Supplementary Material (ESI) for Chemical Communications

Electronic Supporting Information

InosAminoAcids: A New Class of Aminocarbasugar Accessed by Microbial Arene Oxidation

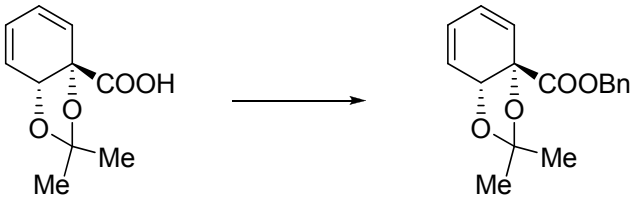
Sarah Pilgrim,[a] Gabriele Kociok-Köhn,[a] Matthew D. Lloyd[b] and Simon E. Lewis[a]*

[a] *Department of Chemistry, University of Bath, Bath, BA2 7AY, UK. Fax:+44 (0)1225 386231; Tel:+44 (0)1225 386568; E-mail: S.E.Lewis@bath.ac.uk*

[b] *Medicinal Chemistry, Department of Pharmacy and Pharmacology, University of Bath, Bath, BA2 7AY, UK.*

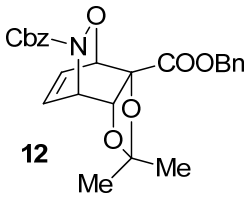
General Synthetic Procedures and Instrumentation. Reactions were carried out under an atmosphere of nitrogen.. Solvents were dried and degassed by passing through anhydrous alumina columns using an Innovative Technology Inc. PS-400-7 solvent purification system. Petrol refers to petroleum ether, bp 40-60 °C. TLCs were performed using aluminum-backed plates precoated with Alugram®SIL G/UV and visualized by UV light (254 nm) and/or $KMnO_4$ followed by gentle warming. Flash column chromatography was carried out using Davisil LC 60Å silica gel (particle size 35-70 μm) purchased from Fisher Scientific Ltd. Reversed-phase chromatography was performed using Silicycle C_{18} ultrapure silica gel (particle size 40-63 μm) purchased from Material Harvest (Cambridge, UK). All reagents were purchased from the Sigma-Aldrich Chemical Co. and were used without further purification. IR spectra were recorded on Perkin-Elmer 1600 FT IR spectrometer with absorbances quoted as ν in cm^{-1}. NMR spectra were run on Brüker Avance 300, 400 or 500 MHz instruments at 298 K, unless otherwise specified. Mass spectra were recorded with a micrOTOF electrospray time-of-flight (ESI-TOF) mass spectrometer (Brüker Daltonik). Specific rotations were recorded on an Optical Activity AA-10 Automatic polarimeter with a path length of 1 dm. Concentrations (c) are quoted in g/100 mL.

(3a*S*,7a*R*)-Benzyl 2,2-dimethyl-3a,7a-dihydrobenzo[d][1,3]dioxole-3a-carboxylate 10

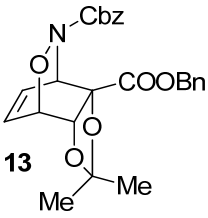


To the known[1] acetonide of **9** (1.79 g, 9.14 mmol, 1.00 equiv.) in DMF (18 mL, 0.5 M) was added triethylamine (1.27 mL, 9.14 mmol, 1.00 equiv.) and benzyl bromide (1.09 mL, 9.14 mmol, 1.00 equiv.) by syringe. The reaction mixture was stirred at rt for 30 min, then diluted with EtOAc (30 mL) and extracted with $LiCl_{(aq)}$ (saturated , 3 x 30 mL). The organic phase was dried over $MgSO_4$ and filtered; the filtrate was concentrated under reduced pressure. The crude product was purified by chromatography (10% EtOAc–petrol) to give *(3a*S*,7a*R*)-benzyl 2,2-dimethyl-3a,7a-dihydrobenzo[d][1,3]-dioxole-3a-carboxylate* **10** (1.20 g, 57%) as a colourless oil; R_f 0.25 (10% EtOAc–petrol); $[\alpha]_D^{25}$ –33.0 (c. 1.0, CH_2Cl_2); δ_H (300 MHz, $CDCl_3$) 7.37-7.31 (5H, m, Ar-H), 6.13-6.07 (2H, m, Alkene C-H), 6.03-5.98 (1H, m, Alkene C-H), 5.86-5.81 (1H, m, Alkene C-H), 5.22 (2H, s, -CH_2-Ar), 4.97 (1H, d, *J* 4.5 Hz -O-CH-), 1.40 (3H, s, H_3C-C-C*H*$_3$), 1.39 (3H, s, *H*$_3$C-C-CH_3); δ_C (75.5 MHz, $CDCl_3$) 171.5, 135.3, 128.5, 128.3, 128.0, 124.6, 124.5, 124.1, 124.0, 106.7, 79.4, 72.7, 67.3, 26.9, 25.1; ν_{max} (film) 3047, 2989, 2937, 1732, 1587, 1498, 1455, 1412, 1381, 1371, 1226, 1212, 1166, 1135, 1080, 1036, 1010, 967, 951, 914, 883, 824, 780, 736, 696 cm^{-1}; HRMS (+ve ESI-TOF) m/z calculated for $(C_{17}H_{18}O_4+Na)^+$, 309.1103; found 309.1096.

(3a*R*,4*R*,7*S*,7a*R*)-Dibenzyl 2,2-dimethyl-3a,4,7,7a-tetrahydro-4,7-(epoxyimino)-benzo[d][1,3]dioxole-3a,8-dicarboxylate 12 and (3a*R*,4*S*,7*R*,7a*S*)-Dibenzyl 2,2-dimethyl-3a,4,7,7a-tetrahydro-4,7-(epoxyimino)benzo[d][1,3]dioxole-7a,8-dicarboxylate 13



12

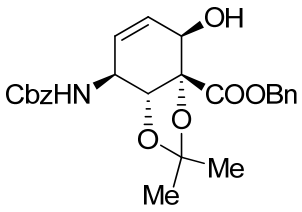


13

Diene **10** (1.99 g, 6.95 mmol, 1.00 equiv.), and tetrabutylammonium periodate (6.01 g, 13.9 mmol, 2.00 equiv.) were dissolved in CH_2Cl_2 (30 mL) and cooled to –78 °C. A solution of *N*-carbobenzoxyhydroxylamine **11** (2.32 g, 13.9 mmol, 2.00 equiv.) in CH_2Cl_2 (5 mL) was added dropwise to the reaction mixture via cannula over 10 min. The reaction mixture was warmed to rt over 2 h, then washed with $Na_2S_2O_{3(aq)}$ (saturated, 2 x 10 mL) and H_2O (10 mL). The organic layer was dried over $MgSO_4$ and filtered; the filtrate was concentrated under reduced pressure. The crude product was purified by chromatography (5% Et_2O–toluene) to give *(3a*R*,4*R*,7*S*,7a*R*)-dibenzyl 2,2-dimethyl-3a,4,7,7a-tetrahydro-4,7-(epoxyimino)benzo[d][1,3]dioxole-3a,8-dicarboxylate* **12** (1.81 g, 58%) and *(3a*R*,4*S*,7*R*,7a*S*)-dibenzyl 2,2-dimethyl-3a,4,7,7a-tetrahydro-4,7-(epoxyimino)benzo[d][1,3]dioxole-7a,8-dicarboxylate* **13** (416 mg, 13%) as colorless oils. **12:** R_f 0.55 (5% Et_2O–toluene); $[\alpha]_D^{25}$ –8.0 (c 1.0, CH_2Cl_2); δ_H (500 MHz, $CDCl_3$) 7.38-7.30 (10H, m, Ar), 6.49 (1H, dd, *J* 8.0 5.5 Hz, Alkene-H), 6.45 (1H, ddd, *J* 8.0 6.0 1.5 Hz, Alkene-H), 5.32 (1H, d, *J* 12.5 Hz, Ar^1-C*H*H-), 5.24 (1H, d, 12.5 Hz, Ar^1-CH*H*-), 5.19 (1H, d, 12.5 Hz, Ar^2-C*H*H-), 5.19-5.16 (3H, m, N-CH-, 2× O-CH-), 5.14 (1H, d, 12.5 Hz, Ar^2-CH*H*-), 1.30 (3H, s, CH_3), 1.21 (3H, s, CH_3); δ_C (125 MHz, $CDCl_3$) 170.1 (O-C=O), 157.6 (N-C=O), 135.3 (4° Ar), 135.0 (4° Ar), 131.0 (Alkene, br), 128.8 (Alkene), 128.4 (3° Ar), 128.3 (3° Ar), 128.2 (3° Ar), 128.1 (3° Ar), 128.0 (3° Ar), 112.6 (H_3C-*C*-CH_3), 82.1 (BnO-C(O)-*C*-), 74.1 (O-N-C-*C*-O-), 72.9 (N-O-C-), 68.2 (Ar^2-C-), 67.6 (Ar^1-C-), 53.1 (O-N-*C*-C-O-), 26.0 (CH_3), 25.9 (CH_3); ν_{max} (film), 3035, 2991, 2941, 1739, 1711, 1498, 1456, 1376, 1328, 1286, 1254, 1213, 1178, 1109, 1087, 1067, 1026, 1002, 973, 904, 874, 809, 752, 734, 697, 677, 658 cm^{-1}; HRMS (+ve ESI-TOF) m/z calculated for

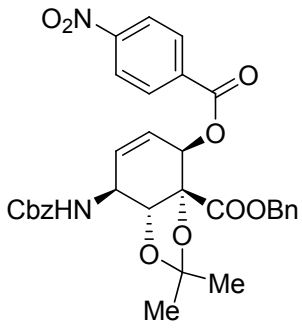
$(C_{25}H_{25}NO_7+H)^+$, 452.1709, found, 452.1721; calculated for $(C_{25}H_{25}NO_7+Na)^+$, 474.1529; found, 474.1524. **13**: R_f 0.42 (5% Et_2O–toluene); $[\alpha]_D^{25}$ –5.0 (c 2.0, CH_2Cl_2); δ_H (500 MHz, $CDCl_3$) 7.35- 7.31 (5H, m, Ar-H), 7.30-7.28 (5H, m, Ar-H), 6.49-6.43 (2H, m, Alkene C-H), 5.37 (1H, dd, *J* 5.5, 2.0 Hz, N-CH-), 5.29 (1H, d, *J* 12.5 Hz, Ar^1-C*H*H-), 5.23 (1H, d, *J* 12.5 Hz, Ar^1-CH*H*-), 5.19 (1H, d, *J* 4.5 Hz, N-O-CH-C*H*-O-), 5.18 (1H, d, *J* 12.5 Hz, Ar^2-CH*H*-), 5.06 (1H, d, *J* 12.5 Hz, Ar^2-CH*H*-), 5.00 (1H, td, *J* 5.0, 2.0 Hz, N-O-C*H*-CH-O-), 1.29 (3H, s, CH_3), 1.21 (3H, s, CH_3); δ_C (125 MHz, $CDCl_3$) 169.8 (O-C=O), 157.3 (N-C=O), 135.2 (4° Ar), 134.9 (4° Ar), 130.0 (Alkene), 129.7 (Alkene, br), 128.3 (3° Ar), 128.3 (3° Ar), 128.1 (3° Ar), 128.0 (3° Ar), 127.8 (3° Ar), 112.6 (H_3C-*C*-CH_3), 81.9 (BnO-C(O)-*C*-), 74.5 (N-O-C-*C*-O-), 71.4 (N-O-*C*-C-O-), 68.0 (Ar^2-C-), 67.5 (Ar^1-C-), 55.0 (O-N-*C*-C-), 25.9 (CH_3), 25.8 (CH_3); ν_{max} (film) 3034, 2982, 2948, 1742, 1713, 1498, 1456, 1383, 1351, 1323, 1261, 1213, 1178, 1110, 1090, 1061, 1025, 967, 872, 835, 697, 662 cm^{-1}; HRMS (+ve ESI-TOF) m/z calculated for $(C_{25}H_{25}NO_7+H)^+$, 452.1709, found, 452.1711; calculated for $(C_{25}H_{25}NO_7+Na)^+$, 474.1529, found, 474.1517.

(3a*S*,4*R*,7*S*,7a*R*)-Benzyl 4-(benzyloxycarbonylamino)-7-hydroxy-2,2-dimethyl-3a,4,7,7a-tetrahydrobenzo[d][1,3]dioxole-3a-carboxylate 14



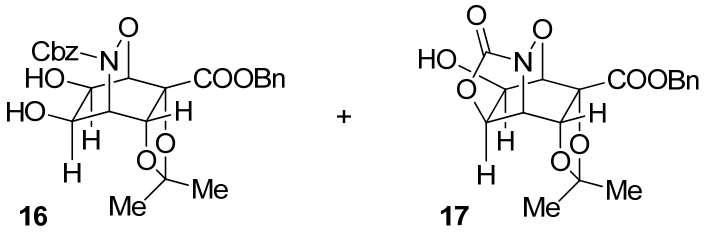
To a solution of **12** (93 mg, 0.206 mmol, 1.00 equiv) in MeCN (12 mL) and water (0.4 mL) was added $Mo(CO)_6$ (82 mg, 0.309 mmol, 1.50 equiv). The reaction mixture was refluxed for 72 h. The cooled mixture was filtered through celite and the filtrate evaporated under reduced pressure to give a dark brown oil. This was purified by chromatography (40% EtOAc–petrol) to give *(3a*S*,4*R*,7*S*,7a*R*)-benzyl 4-(benzyloxycarbonylamino)-7-hydroxy-2,2-dimethyl-3a,4,7,7a-tetrahydrobenzo-[d][1,3]dioxole-3a-carboxylate* **14** (65 mg, 69%) as a colorless oil; R_f 0.63 (40% EtOAc–petrol); $[\alpha]_D^{25}$ –2.0 (c 2.0, $CHCl_3$); δ_H (300 MHz, $CDCl_3$) 7.37-7.28 (10H, m, Ar-H), 6.01 (1H, ddd, *J* 10.0 4.0 1.5 Hz, Alkene C-H), 5.90 (1H, dd, *J* 10.0 4.5 Hz, Alkene C-H), 5.36 (1H, br d, *J* 9.0 Hz), 5.23 (2H, s, Ar^1-CH_2-), 5.13 (1H, d, *J* 12.0 Hz, Ar^2-C*H*H-), 5.06 (1H, d, *J* 12.0 Hz, Ar^2-CH*H*-), 4.63 (1H, d, *J* 3.0 Hz), 4.44-4.37 (2H, m), 2.92 (1H, d, *J* 5.5 Hz), 1.47 (3H, s, CH_3), 1.31 (3H, s, CH_3); δ_C (75 MHz, $CDCl_3$) 171.1, 155.7, 136.3, 135.0, 130.2, 129.1, 128.6, 128.5, 128.5, 128.4, 128.1, 110.4, 85.3, 79.8, 69.7, 67.5, 66.9, 49.2, 27.1, 25.5; ν_{max} (film) 3340, 2992, 2251, 1725, 1509, 1456, 1376, 1232, 1171, 1067, 1028, 909, 883, 814, 730, 696, 648 cm^{-1}; HRMS (ESI +ve) calculated for $(C_{25}H_{27}NO_7+H)^+$ 454.1866; found, 454.1853; calculated for $(C_{25}H_{27}NO_7+Na)^+$, 476.1685; found, 476.1644.

(3a*S*,4*R*,7*S*,7a*R*)-Benzyl 7-(benzyloxycarbonylamino)-2,2-dimethyl-4-(4-nitro-benzoyloxy)-3a,4,7,7a-tetrahydrobenzo[d][1,3]dioxole-3a-carboxylate 15



To a stirred solution of **14** (70 mg, 0.154 mmol, 1.00 equiv) in CH_2Cl_2 (1 mL) at rt, were added *p*-nitrobenzoylchloride (129 mg, 0.695 mmol, 4.5 equiv), pyridine (1 mL) and a catalytic amount of DMAP. The stirring continued for 24 h at rt under N_2. The reaction mixture was transferred to a separating funnel, diluted with EtOAc (30 mL) and washed with water (2 x 10 mL). The organic phase dried over $MgSO_4$ and filtered; the filtrate was concentrated under reduced pressure, then purified by chromatography (20% EtOAc–petrol) to give *(3a*S*,4*R*,7*S*,7a*R*)-benzyl 7-(benzyloxycarbonylamino)-2,2-dimethyl-4-(4-nitrobenzoyloxy)-3a,4,7,7a-tetrahydro-benzo[d][1,3]dioxole-3a-carboxylate* **15** (20 mg, 22%) as white crystals; m. pt. 106 ^{0}C; R_f 0.32 (20% EtOAc–petrol); $[\alpha]_D^{25}$ –7.0 (c 1.0, $CHCl_3$); δ_H (500 MHz, $CDCl_3$) 7.95 (2H, d, *J* 8.5 Hz, O_2N-Ar-H), 7.81 (2H, d, *J* 8.5, O_2N-Ar-H), 7.39-7.05 (10H, m, Ph-H), 6.18 (1H, dd, *J* 10.0 5.0 Hz, Alkene C-H), 6.13 (1H, dd, *J* 10.0 4.0 Hz, Alkene C-H), 5.64 (1H, d, *J* 4.0 Hz), 5.26 (1H, d, *J* 12.0 Hz, Ph^1-C*H*H-), 5.15 (1H, d, J 12.0 Hz, Ph^2-C*H*H-), 5.14 (1H, d, J 12.0 Hz, Ph^2-CH*H*-), 5.06 (2H, br d, *J* 12.0 Hz), 4.82 (1H, br s), 4.61 (1H, br s), 1.48 (3H, s, CH_3), 1.34 (3H, s, CH_3); δ_C 170.2, 162.8, 155.4, 150.6, 136.0, 134.7, 134.1, 131.9, 130.6, 128.6, 128.6, 128.4, 128.3, 126.6, 123.5, 110.5, 83.0, 78.9, 71.1, 67.7, 67.2, 47.8, 26.8, 25.2; ν_{max} (film) 3415, 3346, 2993, 2947, 1728, 1613, 1528, 1459, 1350, 1268, 1178, 1102, 1018, 876, 719 cm^{-1}; HRMS (ESI +ve) *m/z* calculated for $(C_{32}H_{30}N_2O_{10}+H)^+$, 603.1979; found, 603.1945. Crystallization by vapor diffusion of hexane into a $CHCl_3$ solution of **15** afforded crystals suitable for X-ray analysis.

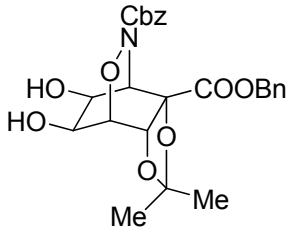
(3a*R*,4*R*,5*R*,6*R*,7*S*,7a*R*)-Dibenzyl 5,6-dihydroxy-2,2-dimethylhexahydro-4,7-(epoxyimino)benzo[d][1,3]dioxole-3a,8-dicarboxylate 16 and benzyl 5-hydroxy-2,2-dimethyl-7-oxohexahydro-3aH-4,8-epoxy[1,3]dioxolo[4',5':5,6]benzo[1,2-d]oxazole-3a-carboxylate 17



To a solution of **12** (493 mg, 1.093 mmol, 1.0 equiv.) in acetone/water (4:1, 50 mL) was added *N*-methyl morpholine *N*-oxide (295 mg, 2.19 mmol, 2.0 equiv) as a solid. OsO_4 (200 μL, 2.5% w/v in ^{t}BuOH, 0.022 mmol, 0.02 equiv) was added via syringe and the reaction mixture was stirred at rt for 24 h. The reaction mixture was transferred to a separating funnel, diluted with EtOAc (100 mL) and washed with $Na_2S_2O_{3(aq)}$ (saturated, 2 × 30 mL). The organic phase was then washed further with $NaCl_{(aq)}$ (saturated, 2 × 30 mL), dried over $MgSO_4$, concentrated under reduced pressure and purified by chromatography (50% EtOAc–petrol) to give *(3a*R*,4*R*,5*R*,6*R*,7*S*,7a*R*)-dibenzyl 5,6-dihydroxy-2,2-dimethylhexahydro-4,7-(epoxy-imino)benzo[d][1,3]dioxole-3a,8-dicarboxylate* **16** (204 mg, 39%) as a colorless oil and *benzyl 5-hydroxy-2,2-dimethyl-7-oxohexahydro-3aH-4,8-epoxy[1,3]dioxolo-[4',5':5,6]benzo[1,2-d]oxazole-3a-carboxylate* **17** (132 mg, 32%) as a colorless oil. Diol **16**: R_f 0.47 (50% EtOAc–petrol); $[\alpha]_D^{25}$ –2.0 (*c* 2.0, $CHCl_3$); δ_H (300 MHz, $CDCl_3$) 7.38-7.30 (10H, m, Ar-H), 5.21 (2H, s, Ar-CH_2-), 5.17-5.16 (3H, m, H_3C-C-O-C*H*-, Ar-CH_2-), 4.73 (1H, br s, N-CH-), 4.52 (1H, s, N-O-CH-), 4.38-4.32 (1H, m, N-CH-C*H*OH-), 4.18 (1H, td, *J* 8.5 1.0 Hz, N-O-CH-C*H*OH-), 3.54 (1H, br s, N-O-CH-CHO*H*-), 3.24 (1H, d, *J* 6.0 Hz, N-CH-CHO*H*-), 1.45 (3H, s, CH_3), 1.21 (3H, s, CH_3); δ_C (75 MHz, $CDCl_3$), 169.6 (O-C=O), 157.2 (N-C=O), 135.4 (4° Ar), 134.8 (4° Ar), 128.5 (3° Ar), 128.5 (3° Ar), 128.3 (3° Ar), 128.2 (3° Ar), 128.1 (3° Ar), 112.2 (H_3C-*C*-CH_3), 80.2 (N-O-CH-), 79.2 (br, -*C*-C=O), 72.3 (br, H_3C-C-O-*C*H-), 68.3 (Ar-*C*H_2-), 67.9 (Ar-*C*H_2-), 61.2 (N-O-CH-*C*HOH-), 60.6 (N-CH-*C*HOH-), 56.3 (br, N-CH-), 25.7 (CH_3), 24.6 (CH_3); ν_{max} (film) 3429, 3066, 3034, 2990, 2944, 1737, 1708, 1587, 1498, 1456, 1404, 1385, 1347, 1268, 1213,

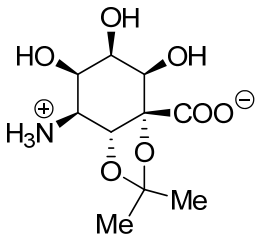
1167, 1098, 1066, 1020, 974, 908, 868, 822, 734 cm^{-1}; HRMS (ESI +ve) *m/z* calculated for $(C_{25}H_{27}NO_9+H)^+$, 486.1759; found, 486.1753; calculated for $(C_{25}H_{27}NO_9+Na)^+$, 508.1578; found, 508.1569). Carbamate **17**: R_f 0.59 (50% EtOAc–petrol; $[\alpha]_D^{25}$ +1.5 (*c* 2.0, $CHCl_3$); δ_H (400 MHz, $CDCl_3$) 7.37-7.36 (5H, m, Ar-H), 5.31-5.21 (2H, m), 5.09-5.03 (1H, m), 4.83 (1H, s), 4.68 (1H, s), 4.53 (1H, s), 2.43 (2H, br s), 1.52 (3H, s, $-CH_3$), 1.28 (3H, s, $-CH_3$); δ_C (100 MHz, $CDCl_3$, 323 K) 169.3, 154.0, 134.8, 128.8, 128.7, 128.5, 120.9, 98.2, 87.9, 84.4, 79.6, 78.2, 77.4, 68.2, 26.1, 25.3; ν_{max} (film) 3438, 3341, 2994, 1805, 1737, 1498, 1456, 1380, 1292, 1247, 1214, 1156, 1128,1090, 1047, 976, 907, 735, 698 cm^{-1}; HRMS (ESI +ve) m/z calculated for $(C_{18}H_{19}NO_8+H)^+$, 378.1183; found, 378.1188.

(3a*R*,4*S*,5*S*,6*S*,7*R*,7a*S*)-Dibenzyl 5,6-dihydroxy-2,2-dimethylhexahydro-4,7-(epoxyimino)benzo[d][1,3]dioxole-7a,8-dicarboxylate 18



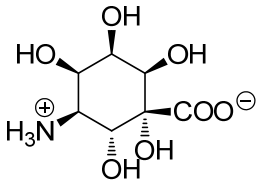
To a solution of **13** (52 mg, 0.115 mmol, 1.00 equiv.) in acetone:water (4:1, 5 mL) at rt was added *N*-methylmorpholine-*N*-oxide (31 mg, 0.230 mmol, 2.00 equiv) as a solid. OsO_4 (27 μL, 2.5% w/v in ^{t}BuOH, 0.0023 mmol, 0.02 equiv) was added via syringe. The reaction mixture was stirred at rt for 24 h, then transferred to a separating funnel, diluted with EtOAc (50 mL) and washed with $Na_2S_2O_{3(aq)}$ (saturated, 2× 10 mL).The organic phase was then washed further with $NaCl_{(aq)}$ (saturated, 2 × 10 mL), dried over $MgSO_4$, concentrated under reduced pressure and purified by chromatography (50% EtOAc–petrol) to give *(3a*R*,4*S*,5*S*,6*S*,7*R*,7a*S*)-dibenzyl 5,6-dihydroxy-2,2-dimethylhexahydro-4,7-(epoxy-imino)benzo[d][1,3]dioxole-7a,8-dicarboxylate* **18** (36 mg, 64%) as a colorless oil. R_f 0.41 (50% EtOAc–petrol); $[\alpha]_D^{25}$ +14.0 (c 1.0, $CHCl_3$); δ_H (300 MHz, $CDCl_3$) 7.30 (5H, br s, Ar-H), 7.22 (5H, br s, Ar-H), 5.15 (1H, d, *J* 5.0 Hz, H_3C-C-O-C*H*-), 5.13-5.05 (4H, m, 2× Ph-CH_2-), 4.72 (1H, br s, N-CH-), 4.50 (1H, dd, *J* 5.0 1.5 Hz, N-O-CH-), 4.26-4.16 (2H, m, 2× HO-C*H*-), 3.48 (1H, br s, -OH), 3.26 (1H, d, *J* 3.0 Hz, -OH), 1.42 (3H, s, CH_3), 1.20 (3H, s, CH_3); δ_C (75 MHz, $CDCl_3$) 169.7 (O-C=O), 157.2 (N-C=O), 135.3 (4° Ar), 134.7 (4° Ar), 128.4 (3° Ar), 128.4 (3° Ar), 128.3 (3° Ar), 128.2 (3° Ar), 128.1 (3° Ar), 112.5 (H_3C-*C*-CH_3), 80.7 (-*C*-C=O), 76.0 (br, N-O-CH-), 73.0 (H_3C-C-O-*C*H-), 68.3 (Ar-CH_2-), 68.0 (Ar-CH_2-), 61.4 (HO-CH-), 60.6 (HO-CH-), 59.6 (br, N-CH-), 25.8 (CH_3), 24.7 (CH_3); ν_{max} (film) 3397, 3034, 2944, 1737, 1609, 1498, 1455, 1380, 1340, 1268, 1212, 1171, 1064, 973, 907, 869, 787, 697 cm^{-1}; HRMS (ESI +ve) *m/z* calculated for $(C_{25}H_{27}NO_9+H)^+$ 486.1764; found, 486.1766; calculated for $(C_{25}H_{27}NO_9+Na)^+$ 508.1584; found, 508.1571.

(3a*S*,4*R*,5*R*,6*R*,7*S*,7a*R*)-7-Ammonio-4,5,6-trihydroxy-2,2-dimethylhexahydrobenzo[d][1,3]dioxole-3a-carboxylate 19



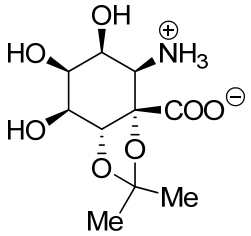
Diol **16** (204 mg, 0.420 mmol, 1.0 equiv) was dissolved in MeOH (30 mL). Pd/C was added (20 mg, 10 mass%). The reaction mixture was stirred under an atmosphere of H_2 at rt for 24 h, then filtered through Celite. The filtrate was concentrated under reduced pressure, then redissolved in EtOH and filtered again under gravity. The filtrate was concentrated to give *(3a*S*,4*R*,5*R*,6*R*,7*S*,7a*R*)-7-ammonio-4,5,6-trihydroxy-2,2-dimethylhexahydrobenzo[d][1,3]dioxole-3a-carboxylate* **19** (116 mg, quant.) as a colorless oil; used crude in next step. $[\alpha]_D^{25}$ +1.0 (c 1.0, EtOH); δ_H (300 MHz, D_2O) 4.93 (1H, d, *J* 6.0 Hz, H_3C-C-O-C*H*-), 4.25 (1H, t, *J* 3.0 Hz, N-CH-C*H*OH-), 4.21 (1H, d, *J* 3.5 Hz, H_3C-C-O-C-C*H*OH-), 4.08 (1H, t, *J* 3.0 Hz, N-CH-CHOH-C*H*OH-), 3.75 (1H, dd, *J* 6.0 4.0 Hz, N-CH-), 1.54 (3H, s, CH_3), 1.41 (3H, s, CH_3); δ_C (75 MHz, D_2O) 174.4 (C=O), 112.7 (H_3C-*C*-CH_3), 86.2 (-*C*-C=O), 75.1 (H_3C-C-O-*C*H-), 72.8 (H_3C-C-O-C-*C*HOH-), 69.2 (N-CH-CHOH-*C*HOH-), 68.1 (N-CH-*C*HOH-), 53.7 (N-CH), 27.9 (CH_3), 26.4 (CH_3); ν_{max} (film) 3422, 3061, 2561, 2494, 2198, 2160, 2020, 1587, 1486, 1453, 1356, 1288, 1206, 1182, 1159, 1071, 1024, 1005, 959, 863 cm^{-1}; HRMS (ESI –ve) m/z calculated for $(C_{10}H_{16}NO_7)^-$, 262.0927; found, 262.0916.

(1*R*,2*R*,3*S*,4*R*,5*R*,6*R*)-3-Ammonio-1,2,4,5,6-pentahydroxycyclohexanecarboxylate 20



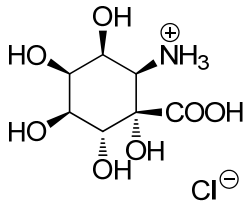
Acetonide **19** (116 mg, 0.441 mmol, 1.00 equiv) was dissolved in 1 M HCl (20 mL) at rt and stirred for 24 h. The reaction mixture was concentrated under reduced pressure and purified by reversed phase silica column chromatography (20% H_2O–MeCN) to give *(1*R*,2*R*,3*S*,4*R*,5*R*,6*R*)-3-ammonio-1,2,4,5,6-pentahydroxycyclohexane-carboxylate* **20** (69 mg, 70%) as a brown oil; R_f 0.42 (20% H_2O–MeCN; C_{18} silica); $[\alpha]_D^{25}$ +2.0 (c 1.0, H_2O/MeOH 1:1); δ_H (400 MHz, D_2O) 4.48 (1H, d, *J* 11.0 Hz, N-CH-C*H*OH-C-C=O), 4.26-4.23 (1H, m, C*H*OH-CHN-C-C-C=O), 4.06 (1H, t, *J* 3.0 Hz, C*H*OH-CHOH-C-C=O), 3.96 (1H, dd, *J* 3.0 1.5 Hz, CHOH-C*H*OH-C-C=O), 3.50 (1H, dd, *J* 11.0, 3.0 Hz, N-CH-); δ_C (125 MHz, D_2O) 174.9 (C=O), 78.9 (*C*-C=O), 75.1 (CHOH-*C*HOH-C-C=O), 70.5 (*C*HOH-CHN-C-C-C=O), 65.9 (*C*HOH-CHOH-C-C=O), 65.2 (N-CH-*C*HOH-C-C=O), 53.4 (N-CH-); ν_{max} (film) 3404, 1607, 1451, 1398, 1203, 1108, 1019 cm^{-1}; HRMS (ESI –ve) calculated for $(C_7H_{12}NO_7)^-$, 222.0619; found, 222.0624.

(3a*S*,4*R*,5*S*,6*S*,7*S*,7a*R*)-4-Ammonio-5,6,7-trihydroxy-2,2-dimethylhexahydro-benzo[d][1,3]dioxole-3a-carboxylate, 21



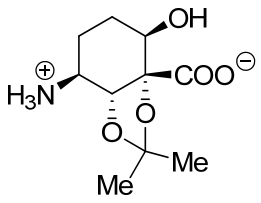
To **18** (80 mg, 0.165 mmol, 1.0 equiv) and Pd/C (8 mg, 10 mass%) was added MeOH (30 mL). The reaction mixture was stirred under an atmosphere of H_2 at rt for 24 h, then filtered through Celite. The filtrate was concentrated under reduced pressure, then triturated with EtOH and filtered again under gravity filtration; in this instance the filtrate contained impurities and pure product remained as residue, *(3a*S*,4*R*,5*S*,6*S*,7*S*,7a*R*)-4-ammonio-5,6,7-trihydroxy-2,2-dimethylhexahydrobenzo-[d][1,3]dioxole-3a-carboxylate* **21** (35 mg, 81%) as a white solid; $[\alpha]_D^{25}$ +2.0 (c 0.2, MeOH); δ_H (500 MHz, D_2O) 4.68 (1H, d, *J* 4.0 Hz, H_3C-C-O-C*H*-), 4.20 (1H, t, *J* 3.5 Hz, H_3C-C-O-CH-C*H*OH-) 4.17 (1H, t, *J* 4.0 Hz, ^+H_3N-CH-C*H*OH-), 4.01 (1H, t, *J* 3.5 Hz, ^+H_3N-CH-CHOH-C*H*OH-), 3.66 (1H, d, *J* 4.0, ^+H_3N-C*H*-), 1.54 (3H, s, CH_3), 1.50 (3H, s, CH_3); δ_C (125 MHz, D_2O) 174.2 (C=O), 111.3 (H_3C-*C*-CH_3), 82.0 (-*C*-C=O), 80.7 (H_3C-C-O-*C*H-), 69.6 (H_3C-C-O-CH-*C*HOH-), 68.4 (^+H_3N-CH-CHOH-*C*HOH-), 68.3 (^+H_3N-CH-*C*HOH-), 55.5 (N-CH-), 27.0 (CH_3), 25.3 (CH_3); ν_{max} (film) 3340, 2987, 2944, 1637, 1455, 1409, 1117, 1021 cm^{-1}; HRMS (ESI +ve) calculated for $(C_{10}H_{17}NO_7+H)^+$ 264.1078; found, 264.1083.

(1*R*,2*S*,3*R*,4*S*,5*S*,6*S*)-2-Carboxy-2,3,4,5,6-pentahydroxycyclohexylammonium chloride 22



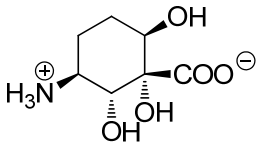
Acetonide **21** (35 mg, 0.133 mmol, 1 equiv) was dissolved in 1 M HCl (20 mL) at rt and stirred for 24 h. Reaction mixture was concentrated under reduced pressure to give *(1*R*,2*S*,3*R*,4*S*,5*S*,6*S*)-2-carboxy-2,3,4,5,6-pentahydroxycyclohexylammonium chloride* **22** (11.6 mg, 34%) of sufficient purity to be used without further purification; $[\alpha]_D^{25}$ +1.5 (c 1.0, MeOH/H_2O 1:1); δ_H (500 MHz, D_2O) 4.27 (1H, dd, *J* 4.5 3.0 Hz, ^+H_3N-CH-C*H*OH-), 4.25-4.23 (1H, m, ^+H_3N-CH-CHOH-C*H*OH-), 4.22 (1H, d, *J* 10.0 Hz, HOOC-C-C*H*OH-), 3.83 (1H, dd, *J* 10.0 3.0 Hz, HOOC-C-CHOH-C*H*OH-), 3.58 (1H, dd, *J* 4.5 1.0 Hz, ^+H_3N-C*H*-); δ_C (125 MHz, D_2O) 174.5 (-COOH), 75.6 (-*C*-COOH), 73.5 (^+H_3N-CH-CHOH-*C*HOH-), 69.7 (HOOC-C-CHOH-*C*HOH-), 68.7 (HOOC-C-*C*HOH-), 64.1 (^+H_3N-CH-*C*HOH-), 56.2 (-CH-NH_3^+); ν_{max} (film) 3519, 3326, 3144, 2909, 1606, 1574, 1502, 1395, 1323, 1275, 1244, 1202, 1154, 1069, 1031, 908, 838, 801, 703 cm^{-1}; HRMS (ESI +ve) calculated for $(C_7H_{13}NO_7+H)^+$ 224.0770; found, 224.0771; calculated for $(C_7H_{13}NO_7+Na)^+$ 246.0590; found, 246.0592.

