Supporting Information

for

Synthesis of D-fructose derived spirocyclic 2-substituted-2-oxazoline ribosides

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Detailed experimental procedures, compound characterization, copies of ^{1}H, ^{13}C NMR spectra of all new compounds, NOESY spectra of 11a, 17a and HRMS spectra of all new compounds

EXPERIMENTAL SECTION

General Methods. All reagents were purchased from commercial sources and were used without further purification unless otherwise stated. Reactions were carried out with distilled and dried solvents using oven-dried glassware. ^{1}H NMR and ^{13}C NMR were recorded in $CDCl_3$ using TMS as internal standard on 400 and 100 MHz spectrometer respectively. Coupling constants (*J*) are reported in Hertz (Hz). In ^{1}H NMR spectra signal multiplicity is abbreviated as s = singlet, d = doublet, dd = doublet of doublet, dt = doublet of triplet, td = triplet of doublet, qd, quartet of doublet, t = triplet, q = quartet, m = multiplet, br = broad. IR spectra were recorded on a FT-IR spectrometer, and only major peaks were reported in cm^{-1}. Optical rotations were measured on a polarimeter using sodium light (D line 589 nm). High resolution mass spectroscopy (HRMS) were obtained by the ESI (TOF) ionization sources.

1,2:3,4-Di-O-isopropylidene-β-D-psicofuranose (***2a***). Thick liquid: $[\alpha]_D^{25}$ = -80.3 (*c* 1.02, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.90 (dd, *J* = 5.9, 0.8 Hz, 1H), 4.63 (d, *J* = 5.9 Hz, 1H), 4.32 (d, *J* = 9.7 Hz, 1H), 4.28 (t, *J* = 2.8 Hz, 1H), 4.06 (d, *J* = 5.9 Hz, 1H), 3.74 (dt, *J* = 12.6, 2.8 Hz, 1H), 3.67 – 3.59 (m, 1H), 3.20 (dd, *J* = 10.5, 3.0 Hz, 1H), 1.49 (s, 3H), 1.43 (s, 3H), 1.39 (s, 3H), 1.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 113.5, 112.4, 111.8, 86.9, 85.9, 81.7, 70.0, 64.0, 26.6, 26.4, 26.2; 24.9; IR ($CHCl_3$) *ν* 3495, 2988, 1376, 1205, 1015, 852 cm^{-1}; HRMS (TOF): $[M.+ Na]^+$ calcd for $C_{12}H_{20}NaO_6$ 283.1158, found 283.1159.

1,2:3,4-di-O-isopropylidene-6-O-benzyl-β-D-psicofuranose (***3a***). To a stirring solution of **2a** (2 g, 7.6 mmol) in DMF at 0 °C, NaH (0.4 g, 10.0 mmol) was added under N_2 atmosphere and stirred for 10 min. To this, benzyl bromide (1 mL, 8.4 mmol) was added drop-wise. The resulting mixture was slowly allowed to warm to room temperature and stirred overnight. After completion of starting material saturated aq. $NaHCO_3$ is added and extracted with EtOAc. The combined organic layers were washed with water, brine, dried over Na_2SO_4 filtered and concentrated *in vacuo*. Purification of the crude product by column chromatography using petroleum ether/EtOAC gave the title compound **3a**. Thick liquid; R_f = 0.5 (petroleum ether/EtOAC, 85:15); Yield: (2.4 g, 92%); $[\alpha]_D^{25}$ = -65.6 (*c* 0.67, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.25 (m, 5H,), 4.76 (d, *J* = 5.9 Hz, 1H), 4.61 (d, *J* = 5.7 Hz, 1H), 4.57 (d, *J* = 4.9 Hz, 2H), 4.34-4.27 (m, 2H), 4.06 (d, *J* = 9.6 Hz, 1H), 3.62 – 3.50 (m, 2H), 1.45 (s, 3H), 1.44 (s, 3H), 1.38 (s, 3H), 1.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.1, 128.4, 127.6, 113.5, 112.6, 111.5, 85.1, 83.9, 82.5, 73.3, 70.9, 69.8, 26.6, 26.5, 26.4, 25.2; IR ($CHCl_3$) *ν* 3495, 2988, 1376, 1205, 1015, 852 cm^{-1}; HRMS (TOF): $[M.+ Na]^+$ calcd for $C_{19}H_{26}NaO_6$ 373.1627, found 373.1631.

6-Azido-6-deoxy-1,2;3,4-di-O-isopropylidene-β-D-psicofuranose (***4a***). Thick liquid: $[\alpha]_D^{25}$ = -53.0 (*c* 1.06, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.63 (dd, *J* = 5.9, 1.0 Hz, 1H), 4.59 (d, *J* = 5.8 Hz, 1H), 4.30 (d, *J* = 9.7 Hz, 1H), 4.21 – 4.15 (m, 1H), 4.04 (d, *J* = 9.9 Hz, 1H), 3.51 (dd, *J* = 12.6, 7.6 Hz, 1H), 3.28 (dd, *J* = 12.6, 6.8 Hz, 1H), 1.46 (s, 3H), 1.43 (s, 3H), 1.37 (s, 3H), 1.30 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 113.9, 113.0, 112.0, 85.3, 84.2, 82.5, 69.7, 53.3, 26.5, 26.5, 26.3, 25.2; IR ($CHCl_3$) *ν* 2989, 2099, 1376, 1205, 1065, 1020, 853 cm^{-1}; HRMS (TOF): $[M + Na]^+$ calcd for $C_{12}H_{19}N_3NaO_5$ 308.1222, found 308.1219.

6-deoxy-6-((9H-fluoren-9-yl)methylcarbamate)-1,2;3,4-di-O-isopropylidene-β-D-psicofuranose (***5a)***. To a solution of compound **4a** (3.5 g, 12.2 mmol) in EtOAc (15 mL) in a RB flask was added 10% Pd–C 0.5 g. The mixture was hydrogenated using H_2 balloon at room temperature for 3 h. After completion of reaction the slurry was filtered through celite and concentrated *in vacuo* to give amine quantitatively. This crude amine was dissolved in THF and 10% $NaHCO_3$ soln (7.5 mL) added. The resulting solution was cooled to 0 °C and Fmoc-OSu 1.1 eq (4.5 g, 13.5 mmol) with respect to amine was added slowly as a solution in THF. The resulting mixture was allowed to warm to room temperature overnight. Water was then added and extracted with EtOAc (100 mL X 3). The combined organic layers were washed with water, brine and dried over Na_2SO_4 and concentrated to dryness. The dry residue was chromatographed on a column of silica gel using petroleum ether/EtOAC to get **5a**. White solid: R_f = 0.5 (petroleum ether/EtOAC, 75:25); Yield: (5.0 g, 85%); $[\alpha]_D^{25}$ = -53.0 (*c* 0.7, $CHCl_3$); mp- 102-104 ºC; ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.77 (d, *J* = 7.5 Hz, 2H), 7.62 – 7.57 (m, 2H), 7.40 (t, *J* = 7.4 Hz, 2H), 7.31 (t, *J* = 7.4 Hz, 2H), 5.54 (t, *J* = 5.4 Hz, 1H), 4.66 (d, *J* = 5.8 Hz, 1H), 4.59 (d, *J* = 5.7 Hz, 1H), 4.48 – 4.37 (m, 2H), 4.34 (d, *J* = 9.8 Hz, 1H), 4.25 (dt, *J* = 13.9, 6.2 Hz, 2H), 4.06 (d, *J* = 9.9 Hz, 1H), 3.42 (t, *J* = 5.7 Hz, 2H), 1.49 (s, 3H), 1.44 (s, 3H), 1.41 (s, 3H), 1.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 156.6, 144.1, 144.0, 141.5, 141.4, 127.8, 127.1, 125.1, 120.1, 113.7, 112.8, 111.8, 85.7, 84.6, 82.3, 70.0, 66.8, 47.3, 43.6, 26.5, 26.5, 26.4, 25.2; IR ($CHCl_3$) *ν* 3356, 2988, 1718, 1519, 1243, 1064, 855, 733 cm^{-1}; HRMS (TOF): $[M + Na]^+$ calcd for $C_{27}H_{31}NNaO_7$ 504.1998, found 504.1998.

General procedure for the synthesis of spirooxazolines **6a** & **7a**.
To a solution of psicofuranose derivative **5a** (0.2 g, 0.415 mmol) and acetonitrile (**a**) (2 mL) or propionitrile (**b**) (2 mL) at 0 °C was added TMSOTf (0.074 mL, 0.415 mmol) under N_2 atmosphere. After addition, the reaction mixture was stirred at room temperature for 1-1.5 h. After complete consumption of the starting material, triethylamine was added to quench the reaction. The mixture was concentrated *in vacuo*. Water is then added and extracted with EtOAc (20 mL X 2). The combined organic layers were washed with water, brine and dried over Na_2SO_4 and concentrated to dryness. The dry residue was chromatographed on a column of silica gel using petroleum ether (bp 60−70 °C) and EtOAc to afford compounds **6a** & **7a**.

General procedure for the synthesis of spiro oxazolines **8a-18a**.
To a solution of psicofuranose derivative **3a** (0.2 g, 0.57 mmol) or **5a** (0.2 g, 0.415 mmol) and nitrile (**c-m**) (15 equiv) in toluene (2 mL) at 0 °C was added TMSOTf (1 equiv) under N_2 atmosphere. After addition, the reaction mixture was stirred at room temperature for 1-1.5 h. After complete consumption of the starting material, triethylamine was added to quench the reaction and followed the same workup and purification procedure as above mentioned to afford compounds **8a-18a**.

Compound (***6a***). White foam: R_f = 0.3 (petroleum ether/EtOAc, 70:30); Yield: (133 mg, 69%); $[\alpha]_D^{25}$ = -44.8 (*c* 0.24, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.77 (d, *J* = 7.5 Hz, 2H), 7.68-7.60 (m, 2H), 7.40 (t, *J* = 7.4 Hz, 2H), 7.35 – 7.26 (m, 2H), 7.06 (d, *J* = 5.5 Hz, 1H), 4.77 (d, *J* = 5.8 Hz, 1H), 4.58 (d, *J* = 10.8 Hz, 1H), 4.52 (d, *J* = 5.9 Hz, 1H), 4.40 (d, *J* = 7.3 Hz, 2H), 4.35 (br, 1H), 4.24 (t, *J* = 7.0 Hz, 1H), 4.18 (d, *J* = 10.8 Hz, 1H), 3.63 (ddd, *J* = 13.2, 8.2, 4.7 Hz, 1H), 3.34 (dt, *J* = 14.3, 3.1 Hz, 1H), 2.05 (s, 3H), 1.46 (s, 3H), 1.32 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 168.2, 156.9, 144.2, 144.1, 141.4, 127.7, 127.0, 125.3, 125.2, 120.0, 112.7, 110.1, 86.2, 84.6, 83.3, 72.5, 66.6, 47.4, 43.8, 26.5, 25.1, 14.5; IR ($CHCl_3$) *ν* 3303, 2939, 1709, 1657, 1517, 1214, 1075, 741 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{26}H_{29}N_2O_6$ 465.2026, found 465.2029.

Compound (***7a***).Thick liquid: R_f = 0.4 (petroleum ether/EtOAc, 80:20); Yield: (143 mg, 72%); $[\alpha]_D^{25}$ = -73.1 (*c* 0.2, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.76 (d, *J* = 7.5 Hz, 2H), 7.63 (t, *J* = 7.1 Hz, 2H), 7.43 – 7.34 (m, 2H), 7.32 – 7.26 (m, 2H), 4.77 (d, *J* = 5.9 Hz, 1H), 4.57 (d, *J* = 10.8 Hz, 1H), 4.51 (d, *J* = 5.9 Hz, 1H), 4.41 (d, *J* = 8.0 Hz, 2H), 4.37 (t, *J* = 3.2 Hz, 1H), 4.23 (t, *J* = 7.0 Hz, 1H), 4.18 (d, *J* = 10.8 Hz, 1H), 3.73 – 3.63 (m, 1H), 3.31 (dt, *J* = 14.3, 2.6 Hz, 1H), 2.33 (qd, *J* = 7.5, 3.1 Hz, 2H), 1.46 (s, 3H), 1.33 (s, 3H), 1.18 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 172.4, 157.0, 144.3, 144.0, 141.4, 127.7, 127.0, 125.3, 125.2, 120.0, 112.6, 109.7, 86.2, 84.7, 83.2, 72.4, 66.6, 47.4, 43.8, 26.7, 25.1, 21.8, 10.0. IR ($CHCl_3$) *ν* 3246, 2931, 1720, 1656, 1536, 1250, 1085, 749 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{27}H_{31}N_2O_6$ 479.2182, found 479.2184.

Compound (***8a***).White foam: R_f = 0.4 (petroleum ether/EtOAc, 80:20); Yield: (143 mg, 65%); $[\alpha]_D^{25}$ = -67.2 (*c* 0.88, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.77 (d, *J* = 7.5 Hz, 2H), 7.65 (t, 8.3 Hz, 2H), 7.47 (d, *J* = 7.4 Hz, 1H), 7.40 (t, *J* = 7.4 Hz, 2H), 7.34 – 7.27 (m, 2H), 4.78 (d, *J* = 5.9 Hz, 1H), 4.55 (d, *J* = 10.8 Hz, 1H), 4.52 (d, *J* = 5.9 Hz, 1H), 4.41 (d, *J* = 7.6 Hz, 2H), 4.37 (br s, 1H), 4.23 (t, *J* = 7.1 Hz, 1H), 4.17 (d, *J* = 10.8 Hz, 1H), 3.71 (ddd, *J* = 13.4, 8.9, 4.2 Hz, 1H), 3.31 (dt, *J* = 14.3, 2.5 Hz, 1H), 2.37-2.27 (m, 1H), 2.03-1.91 (m, 2H), 1.79 – 1.69 (m, 2H), 1.67-1.57 (m, 1H), 1.54-1.48 (m, 1H), 1.47 (s, 3H), 1.45 – 1.37 (m, 1H), 1.34 (s, 3H), 1.31 – 1.18 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.4, 157.0, 144.4, 144.1, 141.4 127.7, 127.1, 127.0, 125.2, 120.0, 112.6, 109.7, 86.4, 84.6, 83.3, 72.1, 66.8, 47.5, 43.9, 37.5, 29.8, 29.6, 26.6, 25.8, 25.6, 25.5, 25.2; IR ($CHCl_3$) ν 3247, 2932, 1716, 1648, 1534, 1249, 1057, 747 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{31}H_{37}N_2O_6$ 533.2652, found 533.2652.

Compound (***9a***). Sticky liquid: $R_f = 0.4$ (petroleum ether/EtOAc, 70:30); Yield: (107 mg, 53%); $[\alpha]_D^{25}$ = -52.3 (*c* 0.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$); 7.77 (d, *J* = 7.5 Hz, 2H), 7.69 – 7.59 (m, 2H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.30 (t, *J* = 7.4 Hz, 2H), 7.19 (d, *J* = 6.1 Hz, 1H), 6.86 – 6.73 (m, 1H), 5.98 (dd, *J* = 15.8, 1.7 Hz, 1H), 5.24 – 5.10 (m, 1H), 4.79 (d, *J* = 5.8 Hz, 1H), 4.61 (d, *J* = 10.7 Hz, 1H), 4.54 (d, *J* = 5.8 Hz, 1H), 4.46 – 4.34 (m, 3H), 4.29 – 4.18 (m, 2H), 3.71 – 3.59 (m, 1H), 3.40 – 3.29 (m, 1H), 1.89 (dd, *J* = 6.9, 1.6 Hz, 2H), 1.47 (s, 3H), 1.33 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 157.0, 144.3, 144.2, 142.3, 141.5, 130.5, 127.8, 127.1, 125.3, 120.1, 118.7, 112.7, 110.0, 86.4, 84.8, 83.4, 72.0, 66.7, 47.5, 44.0, 33.0, 26.6, 25.2; IR ($CHCl_3$) ν 3253, 2931, 1713, 1674, 1606, 1532, 1247, 1053, 746 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{28}H_{31}N_2O_6$ 491.2182, found 491.2189.

Compound (***10a***). Light brown foam: $R_f = 0.3$ (petroleum ether/EtOAc, 80:20); Yield: (137 mg, 61%); $[\alpha]_D^{25}$ = -85.8 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 (d, *J* = 7.2 Hz, 2H), 7.75 (d, *J* = 7.6 Hz, 2H), 7.66 (d, *J* = 7.5 Hz, 2H), 7.45 (d, *J* = 6.5 Hz, 1H), 7.41-7.33 (m, 2H), 7.32 – 7.18 (m, 4H), 4.89 (d, *J* = 5.8 Hz, 1H), 4.79 (d, *J* = 10.8 Hz, 1H), 4.67 (d, *J* = 5.9 Hz, 1H), 4.51 – 4.36 (m, 4H), 4.30 (t, *J* = 7.3 Hz, 1H), 3.76 (ddd, *J* = 13.0, 8.4, 4.3 Hz, 1H), 3.42 (dt, *J* = 14.2, 2.8 Hz, 1H), 2.26 (s, 3H), 1.51 (s, 3H), 1.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.6, 157.0, 144.2, 141.4, 138.4, 133.2, 129.4, 128.6, 127.8, 127.2, 127.1, 126.8, 126.0, 125.3, 120.1, 112.8, 110.2, 86.5, 85.0, 83.5, 72.6, 67.0, 47.6, 44.0, 26.7, 25.3, 21.4; IR ($CHCl_3$) ν 3245, 2940, 1713, 1641, 1246, 1078, 745 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{32}H_{33}N_2O_6$ 541.2339, found 541.2339.

Compound (***11a***). Thick liquid: $R_f = 0.5$ (petroleum ether/EtOAc, 80:20); Yield: (121 mg, 52%); $[\alpha]_D^{25}$ = -96.8 (*c* 0.46, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.2 Hz, 2H), 7.30 – 7.17 (m, 5H), 7.13 (d, *J* = 7.9 Hz, 2H), 4.81 (dd, *J* = 5.9, 1.4 Hz, 1H), 4.59 (d, *J* = 10.8 Hz, 1H), 4.57 (d, *J* = 6.2 Hz, 1H), 4.54 (d, *J* = 4.6 Hz, 2H), 4.32 – 4.26 (m, 2H), 3.74 – 3.63 (m, 2H), 2.32 (s, 3H), 1.42 (s, 3H), 1.27 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) 166.2, 142.5, 138.4, 129.2, 128.8, 128.5, 127.9, 127.7, 124.8, 112.8, 110.4, 85.9, 84.3, 83.7, 73.5, 72.2, 71.3, 26.7, 25.4, 21.7; IR ($CHCl_3$) ν 2933, 1641, 1351, 1079, 736 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{24}H_{28}NO_5$ 410.1967, found 410.1976.

Compound (***12a***). Thick liquid: $R_f = 0.4$ (petroleum ether/EtOAc, 85:15); Yield: (174 mg, 72%); $[\alpha]_D^{25}$ = -74.9 (*c* 0.48, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, *J* = 9.0 Hz, 2H), 7.40 – 7.24 (m, 5H), 6.90 (d, *J* = 9 Hz, 2H), 4.88 (dd, *J* = 5.9, 1.4 Hz, 1H), 4.66 (d, *J* = 7.9 Hz, 1H), 4.64 (d, *J* = 3.1 Hz, 1H), 4.61 (d, *J* = 4.5 Hz, 2H), 4.41 – 4.32 (m, 2H), 3.85 (s, 3H), 3.81-3.70 (m, 2H), 1.50 (s, 3H), 1.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.0, 162.7, 138.4, 130.6, 128.5, 127.9, 127.7, 120.0, 113.8, 112.8, 110.4, 85.9, 84.2, 83.7, 73.5, 72.2, 71.3, 55.5, 26.7, 25.4. IR ($CHCl_3$) ν 2936, 1638, 1609, 1512, 1254, 1078, 741 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{24}H_{28}NO_6$ 426.1917, found 426.1925.

Compound (***13a***). White foam: $R_f = 0.4$ (petroleum ether/EtOAc, 60:40); Yield: (155 mg, 69%); $[\alpha]_D^{25}$ = -69.1 (*c* 0.3, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88 (d, *J* = 8.7 Hz, 2H), 7.75 (d, *J* = 7.6 Hz, 2H), 7.65 (d, *J* = 7.5 Hz, 2H), 7.58 (d, *J* = 6.6 Hz, 1H), 7.38 (td, *J* = 7.5, 2.1 Hz, 2H), 7.25 (td, *J* = 7.4, 2.9 Hz, 2H), 6.79 (d, *J* = 8.7 Hz, 2H), 4.86 (d, *J* = 5.8 Hz, 1H), 4.77 (d, *J* = 10.8 Hz, 1H), 4.65 (d, *J* = 5.9 Hz, 1H), 4.52 – 4.36 (m, 4H), 4.26 (t, *J* = 7.1 Hz, 1H), 3.78 – 3.68 (m, 1H), 3.40 (dt, *J* = 14.1, 2.8 Hz, 1H), 1.52 (s, 3H), 1.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.5, 159.9, 157.3, 144.2, 144.1, 141.4, 131.0, 127.8, 127.2, 125.3, 120.1, 119.0, 115.7, 112.8, 110.1, 86.4, 84.8, 83.4, 72.6, 67.1, 47.5, 44.0, 26.7, 25.3; IR ($CHCl_3$) ν 3237, 2937, 1695, 1635, 1515, 1262, 1080, 746 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{31}H_{31}N_2O_7$ 543.2131, found 543.2131.

Compound (***14a***). Thick liquid: R_f = 0.5 (petroleum ether/EtOAc, 85:15); Yield: (127 mg, 50%); $[\alpha]_D^{25}$ = -100.8 (*c* 0.87, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 9.14-9.05 (m, 1H), 8.13 (dd, *J* = 7.3, 1.2 Hz, 1H), 8.01 (d, *J* = 8.2 Hz, 1H), 7.95 – 7.86 (m, 1H), 7.60 – 7.48 (m, 3H), 7.44 – 7.25 (m, 5H), 4.98 (dd, *J* = 5.9, 1.2 Hz, 1H), 4.79 (d, *J* = 5.9 Hz, 1H), 4.76 (d, *J* = 10.7 Hz, 1H), 4.72 (d, *J* = 12.1 Hz, 1H), 4.64 (d, *J* = 12.1 Hz, 1H), 4.48 (t, *J* = 6.8 Hz, 1H), 4.45 (d, *J* = 10.8 Hz, 1H), 3.83 (m, 2H), 1.57 (s, 3H), 1.41 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 165.9, 138.3, 133.9, 132.7, 131.3, 129.7, 128.7, 128.5, 127.9, 127.8, 127.4, 126.4, 126.3, 124.8, 124.0, 112.8, 111.0, 86.0, 84.3, 83.8, 73.6, 71.1, 26.7, 25.4; IR ($CHCl_3$) *ν* 2936, 1638, 1511, 1208, 1077, 777 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{27}H_{28}NO_5$ 446.1967, found 446.1964.

Compound (***15a***). Thick liquid: R_f = 0.4 (petroleum ether/EtOAc, 80:20); Yield: (155 mg, 66%); $[\alpha]_D^{25}$ = -82.9 (*c* 1.21, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.97 – 7.90 (m, 2H), 7.42 – 7.26 (m, 5H), 7.11 (t, *J* = 8.7 Hz, 2H), 4.92 (dd, *J* = 5.9, 1.4 Hz, 1H), 4.72 (d, *J* = 10.7 Hz, 1H), 4.67 (d, *J* = 6.0 Hz, 1H), 4.64 (d, *J* = 2.7 Hz, 2H), 4.44 – 4.38 (m, 2H), 3.82 – 3.73 (m, 2H), 1.53 (s, 3H), 1.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$, C−F coupling not assigned) *δ* 166.4, 165.1, 163.9, 138.3, 131.1, 131.0, 129.1, 128.4, 127.8, 127.7, 115.7, 115.5, 112.8, 110.4, 85.8, 84.2, 83.6, 73.5, 72.4, 71.1, 26.6, 25.3; IR ($CHCl_3$) *ν* 2936, 1643, 1509, 1215, 1073, 739 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{23}H_{25}FNO_5$ 414.1717, found 414.1719.

Compound (***16a***). White foam: R_f = 0.3 (petroleum ether/EtOAc, 80:20); Yield: (110 mg, 44%); $[\alpha]_D^{25}$ = -77.2 (*c* 0.19, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.80 (d, *J* = 8.5 Hz, 2H), 7.74 (dd, *J* = 7.5, 3.8 Hz, 2H), 7.63 (dd, *J* = 7.4, 2.1 Hz, 2H), 7.47 (d, *J* = 8.5 Hz, 2H), 7.38 (dd, *J* = 13.1, 7.3 Hz, 2H), 7.26 – 7.18 (m, 2H), 4.83 (dd, *J* = 5.9, 1.2 Hz, 1H), 4.78 (d, *J* = 10.9 Hz, 1H), 4.59 (d, *J* = 5.8 Hz, 1H), 4.54 – 4.42 (m, 2H), 4.39 (d, *J* = 10.9 Hz, 2H), 4.26 (t, *J* = 6.9 Hz, 1H), 3.71 (ddd, *J* = 13.0, 8.4, 4.4 Hz, 1H), 3.37 (dt, *J* = 14.2, 2.9 Hz, 1H), 1.49 (s, 3H), 1.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 165.7, 157.0, 144.3, 144.1, 141.5, 141.5, 132.1, 130.3, 127.8, 127.3, 127.2, 125.9, 125.2, 120.1, 112.9, 110.2, 86.3, 85.1, 83.4, 72.8, 66.8, 47.6, 43.9, 26.7, 25.3; IR ($CHCl_3$) *ν* 3261, 2933, 1717, 1642, 1246, 1081, 743 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{31}H_{30}BrN_2O_6$ 605.1287, found 605.1284.

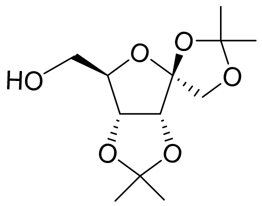
Compound (***17a***). Thick liquid: R_f = 0.4 (petroleum ether/EtOAc, 85:15); Yield: (125 mg, 45%); $[\alpha]_D^{25}$ = -74.5 (*c* 0.39, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.79 (s, 1H), 7.59 (d, *J* = 1.2 Hz, 2H), 7.42 – 7.26 (m, 5H), 4.91 (dd, *J* = 5.9, 1.4 Hz, 1H), 4.70 (d, *J* = 10.7 Hz, 1H), 4.66 (d, *J* = 6.0 Hz, 1H), 4.64 (d, *J* = 2.6 Hz, 2H), 4.44 – 4.36 (m, 2H), 3.82 – 3.71 (m, 2H), 2.45 (s, 3H), 1.53 (s, 3H), 1.37 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 165.5, 138.3, 132.6, 130.8, 129.3, 128.5, 127.8, 127.7, 127.5, 126.7, 112.9, 110.4, 85.8, 84.3, 83.6, 73.5, 72.4, 71.2, 26.7, 25.4, 23.0; IR ($CHCl_3$) *ν* 2929, 1642, 1462, 1081, 739 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{24}H_{27}BrNO_5$ 488.1073, found 488.1079.

Compound (***18a***). White solid: R_f = 0.4 (petroleum ether/EtOAc, 70:30); Yield: (99 mg, 45%); $[\alpha]_D^{25}$ = -84.4 (*c* 0.56, $CHCl_3$); mp- 137-139 ºC; ^{1}H NMR (400 MHz, $CDCl_3$) *δ* 7.75 (d, *J* = 7.6 Hz, 2H), 7.71-7.65 (m, 3H), 7.49 (dd, *J* = 4.9, 1.0 Hz, 1H), 7.38 (td, *J* = 7.4, 2.6 Hz, 2H), 7.25 (t, *J* = 7.5 Hz, 2H), 7.20 (br, 1H), 7.06 (t, *J* = 3.9 Hz, 1H), 4.84 (d, *J* = 5.9 Hz, 1H), 4.77 (d, *J* = 10.7 Hz, 1H), 4.65 (d, *J* = 5.9 Hz, 1H), 4.47 – 4.36 (m, 4H), 4.28 (t, *J* = 7.2 Hz, 1H), 3.78 – 3.69 (m, 1H), 3.37 (dt, *J* = 14.3, 2.8 Hz, 1H), 1.49 (s, 3H), 1.34 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) *δ* 162.1, 157.0, 144.3, 144.1, 141.4, 132.0, 131.5, 129.4, 128.1, 127.7, 127.1, 125.4, 125.3, 120.0, 112.8, 110.2, 86.3, 84.9, 83.3, 73.0, 66.8, 47.5, 43.9, 26.6, 25.1; IR ($CHCl_3$) *ν* 3267, 2929, 1714, 1638, 1521, 1245, 1070, 748 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{29}H_{29}N_2O_6S$ 533.1746, found 533.1747.

Compound (***3ab***). To a solution of **3a** (0.2 g, 0.57 mmol) in toluene at 0 °C, was added TMSOTf (0.103 mL, 0.57 mmol). After addition ice bath was removed and reaction stirred at room temperature. After 45 min complete consumption of starting material was observed and reaction quenched by adding Et_3N. Toluene removed on rota evaporator. Water was added and extracted into EtOAc. The combined organic layers were washed with water, brine and dried over Na_2SO_4 and concentrated to dryness. The dry residue was chromatographed on a column of silica gel using petroleum ether/EtOAC to get **3ab**. Thick liquid: R_f = 0.4 (petroleum ether/EtOAC, 85:15); Yield: (125 mg, 75%); $[\alpha]_D^{25}$ = -74.2 (*c* 0.73, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.27 (m, 5H X 2), 4.73 (dd, J = 6.0, 1.1 Hz, 1H X 2), 4.59 (d, J = 6.0 Hz, 1H X 2), 4.54 (d, J = 2.1 Hz, 2H X 2), 4.34 – 4.27 (m, 1H X 2), 3.95 (d, J = 12.5 Hz, 1H X 2), 3.78 (d, J = 12.5 Hz, 1H X 2), 3.59 – 3.46 (m, 2H X 2), 1.46 (s, 3H X 2), 1.32 (s, 3H X 2); ^{13}C NMR (100 MHz, $CDCl_3$) δ 138.1, 128.5, 127.9, 113.1, 106.4, 84.2, 83.7, 83.0, 73.4, 71.0, 60.1, 26.5, 25.2; IR ($CHCl_3$) ν 2925, 1375, 1212, 1093 cm^{-1}; HRMS (TOF): $[M + Na]^+$ calcd for $C_{32}H_{40}NaO_{10}$ 607.2519, found 607.2515.

