Electronic supplementary information for the paper under the title:

Total Synthesis of (+)-Swainsonine and (+)-8-*epi*-Swainsonine

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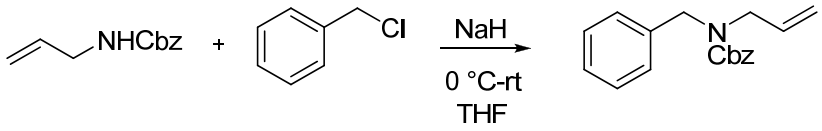
Contents

General experimental

All chromatographic separations[1] were performed on silica gel, 10–18 mesh, 60 Å (dry-flash), 100–200 mesh, 60 Å (column chromatography), ICN Biomedicals, and ion-exchange column chromatography (acidic resin DOWEX 50WX8-100). Standard techniques were used for the purification of the reagents and solvents.[2] Petroleum ether refers to the fraction boiling at 70–72 °C. NMR spectra were recorded with a Bruker Avance III 500 (1H NMR at 500 MHz, 13C NMR at 125 MHz). Chemical shifts are expressed in ppm (δ) using tetramethylsilane as the internal standard. IR spectra were recorded with a Nicolet 6700 FT instrument. Mass spectra were obtained with an Agilent Technologies 6210 TOF LC– MS instrument (LC: series 1200) and LTQ Orbitrap XL hybrid FTMS (Thermo Scientific). Melting points were determined with a Kofler hot-stage and Electrothermal apparatus and are uncorrected, unless otherwise stated. Optical rotation was determined with a Rudolph Research Analytical AUTOPOL IV Automatic Polarimeter. Diffraction data were collected with an Oxford Diffraction KM4 four-circle goniometer equipped with a Sapphire CCD detector.

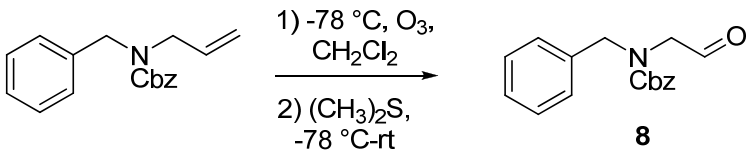
Benzyl allyl(benzyl)carbamate



Sodium hydride (1.00 g, 41.67 mmol) was added in portions to a cold (0 °C) solution of benzyl allylcarbamate (2.00 g, 10.46 mmol) in THF (10 mL), under an argon atmosphere. The reaction mixture was stirred for 30 min at 0 °C, then benzyl chloride (3.85 g, 30.42 mmol) was added and the resulting suspension was stirred at rt for 15 h. The reaction mixture was quenched with water (10 mL), extracted with EtOAc and the combined organic extract was dried over anh. $MgSO_4$ and concentrated under reduced pressure. Purification of the crude product by dry-flash chromatography (SiO_2; eluent: petroleum ether/EtOAc = 9/1) afforded title compound (2.00 g; 68%) as a colorless oil.

^{1}H NMR (500 MHz, DMSO-d_6, 65 °C) δ 7.35-7.23 (m, 10H), 5.81-5.73 (m, 1H), 5.15 (s, 2H), 5.13-5.10 (m, 2H), 4.45 (s, 2H), 3.86 (d, J = 5.8, 2H); ^{13}C NMR (500 MHz, DMSO-d_6, 65 °C) δ 155.2 (C), 137.5 (C), 136.6 (C), 133.3 (CH), 128.0 (CH), 127.9 (CH), 127.4 (CH), 127.1 (2 x CH), 126.8 (CH), 116.4 (CH_2), 66.2 (CH_2), 49.3 (CH_2), 48.6 (CH_2); IR (ATR) v 3064, 3031, 1702, 1456, 1416, 1237, 699 cm^{-1}; HRMS (m/z) calcd for $C_{18}H_{20}NO_2$ $[M+H]^+$: 282.1489, found: 282.1485.

Benzyl benzyl(2-oxoethyl)carbamate (8)[3]

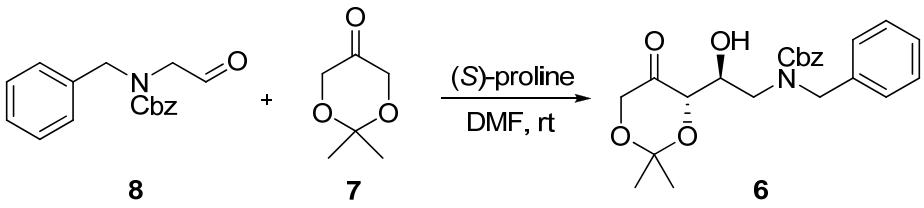


8

A cold (-78 °C) solution of benzyl allyl(benzyl)carbamate (3.00 g, 10.66 mmol) in CH_2Cl_2 (100 mL) was treated with ozone until a blue color persisted. Excess ozone was purged from the reaction by bubbling argon through the cold reaction mixture for 15 min, followed by the addition of dimethyl sulfide (22 mL, 299.53 mmol). The reaction mixture was stirred at rt overnight and concentrated under reduced pressure. The residue was dissolved in EtOAc, washed with water, dried over anh. $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by dry-flash chromatography (SiO_2; eluent: petroleum ether/EtOAc = 6/4), to give aldehyde **8** (2.26 g, 75%) as a colorless oil.

^{1}H NMR (500 MHz, DMSO-d_6, 65 °C) δ 9.45 (s, 1H), 7.35-7.27 (m, 10H), 5.14 (s, 2H), 4.53 (s, 2H), 4.08 (s, 2H); ^{13}C NMR (500 MHz, DMSO-d_6, 65 °C) δ 198.5 (CH), 155.5 (C), 137.2 (C), 136.3 (C), 128.1 (CH), 128.0 (CH), 127.5 (CH), 127.3 (CH), 127.1 (CH), 127.0 (CH), 66.5 (CH_2), 56.4 (CH_2), 51.1 (CH_2); IR (ATR) *v* 3063, 3031, 2946, 2821, 1734, 1702, 1454, 1427, 1235, 1125, 699 cm^{-1}; HRMS (*m/z*) calcd for $C_{17}H_{18}NO_3$ $[M+H]^+$: 284.1281, found: 284.1277.

Benzyl benzyl(2-(2,2-dimethyl-5-oxo-1,3-dioxan-4-yl)-2-hydroxyethyl)carbamate (6)

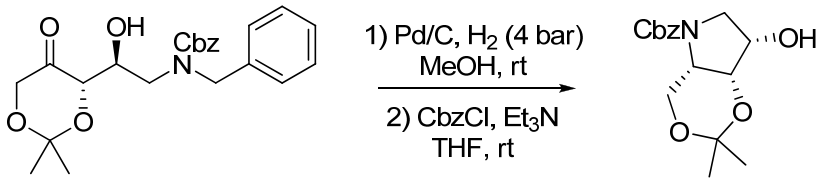


8 **7** **6**

A solution of dioxanone **7** (0.60 g, 4.61 mmol), aldehyde **8** (0.66 g, 2.33 mmol) and (*S*)-proline (100.0 mg, 0.87 mmol) in DMF (10.6 mL) was stirred overnight at rt. The reaction mixture was diluted with water and extracted with EtOAc. The combined organic extract was washed with water, dried over anh. $MgSO_4$ and concentrated under reduced pressure. Purification of the crude product by two dry-flash chromatographies (SiO_2; 1st eluent: toluene/EtOAc = 7/3; 2nd eluent: petroleum ether/EtOAc = 7/3) afforded aldol **6** (640.0 mg, 66%) as a pale yellow oil.

$[\alpha]_D^{25}$ -71.1 (*c* 0.81, $CHCl_3$); ^{1}H NMR (500 MHz, DMSO-d_6, 65 °C) δ 7.33-7.30 (m, 7H), 7.27-7.24 (m, 1H), 7.21-7.20 (m, 2H), 5.12 (s, 2H), 5.02 (bs, 1H, OH), 4.59 (d, *J* = 15.9, 1H), 4.49 (d, *J* = 15.9 Hz, 1H), 4.32 (dd, *J* = 3.1, 1.3 Hz, 1H), 4.26-4.22 (m, 2H), 3.95 (d, *J* = 16.8 Hz, 1H), 3.40 (dd, *J* = 14.3, 4.7 Hz, 1H), 3.34 (dd, *J* = 14.3, 7.9 Hz, 1H), 1.40 (s, 6H); ^{13}C NMR (500 MHz, DMSO-d_6, 65 °C) δ 206.8 (C), 155.6 (C), 137.8 (C), 136.6 (C), 128.0 (CH), 127.9 (CH), 127.3 (CH), 127.0 (CH), 126.8 (CH), 126.6 (CH), 99.6 (C), 77.0 (CH), 68.2 (CH), 66.4 (CH_2), 66.1 (CH_2), 50.6 (CH_2), 48.3 (CH_2), 24.4 (CH_3), 22.7 (CH_3); IR (ATR) *v* 3462, 3032, 2988, 2942, 1744, 1698, 1495, 1456, 1423, 1378, 1228, 1124, 1086, 736 cm^{-1}; HRMS (*m/z*) calcd for $C_{23}H_{27}KNO_6$ $[M+K]^+$: 452.1470, found: 452.1461.

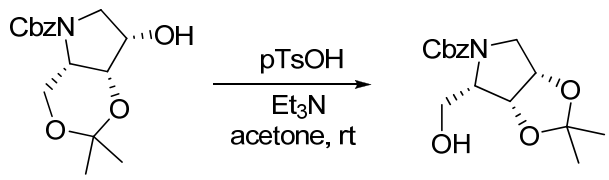
(4a*S*,7*S*,7a*R*)-Benzyl 7-hydroxy-2,2-dimethyltetrahydro-[1,3]dioxino[5,4-b]pyrrole-5(6*H*)-carboxylate (5)



8 **5**

A suspension of aldol **8** (44.4 mg, 0.11 mmol) and 10% Pd/C (11.8 mg, 0.01 mmol; Merck hydrogenation catalyst (oxidic form; cat. no. 8.0714.0010) for synthesis was used) in methanol (7.5 mL) was stirred for 2 h under a hydrogen atmosphere (4 bar). The reaction mixture was filtered and concentrated under reduced pressure. The crude product was dissolved in THF (2.5 mL), triethylamine (36.3 mg, 0.36 mmol) was added and the solution was cooled to 0 °C. Benzyl chloroformate (35.8 mg, 0.21 mmol) was added dropwise, ice bath was removed and the mixture was stirred for 1 h at rt. The reaction mixture was diluted with EtOAc, washed with water, dried over anh. $MgSO_4$ and concentrated under reduced pressure. The residue was purified by column chromatography (SiO_2; eluent: CH_2Cl_2/methanol = 98.5/1.5) to afford compound **5** (23.3 mg, 71%), as white crystals, and ***epi*-5** (1.9 mg, 6%), as colorless film. (For the results of the X-ray crystallographic analysis of **5**, see the CIF file in the Supporting information).
mp 98-99 °C; $[\alpha]_D^{25}$ 94.4 (*c* 1.03, $CHCl_3$); ^{1}H NMR (500 MHz, DMSO-d_6, 65 °C) δ 7.39-7.30 (m, 5H), 5.10 (d, J = 12.7 Hz, 1H), 5.04 (d, J = 12.6 Hz, 1H), 4.67 (d, J = 6.6, 1H, OH), 4.21 (t, J = 3.9 Hz, 1H), 4.12-4.06 (m, 1H), 3.96 (dd, J = 12.2, 4.2 Hz, 1H), 3.71-3.66 (m, 1H), 3.69 (dd, J = 9.5, 7.4 Hz, 1H), 3.20 (t, J = 9.7 Hz, 1H), 1.39 (s, 3H), 1.30 (s, 3H); The signal corresponding to one of the H atoms on the C-6 atom was not observed under the recording conditions. ^{13}C NMR (500 MHz, DMSO-d_6, 65 °C) δ 154.1 (C), 136.6 (C), 128.0 (CH), 127.4 (CH), 127.2 (CH), 97.1 (C), 69.2 (2 x CH), 65.7 (CH_2), 58.6 (CH_2), 53.4 (CH), 49.6 (CH_2), 27.5 (CH_3), 19.9 (CH_3); IR (ATR) ν 3440, 2991, 2942, 2888, 1702, 1420, 1358, 1234, 1139, 1083 cm^{-1}; HRMS (*m/z*) calcd for $C_{16}H_{22}NO_5$ $[M+H]^+$: 308.1492, found: 308.1500.

