Regioselective sulfamoylation at low temperature enables concise syntheses of putative small molecule inhibitors of sulfatases

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Experimental Procedures

Biological Assay Protocols

Sulf-2 Assay Protocol

Compounds were screened using 4-MUS as a substrate for Sulf-2 according to a protocol described by Morimoto-Tomita et al.[1] Briefly 293T cells were transiently transfected with pcDNA3.1/Myc-His(-)-HSulf-2 DNA (Addgene) using Fugene 6 according to the manufacturers protocol. Conditioned medium containing Sulf-2 was bound to Ni-NTA agarose beads overnight at 4 ˚C. Beads were washed three times with 15 mL of washing buffer containing 50 mM HEPES (pH 7.5), 300 mM NaCl and 0.05% Tween 20, followed by 15 mL of washing buffer without Tween 20. Beads were suspended in reaction buffer 50 mM HEPES (pH 7.5), 10 mM $CaCl_2$ prior to inhibition assays. 20 µL of bead suspension was incubated with 1 mM compound (dissolved in DMSO; final concentration of DMSO in reaction is 2%) plus 10µL 5X reaction buffer for 1 h at 37 ˚C in a 96-well black plate (Sterilin). The reaction was started by the addition of 20 µLs of 20 mM 4-MUS (final concentration 8 mM) and incubated at 37 ˚C for 1 h. The reaction was stopped with 100 µL 1 M Tris buffer (pH 10.4) and read at 460 nm following excitation at 355 nm in FLUOstar Omega plate reader (BMG Labtech) using Omega data analysis software.

ARSA and ARSB Assay Protocols

Compounds were screened in a 96-well black plate using 4-MUS as a substrate, using 50 µl reaction mixture containing 40 ng of the commercially available enzymes (ARSA or ARSB from R & D Systems), 50 mM HEPES (pH = 4.5), 10 mM $CaCl_2$, 1 mM test compound and H_2O (45 µL). The assay mixture was incubated for 1 h at 37 °C, followed by addition of 5 µL of 4-MUS (Km = 1.6 mM for ARSA and 612 µM for ARSB), and incubation for a further 1 h

at 37 °C. The reaction was stopped with 100 µL of 1 M Tris (pH = 10.4) and read at 460 nm following excitation at 355 nm in FLUOstar Omega plate reader.

Summary of Generic Analytical and Chromatographic Conditions

All commercial reagents were obtained from Aldrich Chemical Company or Apollo Scientific Ltd and were of the highest available purity. Unless otherwise stated, chemicals were used as supplied without further purification. Anhydrous solvents were obtained from Aldrich SureSeal™ bottles and were stored under nitrogen. Petrol refers to the fraction with a boiling point between 40 and 60°C. All reactions carried out in a microwave were performed in a Biotage Initiator Sixty apparatus.

The progress of reactions was monitored by thin layer chromatography was conducted on plates pre-coated with silica gel (Merck $60F_{254}$), NH_2F_{254}s or C18-SiO_2. Eluent mixture ratios are quoted as volume:volume. Visualisation was either by short wave (254 nm) ultraviolet light, or by treatment with the visualisation reagent stated. 'Flash' medium pressure liquid chromatography (MPLC) was carried out either on a Biotage SP4 automated purification system or a Varian automated purification system, using pre-packed Varian or Grace silica, amino-bonded or C18 silica cartridges. Elution gradients are quoted as per cent polar component at the start and end of the elution.

Compounds requiring semi-preparative HPLC were purified on one of the following machines: (i) Varian Prostar Modular HPLC system equipped with a binary pumping system, UV detector and fraction collector and controlled by Varian Star software. (ii) Agilent 1200 HPLC system equipped with a binary pump, autosampler, fraction collector and diode array detector and controlled by Agilent ChemStation software.

Melting points were determined with on either a Stuart Scientific SMP3 or SMP40 apparatus and are uncorrected. ^{1}H, ^{13}C and ^{19}F nuclear magnetic resonance (NMR) spectra were obtained as CD_3OD, $CDCl_3$, D_2O, or DMSO-d^6 solutions and recorded at 500 MHz, 75 MHz, and 125 MHz, respectively, on a Bruker Avance III 500 spectrometer. Where ^{13}C NMR data are not quoted, insufficient material was available or problems obtaining adequate spectra were encountered. Chemical shifts are quoted in parts per million (δ) referenced to the appropriate deuterated solvent employed. Multiplicities are indicated by s (singlet), d (doublet), t (triplet), q (quartet), quin (quintet), sept (septet), m (multiplet) or (br) broad, or combinations thereof. Coupling constant values are given in Hz. Homonuclear and

heteronuclear two dimensional NMR experiments were used where appropriate to facilitate assignment of chemical shifts. LC-MS was carried out on a Waters Acquity LC platform running either positive ion or negative ion electrospray mode, unless otherwise stated. Optical rotations were determined on an Optical Activity PolAAR 3001 polarimeter with a path length of 0.25 dm. IR spectra were recorded on either a Bio-Rad FTS 3000MX diamond ATR or an Agilent Cary 630 FTIR as a neat sample. UV spectra were obtained using a U-2001 Hitachi Spectrophotometer and performed in ethanol. High resolution mass spectra were performed by the EPSRC National Mass Spectrometry Service, University of Wales Swansea, Singleton Park, Swansea, SA2 8PP. Data were compared with literature data for compounds which had been previously reported.

Procedures for the Synthesis of Sulfamoyl Chloride

Method 1: Formic acid (460 μL, 550 mg, 12 mmol, 1 eq) was added dropwise to chlorosulfonyl isocyanate (1.05 mL, 1.7 g, 12 mmol, 1 eq) in anhydrous dichloromethane (5 mL) at 0 °C. Gentle gas evolution was observed. The mixture was allowed to warm to room temperature and stirred at room temperature for 3 h to give a white suspension.

Method 2: Formic acid (460 μL, 550 mg, 12 mmol, 1 eq) was added dropwise to chlorosulfonyl isocyanate (1.05 mL, 1.7 g, 12 mmol, 1 eq) at 0 °C. Gentle gas evolution was observed. The mixture was allowed to warm to room temperature and stirred at room temperature for 3 h to give a white solid. The solid was dissolved in anhydrous toluene (6 mL) to give a clear 2 M solution. Stock solutions were used immediately.

Method 3: Formic acid (460 μL, 550 mg, 12 mmol, 1 eq) was added dropwise to chlorosulfonyl isocyanate (1.05 mL, 1.7 g, 12 mmol, 1 eq) in anhydrous MeCN (5 mL) at 0 °C. Gentle gas evolution was observed. The mixture was allowed to warm to room temperature and stirred at room temperature for 3 h to give a white suspension.

General Procedures for Sulfamoylation of Alcohols and Phenols

Sulfamoylation Method 1: Sulfamoyl chloride (1.5-3 eq.) was added portion-wise over 30 minutes to the substrate alcohol (1 eq.) in anhydrous DMA (2 mL) at -15 °C. The reaction mixture was stirred at -15 °C for 2 h.

Sulfamoylation Method 2: Sulfamoyl chloride (1.5 eq.) was added to the substrate alcohol (1 eq.) in anhydrous DMF (4 mL/mmol) at -40 °C over 15 minutes. The mixture was stirred at -40 °C for 18 h. The reaction was quenched with water (2 mL) and extracted with EtOAc (20 mL). Saturated $NaCl_{(aq)}$ (10 mL) added to aqueous layer and further extracted with EtOAc (3 × 20 mL). The organic layers were combined, dried ($MgSO_4$) and the solvent was removed *in vacuo*.

Sulfamoylation Method 3: Sulfamoyl chloride (1.5 eq.) was added to the substrate alcohol (1 eq.) in anhydrous MeCN (5.4 mL) containing 600 μL DMA at room temperature. The mixture was stirred at room temperature for 15 min, quenched with EtOH (1.5 mL) and partitioned between EtOAc (2 × 10 mL) and H_2O (10 mL). The aqueous layer was extracted with a further 10 mL of CH_2Cl_2, the organic extracts were combined, dried over $MgSO_4$ and solvent removed *in vacuo*.

Sulf-2 General Synthetic Procedures

General Procedure A: Deprotection of Benzyl Carbamate using Palladium-Catalysed Flow Hydrogenation

The appropriate benzyl carbamate (1 eq.) was dissolved in MeOH (25 mL/mmol) and hydrogenated on a Thales H-cube over 10% Pd/C on full H_2 mode at 40 °C for 18 h with continuous recycling of the reaction mixture. The solvent was removed *in vacuo*.

General Procedure B: Chemoselective *N*-Sulfation

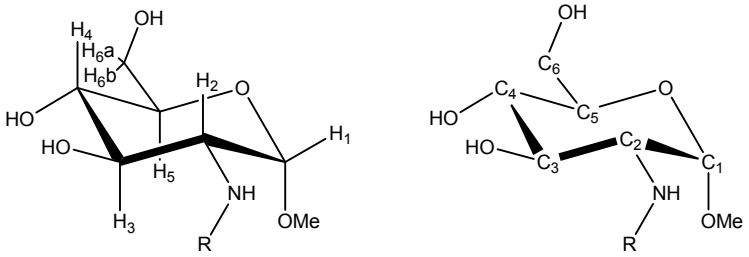
The substrate amine (1 eq.) was dissolved in de-ionised water (6 mL/mmol) and the pH of the solution was adjusted to between pH 9 and 10 with NaOH (2 M aq.). Pyridine-sulfur trioxide complex (1.1 eq.) was added portion-wise at 30 minute intervals. After each addition the pH of the solution was adjusted to pH 9-10 by the addition of 2 M aqueous NaOH. The mixture was stirred at room temperature for 2 h and the solvent removed *in vacuo*.

General Procedure C: Synthesis of Trichloroethysulfate Protected Amines

2,3-Dimethyl-1-((2,2,2-trichloroethoxy)sulfonyl)-1*H*-imidazol-3-ium tetrafluoroborate (1 eq.) was added to the substrate alcohol (1 eq.) in THF (10 mL/mmol) at r.t., and the mixture was stirred at room temperature for 18 h. The solvent was removed *in vacuo.*

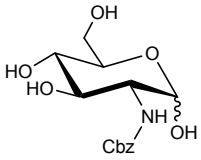
Nomenclature

The monosaccharide sulfamates prepared below have been titled using their IUPAC names. However, NMR peaks have been assigned using the common saccharide numbering system. This allows direct comparison with NMR assignments from the carbohydrate chemistry literature for known compounds. The numbering system used for the NMR assignments is outlined on the generic structures below.



Compound preparations

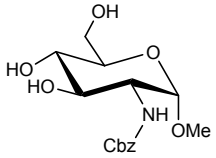
Benzyl ((3*R*,4*R*,5*S*,6*R*)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)carbamate (3) [2]



$NaHCO_{3(s)}$ (9.3 g, 110.7 mmol, 3 eq.) was added to a solution of D-glucosamine hydrochloride (7.7 g, 35.7 mmol, 1 eq.) in H_2O (230 mL). Benzyl chloroformate (5.60 mL, 39.3 mmol, 1.1 eq.) was added portion-wise over 30 min and the mixture was stirred at room temperature for 18 h. The white precipitate formed was filtered off, azeotroped with toluene (2 × 50 mL) and dried *in vacuo* at 45 °C to give the product mixture of anomers as a white solid (10.25 g, 92 %). R_f 0.2 (10% MeOH/CH_2Cl_2; anisaldehyde); mp 180 °C dec.; λ_{max}(EtOH)/nm < 210***;*** IR ν_{max}/cm^{-1} 3297, 1681 (carbamate I), 1543 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.27-3.47 (2H, m), 3.56-3.90 (4H, m), 4.59 (0.3 H, d, J = 8.2 Hz, β anomer H-1), 5.11 (2H, s, CH_2Ph), 5.14 (0.7 H, d, J = 3.3 Hz, α anomer H-1), 7.26-7.44 (5H,

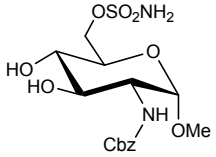
m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 57.7 (C-2), 67.5, 62.8, 72.5, 72.9, 73.1, 78.0, 93.0, 97.3 (C-1), 128.9 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 158.9 (CO); MS (ESI-) *m/z* 312.2 $[M-H]^-$.

Benzyl((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-6-(hydroxymethyl)-2-methoxy tetrahydro - 2H-pyran-3-yl) carbamate (4)



Carbamate **3** (5 g, 16 mmol) was suspended in a 1.25 M solution of HCl in methanol (40 mL) and heated to 80 °C for 18 h. The resulting solution was evaporated and the residue purified by MPLC on SiO_2 with a gradient elution from 2-12% MeOH/CH_2Cl_2. Product containing fractions were combined and evaporated to give a white solid (3.8 g, 73%). R_f 0.3 (10% MeOH/CH_2Cl_2; anisaldehyde); mp 159-160 °C; $[\alpha]_D^{22.8}$ +84.8° (c = 1.0, MeOH); λ_{max}(EtOH)/nm 204; IR ν_{max}/cm^{-1} 3330 br, 1678 (carbamate I), 1539 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.36-3.40 (1H, m, H-4), 3.52-3.67 (3H, m, H-2, H-3, H-5), 3.71 (1H, dd, J = 5.7 and 11.8 Hz, H-6$_a$), 3.84 (1H, dd, J = 2.1 and 11.8 Hz, H-6$_b$), 4.70 (1H, d, J = 3.2 Hz, H-1), 5.11 (2H, s, CH_2Ph), 7.28-7.41 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 55.5 (OMe), 56.1 (C-2), 62.7 (C-6), 67.6 (CH_2Ph), 72.3 (C-4), 73.2 (C-5), 73.7 (C-3), 100.2 (C-1), 128.9 (C-Ar), 129.4 (C-Ar), 138.3 (C-Ar), 158.9 (CO); MS (ESI-) *m/z* 313.1$[M-H]^-$; (ESI+) *m/z* 315.2 $[M+H]^+$.

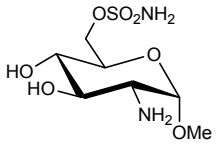
((2*R*,3*S*,4*R*,5*R*,6*S*)-5-(((Benzyloxy)carbonyl)amino)-3,4-dihydroxy-6-methoxy tetrahydro-2H-pyran-2-yl)methyl sulfamate (5)



Prepared according to sulfamoylation method 2 using sulfamoyl chloride (1.0 mL, 1.0 M in toluene, 1.0 mmol, 1.65 eq.), alcohol **4** (200 mg, 0.61 mmol, 1 eq.) and DMF (4 mL) at -40 °C. The mixture was stirred at -40 °C for 18 h, quenched by cautious addition of water (2 mL) and extracted with EtOAc (20 mL). Saturated $NaCl_{(aq)}$ (10 mL) was added to aqueous layer and further extracted with EtOAc (3 × 20 mL). The organic layers were combined, dried ($MgSO_4$) and the solvent was removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 50% EtOAc/petrol to 100% EtOAc to 10% MeOH/EtOAc

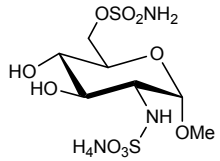
to give a white solid (136 mg, 55%). R_f 0.5 (5% MeOH/EtOAc; anisaldehyde); mp 104-106 °C; $[\alpha]_D^{22.6}$ +40.93° (c = 0.43, MeOH); λ_{max}(EtOH)/nm 257.5 (weak), 210; IR ν_{max}/cm^{-1} 3377, 3332, 3236, 1685 (carbamate I), 1542 (carbamate II), 1372 (SO), 1180 (SO); ^{1}H NMR (500 MHz; DMSO-d^6) δ_H 3.14 (1H, m, H-4), 3.26 (3H, s, OCH_3), 3.39-3.51 (2H, m, H-2 and H-3), 3.60 (1H, ddd, J = 1.6, 6.6 and 8.0 Hz, H-5), 4.08 (1H, dd, J = 6.6 and 10.6 Hz, H-6$_a$), 4.28 (1H, dd, J = 1.6 and 10.6 Hz, H-6$_b$), 4.61 (1H, d, J = 3.2 Hz, H-1), 4.91 (1H, d, J = 5.6 Hz, OH-3), 5.01 (1H, d, J = 12.5 Hz, CH_aH$_b$Ph), 5.05 (1H, d, J = 12.5 Hz, CH$_a$$H_b$Ph), 5.31 (1H, d, J = 5.7 Hz, OH-4), 7.18 (1H, d, J = 7.9 Hz, NHCO$_2$Bn), 7.29-7.41 (5H, m, H-Ar), 7.49 (2H, br s, OSO_2NH_2); ^{1}H NMR δ_H (500 MHz; CD_3OD) 3.36-3.44 (4H, m, OCH_3 and H-4), 3.58-3.68 (2H, m, H-2 and H-3), 3.79 (1H, ddd, J = 1.6, 6.0 and 9.9 Hz, H-5), 4.27 (1H, dd, J = 10.7 and 6.0 Hz, H-6$_a$), 4.42 (1H, dd, J = 10.7 and 1.6 Hz, H-6$_b$), 4.70 (1H, d, J = 3.2 Hz, H-1), 5.11 (2H, s, CH_2Ph), 7.29-7.41 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 55.7 (OCH_3), 57.1 (C-2), 67.6 (CH_2Ph), 70.1 (C-6), 71.3 (C-5), 72.0 (C-4), 73.1 (C-3), 100.2 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 158.9 (CO); HRMS calc. for $C_{15}H_{23}N_2O_9S$ $[M+H]^+$ 407.1119**,** found 407.1119.

((2*R*,3*S*,4*R*,5*R*,6*S*)-5-Amino-3,4-dihydroxy-6-methoxytetrahydro-2H-pyran-2-yl)methyl sulfamate (6)



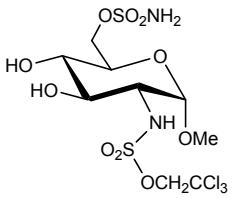
Prepared according to general procedure A using sulfamate **5** (1.525 g, 3.8 mmol), MeOH (90 mL) and CH_2Cl_2 (30 mL) for 18 h to give a white solid (1.015 g, 99%). R_f 0.05 (CH_2Cl_2/MeOH/NH_4OH 80:20:3; anisaldehyde); mp 104-112 °C; $[\alpha]_D^{17.1}$ +59.2° (c = 0.5, MeOH); λ_{max}(EtOH)/nm <220; IR ν_{max}/cm^{-1} 3297, 1359 (SO), 1176 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.17 (1H, dd, J = 3.7 and 10.5 Hz, H-2), 3.40 (1H, dd, J = 8.9 and 10.1 Hz, H-4), 3.5 (3H, s, OCH_3), 3.77 (1H, dd, J = 8.9 and 10.5 Hz, H-3), 3.84 (1H, ddd, J = 2.0, 5.8 and 10.1 Hz, H-5), 4.31 (1H, dd, J = 5.8 and 10.9 Hz, H-6$_a$), 4.45 (1H, dd, J = 2.0 and 10.9 Hz, H-6$_b$), 4.94 (1H, d, J = 3.7 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 55.8 (OCH_3), 56.2 (C-2), 69.8 (C-6), 71.5 (C-4), 71.6 (C-5), 73.6 (C-3), 99.4 (C-1); HRMS calc. for $C_7H_{17}N_2O_7S$ $[M+H]^+$ 273.0751**,** found 273.0755.

Ammonium ((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-2-methoxy-6-((sulfamoyloxy) methyl)tetrahydro-2*H*-pyran-3-yl)sulfamate (1)



Prepared according to general procedure B, using amine **6** (140 mg, 0.52 mmol, 1 eq.), de-ionised water (3 mL) and pyridine-sulfur trioxide complex (90 mg, 0.565 mmol, 1.1 eq.). The crude product was purified by MPLC on SiO_2 with a gradient elution from 70/30/3 to 35/65/3 CH_2Cl_2/MeOH/NH_4OH to give an off-white solid (81 mg, 0.23 mmol, 43%); (Found: C, 21.4; H, 5.1; N, 10.5; C, 21.6; H, 5.1; N, 11.1; calcd for $C_7H_{19}N_3O_{10}S_2.H_2O$: C, 21.7; H, 5.5; N, 10.9); R_f 0.1 (MeOH/NH_3 95:5; anisaldehyde); mp 125-135 °C; $[\alpha]_D^{16.9}$ +103.13° (c = 0.32, MeOH); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3218, 3084, 1356 (SO), 1170 (SO); ^{1}H NMR (500 MHz; DMSO-d^6) δ_H 3.01 (1H, ddd, *J* = 3.5, 8.0 and 10.7 Hz, H-2), 3.12 (1H, ddd, *J* = 5.6, 8.5 and 9.9 Hz, H-4), 3.28 (3H, s, OCH_3), 3.40-3.46 (1H, m, H-3), 3.60 (1H, ddd, *J* = 1.6, 6.9 and 9.9 Hz, H-5), 4.08 (1H, dd, *J* = 6.9 and 10.1 Hz, H-6$_a$), 4.20 (1H, d, *J* = 8.0 Hz, $NHSO_3^-$), 4.31 (1H, dd, *J* = 1.6 and 10.1 Hz, H-6$_b$), 4.69 (1H, d, *J* = 3.5 Hz, H-1), 5.24 (1H, d, *J* = 5.6 Hz, OH-4), 5.49 (1H, d, *J* = 2.2 Hz, OH-3), 7.09 (4H, br s, NH_4^+), 7.50 (2H, br s, OSO_2NH_2); ^{1}H NMR (500 MHz; D_2O) δ_H 3.30 (1H, dd, *J* = 3.6 and 10.0 Hz, H-2), 3.47 (3H, s, OCH_3), 3.57 (1H, app t, *J* = 10.0 Hz, H-4), 3.64 (1H, app t, *J* = 10.0 Hz, H-3), 3.95 (1H, ddd, *J* = 2.3, 4.6 and 10.0 Hz, H-5), 4.47 (1H, dd, *J* = 4.6 and 11.2 Hz, H-6$_a$), 4.51 (1H, dd, *J* = 2.3 and 11.2 Hz, H-6$_b$), 5.07 (1H, d, *J* = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; D_2O) δ_C 55.5 (OCH_3), 57.6 (C-2), 68.9 (C-6), 69.1 (C-5), 69.5 (C-4), 71.3 (C-3), 98.7 (C-1); HRMS calc. for $C_7H_{15}N_2O_{10}S_2$ $[M-H]^-$ 351.074, found 351.074.

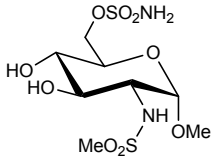
2,2,2-Trichloroethyl ((*2S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-2-methoxy-6-(sulfamoyloxy)methyl)tetrahydro-2*H*-pyran-3-yl)sulfamate (9)



Amine **6** (50 mg, 0.18 mmol, 1 eq.) and 2,3-dimethyl-1-((2,2,2-trifluoroethoxy)sulfonyl)-1*H*-imidazol-3-ium tetrafluoroborate (70 mg, 0.18 mmol, 1 eq.) were combined in THF and stirred at r.t. for 18 h. The solvent was removed *in vacuo* and the residue purified by MPLC

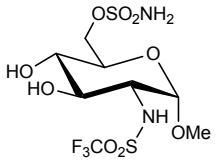
on SiO_2 with gradient elution from 60-80% EtOAc/petrol to give a clear gum (54 mg, 61%); R_f 0.55 (EtOAc; anisaldehyde); λ_{max}(EtOH)/nm <220; $[\alpha]_D^{19.5}$ +106.7° (c = 0.15, EtOH); IR ν_{max}/cm^{-1} 3281 (br), 2926, 1358 (SO), 1178 (SO); ^{1}H NMR (500 MHz; DMSO-*d*^{6}) δ_H 3.17-3.24 (2H, m, H-4 and H-2), 3.36 (3H, s, OMe), 3.49-3.55 (1H, ddd, *J* = 6.0, 8.7 and 10.4 Hz, H-3), 3.65 (1H, ddd, *J* = 1.7, 6.5 and 9.9 Hz, H-5), 4.08-4.15 (1H, m, H-6$_a$), 4.32 (1H, dd, *J* = 1.7 and 10.4 Hz, H-6$_b$), 4.67 (1H, d, *J* = 11.2 Hz, C*H*$_a$H$_b$CCl$_3$), 4.73 (1H, d, *J* = 3.6 Hz, H-1), 4.91 (1H, d, *J* = 11.2 Hz, CH$_a$*H*$_b$CCl$_3$), 5.41-5.48 (2H, m, OH^3 and OH^4), 8.77 (1H, s, CHN*H*), 7.53 (2H, s, NH$_2$); ^{13}C NMR (125 MHz; DMSO-*d*^{6}) δ_C 54.7 (OMe), 58.2 (C-2), 68.3 (C-6), 69.5 (C-5), 70.2 (C-3), 70.5 (C-4), 77.4 (*C*H$_2$CCl$_3$), 98.1 (C-1); HRMS calcd for $C_9H_{16}N_2O_{10}S_2{}^{35}Cl_3$ [M-H]$^-$ 480.9317, found 480.9314.

((2*R*,3*S*,4*R*,5*R*,6*S*)-3,4-Dihydroxy-6-methoxy-5-(methylsulfonamido) tetrahydro-2*H*-pyran-2-yl)methyl sulfamate (10)



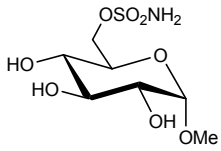
Methanesulfonyl chloride (76 µL, 0.77 mmol, 1.05 eq.) was added dropwise to amine **6** (200 mg, 0.74 mmol, 1 eq.) and *N,N*-diisopropylethylamine (192 µL, 1.1 mmol, 1.5 eq.) in anhydrous dichloromethane (2 mL) and dioxane (2 mL) at 0 °C. The mixture was stirred at 0 °C for 1 h. A further 19 µL (0.19 mmol, 0.25 eq.) of methanesulfonyl chloride was added and the mixture stirred at 0 °C for 1 h. Water was added, and the mixture extracted with CH_2Cl_2 (2 × 10 mL). The organic layer was evaporated *in vacuo* and purified by MPLC on SiO_2 with a gradient elution from EtOAc to 8% MeOH/EtOAc to give a clear gum (73 mg, 0.21 mmol, 28%). R_f 0.2 (CH_2Cl_2/MeOH 90:10; anisaldehyde); $[\alpha]_D^{22.6}$ +41.48° (c = 0.27, MeOH); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3316 br, 2938, 1368 (SO), 1178 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.08 (3H, s, CH_3SO_2), 3.32-3.37 (2H, m, H-2 and H-4), 3.45 (1H, s, OCH_3), 3.64 (1H, dd, *J* = 8.8 and 10.4 Hz, H-3), 3.80 (1H, ddd, *J* = 2.0, 5.9 and 10.1 Hz, H-5), 4.29 (1H, dd, *J* = 5.9 and 10.7 Hz, H-6$_a$), 4.44 (1H, dd, *J* = 2.0 and 10.7 Hz, H-6$_b$), 4.72 (1H, d, *J* = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 41.1 (CH_3SO_2), 55.5 (OCH_3), 57.3 (C-2), 68.8 (C-6), 69.3 (C-5), 69.6 (C-4), 71.4 (C-3), 99.4 (C-1); HRMS calc. for $C_9H_{17}N_2O_9S_2$ [M-H]$^-$ 349.0381, found 349.0383.

((2*R*,3*S*,4*R*,5*R*,6*S*)-3,4-Dihydroxy-6-methoxy-5-(trifluoromethylsulfonamido) tetrahydro-2*H*-pyran-2-yl)methyl sulfamate (11)



Trifluoromethanesulfonic anhydride (62 μL, 0.37 mmol, 1 eq.) was added to amine **6** (100 mg, 0.37 mmol, 1 eq.) and triethylamine (57 μL, 0.44 mmol, 1.2 eq.) in a mixture of dioxane (8 mL) and dichloromethane (2 mL) at 0 °C. The mixture was stirred at 0 °C for 1 h, and then further trifluoromethanesulfonic anhydride (31 μL, 0.18 mmol, 0.5 eq.) was added at 0 °C. The mixture was stirred at 0 °C for a further 1 h, and then quenched by the cautious addition of water. The mixture was extracted with CH_2Cl_2 (2 × 20 mL). The aqueous layer was diluted with saturated $NaCl_{(aq)}$ and extracted with further CH_2Cl_2 (2 × 20 mL). The organic layers were combined, dried over $MgSO_4$, and the solvent was removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 2-15% MeOH/CH_2Cl_2 to give a clear gum which was dissolved in EtOAc (20 mL) and washed with water (4 × 30 mL). The organic layer was dried over $MgSO_4$ and the solvent removed *in vacuo* to give a white solid (55 mg, 0.14 mmol, 37%). R_f 0.6 (CH_2Cl_2/MeOH 80:20; anisaldehyde,); mp 55-65 °C; $[\alpha]_D^{22.6}$ +95.5° (c = 0.18, MeOH); λ_{max}(EtOH)/nm <220; IR ν_{max}/cm^{-1} 3274 (br), 2923, 2851, 1363 (SO), 1178 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.35-3.42 (2H, m, H-2 and H-4), 3.46 (3H, s, OCH_3), 3.65 (1H, dd, *J* = 8.8 and 10.4 Hz, H-3), 3.81 (1H, ddd, *J* = 2.0, 6.0 and 10.0 Hz Hz, H-5), 4.28 (1H, dd, *J* = 6.0 and 10.8 Hz, H-6$_a$), 4.44 (1H, dd, *J* = 2.0 and 10.8 Hz, H-6$_b$), 4.73 (1H, d, *J* = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 59.9 (OCH_3), 60.3 (C-2), 69.9 (C-6), 71.2 (C-5), 72.0 (C-4), 72.5 (C-3), 100.7 (C-1), 128.3 (q, J_{CF} = 320.1 Hz, CF_3); ^{19}F NMR (470 MHz; CD_3OD) δ_F -79.51; HRMS calc. for $C_8H_{14}O_9N_2F_3S_2$ $[M-H]^-$ 403.0098, found 403.0100.

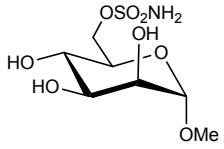
((2*R*,3*S*,4*S*,5*R*,6*S*)-3,4,5-Trihydroxy-6-methoxytetrahydro-2*H*-pyran-2-yl)methyl sulfamate (13)



Prepared according to sulfamoylation method 2 using sulfamoyl chloride (1.85 mL, 1 M in MeCN, 1.85 mmol, 1.8 eq.), methyl-α-D-glucopyranoside (200 mg, 1.02 mmol, 1 eq.), and DMF (7 mL). The residue was purified by MPLC on SiO_2 with a gradient elution from 2-8%

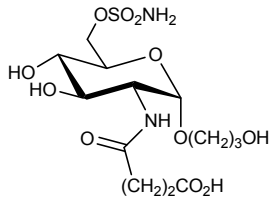
MeOH/EtOAc to give a white solid (70 mg, 25%); R_f 0.25 (15% MeOH/EtOAc; anisaldehyde); mp 55-60 °C; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{18.1}$ +105.8° (c = 0.31, MeOH); IR ν_{max}/cm^{-1} 3339, 2919, 1360 (SO), 1177 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.32 (1H, dd, *J* = 9.2 and 10.0 Hz, H-4), 3.43 (1H, dd, 3.7 and 9.2 Hz, H-2), 3.45 (3H, s, OCH_3), 3.66 (1H, app t, *J* = 9.2 Hz, H-3), 3.80 (1H, ddd, *J* = 2.0, 5.9 and 10.0 Hz, H-5), 4.28 (1H, dd, *J* = 5.9 and 10.7 Hz, H-6$_a$), 4.43 (1H, dd, *J* = 2.0 and 10.7 Hz, H-6$_b$), 4.71 (1H, d, *J* = 3.7 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 68.2 (OCH_3), 70.1 (C-6), 71.2 (C-5), 71.5 (C-4), 73.4 (C-2), 75.1 (C-3), 101.3 (C-1); HRMS calc. for $C_7H_{14}N_1O_8S_1$ $[M-H]^-$ 272.0446, found 272.0442.

((2*R*,3*S*,4*S*,5*S*,6*S*)-3,4,5-Trihydroxy-6-methoxytetrahydro-2*H*-pyran-2-yl)methyl sulfamate (15)

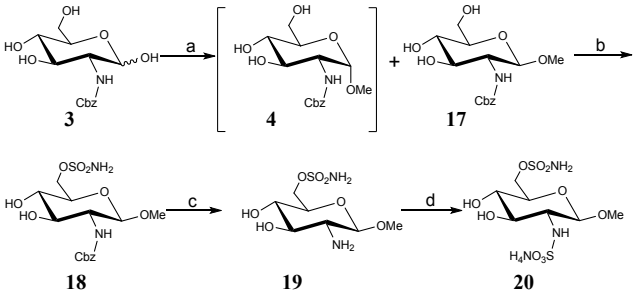


Prepared according to sulfamoylation method 2 using sulfamoyl chloride (1.85 mL, 1 M in MeCN, 1.85 mmol, 1.8 eq.), methyl-α-D-mannopyranoside (200 mg, 1.02 mmol, 1 eq.), and DMF (7 mL). The residue was purified by MPLC on SiO_2 with a gradient elution from EtOAc to 8% MeOH/EtOAc to give a white solid. This material was re-purified by MPLC on SiO_2 with a gradient elution from 5-10% MeOH/CH_2Cl_2 to give a white solid (25 mg, 9%); R_f 0.2 (5% MeOH/EtOAc; anisaldehyde); m.p. 65-70 °C; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{18.8}$ +96.8° (c = 0.28, EtOH); IR ν_{max}/cm^{-1} 3341, 1356 (SO), 1176 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.42 (3H, s, OCH_3), 3.63-3.72 (2H, m, H-3 and H-4), 3.75 (1H, ddd, *J* = 1.8, 6.3 and 9.6 Hz, H-5), 3.83 (1H, dd, *J* = 1.7 and 3.2 Hz, H-2), 4.30 (1H, dd, *J* = 6.3 and 10.8 Hz, H-6$_a$), 4.48 (1H, dd, *J* = 1.8 and 10.8 Hz, H-6$_b$), 4.67 (1H, d, *J* = 1.7 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 55.4 (OCH_3), 68.3 (C-4), 70.4 (C-6), 71.9 (C-2), 72.2 (C-5), 72.5 (C-3), 102.8 (C-1); HRMS calcd for $C_7H_{14}N_1O_8S_1$ $[M-H]^-$ 272.0446, found 272.0434.