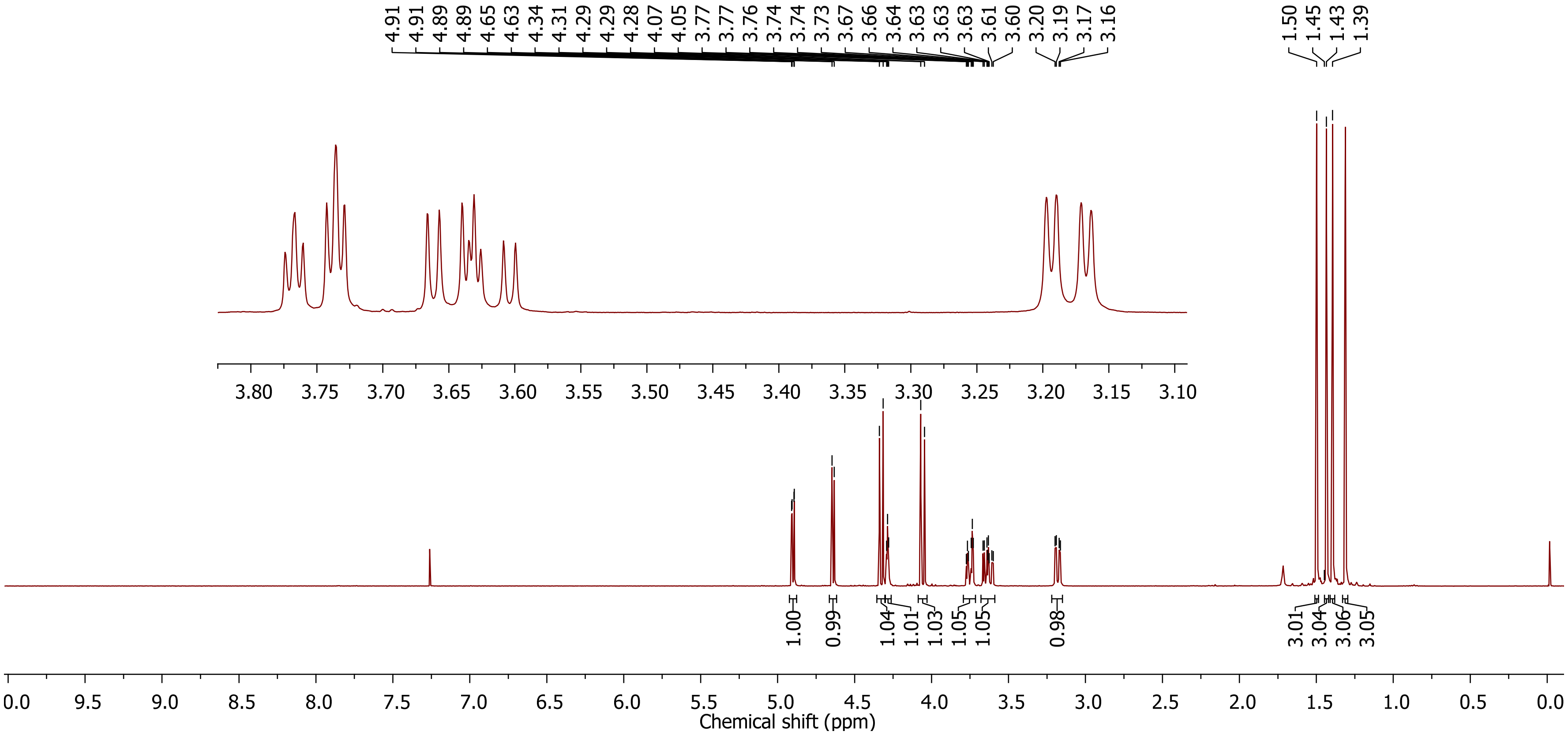
Compound (***5ab***). This compound was prepared following the above procedure for **3ab** using **5a** (0.2 g, 0.57 mmol) of the starting material to obtain **5ab**, **5ac** as 1:1 in 74% yield. White solid: R_f = 0.3 (petroleum ether/EtOAC, 60:40); Yield: (70 mg, 40%); $[\alpha]_D^{25}$ = -48.8 (*c* 0.44, $CHCl_3$); mp- 101-103 ºC; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, J = 7.5 Hz, 2H X 2), 7.60 (d, J = 7.4 Hz, 2H X 2), 7.40 (t, J = 7.5 Hz, 2H X 2), 7.32 (td, J = 7.4, 0.9 Hz, 2H X 2), 5.36 (t, J = 5.5 Hz, 1H X 2), 4.67 (dd, J 1= 8.2, 5.8 Hz, 2H X 2), 4.50 – 4.35 (m, 2H X 2), 4.30 (t, J = 5.1 Hz, 1H X 2), 4.22 (t, J = 6.9 Hz, 1H X 2), 4.07 (d, J = 12.4 Hz, 1H X 2), 3.88 (d, J = 12.3 Hz, 1H X 2), 3.53 – 3.33 (m, 2H X 2), 1.49 (s, 3H X 2), 1.35 (s, 3H X 2); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.6, 144.1, 144.0, 141.5, 127.8, 127.2, 125.2, 120.1, 113.4, 106.0, 85.4, 83.9, 82.6, 66.9, 61.3, 47.4, 44.1, 26.6, 25.1; IR ($CHCl_3$) ν 3345, 2940, 1708, 1519, 1245, 1074, 739 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{48}H_{51}N_2O_{12}$ 847.3442, found 847.3442.

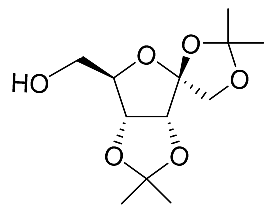
Compound (***5ac***). Thick liquid: R_f = 0.25 (petroleum ether/EtOAC, 60:40); Yield: (60 mg, 34%); $[\alpha]_D^{25}$ = -12.8 (*c* 0.83, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, J = 7.5 Hz, 4H), 7.64 – 7.55 (m, 4H), 7.40 (t, J = 7.5 Hz, 4H), 7.35 – 7.28 (m, 4H), 5.35 (br t, 1H), 5.03 (t, J = 5.9 Hz, 1H), 4.70 (d, J = 5.9 Hz, 1H), 4.59 (d, J = 5.8 Hz, 1H), 4.53 – 4.32 (m, 6H), 4.28 – 4.07 (m, 6H), 3.81 (d, J = 12.2 Hz, 1H), 3.58 – 3.44 (m, 3H), 3.43 – 3.31 (m, 2H), 1.58 (s, 3H), 1.47 (s, 3H), 1.34 (s, 3H), 1.30 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 156.6, 144.0, 141.4, 127.8, 127.2, 125.2, 125.1, 120.1, 117.1, 113.2, 104.1, 99.3, 85.9, 85.7, 82.5, 82.0, 81.0, 67.0, 66.8, 63.9, 62.8, 47.3, 44.1, 42.5, 26.4, 26.3, 26.1, 25.0; IR ($CHCl_3$) ν 3017, 1712, 1517, 1214, 1086, 741 cm^{-1}; HRMS (TOF): $[M + H]^+$ calcd for $C_{48}H_{51}N_2O_{12}$ 847.3442, found 847.3448.