(3a*S*,4*R*,7*S*,7a*R*)-7-Ammonio-4-hydroxy-2,2-dimethylhexahydrobenzo-[d][1,3]dioxole-3a-carboxylate 23

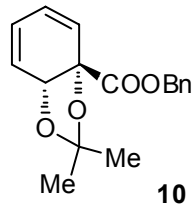


To **12** (472 mg, 1.047 mmol, 1.00 equiv.) and Pd/C (47 mg, 10 mass%) was added MeOH (50 mL). The reaction mixture was stirred under an atmosphere of H_2 at rt for 24 h, then filtered through Celite. The filtrate was concentrated under reduced pressure. The crude product was then redissolved in EtOH and filtered under gravity to remove traces of Celite. Concentration under reduced pressure gave crude *(3a*S*,4*R*,7*S*,7a*R*)-7-ammonio-4-hydroxy-2,2-dimethylhexahydrobenzo[d][1,3]dioxole-3a-carboxylate* **23** (234 mg, 97%) as a white solid of sufficient purity to be used without further purification; m. pt. 170 ^{0}C; $[\alpha]_D^{25}$ +2.0 (c 1.0, H_2O); δ_H (300 MHz, D_2O) 4.37 (1H, d, *J* 2.5 Hz, C-O-CH-), 3.98 (1H, dd, *J* 9.5 6.0 Hz HO-C*H*-), 3.73 (1H, app q, *J* 4.0 Hz, H_3N^+-C*H*-), 2.10-2.03 (1H, m, H_3N^+-CH-*CH*H-), 1.99-1.86 (3H, m, H_3N^+-CH-*C*H*H*-, HO-CH-C*H_2*-), 1.55 (3H, s, CH_3), 1.43 (3H, s, CH_3); δ_C (75 MHz, D_2O) 175.9 (C=O), 110.7 (H_3C-*C*-CH_3), 87.4 (-*C*-C=O), 76.0 (H_3N^+-C-*C*-O-), 72.7 (HO-C-), 48.2 (H_3N^+-C-), 27.4, 25.9, 24.8, 22.7; ν_{max} (film) 3375, 2960, 2930, 2862, 1727, 1601, 1462, 1380, 1274, 1124, 1072, 741, 705, 617 cm^{-1}; HRMS (ESI – ve) *m/z* calculated for $(C_{10}H_{17}NO_5–H)^–$, 230.1028; found, 230.1018.

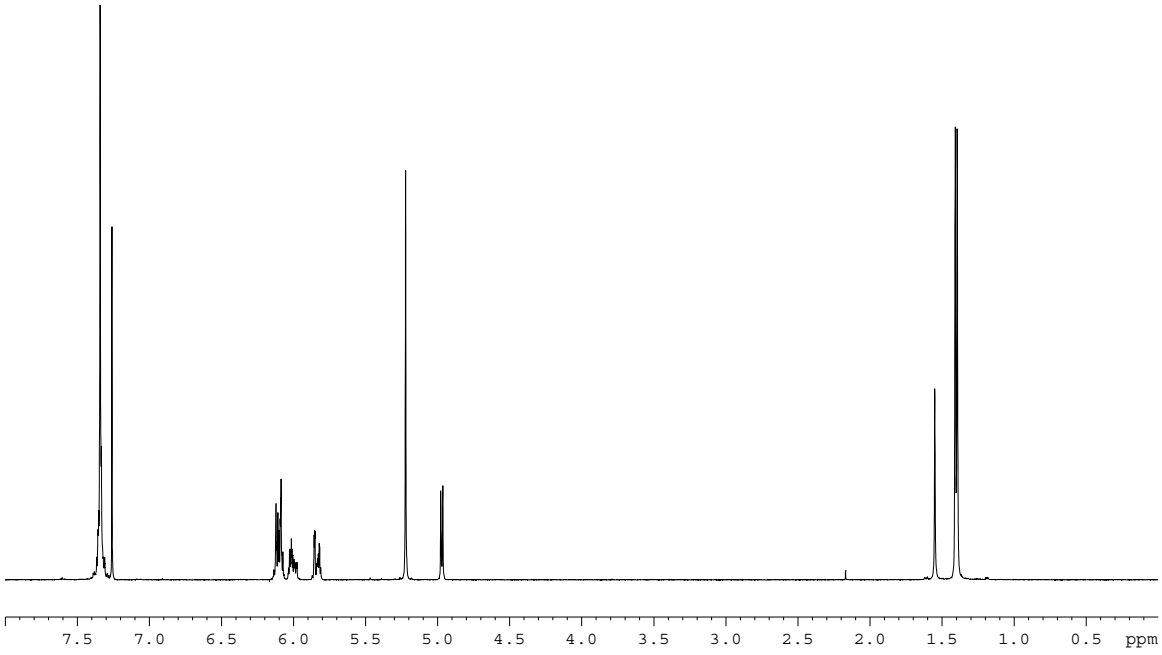
(1*S*,2*R*,3*S*,6*R*)-3-Ammonio-1,2,6-trihydroxycyclohexanecarboxylate 24

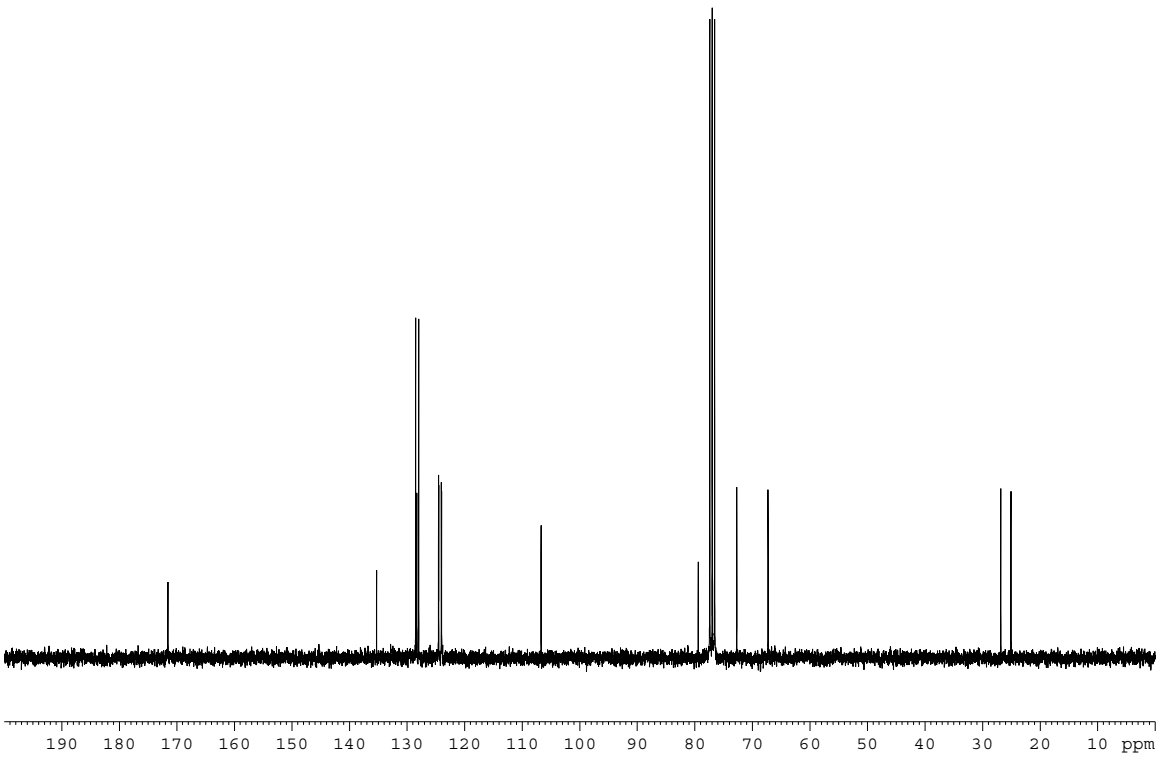


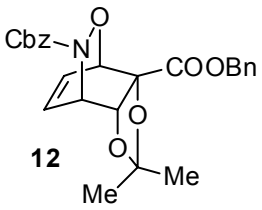
Acetonide **23** (234 mg, 1.01 mmol, 1.0 equiv.) was dissolved in 1M $HCl_{(aq)}$ (30 mL) and stirred at rt for 24 h then evaporated under reduced pressure to give crude product (219 mg). Repeated reversed phase chromatography (10% H_2O–MeCN) gave pure *(1*S*,2*R*,3*S*,6*R*)-3-ammonio-1,2,6-trihydroxycyclohexanecarboxylate* **24** (30 mg, 16%) as a white solid; m. pt. 248 ^{0}C; R_f 0.22 (10% H_2O–MeCN; reversed phase silica); $[\alpha]_D^{25}$ +4.0 (c 0.5, H_2O); δ_H (500 MHz, D_2O) 4.15 (1H, d, *J* 10.5 Hz, HO-C*H*-CH-NH_3^+), 3.85 (1H, br s, HO-C*H*-CH_2-), 3.34 (1H, t, *J* 10.5 Hz, HO-CH-C*H*-NH_3^+), 1.95-1.86 (3H, m, HO-CH-C*H*H-, -C*H*$_2$-CH-NH_3^+), 1.83-1.80 (1H, m, HO-CH-CH*H*-); δ_C (75 MHz, D_2O) 178.7 (C=O), 77.8 (-*C*-C=O), 71.3 (CH_2-*C*H-OH), 70.6 (HO-*C*H-$CHNH_3^+$), 52.6 (-CH-NH_3^+), 25.6 (CH_2), 22.9 (CH_2); ν_{max} (film) 3783, 3382, 1605, 1459, 1207 cm^{-1}; HRMS (ESI –ve) *m/z* calculated for $(C_7H_{13}NO_5–H)^–$, 190.0715; found, 190.0709.


COOBn
O
O
Me
Me

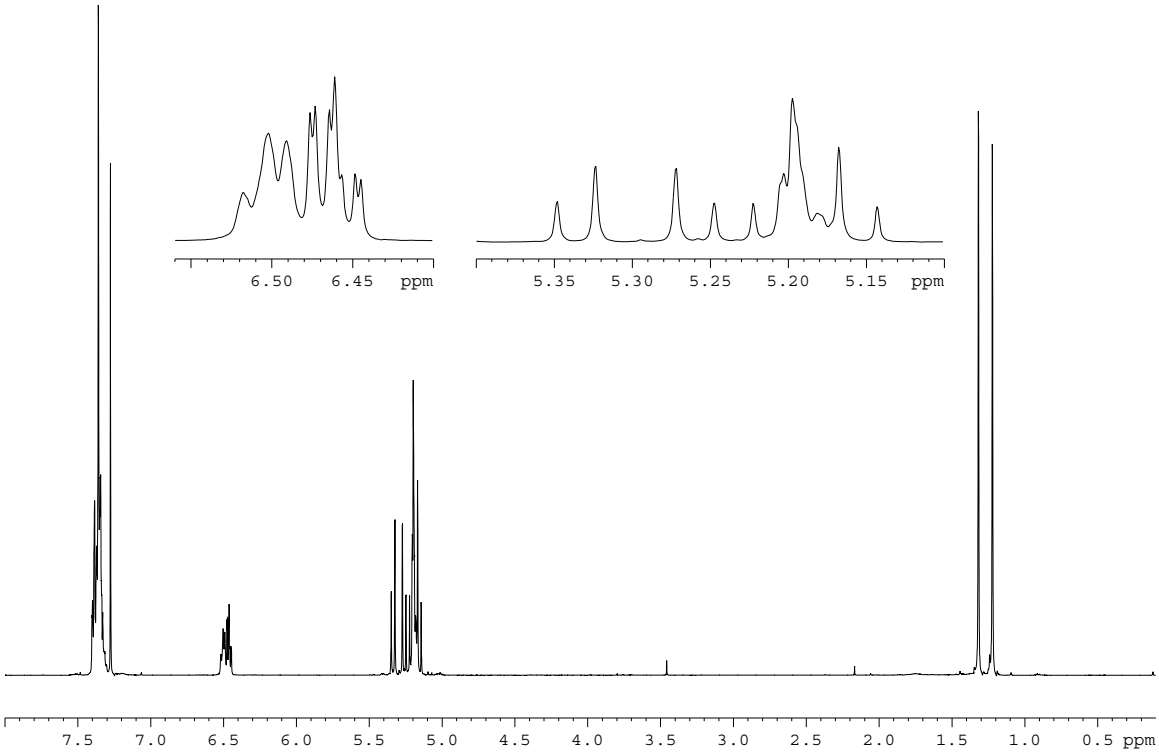
10

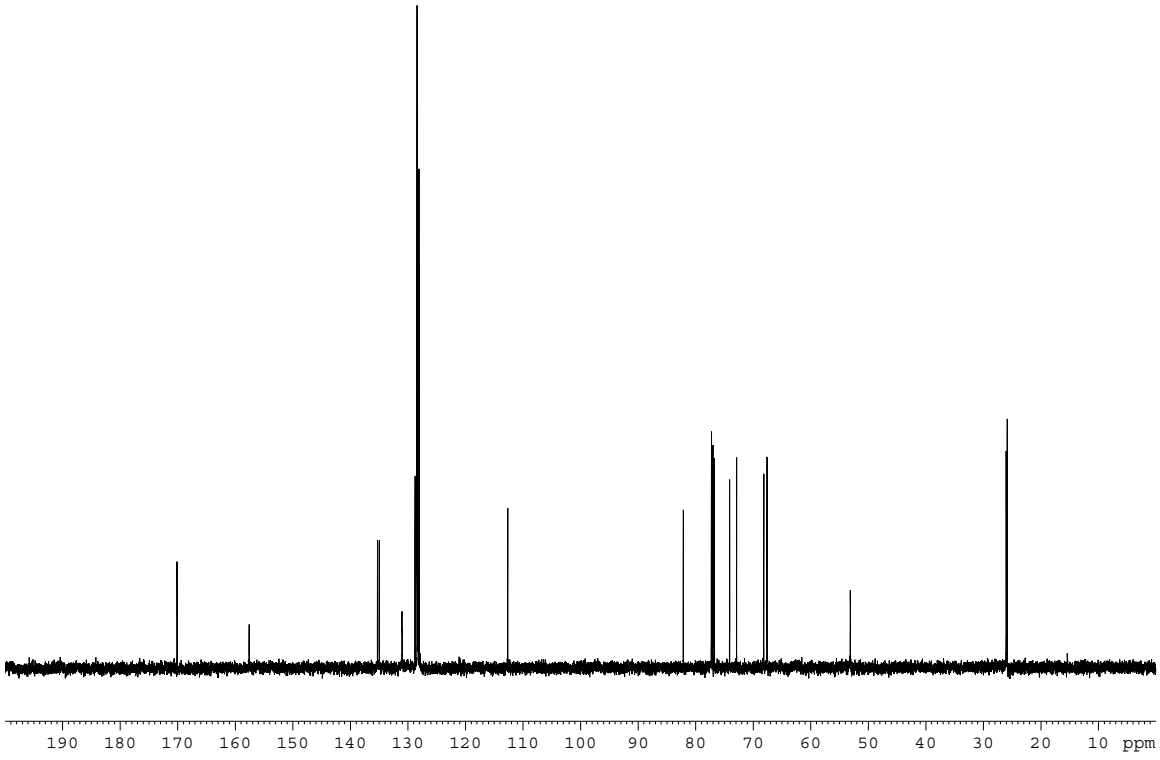

7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm


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

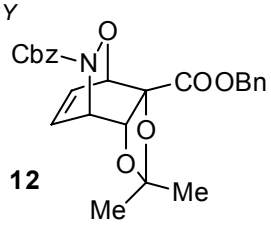

Cbz
N
O
COOBn
O
O
Me
Me

12

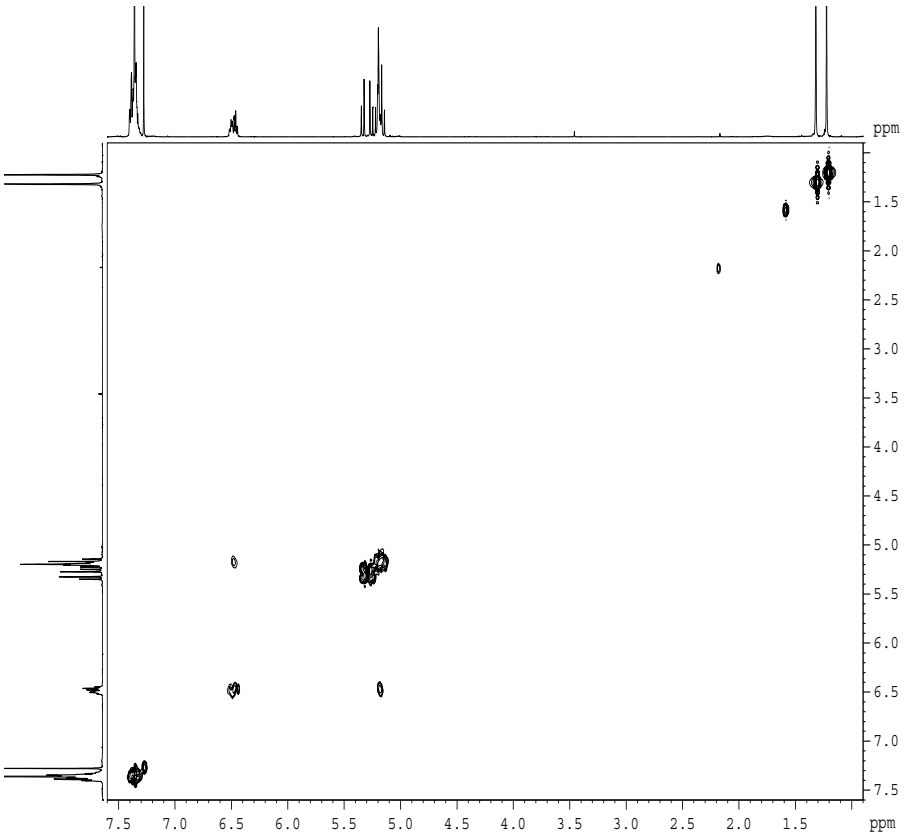

6.50
6.45
ppm
5.35
5.30
5.25
5.20
5.15
ppm
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5 ppm


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

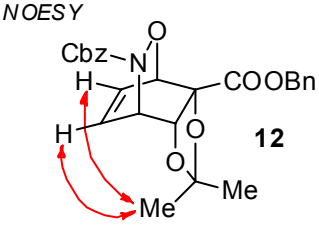
COSY



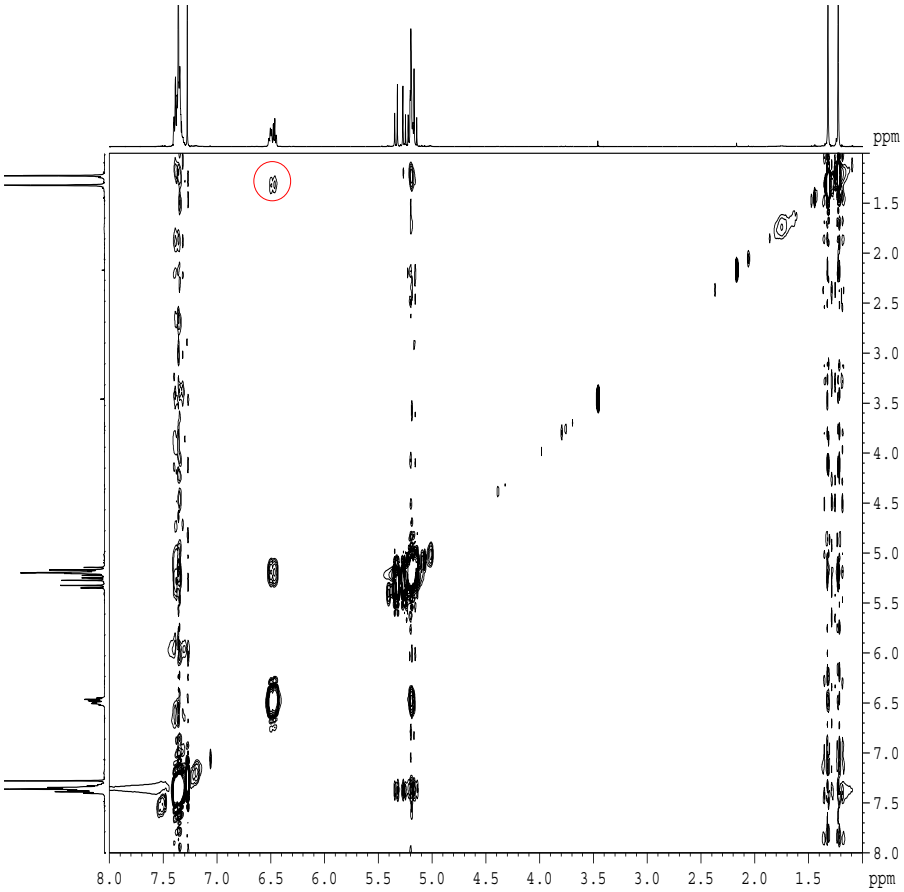
12



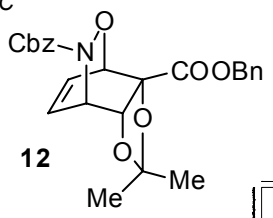
NOESY



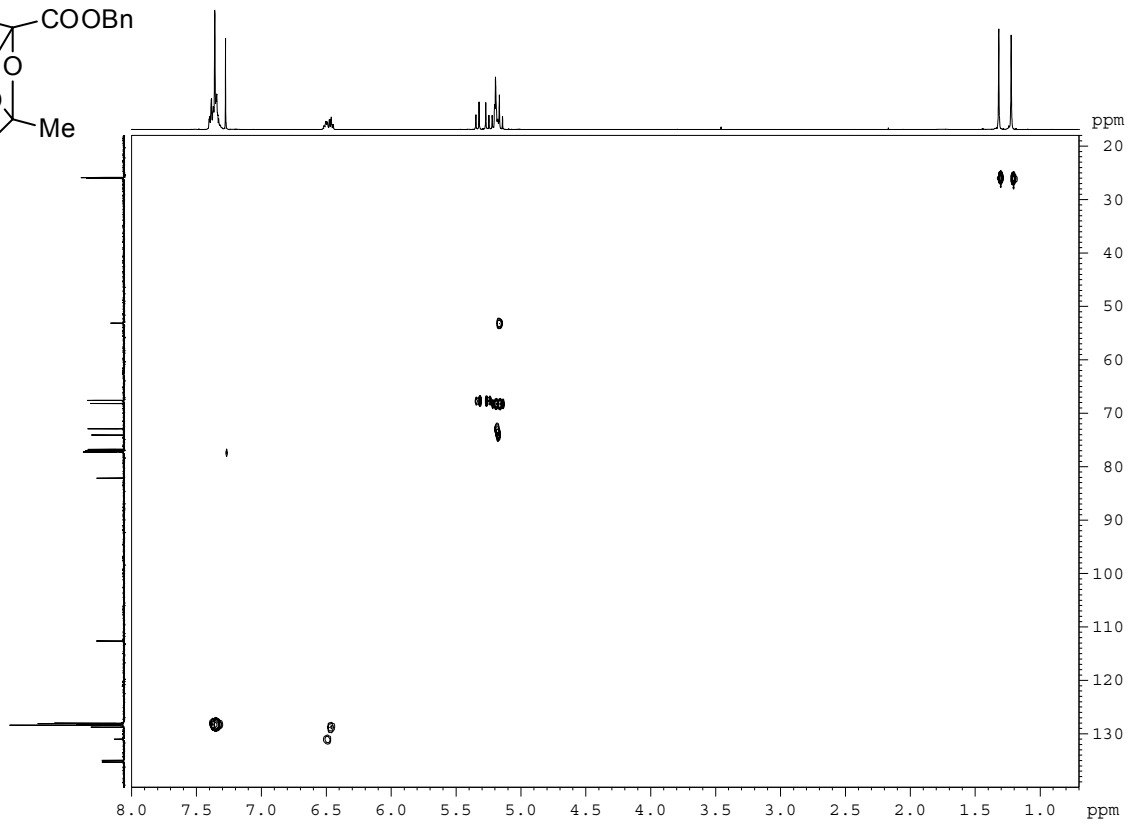
12



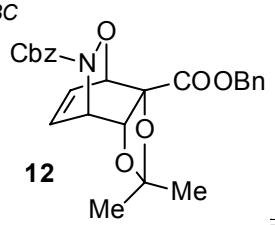
HSQC



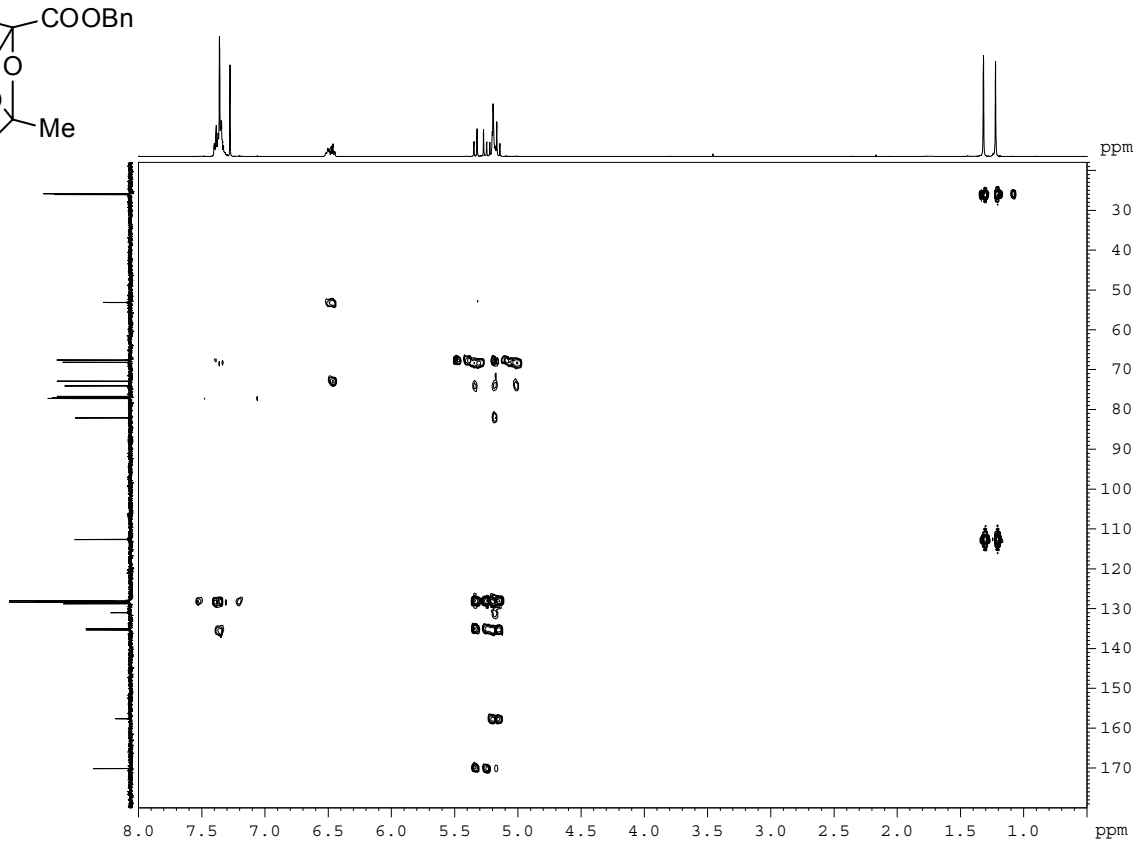
12

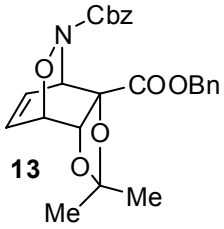


HMBC

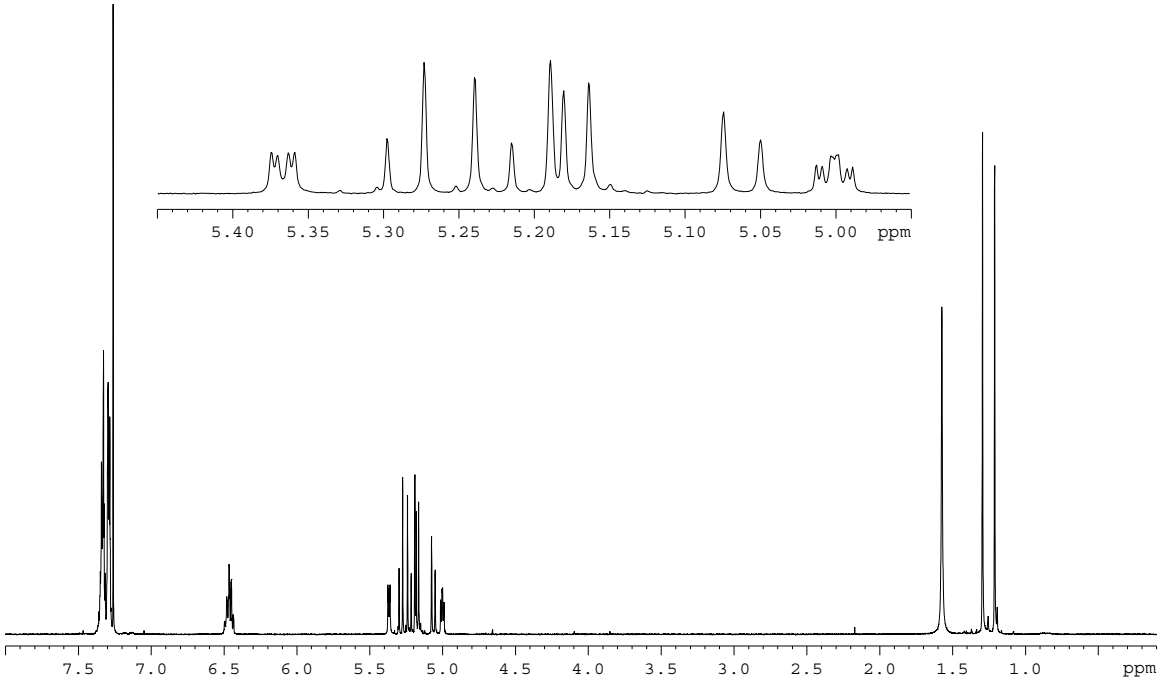


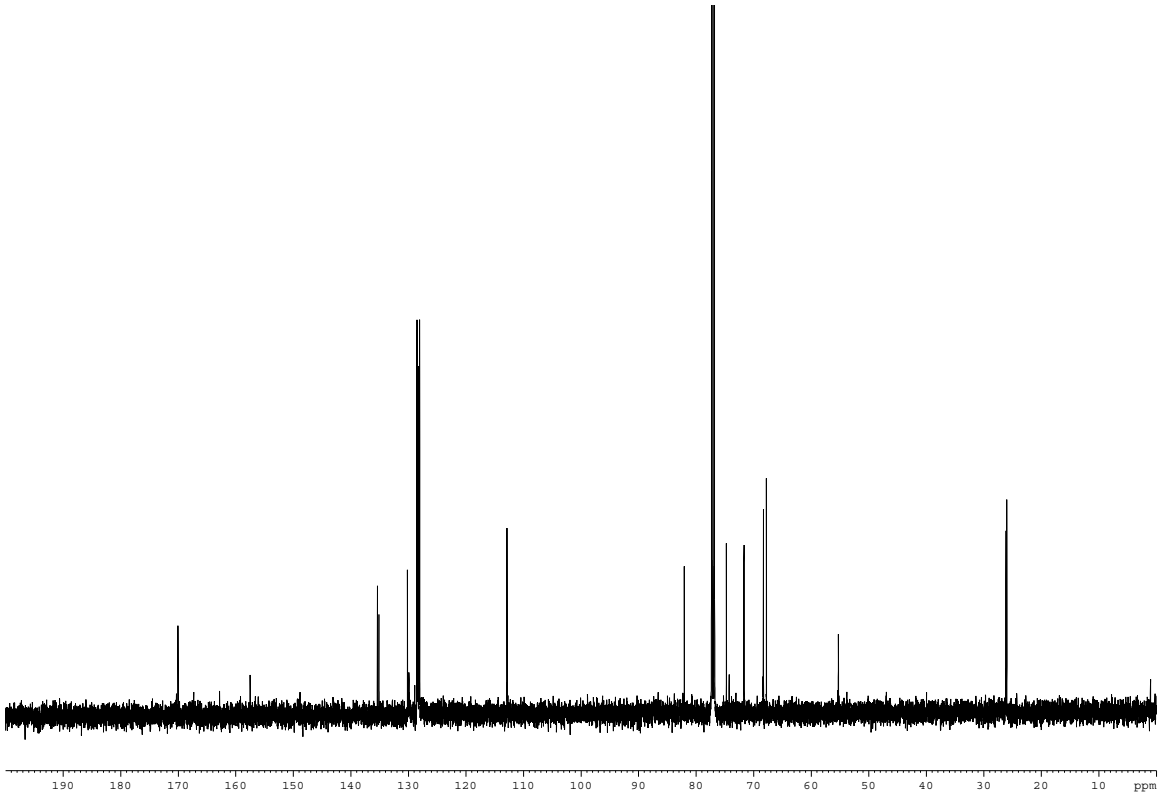
12



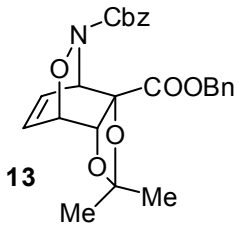

Cbz
N
O
COOBn
O
O
Me
Me

13

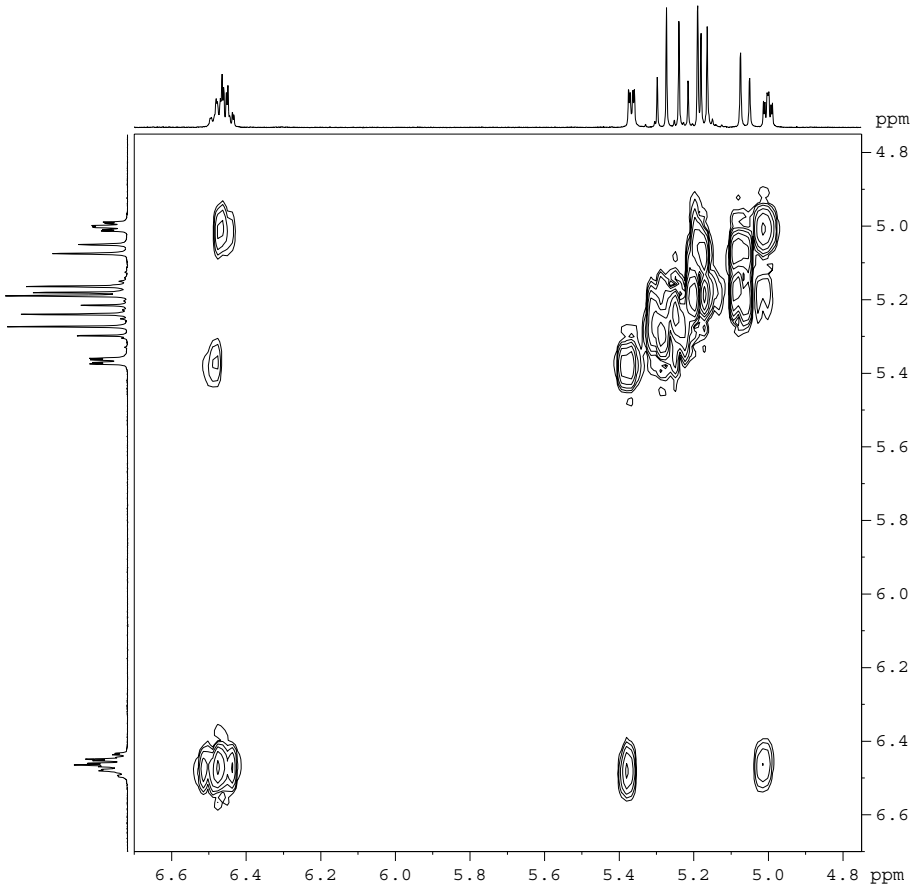

5.40 5.35 5.30 5.25 5.20 5.15 5.10 5.05 5.00 ppm
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 ppm