4-(((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-Dihydroxy-2-methoxy-6-((sulfamoyloxy) methyl) tetrahydro-2*H*-pyran-3-yl)amino)-4-oxobutanoic acid (16)

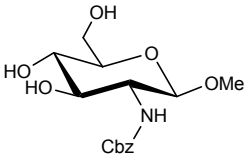


Succinic anhydride (38 mg, 0.37 mmol, 1 eq.) was added to a solution of compound **6** (100 mg, 0.37 mmol, 1 eq.) in a mixture of water (3 mL) and dioxane (3 mL), and the mixture was stirred at room temperature for 18 h. The solvent was removed *in vacuo* and purified by MPLC on SiO_2 with a gradient elution from EtOAc to 50 % MeOH/EtOAc. Product containing fractions were evaporated, and triturated with EtOAc (2 × 3 mL). The resultant solid was dried under vacuum to give a white solid (25 mg, 0.067 mmol, 18%); R_f 0.1 (40% MeOH/EtOAc; anisaldehyde); mp 87-90 °C; $[\alpha]_D^{22.6}$ +90.0° (c = 0.08, MeOH); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3319, 1716 (carbamate I), 1636 (CO_2H), 1542 (carbamate II), 1361 (SO), 1176 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 2.55-2.68 (4H, m, C*H*$_2$C*H*$_2$CO$_2$H), 3.39 (1H, dd, *J* = 9.0 and 9.9 Hz, H-4), 3.42 (3H, s, OCH_3), 3.69 (1H, dd, *J* = 9.0 and 10.6 Hz, H-3), 3.82 (1H, ddd, *J* = 1.7, 6.0 and 9.9 Hz, H-5), 3.95 (1H, dd, *J* = 3.5 and 10.6 Hz, H-2), 4.29 (1H, dd, *J* = 6.0 and 10.7 Hz, H-6$_a$), 4.44 (1H, dd, *J* = 1.7 and 10.7 Hz, H-6$_b$), 4.69 (1H, d, *J* = 3.5 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 30.4 (*C*H$_2$CO$_2$H), 31.5 (*C*H$_2$CONH), 55.2 (C-2), 55.8 (OCH_3), 70.1 (C-6), 71.3 (C-5), 72.0 (C-4), 72.9 (C-3), 99.9 (C-1), 175.1 (CO), 176.5 (CO); HRMS calcd for $C_{11}H_{19}N_2O_{10}S$ [M-H]$^-$ 371.0766, found 371.0771.



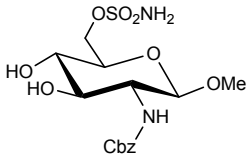
Scheme S1: Preparation of β-anomer **20**. *Reagents and conditions*: a) HCl/MeOH, 70 °C, 1 h, **17** 21% (+ **4** 37%); b) $ClSO_2NH_2$, Tol/DMA, -15 °C, 2.5 h, 19%; c) H_2/10% Pd/C, MeOH/CH_2Cl_2, 40 °C, 1 h, 95%; d) SO_3.Py, H_2O, pH 9-10, r.t. 2.5 h, 29%.

Benzyl ((2*R*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-6-(hydroxymethyl)-2-methoxy tetrahydro-2*H*-pyran-3-yl)carbamate (17)



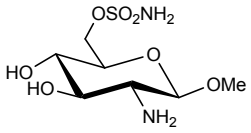
A solution of hydrogen chloride (15 mL, 1.25 M in MeOH) was added to glucosamine derivative **3** (2.0 g, 6.4 mmol, 1 eq.) and the mixture was heated to 70 °C for 1 h. The solvent was removed *in vacuo*, and the residue purified by MPLC on SiO_2 with a gradient elution from 2-15% MeOH/CH_2Cl_2 to give a white solid (430 mg, 1.31 mmol, 21%, β anomer). The α anomer (**4**) was also obtained (770 mg, 2.14 mmol, 37%). Data for the β anomer **17**: R_f 0.25 (5% MeOH/EtOAc; anisaldehyde); mp 174-176 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3297 br, 1696 (carbamate I), 1542 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.26-3.47 (4H, m, H-2, H-3, H-4, H-5), 3.51 (3H, s, OCH_3), 3.72 (1H, dd, *J* = 5.8 and 12.0 Hz, H-6$_a$), 3.92 (1H, dd, *J* = 2.1 and 12.0 Hz, H-6$_b$), 4.31 (1H, d, *J* = 7.9 Hz, H-1), 5.13 (2H, s, CH_2Ph), 7.30-7.43 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 57.2 (C-2), 59.0 (OCH_3), 62.8 (C-6), 67.4 (CH_2Ph), 72.2 (C-3), 76.1 (C-5), 78.0 (C-4), 104.2 (C-1), 128.8 (C-Ar), 128.9 (C-Ar), 129.4 (C-Ar), 138.4 (C-Ar), 159.1 (CO); MS (ESI-) *m*/*z* 326.3 [M-H]$^-$.

((2*R*,3*S*,4*R*,5*R*,6*R*)-5-Amino-3,4-dihydroxy-6-methoxytetrahydro-2*H*-pyran-2-yl) methyl sulfamate (18)



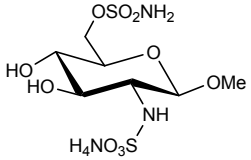
Prepared according to sulfamoylation method 1 using sulfamoyl chloride (3.75 mL, 1 M, 3.75 mmol, 3 eq.), alcohol **17** (410 mg, 1.25 mmol, 1 eq.) and DMA (3 mL) at -20 °C. The mixture was stirred at -20 °C for 1 h, and then allowed to warm to -5 °C and stirred at -5 °C for 90 minutes. The reaction was quenched by the addition of water, and extracted with EtOAc (20 mL). Saturated aqueous sodium chloride solution was added to the aqueous layer, and further extracted with CH_2Cl_2 (7 × 20 mL). The organic extracts were combined, dried over $MgSO_4$, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 70% EtOAc/petrol to 100% EtOAc to give a white solid. (96 mg, 0.24 mmol, 19%); R_f 0.25 (EtOAc; anisaldehyde); mp 155 °C dec.; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3464, 3391, 3325, 3231, 1695 (carbamate I), 1534 (carbamate II), 1369 (SO), 1180 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.36-3.51 (6H, m, OCH_3, H-2, H-3, H-4), 3.55 (1H, ddd, *J* = 1.9, 6.0 and 9.7 Hz, H-5), 4.28 (1H, dd, *J* = 6.0 and 10.9 Hz, H-6$_a$), 4.34 (1H, d, *J* = 7.9 Hz, H-1), 4.49 (1H, dd, *J* = 1.9 and 10.9 Hz, H-6$_b$), 5.13 (2H, s, C*H*$_2$Ph), 7.30-7.42 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 54.9 (OMe), 57.3 (C-2), 67.4 (*C*H$_2$Ph), 71.8 (C-6), 73.9 (C-5), 75.3 (C-4), 75.9 (C-3), 102.4 (C-1), 128.8 (C-Ar), 128.9 (C-Ar), 129.4 (C-Ar), 138.4 (C-Ar), 159.1 (CO); HRMS calcd for $C_{15}H_{21}O_9N_2S$ [M-H]$^-$ 405.0973, found 405.0973.

((2*R*,3*S*,4*R*,5*R*,6*R*)-5-Amino-3,4-dihydroxy-6-methoxytetrahydro-2H-pyran-2-yl)methyl sulfamate (19)



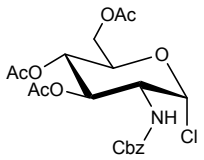
Prepared according to general procedure A using sulfamate **18** (90 mg, 0.22 mmol), MeOH (3 mL) and CH_2Cl_2 (1.5 mL) for 1 h to give a clear gum (57 mg, 0.21 mmol, 95%). R_f 0.2 (70:30:3 CH_2Cl_2/MeOH/NH_4OH; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3321 br, 1358 (SO), 1176 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 2.62 (1H, dd, *J* = 8.1 and 9.6 Hz, H-2), 3.29-3.38 (2H, m, H-3 and H-4), 3.54-3.59 (4H, m, OCH_3 and H-5), 4.22 (1H, d, *J* = 8.1 Hz, H-1), 4.29 (1H, dd, *J* = 5.8 and 10.8 Hz, H-6$_a$), 4.47 (1H, dd, *J* = 1.9 and 10.8 Hz, H-6$_b$); ^{13}C NMR (125 MHz; CD_3OD) δ_C 57.4 (OMe), 58.2 (C-2), 69.8 (C-6), 71.5 (C-4), 75.6 (C-5), 77.1 (C-3), 105.2 (C-1); HRMS calcd for $C_7H_{15}O_7N_2S$ [M-H]$^-$ 271.0606, found 271.0606**.**

Ammonium ((2*R*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-2-methoxy-6-((sulfamoyloxy) methyl)tetrahydro-2*H*-pyran-3-yl)sulfamate (20)



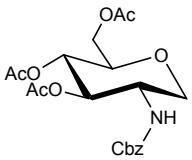
Prepared according to general procedure B, using amine **19** (50 mg, 0.18 mmol, 1 eq.) de-ionised water (2 mL) and pyridine-sulfur trioxide complex (32 mg, 0.20 mmol, 2.1 eq.). for 2 h. The crude product was purified by MPLC on SiO_2 with a gradient elution from 70:30:3 to 50:50:5 CH_2Cl_2/MeOH/NH_4OH. Product containing fractions were evaporated, dissolved in MeOH (5 mL) and filtered. The solvent was removed *in vacuo* and the residue dissolved in water, frozen and lyophilized to give a white solid (20 mg, 0.054 mmol, 29%); R_f 0.25 (70:30:3 CH_2Cl_2/MeOH/NH_4OH; anisaldehyde); mp 130 °C dec.; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3372, 3261 br, 1363 (SO), 1177 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.05 (1H, dd, *J* = 8.2 and 9.7 Hz, H-2), 3.39 (1H, dd, *J* = 8.8 and 9.9 Hz, H-4), 3.54 (3H, s, OMe), 3.58 (1H, ddd, *J* = 1.9, 6.1 and 9.9 Hz, H-5), 3.72 (1H, dd, *J* = 8.8 and 9.7 Hz, H-3), 4.28 (1H, dd, *J* = 6.1 and 10.9 Hz, H-6$_a$), 4.41 (1H, d, *J* = 8.2 Hz, H-1), 4.48 (1H, dd, *J* = 1.9 and 10.9 Hz, H-6$_b$); ^{13}C NMR (125 MHz; CD_3OD) δ_C 57.1 (OMe), 61.6 (C-2), 70.0 (C-6), 71.5 (C-4), 75.3 (C-5), 77.3 (C-3), 103.5 (C-1); HRMS calcd for $C_7H_{15}O_{10}N_2S_2$ [M-H]$^-$ 351.0175, found 351.0174**.**

(2*R*,3*S*,4*R*,5*R*,6*R*)-2-(Acetoxymethyl)-5-(((benzyloxy)carbonyl)amino)-6-chloro tetrahydro-2*H*-pyran-3,4-diyl diacetate (21)



Benzyl carbamate protected glucosamine **3** (1.0 g, 3.2 mmol, 1 eq.) was suspended in acetyl chloride (3 mL), and stirred at room temperature for 48 h. The mixture was diluted with CH_2Cl_2 (20 mL) and poured onto ice. The organic layer was separated, and treated with saturated aqueous $NaHCO_3$ solution until the aqueous layer was pH 7. The organic layer was separated, the aqueous layer extracted with CH_2Cl_2. The organic layers were combined, washed with brine, dried over $MgSO_4$, and the solvent removed *in vacuo* to give a white solid (800 mg, 1.74 mmol, 55 %); R_f 0.2 (25% EtOAc/petrol; anisaldehyde); mp 116-117 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3372, 2940, 1742, 1720, 1517; ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.94 (3H, s, CH_3), 2.05 (3H, s, CH_3), 2.09 (3H, s, CH_3), 4.16 (1H, dd, *J* = 3.8 and 13.9 Hz, H-6$_a$), 4.29 (1H, dd, *J* = 3.7 and 10.6 Hz, H-2), 4.34-4.39 (2H, m, H-5 and H-6$_b$), 5.10 (1H, d, *J* = 12.5 Hz, C*H*$_a$H$_b$Ph), 5.15 (1H, app t, *J* = 9.5 Hz, H-4), 5.19 (1H, d, *J* = 12.5 Hz, CH$_a$*H*$_b$Ph), 5.37 (1H, dd, *J* = 9.5 and 10.6 Hz, H-3), 6.29 (1H, d, *J* = 3.7 Hz, H-1), 7.31-7.41 (5H, m, H-Ar); ^{13}C NMR (125 MHz; $CDCl_3$) δ_C 20.5 (*C*H_3CO_2), 20.6 (*C*H_3CO_2), 20.7 (*C*H_3CO_2), 55.3 (C-2), 61.2 (*C*H_2Ph), 67.1 (C-4), 67.4 (C-6), 70.1 (C-3), 70.9 (C-5), 93.8 (C-1), 128.2 (C-Ar), 128.4 (C-Ar), 128.6 (C-Ar), 138.4 (C-Ar), 158.6 (CO), 169.2 (CO), 170.5 (CO), 171.0 (CO); MS (ESI-) *m*/*z* 456.3 [M-H]$^-$; (ESI+) *m*/*z* 458.4 [M+H]$^+$.

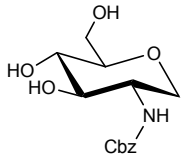
(2*R*,3*S*,4*R*,5*S*)-2-(Acetoxymethyl)-5-(((benzyloxy)carbonyl)amino) tetrahydro-2*H*-pyran-3,4-diyl diacetate (22)



TMS_3SiH (1.94 mL, 6.3 mmol, 1.2 eq.) was added to a solution of chloride **21** (2.4 g, 5.2 mmol, 1 eq.) in anhydrous toluene (30 mL). A solution of AIBN (0.2 M in toluene, 1 mL, 0.2 mmol, 0.04 eq.) was added and the mixture heated to 110 °C for 1.5 h. The reaction was allowed to cool to r.t., the solvent removed *in vacuo,* and the residue purified by MPLC on SiO_2 with a gradient elution from 20-70% EtOAc/petrol to give a white solid (1.85 g, 84%); R_f 0.65 (50% EtOAc/petrol; anisaldehyde); mp 115-117 °C; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{23.3}$ +31.2° (c = 0.50, EtOH); IR ν_{max}/cm^{-1} 3365, 2953, 1738, 1695, 1531; ^{1}H NMR (500 MHz;

CD_3OD) δ_H 1.93 (3H, s, CH_3), 2.04 (3H, s, CH_3), 2.08 (3H, s, CH_3), 3.41 (1H, app. t, J = 11.0 Hz, H-1_a), 3.67 (1H, ddd, J = 2.0, 4.7 and 9.7 Hz, H-5), 3.87 (1H, app. td, J = 11.0 and 5.4 Hz, H-2), 3.97 (1H, dd, J = 5.4 and 11.0 Hz, H-1_b), 4.12 (1H, dd, J = 2.0 and 12.3 Hz, H-6_a), 4.25 (1H, dd, J = 4.7 and 12.3 Hz, H-6_b), 4.97 (1H, app t, J = 9.7 Hz, H-4), 5.04-5.17 (3H, m, CH_aH$_b$Ph, CH$_a$$H_b$Ph and H-3*)*, 7.31-7.40 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 20.6 (3 × *C*H_3CO), 52.6 (C-2), 63.7 (C-6), 67.6 (*C*H_2Ph), 69.1 (C-1), 70.5 (C-4), 75.7 (C-3), 77.6 (C-5), 128.8 (C-Ar), 129.1 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 158.3 (PhCH$_2$*C*O), 171.4 (CH$_3$*C*O), 172.1 (CH$_3$*C*O), 172.4 (CH$_3$*C*O); HRMS calcd for $C_{20}H_{25}O_9N_1$ $[M-H]^-$ 422.1457, found 422.1450**.**

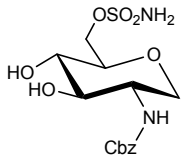
Benzyl ((3*S*,4*R*,5*S*,6*R*)-4,5-dihydroxy-6-(hydroxymethyl)tetrahydro-2*H*-pyran-3-yl)carbamate (23)



Triacetate ester **22** (100 mg, 0.24 mmol) was dissolved in methanol (3 mL) and sodium methoxide (10 mg, 0.19 mmol, 0.8 eq.) was added. The mixture was stirred at room temperature for 2 h. Three drops of 4 M HCl in dioxane were added, and the solvent was removed *in vacuo*. The material was purified by MPLC on SiO_2 with a gradient elution from EtOAc to 5% MeOH/EtOAc to give a white solid (50 mg, 0.17 mmol, 71%); R_f 0.15 (5% MeOH/EtOAc; anisaldehyde); mp 172-175 °C; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{16.9}$ +18.6° (c = 0.22, EtOH); IR ν_{max}/cm^{-1} 3372 br, 3301 br, 2954, 2894, 2860, 1693 (carbamate I), 1543 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.15-3.22 (2H, m, H-1_a and H-5), 3.29 (1H, app t, J = 9.3 Hz, H-4), 3.36-3.42 (1H, m, H-3), 3.59 (1H, app td, J = 10.2 and 5.1 Hz, H-2), 3.66 (1H, dd, J = 6.0 and 12.0 Hz, H-6_a), 3.87 (1H, dd, J = 1.9 and 12.0 Hz, H-6_b), 3.97 (1H, dd, J = 5.1 and 11.0 Hz, H-1_b), 5.12 (2H, s, CH_2Ph), 7.30-7.42 (5H, m, H-Ar), ; ^{13}C NMR (125 MHz; CD_3OD) δ_C 54.6 (C-2), 63.1 (C-6), 67.6 (*C*H_2Ph), 69.5 (C-1), 72.5 (C-4), 77.1 (C-3), 82.6 (C-5), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar); HRMS Calc for $C_{14}H_{20}O_6N_1$ $[M+H]^+$ 298.1285, found 298.1290.

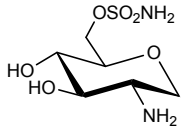
Note: Unable to visualise all carbon signals by ^{13}C nmr.

((2*R*,3*S*,4*R*,5*S*)-5-(((Benzyloxy)carbonyl)amino)-3,4-dihydroxytetrahydro-2*H*-pyran-2-yl)methyl sulfamate (24)



Prepared according to sulfamoylation method 1 using sulfamoyl chloride (10 mL, 1 M in toluene, 10 mmol, 1.7 eq.), alcohol **23** (950 mg, 5.9 mmol, 1 eq.), and DMA (15 mL) at -20 °C. The mixture was stirred at -20 °C for 1 h. Further sulfamoyl chloride (7.6 mL, 1 M in toluene, 7.6 mmol, 1.3 eq.) was added at -20 °C and the mixture was stirred at -20 °C for 1 h. The reaction was quenched by the addition of water, and extracted with EtOAc (50 mL). Saturated aqueous sodium chloride solution was added to the aqueous layer, and further extracted with CH_2Cl_2 (5 × 30 mL). The organic extracts were combined, dried over $MgSO_4$, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 50% EtOAc/petrol to 100% EtOAc to 12 % MeOH/EtOAc to give a white solid. (200 mg, 0.53 mmol, 17%); R_f 0.25 (EtOAc; anisaldehyde); mp 158-162 °C dec.; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{16..9}$ -8.7° (c = 0.23, EtOH); IR ν_{max}/cm^{-1} 3414, 3388, 3336, 3237, 1685 (carbamate I), 1534 (carbamate II), 1374 (SO), 1182 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.21 (1H, app t, J = 11.2 Hz, H-1$_a$), 3.28-3.34 (1H, m, H-4), 3.38-3.46 (2H, m, H-3 and H-5), 3.60 (1H, app td, J = 11.2 and 5.3 Hz, H-2), 3.96 (1H, dd, J = 5.3 and 11.2 Hz, H-1$_b$), 4.24 (1H, dd, J = 6.0 and 10.8 Hz, H-6$_a$), 4.45 (1H, dd, J = 1.3 and 10.8 Hz, H-6$_b$), 5.12 (2H, s, CH_2Ph), 7.31-7.42 (5H, m, H-Ar); HRMS calcd for $C_{14}H_{19}O_8N_2S_1$ [M-H]$^-$ 375.0868 , found 379.0877.

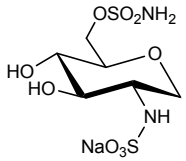
((2*R*,3*S*,4*R*,5*S*)-5-Amino-3,4-dihydroxytetrahydro-2*H*-pyran-2-yl) methyl sulfamate (25)



Prepared according to general procedure A using carbamate **24** (175 mg, 0.47 mmol, 1 eq.), MeOH (15 mL) and CH_2Cl_2 (10 mL) for 3 h to give a clear gum (110 mg, 0.45 mmol, 97%); R_f 0.1 (CH_2Cl_2:MeOH:NH_4OH 70:30:3; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3921, 2876, 1355 (SO), 1174 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 2.79 (1H, ddd, J = 5.0, 9.4 and 10.7 Hz, H-2), 3.19-3.26 (2H, m, H-1$_a$ and H-3), 3.29 (1H, app t, J = 9.4 Hz, H-4), 3.45 (1H, ddd, J = 1.8, 6.0 and 9.4 Hz, H-5), 3.95 (1H, dd, J = 5.0 and 11.3 Hz, H-1$_b$), 4.25

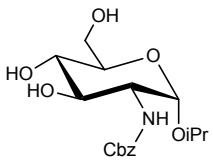
(1H, dd, J = 6.0 and 10.8 Hz, H-6_a), 4.43 (1H, dd, J = 1.8 and 10.8 Hz, H-6_b); ^{13}C NMR (125 MHz; CD_3OD) δ_C 54.1 (C-2), 70.4 (C-6), 71.2 (C-1), 71.7 (C-4), 79.9 (C-5), 80.1 (C-3); HRMS calcd for $C_6H_{13}O_6N_2S_1$ $[M-H]^-$ 241.0500, found 241.0500.

Sodium ((3*S*,4*R*,5*S*,6*R*)-4,5-Dihydroxy-6-((sulfamoyloxy)methyl)tetrahydro-2*H*-pyran-3-yl)sulfamate (26)



Prepared according to general procedure B, using amine **25** (130 mg, 0.54 mmol, 1 eq.), de-ionised water (3 mL) and pyridine-sulfur trioxide complex (165 mg, 1.07 mmol, 2.0 eq.) for 2 h. The crude product was purified by MPLC on SiO_2 with a gradient elution from 20% EtOAc/MeOH to 100% MeOH. Product containing fractions were evaporated, dissolved in MeOH (5 mL) and filtered. The solvent was removed *in vacuo* to give a pale yellow solid (42 mg, 0.13 mmol, 24%); R_f 0.15 (20% MeOH /EtOAc; anisaldehyde); mp 120-124 °C; $[\alpha]_D^{22.2}$ +8.0° (c = 0.20, MeOH); λ_{max} (EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3290 (br), 1358 (SO), 1173 (SO); ^{1}H NMR (500 MHz; D_2O) δ_H 3.22-3.28 (1H, m, H-2), 3.35 (app t, J = 11.2 Hz, H-1_a), 3.42 (1H, app t, J = 8.5 Hz, H-3), 3.49 (1H, app t, J = 8.5 Hz, H-4), 3.59 (1H, ddd, J = 2.0, 5.0 and 8.5 Hz, H-5), 4.25 (1H, dd, J = 4.8 and 11.2 Hz, H-1_b), 4.33 (1H, dd, J = 5.0 and 11.2 Hz, H-6_a), 4.43 (1H, dd, J = 2.0 and 11.2 Hz, H-6_b); ^{13}C NMR (125 MHz; CD_3OD) δ_C 58.5 (C-2), 70.4 (C-1 and C-6), 71.9 (C-4), 78.1 (C-3), 79.7 (C-5); ^{13}C NMR (D_2O) δ_C 54.9 (C-2), 68.7 (C-1), 69.0 (C-6), 69.6 (C-4), 75.2 (C-3), 77.5 (C-5); HRMS calcd for $C_6H_{13}N_2O_9S_2$ $[M-H]^-$ 321.0068, found 321.0069.

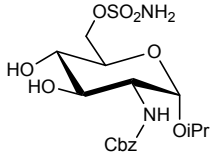
Benzyl ((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-6-(hydroxymethyl)-2-isopropoxy tetrahydro-2*H*-pyran-3-yl)carbamate (27)



Benzyl carbamate protected glucosamine **3** (500 mg, 1.6 mmol, 1 eq.) was dissolved in isopropyl alcohol (15 mL) and a HCl in dioxane (1.5 mL, 4 M) was added. The mixture was heated to 60 °C for 4 h, allowed to cool, and the solvent was removed *in vacuo*. The mixture was dissolved in MeOH and purified by MPLC on SiO_2, with a gradient elution from 2-10% MeOH/CH_2Cl_2, to give a white solid (414 mg, 1.17 mmol, 73%). R_f 0.5 (10%

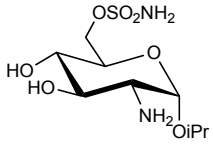
MeOH/CH_2Cl_2; anisaldehyde); mp 158-159 °C; λ_{max} (EtOH)/nm < 220; $[\alpha]_D^{22.7}$ +114.1° (c = 0.27, EtOH); IR ν_{max}/cm^{-1} 3318 br, 2967, 1689 (carbamate I), 1535 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.13 (3H, d, *J* = 6.2 Hz, CH_3), 1.25 (3H, d, *J* = 6.2 Hz, CH_3), 3.37-3.40 (1H, m, H-3), 3.59-3.75 (4H, m, H-2, H-4, H-5 and H-6_a), 3.83 (1H, dd, 1.1 and 11.0 Hz, H-6_b), 3.91 (1H, sept, *J* = 6.2 Hz, C*H*$(CH_3)_2$), 4.95 (1H, d, *J* = 2.8 Hz, H-1), 5.10 (1H, d, *J* = 12.5 Hz, C$H_a$$H_b$Ph), 5.17 (1H, d, *J* = 12.5 Hz, C$H_a$$H_b$Ph), 7.31-7.45 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 21.7 (CH_3), 23.6 (CH_3), 55.8 (C-2), 62.8 (C-6), 67.5 (CH_2Ph), 71.1 (*C*H$(CH_3)_2$), 72.4 (C-4), 73.0 (C-3), 73.8 (C-5), 97.1 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.4 (C-Ar), 138.4 (C-Ar), 158.8 (CO); HRMS calc. for $C_{17}H_{26}O_7N_1$ $[M+H]^+$ 356.1704, found 356.1708.

((2*R*,3*S*,4*R*,5*R*,6*S*)-5-(((Benzyloxy)carbonyl)amino)-3,4-dihydroxy-6-isopropoxy tetrahydro-2*H*-pyran-2-yl)methyl sulfamate (28)



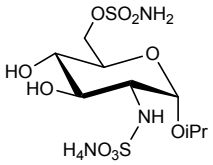
Prepared according to sulfamoylation method 1 using sulfamoyl chloride (3.3 mL, 1.0 M in toluene, 3.3 mmol, 3 eq.), alcohol **27** (390mg, 1.1 mmol, 1 eq.), and DMA (5 mL) at -20 °C. The mixture was allowed to warm to -5 °C over 1 h, and stirred at -5 °C for a further 1 h. The reaction was quenched with water, and extracted with EtOAc (20 mL). Saturated aqueous NaCl solution was added, and the mixture extracted with CH_2Cl_2 (2 × 20 mL). The organic layers were combined, dried over $MgSO_4$, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 70% EtOAc/Petrol to 100% EtOAc to give a white solid (148 mg, 0.32 mmol, 31%). R_f 0.4 (EtOAc; anisaldehyde); mp 166-168 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3336 br, 3244, 2973, 1683 (carbamate I), 1537 (carbamate II), 1371 (SO), 1178 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.13 (3H, d, *J* = 6.2 Hz, CH_3), 1.25 (3H, d, *J* = 6.2 Hz, CH_3), 3.35-3.41 (1H, m, H-4), 3.60 - 3.67 (2H, m, H-2 and H-3), 3.87-3.95 (2H, m, H-5 and C*H*Me_2), 4.29 (1H, dd, *J* = 5.9 and 10.8 Hz, H-6_a), 4.41 (1H, dd, *J* =1.7 and 10.8 Hz, H-6_b), 4.95 (1H, d, *J* = 2.4 Hz, H-1), 5.10 (1H, d, *J* = 12.5 Hz, C$H_a$$H_b$Ph), 5.16 (1H, d, *J* = 12.5 Hz, C$H_a$$H_b$Ph), 7.30-7.45 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 21.7 (CH_3), 23.6 (CH_3), 57.1 (C-2), 67.6 (CH_2Ph), 70.2 (C-6), 71.4 (C-5), 71.6 (*C*H$(Me)_2$), 72.1 (C-4), 72.8 (C-3), 96.0 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.4 (C-Ar), 158.8 (CO); HRMS calcd for $C_{17}H_{25}O_9N_2S$ $[M-H]^-$ 433.1286, found 433.1286.

(2*R*,3*S*,4*R*,5*R*,6*S*)-5-Amino-3,4-dihydroxy-6-isopropoxytetrahydro-2*H*-pyran-2-yl)methyl sulfamate (29)



Prepared according to general procedure A using carbamate **28** (108 mg, 0.25 mmol), MeOH (4 mL) and CH_2Cl_2 (4 mL) for 1 h to give a clear oil (75 mg, 0.25 mmol, 100%); R_f 0.02 (10% MeOH/EtOAc; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 1368 (SO), 1179 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.22 (3H, d, J = 6.2 Hz, CH_3), 1.29 (3H, d, J = 6.2 Hz, CH_3), 2.69 (1H, dd, J = 3.7 and 10.0 Hz, H-2), 3.31 (1H, dd, J = 9.0 and 10.0 Hz, H-4), 3.52 (1H, dd, J = 9.0 and 10.0 Hz, H-3), 3.92 (1H, ddd, J = 1.9, 5.9 and 10.0 Hz, H-5), 3.97 (1H, sept, J = 6.2 Hz, C*H*(Me)$_2$), 4.28 (1H, dd, J = 5.9 and 10.7 Hz, H-6$_a$), 4.41 (1H, dd, J = 1.9 and 10.7 Hz, H-6$_b$), 4.97 (1H, d, J = 3.7 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 21.9 (CH_3), 23.7 (CH_3), 56.8 (C-2), 70.1 (C-6), 71.6 (*C*H(CH$_3$)$_2$), 71.8 (C-5), 71.8 (C-4), 75.5 (C-3), 98.2 (C-1); HRMS calcd for $C_9H_{19}O_7N_2S$ $[M-H]^-$ 299.0918, found 299.0914.

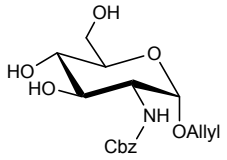
Ammonium ((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-2-isopropoxy-6-((sulfamoyloxy) methyl)tetrahydro-2*H*-pyran-3-yl)sulfamate (30)



Prepared according to general procedure B, using amine **29** (70 mg, 0.23 mmol, 1 eq.), de-ionised water (2 mL), and pyridine-sulfur trioxide complex (41 mg, 0.26 mmol, 1.1 eq.). After 30 min further SO_3.pyridine complex (15 mg, 0.09 mmol, 0.4 eq.) was added, the pH of the mixture re-adjusted to pH 9-10. The mixture was stirred at room temperature for 1 h and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 70:30:3 to 50:50:5 CH_2Cl_2/MeOH/NH_4OH. Product containing fractions were evaporated, dissolved in MeOH (5 mL) and filtered. The solvent was removed *in vacuo*, the residue dissolved in water (1 mL), frozen and lyophilized to give a white solid (24 mg, 27%); R_f 0.1 (70:30:3 CH_2Cl_2/MeOH/NH_4OH; anisaldehyde); mp 50-70 °C; $[\alpha]_D^{22.6}$ +97.3° (c = 0.30, MeOH); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3222 br, 3069, 2976, 2932, 1360 (SO), 1172 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.24-1.29 (6H, 2 × d, J = 6.2 Hz, 2 × CH_3), 3.25 (1H, dd, J = 3.7 and 10.2 Hz, H-2), 3.38 (1H, app t, J = 9.6 Hz, H-4), 3.57 (1H, dd, J = 9.6 and 10.2 Hz, H-3), 3.91 (1H, ddd, J = 1.9, 6.0 and 9.6 Hz, H-5), 3.96 (1H, sept, J = 6.2 Hz,

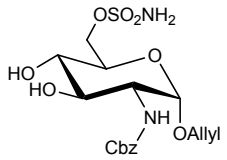
C*H*$(Me)_2$), 4.28 (1H, dd, *J* = 6.0 and 10.6 Hz, H-6_a), 4.42 (1H, dd, *J* = 1.9 and 10.6 Hz, H-6_b), 5.23 (1H, d, *J* = 3.7 Hz, H-1); ^{13}C NMR (125 MHz; D_2O) δ_C 20.6 (CH_3), 22.3 (CH_3), 57.5 (C-2), 68.9 (C-6), 69.2 (C-5), 69.6 (C-4), 71.3 (C-3), 71.5 (*C*HMe_2), 95.8 (C-1); HRMS calcd for $C_9H_{19}O_{10}N_2S_2$ [M-H]$^-$ 379.0487, found 379.0484.

