Electronic Supplementary Information (ESI)

for

Regioisomeric Branched Trisaccharides: A Combined Synthetic, Biological, and Computational Approach to Understand Details of FimH-Mediated Bacterial Adhesion

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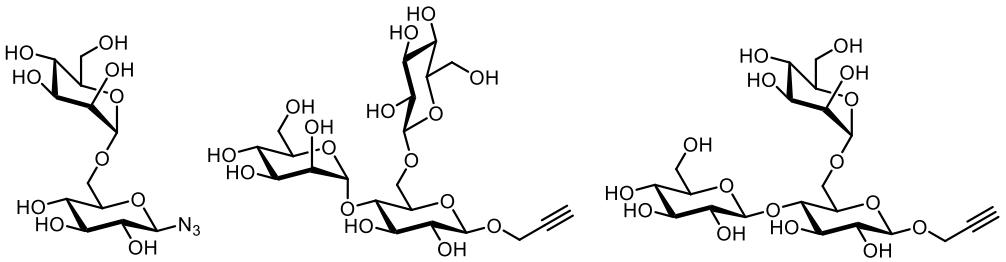
1. General Synthetic Methods

Unless otherwise stated, reactions were carried out under atmospheric conditions. Moisture or oxygen sensitive reactions were performed in oven-dried glassware under a positive pressure of nitrogen. Analytical thin layer chromatography (TLC) was performed on silica gel plates (Alugram® Xtra Sil G/UV_{254}). Visualization of developed TLC plates was achieved by UV light and/or 10% sulfuric acid in ethanol or vanillin stain (900 mg vanillin, 12 mL H_2SO_4, 90 mL H_2O, 90 mL EtOH) or ninhydrin stain (200 mg ninhydrin, 1 mL acidic acid, 200 mL acetone), followed by heating at approx. 200 °C. Purification of products by flash chromatography was performed on silica gel (Merck, 230–400 mesh, particle size 0.040–0.063 mm) or prepacked silica columns (Interchim®, 30 µm spherical particle size, 4-80 g) in combination with a puriFlash 450 or puriFlash 5.020 automated flash chromatography system. Automated reverse phase flash chromatography was performed on prepacked columns (C18AQ, particle size 15 µm, Interchim®). The solvents MeOH and DMF were dried over molecular sieves (3Å) under a nitrogen atmosphere. CH_2Cl_2 was dried over aluminum oxide columns utilizing a PureSolv MD5 solvent purification system from Inert Corporation®. Infrared (IR) spectra were recorded on a PerkinElmer FT-IR Paragon 1000 (ATR) spectrometer. Optical rotation values were measured on an Anton Paar MCP5100 polarimeter at 20 °C with a sodium D-line (589 nm) and a cuvette of 10 cm path length in the indicated solvents. Proton (^1H) or Carbon (^{13}C) nuclear magnetic resonance (NMR) spectra were recorded on a Bruker® AvanceNeo 500 or Bruker® Avance 600 spectrometer at 298 K. NMR spectra were referenced to tetramethylsilane (TMS) as an internal standard. Multiplets (multiplicity s=singlet, d=doublet, t=triplet, q=quartet, m=multiplet) are listed according to chemical shift, coupling constants are given in Hertz (Hz). Full assignment of the signals was achieved by using 2D NMR techniques (^1H-^1H COSY, ^1H-^1H TOCSY, ^1H-^1H NOESY, ^1H-^{13}C HMBC and ^1H-^{13}C HSQC). HR-ESI mass spectra were recorded on a ThermoFischer Orbitrap using MeCN, MeOH, CH_2Cl_2 or a solvent mixture of MeCN/H_2O-80/20 with 1.3 mM ammonium formate additive as a solvent.

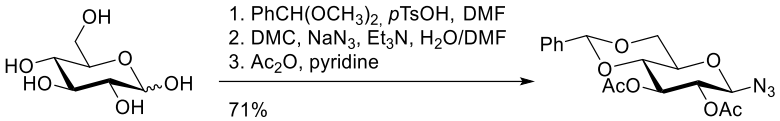
2. Synthesis of Oligosaccharides



S1 **S2** **S3**

Figure S1. Literature-known saccharides **S1**,[1] **S2**[2] and **S3**[2] were synthesized according to literature procedures and utilized in the biological assay.

2.1. 2,3-Di-*O*-acetyl-4,6-*O*-benzyliden-β-D-glucopyranosyl azide (2)[3]



1 **2**

D-Glucose (**1**) (5.00 g, 27.8 mmol, 1 equiv) was suspended in dry DMF (114 mL). Benzaldehyde dimethyl acetal (6.27 mL, 41.6 mmol, 1.5 equiv) and a catalytic amount of *p*-toluenesulfonic acid monohydrate (52.8 mg, 278 µmol, 0.01 equiv) were added and the reaction mixture was stirred under vacuum (100 mbar) at 60 °C for 6 h. Afterwards, triethylamine (38.5 mL, 278 mmol, 10 equiv) and water (114 mL) were added at room temperature. The reaction mixture was cooled to 0 °C and first sodium azide (18.0 g, 278 mmol, 10 eq.), then 2-chloro-1,3-dimethylimidazolinium chloride (DMC, 14.1 g, 83.3 mmol, 3 equiv) were added. The reaction mixture was stirred and allowed to warm to room temperature slowly over a period of 18 h. Afterwards, the reaction mixture was extracted with ethyl acetate (800 mL and 100 mL subsequently), the organic phases were combined and the solvent was removed under reduced pressure. The residue was co-evaporated with toluene (10 mL) and purified on silica gel via flash chromatography (cyclohexane:ethyl acetate, 3:1 → 1:1). To the crude intermediate pyridine (20 mL) and acetic anhydride (10 mL, 106 mmol, 3.8 equiv) were added and stirred at room temperature for 18 h. The solvent was removed under reduced pressure and co-evaporated with toluene (20 mL). The crude was recrystallized from acetone:water (31 mL:14 mL) to yield the product **2**[3] as a colorless solid (7.42 g, 19.7 mmol, 71%).

R_F (cyclohexane:ethyl acetate, 3:1) = 0.60.

$[\alpha]_D^{20}$ = -75.7 (*c* = 1.04 in $CHCl_3$).

IR (ATR): $\tilde{\nu}$ = 2941 (w), 2116 (m), 1748 (s), 1394 (m), 1373 (m), 1268 (m), 1235 (s), 1215 (s), 1097 (m), 1075 (s), 1031 (s), 1008 (s), 967 (s), 759 (m), 696 (m) cm^{-1}.

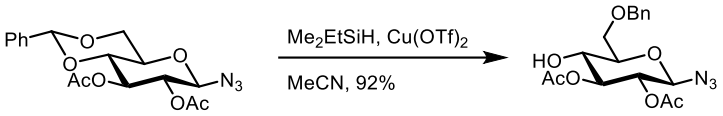
^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 7.47 – 7.33 (m, 5H, Ar-H), 5.52 (s, 1H, H-7), 5.34 (t, $^3J_{3,4}$ = $^3J_{2,3}$ = 9.5 Hz, 1H, H-3), 4.95 (dd, $^3J_{2,3}$ = 9.1 Hz, $^3J_{1,2}$ = 8.9 Hz, 1H, H-2), 4.74 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1), 4.41 (dd, $^2J_{6a,6b}$ = 10.6 Hz, $^3J_{5,6a}$ = 4.9 Hz, 1H, H-6a), 3.82 (t, $^2J_{6b,6a}$ = $^3J_{6b,5}$ = 10.2 Hz,

1H, H-6b), 3.72 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.6 Hz, 1H, H-4), 3.63 (td, $^3J_{4,5}$ = $^3J_{5,6b}$ = 9.6 Hz, $^3J_{5,6a}$ = 4.9 Hz, 1H, H-5), 2.10 (s, 3H, CH_3), 2.06 (s, 3H, CH_3) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.2 (<u>C</u>(O)CH_3), 169.6 (<u>C</u>(O)CH_3), 136.7 (C-8), 129.4 (C-11), 128.4 (C-10, C-10‘), 126.3 (C-9, C-9‘), 101.8 (C-7), 88.7 (C-1), 78.2 (C-4), 71.73 (C-2/C-3), 71.69 (C-2/C-3), 68.7 (C-5), 68.4 (C-6), 20.9 (CH_3), 20.8 (CH_3) ppm.

ESI-HRMS: *m/z* = 400.11082 $[M+Na]^+$ (calculated *m/z* = 400.11152).

2.2. 2,3-Di-*O*-acetyl-6-*O*-benzyl-β-D-glucopyranosyl azide (3)



2 **3**

The benzylidene-protected glucosyl azide **2** (3.30 g, 8.74 mmol, 1 equiv) was dissolved in dry acetonitrile (28 mL) under a nitrogen atmosphere. At room temperature, ethyldimethylsilane (2.31 mL, 17.5 mmol, 2 equiv) was added and then cooled to 0°C. Freshly dried (vacuum, ~200°C, 10 min) copper(II) trifluoromethanesulfonate (35 mg, 95.4 µmol, 0.01 equiv) was added to the reaction mixture, stirred at 0°C for 1 h and at room temperature for 2 h. Ethyl acetate (70 mL) was added and vigorously stirred under air atmosphere for 2 h. The reaction mixture was washed with satd. aq. $NaHCO_3$ solution (50 mL) and the separated organic phase was dried over $MgSO_4$. It was filtrated and the solvent removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 80:20→50:50 over 16 CV) to yield the product **3** as a colorless syrup (3.04 g, 8.01 mmol, 92%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 2:1) = 0.29.

$[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{20}}$ = -70.8 (*c* = 0.07 in CH_2Cl_2).

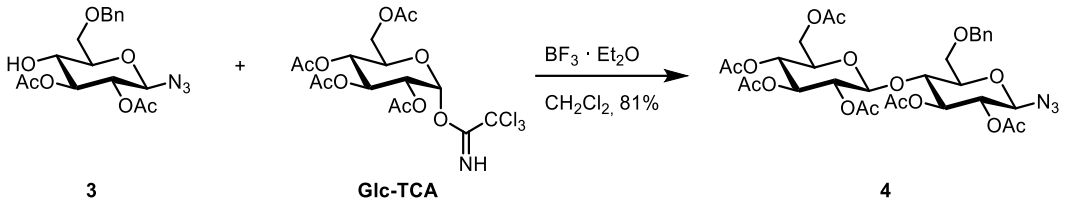
IR (ATR): $\tilde{\nu}$ = 3457 (br, w), 2870 (w), 2116 (s), 1751 (s), 1367 (m), 1231 (s), 1062 (s), 1032 (s) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 7.39 – 7.28 (m, 5H, Ar-H), 5.06 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.5 Hz, 1H, H-3), 4.88 (dd, $^3J_{2,3}$ = 9.6 Hz, $^3J_{1,2}$ = 8.9 Hz, 1H, H-2), 4.65 – 4.54 (m, 3H, H-1, Ph-C<u>H</u>$_2$), 3.86 – 3.75 (m, 3H, H-4, H-6a, H-6b), 3.62 (dt, $^3J_{4,5}$ = 9.2 Hz, $^3J_{5,6a}$ = $^3J_{5,6b}$ = 4.6 Hz, 1H, H-5), 2.95 (d, $^3J_{OH,4}$ = 3.0 Hz, 1H, OH), 2.09 (s, 3H, CH_3), 2.08 (s, 3H, CH_3) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 171.2 (<u>C</u>(O)CH_3), 169.5 (<u>C</u>(O)CH_3), 137.3 (OBn_{ipso}), 128.6 (2 Ar-<u>C</u>H), 128.0 (Ar-<u>C</u>H), 127.8 (2 Ar-<u>C</u>H), 87.9 (C-1), 76.4 (C-5), 75.3 (C-3), 73.9 (Ph-<u>C</u>H_2), 70.7 (C-2), 70.2 (C-4), 69.5 (C-6), 20.8 (CH_3), 20.6 (CH_3) ppm.

ESI-HRMS: *m/z* = 402.12748 $[M+Na]^+$ (calculated *m/z* = 402.12717).

2.3. 2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl-(1→4)-2,3-di-*O*-acetyl-6-*O*-benzyl-β-D-glucopyranosyl azide (4)



3 **Glc-TCA** **4**

The acceptor glucosyl azide **3** (1.52 g, 4.01 mmol, 1 equiv) was dissolved in dry dichloromethane (6 mL) under a nitrogen atmosphere, freshly activated molecular sieve (3Å, ~200 mg) was added and a solution of glucosyl donor Glc-TCA (2.37 g, 4.81 mmol, 1.2 equiv) in dry dichloromethane (10 mL) was added. The reaction mixture was stirred at room temperature for 15 min. After cooling to 0 °C boron trifluoride diethyl etherate (102 µL, 801 µmol, 0.2 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 13 h. Triethylamine (500 µL, 3.61 mmol, 0.9 equiv) was added and the reaction mixture stirred for 15 min at room temperature, then filtrated over celite. The solvent was removed under reduced pressure and the crude product was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 80:20→66:33) to yield the product **4** as a colorless amorphous solid (2.30 g, 3.25 mmol, 81%).

R_F (cyclohexane:ethyl acetate, 2:1) = 0.16.

$[\alpha]_D^{20}$ = -27.5 (*c* = 0.76 in CH_2Cl_2).

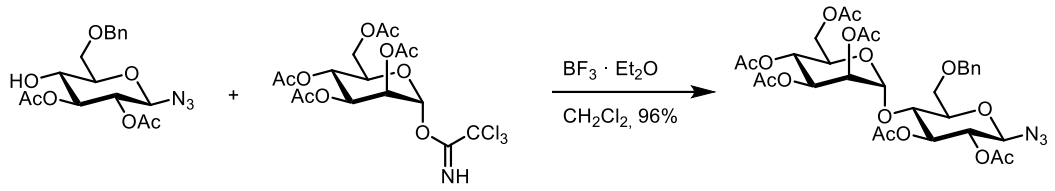
IR (ATR): $\tilde{\nu}$ = 2942 (w), 2119 (m), 1745 (s), 1367 (m), 1211 (s), 1035 (s), 904 (m), 599 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 7.47 – 7.33 (m, 5H, Ar-H), 5.13 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.5 Hz, 1H, H-3_{Glc}), 5.05 – 4.96 (m, 2H, H-$3_{Glc'}$, H-$4_{Glc'}$), 4.89 (dd, $^3J_{2,3}$ = 9.7 Hz, $^3J_{1,2}$ = 8.8 Hz, 1H, H-2_{Glc}), 4.84 (dd, $^3J_{2,3}$ = 9.4 Hz, $^3J_{1,2}$ = 8.1 Hz, 1H, H-$2_{Glc'}$), 4.78 (d, ^2J = 12.0 Hz, 1H, Ph-C<u>H</u>H'), 4.57 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1_{Glc}), 4.50 (d, ^2J = 12.0 Hz, 1H, Ph-CH<u>H</u>'), 4.47 (d, $^3J_{1,2}$ = 8.1 Hz, 1H, H-$1_{Glc'}$), 4.33 (dd, $^2J_{6a,6b}$ = 12.5 Hz, $^3J_{5,6a}$ = 4.3 Hz, 1H, H-$6_{Glc'}$), 4.03 – 3.95 (m, 2H, H-4_{Glc}, H-$6b_{Glc'}$), 3.76 (m, 2H, H-$6a_{Glc}$, H-$6b_{Glc}$), 3.54 – 3.49 (m, 1H, H-5_{Glc}), 3.42 (ddd, $^3J_{4,5}$ = 9.9 Hz, $^3J_{5,6a}$ = 4.3 Hz, $^3J_{5,6b}$ = 2.1 Hz, 1H, H-$5_{Glc'}$), 2.07, 2.06, 2.02, 2.00, 1.98, 1.94 (each s, each 3H, 6 CH_3) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.6, 170.4, 170.0, 169.6, 169.5, 168.9 (6 <u>C</u>(O)CH_3), 137.6 (Ar-C_{quart}), 128.9, 128.9, 128.4, 128.3, 128.3 (5 Ar-<u>C</u>H) 100.2 (C-$1_{Glc'}$), 88.2 (C-1_{Glc}), 77.0 (C-5_{Glc}), 74.6 (C-4_{Glc}), 73.9 (Ph-CH_2), 73.2 (C-$3_{Glc'}$/C-$4_{Glc'}$), 72.5 (C-3_{Glc}), 71.9 (C-$5_{Glc'}$), 71.7 (C-$2_{Glc'}$), 71.0 (C-2_{Glc}), 68.0 (C-$3_{Glc'}$/C-$4_{Glc'}$), 66.9 (C-6_{Glc}), 61.7 (C-$6_{Glc'}$), 20.8, 20.8, 20.8, 20.7, 20.7, 20.6 (6 CH_3) ppm.

ESI-HRMS: *m/z* = 710.23937 $[M+Na]^+$ (calculated *m/z* = 710.24031).

2.4. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→4)-2,3-di-*O*-acetyl-6-*O*-benzyl-β-D-glucopyranosyl azide (5)



3 **Man-TCA** **5**

The acceptor glucosyl azide **3** (1.52 g, 4.01 mmol, 1 equiv) was dissolved in dry dichloromethane (6 mL) under a nitrogen atmosphere, freshly activated molecular sieve (3Å, ~200 mg) was added and a solution of mannosyl donor Man-TCA (2.37 g, 4.81 mmol, 1.2 equiv) in dry dichloromethane (10 mL) was added. The reaction mixture was stirred at room temperature for 15 min. After cooling to 0 °C boron trifluoride diethyl etherate (102 µL, 801 µmol, 0.2 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 13 h. Triethylamine (500 µL, 3.61 mmol, 0.9 equiv) was added and the reaction mixture stirred for 15 min at room temperature, then filtrated over celite. The solvent was removed under reduced pressure and the crude product was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 80:20→66:33) to yield the product **5** as a pale yellow oil (2.74 g, 3.86 mmol, 96%).

R_F (cyclohexane:ethyl acetate, 2:1) = 0.17.

$[\alpha]_D^{20}$ = -11.5 (*c* = 0.09 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 2119 (m), 1754 (m), 1371 (w), 971 (s), 751 (m) cm^{-1}.

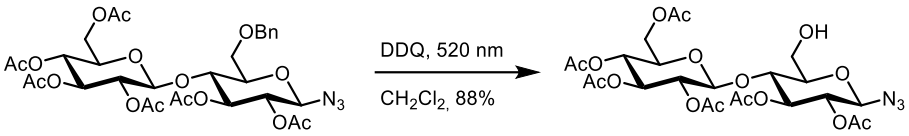
^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 7.37 – 7.27 (m, 5H, Ar-H), 5.27 – 5.17 (m, 3H, H-3_{Glc}, H-3_{Man}, H-4_{Man}), 5.05 (dd, $^3J_{1,2}$ = 1.9 Hz, $^3J_{2,3}$ = 3.2 Hz , 1H, H-2_{Man}), 5.03 (d, $^3J_{1,2}$ = 1.9 Hz, 1H, H-1_{Man}), 4.83 (dd, $^3J_{1,2}$ = 8.8 Hz, $^3J_{2,3}$ = 9.6 Hz, 1H, H-2_{Glc}), 4.66 – 4.57 (m, 3H, Ph-C$\underline{H}_2$,H-1_{Glc}), 4.17 (dd, $^2J_{6a,6b}$ = 12.4 Hz, $^3J_{5,6a}$ = 5.2 Hz, 1H, H-$6a_{Man}$), 4.01 – 3.93 (m, 3H, H-4_{Glc}, H-5_{Man}, H-$6b_{Man}$), 3.87 – 3.78 (m, 2H, H-$6a_{Glc}$, H-$6b_{Glc}$), 3.66 (ddd, $^3J_{4,5}$ = 9.7 Hz, $^3J_{5,6a}$ = 4.0 Hz, $^3J_{5,6b}$ = 2.1 Hz, 1H, H-5_{Glc}), 2.13, 2.08, 2.07, 2.05, 2.03, 1.98 (each s, each 3H, 6 CH_3) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.6 ($\underline{C}$(O)CH_3), 170.3 ($\underline{C}$(O)CH_3), 170.0 ($\underline{C}$(O)CH_3), 169.79 ($\underline{C}$(O)CH_3), 169.75 ($\underline{C}$(O)CH_3), 169.68 ($\underline{C}$(O)CH_3), 137.9 (Ar-$\underline{C}_{ipso}$), 128.6 (2 Ar-$\underline{C}$H), 128.0 (Ar-$\underline{C}$H), 127.8 (2 Ar-$\underline{C}$H), 99.4 (C-1_{Man}), 87.8 (C-1_{Glc}), 77.0 (C-5_{Glc}), 76.1 (C-4_{Glc}), 74.2*, 73.8 (Ph$\underline{C}H_2$), 71.5 (C-2_{Glc}), 69.8 (C-2_{Man}, C-5_{Man}), 68.6 (C-3_{Man}), 68.2 (C-6_{Glc}), 65.9*, 62.5 (C-6_{Man}), 20.96, 20.88, 20.86, 20.83, 20.76, 20.76 (6 CH_3) ppm.

*Assignment is ambiguous due to signal overlap (C-3_{Glc}, C-4_{Man}).

ESI-HRMS: *m/z* = 727.26590 $[M+NH_4]^+$ (calculated *m/z* = 727.26686).

