Facile preparation of CF_3-substituted carbinols with an azine donor and subsequent kinetic resolution through stereoselective Si–O coupling

Anne Steves and Martin Oestreich*

Organisch-Chemisches Institut, Westfälische Wilhelms-Universität Münster,
Corrensstrasse 40, D-48149 Münster, Germany
e-mail: martin.oestreich@uni-muenster.de

Electronic Supplementary Information

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1 General information

Reagents obtained from commercial suppliers were used without further purification unless otherwise noted. All reactions were performed in flame-dried glassware under a static pressure of argon. Liquids and solutions were transferred with syringes. Solvents were dried prior to use following standard procedures. Technical grade solvents for chromatography (cyclohexane, *t*-butyl methyl ether, dichloromethane, methanol) were distilled prior to use. Analytical thin layer chromatography was performed on silica gel SIL G-25 glass plates by *Macherey-Nagel* and flash chromatography on silica gel 60 (40-63 μm, 230-400 mesh, ASTM) by *Merck* using the indicated solvents. ^{1}H, ^{13}C and ^{19}F NMR spectra were recorded in $CDCl_3$ on *Bruker* AV 300 and *Bruker* AV 400 instruments. Chemical shifts are reported relative to $CDCl_3$ in ppm for ^{1}H NMR (δ = 7.26 ppm) and for ^{13}C NMR (δ = 77.0 ppm). ^{19}F NMR were recorded without internal standard. Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, m_c = centrosymmetrical multiplet, br = broad), coupling constants (Hz) and integration. AB signals in the ^{1}H NMR spectra were denoted by the symbol "$^{◊}$". Infrared spectra were recorded on a *Digilab* Excalibur Series FTS 4000 spectrometer. Intensities of the bands are abbreviated as broad (br), strong (s), medium (m), and weak (w). Gas liquid chromatography (GLC) was performed on a *Shimadzu* GC-17A with a SE-54 (30 m × 0.32 mm × 0.25 μm film thickness) column by *CS-Chromatographie Service* using the following program: column flow 1.7 mL/min N_2, start at 40 °C, heat rate 10 °C/min to 280 °C, 5 min at 280 °C. Enantiomeric ratios were determined by analytical HPLC analysis on an *Agilent* 1200 Series instrument with a chiral stationary phase using *Daicel Chiralpak* IA and *Daicel Chiralpak* IB columns (*n*-heptane:*i*-propanol mixtures as solvent). Optical rotations were measured on a *Perkin Elmer* 341 polarimeter. Melting points (m.p.) were determined with a *Stuart Scientific MP3* apparatus and are not corrected. High resolution mass spectrometry (HRMS) was performed by electron spray ionization mass spectrometry (ESI-MS) using a *Bruker* MicroTOF instrument, elemental analysis were obtained using a *Elementaranalysensysteme* VarioEL III instrument.

2 Synthesis of 1,1,1-Trifluoro-3-(4-methylpyridin-2-yl)propan-2-ol (*rac*-10)

1,1,1-Trifluoro-3-pyridin-2-ylpropan-2-one was prepared according to literature procedure.[1] The ketone (1.89 g, 10.0 mmol, 1.00 equiv.) was dissolved in methanol (15 mL) and $CeCl_3 \cdot 7H_2O$ (4.66 g, 12.5 mmol, 1.25 equiv.) was added. The reaction mixture was vigorously stirred for 15 min. After cooling to 0 °C $NaBH_4$ (757 mg, 20.0 mmol, 2.00 equiv.) was added. The reaction mixture was then allowed to warm to room temperature and maintained at ambient temperature for 5 h. The reaction mixture was cooled to 0 °C, and treated with aqueous HCl (2M, 10 mL) and diluted with *t*-butyl methyl ether (20 mL). The organic phase was separated, the aqueous phase was extracted with dichloromethane (3 × 25 mL), and the combined organic extracts were washed with brine (20 mL) and dried over $MgSO_4$. The solvents were evaporated under reduced pressure and the resulting residue

[1] M. Kawase, M. Teshima, S. Saito and S. Tani, *Heterocycles*, 1998, **48**, 2103–2109.

was purified by flash column chromatography on silica gel (cyclohexane:*t*-butyl methyl ether mixture as eluent) affording the desired alcohol *rac*-**10** as a pale yellow solid (1.38 g, 72%).

3 Characterisation data of 11–19

(^Si^*R**,*R**)-2-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-pyridine [(^Si^*R**,*R**)-11]

Analytical data for (^{Si}R*,*R**)-**11**: Yield: 97%. GLC (SE-54): t_R = 20.4, 20.8 min. R_f = 0.13 (cyclohexane:*t*-butyl methyl ether = 95:5). M.p. 68 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 0.83 (s, 9H), 0.99$^\Diamond$ (ddd, *J* = 15.4, 6.7, 1.5 Hz, 1H), 1.07$^\Diamond$ (ddd, *J* = 15.4, 5.0, 5.0 Hz, 1H), 1.53–1.68 (m, 1H), 1.90–2.02 (m, 1H), 2.49$^\Diamond$ (ddd, *J* = 15.6, 10.7, 2.6 Hz, 1H), 2.64$^\Diamond$ (br dd, *J* = 15.6, 5.7 Hz, 1H), 2.92$^\Diamond$ (dd, *J* = 14.1, 9.2 Hz, 1H), 3.09$^\Diamond$ (dd, *J* = 14.1, 2.9 Hz, 1H), 4.66 (dqd, *J* = 9.2, 3.2, 2.9 Hz, 1H), 6.91–7.04 (m, 5H), 7.14–7.21 (m, 1H), 7.40 (dt, *J* = 7.6, 1.4 Hz, 1H), 8.35 (d, *J* = 4.3 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.9, 18.9, 22.5, 25.9, 35.5, 39.9, 71.7 (q, *J* = 31 Hz), 122.0, 124.9, 125.1, 125.3 (q, *J* = 283 Hz), 128.6, 129.4, 130.3, 134.9, 136.5, 149.1, 150.3, 156.1. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.8, –78.2. IR (ATR) 1278 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{21}H_{26}F_3NOSiNa$ (M + Na^+): 416.1628; found: 416.1626. Anal. calcd for $C_{21}H_{26}F_3NOSi$ (393.52): C, 64.09; H, 6.66; N, 3.56; found: C, 63.25; H, 6.87; N, 3.68. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 20.4 min (major diastereomer) and 20.8 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

Analytical data for (^{Si}R,*R*)-**11** (dr = 88:12, entry 1, Table 1): Yield: 53%. $[\alpha]_D^{20}$ = +26.3, $[\alpha]_{578}^{20}$ = +27.7, $[\alpha]_{546}^{20}$ = +32.2, $[\alpha]_{436}^{20}$ = +64.4, $[\alpha]_{365}^{20}$ = +130.1 (*c* = 0.840, $CHCl_3$).

(^Si^*R**,*R**)-2-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-quinoline [(^Si^*R**,*R**)-12]

Analytical data for (^{Si}R*,*R**)-**12**: Yield: 96%. GLC (SE-54): t_R = 24.4, 24.8 min. R_f = 0.26 (cyclohexane:*t*-butyl methyl ether = 90:10). ^{1}H NMR (400 MHz, $CDCl_3$): δ 0.74 (s, 9H), 0.90$^\Diamond$ (ddd, *J* = 15.6, 6.7, 1.2 Hz, 1H), 1.11$^\Diamond$ (ddd, *J* = 15.6, 5.3, 5.1 Hz, 1H), 1.70–1-81 (m, 1H), 1.93–2.02 (m, 1H), 2.47$^\Diamond$ (ddd, *J* = 15.7, 11.1, 2.5 Hz, 1H), 2.66$^\Diamond$ (br dd, *J* = 15.6, 5.8 Hz, 1H), 3.41$^\Diamond$ (dd, *J* = 14.5, 3.2 Hz, 1H), 3.77$^\Diamond$ (dd, *J* = 14.6, 9.2 Hz, 1H), 5.02 (dqd, *J* = 9.2, 3.1, 3.1 Hz, 1H), 6.49–6.56 (m, 2H), 6.93 (d, *J* = 7.7 Hz, 1H), 7.02 (dt, *J* = 7.0, 1.8 Hz, 1H), 7.33 (d, *J* = 5.7 Hz, 1H), 7.54 (ddd, *J* = 7.0, 2.9, 1.2 Hz, 1H), 7.66 (ddd, *J* = 7.0, 2.4, 1.0 Hz, 1H), 7.75 (br d, *J* = 8.2 Hz, 1H), 8.01 (dd, *J* = 8.3, 0.5 Hz, 1H), 8.18 (d, *J* = 5.7 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 9.0, 18.8, 22.5, 25.9, 26.1, 35.4, 71.4 (q, *J* = 31 Hz), 122.9, 124.6, 125.1, 125.3 (q, *J* = 282 Hz), 127.1, 127.6, 127.7, 128.2, 128.6, 128.7, 128.9, 129.7, 129.9, 134.4, 134.6, 149.5. ^{19}F NMR (282 MHz, $CDCl_3$): δ –78.2, –77.8. IR (ATR) 1278 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{25}H_{29}F_3NOSi$ (M + H^+): 444.1965; found: 444.1965. Anal. calcd for $C_{25}H_{28}F_3NOSi$ (443.58): C, 67.69; H, 6.36; N, 3.16; found: C, 68.21; H, 6.62; N, 3.31. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 24.4 min (major diastereomer) and 24.8 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

Analytical data for (^{Si}R,R)-**12** (dr = 77:23, entry 2, Table 1): Yield: 51%. $[\alpha]_D^{20}$ = +50.1, $[\alpha]_{578}^{20}$ = +53.0, $[\alpha]_{546}^{20}$ = +62.0, $[\alpha]_{436}^{20}$ = +125.7, $[\alpha]_{365}^{20}$ = +278.6 (*c* = 0.875, $CHCl_3$).

($^{Si}R^*$,R^*)-1-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-isoquinoline [($^{Si}R^*$,R^*)-13]

Analytical data for ($^{Si}R^*$,R^*)-**13**: Yield: 95%. GLC (SE-54): t_R = 24.6, 25.1 min. R_f = 0.16 (cyclohexane:*t*-butyl methyl ether = 90:10). M.p. 60 °C. ^1H NMR (400 MHz, $CDCl_3$): δ 0.74 (s, 9H), 0.90$^\lozenge$ (ddd, *J* = 15.3, 6.6, 1.1 Hz, 1H), 1.10$^\lozenge$ (ddd, *J* = 15.3, 10.5, 2.1 Hz, 1H), 1.67–1.81 (m, 1H), 1.93–2.02 (m, 1H), 2.47$^\lozenge$ (ddd, *J* = 15.5, 10.8, 2.6 Hz, 1H), 2.66$^\lozenge$ (br dd, *J* = 15.5, 6.2 Hz, 1H), 3.41$^\lozenge$ (dd, *J* = 14.7, 3.2 Hz, 1H), 3.77$^\lozenge$ (dd, *J* = 14.8, 9.3 Hz, 1H), 5.02 (dqd, *J* = 9.3, 3.3, 3.2 Hz, 1H), 6.49–6.56 (m, 2H), 6.93 (d, *J* = 7.4 Hz, 1H), 7.02 (ddd, *J* = 7.4, 5.7, 1.9 Hz, 1H), 7.34 (d, *J* = 5.7 Hz, 1H), 7.54 (ddd, *J* = 6.9, 5.6, 1.0 Hz, 1H), 7.65 (ddd, *J* = 6.9, 5.7, 1.0 Hz, 1H), 7.75 (d, *J* = 8.5 Hz, 1H), 8.01 (dd, *J* = 8.5, 0.5 Hz, 1H), 8.17 (d, *J* = 5.7 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 9.0, 18.7, 22.7, 25.8, 27.0, 35.5 (m), 71.3 (q, *J* = 31 Hz), 120.0, 124.1, 125.1, 127.4, 127.5, 128.0, 128.3, 128.3 (q, *J* = 286 Hz), 129.1, 129.9, 130.0, 134.2, 136.3, 141.5, 149.8, 156.1. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.9, –78.1. IR (ATR) 1275 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{25}H_{29}F_3NOSi$ (M + H^+): 444.1965; found: 444.1965. Anal. calcd for $C_{25}H_{28}F_3NOSi$ (443.58): C, 67.69; H, 6.36; N, 3.16; found: C, 67.36; H, 6.36; N, 3.10. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 24.6 min (major diastereomer) and 25.1 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

Analytical data for (^{Si}R,R)-**13** (dr = 84:16, entry 3, Table 1): Yield: 50%. $[\alpha]_D^{20}$ = –5.4, $[\alpha]_{578}^{20}$ = –5.7, $[\alpha]_{546}^{20}$ = –6.4, $[\alpha]_{436}^{20}$ = –3.8, $[\alpha]_{365}^{20}$ = +48.8 (*c* = 0.740, $CHCl_3$).

($^{Si}R^*$,R^*)-2-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-6-methylpyridine [($^{Si}R^*$,R^*)-14]

Analytical data for ($^{Si}R^*$,R^*)-**14**: Yield: 98%. GLC (SE-54): t_R = 20.6, 21.0 min. R_f = 0.20 (cyclohexane:*t*-butyl methyl ether = 90:10). M.p. 60 °C. ^1H NMR (400 MHz, $CDCl_3$): δ 0.80 (s, 9H), 0.88$^\lozenge$ (ddd, *J* = 15.3, 6.8, 1.5 Hz, 1H), 1.03–1.13 (m, 1H), 1.61–1.74 (m, 1H), 1.94–2.02 (m, 1H), 2.37 (s, 3H), 2.50$^\lozenge$ (ddd, *J* = 15.6, 11.1, 2.1 Hz, 1H), 2.67$^\lozenge$ (br dd, *J* = 15.6, 6.1 Hz, 1H), 2.95$^\lozenge$ (dd, *J* = 14.0, 9.9 Hz, 1H), 3.11$^\lozenge$ (br d, *J* = 15.6 Hz, 1H), 4.72–4.82 (m, 1H), 6.82–6.88 (m, 2H), 6.91 (d, *J* = 2.1 Hz, 1H), 6.93 (d, *J* = 0.8 Hz, 1H), 7.01 (d, *J* = 7.6 Hz, 1H), 7.17 (ddd, *J* = 7.6, 5.6, 1.1 Hz, 1H), 7.31 (t, *J* = 7.6 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 9.2, 18.9, 22.5, 25.9, 28.9, 35.6, 39.8, 71.5 (q, *J* = 31 Hz), 121.6, 122.0, 125.1, 125.4 (q, *J* = 284 Hz), 128.6, 129.3, 129.7, 130.1, 134.8, 150.1, 155.5, 158.0. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.8, –78.2. IR (ATR) 1300 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{22}H_{29}F_3NOSi$ (M + H^+): 408.1965; found: 408.1965. Anal. calcd for $C_{22}H_{28}F_3NOSi$ (407.54): C, 64.84; H, 6.92; N, 3.44; found: C, 65.27; H, 6.82; N, 3.35. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 20.6 min (major diastereomer) and 21.0 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

Analytical data for (^{Si}*R*,*R*)-**14** (dr = 80:20, entry 4, Table 1): Yield: 55%. $[\alpha]_D^{20}$ = +26.8, $[\alpha]_{578}^{20}$ = +28.2, $[\alpha]_{546}^{20}$ = +34.4, $[\alpha]_{436}^{20}$ = +63.2, $[\alpha]_{365}^{20}$ = +123.4 (*c* = 1.04, $CHCl_3$).

(^{Si}*R**,*R**)-3-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-pyridazine [(^{Si}*R**,*R**)-15]

Analytical data for (^{Si}*R**,*R**)-**15**: Yield: 95%. GLC (SE-54): t_R = 21.9, 22.4 min. R_f = 0.21 (cyclohexane:*t*-butyl methyl ether = 1:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ 0.86 (s, 9H), 0.87–0.93 (m, 1H), 1.07 (ddd, *J* = 15.4, 6.1, 4.4 Hz, 1H), 1.51–1.62 (m, 1H), 1.91–2.00 (m, 1H), 2.46$^◊$ (ddd, *J* = 15.9, 10.6, 2.7 Hz, 1H), 2.61$^◊$ (br dd, *J* = 15.9, 6.4 Hz, 1H), 3.10$^◊$ (dd, *J* = 14.1, 9.1 Hz, 1H), 3.37$^◊$ (dd, *J* = 14.1, 3.2 Hz, 1H), 4.84 (dqd, *J* = 9.4, 3.4, 3.2 Hz, 1H), 6.98–7.04 (m, 2H), 7.05–7.10 (m, 2H), 7.15–7.21 (m, 2H), 8.85 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.4, 18.8, 22.4, 25.9, 35.3, 38.3, 71.8 (q, *J* = 31 Hz), 125.1, 125.5 (q, *J* = 283 Hz), 126.2, 128.0, 129.6, 130.0, 130.6, 134.7, 149.8, 150.0, 158.8. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.6, –78.3. IR (ATR) 1191 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{20}H_{26}F_3N_2OSi$ (M + H^+): 395.1760; found: 395.1761. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 21.9 min (major diastereomer) and 22.4 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

Analytical data for (^{Si}*R*,*R*)-**15** (dr = 80:20, entry 5, Table 1): Yield: 29%. $[\alpha]_D^{20}$ = +30.9, $[\alpha]_{578}^{20}$ = +33.1, $[\alpha]_{546}^{20}$ = +38.2, $[\alpha]_{436}^{20}$ = +77.7, $[\alpha]_{365}^{20}$ = +186.9 (*c* = 0.710, $CHCl_3$).

(^{Si}*R**,*R**)-4-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-pyrimidine [(^{Si}*R**,*R**)-16]

Analytical data for (^{Si}*R**,*R**)-**16**: Yield: 54%. GLC (SE-54): t_R = 20.6, 21.0 min. R_f = 0.30 (cyclohexane:*t*-butyl methyl ether = 1:8). ^{1}H NMR (400 MHz, $CDCl_3$): δ 0.86 (s, 9H), 0.90–0.96 (m, 1H), 1.10 (ddd, *J* = 15.9, 5.4, 5.4 Hz, 1H), 1.61–1.72 (m, 1H), 1.96–2.03 (m, 1H), 2.51$^◊$ (ddd, *J* = 15.9, 10.9, 2.8 Hz, 1H), 2.67$^◊$ (br dd, *J* = 15.9, 6.6 Hz, 1H), 2.96$^◊$ (dd, *J* = 14.5, 9.1 Hz, 1H), 3.10$^◊$ (dd, *J* = 14.1, 3.1 Hz, 1H), 4.80 (dqd, *J* = 9.4, 3.1, 3.1 Hz, 1H), 6.95 (br t, *J* = 7.5 Hz, 1H), 6.99–7.05 (m, 3H), 7.21 (ddd, *J* = 7.5, 7.5, 1.5 Hz, 1H), 8.37 (br s, 1H), 8.81 (s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.6, 18.8, 22.6, 25.9, 35.4, 39.5, 70.8 (q, *J* = 31 Hz), 122.3, 125.1 (q, *J* = 282 Hz), 125.2, 128.8, 129.8, 130.5, 134.4, 149.8, 156.4, 158.3, 165.1. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.8, –78.4. IR (ATR) 1278 (br, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{20}H_{25}F_3N_2OSiNa$ (M + Na^+): 417.1580; found: 417.1576. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 20.6 min (major diastereomer) and 21.0 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

Analytical data for (^{Si}*R*,*R*)-**16** (dr = 79:21, entry 6, Table 1): Yield: 52%. $[\alpha]_D^{20}$ = +25.3, $[\alpha]_{578}^{20}$ = +26.4, $[\alpha]_{546}^{20}$ = +30.5, $[\alpha]_{436}^{20}$ = +57.8, $[\alpha]_{365}^{20}$ = +108.2 (*c* = 0.790, $CHCl_3$).

(^{Si}*R**,*R**)-2-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-pyrazine [(^{Si}*R**,*R**)-17]

Analytical data for (^{Si}*R**,*R**)-**17**: Yield: 33%. GLC (SE-54): t_R = 20.5, 20.9 min. R_f = 0.28 (cyclohexane:*t*-butyl methyl ether = 1:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ 0.85 (s, 9H), 0.94$^◊$ (ddd, *J* = 15.6, 6.8, 2.2 Hz, 1H), 1.11 (ddd, *J* = 15.6, 5.4, 4.9 Hz, 1H), 1.68–1.76 (m, 1H), 1.98–2.07 (m, 1H), 2.53$^◊$ (ddd, *J* = 15.8, 10.9, 2.7 Hz, 1H), 2.70$^◊$ (br dd, *J* = 15.7, 6.3 Hz, 1H), 3.06$^◊$ (dd, *J* = 14.5, 9.0 Hz, 1H), 3.13$^◊$ (dd, *J* = 14.5, 3.5 Hz, 1H), 4.71 (dqd, *J* = 9.4, 3.6, 3.5 Hz, 1H), 6.88–6.93 (m, 3H), 7.00 (d, *J* = 7.7 Hz, 1H), 7.15–7.19 (m, 1H), 8.13 (s, 1H), 8.19 (br s, 1H), 8.35 (br s, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.8, 18.8, 22.7, 25.8, 35.5, 36.9, 70.8 (q, *J* = 31 Hz), 125.2 (q, *J* = 280 Hz), 125.3, 128.6, 129.5, 130.3, 134.3, 142.8, 144.2, 145.2, 149.9, 152.2. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.8, –78.3. IR (ATR) 1272 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{20}H_{25}F_3N_2OSiNa$ (M + Na^+): 417.1580; found: 417.1580. Anal. calcd for $C_{20}H_{25}F_3N_2OSi$ (394.51): C, 60.89; H, 6.39; N, 7.10; found: C, 60.48; H, 6.42; N, 6.89. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 20.5 min (major diastereomer) and 20.9 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

Analytical data for (^{Si}*R*,*R*)-**17** (dr = 85:15, entry 7, Table 1): Yield: 53%. $[\alpha]_D^{20}$ = +42.3, $[\alpha]_{578}^{20}$ = +44.6, $[\alpha]_{546}^{20}$ = +51.1, $[\alpha]_{436}^{20}$ = +98.9 (*c* = 1.10, $CHCl_3$).

(^{Si}*R**,*R**)-2-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-6-chloropyridine [(^{Si}*R**,*R**)-18]

Analytical data for (^{Si}*R**,*R**)-**18**: Yield: 93%. GLC (SE-54): t_R = 21.8, 22.2 min. R_f = 0.14 (cyclohexane:*t*-butyl methyl ether = 90:10). ^{1}H NMR (400 MHz, $CDCl_3$): δ 0.82 (s, 9H), 0.89$^◊$ (ddd, *J* = 15.5, 6.9, 1.4 Hz, 1H), 1.10 (ddd, *J* = 15.5, 10.4, 2.4 Hz, 1H), 1.69–1.80 (m, 1H), 1.96–2.05 (m, 1H), 2.46–2.55 (m, 1H), 2.71$^◊$ (br dd, *J* = 15.9, 6.4 Hz, 1H), 2.94$^◊$ (dd, *J* = 14.3, 9.9 Hz, 1H), 3.11$^◊$ (dd, *J* = 14.3, 2.5 Hz, 1H), 4.71 (dqd, *J* = 9.4, 2.7, 2.5 Hz, 1H), 6.92 (d, *J* = 4.1 Hz, 1H), 6.94 (d, *J* = 3.5 Hz, 1H), 6.98 (d, *J* = 7.3 Hz, 1H), 7.00–7.06 (m, 2H), 7.17 (dt, *J* = 7.8, 1.5 Hz, 1H), 7.31 (t, *J* = 7.8 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.9, 18.8, 22.4, 25.9, 35.5, 39.3, 71.2 (q, *J* = 31 Hz), 122.6, 123.4, 125.1, 126.6, 126.6 (q, *J* = 281 Hz), 128.7, 129.5, 134.6, 139.0, 149.9, 150.9, 157.1. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.7, –78.3. IR (ATR) 1272 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{21}H_{26}F_3ClNOSi$ (M + H^+): 428.1419; found: 428.1423. Anal. calcd for $C_{21}H_{25}F_3ClNOSi$ (427.96): C, 58.94; H, 5.89; N, 3.27; found: C, 59.40; H, 5.92; N, 3.29. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 21.8 min (major diastereomer) and 22.2 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

Analytical data for (^{Si}*R*,*R*)-**18** (dr = 76:24, entry 8, Table 1): Yield: 58%. $[\alpha]_D^{20}$ = +40.1, $[\alpha]_{578}^{20}$ = +42.3, $[\alpha]_{546}^{20}$ = +48.7, $[\alpha]_{436}^{20}$ = +58.3, $[\alpha]_{365}^{20}$ = +170.2 (*c* = 1.01, $CHCl_3$).