Benzyl ((2*S*,3*R*,4*R*,5*S*,6*R*)-2-(allyloxy)-4,5-dihydroxy-6-(hydroxymethyl) tetrahydro-2*H*-pyran-3-yl)carbamate[2] (31)



Benzyl carbamate protected glucosamine **3** (6 g, 19 mmol, 1 eq.) was dissolved in allyl alcohol (40 mL) and HCl in dioxane (5 mL, 4 M) was added. The mixture was heated to 60 °C for 4 h, allowed to cool, and the solvent removed *in vacuo*. The mixture was purified by MPLC on SiO_2, with a gradient elution from 0-12% MeOH/CH_2Cl_2, to give a white solid (3.53 g, 10 mmol, 52%); R_f 0.5 (10% MeOH/CH_2Cl_2; anisaldehyde); mp 135-138 °C; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{23.1}$ +17.4° (c = 0.46, EtOH); IR ν_{max}/cm^{-1} 3309, 2921, 1686 (carbamate I), 1536 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.38-3.42 (1H, m, H-4), 3.62 (1H, ddd, *J* = 2.0 , 5.9 and 9.6 Hz, H-5), 3.67 (2H, m, H-2 and H-3), 3.72 (1H, dd, *J* = 5.9 and 12.0 Hz, H-6_a), 3.85 (1H, dd, *J* = 2.0 and 12.0 Hz, H-6_b), 4.03 (1H, dd, *J* = 6.0 and 13.1 Hz, OC*H*$_a$H$_b$CHCH_2), 4.23 (1H, dd, *J* = 5.0 and 13.1 Hz, OCH_a*H*$_b$CHCH_2), 4.88 (1H, d, *J* = 2.6 Hz, H-1), 5.09-5.20 (3H, m, C*H*$_a$H$_b$CHCH_2O and CH_2Ph), 5.34 (1H, ddd, *J* = 1.7, 2.6 and 17.1 Hz, CH_a*H*$_b$CHCH_2O), 5.90-5.99 (1H, m, OCH_2C*H*CH_2), 7.31-7.43 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 57.2 (C-2), 62.8 (C-6), 67.6 (CH_2Ph), 69.2 (CH_2CH*C*H_2O), 72.3 (C-4), 73.0 (C-3), 74.0 (C-5), 98.1 (C-1), 117.5 (*C*H_2CHCH_2O), 128.9 (C-Ar), 129.0 (C-Ar), 129.4 (C-Ar), 135.4 (C-Ar), 138.4 (CH_2*C*HCH_2O), 158.8 (*C*O_2Bn); HRMS calcd for $C_{17}H_{22}O_7N_1$ [M-H]$^-$ 352.1402, found 352.1409.

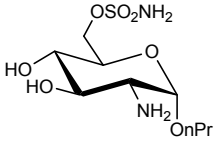
((2*R*,3*S*,4*R*,5*R*,6*S*)-6-(Allyloxy)-5-(((benzyloxy)carbonyl)amino)-3,4-dihydroxy tetrahydro-2*H*-pyran-2-yl)methyl sulfamate (32)



Prepared according to sulfamoylation method 1 using sulfamoyl chloride (11.4 mL, 1.0 M in toluene, 11.4 mmol, 2 eq.), alcohol **31** (2.0 g, 5.7 mmol, 1 eq.), and DMA (15 mL) at -20 °C. The mixture was allowed to stir at -20 °C for 1 h, and allowed to warm to 10 °C over 45 min.

The reaction was cooled to -20 °C and further sulfamoyl chloride (5.7 mL, 1.0 M in toluene, 5.7 mmol, 1 eq.) was added. The reaction was allowed to warm to 10 °C over 45 min, quenched with water, and extracted with EtOAc (50 mL). Saturated aqueous NaCl solution was added, and the mixture extracted with CH_2Cl_2 (3 × 50 mL). The organics were combined, dried ($MgSO_4$), and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 50% EtOAc/Petrol to 100% EtOAc to give a clear glass. (970 mg, 2.24 mmol, 40 %); R_f 0.2 (EtOAc; anisaldehyde); λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{23.2}$ +83° (c = 0.51, EtOH); IR ν_{max}/cm^{-1} 3449, 3384, 3331, 3235, 2915, 1681 (carbamate I), 1538 (carbamate II), 1370 (SO), 1180 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.35-3.43 (1H, m, H-4), 3.65-3.69 (2H, m, H-2 and H-3), 3.85 (1H, ddd, *J* = 1.6, 6.0 and 10.2 Hz, H-5), 4.04 (1H, dd, *J* = 6.0 and 13.1 Hz, OC*H*$_a$H$_b$CHCH$_2$), 4.22 (1H, dd, *J* = 5.0 and 13.1 Hz, OCH$_a$*H*$_b$CHCH$_2$), 4.29 (1H, dd, *J* = 6.0 and 10.7 Hz, H-6$_a$), 4.43 (1H, dd, *J* = 1.6 and 10.7 Hz, H-6$_b$), 4.89 (1H, d, H-1), 5.11 (1H, d, *J* = 12.5 Hz, C*H*$_a$H$_b$Ph), 5.16 (1H, d, *J* = 12.5 Hz, CH$_a$*H*$_b$Ph), 5.20 (1H, dd, *J* = 1.3 and 10.6 Hz, C*H*$_a$H$_b$CHCH$_2$O), 5.27-5.37 (1H, app dq, *J* = 1.3 and 17.5 Hz, CH$_a$*H*$_b$CHCH$_2$O), 5.90-6.00 (1H, m, CH$_2$C*H*CH$_3$), 7.30-7.43 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 57.1 (C-2), 67.6 (*C*H$_2$Ph), 69.5 (CH$_2$CH*C*H$_2$O), 70.1 (C-6), 71.5 (C-5), 72.1 (C-4), 72.9 (C-3), 98.1 (C-1), 117.8 (*C*H$_2$CHCH$_2$O), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 135.3 (CH$_2$*C*HCH$_2$O), 138.3 (C-Ar), 158.8 (CO); HRMS calcd for $C_{17}H_{23}O_9N_2S_1$ [M-H]$^-$ 431.1130, found 431.1126.

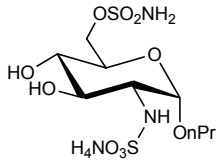
((2*R*,3*S*,4*R*,5*R*,6*S*)-5-Amino-3,4-dihydroxy-6-propoxytetrahydro-2*H*-pyran-2-yl)methyl sulfamate (33)



Prepared according to general procedure A using carbamate **32** (150 mg, 0.35 mmol), MeOH (2 mL) and CH_2Cl_2 (2 mL) for 2 h to give a clear glass (104 mg, 0.35 mmol, 100%); R_f 0.15 (CH_2Cl_2:MeOH 70:30; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3348, 3299, 2965, 2932, 1359 (SO), 1176 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.02 (3H, t, *J* = 7.4 Hz, CH$_2$C*H*$_3$), 1.65-1.74 (2H, m, C*H*$_2$CH$_3$), 2.70 (1H, dd, *J* = 3.6 and 9.9 Hz, H-2), 3.32 (1H, dd, *J* = 9.0 and 9.9 Hz, H-4), 3.44 (1H, *J* = 6.4 and 9.6 Hz, CH$_3$CH$_2$C*H*$_a$H$_b$O), 3.53 (1H, dd, *J* = 9.0 and 9.9 Hz, H-3), 3.75 (1H, dt, *J* = 9.6 and 6.7 Hz, CH$_3$CH$_2$CH$_a$*H*$_b$O), 3.85 (1H, ddd, *J* = 1.9, 5.9 and 9.9 Hz, H-5), 4.28 (1H, dd, *J* = 5.9 and 10.7 Hz, H-6$_a$), 4.42 (1H, dd, *J* = 1.9 and 10.7 Hz, H-6$_b$), 4.84 (1H, d, *J* = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 11.1 (CH$_3$),

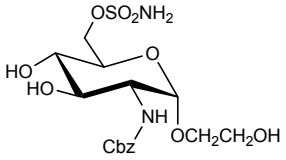
23.8 (CH_2CH_3), 57.0 (C-2), 70.1 (C-6), 70.8 ($CH_2CH_2CH_3$), 71.7 (C-5), 71.8 (C-4), 75.7 (C-3), 99.8 (C-1); HRMS calcd for $C_9H_{19}O_7N_2S$ $[M-H]^-$ 299.0918, found 299.0913.

Ammonium ((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-2-propoxy-6-((sulfamoyloxy) methyl)tetrahydro-2*H*-pyran-3-yl)sulfamate (34)



Prepared according to general procedure B, using amine **33** (100 mg, 0.33 mmol, 1 eq.), de-ionised water (4 mL) and pyridine-sulfur trioxide complex (79 mg, 0.50 mmol, 2 eq.) for 1 h. The crude product was purified by MPLC on SiO_2 with a gradient elution from 70:30:3 to 50:50:5 CH_2Cl_2/MeOH/NH_4OH. Product containing fractions were evaporated, the residue dissolved in water (1 mL) and lyophilized to give a white solid (50 mg, 0.13 mmol, 39%); R_f 0.1 (CH_2Cl_2:MeOH:NH_4OH 70:30:3; anisaldehyhde); mp 50-60 °C; $[\alpha]_D^{22.2}$ +48.0° (c = 0.10, MeOH); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3224, 3085, 2968, 2937, 1359 (SO), 1171 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.01 (3H, t, J = 7.4 Hz, CH_2CH_3), 1.65-1.74 (2H, m, CH_2CH_3), 3.27 (1H, dd, J = 3.6 and 10.1 Hz, H-2), 3.40 (1H, dd, J = 8.8 and 10.0 Hz, H-4), 3.48 (1H, dt, J = 9.5 and 6.5 Hz, $CH_aH_bCH_2CH_3$), 3.60 (1H, dd, J = 8.8 and 10.1 Hz, H-3), 3.71 (1H, dt, J = 9.5 and 6.8 Hz, $CH_aH_bCH_2CH_3$), 3.84 (1H, ddd, J = 1.9, 6.0 and 10.0 Hz, H-5), 4.29 (1H, dd, J = 6.0 and 10.7 Hz, H-6_a), 4.43 (1H, dd, J = 1.9 and 10.7 Hz, H-6_b), 5.10 (1H, d, J = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 11.1 (CH_2CH_3), 23.8 (CH_2CH_3), 59.6 (C-2), 70.2 (C-6), 71.0 ($CH_2CH_2CH_3$), 71.1 (C-5), 72.0 (C-4), 74.1(C-3), 99.3 (C-1); HRMS calcd for $C_9H_{19}O_{10}N_2S_2$ $[M-H]^-$ 379.0487, found 379.0489.

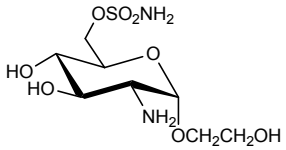
((2*R*,3*S*,4*R*,5*R*,6*S*)-5-(((Benzyloxy)carbonyl)amino)-3,4-dihydroxy-6-(2-hydroxyethoxy)tetrahydro-2*H*-pyran-2-yl)methyl sulfamate (35)



Allyl ether **32** (200 mg, 0.46 mmol) was dissolved in methanol (10 mL), and ozone was bubbled through the solution at -78 °C for 30 min. The mixture was allowed to stir at -78 °C to r.t. for 2 h and then $NaBH_4$ was added, and stirred for 1 h. The solvent was removed *in vacuo,* and the residue purified by MPLC on SiO_2 with a gradient elution from 5-12% MeOH/CH_2Cl_2 to give a white solid (140 mg, 0.32 mmol, 69%); R_f 0.5 (10% MeOH/CH_2Cl_2; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3335, 3094, 2923, 1693 (carbamate I),

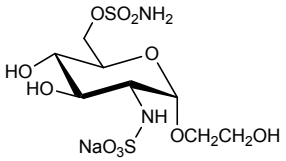
1535 (carbamate II), 1365 (SO), 1178 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.39 (1H, dd, *J* = 8.8 and 9.9 Hz, H-4), 3.48-3.55 (1H, m, C*H*$_a$H$_b$CH$_2$OH), 3.65-3.71 (2H, m, H-2 and H-3), 3.72-3.76 (2H, m, CH$_a$*H*$_b$CH$_2$OH and CH$_2$C*H*$_a$H$_b$OH), 3.80-3.84 (1H, m, CH$_2$CH$_a$*H*$_b$OH), 3.88 (1H, ddd, *J* = 1.9, 6.0 and 9.9 Hz, H-5), 4.29 (1H, dd, *J* = 6.0 and 10.9 Hz, H-6$_a$), 4.44 (1H, dd, *J* = 1.9 and 10.9 Hz, H-6$_b$), 4.83 (1H, d, *J* = 3.3 Hz, H-1), 5.13 (2H, s, CH_2Ph), 7.30-7.44 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 57.1 (C-2), 62.1 (CH$_2$*C*H$_2$OH), 67.7 (*C*H$_2$Ph), 70.1 (C-6), 70.5 (*C*H$_2$CH$_2$OH), 71.5 (C-5), 72.0 (C-4), 73.4 (C-3), 99.5 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 159.0 (CO); HRMS calcd for $C_{16}H_{23}O_{10}N_2S_1$ $[M-H]^-$ 436.1079, found 436.1085.

((2*R*,3*S*,4*R*,5*R*,6*S*)-5-Amino-3,4-dihydroxy-6-(2-hydroxyethoxy) tetrahydro-2*H*-pyran-2-yl)methyl sulfamate (36)



Prepared according to general procedure A using alcohol **35** (135 mg, 0.31 mmol), MeOH (5 mL) and CH_2Cl_2 (1 mL) for 3 h to give a clear gum (70 mg, 78%); R_f 0.2 (MeOH; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3360, 3286, 3100, 2939, 2909, 1351 (SO), 1188 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 2.70 (1H, dd, *J* = 3.6 and 10.0 Hz, H-2), 3.32 (1H, dd, *J* = 9.0 and 10.1 Hz, H-4), 4.87 (1H, d, *J* = 3.6 Hz, H-1), 3.53-3.59 (2H, m, H-3 and C*H*$_a$CH$_b$CH$_2$OH), 3.76 (2H, m, CH$_2$C*H*$_2$OH), 3.85 (1H, ddd, *J* = 3.7, 5.0 and 10.6 Hz, CH$_a$C*H*$_b$CH$_2$OH), 3.89 (1H, ddd, *J* = 1.9, 5.8 and 10.1 Hz, H-5), 4.29 (1H, dd, *J* = 5.8 and 10.7 Hz, H-6$_a$), 4.43 (1H, dd, *J* =1.9 and 10.7 Hz, H-6$_b$); ^{13}C NMR (125 MHz; CD_3OD) δ_C 57.1 (C-2), 62.1 (CH_2OH), 70.1 (C-6), 70.6 (*C*H$_2$CH$_2$OH), 71.7 (C-5), 71.8 (C-4), 75.8 (C-3), 100.4 (C-1); HRMS calcd for $C_8H_{17}O_8N_2S_1$ $[M-H]^-$ 301.0711, found 301.0705.

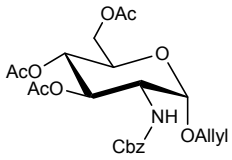
Sodium ((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-Dihydroxy-2-(2-hydroxyethoxy)-6-((sulfamoyloxy)methyl) tetrahydro-2*H*-pyran-3-yl)sulfamate (37)



Prepared according to general procedure B, using amine **36** (65 mg, 0.22 mmol, 1 eq.), de-ionised water (1.5 mL) and pyridine-sulfur trioxide complex (40 mg, 0.26 mmol, 1.2 eq.) for 1 h. The solvent was removed *in vacuo* and the residue was purified by MPLC on C-18 reversed phase SiO_2 with a gradient elution from 20-50% MeOH/H_2O. Product containing

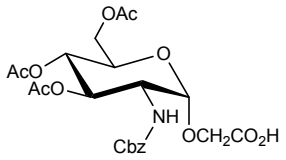
fractions were evaporated, dissolved in MeOH (5 mL) and filtered. The solvent was removed *in vacuo*. The residue was dissolved in water (3 mL), frozen and lyophilized to give a pale yellow solid (22 mg, 0.058 mmol, 27%); R_f 0.9 (MeOH; anisaldehyde); mp 184 °C dec.; $[\alpha]_D^{20.6}$ +50.0° (c = 0.08, MeOH); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3262 (br), 1359 (SO), 1175 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.30 (1H, dd, *J* = 3.6 and 10.2 Hz, H-2), 3.40 (1H, dd, *J* = 8.8 and 10.0 Hz, H-4), 3.58-3.63 (1H, m, 1H, C*H*$_a$CH$_b$CH$_2$OH), 3.65 (1H, dd, *J* = 8.8 and 10.2 Hz, H-3), 3.71-3.85 (3H, m, CH$_2$C*H*$_2$OH and CH$_a$C*H*$_b$CH$_2$OH), 3.89 (1H, ddd, *J* = 1.8, 6.0 and 10.0 Hz, H-5), 4.28 (1H, dd, *J* = 6.0 and 10.7 Hz, H-6$_a$), 4.44 (1H, dd, *J* = 1.8 and 10.7 Hz, H-6$_b$), 5.15 (1H, d, *J* = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 59.6 (C-2), 62.1 (CH$_2$*C*H$_2$OH), 70.2 (C-6), 70.6 (*C*H$_2$CH$_2$OH), 71.1 (C-5), 72.0 (C-4), 73.9 (C-3), 99.3 (C-1); HRMS calcd for $C_8H_{17}O_{11}N_2S_2$ [M-H]$^-$ 381.0279, found 381.0281.

(2*R*,3*S*,4*R*,5*R*,6*S*)-2-(Acetoxymethyl)-6-(allyloxy)-5-(((benzyloxy) carbonyl) amino) tetrahydro-2*H*-pyran-3,4-diyl diacetate (38)



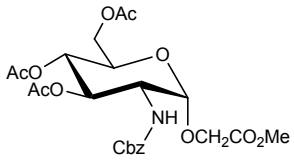
Alcohol **32** (500 mg, 1.41 mmol, 1 eq.) was dissolved in pyridine (3 mL) and Ac_2O (3 mL) was added. The mixture was stirred at room temperature for 18 h. The solvent was removed *in vacuo*, and the residue purified by MPLC on SiO_2 with a gradient elution from 20-80% EtOAc/petrol to give a white solid (650 mg, 1.35 mmol, 96%); R_f 0.5 (50% EtOAc/petrol; anisaldehyde); mp 67-69 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 1742, 1514; ^{1}H NMR (500 MHz; $CDCl_3$) δ_H 1.92 (3H, CH_3CO), 2.04 (3H, CH_3CO), 2.12 (3H, CH_3CO), 3.97-4.12 (4H, m, H-2, H-4, H-5, H-6$_a$), 4.19 (1H, dd, *J* = 5.5 and 12.6 Hz, OC*H*$_a$H$_b$CHCH$_2$), 4.27 (1H, dd, *J* = 4.4 and 12.3 Hz, H-6$_b$), 4.94 (1H, d, *J* = 3.5 Hz, H-1), 5.03-5.18 (3H, m, CH_2Ph and H-4), 5.22-5.34 (3H, m, OCH$_2$CHC*H*$_2$ and H-3), 5.85-5.94 (1H, m, OCH$_2$C*H*CH$_2$), 7.31-7.41 (5H, m, H-Ar); ^{13}C NMR (125 MHz; $CDCl_3$) δ_C 20.5 (*C*H$_3$CO), 20.6 (*C*H$_3$CO), 20.7 (*C*H$_3$CO), 53.7 (C-2), 62.0 (C-6), 67.0 (*C*H$_2$Ph), 67.9 (C-5), 68.3 (C-4), 68.9 (O*C*H$_2$CHCH$_2$), 71.3 (C-3), 96.6 (C-1), 118.5 (OCH$_2$CH*C*H$_2$), 128.1 (C-Ar), 128.2 (C-Ar), 128.5 (C-Ar), 133.0 (C-Ar), 136.2 (OCH$_2$*C*HCH$_2$), 169.4 (CH$_3$*C*O), 155.8 (*C*OCH$_2$Ph), 170.7 (CH$_3$*C*O), 171.0 (CH$_3$*C*O); HRMS calcd for $C_{23}H_{28}O_{10}N_1$ [M-H]$^-$ 478.1719, found 478.1721.

2-(((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-Diacetoxy-6-(acetoxymethyl)-3-(((benzyloxy) carbonyl)amino)tetrahydro-2*H*-pyran-2-yl)oxy)acetic acid (39)



Allyl ether **38** (3.0 g, 6.2 mmol) was dissolved in a mixture of CH_2Cl_2:MeCN:H_2O (10 mL:10 mL:15 mL). $NaIO_4$ (10.7 g, 50 mmol, 8 eq.) was added, followed by $RuCl_3$ (50 mg, 0.24 mmol, 0.04 eq.) and the mixture was stirred at room temperature for 30 minutes. The reaction was quenched with water, partitioned between CH_2Cl_2 (5 × 50 mL), and water (100 mL). The organic extracts were combined, washed with brine (50 mL), dried over $MgSO_4$ and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 90:10:1 to 75:25:2.5 CH_2Cl_2/MeOH/NH_4OH to give a clear glass (1.85g 3.7 mmol, 60%); R_f 0.15 (25% MeOH/EtOAc; anisaldehyde); mp 82-85 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 1739, 1586, 1535; ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.85 (3H, s, CH_3CO), 2.03 (3H, s, CH_3CO), 2.09 (3H, s, CH_3CO), 4.02 (1H, dd, J = 3.2 and 10.4 Hz, H-2), 4.12 (1H, d, J = 12.3 Hz, CH_aH$_b$CO$_2$H), 4.17 (1H, app. d, J = 10.3 Hz, H-5), 4.24-4.32 (3H, m, CH_2Ph and CH$_a$H$_b$CO$_2$H), 5.00 (1H, d, J = 3.2 Hz, H-1), 5.02-5.10 (2H, m, H-4 and H-6$_a$), 5.18 (1H, d, J = 12.4 Hz, H-6$_b$), 5.33 (1H, app. t, J = 10.4 Hz, H-3), 7.30-7.40 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 20.6 (2 × *C*H$_3$CO), 20.7 (*C*H$_3$CO), 55.0 (C-2), 63.4 (*C*H$_2$CO$_2$H), 67.5 (C-6), 67.8 (*C*H$_2$Ph), 69.1 (C-5), 70.2 (C-4), 73.2 (C-3), 99.1 (C-1), 128.7 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.5 (C-Ar), 158.7 (*C*OCH$_2$Ph), 171.4 (CH$_3$*C*O), 171.8 (CH$_3$*C*O), 172.4 (CH$_3$*C*O), 175.4 (CO_2H); HRMS calcd for $C_{22}H_{26}O_{12}N_1$ [M-H]$^-$ 496.1460, found 496.1474**.**

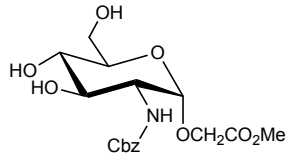
(2*R*,3*S*,4*R*,5*R*,6*S*)-2-(Acetoxymethyl)-5-(((benzyloxy)carbonyl)amino)-6-(2-methoxy-2-oxoethoxy)tetrahydro-2*H*-pyran-3,4-diyl diacetate (40)



Carboxylic acid **39** (1.5 g, 3.0 mmol, 1 eq.) was dissolved in MeCN (30 mL) and $Cs_2CO_{3(s)}$ (1.97 g, 6.0 mmol, 2 eq.) was added followed by methyl iodide (371 µL, 6.0 mmol, 2 eq.). The mixture was stirred at room temperature for 18 h, filtered, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 20-80% EtOAc/Petrol, to give a clear gum, (1.19 g, 2.32 mmol, 77%); R_f 0.4 (50% EtOAc/Petrol; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 1739, 1518; ^{1}H NMR (500 MHz;

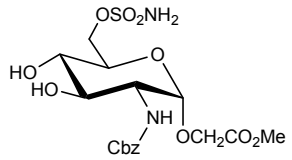
CD_3OD) δ_H 1.89 (3H, s, CH_3CO_2R), 2.04 (3H, s, CH_3CO_2R), 2.09 (3H, s, CH_3CO_2R), 3.79 (3H, s, CO_2CH_3), 4.02 (1H, dd, J = 3.7 and 10.7 Hz, H-2), 4.13 (1H, dd, J = 2.2 and 12.3 Hz, H-6_a), 4.19 (1H, ddd, J = 2.2, 4.2 and 10.2 Hz, H-5), 4.29 (1H, dd, J = 4.2 and 12.3 Hz, H-6_b), 4.34 (2H, s, CH_2CO_2Me), 5.01 (1H, d, J = 3.7 Hz, H-1), 5.07 (1H, dd, J = 9.7 and 10.2 Hz, H-4), 5.10 (1H, d, J = 12.6 Hz, CH_aH_bPh), 5.19 (1H, d, J = 12.6 Hz, CH_aH_bPh), 5.31 (1H, dd, J = 9.7 and 10.7 Hz, H-3), 7.30-7.42 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 20.5 (CH_3CO), 20.6 (2 × CH_3CO), 52.6 (CO_2CH_3), 55.0 (C-2), 63.2 (C-6), 66.0 (CH_2CO_2Me), 67.7 (CH_2Ph), 69.5 (C-5), 70.0 (C-4), 72.5 (C-3), 99.6 (C-1), 128.8 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 158.5 (NCO_2CH_2Ph), 171.3 (CO_2R), 172.0 (CO_2R), 172.1 (CO_2R), 172.4 (CO_2Me); MS (ESI-) *m/z* 510.2 $[M-H]^-$; HRMS calc for $C_{23}H_{33}N_2O_{12}$ $[M+NH_4OAc]^+$ 529.2028, found 529.2039.

Methyl 2-(((2*S*,3*R*,4*R*,5*S*,6*R*)-3-(((benzyloxy)carbonyl)amino)-4,5-dihydroxy-6-(hydroxymethyl)tetrahydro-2*H*-pyran-2-yl)oxy)acetate (41)



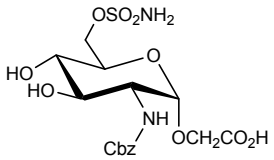
$NaOMe_{(s)}$ (8 mg, 0.16 mmol, 0.2 eq.) was added to methyl ester **40** (400 mg, 0.78 mmol, 1 eq.) in MeOH (5 mL) at room temperature, and the mixture was stirred at room temperature for 1 h. The solvent was removed *in vacuo*, and the residue purified by MPLC on SiO_2 with a gradient elution from 0-20% MeOH/EtOAc to give a white solid (300 mg, 0.78 mmol, 100%); R_f 0.5 (5% MeOH/EtOAc; anisaldehyde); mp 150-152 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3489, 3327, 3268, 2945, 2890, 1721, 1685, 1530; ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.39 (1H, app t, J = 9.0 Hz, H-4), 3.65 (1H, ddd, J = 2.1, 5.8 and 9.8 Hz, H-5), 3.68-3.74 (3H, m, H-2, H-3 and H-6_a), 3.77 (3H, s, CO_2CH_3), 3.85 (1H, dd, J = 2.1 and 11.8 Hz, H-6_b), 4.25 (1H, d, J = 16.4 Hz, $CH_aH_bCO_2Me$), 4.31 (1H, d, J = 16.4 Hz, $CH_aH_bCO_2Me$), 4.93 (1H, d, J = 3.1 Hz, H-1), 5.11 (1H, d, J = 12.4 Hz, CH_aH_bPh), 5.15 (1H, d, J = 12.4 Hz, CH_aH_bPh), 7.39-7.43 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 52.5 (CO_2CH_3), 57.0 (C-2), 62.7 (C-6), 65.2 ($CH_2CO_2CH_3$), 67.6 (CH_2Ph), 72.1 (C-4), 73.0 (C-3), 74.4 (C-5), 99.4 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 159.0 ($NHCO_2Bn$), 172.5 (CO_2Me); HRMS calcd for $C_{17}H_{22}N_1O_9$ $[M-H]^-$ 384.1300, found 384.1305.

Methyl 2-(((2*S*,3*R*,4*R*,5*S*,6*R*)-3-(((benzyloxy)carbonyl)amino)-4,5-dihydroxy-6-((sulfamoyloxy)methyl)tetrahydro-2*H*-pyran-2-yl)oxy)acetate (42)



Prepared according to sulfamoylation method 2 using sulfamoyl chloride (0.78 mL, 1 M in MeCN, 0.78 mmol, 1.5 eq.), alcohol **41** (200 mg, 0.52 mmol, 1 eq.) and DMF (4 mL) at -40 °C. The residue was purified by MPLC on SiO_2 with a gradient elution from 50% EtOAc/petrol to 100% EtOAc to 7 % MeOH/EtOAc to give a white solid. (162 mg, 0.35 mmol, 67 %); R_f 0.2 (EtOAc; anisaldehyde); mp 136-137 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3432, 3389, 3248, 3242, 1760 (CO ester), 1686 (carbamate I), 1541 (carbamate II), 1372 (SO), 1180 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.38-3.44 (1H, m, H-4), 3.67-3.74 (2H, m, H-2 and H-3), 3.77 (3H, s, OMe), 3.93 (1H, ddd, *J* = 1.7, 5.8 and 9.9 Hz, H-5), 4.244.33 (3H, m, H-6$_a$ and C*H*$_2$CO$_2$Me), 4.42 (1H, dd, *J* = 1.7 and 10.9 Hz, H-6$_b$), 4.93 (1H, d, *J* = 2.9 Hz, H-1), 5.13 (1H, d, *J* = 12.6 Hz, C*H*$_a$H$_b$Ph), 5.16 (1H, d, *J* = 12.6 Hz, CH$_a$*H*$_b$Ph), 7.30-7.45 (5H, m, H-Ar); ^{1}H NMR (500 MHz; DMSO-*d*$_6$) δ_H 3.16-3.24 (1H, m, H-4), 3.45-3.58 (2H, m, H-2 and H-3), 3.68 (3H, s, OMe), 3.80 (1H, ddd, *J* = 1.7, 6.0 and 10.1 Hz, H-5), 4.13 (1H, dd, *J* = 6.0 and 10.7 Hz, H-6$_a$), 4.19-4.29 (3H, m, CH$_2$CO$_2$Me and H-6$_b$), 4.89 (1H, d, *J* = 3.3 Hz, H-1), 4.97 (1H, d, *J* = 5.7 Hz, OH-3), 5.08 (2H, s, CH$_2$Ph), 5.38 (1H, d, *J* = 6.3 Hz, OH-4), 7.12 (1H, d, *J* = 8.0 Hz, N*H*CO$_2$Bn), 7.33-7.37 (1H, m, H-Ar), 7.38-7.43 (4H, m, H-Ar), 7.50 (2H, br s, SONH$_2$); ^{13}C NMR (125 MHz; CD_3OD) δ_C 52.5 (CO$_2$*C*H$_3$), 56.9 (C-2), 65.6 (*C*H$_2$CO$_2$Me), 67.7 (CH$_2$Ph), 70.0 (C-6), 71.8 (C-4), 71.9 (C-5), 72.9 (C-3), 99.6 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 158.9 (NH*C*O$_2$Bn), 172.4 (*C*O$_2$Me); HRMS calcd for $C_{17}H_{23}O_{11}N_2S_1$ $[M-H]^-$ 463.1028, found 463.1031.

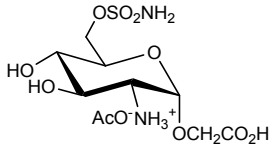
2-(((2*S*,3*R*,4*R*,5*S*,6*R*)-3-(((benzyloxy)carbonyl)amino)-4,5-dihydroxy-6-((sulfamoyloxy)methyl)tetrahydro-2*H*-pyran-2-yl)oxy)acetic acid (43)



To methyl ester **42** (100 mg, 0.22 mmol, 1 eq.) in THF (2 mL) at room temperature was added NaOH (216 μL, 2 M aq., 0.43 mmol, 2 eq.), and the reaction was stirred at room temperature for 2 hours. HCl (324 μL, 2 M aq., 0.65 mmol, 3 eq.) was added, and the mixture extracted with EtOAc (10 mL) and CH_2Cl_2 (10 mL). The organic extracts were combined,

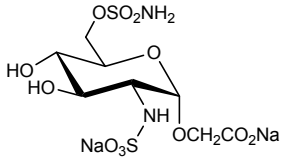
dried ($MgSO_4$) and the solvent removed *in vacuo* to give a clear gum (80 mg, 0.18 mmol, 82%); R_f 0.15 (20% MeOH/EtOAc; ninhydrin); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3400 br, 1693 (str, br), 1531, 1358 (SO), 1178 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.38-3.42 (1H, m, H-4), 3.66-3.72 (2H, m, H-2 and H-3), 3.88 (1H, ddd, *J* = 1.6 , 5.7 and 9.9 Hz, H-5), 4.17 (1H, d, *J* = 16.6 Hz, CH_aH$_b$$CO_2$H), 4.24-4.31 (2H, m, H-$6_a$ and CH$_a$$H_b$$CO_2$H), 4.41 (1H, dd, *J* = 1.6 and 10.7 Hz, H-6_b), 4.90 (1H, d, *J* = 2.7 Hz, H-1), 5.12 (2H, s, CH_2Ph), 7.28-7.42 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 56.9 (C-2), 65.4 (*C*H_2CO_2H), 67.7 (CH_2Ph), 70.0 (C-6), 71.8 (C-5), 71.9 (C-4), 73.1 (C-3), 99.5 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 159.0 (CO_2Bn), 173.6 (CO_2H); HRMS calcd for $C_{16}H_{21}O_{11}N_2S_1$ [M-H]$^-$ 449.0872, found 449.0864.