2.5. 2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl-(1→4)-2,3-di-*O*-acetyl-β-D-glucopyranosyl azide (6)



4 **6**

Following the procedure from Cavedon[4] et al., the disaccharide **4** (2.30 g, 3.24 mmol, 1 equiv) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (1.10 g, 4.86 mmol, 1.5 equiv) were dissolved in dry dichloromethane (166 mL) under a nitrogen atmosphere and water (1.7 mL) was added. During strong stirring the reaction mixture was irradiated with 520 nm green light for 7 h at room temperature. The reaction mixture was diluted with dichloromethane (200 mL) and washed with satd. aq. $NaHCO_3$ solution (200 mL). The aq. phase was extracted with dichloromethane (100 mL). All organic phases were combined and dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 80:20→45:55) to yield the product **6** as a colorless amorphous solid (1.77 g, 2.86 mmol, 88%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:1) = 0.24.

$[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{20}}$ = -36.7 (*c* = 0.28 in CH_2Cl_2).

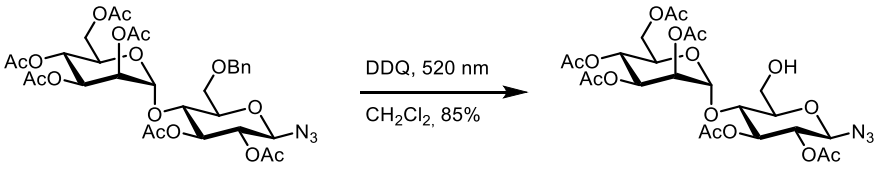
IR (ATR): $\tilde{\nu}$ = 2119 (m), 1742 (s), 1369 (m), 1219 (s), 1039 (s), 904 (m), 601 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.22 – 5.13 (m, 2H, H-3$_{Glc}$, H-3$_{Glc'}$), 5.07 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.7 Hz, 1H, H-4$_{Glc'}$), 4.93 (dd, $^3J_{2,3}$ = 9.5 Hz, $^3J_{1,2}$ = 8.1 Hz, 1H, H-2$_{Glc'}$), 4.85 (dd, $^3J_{2,3}$ = 9.7 Hz, $^3J_{1,2}$ = 8.9 Hz, 1H, H-2$_{Glc}$), 4.66 – 4.63 (m, 2H, H-1$_{Glc}$, H-1$_{Glc'}$), 4.37 (dd, $^2J_{6a,6b}$ = 12.5 Hz, $^3J_{5,6a}$ = 4.3 Hz, 1H, H-6a$_{Glc'}$), 4.04 (dd, $^2J_{6b,6a}$ = 12.5 Hz, $^3J_{5,6b}$ = 2.2 Hz, 1H, H-6b$_{Glc'}$), 4.01 – 3.92 (m, 2H, H-4$_{Glc}$, H-6a$_{Glc}$), 3.84 – 3.76 (m, 1H, H-6b$_{Glc}$), 3.69 (ddd, $^3J_{4,5}$ = 9.7 Hz, $^3J_{5,6a}$ = 4.3 Hz, $^3J_{5.6b}$ = 2.2 Hz, 1H, H-5$_{Glc'}$), 3.48 (dt, $^3J_{4,5}$ = 9.7 Hz, $^3J_{5,6a}$ = $^3J_{5,6b}$ = 2.4 Hz, 1H, H-5$_{Glc}$), 1.92 (m, 1H, OH), 2.08, 2.07, 2.04, 2.02, 2.01, 1.98 (each s, each 3H, 6 CH_3) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.7, 170.4, 170.0, 169.6, 169.5, 169.1 (6 $\underline{C}(O)CH_3$), 100.7 (C-1$_{Glc'}$), 88.2 (C-1$_{Glc}$), 77.3 (C-5$_{Glc}$) 74.6 (C-4$_{Glc}$), 73.1 (C-3$_{Glc/Glc'}$), 72.5 (C-3$_{Glc/Glc'}$), 72.1 (C-5$_{Glc'}$), 71.8 (C-2$_{Glc'}$), 71.1 (C-2$_{Glc}$), 67.9 (C-4$_{Glc'}$), 61.7 (C-6$_{Glc'}$), 60.1 (C-6$_{Glc}$), 20.8, 20.8, 20.8, 20.7, 20.7, 20.6 (6 CH_3) ppm.

ESI-HRMS: *m/z* = 642.17472 $[M+Na]^+$ (calculated *m/z* = 642.17530).

2.6. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→4)-2,3-di-*O*-acetyl-β-D-glucopyranosyl azide (7)



5 **7**

Following the procedure from Cavedon[4] et al., the disaccharide **5** (2.74 g, 3.86 mmol, 1 equiv) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (1.32 g, 5.79 mmol, 1.5 equiv) were dissolved in dry dichloromethane (198 mL) under a nitrogen atmosphere and water (2 mL) was added. During strong stirring the reaction mixture was irradiated with 520 nm green light for 7 h at room temperature. The reaction mixture was diluted with dichloromethane (200 mL) and washed with satd. aq. $NaHCO_3$ solution (200 mL). The aq. phase was extracted with dichloromethane (100 mL). All organic phases were combined and dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 80:20→45:55) to yield the product **7** as a colorless foam (2.04 g, 3.29 mmol, 85%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:1) = 0.37.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -13.2 (*c* = 0.44 in CH_2Cl_2).

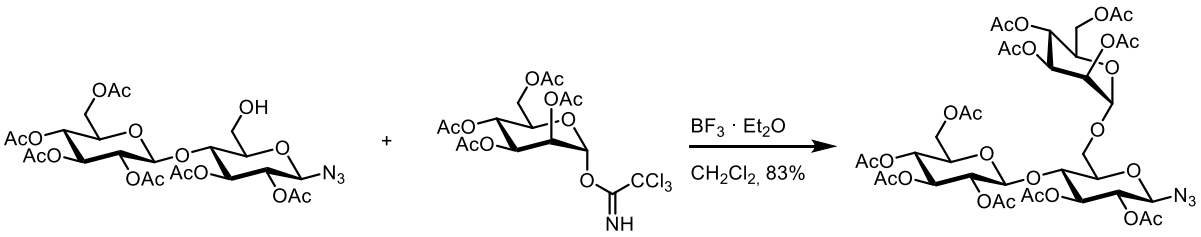
IR (ATR): $\tilde{\nu}$ = 3504 (w), 2942 (w), 2119 (m), 1743 (s), 1369 (m), 1231 (s), 1036 (s) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.28 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.5 Hz, 1H, H-3_{Glc}), 5.26 – 5.19 (m, 2H, H-4_{Man}, H-3_{Man}), 5.06 (d, $^3J_{1,2}$ = 2.1 Hz, 1H, H-1_{Man}), 5.03 (t, $^3J_{1,2}$ = $^3J_{2,3}$ = 2.5 Hz, 1H, H-2_{Man}), 4.81 (dd, $^3J_{1,2}$ = 8.8 Hz, $^3J_{2,3}$ = 9.5 Hz, 1H, H-2_{Glc}), 4.70 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1_{Glc}), 4.23 (dd, $^2J_{6a,6b}$ = 12.2 Hz, $^3J_{5,6a}$ = 6.5 Hz, 1H, H-$6a_{Man}$), 4.14 (dd, $^2J_{6b,6a}$ = 12.2 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-$6b_{Man}$), 4.07 – 3.95 (m, 2H, H-$6a_{Glc}$, H-5_{Man}), 4.01 (t, $^3J_{4,5}$ = $^3J_{3,4}$ = 9.5 Hz, 1H, H-4_{Glc}), 3.88 (dd, $^2J_{6b,6a}$ = 12.8 Hz, $^3J_{5,6b}$ = 3.7 Hz, 1H, H-$6b_{Glc}$), 3.58 (ddd, $^3J_{4,5}$ = 9.7 Hz, $^3J_{5,6a}$ = 3.7 Hz, $^3J_{5,6b}$ = 2.0 Hz, 1H, H-5_{Glc}), 2.13, 2.12, 2.09, 2.07, 2.05, 2.00 (each s, each 3H, 6 CH_3), 1.63 (s, 1H, OH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.8, 170.3, 170.0 169.8, 169.8, 169.6 (6 $\underline{C}(O)CH_3$), 99.4 (C-1_{Man}), 88.0 (C-1_{Glc}), 76.9 (C-5_{Glc}), 75.4 (C-4_{Glc}), 74.3 (C-3_{Glc}), 71.5 (C-2_{Glc}), 70.1 (C-5_{Man}), 69.9 (C-2_{Man}), 68.4 (C-3_{Man}), 66.3 (C-4_{Man}), 63.0 (C-6_{Man}), 61.2 (C-6_{Glc}), 20.9, 20.8, 20.8, 20.8, 20.8, 20.7 (6 CH_3) ppm.

ESI-HRMS: *m/z* = 642.17513 $[M+Na]^+$ (calculated *m/z* = 642.17530).

2.7. 2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl-(1→4)-[2,3,4,6-tetra-*O*-acetyl-α-D-mannopyranosyl-(1→6)]-2,3-di-*O*-acetyl-β-D-glucopyranosyl azide (8)



6 **Man-TCA** **8**

The acceptor disaccharide **6** (1.77 g, 2.86 mmol, 1 equiv) and the mannosyl donor Man-TCA (1.69 g, 3.43 mmol, 1.2 equiv) were dissolved in dry dichloromethane (11.5 mL) under a nitrogen atmosphere, freshly activated molecular sieve (3Å, ~500 mg) was added and the reaction mixture was stirred at room temperature for 20 min. After cooling to 0 °C boron trifluoride diethyl etherate (72 µL, 571 µmol, 0.2 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 21 h. Triethylamine (500 µL, 3.61 mmol, 0.9 equiv) was added and the reaction mixture stirred for 15 min at room temperature, then filtrated over celite and diluted with dichloromethane (90 mL). The organic phase was washed with brine (30 mL) and the separated aq. phase was extracted with dichloromethane (30 mL). The combined org. phases were dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude product was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 90:10→45:55) to yield the product **8** as a colorless foam (2.24 g, 2.36 mmol, 83%).

R_F (cyclohexane:ethyl acetate, 1:1) = 0.22.

$[\alpha]_D^{20}$ = +0.80 (*c* = 0.49 in CH_2Cl_2).

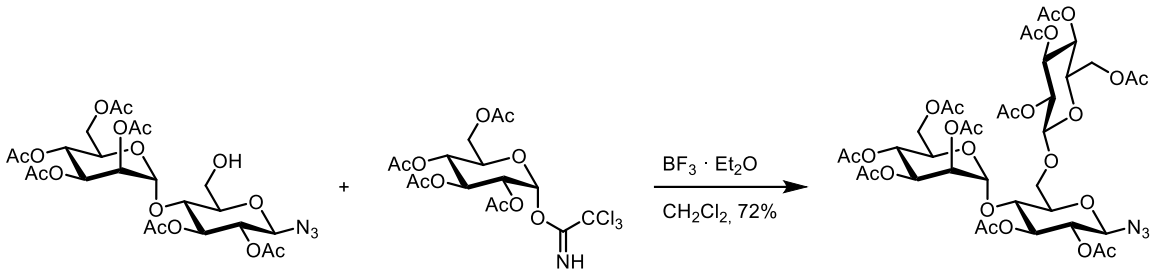
IR (ATR): $\tilde{\nu}$ = 2942 (w), 2122 (m), 1741 (s), 1367 (m), 1209 (s), 1035 (s), 904 (m), 601 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.42 – 5.32 (m, 2H, H-3$_{Man}$, H-4$_{Man}$), 5.29 (dd, $^3J_{2,3}$ = 3.2 Hz, $^3J_{1,2}$ = 1.8 Hz, 1H, H-2$_{Man}$), 5.21 (t, $^3J_{3,4}$ = $^3J_{2,3}$ = 9.5 Hz, 1H, H-3$_{Glc'}$), 5.18 (t, $^3J_{3,4}$ = $^3J_{2,3}$ = 9.5 Hz, 1H, H-3$_{Glc}$), 5.11 (t, $^3J_{4,5}$ = $^3J_{3,4}$ = 9.8 Hz, 1H, H-4$_{Glc'}$), 5.04 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-1$_{Man}$), 4.95 (dd, $^3J_{2,3}$ = 9.5 Hz, $^3J_{1,2}$ = 8.2 Hz, 1H, H-2$_{Glc'}$), 4.92 – 4.88 (m, 1H, H-2$_{Glc}$), 4.68 (d, $^3J_{1,2}$ = 8.1 Hz, 1H, H-1$_{Glc'}$), 4.57 (d, $^3J_{1,2}$ = 8.9 Hz, 1H, H-1$_{Glc}$), 4.49 (dd, $^2J_{6a,6b}$ = 12.8 Hz, $^3J_{5,6a}$ = 3.8 Hz, 1H, H-6a$_{Glc'}$), 4.40 (dd, $^2J_{6a,6b}$ = 12.4 Hz, $^3J_{5,6a}$ = 4.3 Hz, 1H, H-6a$_{Man}$), 4.17 (dd, $^2J_{6b,6a}$ = 12.4 Hz, $^3J_{5,6b}$ = 2.5 Hz, 1H, H-6b$_{Man}$), 4.12 – 4.06 (m, 2H, H-5$_{Man}$, H-6b$_{Glc'}$), 3.96 – 3.86 (m, 4H, H-4$_{Glc}$, H-5$_{Glc'}$, H-6a$_{Glc}$, H-6b$_{Glc}$), 3.60 (ddd, $^3J_{4,5}$ = 10.0 Hz, $^3J_{5,6a}$ = 2.9 Hz, $^3J_{5,6b}$ = 1.3 Hz, 1H, H-5$_{Glc}$), 2.18, 2.12, 2.08, 2.08, 2.07, 2.05, 2.04, 2.02, 1.98, 1.98 (each s, each 3H, 10 CH_3) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.6, 170.6, 170.3, 170.0, 169.9, 169.9, 169.7, 169.3, 169.2, 168.6 (10 $\underline{C}(O)CH_3$), 100.3 (C-1$_{Glc'}$), 98.2 (C-1$_{Man}$), 88.0 (C-1$_{Glc}$), 76.4 (C-5$_{Glc}$), 74.8 (C-5$_{Glc'}$), 72.9 (C-3$_{Glc'}$), 72.0 (C-4$_{Glc}$), 71.9 (C-3$_{Glc}$), 71.9 (C-2$_{Glc'}$), 70.7 (C-2$_{Glc}$), 69.2 (C-5$_{Man}$), 69.0 (C-2$_{Man}$), 68.7 (C-3$_{Man}$/C-4$_{Man}$), 67.4 (C-4$_{Glc'}$), 65.9 (C-3$_{Man}$/C-4$_{Man}$), 65.0 (C-6$_{Glc}$), 62.1 (C-6$_{Man}$), 61.3 (C-6$_{Glc'}$), 20.8, 20.7, 20.7, 20.7, 20.7, 20.6, 20.5, 20.5, 20.5, 20.4 (10 CH_3) ppm.

ESI-HRMS: *m/z* = 927.26964 $[M+Na]^+$ (calculated *m/z* = 972.27038).

2.8. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→4)-[2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl-(1→6)]-2,3-di-*O*-acetyl-β-D-glucopyranosyl azide (9)



7 **Glc-TCA** **9**

The acceptor disaccharide **7** (2.04 g, 3.29 mmol, 1 equiv) and the glucosyl donor Glc-TCA (1.95 g, 3.95 mmol, 1.2 equiv) were dissolved in dry dichloromethane (13 mL) under a nitrogen atmosphere, freshly activated molecular sieve (3Å, ~500 mg) was added and the reaction mixture was stirred at room temperature for 20 min. After cooling to 0 °C boron trifluoride diethyl etherate (84 µL, 659 µmol, 0.2 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 21 h. Triethylamine (500 µL, 3.61 mmol, 0.9 equiv) was added and the reaction mixture stirred for 15 min at room temperature, then filtrated over celite and diluted with dichloromethane (90 mL). The organic phase was washed with brine (30 mL) and the separated aq. phase was extracted with dichloromethane (30 mL). The combined org. phases were dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude product was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 90:10→45:55) to yield the product **9** as a colorless foam (2.26 g, 2.38 mmol, 72%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 4:6) = 0.31.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -13.0 (*c* = 0.35 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 2120 (m), 1743 (s), 1434 (w), 1368 (m), 1211 (s), 1136 (m), 1035 (s), 901 (m), 601 (m) cm^{-1}.

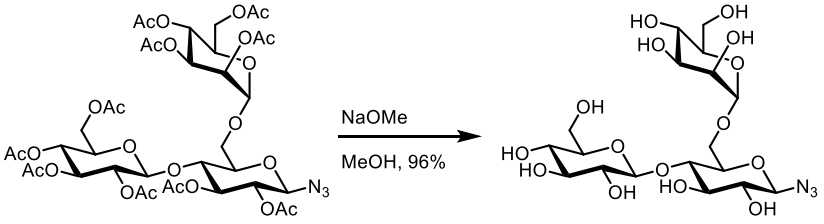
^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.29 – 5.17 (m, 4H, H-3_{Man}, H-3_{Glc}, H-$3_{Glc'}$, H-4_{Man}), 5.11 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.7 Hz, 1H, H-$4_{Glc'}$), 5.06 – 4.97 (m, 2H, H-2_{Man}, H-$2_{Glc'}$), 4.91 (d, $^3J_{1,2}$ = 1.9 Hz, 1H, H-1_{Man}), 4.79 (dd, $^3J_{2,3}$ = 9.5 Hz, $^3J_{1,2}$ = 8.8 Hz, 1H, H-2_{Glc}), 4.70 (d, $^3J_{1,2}$ = 7.9 Hz, 1H, H-$1_{Glc'}$), 4.66 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1_{Glc}), 4.30 – 4.21 (m, 2H, H-$6a_{Glc'}$, H-$6a_{Man}$), 4.19 – 4.12 (m, 3H, H-$6b_{Man}$, H-$6a_{Glc}$, H-$6b_{Glc'}$), 4.02 (ddd, $^3J_{4,5}$ = 9.7 Hz, $^3J_{5,6a}$ = 5.3 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-5_{Man}), 3.83 (dd, $^2J_{6b,6a}$ = 11.7 Hz, $^3J_{5,6b}$ = 5.6 Hz, 1H, H-$6b_{Glc}$), 3.78 – 3.65 (m, 3H, H-5_{Glc}, H-$5_{Glc'}$, H-4_{Glc}), 2.14, 2.11, 2.09, 2.09, 2.06, 2.06, 2.06, 2.02, 2.01, 1.99 (each s, each 3H, 10 CH_3) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.8, 170.6, 170.4, 170.2, 169.9, 169.8, 169.7, 169.6, 169.5, 169.3 (10 $\underline{C}(O)CH_3$), 101.0 (C-$1_{Glc'}$), 100.0 (C-1_{Man}), 87.7 (C-1_{Glc}), 77.7 (C-4_{Glc}), 76.7 (C-5_{Glc}), 74.0*, 72.9*, 72.1(C-$5_{Glc'}$), 71.4 (C-$2_{Glc'}$), 71.3 (C-2_{Glc}), 69.9 (C-5_{Man}), 69.7 (C-2_{Man}), 68.5*, 68.3 (C-$4_{Glc'}$), 68.1 (C-6_{Glc}), 65.9*, 62.4 (C-$6_{Glc'}$/C-6_{Man}), 61.8 (C-$6_{Glc'}$/C-6_{Man}), 20.9, 20.8, 20.8, 20.8, 20.8, 20.7, 20.7, 20.7, 20.7, 20.7 (10 CH_3) ppm.

*Assignment is ambiguous due to signal overlap (C-3_{Man}, C-3_{Glc}, C-$3_{Glc'}$, C-4_{Man}).

ESI-HRMS: *m/z* = 950.28809 $[M+H]^+$ (calculated *m/z* = 950.28844).

2.9. β-D-Glucopyranosyl-(1→4)-[α-D-mannopyranosyl-(1→6)]-β-D-glucopyranosyl azide (10)



8 **10**

The protected trisaccharide **8** (476 mg, 501 µmol, 1 equiv) was suspended in methanol (10 mL) and a solution of sodium methoxide in methanol (25 µL, 125 µmol, 5 M, 0.25 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 18 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 15 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) to obtain the title compound **10** after lyophilization (255 mg, 482 µmol, 96%).

$[\alpha]_D^{20}$ = +11.4 (*c* = 0.11 in MeOH).

IR (ATR): $\tilde{\nu}$ = 3329 (m, br), 2920 (w), 2119 (m), 1638 (w), 1369 (w), 1250 (m), 1017 (s), 573 (m) cm^{-1}.

