Electronic Supplementary Information

De novo chemoenzymatic synthesis of sialic acid

Pierre Stallforth, Stefan Matthies, Alexander Adibekian, Dennis G. Gillingham, Donald Hilvert, Peter H. Seeberger*

Department of Biomolecular Systems, Max-Planck-Institute of Colloids and Interfaces, Am Mühlenberg 1, 14476 Potsdam, Germany and Institute of Chemistry and Biochemistry, Freie Universität Berlin, Arnimallee 22, 14195 Berlin, Germany
Laboratory of Organic Chemistry, ETH Zurich, 8093 Zurich, Switzerland

Peter.seeberger@mpikg.mpg.de

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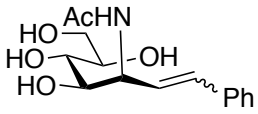
General Methods

Unless otherwise noted, *non*-aqueous reactions were performed under an atmosphere of dried argon in dried glassware, and all chemicals used were reagent grade and used as supplied. Dichloromethane (CH_2Cl_2) and diethyl ether (Et_2O) were purchased from *JT Baker* or *VWR International* and purified by a Cycle-Tainer Solvent Delivery System. Dioxane was taken from *Acros Organics AcroSeal Extra Dry Solvent* bottles and used as shipped. Solvents for chromatography and workup procedures were distilled from technical grade solvents. Zinc dust used for the ozonolysis reductive workup procedure was purchased from Sigma Aldrich (<10 µm, ≥98%, catalogue number: 209988). Analytical thin-layer chromatography was performed on *Macherey-Nagel* silica gel SIL G-25 UV_{254} plates (0.25 mm). Compounds were visualized by UV-light at 254 nm and by dipping the plates in a cerium sulfate ammonium molybdate (CAM) solution followed by heating. Liquid chromatography was performed using forced flow of the indicated solvent on *Fluka* silica gel 60 (230-400 mesh). ^{1}H NMR spectra were obtained on a *Varian* MR-400 (400 MHz) or on a *Varian* PremiumCOMPACT 600 (600 MHz) and are reported in parts per million (δ) relative to the resonance of the solvent. Coupling constants (*J*) are reported in Hertz (Hz). ^{13}C NMR spectra were obtained on a *Varian* MR-400 (100 MHz) or on a *Varian* PremiumCOMPACT 600 (125 MHz) and are reported in δ relative to the resonance of the solvent. IR Spectra were measured neat on a *Perkin-Elmer*-100 FT-IR spectrometer. Specific α_D values were determined on a Schmidt+Haensch Unipol L1000. High-resolution mass spectra were performed by the MS service at the Institute of Organic Chemistry, FU Berlin and are given in *m/z*. MPS and MPS-buffers were prepared according to literature.[1] MPS catalyzed reactions were typically run in a buffer containing 50 mM NaP_i, 5 mM $MgCl_2$ adjusted to pH 7.5. RP-HPLC was performed on an Agilent 1200 series on Waters XBridge Prep C18 100 5µm column. The respective flow rate used was as indicated. The products were eluted with short isocratic, then linear gradients, typically 5% to 30% MeCN in water under neutral conditions to prevent any decomposition or elimination reactions during purification.

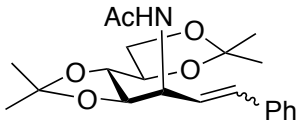
Experimental Procedures

(*E/Z*)-3-Acetamido-1,2,3-trideoxy-1-phenyl-D-*manno*-hept-1-enitol (6)