2-(((2*S*,3*R*,4*R*,5*S*,6*R*)-3-amino-4,5-dihydroxy-6-((sulfamoyloxy) methyl) tetrahydro-2H-pyran-2-yl)oxy)acetic acid (44)



Carbamate **43** (70 mg, 0.16 mmol) was dissolved in acetic acid (5 mL) and hydrogenated on a Thales H-cube on full H_2 mode through 5% Pd/C catalyst cartridge at 40 °C for 3 h, with constant recycling of reaction mixture. The solvent was removed *in vacuo* to give a clear gum. (63 mg, 100%); R_f 0.3 (50:50:5 EtOAc:MeOH:NH_4OH; ninhydrin); λ_{max}(EtOH)/nm < 220;IR ν_{max}/cm^{-1} 3012, 1710, 1365 (SO), 1172 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.20 (1H, dd, *J* = 3.6 and 10.6 Hz, H-2), 3.42 (1H, dd, *J* = 9.3 and 9.8 Hz, H-4), 3.85-3.92 (2H, m, H-3 and H-5), 4.00 (1H, d, *J* = 15.6 Hz, CH_aH$_b$$CO_2$H), 4.18 (1H, d, *J* = 15.6 Hz, CH$_a$$H_b$$CO_2$H), 4.33 (1H, dd, *J* = 5.4 and 10.9 Hz, H-6_a), 4.42 (1H, dd, *J* = 1.8 and 10.9 Hz, H-6_b), 5.11 (1H, d, *J* = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 20.9 (*C*$H_3CO_2^-$), 55.6 (C-2), 68.1 (*C*H_2CO_2H), 69.3 (C-6), 71.3 (C-4), 71.7 (C-3), 72.0 (C-5), 97.2 (C-1), 175.4 (CO_2H), 176.7 (CH_3*C*O_2^-); MS (ESI-) *m/z* 315.1 [M-H]$^-$, (ESI+) 317.2.3 [M+H]$^+$.

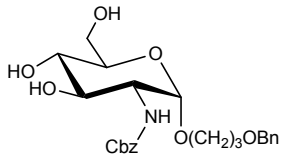
Disodium 2-(((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-6-((sulfamoyloxy) methyl)-3-(sulfoamino)tetrahydro-2*H*-pyran-2-yl)oxy)acetate (45)



Prepared according to general procedure B, using amine **44** (70 mg, 0.18 mmol), de-ionised water (2 mL) and pyridine-sulfur trioxide complex (59 mg, 0.37 mmol, 3.7 eq.) for 18 h. The

crude product was purified by MPLC on SiO_2 with a gradient elution from 50-80% MeOH/EtOAc. Product containing fractions were evaporated *in vacuo*. The residue was dissolved in water, frozen, and lyophilized to give a white solid (28 mg, 38%); R_f 0.7 (MeOH; ninhydrin); mp 150 °C dec.; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3224 br, 1587, 1356 (SO), 1176 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 3.29 (1H, dd, *J* = 3.6 and 10.1 Hz, H-2), 3.42 (1H, dd, *J* = 9.0 and 10.1 Hz, H-4), 3.74 (1H, dd, *J* = 9.0 and 10.1 Hz, H-3), 3.90 (1H, ddd, *J* = 1.7, 5.8 and 10.1 Hz, H-5), 4.05 (1H, d, *J* = 15.8 Hz, CH_aH$_b$CO$_2$H), 4.21 (1H, d, *J* = 15.8 Hz CH$_a$*H*$_b$CO$_2$H), 4.30 (1H, dd, *J* = 5.8 and 10.8 Hz, H-6$_a$), 4.42 (1H, d, *J* = 1.7 and 10.8 Hz, H-6$_b$), 5.11 (1H, d, *J* = 3.6 Hz, H-1); ^{1}H NMR (500 MHz; D_2O) δ_H 3.19 (1H, dd, *J* = 3.6 and 10.3 Hz, H-2), 3.47 (1H, dd, *J* = 9.2 and 10.1 Hz, H-4), 3.67 (1H, dd, *J* = 9.2 and 10.3 Hz, H-3), 3.89-3.95 (2H, m, H-5 and CH$_a$*H*$_b$CO$_2$H), 4.05 (1H, d, *J* = 15.3 Hz, C*H*$_a$H$_b$CO$_2$H), 4.36 (2H, d, *J* = 3.3 Hz, H-6), 5.06 (1H, d, *J* = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 59.5 (C-2), 67.5 (*C*H$_2$CO$_2$H), 70.0 (C-6), 71.4 (C-5), 71.9 (C-4), 73.9 (C-3), 99.9 (C-1), 175.7 (CO_2H); HRMS calcd for $C_8H_{15}N_2O_{12}S_2$ [M-H]$^-$ 395.0072, found 395.0057.

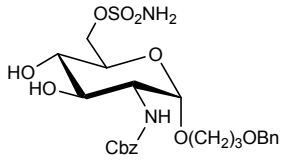
Benzyl ((2*S*,3*R*,4*R*,5*S*,6*R*)-2-(3-(benzyloxy)propoxy)-4,5-dihydroxy-6-(hydroxymethyl)tetrahydro-2*H*-pyran-3-yl)carbamate (46)



Compound **3** (1.5g, 4.8 mmol), 3-benzyloxy-1-propanol (5 mL), HCl in dioxane (2 mL, 4 M) and dioxane (20 mL) were combined and heated to 75 °C for 5 h. The mixture was allowed to cool to room temperature and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 0-5% MeOH/EtOAc. Product containing fractions were combined, evaporated, and re-purified by MPLC on SiO_2 with a gradient elution from 70% EtOAc/Petrol to 100% EtOAc to 8% MeOH/EtOAc to give a pale brown solid (685 mg, 1.49 mmol, 31%). R_f 0.5 (5% MeOH/EtOAc; anisaldehyde); mp 98-101 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3324, 2932, 2881, 1689 (carbamate I), 1536 (carbamate II); ^{1}H NMR (500 MHz; $CDCl_3$) δ_H 1.87 (2H, quint, C*H*$_2$CH$_2$OBn), 1.98 (1H, br t, *J* = 5.7 Hz, C$_6$OH), 2.72 (1H, br s, OH), 2.99 (1H, br s, OH), 3.47-3.72 (6H, m, H-3, H-4, H-5, H-6$_a$, CH$_2$O), 3.75-3.86 (4H, m, CH$_2$O, H-2, H-6$_b$), 4.47 (2H, s, CH$_2$OC*H*$_2$Ph), 4.80 (1H, d, *J* = 3.4 Hz, H-1), 5.11 (2H, s, NCO$_2$C*H*$_2$Ph), 5.32-5.38 (1H, d, *J* = 8.4 Hz, NH), 7.26-7.36 (10H, m, H-Ar); ^{13}C NMR (125 MHz; $CDCl_3$) δ_C 29.6 (OCH$_2$*C*H$_2$CH$_2$O), 55.4 (C-2), 62.4, 65.5

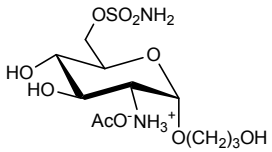
(NHCOCH$_2$Ph), 67.1, 67.5, 71.1, 73.0 (CH$_2$CH$_2$O*C*H$_2$Ph), 74.4, 97.5 (C-1), 127.7 (C-Ar), 128.4 (C-Ar), 128.5 (C-Ar), 128.6 (C-Ar), 138.2 (C-Ar), 157.2 (CO); HRMS calcd for $C_{24}H_{32}O_8N_1$ $[M+H]^+$ 462.2122, found 462.2119.

((2*R*,3*S*,4*R*,5*R*,6*S*)-5-(((benzyloxy)carbonyl)amino)-6-(3-(benzyloxy) propoxy)-3,4-dihydroxytetrahydro-2*H*-pyran-2-yl)methyl sulfamate (47)



Prepared according to sulfamoylation method 2 using sulfamoyl chloride (2.1 mL, 1 M in MeCN, 2.1 mmol, 1.5 eq.), compound **46** (650 mg, 1.4 mmol, 1 eq.), and DMF (8 mL). The residue was purified by MPLC on SiO_2 with gradient elution from 50% EtOAc/petrol to 100% EtOAc to give a white solid (435 mg, 57 %); R_f 0.2 (EtOAc; anisaldehyde); mp 137-139 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3336, 1684 (carbamate I), 1542 (carbamate II), 1372 (SO), 1182 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.86-1.95 (2H, m, OCH$_2$C*H$_2$*CH$_2$OBn), 3.36-3.42 (1H, m, H-4), 3.52-3.58 (1H, m, OC*H*$_a$H$_b$CH$_2$CH$_2$OBn), 3.61-3.68 (4H, m, H-2, H-3, OCH$_2$CH$_2$C*H$_2$*OBn), 3.81-3.89 (2H, m, H-5 and OCH$_a$*H*$_b$CH$_2$CH$_2$OBn), 4.28 (1H, dd, J = 5.8 and 10.7 Hz, H-6$_a$), 4.41 (1H, dd, J = 1.7 and 10.7 Hz, H-6$_b$), 4.50 (2H, s, CH$_2$OC*H$_2$*Ph), 4.83 (1H, d, J = 1.8 Hz, H-1), 5.11 (2H, s, NHCO$_2$C*H$_2$*Ph), 7.27-7.40 (10H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 30.7 (OCH$_2$*C*H$_2$CH$_2$OBn), 57.1 (C-2), 66.2 (O*C*H$_2$CH$_2$CH$_2$OBn), 67.6 (NHCO$_2$*C*H$_2$Ph), 68.2 (OCH$_2$CH$_2$*C*H$_2$OBn), 70.1 (C-6), 71.4 (C-5), 72.0 (C-4), 73.0 (C-3), 74.1 (CH$_2$O*C*H$_2$Ph), 99.1 (C-1), 128.7 (C-Ar), 128.9 (C-Ar), 129.0 (C-Ar), 129.1 (C-Ar), 129.4 (C-Ar), 129.5 (C-Ar), 138.2 (C-Ar), 139.8 (C-Ar), 158.8 (CO); HRMS calcd for $C_{24}H_{33}O_{10}N_2S_1$ $[M+Na]^+$ 541.1850, found 541.1846.

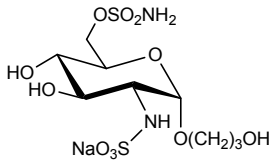
(2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-2-(3-hydroxypropoxy)-6-((sulfamoyloxy)methyl) tetrahydro-2*H*-pyran-3-aminium acetate (48)



Compound **47** (190 mg, 0.35 mmol) was dissolved in acetic acid (9 mL) and hydrogenated on a Thales H-cube at a hydrogen pressure of 20 bar through 5% Pd/C catalyst cartridge at 20 °C for 1 h, with constant recycling of the reaction mixture at a flow rate of 1 mL/minute. The solvent was removed *in vacuo* to give a clear gum, which was triturated with Et$_2$O (4 × 5

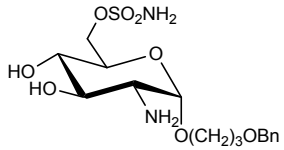
mL). The resulting gum was dried *in vacuo* at 40 °C for 18 h to give a clear glass (110 mg, 83%); R_f 0.1 (25% MeOH/EtOAc); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 2939 br, 1707 w, 1539 (CO_2^-), 1361 (SO), 1176 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.91 (2H, app. quin, *J* = 6.2 Hz, $CH_2CH_2CH_2OH$), 2.00 (3H, s, $CH_3CO_2^-$), 3.12 (1H, dd, *J* = 3.1 and 10.4 Hz, H-2), 3.40 (1H, app. t, *J* = 9.5 Hz, H-4), 3.63 (1H, dt, *J* = 9.8 and 6.2 Hz, $CH_aH_bCH_2CH_2OH$), 3.69-3.80 (3H, m, H-3 and CH_2OH), 3.87 (1H, ddd, *J* = 1.7, 5.7 and 9.5 Hz, H-5), 3.93 (1H, dt, *J* = 9.8 and 6.2 Hz, $CH_aH_bCH_2CH_2OH$), 4.31 (1H, dd, *J* = 5.7 and 10.9 Hz, H-6$_a$), 4.45 (1H, dd, *J* = 1.7 and 10.9 Hz, H-6$_b$), 5.01 (1H, d, *J* = 3.1 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 22.2 (CH_3 acetate), 33.2 ($CH_2CH_2CH_2OH$), 55.8 (C-2), 59.7 ($CH_2CH_2CH_2OH$), 66.4 ($CH_2CH_2CH_2OH$), 69.6 (C-6), 71.5 (C-4), 71.8 (C-5), 72.5 (C-3), 97.5 (C-1), 177.3 (CO); HRMS calcd for $C_9H_{21}N_2O_8S_1$ $[M+H]^+$ 317.1013, found 317.1017.

Sodium ((2*S*,3*R*,4*R*,5*S*,6*R*)-4,5-dihydroxy-2-(3-hydroxypropoxy)-6-((sulfamoyloxy)methyl)tetrahydro-2*H*-pyran-3-yl)sulfamate (49)



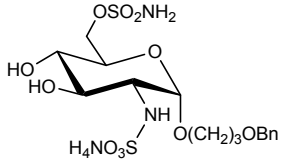
Prepared according to general procedure B, using compound **48** (100 mg, 0.27 mmol, 1 eq.), de-ionised water (5 mL) and pyridine-sulfur trioxide complex (126 mg, 0.53 mmol, 3 eq.) for 18 h. The crude product was purified by MPLC on SiO_2 with a gradient elution from 20-40% MeOH/EtOAc. Product containing fractions were evaporated *in vacuo* to give a pale glass (43 mg, 41%); R_f 0.3 (30% MeOH/EtOAc; anisaldehyde); mp 105-110 °C; $[\alpha]_D^{18.0}$ +85.71° (c = 0.21, MeOH); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3287, 2929, 1361 (SO), 1175 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.82-1.93 (2H, m, $CH_2CH_2CH_2OH$), 3.28 (1H, dd, *J* = 3.6 and 10.4 Hz, H-2), 3.40 (1H, dd, 9.6 and 10.1 Hz, H-4), 3.56-3.63 (2H, m, H-3 and $CH_aH_bCH_2CH_2OH$), 3.67-3.79 (2H, m, $CH_2CH_2CH_2OH$), 3.81-3.90 (1H, m, H-5), 4.44 (1H, dd, *J* = 2.0 and 10.8 Hz, H-6$_a$), $CH_aH_bCH_2CH_2OH$), 4.28 (1H, dd, *J* = 6.0 and 10.8 Hz, H-6$_b$), 5.11 (1H, d, *J* = 3.6 Hz H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 33.40 ($CH_2CH_2CH_2OH$), 59.54 (C-2), 59.94 ($CH_2CH_2CH_2OH$), 66.2 ($CH_2CH_2CH_2OH$), 70.2 (C-6), 71.1 (C-5), 71.9 (C-4), 74.0 (C-3), 99.3 (C-1); HRMS calcd for $C_9H_{19}N_2O_{11}S_1$ 395.0436 $[M-H]^-$, found 495.0417.

((2*R*,3*S*,4*R*,5*R*,6*S*)-5-amino-6-(3-(benzyloxy)propoxy)-3,4-dihydroxytetrahydro-2H-pyran-2-yl)methyl sulfamate (50)



Compound **47** (200 mg, 0.37 mmol) was dissolved in EtOH (10 mL) and hydrogenated on a Thales H-cube at a hydrogen pressure of 20 bar through 5% Pd/C catalyst cartridge at 20 °C for 1 h, with constant recycling of the reaction mixture at a flow rate of 1 mL/minute. The solvent was removed *in vacuo* to give a clear gum, which was purified by MPLC on SiO_2 with gradient elution from 15-30% MeOH/EtOAc to give a clear gum (113 mg, 75 %); R_f 0.1 (15% MeOH/EtOAc; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 2931, 1363 (SO), 1178 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.96 (2H, m, C*H*$_2$CH$_2$OBn), 2.63 (1H, dd, *J* = 3.6 and 9.9 Hz, H-2), 3.31 (2H, dd, *J* = 9.0 and 9.9 Hz, H-4), 3.48 (1H, dd, *J* = 9.0 and 9.9 Hz, H-3), 3.57 (1H, app. dt, *J* = 9.8 and 6.2 Hz, C*H*$_a$H$_b$O), 3.65 (2H, t, *J* = 6.3 Hz, C*H*$_2$OBn), 3.83 (1H, ddd, *J* = 1.9, 5.8 and 9.9 Hz, H-5), 3.90 (1H, app dt, *J* = 9.8 and 6.2 Hz, CH$_a$*H*$_b$O), 4.27 (1H, dd, *J* = 5.8 and 10.7 Hz, H-6$_a$), 4.40 (1H, dd, *J* = 1.9 and 10.7 Hz, H-6$_b$), 4.60 (2H, s, C*H*$_2$Ph), 4.81 (1H, d, *J* = 3.6 Hz, H-1), 7.29-7.34 (1H, m, H-Ar), 7.36-7.40 (4H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 30.8 (OCH$_2$*C*H$_2$CH$_2$OBn), 57.0 (C-2), 66.1 (O*C*H$_2$*C*H$_2$CH$_2$OBn), 68.2 (OCH$_2$*C*H$_2$*C*H$_2$OBn), 70.1 (C-6), 71.7 (C-4 and C-5), 74.0 (CH$_2$Ph), 76.1 (C-3), 100.3 (C-1), 128.7 (C-Ar), 128.9 (C-Ar), 129.4 (C-Ar), 139.8 (C-Ar); HRMS calcd for $C_{16}H_{25}N_2O_8S_1$ [M-H]$^-$ 405.1337, found 405.1339.

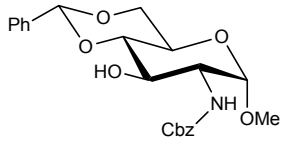
Ammonium ((2*S*,3*R*,4*R*,5*S*,6*R*)-2-(3-(benzyloxy)propoxy)-4,5-dihydroxy-6-((sulfamoyloxy) methyl)tetrahydro-2*H*-pyran-3-yl)sulfamate (51)



Prepared according to general procedure B, using compound **50** (100 mg, 0.25 mmol), de-ionised water (3 mL) and pyridine-sulfur trioxide complex (46 mg, 0.30 mmol, 2.2 eq.) for 18 h. The crude product was purified by MPLC on SiO_2 with gradient elution from 85:15:1.5 to 65:35:3.5 EtOAc:MeOH:NH_4OH to give a white solid (74 mg, 62%); R_f 0.2 (70:30:3 EtOAc/MeOH/NH_4OH; anisaldehyde); mp 85-90 °C; $[\alpha]_D^{22.7}$ +108.6° (c = 0.14, MeOH); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3246, 3064, 2880, 1363 (SO), 1175 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.90-2.02 (2H, m, OCH$_2$C*H*$_2$CH$_2$OBn), 3.28 (1H, dd, *J* = 3.6 and 10.2 Hz,

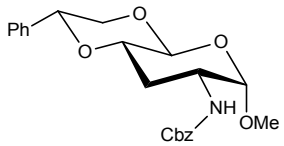
H-2), 3.41 (1H, dd, J = 8.9 and 10.0 Hz, H-4), 3.57-3.64 (2H, m, H-3 and OCH_aH$_b$CH$_2$CH$_2$OBn), 3.64-3.71 (2H, m, OCH$_2$CH$_2$CH_2OBn), 3.80-3.91 (2H, m, OCH$_a$H$_b$CH$_2$CH$_2$OBn and H-5), 4.27 (1H, dd, J = 6.0 and 10.7 Hz, H-6$_a$), 4.41 (1H, dd, J = 1.9 and 10.7 Hz, H-6$_b$), 4.56 (2H, s, CH_2Ph), 5.10 (1H, d, J = 3.6 Hz, H-1), 7.28-7.32 (1H, m, H-Ar), 7.35-7.41 (4H, m, H-Ar); ^{13}C NMR (125 MHz; CD$_3$OD) δ_C 30.8 (OCH$_2$CH$_2$CH$_2$OBn), 59.6 (C-2), 66.4 (OCH$_2$CH$_2$CH$_2$OBn), 68.4 (OCH$_2$CH$_2$CH$_2$OBn), 70.2 (C-6), 71.1 (C-5), 71.9 (C-4), 74.0 (CH$_2$Ph), 74.1 (C-3), 99.4 (C-1), 128.6 (C-Ar), 129.0 (C-Ar), 129.4 (C-Ar), 139.9 (C-Ar); HRMS calcd for $C_{16}H_{25}N_2O_{11}S_2$ [M-H]$^-$ 485.0905, found 485.0914.

Benzyl ((2*R*,4a*R*,6*S*,7*R*,8*R*,8a*S*)-8-hydroxy-6-methoxy-2-phenyl hexahydropyrano[3,2-*d*][1,3]dioxin-7-yl)carbamate[3] (52)



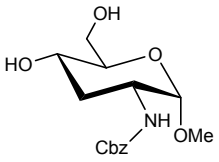
Compound **4** (200 mg, 0.6 mmol), benzaldehyde dimethyl acetal (230 μL, 1.52 mmol, 3 eq.), and *p*-toluenesulfonic acid (5 mg, cat.), were combined in DMF (5 mL) and heated to 75 °C for 3 h. The reaction mixture was diluted with EtOAc (20 mL), washed with brine (10 mL), dried over MgSO$_4$, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO$_2$ with gradient elution from 25% EtOAc/petrol to 100% EtOAc to give a white solid (197 mg, 78%); R_f 0.4 (40% EtOAc/petrol; anisaldehyde); mp 207-210 °C (lit.[4] 207-208 °C); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3313, 1685 (carbamate I), 1546 (carbamate II); ^{1}H NMR (500 MHz; CDCl$_3$) δ_H 2.68 (1H, d, J = 1.8 Hz, OH), 3.42 (3H, s, OCH$_3$), 3.61 (1H, app t, J = 8.5 Hz, H-4), 3.77-3.87 (2H, m, H-6$_a$ and H-5), 3.90-4.02 (2H, m, H-2 and H-3), 4.31 (1H, dd, J = 3.5 and 9.0 Hz, H-6$_b$), 4.77 (1H, d, J = 3.6 Hz, H-1), 5.12-5.21 (3H, m, CH$_2$Ph and NH), 5.59 (1H, s, PhCH(OR)$_2$), 7.33-7.44 (8H, m, H-Ar), 7.49-7.55 (2H, m, H-Ar); ^{13}C NMR (125 MHz; CDCl$_3$) δ_C 55.1 (OMe), 56.0 (C-2), 62.5 (C-5), 67.1 (CH$_2$Ph), 68.8 (C-6), 70.8 (C-3), 81.8 (C-4), 99.5 (C-1), 102.3 (PhCH(O)$_2$), 126.3 (C-Ar), 127.1 (C-Ar), 128.3 (C-Ar), 128.6 (C-Ar), 129.1 (C-Ar), 129.3 (C-Ar), 136.1 (C-Ar)137.1 (C-Ar), 156.8 (CO); HRMS calcd for $C_{22}H_{26}O_7N_1$ [M+H]$^+$ 416.1704, found 416.1705.

Benzyl ((2*R*,4a*R*,6*S*,7*R*,8a*S*)-6-methoxy-2-phenylhexahydropyrano [3,2-*d*][1,3] dioxin-7-yl)carbamate[5] (53)



Compound **52** (500 mg, 1.20 mmol, 1 eq.) and 1,1-thiocarbonyl diimidazole (322 mg, 1.81 mmol, 1.5 eq.) were combined in toluene (12 mL), degassed, and heated at reflux for 3 h under a nitrogen atmosphere. *Tris*(trimethylsilyl) silane (743 μL, 2.40 mmol, 2 eq.) and AIBN (604 μL, 0.2 M solution in toluene, 0.12 mmol, 0.1 eq.) were added and the mixture heated at reflux for 1 h. A further 0.1 eq. of AIBN solution was added and heating continued for a further 30 minutes. The solvent was removed *in vacuo*, and the residue purified by MPLC on SiO_2 with a gradient elution from 5-35% EtOAc/petrol to give a white solid (400 mg, 1.00 mmol, 83%); R_f 0.75 (40% EtOAc/Petrol; anisaldehyde); mp 180-183 °C (lit.[5] 175-176 °C); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3320, 1686 (carbamate I), 1539 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.91 (app. q, J = 11.5 Hz, H-3$_a$), 2.10 (1H, app. dt, J = 11.5 and 4.4 Hz, H-3$_b$), 3.46 (3H, s, OMe), 3.66-3.74 (2H, m, H-4 and H-5), 3.79 (1H, app. t, J = 10.0 Hz, H-6$_a$), 3.94 (1H, app. dt, J = 12.4 and 3.7 Hz, H-2), 4.23 (1H, dd, J = 4.4 and 10.0 Hz, H-6$_b$), 4.69 (1H, d, J = 3.7 Hz, H-1), 5.12 (2H, s, CH_2Ph), 5.64 (1H, s, $PhCH(O)_2$), 7.31-7.44 (8H, m, H-Ar), 7.46-7.51 (2H, m, H-Ar); ^{1}H NMR (500 MHz; $CDCl_3$) δ_H 1.83 (1H, app. q, J = 11.4 Hz, H-3$_a$), 2.23 (app. dt, J = 11.4 and 4.5 Hz, H-3$_b$), 3.40 (3H, s, OMe), 3.60-3.66 (1H, m, H-4), 3.69-3.77 (2H, m, H-5 and H-6$_a$), 3.98-4.06 (1H, m, H-2), 4.26 (1H, dd, J = 5.5 and 10.2 Hz, H-6$_b$), 4.63 (1H, d, J = 3.5 Hz, H-1), 5.05 (1H, d, J = 9.6 Hz, NH), 5.11 (2H, s, CH_2Ph), 5.54 (1H, s, $PhCH(O)_2$), 7.31-7.39 (8H, m, H-Ar), 7.46-7.49 (2H, m, H-Ar); ^{13}C NMR (125 MHz; $CDCl_3$) δ_C 31.2 (C-3), 49.3 (C-2), 55.1 (OMe), 64.0 (C-6), 67.0 (C-5), 69.3 (C-4), 98.0 (C-1), 101.8 ($PhCH(O)_2$), 126.2 (C-Ar), 128.2 (C-Ar), 128.3 (C-Ar), 128.4 (C-Ar), 128.6 (C-Ar), 129.1 (C-Ar), 136.2 (C-Ar), 137.4 (C-Ar), 155.5 (CO); HRMS calcd for $C_{22}H_{26}O_6N_1$ $[M-H]^-$ 400.1755, found 400.1757.

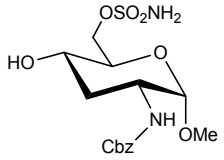
Benzyl ((2*S*,3*R*,5*S*,6*R*)-5-hydroxy-6-(hydroxymethyl)-2-methoxytetrahydro-2*H*-pyran-3-yl)carbamate (54)



para-Toluenesulfonic acid (10 mg. cat.) was added to a solution of compound **53** (170 mg, 0.43 mmol) in CH_2Cl_2 (6 mL) and methanol (6 mL), and the mixture was heated to 80 °C under microwave irradiation for 20 min. The mixture was diluted with CH_2Cl_2 (50 mL) and washed with K_2CO_3 (2 × 20 mL, 1 M aq.). The organic layer was dried over $MgSO_4$, filtered, and evaporated. The residue was purified by MPLC on SiO_2 with a gradient elution from 80% EtOAc/petrol to 100% EtOAc to give a white solid (95 mg, 72%); R_f 0.2 (80%

EtOAc/petrol; anisaldehyde); mp 109-111 °C; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{19.2}$ +52.3° (c = 0.11, MeOH); IR ν_{max}/cm^{-1} 3327, 2921, 1681 (carbamate I), 1538 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) 1.76 (1H, app. dt, *J* = 12.5 and 11.7 Hz, H-3$_a$), 2.02 (1H, app. t, *J* = 4.0 and 11.7 Hz, H-3$_b$), 3.40-3.50 (4H, m, H-5 and OMe), 3.57 (1H, app. td, *J* = 11.0 and 4.7 Hz, H-4), 3.69 (1H, dd, *J* = 5.8 and 11.8 Hz, H-6$_a$), 3.78 (1H, app dt, *J* = 12.8 and 4.0 Hz, H-2), 3.85 (1H, d, *J* = 2.2 and 11.8 Hz, H-6$_b$), 4.64 (1H, d, *J* = 4.0 Hz, H-1), 5.11 (2H, s, CH_2Ph), 7.30-7.42 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 34.6 (C-3), 50.9 (C-2), 55.3 (OMe), 62.8 (C-6), 66.2 (C-4), 67.4 (*C*H_2Ph), 74.5 (C-5), 98.7 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 140.8 (C-Ar), 160.7 (CO); HRMS calcd for $C_{15}H_{22}N_1O_6$ $[M+H]^+$ 312.1447, found 312.1442.

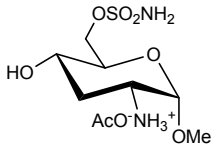
((2*R*,3*S*,5*R*,6*S*)-5-(((Benzyloxy)carbonyl)amino)-3-hydroxy-6-methoxy tetrahydro-2*H*-pyran-2-yl)methyl sulfamate (55)



Prepared according to sulfamoylation method 2 using sulfamoyl chloride (1.6 mL, 1 M in MeCN, 1.6 mmol, 1.5 eq.), compound **54** (330 mg, 1.06 mmol, 1 eq.), and DMF (7 mL). After 18 h further sulfamoyl chloride (320 μL, 1 M in MeCN, 0.32 mmol, 0.3 eq.) was added and the reaction mixture was stirred at -40 °C for 4 h. The mixture was allowed to warm to -20 °C and stirred at -20 °C for 2 h. The reaction was quenched with MeOH, allowed to warm to room temperature, diluted with EtOAc (30 mL) and the layers separated. The aqueous layer was further extracted with CH_2Cl_2 (3 × 30 mL), the organics combined, dried over $MgSO_4$, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 65-85% EtOAc/petrol to give a white solid (150 mg, 36 %); R_f 0.7 (EtOAc; anisaldehyde); mp 45-48 °C; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{15.9}$ +103.3° (c = 0.12, MeOH); IR ν_{max}/cm^{-1} 3342, 2946, 1692 (carbamate I), 1522 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.78 (1H, app dt, *J* = 12.5 and 11.7 Hz, H-3$_a$), 2.05 (1H, app dt, *J* = 11.7 and 4.6 Hz, H-3$_b$), 3.42 (3H, s, OCH_3), 3.58 (1H, app td, *J* = 10.7 and 4.6 Hz, H-3), 3.71 (1H, ddd, *J* = 1.5, 6.2 and 9.9 Hz, H-5), 3.79 (1H, app dt, *J* = 12.5 and 3.6 Hz, H-2), 4.25 (1H, dd, *J* = 6.2 and 10.6 Hz, H-6$_a$), 4.43 (1H, dd, *J* = 1.5 and 10.6 Hz, H-6$_b$), 4.64 (1H, d, *J* = 3.6 Hz, H-1), 5.11 (2H, s, CH_2Ph), 7.30-7.42 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 34.7 (C-3), 50.7 (C-2), 55.5 (OCH_3), 65.9 (C-4), 67.6 (CH_2Ph), 70.1 (C-6), 72.1 (C-5), 98.8 (C-1),

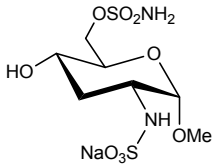
128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar), 158.2 (CO); HRMS calc. for $C_{15}H_{23}N_2O_8S_1$ $[M+H]^+$ 391.1170, found 391.1174.

(2*S*,3*R*,5*S*,6*R*)-5-Hydroxy-2-methoxy-6-((sulfamoyloxy)methyl) tetrahydro-2*H*-pyran-3-aminium acetate (56)



Compound **55** (145 mg, 0.37 mmol, 1 eq.), was dissolved in acetic acid (6 mL) and hydrogenated on a Thales H-cube on full H_2 mode through 10% Pd/C catalyst cartridge at 40 °C for 2 h, with constant recycling of reaction mixture at a flow rate of 1 mL/minute. The solvent was removed *in vacuo* to give a clear gum, which was triturated with toluene (4 × 5 mL), dissolved in water, frozen and lyophilised. The residue was dried *in vacuo* at 40 °C to give a clear gum. (115 mg, 98%); R_f 0.05 (20% MeOH/CH_2Cl_2; anisaldehyde); λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{18.3}$ +94.3° (c = 0.14, MeOH); IR ν_{max}/cm^{-1} 1342 (SO), 1169 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.86 (1H, app dt, *J* = 12.1 and 11.7 Hz, H-3$_a$), 2.20 (1H, app dt, *J* = 11.7 and 4.6 Hz, H-3$_b$), 3.26-3.32 (1H, m, H-2), 3.52 (3H, s, OCH_3), 3.60-3.67 (1H, m, H-4), 3.76 (1H, ddd, *J* = 1.9, 5.8 and 9.8 Hz, H-5), 4.27 (1H, dd, *J* = 5.8 and 10.9 Hz, H-6$_a$), 4.44 (1H, dd, *J* = 1.9 and 10.9 Hz, H-6$_b$), 4.80 (1H, d, *J* = 3.5 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 34.1 (C-3), 49.9 (C-2), 55.6 (OMe), 65.1 (C-4), 69.7 (C-6), 72.3 (C-5), 97.6 (C-1); MS (ESI+) *m/z* 257.3 $[M+H]^+$; (ESI-) *m/z* 255.3 $[M-H]^-$.