(^{Si}*R**,*R**)-2-[2-(1-*tert*-Butyl-1,2,3,4-tetrahydro-1-silanaphthalyloxy)-3,3,3-trifluoropropyl]-4-methylpyridine [(^{Si}*R**,*R**)-19]

Analytical data for (^{Si}*R**,*R**)-**19**: Yield: 97%. GLC (SE-54): t_R = 21.1, 21.5 min. R_f = 0.11 (cyclohexane:*t*-butyl methyl ether = 90:10). ^{1}H NMR (400 MHz, $CDCl_3$): δ 0.83 (s, 9H), 0.88$^◊$ (ddd, *J* = 15.3, 6.8, 1.3 Hz, 1H), 1.02–1.09 (m, 1H), 1.55–1.67 (m, 1H), 1.92–2.00 (m, 1H), 2.20 (s, 3H), 2.48◊ (ddd, *J* = 15.9, 10.9, 2.6 Hz, 1H), 2.64◊ (br dd, *J* = 15.8, 6.5 Hz, 1H), 2.91◊ (dd, *J* = 14.1, 9.4 Hz, 1H), 3.11◊ (dd, *J* = 14.1, 2.8 Hz, 1H), 4.71 (dqd, *J* = 9.4, 3.1, 2.8 Hz, 1H), 6.81 (d, *J* = 5.0 Hz, 1H), 6.82 (s, 1H), 6.92–6.96 (m, 2H), 6.99 (d, *J* = 7.3 Hz, 1H), 7.16 (ddd, *J* = 7.3, 5.2, 2.7 Hz, 1H), 8.20 (d, *J* = 5.0 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 8.8, 18.9, 21.1, 22.5, 25.8, 35.5, 39.7, 71.7 (q, *J* = 31 Hz), 123.0, 124.9, 125.2 (q, *J* = 283 Hz), 126.0, 128.5, 129.4, 130.3, 134.8, 147.8, 148.9, 150.0, 155.9. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.9, –78.2. IR (ATR) 1297 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{22}H_{29}F_3NOSi$ (M + H^+): 408.1965; found: 408.1964. Anal. calcd for $C_{22}H_{28}F_3NOSi$ (407.54): C, 64.84; H, 6.92; N, 3.44; found: C, 64.78; H, 7.02; N, 3.32. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 21.1 min (major diastereomer) and 21.5 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

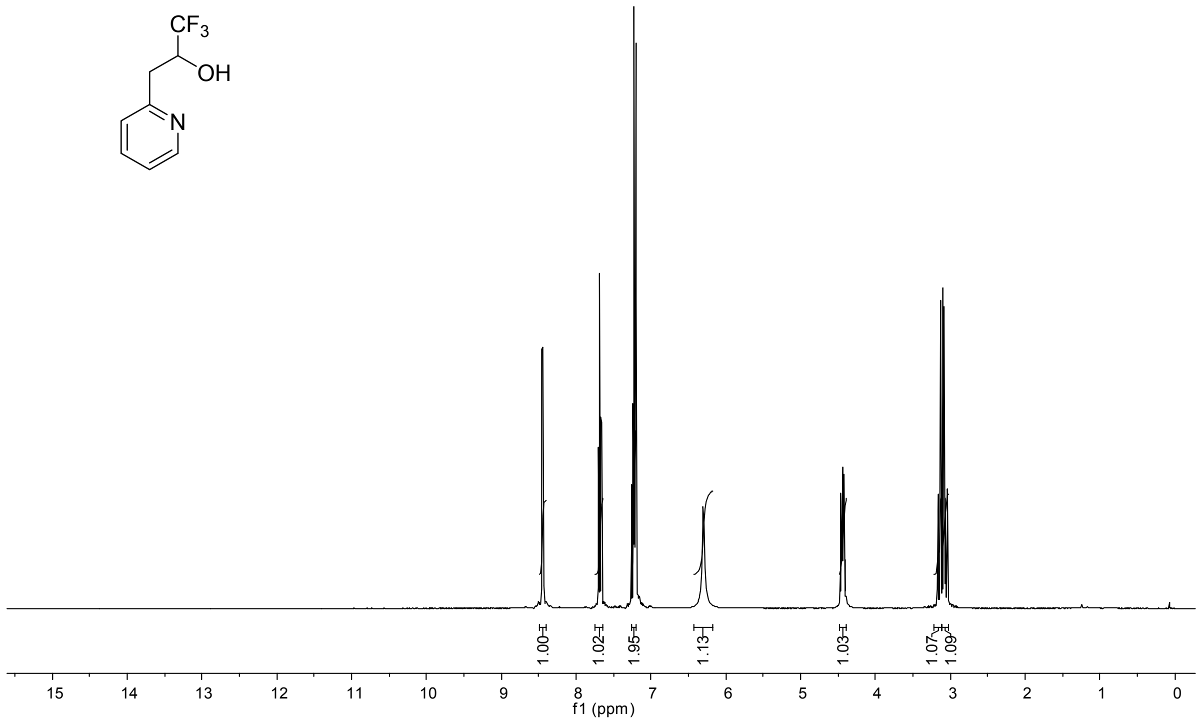
Analytical data for (^{Si}R,*R*)-**19** (dr = 76:24, entry 9, Table 1): Yield: 55%. $[\alpha]_D^{20}$ = +12.5, $[\alpha]_{578}^{20}$ = +12.6, $[\alpha]_{546}^{20}$ = +15.7, $[\alpha]_{436}^{20}$ = +33.9 (*c* = 0.830, $CHCl_3$).

($^{Si}R^*$,*R**)-1-(1-Benzyl-2,2,2-trifluoroethoxy)-1-*tert*-butyl-1,2,3,4-tetrahydro-1-silanaphthalene [($^{Si}R^*$,*R**)-21]

Analytical data for ($^{Si}R^*$,*R**)-**21**: Yield: 32%. GLC (SE-54): t_R = 20.3, 20.5 min. R_f = 0.21 (cyclohexane:*t*-butyl methyl ether = 90 : 10). ^{1}H NMR (400 MHz, $CDCl_3$): δ 0.89 (s, 9H), 0.94–0.98 (m, 1H), 1.02–1.09 (m, 1H), 1.54–1.65 (m, 1H), 1.95–2.04 (m, 1H), 2.50–2.58 (m, 1H), 2.70◊ (br dd, *J* = 15.5, 6.1 Hz, 1H), 2.85◊ (dd, *J* = 14.1, 8.4 Hz, 1H), 3.04◊ (dd, *J* = 14.1, 4.2 Hz, 1H), 4.71 (dqd, *J* = 9.5, 4.4, 4.2 Hz, 1H), 6.91 (dd, *J* = 7.6, 1.3 Hz, 1H), 7.01 (br t, *J* = 7.4 Hz, 1H), 7.06–7.09 (m, 2H), 7.19–7.32 (m, 5H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 9.7, 18.9, 22.7, 26.0, 35.6, 38.2, 73.3 (q, *J* = 33 Hz), 125.3 (q, *J* = 283 Hz), 125.3, 126.9, 128.5, 128.7, 128.8, 129.6, 129.8, 129.9, 130.0, 135.2, 136.4, 150.7. ^{19}F NMR (282 MHz, $CDCl_3$): δ –77.6, –77.4. IR (ATR) 1276 (m, C–F) cm^{-1}. HRMS (ESI) calcd for $C_{22}H_{27}F_3OSiNa$ (M + Na^+): 415.1675; found: 415.1673. The diastereomeric ratio was determined by GLC (SE-54) – t_R = 20.3 min (major diastereomer) and 20.5 min (minor diastereomer) – and agrees with the ratio determined by ^{19}F NMR.

4 ^{1}H, ^{13}C and ^{19}F NMR spectra of all new compounds

rac-**2** (^{1}H):



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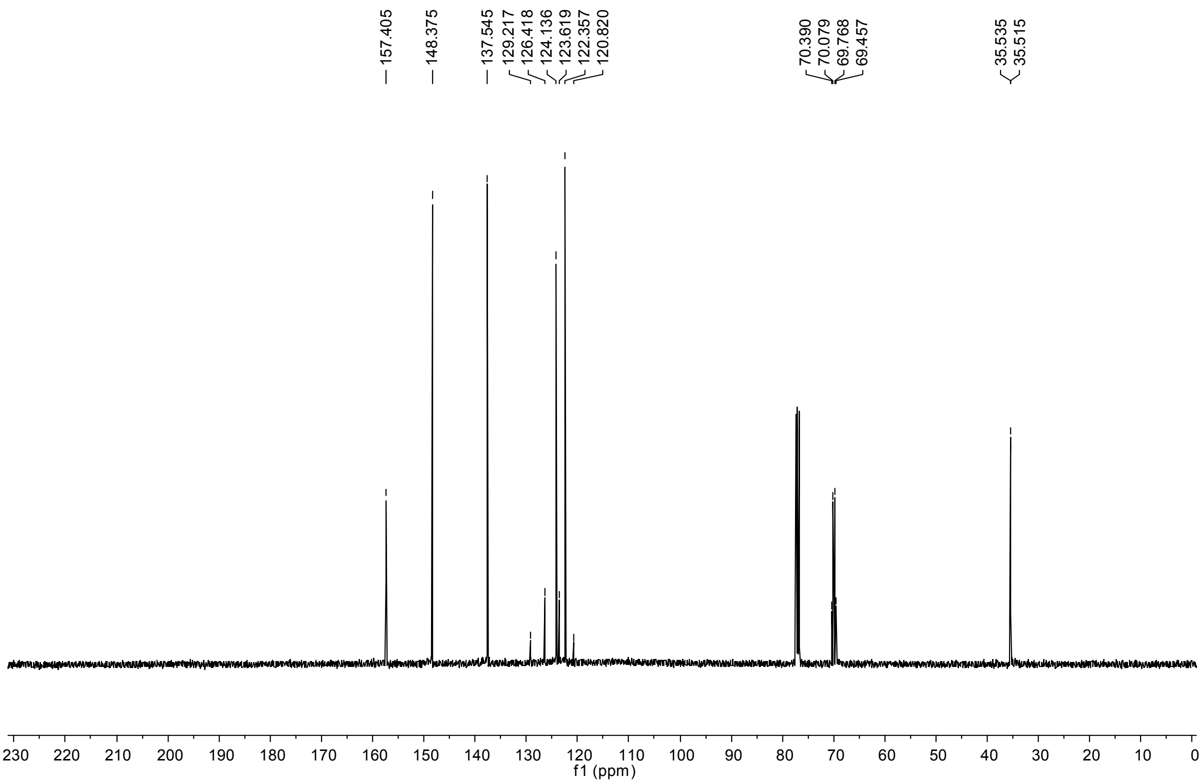

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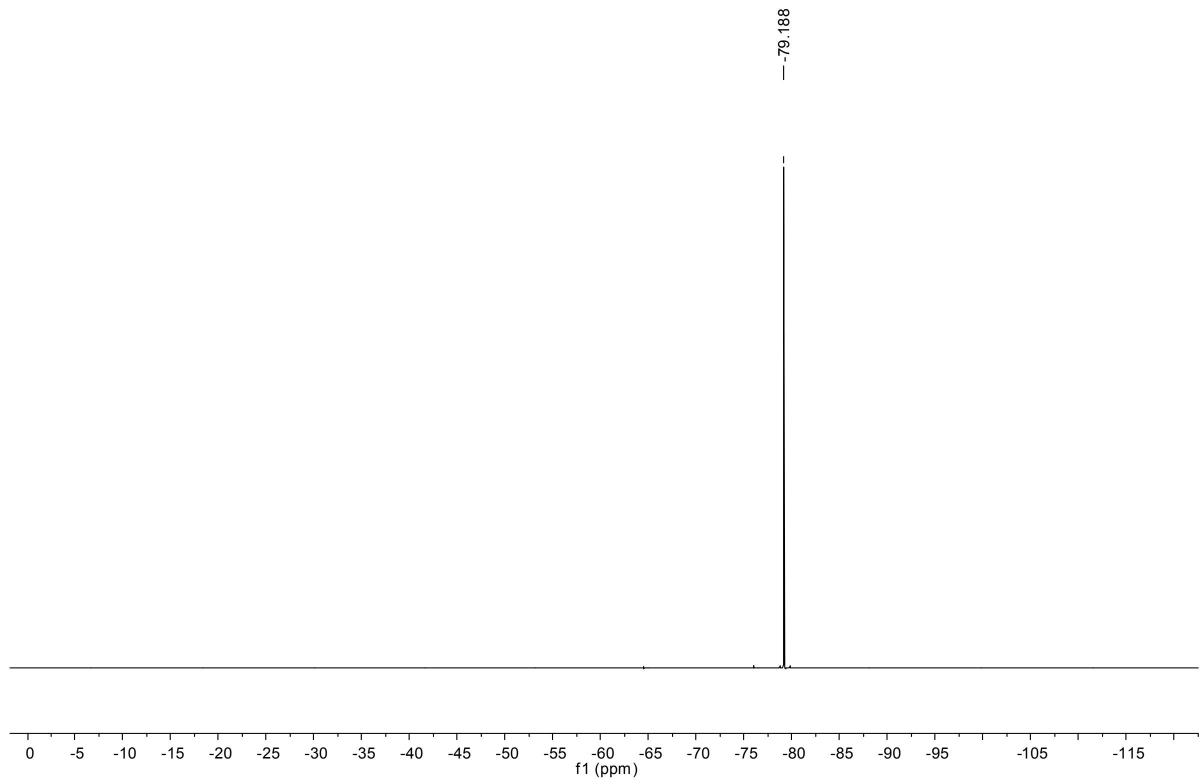

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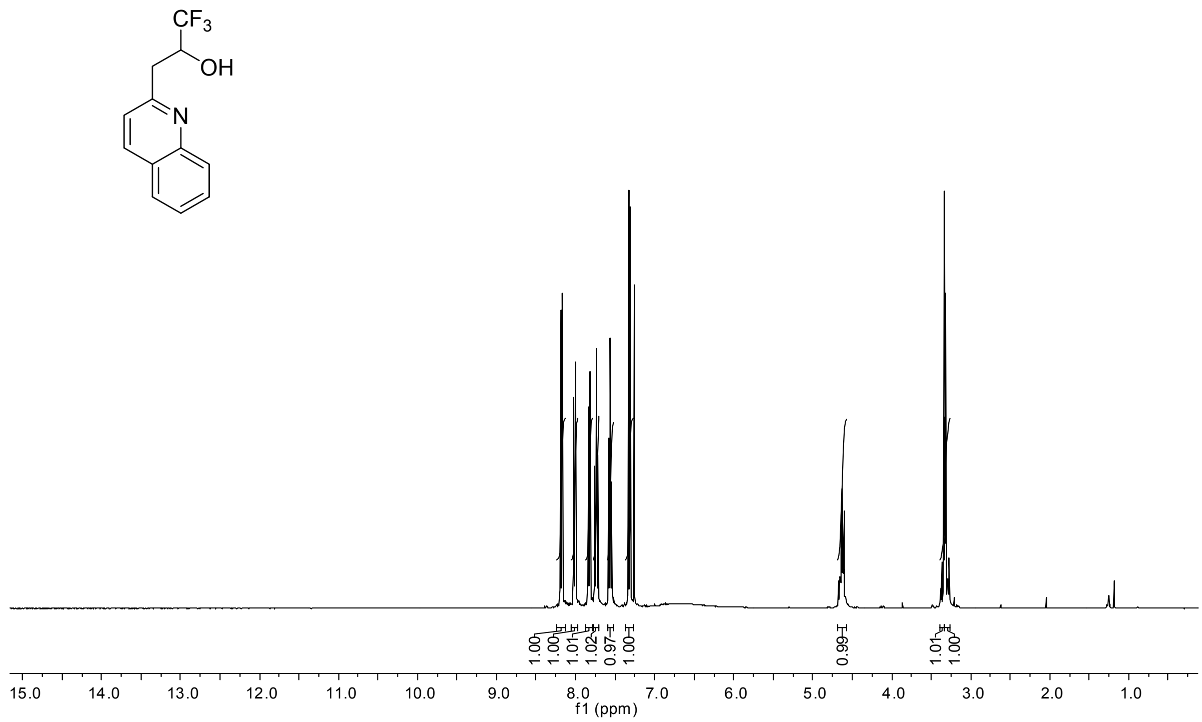

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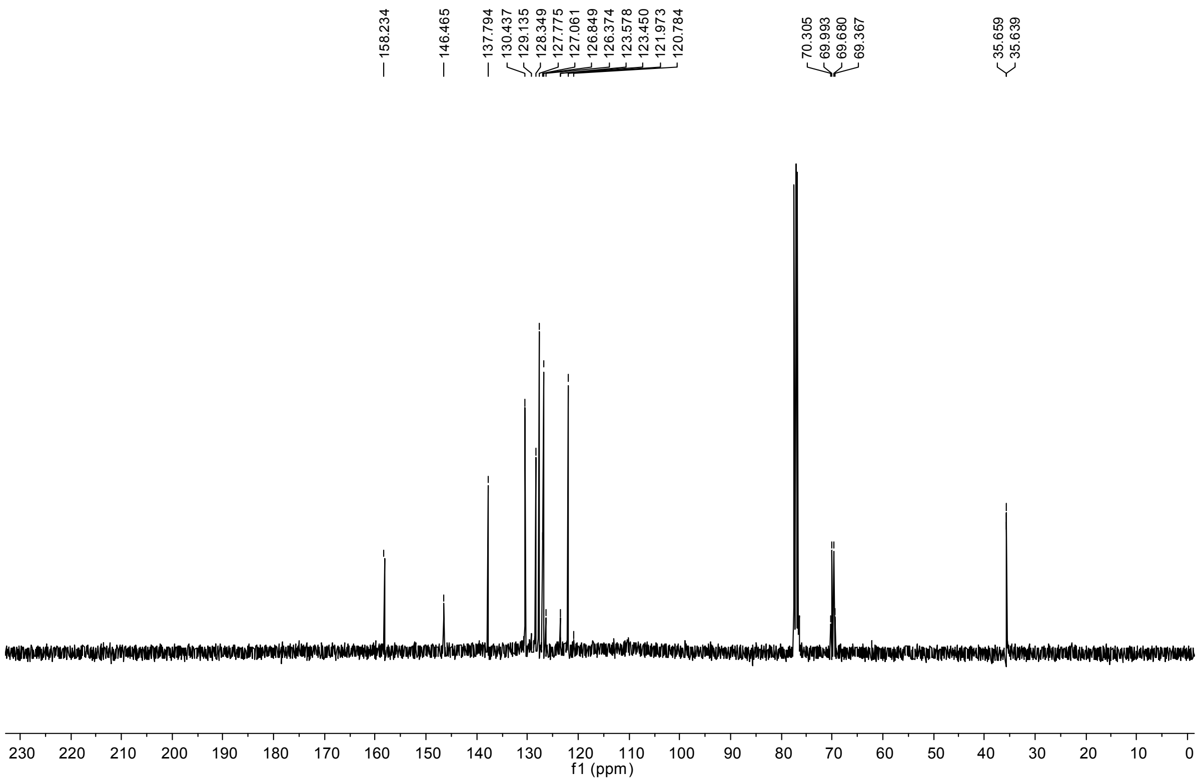
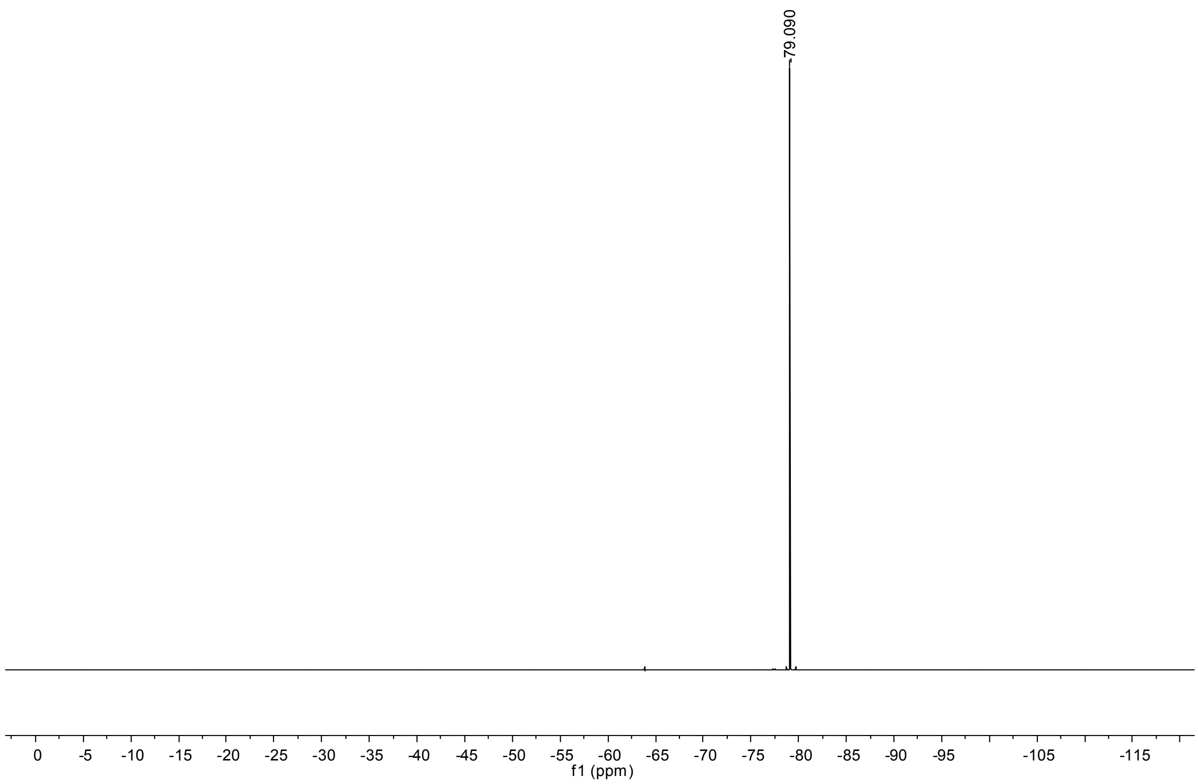


rac-**3** (^{19}F):



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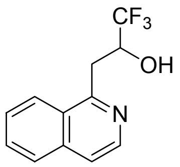

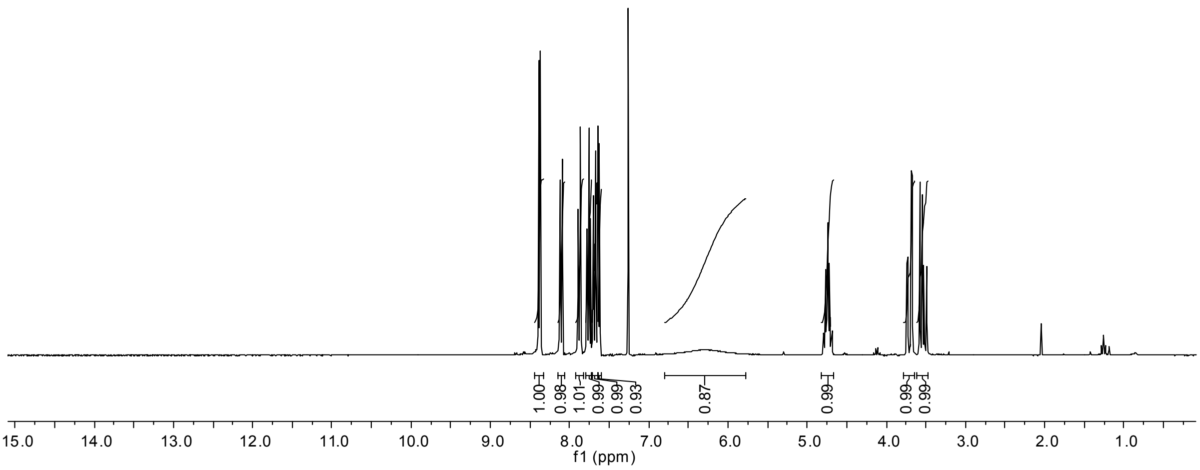

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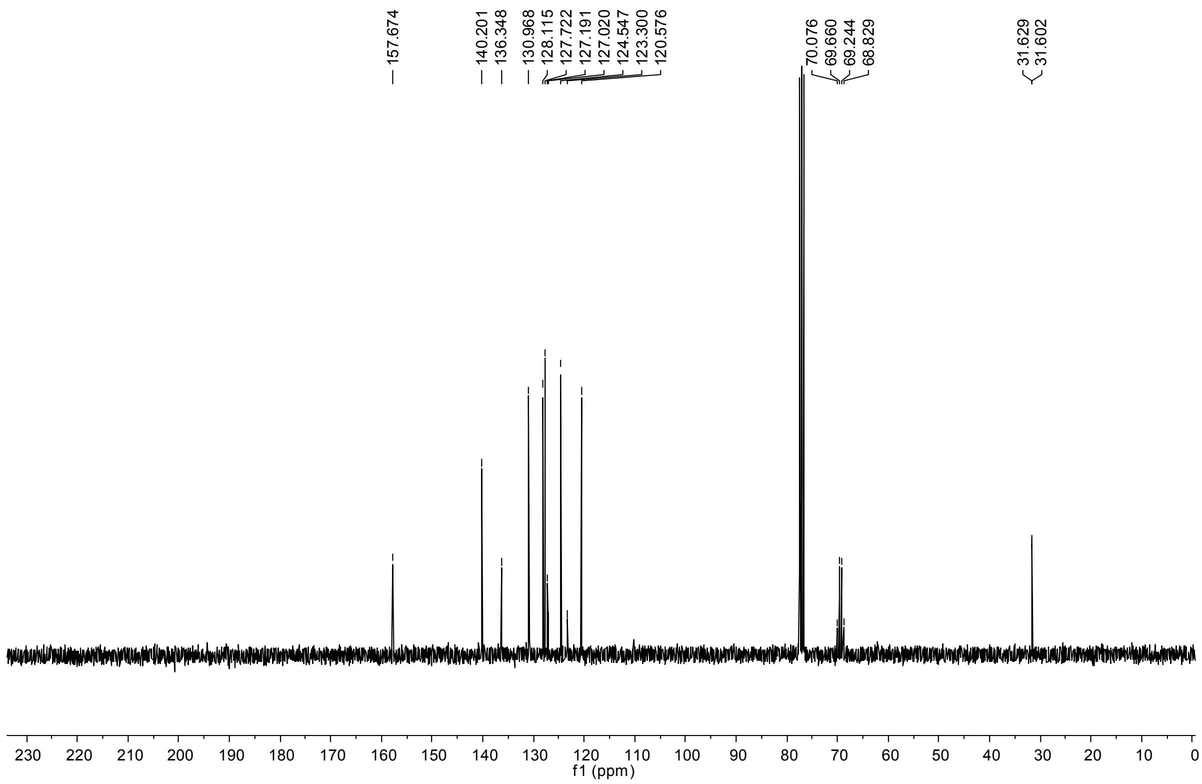