N-Acetyl-glucosamine **5** (5.0 g, 22.6 mmol), $BnPPh_3Cl$ (17.5 g, 45.0 mmol) and K_2CO_3 (12.5 g, 90 mmol) were dissolved in dioxane (150 mL) and formamide (4 mL, 100 mmol) and heated to reflux for 24 h. The reaction mixture was quenched by the addition of water (3 mL) and solvents were removed *in vacuo*. The crude product was purified by flash column chromatography on silica gel (CH_2Cl_2/MeOH = 5.5:1) and subsequently recrystallized from EtOH/Et_2O to yield olefin **6** (as a mixture of (*E/Z*) stereoisomers) as a white solid (2.1 g). R_f = 0.44 (CH_2Cl_2/MeOH = 4:1); IR (neat) ν_{max} 3296, 2931, 1645, 1532, 1372, 1033, 693 cm^{-1}; ^1H NMR (400 MHz, *DMSO-d6*) (*E/Z*)-mixture: δ 8.03 (d, *J* = 8.4 Hz, 1H), 7.98 (d, *J* = 8.7 Hz, 1H), 7.44 – 7.19 (m, 10H), 6.51 (d, *J* = 11.8 Hz, 1H), 6.47 (d, *J* = 16.2 Hz, 1H), 6.40 (dd, *J* = 16.1, 5.2 Hz, 1H), 5.69 (dd, *J* = 11.8, 9.7 Hz, 1H), 4.85 (q, *J* = 8.9 Hz, 1H), 4.56 (d, *J* = 3.9 Hz, 1H), 4.54 (d, *J* = 4.6 Hz, 1H), 4.55 – 4.50 (m, 1H), 4.47 (d, *J* = 5.5 Hz, 1H), 4.43 (d, *J* = 5.6 Hz, 1H), 4.36 (d, *J* = 6.7 Hz, 1H), 4.34 (d, *J* = 6.3 Hz, 1H), 4.33 (d, *J* = 6.2 Hz, 2H), 4.29 (d, *J* = 5.7 Hz, 1H), 3.70 – 3.56 (m, 4H), 3.53 – 3.45 (m, 2H), 3.44 – 3.25 (m, 3H), 1.89 (s, 3H), 1.81 (s, 3H). ^{13}C NMR (100 MHz, *DMSO-d6*) (*E/Z*)-mixture: δ 169.4, 169.3, 137.0, 136.5, 131.2, 130.6, 129.6, 129.5, 128.8, 128.6, 128.2, 127.2, 127.0, 126.1, 71.3, 71.1, 71.0, 71.0, 70.4, 70.1, 63.6, 63.6, 52.8, 48.8, 22.8, 22.6; HR ESI MS Calcd for $C_{15}H_{21}NO_5$ [$M+Na^+$]: 318.1312 found: 318.1331. All spectroscopic data are in good accordance with reported data.[2]

(*E/Z*)-3-Acetamido-4:5,6:7-*O*-diisopropylidene-1,2,3-trideoxy-1-phenyl-D-*manno*-hept-1-enitol (7)