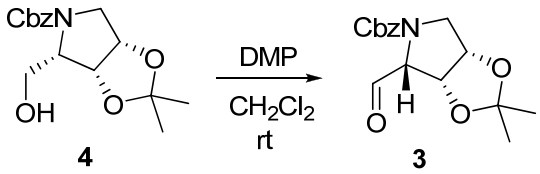
(3a*R*,4*S*,6a*S*)-Benzyl 4-(hydroxymethyl)-2,2-dimethyldihydro-3a*H*-[1,3]dioxolo[4,5-c]pyrrole-5(4*H*)-carboxylate (4)



5 **4**

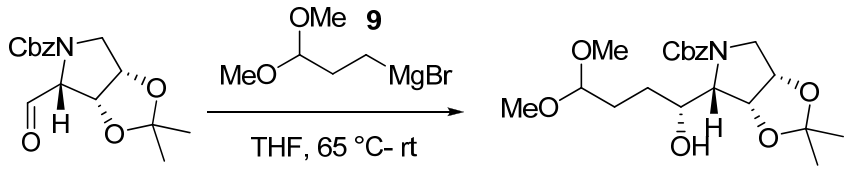
To a solution of alcohol **5** (200.0 mg, 0.65 mmol) in acetone (10.8 mL) *p*TsOH•H_2O (12.8 mg, 0.07 mmol) was added and the mixture was stirred at rt for 48 h. The reaction mixture was treated with triethylamine (43.5 mg, 0.43 mmol) and concentrated under reduced pressure. The residue was purified by column chromatography (SiO_2; eluent: CH_2Cl_2/methanol = 98.5/1.5), to afford compound **4** (170.0 mg, 85%) as a colorless oil.
$[\alpha]_D^{25}$ 33.0 (*c* 1.00, $CHCl_3$); ^{1}H NMR (500 MHz, DMSO-d_6, 65 °C) δ 7.38-7.35 (m, 4H), 7.34-7.30 (m, 1H), 5.10 (d, *J* = 12.7 Hz, 1H), 5.07 (d, *J* = 12.8 Hz, 1H), 4.79 (t, *J* = 6.2, 1H), 4.74 (dt, *J* = 6.5, 3.6 Hz, 1H), 4.24-4.22 (m, 1H, OH), 3.87-3.78 (m, 2H), 3.71 (dd, *J* = 12.1, 6.6 Hz, 1H), 3.66 (dt, *J* = 10.5, 6.9 Hz, 1H), 3.33 (dd, *J* = 12.1, 3.5 Hz, 1H), 1.42 (s, 3H), 1.29 (s, 3H); ^{13}C NMR (500 MHz, DMSO-d_6, 65 °C) δ 154.6 (C), 136.5 (C), 128.0 (CH), 127.4 (CH), 127.1 (CH), 111.2 (C), 79.2 (CH), 76.7 (CH), 65.9 (CH_2), 61.3 (CH), 58.9 (CH_2), 51.2 (CH_2), 26.2 (CH_3), 24.7 (CH_3); IR(ATR) *v* 3429, 2986, 2940, 1699, 1670, 1418, 1347, 1245, 1211, 1085 cm^{-1}; HRMS (*m/z*) calcd for $C_{16}H_{22}NO_5$ $[M+H]^+$: 308.1492, found: 308.1477.

(3a*R*,4*R*,6a*S*)-Benzyl 4-formyl-2,2-dimethyldihydro-3a*H*-[1,3]dioxolo[4,5-c]pyrrole-5(4*H*)-carboxylate (3)



Dess-Martin's periodinane (100.0 mg, 0.24 mmol) was added to a solution of alcohol **4** (50.0 mg, 0.16 mmol) in CH_2Cl_2 (3.3 mL) and the reaction mixture was stirred at room temperature for 15 min. The reaction mixture was diluted with CH_2Cl_2, washed with 5% $Na_2S_2O_3$ and sat. aq. $NaHCO_3$, dried over anh. $MgSO_4$ and concentrated under reduced pressure. The residue was purified by dry-flash chromatography (SiO_2; eluent: petroleum ether/EtOAc = 6/4) to afford aldehyde **3** (42.0 mg, 85%) as a colorless oil.
$[\alpha]_D^{25}$ 66.5 (*c* 1.23, $CHCl_3$); ^{1}H NMR (500 MHz, DMSO-d_6, 65 °C) δ 9.41 (d, *J* = 2.5 Hz, 1H), 7.39-7.30 (m, 5H), 5.10 (s, 2H), 5.06 (t, *J* = 6.5 Hz, 1H), 4.87 (dt, *J* = 5.8, 2.1 Hz, 1H), 4.30-4.27 (m, 1H), 3.69 (dd, *J* = 12.2, 5.7 Hz, 1H), 3.59 (dd, *J* = 12.2, 1.5 Hz, 1H), 1.37 (s, 3H), 1.26 (s, 3H); ^{13}C NMR (500 MHz, DMSO-d_6, 65 °C) δ 197.6 (CH), 154.5 (C), 136.1 (C), 128.0 (CH), 127.5 (CH), 127.2 (CH), 111.7 (C), 80.0 (CH), 78.1 (CH), 66.8 (CH), 66.3 (CH_2), 51.3 (CH_2), 25.6 (CH_3), 24.1 (CH_3); IR(ATR) *v* 2988, 2942, 1737, 1705, 1414, 1349, 1212, 1125, 1088, 1001 cm^{-1}; HRMS (*m/z*) calcd for $C_{16}H_{20}NO_5$ $[M+H]^+$: 306.1336, found: 306.1326.

(3a*R*,4*S*,6a*S*)-Benzyl 4-((*R*)-1-hydroxy-4,4-dimethoxybutyl)-2,2-dimethyldihydro-3a*H*-[1,3]dioxolo[4,5-c]pyrrole-5(4*H*)-carboxylate (10)

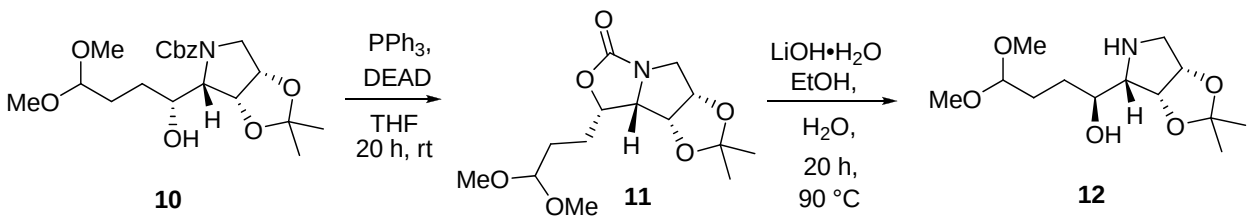


3 **10**

To the suspension of Mg turnings (203.5 mg, 8.37 mmol) and a crystal of I_2 in THF (3.5 mL), a solution of 3-bromo-1,1-dimethoxypropane (0.95 g, 5.19 mmol) and 1 drop of 1,2-dibromoethane in THF (3.5 mL) was added in small portions during 1 h, while keeping the temperature of the reaction mixture at 65 °C. After the entire bromide was added, the reaction mixture was stirred at the same temperature for 30 minutes. The reaction mixture was cooled to rt and a solution of aldehyde **3** (526.5 mg, 1.72 mmol) in THF (3.5 mL) was added dropwise. After the reaction mixture was stirred for 15 min at rt, it was cooled to 0 °C, quenched with sat. aq. NH_4Cl and extracted with EtOAc. Organic extract was dried over anh. $MgSO_4$ and concentrated under reduced pressure. The residue was purified by column chromatography (SiO_2; eluent: petroleum ether/EtOAc= 1/1) to afford alcohol **10** (611.4 mg, 87%) as a colorless oil.

$[\alpha]_D^{25}$ 29.3 (*c* 1.64, MeOH); ^{1}H NMR (500 MHz, DMSO-d_6, 65 °C) δ 7.37-7.30 (m, 5H), 5.09 (d, J = 12.8 Hz, 1H), 5.06 (d, J = 12.8 Hz, 1H), 4.77-4.75 (m, 1H), 4.72 (dt, J = 6.8, 4.5 Hz, 1H), 4.41 (bd, J = 2.2 Hz, 1H, OH), 4.31 (t, J = 5.3 Hz, 1H), 3.84 (dd, J = 12.0, 7.0 Hz, 1H), 3.82-3.80 (m, 2H), 3.30 (dd, J = 12.0, 4.2 Hz, 1H), 3.23 (s, 3H), 3.22 (s, 3H), 1.77-1.70 (m, 1H), 1.67-1.60 (m, 1H), 1.58-1.51 (m, 1H), 1.46-1.39 (m, 1H), 1.42 (s, 3H), 1.28 (s, 3H); ^{13}C NMR (500 MHz, DMSO-d_6, 65 °C) δ 154.8 (C), 136.6 (C), 128.0 (CH), 127.4 (CH), 127.1 (CH), 111.9 (C), 104.1 (CH), 79.1 (CH), 76.9 (CH), 68.1 (CH), 65.9 (CH_2), 63.3 (CH), 52.2 (CH_3), 52.0 (CH_3), 50.6 (CH_2), 28.8 (CH_2), 28.6 (CH_2), 26.1 (CH_3), 24.5 (CH_3); IR (ATR) ν 3511, 3446, 3408, 3383, 2984, 2939, 2830, 1692, 1419, 1379, 1210, 1128, 1081 cm^{-1}; HRMS (*m/z*) calcd for $C_{21}H_{31}NNaO_7$ $[M+Na]^+$: 432.1993, found: 432.1976.

(*S*)-1-((3a*R*,4*S*,6a*S*)-2,2-Dimethyltetrahydro-3a*H*-[1,3]dioxolo[4,5-c]pyrrol-4-yl)-4,4-dimethoxybutan-1-ol (12)

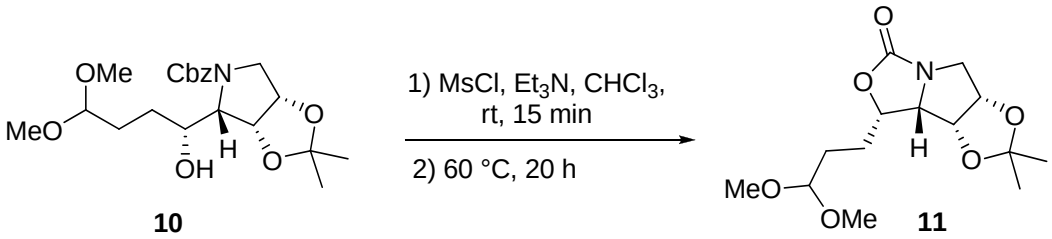


10 **11** **12**

A solution of alcohol **10** (0.21 g, 0.51 mmol), PPh_3 (0.42 g, 1.60 mmol) and DEAD (0.25 mL, 0.28 g, 1.59 mmol) in THF (2.3 mL) was stirred over 20 h at rt. The reaction mixture was diluted with CH_2Cl_2, washed with water, dried over anh. $MgSO_4$ and concentrated under reduced pressure. The crude product **11** was dissolved in EtOH (4 mL), the solution of $LiOH•H_2O$ (0.44g, 10.48 mmol) in water (4 mL) was added and the mixture was stirred over 20 h at 90 °C. The reaction mixture was diluted with $CHCl_3$ and water, extracted with $CHCl_3$ (3x), dried over anh. $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by column chromatography (SiO_2; eluent PhH/EtOH = 8/2) to afford compound **12** (122.2 mg, 87%) as a colorless oil.