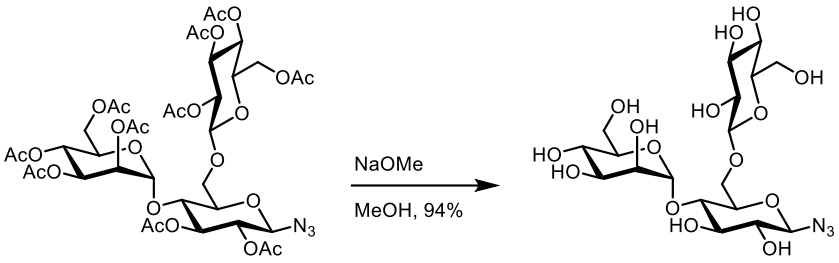
^{1}H NMR (500 MHz, D_2O, 298 K) δ = 4.92 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-1_{Man}), 4.78 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1_{Glc}), 4.49 (d, $^3J_{1,2}$ = 7.9 Hz, 1H, H-$1_{Glc'}$), 4.04 – 3.98 (m, 2H, H-2_{Man}, H-$6a_{Man}$), 3.94 – 3.87 (m, 3H, H-$6a_{Glc}$, H-$6a_{Glc'}$, H-$6b_{Man}$), 3.84 – 3.62 (m, 8H, H-3_{Man}, H-$3_{Glc'}$, H-4_{Man}, H-$4_{Glc'}$, H-5_{Man}, H-$5_{Glc'}$, H-$6b_{Glc}$, H-$6b_{Glc'}$), 3.53 – 3.44 (m, 2H, H-3_{Glc}, H-5_{Glc}), 3.43 – 3.37 (m, 1H, H-4_{Glc}), 3.33 – 3.27 (m, 2H, H-2_{Glc}, H-$2_{Glc'}$) ppm.

^{13}C NMR (126 MHz, D_2O, 298 K) δ = 105.3 (C-$1_{Glc'}$), 103.2 (C-1_{Man}), 92.8 (C-1_{Glc}), 80.7*, 78.9 (C-$5_{Glc'}$), 78.2 (C-$3_{Glc'}$), 78.1*, 76.9 (C-3_{Glc}), 75.9 (C-$2_{Glc/Glc'}$), 75.8*, 75.3 (C-$2_{Glc/Glc'}$), 73.3*, 72.6 (C-2_{Man}), 72.3 (C-$4_{Glc'}$), 69.3*, 68.3 (C-6_{Man}), 63.7 (C-$6_{Glc/Glc'}$), 63.4 (C-$6_{Glc/Glc'}$) ppm.

*Assignment is ambiguous due to signal overlap (C-3_{Man}, C-4_{Glc}, C-4_{Man}, C-5_{Glc}, C-5_{Man}).

ESI-HRMS: *m/z* = 530.18314 $[M+H]^+$ (calculated *m/z* = 530.18279).

2.10. α-D-Mannopyranosyl-(1→4)-[β-D-glucopyranosyl-(1→6)]-β-D-glucopyranosyl azide (11)



9 11

The protected trisaccharide **9** (957 mg, 1.01 mmol, 1 equiv) was suspended in methanol (20 mL) and a solution of sodium methoxide in methanol (100 µL, 500 µmol, 5 M, 0.5 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 5 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 15 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) to obtain the title compound **11** after lyophilization (501 mg, 946 µmol, 94%).

$[\alpha]_D^{20}$ = +20.1 (*c* = 0.88 in MeOH).

IR (ATR): $\tilde{\nu}$ = 3324 (m, br), 2892 (w), 2119 (m), 1251 (w), 1019 (s), 814 (w) cm^{-1}.

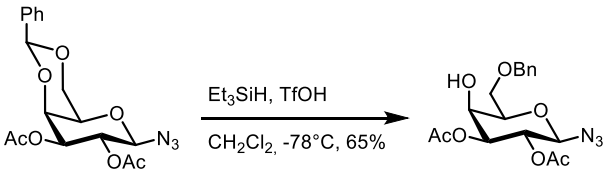
^{1}H NMR (600 MHz, D_2O, 298 K) δ = 5.21 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-1_{Man}), 4.75 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1_{Glc}), 4.53 (d, $^3J_{1,2}$ = 8.0 Hz, 1H, H-$1_{Glc'}$), 4.21 (dd, $^2J_{6a,6b}$ = 11.5 Hz, $^3J_{5,6a}$ = 1.8 Hz, 1H, H-$6a_{Man}$), 4.06 (dd, $^3J_{2,3}$ = 3.2 Hz, $^3J_{1,2}$ = 2.0 Hz, 1H, H-2_{Man}), 3.93 – 3.86 (m, 3H, H-$6a_{Glc}$, H-$6a_{Glc'}$, H-$6b_{Man}$), 3.81 (m, 2H, H-3_{Man}, H-4_{Man}), 3.77 – 3.61 (m, 6H, H-$3_{Glc'}$, H-$4_{Glc'}$, H-5_{Man}, H-$5_{Glc'}$, H-$6b_{Glc}$, H-$6b_{Glc'}$), 3.49 (t, $^3J_{3,4}$ = $^3J_{2,3}$ = 9.0 Hz, 1H, H-3_{Glc}), 3.46 – 3.37 (m, 2H, H-4_{Glc}, H-5_{Glc}), 3.32 – 3.25 (m, 2H, H-2_{Glc}, H-$2_{Glc'}$) ppm.

^{13}C NMR (151 MHz, D_2O, 298 K) δ = 102.8 (C-$1_{Glc'}$), 101.9 (C-1_{Man}), 90.0 (C-1_{Glc}), 77.1*, 76.0*, 75.9*, 75.7*, 75.7*, 73.9*, 73.1 (C-$2_{Glc/Glc'}$), 72.8 (C-$2_{Glc/Glc'}$), 70.3*, 70.2*, 69.6 (C-4_{Glc}), 68.9 (C-6_{Man}), 66.6*, 61.0 (C-$6_{Glc/Glc'}$), 60.7 (C-$6_{Glc/Glc'}$) ppm.

*Assignment is ambiguous due to signal overlap (C-2_{Man}, C-3_{Glc}, C-$3_{Glc'}$, C-3_{Man}, C-$4_{Glc'}$, C-4_{Man}, C-5_{Glc}, C-$5_{Glc'}$, C-5_{Man}).

ESI-HRMS: *m/z* = 552.16449 $[M+Na]^+$ (calculated *m/z* = 552.16474).

2.11. 2,3-Di-*O*-acetyl-6-*O*-benzyl-β-D-galactopyranosyl azide (13)



12 **13**

The benzylidene-protected galactosyl azide **12**[5] (1.90 g, 5.04 mmol, 1 equiv) was dissolved in dry dichloromethane (34 mL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~200 mg) was added and the reaction mixture was stirred at room temperature for 30 min. After cooling to -78 °C triethylsilane (804 µL, 5.04 mmol, 1 equiv) and triflic acid (223 µL, 2.52 mmol, 0.5 equiv) were added and the reaction mixture stirred for 15 min. Afterwards, additional triethylsilane (804 µL, 5.04 mmol, 1 equiv) and triflic acid (223 µL, 2.52 mmol, 0.5 equiv) were added at -78 °C. After 15 min, additional triethylsilane (402 µL, 2.52 mmol, 0.5 equiv) and triflic acid (223 µL, 2.52 mmol, 0.5 equiv) were added and stirred for 15 min. Finally, triflic acid (223 µL, 2.52 mmol, 0.5 equiv) was added and the reaction mixture stirred at -78 °C for further 30 min. It was diluted with dichloromethane (20 mL) and satd. aq. $NaHCO_3$ solution (50 mL) was added. After strong stirring for 10 min the reaction mixture was filtrated over celite and extracted with dichloromethane (3x50 mL). The combined org. phases were dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude product was purified on silica gel via automated flash chromatography twice (cyclohexane:ethyl acetate, 9:1→6:4 then toluene:ethyl acetate 90:10→75:25) to yield the product **13** as a viscous light yellow oil (1.25 g, 3.30 mmol, 65%).

R_F (toluene:ethyl acetate, 3:1) = 0.34.

$[\alpha]_D^{20}$ = -9.8 (*c* = 1.00 in $CHCl_3$).

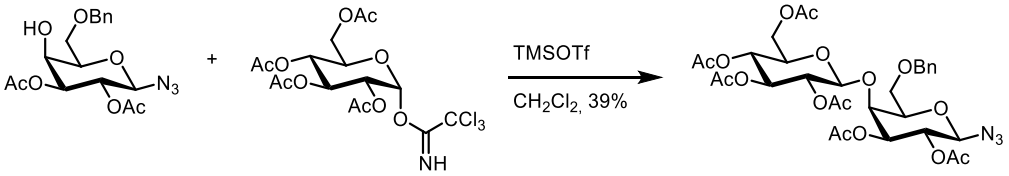
IR (ATR): $\tilde{\nu}$ = 3449 (br, w), 2875 (w), 2116 (m), 1747 (m), 1368 (m), 1216 (s), 1056 (s), 1003 (m), 781 (w), 738 (m), 698 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 7.39 – 7.28 (m, 5H, 5 Ar-H), 5.28 (dd, $^3J_{2,3}$ = 10.1 Hz, $^3J_{1,2}$ = 8.7 Hz, 1H, H-2), 4.95 (dd, $^3J_{2,3}$ = 10.1 Hz, $^3J_{3,4}$ = 3.1 Hz, 1H, H-3), 4.63 – 4.54 (m, 3H, H-1, PhC$\underline{H}_2$), 4.20 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 3.0 Hz, 1H, H-4), 3.86 – 3.74 (m, 3H, H-5, H-6a, H-6b), 2.83 (d, $^3J_{4,OH}$ = 3.3 Hz, 1H, OH), 2.10 (s, 3H, OAc), 2.08 (s, 3H, OAc) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.1 ($\underline{C}$(O)CH_3), 169.5 ($\underline{C}$(O)CH_3), 137.3 (OBn_{ipso}), 128.6 (2 Ar-$\underline{C}$H), 128.0 (Ar-$\underline{C}$H), 127.8 (2 Ar-$\underline{C}$H), 88.4 (C-1), 75.1 (C-5), 73.9 (Ph$\underline{C}H_2$), 73.2 (C-3), 69.1 (C-6), 68.6 (C-2), 68.0 (C-4), 20.8 (CH_3), 20.7 (CH_3) ppm.

ESI-HRMS: *m/z* = 402.12662 $[M+Na]^+$ (calculated *m/z* = 402.12717).

2.12. 2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl-(1→4)-2,3-di-*O*-acetyl-6-*O*-benzyl-β-D-galactopyranosyl azide (14)



13 **Glc-TCA** **14**

The acceptor galactosyl azide **13** (21.0 mg, 55.4 µmol, 1 equiv) and the glucosyl donor Glc-TCA (40.0 mg, 81.2 µmol, 1.5 equiv) were dissolved in dry dichloromethane (500 µL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~50 mg) was added and the reaction mixture stirred at room temperature for 15 min. At 0 °C trimethylsilyl trifluoromethanesulfonate (5 µL, 27.7 µmol, 0.5 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 14.5 h. The reaction mixture was diluted with dichloromethane (10 mL) and triethylamine (50 µL) was added. After filtration over celite® the solvent was removed under reduced pressure. The crude product was purified on silica gel via automated flash chromatography twice (cyclohexane:ethyl acetate, 66:33→55:45 then toluene:ethyl acetate 75:25→66:33) to yield the product **14** as a colorless oil (15.5 mg, 21.8 µmol, 39%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 2:1) = 0.18.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -11.5 (*c* = 0.24 in $CHCl_3$).

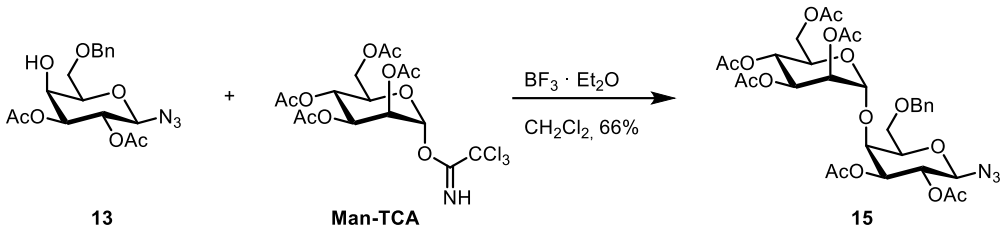
IR (ATR): $\tilde{\nu}$ = 2944 (br, w), 2122 (m), 1747 (s), 1363 (m), 1219 (s), 1094 (m), 1034 (s), 980 (m), 912 (m), 751 (m), 699 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 7.41 – 7.27 (m, 5H, Ar-H), 5.22 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.6 Hz, 1H, H-3_{Glc}), 5.10 – 4.98 (m, 3H, H-2_{Gal}, H-2_{Glc}, H-4_{Glc}), 4.94 (dd, $^3J_{2,3}$ = 10.2 Hz, $^3J_{3,4}$ = 2.9 Hz, 1H, H-3_{Gal}), 4.59 – 4.48 (m, 4H, H-1_{Gal}, H-1_{Glc}, PhC$\underline{H}_2$), 4.20 – 4.13 (m, 2H, H-4_{Gal}, H-$6a_{Glc}$), 4.04 (dd, ^2J = 12.4 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-$6b_{Glc}$), 3.79 (ddd, ^3J = 6.2 Hz, ^3J = 5.0 Hz, ^3J = 1.0 Hz, 1H, H-5_{Gal}), 3.76 – 3.64 (m, 2H, H-$6a_{Gal}$, H-$6b_{Gal}$), 3.60 (ddd, $^3J_{4,5}$ = 10.0 Hz, $^3J_{5,6a}$ = 4.6 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-5_{Glc}), 2.15 (s, 3H, OAc), 2.12 (s, 3H, OAc), 2.06 (s, 3H, OAc), 2.03 (s, 3H, OAc), 2.02 (s, 3H, OAc), 2.02 (s, 3H, OAc) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.6 ($\underline{C}(O)CH_3$), 170.5 ($\underline{C}(O)CH_3$), 170.2 ($\underline{C}(O)CH_3$), 169.6 ($\underline{C}(O)CH_3$), 169.5 ($\underline{C}(O)CH_3$), 169.4 ($\underline{C}(O)CH_3$), 138.0 (OBn_{ipso}), 128.6 (2 Ar-$\underline{C}$H), 127.9 (Ar-$\underline{C}$H), 127.7 (2 Ar-$\underline{C}$H), 101.2 (C-1_{Glc}), 88.1 (C-1_{Gal}), 75.8 (C-5_{Gal}), 73.8 (C-4_{Gal}), 73.6 (Ph$\underline{C}H_2$), 73.3 (C-3_{Gal}), 72.6 (C-3_{Glc}), 72.0 (C-5_{Glc}), 71.3 (C-2_{Glc}), 69.0 (C-6_{Gal}), 68.8 (C-2_{Gal}/C-4_{Glc}), 68.4 (C-2_{Gal}/C-4_{Glc}), 61.8 (C-6_{Glc}), 20.9 (CH_3), 20.8 (2 CH_3), 20.8 (CH_3), 20.7 (CH_3), 20.6 (CH_3) ppm.

ESI-HRMS: *m/z* = 727.26623 $[M+NH_4]^+$ (calculated *m/z* = 727.26686).

2.13. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→4)-2,3-di-*O*-acetyl-6-*O*-benzyl-β-D-galactopyranosyl azide (15)



13 Man-TCA 15

The acceptor galactosyl azide **13** (122 mg, 322 µmol, 1 equiv) was dissolved in dry dichloromethane (2 mL) under a nitrogen atmosphere, freshly activated molecular sieve (3Å, ~50 mg) was added and a solution of mannosyl donor Man-TCA (317 mg, 643 µmol, 2 equiv) in dry dichloromethane (600 µL) was added. The reaction mixture was stirred at room temperature for 15 min. After cooling to 0 °C boron trifluoride diethyl etherate (20 µL, 161 µmol, 0.5 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 16 h. The reaction mixture was diluted with dichloromethane (10 mL) and satd. aq. $NaHCO_3$ solution (10 mL) and vigorously stirred for 10 min. It was filtrated over celite and the separated aq. phase was extracted with dichloromethane (3x50 mL). The combined org. phases were washed with brine (20 mL), dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 70:30→55:45) to yield the product **15** as a colorless oil (150 mg, 211 µmol, 66%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 2:1) = 0.19.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = +16.9 (*c* = 0.76 in $CHCl_3$).

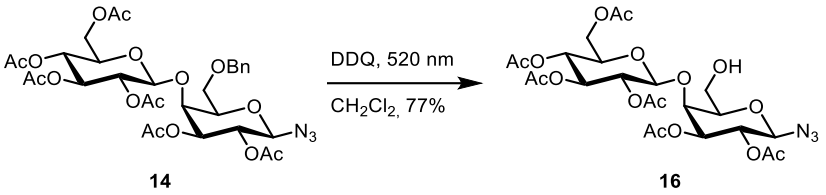
IR (ATR): $\tilde{\nu}$ = 2925 (w), 2118 (m), 1742 (s), 1368 (m), 1213 (s), 1132 (m), 1081 (m), 1039 (s), 983 (m), 908 (m), 739 (w), 699 (m), 599 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 7.36 – 7.27 (m, 5H, Ar-H), 5.43 – 5.31 (m, 3H, H-2_{Man}, H-3_{Man}, H-4_{Man}), 5.16 (dd, $^3J_{2,3}$ = 10.6 Hz, $^3J_{1,2}$ = 8.6 Hz, 1H, H-2_{Gal}), 4.95 (dd, $^3J_{2,3}$ = 10.6 Hz, $^3J_{3,4}$ = 3.0 Hz, 1H, H-3_{Gal}), 4.88 (d, $^3J_{1,2}$ = 1.8 Hz, 1H, H-1_{Man}), 4.64 – 4.56 (m, 2H, H-1_{Gal}, PhC<u>H</u>H'), 4.45 (d, ^2J = 11.8 Hz, 1H, PhCH<u>H</u>'), 4.34 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 3.9 Hz, 1H, H-$6a_{Man}$), 4.30 – 4.24 (m, 2H, H-4_{Gal}, H-5_{Man}), 4.10 (dd, ^2J = 12.2 Hz, $^3J_{5,6b}$ = 2.3 Hz, 1H, H-$6b_{Man}$), 3.84 (t, $^3J_{4,5}$ = $^3J_{5,6}$ = 7.2 Hz, 1H, H-5_{Gal}), 3.76 – 3.67 (m, 2H, H-$6a_{Gal}$, H-$6b_{Gal}$), 2.11 (s, 3H, OAc), 2.10 (s, 3H, OAc), 2.09 (s, 6H, 2x OAc), 2.08 (s, 3H, OAc), 2.02 (s, 3H, OAc) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.8 (<u>C</u>(O)CH_3), 170.3 (<u>C</u>(O)CH_3), 170.1 (<u>C</u>(O)CH_3), 170.0 (<u>C</u>(O)CH_3), 169.9 (<u>C</u>(O)CH_3), 169.4 (<u>C</u>(O)CH_3), 137.6 (OBn_{ipso}), 128.6 (2 Ar-<u>C</u>H), 128.0 (Ar-<u>C</u>H), 128.0 (2 Ar-<u>C</u>H), 100.0 (C-1_{Man}), 88.4 (C-1_{Gal}), 76.2 (C-4_{Gal}/C-5_{Man}), 74.7 (C-5_{Gal}), 73.4 (Ph<u>C</u>H_2), 72.3 (C-3_{Gal}), 69.5 (C-2_{Man}, C-4_{Gal}/C-5_{Man}), 69.2 (C-3_{Man}/C-4_{Man}), 68.7 (C-2_{Gal}), 66.6 (C-6_{Gal}), 65.7 (C-3_{Man}/C-4_{Man}), 62.2 (C-6_{Man}), 21.1 (CH_3), 21.0 (CH_3), 20.9 (CH_3), 20.9 (2 CH_3), 20.8 (CH_3) ppm.

ESI-HRMS: *m/z* = 732.22144 $[M+Na]^+$ (calculated *m/z* = 732.22225).

2.14. 2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl-(1→4)-2,3-di-*O*-acetyl-β-D-galactopyranosyl azide (16)



14 **16**

Following the procedure from Cavedon[4] et al., the disaccharide **14** (89 mg, 126 µmol, 1 equiv) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (43 mg, 189 µmol, 1.5 equiv) were dissolved in dry dichloromethane (6.45 mL) under nitrogen atmosphere and water (65 µL) was added. During strong stirring the reaction mixture was irradiated with 520 nm green light for 4 h at room temperature. The reaction mixture was diluted with dichloromethane (80 mL) and washed with satd. aq. $NaHCO_3$ solution (50 mL). The separated aq. phase was extracted with dichloromethane (2 x 50 mL). All organic phases were combined and dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 60:40→20:80) to yield the product **16** as a colorless solid (60 mg, 96.8 µmol, 77%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:2) = 0.25.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -8.6 (*c* = 0.70 in $CHCl_3$).

IR (ATR): $\tilde{\nu}$ = 3562 (m), 2961 (w), 2915 (w), 2106 (m), 1747 (s), 1736 (s), 1366 (m), 1216 (s), 1167 (m), 1064 (s), 1029 (s), 953 (m) cm^{-1}.

