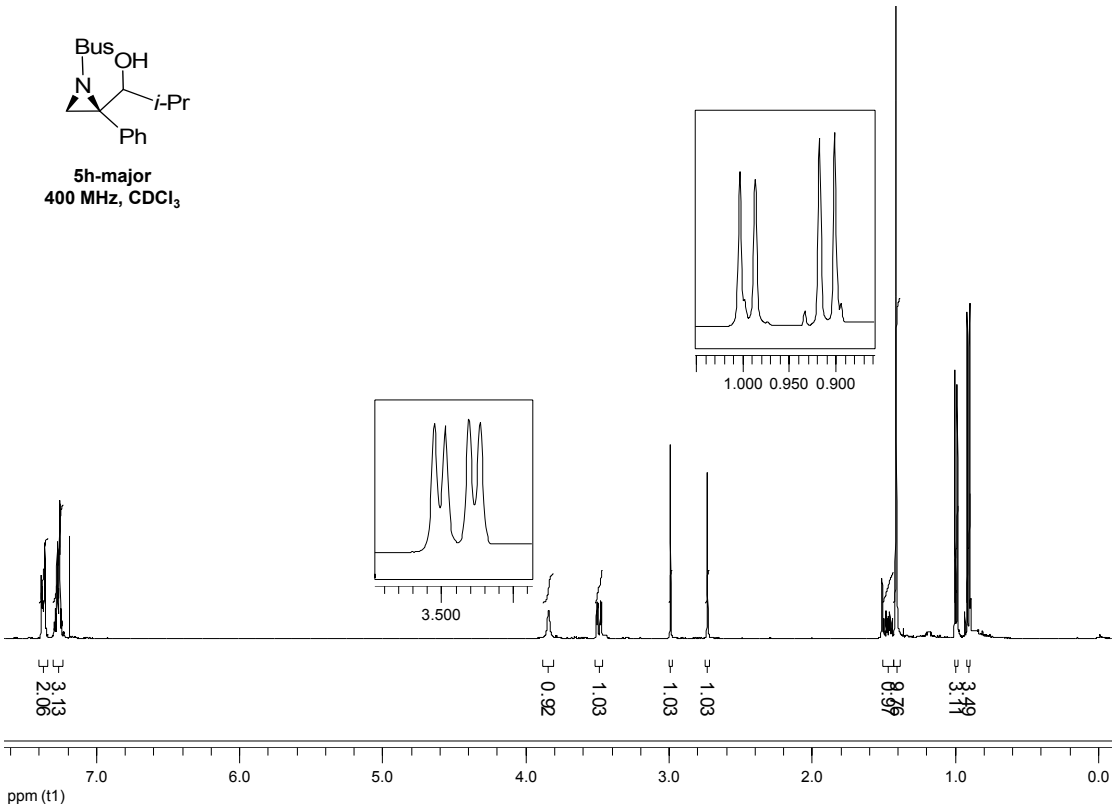

Bus
OH
N
Me
Me
Ph
5f
100 MHz, CDCl3
133.7
131.3
128.7
127.5
77.3
77.0
76.7
71.3
61.3
39.2
27.2
24.9
24.4
150
100
50
0
ppm (t1)

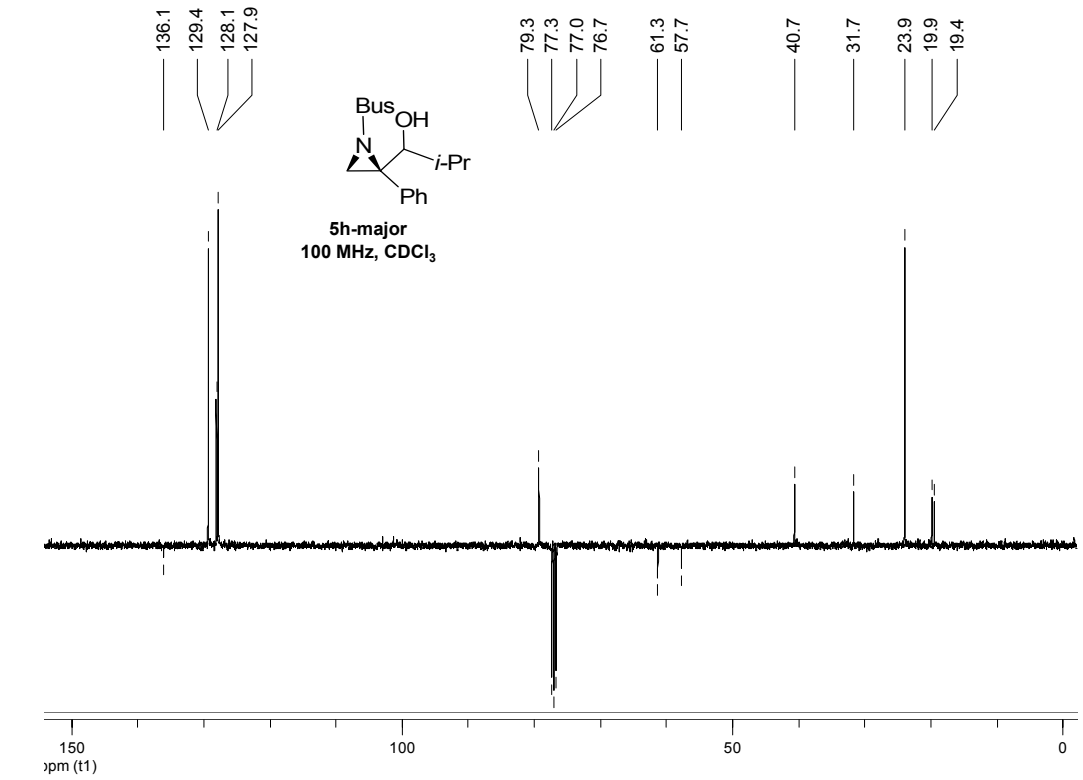

Bus
OH
N
H
Ph
Ph
5g-major
400 MHz, CDCl3
5.250
4.00
3.50
3.00
8.07
2.00
1.00
0.93
1.00
1.00
9.01
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

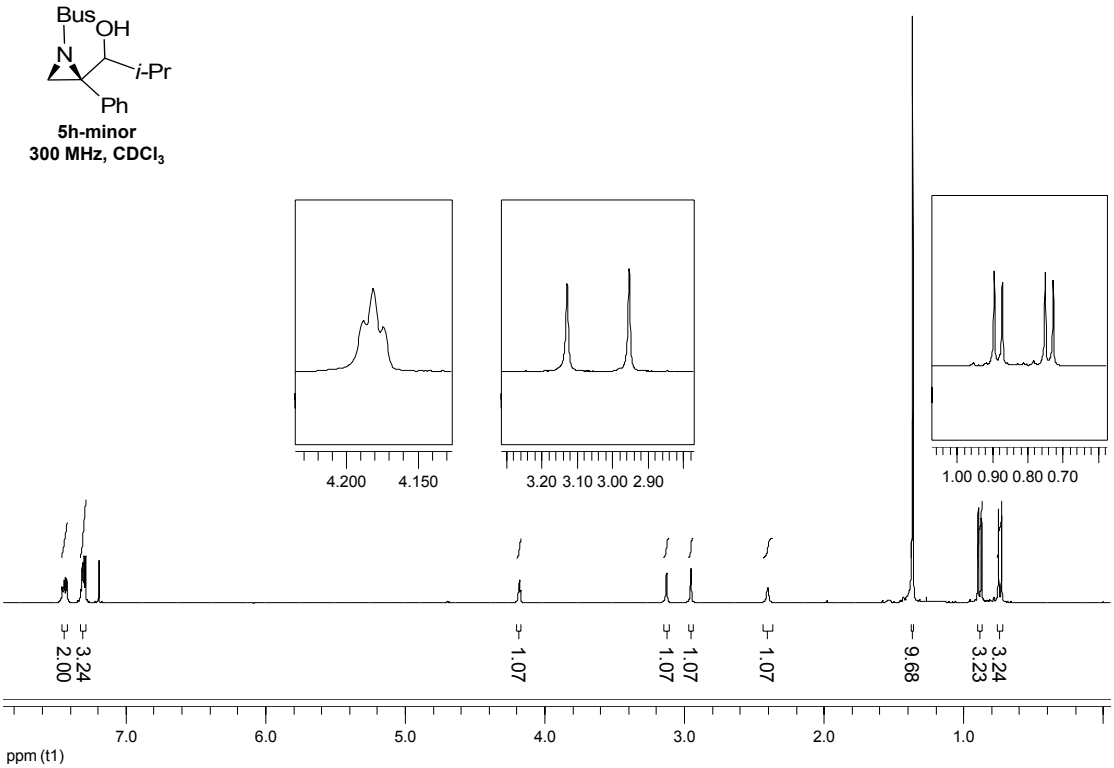

139.2
135.0
129.9
127.8
127.8
127.2
126.6
77.4
77.0
76.6
75.5
61.4
59.4
40.4
24.0
Bus
OH
N
H
Ph
Ph
5g-major
100 MHz, CDCl3
150
100
50
ppm (t1)