$[\alpha]_D^{25}$ 41.1 (*c* 1.01, MeOH); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.75 (dd, J = 5.5, 4.5 Hz, 1H), 4.69 (dd, J = 5.5, 4 Hz, 1H), 4.23 (t, J = 5 Hz, 1H), 3.86- 3.84 (m, 1H), 3.34 (s, 3H), 3.34 (s, 3H), 3.15 (d, J = 13.5 Hz, 1H), 2.67-2.59 (m, 2H, NH, OH), 2.65 (dd, J = 13.5, 4 Hz, 1H), 2.60 (t, J = 4.5 Hz, 1H), 1.95- 1.90 (m, 1H), 1.76-1.71 (m, 3H), 1.47 (s, 3H), 1.31 (s, 3H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 110.9 (C), 104.5 (CH), 82.2 (CH), 82.1 (CH), 71.1 (CH), 66.7 (CH), 53.0 (CH_3), 52.8 (CH_2), 52.5 (CH_3), 30.5 (CH_2), 29.2 (CH_2), 25.6 (CH_3), 23.5 (CH_3); IR (ATR) *v* 3509, 2983, 2934, 2831, 1378, 1207, 1126, 1061 cm^{-1}; HRMS (*m/z*) calcd for $C_{13}H_{26}NO_5$ $[M+H]^+$: 276.1805, found: 276.1807.

(3a*R*,3b*S*,4*S*,8a*S*)-4-(3,3-Dimethoxypropyl)-2,2-dimethyltetrahydro-4*H*,6*H*-[1,3]dioxolo[4',5':3,4]pyrrolo[1,2-c]oxazol-6-one (11)



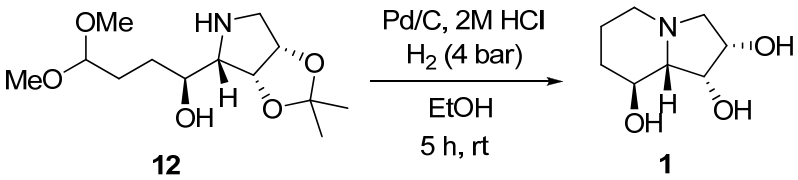
10 **11**

To a solution of **10** (35.1 mg, 0.09 mmol) in $CHCl_3$, triethylamine (18.9 mg, 0.19 mmol) and MsCl (14.8 mg, 0.13 mmol) were added and the reaction mixture was stirred for 15 min at rt and additional 20 h at 60 °C. The reaction mixture was diluted with EtOAc, washed with water, dried over anh. $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by column chromatography (SiO_2; eluent: PhH/EtOH = 95/5) to afford compound **11** (13.6 mg, 53%) as white crystals.

m p 72-73 °C; $[\alpha]_D^{25}$ 26.9 (*c* 1.02, MeOH); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.78 (dt, J = 5.5, 1.5 Hz, 1H), 4.72-4.68 (m, 1H), 4.62 (dd, J = 5.5, 3.5 Hz, 1H), 4.44 (t, J = 5.5 Hz, 1H), 3.89 (dd, J = 13.0, 1.0 Hz, 1H), 3.66 (dd, J = 7.0, 3.0 Hz, 1H), 3.36 (s, 3H), 3.35 (s, 3H), 3.12 (dd, J = 13.0, 5.5 Hz, 1H), 2.31-2.24 (m, 1H), 2.00-1.93 (m, 1H), 1.91-1.84 (m, 1H), 1.76-1.69 (m, 1H), 1.45 (s, 3H), 1.28 (s, 3H); ^{13}C NMR (500 MHz, $CDCl_3$) δ 161.2 (C), 112.9 (C), 104.1 (CH), 81.9 (CH), 79.8 (CH), 76.1 (CH), 65.3 (CH), 53.2 (CH_3), 53.0 (CH_3), 52.3 (CH_2), 29.4 (CH_2), 26.5

(CH_3), 24.4 (CH_3), 24.1 (CH_2); IR (ATR) *v* 2986, 2941, 1753, 1384, 1213, 1128, 1100, 1047 cm^{-1}; HRMS (*m/z*) calcd for $C_{14}H_{23}NNaO_6$ $[M+Na]^+$: 324.1418, found: 324.1397.

(+)-Swainsonine (1)



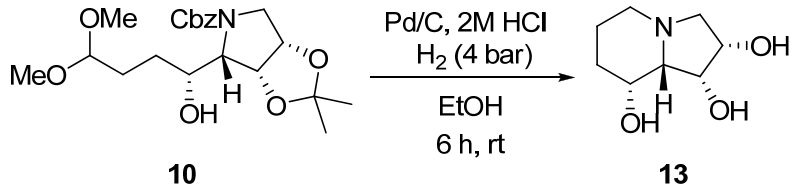
12 **1**

A suspension of **12** (43.9 mg, 0.16 mmol) and 10% Pd/C (22.5 mg, 0.02 mmol) in ethanol (8.6 mL) was stirred under hydrogen atmosphere (4 bar) for 2 minutes, 2 M HCl (3.7 mL) was added and stirring was continued under hydrogen atmosphere (4 bar) for 5 h at rt. The reaction mixture was filtered through celite, concentrated under reduced pressure and purified by ion exchange column chromatography (acidic resin DOWEX 50WX8-100), to give compound **1** (26.0 mg, 94%) as a white solid.

mp 142-144 °C (Lit.[4,5] 143-145 °C); $[\alpha]_D^{25}$ 84.5 (*c* 0.49, MeOH) (Lit.[4] for the enantiomer $[\alpha]_D^{25}$ –87.2 (*c* 2.1, MeOH), (Lit.[5] $[\alpha]_D^{25}$ 83.3 (*c* 0.5, MeOH); ^{1}H NMR (500 MHz, D_2O) δ 4.38 (ddd, *J* = 8.0, 6.0, 2.5 Hz, 1H), 4.29 (dd, *J* = 6.0, 3.7 Hz, 1H), 3.83 (ddd, *J* = 11.1, 9.5, 4.7 Hz, 1H), 2.95-2.93 (m, 1H), 2.92 (dd, *J* = 11.0, 2.5 Hz, 1H), 2.59 (dd, *J* = 11.0, 7.9 Hz, 1H), 2.09 (ddd, *J* = 3.5, 11.5, 7.5 Hz, 1H), 2.02-1.94 (m, 2H), 1.78-1.72 (m, 1H), 1.55 (qt, *J* = 13.5, 4.0 Hz, 1H), 1.31-1.23 (m, 1H); ^{13}C NMR (500 MHz, D_2O) δ 72.3 (CH) 69.2 (CH), 68.6 (CH), 65.9 (CH), 60.1 (CH_2), 51.2 (CH_2), 32.0 (CH_2), 22.7 (CH_2); IR (ATR) *v* 3367, 2942, 2884, 2803, 2726, 1346, 1321, 1150, 1127, 1074, 1027 cm^{-1}; HRMS (*m/z*) calcd for $C_8H_{16}NO_3$ $[M+H]^+$: 174.1125 found: 174.1126.

*Additional purification of **1** by sublimation (0.2 mm Hg, 108-120 °C) gave sample of **1** (77%) as white powder, mp 143-145 °C ($[\alpha]_D^{25}$ 84.4).

(+)-8-*epi*-Swainsonine (13)

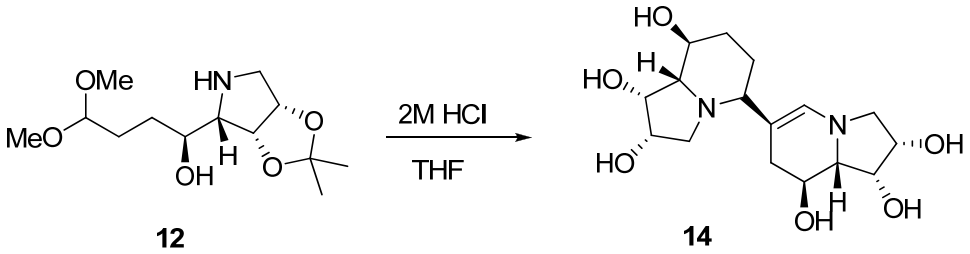


10 **13**

A suspension of **10** (38.9 mg, 0.10 mmol) and 10% Pd/C (19.5 mg, 0.018 mmol) in ethanol (8.0 mL) was stirred under a hydrogen atmosphere (4 bar) for 2 minutes, 2 M HCl (3.5 mL) was added and stirring was continued under hydrogen atmosphere (4 bar) for 6 h at rt. The reaction mixture was filtered through celite, concentrated under reduced pressure and purified by

ion exchange column chromatography (acidic resin DOWEX 50WX8-100), to give the title compound **13** (15.5 mg, 94%) as a white solid.
mp 91-94 °C (Lit.[6] mp 93-95 °C); $[\alpha]_D^{25}$ 22.9 (*c* 0.50, MeOH), (Lit.[6] for the enantiomer $[\alpha]_D^{21}$ – 24.8 (*c* 0.67, MeOH)); ^{1}H NMR (500 MHz, CD_3OD) δ 4.28-4.26 (m, 2H), 4.17 (dt, *J* = 6.9, 1.8 Hz, 1H), 3.06-3.04 (m, 1H), 2.94 (dd, *J* = 10.5, 1.5 Hz, 1H), 2.30 (dd, *J* = 10.5, 6.9 Hz, 1H), 2.04-1.95 (m, 3H), 1.84-1.80 (m, 1H), 1.49-1.39 (m, 2H); ^{13}C NMR (500 MHz, CD_3OD) δ 74.4 (CH) 70.0 (CH), 69.5 (CH), 67.5 (CH), 63.1 (CH_2), 54.4 (CH_2), 32.1 (CH_2), 20.8 (CH_2); IR (ATR) *v* 3355, 2938, 2854, 2792, 1442, 1146, 1012 cm^{-1}; HRMS (*m/z*) calcd for $C_8H_{16}NO_3$ $[M+H]^+$: 174.1125, found: 174.1127.
*Additional purification of **13** by sublimation (0.2 mm Hg, 40-65 °C) gave sample of **13** (79%) as white powder, mp 93-94 °C ($[\alpha]_D^{25}$ 24.7 (*c* 0.87, MeOH)).