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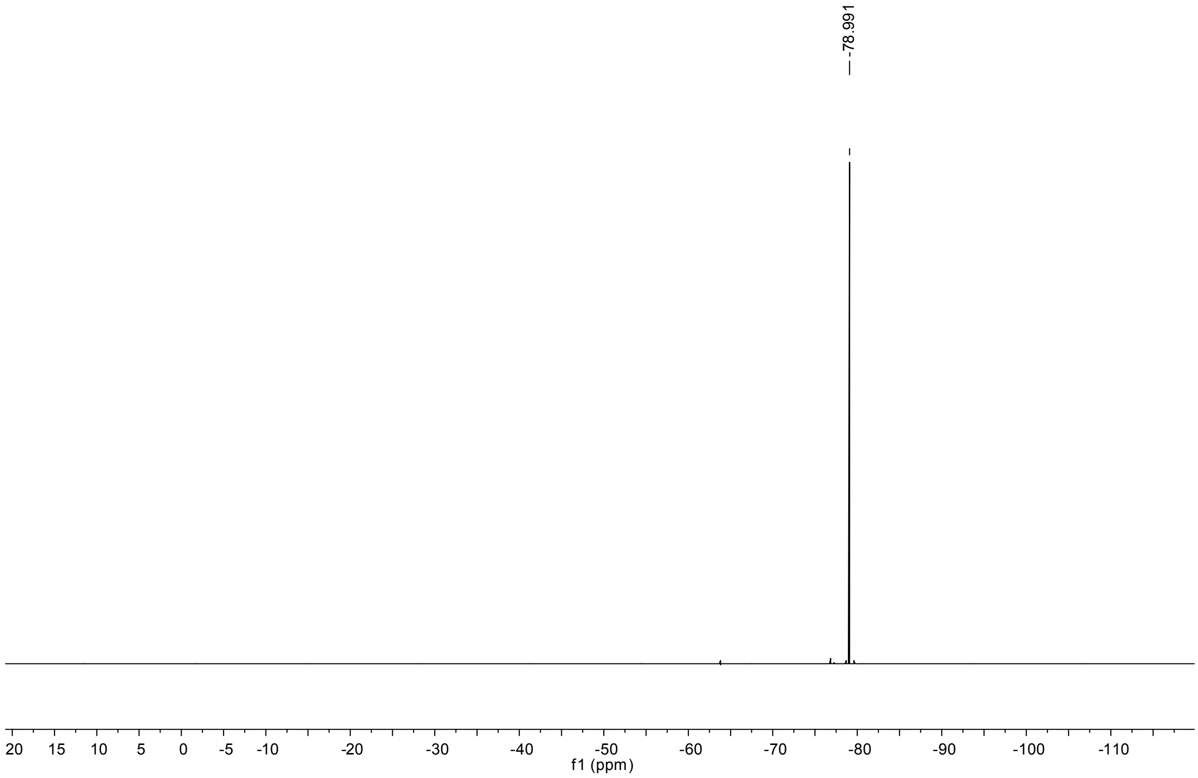

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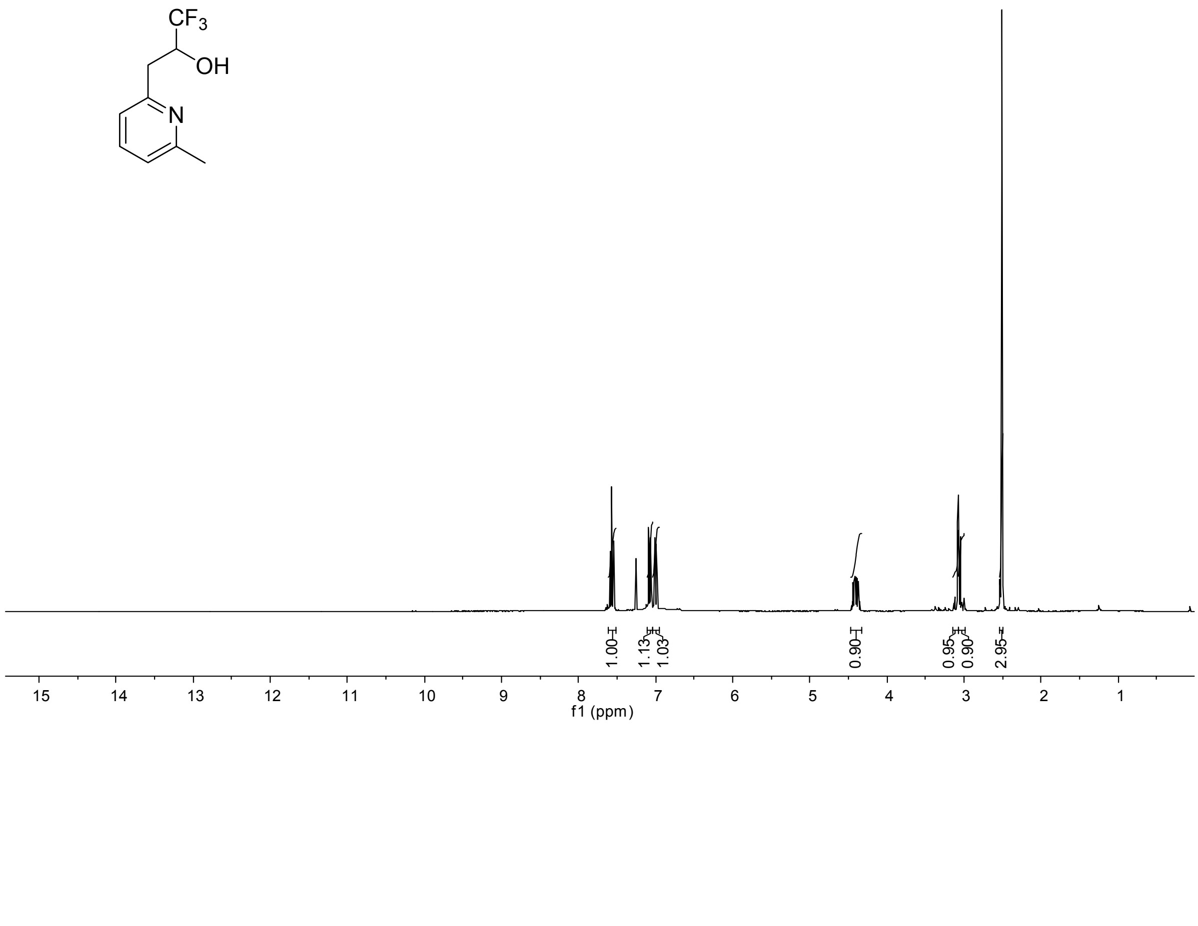

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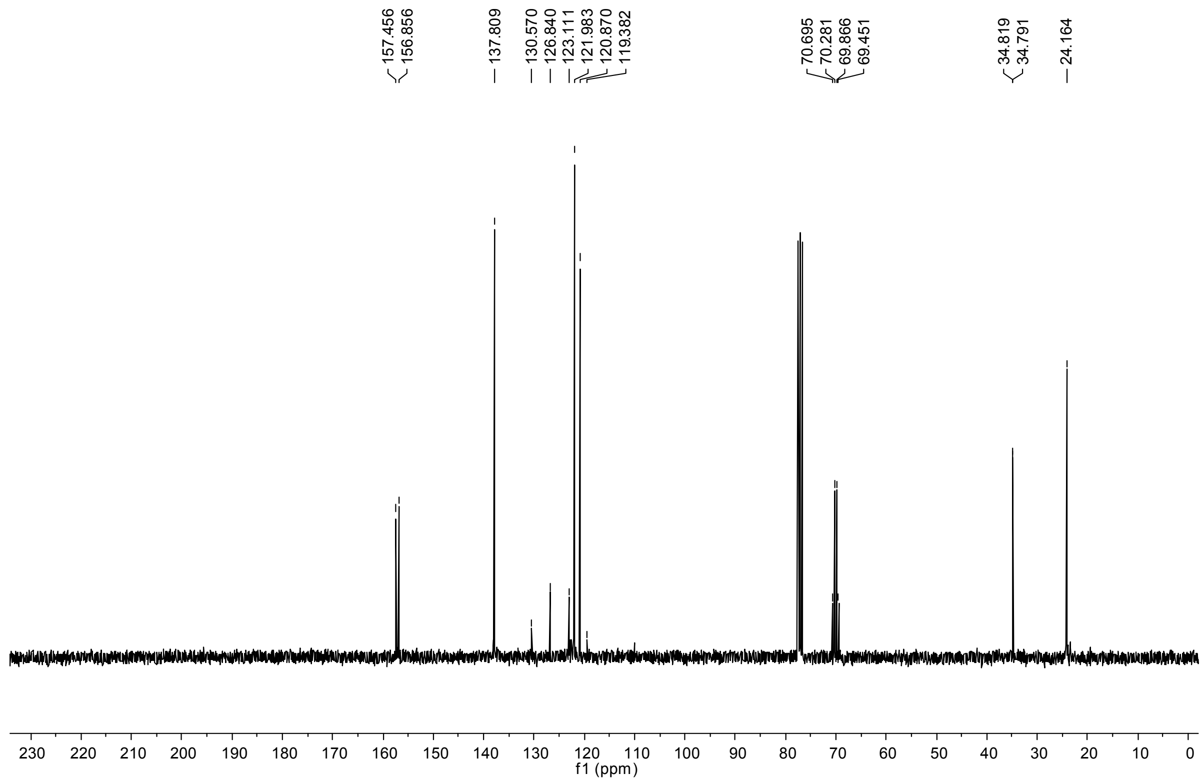

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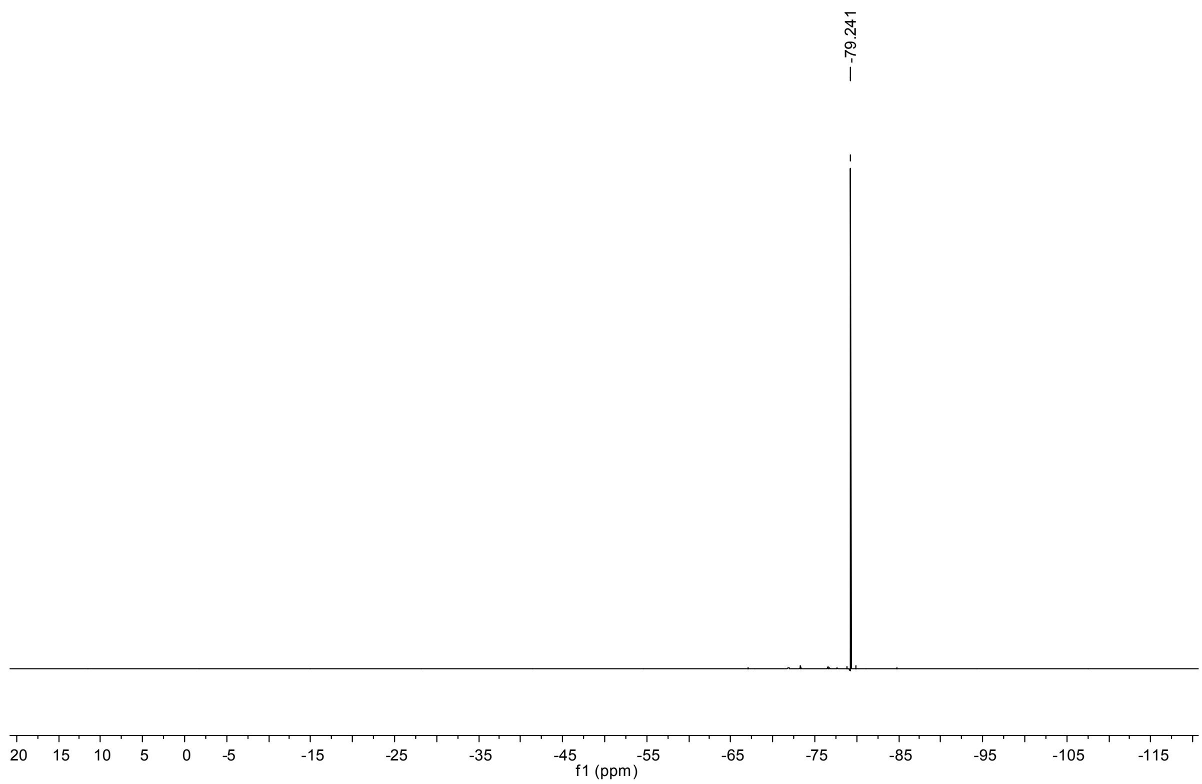

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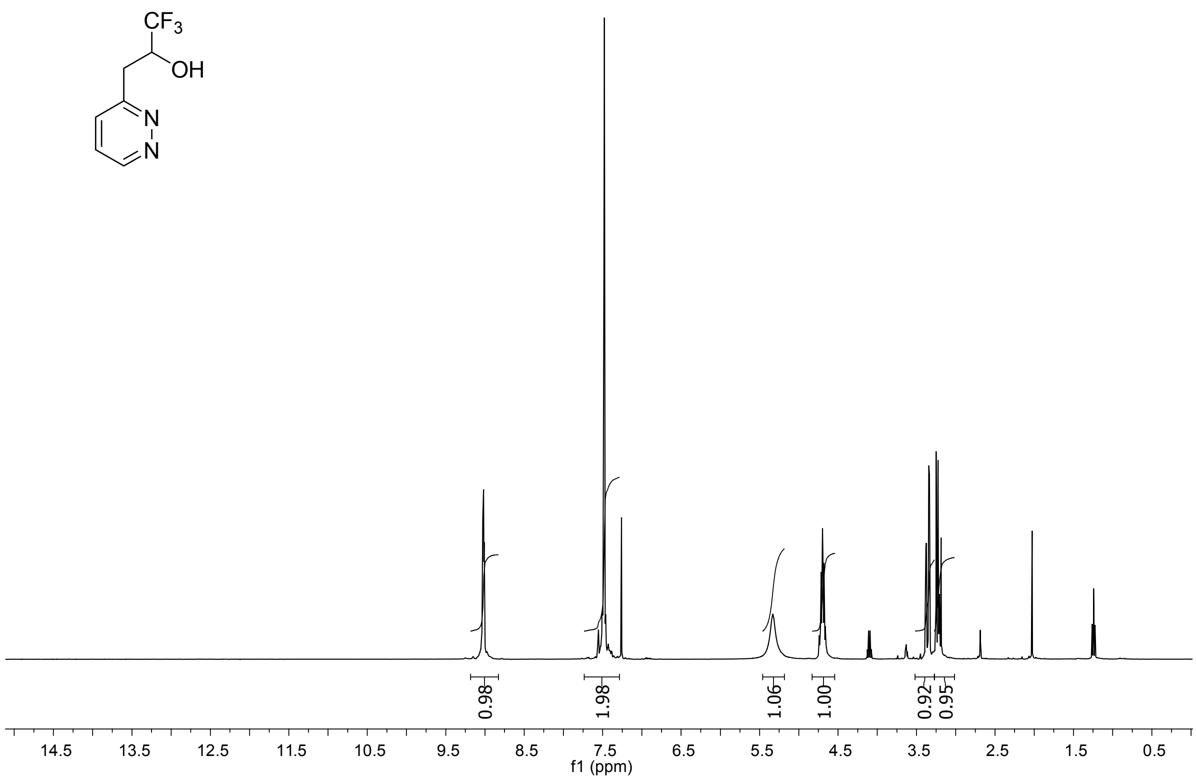

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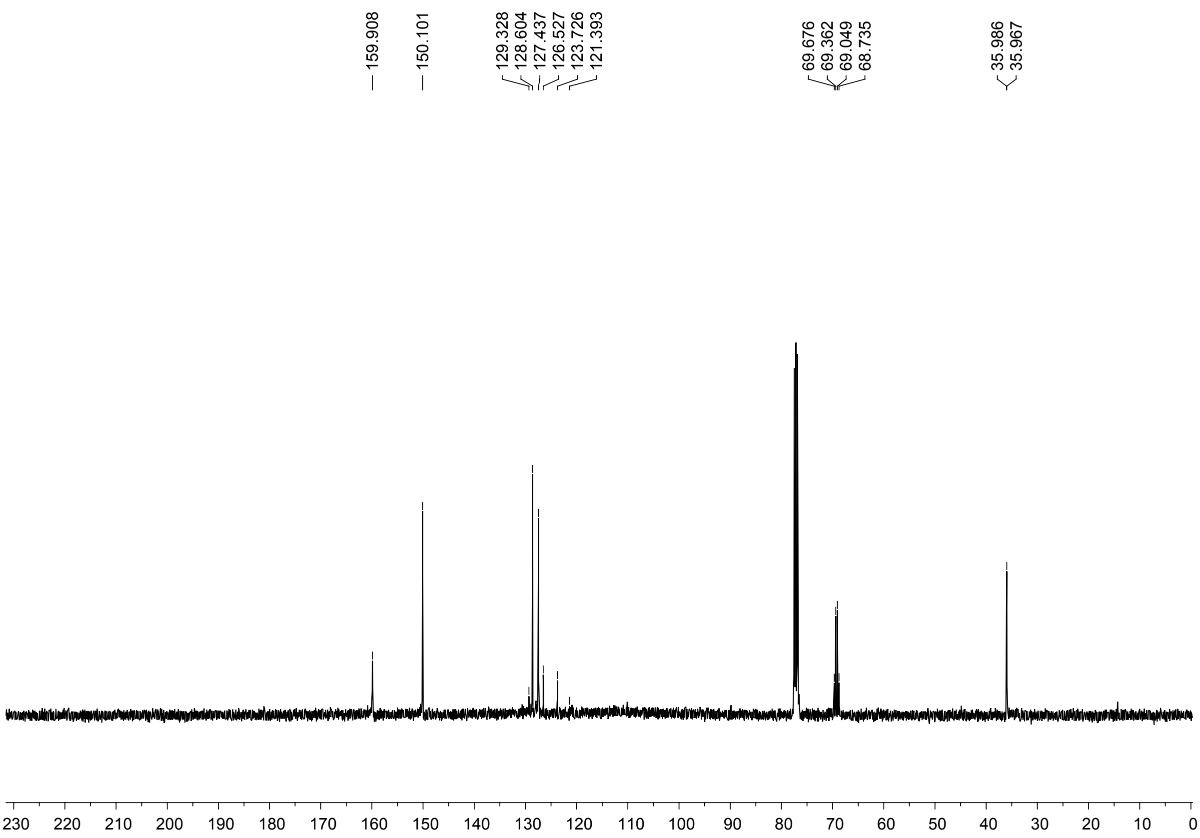
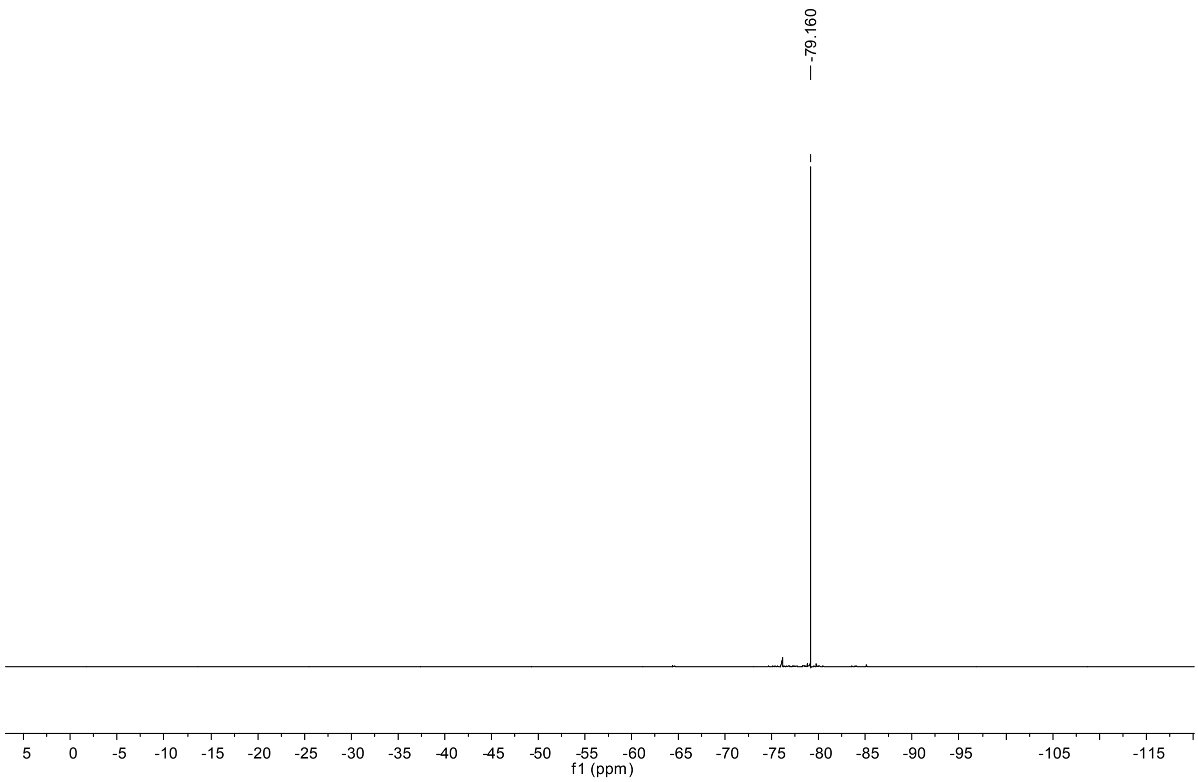


rac-**6** (^{19}F):