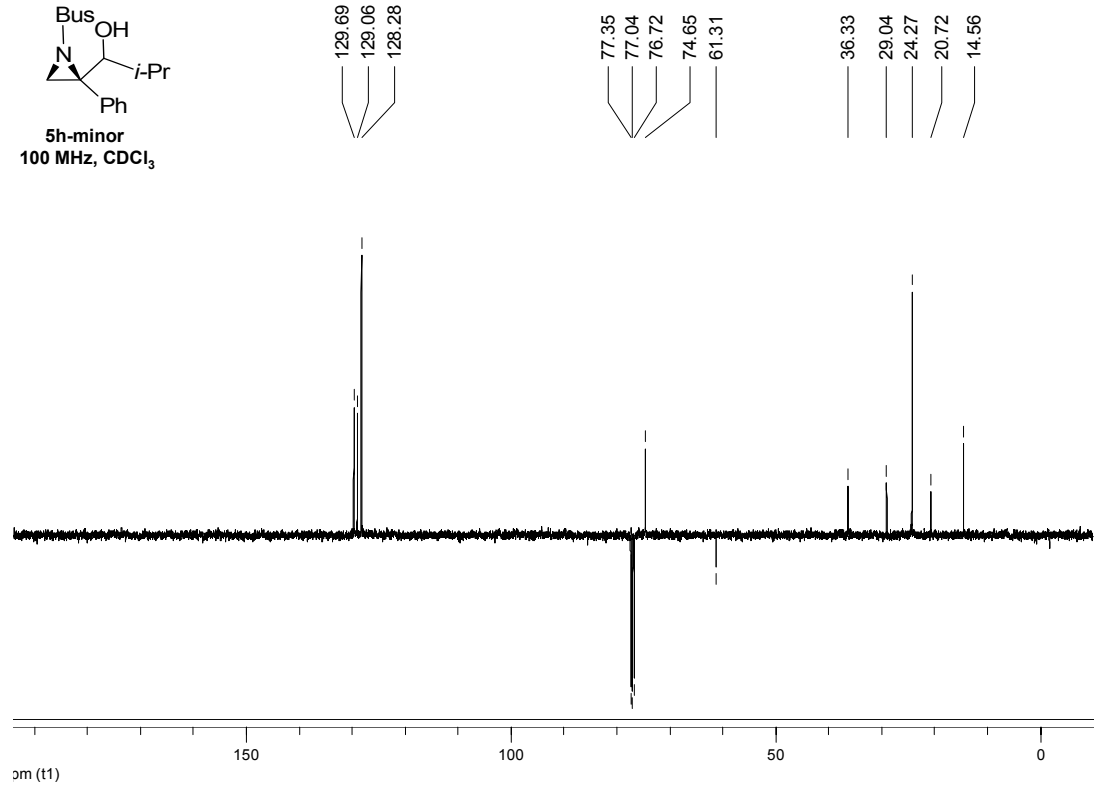

Bus
OH
N
Ph
H
Ph
5g-minor
400 MHz, CDCl3
5.250
3.100 3.050 3.000
8.17
1.99
1.00
0.96
1.00
8.96
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

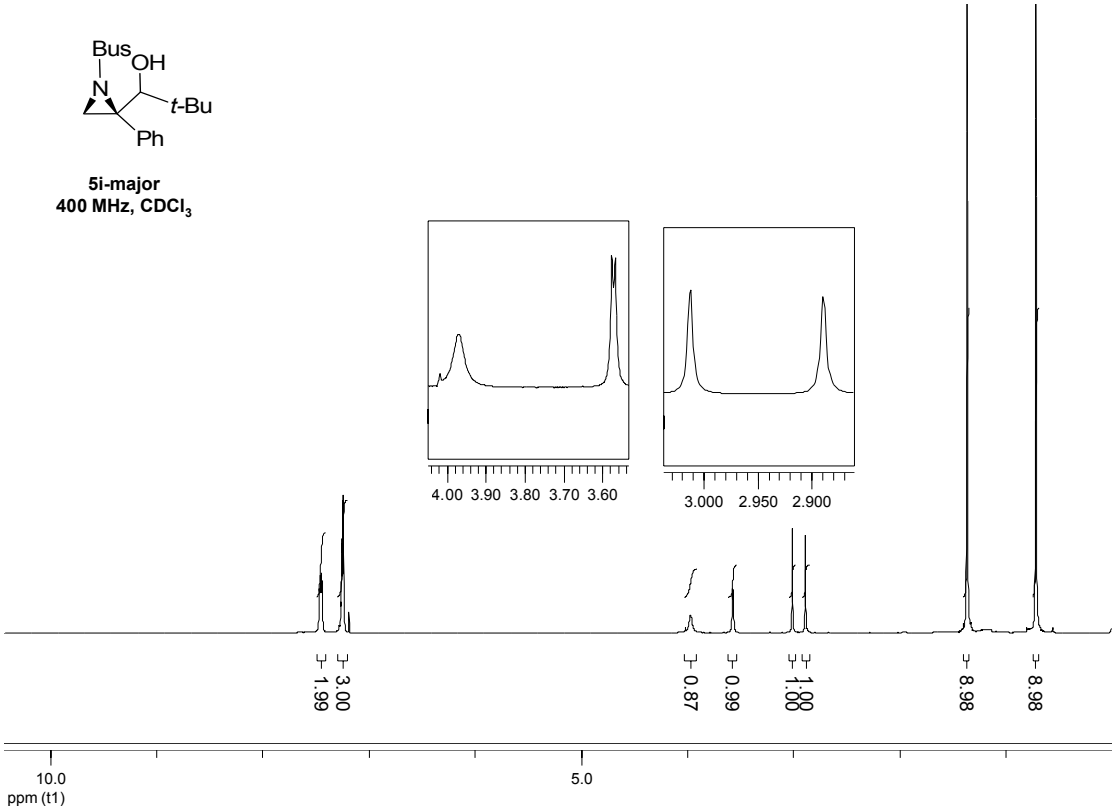

138.2
130.4
128.9
128.0
127.9
127.8
126.9
77.3
77.0
76.7
74.0
61.5
35.9
24.3
Bus
OH
N
Ph
H
Ph
5g-minor
100 MHz, CDCl3
150
100
50
0
pm (t1)

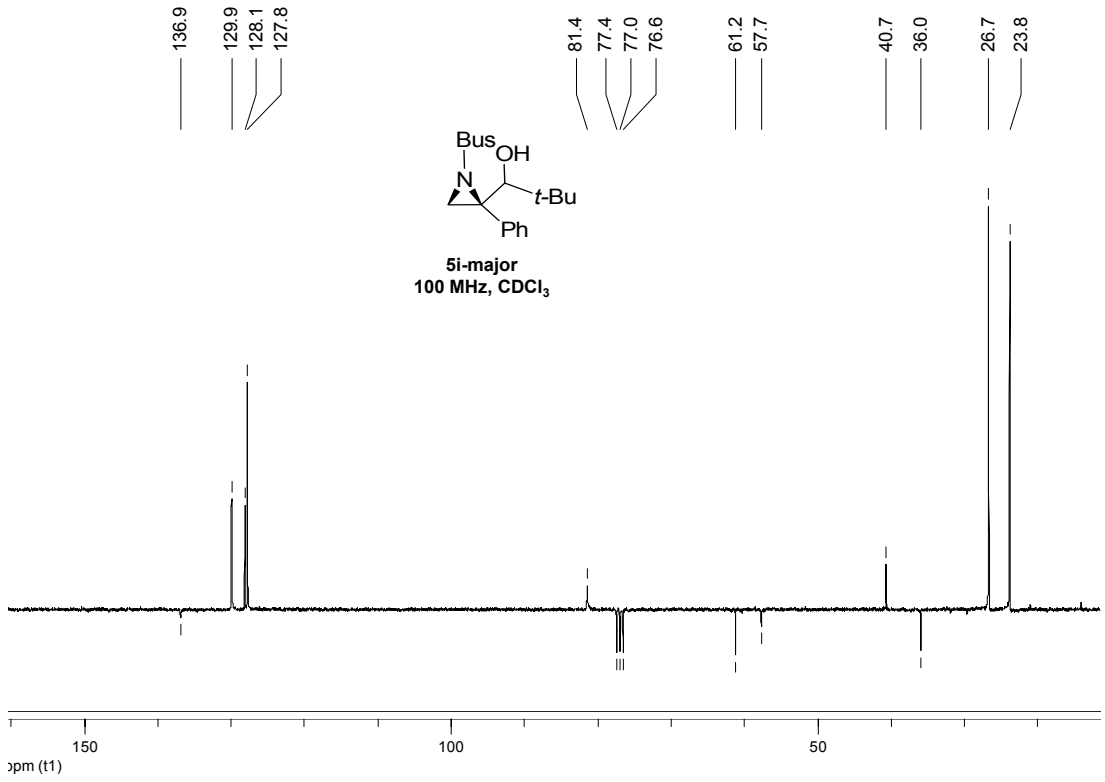

Bus
OH
N
i-Pr
Ph
5h-major
400 MHz, CDCl3
1.000 0.950 0.900
3.500
2.06
3.13
0.92
1.03
1.03
1.03
8.26
8.97
3.49
3.77
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