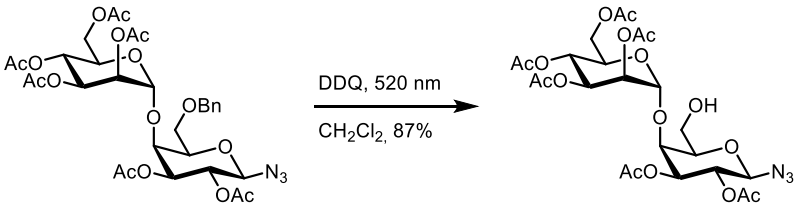
^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 5.25 (dd, $^3J_{2,3}$ = 9.9 Hz, $^3J_{3,4}$ = 9.3 Hz, 1H, H-3_{Glc}), 5.07 (dd, $^3J_{2,3}$ = 9.9 Hz, $^3J_{1,2}$ = 8.1 Hz, 1H, H-2_{Glc}), 5.04 – 4.94 (m, 3H, H-2_{Gal}, H-3_{Gal}, H-4_{Glc}), 4.56 – 4.51 (m, 2H, H-1_{Gal}, H-1_{Glc}), 4.38 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 2.4 Hz, 1H, H-$6a_{Glc}$), 4.25 (dd, $^3J_{3,4}$ = 3.0 Hz, $^3J_{4,5}$ = 0.9 Hz, 1H, H-4_{Gal}), 3.96 (dd, ^2J = 12.3 Hz, $^3J_{5,6b}$ = 7.0 Hz, 1H, H-$6b_{Glc}$), 3.82 (ddd, ^2J = 12.6 Hz, $^3J_{5,6a}$ = 10.7 Hz, $^3J_{OH,6a}$ = 6.7 Hz, 1H, H-$6a_{Gal}$), 3.75 – 3.66 (m, 3H, H-5_{Gal}, H-5_{Glc}, H-$6b_{Gal}$), 2.93 (t, $^3J_{OH,6}$ = 6.9 Hz, 1H, OH), 2.16 (s, 3H, OAc), 2.13 (s, 3H, OAc), 2.10 (s, 3H, OAc), 2.06 (s, 3H, OAc), 2.05 (s, 3H, OAc), 2.03 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.7 ($\underline{C}(O)CH_3$), 170.4 ($\underline{C}(O)CH_3$), 170.3 ($\underline{C}(O)CH_3$), 169.5 (2 $\underline{C}(O)CH_3$), 169.3 ($\underline{C}(O)CH_3$), 102.0 (C-1_{Glc}), 88.2 (C-1_{Gal}), 75.6 (C-$5_{Glc/Gal}$), 73.7 (C-4_{Gal}), 73.1*, 72.3 (C-3_{Glc}), 72.2 (C-$5_{Glc/Gal}$), 70.9 (C-2_{Glc}), 68.8*, 68.7*, 62.3 (C-6_{Glc}), 59.1 (C-6_{Gal}), 20.9 (CH_3), 20.8 (CH_3), 20.7 (2 CH_3), 20.7 (CH_3), 20.6 (CH_3) ppm.

*Assignment is ambiguous due to signal overlap (C-2_{Gal}, C-3_{Gal}, C-4_{Glc})

ESI-HRMS: *m/z* = 637.21922 $[M+NH_4]^+$ (calculated *m/z* = 637.21991).

2.15. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→4)-2,3-di-*O*-acetyl-β-D-galactopyranosyl azide (17)



15 **17**

Following the procedure from Cavedon[4] et al., the disaccharide **15** (122 mg, 172 µmol, 1 equiv) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (58.5 mg, 258 µmol, 1.5 equiv) were dissolved in dry dichloromethane (8.5 mL) under a nitrogen atmosphere and water (85 µL) was added. During strong stirring the reaction mixture was irradiated with 520 nm green light for 6.5 h at room temperature. The reaction mixture was diluted with dichloromethane (50 mL) and washed with satd. aq. $NaHCO_3$ solution (50 mL). The aq. phases were extracted with dichloromethane (2 x 50 mL). All organic phases were combined and dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 50:50→40:60) to yield the product **17** as a colorless solid (92.3 mg, 149 µmol, 87%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:1) = 0.16.

$[\alpha]_D^{20}$ = +15.8 (*c* = 0.82 in $CHCl_3$).

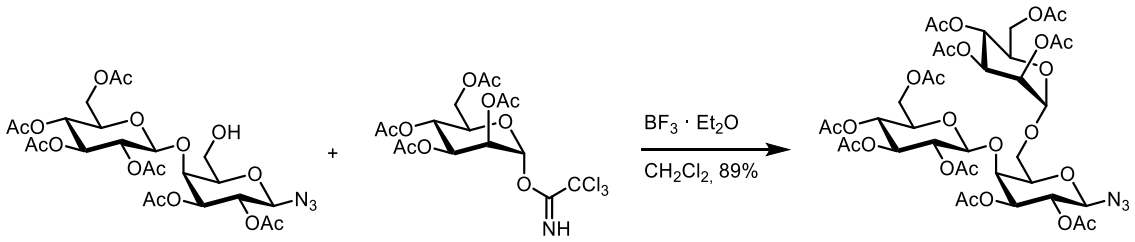
IR (ATR): $\tilde{\nu}$ = 2945 (w), 2121 (m), 1749 (s), 1735 (s), 1368 (m), 1215 (s), 1142 (m), 1107 (m), 1082 (m), 1042 (s), 899 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.39 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 10.0 Hz, 1H, H-4_{Man}), 5.33 (dd, $^3J_{3,4}$ = 10.1 Hz, $^3J_{2,3}$ = 3.3 Hz, 1H, H-3_{Man}), 5.28 (dd, $^3J_{2,3}$ = 3.3 Hz, $^3J_{1,2}$ = 1.9 Hz, 1H, H-2_{Man}), 5.18 (dd, $^3J_{2,3}$ = 10.6 Hz, $^3J_{1,2}$ = 8.6 Hz, 1H, H-2_{Gal}), 4.98 (dd, $^3J_{2,3}$ = 10.6 Hz, $^3J_{3,4}$ = 3.1 Hz, 1H, H-3_{Gal}), 4.93 (d, $^3J_{1,2}$ = 1.9 Hz, 1H, H-1_{Man}), 4.62 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1_{Gal}), 4.34 (dd, ^2J = 12.4 Hz, $^3J_{5,6a}$ = 3.9 Hz, 1H, H-$6a_{Man}$), 4.29 – 4.21 (m, 2H, H-4_{Gal}, H-5_{Man}), 4.11 (dd, ^2J = 12.4 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-$6b_{Man}$), 3.97 – 3.89 (m, 1H, H-$6a_{Gal}$), 3.87 – 3.78 (m, 2H, H-5_{Gal}, H-$6b_{Gal}$), 2.16 (s, 3H, OAc), 2.10 (s, 3H, OAc), 2.09 (s, 9H, 3xOAc), 2.02 (s, 3H, OAc) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.8 (2 x $\underline{C}(O)CH_3$), 170.3 ($\underline{C}(O)CH_3$), 170.2 ($\underline{C}(O)CH_3$), 169.9 ($\underline{C}(O)CH_3$), 169.5 ($\underline{C}(O)CH_3$), 99.8 (C-1_{Man}), 88.5 (C-1_{Gal}), 76.0 (C-5_{Gal}), 75.9 (C-4_{Gal}), 72.4 (C-3_{Gal}), 69.8 (C-2_{Man}), 69.6 (C-5_{Man}), 69.1 (C-3_{Man}), 68.7 (C-2_{Gal}), 65.5 (C-4_{Man}), 62.1 (C-6_{Man}), 60.0 (C-6_{Gal}), 21.1 (CH_3), 21.0 (CH_3), 20.9 (CH_3), 20.9 (2 CH_3), 20.8 (CH_3) ppm.

ESI-HRMS: *m/z* = 642.17428 $[M+Na]^+$ (calculated *m/z* = 642.17530).

2.16. 2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl-(1→4)-[2,3,4,6-tetra-*O*-acetyl-α-D-mannopyranosyl-(1→6)]-2,3-di-*O*-acetyl-β-D-galactopyranosyl azide (18)



16 Man-TCA 18

The acceptor disaccharide **16** (25 mg, 40.5 µmol, 1 equiv) and the mannosyl donor Man-TCA (27 mg, 55.0 µmol, 1.4 equiv) were dissolved in dry dichloromethane (500 µL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~20 mg) was added and the reaction mixture stirred at room temperature for 20 min. At 0 °C boron trifluoride diethyl etherate (5 µL, 39.5 µmol, 1 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 22 h. Triethylamine (50 µL) was added and the reaction mixture was filtered over celite®. The solvent was removed under reduced pressure and the crude product was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 70:30→30:70) to yield the product **18** as a colorless oil (34 mg, 36.0 µmol, 89%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:2) = 0.41.

$[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{20}}$ = +10.5 (*c* = 0.37 in $CHCl_3$).

IR (ATR): $\tilde{\nu}$ = 2941 (w), 2119 (m), 1745 (s), 1434 (w), 1368 (m), 1215 (s), 1038 (s), 903 (m) cm^{-1}.

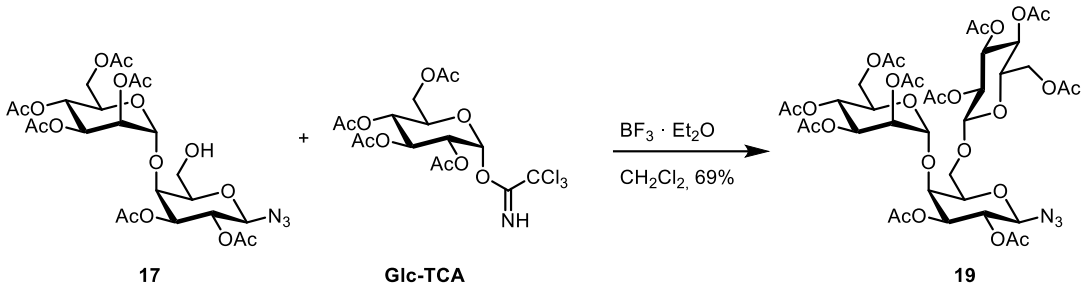
^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 5.30 (dd, $^3J_{3,4}$ = 10.0 Hz, $^3J_{2,3}$ = 3.5 Hz, 1H, H-3_{Man}), 5.26 – 5.18 (m, 3H, H-2_{Man}, H-3_{Glc}, H-4_{Man}), 5.05 (dd, $^3J_{4,5}$ = 10.1 Hz, $^3J_{3,4}$ = 9.4 Hz, 1H, H-4_{Glc}), 5.02 – 4.94 (m, 3H, H-2_{Gal}, H-2_{Glc}, H-3_{Gal}), 4.82 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-1_{Man}), 4.62 (d, $^3J_{1,2}$ = 8.5 Hz, 1H, H-1_{Gal}), 4.53 (d, $^3J_{1,2}$ = 8.0 Hz, 1H, H-1_{Glc}), 4.26 (dd, ^2J = 12.2 Hz, $^3J_{5,6a}$ = 5.7 Hz, 1H, H-$6a_{Man}$), 4.19 (dd, ^2J = 12.2 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-$6b_{Man}$), 4.15 – 4.10 (m, 3H, H-4_{Gal}, H-$6a_{Glc}$, H-$6b_{Glc}$), 4.09 – 4.05 (m, 1H, H-5_{Man}), 3.88 (dd, ^2J = 10.3 Hz, $^3J_{5,6a}$ = 6.7 Hz, 1H, H-$6a_{Gal}$), 3.82 (ddd, $^3J_{5,6a}$ = 6.9 Hz, $^3J_{5,6b}$ = 4.0 Hz, $^3J_{4,5}$ = 1.1 Hz, 1H, H-5_{Gal}), 3.69 (dd, ^2J = 10.4 Hz, $^3J_{5,6b}$ = 4.0 Hz, 1H, H-$6b_{Gal}$), 3.61 (dt, $^3J_{4,5}$ = 10.0 Hz, $^3J_{5,6a}$ = $^3J_{5,6b}$ = 3.4 Hz, 1H, H-5_{Glc}), 2.15 (s, 3H, OAc), 2.14 (s, 3H, OAc), 2.14 (s, 3H, OAc), 2.12 (s, 3H, OAc), 2.08 (s, 3H, OAc), 2.07 (s, 3H, OAc), 2.02 (s, 3H, OAc), 2.02 (s, 3H, OAc), 2.02 (s, 3H, OAc), 1.99 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.9 (C(O)CH_3), 170.6 (C(O)CH_3), 170.5 (C(O)CH_3), 170.3 (C(O)CH_3), 170.2 (C(O)CH_3), 170.1 (C(O)CH_3), 170.0 (C(O)CH_3), 169.5 (C(O)CH_3), 169.5 (C(O)CH_3), 169.4 (C(O)CH_3), 101.2 (C-1_{Glc}), 97.1 (C-1_{Man}), 88.0 (C-1_{Gal}), 75.1 (C-5_{Gal}), 73.8 (C-4_{Gal}), 73.1*, 72.5 (C-3_{Glc}), 72.0 (C-5_{Glc}), 71.2*, 69.4 (C-3_{Man}/C-4_{Man}), 69.3 (C-3_{Man}/C-4_{Man}), 68.8 (C-5_{Man}), 68.6*, 68.3 (C-4_{Glc}), 66.8 (C-6_{Gal}), 66.1 (C-2_{Man}), 62.5 (C-6_{Man}), 61.3 (C-6_{Glc}), 21.0 (CH_3), 20.9 (CH_3), 20.9 (CH_3), 20.9 (CH_3), 20.8 (2 CH_3), 20.8 (2 CH_3), 20.7 (CH_3), 20.6 (CH_3) ppm.

*Assignment is ambiguous due to signal overlap (C-2_{Gal}, C-2_{Glc}, C-3_{Gal})

ESI-HRMS: *m/z* = 967.31341 $[M+NH_4]^+$ (calculated *m/z* = 967.31499).

2.17. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→4)-[2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl-(1→6)]-2,3-di-*O*-acetyl-β-D-galactopyranosyl azide (19)



17 Glc-TCA 19

The acceptor disaccharide **17** (63.5 mg, 102 µmol, 1 equiv) and the glucosyl donor Glc-TCA (60.6 mg, 123 µmol, 1.2 equiv) were dissolved in dry dichloromethane (5 mL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~100 mg) was added and the reaction mixture stirred at room temperature for 30 min. At 0 °C boron trifluoride diethyl etherate (6.5 µL, 51.2 µmol, 0.5 equiv) was added and the reaction mixture was stirred at 0 °C for 1 h, followed by stirring at room temperature for 15 h. Triethylamine (25 µL) was added and the reaction mixture was filtered over celite. The solvent was removed under reduced pressure and the crude product was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 65:35→40:60 over 12 CV) to yield the product **19** as a colorless solid (67.5 mg, 71.1 µmol, 69%).

R_F (cyclohexane:ethyl acetate, 1:1) = 0.17.

$[\alpha]_D^{20}$ = +14.3 (*c* = 0.28 in $CHCl_3$).

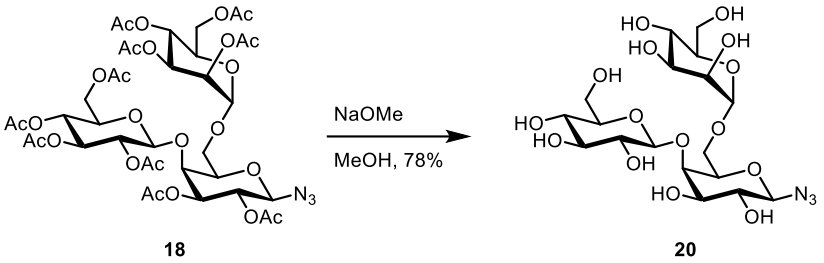
IR (ATR): $\tilde{\nu}$ = 2925 (w), 2120 (m), 1743 (s), 1434 (m), 1368 (m), 1214 (s), 1036 (s), 906 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.39 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 10.0 Hz, 1H, H-4_{Man}), 5.30 (dd, $^3J_{3,4}$ = 10.1 Hz, $^3J_{2,3}$ = 3.2 Hz, 1H, H-3_{Man}), 5.26 (dd, $^3J_{2,3}$ = 3.3 Hz, $^3J_{1,2}$ = 2.0 Hz, 1H, H-2_{Man}), 5.21 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.5 Hz, 1H, H-3_{Glc}), 5.17 – 5.07 (m, 2H, H-2_{Gal}, H-4_{Glc}), 4.99 (dd, $^3J_{2,3}$ = 9.7 Hz, $^3J_{1,2}$ = 8.0 Hz, 1H, H-2_{Glc}), 4.89 (dd, $^3J_{2,3}$ = 10.6 Hz, $^3J_{3,4}$ = 3.0 Hz, 1H, H-3_{Gal}), 4.79 (d, $^3J_{1,2}$ = 2.0 Hz, 1H, H-1_{Man}), 4.65 – 4.60 (m, 2H, H-1_{Gal}, H-1_{Glc}), 4.30 (dd, ^2J = 12.4 Hz, $^3J_{5,6a}$ = 3.8 Hz, 1H, H-$6a_{Man}$), 4.25 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 4.5 Hz, 1H, H-$6a_{Glc}$), 4.21 (dt, $^3J_{4,5}$ = 10.0 Hz, $^3J_{5,6a}$ = $^3J_{5,6b}$ = 3.1 Hz, 1H, H-5_{Man}), 4.18 – 4.14 (m, 1H, H-$6b_{Glc}$), 4.16 – 4.08 (m, 2H, H-4_{Gal}, H-$6b_{Man}$), 4.06 – 3.97 (m, 1H, H-$6a_{Gal}$), 3.89 – 3.81 (m, 2H, H-5_{Gal}, H-$6b_{Gal}$), 3.74 (ddd, $^3J_{4,5}$ = 10.1 Hz, $^3J_{5,6a}$ = 4.5 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-5_{Glc}), 2.15 (s, 3H, OAc), 2.10 (s, 3H, OAc), 2.09 (s, 3H, OAc), 2.09 (s, 3H, OAc), 2.08 (s, 6H, 2 OAc), 2.05 (s, 3H, OAc), 2.02 (s, 3H, OAc), 2.00 (s, 3H, OAc), 2.00 (s, 3H, OAc) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.9 (C(O)CH_3), 170.8 (C(O)CH_3), 170.43 (C(O)CH_3), 170.41 (C(O)CH_3), 170.1 (C(O)CH_3), 170.0 (C(O)CH_3), 169.9 (C(O)CH_3), 169.6 (2 C(O)CH_3), 169.4 (C(O)CH_3), 100.9 (C-1_{Glc}), 100.1 (C-1_{Man}), 88.3 (C-1_{Gal}), 76.8 (C-4_{Gal}), 75.2 (C-5_{Gal}), 72.9 (C-3_{Glc}), 72.3 (C-3_{Gal}), 72.1 (C-5_{Glc}), 71.2 (C-2_{Glc}), 69.8 (C-5_{Man}), 69.5 (C-2_{Man}), 69.2 (C-3_{Man}), 68.5 (C-2_{Gal}/C-4_{Glc}), 68.4 (C-2_{Gal}/C-4_{Glc}), 67.5 (C-6_{Gal}), 65.5 (C-4_{Man}), 62.1 (C-$6_{Glc/Man}$), 61.9 (C-$6_{Glc/Man}$), 21.05 (CH_3), 20.92 (CH_3), 20.88 (CH_3), 20.86 (CH_3), 20.81 (CH_3), 20.79 (3 CH_3), 20.76 (2 CH_3) ppm.

ESI-HRMS: *m/z* = 967.31341 $[M+NH_4]^+$ (calculated *m/z* = 967.31499).

2.18. β-D-Glucopyranosyl-(1→4)-[α-D-mannopyranosyl-(1→6)]-β-D-galactopyranosyl azide (20)



18 20

The protected trisaccharide **18** (29 mg, 30.7 µmol, 1 equiv) was suspended in methanol (3 mL) and a solution of sodium methoxide in methanol (15 µL, 75.0 µmol, 5 M, 2.4 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 19 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 20 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **20** as a lyophilizate (13 mg, 24.0 µmol, 78%).

$[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{20}}$ = +47.3 (*c* = 0.41 in CH_3OH).

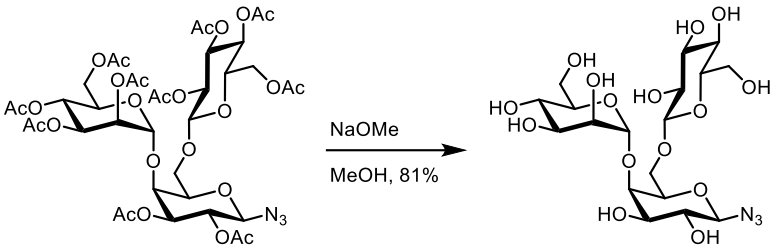
IR (ATR): $\tilde{\nu}$ = 3309 (br, m), 2894 (w), 2117 (m), 1638 (w), 1412 (w), 1364 (m), 1248 (m), 1162 (m), 1132 (m), 1017 (s), 888 (m), 811 (m) cm^{-1}.

^{1}H NMR (600 MHz, D_2O, 298 K) δ = 4.92 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-1_{Man}), 4.74 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1_{Gal}), 4.67 (d, $^3J_{1,2}$ = 7.9 Hz, 1H, H-1_{Glc}), 4.24 (d, $^3J_{3,4}$ = 3.2 Hz, 1H, H-4_{Gal}), 4.00 (dd, $^3J_{5,6a}$ = 7.5 Hz, $^3J_{5,6b}$ = 4.6 Hz, 1H, H-5_{Gal}), 3.96 (dd, $^3J_{2,3}$ = 3.6 Hz, $^3J_{1,2}$ = 1.7 Hz, 1H, H-2_{Man}), 3.96 – 3.88 (m, 3H, H-$6a_{Gal}$, H-$6a_{Glc}$, H-$6a_{Man}$), 3.85 – 3.74 (m, 5H, H-3_{Gal}, H-3_{Man}, H-$6b_{Gal}$, H-$6b_{Glc}$, H-$6b_{Man}$), 3.70 – 3.64 (m, 2H, H-4_{Man}, H-5_{Man}), 3.58 (dd, $^3J_{2,3}$ = 9.8 Hz, $^3J_{1,2}$ = 8.9 Hz, 1H, H-2_{Gal}), 3.53 – 3.47 (m, 1H, H-3_{Glc}), 3.46 – 3.39 (m, 2H, H-4_{Glc}, H-5_{Glc}), 3.37 – 3.31 (m, 1H, H-2_{Glc}) ppm.