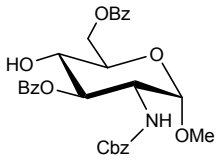
Sodium-((2*S*,3*R*,5*S*,6*R*)-5-Hydroxy-2-methoxy-6-((sulfamoyloxy)methyl) tetrahydro-2*H*-pyran-3-yl)sulfamate (57)



Prepared according to general procedure B, using compound **56** (110 mg, 0.35 mmol, 1 eq.), de-ionised water (5 mL) and pyridine-sulfur trioxide complex (110 mg, 0.70 mmol, 2 eq.) for 2 h. The crude product was purified by MPLC on SiO_2 with a gradient elution from 10-30% MeOH/EtOAc. Product containing fractions were evaporated *in vacuo* to give a pale glass. The material was re-purified by MPLC on SiO_2 with a gradient elution from 10-25% MeOH/CH_2Cl_2. Product containing fractions were evaporated, dissolved in water, frozen and lyophilized to give a yellow solid (25 mg, 21%); R_f 0.2 (20% MeOH/EtOAc; anisaldehyde); mp 130-135 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3283, 1368 (SO), 1173 (SO); ^{1}H NMR

(500 MHz; CD_3OD) δ_H 1.68 (1H, app dt, J = 12.0 and 12.0 Hz, H-3_a), 2.28 (1H, app dt, J = 11.8 and 4.7 Hz, H-3_b), 3.43-3.49 (4H, m, OCH_3 and H-2), 3.51-3.59 (1H, ddd, J = 4.7, 9.8 and 11.2 Hz, H-4), 3.69 (1H, ddd, J = 1.8 Hz, 6.3 and 9.8 Hz, H-5), 4.24 (1H, dd, J = 6.3 and 10.7 Hz, H-6_a), 4.43 (1H, dd, J = 1.8 and 10.7 Hz, H-6_b), 4.87 (1H, d, J = 3.5 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 35.9 (C-3), 53.1 (C-2), 55.6 (OCH_3), 66.3 (C-4), 70.3 (C-6), 72.1 (C-5), 99.5 (C-1); HRMS calcd for $C_7H_{15}N_2O_9S_2$ $[M-H]^-$ 335.0224, found 335.0208.

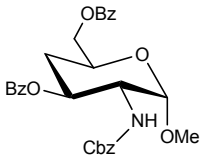
((2*R*,3*S*,4*R*,5*R*,6*S*)-4-(Benzoyloxy)-5-((benzyloxy)carbonyl) amino)-3-hydroxy-6-methoxytetrahydro-2*H*-pyran-2-yl)methyl benzoate (58)



Compound **4** (1.2 g, 3.7 mmol) was dissolved in a mixture of CH_2Cl_2 (6 mL) and pyridine (6 mL) and cooled to -40 °C. Benzoyl chloride (767 μL, 6.6 mmol, 1.8 eq.) was added dropwise over 20 min, and the mixture was allowed to warm to room temperature over 90 min. The mixture was cooled to -40 °C and benzoyl chloride (170 μL, 1.5 mmol, 0.4 eq.) was added dropwise over 20 min, and the mixture was allowed to warm to room temperature over 90 min and stirred at room temperature for 1 h. The reaction was quenched with methanol, and the solvent removed *in vacuo*. The residue was dissolved in CH_2Cl_2 (30 mL) and washed with HCl (2 × 20 mL, 2 M aq.). The organic layer was dried over $MgSO_4$, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 15-65% EtOAc/petrol to give a clear gum (1.05 g, 1.96 mmol, 54%); R_f 0.4 (40% EtOAc/petrol; anisaldehyde); mp 60-64 °C; λ_{max}(EtOH)/nm 229; $[\alpha]_D^{19.3}$ +93.3° (c = 0.39, MeOH); IR ν_{max}/cm^{-1} 3345, 1714 (br) (CO ester and carbamate I), 1603, 1518 (carbamate II); ^{1}H NMR (500 MHz; $CDCl_3$) δ_H 3.30 (1H, br s, C4-O*H*), 3.83 (1H, app. t, J = 9.4 Hz, H-4), 4.00 (1H, ddd, J = 2.1, 4.5 and 9.4 Hz, H-5), 4.21 (1H, app td, J = 10.3 and 3.6 Hz, H-2), 4.59 (1H, dd, J = 2.1 and 12.1 Hz, H-6_a), 4.74 (1H, dd, J = 4.5 and 12.1 Hz, H-6_b), 4.81 (1H, d, J = 3.6 Hz, H-1), 4.94 (1H, d, J = 12.3 Hz, CH_aCH$_b$Ph), 4.99 (1H, d, J = 12.3 Hz, CH$_a$CH_bPh), 5.16 (1H, d, J = 10.3 Hz, NH), 5.33 (1H, dd, J = 9.4 and 10.3 Hz, H-3), 7.11-7.23 (5H, m, H-Ar), 7.39-7.49 (4H, m, H-Ar), 7.53-7.62 (2H, m, H-Ar), 8.02-8.10 (4H, m, H-Ar); ^{13}C NMR (125 MHz; $CDCl_3$) δ_C 55.4 (C-2), 60.4 (OMe), 63.4 (C-6), 66.9 (*C*H$_2$Ph), 69.5 (C-4), 70.4 (C-5), 75.4 (C-3), 98.8 (C-1), 127.8 (C-Ar), 128.1 (C-Ar), 128.4 (C-Ar), 128.5 (C-Ar), 128.5 (C-Ar), 129.3 (C-Ar), 129.7 (C-Ar), 129.8 (C-Ar), 130.1 (C-Ar), 133.3 (C-Ar), 133.5 (C-Ar),

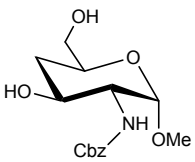
136.1 (C-Ar), 156.0 (CO Cbz), 166.9 (CO Bz), 168.0 (CO Bz); HRMS calcd for $C_{29}H_{30}N_1O_9$ $[M+H]^+$ 536.1915, found 536.1904.

((2*S*,4*S*,5*R*,6*S*)-4-(Benzoyloxy)-5-(((benzyloxy)carbonyl) amino)-6-methoxy tetrahydro-2*H*-pyran-2-yl)methyl benzoate (59)



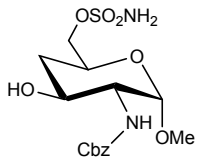
Compound **58** (150 mg, 0.28 mmol, 1 eq.) was dissolved in toluene (4 mL) and the solution degassed. 1,1'-Thiocarbonyldiimidazole (75 mg, 0.42 mmol, 1.5 eq.) was added and the mixture heated at reflux for 3 h. Tris(trimethylsilyl)silane (346 μL, 1.12 mmol, 4 eq.) was added to the hot reaction, followed by AIBN (280 μL, 0.2 M in toluene, 0.056 mmol, 0.2 eq.), and the mixture was heated at reflux for 30 min. The reaction was allowed to cool and the solvent was evaporated *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 10-30% EtOAc/petrol to give a white solid (116 mg, 79%); R_f 0.8 (50% EtOAc/petrol; anisaldehyde); mp 155-158 °C; λ_{max}(EtOH)/nm 229; $[\alpha]_D^{19.9}$ +125.7° (c = 0.11, MeOH); IR ν_{max}/cm^{-1} 3325, 1718 (CO ester), 1681 (carbamate I), 1535 (carbamate II); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.82 (1H, app dt, *J* = 12.4 and 11.8 Hz, H-4$_a$), 2.41 (1H, ddd, *J* = 1.9, 5.0 and 12.4 Hz, H-4$_b$), 3.47 (3H, s, OCH_3), 4.09 (1H, dd, *J* = 3.6 and 10.8 Hz, H-2), 4.30-4.37 (1H, m, H-5), 4.41-4.49 (2H, m, H-6), 4.89 (1H, d, *J* = 3.6 Hz, H-1), 4.99 (1H, d, *J* = 12.5 Hz, C*H*$_a$H$_b$Ph), 5.12 (1H, d, *J* = 12.5 Hz, CH$_a$*H*$_b$Ph), 5.38 (1H, td, *J* = 10.8 and 5.0 Hz, H-3), 7.15-7.23 (5H, m, H-Ar), 7.46-7.56 (4H, m, H-Ar), 7.62-7.68 (2H, m, H-Ar), 8.01-8.04 (2H, m, H-Ar), 8.07-8.11 (2H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 34.3 (C-4), 55.7 (C-2 and OCH_3), 67.0 (C-5), 67.45 (CH_2Ph), 67.5 (C-6), 71.3 (C-3), 101.0 (C-1), 128.5 (C-Ar), 128.8 (C-Ar), 129.4 (C-Ar), 129.6 (C-Ar), 129.7 (C-Ar), 130.6 (C-Ar), 130.8 (C-Ar), 131.2 (C-Ar), 131.2 (C-Ar), 134.4 (C-Ar), 134.4 (C-Ar), 138.2 (C-Ar), 158.8 ($NHCO_2Bn$), 167.6 ($PhCO_2$), 167.7 ($PhCO_2$); HRMS calc. for $C_{29}H_{33}N_2O_8$ $[M+NH_4]^+$ 537.2231, found 537.2224.

Benzyl ((2*S*,3*R*,4*S*,6*S*)-4-hydroxy-6-(hydroxymethyl)-2-methoxy tetrahydro-2*H*-pyran-3-yl)carbamate (60)



Compound **59** (340 mg, 0.66 mmol) was dissolved in methanol and sodium methoxide (160 μL, 1 M in methanol, cat.) was added. The mixture was stirred at room temperature for 18 h. The solvent was evaporated *in vacuo*, the residue was purified by MPLC on SiO_2 with a gradient elution from 80-100% EtOAc/petrol to give a white solid (140 mg, 68%); R_f 0.1 (80% EtOAc/petrol; anisaldehyde); mp 112 °C dec.; λ_{max}(EtOH)/nm < 220; $[\alpha]_D^{20.0}$ +92.0° (c = 0.10, MeOH); IR ν_{max}/cm^{-1} 3334, 2926, 1691; ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.46 (app dt, *J* = 12.8 and 12.0 Hz, H-4$_a$), 2.01 (1H, *J* = 2.0, 4.7 and 12.8 Hz, H-4$_b$), 3.37-3.42 (3H, s, OCH_3), 3.52-3.61 (3H, m, H-2 and H-6), 3.80-3.88 (2H, m, H-3 and H-5), 4.75 (1H, d, *J* = 3.5 Hz, H-1), 5.13 (2H, s, CH_2Ph), 7.30-7.43 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 37.2 (C-4), 55.5 (OCH_3), 58.8 (C-2), 65.8 (C-6), 67.2 (C-5), 67.6 (*C*H_2Ph), 70.0 (C-3), 100.8 (C-1), 128.9 (C-Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.4 (C-Ar), 159.0 (CO); HRMS calcd for $C_{15}H_{22}N_1O_6$ $[M+H]^+$ 312.1442, found 312.1447.

((2*S*,4*S*,5*R*,6*S*)-5-(((Benzyloxy)carbonyl)amino)-4-hydroxy-6-methoxy tetrahydro-2*H*-pyran-2-yl)methyl sulfamate (61)

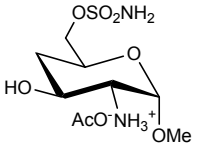


Prepared according to sulfamoylation method 2 using sulfamoyl chloride (0.93 mL, 1 M in MeCN, 0.93 mmol, 1.8 eq.), alcohol **60** (160 mg, 0.51 mmol, 1 eq.), and DMF (4 mL). After stirring at -40 °C for 18 h, further sulfamoyl chloride (200 μL, 1 M in MeCN, 0.2 mmol, 0.4 eq.) was added at -40 °C over 30 min, and the reaction mixture was stirred at -40 °C for 18 h. The reaction was quenched with MeOH, allowed to warm to room temperature, diluted with water (10 mL) and EtOAc (30 mL) and the layers separated. The aqueous layer was further extracted with CH_2Cl_2 (4 × 15 mL). The organic layers were combined, dried over $MgSO_4$, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with a gradient elution from 50-90% EtOAc/petrol to give a white solid (102 mg, 51 %); R_f 0.7 (EtOAc; anisaldehyde); mp 45-48 °C; λ_{max}(EtOH)/nm <220; IR ν_{max}/cm^{-1} 3349, 2925, 1693 (carbamate I), 1527 (carbamate II), 1362 (SO), 1177 (SO); ^{1}H NMR (500 MHz; CD_3OD) δ_H 1.52 (1H, app dt, *J* = 12.0 and 12.0 Hz, H-4$_a$), 2.07 (1H, ddd, *J* = 1.7, 4.5 and 12.0 Hz, H-4$_b$), 3.40 (3H, s, OMe), 3.57 (1H, dd, *J* = 3.4 and 10.3 Hz, H-2), 3.86 (1H, app td, *J* = 10.9 and 4.7 Hz, H-3), 4.10 (1H, m, H-5), 4.13-4.17 (2H, m, H-6), 4.76 (1H, d, *J* = 3.4 Hz, H-1), 5.13 (2H, s, CH_2Ph), 7.30-7.44 (5H, m, H-Ar); ^{13}C NMR (125 MHz; CD_3OD) δ_C 36.9 (C-4), 55.7 (OCH_3), 58.6 (C-2), 66.9 (C-3), 67.2 (C-5), 67.6 (CH_2Ph), 72.3 (C-6), 100.8 (C-1), 128.9 (C-

Ar), 129.0 (C-Ar), 129.5 (C-Ar), 138.3 (C-Ar); HRMS calc. for $C_{15}H_{26}N_3O_8S_1$ $[M+NH_4]^+$ 408.1435, found 408.1436.

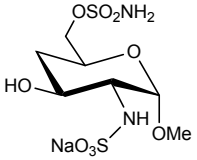
Note: Unable to visualise all carbon signals by ^{13}C nmr.

(2*S*,3*R*,4*S*,6*S*)-4-Hydroxy-2-methoxy-6-((sulfamoyloxy)methyl) tetrahydro-2*H*-pyran-3-aminium acetate (62)



Compound **61** (95 mg, 0.24 mmol) was dissolved in acetic acid (4 mL) and hydrogenated on a Thales H-cube on full H_2 mode through 10% Pd/C catalyst cartridge at 40 °C for 2 h, with constant recycling of the reaction mixture at a flow rate of 1 mL/minute. The solvent was removed *in vacuo* to give a clear gum, which was triturated with toluene (4 × 5 mL). The residue was dried *in vacuo* at 40 °C to give a clear gum (54 mg, 70%); R_f 0.05 (20% MeOH/CH_2Cl_2; anisaldehyde); λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3012, 1706, 1547, 1359 (SO), 1175 (SO); ^1H NMR (500 MHz; CD_3OD) δ_H 1.56 (1H, app dt, J = 12.6 and 11.5 Hz, H-4_a), 2.00 (3H, s, CH_3CO$_2$), 2.07-2.14 (1H, m, H-4_b), 3.03 (1H, dd, J = 3.5 and 10.1 Hz, H-2), 3.49 (3H, s, OCH_3), 4.00 (app. td, J = 10.9 and 4.9 Hz, H-3), 4.10-4.22 (3H, m, H-5 and H-6), 4.96 (1H, d, J = 3.5 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 21.8 (*C*H$_3$CO), 36.6 (C-4), 55.8 (C-2), 57.1 (OCH_3), 66.0 (C-3), 67.6 (C-6), 71.9 (C-5), 98.8 (C-1), 176.8 (CO acetate); HRMS calcd for $C_7H_{15}N_2O_6S_1$ $[M-H]^-$ 255.0656, found 255.0647.

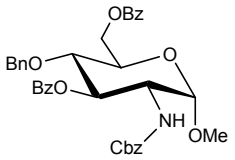
Sodium-((2*S*,3*R*,4*S*,6*S*)-4-hydroxy-2-methoxy-6-((sulfamoyloxy) methyl) tetrahydro-2*H*-pyran-3-yl)sulfamate (63)



Prepared according to general procedure B, using amine **62** (50 mg, 0.16 mmol, 1 eq.), de-ionised water (3 mL) and pyridine-sulfur trioxide complex (50 mg, 0.32 mmol, 2 eq.) for 2 h. The crude product was purified by MPLC on SiO_2 with a gradient elution from 10-30% MeOH/EtOAc. Product containing fractions were evaporated *in vacuo* to give a pale glass. The material was re-purified by MPLC on SiO_2 with a gradient elution from 5-25% MeOH/CH_2Cl_2. Product containing fractions were evaporated, dissolved in water, frozen and lyophilized to give a yellow solid (4 mg, 8%); R_f 0.15 (20% MeOH/EtOAc; anisaldehyde); m.p. 144-148 °C; λ_{max}(EtOH)/nm < 220; IR ν_{max}/cm^{-1} 3272, 2936, 1361 (SO), 1173 (SO); ^1H

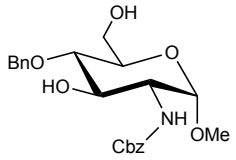
NMR (500 MHz; CD_3OD) δ_H 1.49 (1H, app dt, J = 12.0 and 11.8 Hz, H-4_a), 2.05 (1H, ddd, J = 2.2 , 5.0 and 12.8 Hz, H-4_b), 3.19 (1H, dd, J = 3.6 and 9.9 Hz, H-2), 3.49 (3H, s, OCH_3), 3.82 (1H, ddd, J = 4.9, 10.0 and 11.2 Hz, H-3), 4.05-4.19 (3H, m, H-5 and H-6), 5.03 (1H, d, J = 3.6 Hz, H-1); ^{13}C NMR (125 MHz; CD_3OD) δ_C 36.3 (C-4), 55.8 (OCH_3), 60.8 (C-2), 66.9 (C-5), 68.0 (C-3), 72.4 (C-6), 101.1 (C-1); HRMS calcd for $C_7H_{15}N_2O_9S_2$ $[M-H]^-$ 335.0224, found 335.0210.

((2*R*,3*S*,4*R*,5*R*,6*S*)-4-(Benzoyloxy)-3-(benzyloxy)-5-(((benzyloxy) carbonyl) amino) -6-methoxytetrahydro-2*H*-pyran-2-yl)methyl benzoate (64)



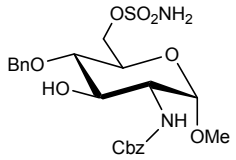
Benzyl-2,2,2-trichloroacetimidate (78 μL, 0.37 mmol, 2 eq.) and trifluoromethanesulfonic acid (300 μL, 10% v/v in CH_2Cl_2, 0.02 eq.), were added to a solution of alcohol **58** (100 mg, 0.19 mmol, 1 eq.) in CH_2Cl_2 (3 mL) and the mixture stirred at room temperature for 1 h. Further benzyl-2,2,2-trichloroacetimidate (78 μL, 0.37 mmol, 2 eq.) was added and the mixture stirred at room temperature for 1 h. Further benzyl-2,2,2-trichloroacetimidate (78 μL, 0.37 mmol, 2 eq.) and trifluoromethanesulfonic acid (300 μL, 10% v/v in CH_2Cl_2, 0.02 eq.) were added and the mixture was stirred at r.t. for 18 h. The reaction was quenched by addition of $NaHCO_3$ (10% w/v aq., 5 mL), diluted with brine (10 mL) and extracted with CH_2Cl_2 (2 × 15 mL). The organic layers were combined, dried over $MgSO_4$, and the solvent removed *in vacuo*. The residue was purified by flash MPLC on SiO_2 with gradient elution from 5-25% EtOAc/petrol to give a clear gum (88 mg, 75%); R_f 0.3 (20% EtOAc/petrol; UV, anisaldehyde); mp. 99-105 °C; λ_{max}(EtOH)/nm 227; $[\alpha]_D^{18.9}$ +31.4° (c = 0.14, EtOH); IR ν_{max}/cm^{-1} 3364, 3318, 3241, 3186, 1692, 1617; ^{1}H NMR (500 MHz; $CDCl_3$) δ_H 3.42 (3H, s, OMe), 3.70-3.94 (2H, m, H-4), 4.06 (1H, dt, J = 9.9 and 3.1 Hz, H-5), 4.18 (1H, td, J = 10.6 and 3.5 Hz, H-2), 4.46-4.62 (4H, m, H-6 and CHOCH_2Ph), 4.79 (1H, d, J = 3.5 Hz, H-1), 4.86-4.96 (2H, m, CO_2CH_2Ph), 5.12 (1H, d, J = 10.1 Hz, NH), 5.63 (1H, dd, J = 9.3 and 10.6 Hz, H-3), 7.07-7.21 (10 H, m, H-Ar), 7.42-7.52 (4H, m, H-Ar), 7.54-7.63 (2H, m, H-Ar), 8.03 - 8.08 (4H, m, H-Ar); ^{13}C NMR (125 MHz; $CDCl_3$) δ_C 54.2, 55.4, 63.1, 66.8, 69.2, 74.2, 74.8, 75.7, 98.7, 127.7, 127.9, 128.0, 128.3, 128.4, 128.4, 128.5, 129.7, 129.9, 133.2, 133.3, 136.9, 156.0; HRMS calcd for $C_{36}H_{39}N_2O_9$ 643.2650 $[M+NH_4]^+$, found 643.2645.

Benzyl ((2*S*,3*R*,4*R*,5*S*,6*R*)-5-(benzyloxy)-4-hydroxy-6-(hydroxymethyl)-2-methoxytetrahydro-2*H*-pyran-3-yl)carbamate (65)



Lithium aluminium hydride (516 μL, 2 M in THF, 1.03 mmol, 3 eq.) was added to dibenzoate ester **64** (215 mg, 0.34 mmol, 1 eq.) in THF (5 mL) at 0 °C and the mixture was stirred at 0 °C for 2 h. Water (60 μL) was added, followed by NaOH (15% w/v aq., 180 μL), followed by further water (60 μL). The mixture was stirred at room temperature for 30 min, filtered through Celite, and the solvent removed *in vacuo*. The residue was purified by MPLC on SiO_2 with gradient elution from 20-80% EtOAc/petrol to give a white solid (98 mg, 69%); R_f 0.25 (50% EtOAc/petrol; UV, anisaldehyde); mp. 101-104 °C; λ_{max}(EtOH)/nm 258; $[\alpha]_D^{18.5}$ +11.2° (c = 0.08, EtOH); IR ν_{max}/cm^{-1} 3296, 2918, 1685, 1540; ^{1}H NMR (500 MHz; DMSO-*d*^{6}) δ_H 3.28 (3H, s, OMe), 3.31-3.36 (1H, m, H-4), 3.42 (1H, m, H-5), 3.47-3.59 (2H, m, H-2 and H-6$_a$), 3.61-3.73 (2H, m, H-3 and H-6$_b$), 4.61 (1H, d, *J* = 11.5 Hz, C*H*$_a$H$_b$Ph), 4.64 (1H, d, *J* = 3.4 Hz, H-1), 4.72 (1H, t, *J* = 5.8 Hz, OH-6), 4.91 (1H, d, *J* = 11.5 Hz, CH$_a$*H*$_b$Ph), 5.02-5.16 (3H, m, CH_2Ph and OH-3), 7.19 (1H, d, *J* = 8.2 Hz, NH), 7.28-7.45 (10H, m, H-Ar); ^{13}C NMR (125 MHz; DMSO-*d*^{6}) δ_C 54.4 (OMe), 56.2 (C-2), 60.4 (C-6), 65.3(CH_2Ph), 70.8 (C-3), 71.4(C-5), 73.7 (NHCO$_2$CH$_2$Ph), 78.6 (C-4), 98.0 (C-1), 127.3 (C-Ar), 127.5 (C-Ar), 127.8 (C-Ar), 128.0 (C-Ar), 128.3 (C-Ar), 137.1 (C-Ar), 139.0 (C-Ar), 156.2 (CO); HRMS calc. for $C_{22}H_{28}N_1O_7$ $[M+H]^+$ 418.1860, found 418.1862.

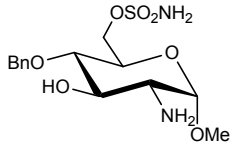
((2*R*,3*S*,4*R*,5*R*,6*S*)-3-(Benzyloxy)-5-(((benzyloxy)carbonyl)amino)-4-hydroxy-6-methoxytetrahydro-2*H*-pyran-2-yl)methyl sulfamate (66)



Prepared according to sulfamoylation method 2 using sulfamoyl chloride (1.15 mL, 1 M in MeCN, 1.15 mmol, 2 eq.), alcohol **65** (200 mg, 0.05 mmol, 1 eq.) and DMF (2 mL). After stirring at -40 °C for 18 h, further sulfamoyl chloride (0.20 mL, 1 M in MeCN, 0.20 mmol, 0.33 eq.) was added and the mixture was stirred at -40 °C for 4 h. The residue was purified by MPLC on SiO_2 with a gradient elution from EtOAc to 8% EtOAc/petrol to give a white solid (150 mg, 52%); R_f 0.3 (50% EtOAc/petrol; anisaldehyde); m.p. 46-48 °C; λ_{max}(EtOH)/nm

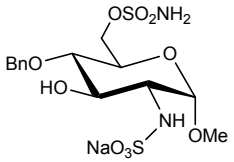
257; $[\alpha]_D^{19.1}$ +74.8° (c = 0.107, EtOH); IR ν_{max}/cm^{-1} 3332 (br), 2939, 1695 (carbamate I), 1523 (Carbamate II), 1365 (SO), 1181 (SO); ^{1}H NMR (500 MHz; DMSO-*d*^{6}) δ_H 3.30 (3H, s, OMe), 3.37 (1H, m, H-4), 3.53 (1H, ddd, *J* = 3.6, 8.5 and 10.6 Hz, H-2), 3.6 -3.76 (2H, m, H-3 and H-5), 4.20-4.28 (2H, m, H-6), 4.62 (1H, d, *J* = 10.9 Hz, OC*H*$_a$H$_b$Bn), 4.67 (1H, d, *J* = 3.5 Hz, H-1), 4.94 (1H, d, *J* = 10.9 Hz, OCH$_a$*H*$_b$Bn), 5.06 (1H, d, *J* = 12.6 Hz, CO_2OC*H*$_a$H$_b$Bn), 5.10 (1H, d, *J* = 12.6 Hz, CO_2CH$_a$*H*$_b$Bn), 5.23 (1H, d, *J* = 7.3 Hz, OH^3), 7.20-7.44 (11H, m, 10 × H-Ar and NH), 7.62 (2H, s, NH_2); ^{13}C NMR (125 MHz; DMSO-*d*^{6}) δ_C 54.7 (OMe), 56.0 (C-2), 65.4 (CO_2*C*H$_2$Ph), 67.8 (C-6), 68.2 (C-5), 70.7 (C-3), 73.8 (CH_2Ph), 78.1 (C-4), 98.1 (C-1), 127.4 (C-Ar), 127.7 (C-Ar), 127.8 (C-Ar), 128.1 (C-Ar), 128.3 (C-Ar), 128.6 (C-Ar), 137.0 (C-Ar), 138.6 (C-Ar), 156.2 (*C*O); MS (ES+) *m/z* 497.5 $[M+H]^+$; HRMS calcd for $C_{22}H_{32}N_3O_9S_1$ $[M+NH_4]^+$ 514.1854, found 514.1848.

((2*R*,3*S*,4*R*,5*R*,6*S*)-5-Amino-3-(benzyloxy)-4-hydroxy-6-methoxytetrahydro-2*H*-pyran-2-yl)methyl sulfamate (67)



Benzyl ether **66** (220 mg, 0.44 mmol) was dissolved in methanol (5 mL) and hydrogenated on a Thales H-cube through 5% Pd/C catalyst cartridge with 10 bar H_2 at r.t. for 35 min, with constant recycling of reaction mixture at a flow rate of 1 mL/minute. The solvent was removed *in vacuo* to give a clear gum which solidified on standing (160 mg, 100%). R_f 0.25 (30% MeOH/EtOAc; anisaldehyde); m.p. 50-52 °C; λ_{max}(EtOH)/nm <258; $[\alpha]_D^{19.2}$ +77.6° (c = 0.107, EtOH); IR ν_{max}/cm^{-1} 3353 (br), 2913, 1362 (SO), 1176 (SO); ^{1}H NMR (500 MHz; DMSO-*d*^{6}) δ_H 1.84 (2H, br, CHN*H*$_2$), 2.48-2.54 (1H, m, H-2), 3.27 (1H, dd, *J* = 8.8 and 9.9 Hz, H-4), 3.32 (3H, s, OMe), 3.43-3.49 (1H, m, H-3), 3.70-3.75 (1H, m, H-5), 4.20-4.27 (2H, m, H-6), 4.62 (2H, m, H-1 and C*H*$_a$H$_b$Ph), 4.93 (1H, d, *J* = 11.0 Hz, CH$_a$*H*$_b$Ph), 5.27 (1H, d, *J* = 5.8 Hz, OH^3), 7.18-7.43 (5H, m, H-Ar), 7.61 (2H, br s, OSO_2NH_2); ^{13}C NMR (125 MHz; DMSO-*d*^{6}) δ_C 54.68 (OMe), 56.4 (C-2), 68.0 (C-6), 68.5 (C-5), 73.6 (CH_2Ph), 75.0 (C-3), 77.7 (C-4), 100.1 (C-1), 127.4 (C-Ar), 127.7 (C-Ar), 128.08 (C-Ar), 138.7 (C-Ar); HRMS calc. for $C_{14}H_{23}N_2O_7S_1$ $[M+H]^+$ 363.1220, found 363.1226.

((2*R*,3*S*,4*R*,5*R*,6*S*)-5-(Benzyloxy)-4-hydroxy-2-methoxy-6-((sulfamoyloxy) methyl) tetrahydro-2H-pyran-3-yl)sulfamic acid (68)



Prepared according to general procedure B, using amine **67** (75 mg, 0.2 mmol, 1 eq.), de-ionised water (6 mL), THF (3 mL) and pyridine-sulfur trioxide complex (132 mg, 0.82 mmol, 4 eq.) for 2 h. The crude product was purified by MPLC on SiO_2 with a gradient elution from 10-30% MeOH/EtOAc. Product containing fractions were evaporated *in vacuo* to give a yellow solid. (23 mg, 25%); R_f 0.3 (30% MeOH/EtOAc; anisaldehyde); m.p. 195 °C dec.; λ_{max}(EtOH)/nm 258; $[\alpha]_D^{19.5}$ +80° (c = 0.15, EtOH); IR ν_{max}/cm^{-1} 3291, 2920, 1363 (SO), 1178 (SO); ^{1}H NMR (500 MHz; DMSO-*d*^{6}) δ_H 3.07-3.14 (1H, ddd, *J* = 3.5, 8.3 and 10.4 Hz, H-2), 3.28 (3H, s, OMe), 3.31 (1H, dd, *J* = 8.7 and 10.1 Hz, H-4), 3.66-3.73 (2H, m, H-3 and H-5), 4.20 (1H, dd, *J* = 5.0 and 10.5 Hz, H-6$_a$), 4.25 (1H, dd, *J* = 1.7 and 10.5 Hz, H-6$_b$), 4.38 (1H, d, *J* = 8.3 Hz, CHN*H*), 4.63 (1H, d, *J* = 11.0 Hz, C*H*$_a$H$_b$Ph), 4.69 (1H, d, *J* = 3.5 Hz, H-1), 4.96 (1H, d, *J* = 11.0 Hz, CH$_a$*H*$_b$Ph), 5.75 (1H, d, *J* = 2.2 Hz, OH^3), 7.26-7.40 (5H, m, H-Ar), 7.60 (2H, br s, NH_2); ^{13}C NMR (125 MHz; DMSO-*d*^{6}) δ_C 54.8 (OMe), 57.8 (C-2), 67.9 (C-5), 68.0 (C-6), 73.3 (C-3), 73.6 (*C*H$_2$Ph), 78.2 (C-4), 99.2 (C-1), 127.3 (C-Ar), 127.6 (C-Ar), 128.1 (C-Ar), 138.8 (C-Ar); HRMS calc. for $C_{14}H_{22}N_2O_{10}S_2$ $[M-H]^-$ 441.0643, found 441.0631.