2a

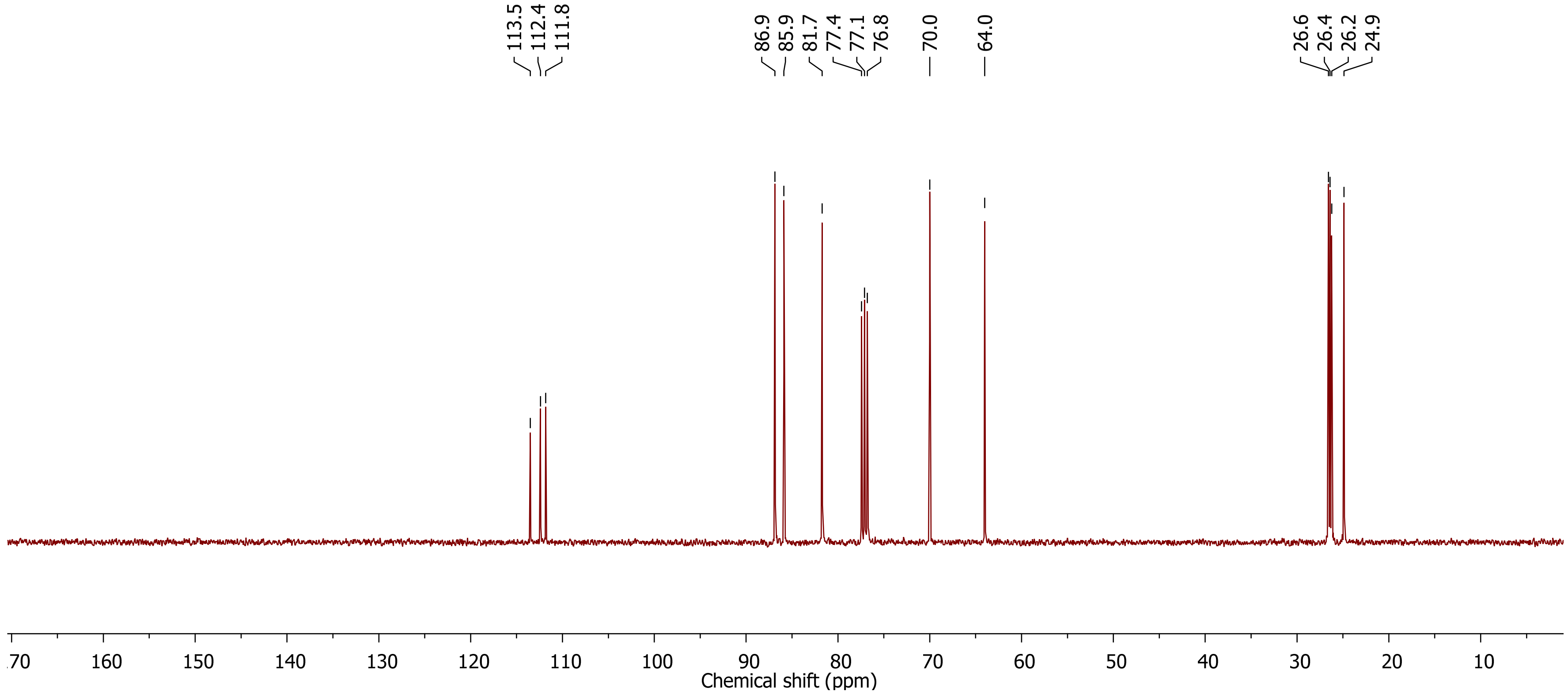
$CDCl_3$, 400 MHz

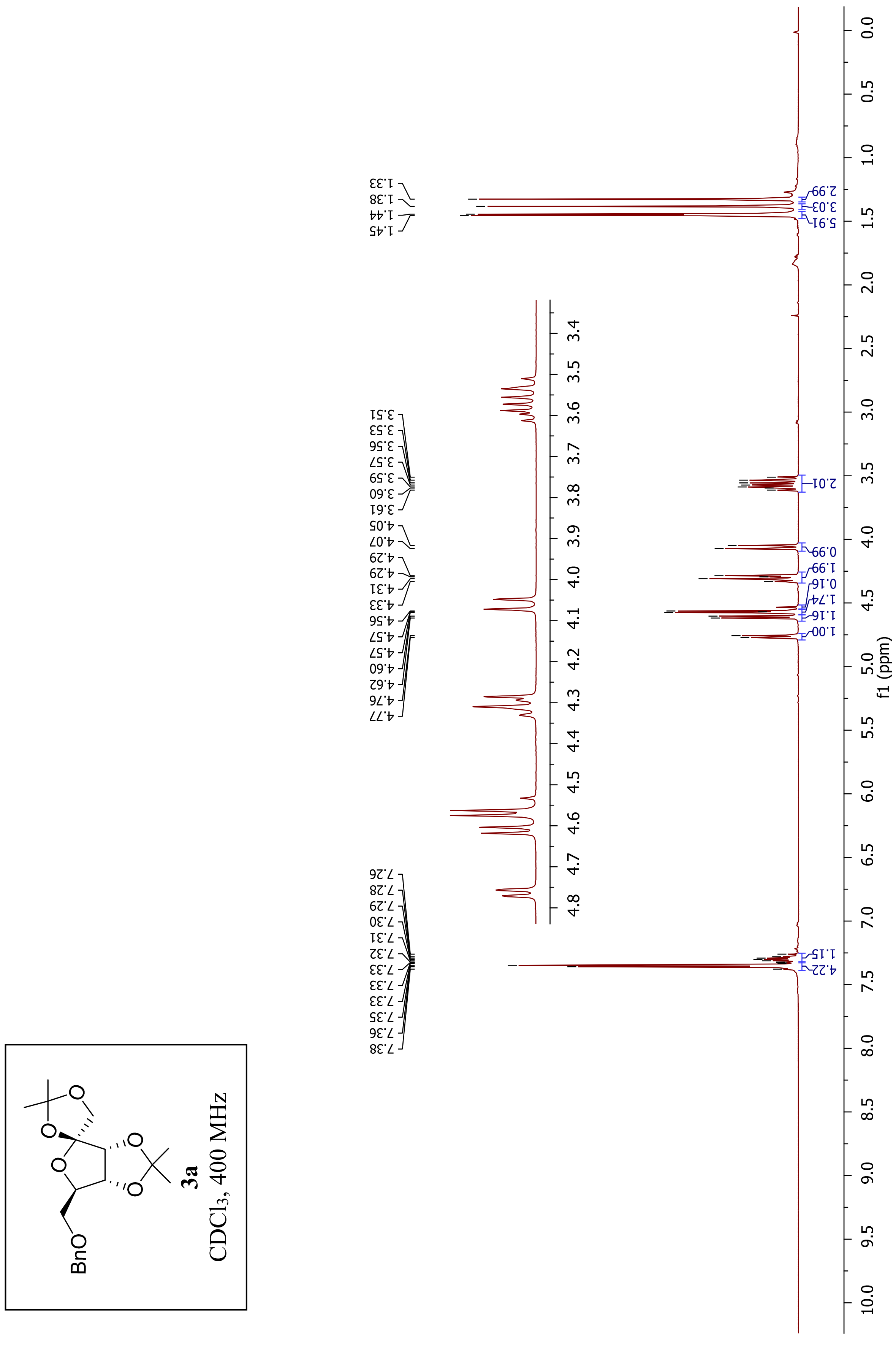




2a

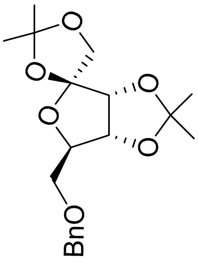
CDCl$_3$, 100 MHz





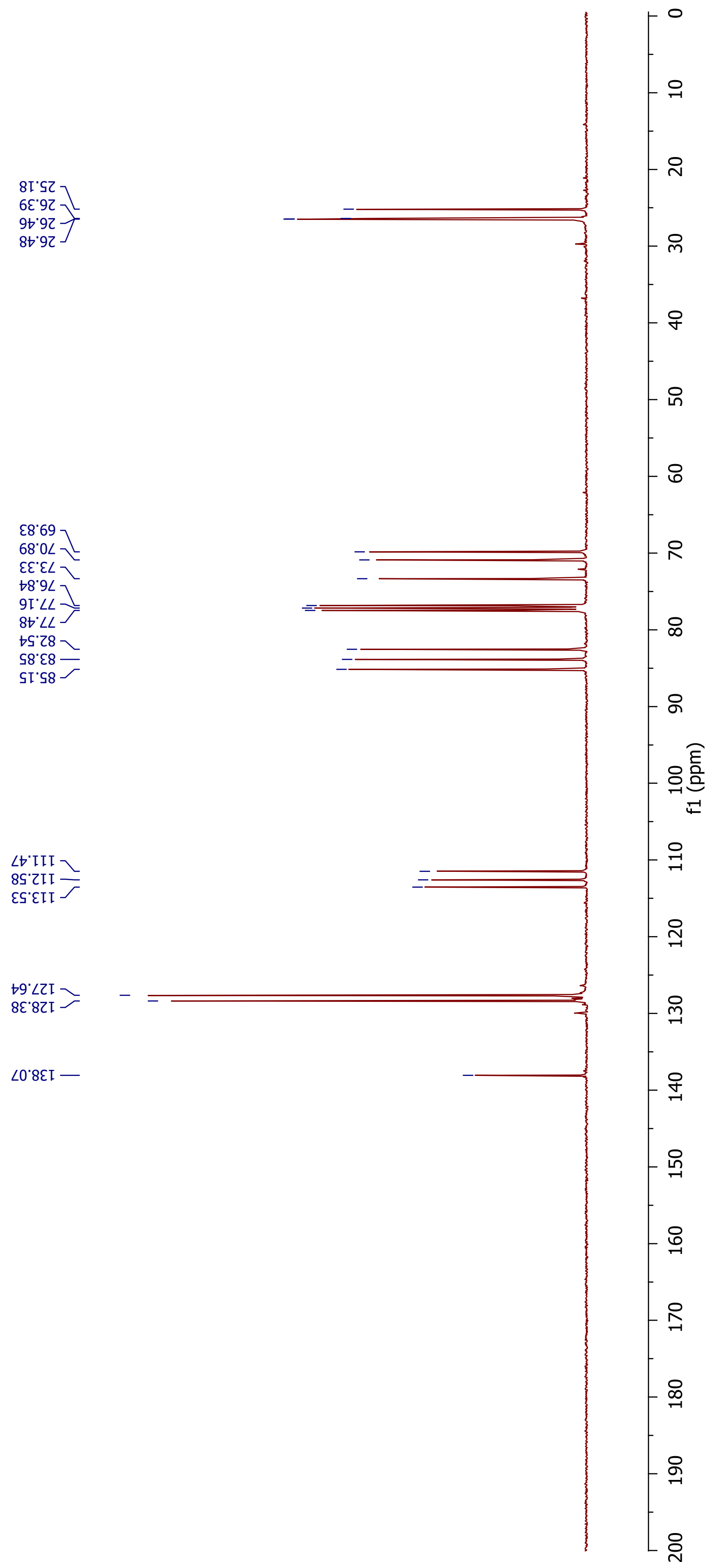
3a

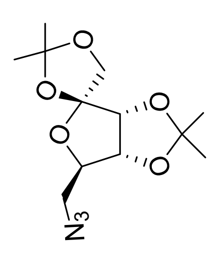
CDCl$_3$, 400 MHz



3a

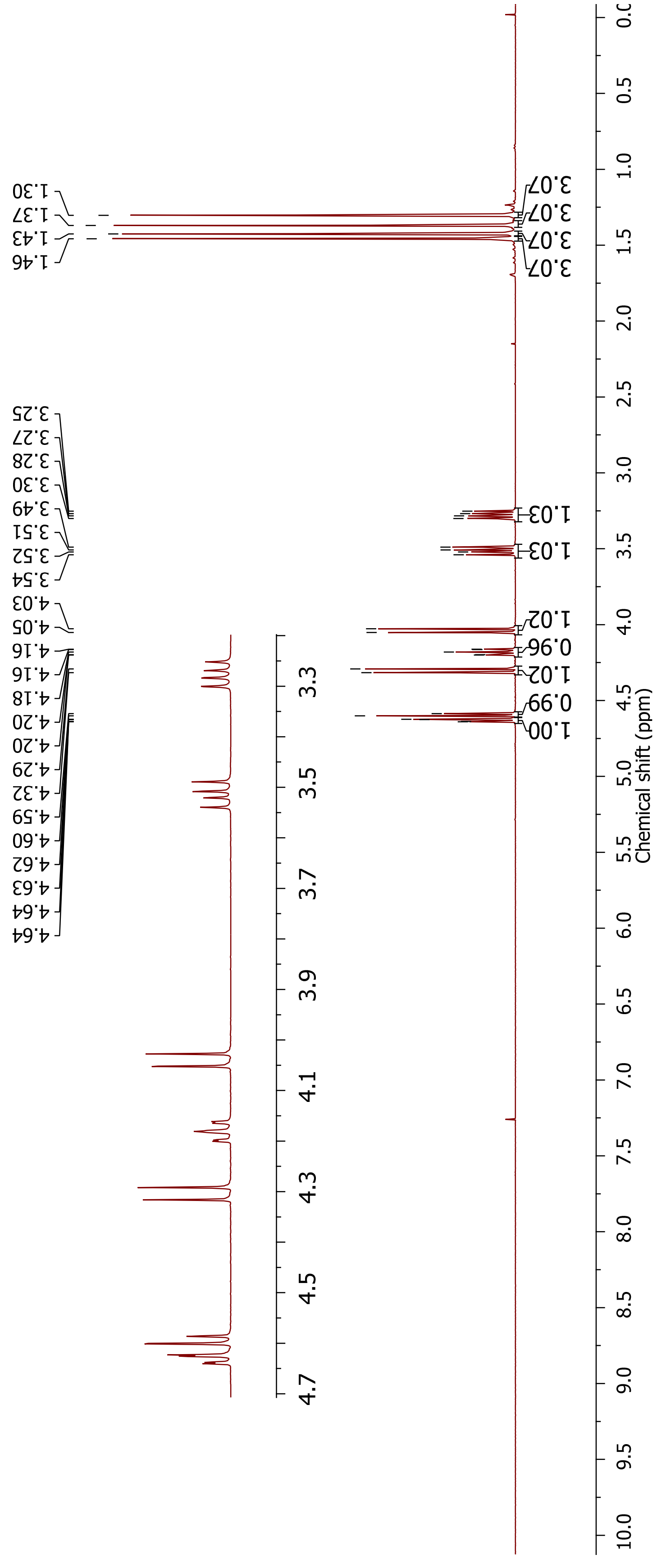
$CDCl_3$, 100 MHz

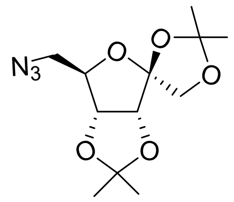




4a

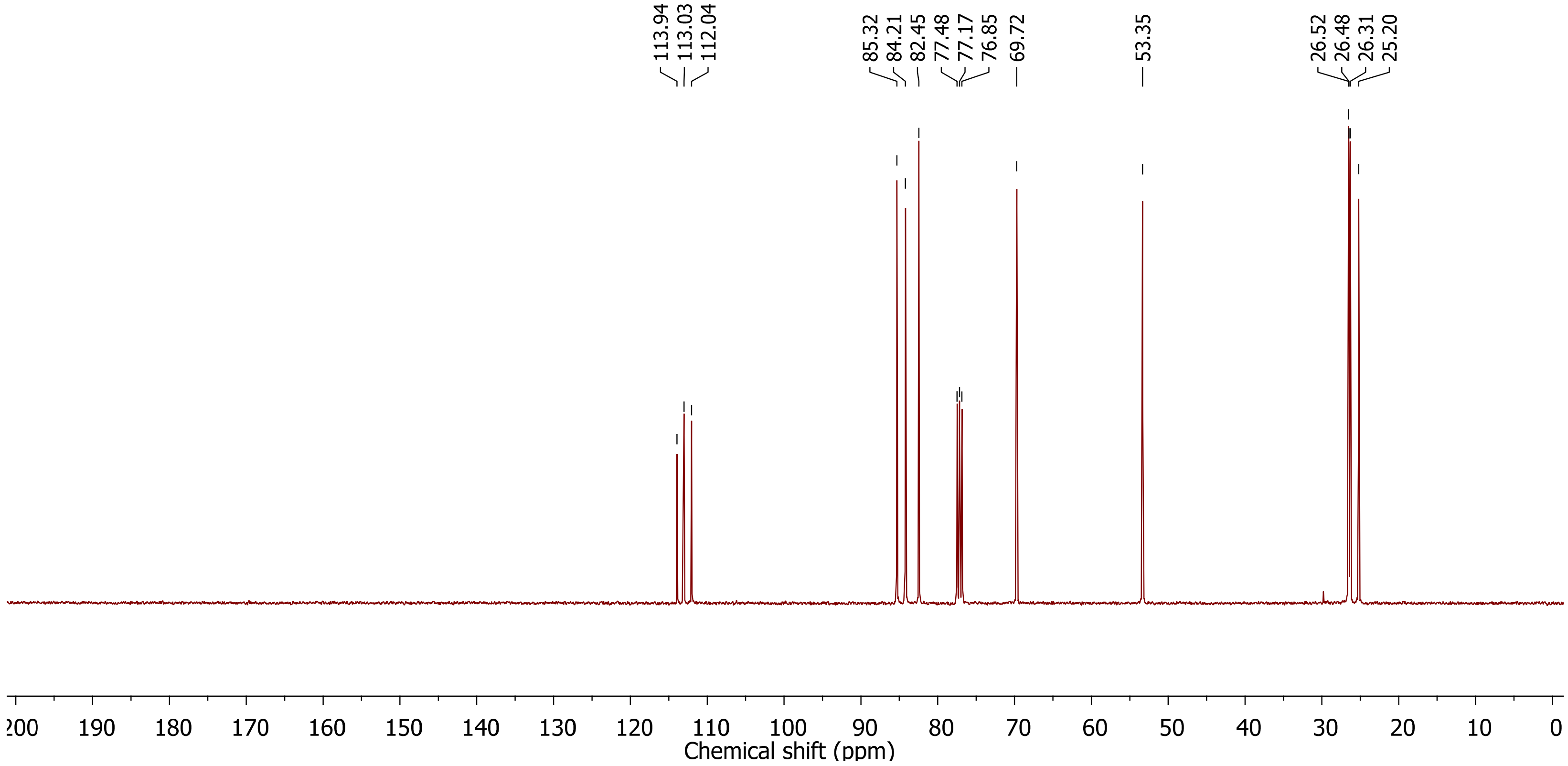
CDCl$_3$, 400 MHz

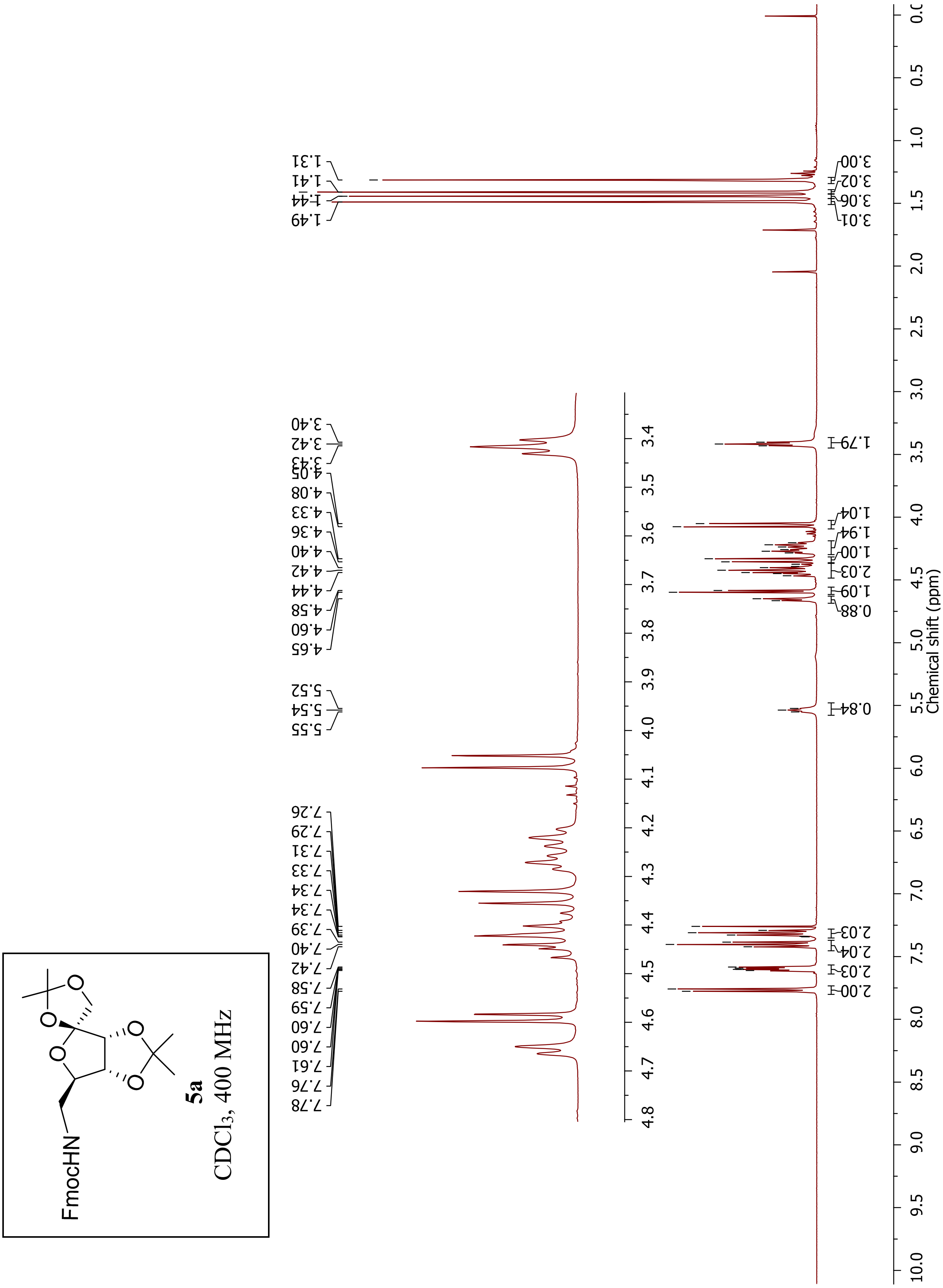




4a

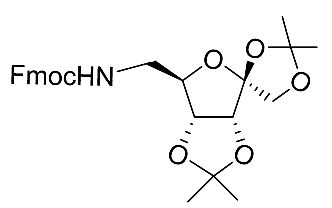
CDCl$_3$, 100 MHz





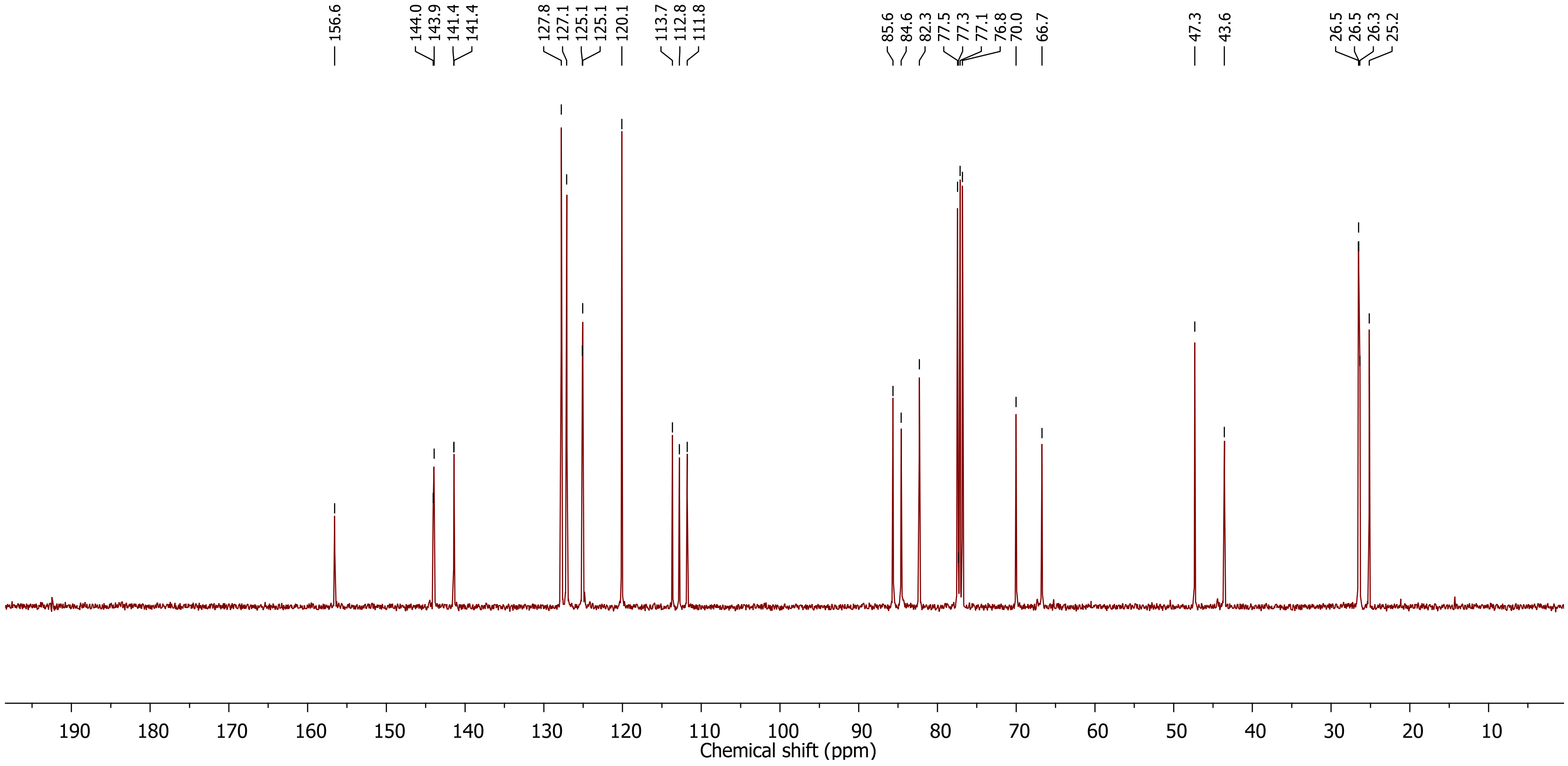
5a

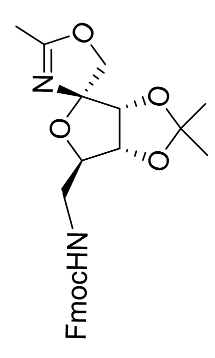
$CDCl_3$, 400 MHz



5a

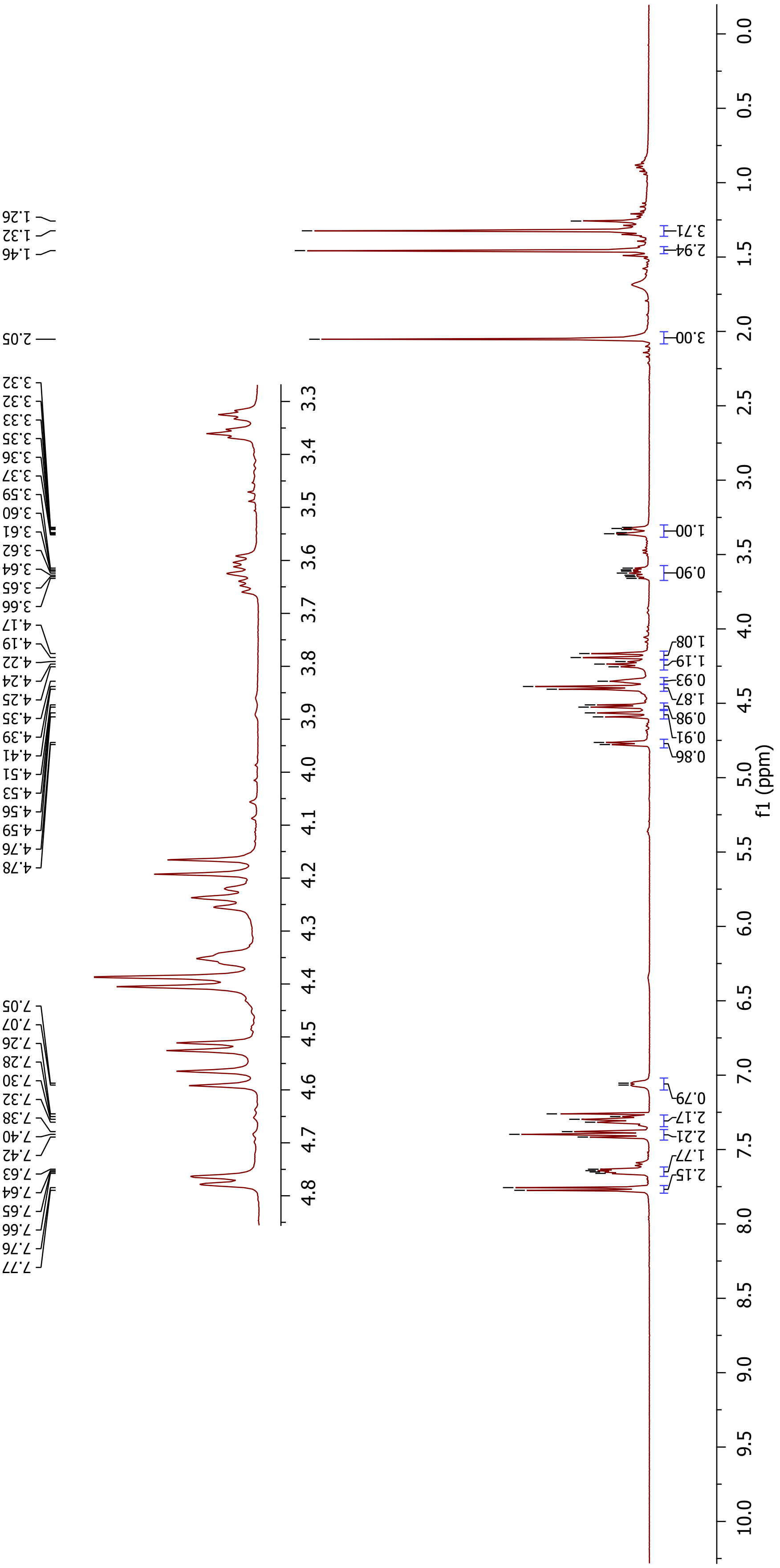
$CDCl_3$, 100 MHz

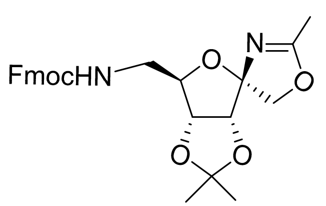




6a

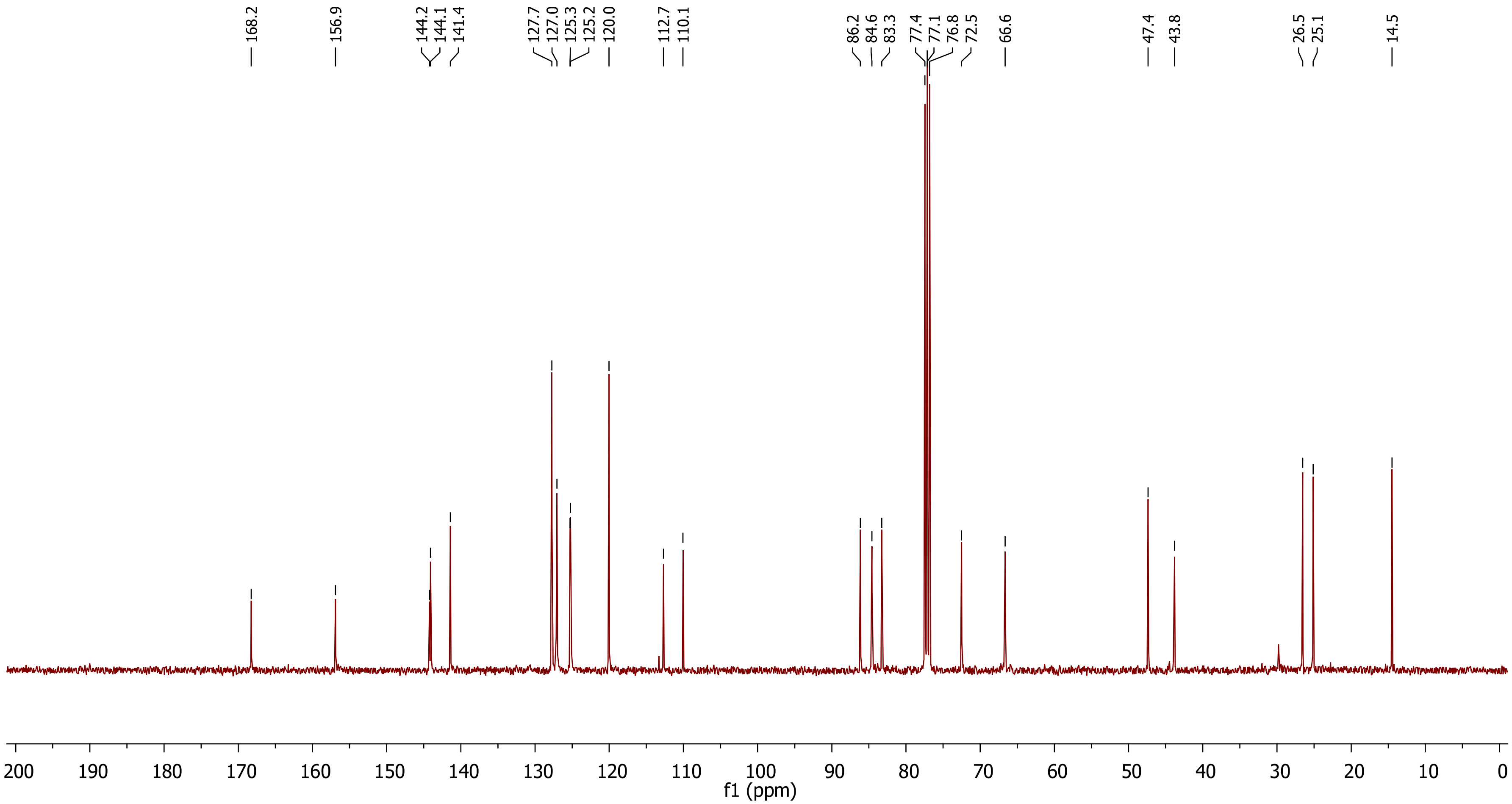
CDCl$_3$, 400 MHz

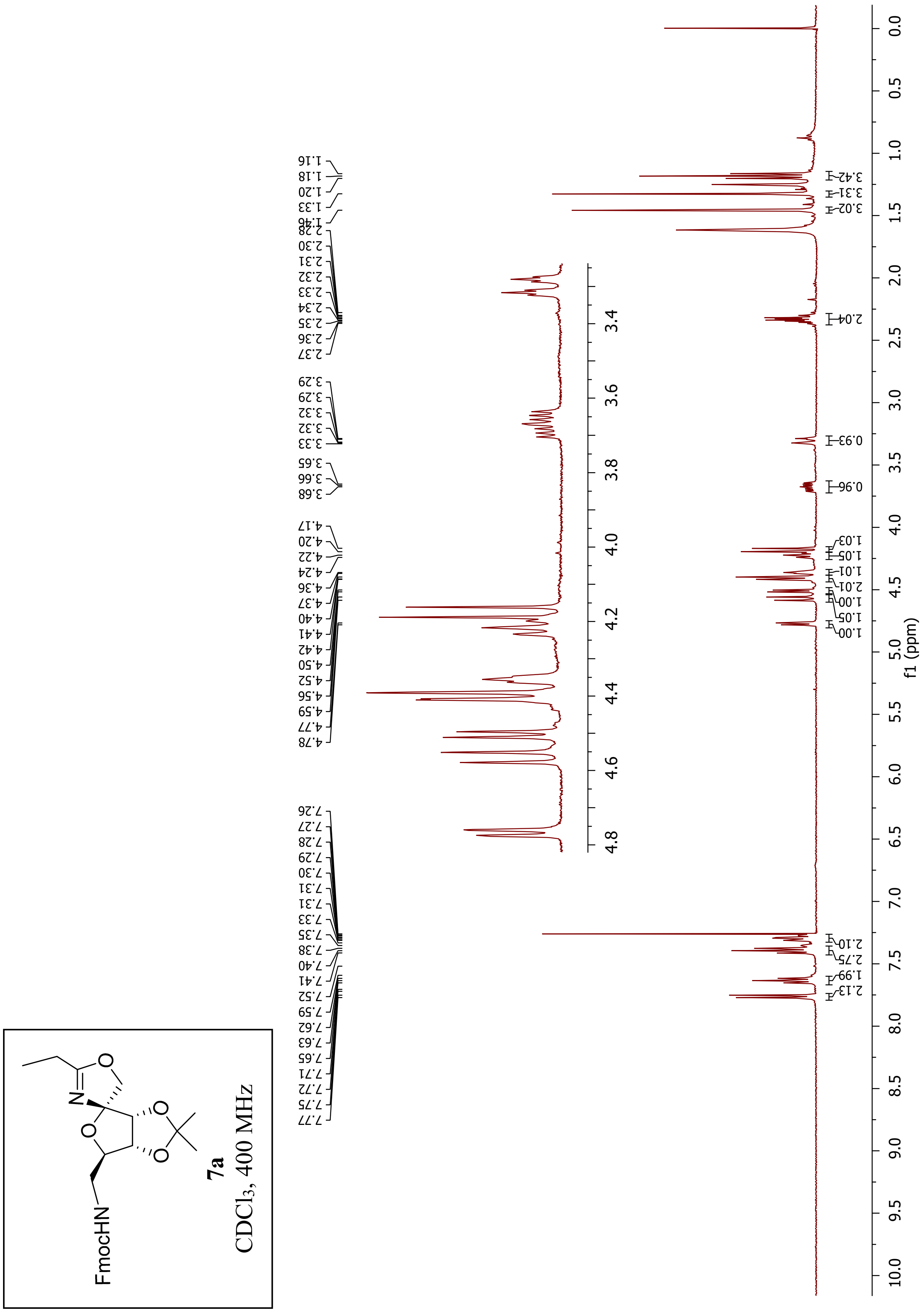




6a

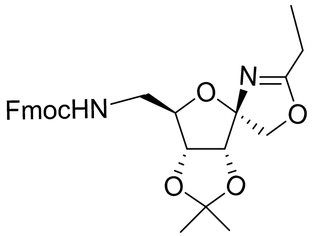
$CDCl_3$, 100 MHz





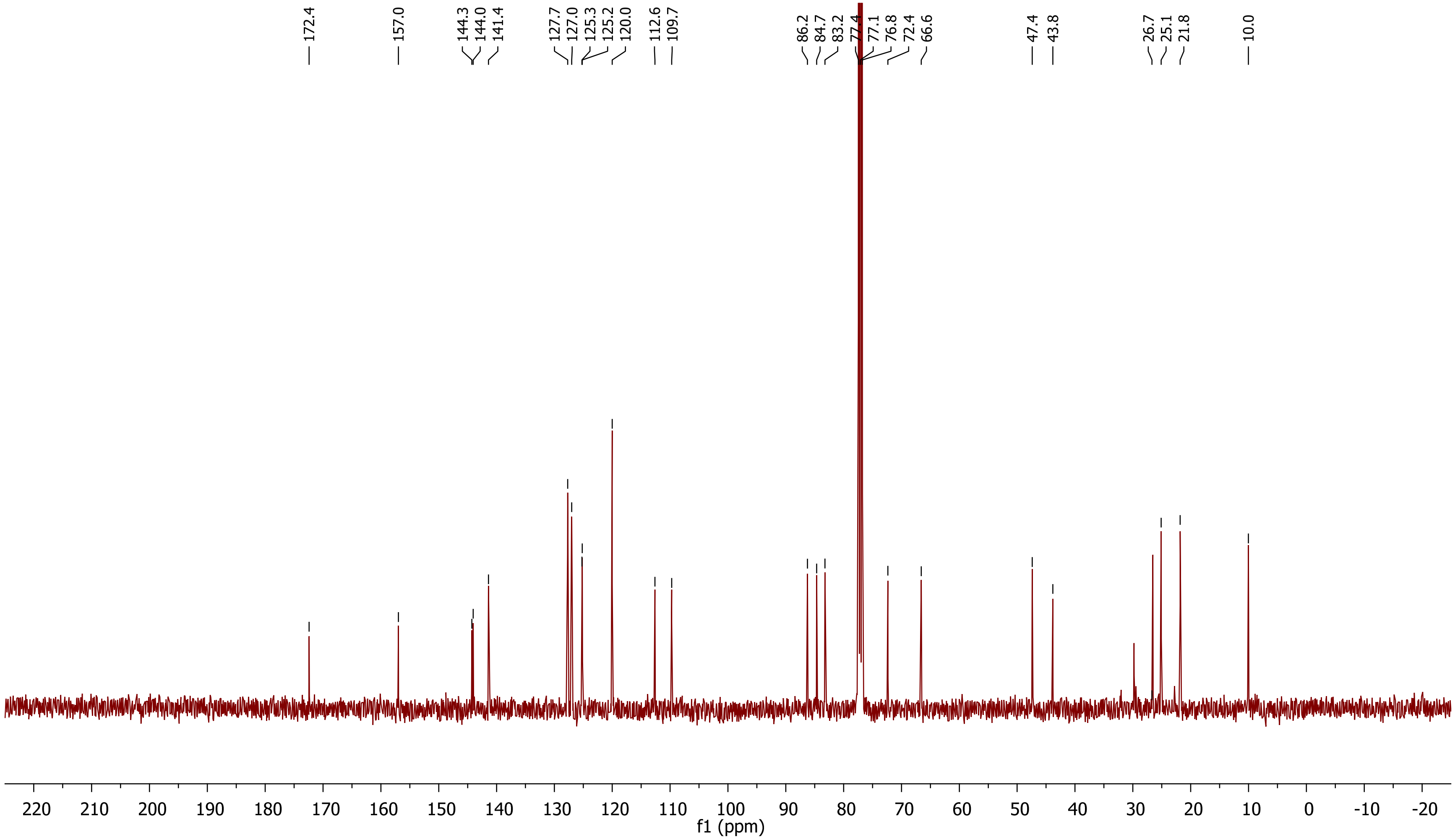
7a

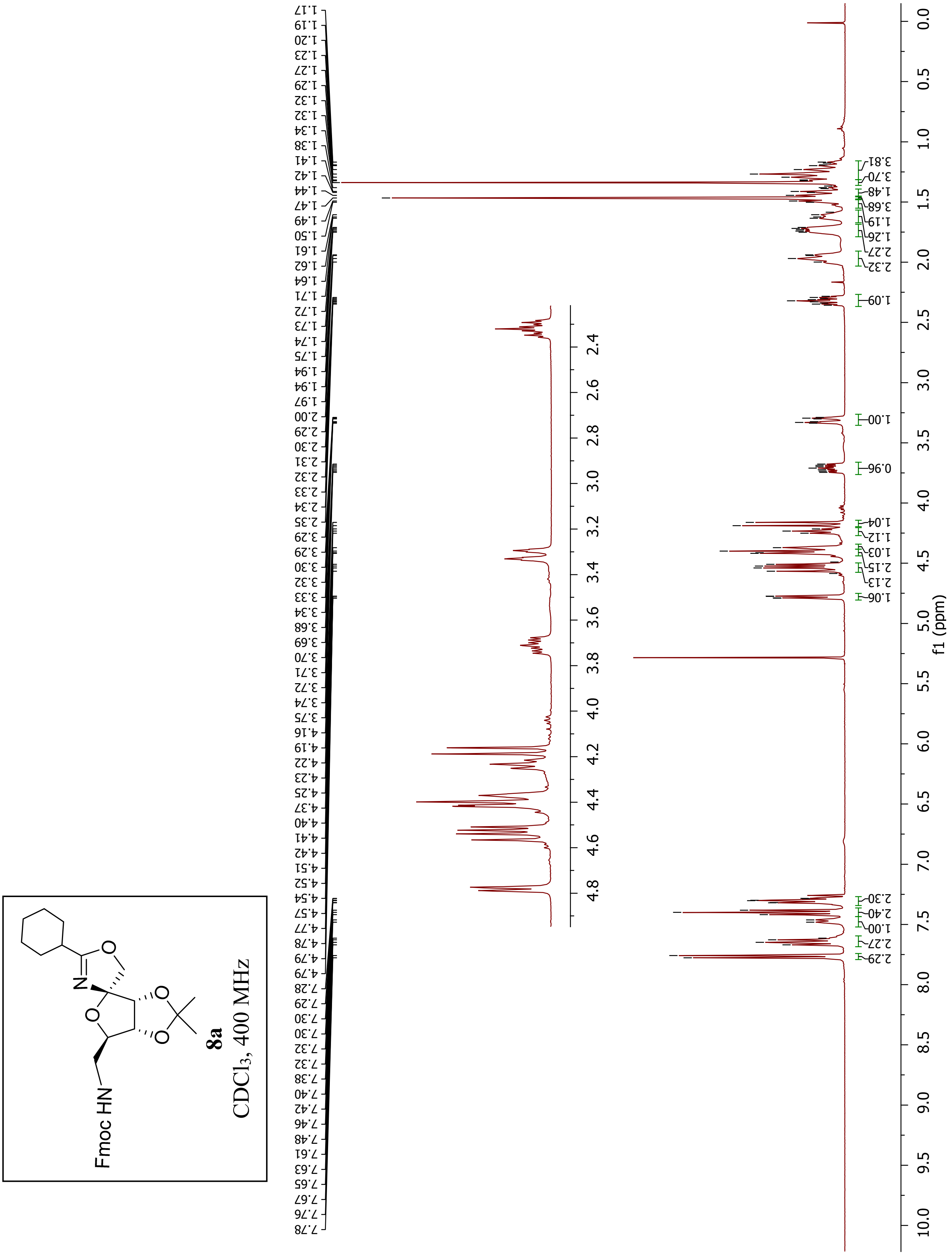
$CDCl_3$, 400 MHz



7a

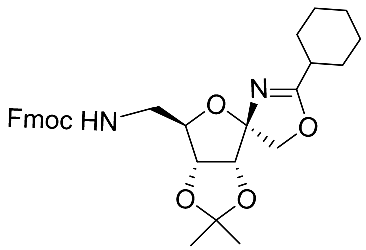
$CDCl_3$, 100 MHz





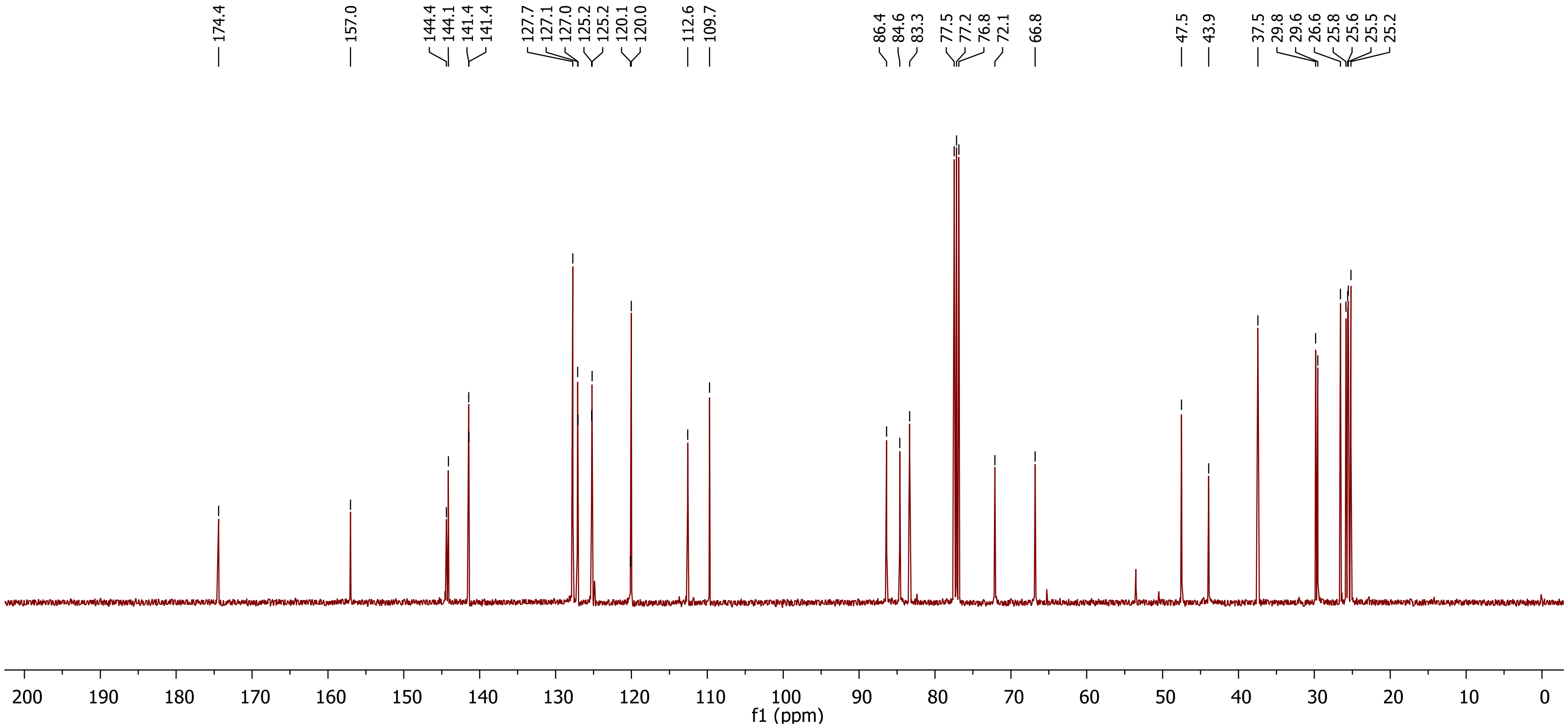
8a

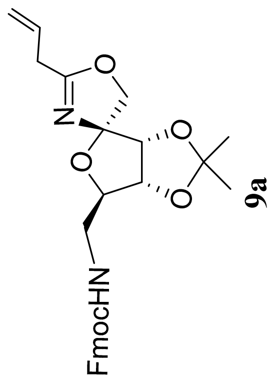
$CDCl_3$, 400 MHz



8a

CDCl$_3$, 100 MHz





9a

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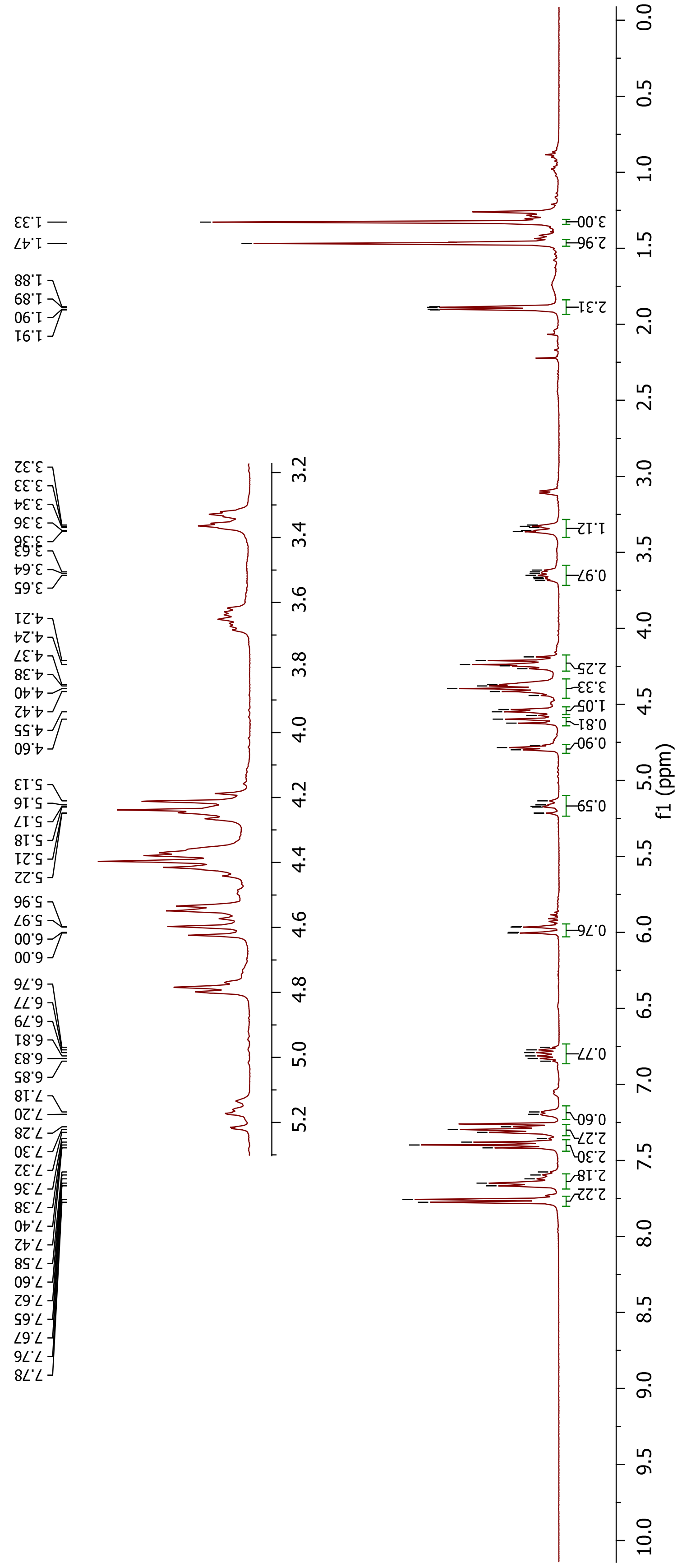
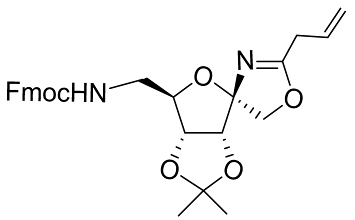
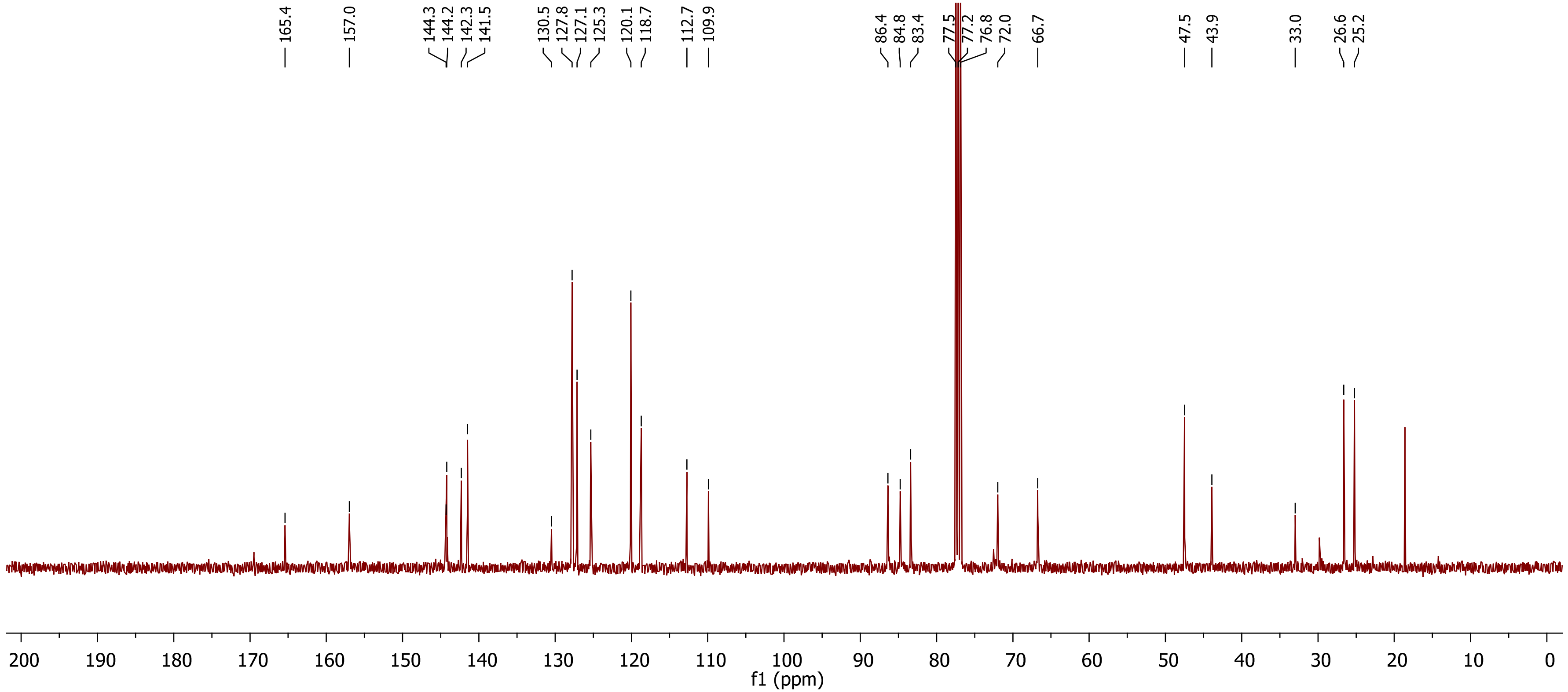
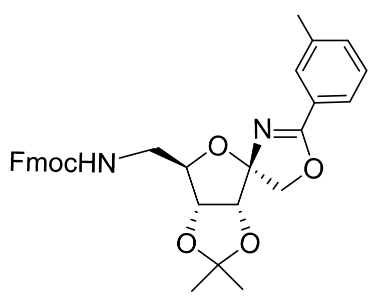