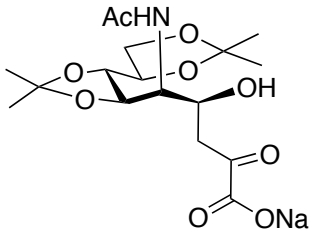


To a solution of olefin **6** (1.0 g, 3.4 mmol) in acetone (170 mL) was added conc. *aq*. HCl (0.7 mL, 23.0 mmol). The mixture was stirred at r.t. for 12 h after which it was poured into a solution of sat. *aq*. $NaHCO_3$ and extracted with CH_2Cl_2 (3 x). The combined organic layers were washed with brine and dried over $MgSO_4$. Solvents were removed *in vacuo* and the crude product was purified by flash column chromatography on silica gel (gradient cyclohexane/EtOAc = 10:1 → 0:1) to yield olefin **7** as clear oil (1.23 g, 31% over two steps). R_f = 0.8 (EtOAc); IR (neat) ν_{max} 3279, 3028, 2987, 2936, 2890, 2447, 1650, 1536, 1496, 1371, 1211, 1069, 845, 729 cm^{-1}; ^1H NMR (400 MHz, *CDCl₃*) (*E*)-isomer: δ 7.47 – 7.18 (m, 5H), 6.63 (d, *J* = 16.0 Hz, 1H), 6.21 (dd, *J* = 16.0, 8.0 Hz, 1H), 6.04 (d, *J* = 8.5 Hz, 1H), 4.98 – 4.75 (m, 1H), 4.16 – 3.96 (m, 3H), 3.88 (dd, *J* = 8.5, 5.5 Hz, 1H), 3.75 (dd, *J* = 8.2, 7.7 Hz, 1H), 2.01 (s, 3H), 1.43 (s, 3H), 1.40 (s, 3H), 1.38 (s, 3H), 1.35 (s, 3H); (*Z*)-isomer: δ 7.47 - 7.18 (m, 5H), 6.70 (d, *J* = 11.8 Hz, 1H), 5.93 (d, *J* = 8.1 Hz, 1H), 5.71 (dd, *J* = 11.8, 10.0 Hz, 1H), 5.27 – 5.20 (m, 1H), 4.16 – 3.97 (m, 2H), 3.94 (dd, *J* = 7.9, 5.7 Hz, 1H), 3.70 (dd, *J* = 8.2, 5.6 Hz, 1H), 3.61 (t, *J* = 7.6 Hz, 1H), 1.99 (s, 3H), 1.34 (s, 3H), 1.33 (s, 3H), 1.22 (s, 3H), 0.94 (s, 3H); ^{13}C NMR (101 MHz, *CDCl₃*) δ 168.9, 168.8, 136.5, 136.1, 134.0, 133.8, 128.8, 128.5, 128.4, 127.8, 127.4, 126.5, 125.7, 124.6, 109.8, 109.8, 109.7, 109.6, 82.3, 81.8, 78.8, 78.7, 76.8, 67.8, 67.5, 52.7, 48.4, 27.1, 27.1, 26.9, 26.7, 26.7, 25.8, 25.2, 25.1, 23.5, 23.4; HR ESI MS Calcd for $C_{21}H_{29}NO_5$ [M+Na^+]: 398.1938 found: 398.1951. All spectroscopic data are in good accordance with reported data.[2]

2-Acetamido-2-deoxy-3:4,5:6-di-*O*-isopropylidene-D-*manno*-hexoaldose (9)

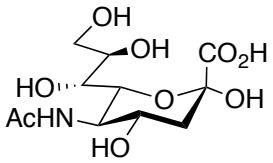
Ozone gas was passed into a solution of olefin **7** (700 mg, 1.86 mmol) in 80 mL CH_2Cl_2 at -78°C for 4 min. After completion of the reaction the production of ozone was stopped and to the mixture were added 10 mL of dimethyl sulfide and Zn dust (~50 mg). The mixture was allowed to warm to r.t. over 2 h and stirring for a further 24 h at r.t.. Solvents were removed *in vacuo* and the crude mixture was coevaporated with toluene to remove benzaldehyde. The crude residue was dissolved in a small amount of CH_2Cl_2 and centrifuged to remove residual Zn dust. Subsequently, the CH_2Cl_2 solution was washed with *aq*. phosphate buffer (pH = 7.5). The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo* to yield crude aldehyde **9** (560 mg) as yellow foam which was used without any further purification. $[\alpha]_D^{20}$ = +27.6 (*c* = 1, CH_2Cl_2); R_f = 0.45 (EtOAc); IR (film) ν_{max} 3285, 3067, 2987, 2936, 2889, 1736, 1658, 1546, 1405, 1372, 1215, 1155, 1070, 845, 722 cm^{-1}; ^1H NMR (400 MHz, *CDCl₃*) δ 9.70 (d, *J* = 0.7 Hz, 1H), 6.49 (d, *J* = 4.7 Hz, 1H), 4.66 (td, *J* = 6.2, 0.5 Hz, 1H), 4.20 – 4.13 (m, 2H), 4.06 – 3.92 (m, 4H), 2.05 (s, 2H), 1.43 (s, 3H), 1.39 (s, 3H), 1.36 (s, 6H); ^{13}C NMR (101 MHz, *CDCl₃*) δ 198.1, 170.3, 110.8, 110.3, 80.0, 79.3, 68.0, 60.1, 27.1, 27.0, 26.7, 25.3, 23.0; HR ESI MS Calcd for $C_{14}H_{23}NO_6$ [M+Na^+]: 324.1418 found: 324.1409.