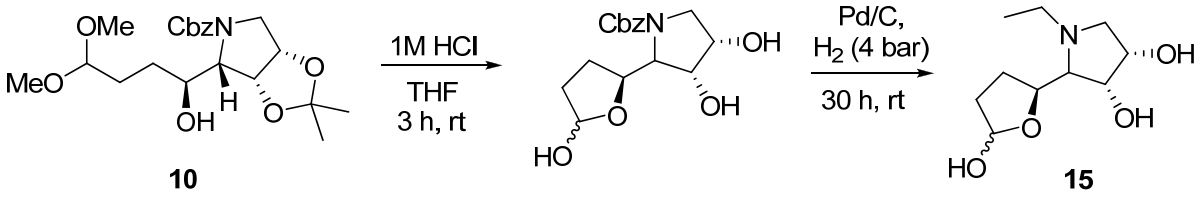
(1*R*,1'*R*,2*S*,2'*S*,5*R*,8*S*,8a*S*,8'*S*,8'a*S*)-1,1',2,2',3,3',5,6,7,7',8,8a,8',8'a-Tetradecahydro-5,6'-biindolizine-1,1',2,2',8,8'-hexaol (14)[7]



12 **14**

To a solution of **12** (23.0 mg, 0.09 mmol) in THF (1.2 mL) 2M HCl (1.2 mL) was added and the mixture was stirred for 1 h at rt. The reaction mixture was concentrated in vacuo and the residue was purified by ion exchange column chromatography (acidic resin DOWEX 50WX8-100) to give compound **14** (9.1 mg, 64%), as a yellow oil.[7]
^{1}H NMR (500 MHz, CD_3OD) δ 5.99 (d, *J* = 1.4 Hz, 1H), 4.22-4.18 (m, 2H), 4.17-4.14 (m, 2H), 3.96 (dt, *J* = 10.0, 5.6 Hz, 1H), 3.78 (ddd, *J* = 11.2, 9.7, 4.7 Hz, 1H), 3.35-3.34 (m, 1H), 3.06 (dd, *J* = 9.7, 3.7, 1H), 3.00 (t, *J* = 8.4 Hz, 1H), 2.89 (dd, *J* = 11.0, 1.8 Hz, 1H), 2.38-2.29 (m, 3H), 2.06-2.01 (m, 1H), 1.94 (ddd, *J* = 15.4, 10.4, 1.6 Hz, 1H), 1.81 (dd, *J* = 9.0, 3.1 Hz, 1H), 1.71-1.62 (m, 1H), 1.47-1.44 (m, 1H), 1.32 (ddd, *J* = 24.8, 13.0, 4.2 Hz, 1H); ^{13}C NMR (500 MHz, CD_3OD) δ 131.3 (CH), 101.2 (C), 75.6 (CH), 72.4 (CH), 72.3 (CH), 71.7 (CH), 69.8 (CH), 69.6 (CH), 67.1 (CH), 66.3 (CH), 64.3 (CH), 61.7 (CH_2), 54.8 (CH_2), 34.8 (CH_2), 32.0 (CH_2), 31.3 (CH_2).

(3*R*,4*S*)-1-Ethyl-2-((*S*)-5-hydroxytetrahydrofuran-2-yl)pyrrolidine-3,4-diol (15)



To a solution of **10** (21.1 mg, 0.05 mmol) in THF (1.2 mL), 1M HCl (1.2 mL) was added and the reaction mixture was stirred for 3 h at rt. The reaction mixture was diluted with EtOAc, washed with sat. aq. $NaHCO_3$, dried over anh. $MgSO_4$ and concentrated under reduced pressure. The crude product was purified by column chromatography (SiO_2; eluent: petroleum ether/ ethyl acetate = 1/4) to afford hemiacetal (13.9 mg, 83%) as colorless oil. A suspension of hemiacetal and 10% Pd/C (5.5 mg, 0.005 mmol) in EtOH (2.2 mL) was stirred under a hydrogen atmosphere (4 bar) over 30 h at rt. The reaction mixture was filtered and concentrated under reduced pressure. The crude product was purified by ion exchange column chromatography (acidic resin DOWEX 50WX8-100) to give compound **15** (3.5 mg, 37%) as a pale-yellow oil. $[\alpha]_D^{25}$ 35.7 (*c* 0.61, H_2O); ^{1}H NMR (500 MHz, D_2O) δ 5.58 (d, J = 4.6 Hz, 1H), 4.54-4.53 (m, 1H), 4.37-4.31 (m, 2H), 3.12 (dd, J = 11.0, 8.0 Hz, 1H), 2.95 (dd, J = 11.0, 8.0 Hz, 1H), 2.88-2.81 (m, 1H), 2.66 (bs, 1H), 2.62-2.55 (m, 1H), 2.22-2.17 (m, 1H), 2.13-2.02 (m, 2H), 1.94-1.89 (m, 1H), 1.10 (t, J = 7.0 Hz, 3H); ^{13}C NMR (500 MHz, D_2O) δ 102.0 (CH), 78.0 (CH), 72.9 (CH), 72.1 (CH), 68.0 (CH), 59.2 (CH_2), 52.1 (CH_2), 31.1 (CH_2), 27.9 (CH_2), 14.5 (CH_3); IR (ATR) *v*3429, 2966, 2802, 1465, 1347, 1294, 1221, 1170, 1135, 1055, 991, 953 cm^{-1}; HRMS (*m/z*) calcd for $C_{10}H_{18}NO_3$ $[M+H-H_2O]^+$: 200.1281, found 200.1278.

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[2] D. D. Perrin, W. L. F. Armarego, *Purification of Laboratory Chemicals*, 3rd edition, Pergamon Press, 1988.

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[5] T. Oishi, T. Iwakuma, M. Hirama, S. Ito, *Synlett* 1995, 404.

[6] K. Tadano, Y. Limura, Y. Hotta, C. Fukabori, T. Soumi, *Bull. Chem. Soc. Jpn.* 1986, **59**, 3885.

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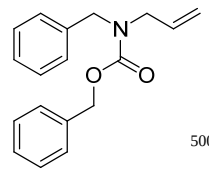
Scanned spectra



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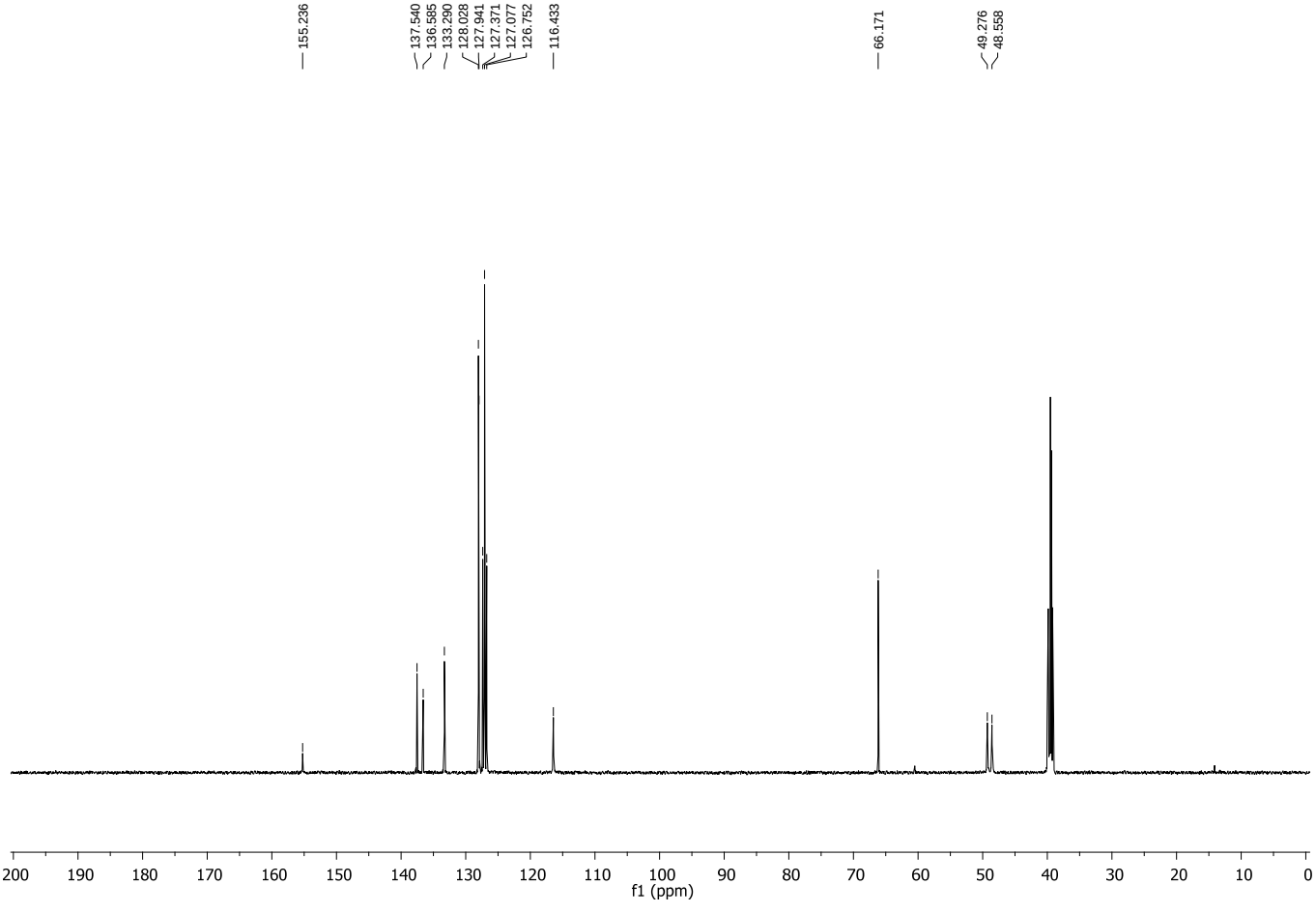

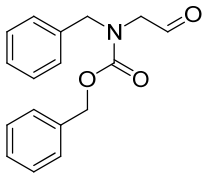

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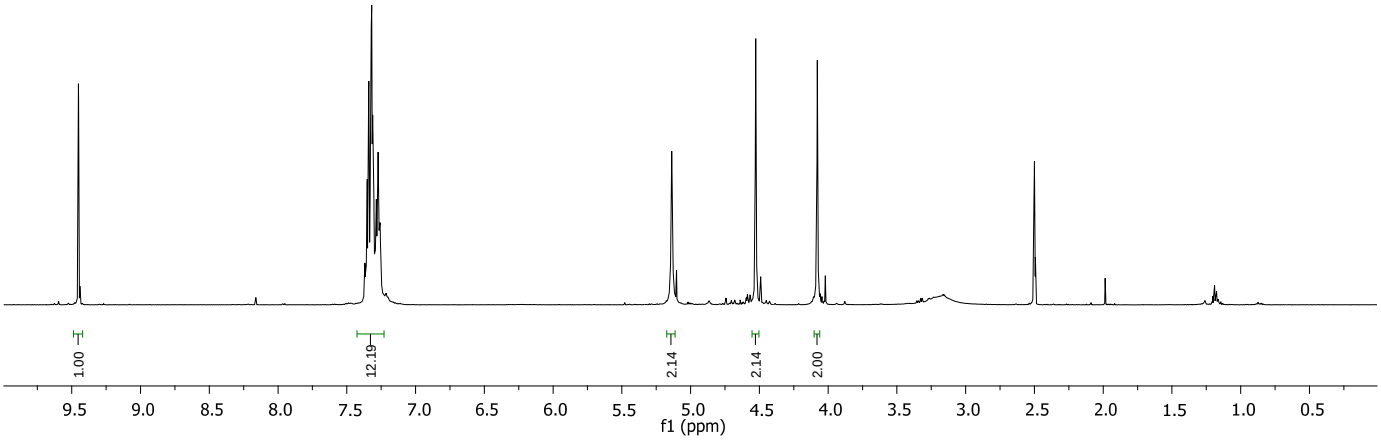