9a

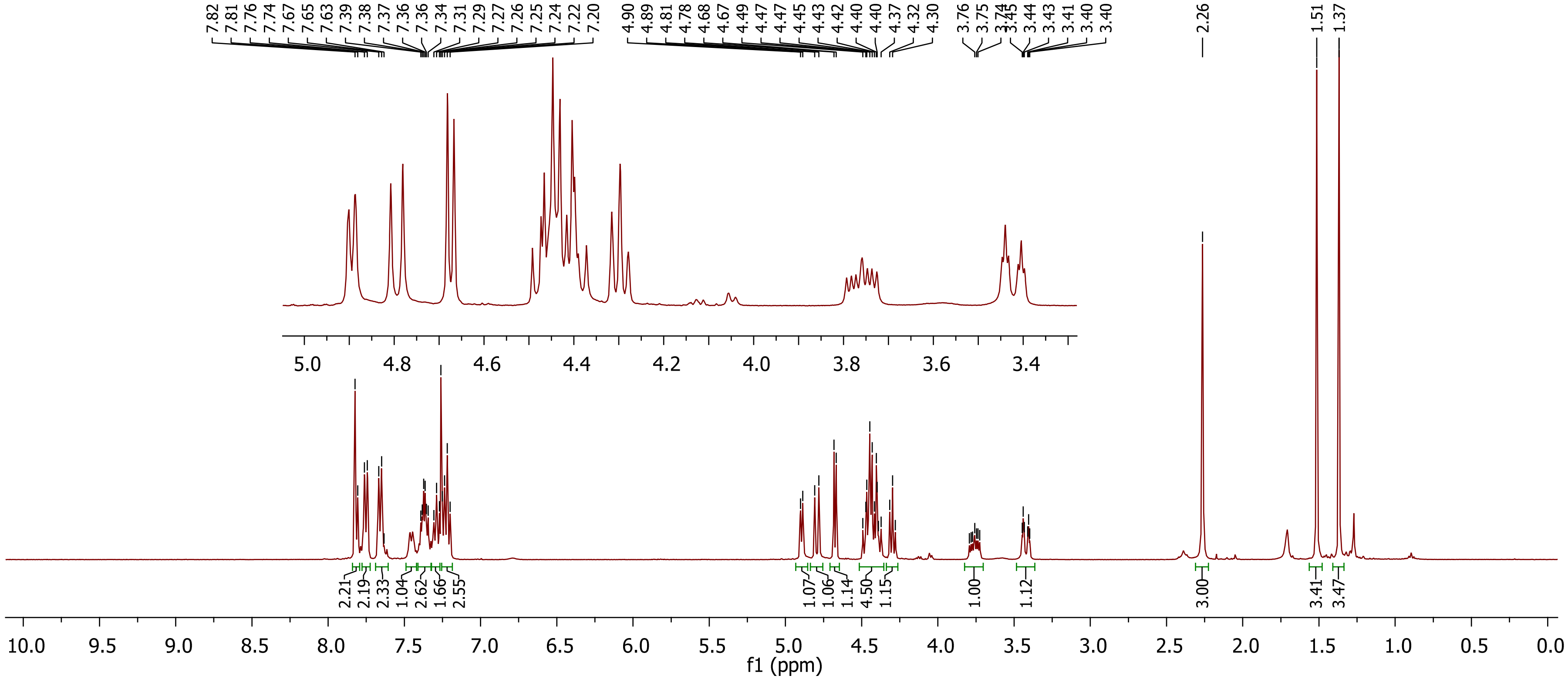
$CDCl_3$, 100 MHz

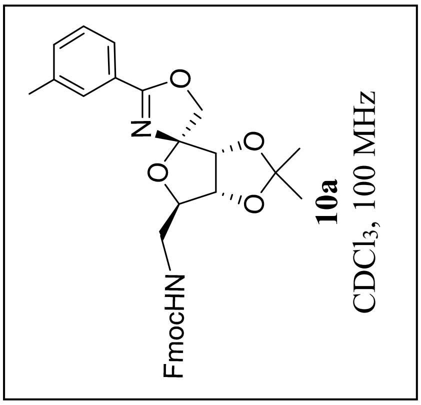




10a

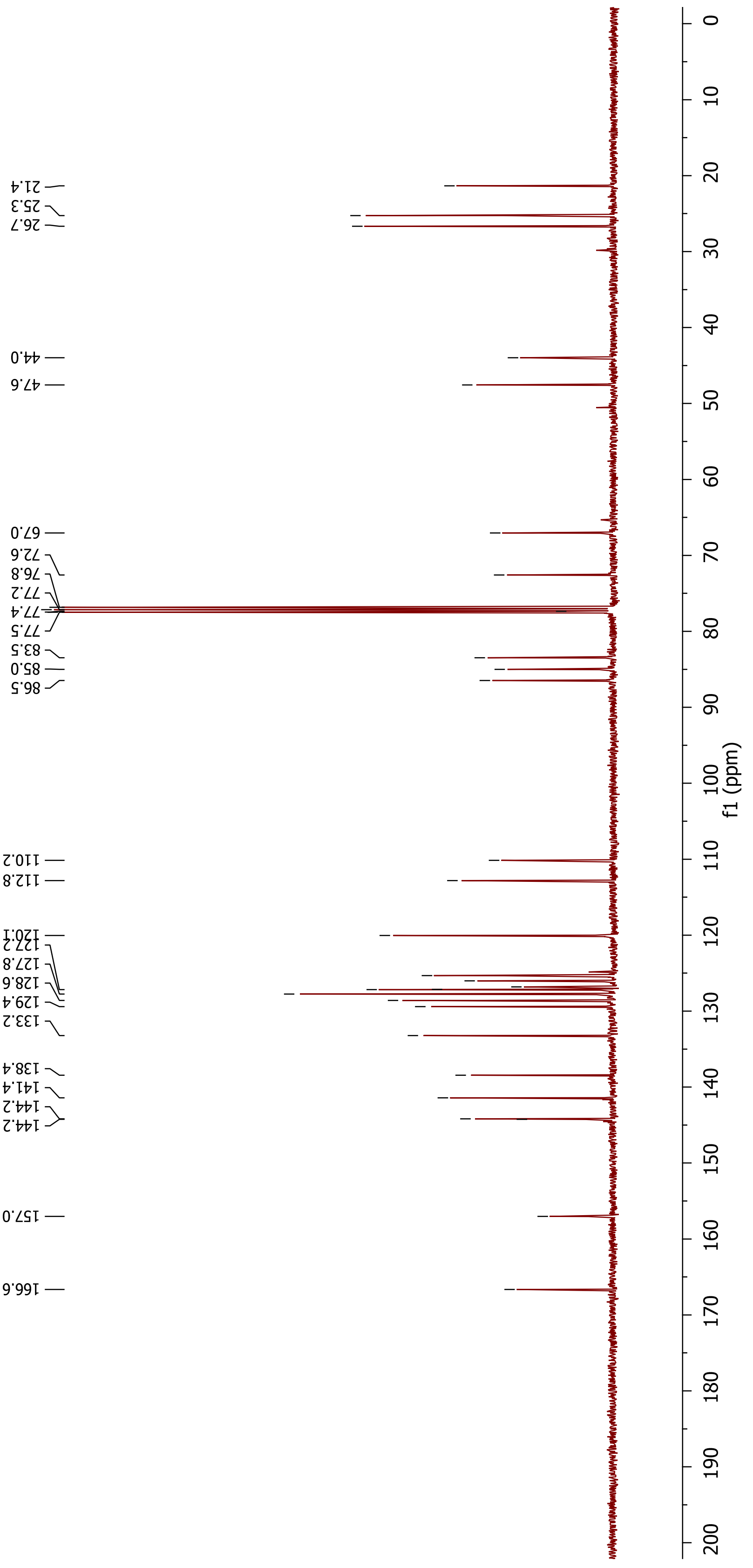
CDCl$_3$, 400 MHz

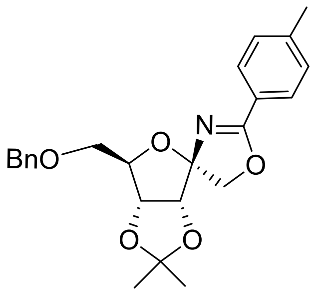




10a

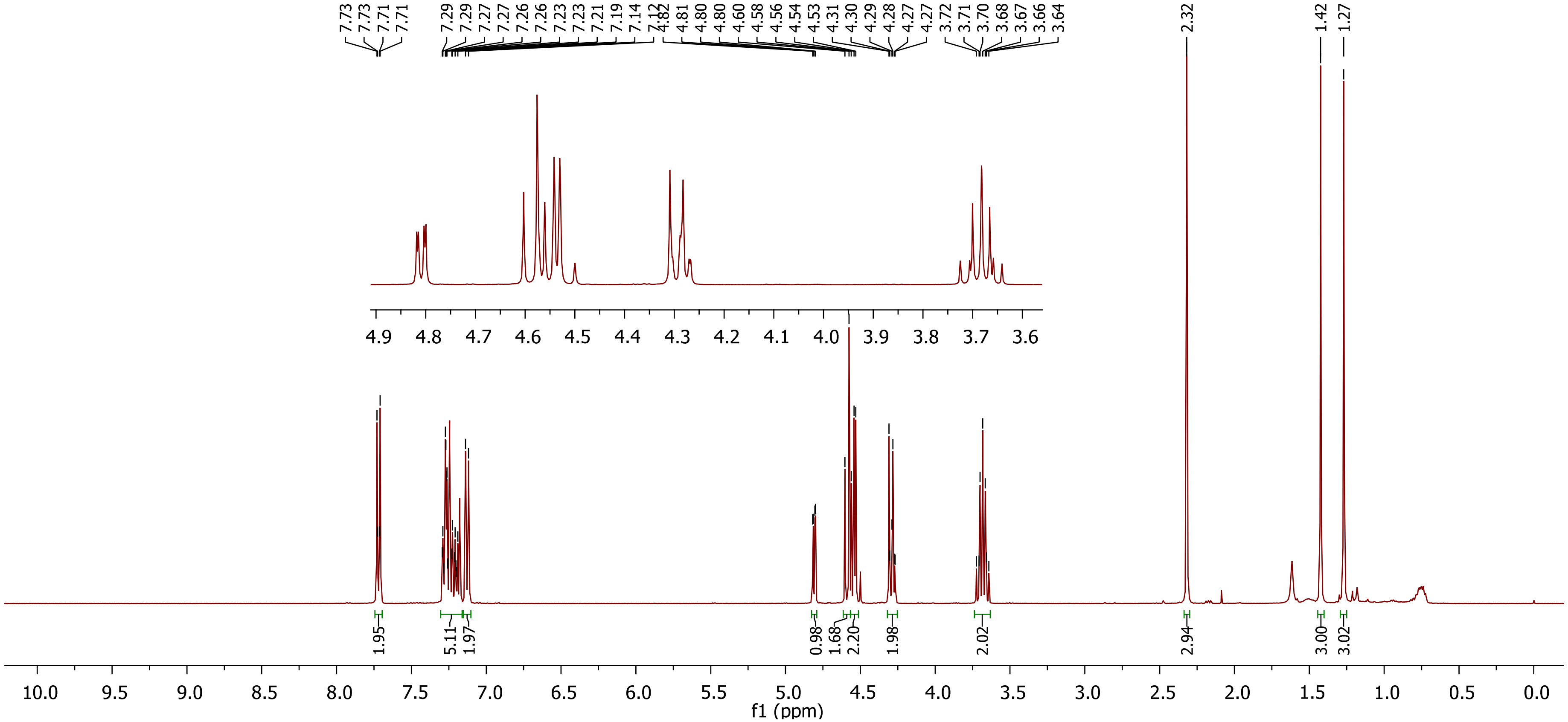
CDCl$_3$, 100 MHz

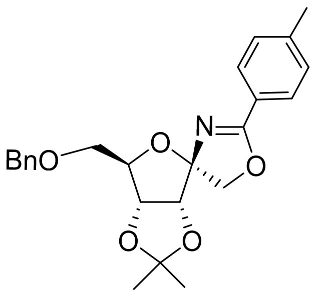




11a

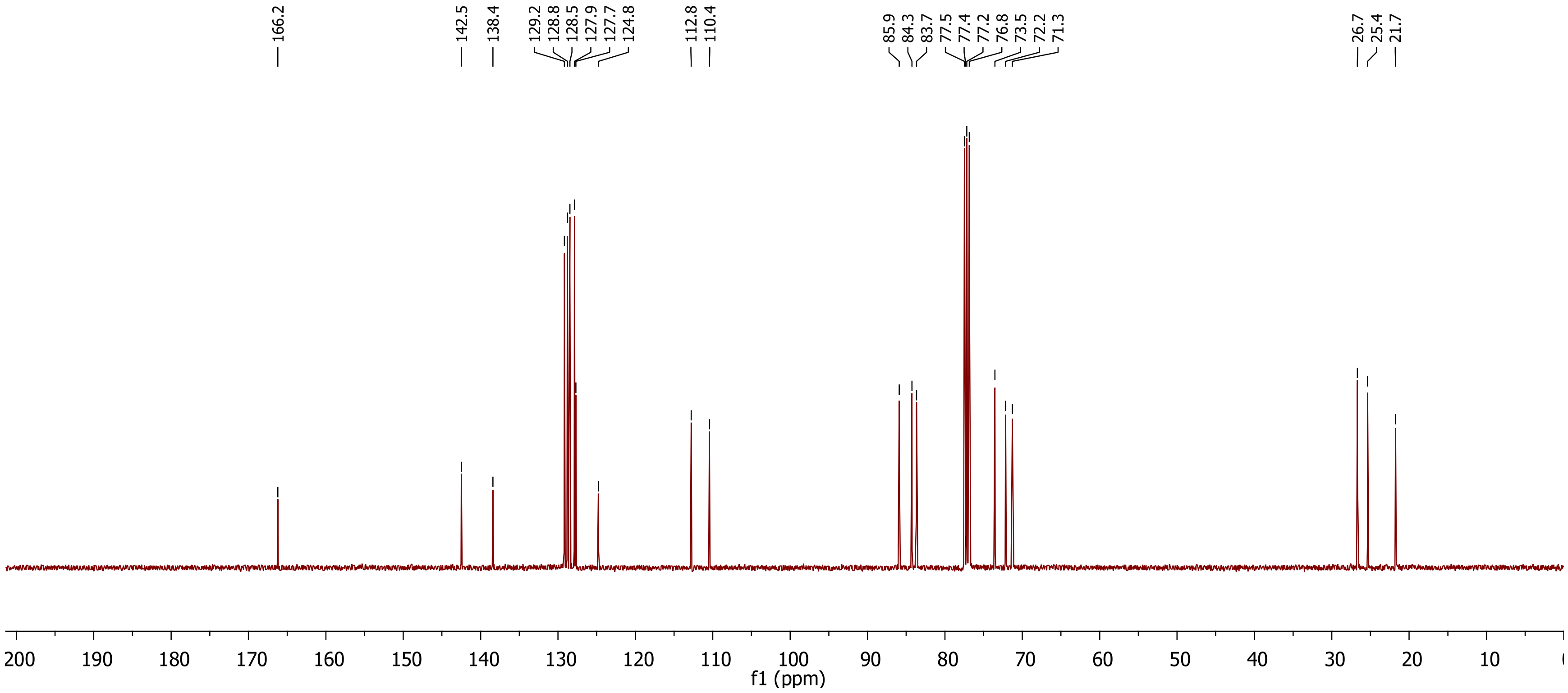
$CDCl_3$, 400 MHz

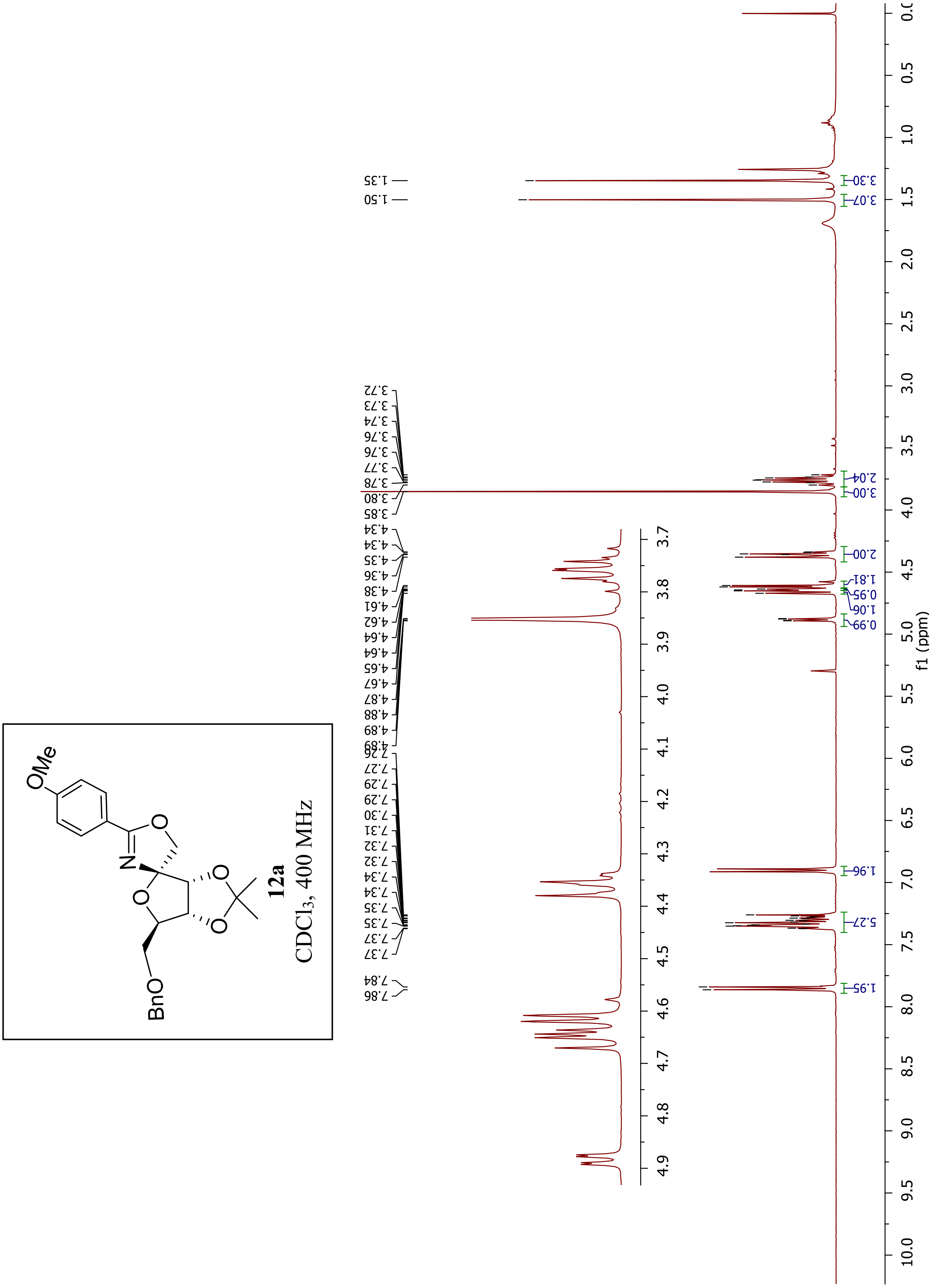


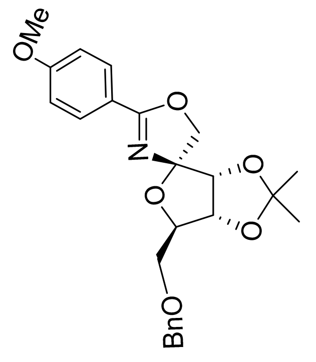


11a

CDCl$_3$, 100 MHz

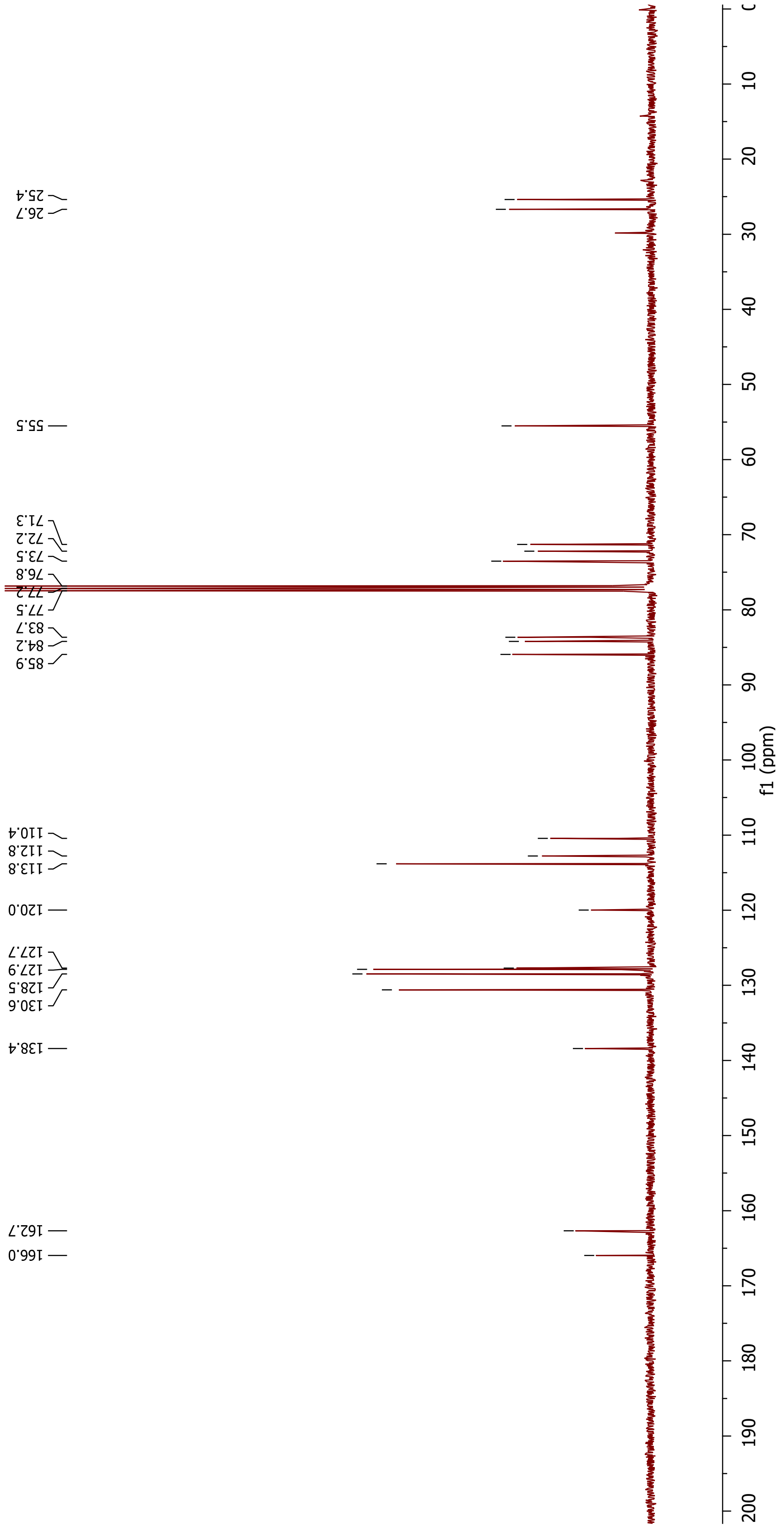


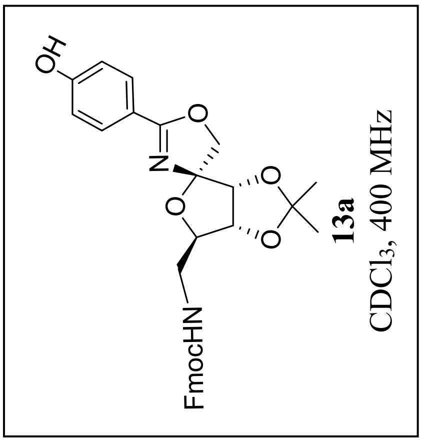

OMe
BnO
N
O
12a
CDCl3, 400 MHz
1.35
1.50
3.72
3.73
3.74
3.76
3.76
3.77
3.78
3.80
3.85
4.34
4.34
4.35
4.36
4.38
4.61
4.62
4.64
4.64
4.65
4.67
4.87
4.88
4.89
4.89
7.26
7.27
7.29
7.29
7.30
7.31
7.32
7.32
7.34
7.34
7.35
7.35
7.37
7.37
7.84
7.86
3.30
3.07
2.04
3.00
2.00
1.81
0.95
1.06
0.99
1.96
5.27
1.95
3.7
3.8
3.9
4.0
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
f1 (ppm)