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

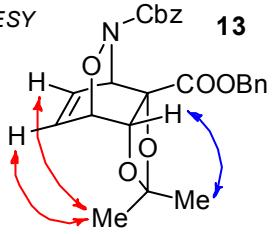
COSY



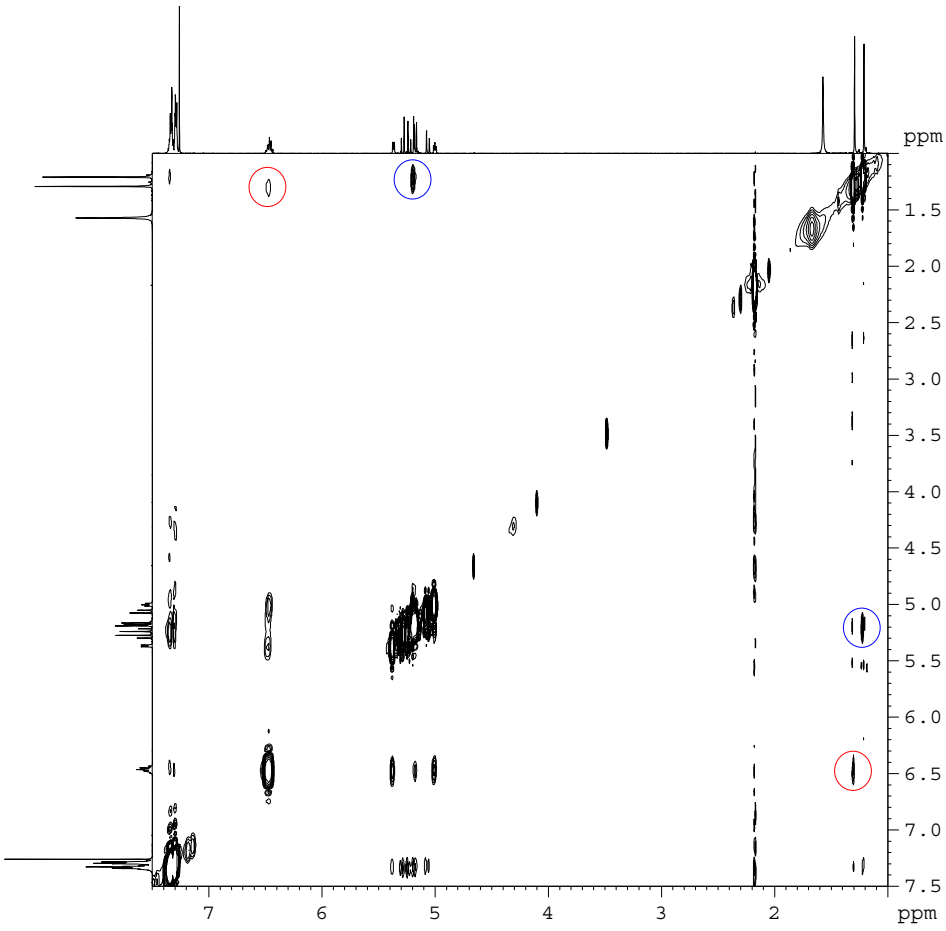
13



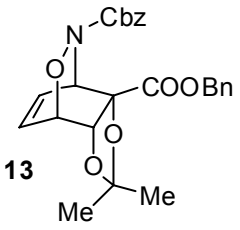
NOESY



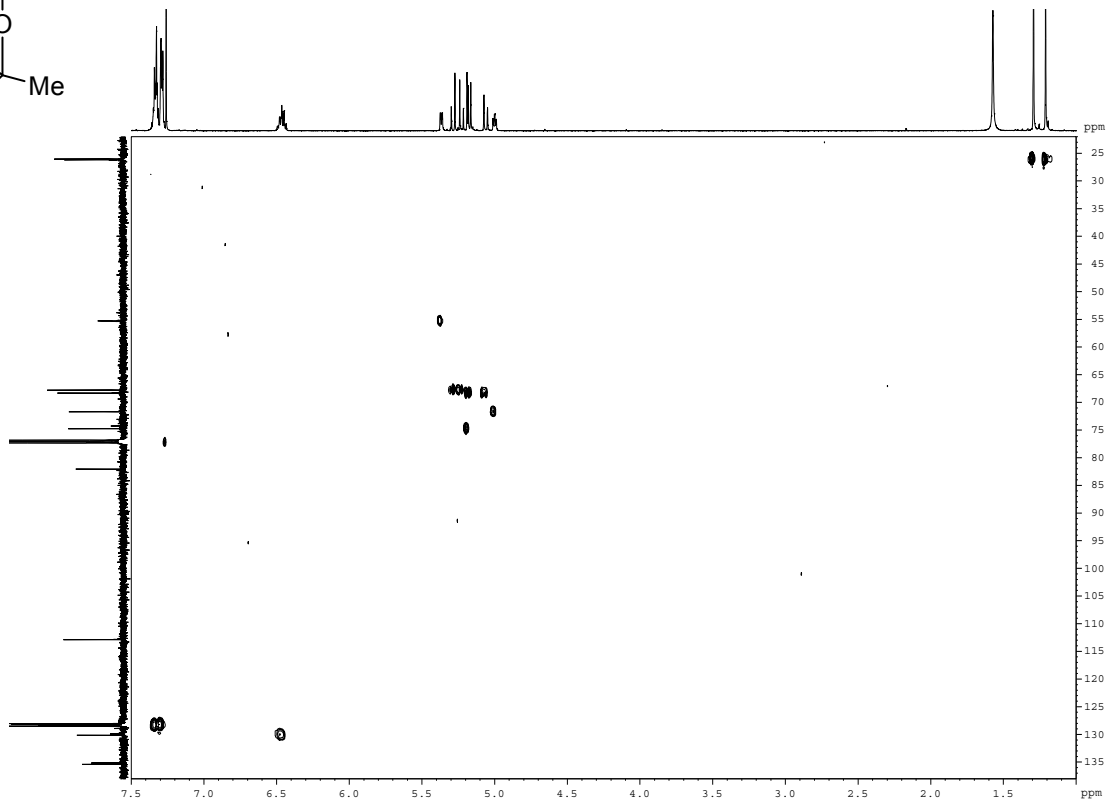
13



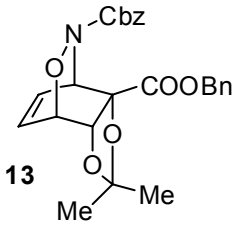
HSQC



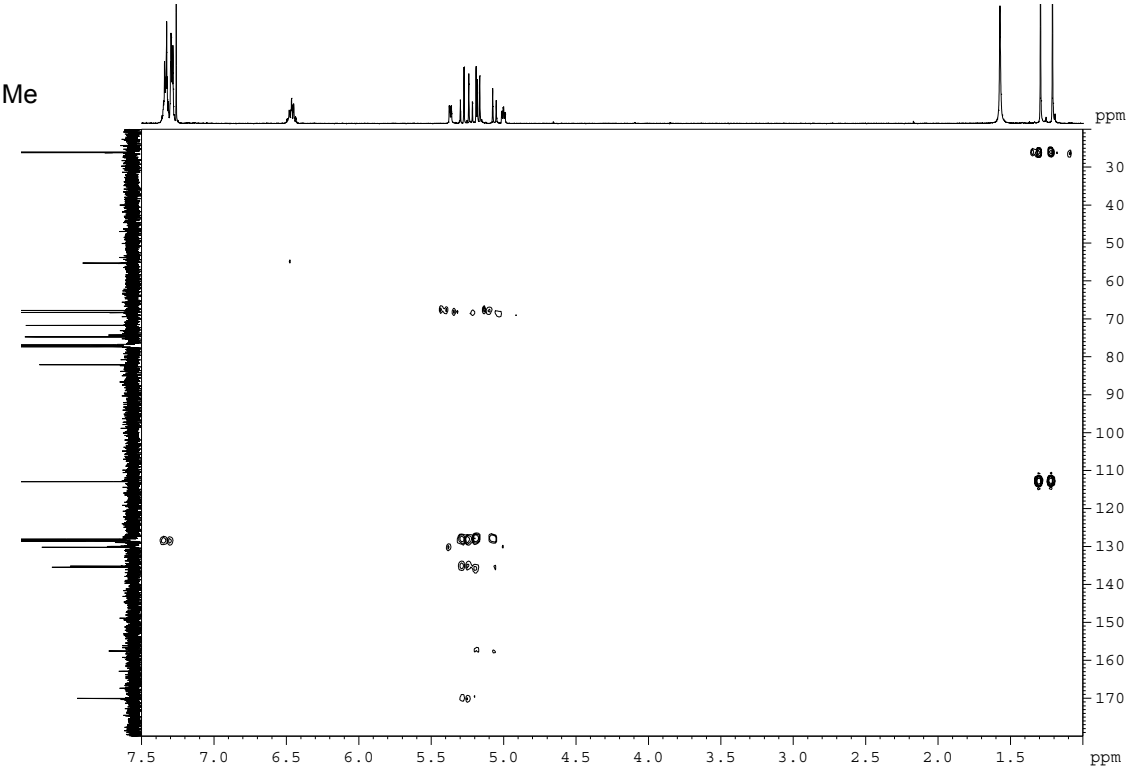
13

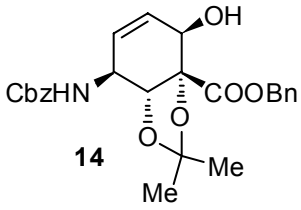


HMBC

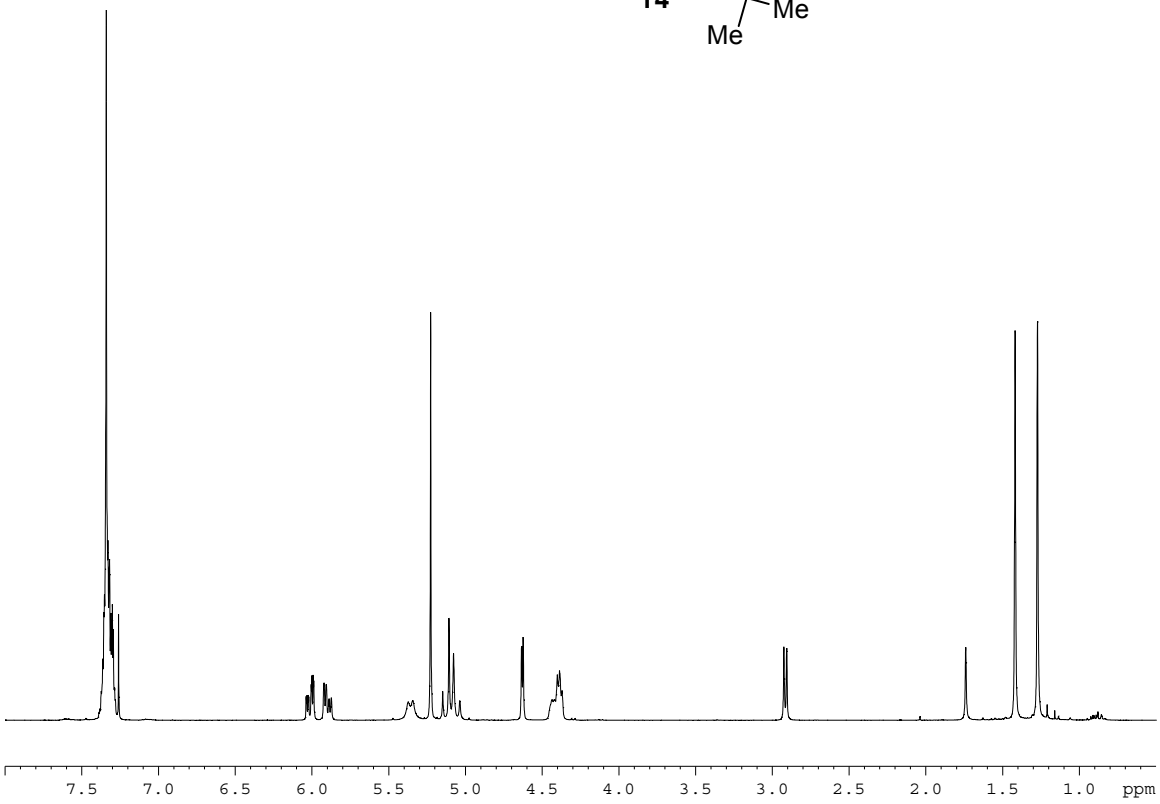


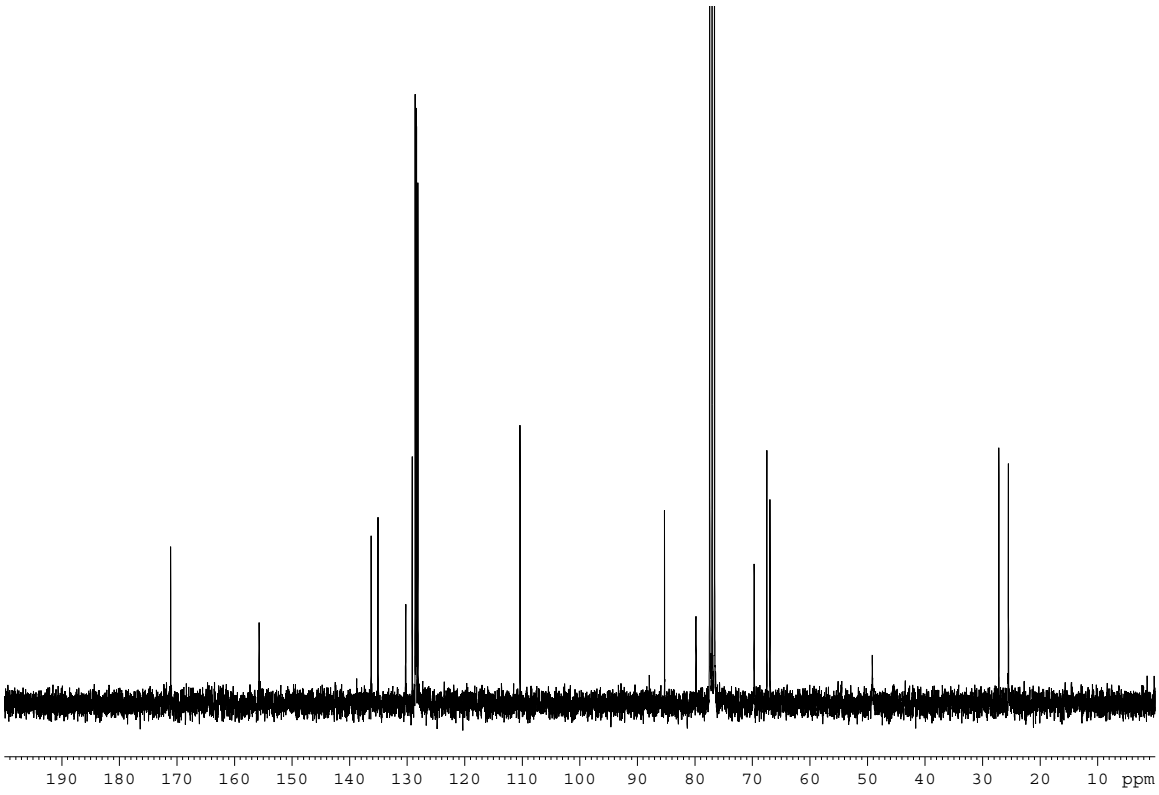
13

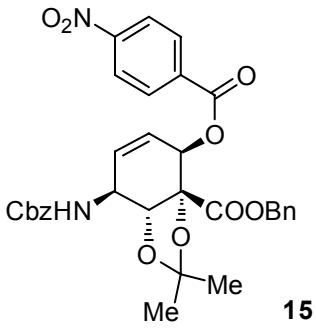



OH
CbzHN
COOBn
O
O
Me
Me

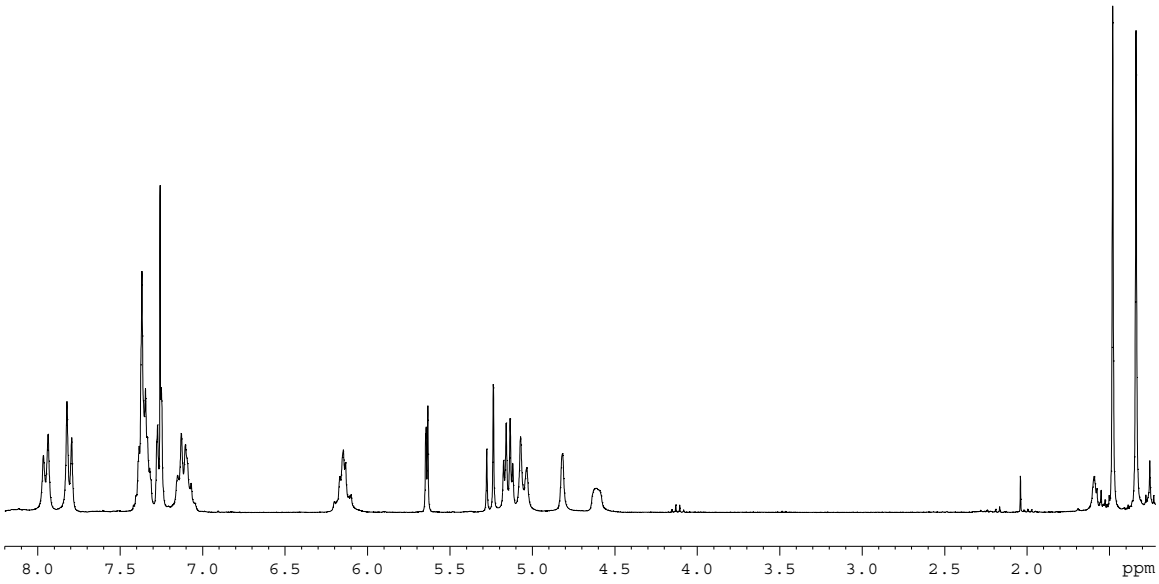
14

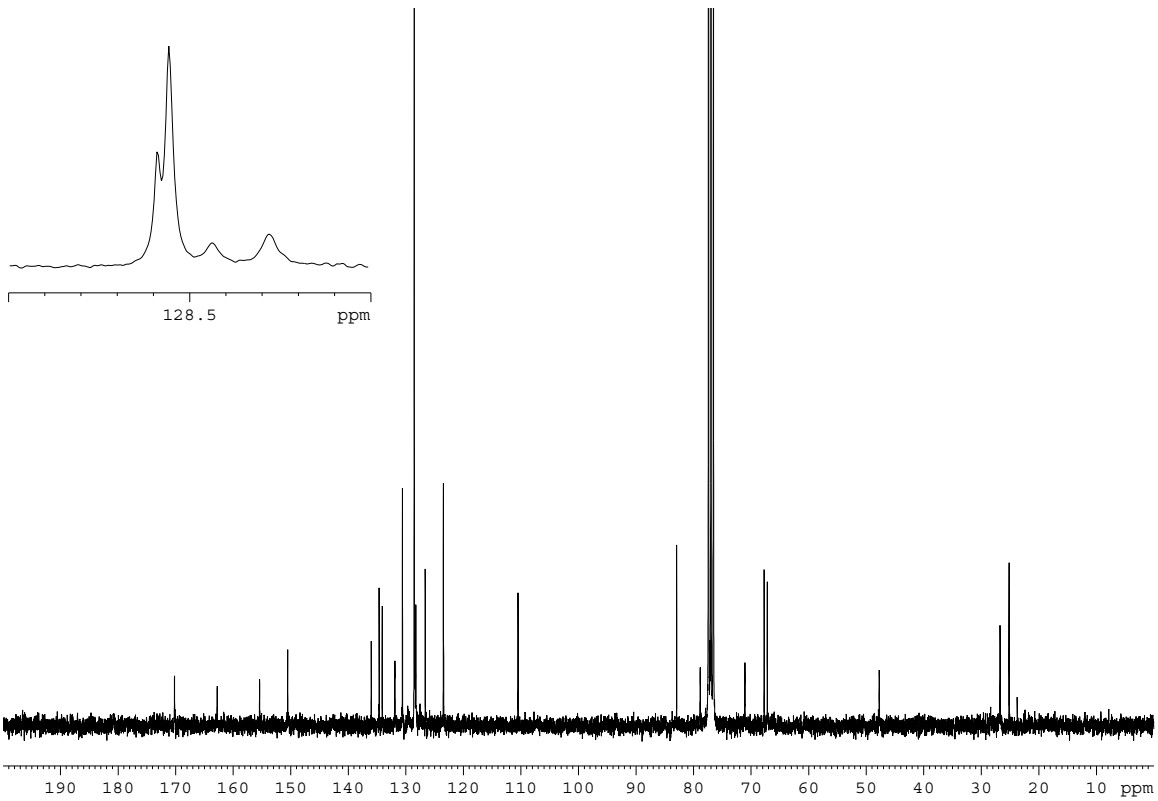

7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm

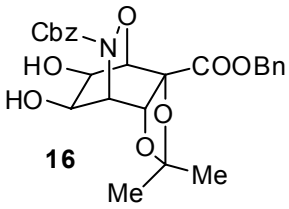

190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


O2N
O
O
CbzHN
COOBn
O
O
Me
Me

15

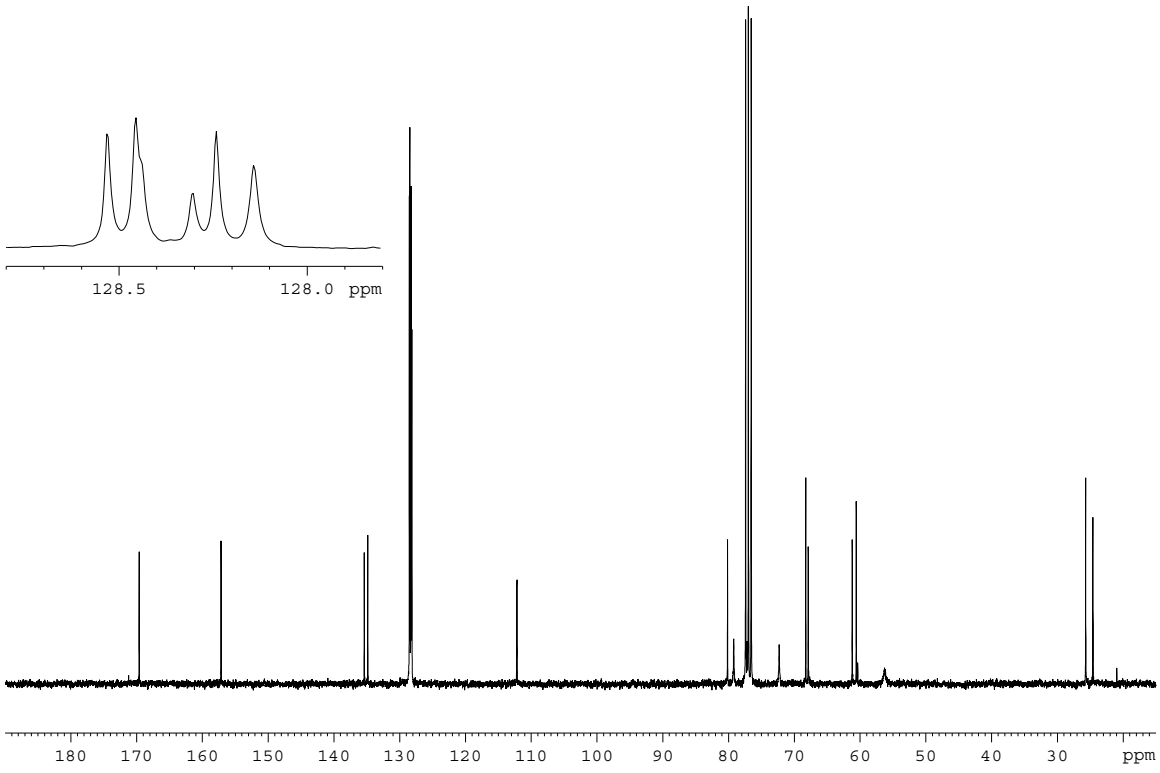

8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
ppm


128.5
ppm
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

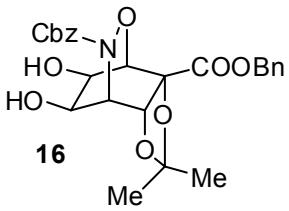

Cbz
N
O
HO
COOBn
HO
O
O
Me
Me

16

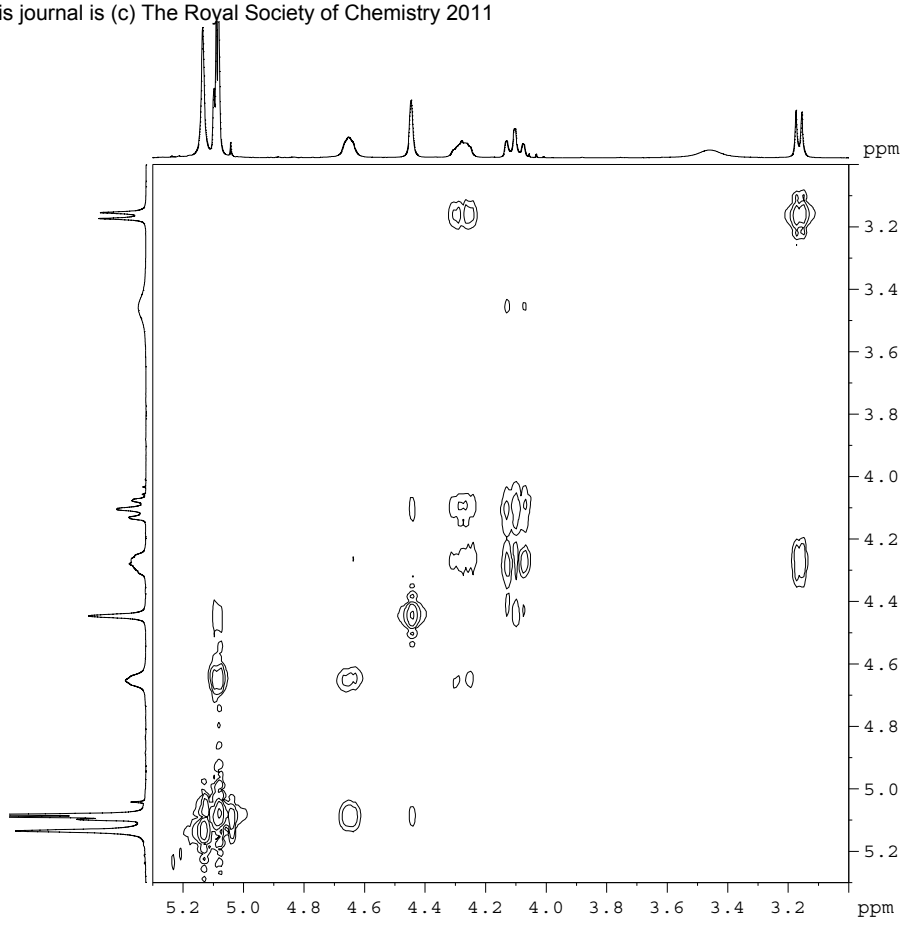
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm