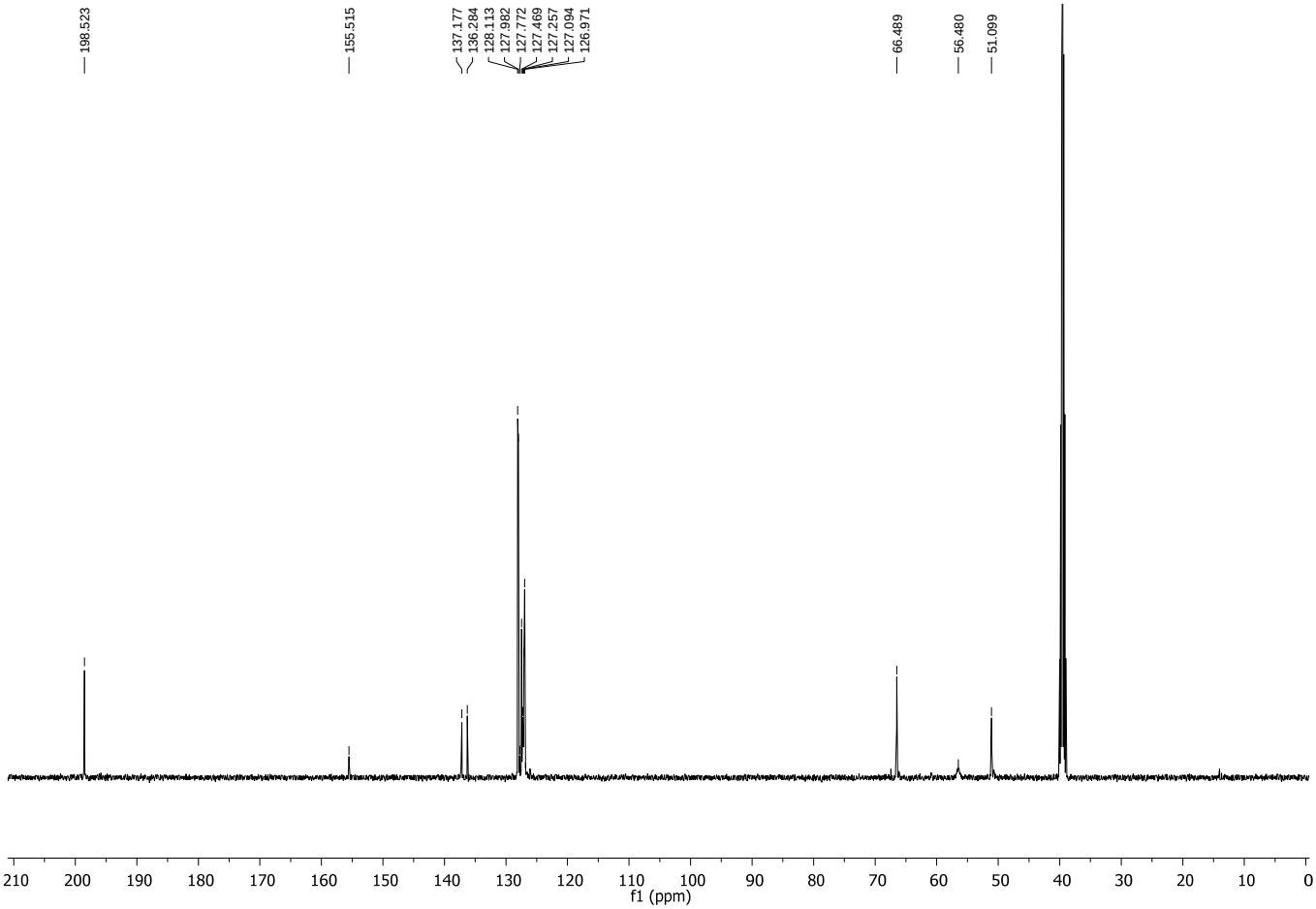

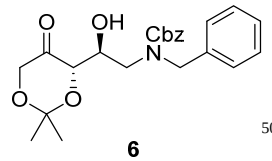

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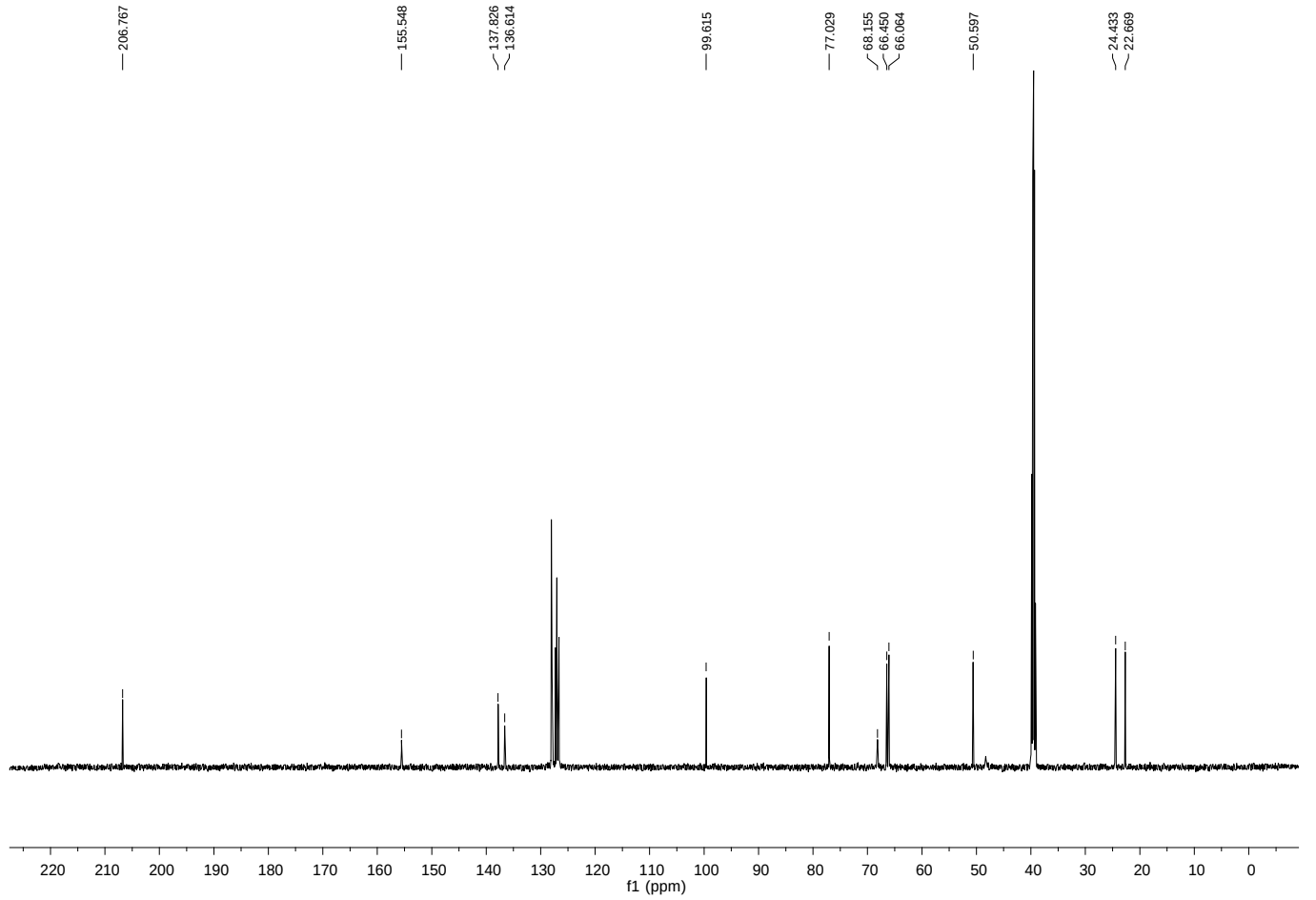

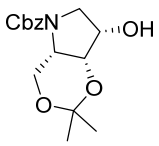

5

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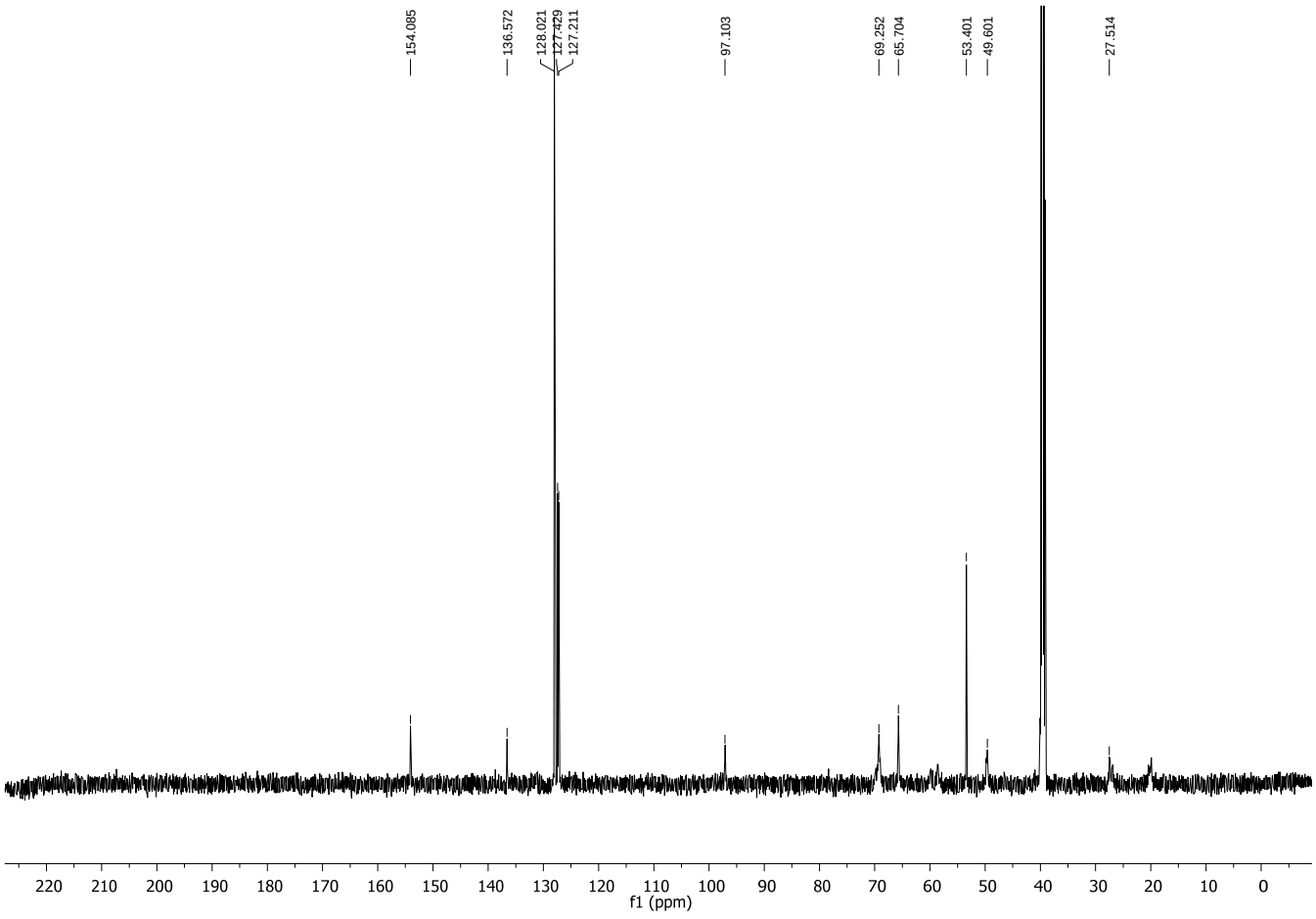