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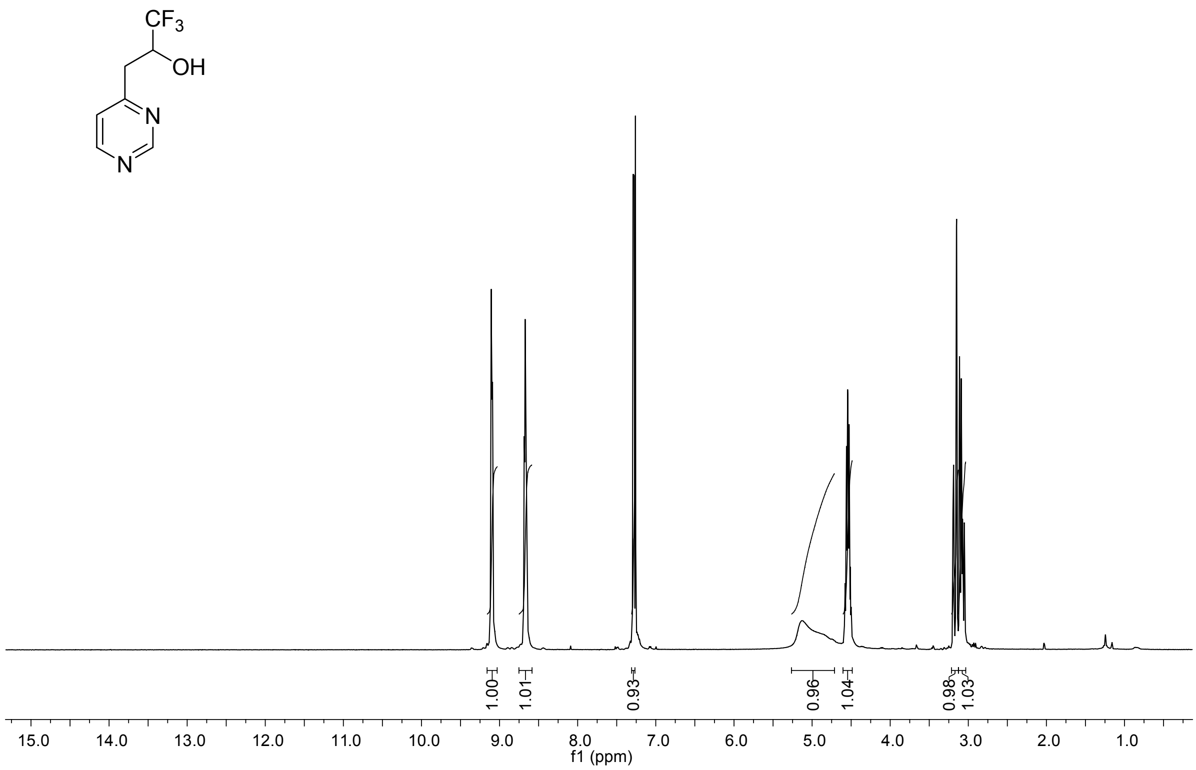
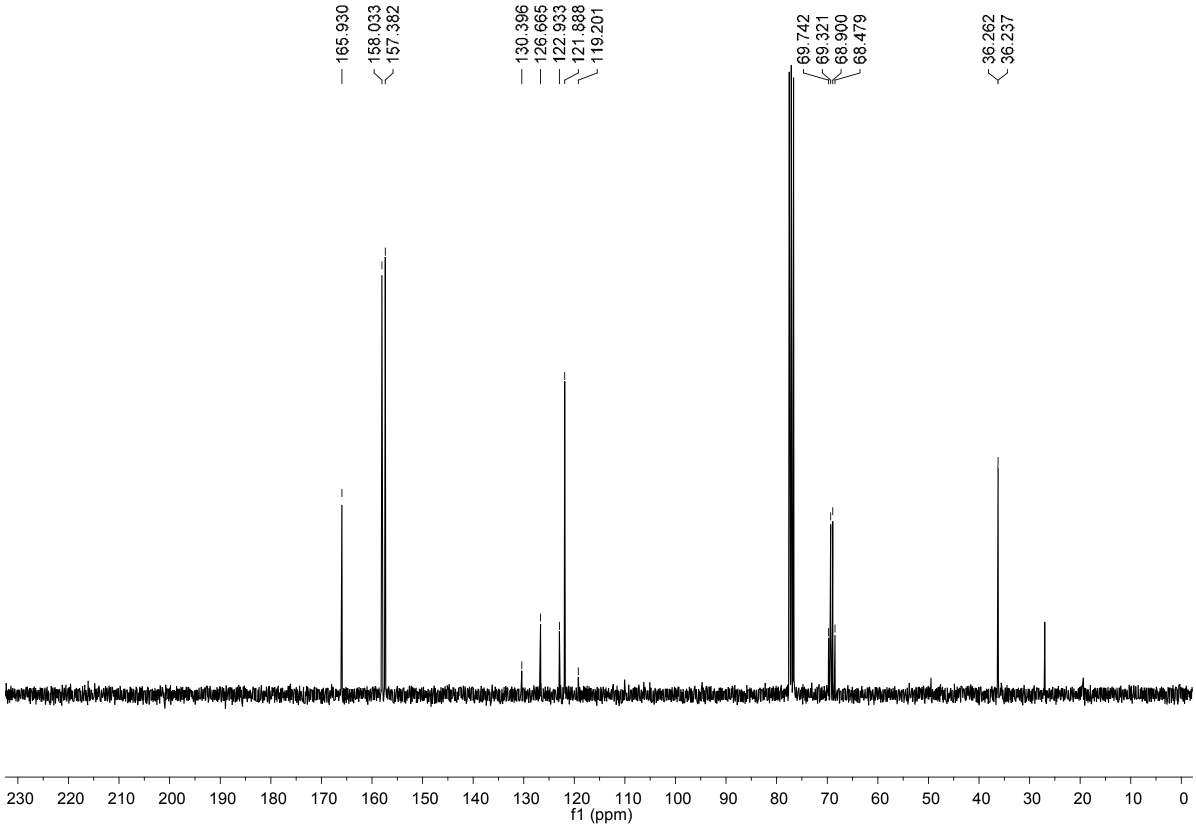
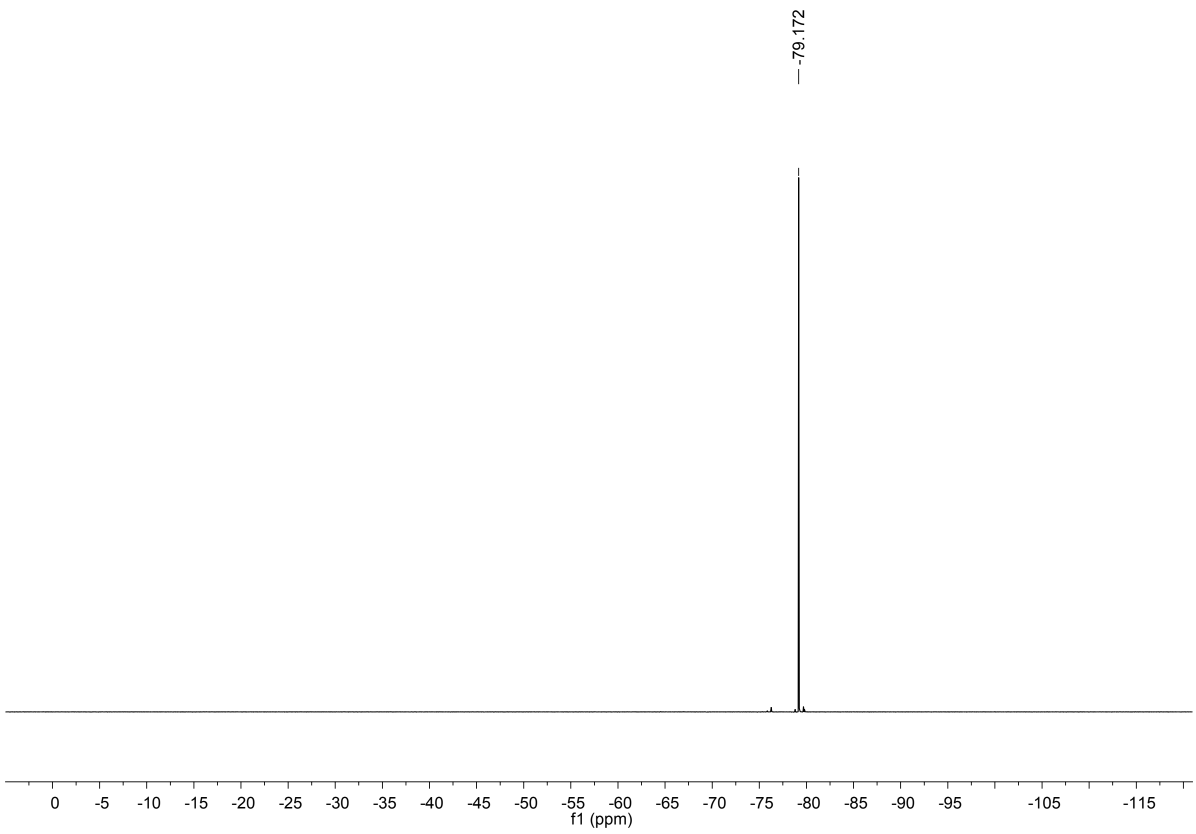


rac-**7** (^{13}C):



rac-**7** (^{19}F):



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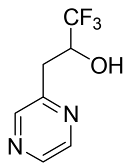

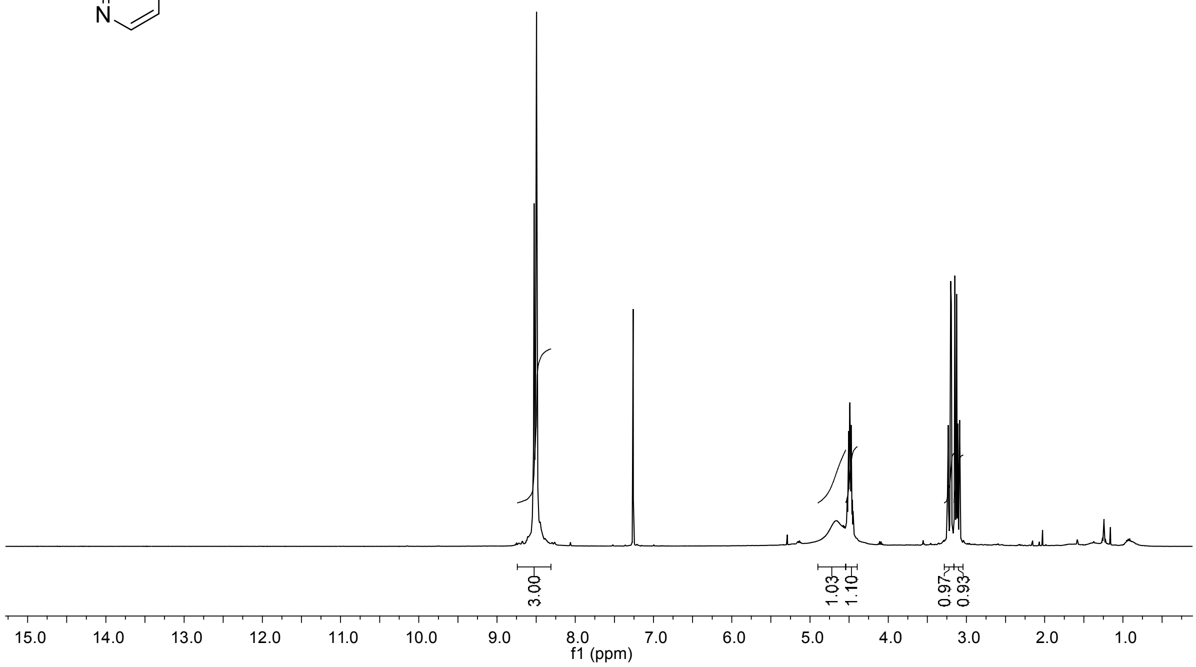

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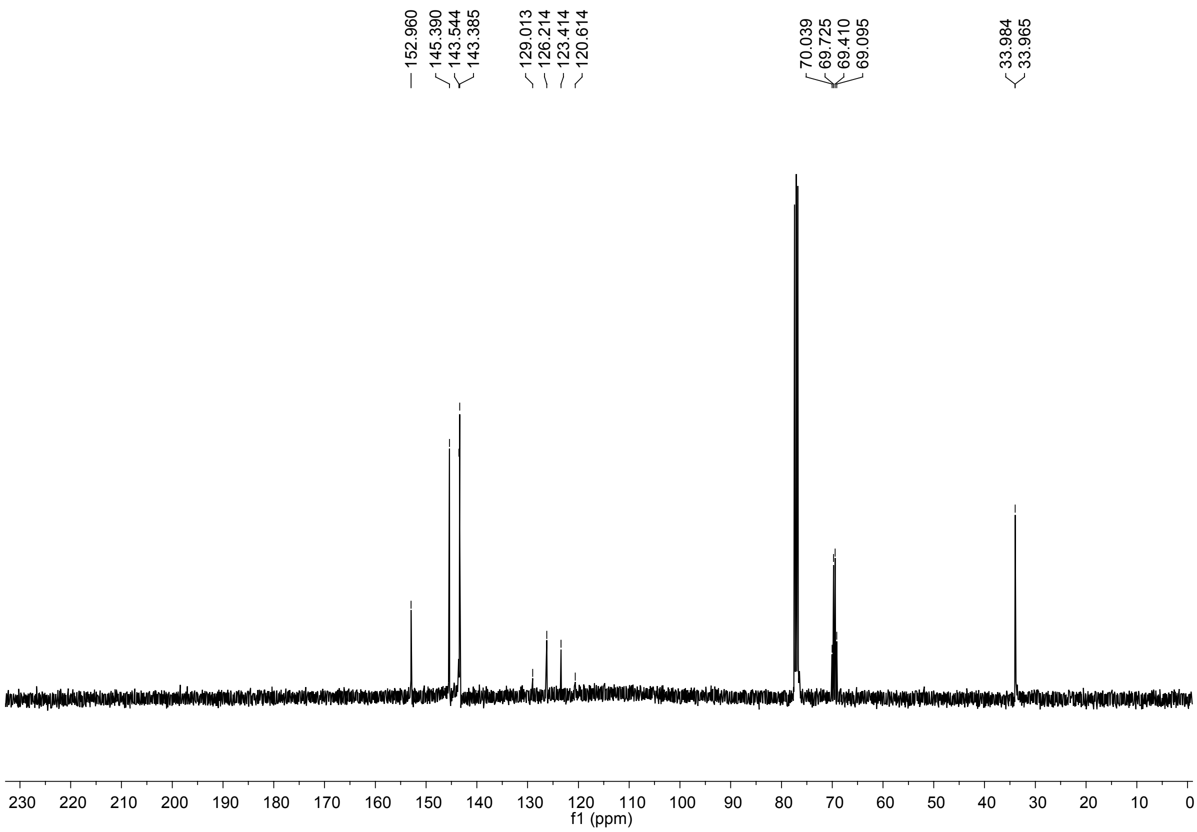

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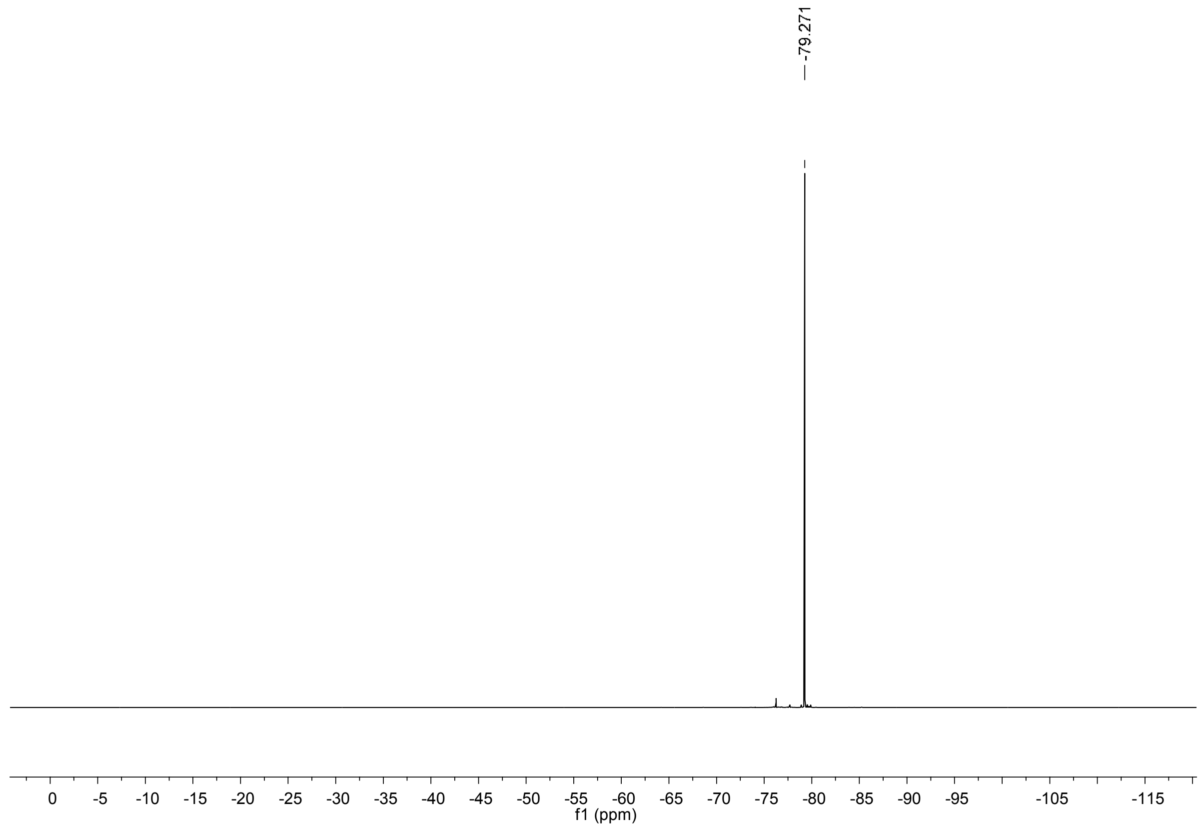

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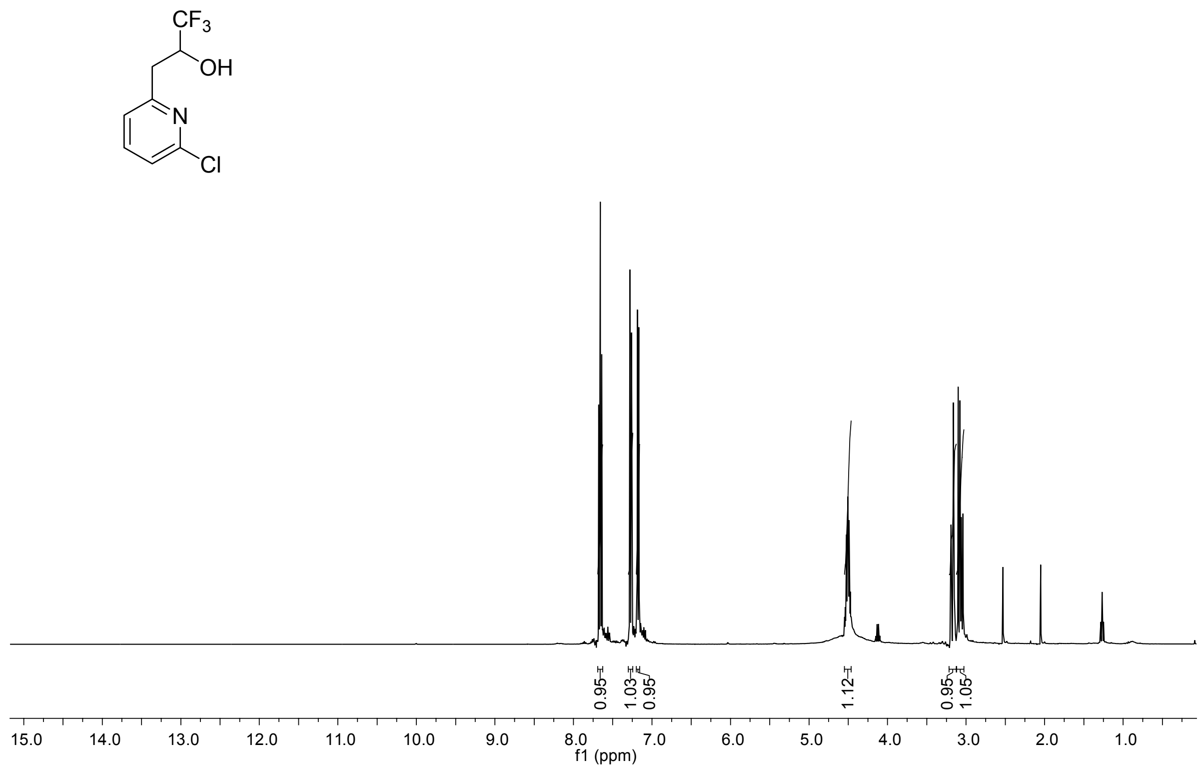

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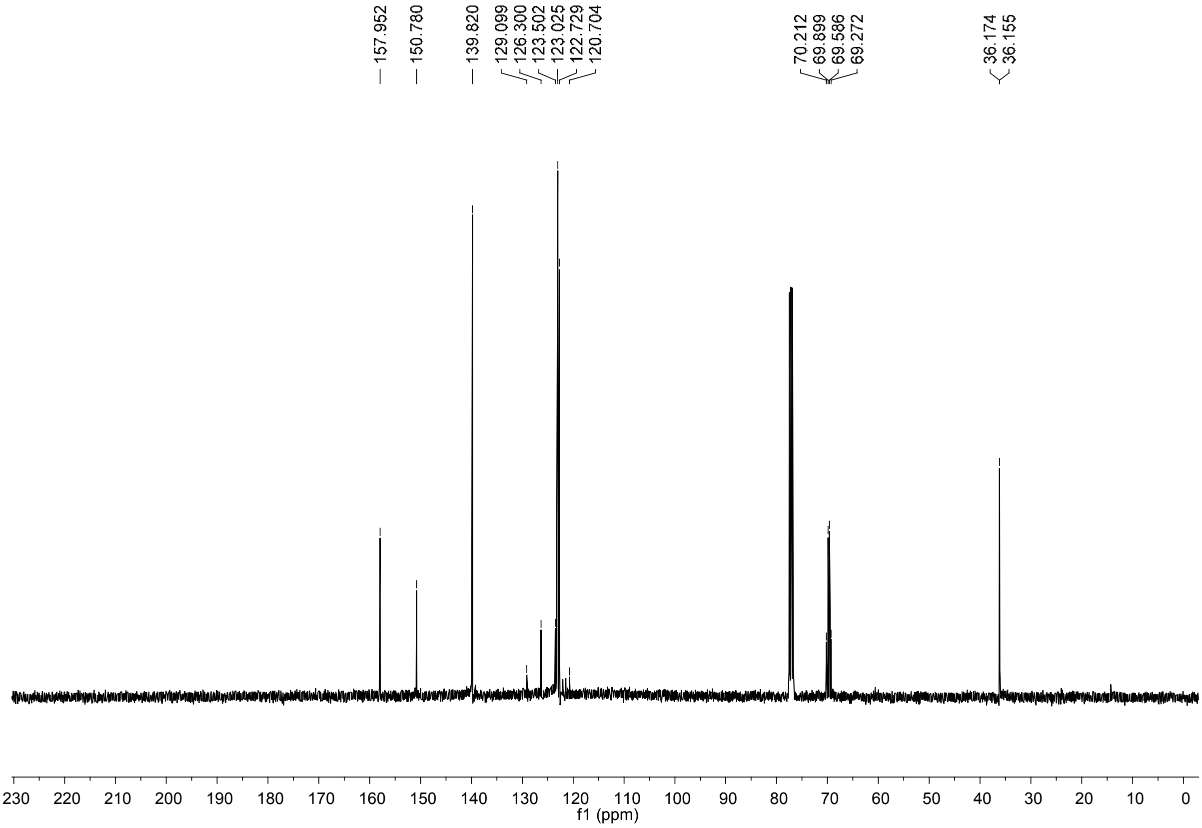