^{13}C NMR (151 MHz, D_2O, 298 K) δ = 103.7 (C-1_{Glc}), 99.7 (C-1_{Man}), 90.5 (C-1_{Gal}), 77.6 (C-4_{Gal}), 75.9 (C-4_{Glc}/C-5_{Glc}), 75.7 (C-3_{Glc}), 74.5 (C-5_{Gal}), 73.8 (C-2_{Glc}), 73.0 (C-$3_{Gal/Man}$), 72.8 (C-4_{Man}/C-5_{Man}), 70.7 (C-2_{Gal}), 70.5 (C-$3_{Gal/Man}$), 70.0 (C-2_{Man}), 69.3 (C-4_{Glc}/C-5_{Glc}), 66.6 (C-4_{Man}/C-5_{Man}), 66.3 (C-6_{Gal}), 60.8 (C-$6_{Glc/Man}$), 60.5 (C-$6_{Glc/Man}$) ppm.

ESI-HRMS: *m/z* = 547.20933 $[M+NH_4]^+$ (calculated *m/z* = 547.20934).

2.19. α-D-Mannopyranosyl-(1→4)-[β-D-glucopyranosyl-(1→6)]-β-D-galactopyranosyl azide (21)



19 21

The protected trisaccharide **19** (58 mg, 60.9 µmol, 1 equiv) was suspended in methanol (6 mL) and a solution of sodium methoxide in methanol (30 µL, 150 µmol, 5 M, 2.5 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 19 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 20 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **21** as a lyophilizate (26.2 mg, 49.5 µmol, 81%).

$[\alpha]_D^{20}$ = -5.7 (*c* = 0.46 in CH_3OH).

IR (ATR): $\tilde{\nu}$ = 3326 (br, m), 2925 (w), 2118 (m), 1639 (w), 1364 (m), 1249 (m), 1016 (s), 899 (m), 809 (m) cm^{-1}.

^{1}H NMR (600 MHz, D_2O, 298 K) δ = 4.92 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-1_{Man}), 4.80 – 4.78 (m, 1H, H-1_{Gal}), 4.52 (d, $^3J_{1,2}$ = 8.0 Hz, 1H, H-1_{Glc}), 4.12 (d, $^3J_{3,4}$ = 3.2 Hz, 1H, H-4_{Gal}), 4.10 – 4.01* (m, 4H, H-2_{Man}, H-5_{Gal}, H-$6a_{Gal}$), 3.94 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 1.8 Hz, 1H, H-$6a_{Glc}$), 3.89 – 3.69* (m, 7H, H-3_{Gal}, H-$6b_{Gal}$, H-$6a_{Man}$, H-$6b_{Man}$, H-$6b_{Glc}$), 3.53 – 3.43 (m, 3H, H-2_{Gal}, H-3_{Glc}, H-5_{Glc}), 3.44 – 3.37 (m, 1H, H-4_{Glc}), 3.33 – 3.29 (m, 1H, H-2_{Glc}) ppm.

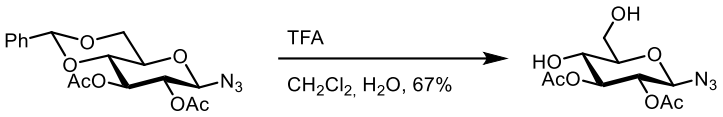
*Assignment is ambiguous due to signal overlap (H-3_{Man}, H-4_{Man}, H-5_{Man}).

^{13}C NMR (151 MHz, D_2O, 298 K) δ = 102.5 (C-1_{Glc}), 101.6 (C-1_{Man}), 90.9 (C-1_{Gal}), 77.2 (C-4_{Gal}), 75.9**, 75.6**, 75.2**, 73.0**, 73.0 (C-2_{Glc}), 72.0**, 70.4**, 70.3**, 70.1**, 69.5 (C-4_{Glc}), 67.6 (C-6_{Gal}), 66.4**, 60.6 (C-$6_{Glc/Man}$), 60.5 (C-$6_{Glc/Man}$) ppm.

**Assignment is ambiguous due to signal overlap (C-2_{Gal}, C-2_{Man}, C-3_{Gal}, C-3_{Man}, C-3_{Glc}, C-4_{Man}, C-5_{Gal}, C-5_{Man}, C-5_{Glc})

ESI-HRMS: *m/z* = 547.20913 $[M+NH_4]^+$ (calculated *m/z* = 547.20934).

2.20. 2,3-Di-*O*-acetyl-β-D-glucopyranosyl azide (22)[6]



2 **22**

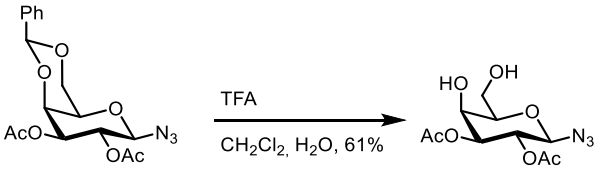
The benzylidene-protected glucosyl azide **2**[3] (141 mg, 374 µmol, 1 equiv) was dissolved in a pre-chilled mixture of dichloromethane/water/trifluoroacetic acid (10:0.5:1 v/v, 1.15 mL) at 0°C and stirred at 0°C for 3 h, then stirred at room temperature for 1 h. Pyridine (300 µL, 3.72 mmol, 10 equiv) was added and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 4:6) to yield the product **22** as a colorless foam (76 mg, 249 µmol, 67%).

R_F (cyclohexane:ethyl acetate, 4:6) = 0.39.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.05 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.5 Hz, 1H, H-3), 4.88 (dd, $^3J_{2,3}$ = 9.6 Hz, $^3J_{1,2}$ = 8.8 Hz, 1H, H-2), 4.67 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1), 3.98 (dd, ^2J = 12.2 Hz, $^3J_{5,6a}$ = 3.3 Hz, 1H, H-6a), 3.88 (dd, ^2J = 12.1 Hz, $^3J_{5,6b}$ = 4.5 Hz, 1H, H-6b), 3.80 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.5 Hz, 1H, H-4), 3.54 (ddd, $^3J_{4,5}$ = 9.7 Hz, $^3J_{5,6b}$ = 4.5 Hz, $^3J_{5,6a}$ = 3.3 Hz, 1H, H-5), 2.11 (s, 3H, OAc), 2.09 (s, 3H, OAc) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 171.7 (C(O)CH_3), 169.6 (C(O)CH_3), 88.1 (C-1), 78.0 (C-5), 75.9 (C-3), 70.8 (C-2), 69.2 (C-4), 62.0 (C-6), 21.0 (CH_3), 20.8 (CH_3) ppm.

2.21. 2,3-Di-*O*-acetyl-β-D-galactopyranosyl azide (23)



12 **23**

The benzylidene-protected galactosyl azide **12**[5] (515 mg, 1.36 mmol, 1 equiv) was dissolved in a pre-chilled mixture of dichloromethane/water/trifluoroacetic acid (10:0.5:1 v/v, 3.75 mL) at 0°C and stirred at 0°C for 3 h, then stirred at room temperature for 1 h. Pyridine (300 µL, 3.72 mmol, 2.7 equiv) was added and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 4:6) to yield the product **23** as a viscous oil (239 mg, 826 µmol, 61%).

R_F (cyclohexane:ethyl acetate, 4:6) = 0.30.

$[\alpha]_D^{20}$ = -8.9 (*c* = 0.66 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 3448 (m), 3298 (m), 2947 (w), 2106 (s), 1741 (s), 1714 (s), 1371 (m), 1256 (s), 1235 (s), 1217 (s), 1052 (s), 1027 (s), 950 (s) cm^{-1}.

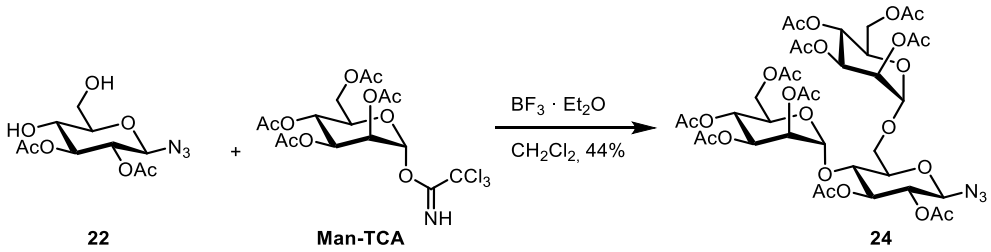
^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.28 (dd, $^3J_{2,3}$ = 10.2 Hz, $^3J_{1,2}$ = 8.8 Hz, 1H, H-2), 4.98 (dd, $^3J_{2,3}$ = 10.1 Hz, $^3J_{3,4}$ = 3.1 Hz, 1H, H-3), 4.61 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1), 4.24 – 4.19 (m, 1H, H-4),

4.01 (dd, ^{2}J = 12.0 Hz, $^{3}J_{5,6a}$ = 5.4 Hz, 1H, H-6a), 3.97 – 3.90 (m, 1H, H-6b), 3.71 (ddd, $^{3}J_{5,6a}$ = 5.4 Hz, $^{3}J_{5,6b}$ = 4.3 Hz, $^{3}J_{4,5}$ = 1.1, 1H, H-5), 2.11 (s, 3H, OAc), 2.09 (s, 3H, OAc) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.2 (C(O)CH_3), 169.7 (C(O)CH_3), 88.6 (C-1), 76.1 (C-5), 73.2 (C-3), 68.6 (C-2/C-4), 68.6 (C-2/C-4), 62.9 (C-6), 21.0 (CH_3), 20.8 (CH_3) ppm.

ESI-HRMS: *m/z* = 307.12461 $[M+NH_4]^+$ (calculated *m/z* = 307.12483).

2.22. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→4)-[2,3,4,6-tetra-O-acetyl-α-D-mannopyranosyl-(1→6)]-2,3-di-*O*-acetyl-β-D-glucopyranosyl azide (24)



The acceptor glucosyl azide **22**[6] (72 mg, 249 µmol, 1 equiv) and the mannosyl donor Man-TCA (338 mg, 686 µmol, 2.8 equiv) were dissolved in dry dichloromethane (12 mL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~330 mg) was added and the reaction mixture stirred at room temperature for 15 min. At 0 °C boron trifluoride diethyl etherate (30 µl, 237 µmol, 0.95 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 16 h. The reaction mixture was diluted with dichloromethane (150 mL) and satd. aq. $NaHCO_3$ solution (5 mL) and strongly stirred for 10 min. After filtration over celite® the phases were separated and the organic phase was washed with satd. aq. $NaHCO_3$ solution (20 mL), water (2 x 25 mL) and brine (20 mL). It was dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude product was purified on silica gel via automated flash chromatography twice (first cyclohexane:ethyl acetate, 6:4→1:1, then toluene:ethyl acetate 1:1) to yield the product **24** as a colorless foam (105 mg, 111 µmol, 44%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:1) = 0.30.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = +10.0 (*c* = 0.47 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 2921 (m), 2851 (w), 2119 (m), 1743 (s), 1434 (w), 1369 (m), 1218 (s), 1138 (m), 1081 (m), 1040 (s), 981 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.36 – 5.19 (m, 6H, H-$2_{Man'}$, H-3_{Glc}, H-3_{Man}, H-$3_{Man'}$, H-4_{Man}, H-$4_{Man'}$), 5.08 – 5.03 (m, 1H, H-2_{Man}), 4.99 (d, $^{3}J_{1,2}$ = 2.2 Hz, 1H, H-1_{Man}), 4.97 (d, $^{3}J_{1,2}$ = 1.6 Hz, 1H, H-$1_{Man'}$), 4.80 (dd, $^{3}J_{2,3}$ = 9.5 Hz, $^{3}J_{1,2}$ = 8.9 Hz, 1H, H-2_{Glc}), 4.71 (d, $^{3}J_{1,2}$ = 8.8 Hz, 1H, H-1_{Glc}), 4.35 – 4.24 (m, 2H, H-$6a_{Man}$, H-$6a_{Man'}$), 4.17 – 4.06 (m, 3H, H-$5_{Man/Man'}$, H-$6b_{Man}$, H-$6b_{Man'}$), 4.02 (ddd, $^{3}J_{4,5}$ = 8.9 Hz, $^{3}J_{5,6a}$ = 5.6 Hz, $^{3}J_{5,6b}$ = 2.9 Hz, 1H, H-$5_{Man/Man'}$), 3.98 – 3.89 (m, 2H, H-$6a_{Glc}$, H-$6b_{Glc}$), 3.80 – 3.70 (m, 2H, H-4_{Glc}, H-5_{Glc}), 2.16 (s, 3H, OAc), 2.14 (s, 3H, OAc), 2.11 (s, 3H, OAc), 2.09 (s, 6H, 2 OAc), 2.07 (s, 3H, OAc), 2.06 (s, 3H, OAc), 2.03 (s, 3H, OAc), 2.00 (s, 3H, OAc), 1.99 (s, 3H, OAc) ppm.

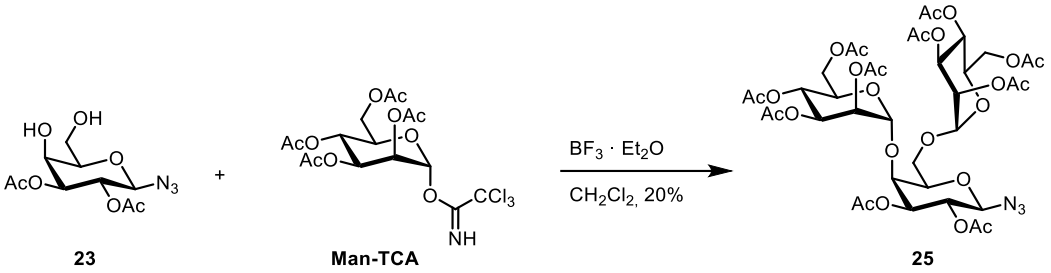
^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.7 (C(O)CH_3), 170.6 (C(O)CH_3), 170.3 (C(O)CH_3), 170.1 (C(O)CH_3), 170.0 (C(O)CH_3), 169.9 (C(O)CH_3), 169.9 (C(O)CH_3), 169.9 (C(O)CH_3), 169.7

(<u>C</u>(O)CH_3), 169.6 (<u>C</u>(O)CH_3), 99.5 (C-1_{Man}), 97.8 (C-$1_{Man'}$), 87.6 (C-1_{Glc}), 76.8 (C-4_{Glc}/C-5_{Glc}), 76.3 (C-4_{Glc}/C-5_{Glc}), 74.1*, 71.3 (C-2_{Glc}), 70.0 (C-$5_{Man/Man'}$), 69.6 (C-2_{Man}), 69.3*, 69.1*, 69.0 (C-$5_{Man/Man'}$), 68.5*, 66.4 (C-6_{Glc}), 66.3*, 66.1*, 62.8 (C-$6_{Man/Man'}$), 62.4 (C-$6_{Man/Man'}$), 21.0 (CH_3), 20.9 (2 CH_3), 20.9 (CH_3), 20.8 (2 CH_3), 20.8 (2 CH_3), 20.7 (CH_3), 20.7 (CH_3) ppm.

*Assignment is ambiguous due to signal overlap (C-$2_{Man'}$, C-3_{Glc}, C-3_{Man}, C-$3_{Man'}$, C-4_{Man}, C-$4_{Man'}$)

ESI-HRMS: *m/z* = 967.31435 $[M+NH_4]^+$ (calculated *m/z* = 967.31499).

2.23. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→4)-[2,3,4,6-tetra-*O*-acetyl-α-D-mannopyranosyl-(1→6)]-2,3-di-*O*-acetyl-β-D-galactopyranosyl azide (25)



23 **Man-TCA** **25**

The acceptor galactosyl azide **23** (108 mg, 373 µmol, 1 equiv) and the mannosyl donor Man-TCA (630 mg, 1.28 µmol, 3.4 equiv) were dissolved in dry dichloromethane (12 mL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~800 mg) was added and the reaction mixture stirred at room temperature for 15 min. At 0 °C boron trifluoride diethyl etherate (50 µl, 395 µmol, 1.1 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 16 h. The reaction mixture was diluted with dichloromethane (150 mL) and satd. aq. $NaHCO_3$ solution (5 mL) and strongly stirred for 10 min. After filtration over celite® the phases were separated and the organic phase was washed with satd. aq. $NaHCO_3$ solution (20 mL), water (2 x 25 mL) and brine (20 mL). It was dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude product was purified on silica gel via automated flash chromatography twice (first cyclohexane:ethyl acetate, 6:4→1:1, then toluene:ethyl acetate 4:6) to yield the product **25** as a colorless foam (71 mg, 74.8 µmol, 20%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:1) = 0.29.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = +32.7 (*c* = 1.00 in CH_2Cl_2).

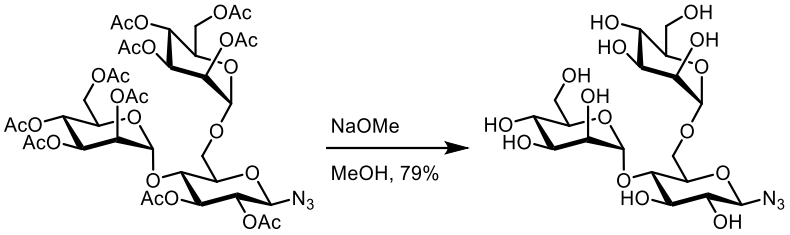
IR (ATR): $\tilde{\nu}$ = 2940 (w), 2119 (m), 1743 (s), 1369 (m), 1218 (s), 1138 (m), 1084 (m), 1041 (s), 981 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 5.41 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 10.1 Hz, 1H, H-$4_{Man/Man'}$), 5.35 – 5.23 (m, 3H, H-3_{Man}, H-$3_{Man'}$, H-$4_{Man/Man'}$), 5.19 – 5.11 (m, 3H, H-2_{Gal}, H-2_{Man}, H-$2_{Man'}$), 5.00 (dd, $^3J_{2,3}$ = 10.6 Hz, $^3J_{3,4}$ = 2.9 Hz, 1H, H-3_{Gal}), 4.96 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-$1_{Man'}$), 4.79 (d, $^3J_{1,2}$ = 2.0 Hz, 1H, H-1_{Man}), 4.69 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1_{Gal}), 4.35 – 4.28 (m, 2H, H-6a_{Man}, H-6$a_{Man'}$), 4.22 (dt, $^3J_{4,5}$ = 9.9 Hz, $^3J_{5,6a}$ = $^3J_{5,6b}$ = 2.9 Hz, 1H, H-$5_{Man/Man'}$), 4.21 – 4.11 (m, 3H, H-4_{Gal}, H-6b_{Man}, H-6$b_{Man'}$), 4.02 – 3.95 (m, 2H, H-$5_{Man/Man'}$, H-6a_{Gal}), 3.90 (dd, $^3J_{5,6b}$ = 7.4 Hz, $^3J_{5,6a}$ = 6.1 Hz, 1H, H-5_{Gal}), 3.71 (dd, ^2J = 9.4 Hz, $^3J_{5,6b}$ = 7.6 Hz, 1H, H-6b_{Gal}), 2.14 (s, 3H, OAc), 2.12 (s, 3H, OAc), 2.11 (s, 3H, OAc), 2.10 (s, 3H, OAc), 2.10 (s, 3H, OAc), 2.09 (s, 3H, OAc), 2.08 (s, 3H, OAc), 2.04 (s, 3H, OAc), 2.00 (s, 3H, OAc), 1.98 (s, 3H, OAc) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 170.8 (C(O)CH_3), 170.8 (C(O)CH_3), 170.5 (C(O)CH_3), 170.2 (C(O)CH_3), 170.0 (C(O)CH_3), 169.9 (C(O)CH_3), 169.9 (C(O)CH_3), 169.9 (C(O)CH_3), 169.8 (C(O)CH_3), 169.4 (C(O)CH_3), 100.1 (C-1_{Man}), 97.6 (C-$1_{Man'}$), 88.3 (C-1_{Gal}), 76.7 (C-4_{Gal}), 74.5 (C-5_{Gal}), 72.0 (C-3_{Gal}), 69.8 (C-$5_{Man/Man'}$), 69.5 (C-$2_{Man/Man'}$), 69.1 (C-$2_{Man/Man'}$), 69.1 (C-$3_{Man/Man'}$), 68.9 (C-$3_{Man/Man'}$), 68.8 (C-$5_{Man/Man'}$), 68.5 (C-2_{Gal}), 66.2 (C-$4_{Man/Man'}$), 65.5 (C-$4_{Man/Man'}$), 64.5 (C-6_{Gal}), 62.5 (C-$6_{Man/Man'}$), 62.0 (C-$6_{Man/Man'}$), 21.0 (CH_3), 21.0 (CH_3), 20.9 (CH_3), 20.9 (2 CH_3), 20.8 (CH_3), 20.8 (CH_3), 20.8 (CH_3), 20.8 (2 CH_3) ppm.

ESI-HRMS: *m/z* = 967.31413 $[M+NH_4]^+$ (calculated *m/z* = 967.31499).