12a

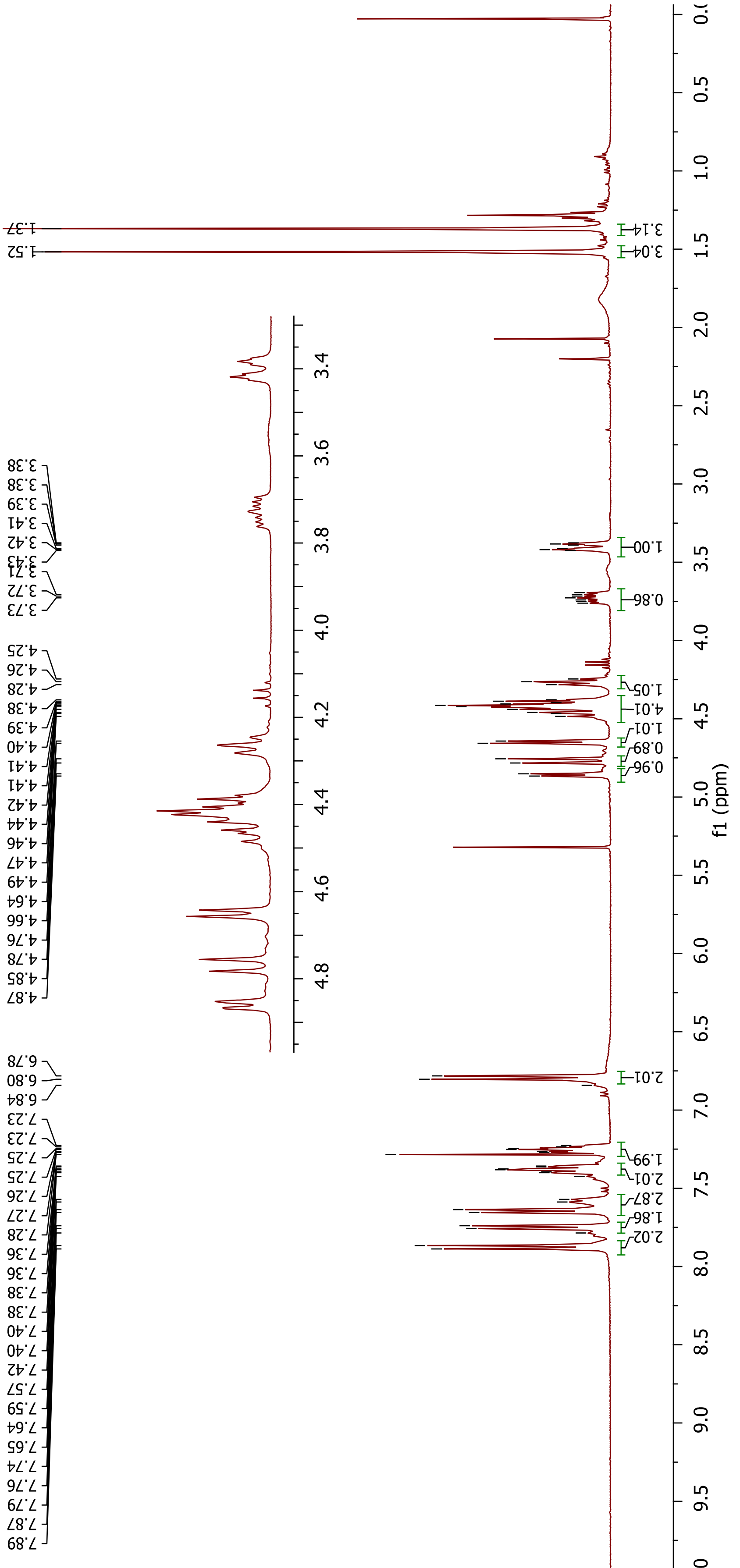
CDCl$_3$, 100 MHz

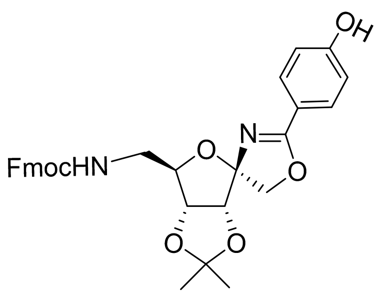




13a

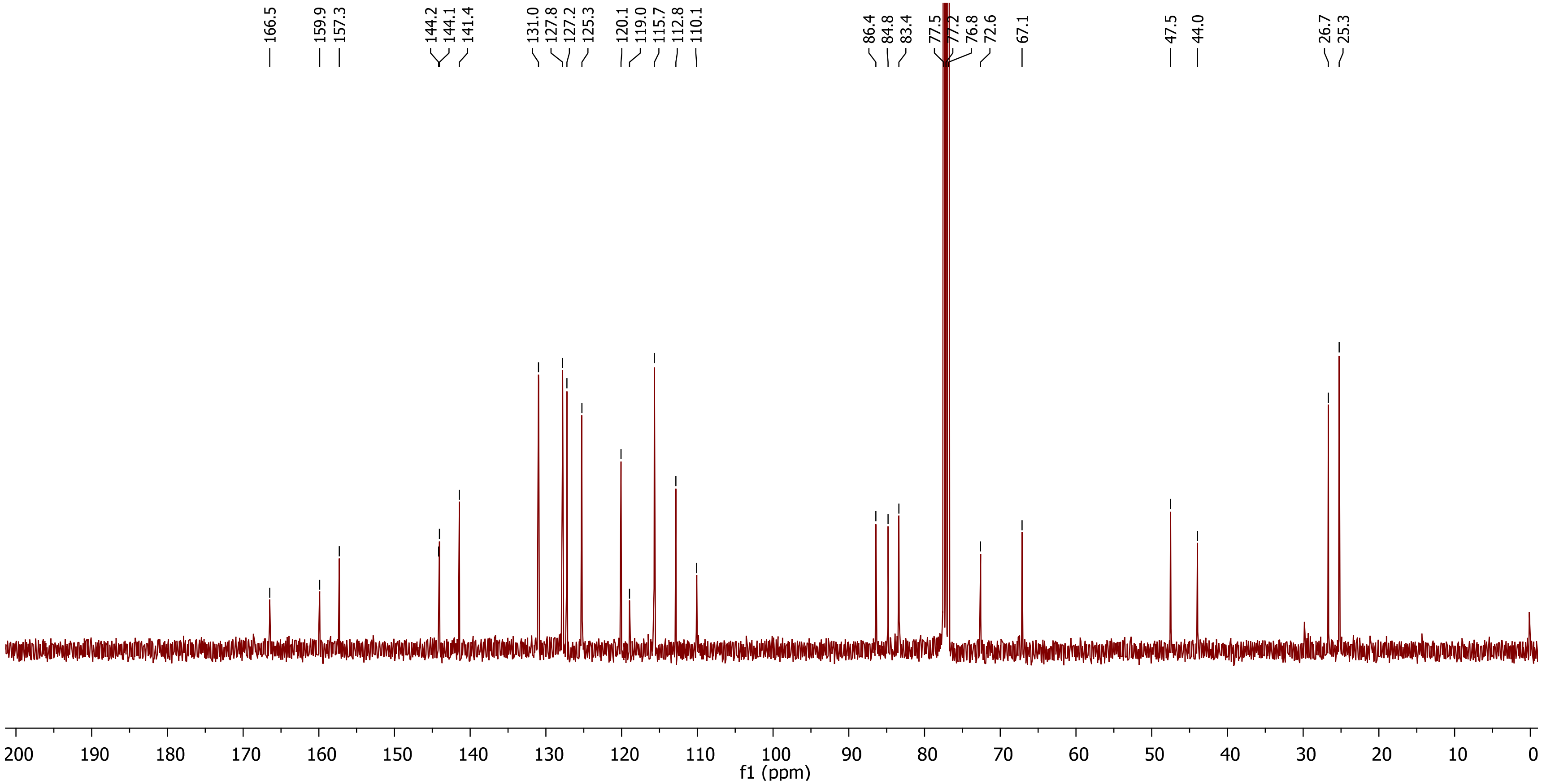
$CDCl_3$, 400 MHz

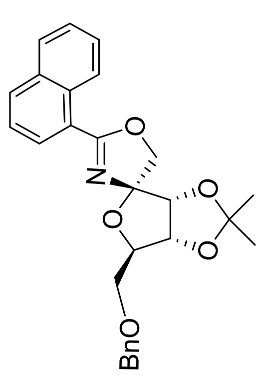




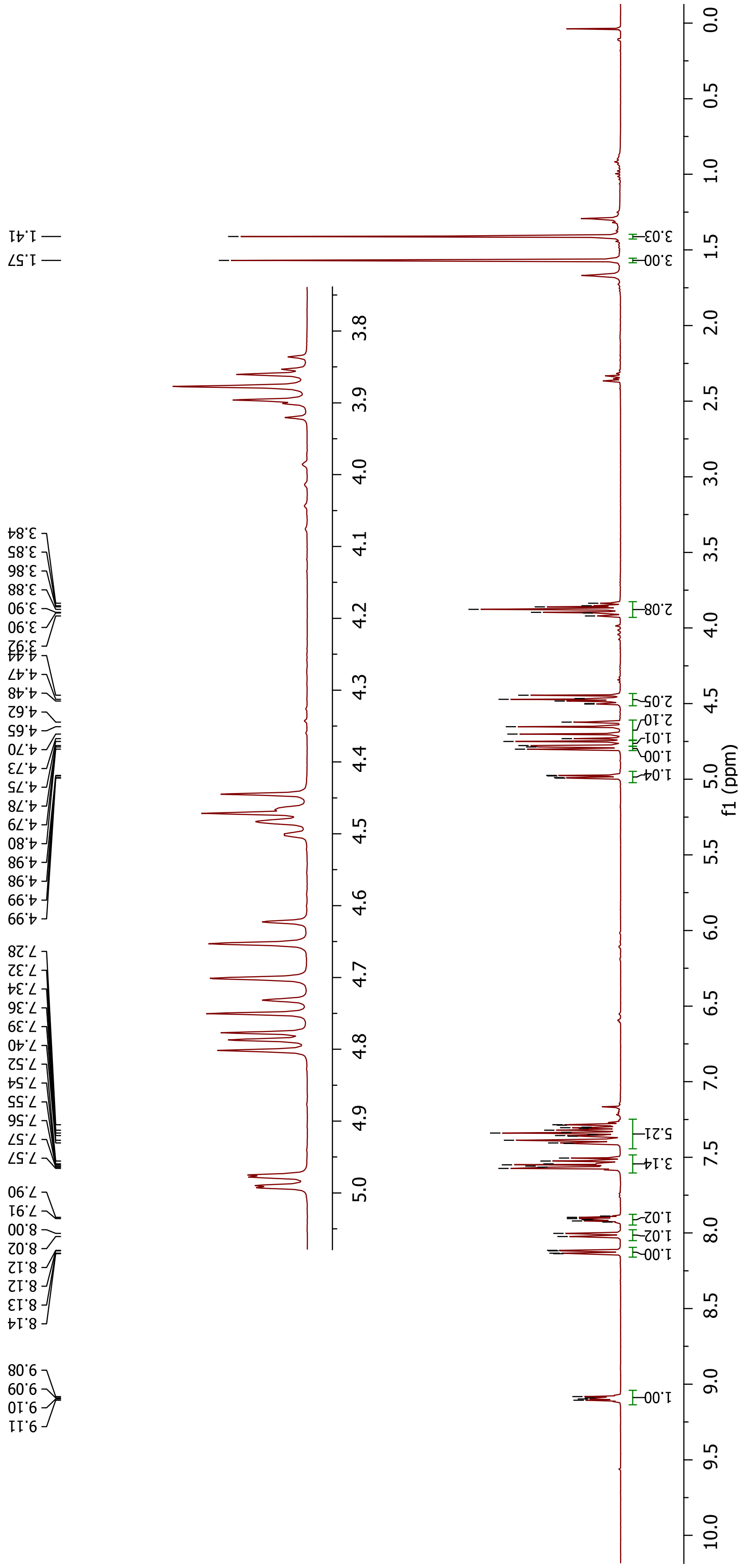
13a

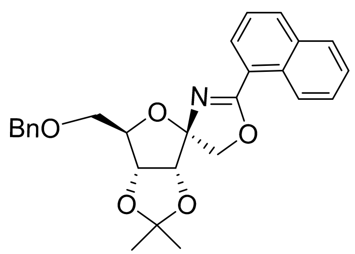
CDCl$_3$, 100 MHz





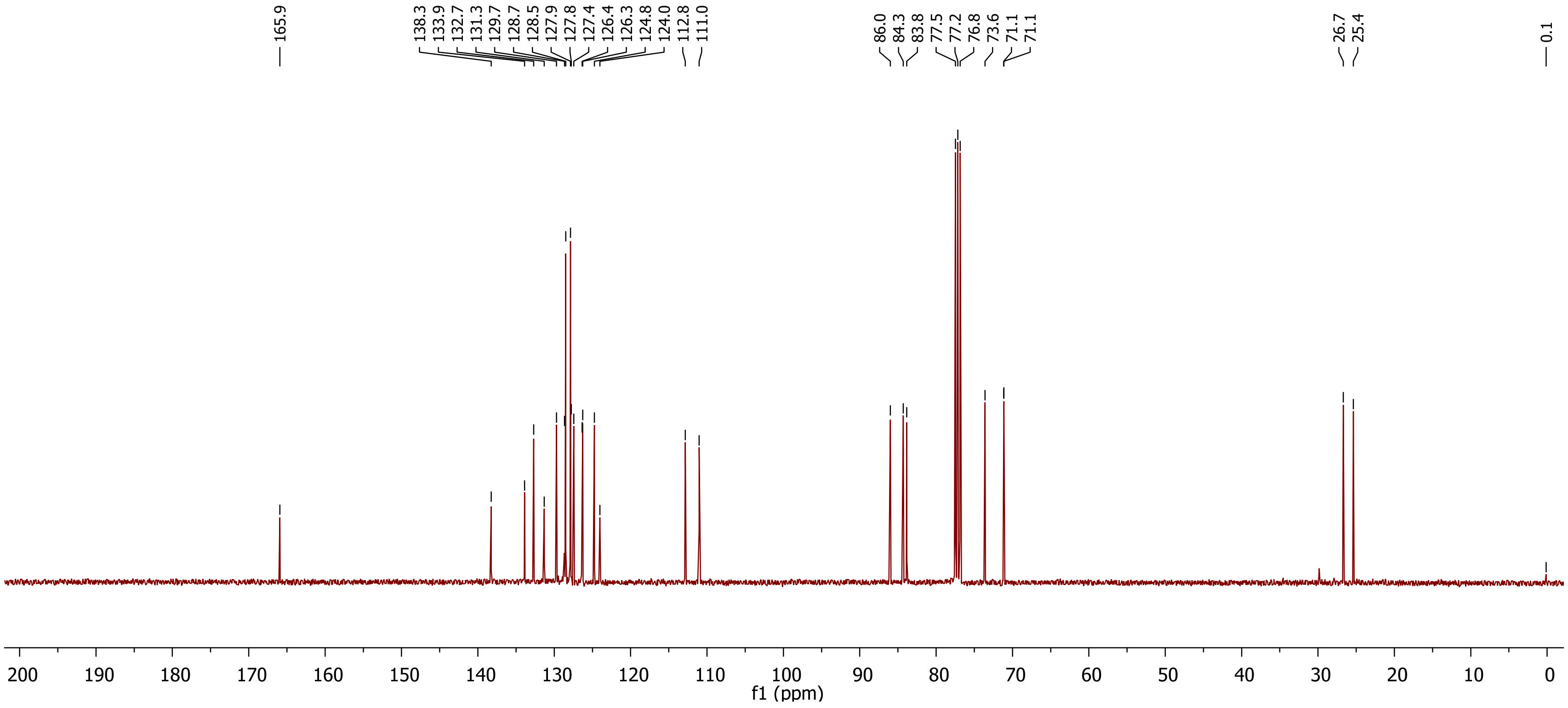
14a
CDCl$_3$, 400 MHz

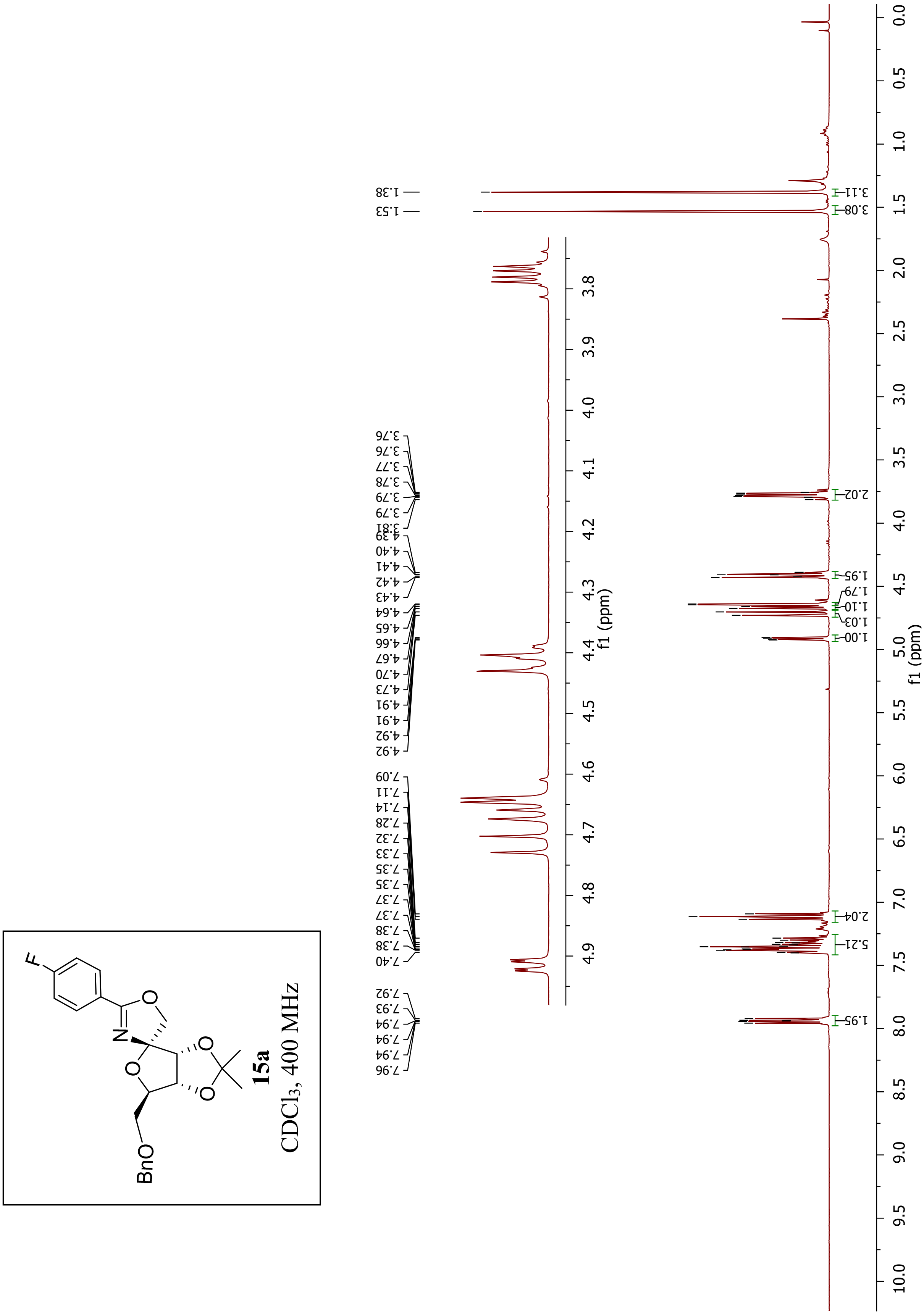




14a

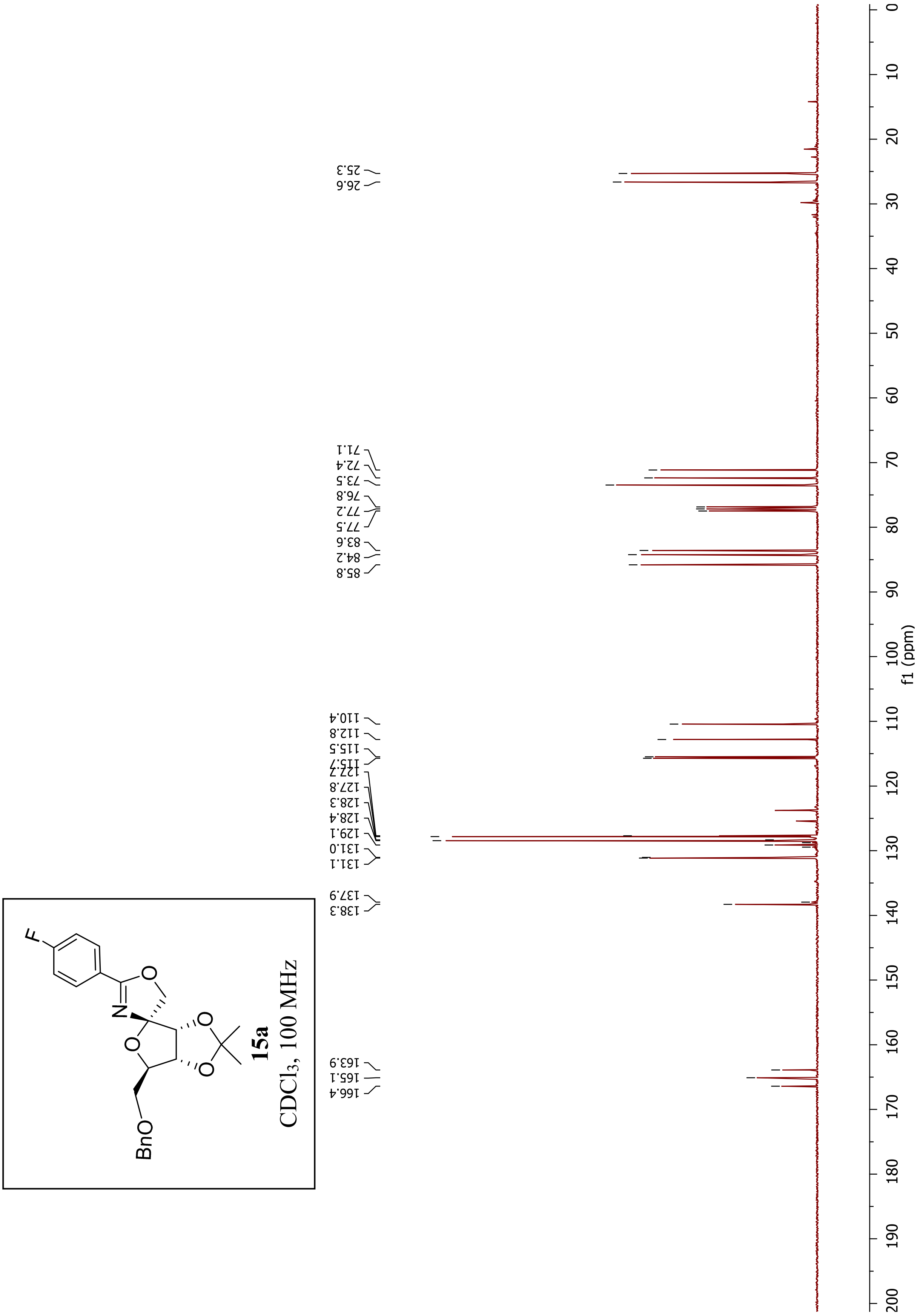
CDCl$_3$, 100 MHz





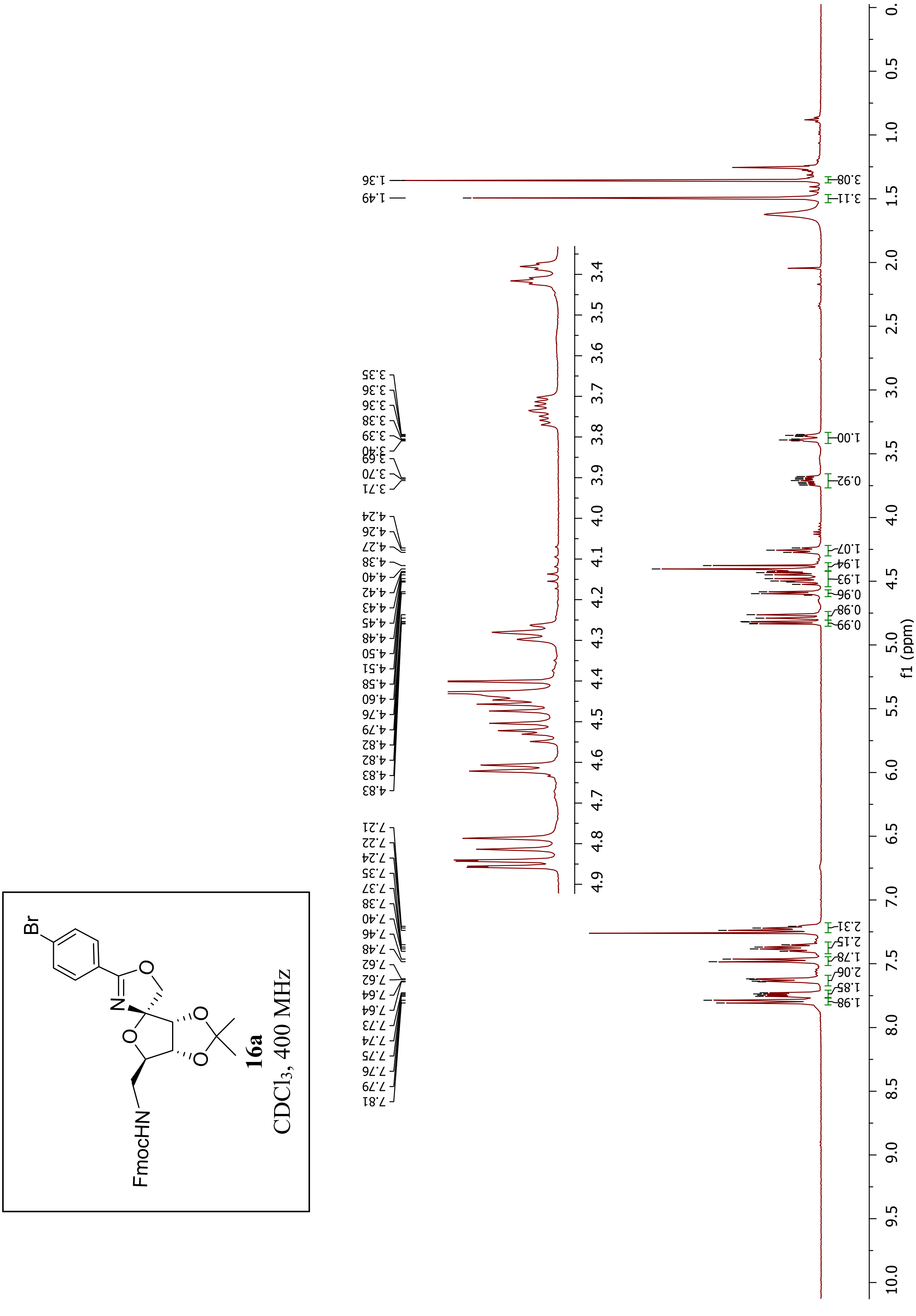
15a

CDCl$_3$, 400 MHz



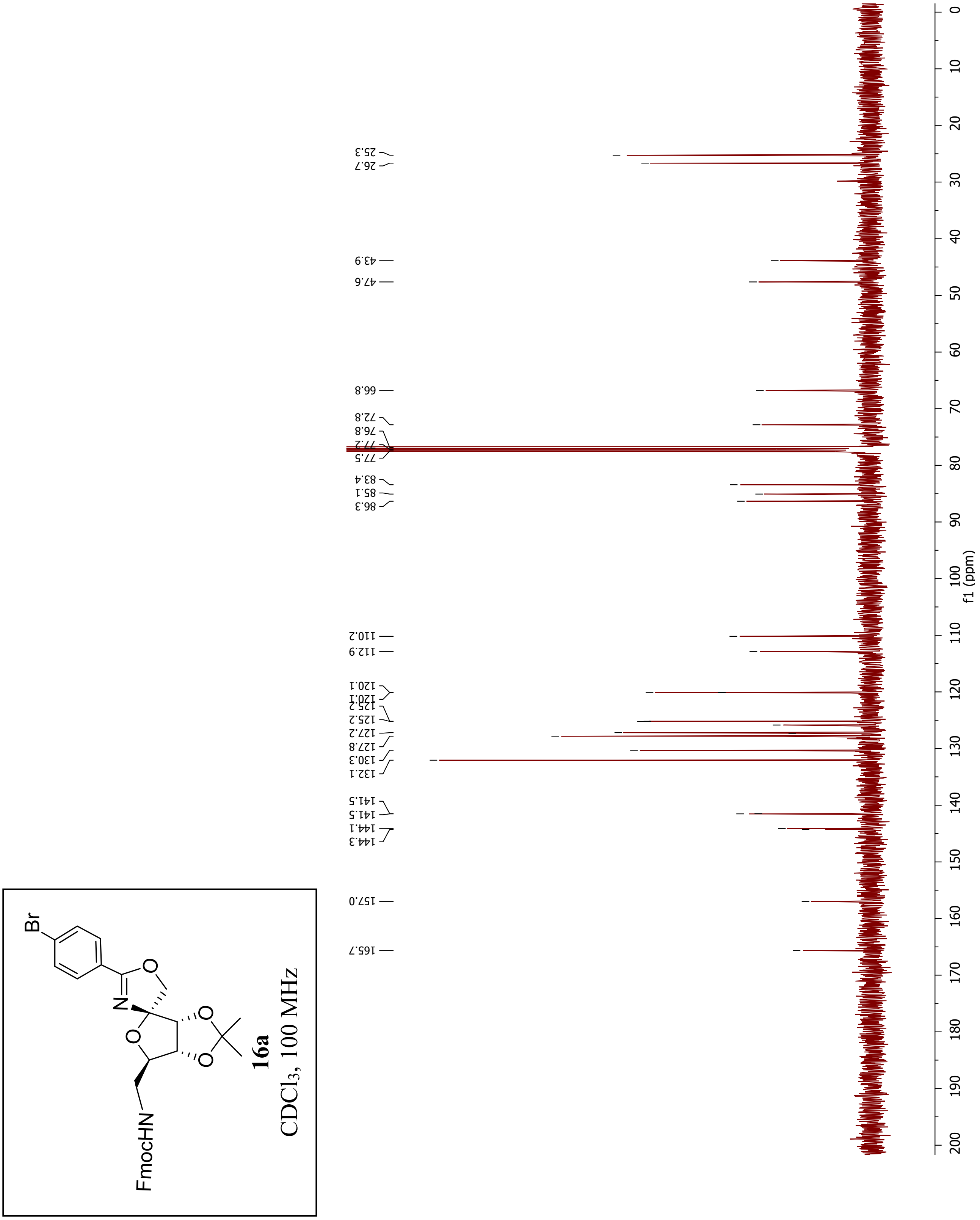
15a

CDCl$_3$, 100 MHz



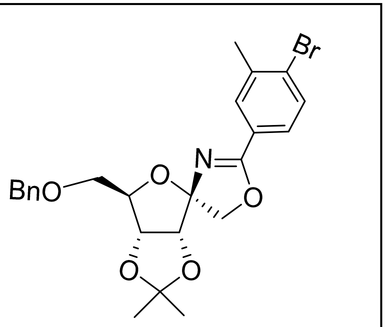
16a

$CDCl_3$, 400 MHz



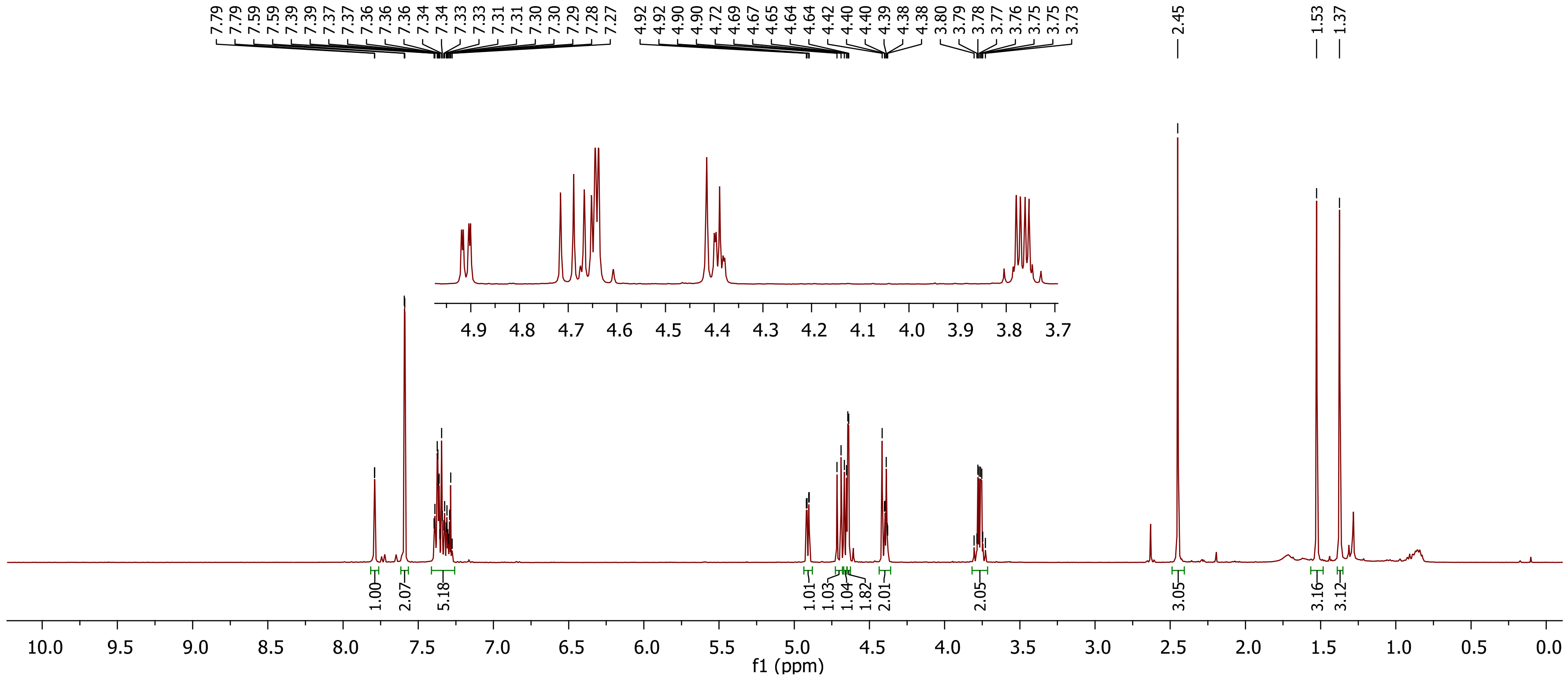
16a

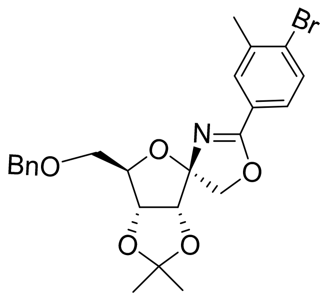
$CDCl_3$, 100 MHz



17a

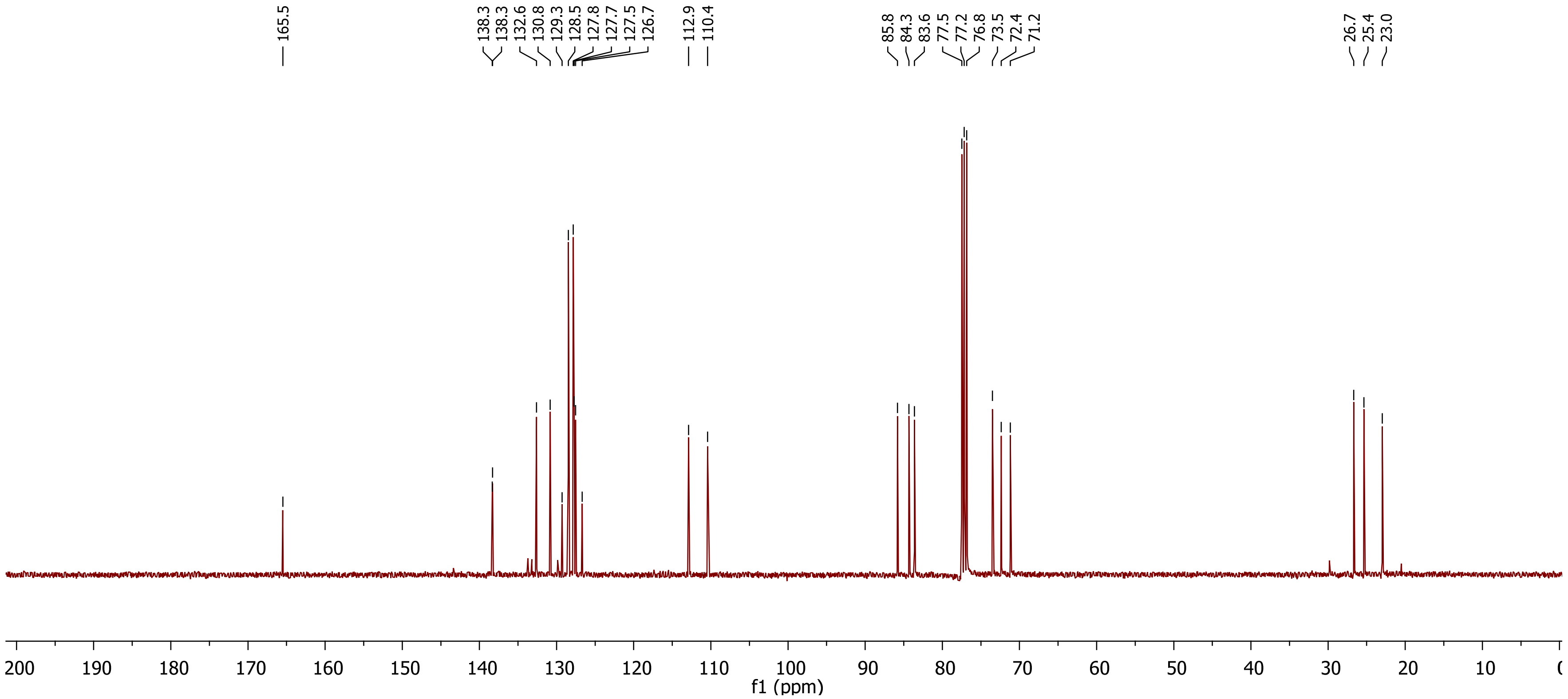