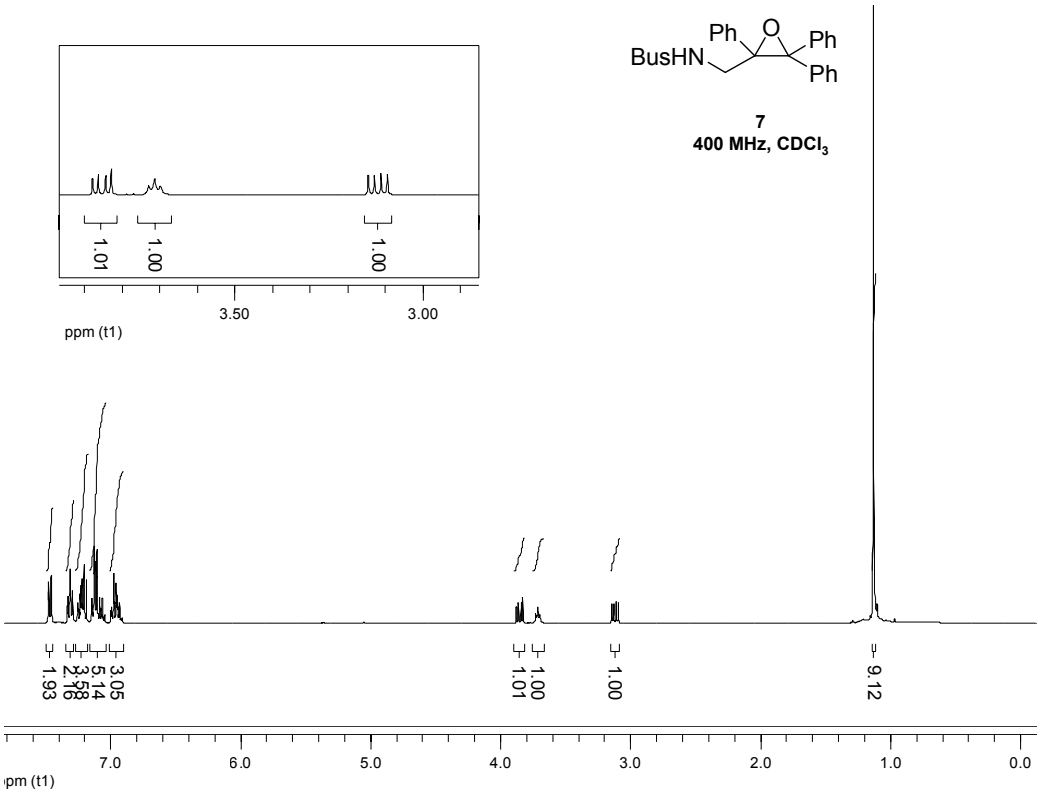

136.1
129.4
128.1
127.9
79.3
77.3
77.0
76.7
61.3
57.7
40.7
31.7
23.9
19.9
19.4
Bus
OH
N
i-Pr
Ph
5h-major
100 MHz, CDCl3
150
100
50
0
ppm (t1)

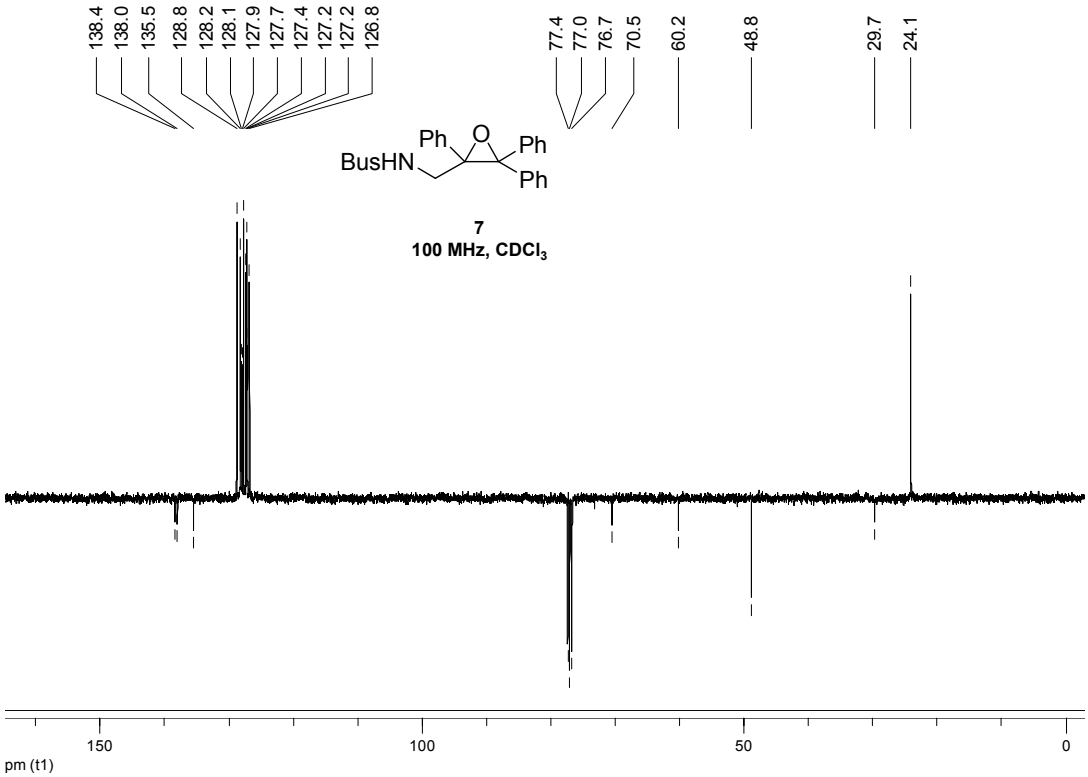

Bus
OH
N
i-Pr
Ph
5h-minor
300 MHz, CDCl3
4.200
4.150
3.20 3.10 3.00 2.90
1.00 0.90 0.80 0.70
2.00
3.24
1.07
1.07
1.07
1.07
9.98
3.23
3.24
7.0
6.0
5.0
4.0
3.0
2.0
1.0
ppm (t1)

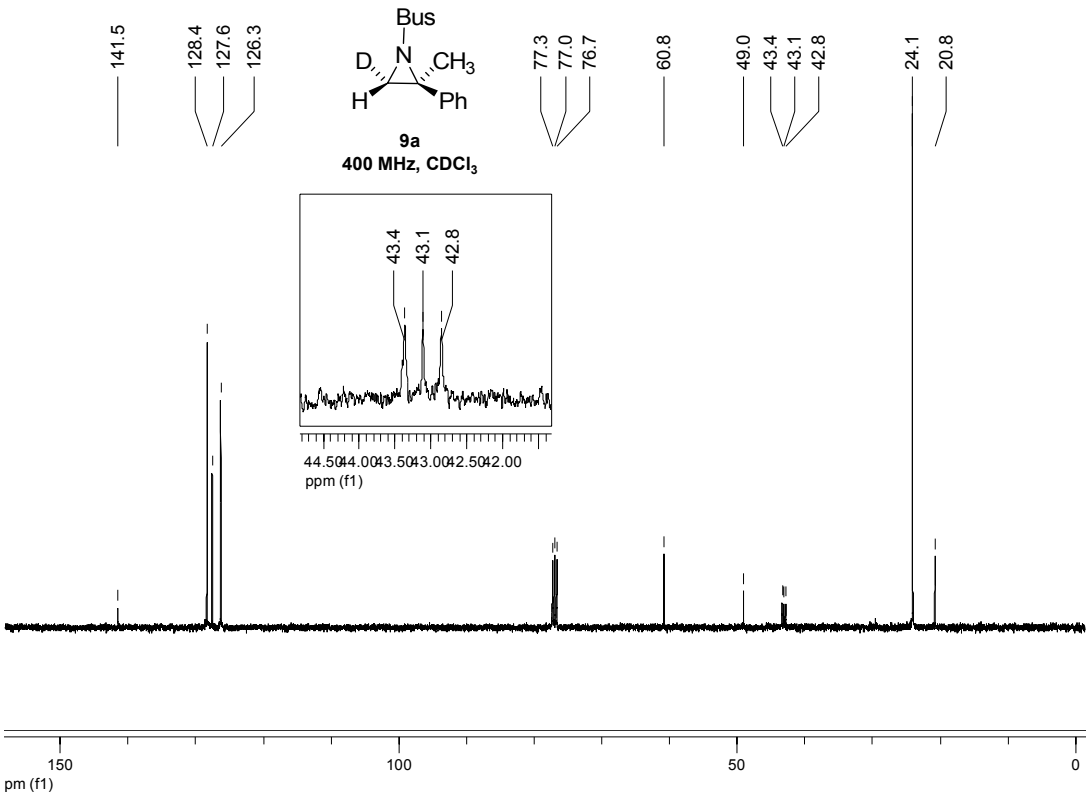

Bus
OH
N
i-Pr
Ph
5h-minor
100 MHz, CDCl3
129.69
129.06
128.28
77.35
77.04
76.72
74.65
61.31
36.33
29.04
24.27
20.72
14.56
150
100
50
0
pm (t1)