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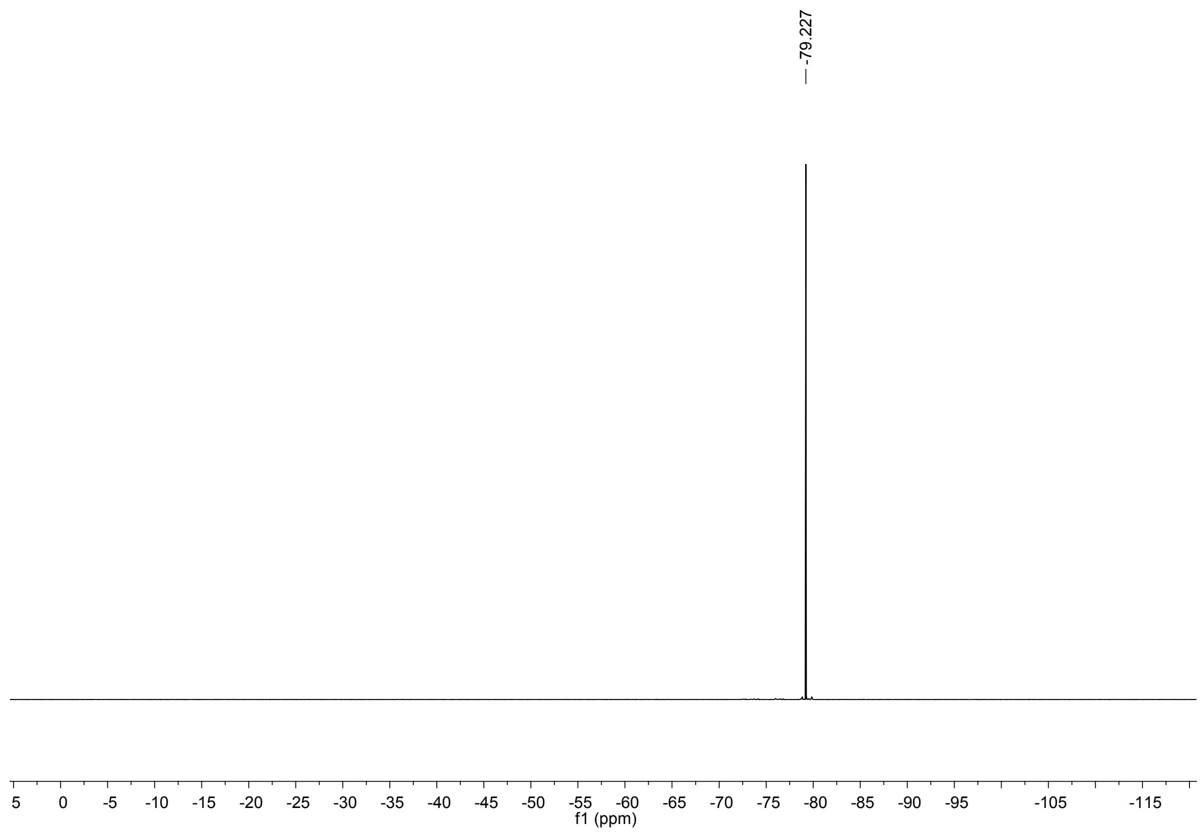
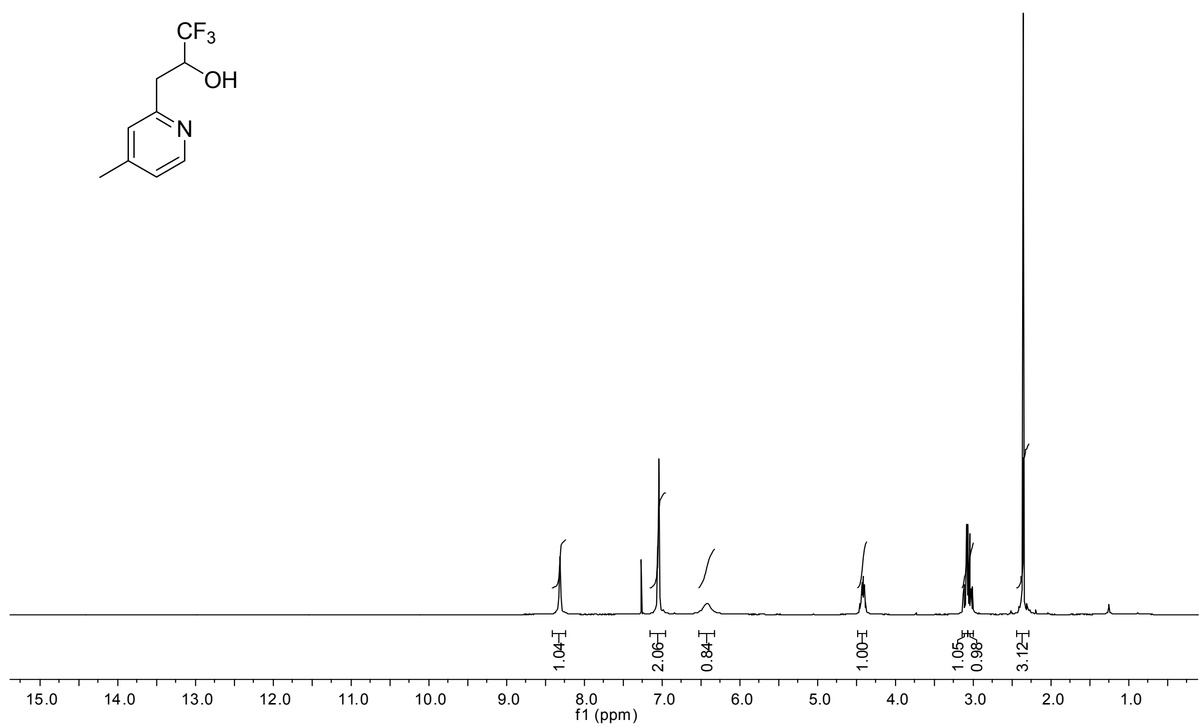


rac-**10** (^{1}H):



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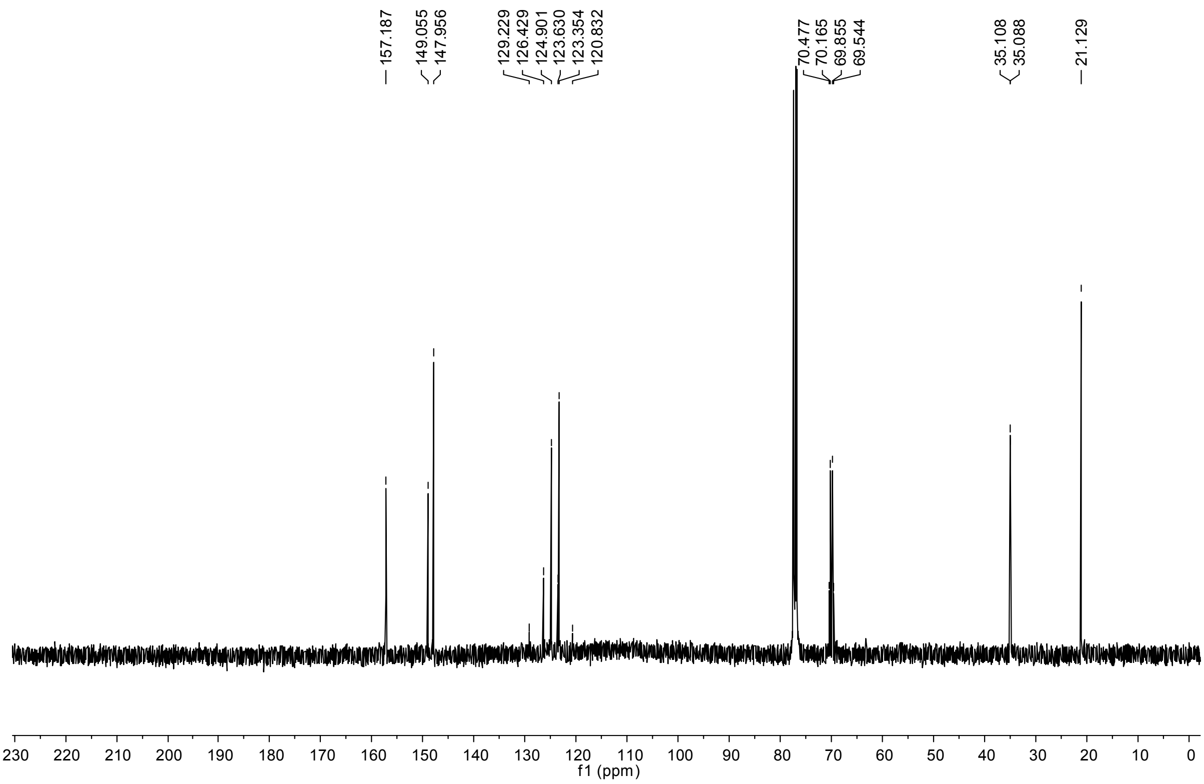
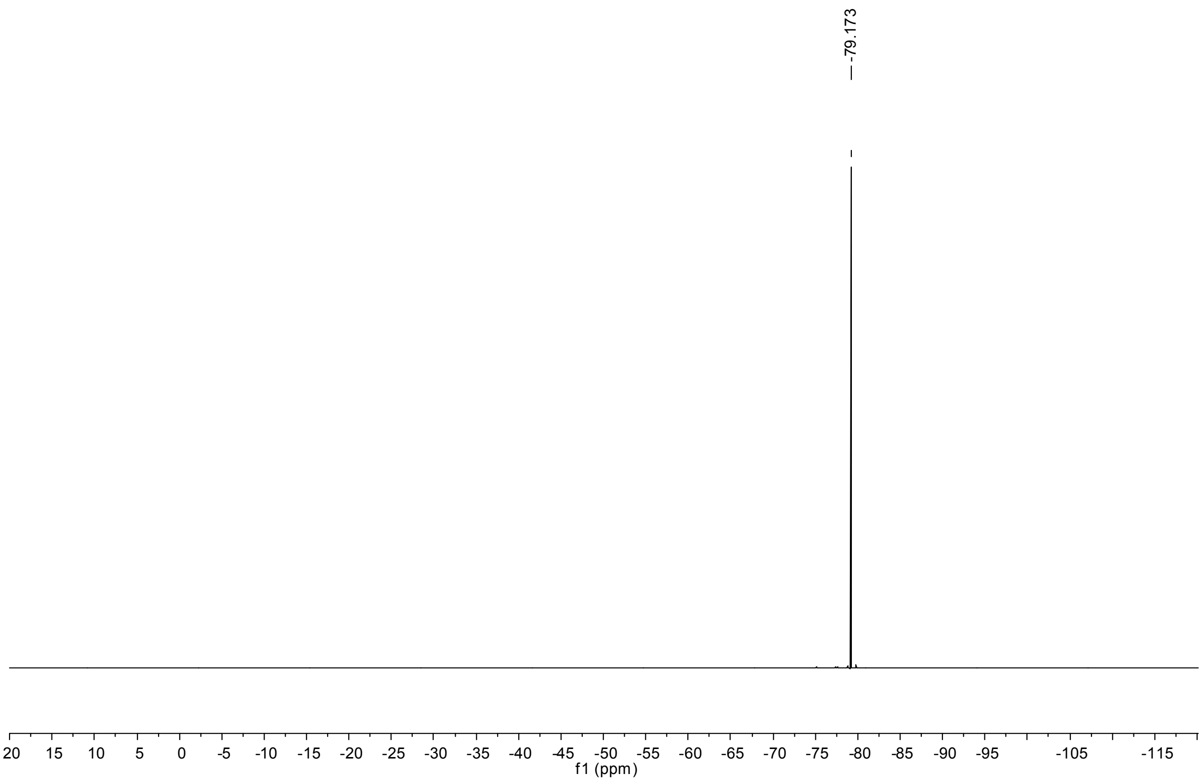
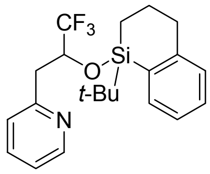
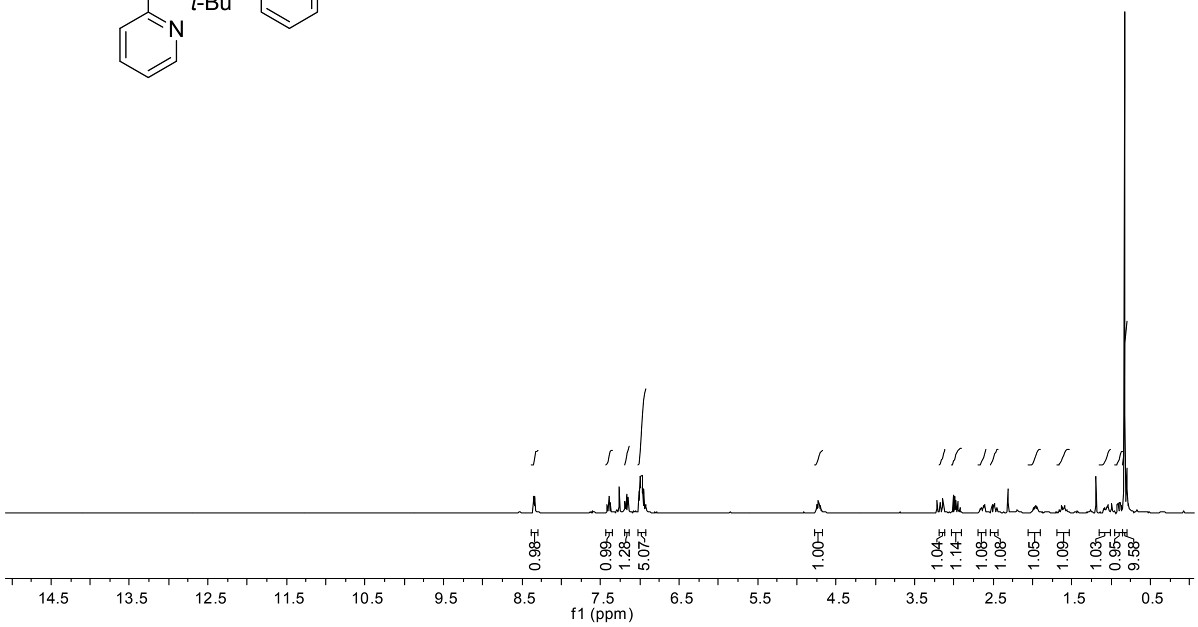


rac-**10** (^{19}F):

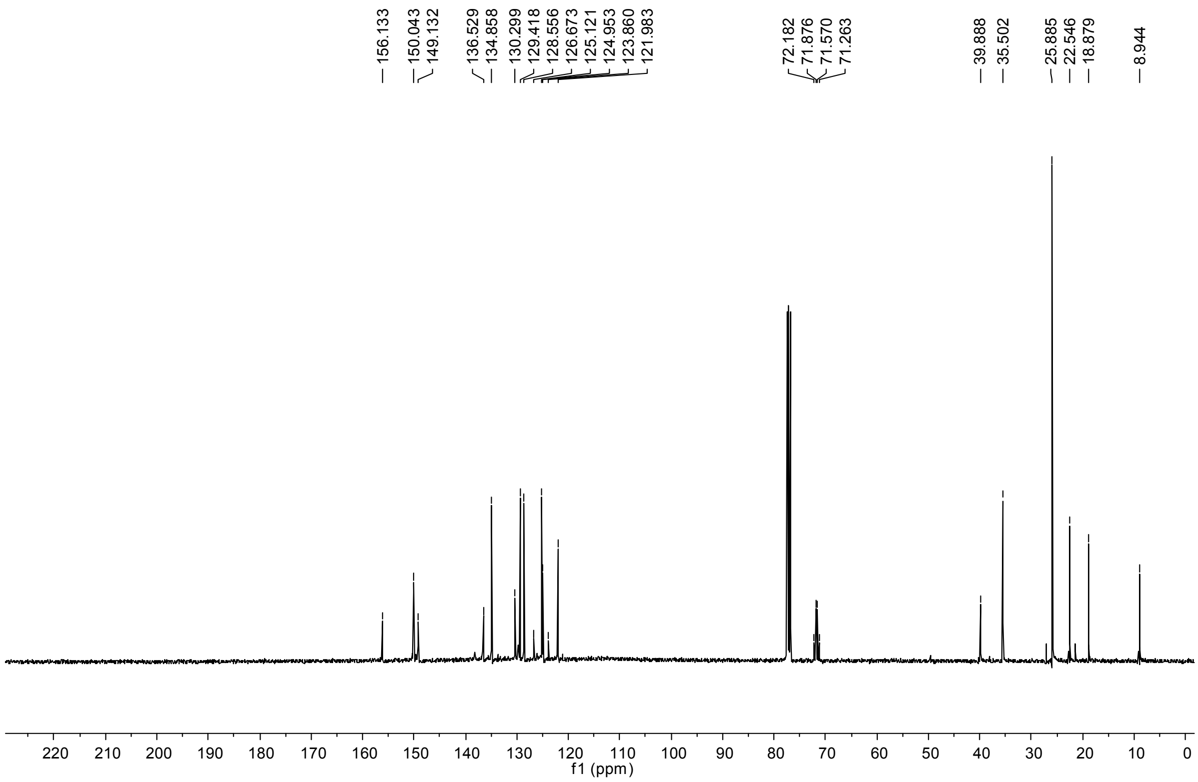


(^{Si}*R**,*R**)-**11** (^{1}H):

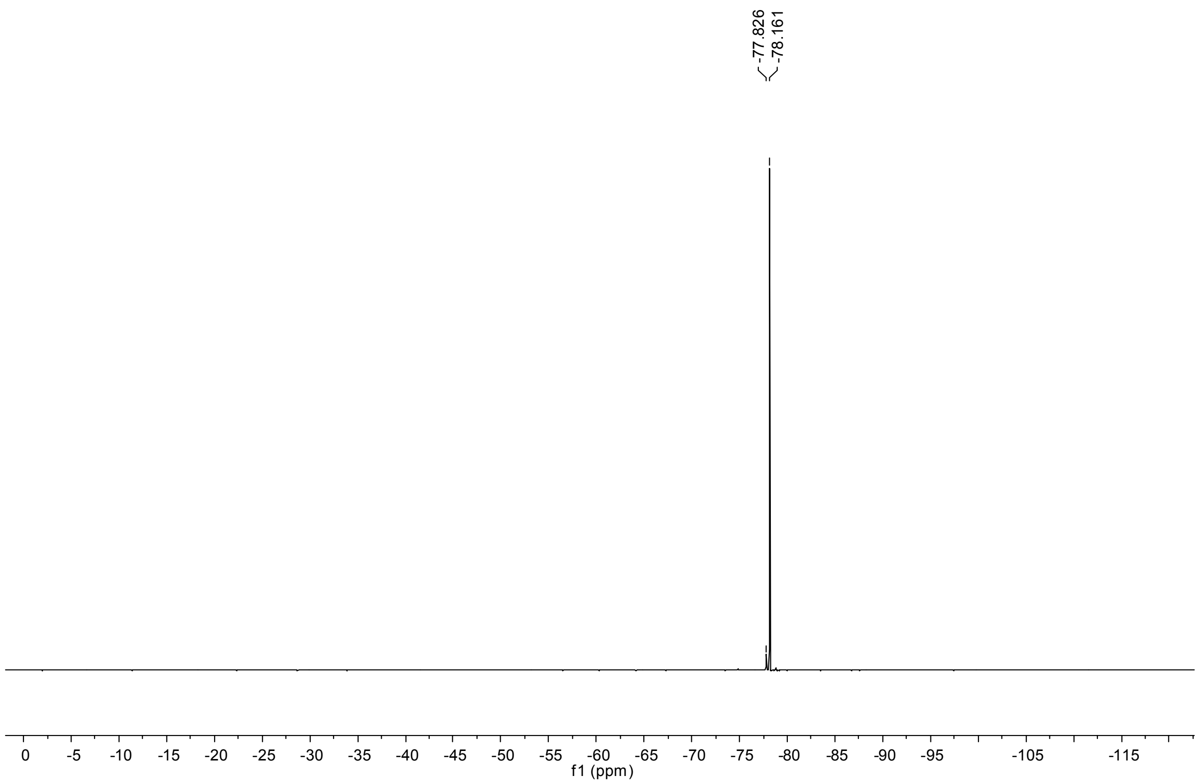




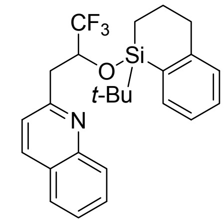
(^{Si}*R**,*R**)-**11** (^{13}C):

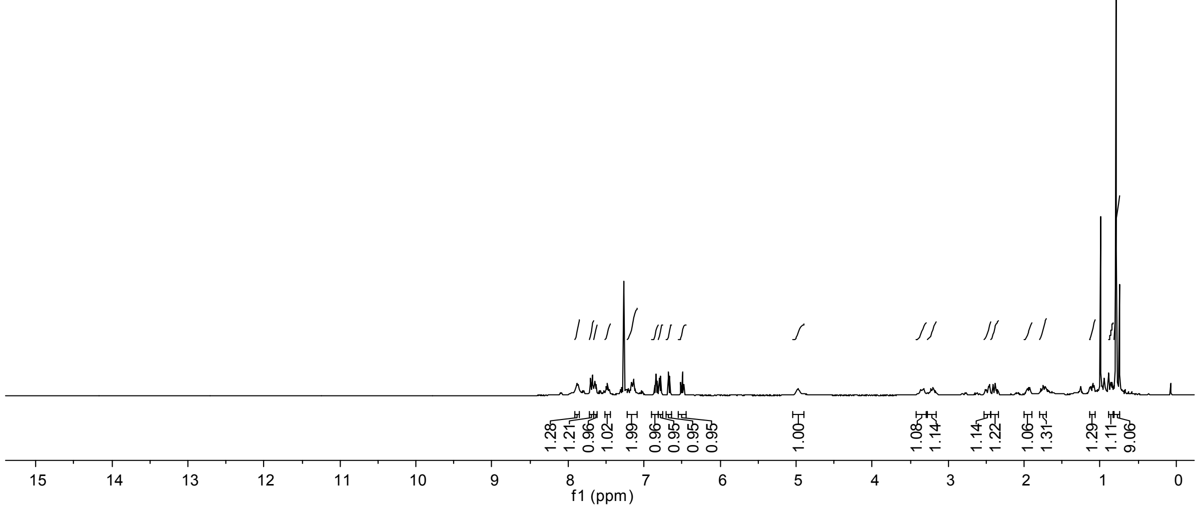


(^{Si}*R**,*R**)-**11** (^{19}F):



($^{Si}R^*$,R^*)-**12** (^{1}H):