2.24. α-D-Mannopyranosyl-(1→4)-[α-D-mannopyranosyl-(1→6)]-β-D-glucopyranosyl azide (26)



24 **26**

The protected trisaccharide **24** (36 mg, 37.9 µmol, 1 equiv) was suspended in methanol (3 mL) and a solution of sodium methoxide in methanol (15 µL, 75.0 µmol, 5 M, 2 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 18 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 15 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **26** as a lyophilizate (15.9 mg, 30.0 µmol, 79%).

$[\alpha]_D^{20}$ = +61.7 (*c* = 0.08 in CH_3OH).

IR (ATR): $\tilde{\nu}$ = 3359 (br, m), 2924 (m), 2853 (m), 2122 (m), 1658 (m), 1632 (m), 1468 (w), 1411 (w), 1134 (m), 1052 (s), 972 (m), 811 (m) cm^{-1}.

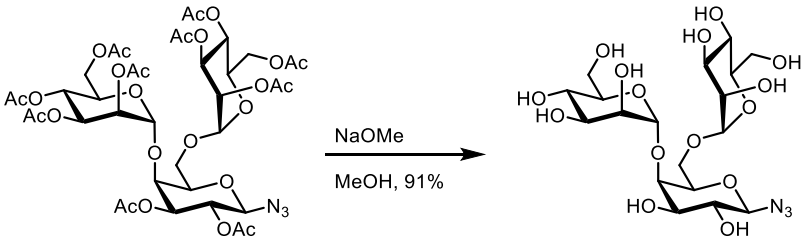
^{1}H NMR (600 MHz, D_2O, 298 K) δ = 5.26 (d, $^3J_{1,2}$ = 1.9 Hz, 1H, H-1_{Man}), 4.94 (d, $^3J_{1,2}$ = 1.8 Hz, 1H, H-$1_{Man'}$), 4.74 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1_{Glc}), 4.07 – 4.03 (m, 1H, H-2_{Man}), 4.02 – 3.98 (m, 1H, H-$2_{Man'}$), 3.97 – 3.86 (m, 4H, H-$6a_{Glc}$, H-$6b_{Glc}$, H-$6a_{Man}$, H-$6a_{Man'}$), 3.85 – 3.74 (m, 5H, H-3_{Man}, H-$3_{Man'}$, H-5_{Glc}, H-$6b_{Man}$, H-$6b_{Man'}$), 3.74 – 3.62 (m, 6H, H-3_{Glc}, H-4_{Glc}, H-4_{Man}, H-$4_{Man'}$, H-5_{Man}, H-$5_{Man'}$), 3.32 – 3.26 (m, 1H, H-2_{Glc}) ppm.

^{13}C NMR (151 MHz, D_2O, 298 K) δ = 101.1 (C-1_{Man}), 100.1 (C-$1_{Man'}$), 89.8 (C-1_{Glc}), 76.3 (C-4_{Glc}), 75.8*, 75.2*, 73.7*, 72.8*, 72.8 (C-2_{Glc}), 70.5*, 70.2*, 70.2 (C-2_{Man}), 69.9 (C-$2_{Man'}$), 66.6*, 66.5*, 66.2 (C-6_{Glc}), 60.9 (C-$6_{Man/Man'}$), 60.8 (C-$6_{Man/Man'}$) ppm.

*Assignment is ambiguous due to signal overlap (C-3_{Glc}, C-3_{Man}, C-$3_{Man'}$, C-4_{Man}, C-$4_{Man'}$, C-5_{Glc}, C-5_{Man}, C-$5_{Man'}$).

ESI-HRMS: *m/z* = 547.17185 $[M+NH_4]^+$ (calculated *m/z* = 547.20934).

2.25. α-D-Mannopyranosyl-(1→4)-[α-D-mannopyranosyl-(1→6)]-β-D-galactopyranosyl azide (27)



25 27

The protected trisaccharide **25** (51 mg, 53.7 µmol, 1 equiv) was suspended in methanol (3 mL) and a solution of sodium methoxide in methanol (15 µL, 75.0 µmol, 5 M, 1.4 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 18 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 15 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **27** as a lyophilizate (26 mg, 49.1 µmol, 91%).

$[\alpha]_D^{20}$ = +46.6 (*c* = 0.25 in CH_3OH).

IR (ATR): $\tilde{\nu}$ = 3351 (br, m), 2929 (w), 2120 (m), 1248 (m), 1131 (m), 1092 (s), 1047 (s), 1023 (s), 810 (m) cm^{-1}.

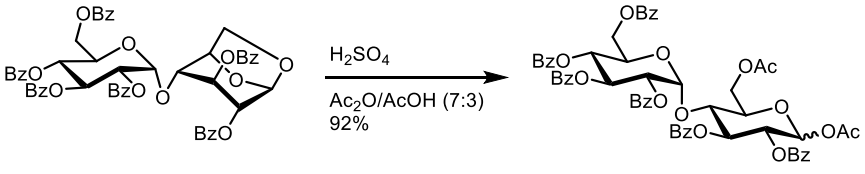
^{1}H NMR (500 MHz, D_2O, 298 K) δ = 4.89 (d, $^3J_{1,2}$ = 1.8 Hz, 1H, H-$1_{Man'}$), 4.85 (d, $^3J_{1,2}$ = 1.9, 1H, H-1_{Man}), 4.76 (d, $^3J_{1,2}$ = 8.6 Hz, 1H, H-1_{Gal}), 4.10 (d, $^3J_{3,4}$ = 3.2 Hz, 1H, H-4_{Gal}), 4.07 – 3.98 (m, 3H, H-2_{Man}, H-5_{Man}, H-$5_{Man'}$), 3.96 (dd, $^3J_{2,3}$ = 3.5 Hz, $^3J_{1,2}$ = 1.7 Hz, 1H, H-$2_{Man'}$), 3.93 – 3.86 (m, 2H, H-$6a_{Gal}$, H-$6a_{Man/Man'}$), 3.86 – 3.61 (m, 10H, H-3_{Gal}, H-3_{Man}, H-$3_{Man'}$, H-4_{Man}, H-$4_{Man'}$, H-5_{Gal}, H-$6a_{Man/Man'}$, H-$6b_{Man}$, H-$6b_{Man'}$, H-$6b_{Gal}$), 3.48 (dd, $^3J_{2,3}$ = 10.2 Hz, $^3J_{1,2}$ = 8.6 Hz, 1H, H-2_{Gal}) ppm.

^{13}C NMR (126 MHz, D_2O, 298 K) δ = 104.5 (C-1_{Man}), 102.6 (C-$1_{Man'}$), 93.6 (C-1_{Gal}), 80.1 (C-4_{Gal}), 77.5 (C-$5_{Man/Man'}$), 75.9 (C-$5_{Man/Man'}$), 75.8 (C-5_{Gal}), 74.8*, 73.2*, 73.2*, 73.1 (C-2_{Gal}), 72.9 (C-2_{Man}), 72.7 (C-$2_{Man'}$), 69.5*, 69.2*, 68.2 (C-6_{Gal}), 63.7 (C-$6_{Man/Man'}$), 63.4 (C-$6_{Man/Man'}$) ppm.

*Assignment is ambiguous due to signal overlap (C-3_{Gal}, C-3_{Man}, C-$3_{Man'}$, C-4_{Man}, C-$4_{Man'}$)

ESI-HRMS: *m/z* = 547.20912 $[M+NH_4]^+$ (calculated *m/z* = 547.20934).

2.26. 2,3,4,6-Tetra-*O*-benzoyl-α-D-glucopyranosyl-(1→4)-1,6-di-*O*-acetyl-2,3-di-*O*-benzoyl-α,β-D-glucopyranose (28)



S9 28

The benzoyl-protected disaccharide **S9** (960 mg, 1.01 mmol, 1 equiv) was dissolved in a mixture of acetic anhydride (9.9 mL) and acetic acid (4.2 mL). While stirring at room temperature,

concentrated sulfuric acid (175 µL, 3.31 mmol, 3.3 equiv) was added and stirred for 1 h. Ethyl acetate (50 mL) was added and the reaction mixture was poured into a satd. aq. $NaHCO_3$ solution (100 mL) at 0 °C. The mixture was vigorously stirred for 2h, then the phases were separated. The organic phase was washed with water (50 mL) and brine (20 mL), dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The residue was codestilled with toluene (4 x 25 mL) to yield the product **28** as a colorless foam (980 mg, 932 µmol, 92%).

Ratio α:β (83:17) deduced from ^{1}H NMR signals of H-$1_{Glc\text{-}\alpha}$ and H-$2_{Glc\text{-}\beta}$.

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 4:1) = 0.18.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = +85.1 (*c* = 1.00 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 2959 (w), 1725 (s), 1602 (m), 1584 (w), 1451 (m), 1371 (w), 1262 (s), 1177 (m), 1092 (s), 1068 (s), 1025 (s) cm^{-1}.

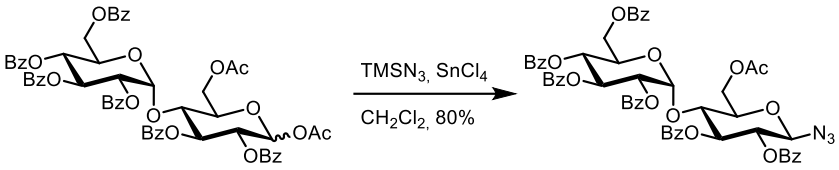
α-Anomer:
^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 8.10 – 7.18 (m, 30H, OBz), 6.49 (d, $^3J_{1,2}$ = 3.6 Hz, 1H, H-1_{Glc}), 6.08 (dd, $^3J_{2,3}$ = 10.6 Hz, $^3J_{3,4}$ = 9.6 Hz, 1H, H-$3_{Glc'}$), 6.02 (dd, $^3J_{2,3}$ = 10.2 Hz, $^3J_{3,4}$ = 8.9 Hz, 1H, H-3_{Glc}), 5.75 (d, $^3J_{1,2}$ = 3.9 Hz, 1H, H-$1_{Glc'}$), 5.72 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.8 Hz, 1H, H-$4_{Glc'}$), 5.27 (dd, $^3J_{2,3}$ = 10.6 Hz, $^3J_{1,2}$ = 3.9 Hz, 1H, H-$2_{Glc'}$), 5.23 (dd, $^3J_{2,3}$ = 10.2 Hz, $^3J_{1,2}$ = 3.6 Hz, 1H, H-2_{Glc}), 4.71 – 4.62 (m, 2H, H-$6a_{Glc}$, H-$6a_{Glc'}$), 4.48 – 4.37 (m, 4H, H-4_{Glc}, H-$5_{Glc'}$, H-$6b_{Glc}$, H-$6b_{Glc'}$), 4.35 (ddd, $^3J_{4,5}$ = 9.9 Hz, $^3J_{5,6a}$ = 3.9 Hz, $^3J_{5,6b}$ = 2.5 Hz, 1H, H-5_{Glc}), 2.21 (s, 3H, OAc), 2.20 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.8 ($\underline{C}(O)CH_3$), 169.0 ($\underline{C}(O)CH_3$), 166.2 (Ph$\underline{C}$O), 165.9 (Ph$\underline{C}$O), 165.6 (Ph$\underline{C}$O), 165.6 (Ph$\underline{C}$O), 165.2 (Ph$\underline{C}$O), 165.1 (Ph$\underline{C}$O), 133.6 (OBz_{para}), 133.5 (OBz_{para}), 133.4 (2 OBz_{para}), 133.4 (OBz_{para}), 133.3 (OBz_{para}), 130.1 (OBz), 130.0 (OBz), 130.0 (OBz), 129.9 (OBz), 129.7 (OBz), 129.7 (OBz), 128.9 (OBz), 128.6 (OBz), 128.6 (OBz), 128.5 (OBz), 128.5 (OBz), 128.4 (OBz), 128.3 (OBz), 128.2 (OBz), 97.2 (C-$1_{Glc'}$), 89.1 (C-1_{Glc}), 73.5 (C-4_{Glc}), 72.1 (C-3_{Glc}), 71.1 (C-$2_{Glc'}$), 70.9 (C-2_{Glc}), 70.7 (C-5_{Glc}), 69.9 (C-$3_{Glc'}$), 69.4 (C-$5_{Glc'}$), 69.2 (C-$4_{Glc'}$), 62.8 (C-$6_{Glc/Glc'}$), 62.4 (C-$6_{Glc/Glc'}$), 21.1 (CH_3), 21.0 (CH_3) ppm.

β-Anomer:
^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 8.10 – 7.18 (m, 30H, OBz), 6.07 – 5.98 (m, 2H, H-1_{Glc}, H-$3_{Glc'}$), 5.78 – 5.66 (m, 3H, H-$1_{Glc'}$, H-3_{Glc}, H-$4_{Glc'}$), 5.38 (dd, $^3J_{2,3}$ = 9.4 Hz, $^3J_{1,2}$ = 7.9 Hz, 1H, H-2_{Glc}), 5.30 – 5.20 (m, 1H, H-$2_{Glc'}$), 4.71 – 4.62 (m, 2H, H-$6a_{Glc}$, H-$6a_{Glc'}$), 4.48 – 4.38 (m, 4H, H-4_{Glc}, H-$5_{Glc'}$, H-$6b_{Glc}$, H-$6b_{Glc'}$), 4.14 – 4.09 (m, 1H, H-5_{Glc}), 2.19 (s, 3H, OAc), 2.04 (s, 3H, OAc) ppm.

ESI-HRMS: *m/z* = 1068.32808 $[M+NH_4]^+$ (calculated *m/z* = 1068.32845).

2.27. 2,3,4,6-Tetra-*O*-benzoyl-α-D-glucopyranosyl-(1→4)-6-*O*-acetyl-2,3-di-*O*-benzoyl-β-D-glucopyranosyl azide (29)



28 29

The protected maltose **28** (3.54 g, 3.37 mmol, 1 equiv) was dissolved in dry dichloromethane (34 mL) under a nitrogen atmosphere. At room temperature trimethylsilyl azide (1.75 mL, 13.3 mmol, 3.6 equiv) and a solution of tin(IV) chloride in dichloromethane (1.45 mL, 1 M, 1.45 mmol, 0.43 equiv) were added and stirred for 22 h. The reaction mixture was diluted with dichloromethane (50 mL) and satd. aq. $NaHCO_3$ solution (25 mL) and strongly stirred for 15 min. The separated org. phase was washed with satd. aq. $NaHCO_3$ solution (2 x 100 mL), water (100 mL) and brine (100 mL). The organic phase was dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude product was purified on silica gel (cyclohexane:ethyl acetate, 3:1) to yield the product **29** as colorless foam (2.79 g, 2.70 mmol, 80%).

R_F (cyclohexane:ethyl acetate, 3:1) = 0.22

$[\alpha]_D^{20}$ = +35.2 (*c* = 0.72 in CH_2Cl_2).

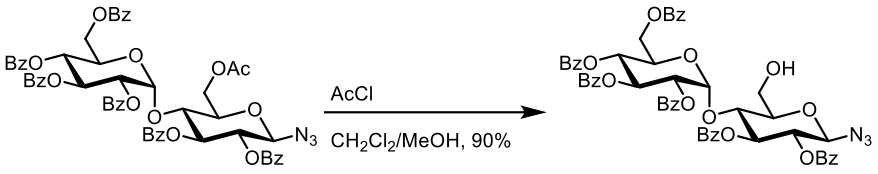
IR (ATR): $\tilde{\nu}$ = 2955 (w), 2119 (m), 1723 (s), 1603 (w), 1452 (m), 1248 (s), 1091 (s), 1068 (s), 1025 (s), 704 (s) cm^{-1}.

^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 8.11 – 7.16 (m, 30H, 6 OBz), 6.05 (dd, $^3J_{2,3}$ = 10.5 Hz, $^3J_{3,4}$ = 9.6 Hz, 1H, H-$3_{Glc'}$), 5.77 – 5.65 (m, 3H, H-$1_{Glc'}$, H-3_{Glc}, H-$4_{Glc'}$), 5.25 (dd, $^3J_{2,3}$ = 10.5 Hz, $^3J_{1,2}$ = 4.0 Hz, 1H, H-$2_{Glc'}$), 5.22 (dd, $^3J_{2,3}$ = 9.5 Hz, $^3J_{1,2}$ = 8.5 Hz, 1H, H-2_{Glc}), 4.86 (d, $^3J_{1,2}$ = 8.5 Hz, 1H, H-1_{Glc}), 4.76 (dd, ^2J = 12.2 Hz, $^3J_{5,6a}$ = 2.6 Hz, 1H, H-$6a_{Glc}$), 4.69 – 4.61 (m, 1H, H-$6a_{Glc'}$), 4.48 – 4.41 (m, 3H, H-$5_{Glc'}$, H-$6b_{Glc}$, H-$6b_{Glc'}$), 4.39 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.2 Hz, 1H, H-4_{Glc}), 4.05 (ddd, $^3J_{4,5}$ = 9.6 Hz, $^3J_{5,6b}$ = 4.5 Hz, $^3J_{5,6a}$ = 2.6 Hz, 1H, H-5_{Glc}), 2.20 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.7 (C(O)CH_3), 166.2 (PhCO), 165.8 (PhCO), 165.6 (PhCO), 165.2 (PhCO), 165.2 (PhCO), 165.0 (PhCO), 133.6 (OBz_{para}), 133.5 (OBz_{para}), 133.5 (OBz_{para}), 133.4 (OBz_{para}), 133.4 (OBz_{para}), 133.3 (OBz_{para}), 130.1 (OBz), 130.0 (OBz), 130.0 (OBz), 129.9 (OBz), 129.8 (OBz), 129.7 (OBz), 129.6 (OBz), 129.7 (OBz), 129.6 (OBz), 129.0 (OBz), 128.8 (OBz), 128.7 (OBz), 128.7 (OBz), 128.6 (OBz), 128.6 (OBz), 128.5 (OBz), 128.5 (OBz), 128.4 (OBz), 128.3 (OBz), 128.2 (OBz), 96.7 (C-$1_{Glc'}$), 87.9 (C-1_{Glc}), 74.9 (C-5_{Glc}), 74.8 (C-3_{Glc}), 73.1 (C-4_{Glc}), 71.7 (C-2_{Glc}), 71.0 (C-$2_{Glc'}$), 70.0 (C-$3_{Glc'}$), 69.4 (C-$5_{Glc'}$), 69.2 (C-$4_{Glc'}$), 62.8 (C-6_{Glc}), 62.5 (C-$6_{Glc'}$), 21.0 (CH_3) ppm.

ESI-HRMS: *m/z* = 1051.32361 $[M+NH_4]^+$ (calculated *m/z* = 1051.32437).

2.28. 2,3,4,6-Tetra-*O*-benzoyl-α-D-glucopyranosyl-(1→4)-2,3-di-*O*-benzoyl-β-D-glucopyranosyl azide (30)



29 **30**

The maltosyl azide **29** (2.72 g, 2.63 mmol, 1 equiv) was dissolved in a mixture of dichloromethane/methanol (1:1 v/v, 50 mL) and cooled to 0 °C. Acetyl chloride (1.7 mL, 23.8 mmol, 9 equiv) was added dropwise over a period of 5 min and stirred for 2 h at 0 °C, followed by stirring at room temperature for 16 h. Triethylamine (5 mL) was added and the solvent removed under reduced pressure. The crude was suspended in ethyl acetate (50 mL), filtrated and the filtrate evaporated to dryness under reduced pressure. The filtrate was purified on silica gel (cyclohexane:ethyl acetate, 3:1) to yield the product **30** as colorless amorphous solid (2.33 g, 2.35 mmol, 90%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 3:1) = 0.18.

$[\boldsymbol{\alpha}]_{\mathbf{D}}^{\mathbf{20}}$ = +24.4 (*c* = 1.00 in CH_2Cl_2).