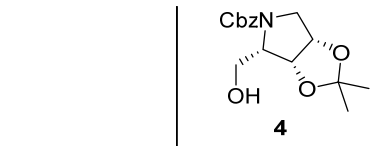

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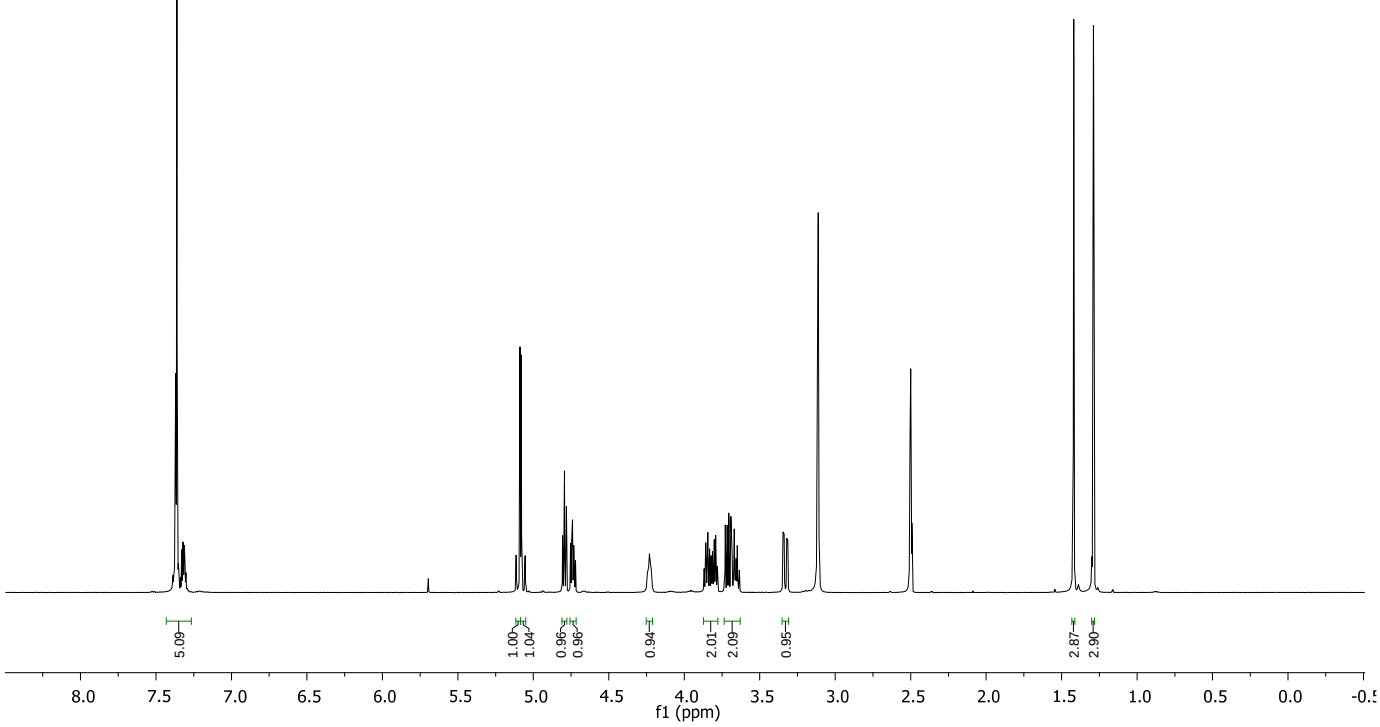

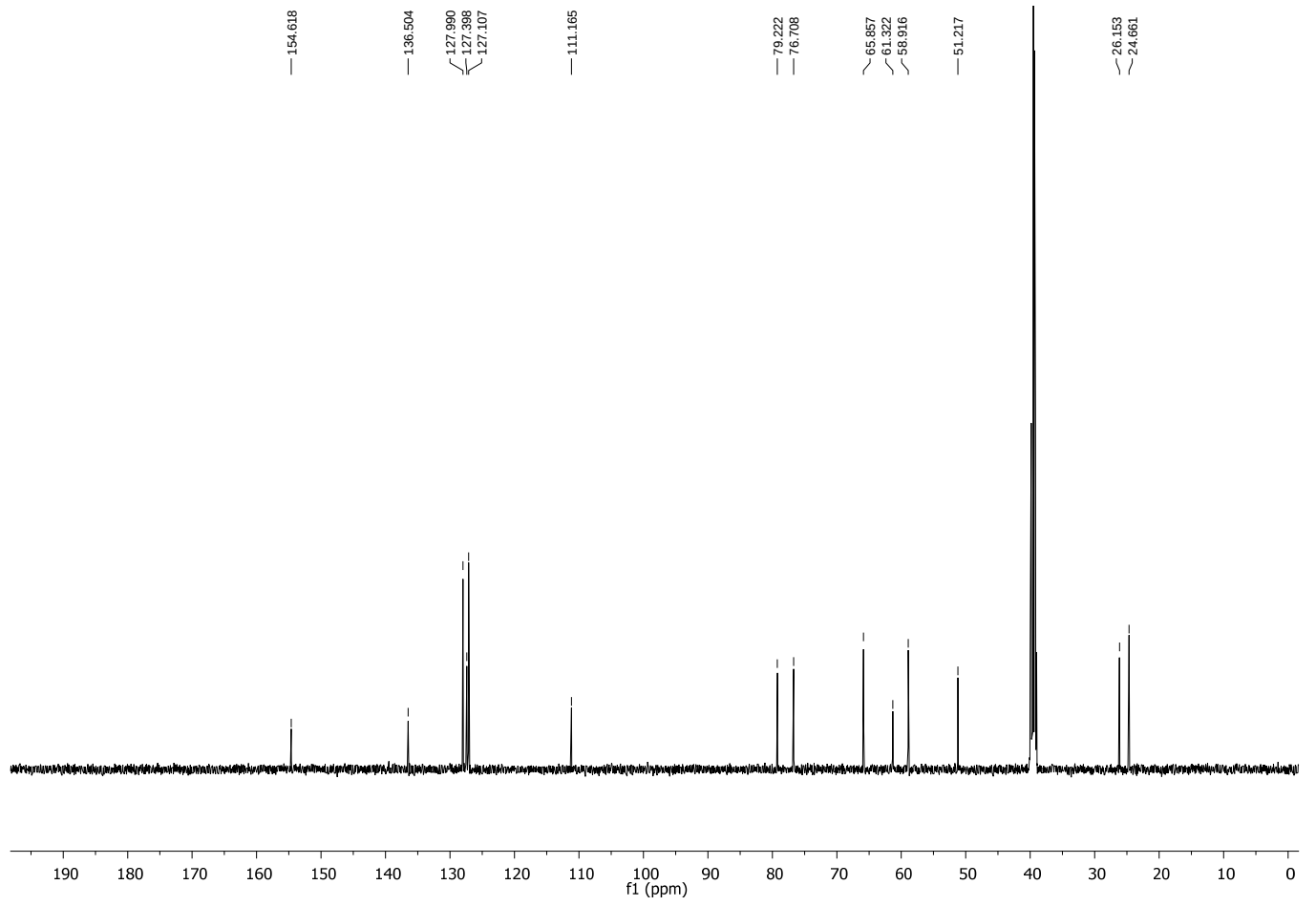

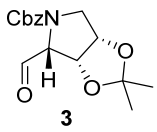

3

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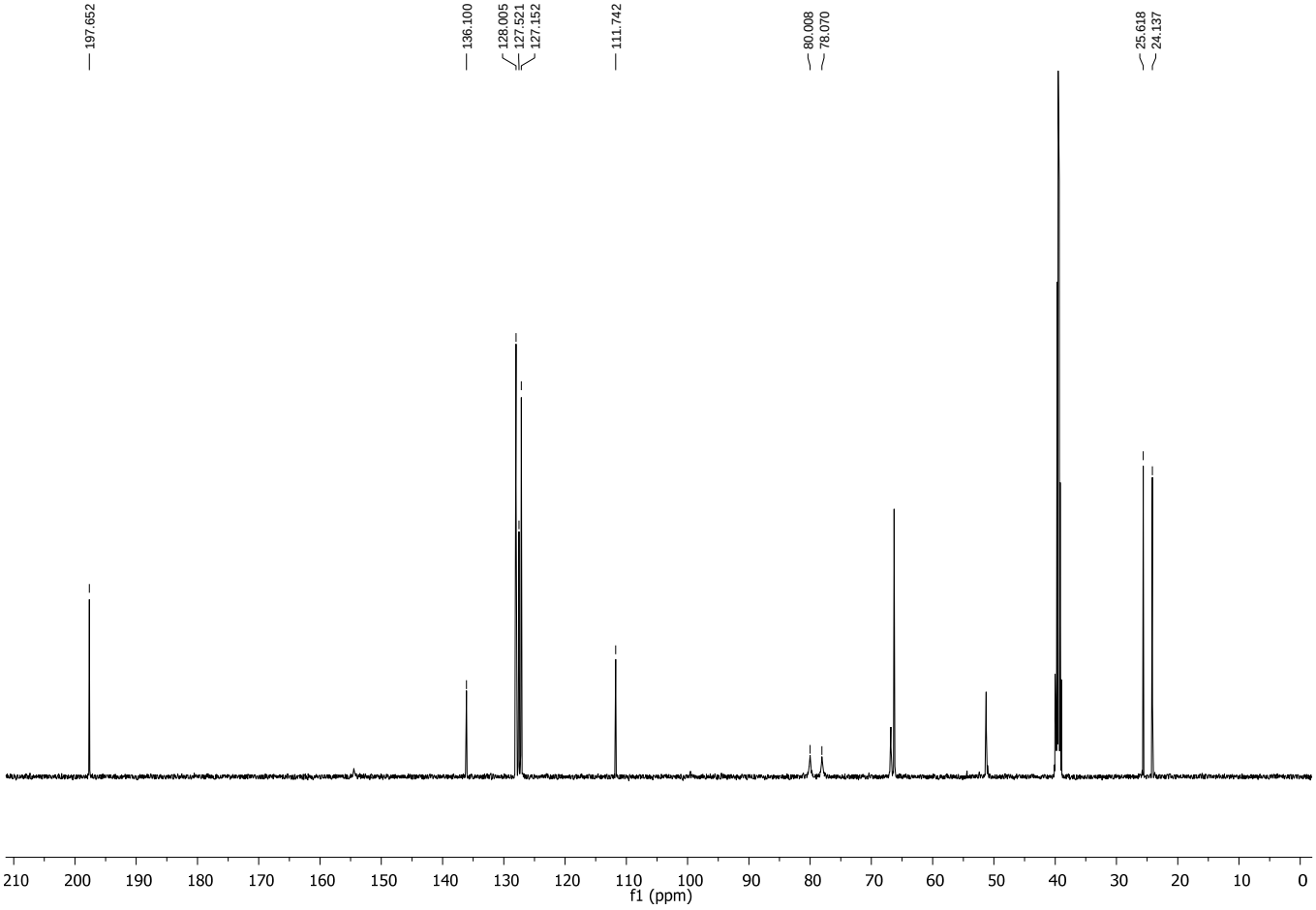