128.5
128.0 ppm
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
ppm

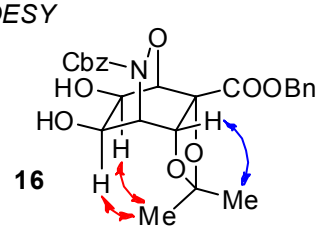
COSY



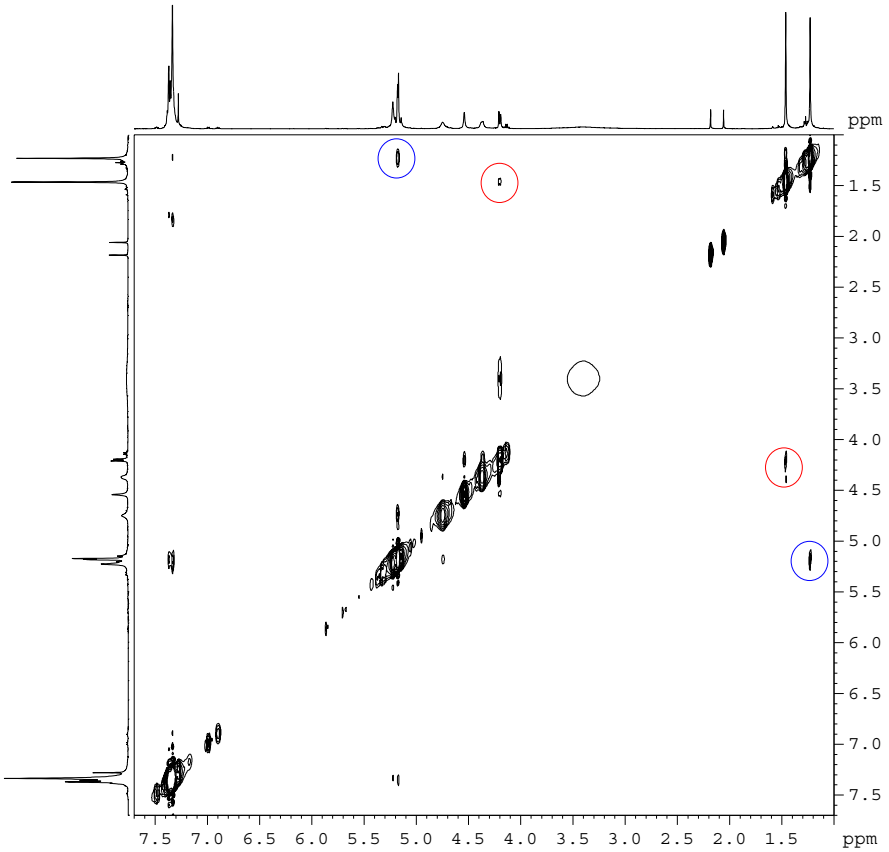
16



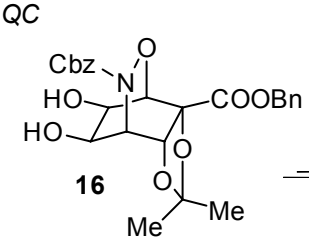
NOESY



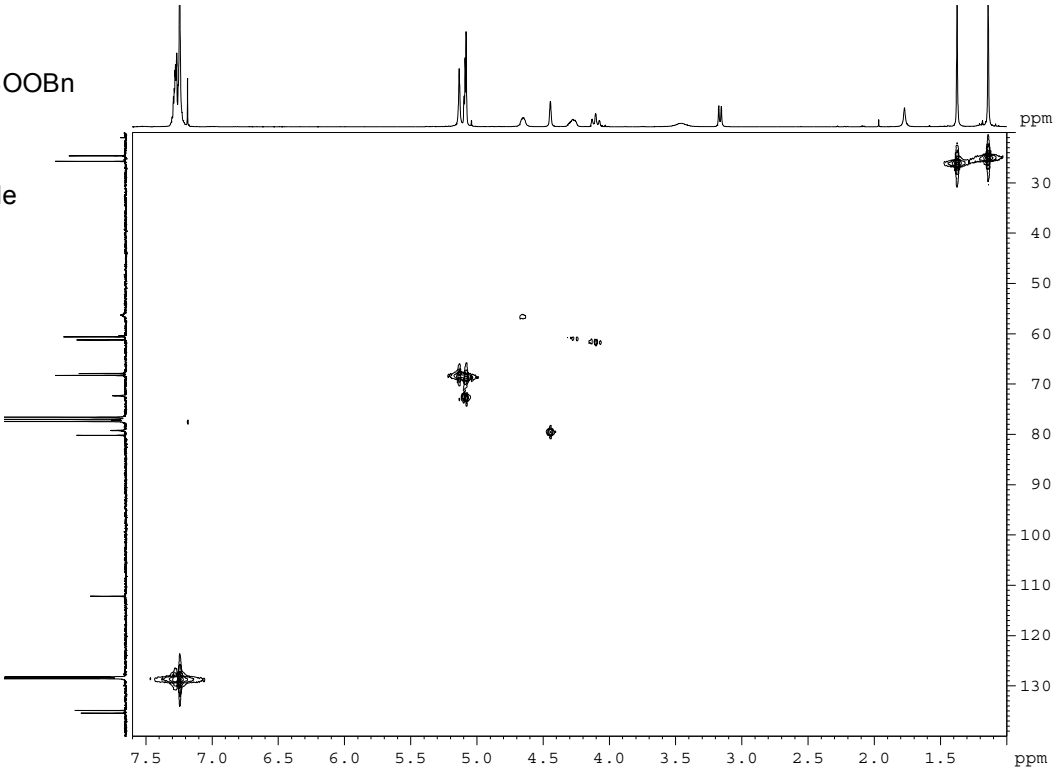
16



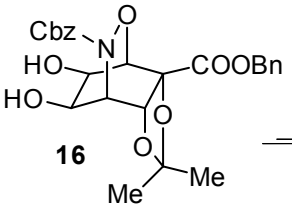
HMQC



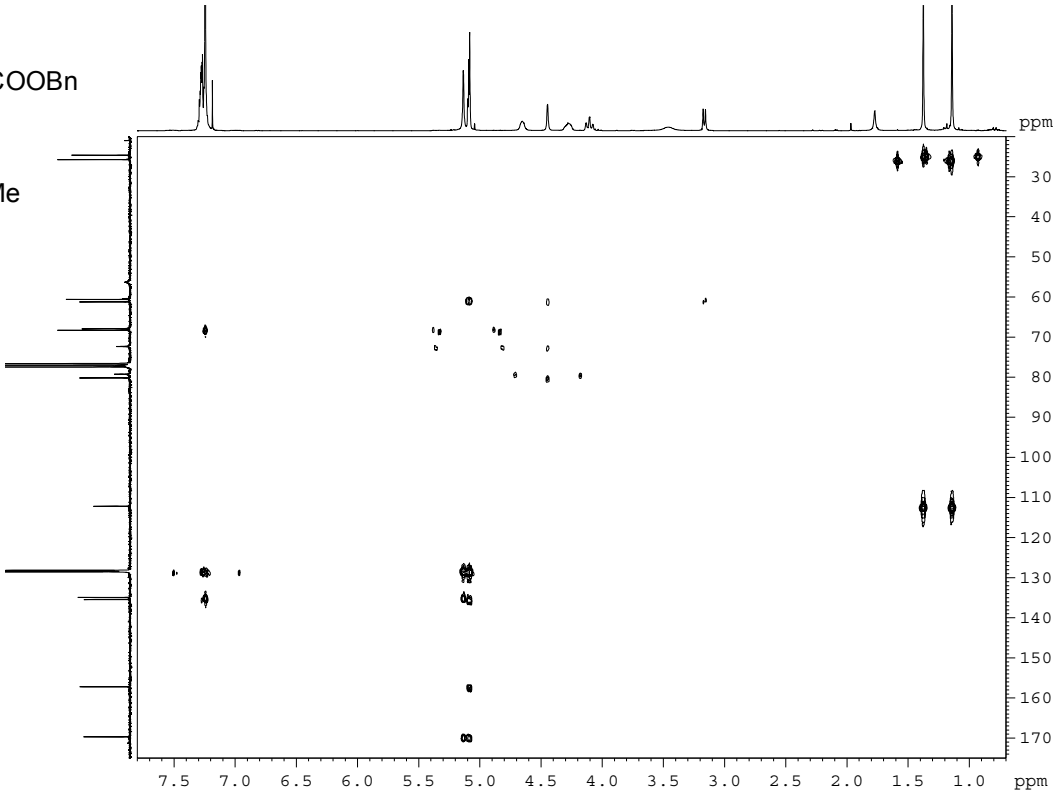
16

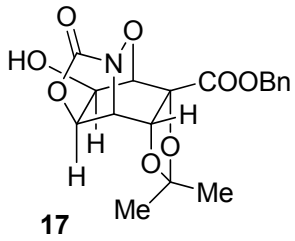


HMBC

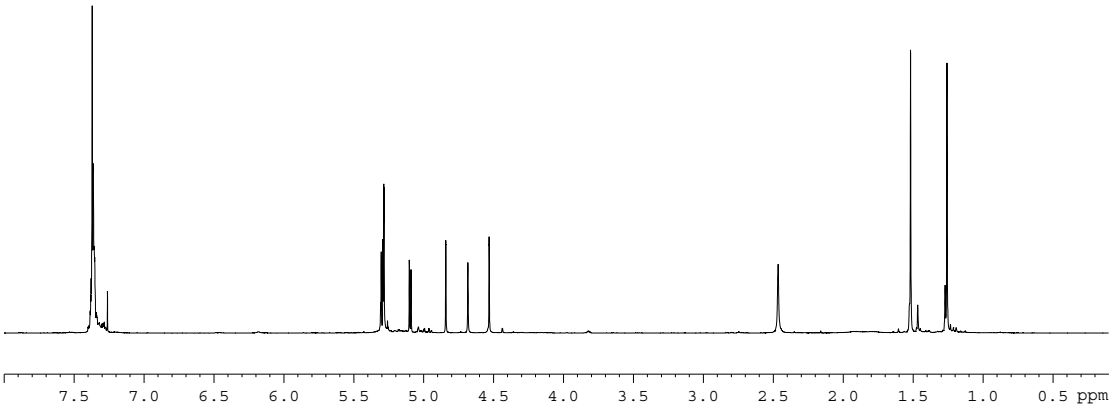


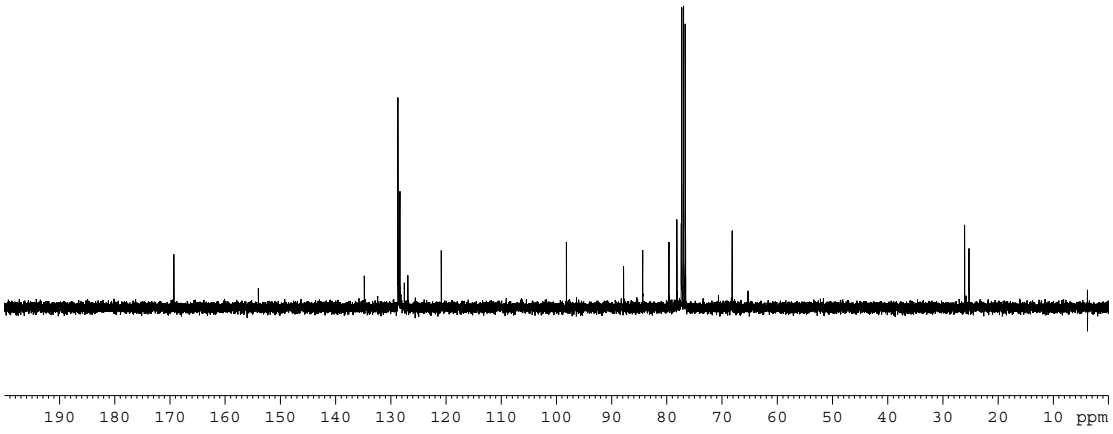
16



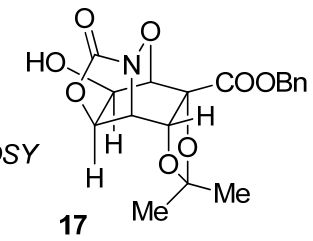

O
HO
N
O
O
COOBn
H
H
O
H
O
Me
Me

17

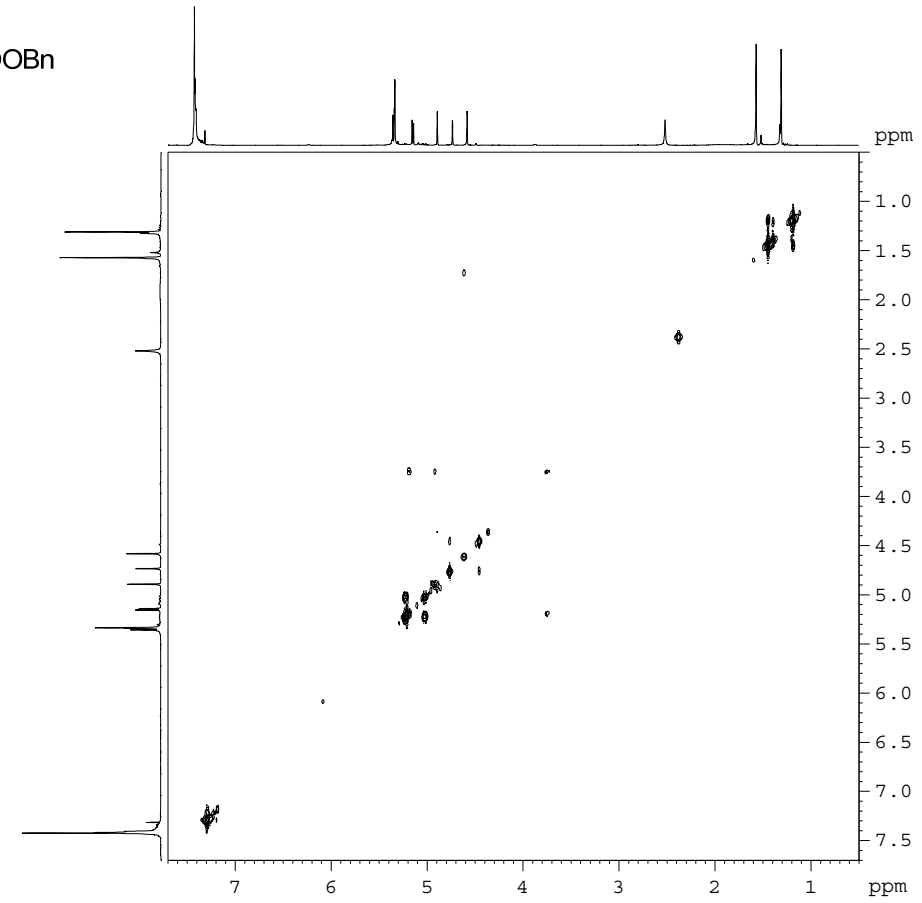

7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm


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

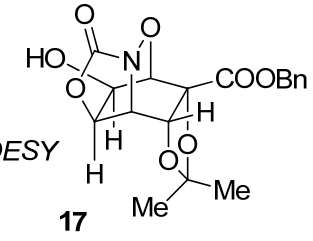
COSY



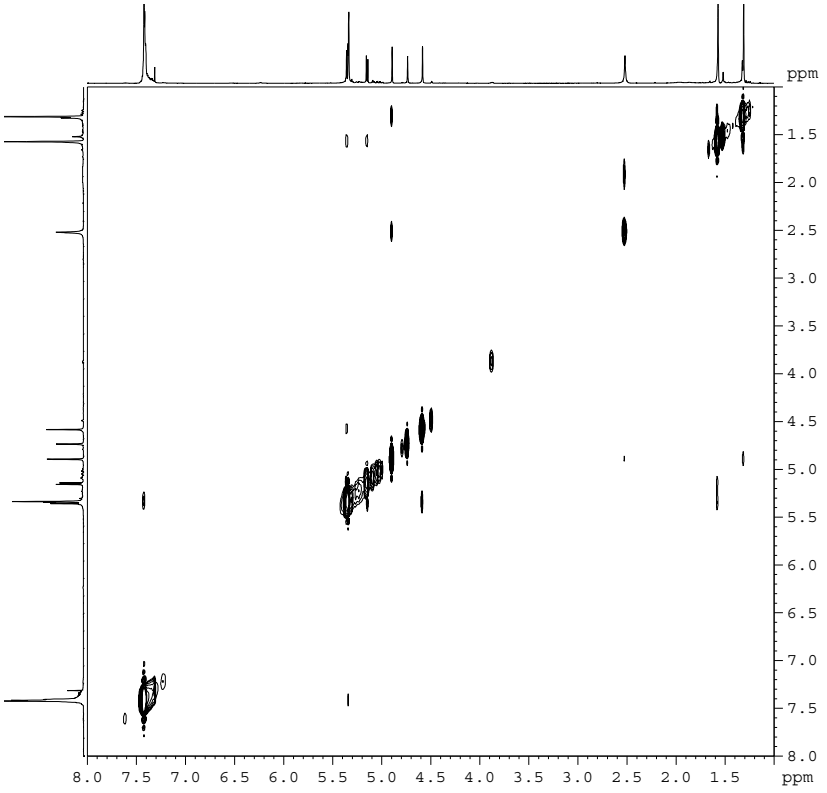
17



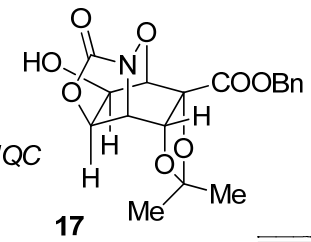
NOESY



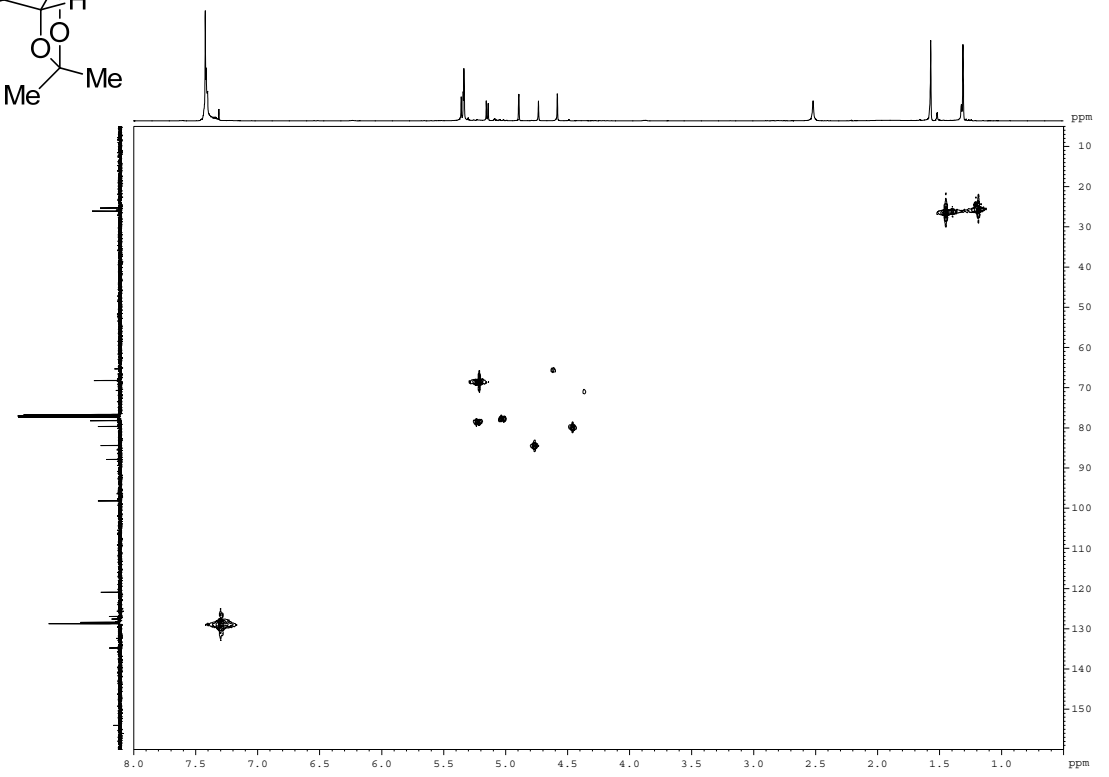
17



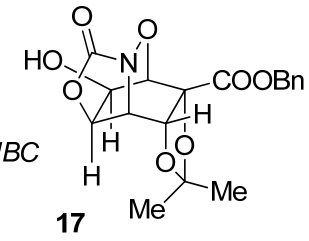
HMQC



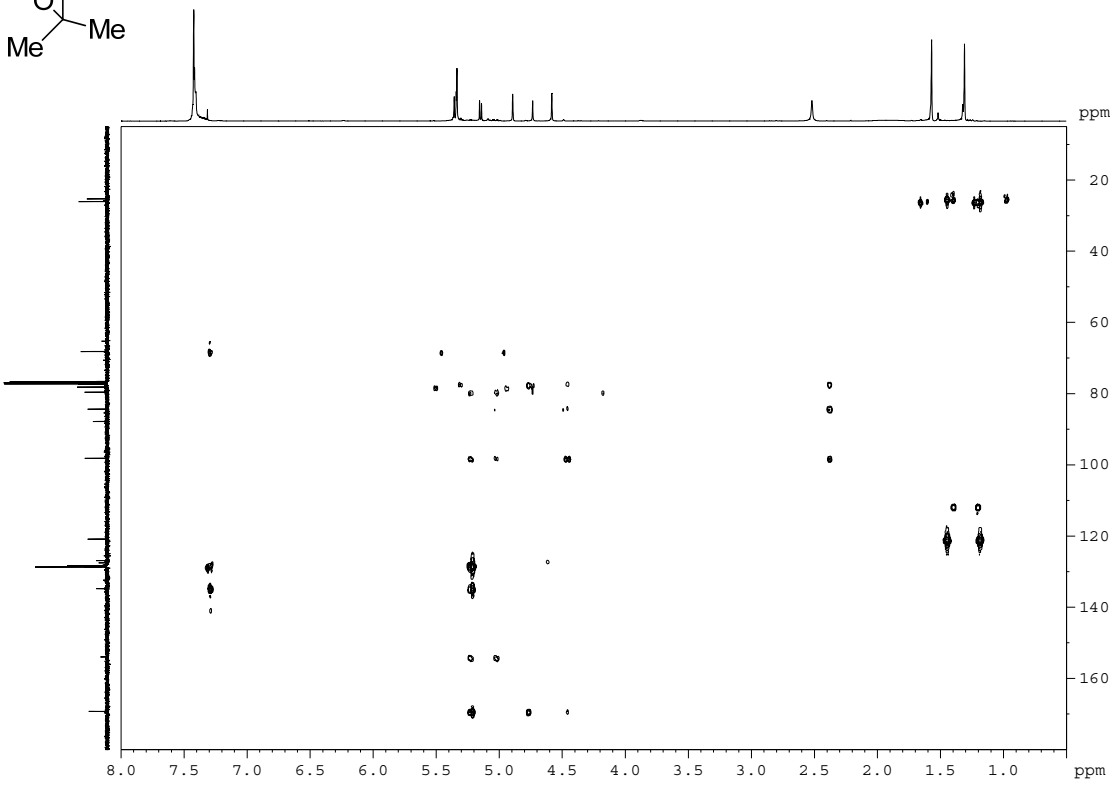
17

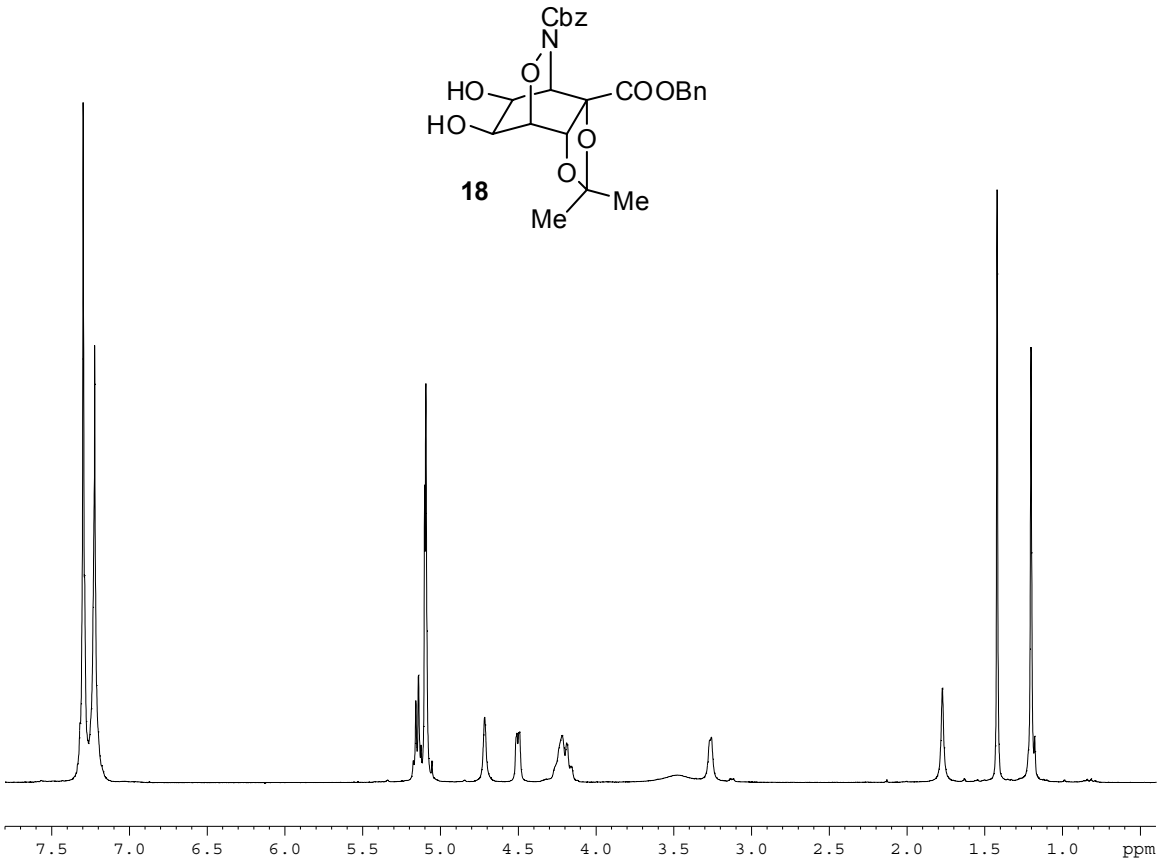


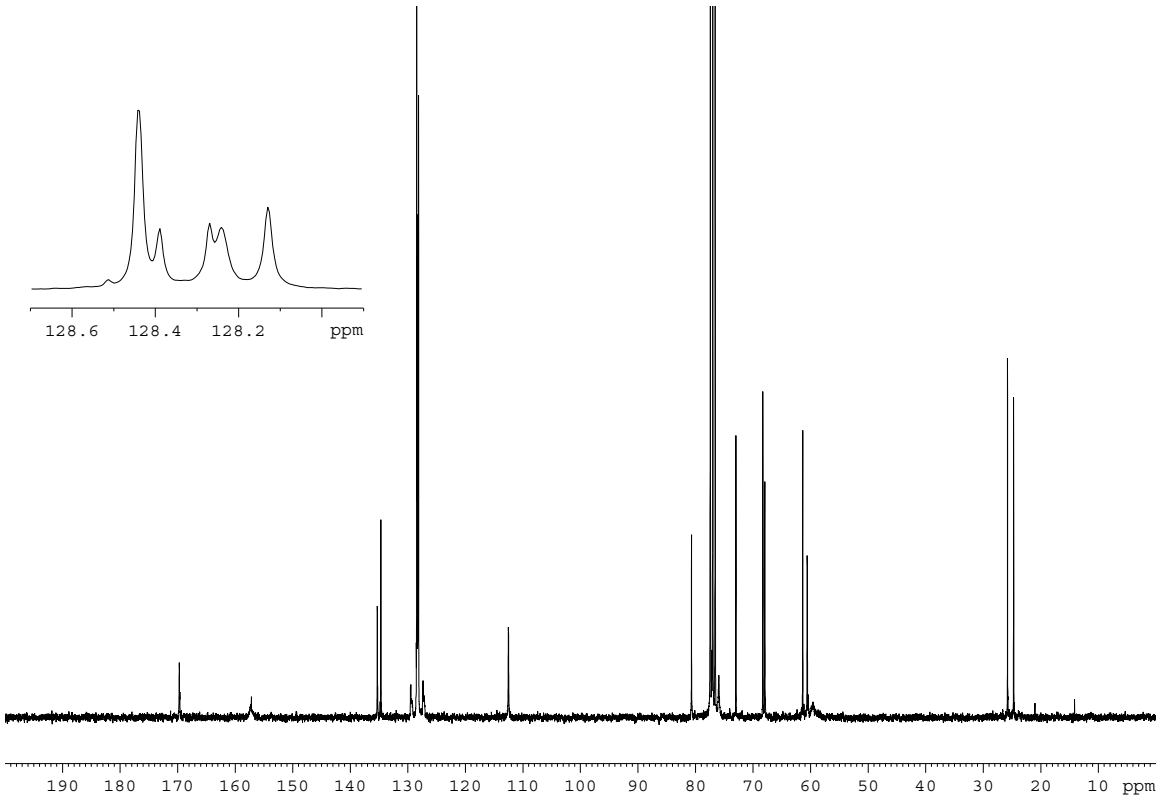
HMBC



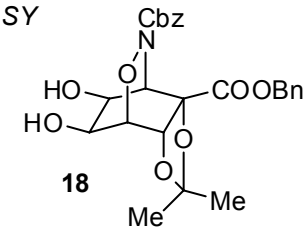
17



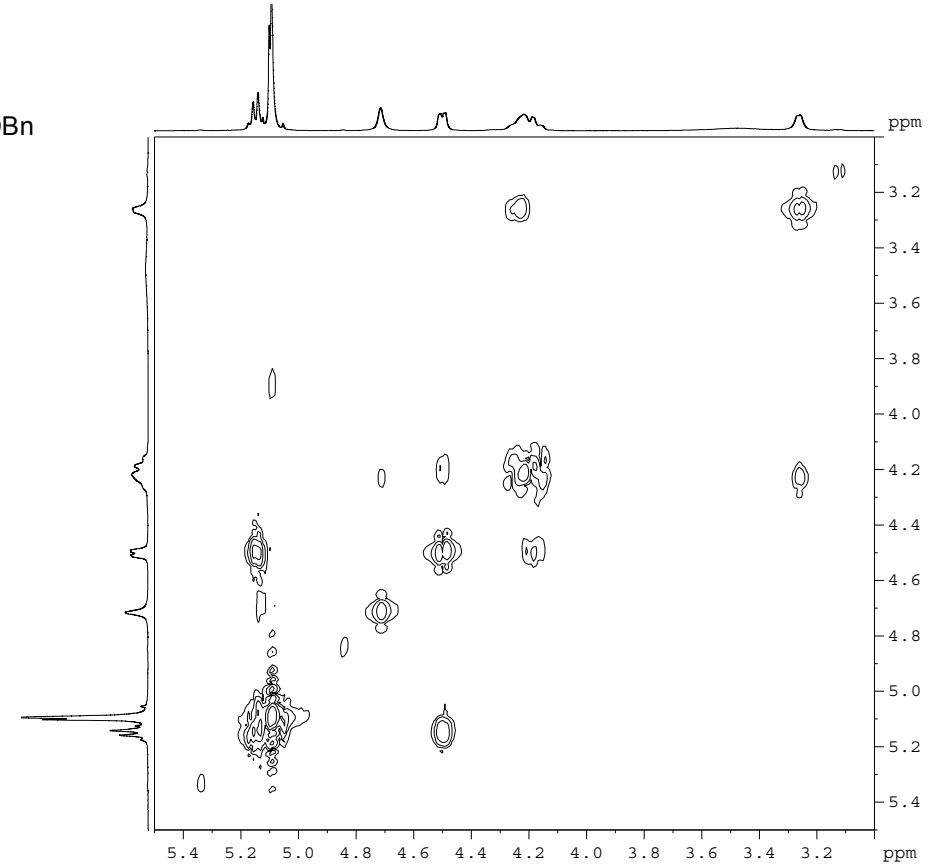

Cbz
N
O
HO
HO
COOBn
O
O
Me
Me
18
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm