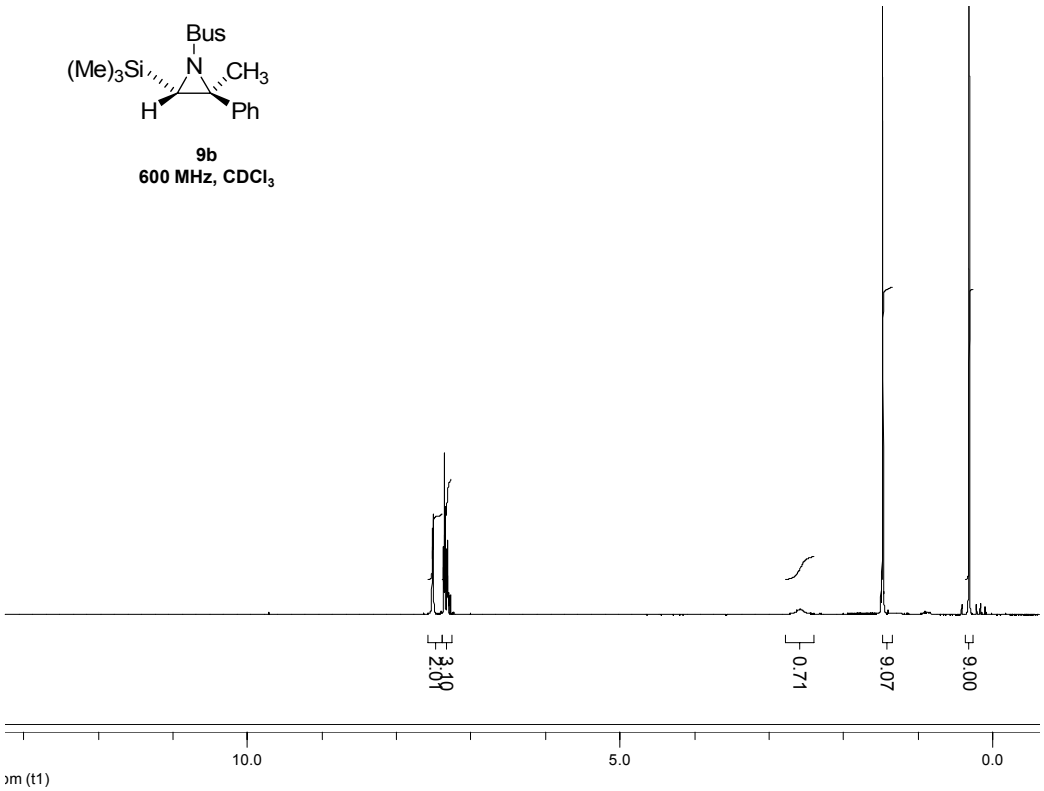

Bus
OH
N
t-Bu
Ph
5i-major
400 MHz, CDCl3
4.00 3.90 3.80 3.70 3.60
3.000 2.950 2.900
1.99
3.00
0.87
0.99
1.00
8.98
8.98
10.0
ppm (t1)
5.0

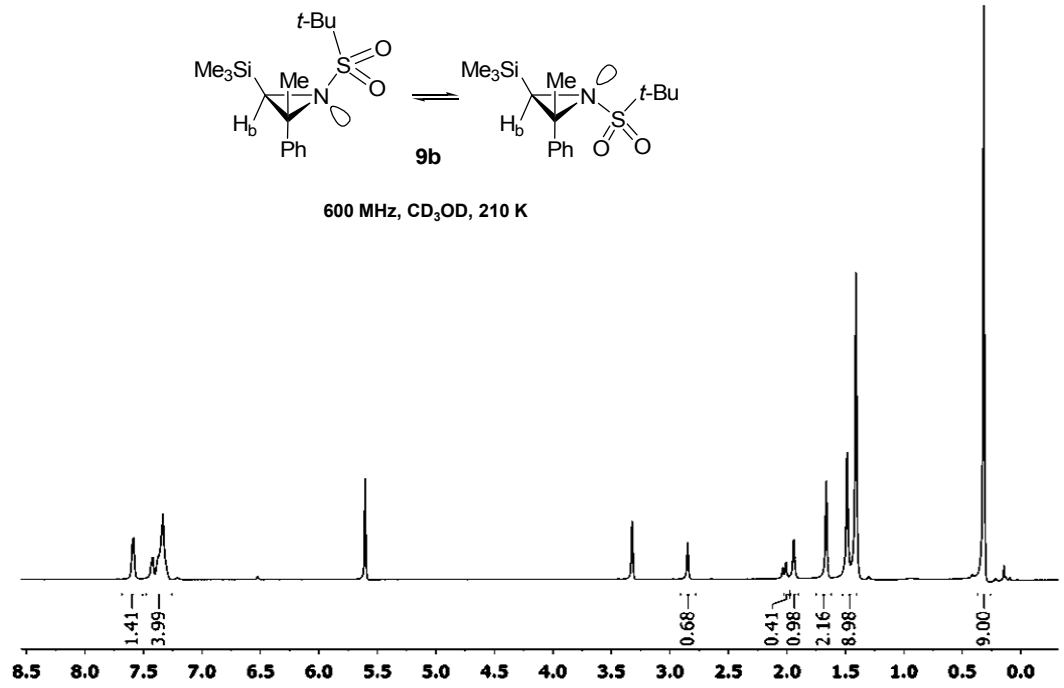

136.9
129.9
128.1
127.8
81.4
77.4
77.0
76.6
61.2
57.7
40.7
36.0
26.7
23.8
Bus
OH
N
t-Bu
Ph
5i-major
100 MHz, CDCl3
150
100
50
ppm (t1)

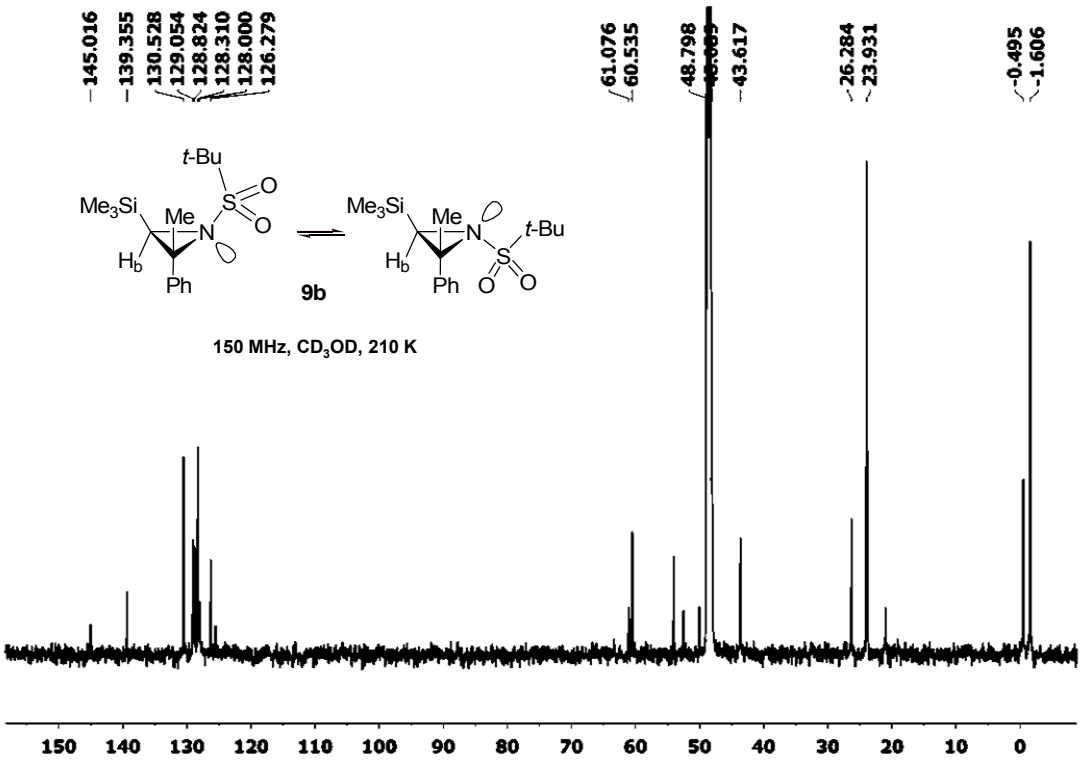

Ph
O
Ph
BusHN
Ph
7
400 MHz, CDCl3
1.01
1.00
1.00
3.50
3.00
ppm (t1)
1.93
2.16
3.58
5.14
3.05
1.01
1.00
1.00
9.12
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)

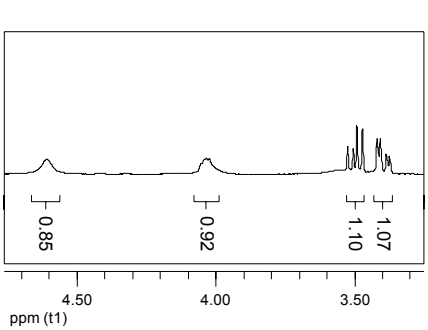

138.4
138.0
135.5
128.8
128.2
128.1
127.9
127.7
127.4
127.2
127.2
126.8
77.4
77.0
76.7
70.5
60.2
48.8
29.7
24.1
Ph
O
Ph
BusHN
Ph
7
100 MHz, CDCl3
150
100
50
0
pm (t1)

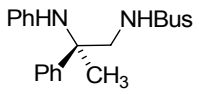

141.5
128.4
127.6
126.3
Bus
D
N
CH3
H
Ph
77.3
77.0
76.7
60.8
49.0
43.4
43.1
42.8
24.1
20.8
9a
400 MHz, CDCl3
43.4
43.1
42.8
44.50 44.00 43.50 43.00 42.50 42.00
ppm (f1)
150
100
50
0
pm (f1)