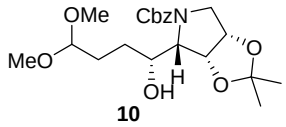

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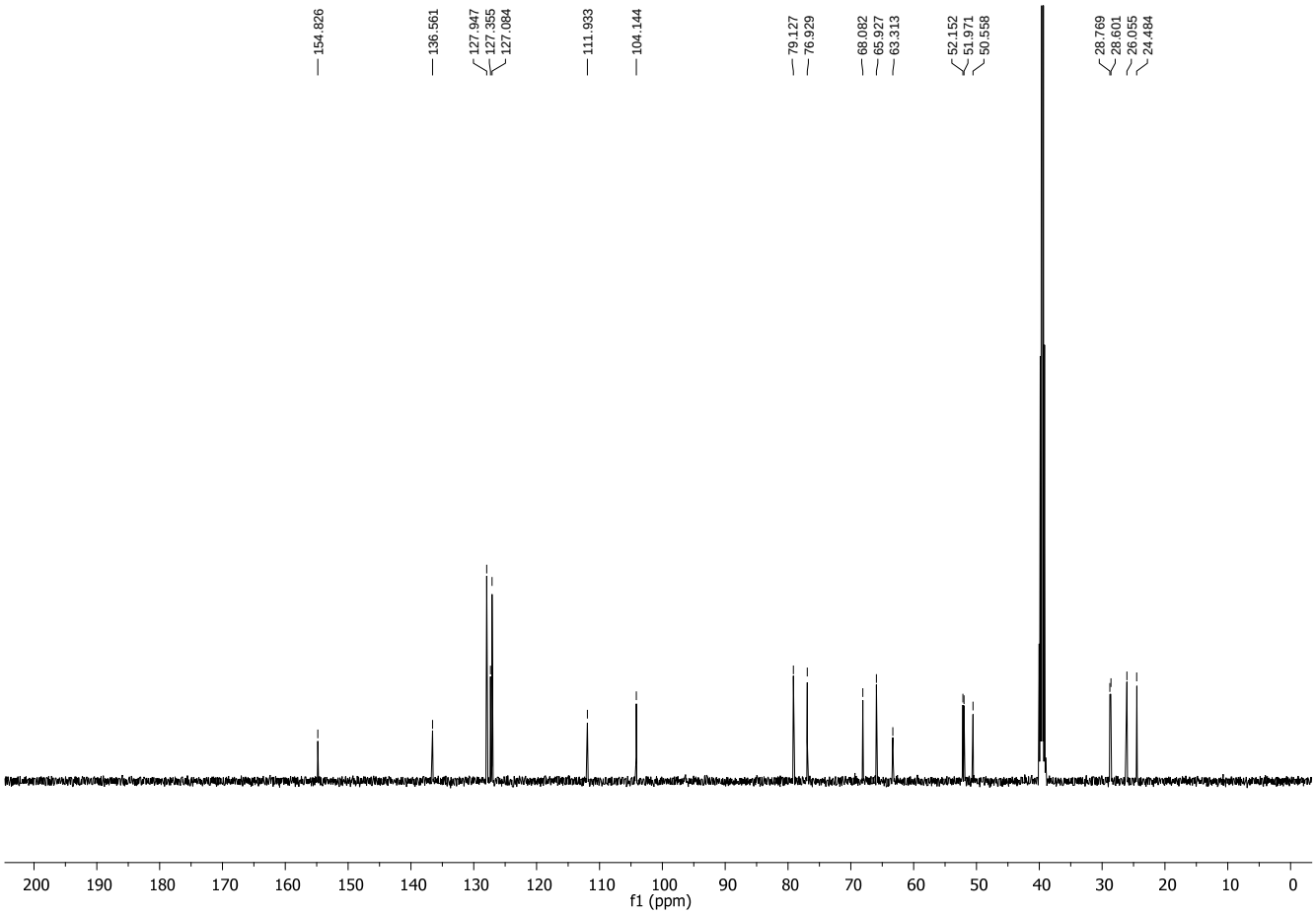

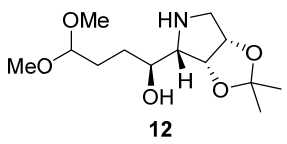

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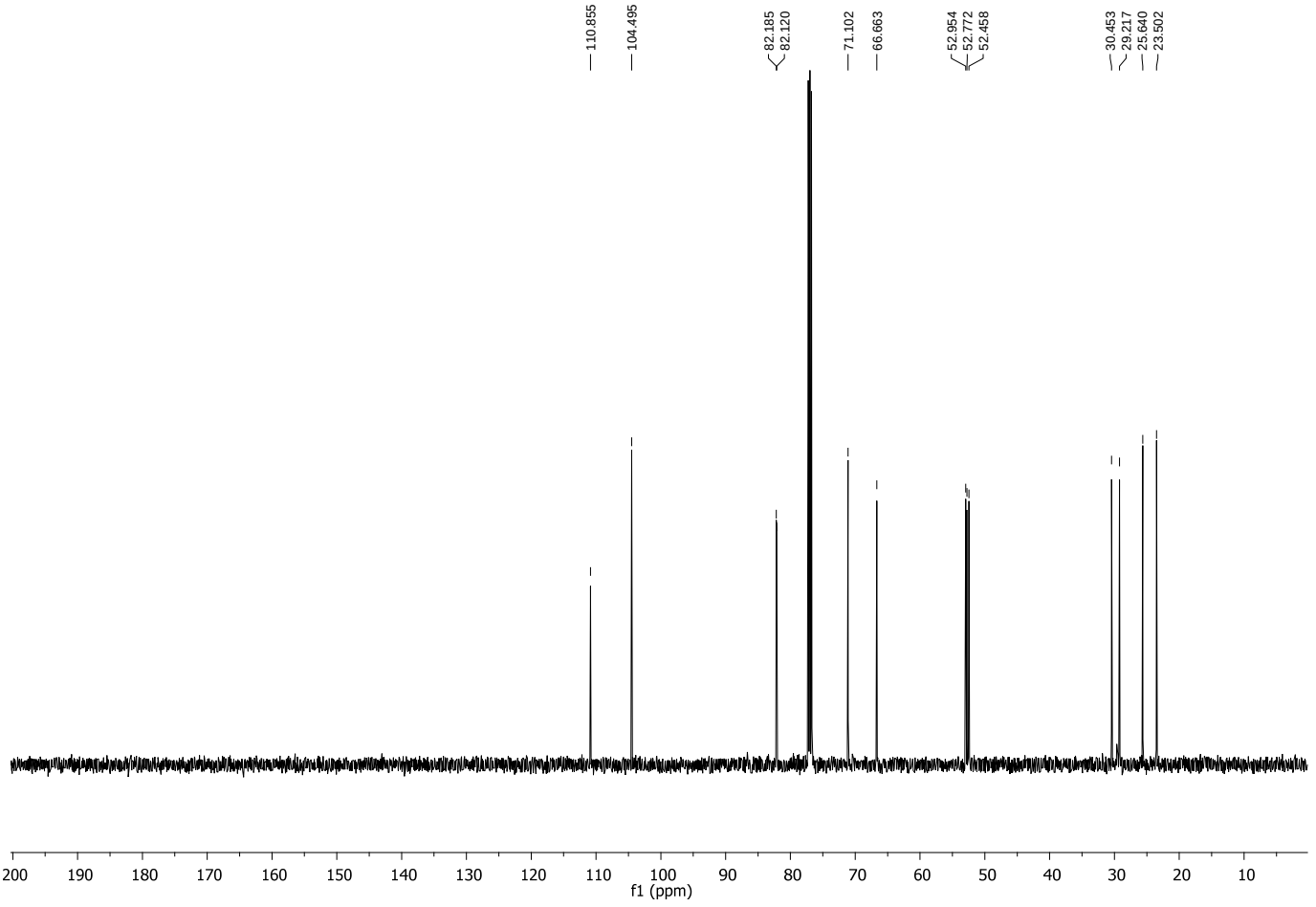

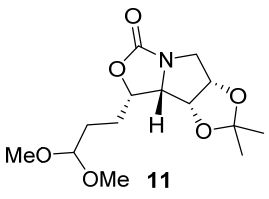

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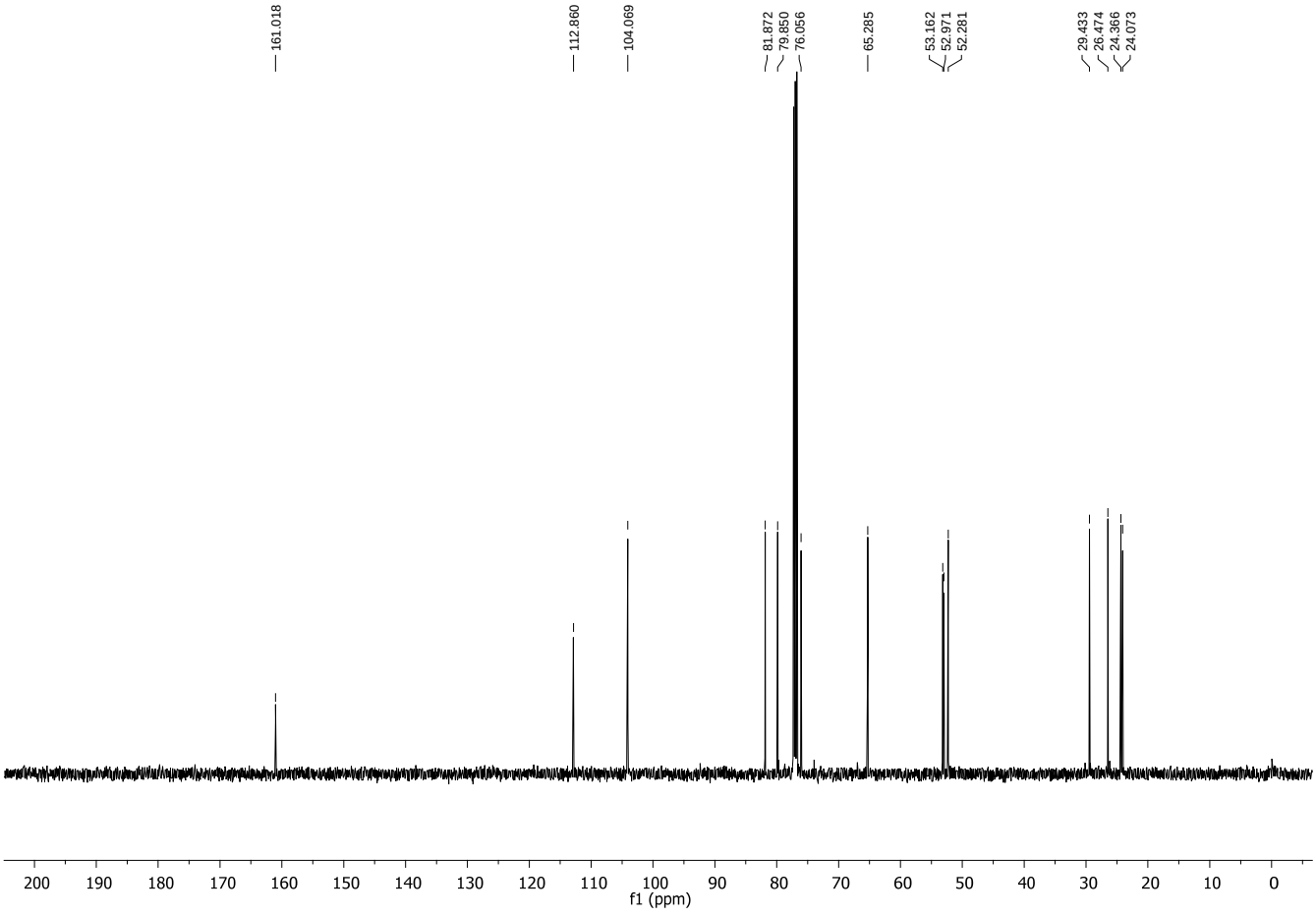