CDCl$_3$, 400 MHz

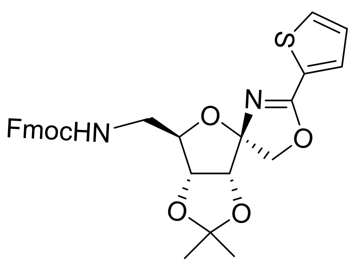




17a

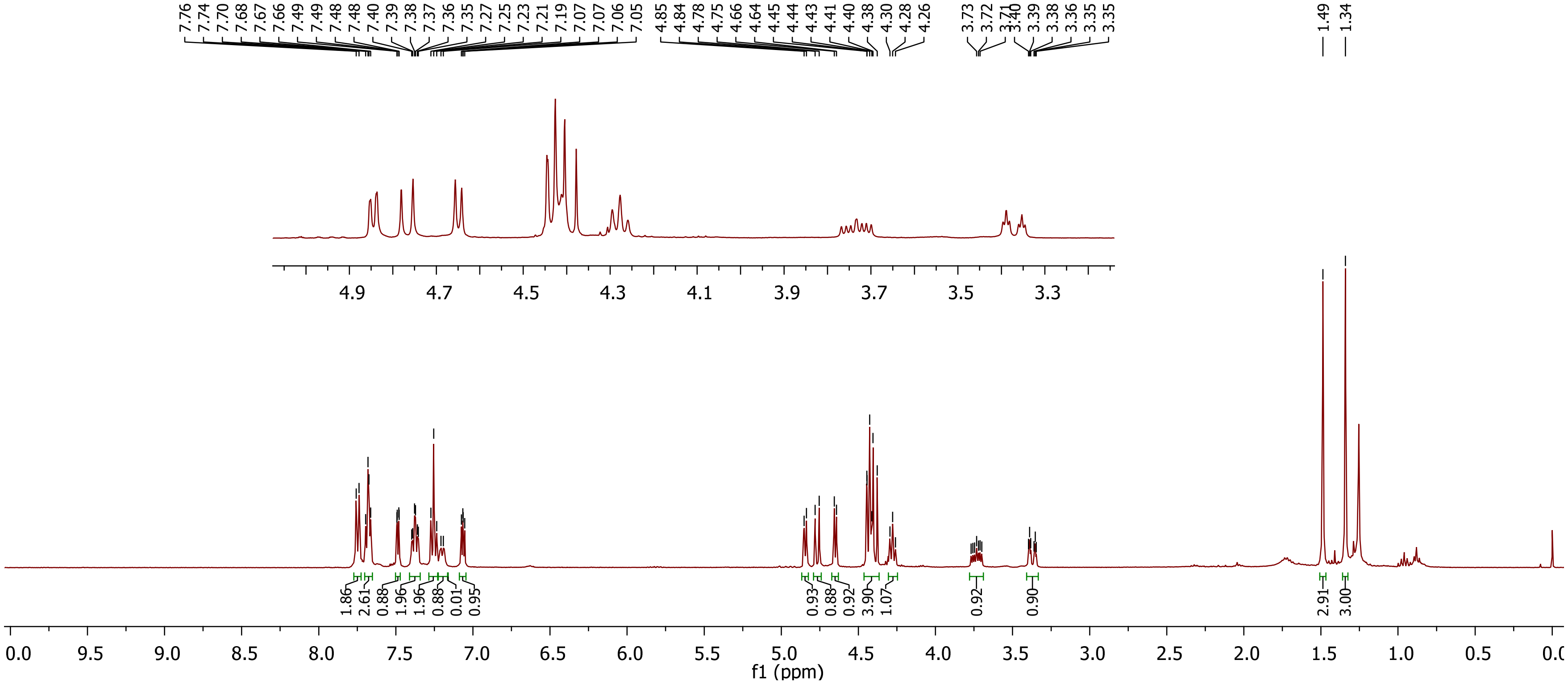
CDCl$_3$, 100 MHz

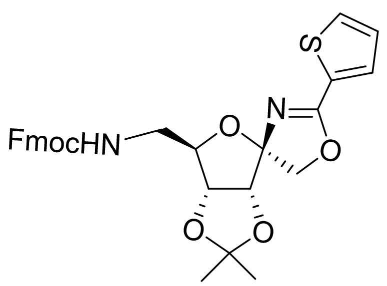




18a

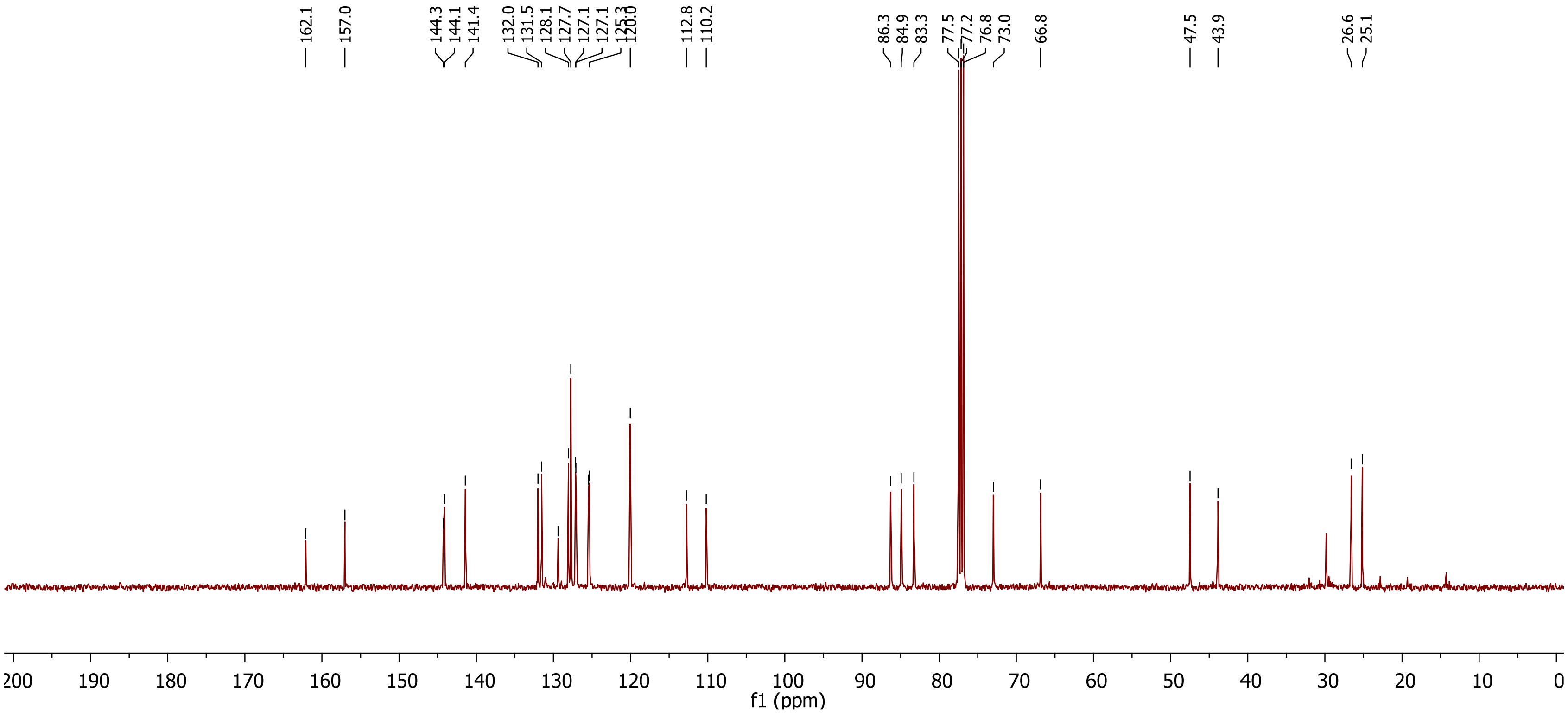
$CDCl_3$, 400 MHz

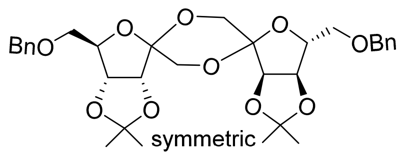




18a

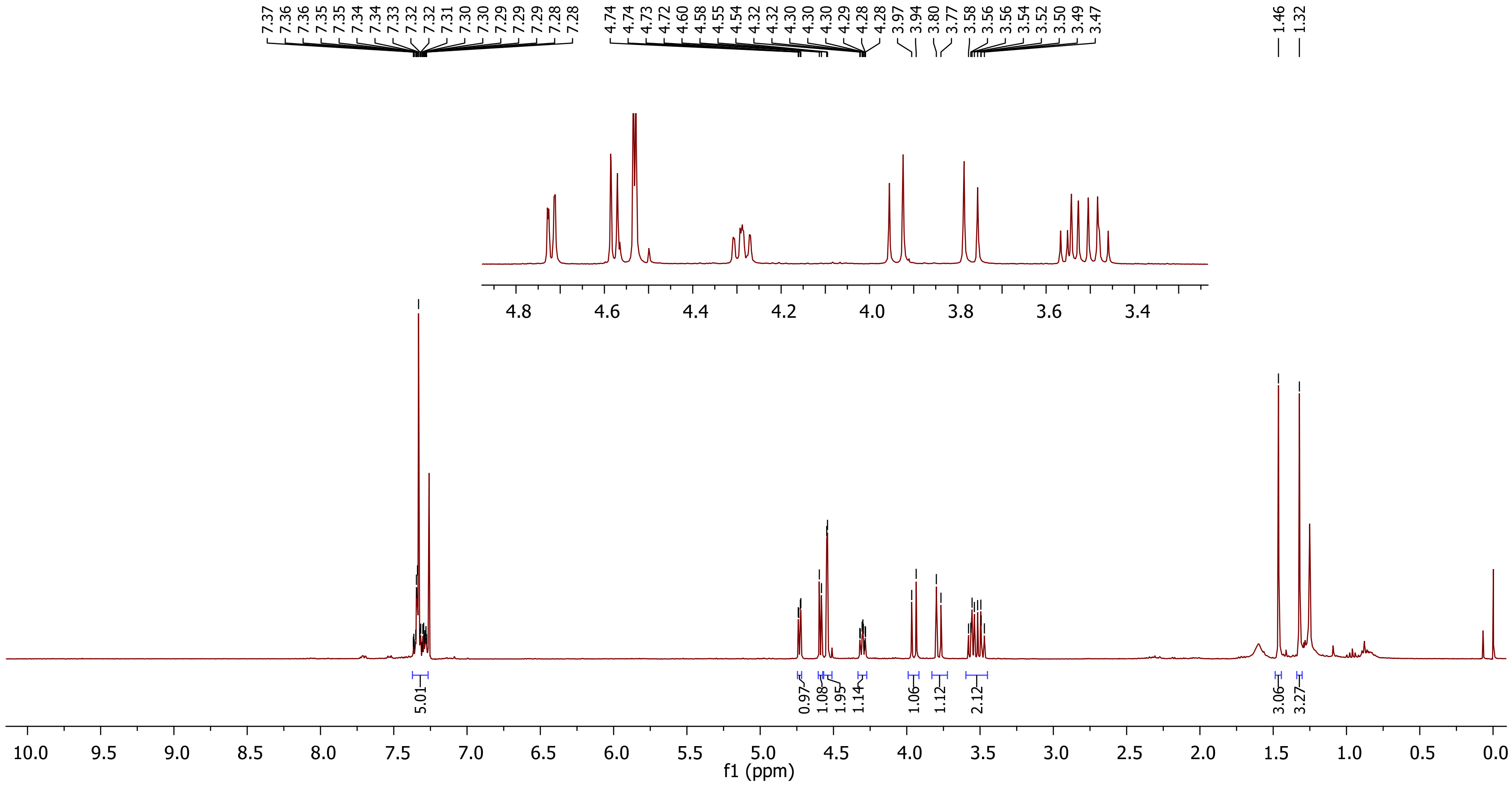
$CDCl_3$, 100 MHz

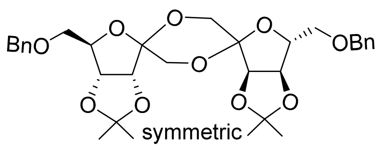




3ab

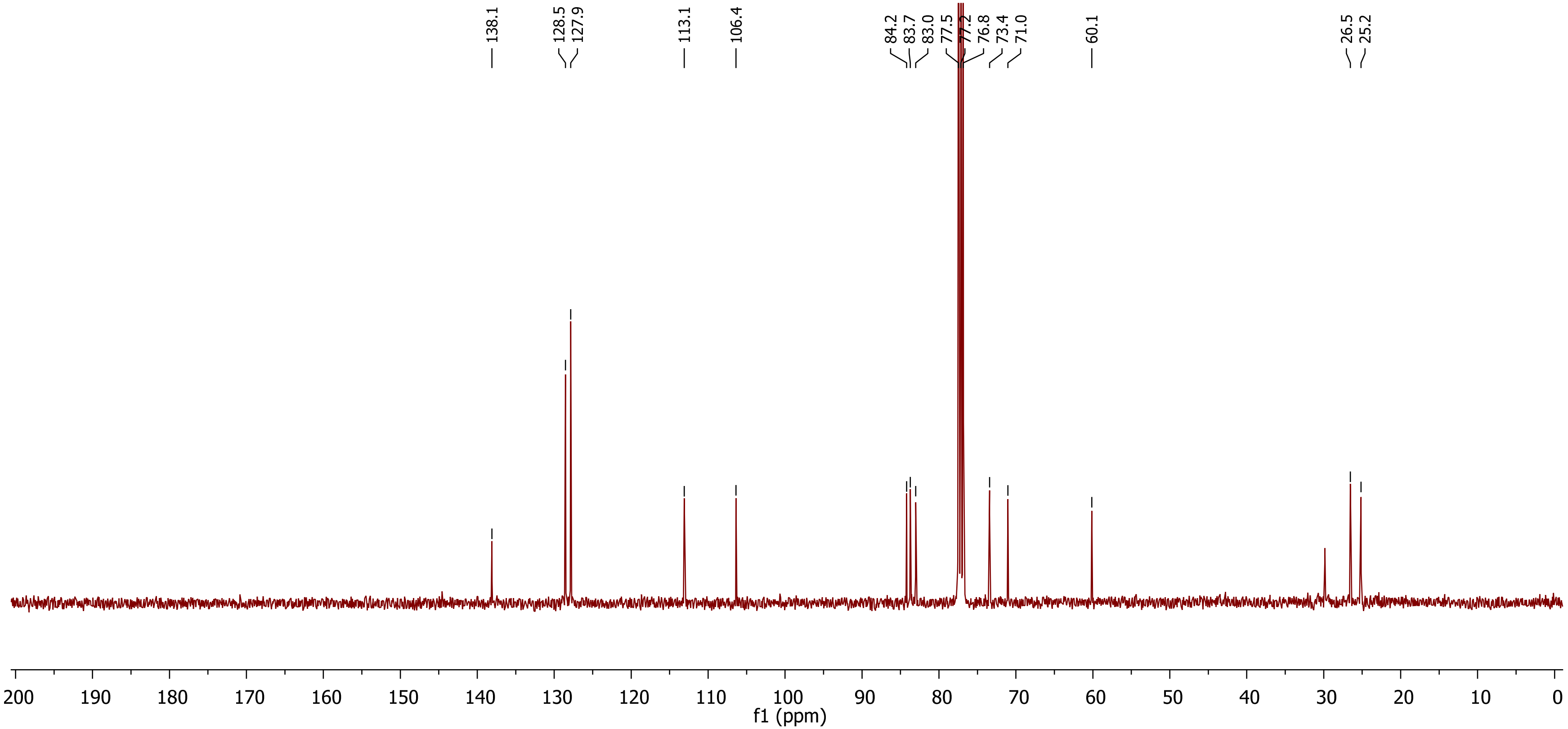
CDCl$_3$, 400 MHz

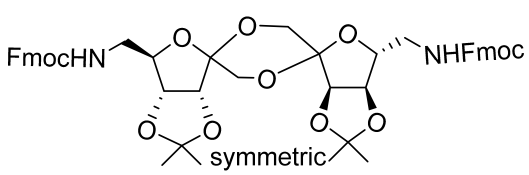




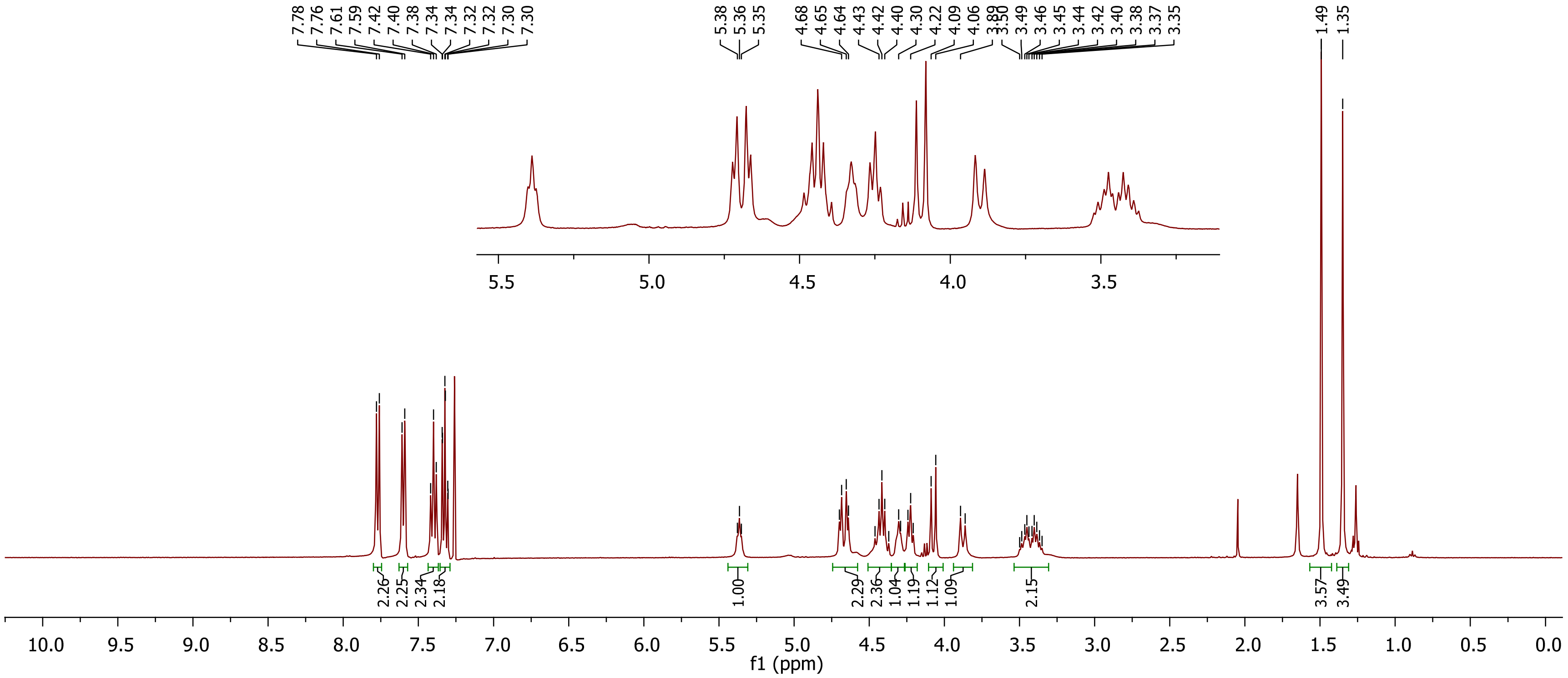
3ab

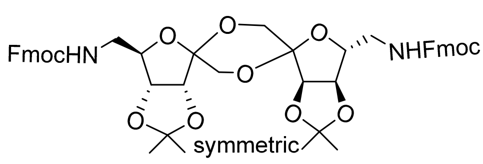
$CDCl_3$, 100 MHz



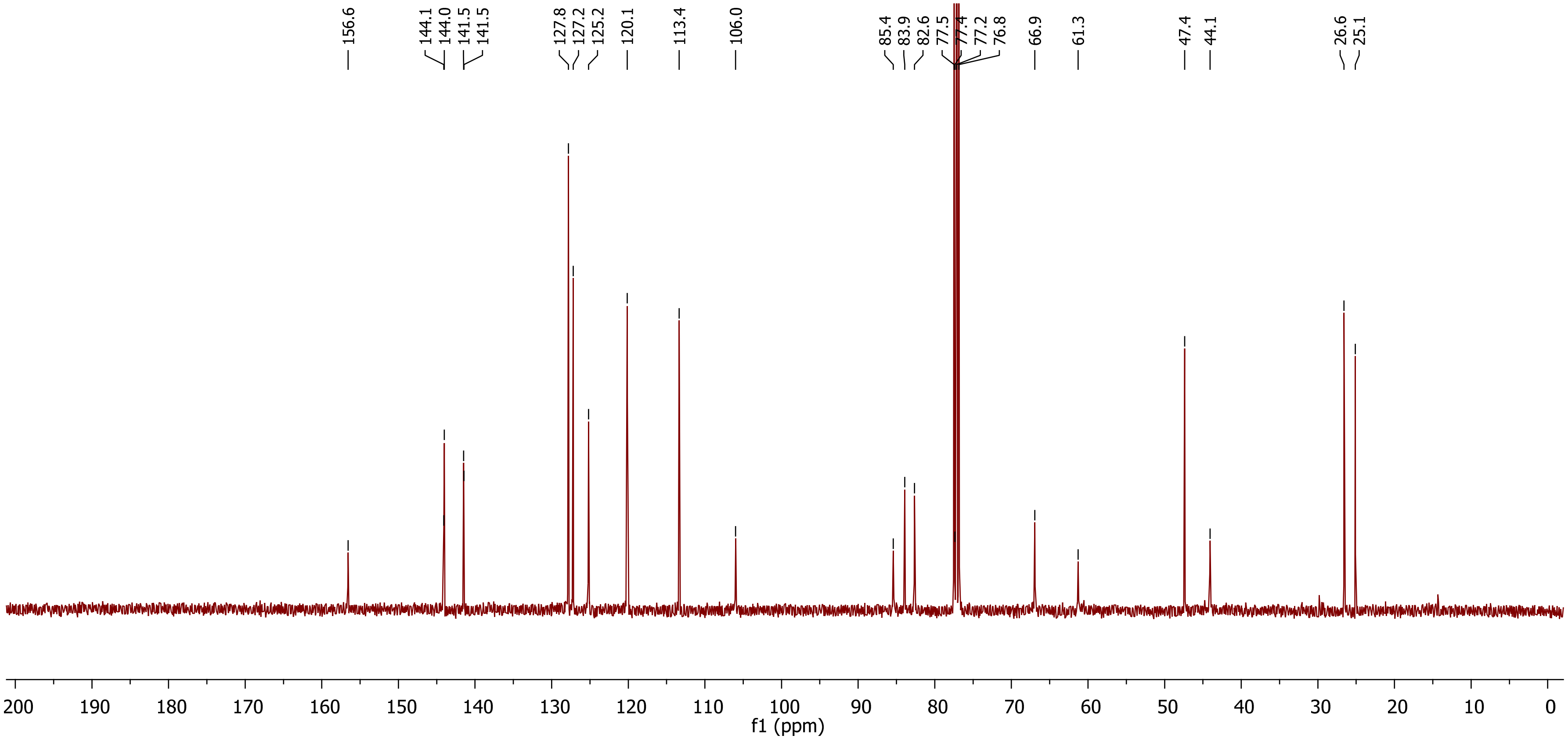


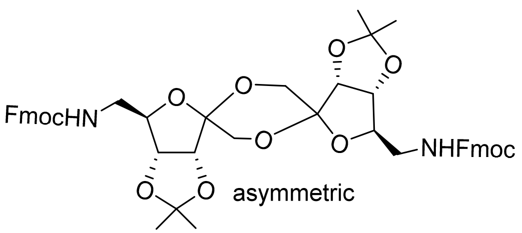
5ab, $CDCl_3$, 400 MHz



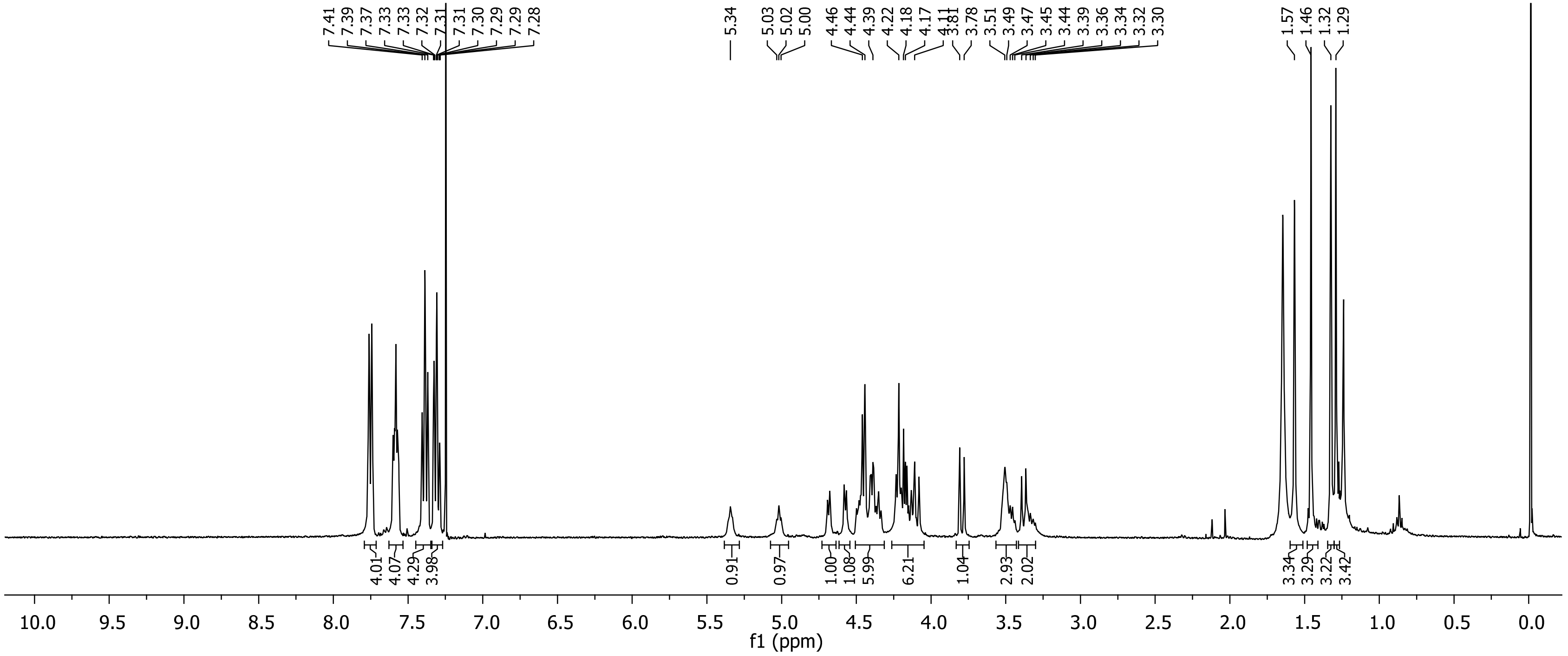


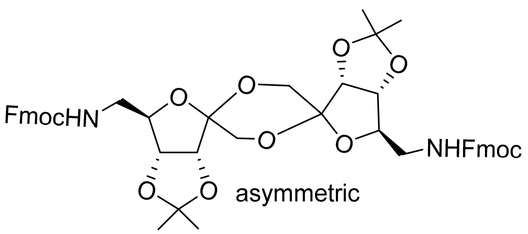
5ab, CDCl$_3$, 100 MHz



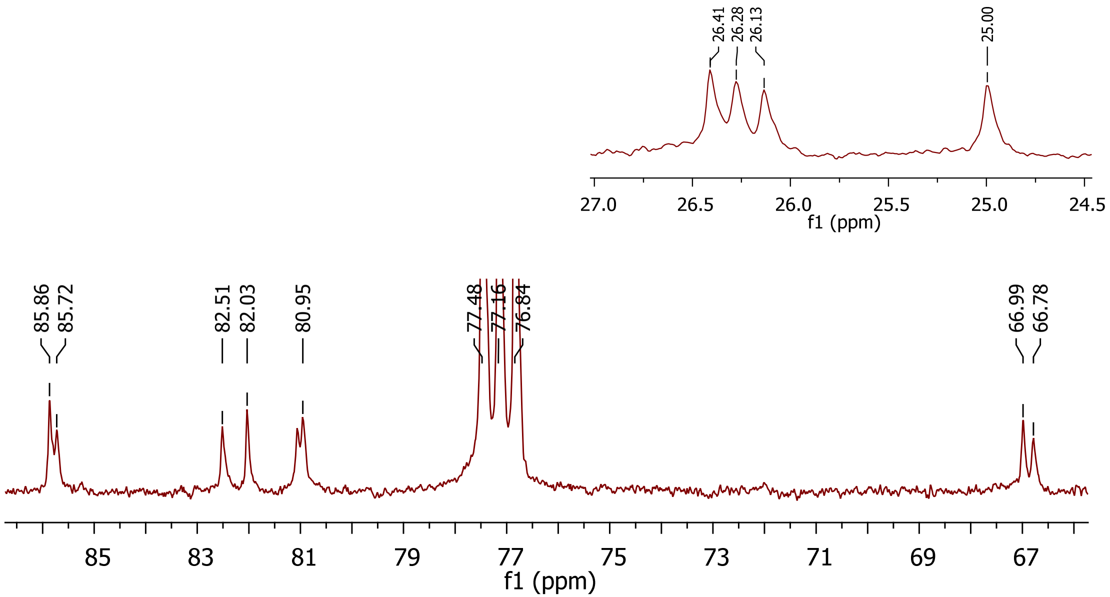