Bus
(Me)3Si
N
CH3
H
Ph
9b
600 MHz, CDCl3
3.19
3.01
0.71
9.07
9.00
10.0
5.0
0.0
pm (t1)

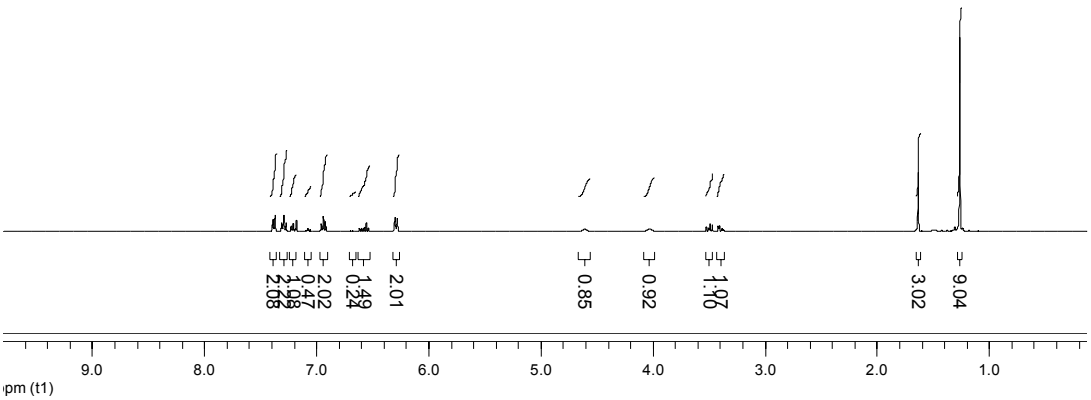

t-Bu
Me3Si
Me
S
O
N
Hb
Ph
9b
600 MHz, CD3OD, 210 K
1.41
3.99
0.68
0.41
0.98
2.16
8.98
9.00
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0

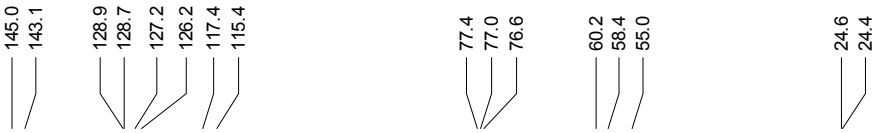

145.016
139.355
130.528
129.054
128.824
128.310
128.000
126.279
61.076
60.535
48.798
43.617
26.284
23.931
-0.495
-1.606
t-Bu
Me3Si
Me
S
O
N
Hb
Ph
9b
150 MHz, CD3OD, 210 K
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