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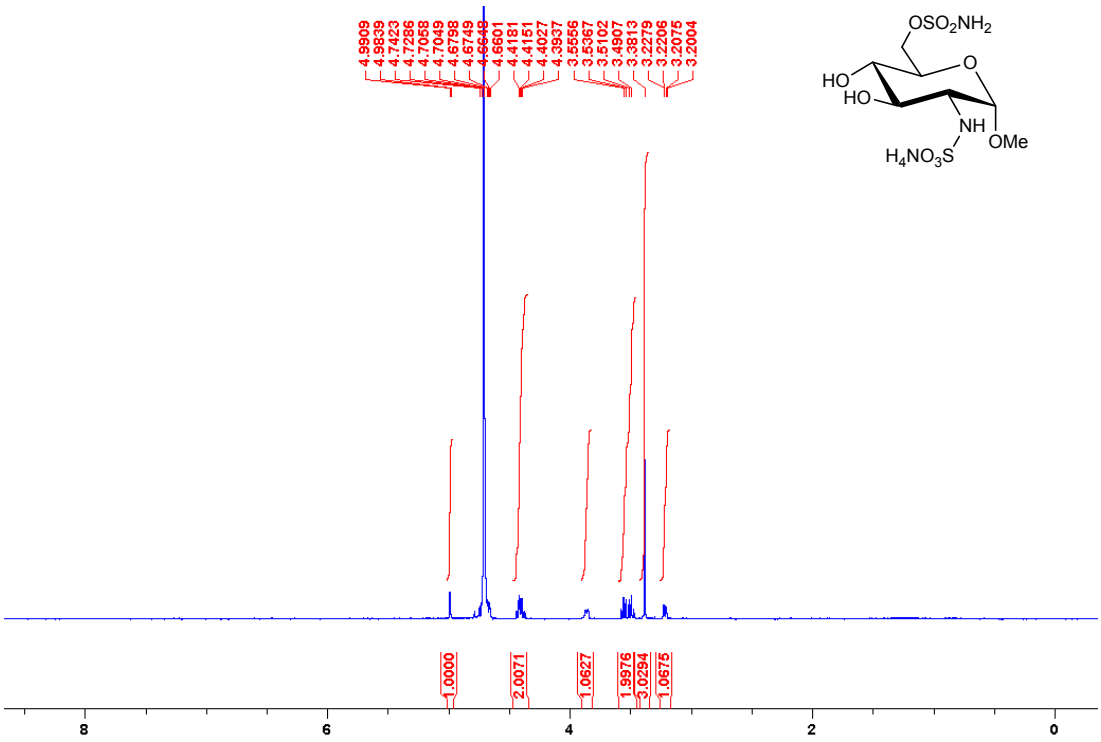
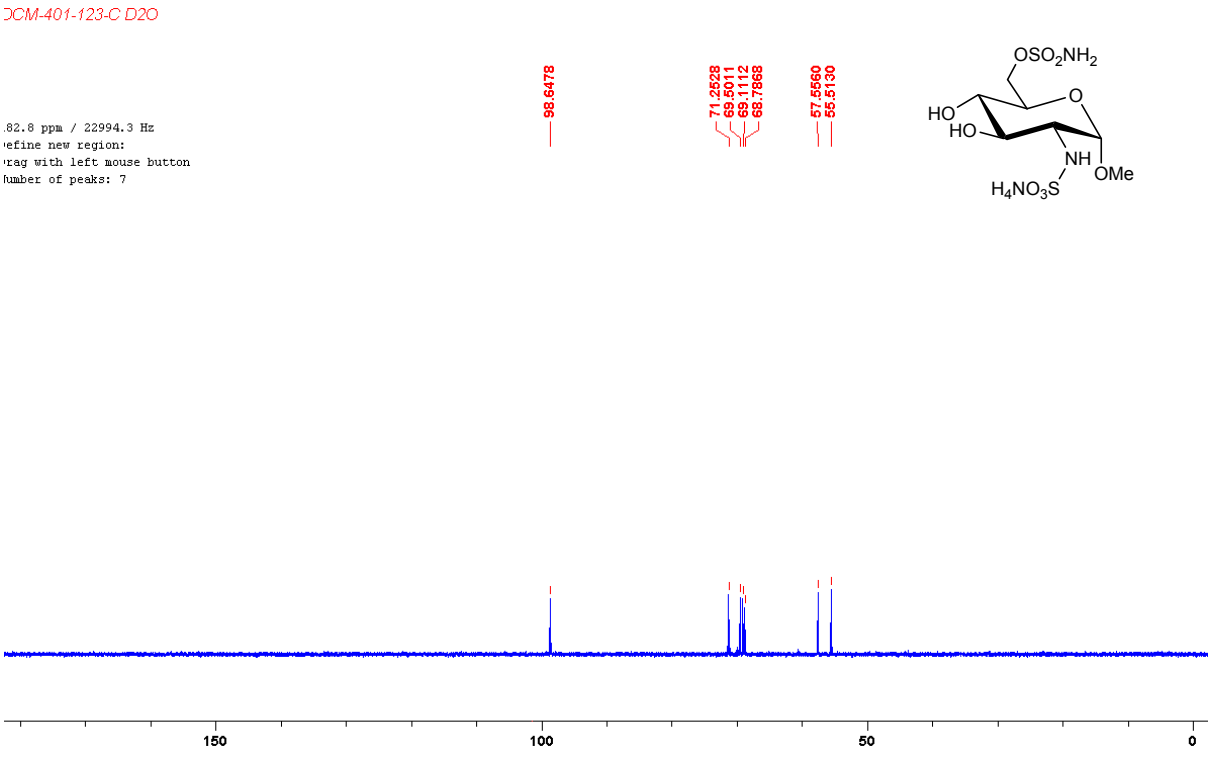
Selected NMR Data

Cmpd 1

^{1}H NMR D_2O



^{13}C NMR D_2O



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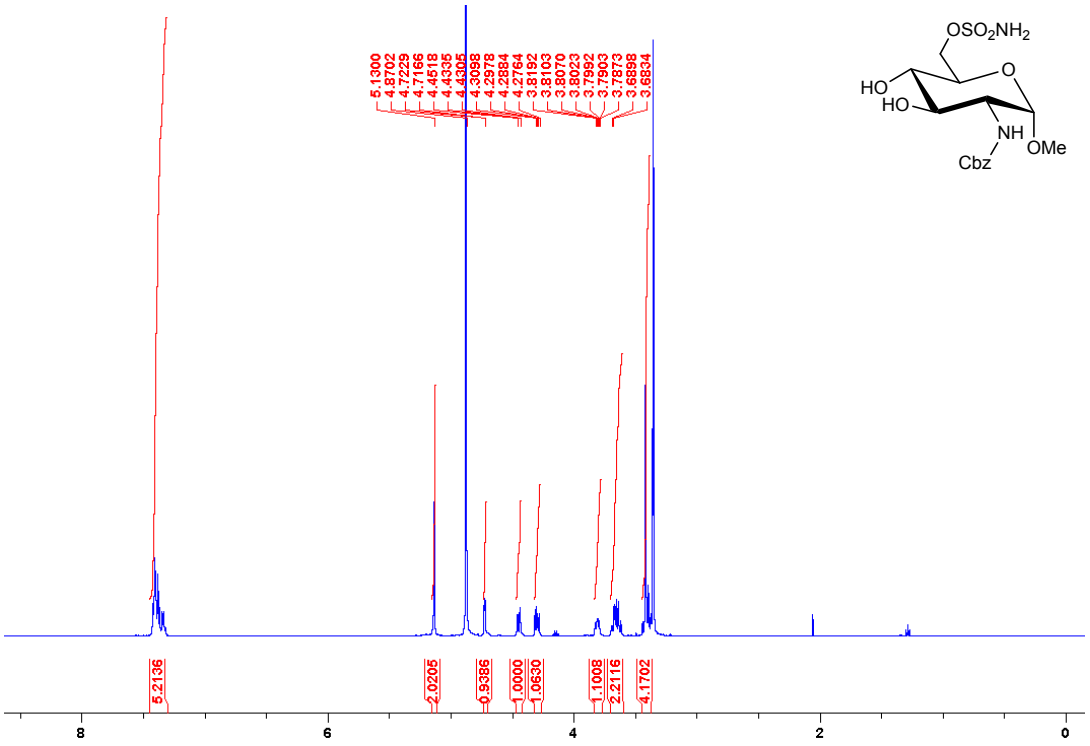

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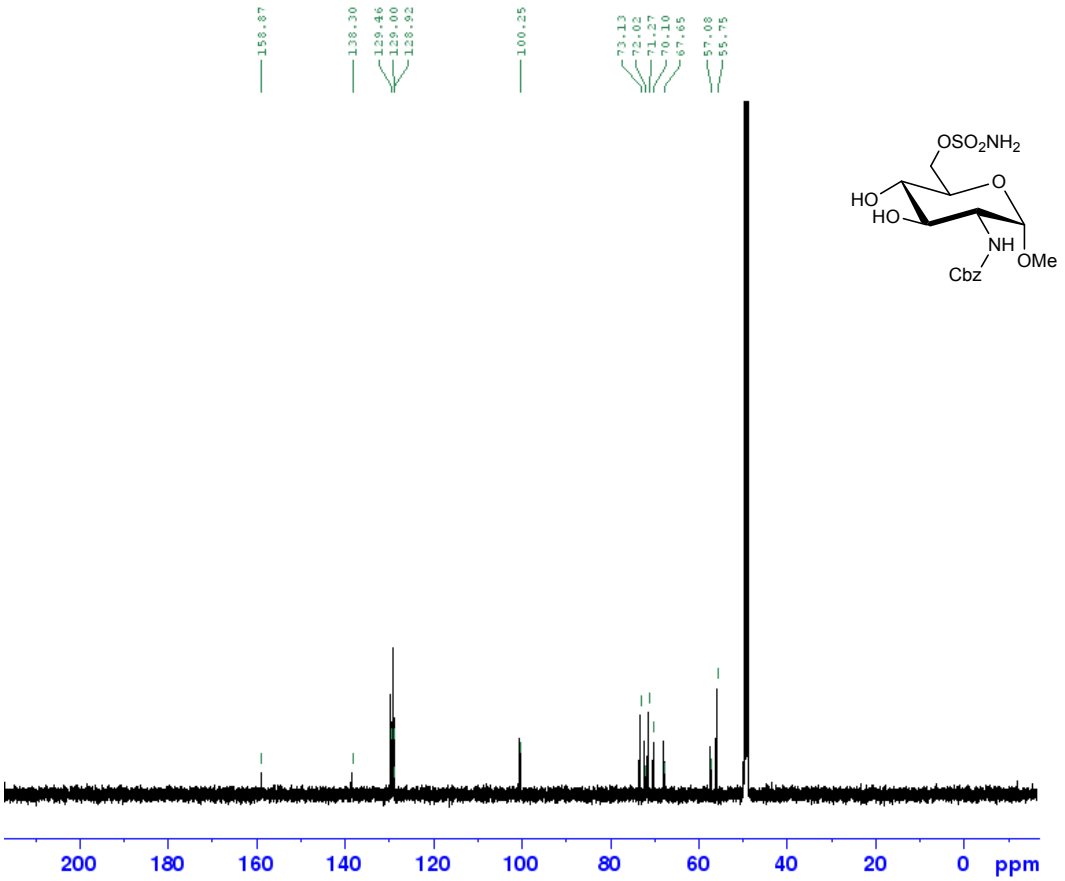

Cmpd 6

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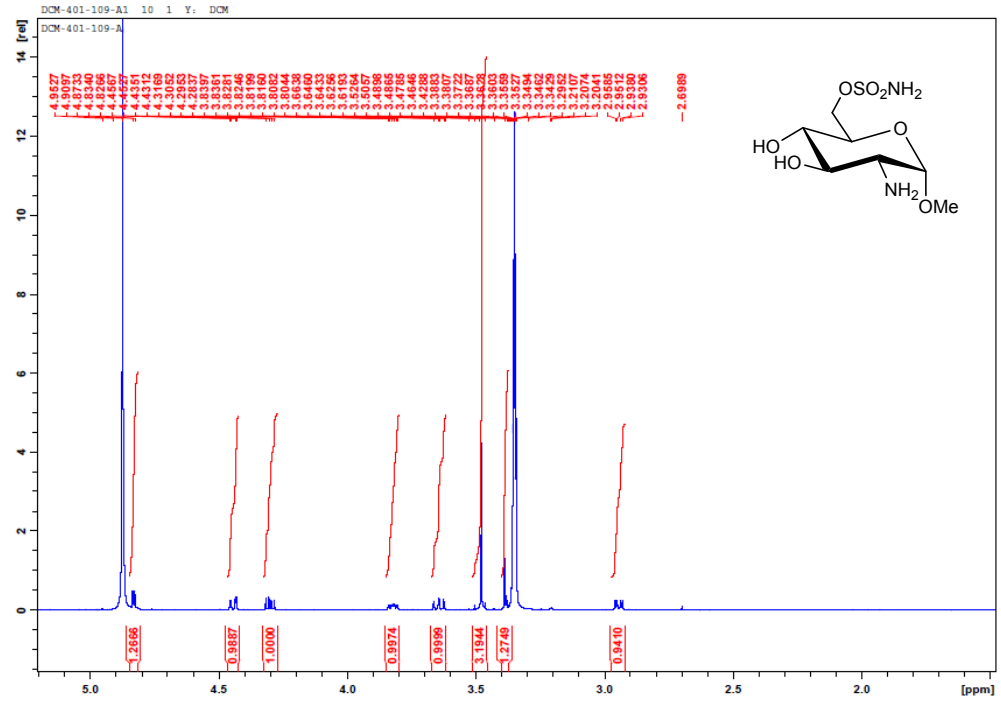

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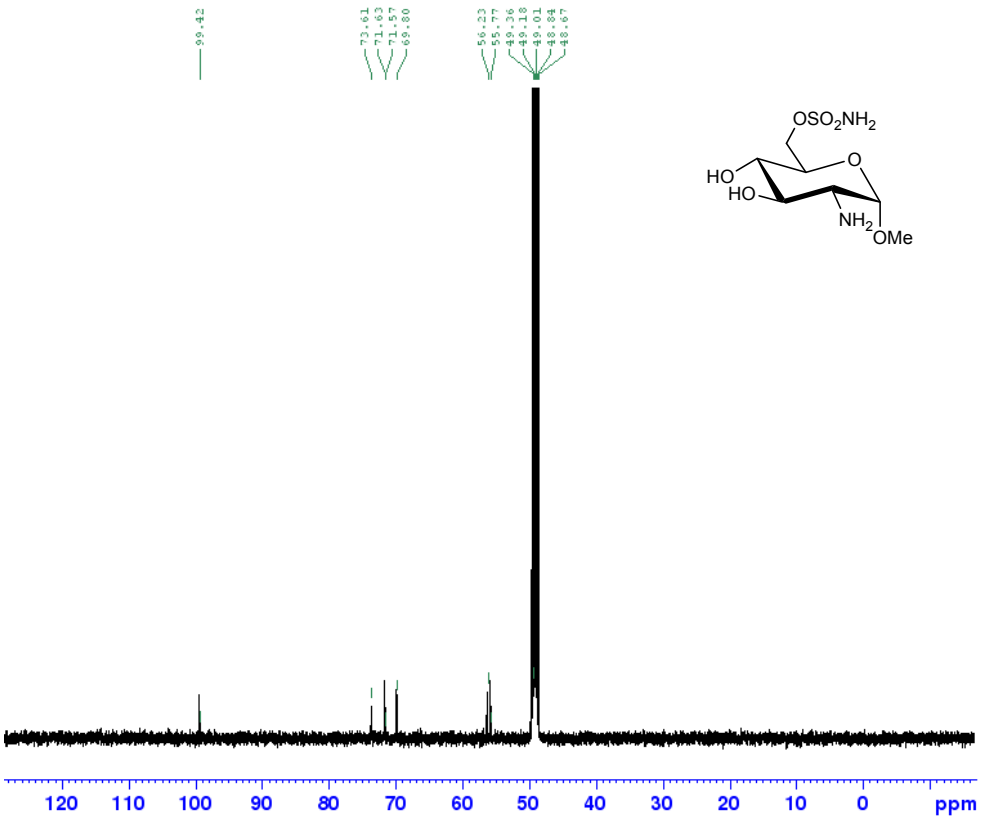

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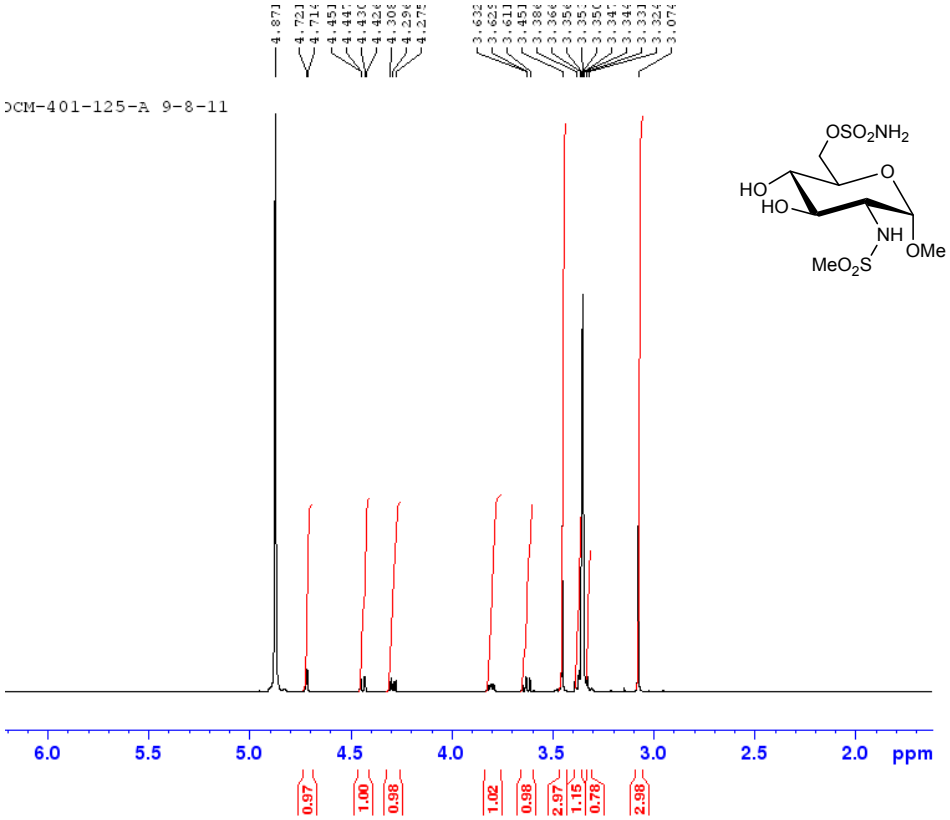

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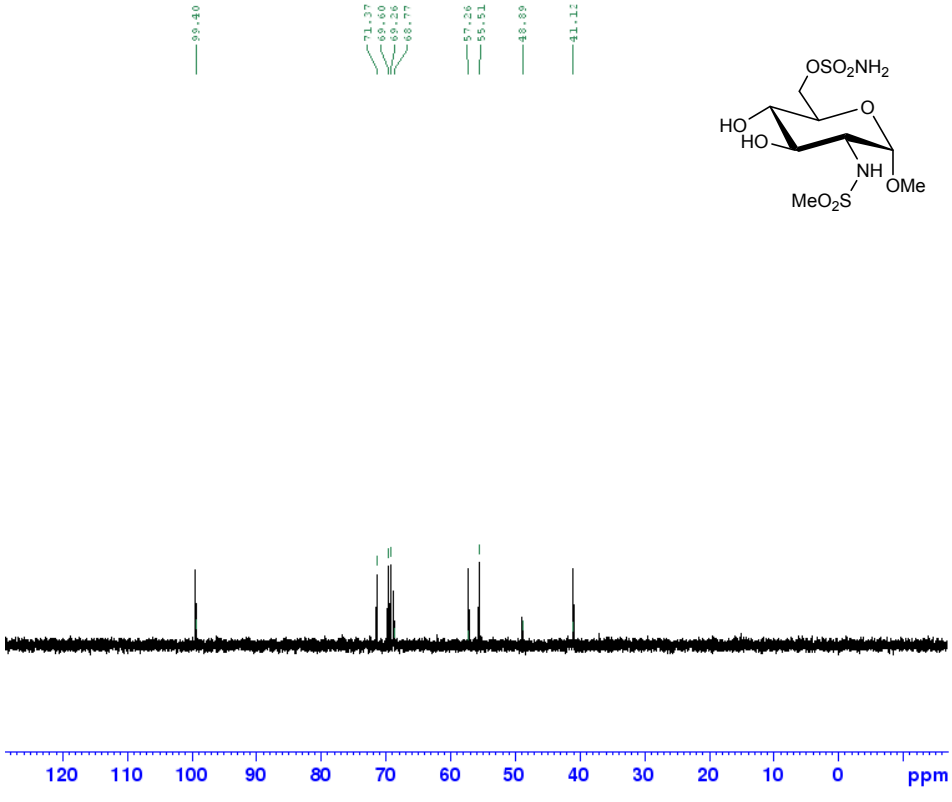

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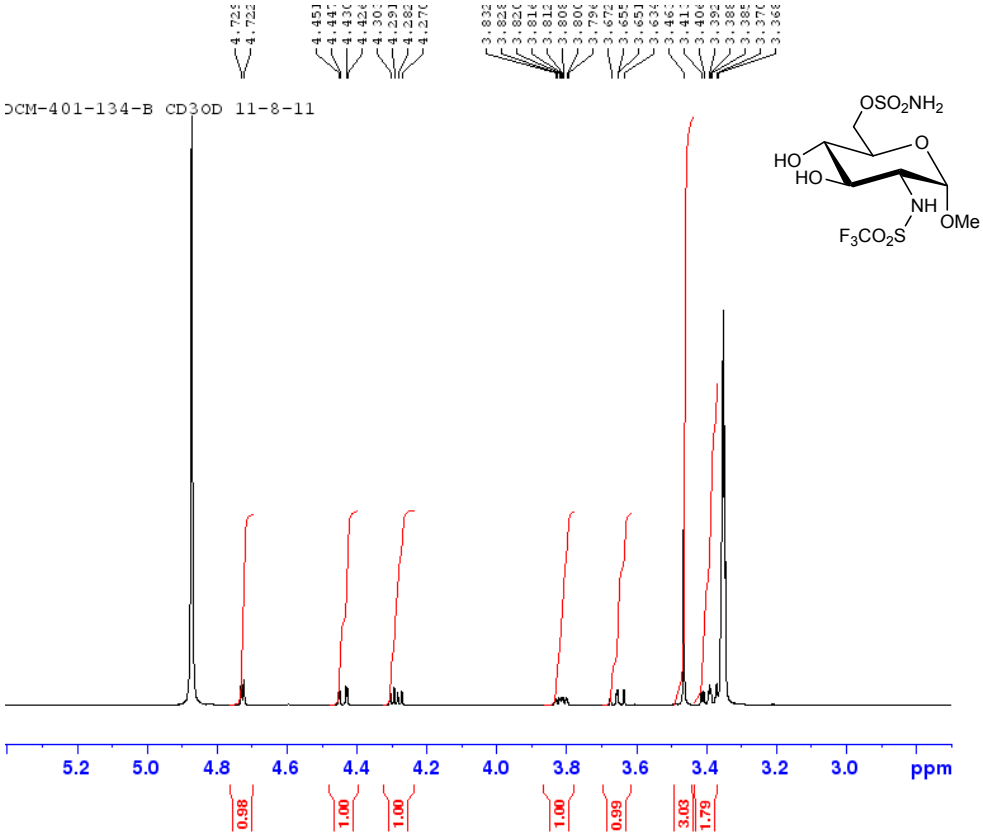

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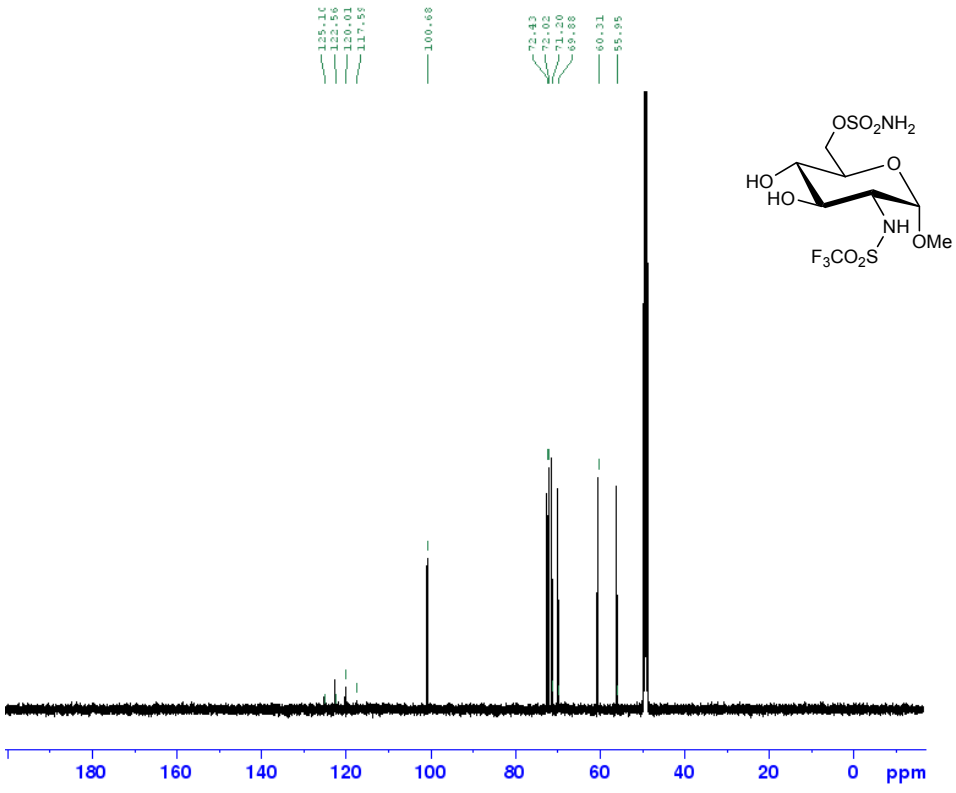

Cmpd 13

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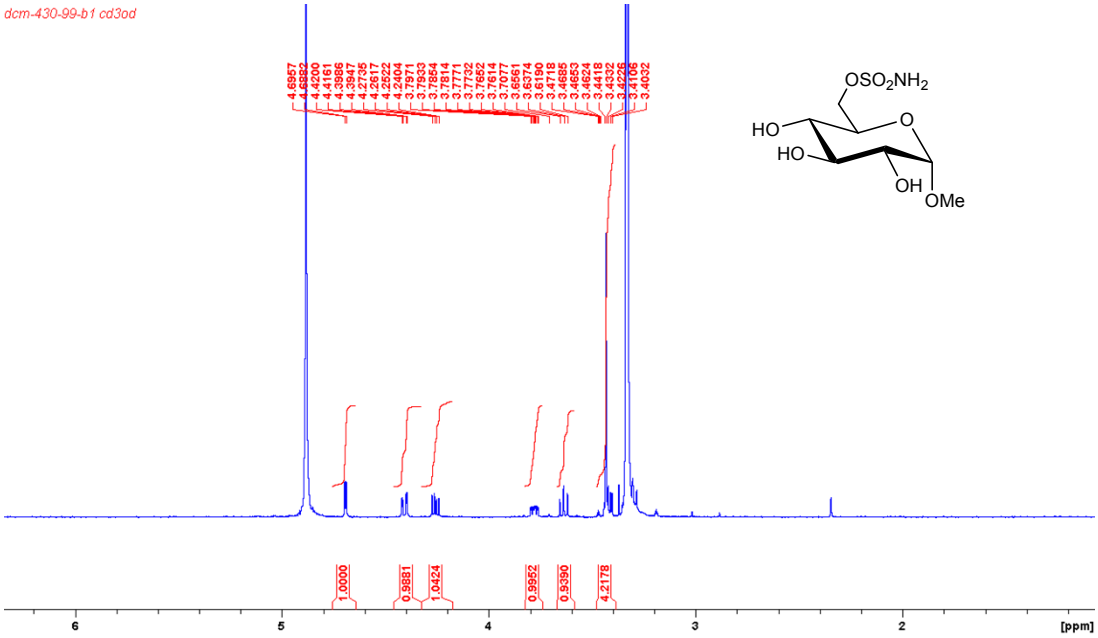

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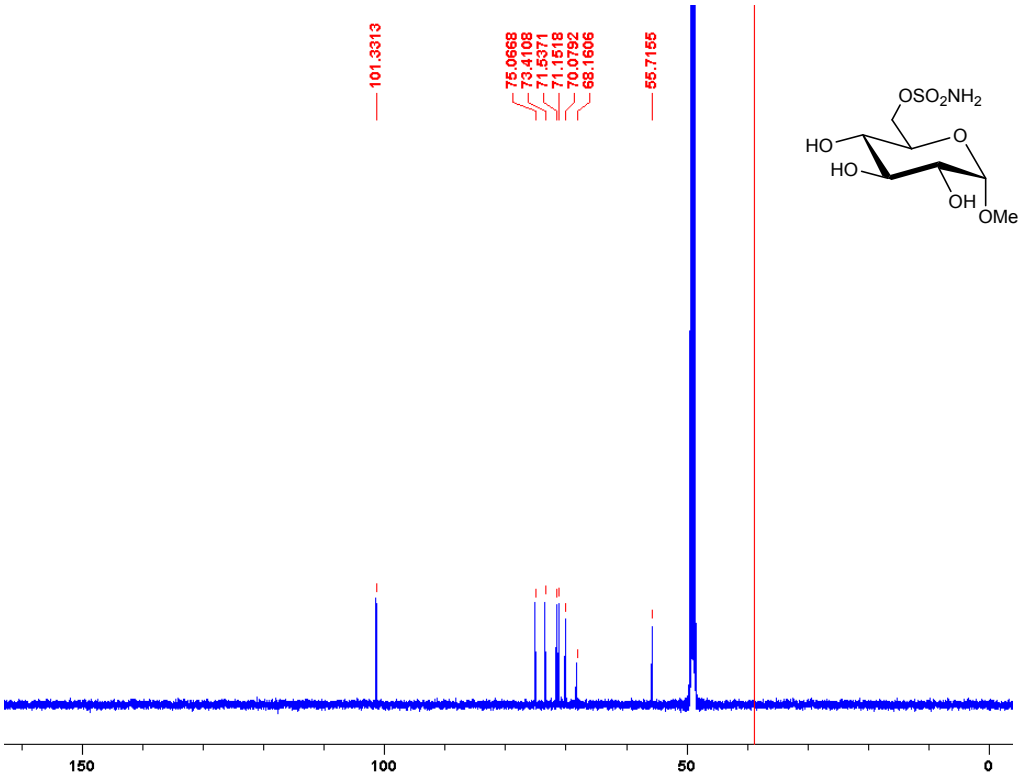

Cmpd 15

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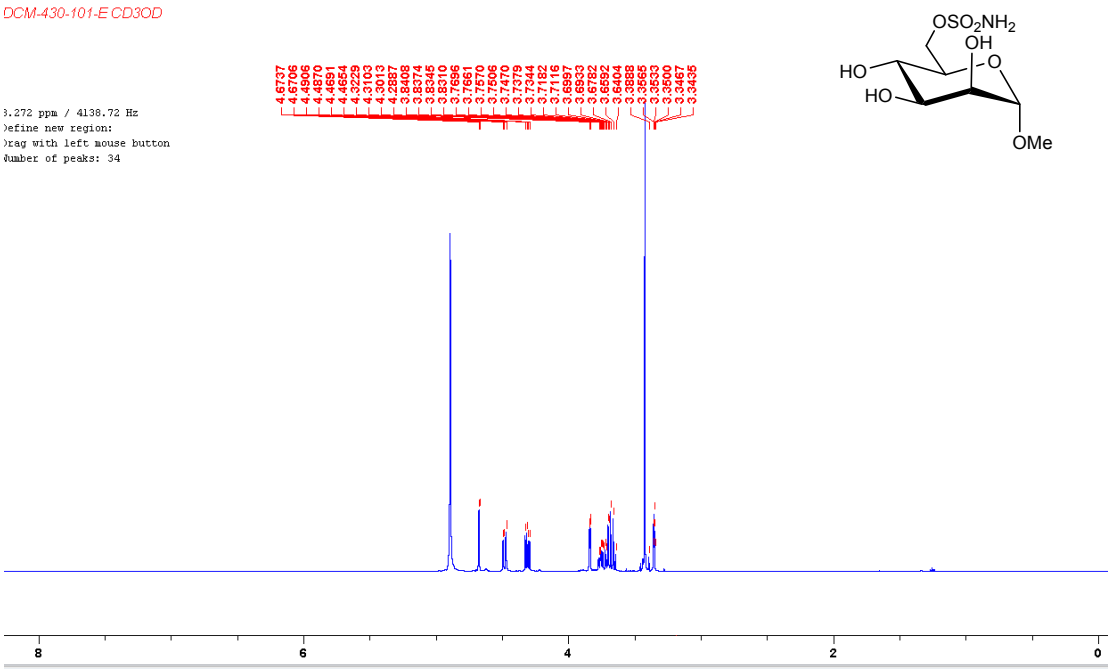

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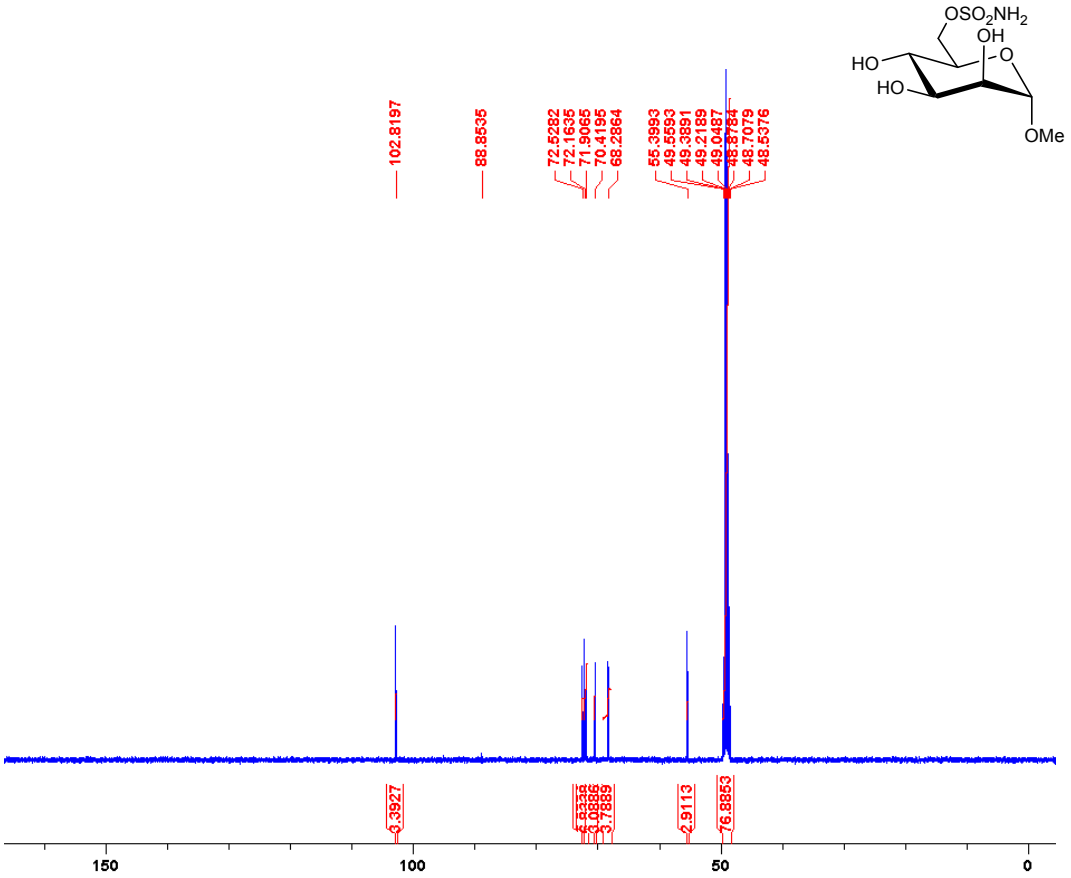