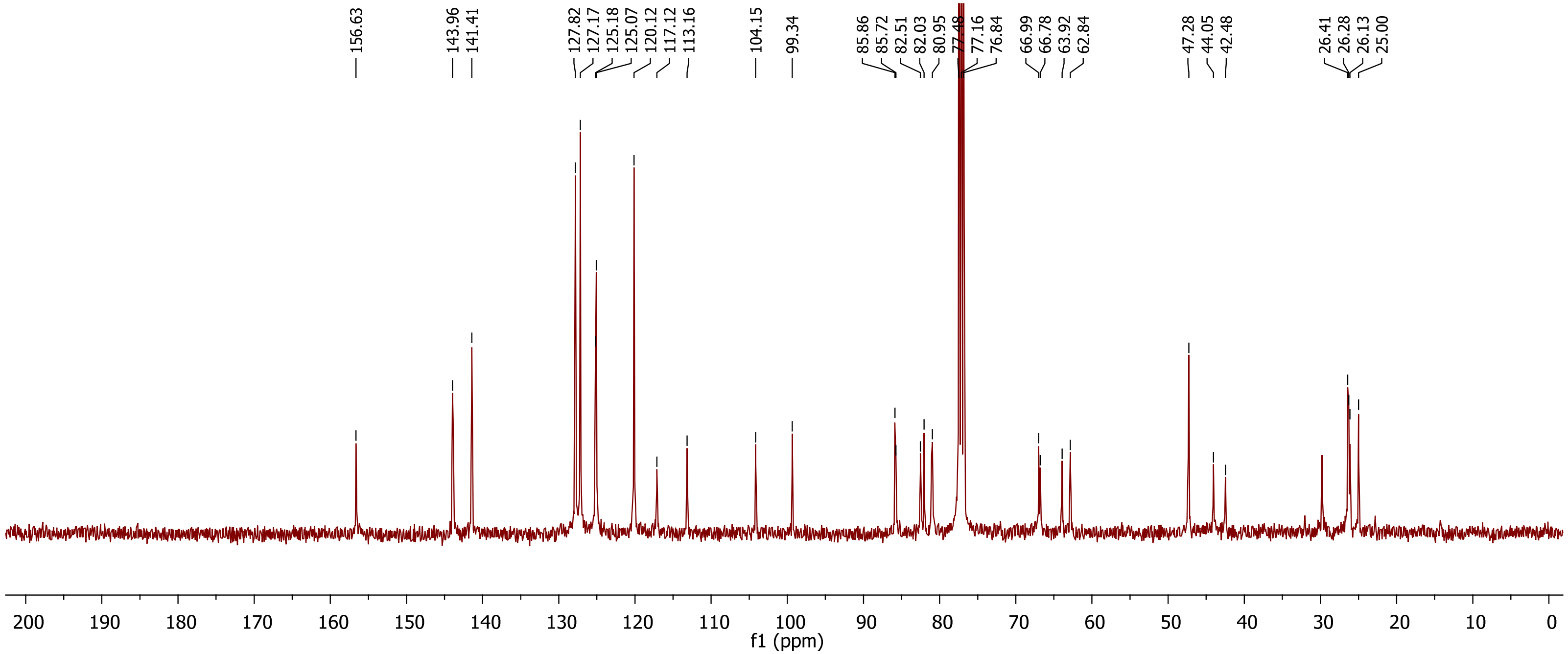
5ac, $CDCl_3$, 400 MHz



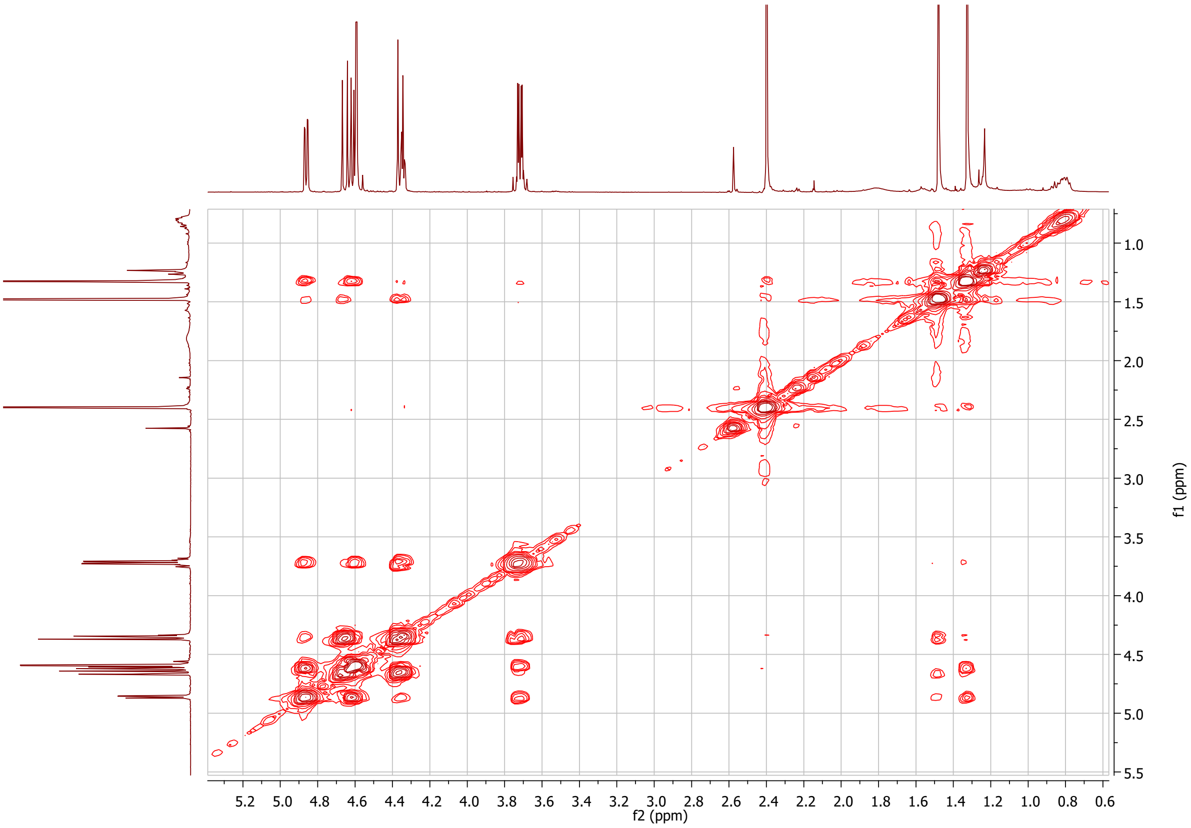


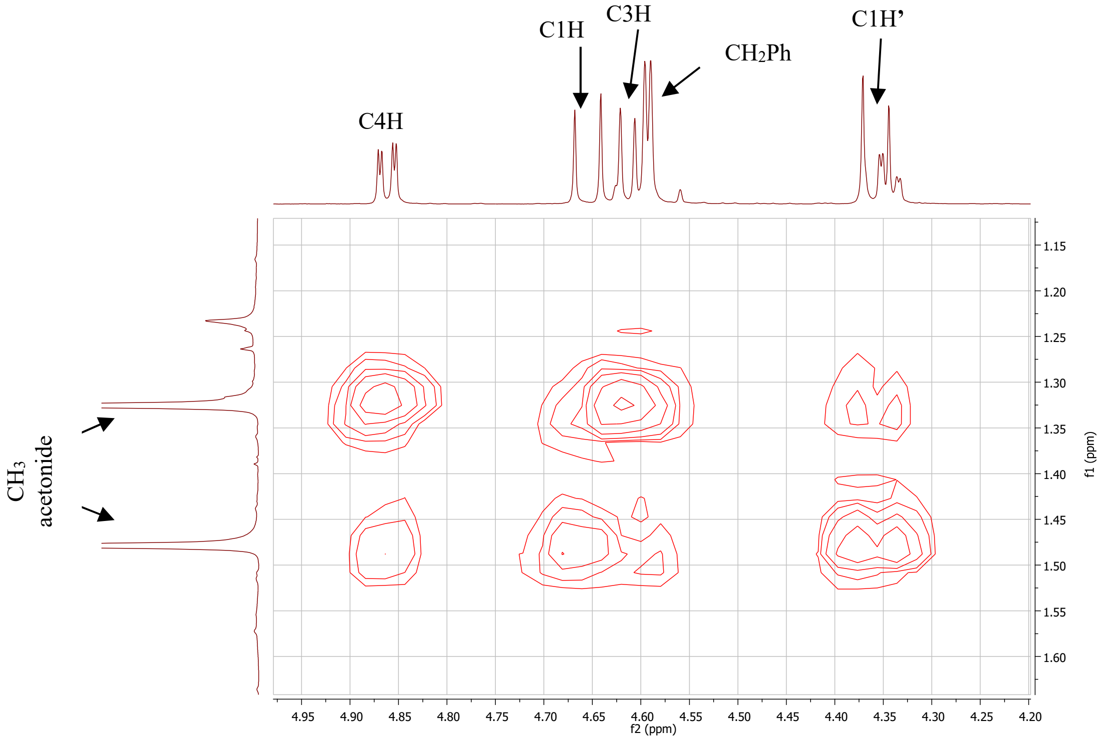
5ac, $CDCl_3$, 100 MHz



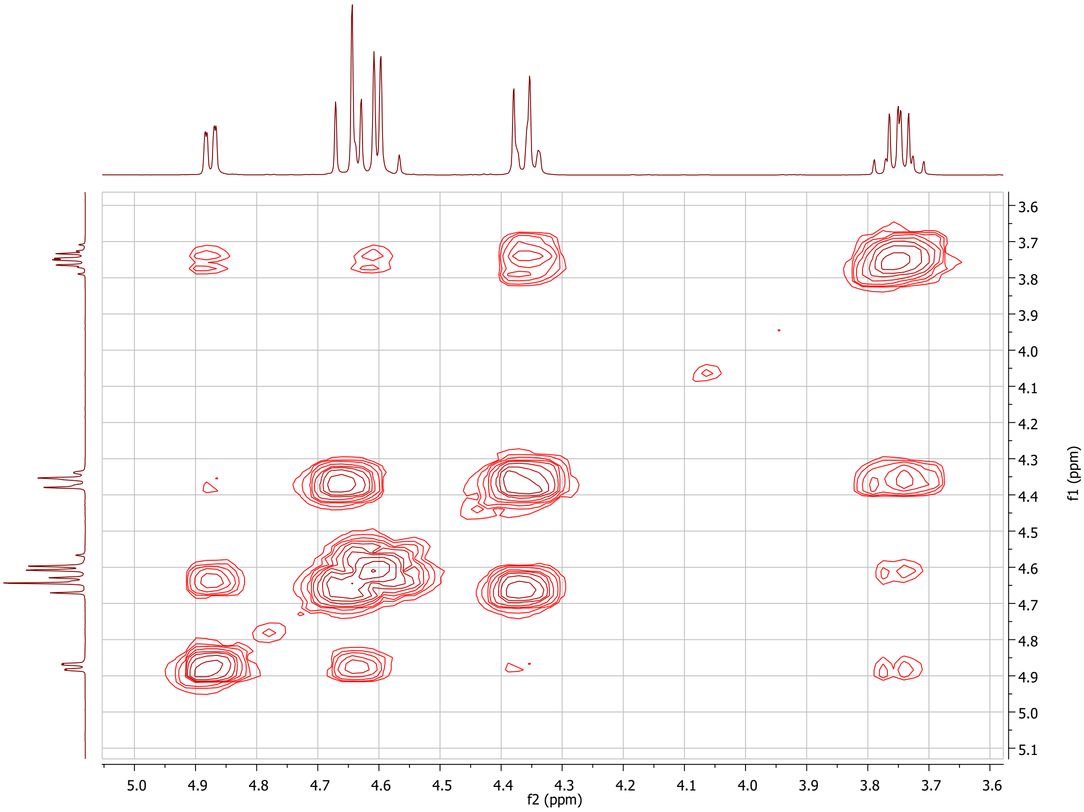


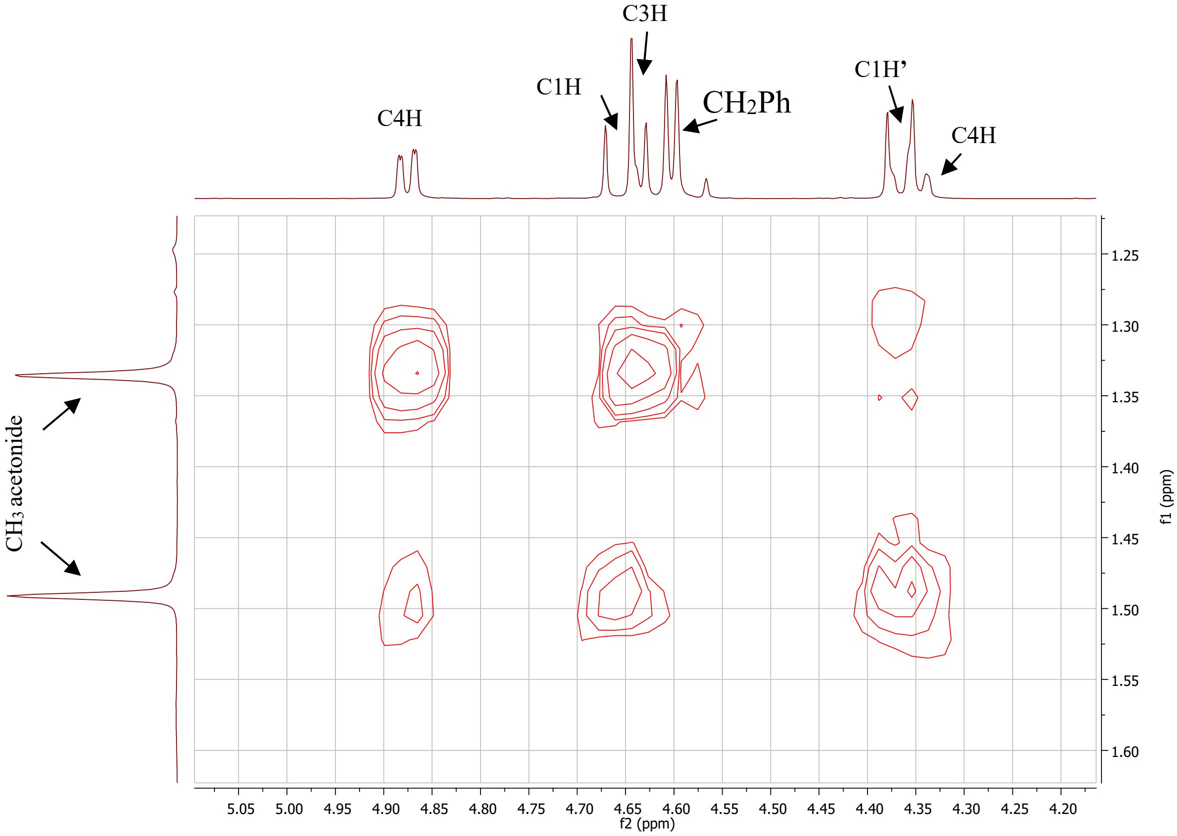
NOESY Spectra of **17a**

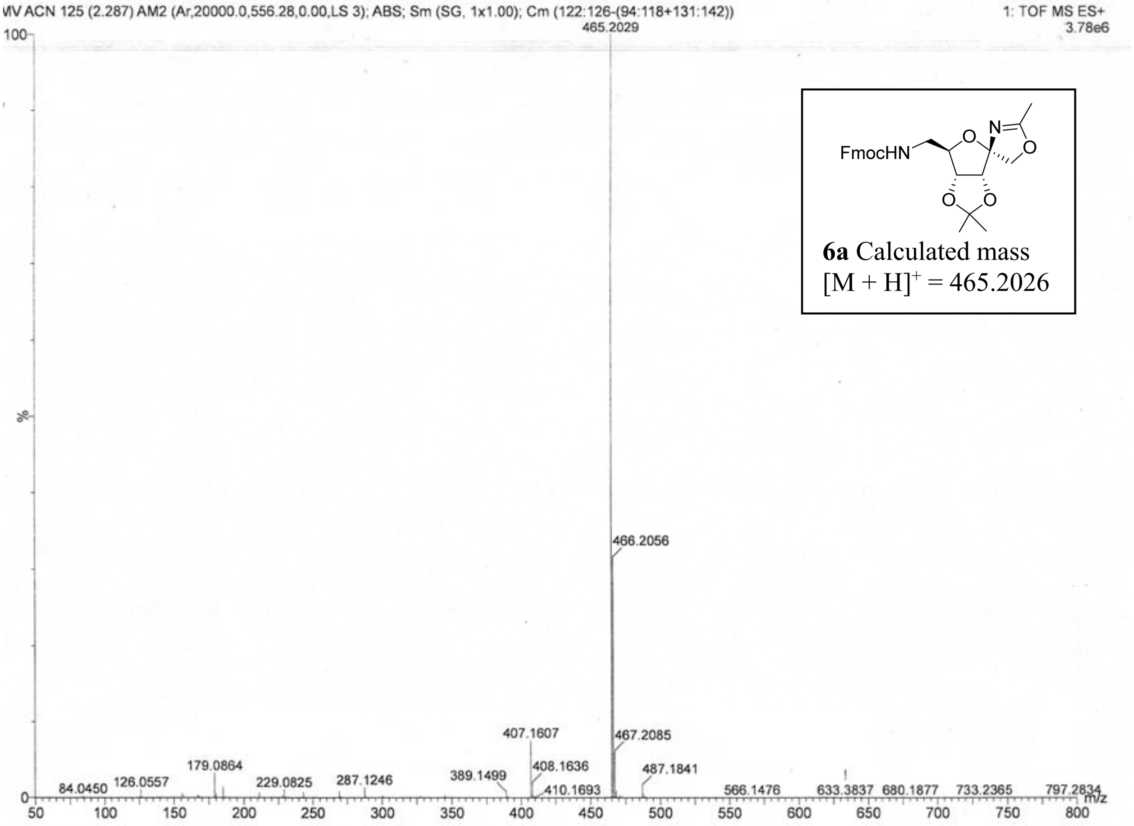




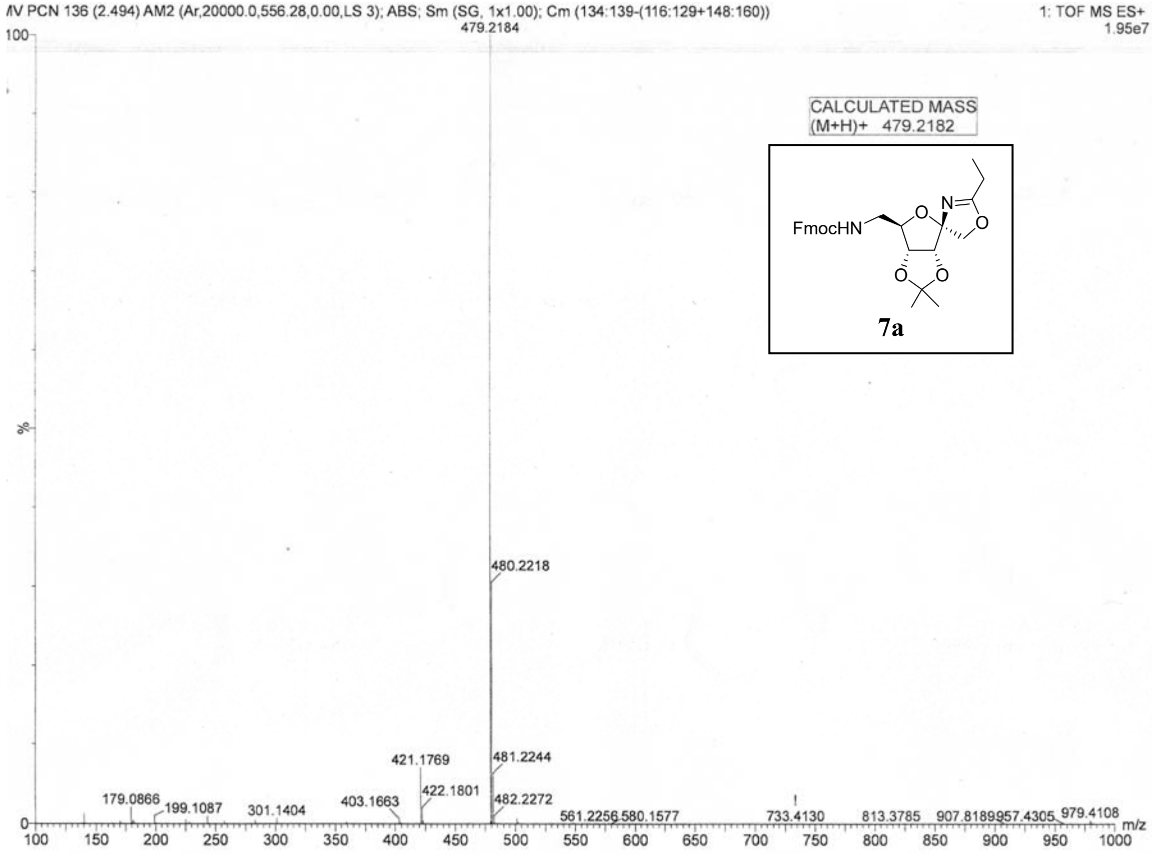
NOESY spectra of **11a**





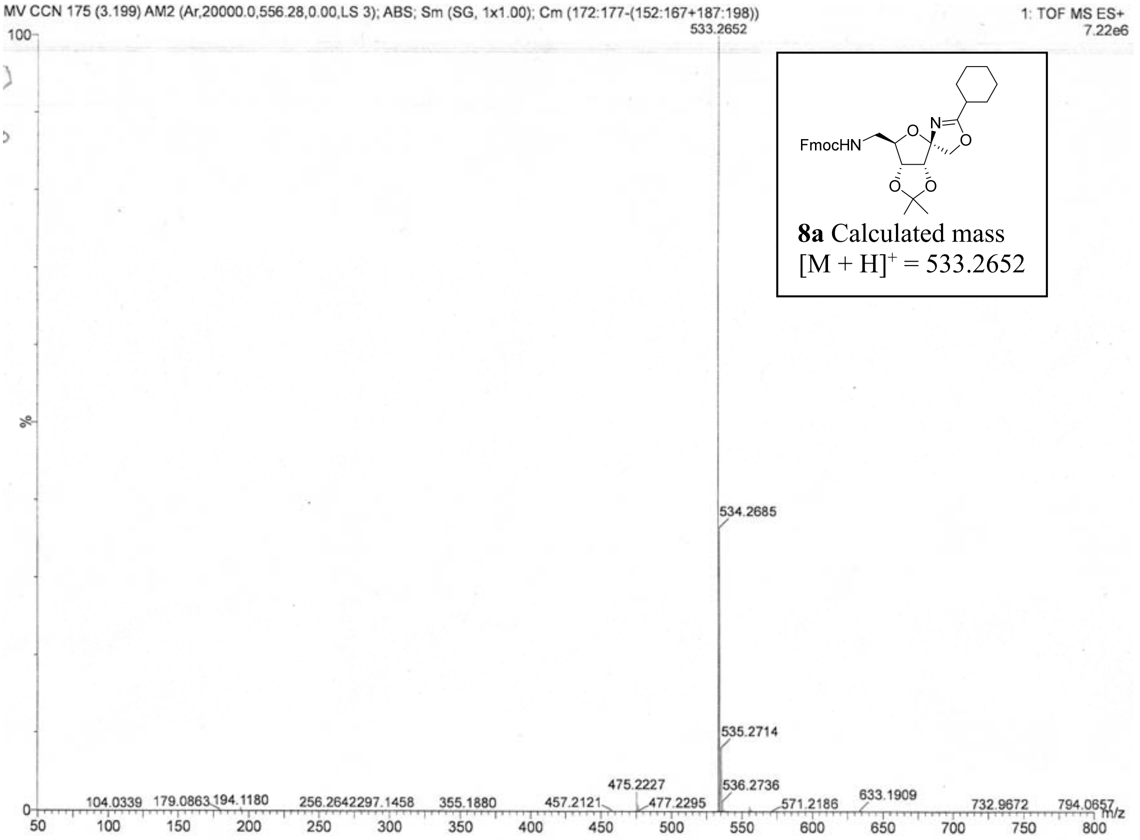


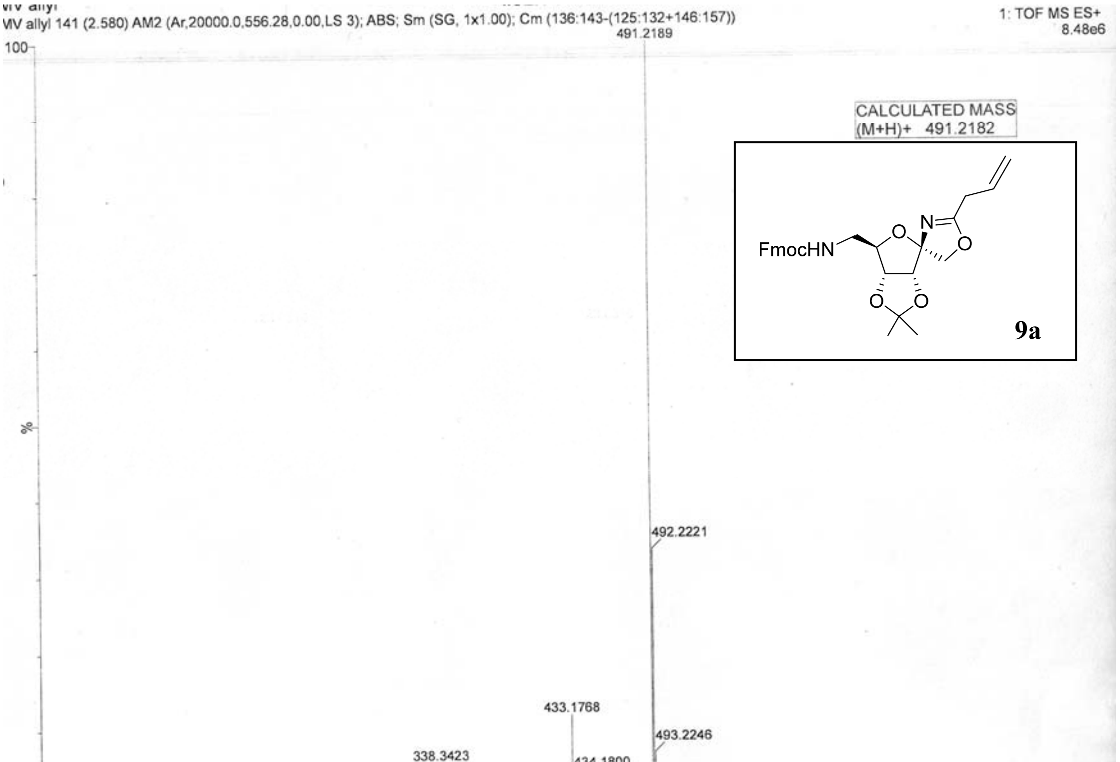
6a Calculated mass
$[M + H]^+ = 465.2026$



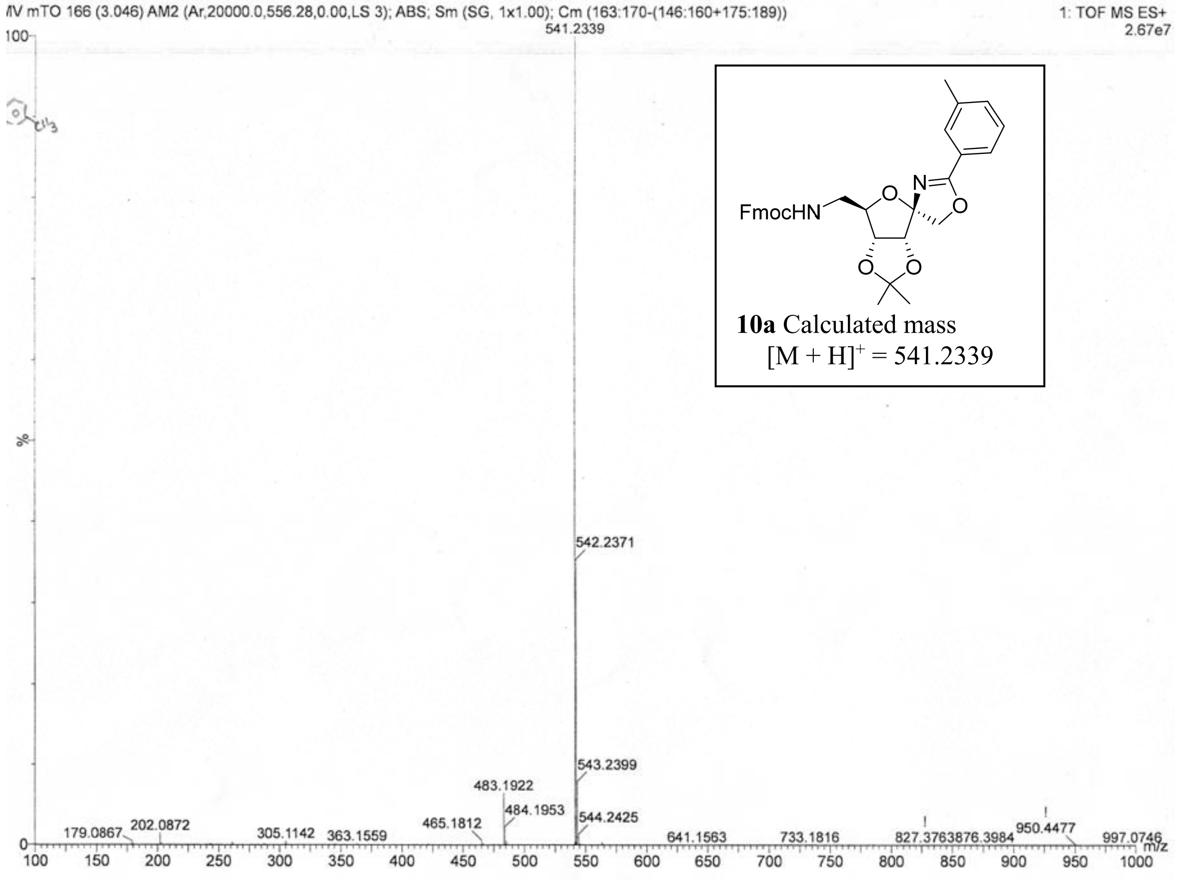
CALCULATED MASS
(M+H)+ 479.2182

7a

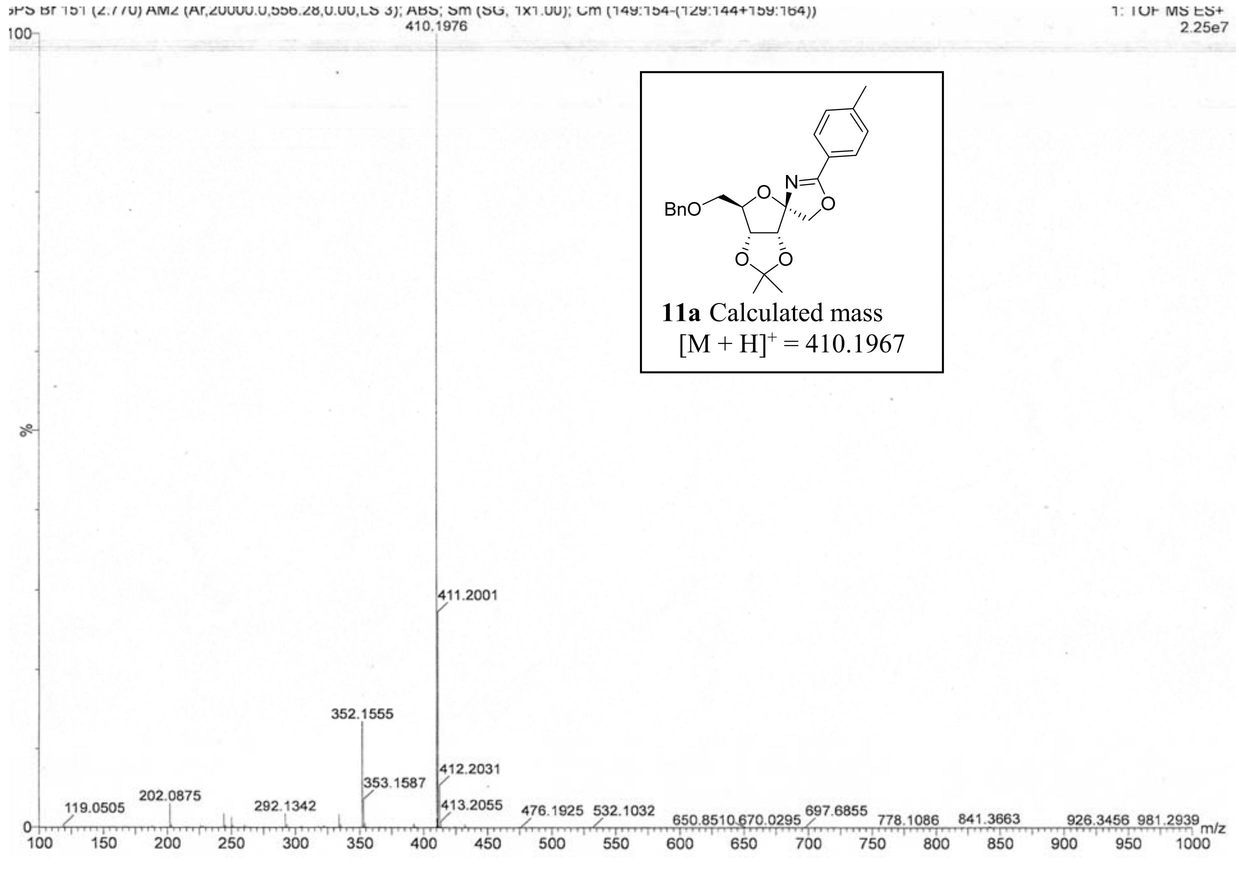

8a Calculated mass $[M + H]^+ = 533.2652$


CALCULATED MASS
(M+H)+ 491.2182

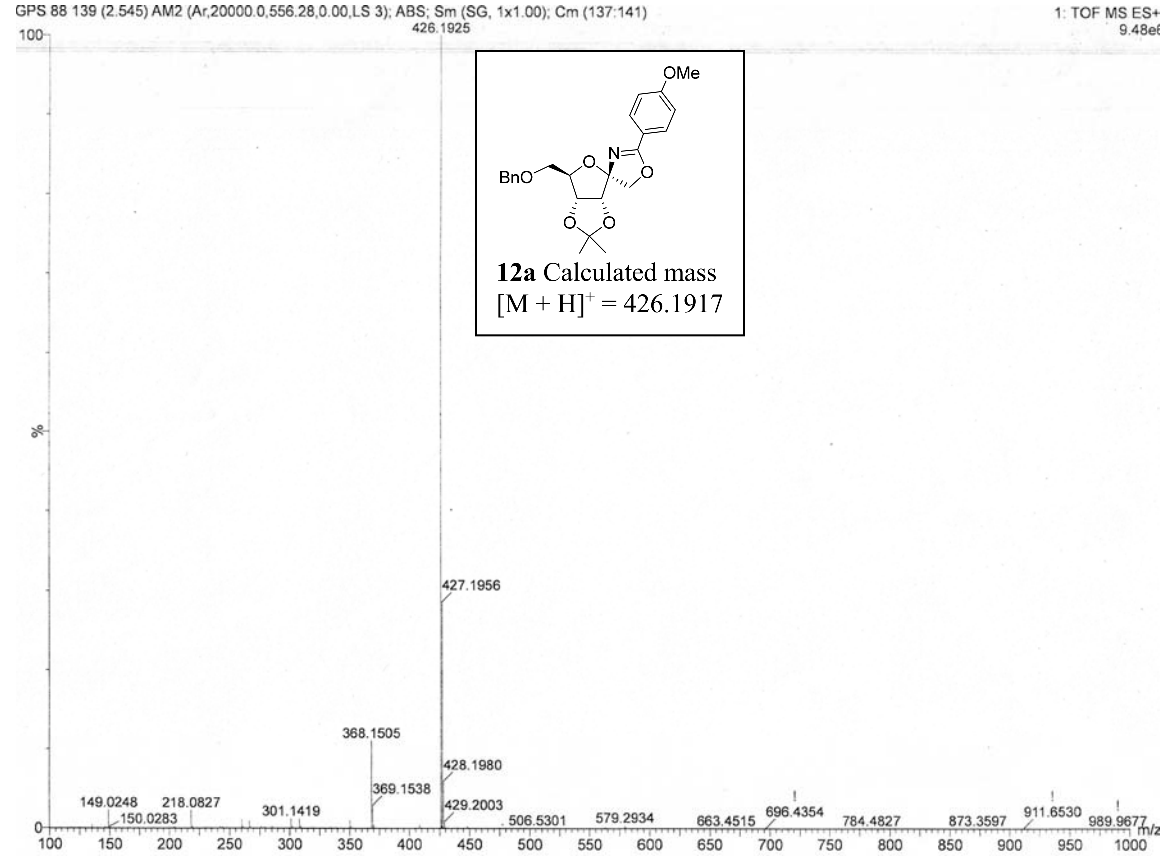
9a



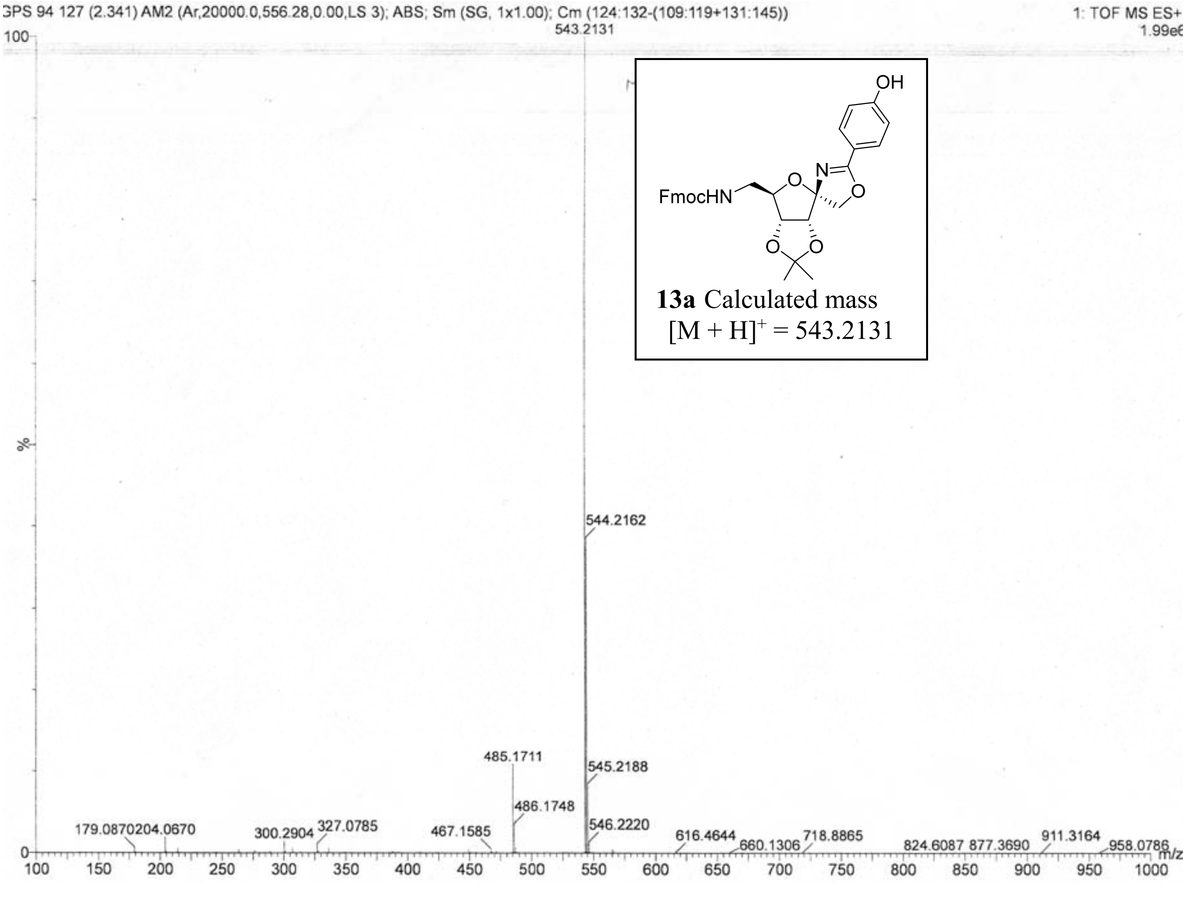
10a Calculated mass
[M + H]$^+$ = 541.2339