128.6
128.4
128.2
ppm
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

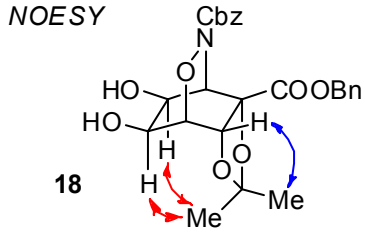
COSY



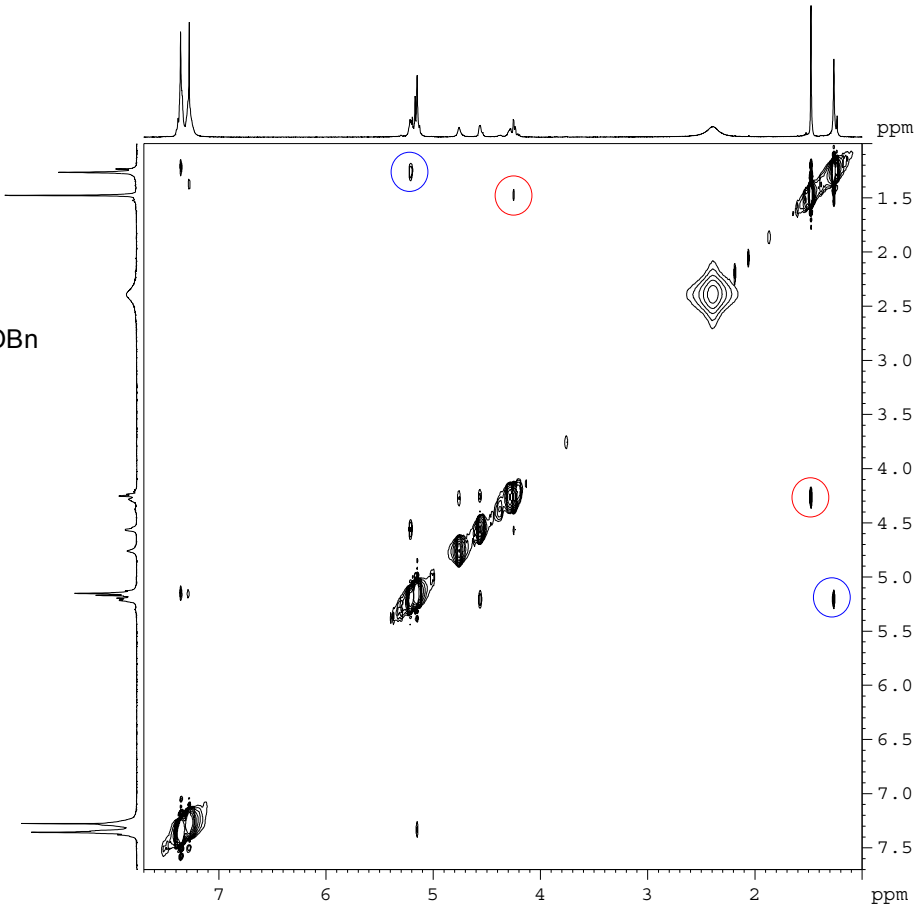
18



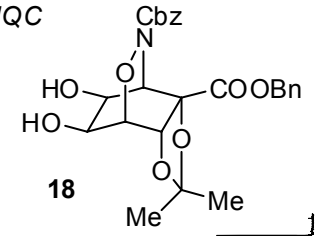
NOESY



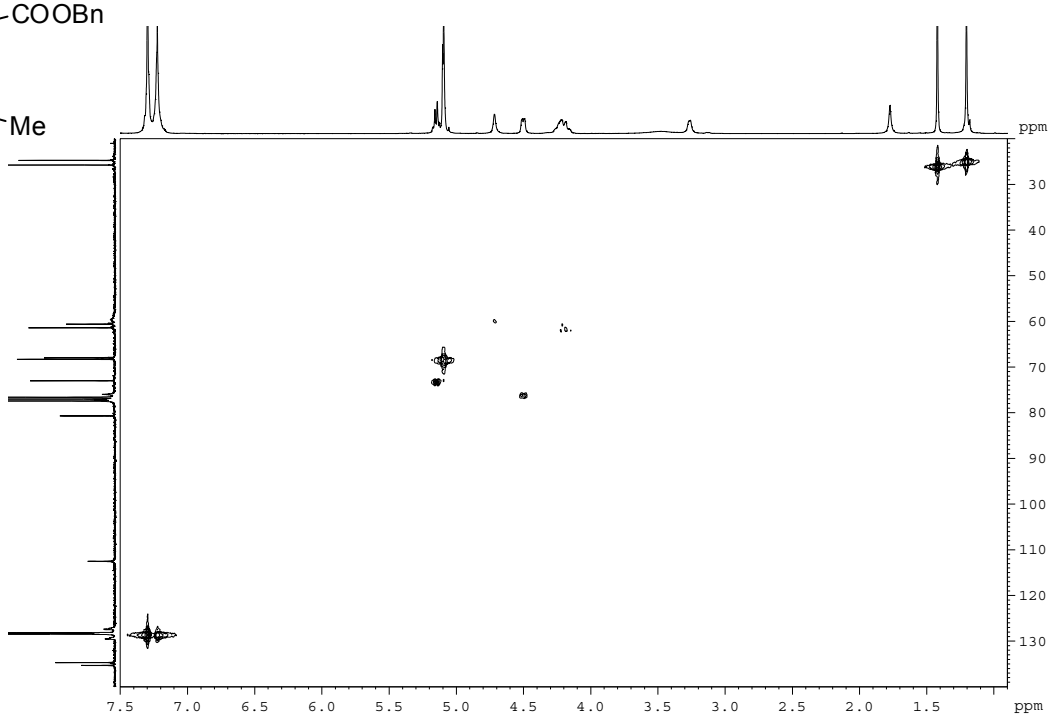
18



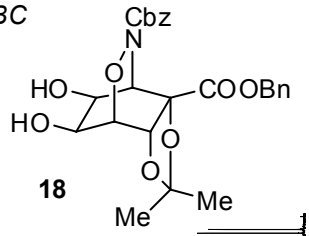
HMQC



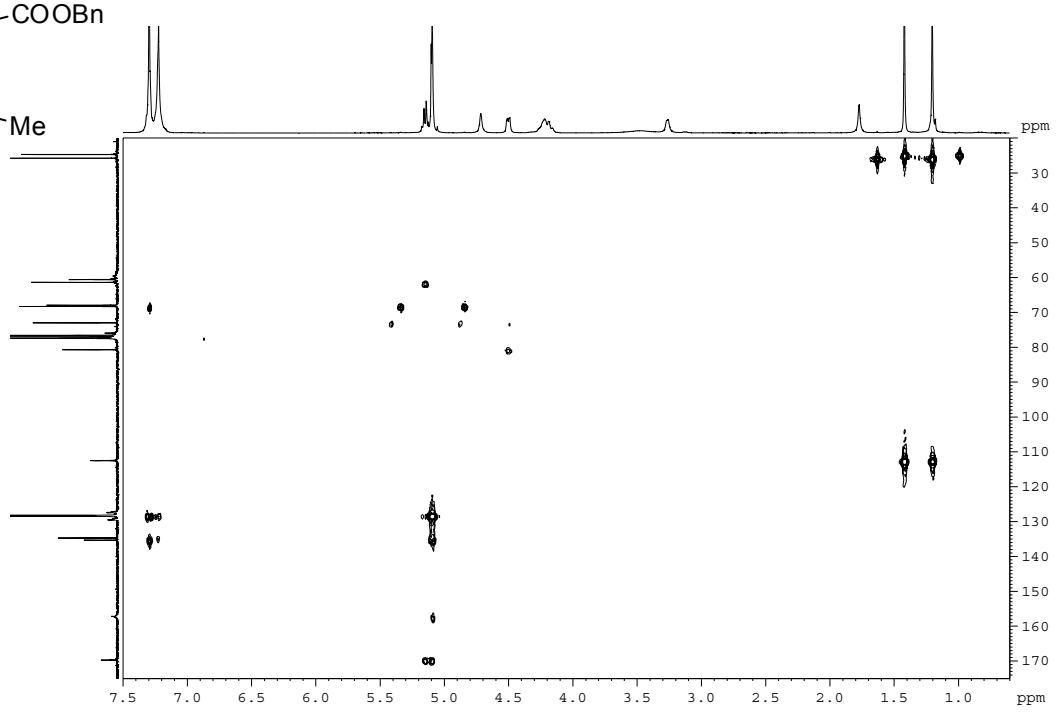
18

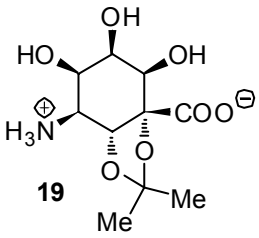


HMBC

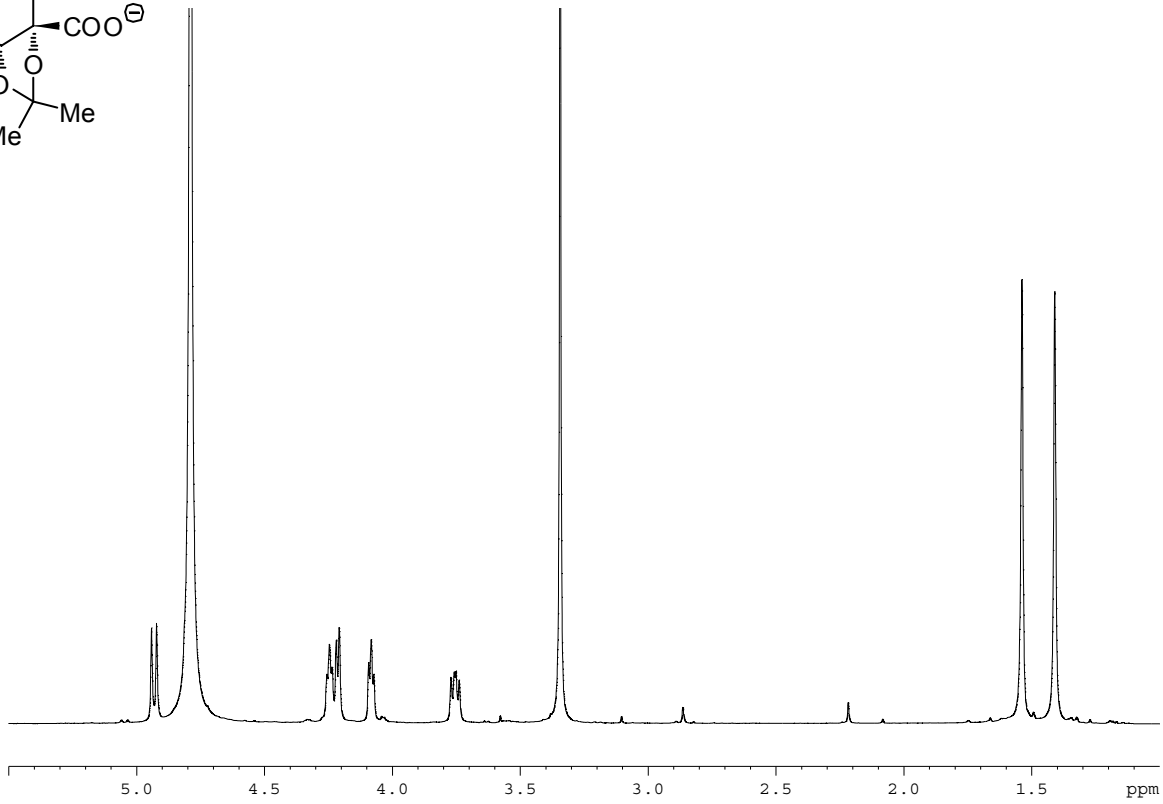


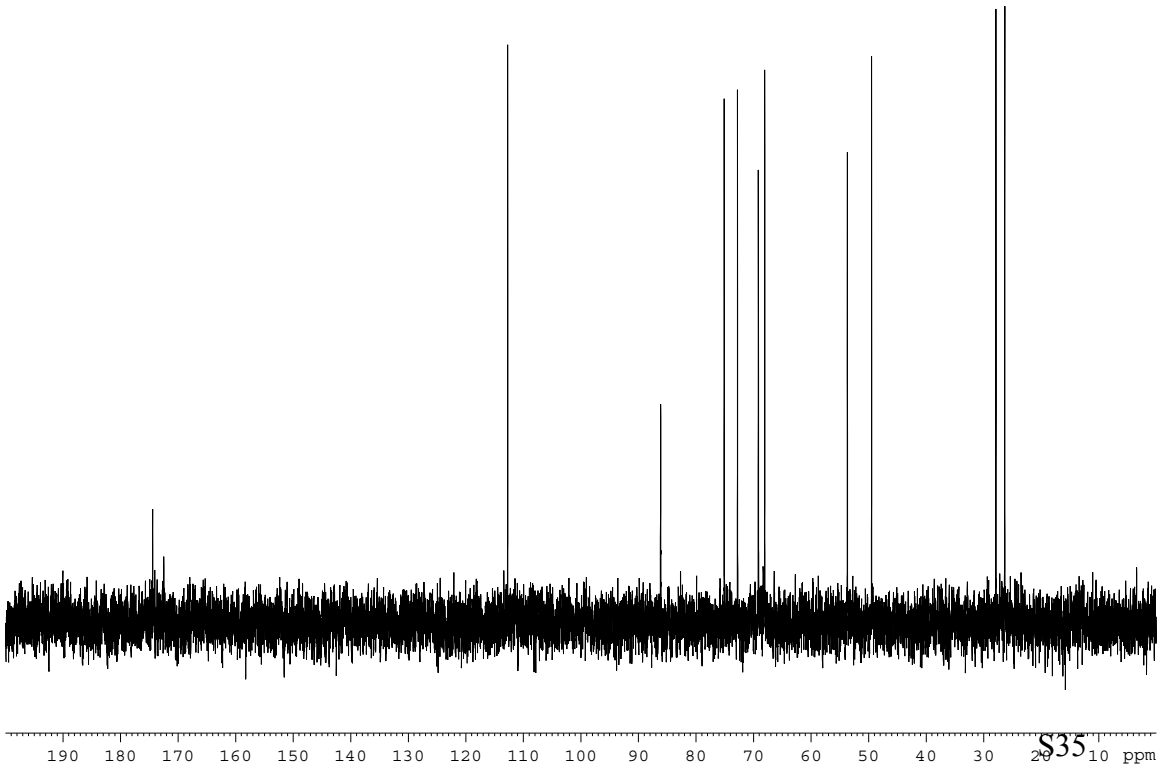
18



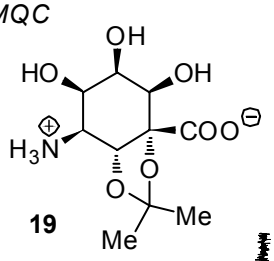

OH
HO
OH
COO
H3N
O
O
Me
Me

19

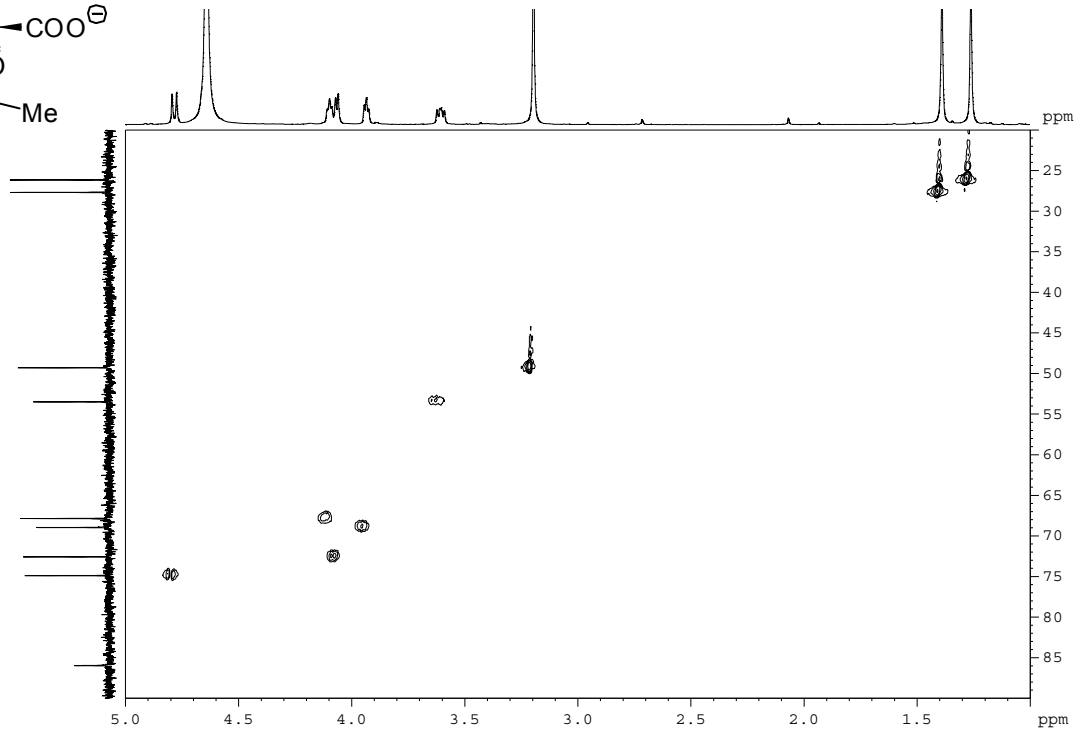

5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm


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

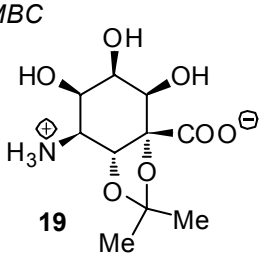
HMQC



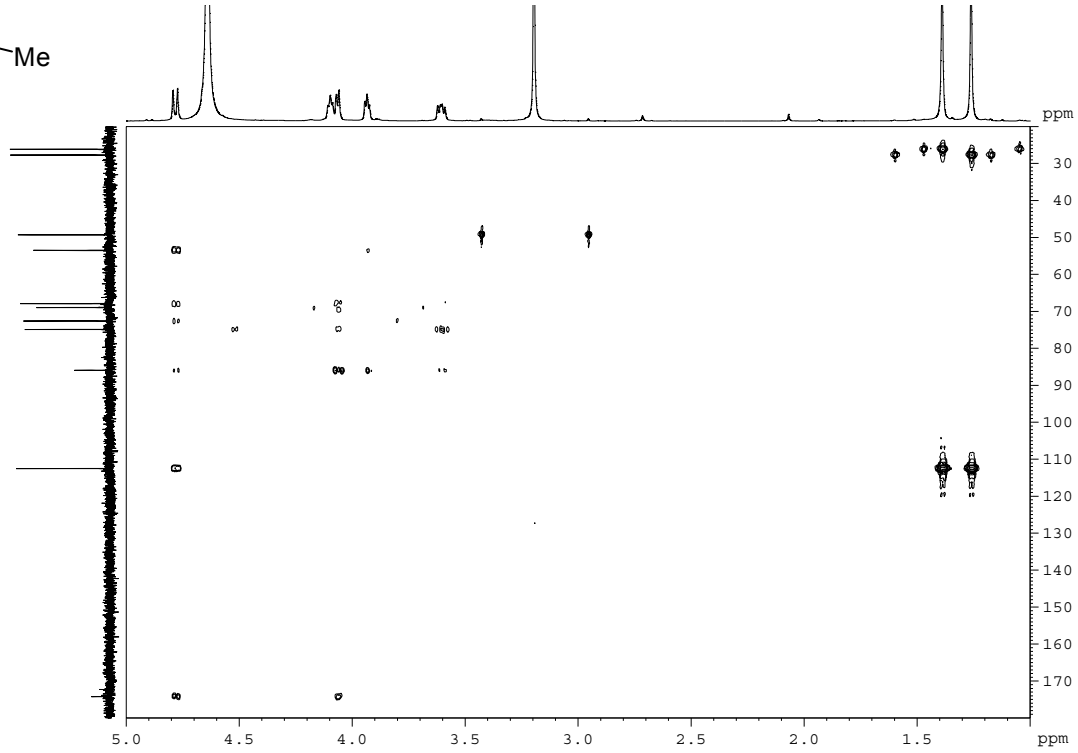
19



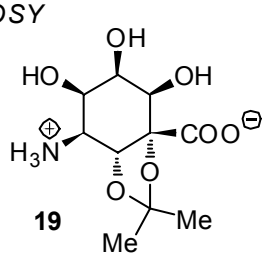
HMBC



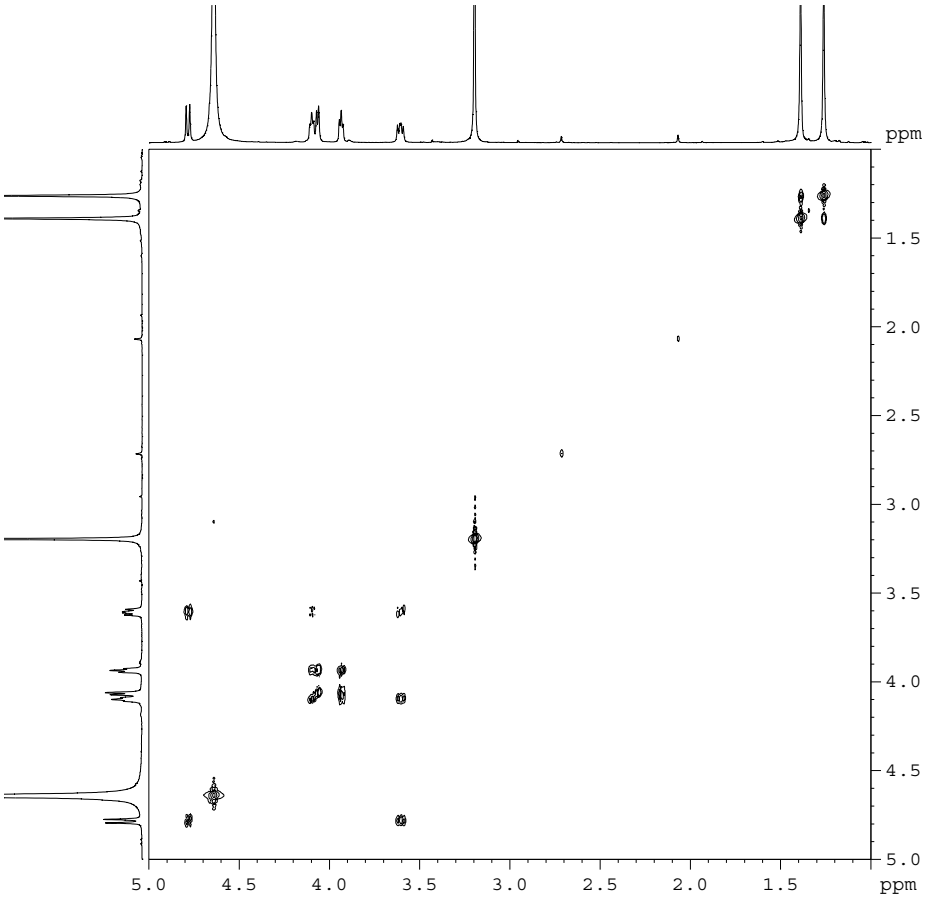
19

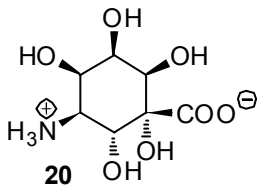


COSY


OH
HO
OH
COO
H3N
O
O
Me
Me

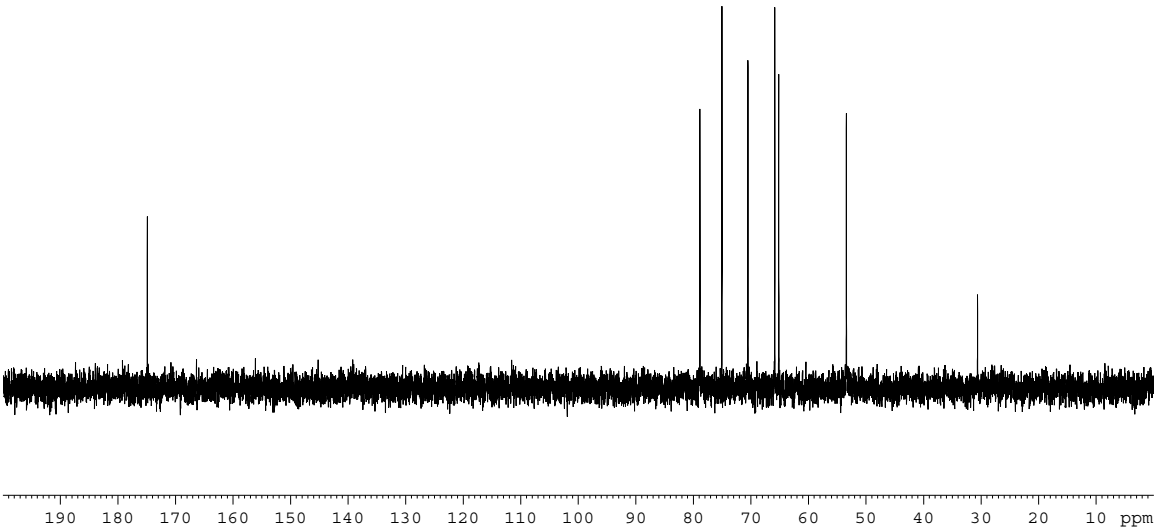
19


ppm
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm

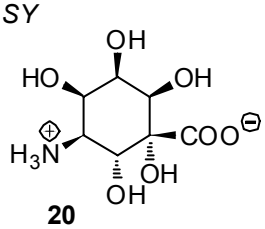

OH
HO
OH
COO
H3N
OH
OH

20

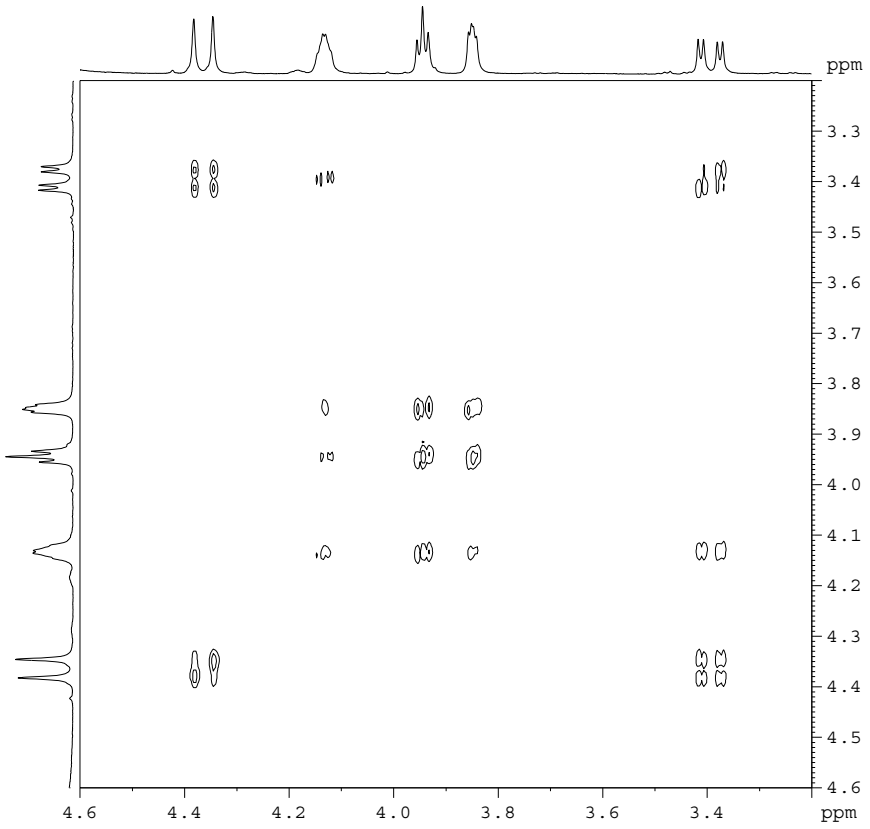
4.5 4.4 4.3 4.2 4.1 4.0 3.9 3.8 3.7 3.6 ppm
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm


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

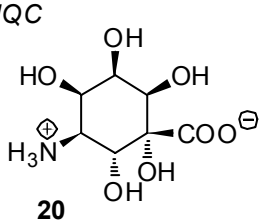
COSY



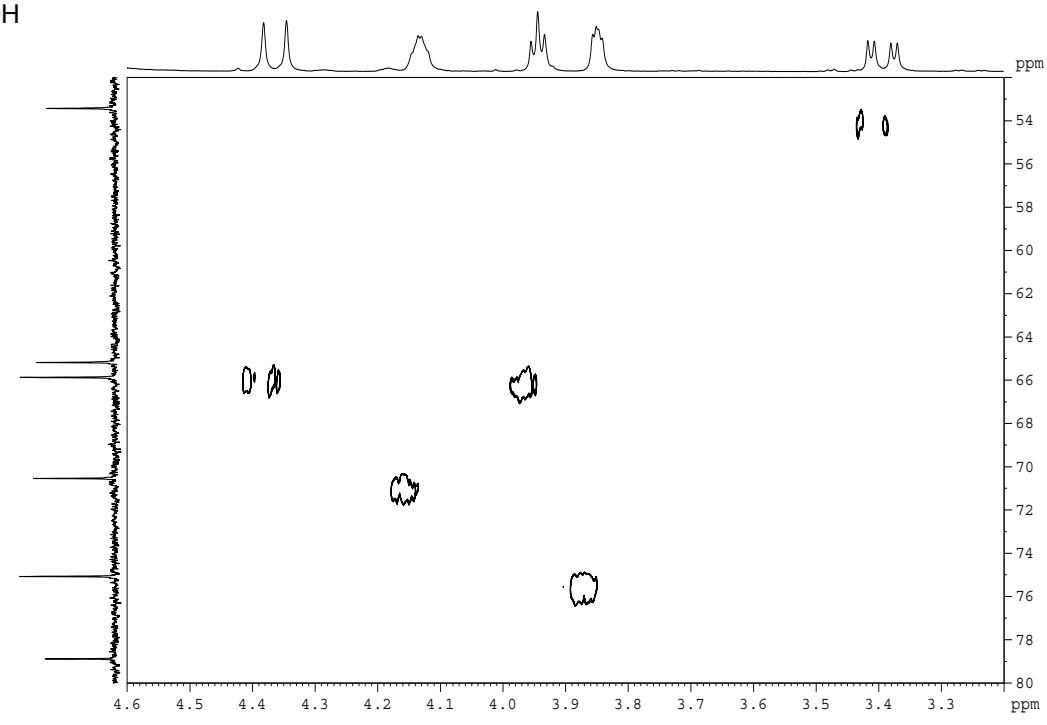
20

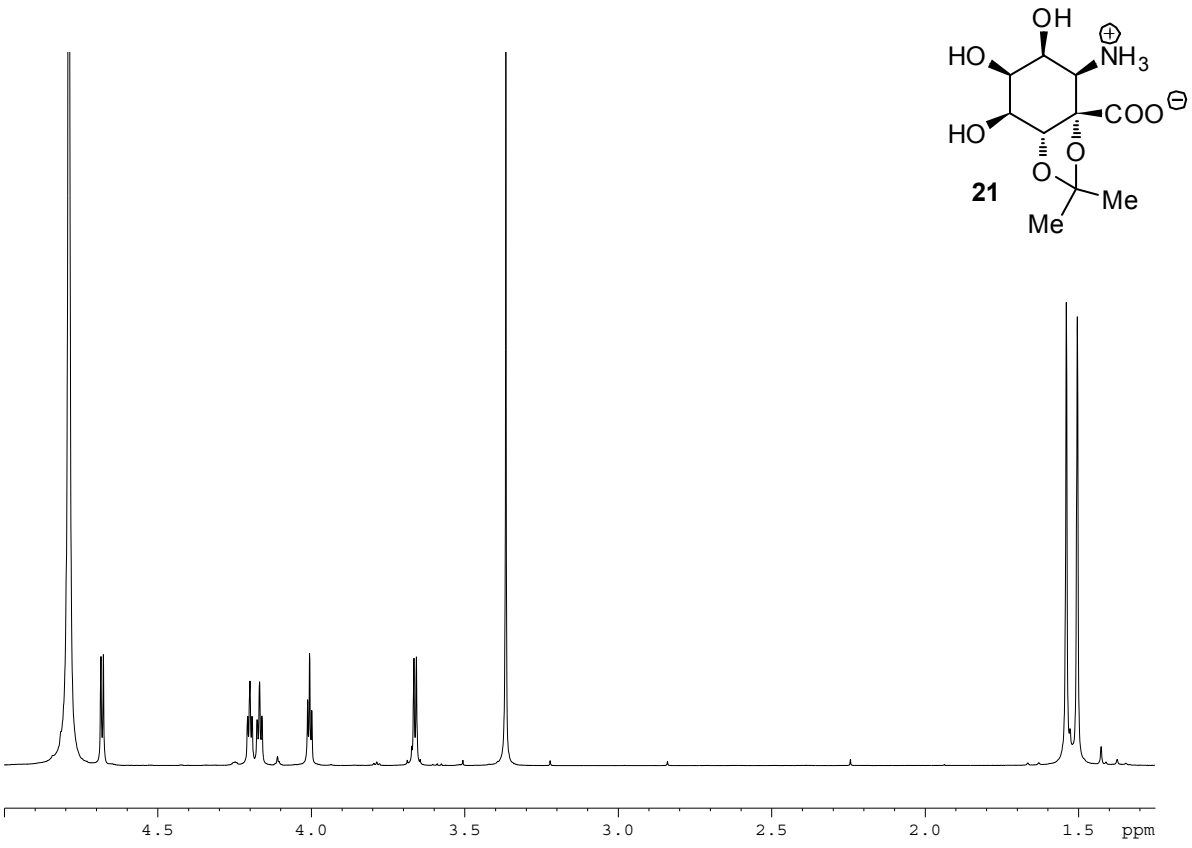


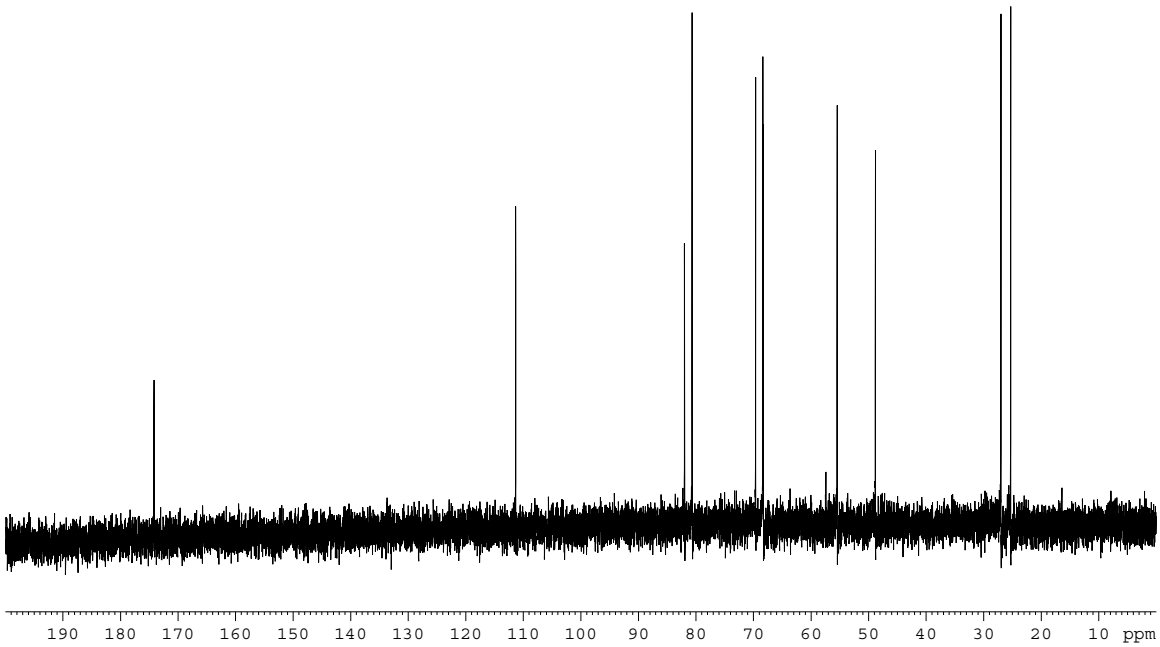
HMQC



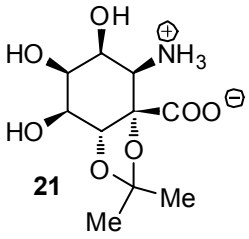
20



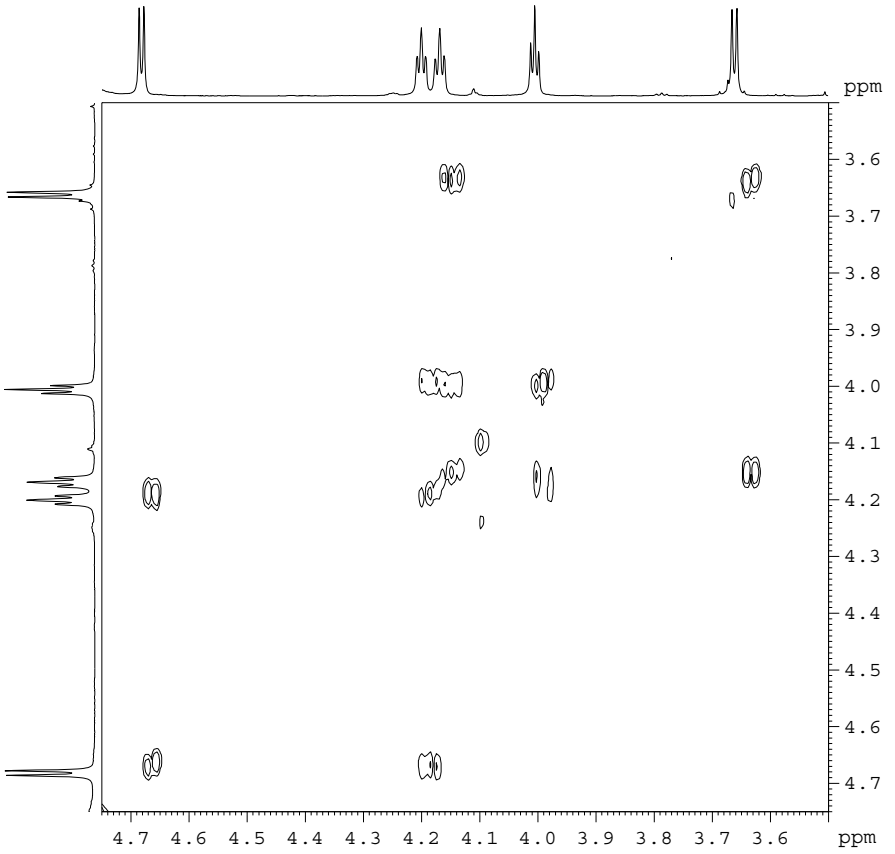

OH
HO
NH3
COO
HO
O
O
Me
Me
21
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm


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

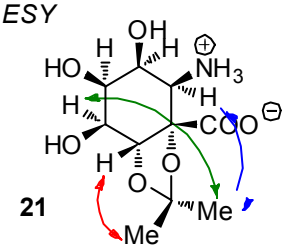
COSY



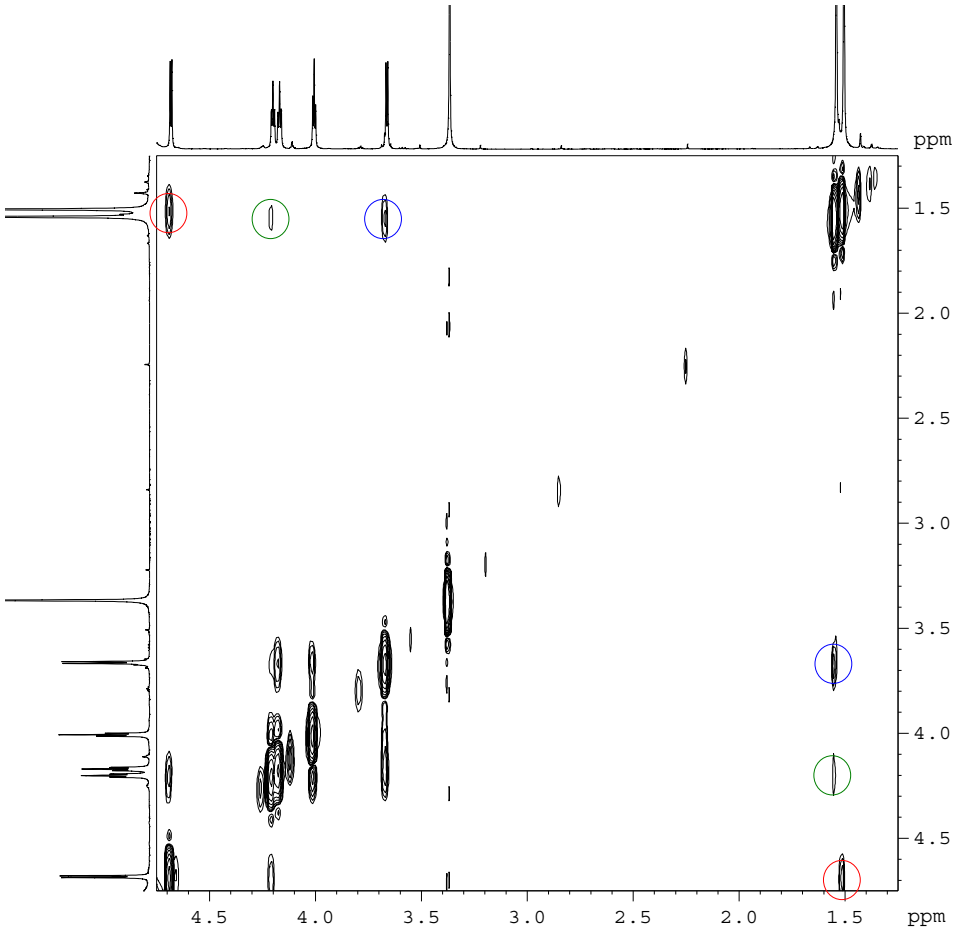
21



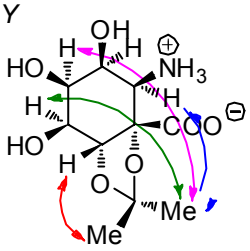
NOESY



21

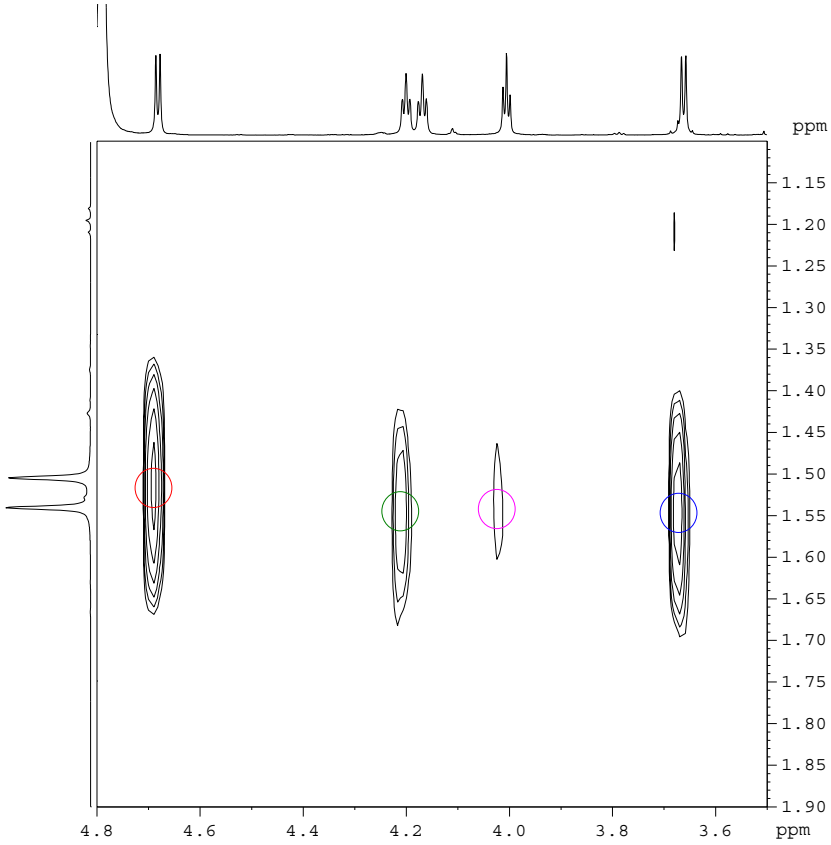


NOESY

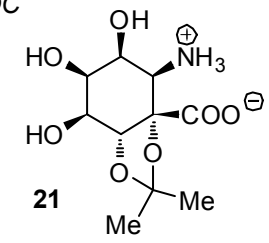


21

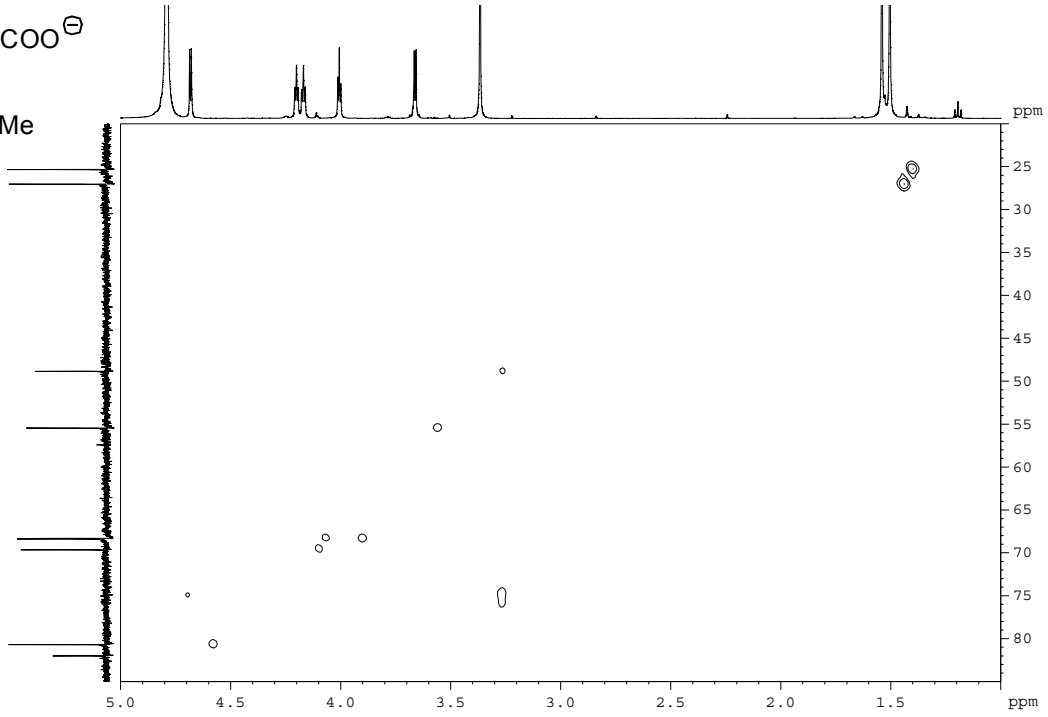
(enlargement)



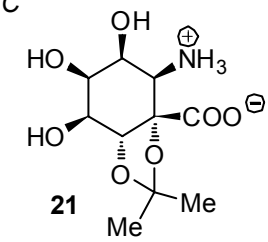
HMQC



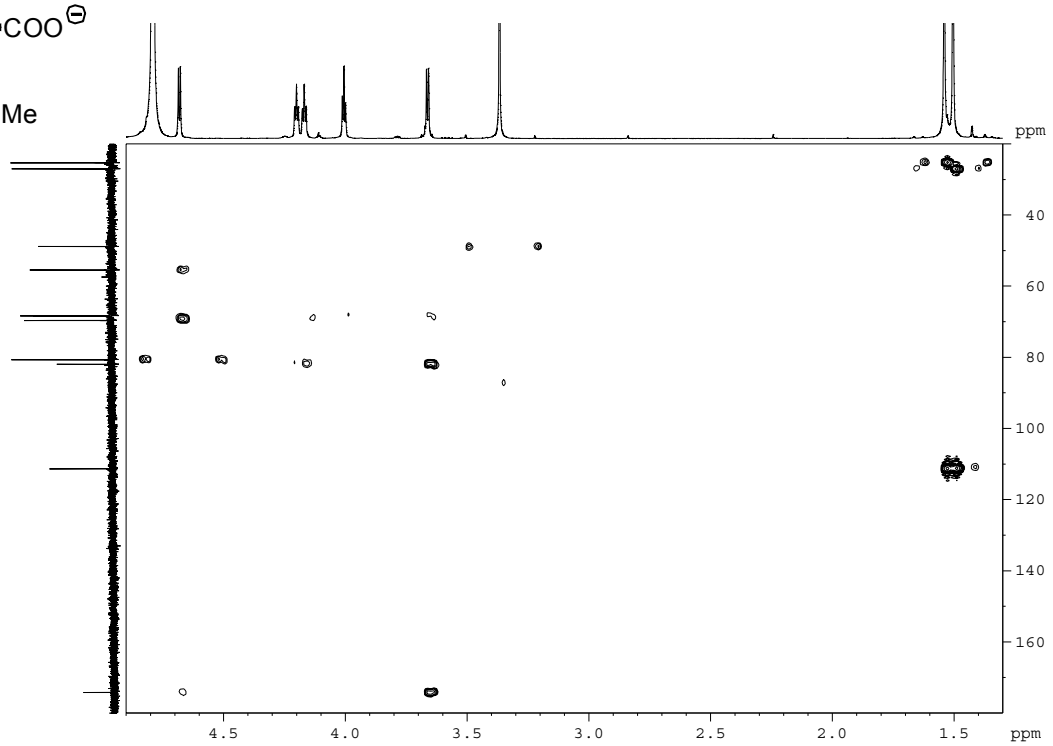
21

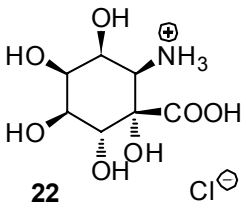


HMBC

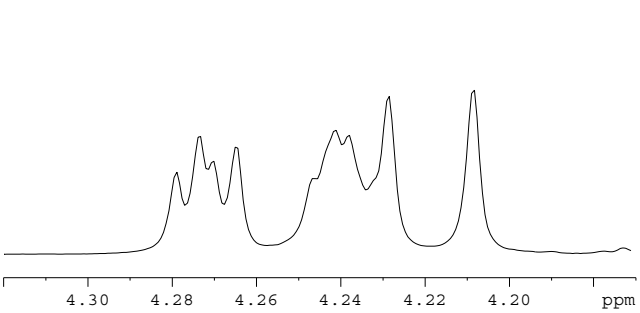


21

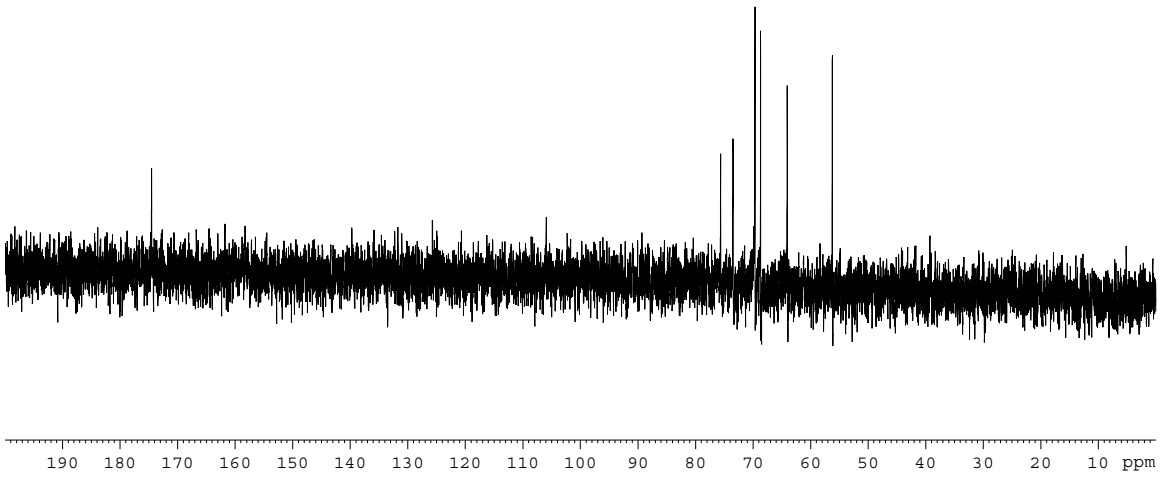



OH
HO
NH3
COOH
HO
OH
OH
Cl

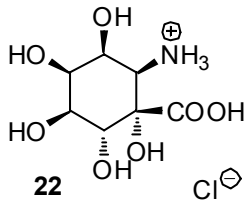
22


4.30
4.28
4.26
4.24
4.22
4.20
ppm

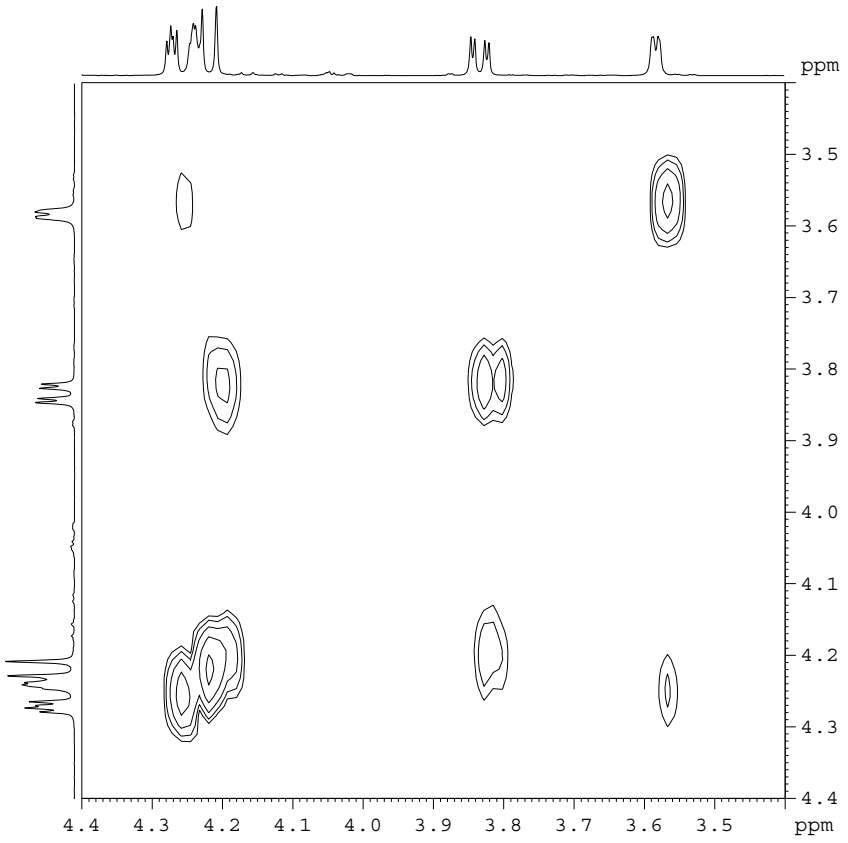
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm