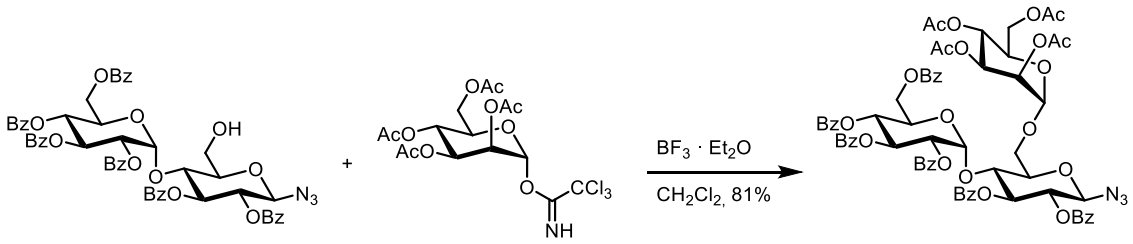
IR (ATR): $\tilde{\nu}$ = 3512 (w), 2928 (w), 2118 (m), 1723 (s), 1602 (m), 1451 (m), 1263 (s), 1090 (s), 1067 (s), 1025 (s), 704 (s) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 8.10 – 7.17 (m, 30H, 6 OBz), 6.04 (dd, $^3J_{2,3}$ = 10.4 Hz, $^3J_{3,4}$ = 9.6 Hz, 1H, H-$3_{Glc'}$), 5.79 – 5.71 (m, 2H, H-$1_{Glc'}$, H-3_{Glc}), 5.66 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.8 Hz, 1H, H-$4_{Glc'}$), 5.26 – 5.19 (m, 2H, H-2_{Glc}, H-$2_{Glc'}$), 4.87 (d, $^3J_{1,2}$ = 8.6 Hz, 1H, H-1_{Glc}), 4.70 – 4.63 (m, 1H, H-$6a_{Glc'}$), 4.58 – 4.46 (m, 3H, H-4_{Glc}, H-$5_{Glc'}$, H-$6b_{Glc'}$), 4.21 – 4.06 (m, 2H, H-$6a_{Glc}$, H-$6b_{Glc}$), 3.87 (dt, $^3J_{4,5}$ = 9.6 Hz, $^3J_{5,6a}$ = $^3J_{5,6b}$ = 2.8 Hz, 1H, H-5_{Glc}), 2.25 (dd, $^3J_{OH,6a}$ = 8.3 Hz, $^3J_{OH,6b}$ = 5.1 Hz, 1H, OH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 166.5 (Ph<u>C</u>O), 165.9 (Ph<u>C</u>O), 165.5 (Ph<u>C</u>O), 165.3 (Ph<u>C</u>O), 165.2 (Ph<u>C</u>O), 165.2 (Ph<u>C</u>O), 133.6 (OBz_{para}), 133.5 (OBz_{para}), 133.5 (OBz_{para}), 133.4 (OBz_{para}), 133.4 (OBz_{para}), 133.3 (OBz_{para}), 130.1 (OBz), 130.0 (OBz), 130.0 (OBz), 129.9 (OBz), 129.8 (OBz), 129.7 (OBz), 129.0 (OBz), 128.9 (OBz), 128.7 (OBz), 128.7 (OBz), 128.6 (OBz), 128.5 (OBz), 128.5 (OBz), 128.4 (OBz), 128.4 (OBz), 128.4 (OBz), 128.3 (OBz), 96.3 (C-$1_{Glc'}$), 88.3 (C-1_{Glc}), 77.3 (C-5_{Glc}), 75.0 (C-3_{Glc}), 71.8 (C-$2_{Glc/Glc'}$), 71.0 (C-$2_{Glc/Glc'}$), 70.9 (C-4_{Glc}), 70.1 (C-$3_{Glc'}$), 69.5 (C-$4_{Glc'}$), 69.0 (C-$5_{Glc'}$), 63.1 (C-$6_{Glc'}$), 61.5 (C-6_{Glc}) ppm.

ESI-HRMS: *m/z* = 1009.31262 $[M+NH_4]^+$ (calculated *m/z* = 1009.31381).

2.29. 2,3,4,6-Tetra-*O*-benzoyl-α-D-glucoopyranosyl-(1→4)-[2,3,4,6-tetra-*O*-acetyl-α-D-mannopyranosyl-(1→6)]-2,3-di-*O*-benzoyl-β-D-glucopyranosyl azide (31)



The acceptor maltosyl azide **30** (497 mg, 501 µmol, 1 equiv) and the mannosyl donor Man-TCA (362 mg, 734 µmol, 1.5 equiv) were dissolved in dry dichloromethane (15 mL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~600 mg) was added and the reaction mixture stirred at room temperature for 15 min. At 0 °C boron trifluoride diethyl etherate (70 µL, 552 µmol, 1.1 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 16 h. The reaction mixture was diluted with dichloromethane (50 mL) and satd. aq. $NaHCO_3$ solution (10 mL) and strongly stirred for 30 min. After filtration over celite® the phases were separated and the organic phase was washed with water (75 mL) and brine (75 mL). The organic phase was dried over $MgSO_4$, it was filtrated and the solvent was removed under reduced pressure. The crude product was purified on silica gel (cyclohexane:ethyl acetate, 2:1) to yield the product **31** as a colorless foam (534 mg, 404 µmol, 81%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 2:1) = 0.28.

$[\alpha]_D^{20}$ = +18.8 (*c* = 0.16 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 2950 (w), 2119 (m), 1725 (s), 1452 (m), 1368 (m), 1247 (s), 1089 (s), 1067 (s), 1025 (s), 706 (s) cm^{-1}.

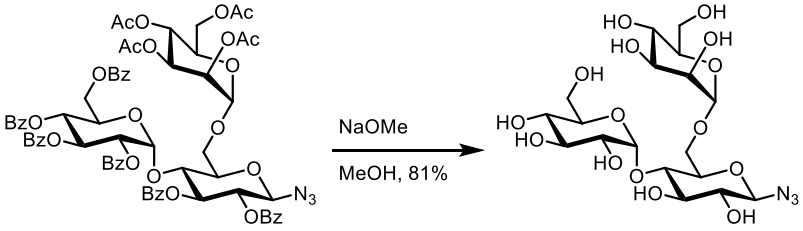
^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 8.06 – 7.13 (m, 30H, 6 OBz), 6.05 (dd, $^3J_{2,3}$ = 10.4 Hz, $^3J_{3,4}$ = 9.6 Hz, 1H, H-3$_{Glc'}$), 5.76 – 5.71 (m, 2H, H-1$_{Glc'}$, H-3$_{Glc}$), 5.63 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.8 Hz, 1H, H-4$_{Glc'}$), 5.43 – 5.37 (m, 2H, H-2$_{Man}$, H-3$_{Man}$), 5.32 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.9 Hz, 1H, H-4$_{Man}$), 5.26 (dd, $^3J_{2,3}$ = 10.4 Hz, $^3J_{1,2}$ = 4.0 Hz, 1H, H-2$_{Glc'}$), 5.21 (dd, $^3J_{2,3}$ = 9.4 Hz, $^3J_{1,2}$ = 8.5 Hz, 1H, H-2$_{Glc}$), 5.08 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-1$_{Man}$), 4.89 (d, $^3J_{1,2}$ = 8.5 Hz, 1H, H-1$_{Glc}$), 4.62 – 4.54 (m, 2H, H-6a$_{Glc'}$, H-6b$_{Glc'}$), 4.49 (dt, $^3J_{4,5}$ = 10.0 Hz, $^3J_{5,6a}$ = $^3J_{5,6b}$ = 4.0 Hz, 1H, H-5$_{Glc'}$), 4.35 – 4.31 (m, 1H, H-4$_{Glc}$), 4.29 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 4.7 Hz, 1H, H-6a$_{Man}$), 4.22 – 4.17 (m, 2H, H-5$_{Man}$, H-6a$_{Glc}$), 4.17 – 4.09 (m, 2H, H-6b$_{Glc}$, H-6b$_{Man}$), 4.04 (ddd, $^3J_{4,5}$ = 9.7 Hz, $^3J_{5,6a}$ = 5.6 Hz, $^3J_{5,6b}$ = 2.1 Hz, 1H, H-5$_{Glc}$), 2.15 (s, 3H, OAc), 2.11 (s, 3H, OAc), 1.99 (s, 3H, OAc), 1.94 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.8 (C(O)CH_3), 170.0 (2 C(O)CH_3), 170.0 (C(O)CH_3), 166.1 (PhCO), 165.8 (PhCO), 165.6 (PhCO), 165.3 (PhCO), 165.1 (PhCO), 165.1 (PhCO), 133.5 (OBz$_{para}$), 133.5 (OBz$_{para}$), 133.5 (OBz$_{para}$), 133.4 (OBz$_{para}$), 133.3 (OBz$_{para}$), 133.3 (OBz$_{para}$), 130.1 (OBz), 130.0 (OBz), 130.0 (OBz), 129.9 (OBz), 129.8 (OBz), 129.7 (OBz), 129.6 (OBz), 129.0 (OBz), 128.9 (OBz), 128.8 (OBz), 128.7 (OBz), 128.6 (OBz), 128.5 (OBz), 128.5 (OBz), 128.4 (OBz), 128.3 (OBz), 128.3 (OBz), 98.0 (C-1$_{Man}$), 96.5 (C-1$_{Glc'}$), 87.8 (C-1$_{Glc}$), 76.5 (C-5$_{Glc}$), 74.6 (C-3$_{Glc}$), 73.3 (C-4$_{Glc}$), 71.6 (C-2$_{Glc}$), 71.0 (C-2$_{Glc'}$), 69.9 (C-3$_{Glc'}$/C-4$_{Glc'}$), 69.9 (C-3$_{Glc'}$/C-4$_{Glc'}$), 69.3

(C-2_{Man}/C-3_{Man}), 69.3 (C-2_{Man}/C-3_{Man}), 69.1 (C-5_{Man}), 69.0 (C-$5_{Glc'}$), 66.4 (C-6_{Glc}), 66.0 (C-4_{Man}), 63.2 (C-$6_{Glc'}$), 62.5 (C-6_{Man}), 21.0 (CH_3), 20.9 (CH_3), 20.8 (CH_3), 20.7 (CH_3) ppm.

ESI-HRMS: *m/z* = 1339.40881 $[M+NH_4]^+$ (calculated *m/z* = 1339.40889).

2.30. α-D-glucopyranosyl-(1→4)-[α-D-mannopyranosyl-(1→6)]-β-D-glucopyranosyl azide (32)



31 **32**

The protected trisaccharide **31** (200 mg, 152 µmol, 1 equiv) was suspended in methanol (10 mL) and a solution of sodium methoxide in methanol (50 µL, 250 µmol, 5 M, 1.6 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 18 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 20 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **32** as a lyophilizate (64.8 mg, 122 µmol, 81%).

$[\alpha]_D^{20}$ = +73.1 (*c* = 0.74 in CH_3OH).

IR (ATR): $\tilde{\nu}$ = 3304 (br, m), 2929 (w), 2120 (m), 1361 (w), 1139 (m), 1019 (s) cm^{-1}.

^{1}H NMR (600 MHz, CD_3OD, 298 K) δ = 5.14 (d, $^3J_{1,2}$ = 3.8 Hz, 1H, H-$1_{Glc'}$), 4.85* (m, 1H, H-1_{Man}) 4.52 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1_{Glc}), 4.04 (dd, ^2J = 11.8 Hz, $^3J_{5,6a}$ = 4.5 Hz, 1H, H-$6a_{Glc}$), 3.89 – 3.79 (m, 4H, H-2_{Man}, H-$6b_{Glc}$, H-$6a_{Glc'}$, H-$6a_{Man}$), 3.74 – 3.51 (m, 10H, H-3_{Glc}, H-$3_{Glc'}$, H-3_{Man}, H-4_{Glc}, H-$4_{Glc'}$, H-4_{Man}, H-5_{Glc}, H-$5_{Glc'/Man}$, H-$6b_{Glc'}$, H-$6b_{Man}$), 3.44 (dd, $^3J_{2,3}$ = 9.7 Hz, $^3J_{1,2}$ = 3.7 Hz, 1H, H-$2_{Glc'}$), 3.27 (m, 1H, H-$5_{Glc'/Man}$), 3.17 (t, $^3J_{1,2}$ = $^3J_{2,3}$ = 8.9 Hz, 1H, H-2_{Glc}) ppm.

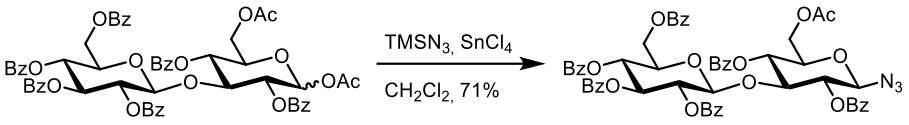
*Signal shift was determined by ^{1}H-^{13}C HSQC NMR due to signal overlap with HDO.

^{13}C NMR (151 MHz, CD_3OD, 298 K) δ = 102.9 (C-$1_{Glc'}$), 102.3 (C-1_{Man}), 91.8 (C-1_{Glc}), 81.1**, 77.6**, 77.4**, 75.1**, 74.9**, 74.6**, 74.4 (C-2_{Glc}), 74.3 (C-$2_{Glc'}$), 72.6**, 72.0 (C-2_{Man}), 71.4 (C-$5_{Glc'/Man}$), 68.7**, 67.6 (C-6_{Glc}), 63.1 (C-$6_{Glc'/Man}$), 62.6 (C-$6_{Glc'/Man}$) ppm.

** Assignment is ambiguous due to signal overlap (C-3_{Glc}, C-$3_{Glc'}$, C-3_{Man}, C-4_{Glc}, C-$4_{Glc'}$, C-4_{Man}, C-5_{Glc}, C-$5_{Glc'/Man}$).

ESI-HRMS: *m/z* = 547.20911 $[M+NH_4]^+$ (calculated *m/z* = 547.20934).

2.31. 2,3,4,6-Tetra-*O*-benzoyl-β-D-glucopyranosyl-(1→3)-6-*O*-acetyl-2,4-di-*O*-benzoyl-β-D-glucopyranosyl azide (34)



33 **34**

The protected disaccharide **33**[7] (868 mg, 826 µmol, 1 equiv) was dissolved in dry dichloromethane (20 mL) under a nitrogen atmosphere. At room temperature trimethylsilyl azide (440 µL, 3.35 mmol, 4 equiv) and a solution of tin(IV) chloride in dichloromethane (370 µL, 1 M, 370 µmol, 0.45 equiv) were added and stirred for 18 h. The reaction mixture was diluted with dichloromethane (50 mL) and washed with satd. aq. $NaHCO_3$ solution (3 x 50 mL), water (2 x 50 mL) and brine (50 mL). The organic phase was dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 80:20→70:30) to yield the product **34** as a colorless foam (605 mg, 585 µmol, 71%).

R_F (cyclohexane:ethyl acetate, 3:1) = 0.18.

$[\alpha]_D^{20}$ = -59.7 (*c* = 0.91 in CH_2Cl_2).

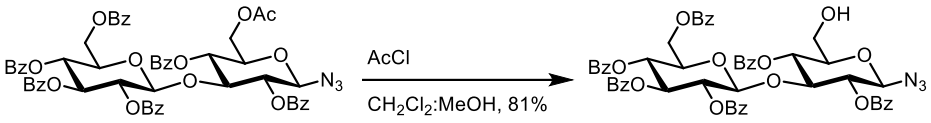
IR (ATR): $\tilde{\nu}$ = 2118 (m), 1732 (s), 1602 (m), 1451 (m), 1259 (s), 1089 (s), 1067 (s), 705 (s) cm^{-1}.

^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 8.13 – 7.15 (m, 30H, 6 OBz), 5.62 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.6 Hz, 1H, H-$3_{Glc'}$), 5.42 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.3 Hz, 1H, H-4_{Glc}), 5.38 (dd, $^3J_{2,3}$ = 9.8 Hz, $^3J_{1,2}$ = 7.8 Hz, 1H, H-$2_{Glc'}$), 5.31 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.7 Hz, 1H, H-$4_{Glc'}$), 5.27 (t, $^3J_{1,2}$ = $^3J_{2,3}$ = 8.9 Hz, 1H, H-2_{Glc}), 4.97 (d, $^3J_{1,2}$ = 7.8 Hz, 1H, H-$1_{Glc'}$), 4.60 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1_{Glc}), 4.41 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.0 Hz, 1H, H-3_{Glc}), 4.32 – 4.21 (m, 2H, H-$6a_{Glc}$, H-$6b_{Glc}$), 4.12 – 4.03 (m, 2H, H-$6a_{Glc'}$, H-$6b_{Glc'}$), 4.02 – 3.96 (m, 2H, H-5_{Glc}, H-$5_{Glc'}$), 2.05 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.8 (C(O)CH_3), 166.0 (PhCO), 165.8 (PhCO), 165.2 (PhCO), 165.1 (PhCO), 164.9 (PhCO), 164.4 (PhCO), 133.8 (OBz_{para}), 133.7 (OBz_{para}), 133.5 (OBz_{para}), 133.3 (2 OBz_{para}), 133.0 (OBz_{para}), 130.0 (OBz), 129.9 (OBz), 129.8 (OBz), 129.7 (OBz), 129.6 (OBz), 129.4 (OBz), 129.1 (OBz), 128.8 (OBz), 128.8 (OBz), 128.7 (OBz), 128.7 (OBz), 128.6 (OBz), 128.5 (OBz), 128.5 (OBz), 128.4 (OBz), 128.3 (OBz), 101.2 (C-$1_{Glc'}$), 88.0 (C-1_{Glc}), 78.5 (C-3_{Glc}), 74.4 (C-$5_{Glc/Glc'}$), 72.9 (C-$3_{Glc'}$), 72.7 (C-2_{Glc}), 72.1 (C-$5_{Glc/Glc'}$), 71.9 (C-$2_{Glc'}$), 70.0 (C-$4_{Glc'}$), 69.1 (C-4_{Glc}), 63.4 (C-$6_{Glc'}$), 62.6 (C-6_{Glc}), 20.9 (CH_3) ppm.

ESI-HRMS: *m/z* = 1056.27956 $[M+Na]^+$ (calculated *m/z* = 1056.27977).

2.32. 2,3,4,6-Tetra-*O*-benzoyl-β-D-glucopyranosyl-(1→3)-2,4-di-*O*-benzoyl-β-D-glucopyranosyl azide (35)



34 **35**

The disaccharide **34** (528 mg, 511 µmol, 1 equiv) was dissolved in a mixture of dichloromethane/methanol (1:1 v/v, 10 mL) and cooled to 0 °C. Acetyl chloride (330 µL, 4.60 mmol, 9 equiv) was added dropwise over a period of 5 min and stirred for 2 h at 0 °C, followed by stirring at room temperature for 16 h. Triethylamine (1 mL) was added and the solvent removed under reduced pressure. The crude was suspended in ethyl acetate (50 mL), filtrated and the filtrate evaporated to dryness under reduced pressure. The filtrate was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 80:20→60:40) to yield the product **35** as a colorless foam (413 mg, 416 mmol, 81%).

R_F (cyclohexane:ethyl acetate, 2:1) = 0.18.

$[\alpha]_D^{20}$ = -65.1 (*c* = 0.54 in CH_2Cl_2).

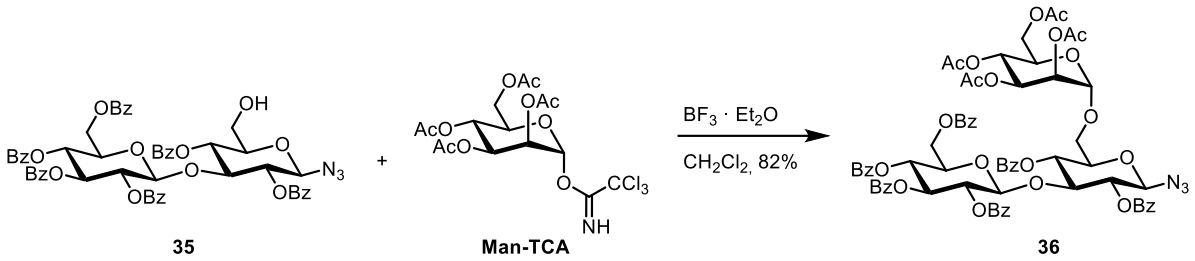
IR (ATR): $\tilde{\nu}$ = 2116 (m), 1732 (s), 1602 (m), 1451 (m), 1259 (s), 1178 (m), 1089 (s), 1067 (s), 1026 (s), 705 (s) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 8.15 – 7.13 (m, 30H, 6 OBz), 5.62 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.6 Hz, 1H, H-3$_{Glc'}$), 5.41 – 5.32 (m, 3H, H-2$_{Glc'}$, H-4$_{Glc}$, H-4$_{Glc'}$), 5.26 (t, $^3J_{1,2}$ = $^3J_{2,3}$ = 9.0 Hz, 1H, H-2$_{Glc}$), 5.01 (d, $^3J_{1,2}$ = 7.8 Hz, 1H, H-1$_{Glc'}$), 4.61 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1$_{Glc}$), 4.45 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.0 Hz, 1H, H-3$_{Glc}$), 4.28 – 4.18 (m, 2H, H-6a$_{Glc'}$, H-6b$_{Glc'}$), 4.01 (ddd, $^3J_{4,5}$ = 9.5 Hz, $^3J_{5,6a}$ = 5.2 Hz, $^3J_{5,6b}$ = 4.1 Hz, 1H, H-5$_{Glc'}$), 3.87 – 3.79 (m, 1H, H-6a$_{Glc}$), 3.77 – 3.67 (m, 2H, H-5$_{Glc}$, H-6b$_{Glc}$), 2.46 (dd, $^3J_{OH,6a}$ = 8.9 Hz, $^3J_{OH,6b}$ = 4.8 Hz, 1H, OH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 166.1 (Ph<u>C</u>O), 165.8 (Ph<u>C</u>O), 165.8 (Ph<u>C</u>O), 165.2 (Ph<u>C</u>O), 165.1 (Ph<u>C</u>O), 164.4 (Ph<u>C</u>O), 133.9 (OBz$_{para}$), 133.8 (OBz$_{para}$), 133.5 (OBz$_{para}$), 133.4 (OBz$_{para}$), 133.3 (OBz$_{para}$), 133.0 (OBz$_{para}$), 130.0 (OBz), 130.0 (OBz), 129.9 (OBz), 129.8 (OBz), 129.7 (OBz), 129.5 (OBz), 129.1 (OBz), 128.8 (OBz), 128.8 (OBz), 128.7 (OBz), 128.6 (OBz), 128.5 (OBz), 128.5 (OBz), 128.4 (OBz), 128.3 (OBz), 101.1 (C-1$_{Glc'}$), 88.1 (C-1$_{Glc}$), 78.2 (C-3$_{Glc}$), 77.2 (C-5$_{Glc}$), 72.9 (C-3$_{Glc'}$, C-2$_{Glc}$), 72.2 (C-5$_{Glc'}$), 71.9 (C-2$_{Glc'}$), 70.0 (C-4$_{Glc'}$), 69.1 (C-4$_{Glc}$), 63.5 (C-6$_{Glc'}$), 61.6 (C-6$_{Glc}$) ppm.