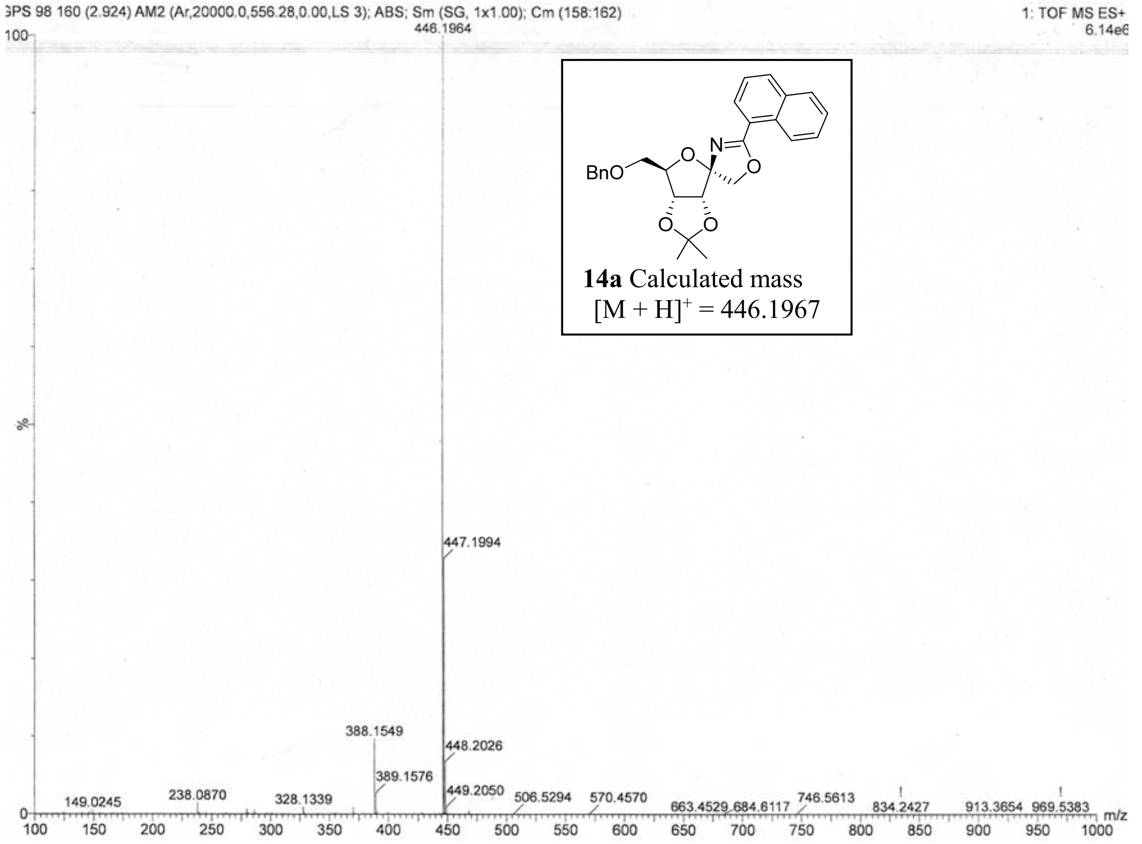
11a Calculated mass
[M + H]$^+$ = 410.1967



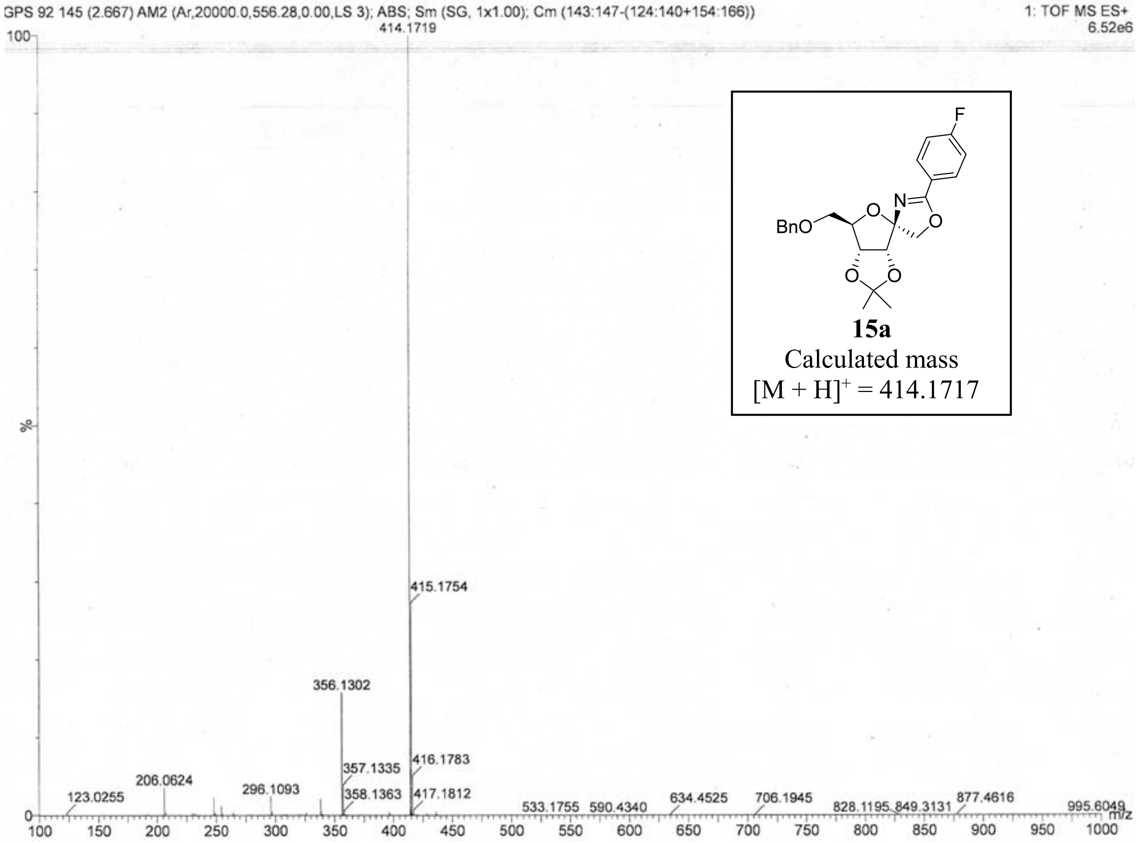
12a Calculated mass
$[M + H]^+ = 426.1917$



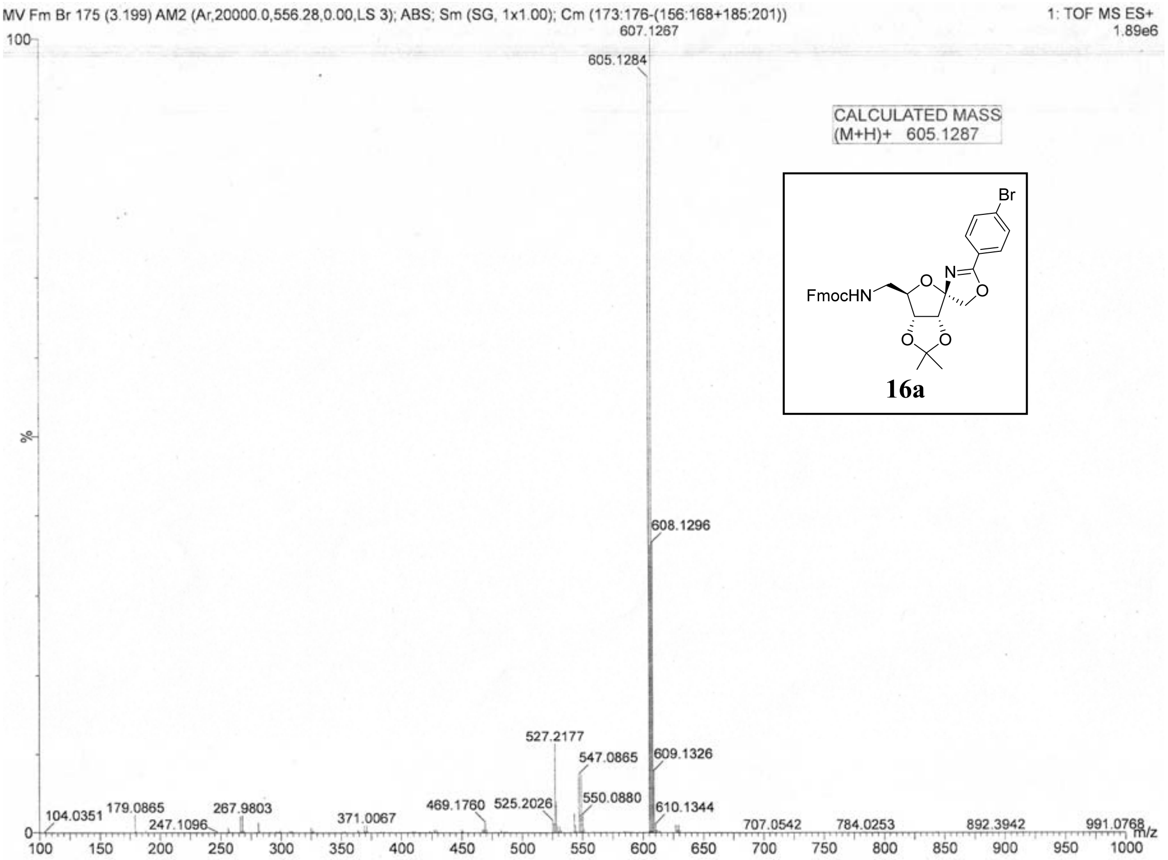
13a Calculated mass
$[M + H]^+ = 543.2131$

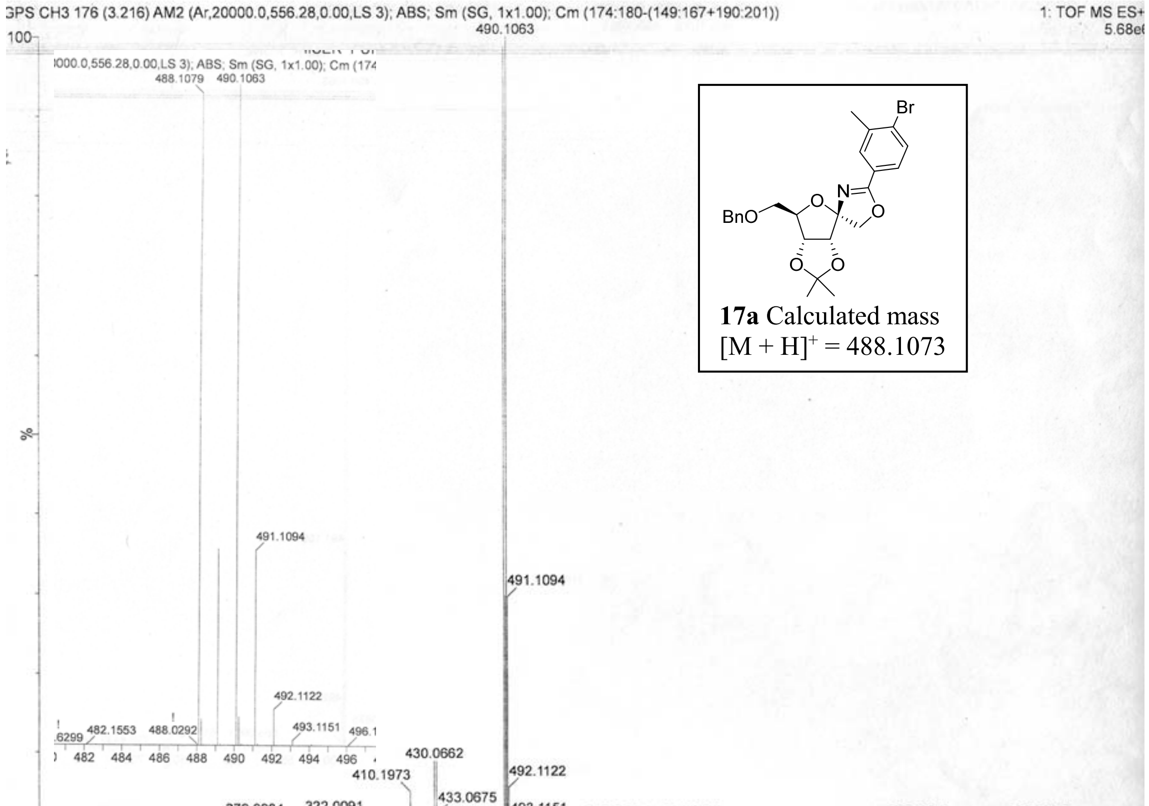


14a Calculated mass
[M + H]$^+$ = 446.1967

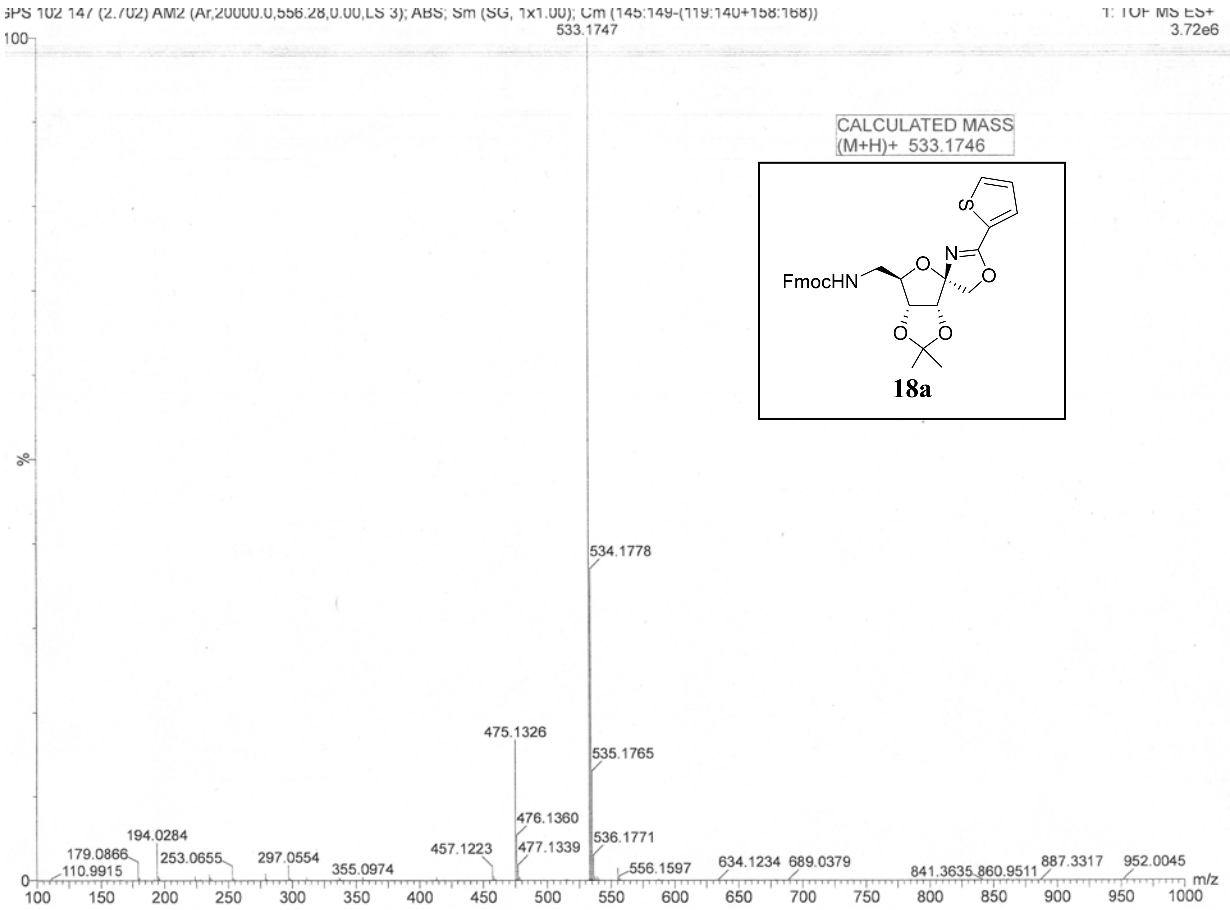


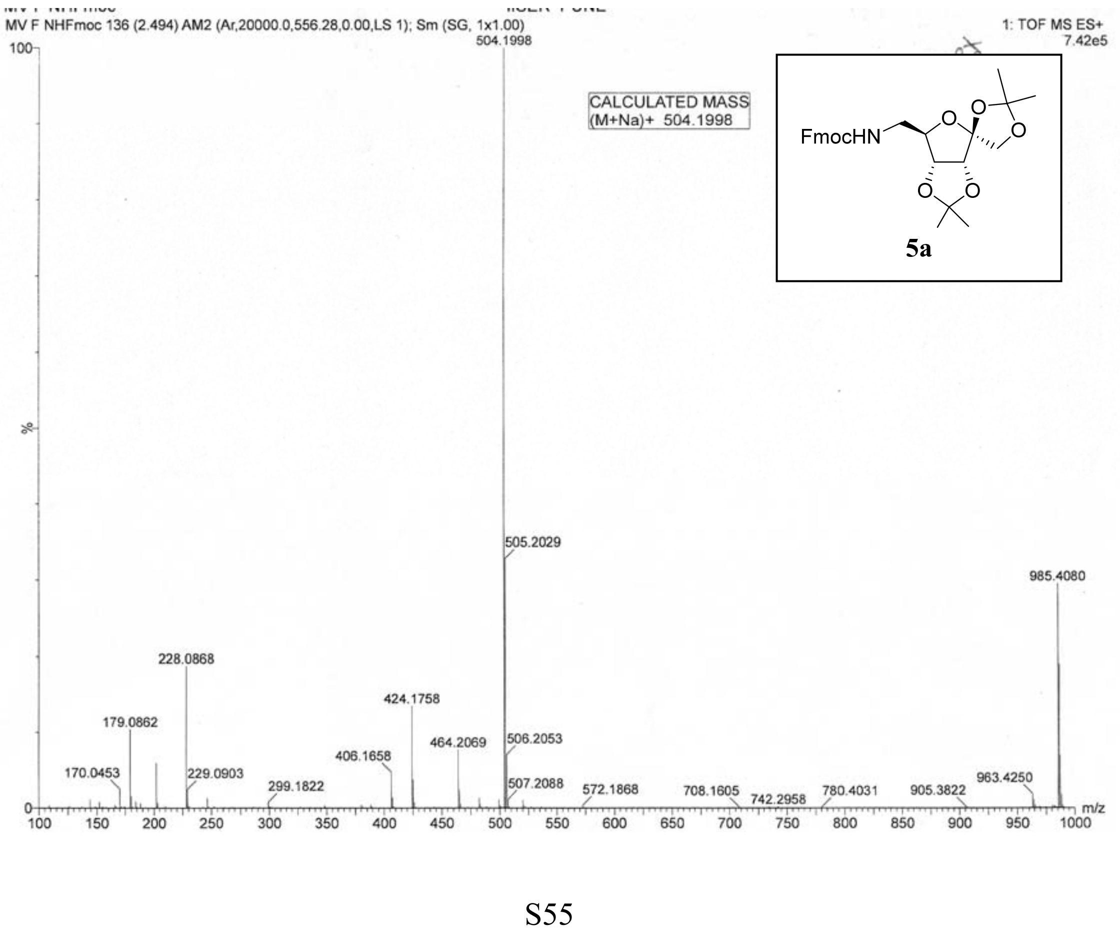
15a
Calculated mass
[M + H]$^+$ = 414.1717

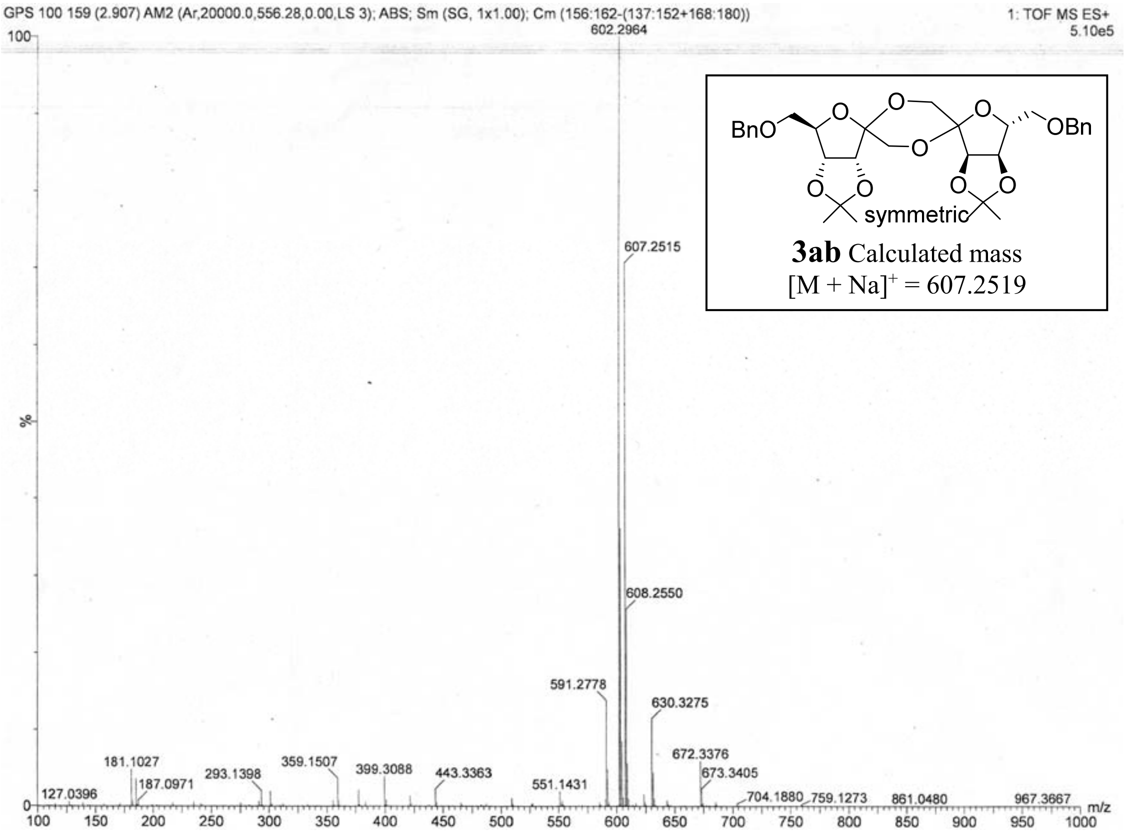


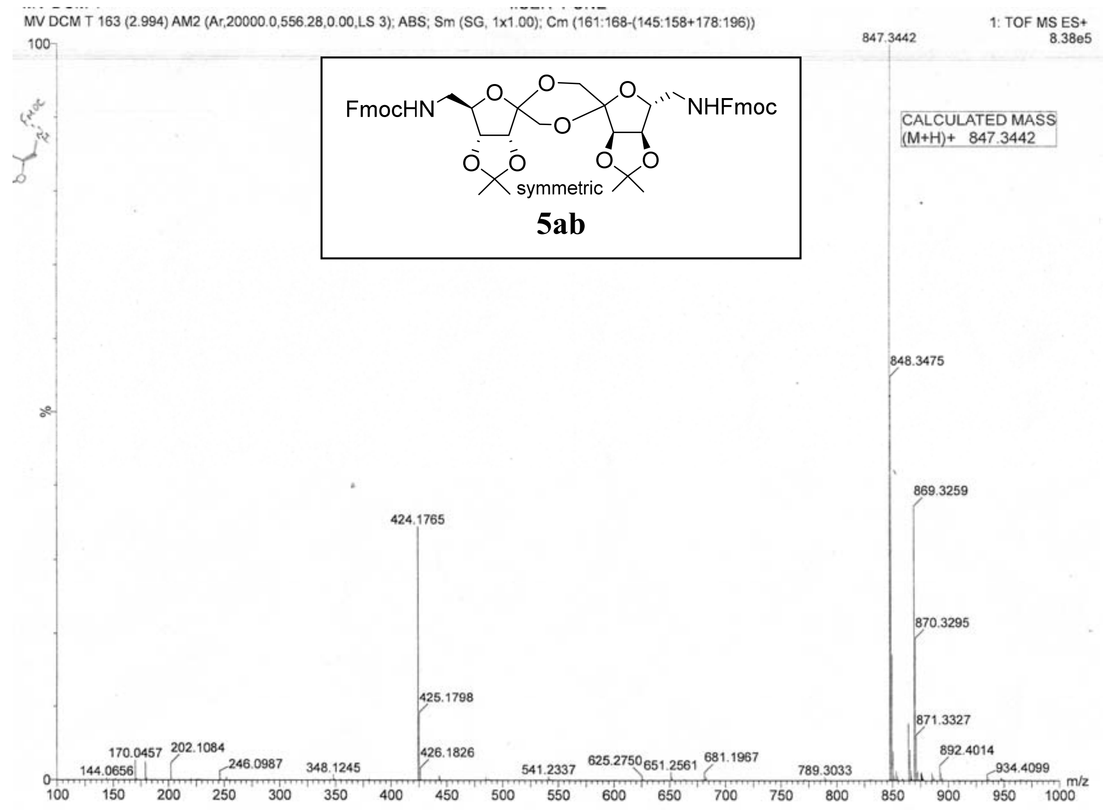


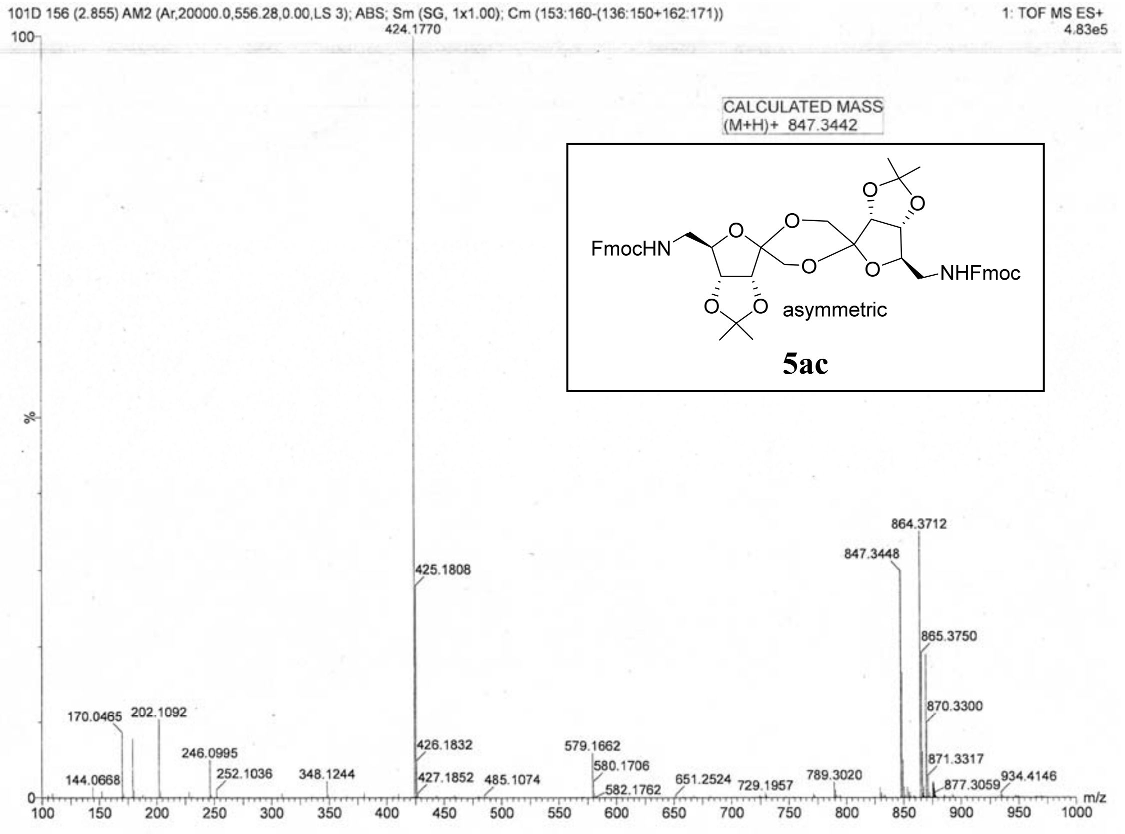
17a Calculated mass
$[M + H]^+ = 488.1073$


GPS 102 147 (2.702) AM2 (Ar,20000.0,556.28,0.00,LS 3); ABS; Sm (SG, 1x1.00); Cm (145:149-(119:140+158:168))
1: TOF MS ES+
3.72e6
100
%
0
CALCULATED MASS
(M+H)+ 533.1746
FmocHN
O
N
S
O
O
O
18a
533.1747
534.1778
475.1326
535.1765
476.1360
536.1771
477.1339
457.1223
194.0284
179.0866
110.9915
253.0655
297.0554
355.0974
556.1597
634.1234
689.0379
841.3635
860.9511
887.3317
952.0045
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
m/z


MV F NHFmoc 136 (2.494) AM2 (Ar,20000.0,556.28,0.00,LS 1); Sm (SG, 1x1.00)
1: TOF MS ES+
7.42e5
100
%
0
CALCULATED MASS
(M+Na)+ 504.1998
FmocHN
O
O
O
O
O
5a
504.1998
505.2029
985.4080
228.0868
424.1758
179.0862
464.2069
506.2053
406.1658
170.0453
229.0903
299.1822
507.2088
572.1868
708.1605
742.2958
780.4031
905.3822
963.4250
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
m/z


GPS 100 159 (2.907) AM2 (Ar,20000.0,556.28,0.00,LS 3); ABS; Sm (SG, 1x1.00); Cm (156:162-(137:152+168:180))
1: TOF MS ES+
5.10e5
602.2964
BnO
OBn
symmetric
3ab Calculated mass
[M + Na]+ = 607.2519
607.2515
608.2550
591.2778
630.3275
672.3376
673.3405
181.1027
187.0971
127.0396
293.1398
359.1507
399.3088
443.3363
551.1431
704.1880
759.1273
861.0480
967.3667
%
m/z
100
0
100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000


MV DCM T 163 (2.994) AM2 (Ar,20000.0,556.28,0.00,LS 3); ABS; Sm (SG, 1x1.00); Cm (161:168-(145:158+178:196))
1: TOF MS ES+
8.38e5
847.3442
FmocHN
NHFmoc
symmetric
5ab
CALCULATED MASS
(M+H)+ 847.3442
848.3475
869.3259
870.3295
871.3327
892.4014
934.4099
424.1765
425.1798
426.1826
170.0457
144.0656
202.1084
246.0987
348.1245
541.2337
625.2750
651.2561
681.1967
789.3033
%
m/z
100
0
100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000


101D 156 (2.855) AM2 (Ar,20000.0,556.28,0.00,LS 3); ABS; Sm (SG, 1x1.00); Cm (153:160-(136:150+162:171))
1: TOF MS ES+
4.83e5
100
%
0
CALCULATED MASS
(M+H)+ 847.3442
FmocHN
NHFmoc
asymmetric
5ac
424.1770
425.1808
426.1832
427.1852
170.0465
202.1092
144.0668
246.0995
252.1036
348.1244
485.1074
579.1662
580.1706
582.1762
651.2524
729.1957
789.3020
847.3448
864.3712
865.3750
870.3300
871.3317
877.3059
934.4146
m/z
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000