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

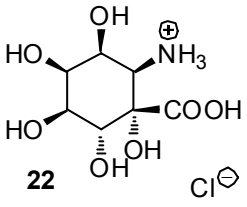
COSY



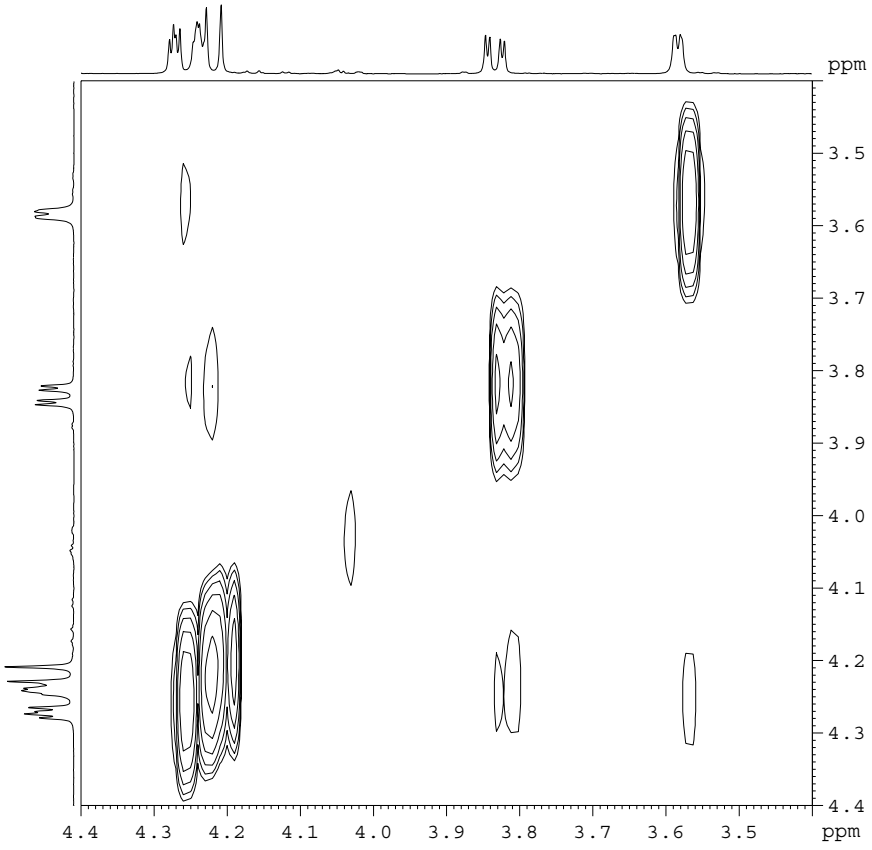
22



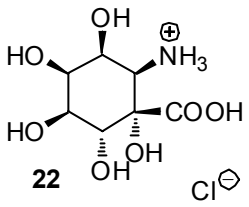
NOESY



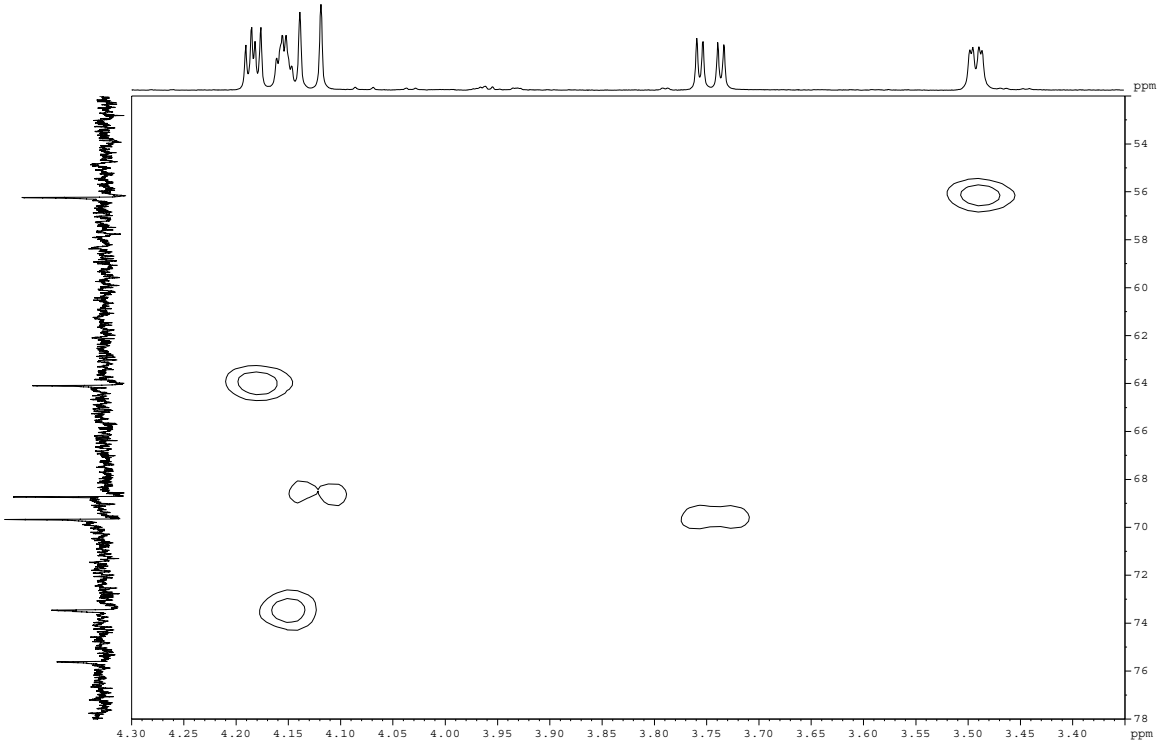
22

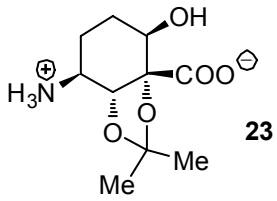


HMQC

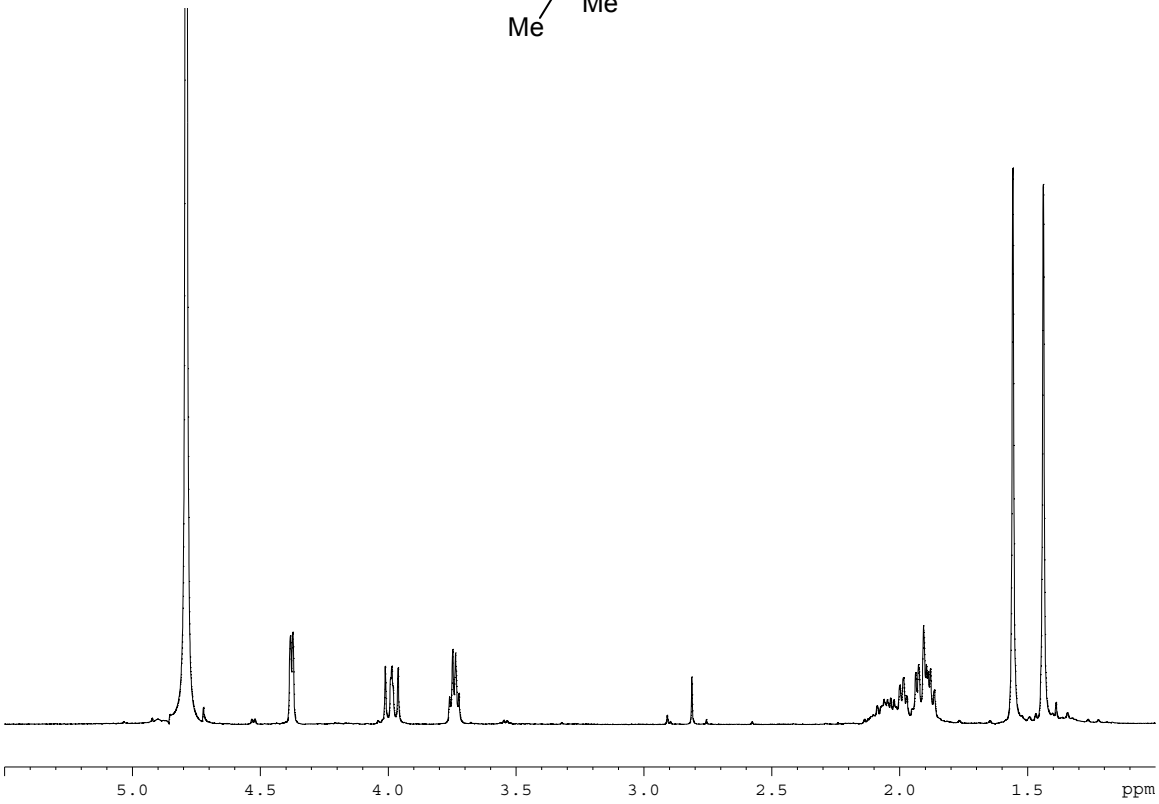

OH
HO
NH3
COOH
HO
OH
OH
Cl

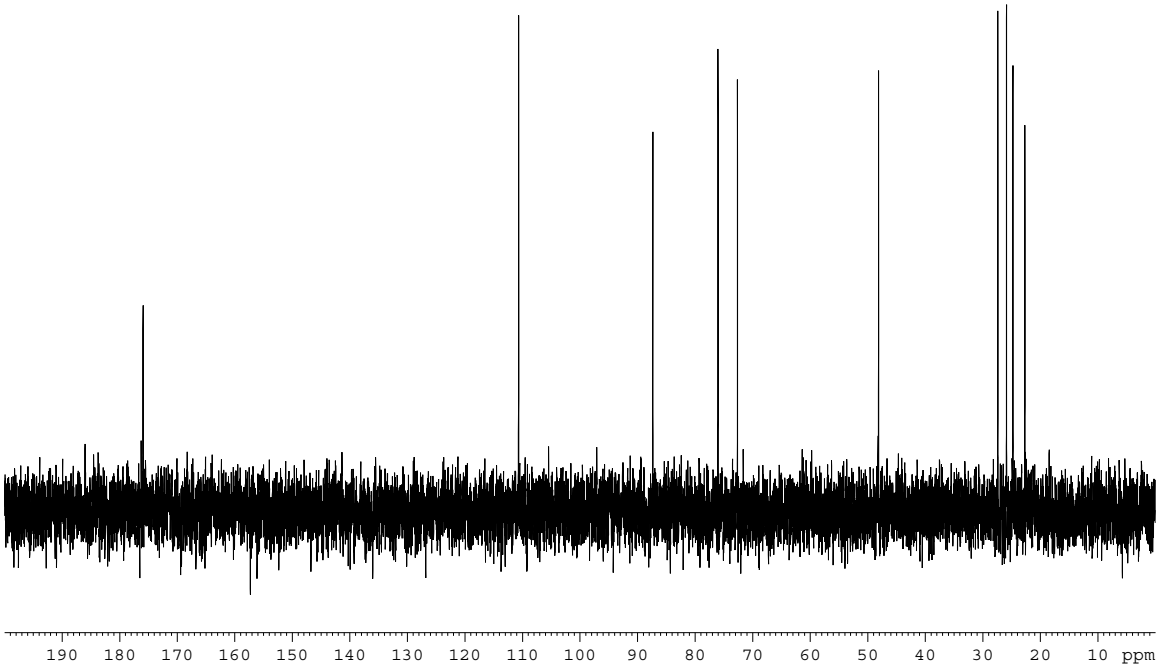
22


ppm
54
56
58
60
62
64
66
68
70
72
74
76
78
4.30
4.25
4.20
4.15
4.10
4.05
4.00
3.95
3.90
3.85
3.80
3.75
3.70
3.65
3.60
3.55
3.50
3.45
3.40
ppm

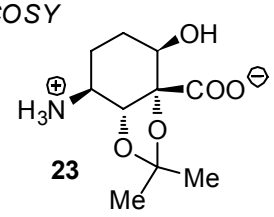

OH
COO
H3N
O
O
Me
Me

23

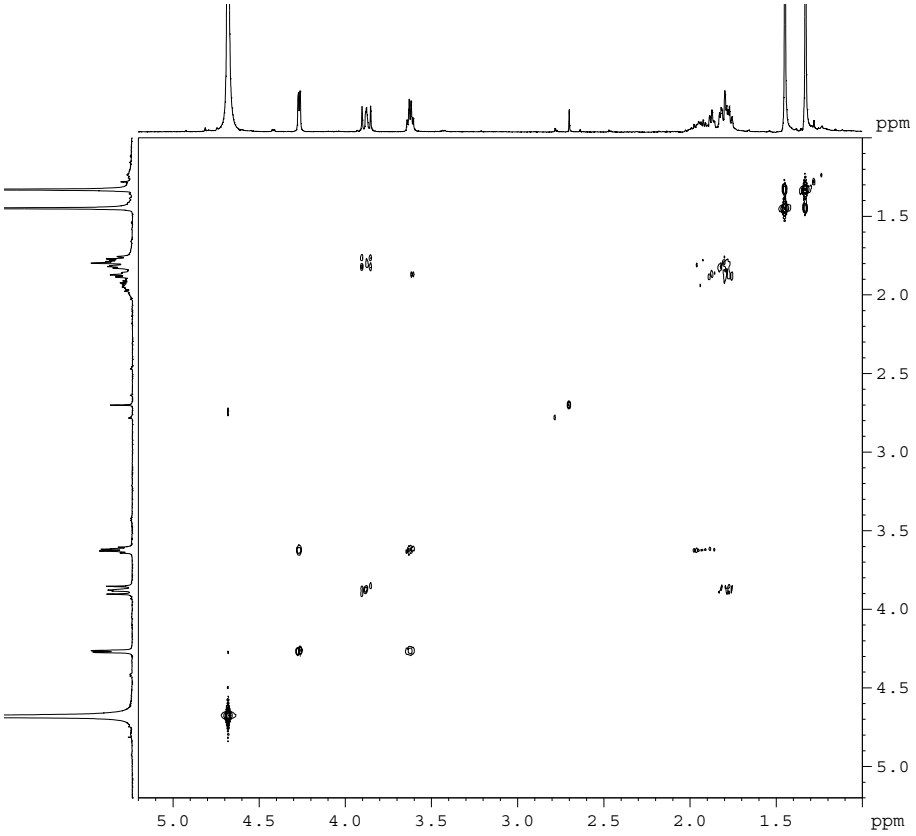

5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm


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

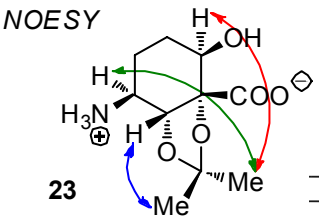
COSY



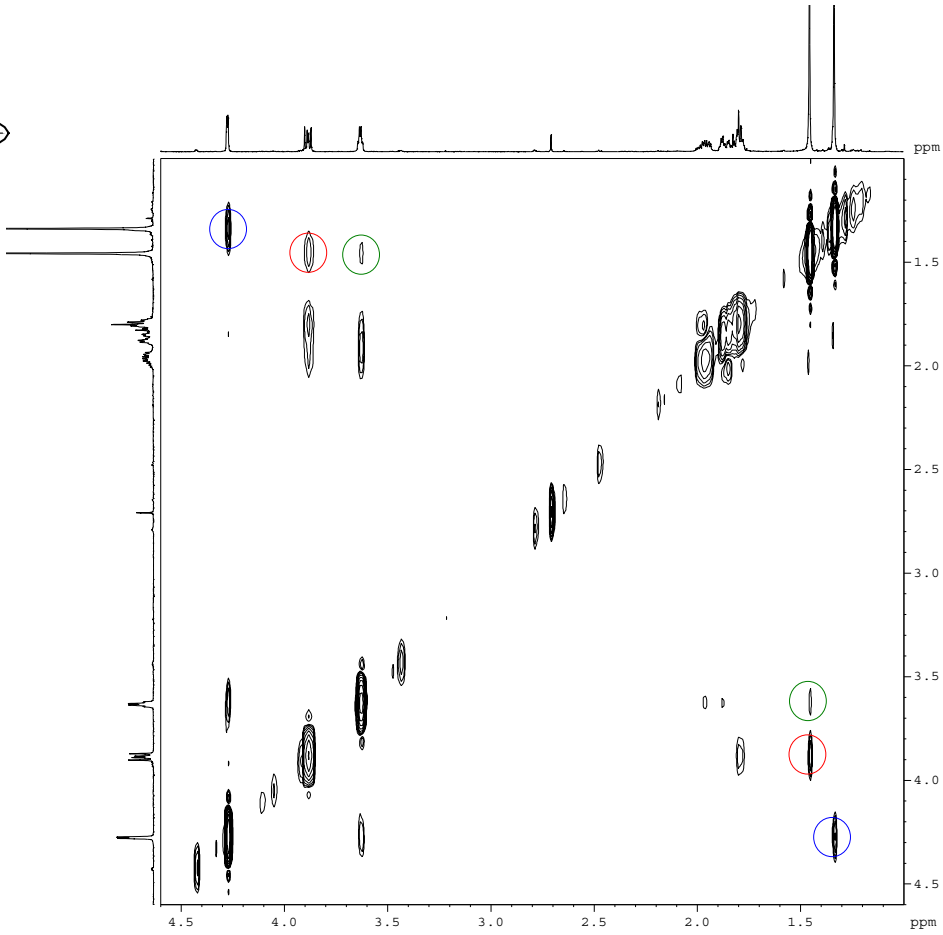
23



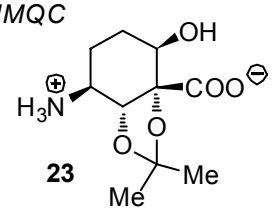
NOESY



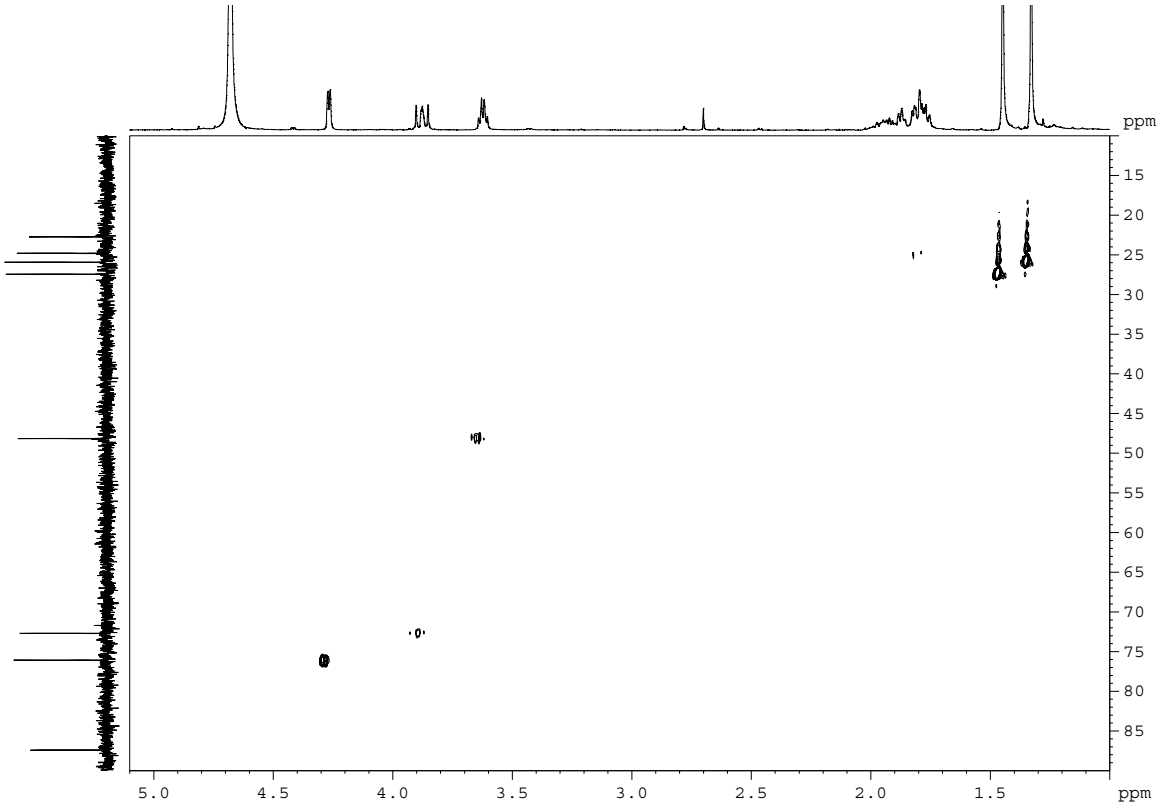
23

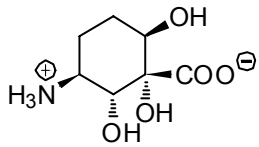


HMQC

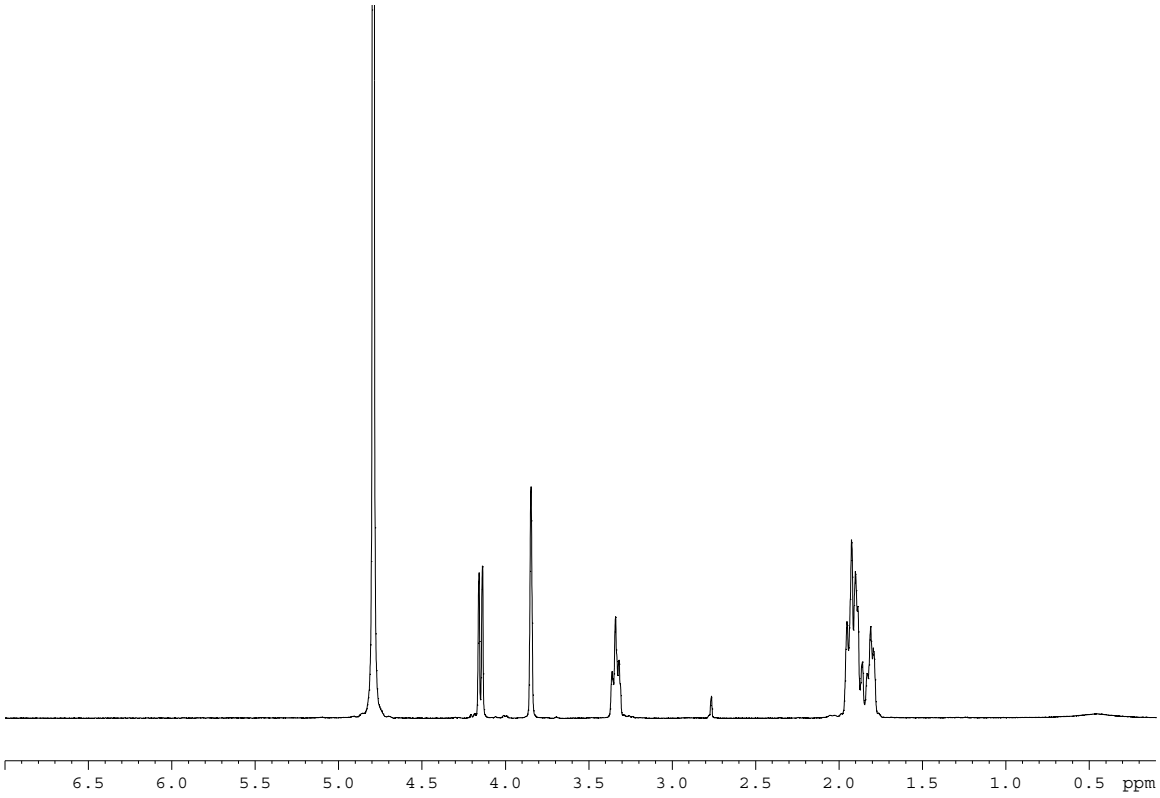

OH
COO
H3N
O
O
Me
Me

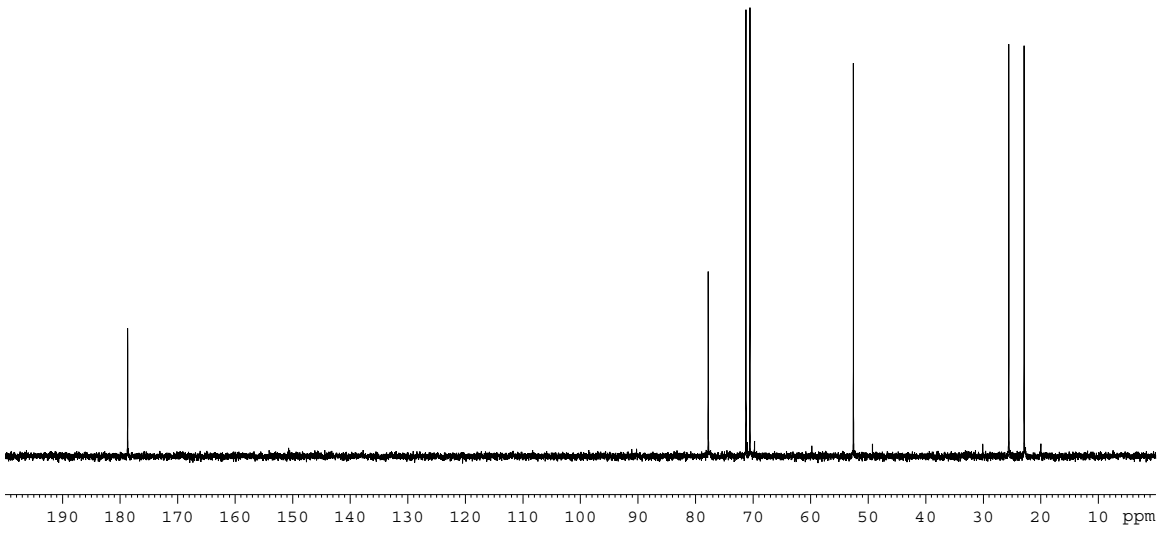
23


ppm
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm

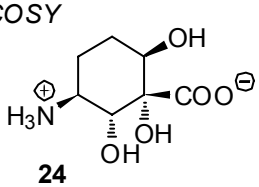

OH
COO
H3N
OH
OH

24

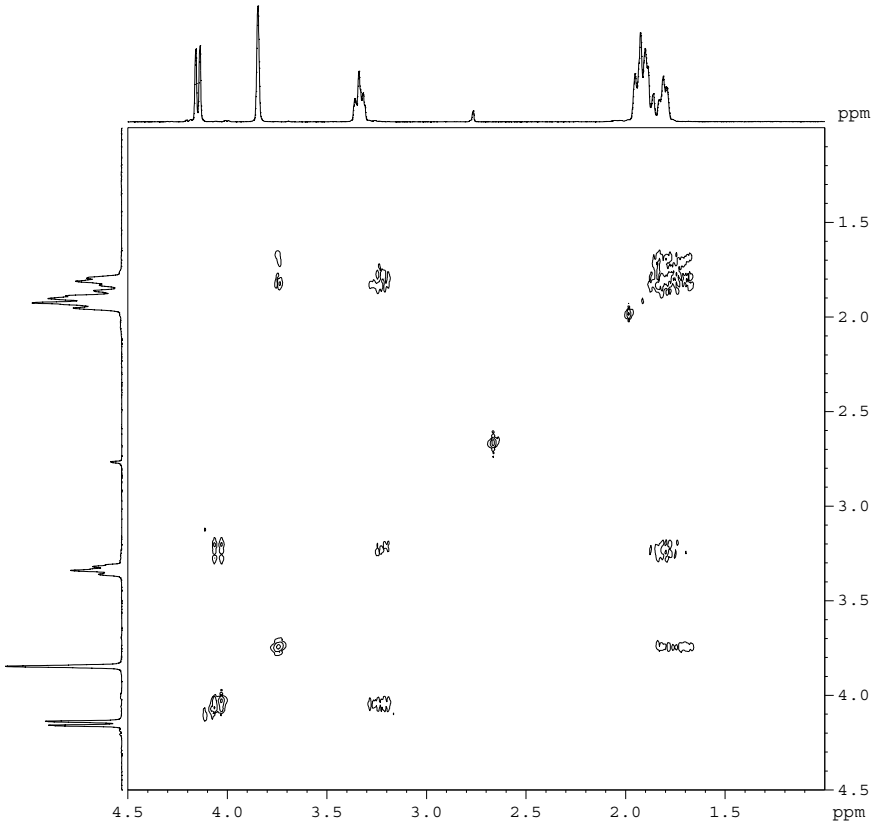

6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm


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

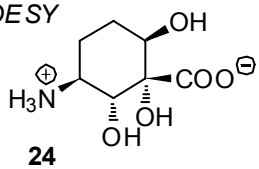
COSY



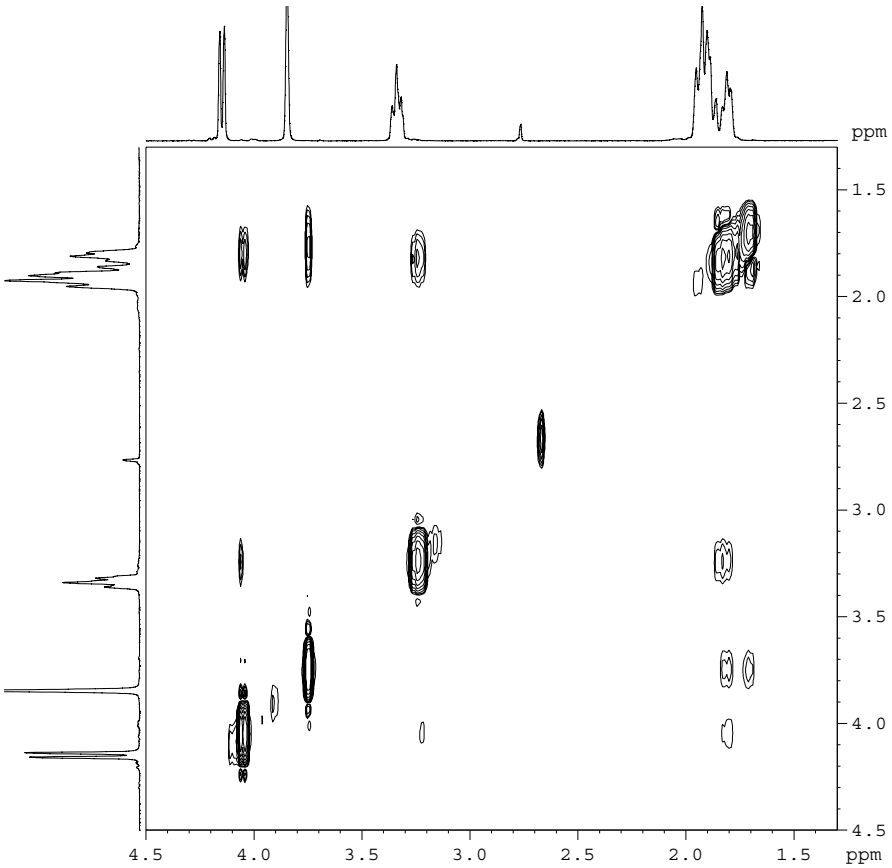
24



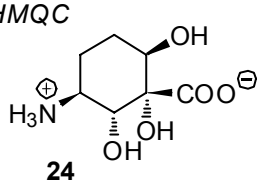
NOESY



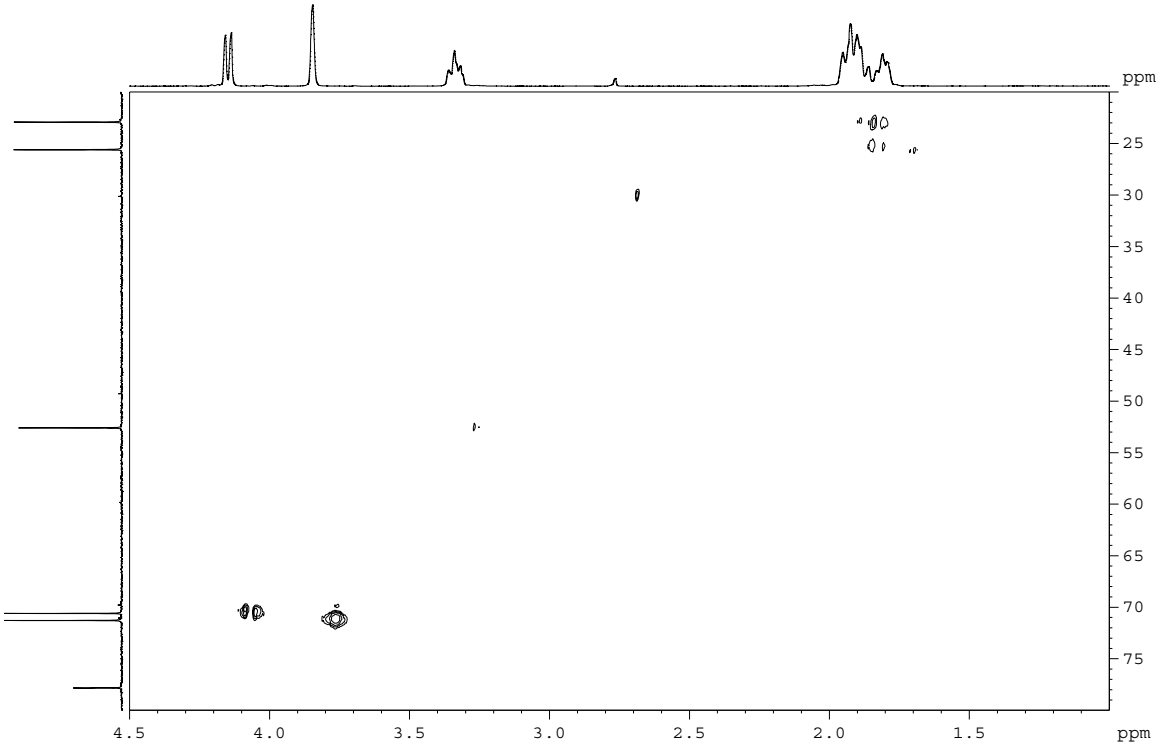
24



HMQC


OH
COO
H3N
OH
OH

24


ppm
25
30
35
40
45
50
55
60
65
70
75
4.5
4.0
3.5
3.0
2.5
2.0
1.5
ppm

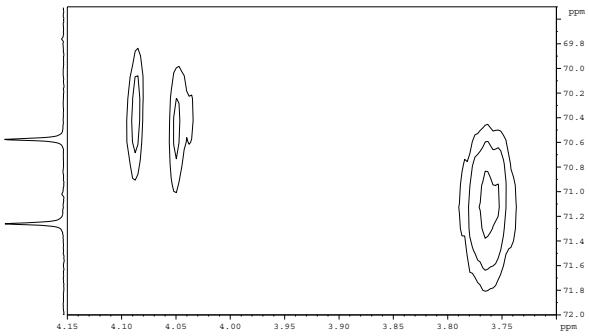

ppm
69.8
70.0
70.2
70.4
70.6
70.8
71.0
71.2
71.4
71.6
71.8
72.0
4.15
4.10
4.05
4.00
3.95
3.90
3.85
3.80
3.75
ppm

Table S1. Crystal data and structure refinement for **15**.