Sodium-5-acetamido-3-deoxy-6:7,8:9-di-*O*-isopropylidene-D-*glycero*-D-*galacto*-non-2-ulosonate (10)



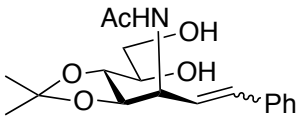
Aldehyde **9** (24 mg, 0.08 mmol) was dissolved in a minimum amount of acetonitrile and transferred to a 50 mL Falcon tube. Enough of the reaction buffer was then added to give a final substrate concentration of 15 mM (10.3 mL), then MPS (318 µL of a 250 µM stock solution to give a final concentration of 5 µM of MPS) was added by pipette. The oxaloacetate was added in four portions (4 x 5.3 mg, 0.16 mmol) as a solid powder over 4 h, and the reaction was allowed to stir for an additional 1 h. After 5 h in total the mixture was frozen and the water removed by lyophilization. The crude residue was suspended in CD_3OD and stirred for 15 min. The resulting suspension was filtered. The product was then purified by reversed phase-HPLC under neutral conditions to prevent elimination. A gradient of eluent, first isocratic at 2% (0-5 min), then from 2% to 25% (in 35 min) MeCN in water at a flow rate of 4 mL/min (retention time = 10 min) was used and the α-ketocarboxylate **10** (10 mg) was obtained as a white powder after lyophilization. The title compound is present as an equilibrium mixture between the keto acid and the corresponding enol form. This feature was commonly observed in a previous study. Upon addition of methanol an H/D-exchange at C3 position was observed due to the keto-enol-equilibriation. $[\alpha]_D^{20} = 7.50$ (*c* = 0.2, MeOH); IR (film) ν_{max} 3315, 2987, 2938, 2893, 1711, 1630, 1534, 1371, 1257, 1237, 1213, 1155, 1065, 846, 789 cm^{-1}; ^1H NMR (600 MHz, *DMSO-d_6*) δ 4.19 (ddd, J = 8.3, 3.7, 1.2 Hz, 1H), 4.02 (q, J = 6.1 Hz, 1H), 3.97 (dd, J = 8.0, 6.6 Hz, 1H), 3.88 – 3.78 (m, 4H), 3.71 (dd, J = 8.0, 6.0 Hz, 1H), 2.56 (dd, J = 15.8, 8.8 Hz, 1H), 2.33 (dd, J = 15.8, 3.9 Hz, 1H), 1.85 (s, 3H), 1.33 (s, 3H), 1.30 (s, 4H), 1.26 (s, 4H), 1.24 (s, 4H). ^{13}C NMR (151 MHz, *DMSO-d_6*) δ 204.2, 171.0, 169.5, 110.0, 109.2, 79.8, 77.8, 76.4, 65.6, 64.9, 55.5, 45.2, 28.3, 28.2, 26.8, 25.7, 22.9; HR ESI MS Calcd for $C_{17}H_{26}O_9Na$ [$M+Na^+$]: 434.1397 found: 434.1419.

_N_-Acetylneuraminic acid (1)