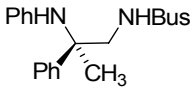




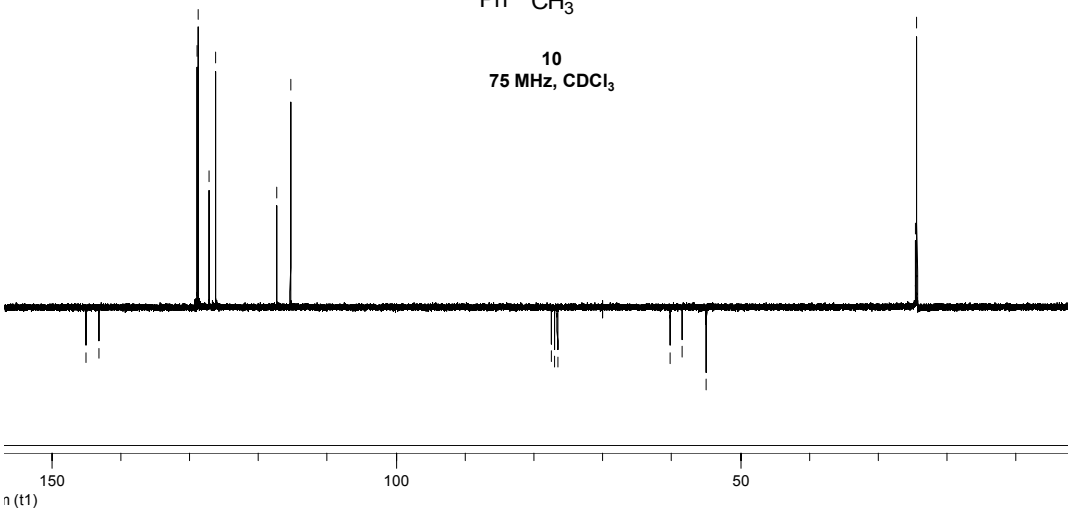
10
300 MHz, $CDCl_3$

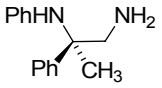




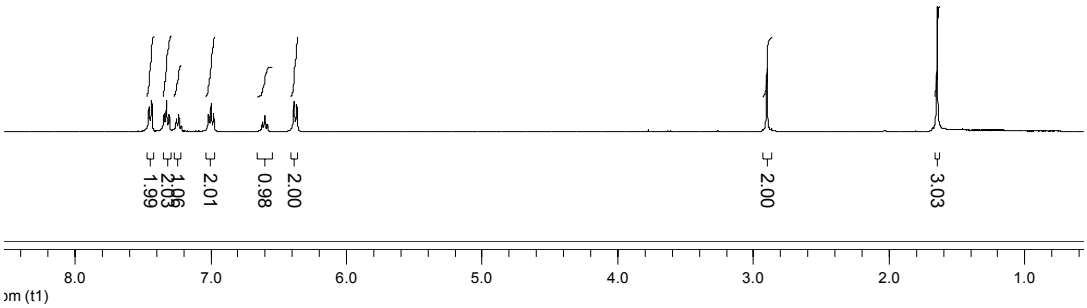


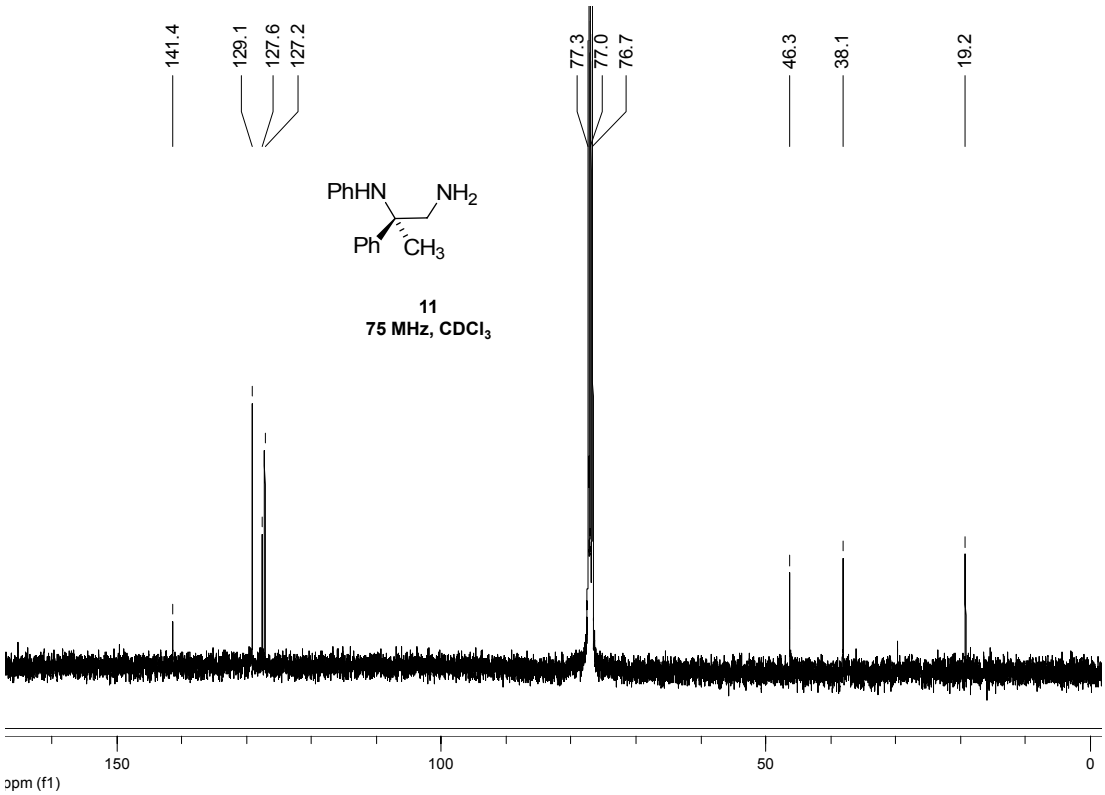
10
75 MHz, $CDCl_3$



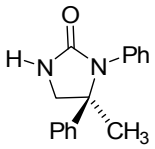


11
400 MHz, $CDCl_3$

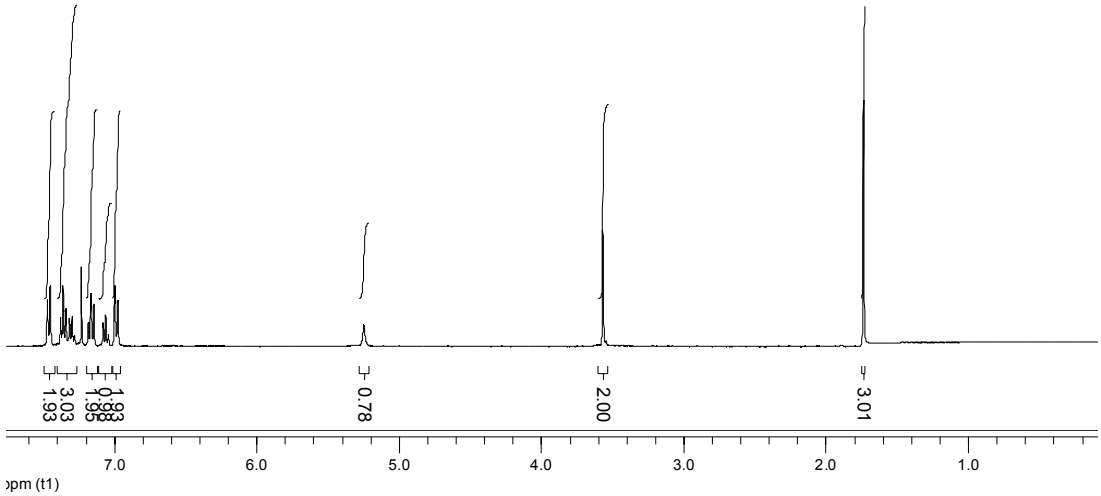


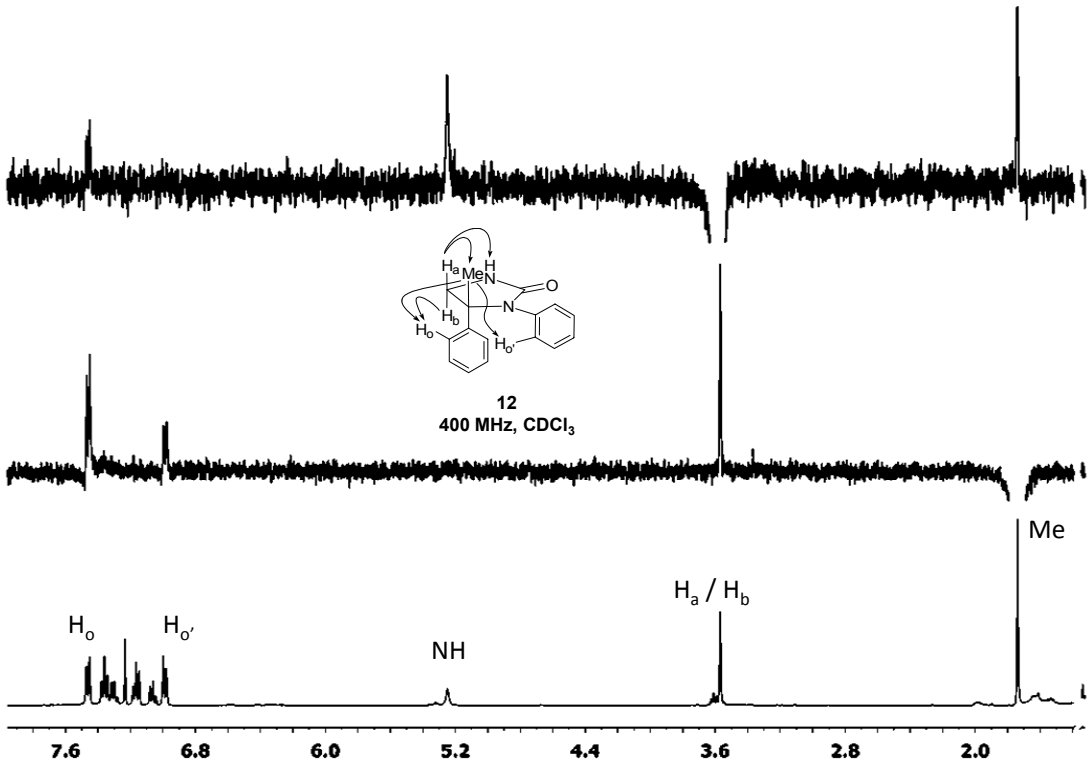