Identification code	p09sel2
Empirical formula	C32.70 H30.70 Cl2.10 N2 O10
Formula weight	686.14
Temperature	150(2) K
Wavelength	1.54184 A
Crystal system, space group	Monoclinic, P 2_1
Unit cell dimensions	a = 11.3398(4) A alpha = 90 deg. b = 9.8085(4) A beta = 97.930(4) deg. c = 15.1771(8) A gamma = 90 deg.
Volume	1671.95(13) A^3
Z, Calculated density	2, 1.363 Mg/m^3
Absorption coefficient	2.327 mm^-1
F(000)	713
Crystal size	0.25 x 0.08 x 0.08 mm
Theta range for data collection	3.94 to 66.59 deg.
Limiting indices	-13<=h<=10, -9<=k<=11, -17<=l<=14
Reflections collected / unique	6576 / 4319 [R(int) = 0.0424]
Completeness to theta = 66.59	98.0 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.8357 and 0.5939
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	4319 / 1 / 460
Goodness-of-fit on F^2	1.043
Final R indices [I>2sigma(I)]	R1 = 0.0612, wR2 = 0.1442
R indices (all data)	R1 = 0.0894, wR2 = 0.1612
Absolute structure parameter	0.07(6)
Extinction coefficient	0.0035(6)
Largest diff. peak and hole	0.349 and -0.308 e.A^-3

To determine the absolute structure data have been collected with Cu K-alpha radiation. The asymmetrical unit contains 0.7 CHCl3 apart from the main compound. The solvent molecule is disordered over two sites in the ratio 40:30 with isotropic refinement for the carbon atoms C40 and C40A. The main compound shows disorder in one phenyl ring in the ratio 45:55. All atoms of involved in the phenyl ring disorder have been refined isotropically.

Table S2. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (A^2 x 10^3) for **15**.
U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	x	y	z	U(eq)
N(1)	9377(3)	7681(5)	4720(3)	31(1)
N(2)	11810(4)	13682(5)	2323(3)	40(1)
O(1)	6929(3)	5370(3)	3916(2)	31(1)
O(2)	5945(3)	6897(3)	2964(2)	29(1)
O(3)	8627(3)	7245(4)	2221(2)	47(1)
O(4)	7031(3)	8577(4)	1806(2)	36(1)
O(5)	7980(3)	9618(3)	3533(2)	28(1)
O(6)	6969(3)	11571(4)	3594(3)	37(1)
O(7)	12601(4)	13015(5)	2080(4)	73(2)
O(8)	11804(5)	14911(5)	2303(4)	77(2)
O(9)	10580(3)	5855(4)	4611(2)	38(1)
O(10)	11222(3)	8029(4)	4488(3)	56(1)
C(1)	7102(4)	7470(5)	3198(3)	24(1)
C(2)	7793(4)	6385(5)	3818(3)	26(1)
C(3)	5990(4)	5474(5)	3180(3)	33(1)
C(4)	6267(5)	4650(6)	2402(4)	47(2)
C(5)	4839(5)	5083(7)	3509(4)	49(2)
C(6)	7691(4)	7719(5)	2352(3)	29(1)
C(7)	7556(6)	9035(7)	1042(4)	50(2)
C(8)	6786(4)	10119(6)	576(3)	37(1)
C(9)	6144(5)	11024(7)	1022(4)	48(2)
C(10)	5468(5)	12047(7)	567(4)	54(2)
C(11)	5458(6)	12185(7)	-338(4)	54(2)
C(12)	6090(5)	11291(7)	-786(4)	51(2)
C(13)	6736(5)	10251(7)	-342(3)	47(1)
C(14)	8276(4)	6914(5)	4746(3)	26(1)
C(15)	7390(4)	7804(5)	5112(3)	30(1)
C(16)	6751(4)	8691(5)	4594(3)	31(1)
C(17)	6909(4)	8835(5)	3628(3)	26(1)
C(18)	7866(4)	10979(5)	3481(3)	28(1)
C(19)	8941(4)	11644(5)	3227(3)	30(1)
C(20)	9869(4)	10902(6)	2956(4)	37(1)
C(21)	10820(4)	11550(6)	2659(4)	37(1)
C(22)	10818(4)	12967(5)	2655(3)	31(1)
C(23)	9942(4)	13731(5)	2951(4)	37(1)
C(24)	8998(4)	13054(5)	3245(4)	34(1)
C(25)	10406(4)	7073(6)	4609(3)	33(1)
C(26)	12285(10)	7295(14)	4114(9)	35(3)
C(27)	12816(13)	8359(17)	3584(11)	22(5)
C(28)	13491(11)	9446(14)	4059(11)	30(4)
C(29)	14024(12)	10437(16)	3596(12)	49(4)
C(30)	13951(11)	10301(15)	2669(12)	38(3)
C(31)	13309(12)	9258(16)	2191(8)	33(3)
C(32)	12810(12)	8285(13)	2697(8)	31(3)
C(26A)	12451(8)	7700(11)	4458(7)	29(2)
C(27A)	12836(14)	8504(18)	3734(11)	36(5)
C(28A)	13553(10)	9605(14)	3813(9)	34(3)
C(29A)	13964(8)	10311(11)	3155(10)	32(3)
C(30A)	13577(11)	9922(16)	2311(9)	46(3)
C(31A)	12751(13)	8821(14)	2105(9)	54(3)
C(32A)	12347(12)	8084(13)	2814(8)	46(3)
C(40)	1330(30)	9920(30)	-490(20)	91(11)
Cl(1)	2658(5)	10465(7)	-222(3)	81(2)
Cl(2)	683(13)	8452(12)	-386(6)	174(5)
Cl(3)	351(8)	11075(19)	114(8)	203(7)
C(40A)	1040(20)	10160(30)	-557(18)	48(7)
Cl(1A)	1874(17)	11056(18)	312(11)	214(9)
Cl(2A)	1552(9)	8374(12)	-721(6)	104(3)
Cl(3A)	-206(17)	10177(15)	-317(14)	186(7)

Table S3. Bond lengths [A] for **15**.

N(1)-C(25)	1.342(6)
N(1)-C(14)	1.463(6)
N(1)-H(1)	1.00(6)
N(2)-O(8)	1.206(6)
N(2)-O(7)	1.207(6)
N(2)-C(22)	1.473(6)
O(1)-C(2)	1.419(6)
O(1)-C(3)	1.436(5)
O(2)-C(1)	1.426(5)
O(2)-C(3)	1.433(6)
O(3)-C(6)	1.200(6)
O(4)-C(6)	1.336(6)
O(4)-C(7)	1.446(6)
O(5)-C(18)	1.342(6)
O(5)-C(17)	1.460(5)
O(6)-C(18)	1.204(6)
O(9)-C(25)	1.211(7)
O(10)-C(25)	1.347(7)
O(10)-C(26A)	1.437(9)
O(10)-C(26)	1.576(13)
C(1)-C(17)	1.517(6)
C(1)-C(6)	1.547(6)
C(1)-C(2)	1.558(6)
C(2)-C(14)	1.529(6)
C(2)-H(2)	1.0000
C(3)-C(4)	1.500(8)
C(3)-C(5)	1.511(7)
C(4)-H(4A)	0.9800
C(4)-H(4B)	0.9800
C(4)-H(4C)	0.9800
C(5)-H(5A)	0.9800
C(5)-H(5B)	0.9800
C(5)-H(5C)	0.9800
C(7)-C(8)	1.491(8)
C(7)-H(7A)	0.9900
C(7)-H(7B)	0.9900
C(8)-C(9)	1.384(8)
C(8)-C(13)	1.392(7)
C(9)-C(10)	1.387(9)
C(9)-H(9)	0.9500
C(10)-C(11)	1.380(9)
C(10)-H(10)	0.9500
C(11)-C(12)	1.371(10)
C(11)-H(11)	0.9500
C(12)-C(13)	1.377(9)
C(12)-H(12)	0.9500
C(13)-H(13)	0.9500
C(14)-C(15)	1.495(7)
C(14)-H(14)	1.0000
C(15)-C(16)	1.321(7)
C(15)-H(15)	0.9500
C(16)-C(17)	1.508(7)
C(16)-H(16)	0.9500
C(17)-H(17)	1.0000
C(18)-C(19)	1.480(7)
C(19)-C(24)	1.384(7)
C(19)-C(20)	1.388(7)
C(20)-C(21)	1.379(7)
C(20)-H(20)	0.9500
C(21)-C(22)	1.391(8)
C(21)-H(21)	0.9500
C(22)-C(23)	1.369(7)
C(23)-C(24)	1.384(8)
C(23)-H(23)	0.9500

C(24)-H(24)	0.9500
C(26)-C(27)	1.49(2)
C(26)-H(26A)	0.9900
C(26)-H(26B)	0.9900
C(27)-C(32)	1.35(2)
C(27)-C(28)	1.45(2)
C(28)-C(29)	1.39(2)
C(28)-H(28)	0.9500
C(29)-C(30)	1.40(2)
C(29)-H(29)	0.9500
C(30)-C(31)	1.40(2)
C(30)-H(30)	0.9500
C(31)-C(32)	1.39(2)
C(31)-H(31)	0.9500
C(32)-H(32)	0.9500
C(26A)-C(27A)	1.468(19)
C(26A)-H(26C)	0.9900
C(26A)-H(26D)	0.9900
C(27A)-C(28A)	1.35(2)
C(27A)-C(32A)	1.487(19)
C(28A)-C(29A)	1.35(2)
C(28A)-H(28A)	0.9500
C(29A)-C(30A)	1.351(18)
C(29A)-H(29A)	0.9500
C(30A)-C(31A)	1.435(19)
C(30A)-H(30A)	0.9500
C(31A)-C(32A)	1.424(19)
C(31A)-H(31A)	0.9500
C(32A)-H(32A)	0.9500
C(40)-Cl(1)	1.59(3)
C(40)-Cl(2)	1.64(3)
C(40)-Cl(3)	1.91(3)
C(40)-H(40)	1.0000
C(40A)-Cl(3A)	1.51(3)
C(40A)-Cl(1A)	1.75(3)
C(40A)-Cl(2A)	1.87(3)
C(40A)-H(40A)	1.0000

Table S4. Bond angles [deg] for **15**.

C(25)-N(1)-C(14)	122.3(4)
C(25)-N(1)-H(1)	121(3)
C(14)-N(1)-H(1)	117(3)
O(8)-N(2)-O(7)	122.5(5)
O(8)-N(2)-C(22)	118.8(5)
O(7)-N(2)-C(22)	118.7(5)
C(2)-O(1)-C(3)	108.5(3)
C(1)-O(2)-C(3)	108.9(3)
C(6)-O(4)-C(7)	115.8(4)
C(18)-O(5)-C(17)	117.0(4)
C(25)-O(10)-C(26A)	122.3(5)
C(25)-O(10)-C(26)	107.7(6)
O(2)-C(1)-C(17)	105.9(3)
O(2)-C(1)-C(6)	110.1(4)
C(17)-C(1)-C(6)	108.8(4)
O(2)-C(1)-C(2)	104.5(3)
C(17)-C(1)-C(2)	115.7(4)
C(6)-C(1)-C(2)	111.7(4)
O(1)-C(2)-C(14)	107.8(4)
O(1)-C(2)-C(1)	104.2(3)
C(14)-C(2)-C(1)	114.3(4)
O(1)-C(2)-H(2)	110.1
C(14)-C(2)-H(2)	110.1
C(1)-C(2)-H(2)	110.1
O(2)-C(3)-O(1)	104.3(3)
O(2)-C(3)-C(4)	110.5(4)
O(1)-C(3)-C(4)	111.2(4)
O(2)-C(3)-C(5)	108.5(4)
O(1)-C(3)-C(5)	107.8(4)
C(4)-C(3)-C(5)	114.1(5)
C(3)-C(4)-H(4A)	109.5
C(3)-C(4)-H(4B)	109.5
H(4A)-C(4)-H(4B)	109.5
C(3)-C(4)-H(4C)	109.5
H(4A)-C(4)-H(4C)	109.5
H(4B)-C(4)-H(4C)	109.5
C(3)-C(5)-H(5A)	109.5
C(3)-C(5)-H(5B)	109.5
H(5A)-C(5)-H(5B)	109.5
C(3)-C(5)-H(5C)	109.5
H(5A)-C(5)-H(5C)	109.5
H(5B)-C(5)-H(5C)	109.5
O(3)-C(6)-O(4)	125.0(5)
O(3)-C(6)-C(1)	124.7(4)
O(4)-C(6)-C(1)	110.2(4)
O(4)-C(7)-C(8)	108.9(4)
O(4)-C(7)-H(7A)	109.9
C(8)-C(7)-H(7A)	109.9
O(4)-C(7)-H(7B)	109.9
C(8)-C(7)-H(7B)	109.9
H(7A)-C(7)-H(7B)	108.3
C(9)-C(8)-C(13)	118.6(5)
C(9)-C(8)-C(7)	122.6(5)
C(13)-C(8)-C(7)	118.8(5)
C(8)-C(9)-C(10)	120.8(5)
C(8)-C(9)-H(9)	119.6
C(10)-C(9)-H(9)	119.6
C(11)-C(10)-C(9)	119.7(6)
C(11)-C(10)-H(10)	120.2
C(9)-C(10)-H(10)	120.2
C(12)-C(11)-C(10)	119.9(6)
C(12)-C(11)-H(11)	120.1
C(10)-C(11)-H(11)	120.1
C(11)-C(12)-C(13)	120.7(5)

C(11)-C(12)-H(12)	119.6
C(13)-C(12)-H(12)	119.6
C(12)-C(13)-C(8)	120.3(6)
C(12)-C(13)-H(13)	119.9
C(8)-C(13)-H(13)	119.9
N(1)-C(14)-C(15)	109.2(4)
N(1)-C(14)-C(2)	110.4(4)
C(15)-C(14)-C(2)	111.5(3)
N(1)-C(14)-H(14)	108.5
C(15)-C(14)-H(14)	108.5
C(2)-C(14)-H(14)	108.5
C(16)-C(15)-C(14)	120.4(4)
C(16)-C(15)-H(15)	119.8
C(14)-C(15)-H(15)	119.8
C(15)-C(16)-C(17)	120.7(4)
C(15)-C(16)-H(16)	119.7
C(17)-C(16)-H(16)	119.7
O(5)-C(17)-C(16)	110.9(4)
O(5)-C(17)-C(1)	104.6(3)
C(16)-C(17)-C(1)	112.3(4)
O(5)-C(17)-H(17)	109.7
C(16)-C(17)-H(17)	109.7
C(1)-C(17)-H(17)	109.7
O(6)-C(18)-O(5)	123.2(5)
O(6)-C(18)-C(19)	124.5(4)
O(5)-C(18)-C(19)	112.2(4)
C(24)-C(19)-C(20)	119.6(5)
C(24)-C(19)-C(18)	118.2(4)
C(20)-C(19)-C(18)	122.1(4)
C(21)-C(20)-C(19)	120.9(5)
C(21)-C(20)-H(20)	119.5
C(19)-C(20)-H(20)	119.5
C(20)-C(21)-C(22)	117.5(5)
C(20)-C(21)-H(21)	121.3
C(22)-C(21)-H(21)	121.3
C(23)-C(22)-C(21)	123.1(5)
C(23)-C(22)-N(2)	118.4(5)
C(21)-C(22)-N(2)	118.5(5)
C(22)-C(23)-C(24)	118.1(5)
C(22)-C(23)-H(23)	120.9
C(24)-C(23)-H(23)	120.9
C(23)-C(24)-C(19)	120.6(5)
C(23)-C(24)-H(24)	119.7
C(19)-C(24)-H(24)	119.7
O(9)-C(25)-N(1)	125.6(5)
O(9)-C(25)-O(10)	124.9(5)
N(1)-C(25)-O(10)	109.4(5)
C(27)-C(26)-O(10)	105.1(10)
C(27)-C(26)-H(26A)	110.7
O(10)-C(26)-H(26A)	110.7
C(27)-C(26)-H(26B)	110.7
O(10)-C(26)-H(26B)	110.7
H(26A)-C(26)-H(26B)	108.8
C(32)-C(27)-C(28)	117.9(14)
C(32)-C(27)-C(26)	123.6(14)
C(28)-C(27)-C(26)	118.1(14)
C(29)-C(28)-C(27)	120.2(14)
C(29)-C(28)-H(28)	119.9
C(27)-C(28)-H(28)	119.9
C(28)-C(29)-C(30)	118.1(15)
C(28)-C(29)-H(29)	120.9
C(30)-C(29)-H(29)	120.9
C(31)-C(30)-C(29)	122.9(13)
C(31)-C(30)-H(30)	118.5
C(29)-C(30)-H(30)	118.5
C(32)-C(31)-C(30)	116.0(11)
C(32)-C(31)-H(31)	122.0
C(30)-C(31)-H(31)	122.0

C(27)-C(32)-C(31)	124.5(13)
C(27)-C(32)-H(32)	117.7
C(31)-C(32)-H(32)	117.7
O(10)-C(26A)-C(27A)	107.1(9)
O(10)-C(26A)-H(26C)	110.3
C(27A)-C(26A)-H(26C)	110.3
O(10)-C(26A)-H(26D)	110.3
C(27A)-C(26A)-H(26D)	110.3
H(26C)-C(26A)-H(26D)	108.6
C(28A)-C(27A)-C(26A)	127.1(14)
C(28A)-C(27A)-C(32A)	116.6(14)
C(26A)-C(27A)-C(32A)	116.3(13)
C(27A)-C(28A)-C(29A)	127.7(13)
C(27A)-C(28A)-H(28A)	116.2
C(29A)-C(28A)-H(28A)	116.2
C(28A)-C(29A)-C(30A)	117.1(11)
C(28A)-C(29A)-H(29A)	121.4
C(30A)-C(29A)-H(29A)	121.4
C(29A)-C(30A)-C(31A)	122.4(12)
C(29A)-C(30A)-H(30A)	118.8
C(31A)-C(30A)-H(30A)	118.8
C(32A)-C(31A)-C(30A)	119.1(12)
C(32A)-C(31A)-H(31A)	120.5
C(30A)-C(31A)-H(31A)	120.5
C(31A)-C(32A)-C(27A)	116.8(13)
C(31A)-C(32A)-H(32A)	121.6
C(27A)-C(32A)-H(32A)	121.6
Cl(1)-C(40)-Cl(2)	134(2)
Cl(1)-C(40)-Cl(3)	105.8(17)
Cl(2)-C(40)-Cl(3)	100.1(18)
Cl(1)-C(40)-H(40)	104.7
Cl(2)-C(40)-H(40)	104.7
Cl(3)-C(40)-H(40)	104.7
Cl(3A)-C(40A)-Cl(1A)	104(2)
Cl(3A)-C(40A)-Cl(2A)	110.9(18)
Cl(1A)-C(40A)-Cl(2A)	115.2(17)
Cl(3A)-C(40A)-H(40A)	108.9
Cl(1A)-C(40A)-H(40A)	108.9
Cl(2A)-C(40A)-H(40A)	108.9

Table S5. Anisotropic displacement parameters (A^2 x 10^3) for **15**.
The anisotropic displacement factor exponent takes the form:
-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
N(1)	23(2)	30(2)	39(2)	-1(2)	3(2)	1(2)
N(2)	39(2)	32(3)	50(3)	5(2)	12(2)	-6(2)
O(1)	35(2)	24(2)	31(2)	3(2)	-1(1)	-4(2)
O(2)	27(2)	22(2)	37(2)	1(2)	3(1)	-3(1)
O(3)	48(2)	50(2)	46(2)	13(2)	22(2)	20(2)
O(4)	38(2)	42(2)	32(2)	10(2)	14(1)	8(2)
O(5)	22(1)	22(2)	40(2)	0(1)	9(1)	1(1)
O(6)	32(2)	25(2)	58(2)	-2(2)	14(2)	6(2)
O(7)	49(2)	53(3)	128(5)	27(3)	48(3)	6(2)
O(8)	87(3)	44(3)	115(4)	-9(3)	63(3)	-22(2)
O(9)	35(2)	38(2)	42(2)	7(2)	11(2)	8(2)
O(10)	26(2)	49(3)	96(3)	27(2)	24(2)	7(2)
C(1)	21(2)	22(2)	30(2)	2(2)	5(2)	-1(2)
C(2)	23(2)	25(2)	31(2)	2(2)	4(2)	1(2)
C(3)	39(3)	22(3)	36(3)	4(2)	-6(2)	-9(2)
C(4)	63(3)	34(3)	42(3)	-4(3)	-8(3)	4(3)
C(5)	41(3)	46(4)	56(3)	20(3)	-2(3)	-17(3)
C(6)	32(2)	25(3)	31(2)	1(2)	7(2)	0(2)
C(7)	69(4)	49(4)	37(3)	15(3)	29(3)	13(3)
C(8)	41(3)	43(3)	27(2)	6(2)	10(2)	-2(2)
C(9)	57(3)	52(4)	35(3)	3(3)	5(3)	5(3)
C(10)	59(3)	46(4)	55(4)	2(3)	4(3)	8(3)
C(11)	61(4)	45(4)	54(4)	15(3)	-2(3)	-6(3)
C(12)	65(4)	49(4)	36(3)	12(3)	-5(3)	-20(3)
C(13)	64(3)	49(3)	30(3)	7(3)	14(2)	-8(3)
C(14)	25(2)	24(2)	29(2)	1(2)	5(2)	-1(2)
C(15)	26(2)	38(3)	25(2)	-5(2)	4(2)	-7(2)
C(16)	27(2)	32(3)	36(3)	-8(2)	12(2)	-1(2)
C(17)	17(2)	21(2)	41(3)	-1(2)	7(2)	-1(2)
C(18)	30(2)	19(3)	36(3)	-4(2)	2(2)	0(2)
C(19)	30(2)	22(3)	36(3)	-2(2)	4(2)	2(2)
C(20)	34(2)	26(3)	52(3)	2(2)	12(2)	-1(2)
C(21)	31(2)	34(3)	47(3)	4(3)	7(2)	1(2)
C(22)	30(2)	29(3)	34(3)	5(2)	6(2)	-6(2)
C(23)	43(3)	25(3)	45(3)	-4(2)	8(2)	-2(2)
C(24)	33(2)	25(3)	47(3)	-4(2)	12(2)	-2(2)
C(25)	24(2)	38(3)	37(3)	8(2)	2(2)	4(2)
Cl(1)	78(3)	104(4)	62(3)	18(3)	16(2)	9(3)
Cl(2)	263(13)	137(8)	107(6)	22(6)	-27(8)	-77(9)
Cl(3)	118(6)	340(20)	166(8)	-124(11)	71(6)	-82(9)
Cl(1A)	257(17)	179(15)	170(13)	77(12)	-97(13)	-91(14)
Cl(2A)	112(6)	124(8)	78(5)	19(5)	17(4)	57(6)
Cl(3A)	201(14)	119(10)	270(20)	-23(11)	155(15)	11(10)

Table S6. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (A^2 x 10^3) for **15**.

	x	y	z	U(eq)
H(1)	9350(40)	8680(60)	4830(30)	35(14)
H(2)	8453	5988	3527	32
H(4A)	7044	4923	2248	71
H(4B)	5652	4808	1892	71
H(4C)	6286	3680	2558	71
H(5A)	4181	5154	3020	73
H(5B)	4693	5698	3992	73
H(5C)	4895	4143	3731	73
H(7A)	7624	8261	633	60
H(7B)	8364	9399	1236	60
H(9)	6166	10945	1648	57
H(10)	5014	12648	878	64
H(11)	5015	12899	-651	65
H(12)	6081	11389	-1409	61
H(13)	7150	9621	-663	56
H(14)	8455	6115	5152	31
H(15)	7287	7731	5721	36
H(16)	6185	9246	4832	37
H(17)	6197	9296	3295	32
H(20)	9850	9934	2975	44
H(21)	11451	11046	2464	45
H(23)	9981	14699	2956	45
H(24)	8384	13561	3460	41
H(26A)	12879	6961	4606	43
H(26B)	11993	6513	3733	43
H(28)	13570	9481	4690	36
H(29)	14428	11188	3897	59
H(30)	14355	10946	2352	45
H(31)	13219	9215	1560	40
H(32)	12439	7516	2395	37
H(26C)	12539	6714	4344	35
H(26D)	12938	7930	5031	35
H(28A)	13798	9923	4401	41
H(29A)	14503	11051	3280	39
H(30A)	13862	10394	1836	55
H(31A)	12478	8587	1504	65
H(32A)	11791	7359	2705	55
H(40)	1129	10164	-1131	110
H(40A)	1054	10684	-1123	58

Table S7. Crystal data and structure refinement for **24**.

Identification code	h10sel2
Empirical formula	C7 H13 N O5
Formula weight	191.18
Temperature	150(2) K
Wavelength	0.71073 A
Crystal system, space group	Orthorhombic, P 2_1 2_1 2_1
Unit cell dimensions	a = 7.8655(2) A alpha = 90 deg. b = 8.6674(2) A beta = 90 deg. c = 11.9470(3) A gamma = 90 deg.
Volume	814.47(3) A^3
Z, Calculated density	4, 1.559 Mg/m^3
Absorption coefficient	0.133 mm^-1
F(000)	408
Crystal size	0.30 x 0.30 x 0.25 mm
Theta range for data collection	3.89 to 27.45 deg.
Limiting indices	-10<=h<=10, -11<=k<=11, -15<=l<=15
Reflections collected / unique	15698 / 1854 [R(int) = 0.0461]
Completeness to theta = 27.45	99.4 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.9675 and 0.9612
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	1854 / 0 / 142
Goodness-of-fit on F^2	1.037
Final R indices [I>2sigma(I)]	R1 = 0.0278, wR2 = 0.0712
R indices (all data)	R1 = 0.0304, wR2 = 0.0727
Absolute structure parameter	0.2(8)
Largest diff. peak and hole	0.231 and -0.183 e.A^-3

Table S8. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters (A^2 x 10^3) for **24**.
U(eq) is defined as one third of the trace of the orthogonalized Uij tensor.

	x	y	z	U(eq)
N	5930(2)	2822(1)	1116(1)	17(1)
O(1)	3051(1)	2681(1)	2527(1)	20(1)
O(2)	2116(1)	5735(1)	2603(1)	18(1)
O(3)	-502(1)	3152(1)	1059(1)	20(1)
O(4)	-1131(1)	5051(1)	2252(1)	26(1)
O(5)	1326(1)	5295(1)	-362(1)	20(1)
C(1)	4822(2)	4183(1)	1348(1)	15(1)
C(2)	3018(2)	3580(1)	1524(1)	15(1)
C(3)	1731(2)	4904(2)	1612(1)	14(1)
C(4)	-123(2)	4314(1)	1653(1)	16(1)
C(5)	1894(2)	6051(2)	628(1)	17(1)
C(6)	3708(2)	6636(2)	518(1)	20(1)
C(7)	4976(2)	5315(2)	378(1)	20(1)

Table S9. Bond lengths [A] for **24**.

N-C(1)	1.4925(16)
N-H(1A)	0.91(2)
N-H(1B)	0.887(19)
N-H(1C)	0.86(2)
O(1)-C(2)	1.4289(15)
O(1)-H(10)	0.86(3)
O(2)-C(3)	1.4192(15)
O(2)-H(20)	0.85(2)
O(3)-C(4)	1.2679(16)
O(4)-C(4)	1.2441(16)
O(5)-C(5)	1.4244(16)
O(5)-H(50)	0.86(3)
C(1)-C(7)	1.5234(17)
C(1)-C(2)	1.5271(17)
C(2)-C(3)	1.5337(17)
C(3)-C(5)	1.5444(17)
C(3)-C(4)	1.5467(17)
C(5)-C(6)	1.5202(18)
C(6)-C(7)	1.5280(18)

Table S10. Bond angles [deg] for **24**.

C(1)-N-H(1A)	110.2(12)
C(1)-N-H(1B)	110.9(11)
H(1A)-N-H(1B)	103.5(16)
C(1)-N-H(1C)	109.3(13)
H(1A)-N-H(1C)	111.5(17)
H(1B)-N-H(1C)	111.4(17)
C(2)-O(1)-H(10)	113.1(16)
C(3)-O(2)-H(20)	110.4(14)
C(5)-O(5)-H(50)	102.5(18)
N-C(1)-C(7)	108.75(10)
N-C(1)-C(2)	107.32(10)
C(7)-C(1)-C(2)	113.54(10)
O(1)-C(2)-C(1)	106.60(10)
O(1)-C(2)-C(3)	111.27(10)
C(1)-C(2)-C(3)	111.49(10)
O(2)-C(3)-C(2)	107.23(10)
O(2)-C(3)-C(5)	106.89(10)
C(2)-C(3)-C(5)	112.04(10)
O(2)-C(3)-C(4)	110.01(10)
C(2)-C(3)-C(4)	112.15(10)
C(5)-C(3)-C(4)	108.38(10)
O(4)-C(4)-O(3)	125.50(12)
O(4)-C(4)-C(3)	116.69(11)
O(3)-C(4)-C(3)	117.79(11)
O(5)-C(5)-C(6)	112.09(11)
O(5)-C(5)-C(3)	108.08(10)
C(6)-C(5)-C(3)	111.00(10)
C(5)-C(6)-C(7)	111.83(11)
C(1)-C(7)-C(6)	110.32(11)

Table S11. Anisotropic displacement parameters (A^2 x 10^3) for **24**.
The anisotropic displacement factor exponent takes the form:
-2 pi^2 [h^2 a*^2 U11 + ... + 2 h k a* b* U12]

	U11	U22	U33	U23	U13	U12
N	14(1)	18(1)	20(1)	-1(1)	0(1)	1(1)
O(1)	18(1)	21(1)	20(1)	8(1)	-1(1)	-1(1)
O(2)	16(1)	22(1)	17(1)	-6(1)	-2(1)	2(1)
O(3)	16(1)	21(1)	23(1)	-4(1)	1(1)	-4(1)
O(4)	18(1)	27(1)	34(1)	-7(1)	7(1)	1(1)
O(5)	23(1)	23(1)	15(1)	1(1)	-1(1)	-4(1)
C(1)	13(1)	15(1)	17(1)	0(1)	1(1)	1(1)
C(2)	14(1)	16(1)	15(1)	1(1)	-1(1)	0(1)
C(3)	13(1)	16(1)	14(1)	-2(1)	-1(1)	0(1)
C(4)	13(1)	18(1)	16(1)	2(1)	-1(1)	1(1)
C(5)	16(1)	15(1)	18(1)	1(1)	-2(1)	1(1)
C(6)	17(1)	17(1)	25(1)	5(1)	1(1)	-1(1)
C(7)	15(1)	22(1)	21(1)	5(1)	2(1)	-1(1)

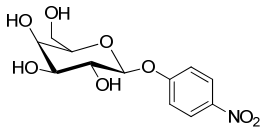
Table S12. Hydrogen coordinates (x 10^4) and isotropic displacement parameters (A^2 x 10^3) for **24**.

	x	y	z	U(eq)
H(1A)	5880(20)	2140(20)	1693(16)	29(5)
H(1B)	7020(20)	3095(19)	1098(14)	20(4)
H(1C)	5620(30)	2400(20)	500(19)	35(5)
H(10)	2350(30)	1920(30)	2510(20)	53(7)
H(20)	1230(30)	6180(20)	2852(17)	35(5)
H(50)	1780(40)	5850(30)	-890(20)	70(8)
H(1)	5218	4697	2050	18
H(2)	2700	2900	881	18
H(5)	1132	6951	777	20
H(6A)	4008	7239	1194	24
H(6B)	3786	7333	-136	24
H(7A)	4753	4772	-336	23
H(7B)	6146	5734	350	23

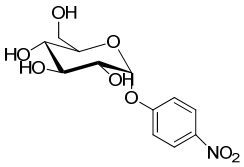
Enzyme Inhibition Assays

Enzymes were purchased from the Sigma-Aldrich Chemical Co. and were assayed in the recommended buffer at the required pH. Enzyme kinetic parameters were determined for β-galactosidase from *E. coli* (G-5635), α-glucosidase type I from Baker's yeast (G-5003), and β-glucosidase from almonds (49290) using the appropriate 4-nitrophenyl- substrate at 37 ºC, as previously described.[2] Twelve different concentrations in duplicate were used. Rates were determined by plotting absorbance data in Excel, and converted into amount of product with reference to the standard curve.[2] Kinetic parameters were derived using the Direct Linear Plot[3,4] in SigmaPlot 11 and the enzyme kinetics module 1.3 (Systat) (Supplementary Information). Enzyme concentrations were calculated based on the U/mg data from the Sigma-Aldrich Chemical Co.

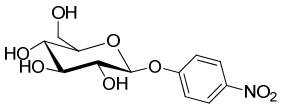
Inhibition assays were determined using the appropriate substrate (at substrate concentration = K_m) and buffer conditions. The concentration of enzyme was chosen so that A_{405} = 0.7 – 1.5 after 10 minutes incubation at ambient room temperature. Assays were conducted by mixing 4 x stock solution of inhibitor (75 μL; final concentrations in assay = 100, 33.333, 11.111, 3.70, 1.23, 0.41, 0.137, 0.045 μM) with 4 x stock solution of enzyme (75 μL) in a 96 well plate. After 10 minutes 50 μL of solution was transferred into adjacent wells, thus each inhibitor concentration was assayed in triplicate. The reaction was initiated by addition of 50 μL of 2 x stock solution of substrate and incubated for 10 minutes before terminating the reaction with 100 μL of 1 M NaOH, and the absorbance measured at 405 nm. Positive control reactions contained enzyme and buffer; negative control reactions contained the same and were terminated with NaOH before addition of substrate.



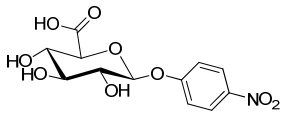
4-Nitrophenyl-β-*D*-galactopyranoside **S1**



4-Nitrophenyl-α-*D*-glucopyranoside **S2**



4-Nitrophenyl-β-*D*-glucopyranoside **S3**



4-Nitrophenyl-β-*D*-glucuronide **S4**

Enzyme	***buffer***	***Substrate (μM)***	***K_m (μM)****	***Enzyme Units/well***
β-Galactosidase from *E. coli* (G-5635)	100 mM NaH_2PO_4-NaOH, pH 7.3.	**S1**, 200	194.8	0.25
α-Glucosidase type I from Baker's yeast (G-5003)	50 mM NaH_2PO_4-NaOH, pH 6.8, 0.1 mM glutathione-SH.	**S2**, 150	167.1	0.03
β-*D*-Glucosidase from almonds (49290)	100 mM NaOAc/HCl, pH 5.0.	**S3**, 4000	3875	2.5×10^{-3}
β-*D*-Glucosidase from almonds (G4511)	50 mM citric acid-NaOH, pH 5.0.	**S3**, 1800	1800[1]	1.95×10^{-3}
β-*D*-Glucuronidase from bovine liver (G-0251)	50 mM citric acid-NaOH, pH 5.0.	**S4**, 950	940[1]	125 Fishman units
β-*D*-Glucuronidase from *E. coli* (G-7396)	50 mM MOPS-NaOH, pH 6.8	**S4**, 250	230[1]	2.5 Fishman units
β-*D*-Glucuronidase from *P. vulgata* (G-8132)	50 mM citric acid-NaOH, pH 3.8	**S4**, 150[2]	52[1]	250 Fishman units
β-Galactosidase from *A. oryzae* (G-5160)	50 mM citric acid-NaOH, pH 4.5	**S1**, 1500	1500[1]	3.75×10^{-3}

Table S13: Assay conditions for determination of inhibition. 1U of enzyme activity is the amount of enzyme that releases 1 μmole of product per minute at 37 ºC under the conditions specified by the Sigma-Aldrich Chemical Co. For glucuronidases, 1 Fishman unit is the amount of enzyme that releases 1 μg of product per minute under the specified conditions. * K_m determined using the Direct Linear Plot. [1]K_m values determined by Ball *et al*., **2008**, *J. Enzym. Inhib. Med. Chem*., **23**, 131-135. [2]It is usually recommended that inhibitors are tested with the substrate close to its K_m value. This enzyme has an extremely low K_m value and hence complete conversion of substrate will give an A_{405} = ~1.0. Therefore a substrate concentration 3 x the K_m value was chosen in order to ensure sufficient colour development without completely depleting the substrate.