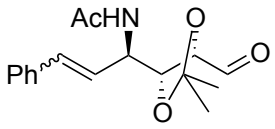
α-Ketoacid sodium salt **10** (1 mg, 2.43 μmol) was dissolved in 1 mL 10% TFA in water and heated to 80 °C for 30 min. Evaporation of solvent gave the crude product. The latter was then purified by RP-HPLC. An isocratic eluent of from 2% MeCN in water (retention time = 3 min) at a flow rate of 2.5 mL/min was used and sialic acid **1** was obtained as a white powder after lyophilization (0.7 mg, 2.24 μmol, 29% over three steps). $[\alpha]_D^{20}$ = -19.8 (*c* = 0.08, H_2O); ^{1}H NMR (600 MHz, *D_2O*) δ 4.06 - 4.01 (m, 1H), 4.01 (dd, *J* = 10.5, 0.8 Hz, 1H), 3.90 (t, *J* = 10.3 Hz, 1H), 3.81 (dd, *J* = 11.9, 2.7 Hz, 1H), 3.72 (ddd, *J* = 9.2, 6.4, 2.7 Hz, 1H), 3.59 (dd, *J* = 11.9, 6.4 Hz, 1H), 3.52 (d, *J* = 9.2 Hz, 1H), 2.27 (dd, *J* = 13.1, 4.9 Hz, 1H), 2.02 (s, 3H), 1.84 (dd, *J* = 13.0, 11.6 Hz, 1H); ESI MS Calcd for $C_{11}H_{20}NO_9$ [M-H^+]: 308.1 found: 308.0. 1:1 mixture of synthetic **1** and commercially available Neu5Ac **1** (Sigma Aldrich): $[\alpha]_D^{20}$ = -19.2 (*c* = 0.15, H_2O); ^{1}H NMR (600 MHz, *D_2O*) δ 4.03 – 3.99 (m, 1H), 3.98 (dd, *J* = 10.2, 0.8 Hz, 1H), 3.89 (t, *J* = 10.2 Hz, 1H), 3.81 (dd, *J* = 11.9, 2.7 Hz, 1H), 3.73 (ddd, *J* = 9.1, 6.5, 2.7 Hz, 1H), 3.58 (dd, *J* = 11.9, 6.5 Hz, 1H), 3.50 (d, *J* = 9.2 Hz, 1H), 2.22 (dd, *J* = 13.0, 4.9 Hz, 1H), 2.02 (s, 3H), 1.81 (dd, *J* = 12.7, 11.8 Hz, 1H). The spectral data obtained were in good accordance to literature.[3,4]

(*E/Z*)-3-Acetamido-4:5-*O*-isopropylidene-1,2,3-trideoxy-1-phenyl-D-*manno*-hept-1-enitol (11)



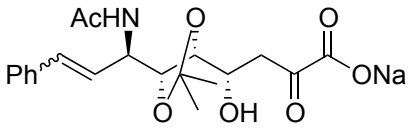
A solution of olefin **7** (400 mg, 1.07 mmol) in 80% aq. acetic acid (22.5 mL) was heated to 50 °C and stirred for 2 h. The reaction mixture was cooled to r.t. and solvents were removed *in vacuo*. The crude product was purified by flash column chromatography on silica gel (CH_2Cl_2/MeOH = 9:1) to yield diol **11** (350 mg, 98%) as a colourless oil. R_f= 0.5 (CH_2Cl_2/MeOH = 9:1); IR (neat) ν_{max} 3287, 3060, 2987, 2934, 2472, 2069, 1635, 1543, 1371, 1076, 872, 695 cm^{-1}; ^1H NMR (400 MHz, *$CDCl_3$*) (*E*)-isomer: δ 7.41 – 7.20 (m, 5H), 6.65 (d, *J* = 16.0 Hz, 1H), 6.32 (d, *J* = 8.2, 1H), 6.25 (dd, *J* = 16.0, 7.8 Hz, 1H), 4.81 (m, 1H), 4.14 (dd, *J* = 7.4, 3.5 Hz, 1H), 3.88 – 3.35 (m, 4H), 1.97 (s, 3H), 1.39 (s, 3H), 1.33 (s, 3H), (*Z*)-isomer: δ 7.41 – 7.20 (m, 5H), 6.75 (d, *J* = 11.7 Hz, 1H), 6.13 (d, *J* = 7.9, 1H), 5.73 (dd, *J* = 11.7, 9.6 Hz, 1H), 5.20 (td, *J* = 9.1, 3.4 Hz, 1H), 4.19 (dd, *J* = 7.0, 3.8 Hz, 1H), 3.88 – 3.35 (m, 4H), 2.02 (s, 3H), 1.39 (s, 3H), 1.36 (s, 3H); ^{13}C NMR (100 MHz, *$CDCl_3$*) δ 170.1, 170.0, 136.6, 136.3, 134.4, 134.2, 128.8, 128.7, 128.6, 128.1, 127.7, 126.7, 125.9, 124.2, 110.2, 110.1, 109.9, 82.0, 81.5, 78.1, 78.0, 73.6, 73.0, 64.4, 63.9, 53.9, 49.0, 27.3, 27.3, 27.1, 26.9, 23.6, 23.4; HR ESI MS Calcd for $C_{18}H_{25}NO_5$ [M+Na^+]: 358.1625, found: 358.1625.