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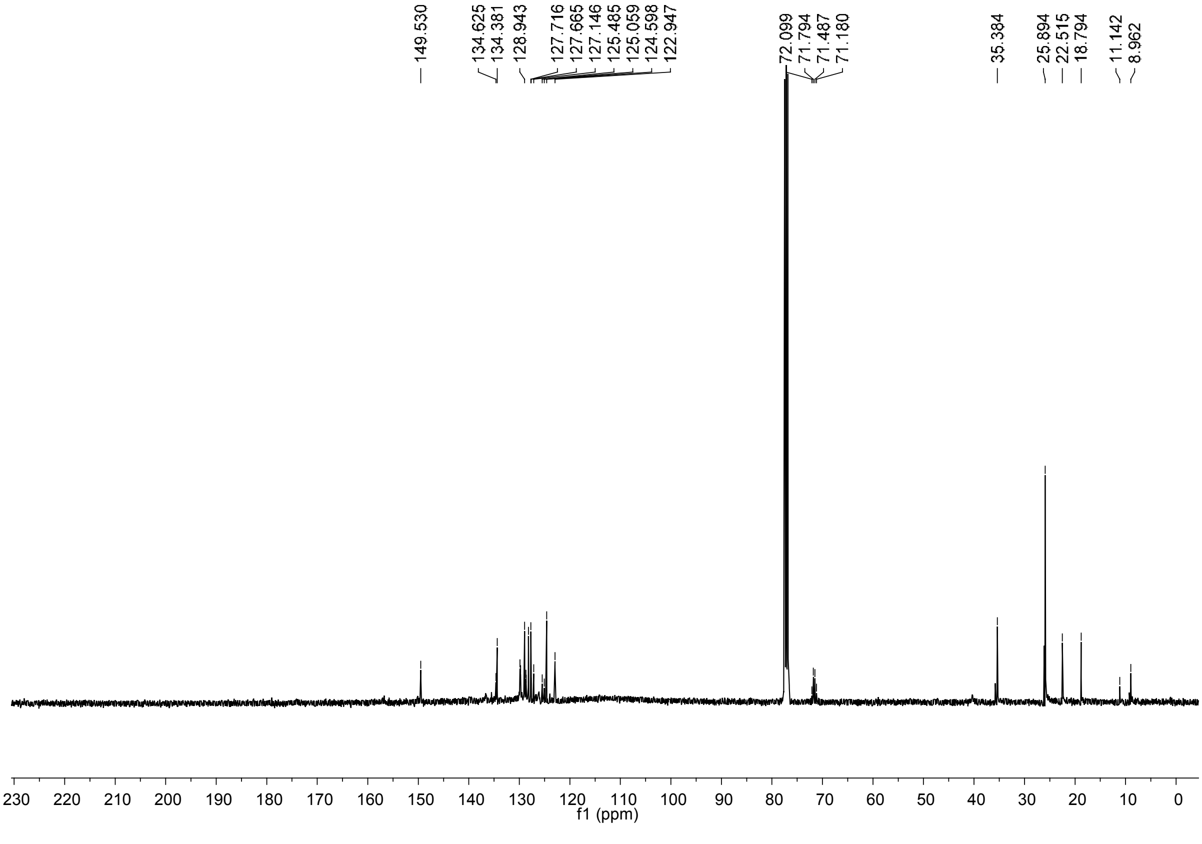
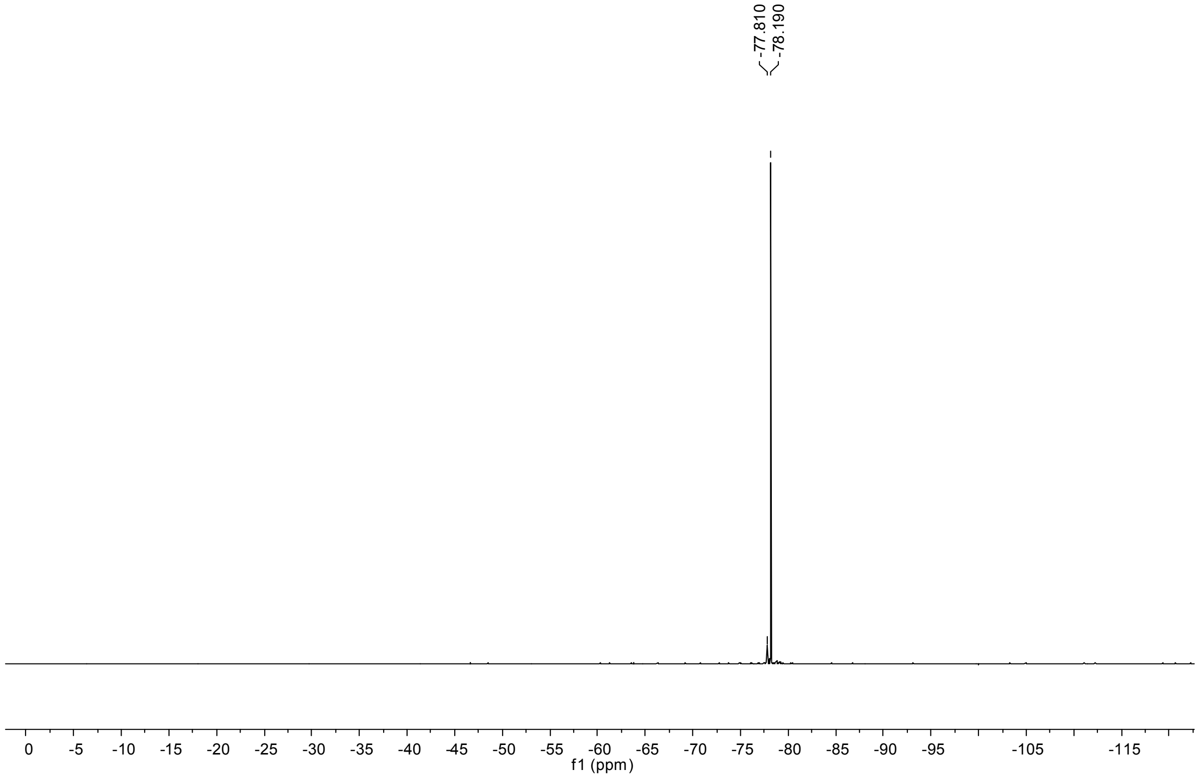
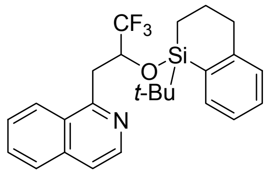
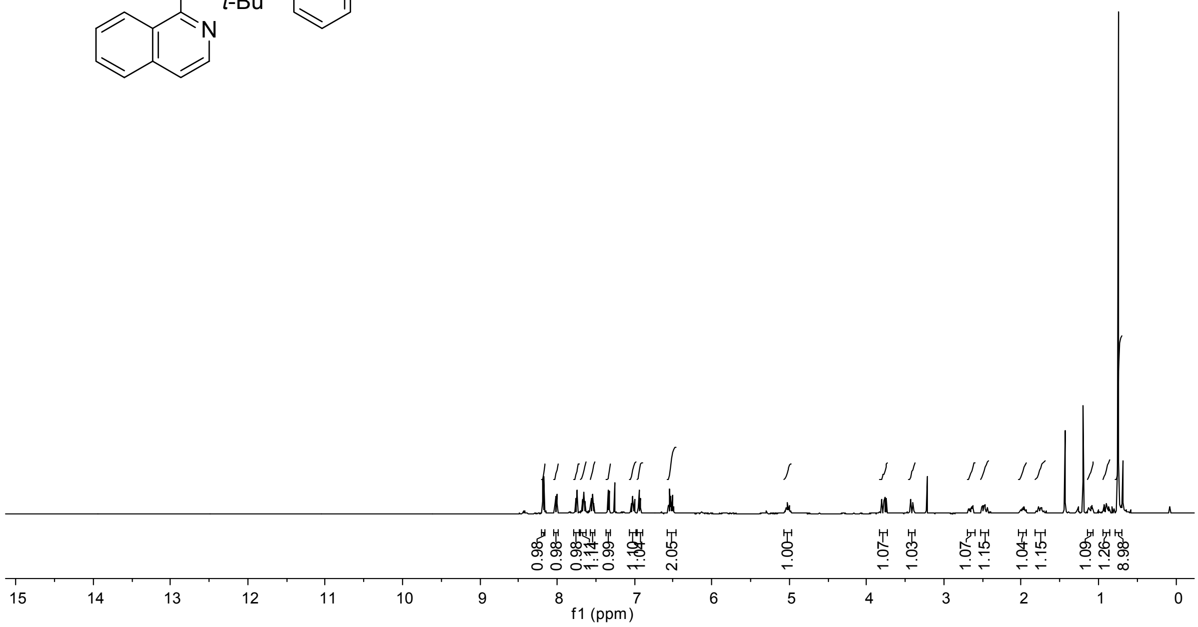


(^{Si}*R**,*R**)-**12** (^{19}F):

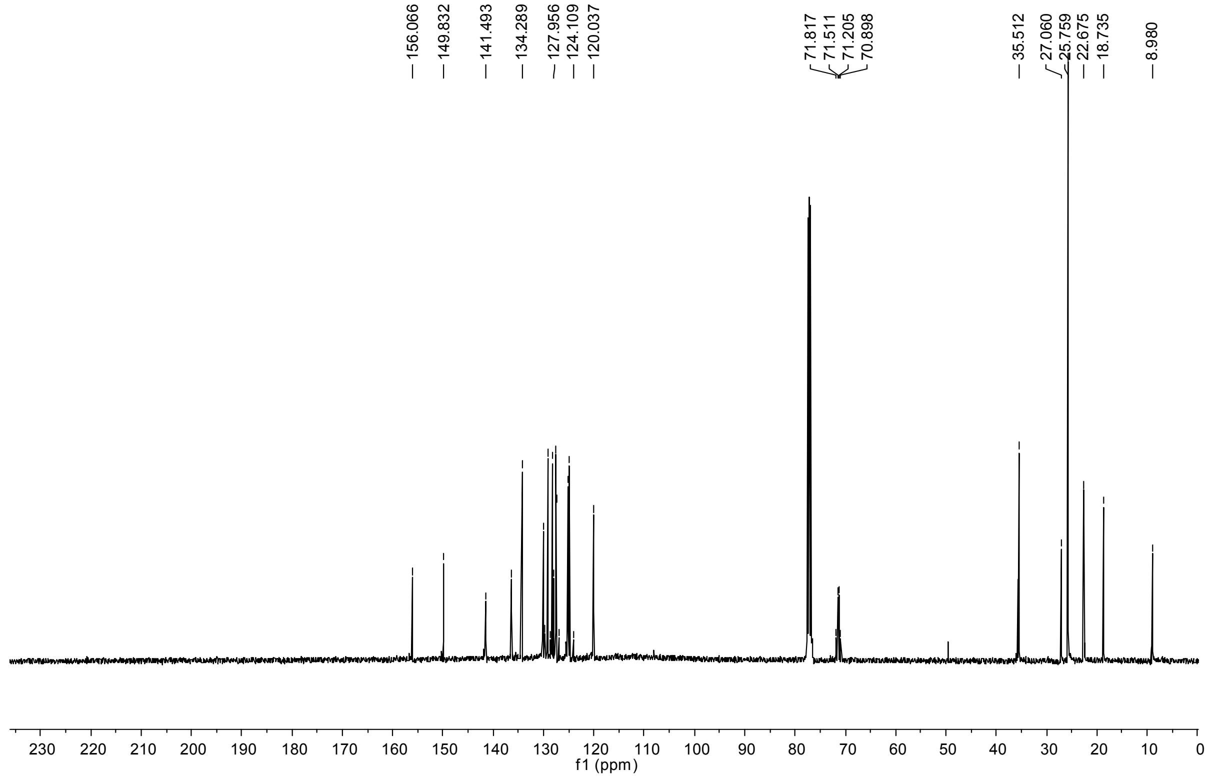


(^{Si}*R**,*R**)-**13** (^{1}H):

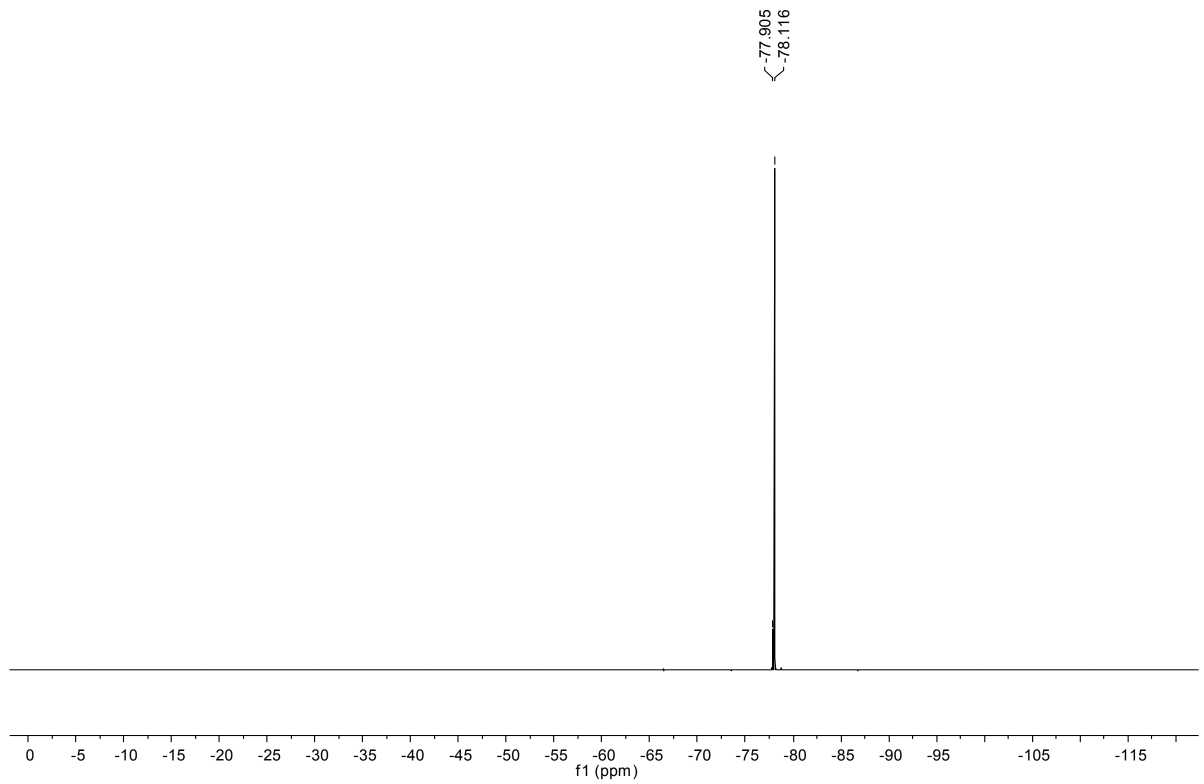




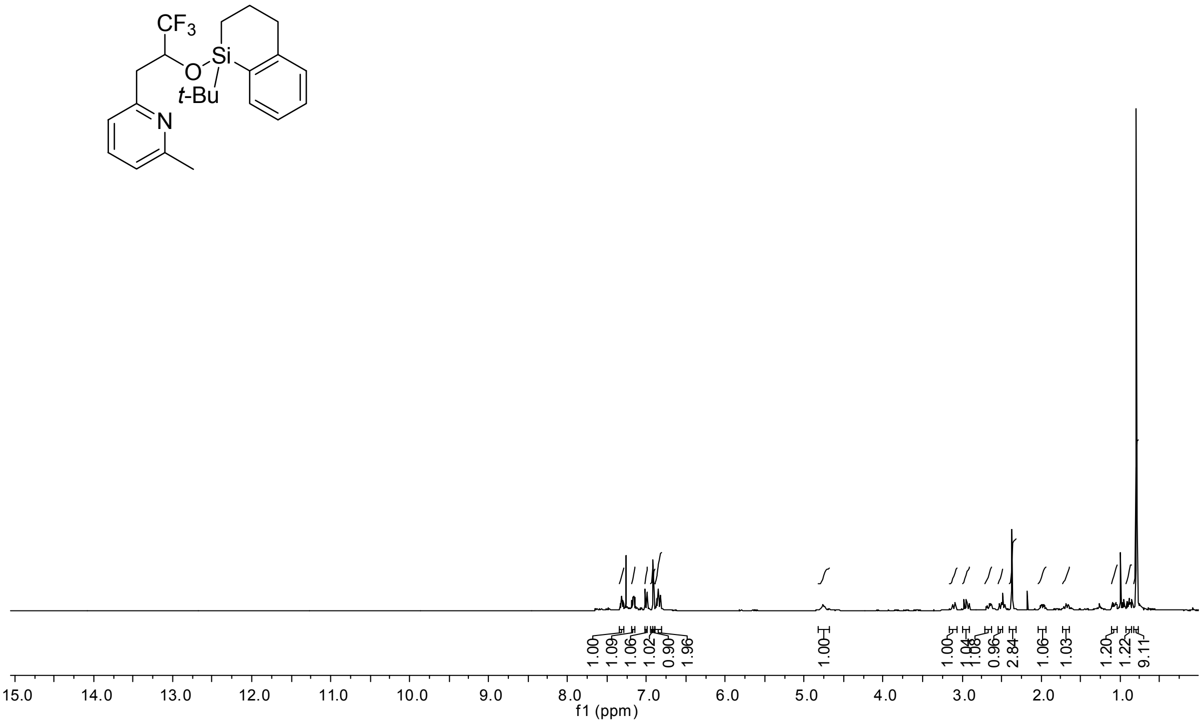
(${}^{Si}R^*,R^*$)-**13** (^{13}C):



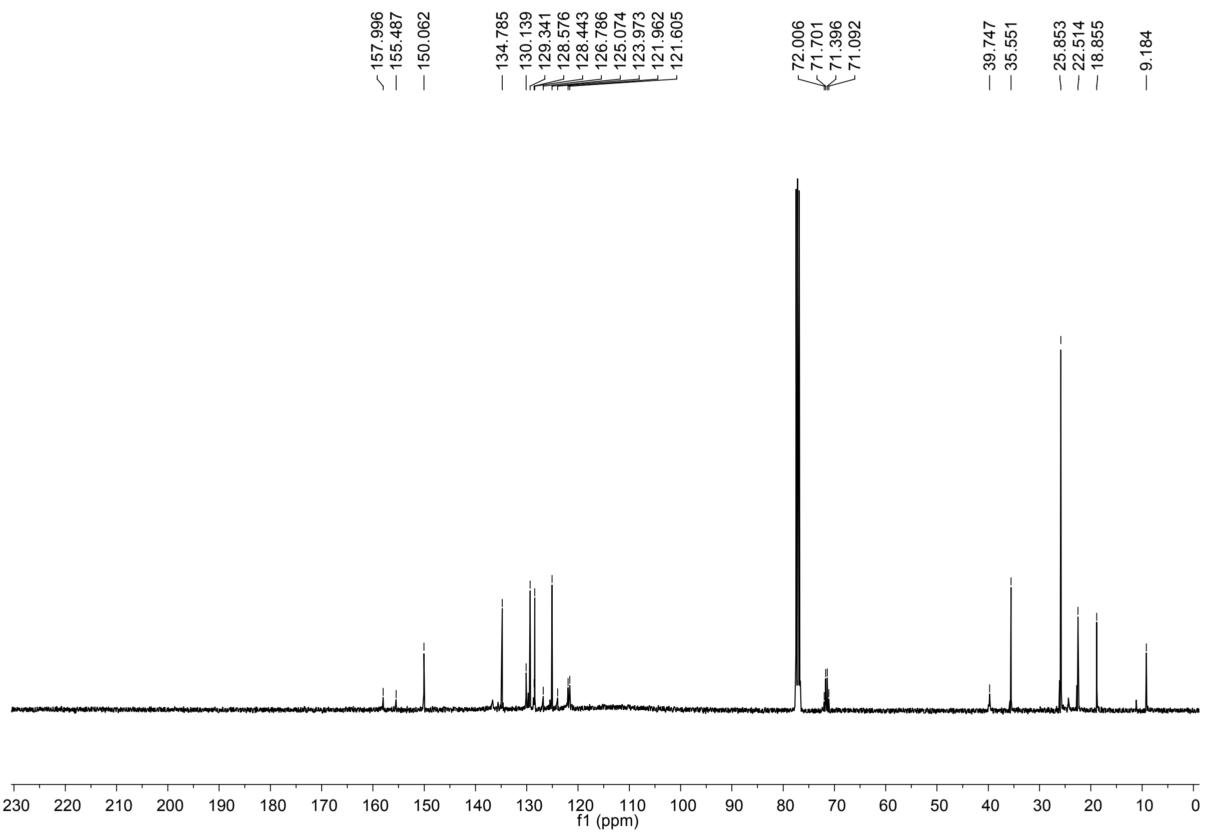
(${}^{Si}R^*,R^*$)-**13** (^{19}F):



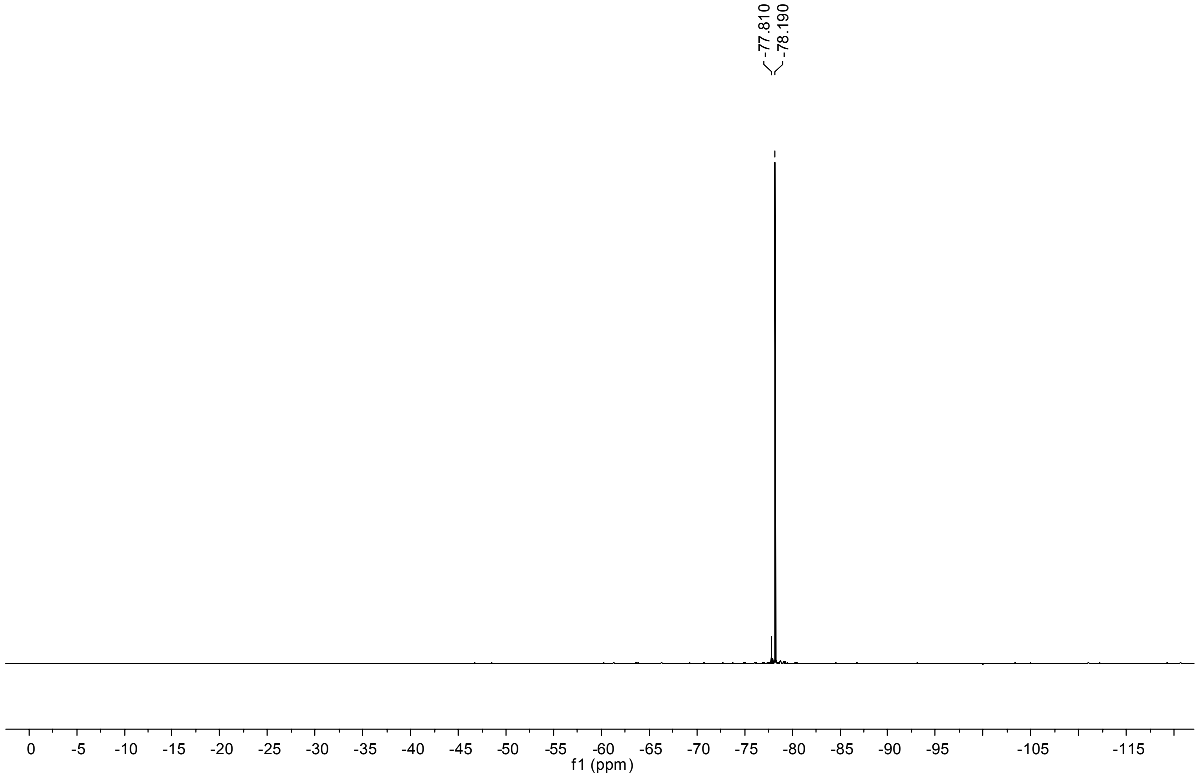
(^{Si}*R**,*R**)-**14** (^{1}H):



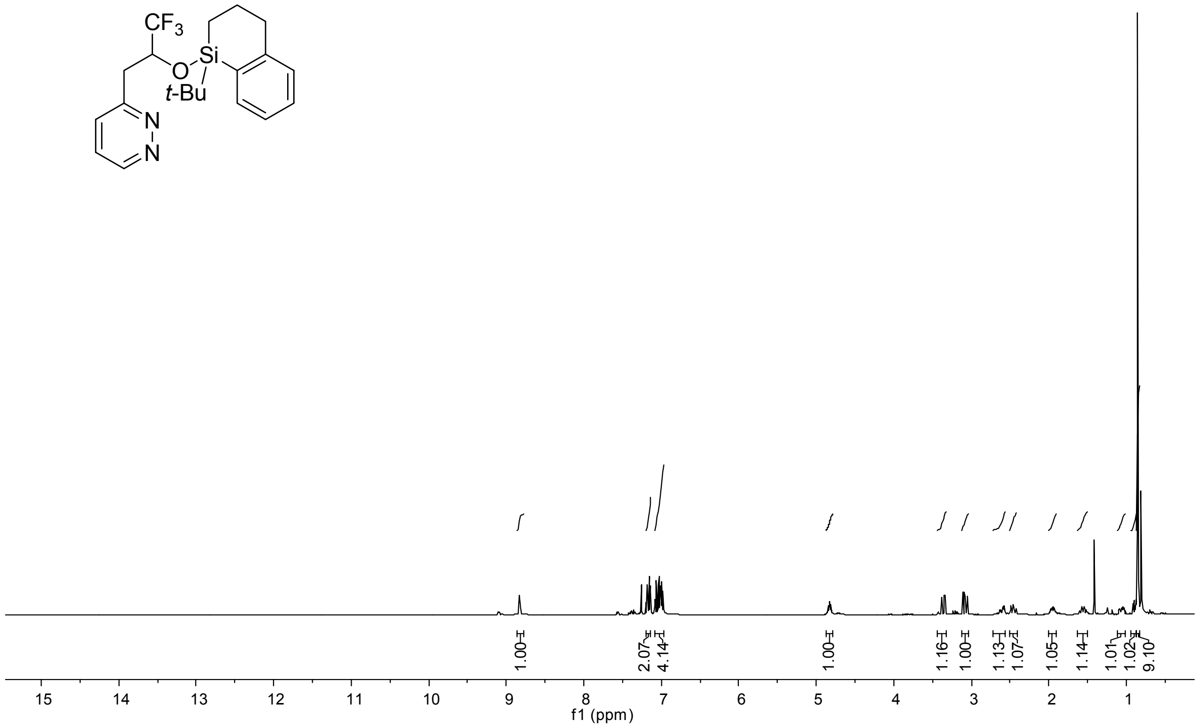
(^{Si}*R**,*R**)-**14** (^{13}C):