β-Galactosidase from *E. coli* (G-5635)

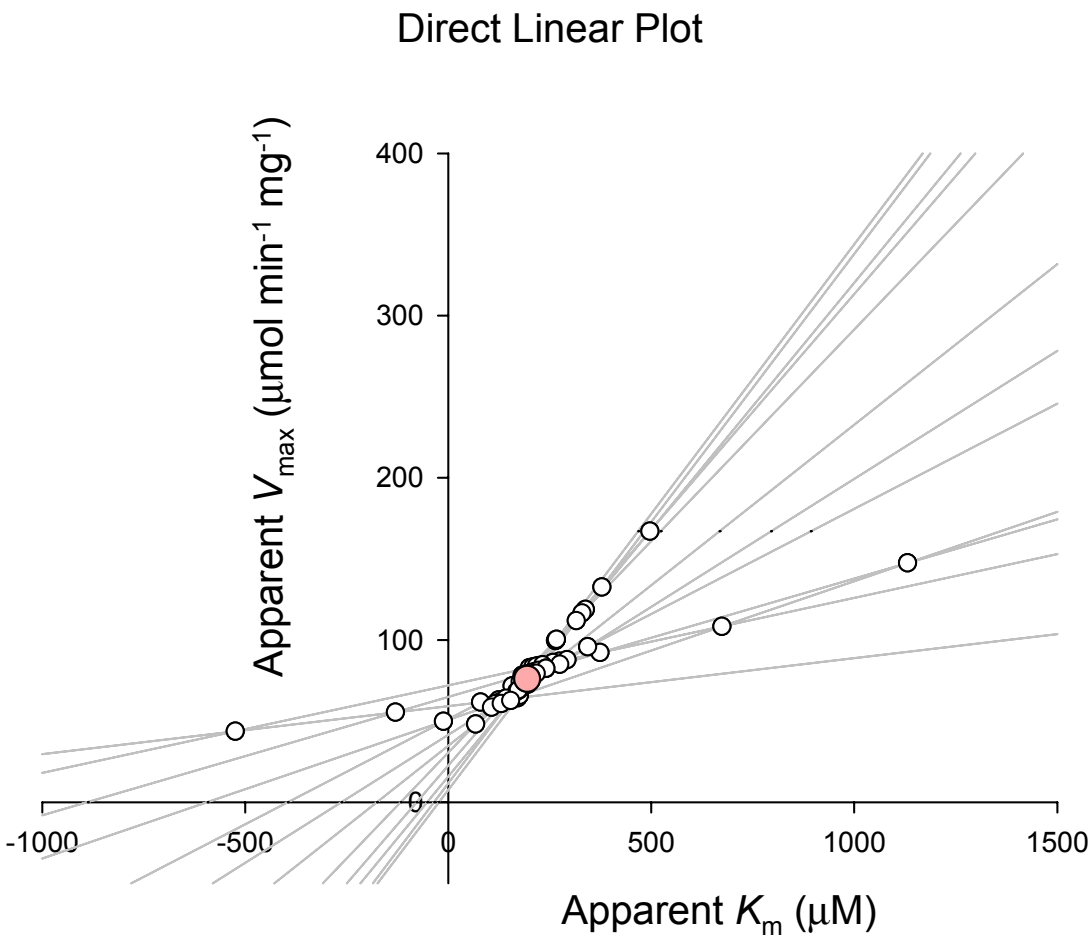


Figure S1

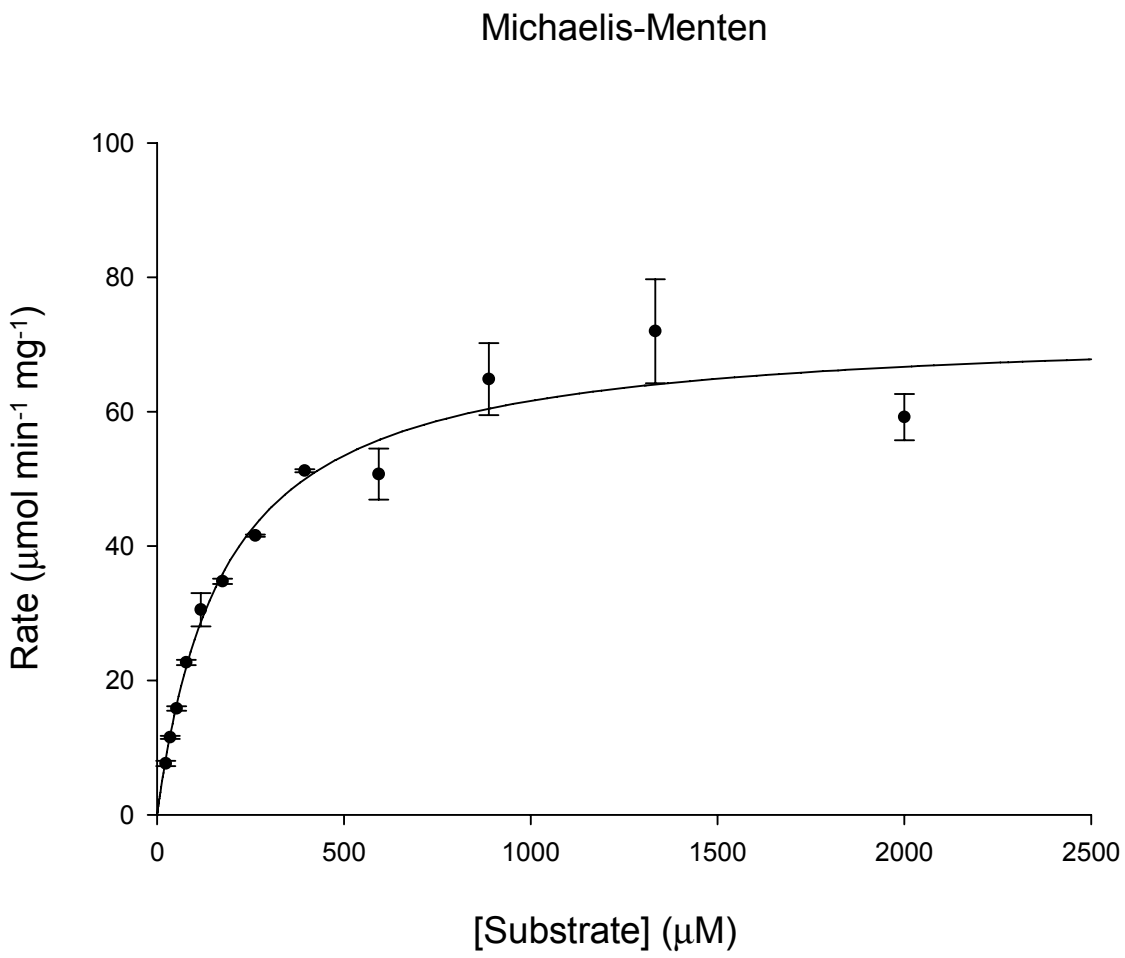


Figure S2

Parameters

	Value	±Std. Error	95% Conf. Interval		
Vmax	72.6778	3.0324	66.3889	to	78.9667
Km	179.7218	24.7403	128.4125	to	231.0312

Goodness of Fit

Degrees of Freedom	22
AICc	84.133
R^2	0.943
Sum of Squares	592.060
Sy.x	5.188
Runs Test p Value	0.264

Data

Number of x values	12
Number of replicates	2
Total number of values	24
Number of missing values	0

Table S14: Michaelis-Menten parameters for β-Galactosidase from E. coli

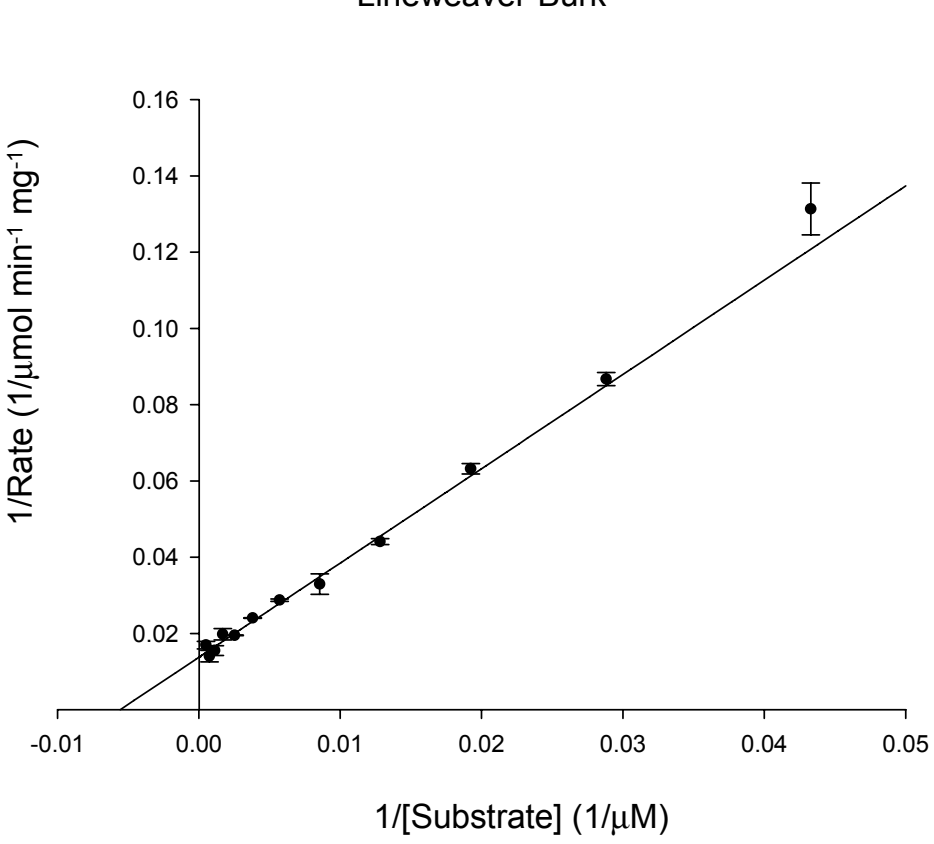


Figure S3

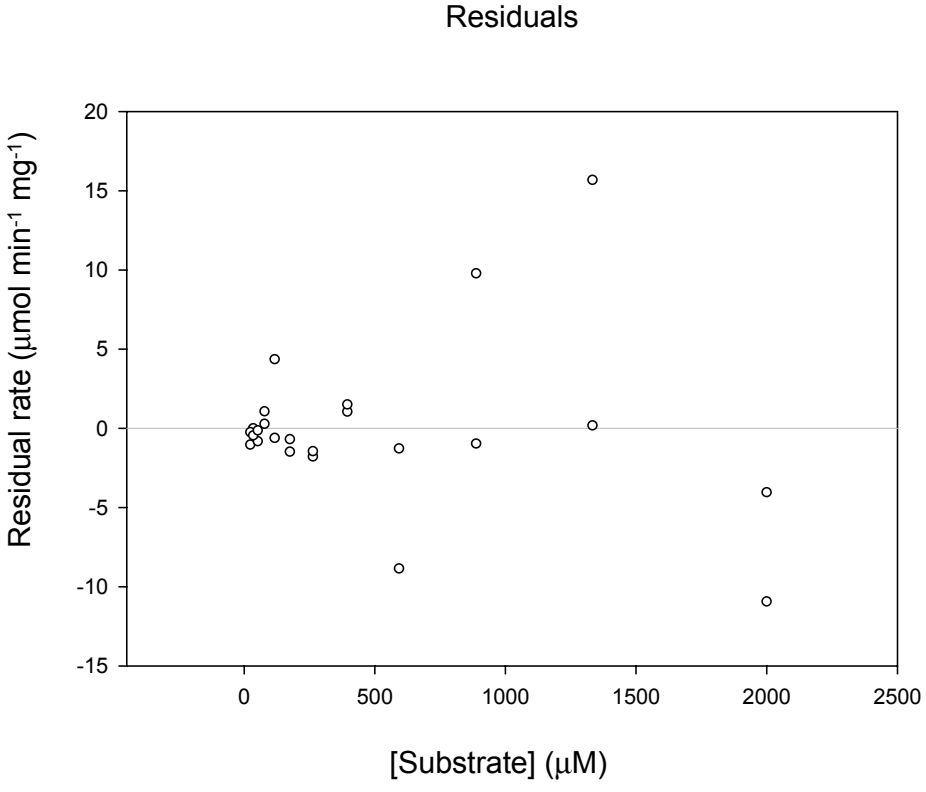


Figure S4

α-Glucosidase type I from Bakers Yeast (G-5003)

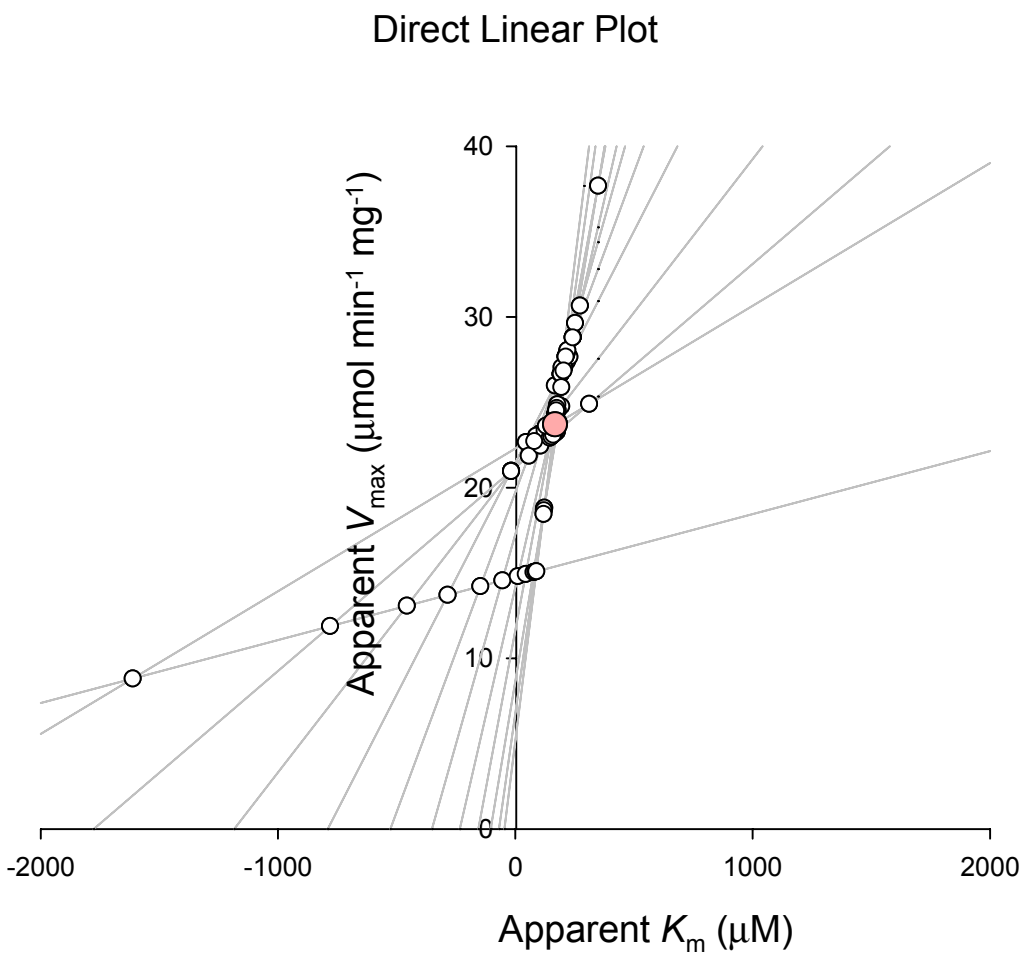


Figure S5

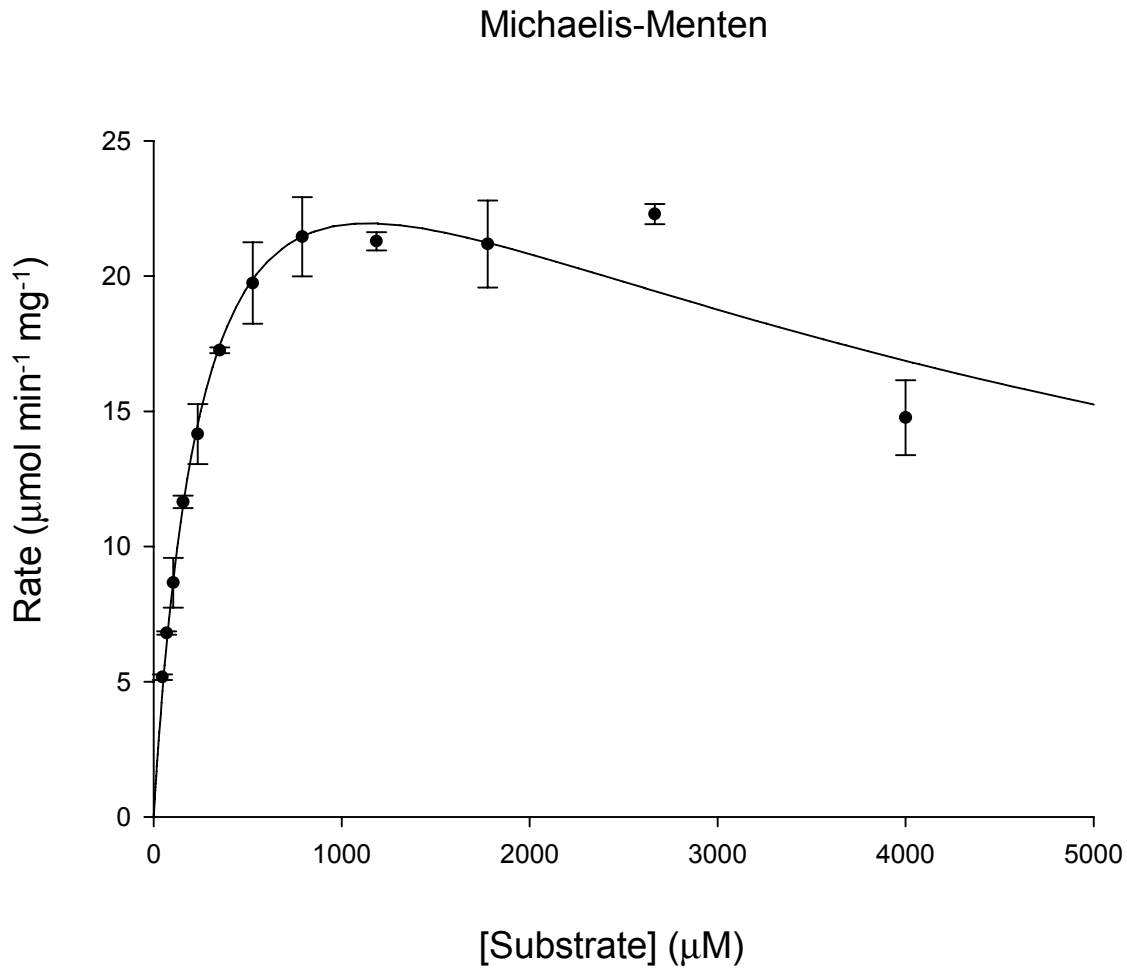


Figure S6

Parameters

	Value	±Std. Error	95% Conf. Interval		
Vmax	33.0136	3.0364	26.6990	to	39.3283
Km	286.6639	52.7169	177.0308	to	396.2969
Ki	4,517.0344	1,211.2522	1,998.0468	to	7,036.0220

Goodness of Fit

Degrees of Freedom	21
AICc	27.737
R^2	0.941
Sum of Squares	50.035
Sy.x	1.544
Runs Test p Value	0.338

Data

Number of x values	12
Number of replicates	2
Total number of values	24
Number of missing values	0

Table S15: Michaelis-Menten parameters for α-Glucosidase type I from Bakers Yeast

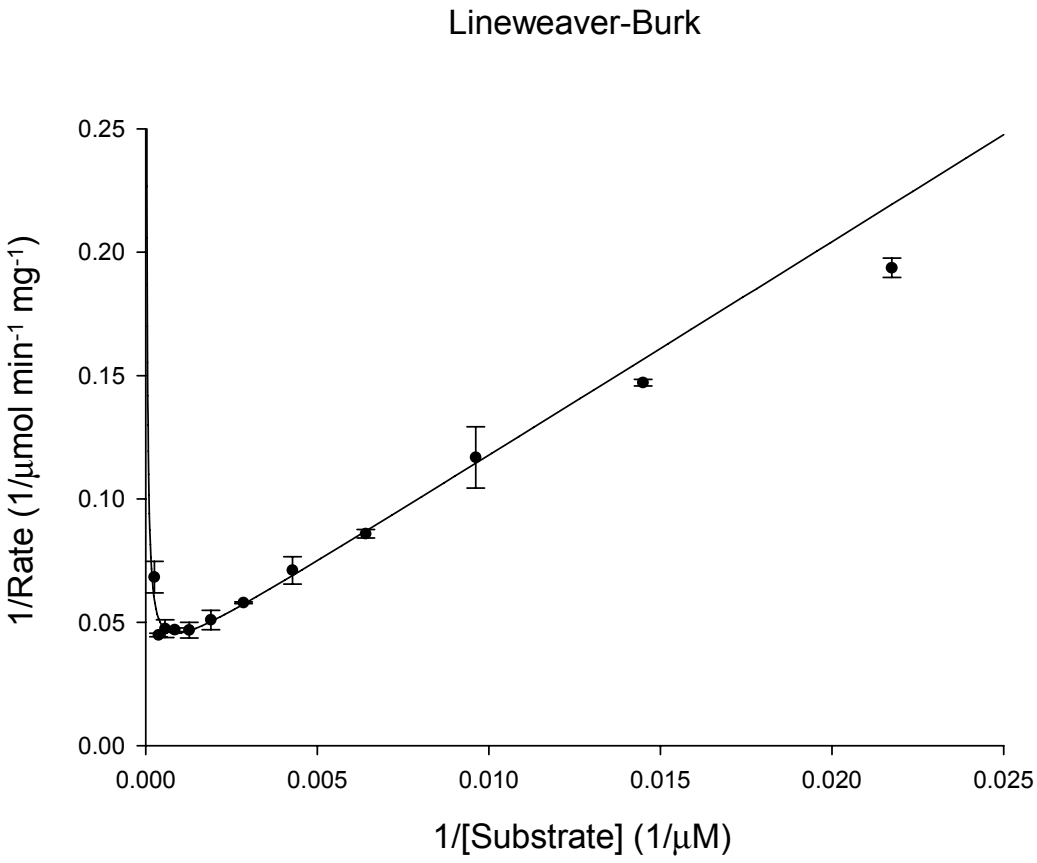


Figure S7

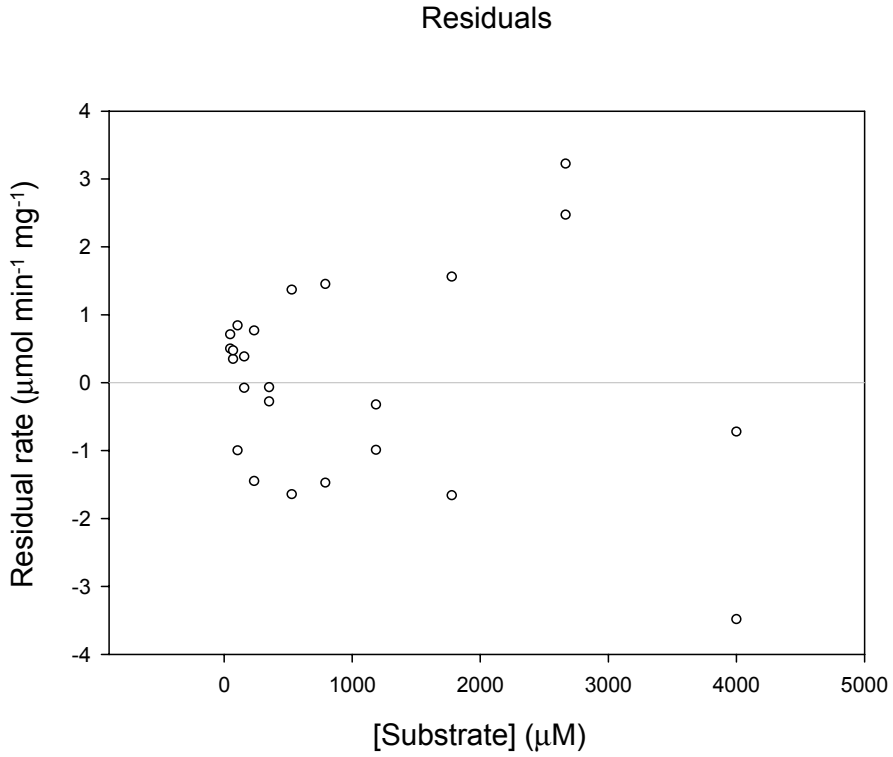


Figure S8

β-Glucosidase from almonds (49290)

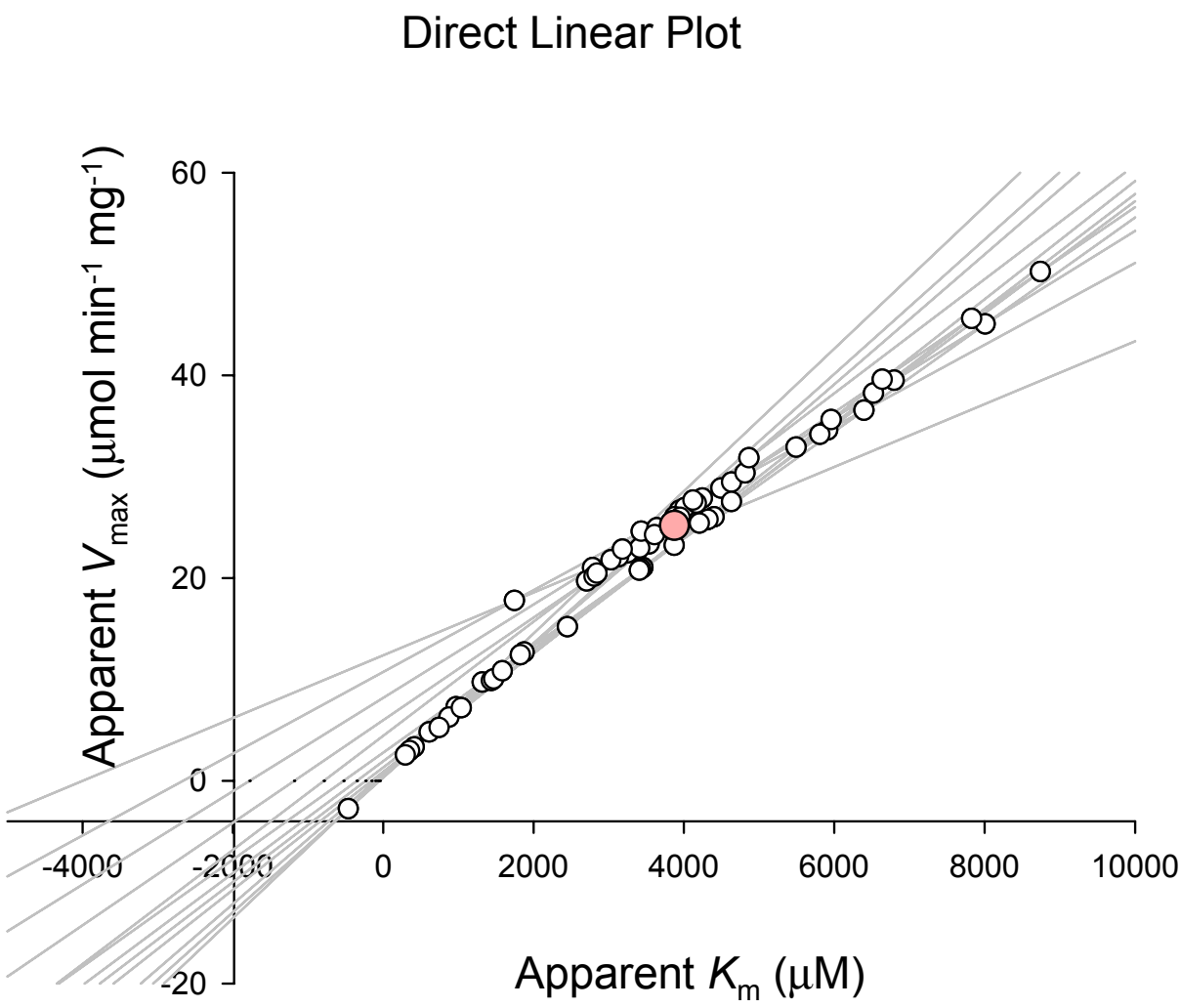


Figure S9

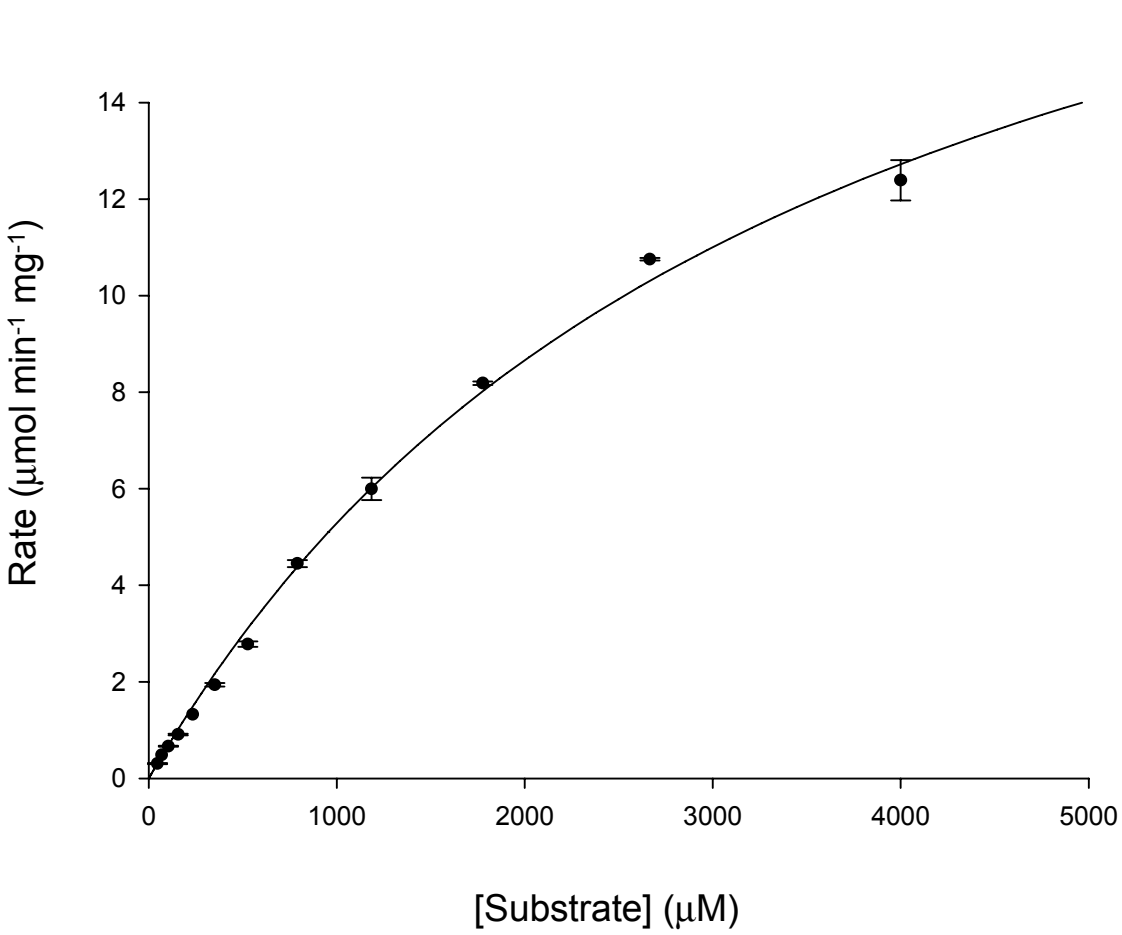


Figure S10

Parameters

	Value	±Std. Error	95% Conf. Interval		
Vmax	23.9589	1.0725	21.7346	to	26.1833
Km	3,531.7697	263.2542	2,985.8030	to	4,077.7364

Goodness of Fit

Degrees of Freedom	22
AICc	-58.170
R^2	0.996
Sum of Squares	1.575
Sy.x	0.268
Runs Test p Value	0.501

Data

Number of x values	12
Number of replicates	2
Total number of values	24
Number of missing values	0

Table S16: Michaelis-Menten parameters for β-Glucosidase from almonds

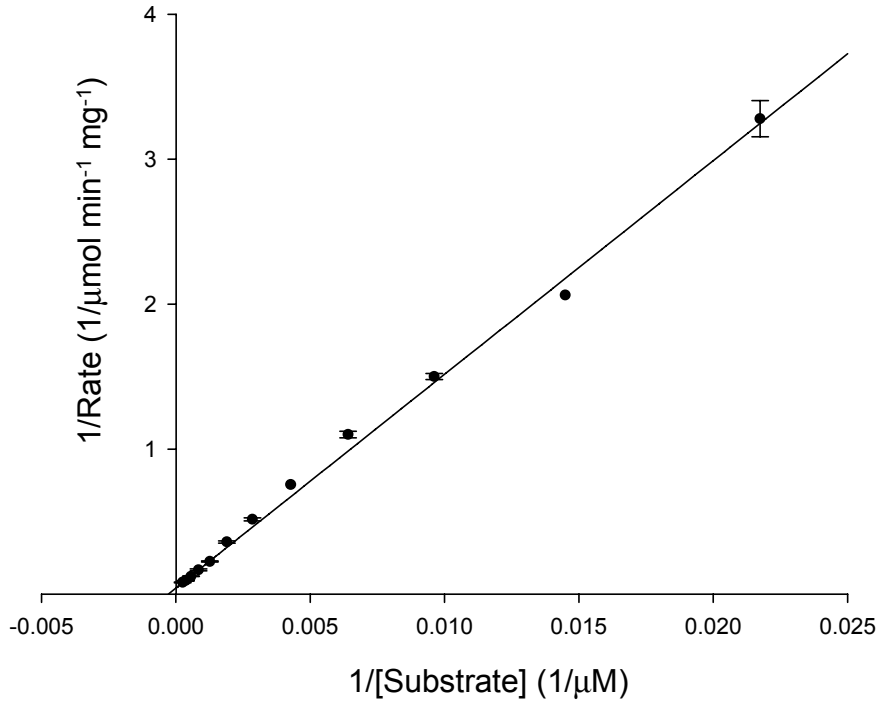


Figure S11

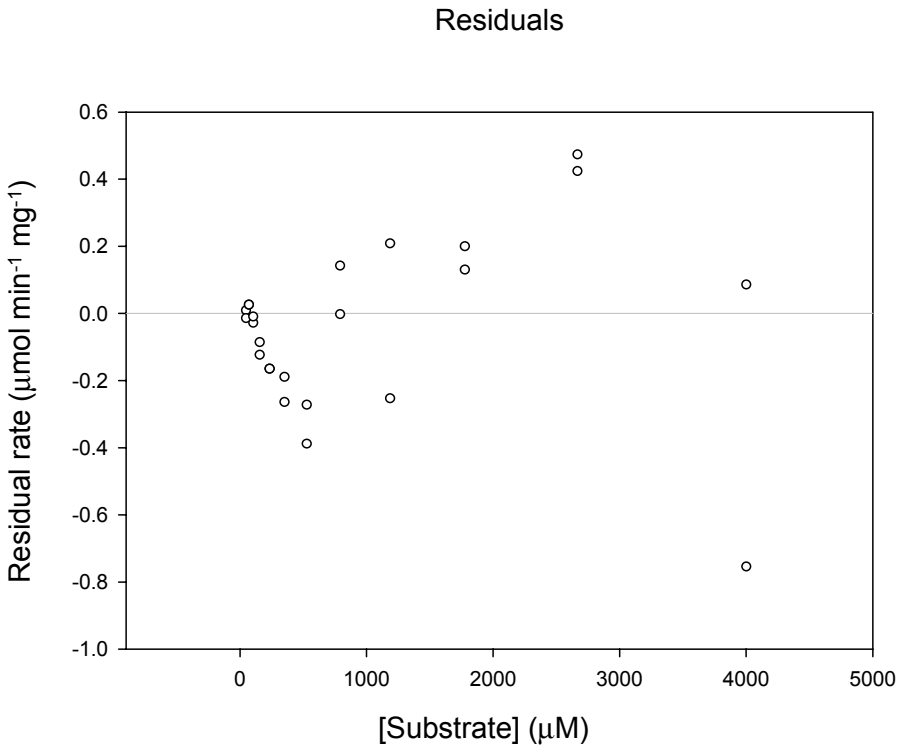


Figure S12

[1] (*a*) G. N. Jenkins, D. W. Ribbons, D. A. Widdowson, A. M. Z. Slawin and D. J. Williams, *J. Chem. Soc., Perkin Trans 1*, 1995, 2647; (*b*) T. C. M. Fischer, H. G. Leisch and M. D. Mihovilovic, *Monatsh. Chem.*, 2010, **141**, 699.
[2] A. L. Ball, K. A. Chambers, M. Hewinson, S. Navaratanarajah, L. Samrin, N. Thomas, A. H. Tyler, A. J. Wall and M. D. Lloyd, *J. Enzym. Inhib. Med. Chem.,* 2008, **23**, 131.
[3] A. Cornish-Bowden and R. Eisenthal, *Biochem. J.*, 1974, **139**, 721.
[4] R. Eisenthal and A. Cornish-Bowden, *Biochem. J.*, 1974, **139**, 715.