11
75 MHz, $CDCl_3$

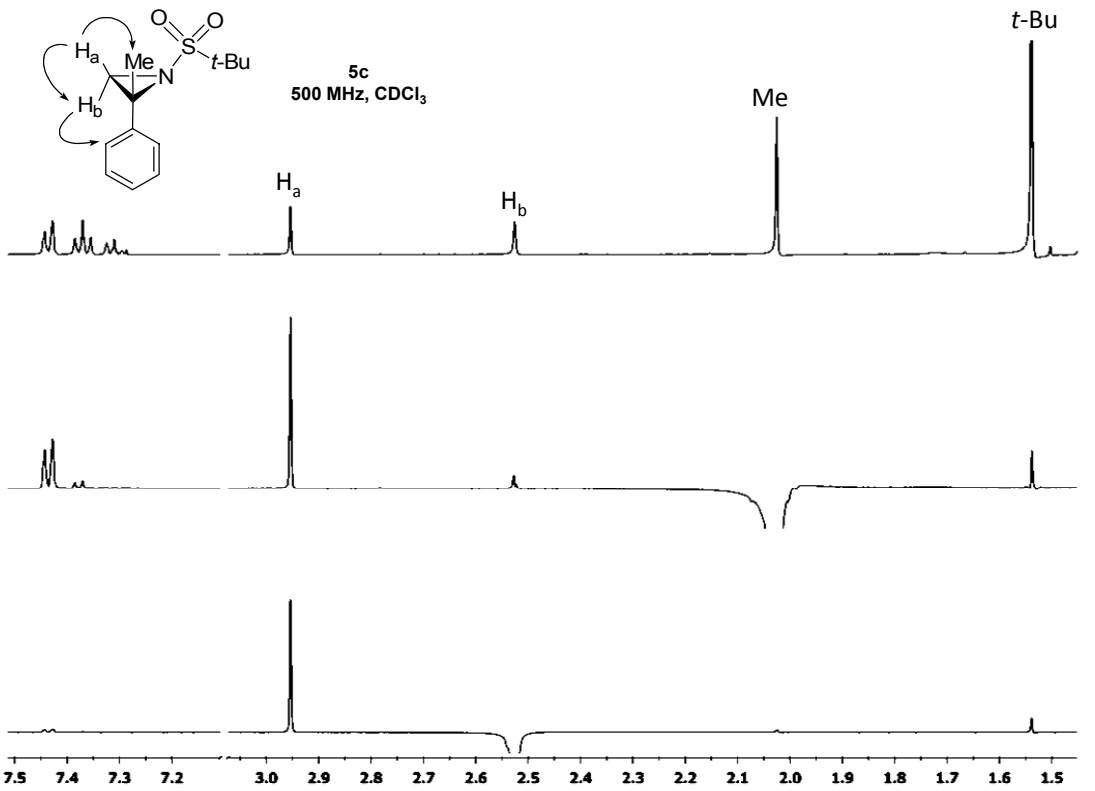


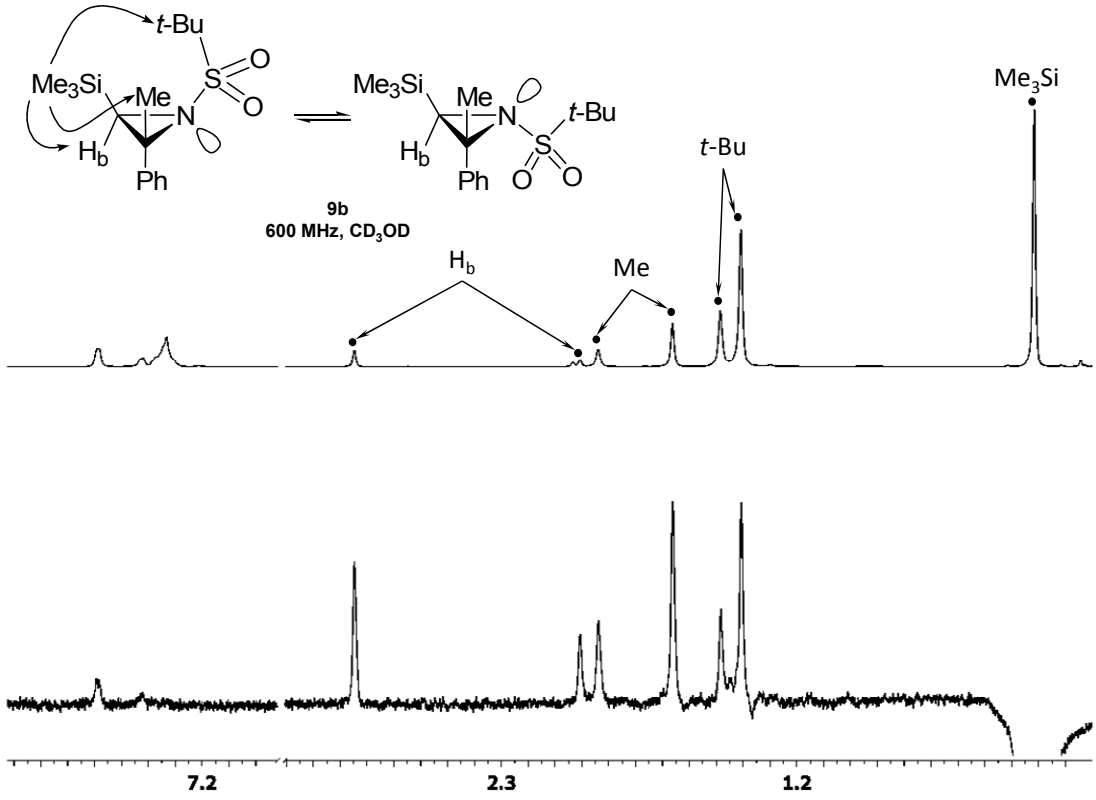
12
400 MHz, $CDCl_3$

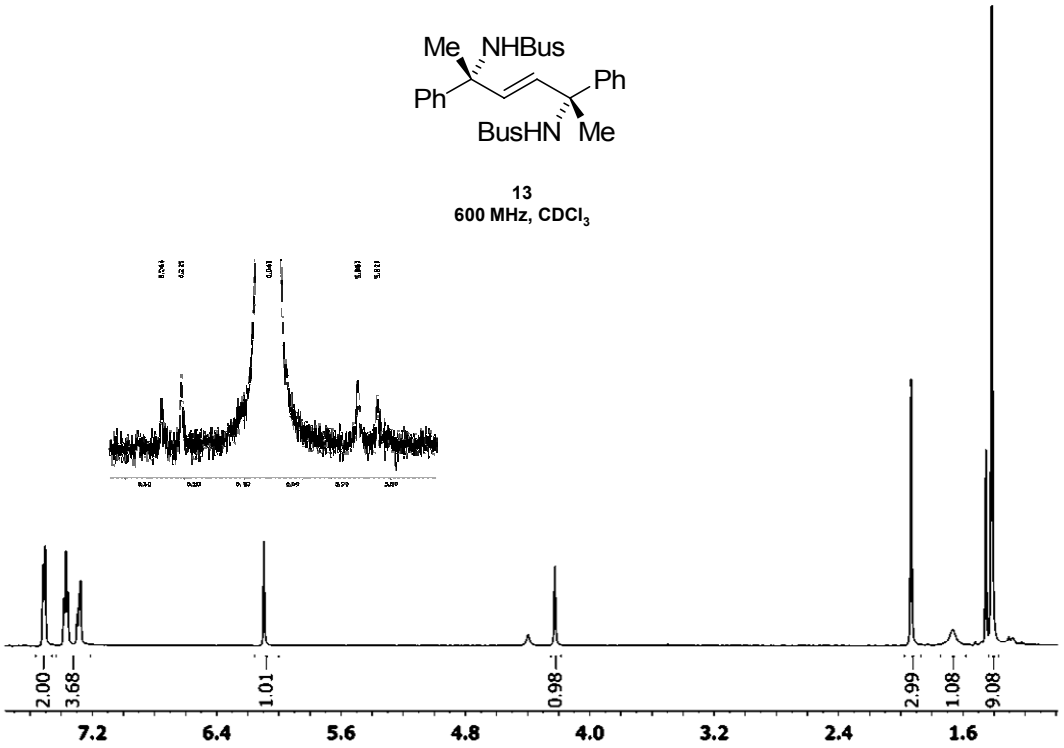


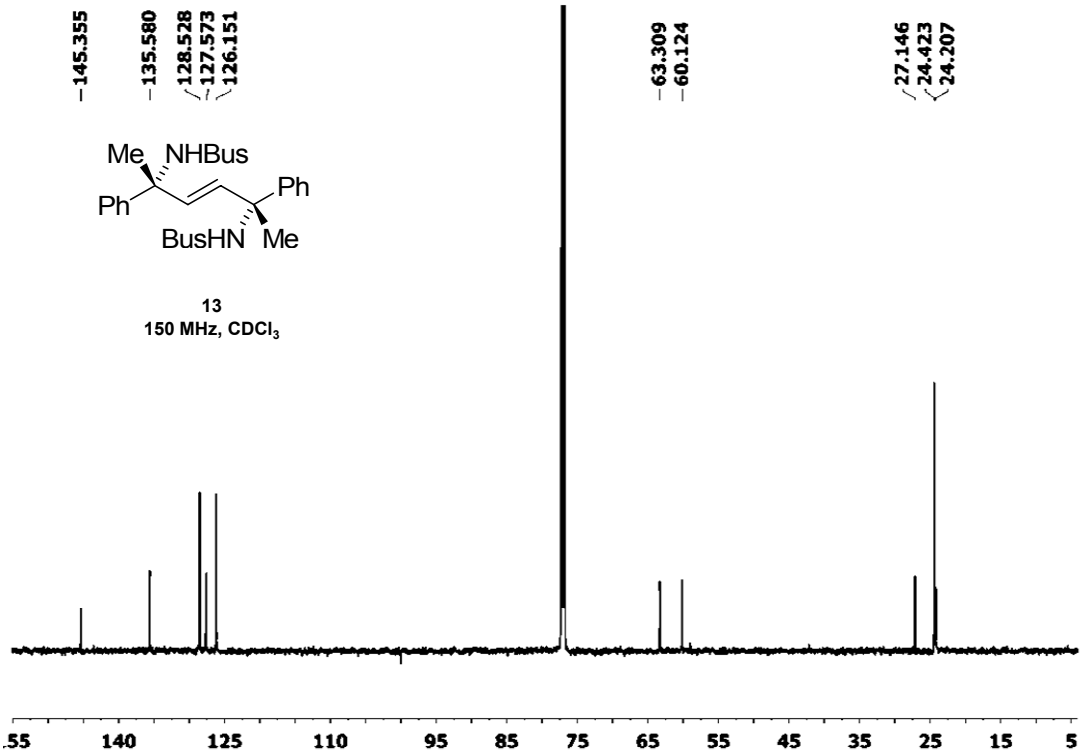


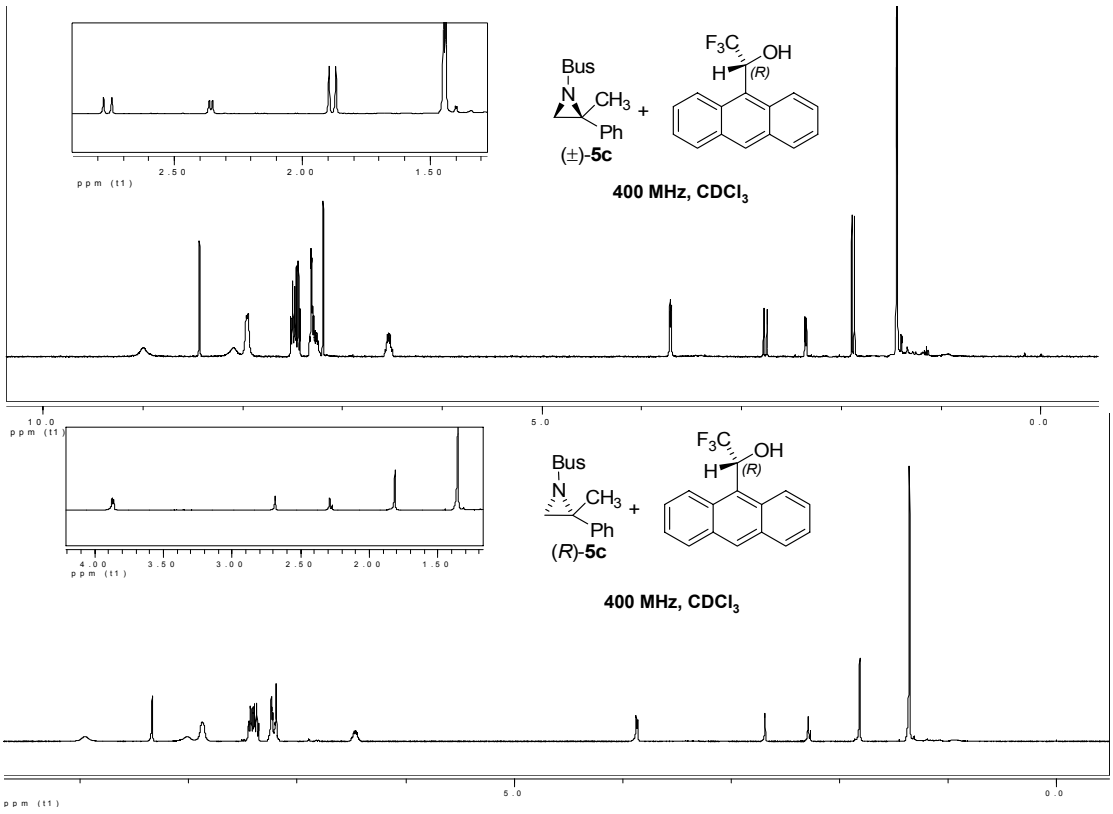
12
400 MHz, $CDCl_3$


Ha
Me
N
t-Bu
Hb
O
S
O
5c
500 MHz, CDCl3
Ha
Hb
Me
t-Bu
7.5 7.4 7.3 7.2 3.0 2.9 2.8 2.7 2.6 2.5 2.4 2.3 2.2 2.1 2.0 1.9 1.8 1.7 1.6 1.5