(*E/Z*)-3-Acetamido-1,2,3-trideoxy-1-phenyl-4:5-*O*-isopropylidene-D-*lyxo*-hex-1-enose (12)



Diol **11** (50 mg, 0.15 mmol) was dissolved in 1 mL THF and sodium periodate (64 mg, 0.30 mmol) in 1 mL water was added. The reaction mixture was stirred at r.t. for 30 min. Afterwards the reaction mixture was diluted with CH_2Cl_2 (25 mL) and washed with sat. aq. $NaHCO_3$ solution. The organic layer was dried over $MgSO_4$, filtered and concentrated *in vacuo*. The crude product was purified by flash column chromatography on silica gel (gradient cyclohexane/EtOAc = 1:1 → 0:1) to yield aldehyde **12** (as a mixture of (*E/Z*)-diastereomers) (43 mg, 0.14 mmol, 95% yield) as yellow oil. R_f = 0.34 (EtOAc); IR (film) ν_{max} 3275, 3060, 3027, 2988, 2935, 1735, 1649, 1537, 1496, 1448, 1372, 1254, 1213, 1162, 1073, 971, 862, 753, 697 cm^{-1}; ^1H NMR (400 MHz, *CDCl₃*) (*E*)-isomer: δ 9.79 (d, *J* = 1.2 Hz, 1H), 7.40 - 7.22 (m, 5H), 6.65 (d, *J* = 16.0 Hz, 1H), 6.20 (dd, *J* = 16.0, 7.0 Hz, 1H), 5.97 (d, *J* = 8.9 Hz, 1H), 4.88 - 4.79 (m, 1H), 4.28 (dd, *J* = 6.7, 1.2 Hz, 1H), 4.20 – 4.15 (m, 1H), 2.03 (s, 3H), 1.51 (s, 3H), 1.39 (s, 3H); (*Z*)-isomer: δ 9.65 (d, *J* = 1.1 Hz, 1H), 7.40 - 7.22 (m, 5H), 6.74 (d, *J* = 11.7 Hz, 1H), 5.77 (d, *J* = 8.3 Hz, 1H), 5.64 (dd, *J* = 11.7, 9.4 Hz, 1H), 5.25 - 5.16 (m, 1H), 4.24 (dd, *J* = 6.6, 1.0 Hz, 1H), 4.20 – 4.15 (m, 1H), 1.94 (s, 3H), 1.42 (s, 3H), 1.35 (s, 3H); ^{13}C NMR (101 MHz, *CDCl₃*) δ 201.6, 201.0, 169.6, 169.5, 136.3, 135.9, 134.5, 133.9, 128.8, 128.7, 128.6, 128.2, 127.8, 126.7, 126.0, 124.5, 111.9, 111.7, 82.7, 82.5, 79.0 (2C), 53.3, 49.2, 26.8, 26.5, 26.2, 26.1, 23.6, 23.4; ESI MS Calcd for $C_{17}H_{21}NO_4$ [$M+H^+$]: 304.2 found: 304.1.

Sodium-(*E*/*Z*)-3-acetamido-1,2,3-trideoxy-1-phenyl-4:5-*O*-isopropylidene-D-*gluco*-non-2-ulosonate (13)



The reaction was carried out in analogy to compound **10** starting with aldehyde **12**. Conversion based on ^{1}H NMR was quantitative with a (*S*/*R*)-diastereomeric ratio of >19:1. Preparative RP-HPLC at a flow rate of 4 mL/min, with a gradient of eluent, first isocratic at 2% (0-5min), then from 2% to 30% (in 25 min) MeCN in water (retention time = 19.5 min (*Z*)- and 21.5 min (*E*)-isomer) was used for purification. Both diastereoisomers were isolated and the α-ketocarboxylate **13** was delivered in a total yield of 38% (19% yield for both (*E*)- and (*Z*)-diastereomers) as a white powder.