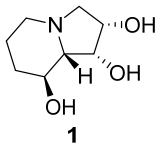

1

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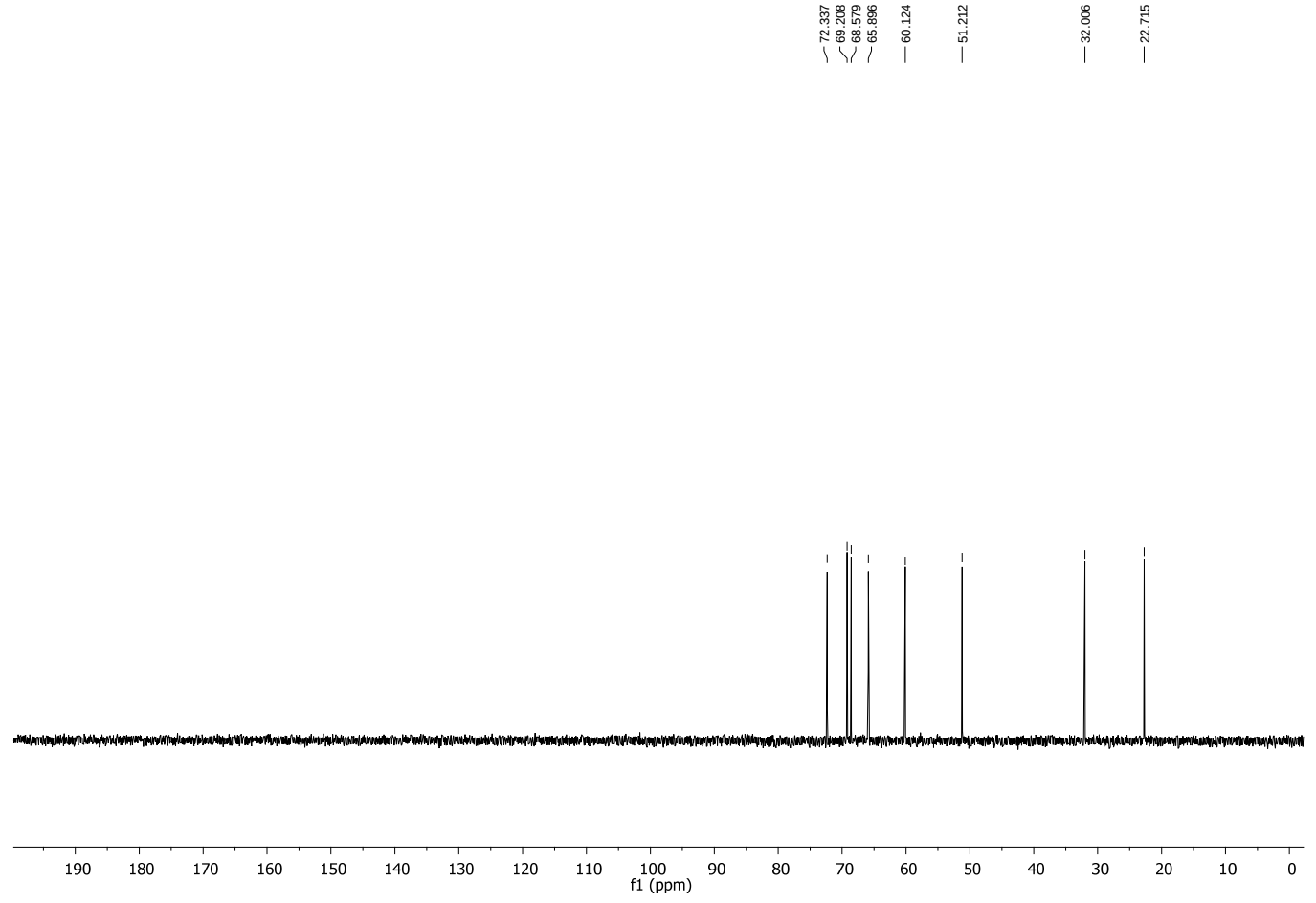

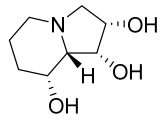

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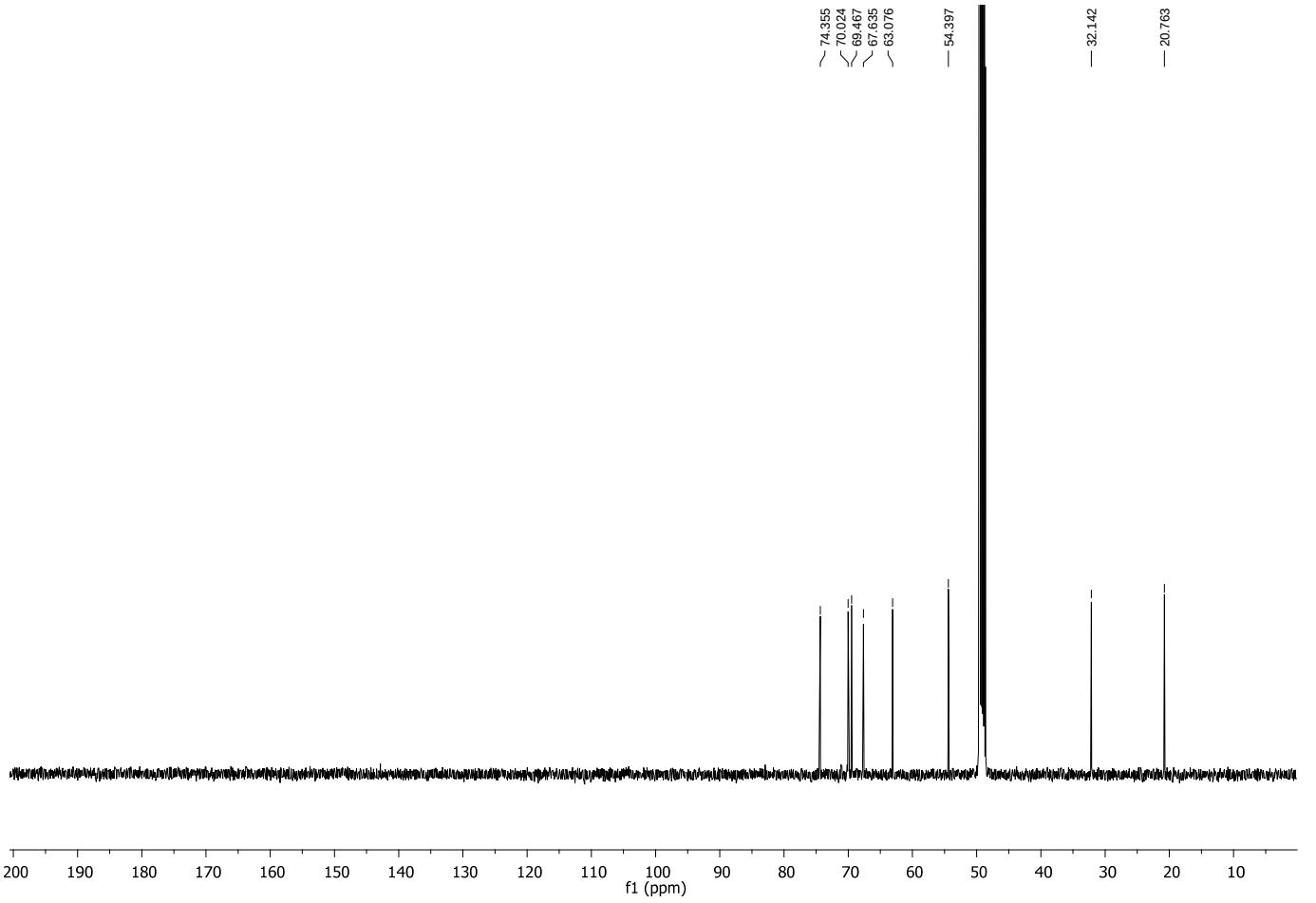

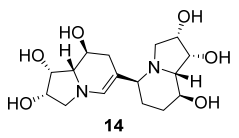

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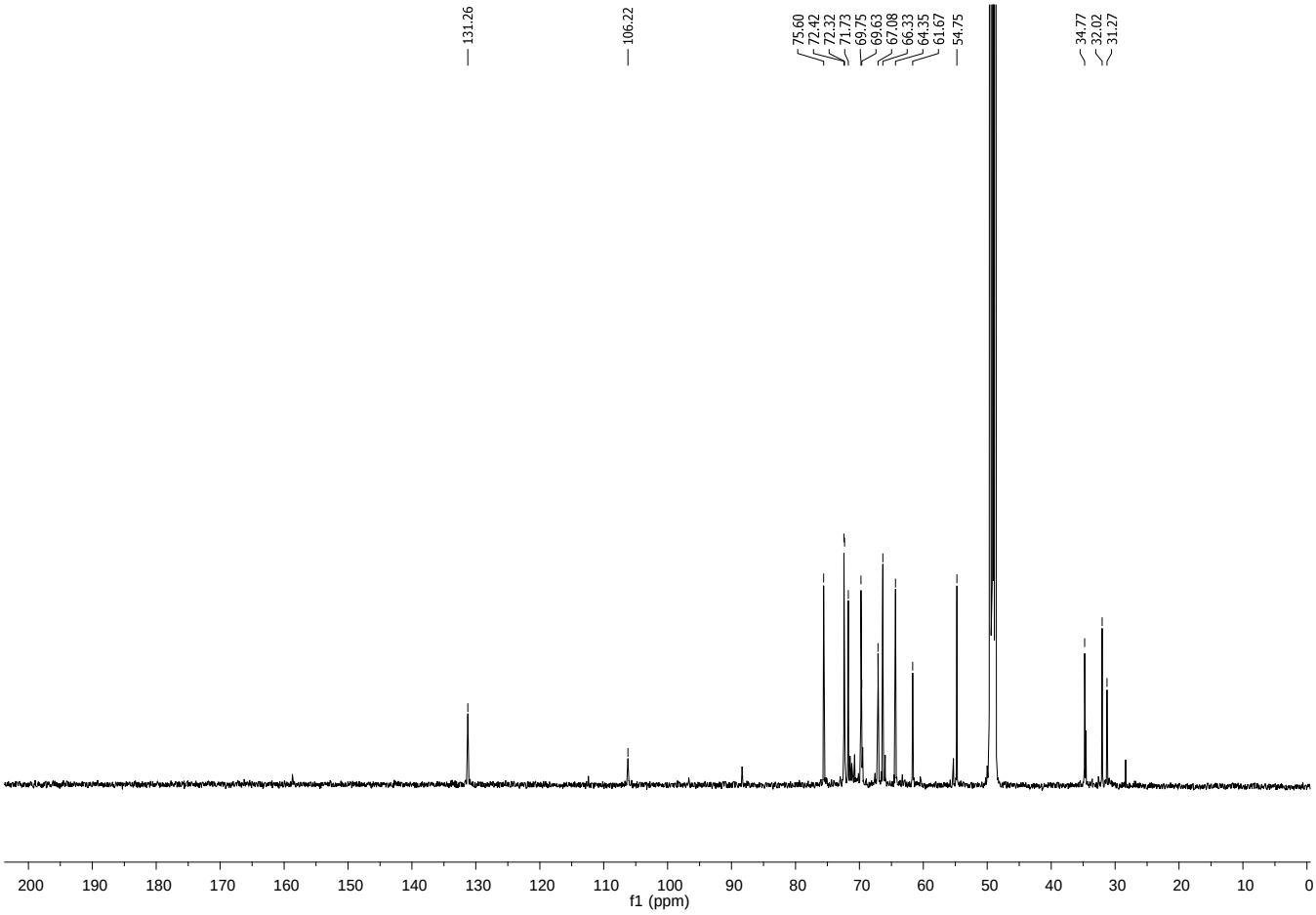

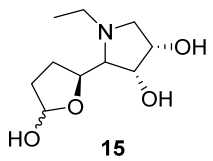

15

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