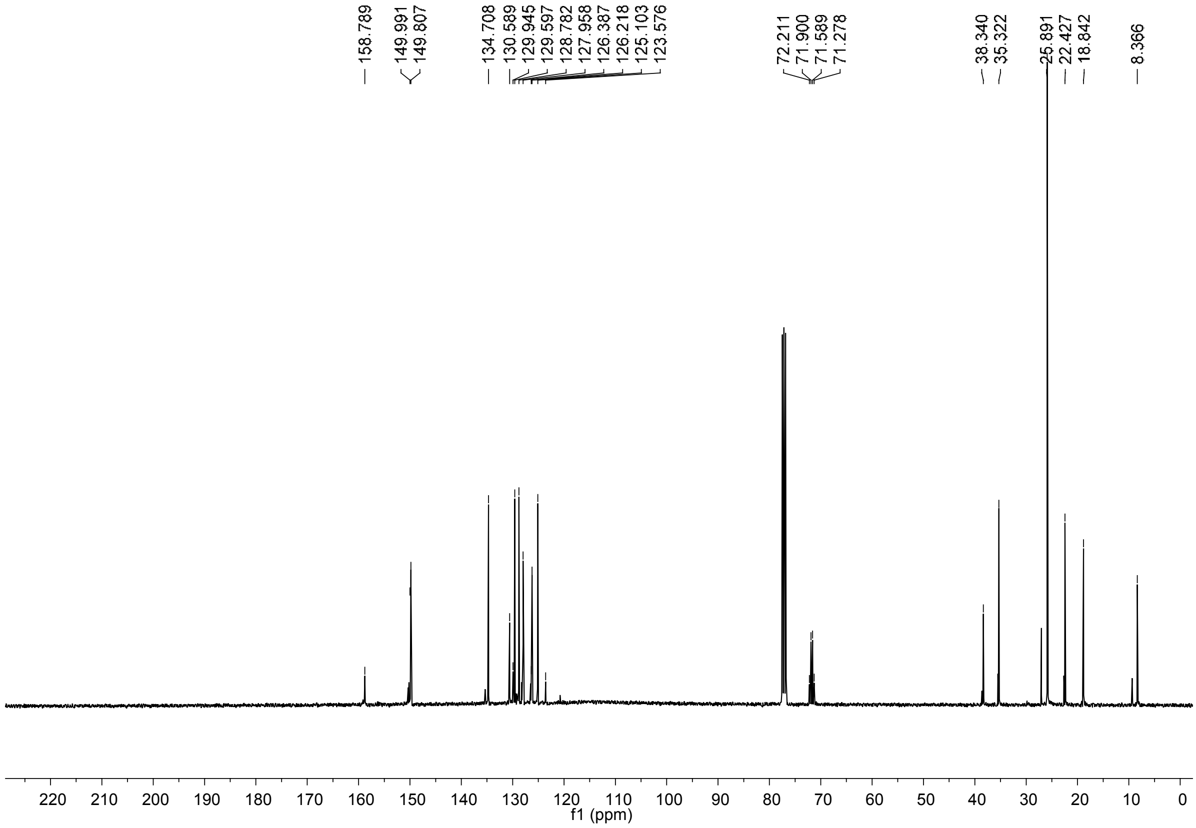
(^{Si}*R**,*R**)-**14** (^{19}F):



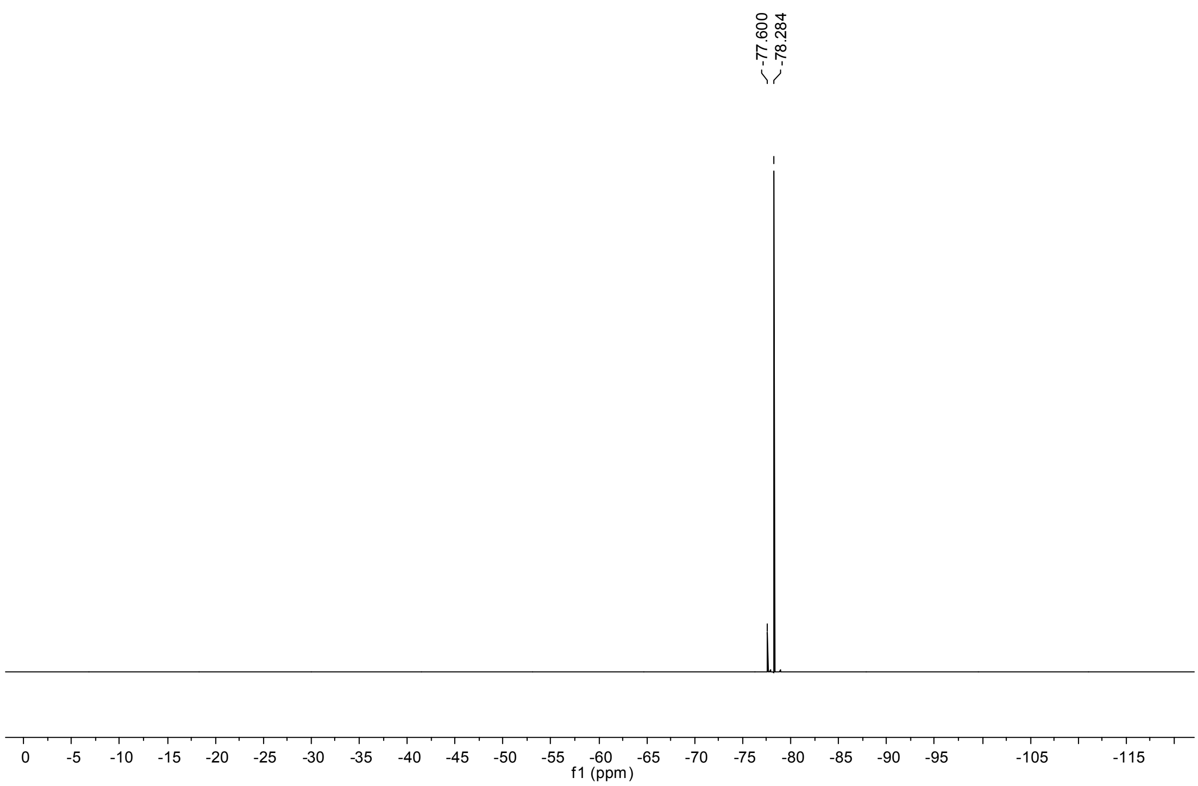
(^{Si}*R**,*R**)-**15** (^{1}H):



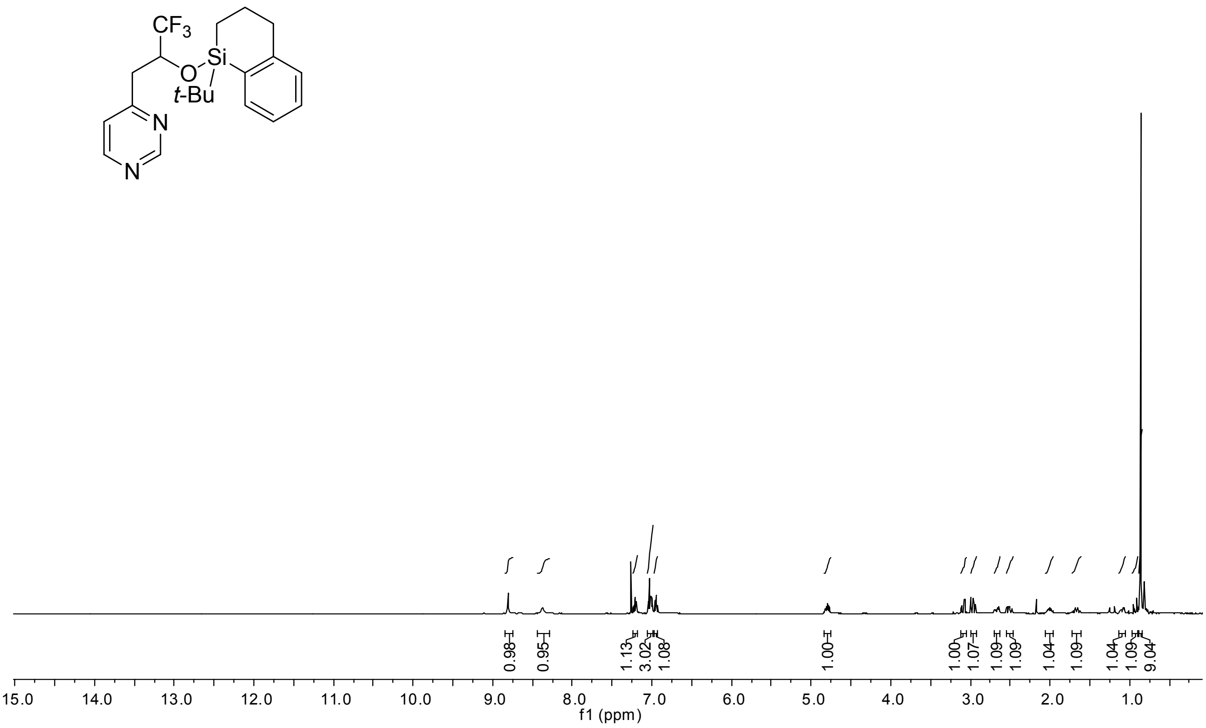
(^{Si}R*,R*)-**15** (^{13}C):



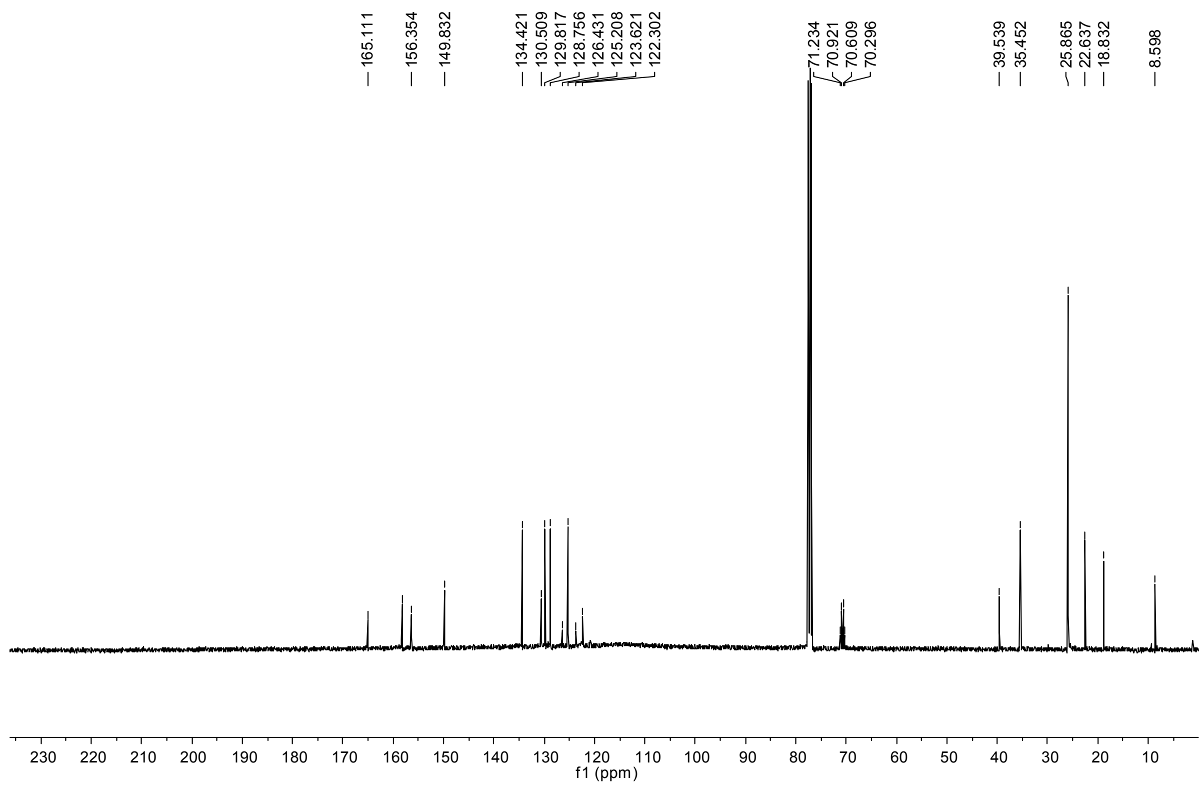
(^{Si}R*,R*)-**15** (^{19}F):



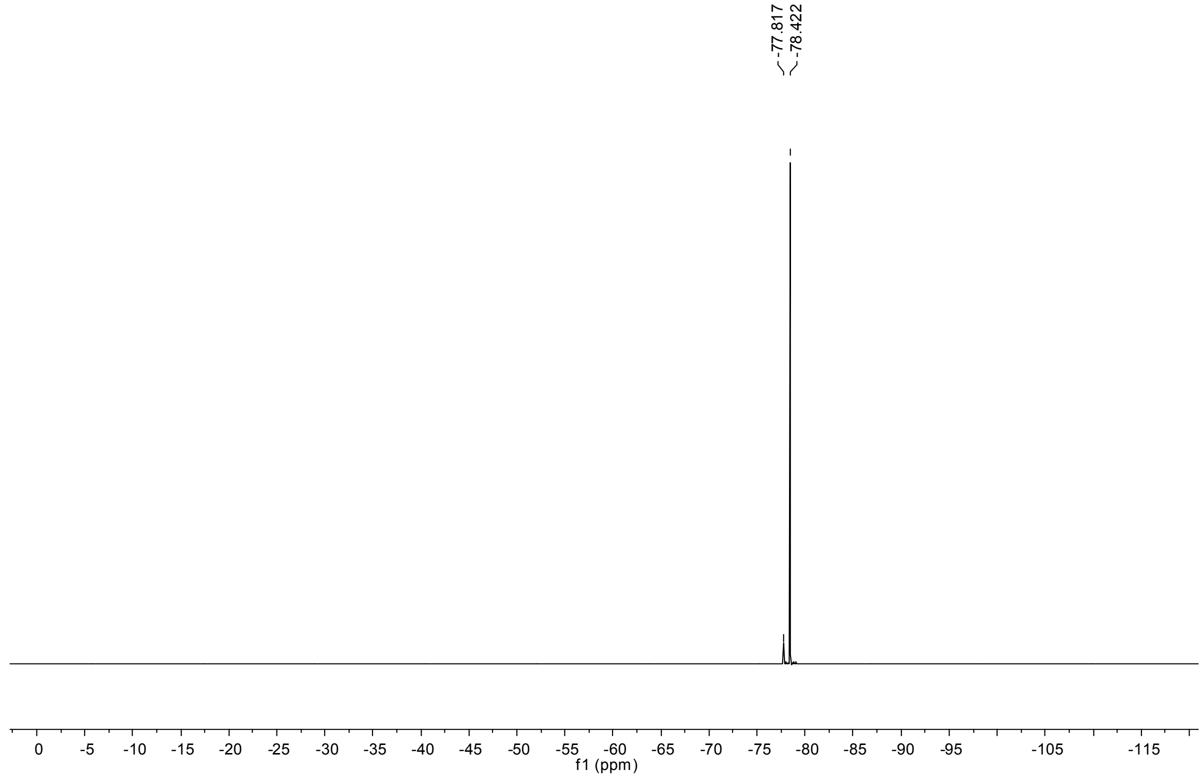
(^{Si}*R**,*R**)-**16** (^{1}H):



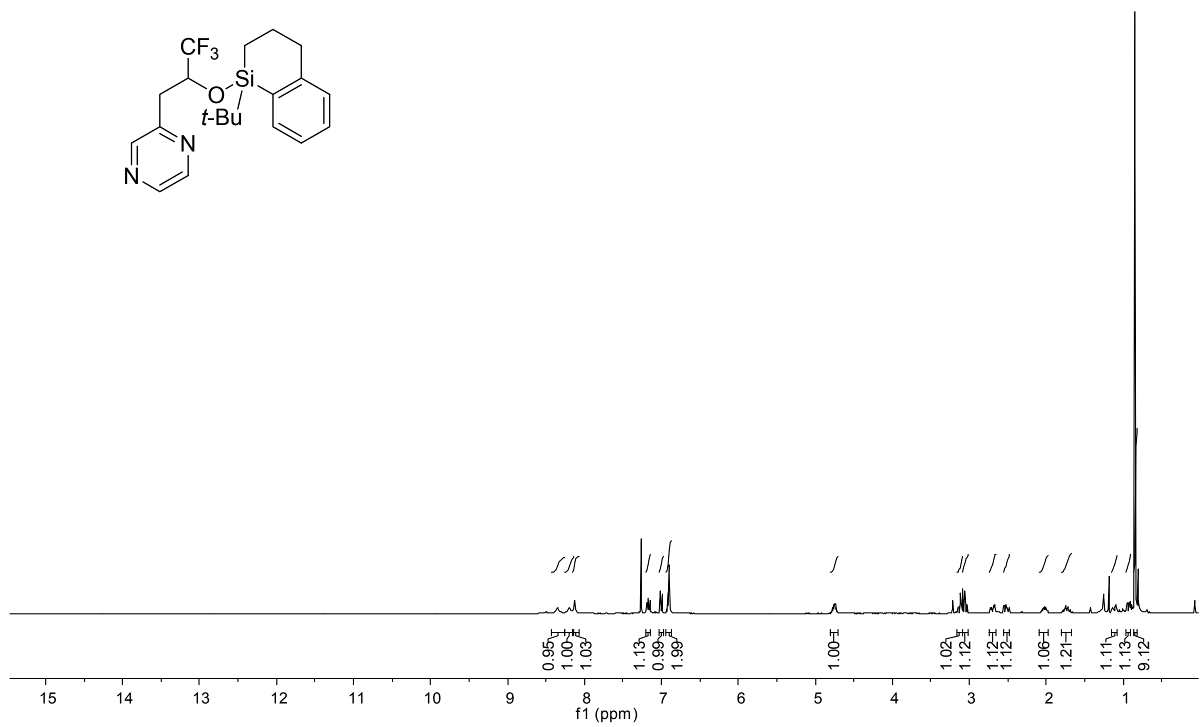
(^{Si}*R**,*R**)-**16** (^{13}C):



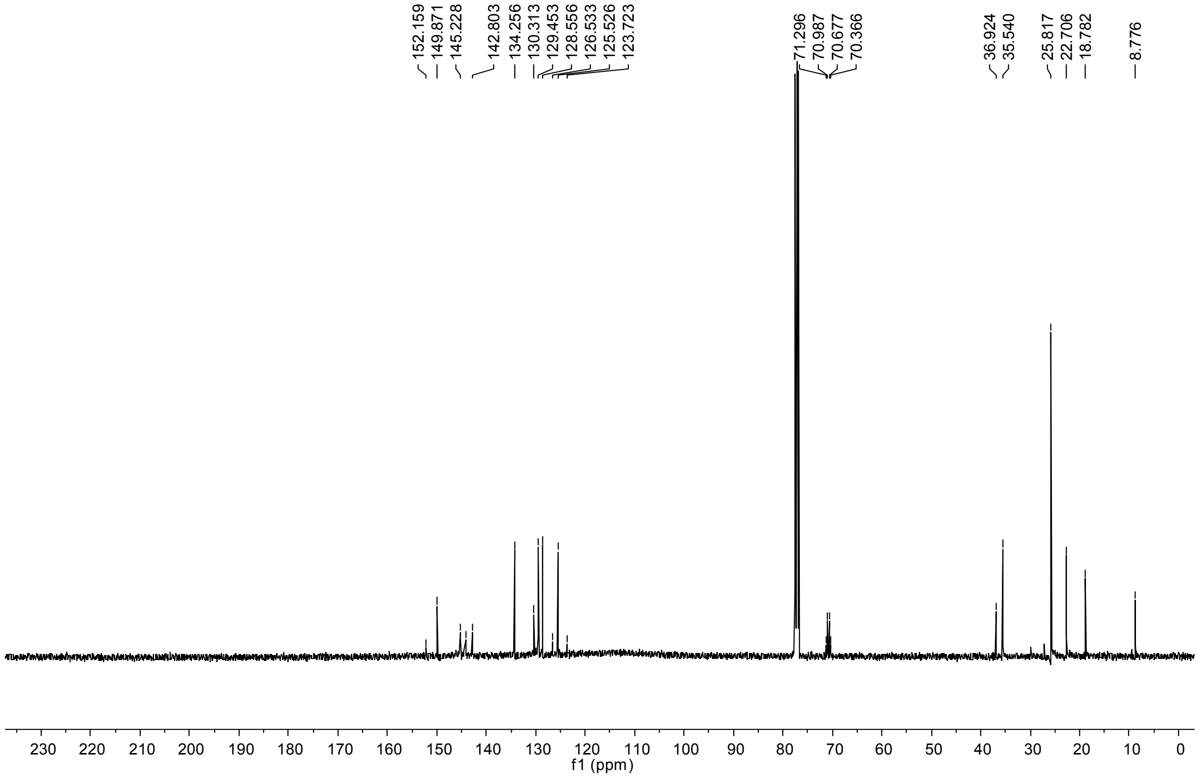
(^{Si}*R**,*R**)-**16** (^{19}F):



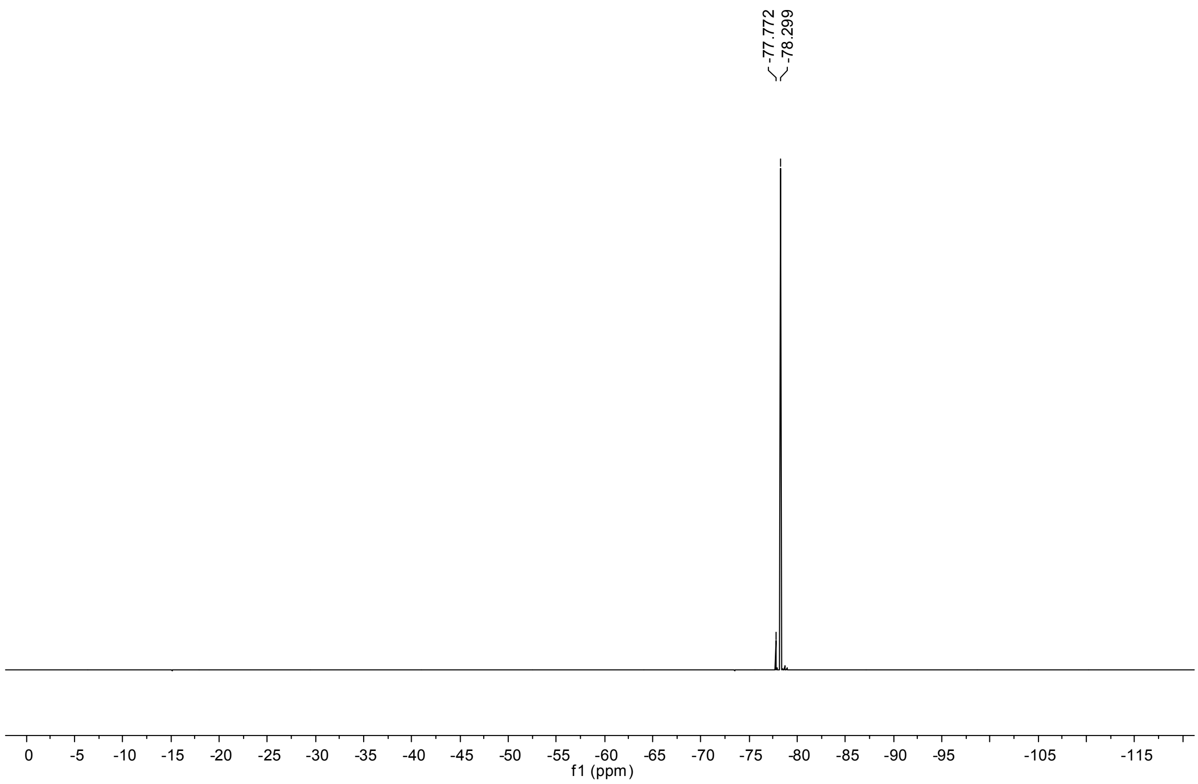
(^{Si}*R**,*R**)-**17** (^{1}H):



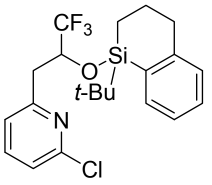
(^{Si}*R**,*R**)-**17** (^{13}C):

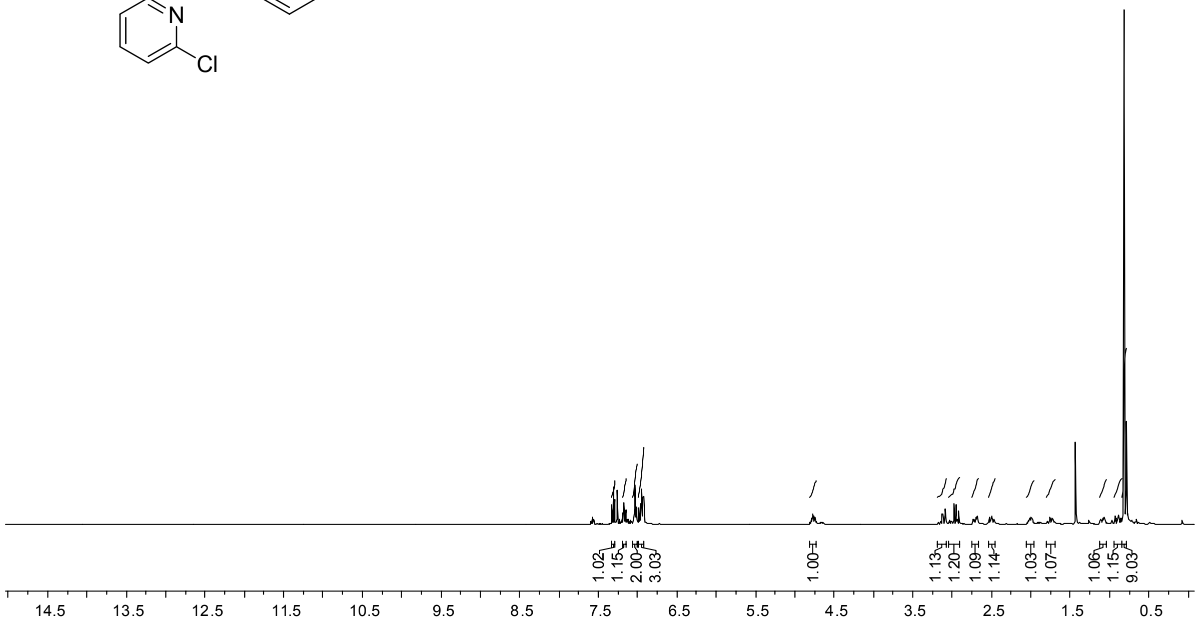


(^{Si}*R**,*R**)-**17** (^{19}F):