Sodium-(*Z*)-3-acetamido-1,2,3-trideoxy-1-phenyl-4:5-*O*-isopropylidene-D-*gluco*-non-2-ulosonate:

$[\alpha]_D^{20}$ = 178.1 (*c* = 0.1, MeOH); IR (film) ν_{max} 3273, 3061, 2987, 2935, 1712, 1632, 1544, 1495, 1447, 1372, 1308, 1251, 1213, 1164, 1072, 877, 811, 777, 700 cm^{-1}; ^{1}H NMR (400 MHz, *DMSO-d*$_6$) δ 8.16 (d, *J* = 8.8 Hz, 1H), 7.41 – 7.22 (m, 5H), 6.66 (d, *J* = 3.4 Hz, 1H), 6.57 (d, *J* = 11.8 Hz, 1H), 5.62 (dd, *J* = 11.7, 10.2 Hz, 1H), 5.05 – 4.97 (m, 1H), 4.01 (t, *J* = 6.7 Hz, 1H), 3.66 (dd, *J* = 7.1, 3.0 Hz, 1H), 3.63 – 3.56 (m, 1H), 2.55 – 2.51 (m, 1H), 2.25 (dd, *J* = 13.7, 3.1 Hz, 1H), 1.81 (s, 3H), 1.29 (s, 3H), 1.18 (s, 3H); ^{13}C NMR (151 MHz, *DMSO-d*$_6$) δ 203.9, 168.6, 168.3, 136.2, 131.1, 128.7, 128.5, 128.3, 127.2, 108.5, 81.7, 78.4, 66.7, 48.1, 45.7, 40.1, 39.5, 27.2, 27.0, 22.6; HR ESI MS Calcd for $C_{20}H_{24}NNa_2O_7$ [M+Na$^+$]: 436.1343 found: 436.1347.

Sodium-(*E*)-3-acetamido-1,2,3-trideoxy-1-phenyl-4:5-*O*-isopropylidene-D-*gluco*-non-2-ulosonate:

$[\alpha]_D^{20}$ = -1.0 (*c* = 0.1, MeOH); IR (film) ν_{max} 3276, 3061, 2987, 2935, 1712, 1632, 1544, 1496, 1449, 1372, 1251, 1214, 1164, 1073, 1031, 971, 881, 752, 694 cm^{-1}; ^1H NMR (600 MHz, *DMSO-d_6*) δ 8.25 (d, *J* = 9.0 Hz, 1H), 7.42 – 7.22 (m, 5H), 6.61 (d, *J* = 3.5 Hz, 1H), 6.53 (d, *J* = 15.8 Hz, 1H), 6.27 (dd, *J* = 16.1, 6.7 Hz, 1H), 4.64 (ddd, *J* = 10.1, 6.9, 1.2 Hz, 1H), 4.04 (dd, *J* = 6.8, 5.9 Hz, 1H), 3.79 – 3.75 (m, 2H), 2.65 (dd, *J* = 13.9, 9.0 Hz, 1H), 2.40 (dd, *J* = 13.8, 3.2 Hz, 1H), 1.87 (d, *J* = 3.0 Hz, 3H), 1.34 (s, 3H), 1.31 (s, 3H); ^{13}C NMR (151 MHz, *DMSO-d_6*) δ 204.2, 168.7 (2C), 136.5, 131.0, 128.7, 127.6, 127.0, 126.2, 108.7, 81.4, 78.5, 66.5, 52.3, 45.4, 40.1, 39.5, 27.5, 27.1, 22.7. HR ESI MS Calcd $C_{20}H_{24}NNa_2O_7$ $[M+Na^+]$: 436.1343 found: 436.1337.

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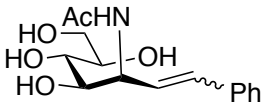

6
in DMSO-d6