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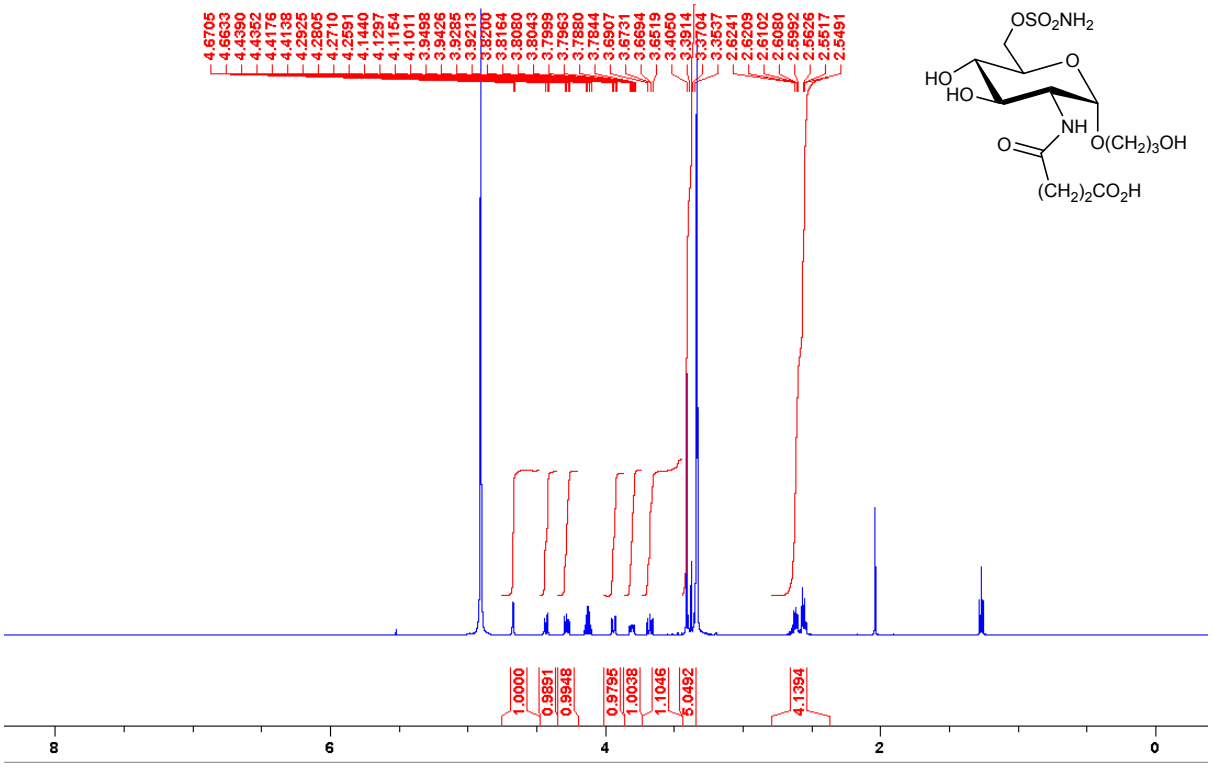

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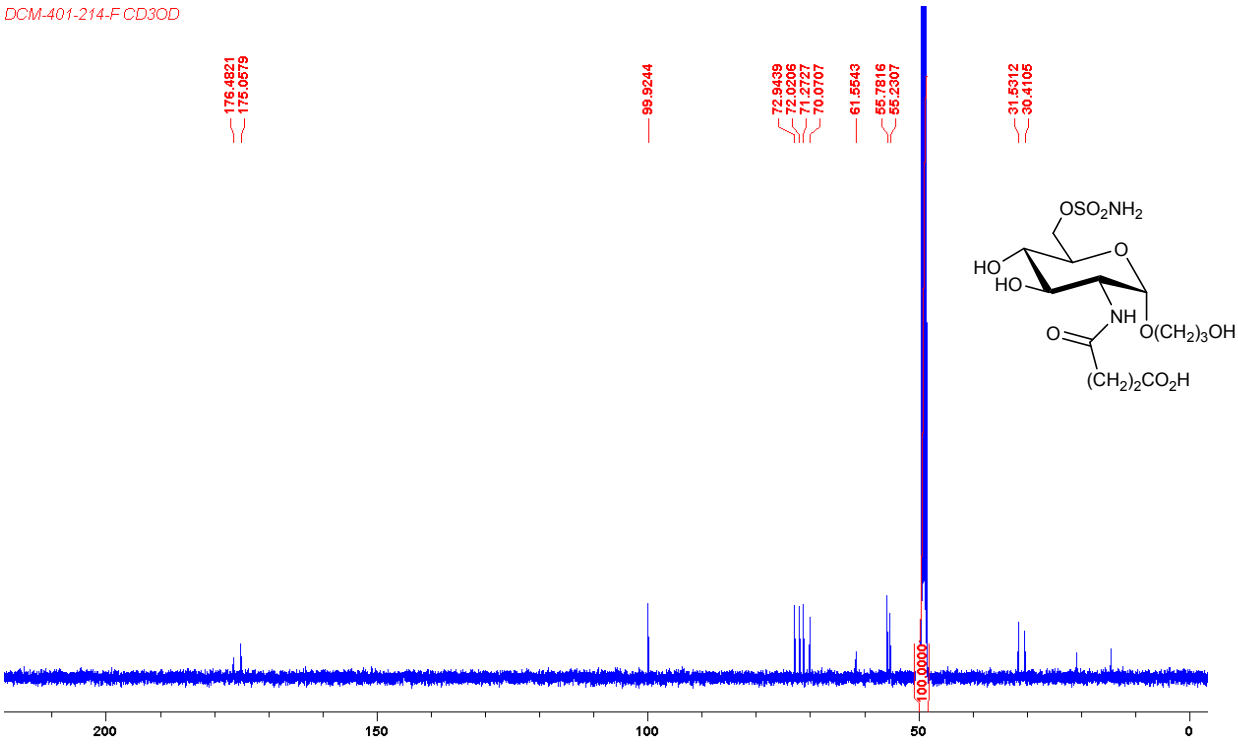

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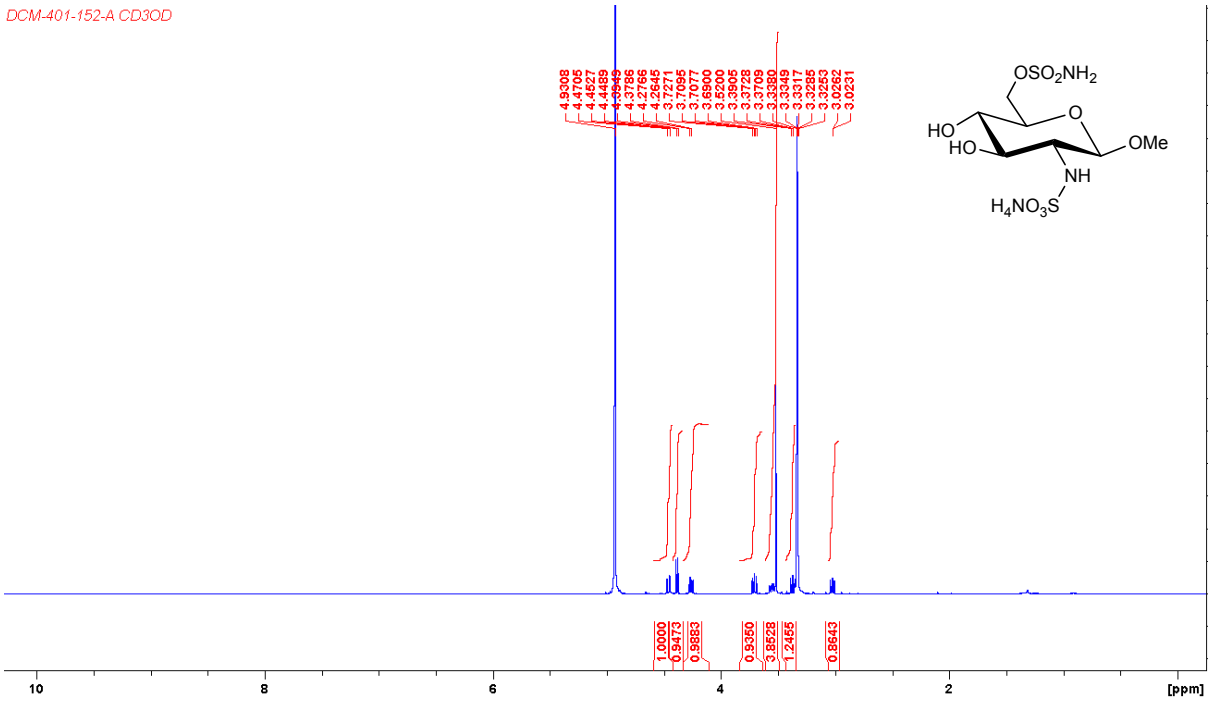

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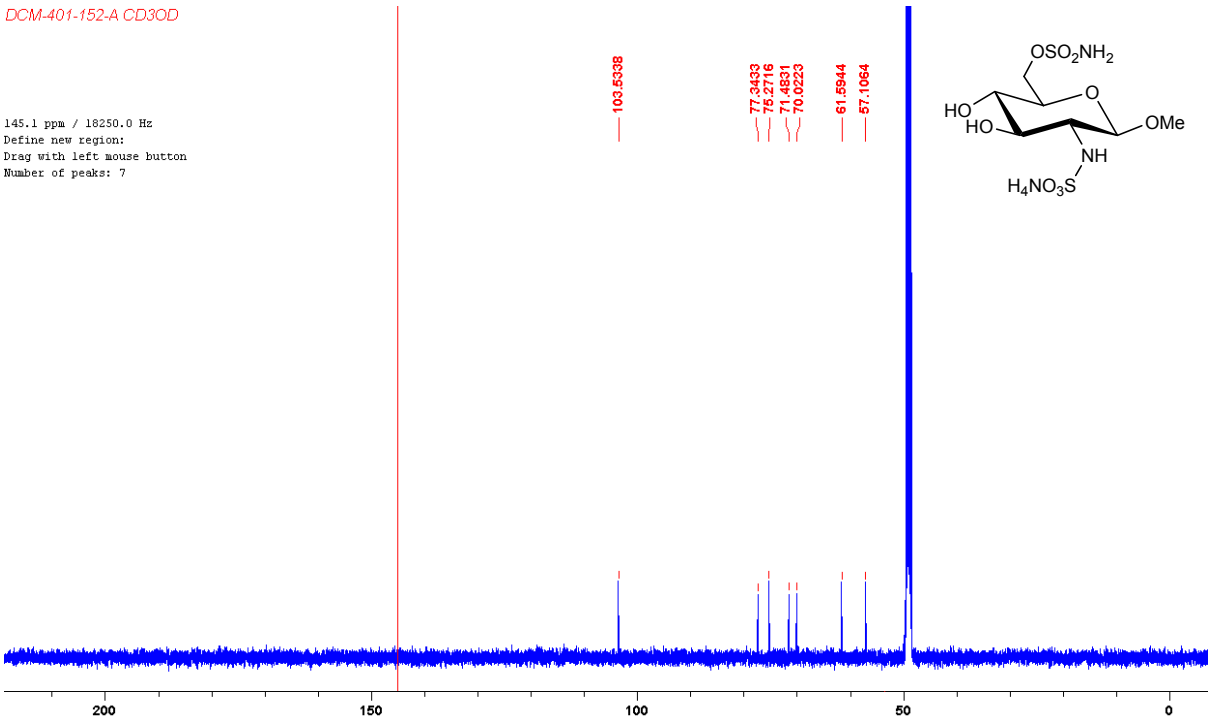
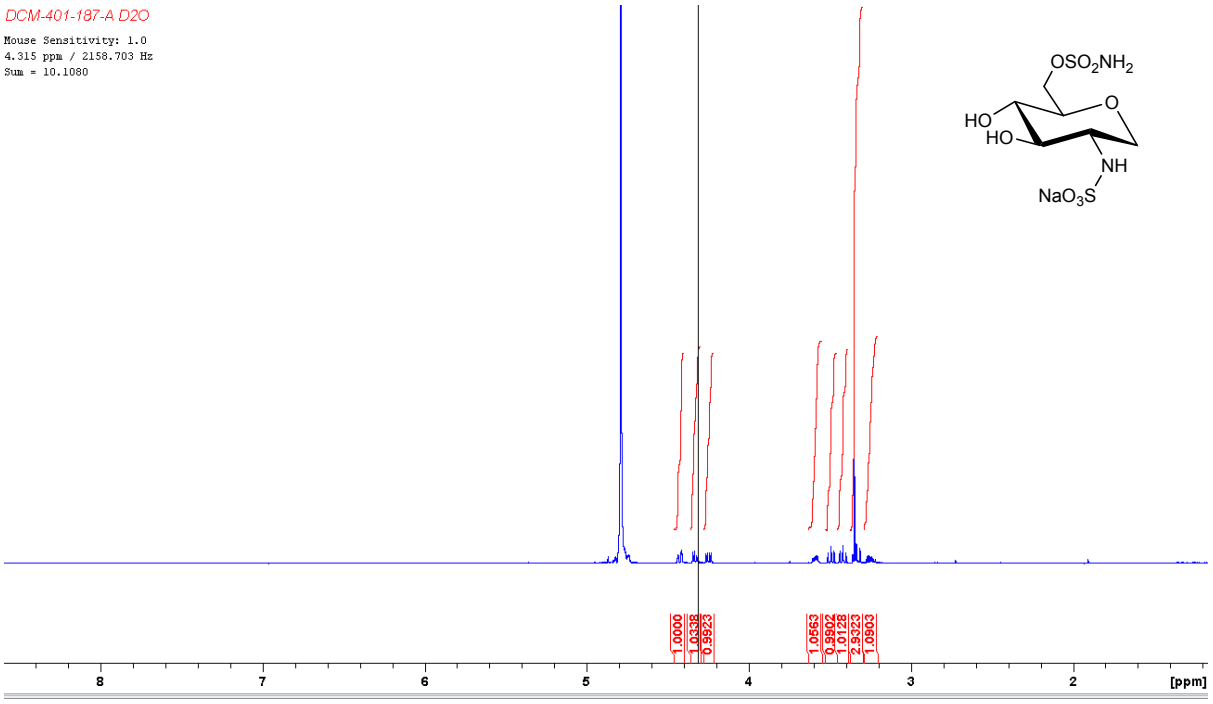


Cmpd 26 ^{1}H NMR D_2O



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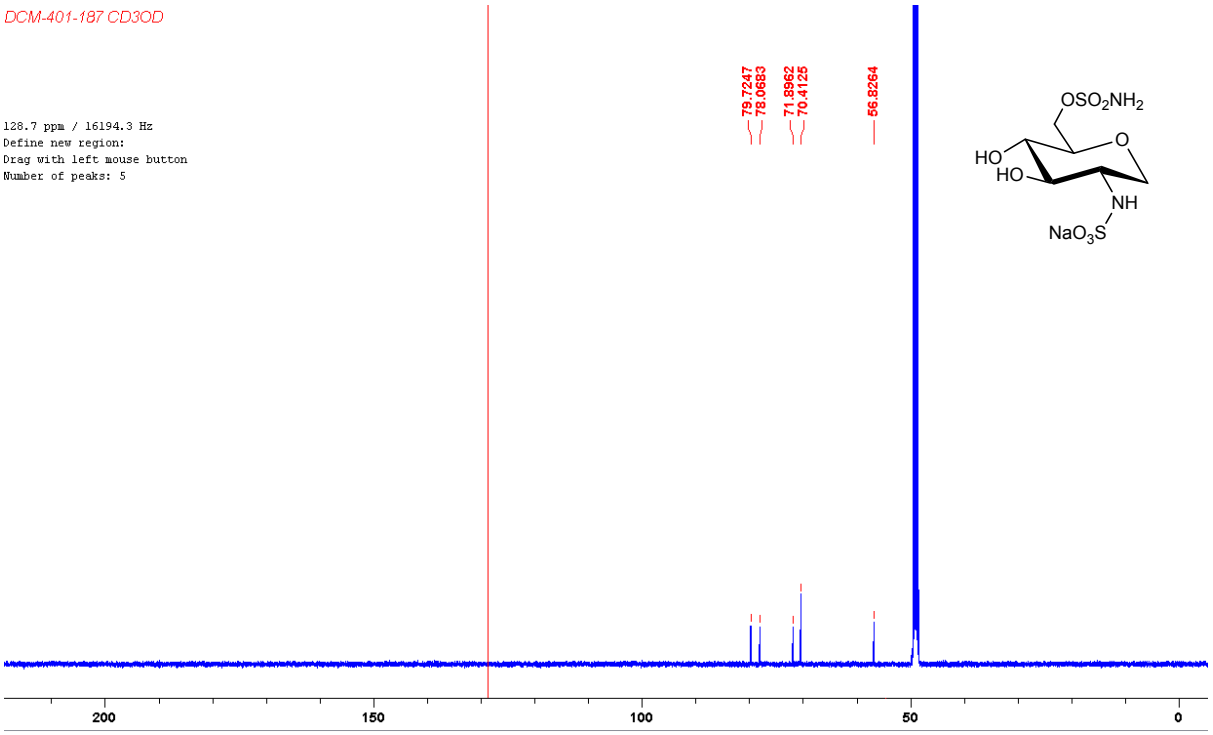

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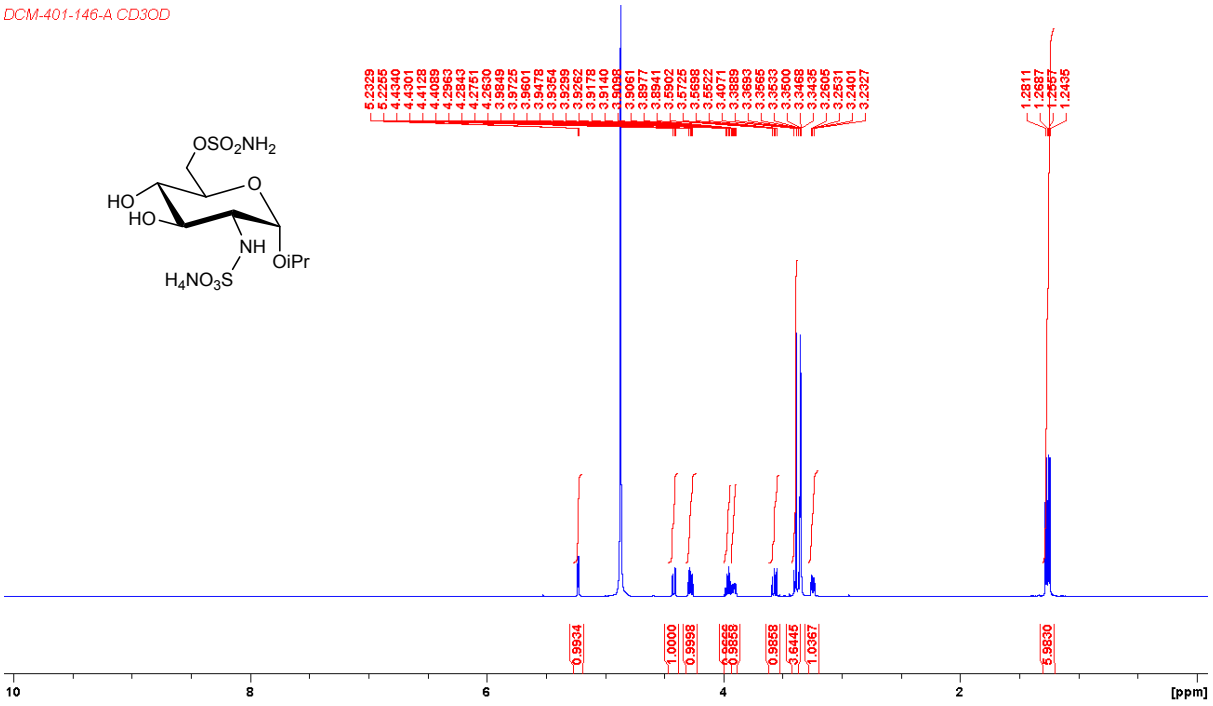

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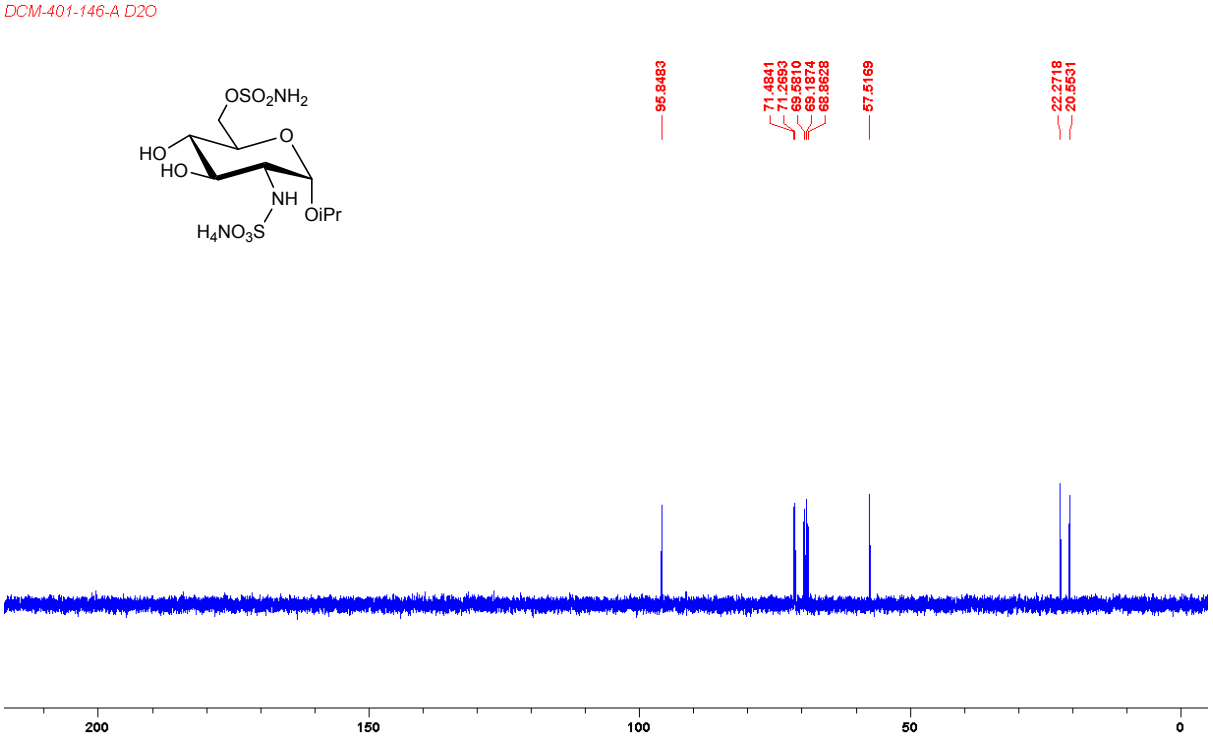
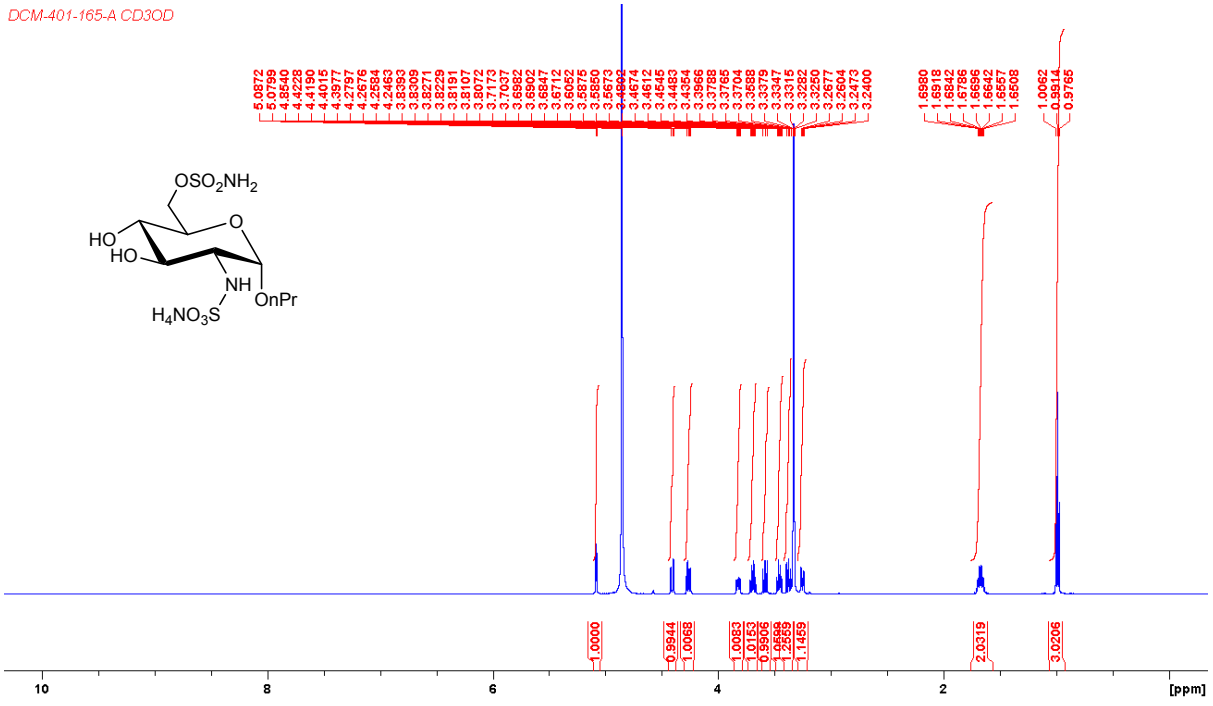
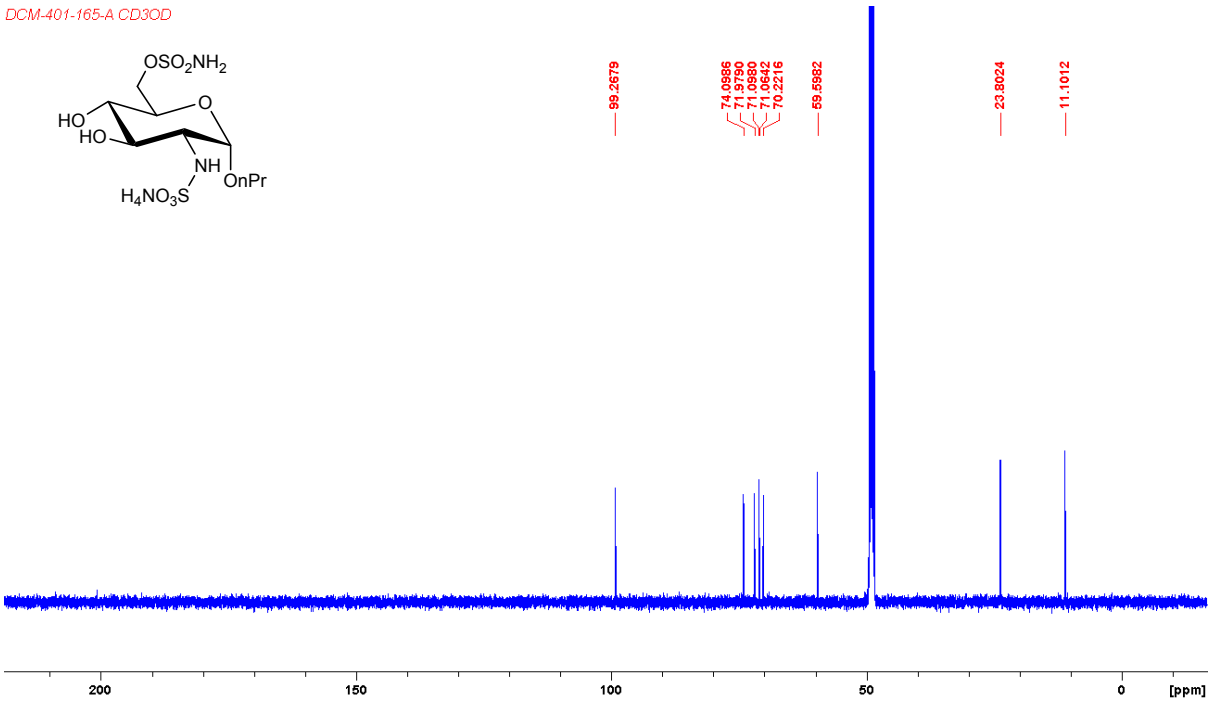