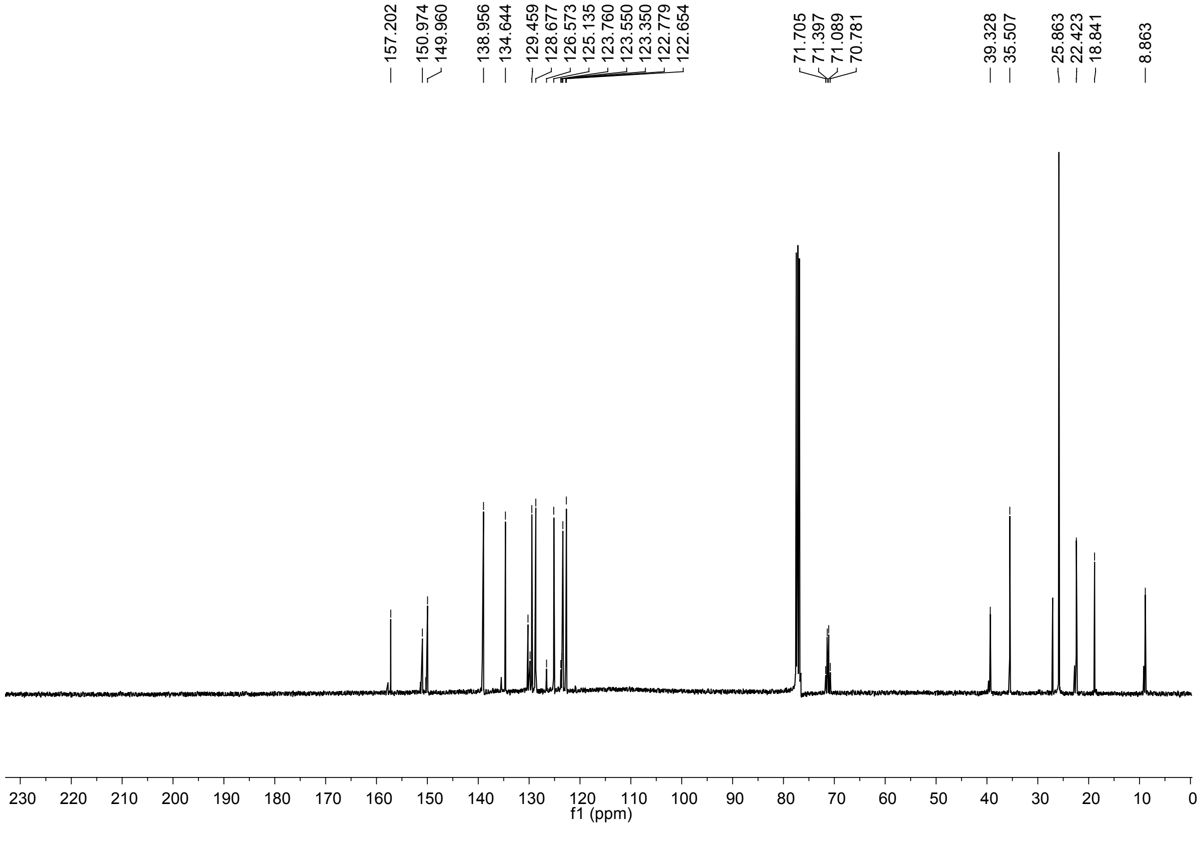


(^{Si}R*,R*)-**18** (^{1}H):

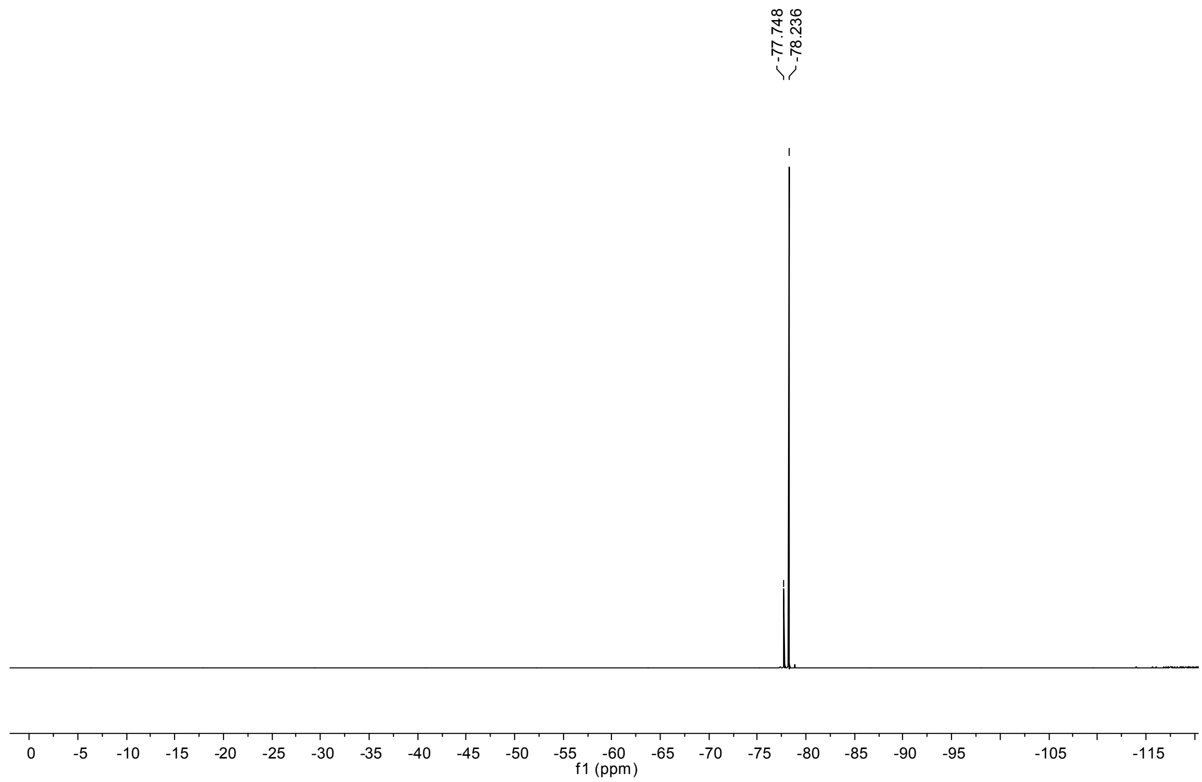




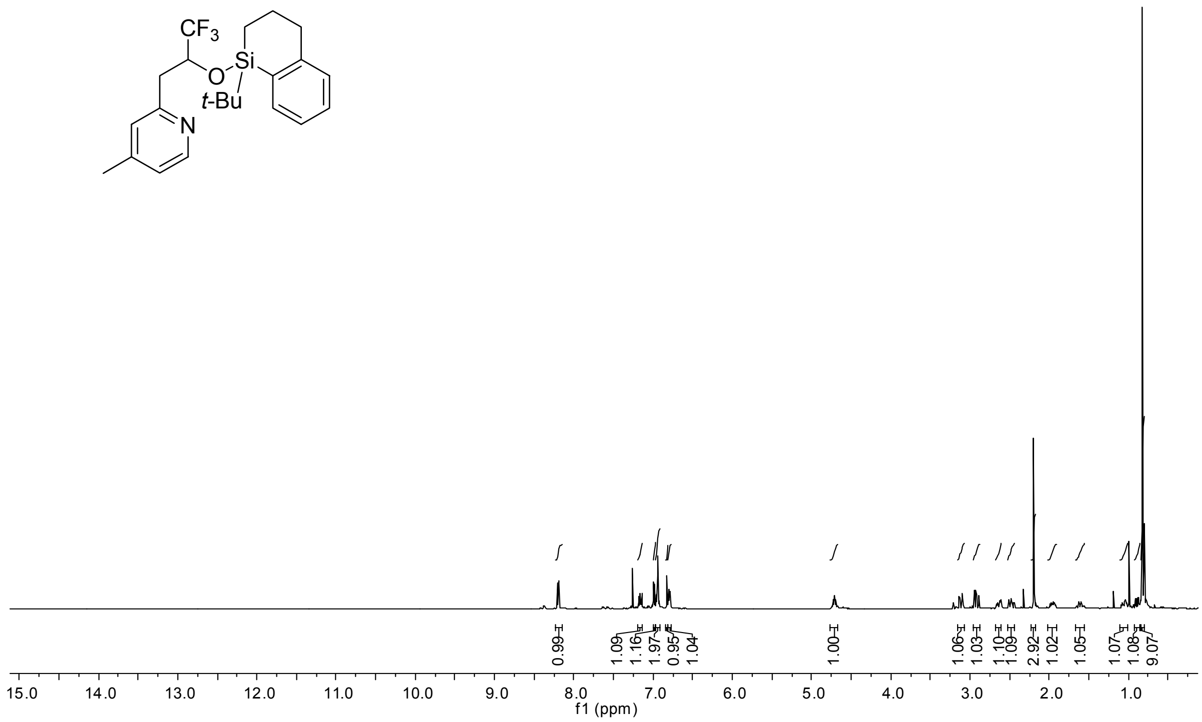
(^{Si}R*,R*)-**18** (^{13}C):



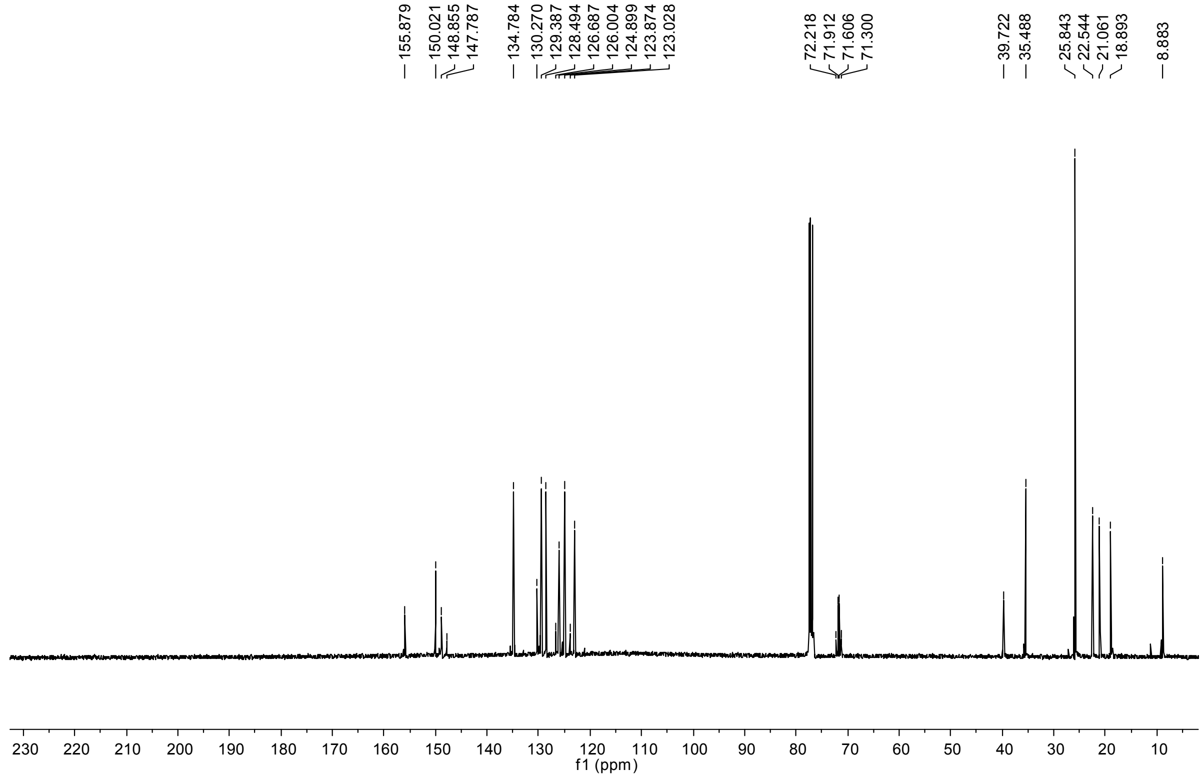
(^{Si}*R**,*R**)-**18** (^{19}F):



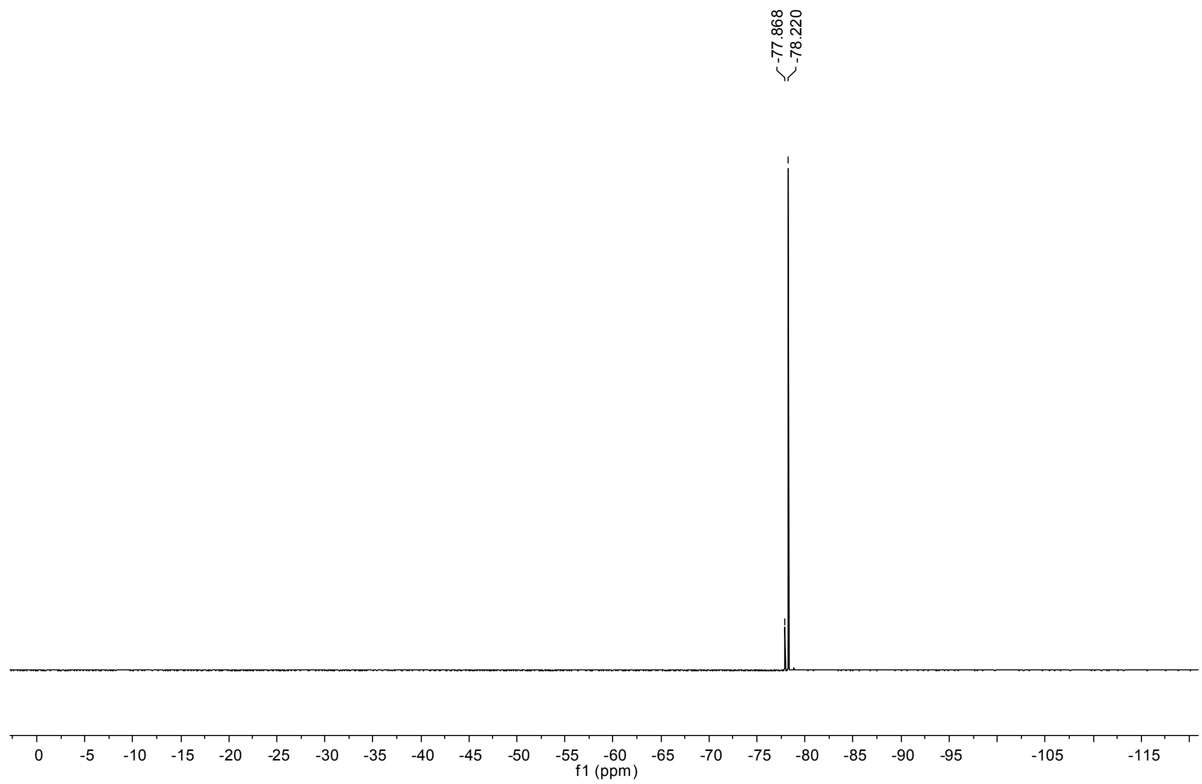
(^{Si}*R**,*R**)-**19** (^{1}H):



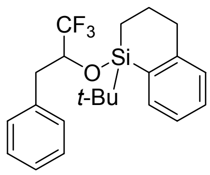
(^{Si}R*,R*)-**19** (^{13}C):

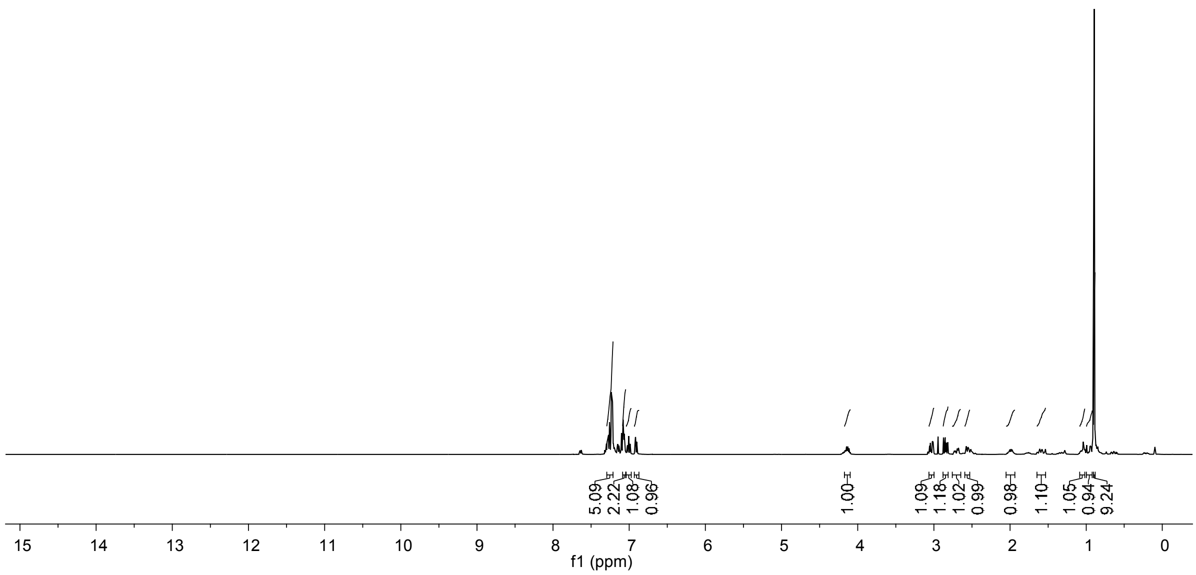


(^{Si}R*,R*)-**19** (^{19}F):

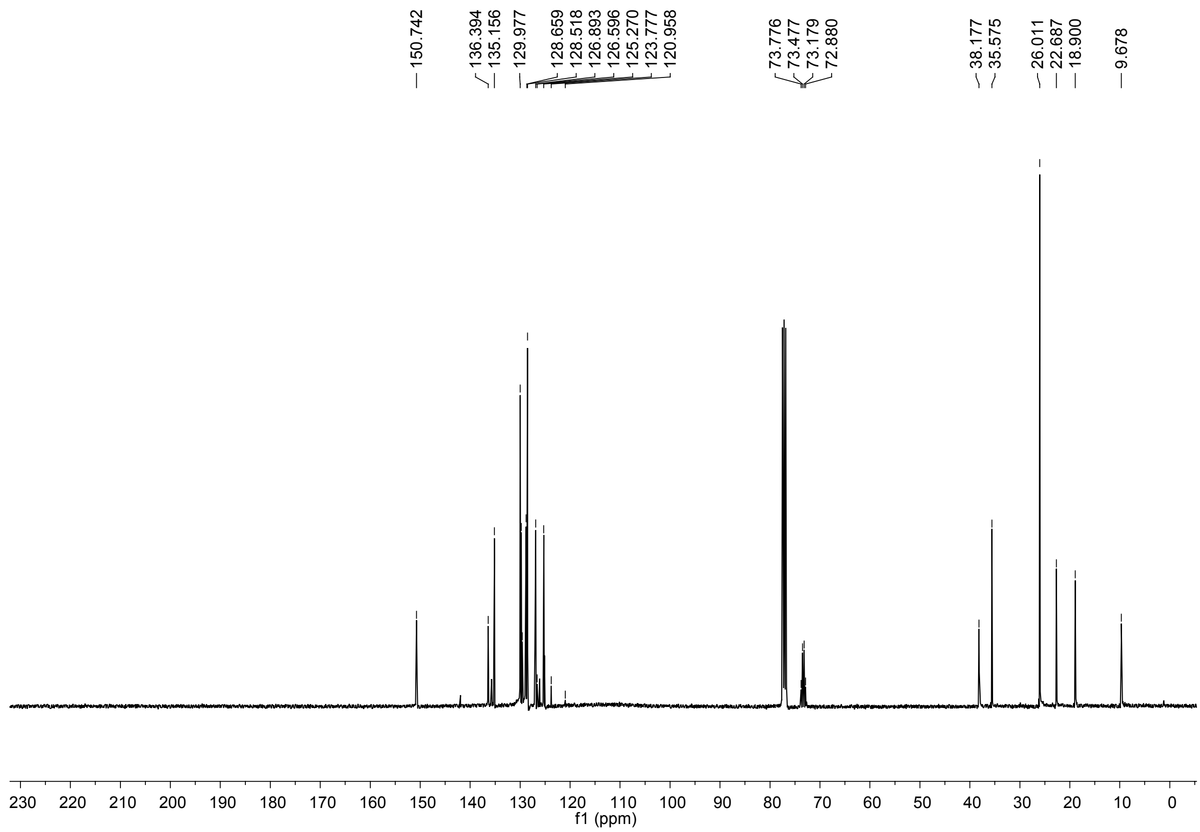


($^{Si}R^*,R^*$)-**21** (^{1}H):

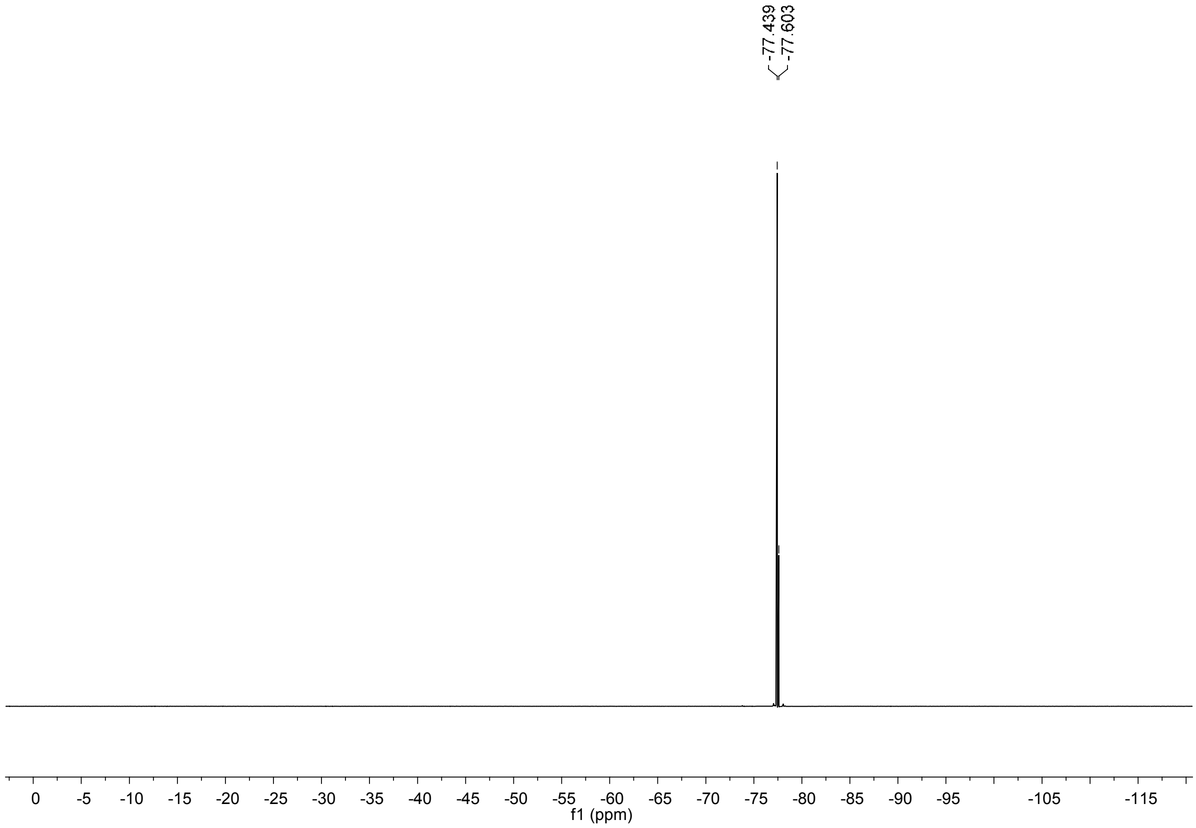




($^{Si}R^*,R^*$)-**21** (^{13}C):



(^{Si}*R**,*R**)-**21** (^{19}F):



-77.439
-77.603
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
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-75
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-90
-95
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-115
f1 (ppm)