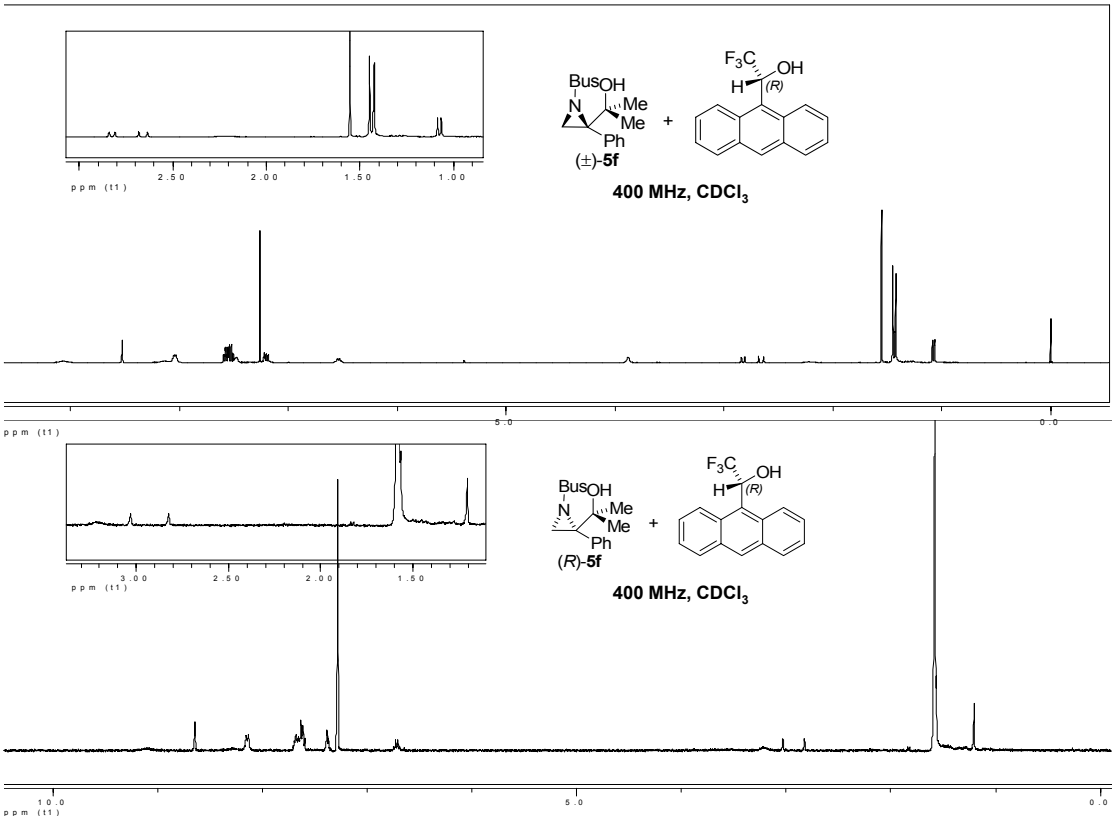

t-Bu
Me3Si
Me
N
S
O
O
Hb
Ph
9b
600 MHz, CD3OD
Hb
Me
t-Bu
Me3Si
7.2 2.3 1.2


Me
NHBus
Ph
Ph
BusHN
Me
13
600 MHz, CDCl3
2.00
3.68
1.01
0.98
2.99
1.08
9.08
7.2
6.4
5.6
4.8
4.0
3.2
2.4
1.6

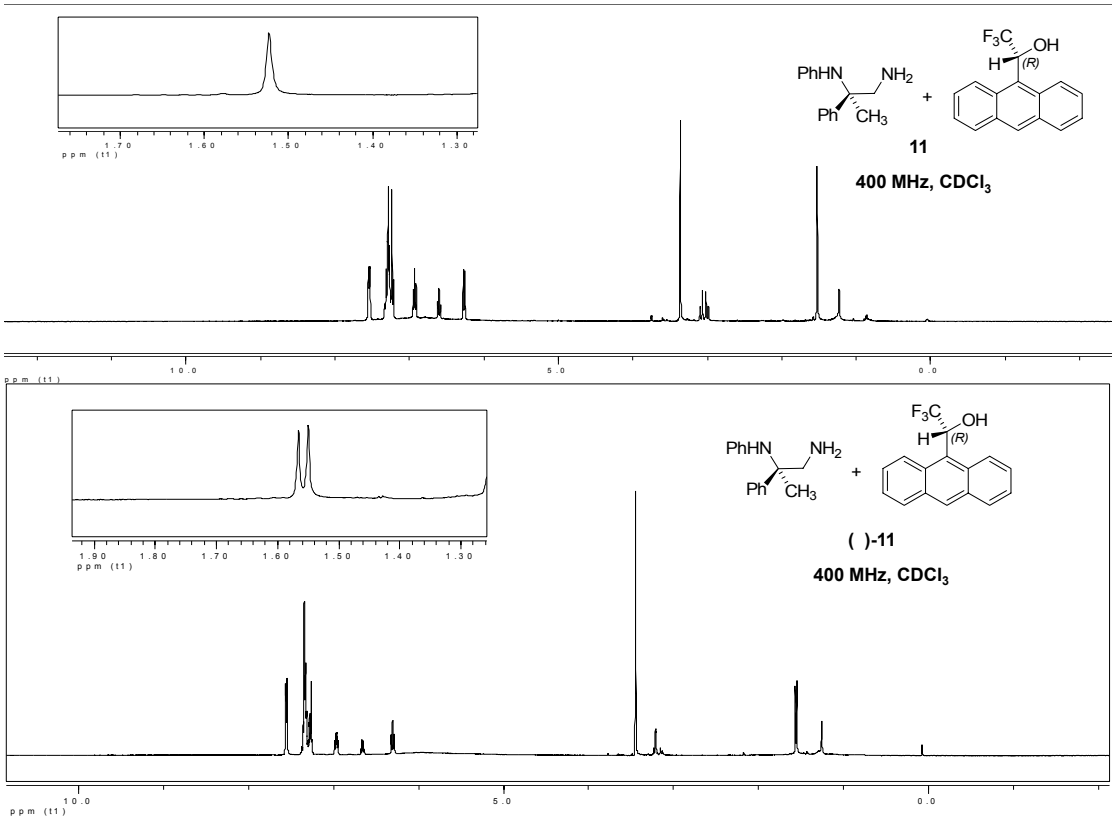

145.355
135.580
128.528
127.573
126.151
63.309
60.124
27.146
24.423
24.207
Me
NHBus
Ph
Ph
BusHN
Me
13
150 MHz, CDCl3
140
125
110
95
85
75
65
55
45
35
25
15
5


Bus
N
CH3
Ph
(±)-5c
F3C
OH
H
(R)
400 MHz, CDCl3

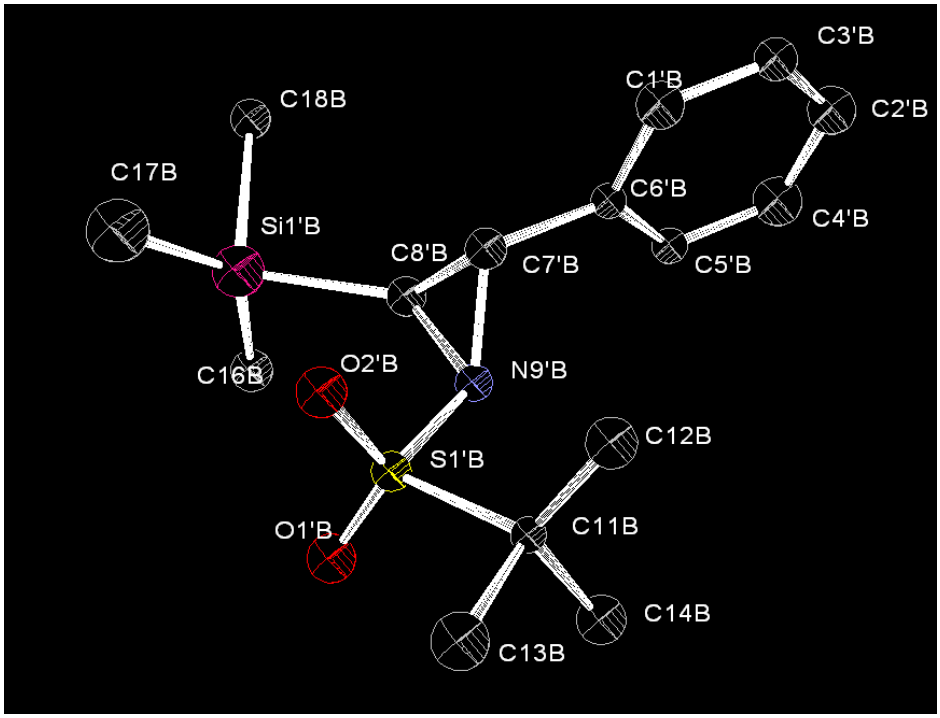
Bus
N
CH3
Ph
(R)-5c
F3C
OH
H
(R)
400 MHz, CDCl3


Bus
OH
N
Me
Me
Ph
(±)-5f
F3C
OH
H
(R)
400 MHz, CDCl3

Bus
OH
N
Me
Me
Ph
(R)-5f
F3C
OH
H
(R)
400 MHz, CDCl3


PhHN
NH2
Ph
CH3
F3C
OH
H
(R)
11
400 MHz, CDCl3
( )-11
400 MHz, CDCl3
ppm (t1)

Ortep view of aziridine **5a** at 50% ellipsoids probability,
(hydrogen omitted for clarity).



Ortep view of aziridine (1*R**, 2'*R**)-**5g** at 50% ellipsoids probability,
(hydrogen omitted for clarity).