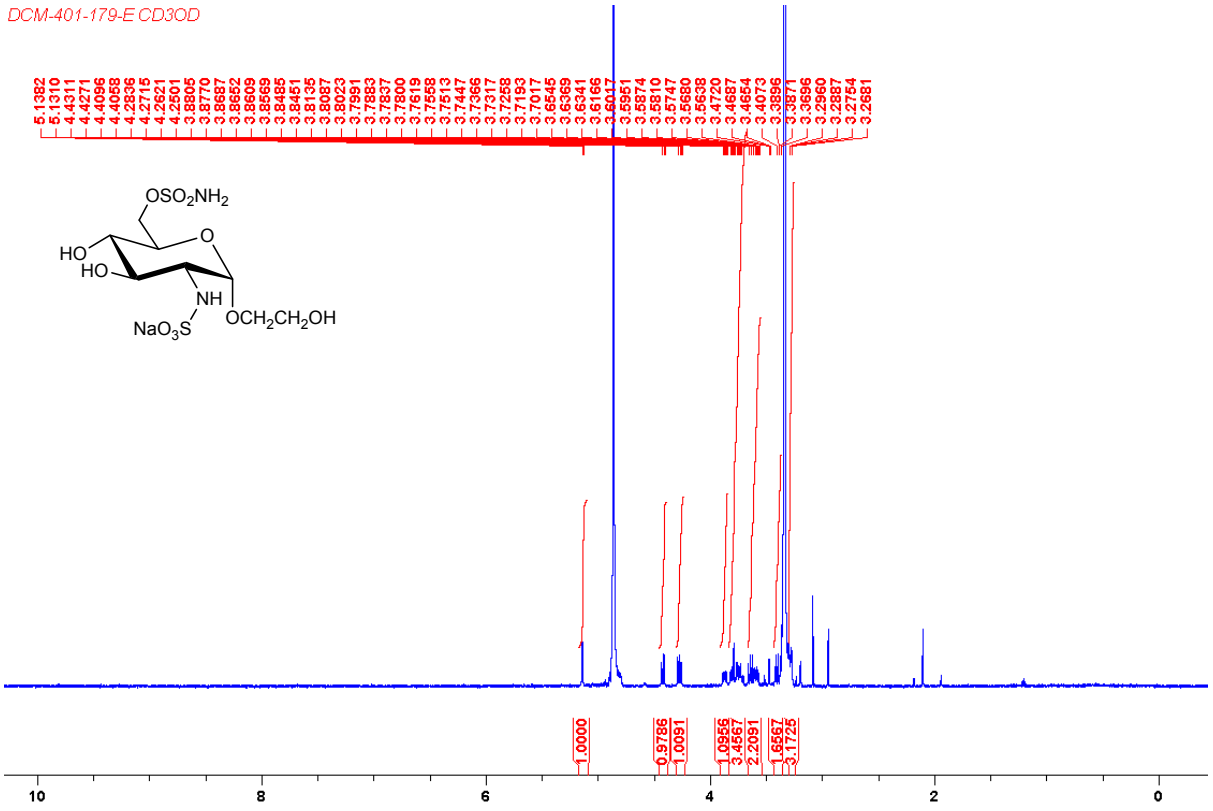
Cmpd 34 ^{1}H NMR MeOD



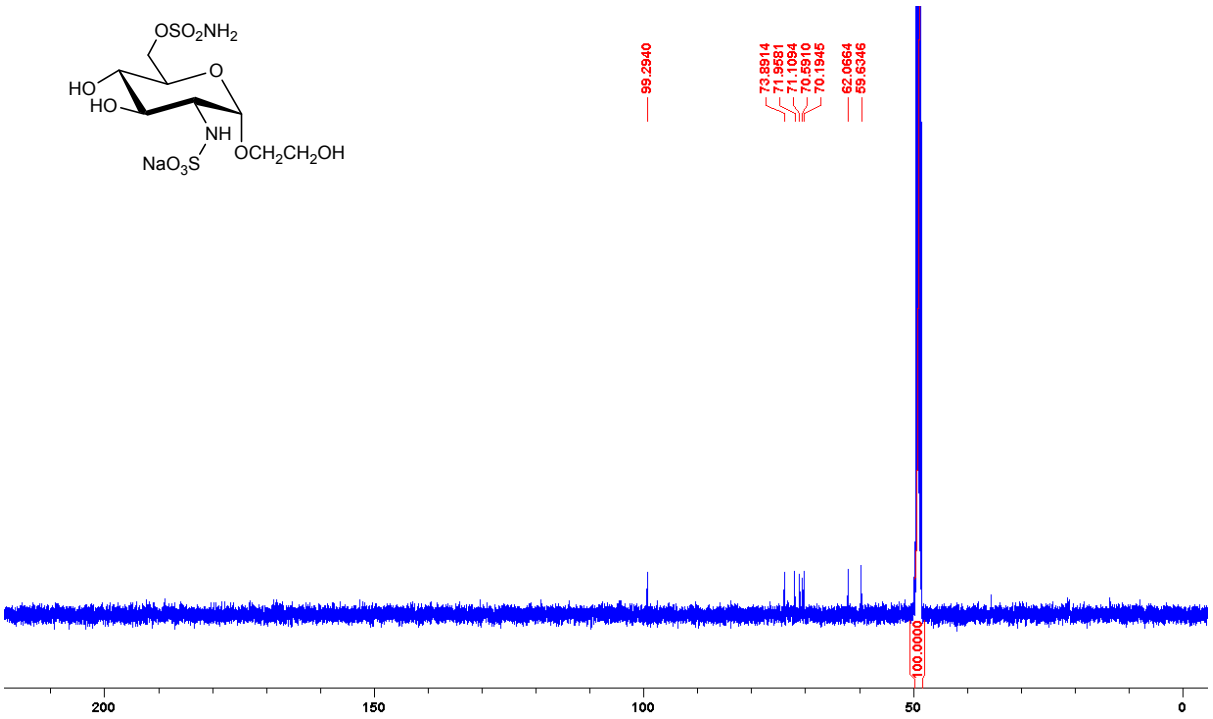
^{13}C NMR MeOD



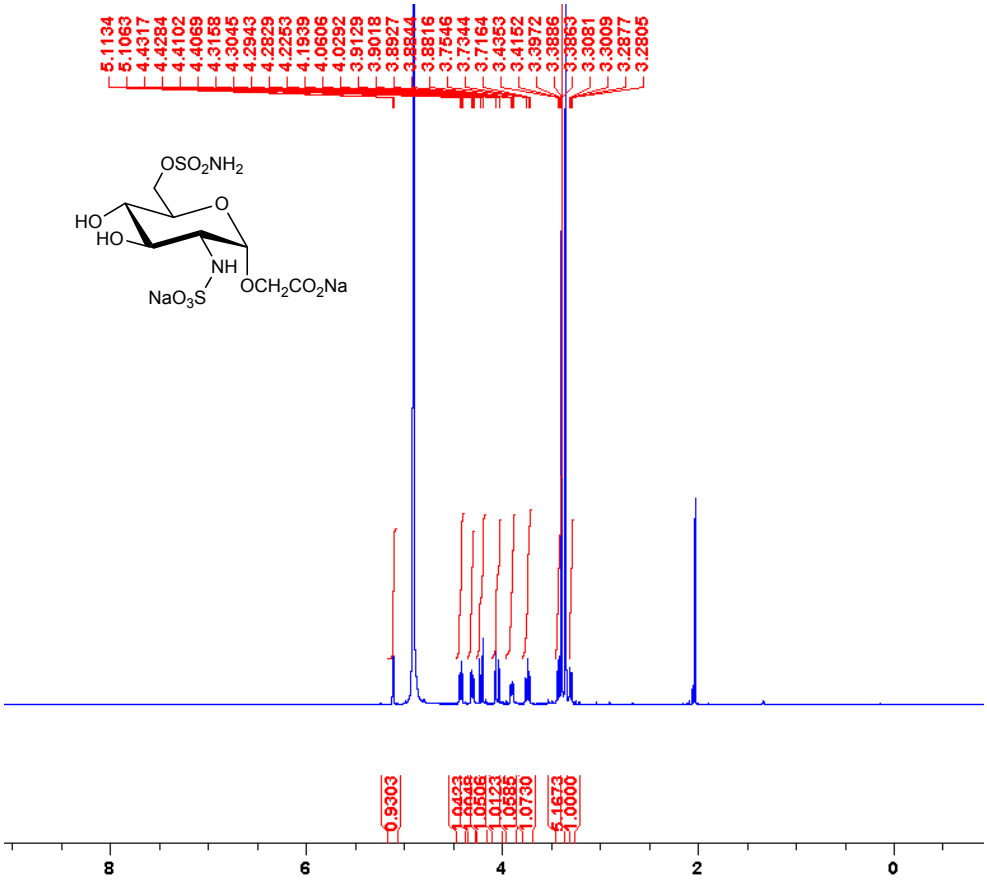
Cmpd 37 ^{1}H NMR MeOD



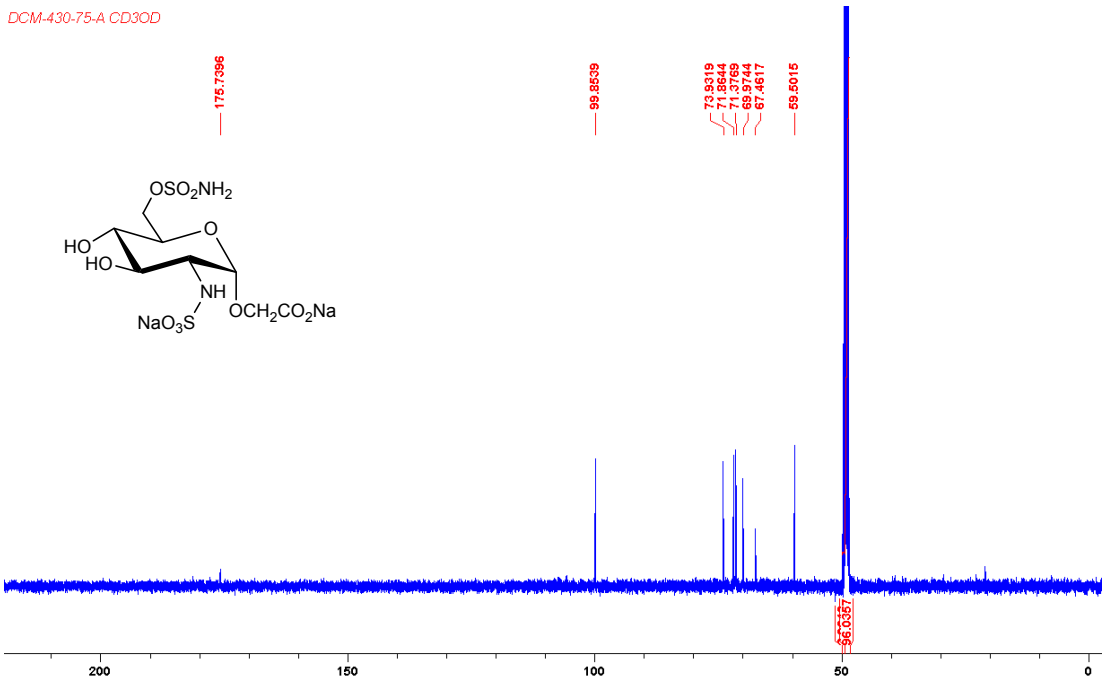
^{13}C NMR MeOD



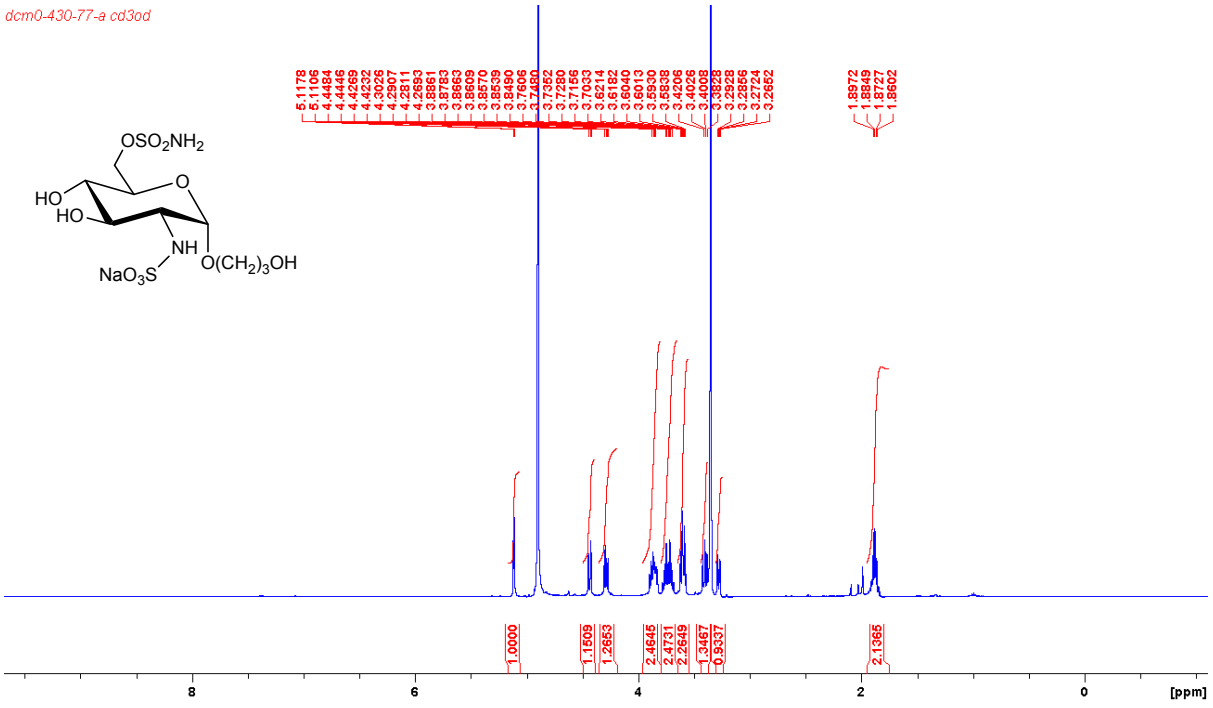
Cmpd 45 ^{1}H NMR MeOD



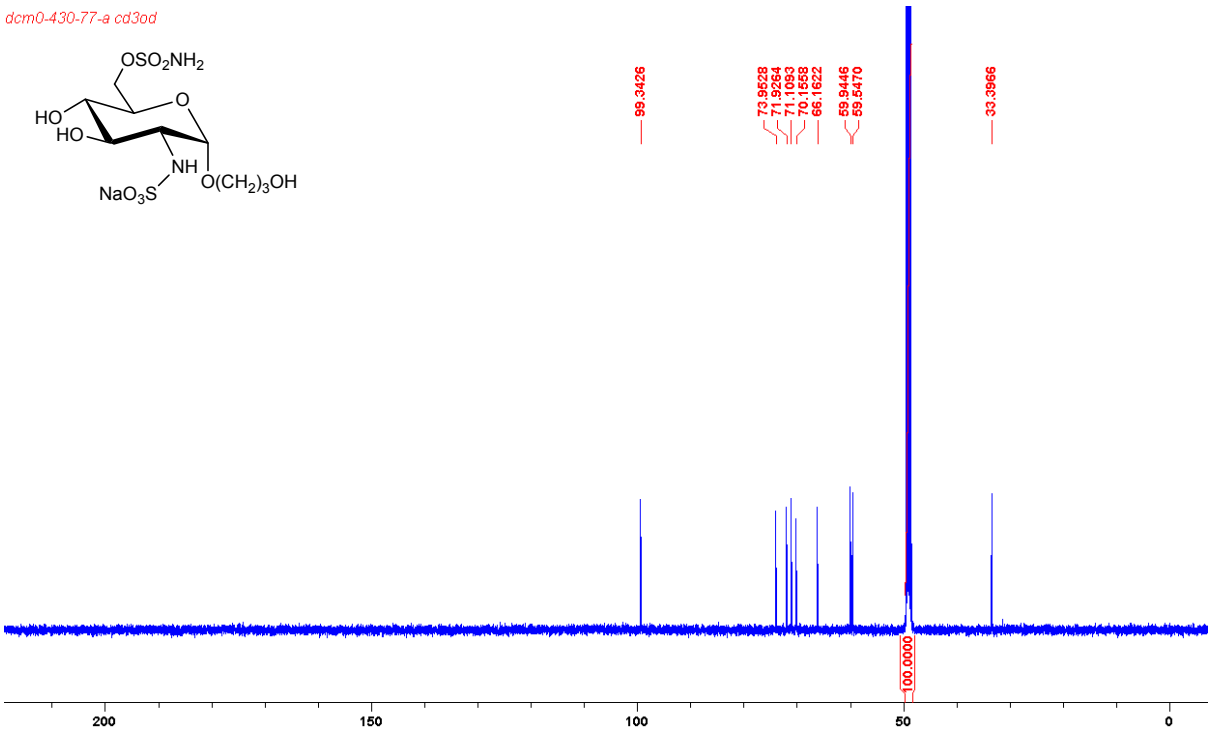
^{13}C NMR MeOD



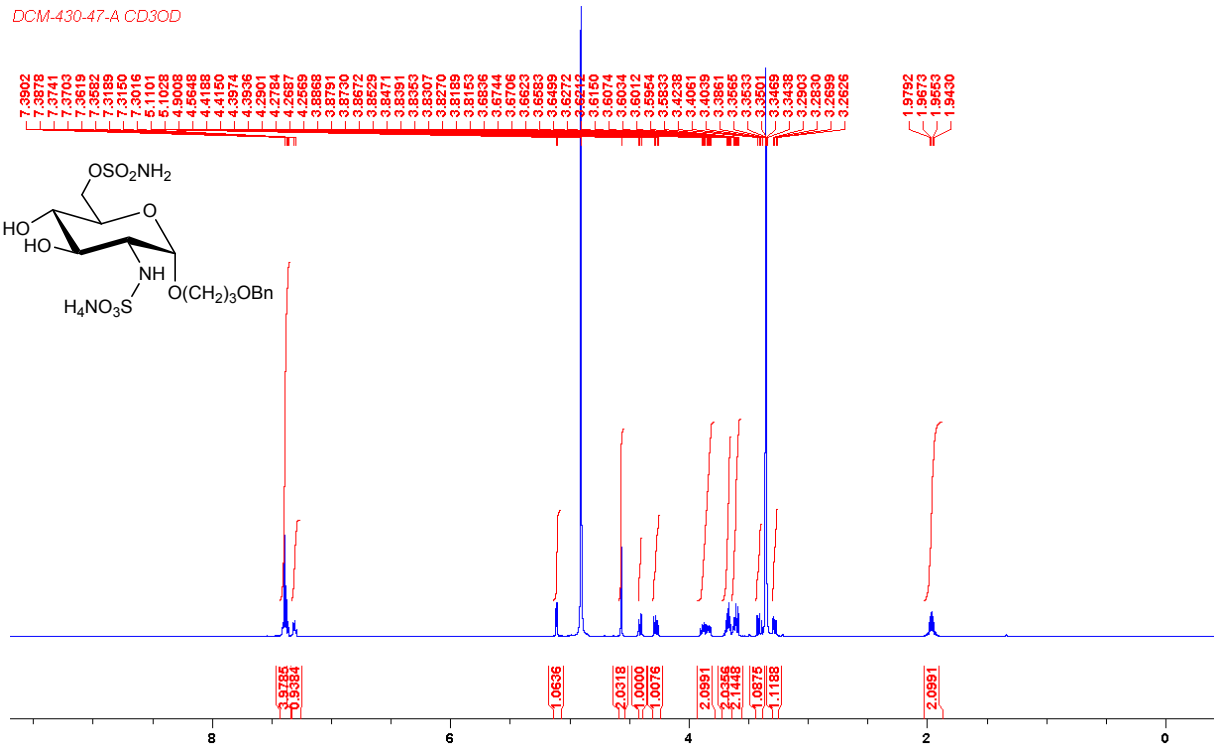
Cmpd 49 ^{1}H NMR MeOD



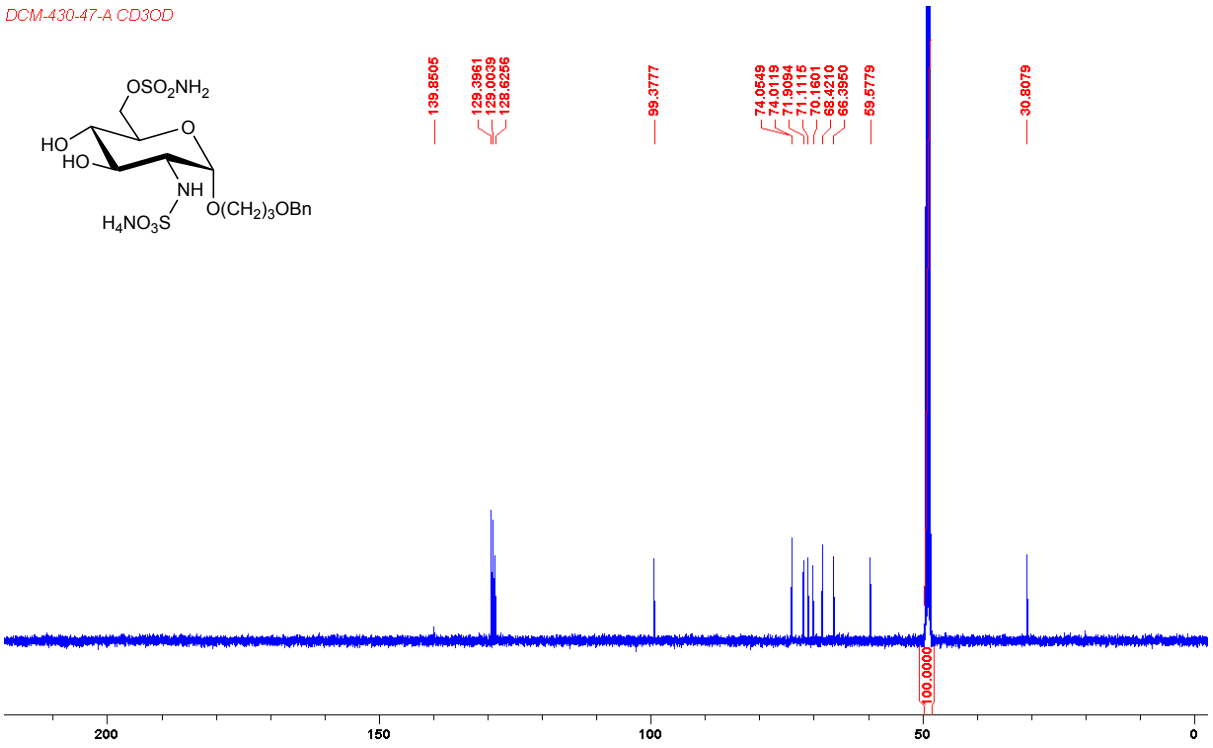
^{13}C NMR MeOD



Cmpd 51 ^{1}H NMR MeOD

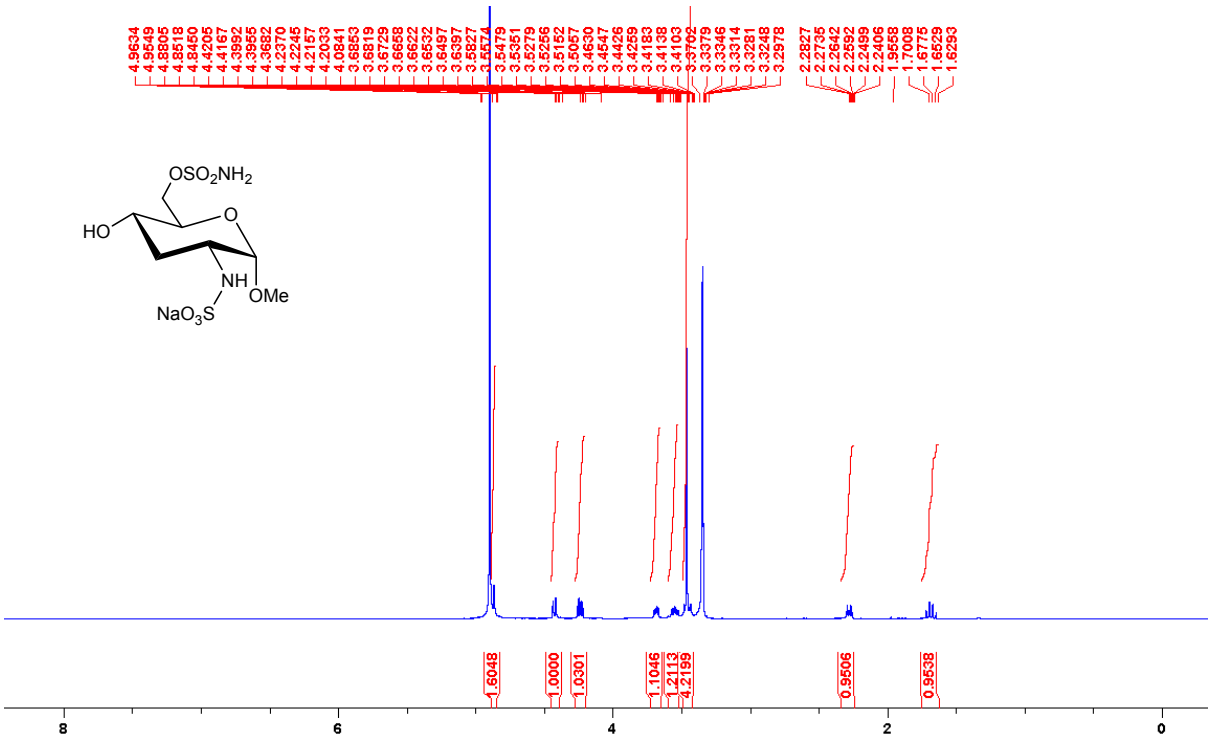


^{13}C NMR MeOD

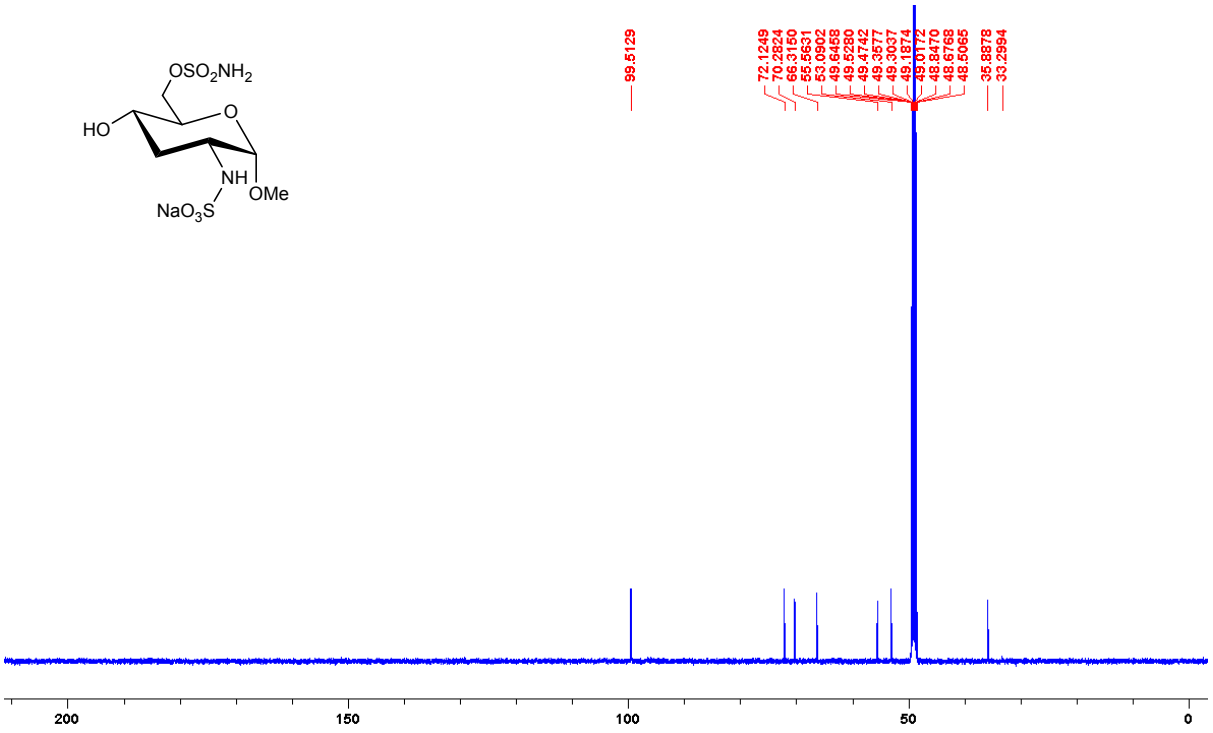


Cmpd 57

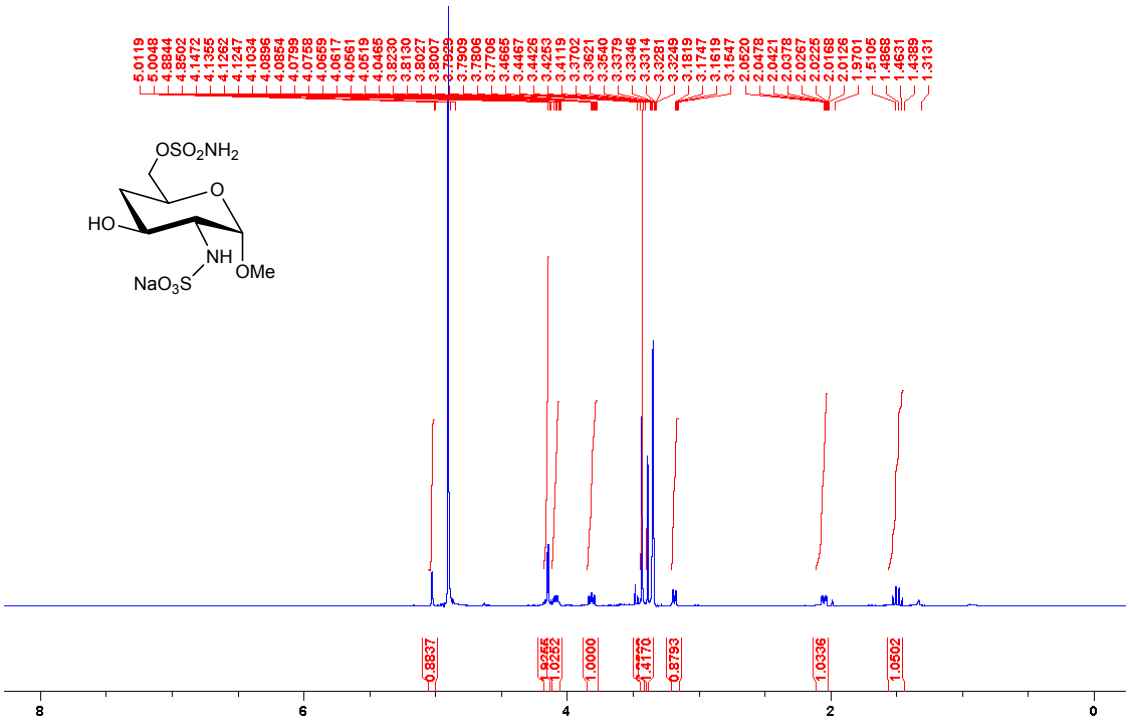
^{1}H NMR MeOD



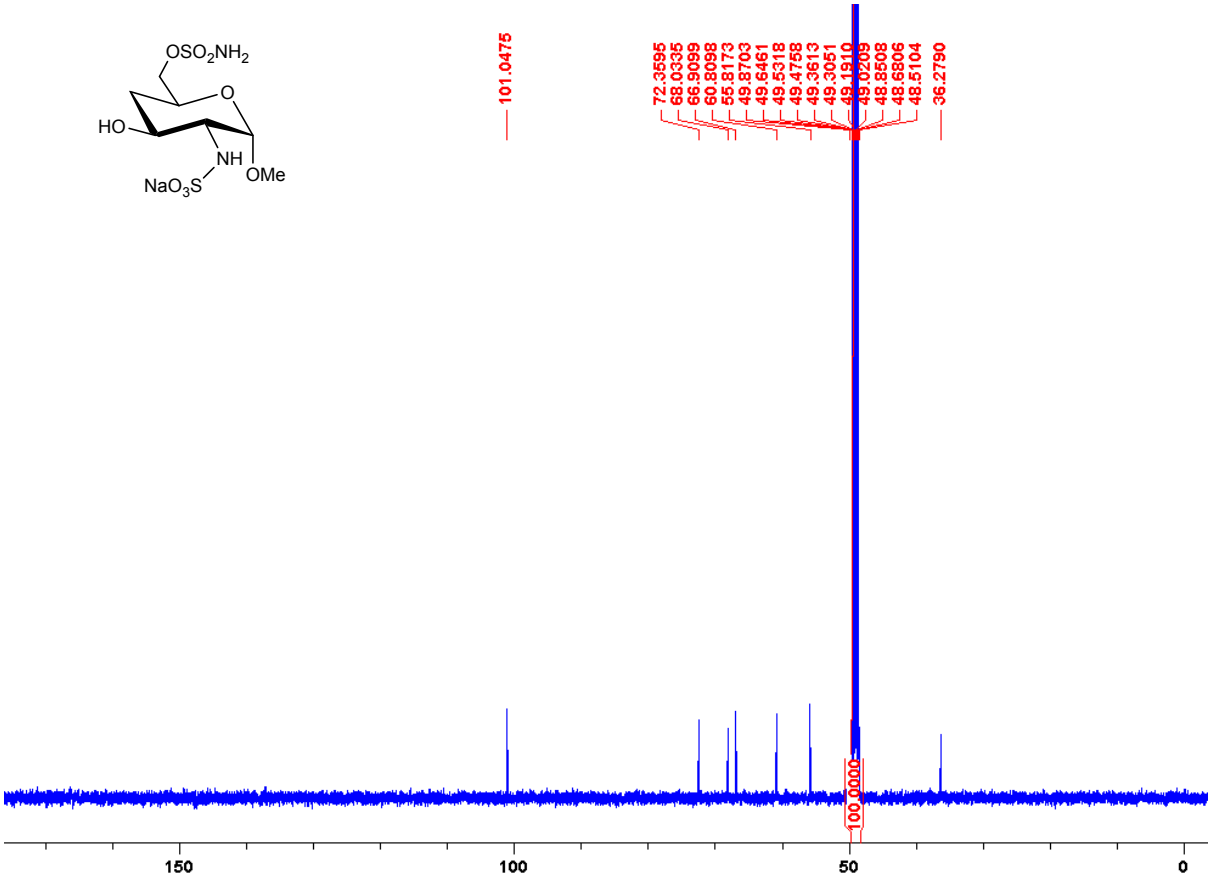
^{13}C NMR MeOD



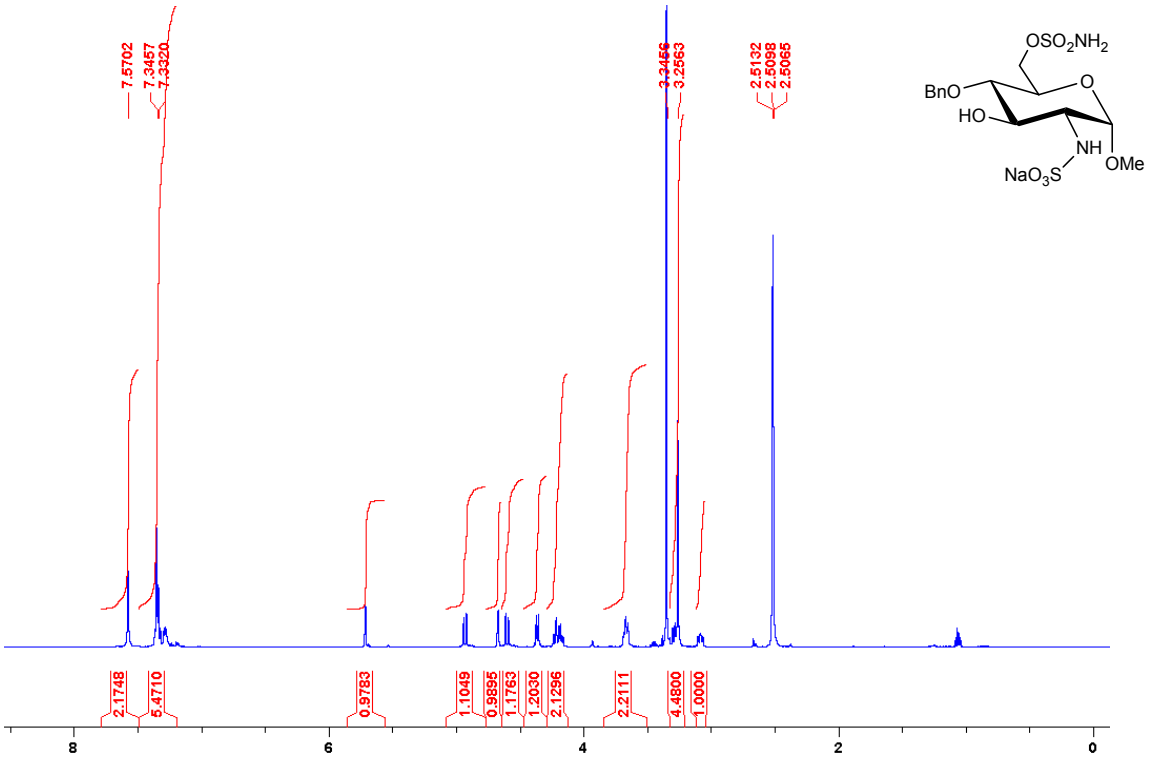
Cmpd 63 ^{1}H NMR MeOD



^{13}C NMR MeOD



Cmpd 68 ^{1}H NMR DMSO-d^{6}



^{13}C NMR DMSO-d^6