ESI-HRMS: *m/z* = 1014.26917 $[M+Na]^+$ (calculated *m/z* = 1014.26920).

2.33. 2,3,4,6-Tetra-*O*-benzoyl-β-D-glucopyranosyl-(1→3)-[2,3,4,6-tetra-*O*-acetyl-α-D-mannopyranosyl-(1→6)]-2,4-di-*O*-benzoyl-β-D-glucopyranosyl azide (36)



The acceptor disaccharide **35** (341 mg, 344 µmol, 1 equiv) and the mannosyl donor Man-TCA (262 mg, 532 µmol, 1.55 equiv) were dissolved in dry dichloromethane (15 mL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~200 mg) was added and the reaction mixture stirred at room temperature for 15 min. At 0 °C boron trifluoride diethyl etherate (70 µL, 552 µmol, 1.6 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 1 h. The reaction mixture was diluted with dichloromethane (40 mL) and satd. aq. $NaHCO_3$ solution (20 mL) and strongly stirred for 30 min. After filtration over celite® the phases were separated and the organic phase was washed with water (2 x 30 mL) and brine (30 mL). The combined aq. phases were extracted with ethyl acetate (2 x 30 mL) and the combined organic phases were dried over $MgSO_4$, it was filtrated and the solvent was removed under reduced pressure. The crude product was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 83:17→50:50) to yield the product **36** as a colorless foam (371 mg, 281 µmol, 82%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:1) = 0.32.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -31.4 (*c* = 0.57 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 2117 (m), 1732 (s), 1602 (m), 1452 (m), 1247 (s), 1178 (m), 1008 (s), 1068 (s), 1026 (s), 750 (m), 707 (s) cm^{-1}.

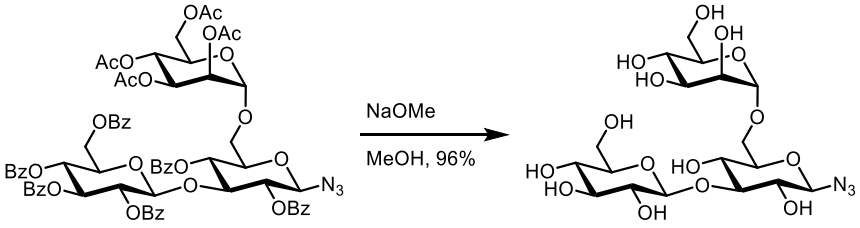
^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 8.10 – 7.16 (m, 30, 6 OBz), 5.61 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.6 Hz, 1H, H-3$_{Glc'}$), 5.39 – 5.20 (m, 7H, H-2$_{Glc}$, H-2$_{Glc'}$, H-2$_{Man}$, H-3$_{Man}$, H-4$_{Glc}$, H-4$_{Glc'}$, H-4$_{Man}$), 4.97 (d, $^3J_{1,2}$ = 7.9 Hz, 1H, H-1$_{Glc'}$), 4.77 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-1$_{Man}$), 4.67 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1$_{Glc}$), 4.41 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.0 Hz, 1H, H-3$_{Glc}$), 4.24 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 5.2 Hz, 1H, H-6a$_{Glc'}$), 4.15 (dd, ^2J = 12.0 Hz, $^3J_{5,6a}$ = 3.8 Hz, 1H, H-6a$_{Man}$), 4.10 – 4.04 (m, 2H, H-5$_{Glc'}$, H-6b$_{Man}$), 4.03 – 3.95 (m, 3H, H-5$_{Glc}$, H-5$_{Man}$, H-6b$_{Glc'}$), 3.88 (dd, ^2J = 10.8 Hz, $^3J_{5,6a}$ = 7.4 Hz, 1H, H-6a$_{Glc}$), 3.64 (dd, ^2J = 10.8 Hz, $^3J_{5,6b}$ = 2.1 Hz, 1H, H-6b$_{Glc}$), 2.12 (s, 3H, OAc), 2.07 (s, 3H, OAc), 2.01 (s, 3H, OAc), 1.98 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.8 (C(O)CH_3), 170.1 (C(O)CH_3), 170.0 (C(O)CH_3), 169.9 (C(O)CH_3), 166.0 (PhCO), 165.8 (PhCO), 165.2 (PhCO), 165.1 (PhCO), 165.1 (PhCO), 164.3 (PhCO), 133.8 (2 OBz$_{para}$), 133.5 (OBz$_{para}$), 133.4 (OBz$_{para}$), 133.3 (OBz$_{para}$), 133.0 (OBz$_{para}$), 130.0 (OBz), 130.0 (OBz), 129.9 (OBz), 129.8 (OBz), 129.7 (OBz), 129.6 (OBz), 129.2 (OBz), 129.1 (OBz), 128.8 (OBz), 128.8 (OBz), 128.7 (OBz), 128.6 (OBz), 128.5 (OBz), 128.5 (OBz), 128.3 (OBz), 128.2 (OBz), 101.2 (C-1$_{Glc'}$), 97.2 (C-1$_{Man}$), 87.8 (C-1$_{Glc}$), 78.5 (C-3$_{Glc}$), 75.5 (C-5$_{Glc}$), 72.9 (C-3$_{Glc'}$), 72.7*, 72.1 (C-5$_{Man}$), 71.9*, 69.9*, 69.4*, 69.4*, 69.2*, 68.7 (C-5$_{Glc'}$), 66.8 (C-6$_{Glc}$), 66.0*, 63.4 (C-6$_{Man}$), 62.3 (C-6$_{Glc'}$), 21.0 (CH_3), 20.9 (CH_3), 20.8 (CH_3), 20.8 (CH_3) ppm.

*Assignment is ambiguous due to signal overlap (C-2_{Glc}, C-$2_{Glc'}$, C-2_{Man}, C-3_{Man}, C-4_{Glc}, C-$4_{Glc'}$, C-4_{Man},)

ESI-HRMS: *m/z* = 1344.36380 $[M+Na]^+$ (calculated *m/z* = 1344.36429).

2.34. β-D-Glucopyranosyl-(1→3)-[α-D-mannopyranosyl-(1→6)]-β-D-glucopyranosyl azide (37)



36 **37**

The protected trisaccharide **36** (213 mg, 161 µmol, 1 equiv) was suspended in methanol (10 mL) and a solution of sodium methoxide in methanol (50 µL, 250 µmol, 5 M, 1.55 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 18 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 15 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **37** as a lyophilizate (82.2 mg, 155 µmol, 96%).

$[\alpha]_D^{20}$ = +13.6 (*c* = 0.91 in CH_3OH).

IR (ATR): $\tilde{\nu}$ = 3343 (br, m), 2895 (w), 2118 (m), 1736 (m), 1247 (s), 1067 (s), 1027 (s), 707 (s) cm^{-1}.

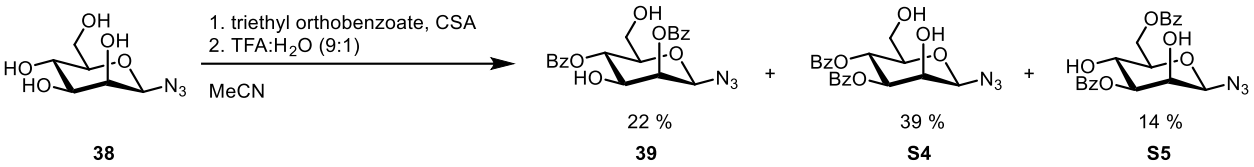
^{1}H NMR (600 MHz, D_2O, 298 K) δ = 4.81 (d, $^3J_{1,2}$ = 1.8 Hz, 1H, H-1_{Man}), 4.73 (d, $^3J_{1,2}$ = 8.9 Hz, 1H, H-1_{Glc}), 4.65 (d, $^3J_{1,2}$ = 8.0 Hz, 1H, H-$1_{Glc'}$), 3.93 – 3.88 (m, 2H, H-2_{Man}, H-$6a_{Glc}$), 3.86 – 3.76 (m, 2H, H-$6a_{Glc'}$, H-$6a_{Man}$), 3.76 – 3.52 (m, 9H, H-3_{Glc}, H-3_{Man}, H-4_{Glc}, H-4_{Man}, H-5_{Glc}, H-5_{Man}, H-$6b_{Glc}$, H-$6b_{Glc'}$, H-$6b_{Man}$), 3.43 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 9.2 Hz, 1H, H-$3_{Glc'}$), 3.42 – 3.35 (m, 2H, H-2_{Glc}, H-$5_{Glc'}$), 3.32 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.4 Hz, 1H, H-$4_{Glc'}$), 3.26 (dd, $^3J_{2,3}$ = 9.4 Hz, $^3J_{1,2}$ = 8.0 Hz, 1H, H-$2_{Glc'}$) ppm.

^{13}C NMR (151 MHz, D_2O, 298 K) δ = 102.8 (C-1_{Man}), 99.5 (C-1_{Glc}), 90.0 (C-$1_{Glc'}$), 84.2 (C-3_{Glc}), 75.9*, 75.8*, 75.5 (C-$3_{Glc'}$), 73.4 (C-$2_{Glc'}$), 72.7*, 72.5*, 70.5*, 69.8 (C-2_{Man}), 69.5 (C-$4_{Glc'}$), 67.5*, 66.6*, 65.0 (C-6_{Glc}), 60.8 (C-$6_{Glc'/Man}$), 60.6 (C-$6_{Glc'/Man}$) ppm.

*Assignment is ambiguous due to signal overlap (C-2_{Glc}, C-3_{Man}, C-4_{Glc}, C-4_{Man}, C-5_{Glc}, C-$5_{Glc'}$, C-5_{Man})

ESI-HRMS: *m/z* = 552.16494 $[M+Na]^+$ (calculated *m/z* = 552.16474).

2.35. 2,4-Di-*O*-benzoyl-β-D-mannopyranosyl azide (39) and 3,4-di-*O*-benzoyl-β-D-mannopyranosyl azide (S4) and 4,6-di-*O*-benzoyl-β-D-mannopyranosyl azide (S5)



β-D-Mannopyranosyl azide (**38**)[8] (360 mg, 1.75 mmol, 1 equiv) was suspended in dry acetonitrile (18 mL) under a nitrogen atmosphere and triethyl orthobenzoate (1.8 mL, 8.05 mmol, 4.6 equiv) was added at room temperature. Then, (+)-10-camphorsulfonic acid (76.8 mg, 330 µmol, 0.19 equiv) was added and the reaction mixture stirred at room temperature for 5 h. Triethylamine (180 µL, 1.30 mmol, 0.74 equiv) was added and the solvent removed under reduced pressure. The crude was dissolved in acetonitrile (18 mL) and while stirring a mixture of trifluoroacetic acid/water (9:1 v/v, 1.13 mL) was added slowly over a period of 5 min at 0 °C. The reaction mixture was kept at 0 °C for further 5 min, then allowed to warm to room temperature over a period of 10 min. Toluene (12 mL) was added and the solvent removed under reduced pressure. The crude was dissolved in dichloromethane (50 mL) and washed with satd. aq. $NaHCO_3$ solution (20 mL). The organic phase was dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 9:1→2:1) to yield the 2,4-di-*O*-benzoyl-β-D-mannopyranosyl azide **39** as a colorless solid (160 mg, 387 µmol, 22%), the 3,4-di-*O*-benzoyl-β-D-mannopyranosyl azide **S4** as a colorless solid (282 mg, 682 µmol, 39%) and the 3,6-di-*O*-benzoyl-β-D-mannopyranosyl azide **S5** as a colorless solid (101 mg, 245 µmol, 14%).

2,4-Di-*O*-benzoyl-β-D-mannopyranosyl azide **39**:

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 2:1) = 0.17.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -86.7 (*c* = 0.96 in $CHCl_3$).

IR (ATR): $\tilde{\nu}$ = 3443 (br, w), 2927 (w), 2117 (m), 1714 (m), 1602 (w), 1451 (w), 1260 (s), 1094 (s), 1069 (s), 1027 (s), 1001 (m), 707 (s) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 8.17 – 8.11 (m, 2H, OBz), 8.07 – 8.01 (m, 2H, OBz), 7.66 – 7.58 (m, 2H, OBz), 7.54 – 7.44 (m, 4H, OBz), 5.72 (dd, $^3J_{2,3}$ = 3.4 Hz, $^3J_{1,2}$ = 1.2 Hz, 1H, H-2), 5.45 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.7 Hz, 1H, H-4), 4.95 (d, $^3J_{1,2}$ = 1.3 Hz, 1H, H-1), 4.22 – 4.16 (m, 1H, H-3), 3.98 – 3.89 (m, 1H, H-6a), 3.85 – 3.77 (m, 2H, H-5, H-6b), 2.80 (d, J=6.2, 1H, OH), 2.42 (s, 1H, OH) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 167.2 (Ph<u>C</u>O), 166.3 (Ph<u>C</u>O), 134.1 (OBz_{para}), 133.9 (OBz_{para}), 130.3 (OBz_{ortho}), 130.1 (OBz_{ortho}), 128.8 (OBz_{meta}), 128.8 (OBz_{meta}), 86.1 (C-1), 77.4 (C-5), 72.1 (C-2), 71.8 (C-3), 69.8 (C-4), 61.6 (C-6) ppm.

ESI-HRMS: *m/z* = 431.15571 $[M+NH_4]^+$ (calculated *m/z* = 431.15613).

3,4-Di-*O*-benzoyl-β-D-mannopyranosyl azide **S4**:

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 2:1) = 0.23.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -112.5 (*c* = 0.23 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 3493 (br, w), 3206 (br, w), 2919 (w), 2114 (m), 1715 (s), 1450 (m), 1316 (m), 1262 (s), 1131 (m), 1111 (s), 1070 (s), 1026 (s), 921 (m) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 8.01 – 7.91 (m, 4H, OBz_{ortho}), 7.56 – 7.45 (m, 2H, OBz_{para}), 7.41 – 7.31 (m, 4H, OBz_{meta}), 5.84 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.7 Hz, 1H, H-4), 5.43 (dd, $^3J_{3,4}$ = 10.1 Hz, $^3J_{2,3}$ = 3.0 Hz, 1H, H-3), 4.96 (d, $^3J_{1,2}$ = 1.1 Hz, 1H, H-1), 4.35 (dd, $^3J_{2,3}$ = 3.1 Hz, $^3J_{1,2}$ = 1.1 Hz, 1H, H-2), 3.93 – 3.86 (m, 1H, H-6a), 3.81 – 3.74 (m, 2H, H-5, H-6b) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 166.2 (PhCO), 165.9 (PhCO), 133.7 (OBz_{para}), 133.6 (OBz_{para}), 129.9 (OBz_{ortho}), 129.8 (OBz_{ortho}), 128.5 (OBz_{meta}), 128.5 (OBz_{meta}), 87.3 (C-1), 77.0 (C-5), 73.6 (C-3), 69.7 (C-2), 66.0 (C-4), 61.3 (C-6) ppm.

ESI-HRMS: *m/z* = 431.15636 $[M+NH_4]^+$ (calculated *m/z* = 431.15613).

3,6-Di-*O*-benzoyl-β-D-mannopyranosyl azide **S5**:

R_F (cyclohexane:ethyl acetate, 2:1) = 0.35.

$[\alpha]_D^{20}$ = -66.5 (*c* = 0.42 in CH_2Cl_2).

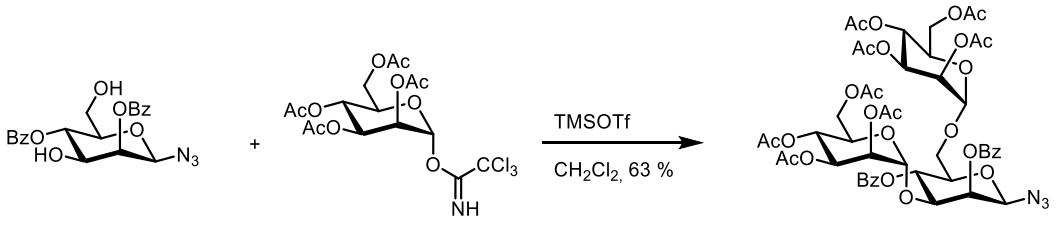
IR (ATR): $\tilde{\nu}$ = 3453 (br, s), 2924 (w), 2118 (s), 1704 (s), 1602 (w), 1452 (m), 1317 (m), 1274 (s), 1117 (m), 1097 (s), 1071 (s), 711 (s) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 8.13 – 8.06 (m, 4H, OBz_{ortho}), 7.63 – 7.56 (m, 2H, OBz_{para}), 7.53 – 7.42 (m, 4H, OBz_{meta}), 5.10 (dd, $^3J_{3,4}$ = 9.8 Hz, $^3J_{2,3}$ = 3.0 Hz, 1H, H-3), 4.92 (d, $^3J_{1,2}$ = 1.1 Hz, 1H, H-1), 4.82 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 4.5 Hz, 1H, H-6a), 4.65 (dd, ^2J = 12.2 Hz, $^3J_{5,6b}$ = 2.3 Hz, 1H, H-6b), 4.24 (dd, $^3J_{2,3}$ = 3.1 Hz, $^3J_{1,2}$ = 1.1 Hz, 1H, H-2), 4.19 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.8 Hz, 1H, H-4), 3.77 (ddd, $^3J_{4,5}$ = 9.7 Hz, $^3J_{5,6a}$ = 4.5 Hz, $^3J_{5,6b}$ = 2.3 Hz, 1H, H-5) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 167.4 (PhCO), 166.5 (PhCO), 133.8 (OBz_{para}), 133.6 (OBz_{para}), 130.1 (2 OBz_{ortho}), 128.7 (OBz_{meta}), 128.6 (OBz_{meta}), 87.5 (C-1), 77.0 (C-5), 76.0 (C-3), 69.6 (C-2), 64.9 (C-4), 63.6 (C-6) ppm.

ESI-HRMS: *m/z* = 431.15605 $[M+NH_4]^+$ (calculated *m/z* = 431.15613).

2.36. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→3)-[2,3,4,6-tetra-*O*-acetyl-α-D-mannopyranosyl-(1→6)]-2,4-di-*O*-benzoyl-β-D-mannopyranosyl azide (40)



39 **Man-TCA** **40**

The acceptor mannosyl azide **39** (110 mg, 265 µmol, 1 equiv) and mannosyl donor Man-TCA (225 mg, 457 µmol, 1.73 equiv) were dissolved in dry dichloromethane (4.5 mL) under a nitrogen atmosphere, freshly activated molecular sieve (3Å, ~300 mg) was added and the reaction mixture stirred at room temperature for 15 min. At 0 °C trimethylsilyl trifluoromethanesulfonate (9.6 µL, 53.0 µmol, 0.2 equiv) was added and the reaction mixture was stirred at 0 °C for 1 h. Afterwards,

a solution of mannosyl donor Man-TCA (225 mg, 457 µmol, 1.73 equiv) in dry dichloromethane (4.5 mL) and trimethylsilyl trifluoromethanesulfonate (9.6 µL, 53.0 µmol, 0.2 equiv) were added at 0 °C and stirred for 1 h, followed by stirring at room temperature for 9 h. Triethylamine (200 µL) was added at room temperature and the reaction mixture was filtrated over celite®. The solvent was removed under reduced pressure and the crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 2:1→1:2) to yield the product **40** as a colorless foam (180 mg, 168 µmol, 63%).

R_F (cyclohexane:ethyl acetate, 1:2) = 0.69.

$[\alpha]_D^{20}$ = -25.8 (*c* = 1.01 in $CHCl_3$).

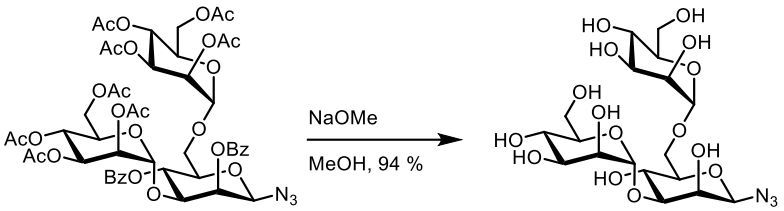
IR (ATR): $\tilde{\nu}$ = 2955 (w), 2121 (m), 1738 (s), 1732 (s), 1368 (m), 1216 (s), 1139 (m), 1084 (s), 1068 (s), 1041 (s), 896 (m), 711 (s) cm^{-1}.

^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 8.17 – 8.12 (m, 2H, OBz), 8.01 – 7.97 (m, 2H, OBz), 7.66 – 7.51 (m, 4H, OBz), 7.48 – 7.42 (m, 2H, OBz), 5.74 (dd, $^3J_{2,3}$ = 3.3 Hz, $^3J_{1,2}$ = 1.3 Hz, 1H, H-2_{Man}), 5.54 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.7 Hz, 1H, H-4_{Man}), 5.35 (dd, $^3J_{3,4}$ = 10.0 Hz, $^3J_{2,3}$ = 3.5 Hz, 1H, H-$3_{Man''}$), 5.27 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 10.1 Hz, 1H, H-$4_{Man''}$), 5.23 (dd, $^3J_{2,3}$ = 3.5 Hz, $^3J_{1,2}$ = 1.8 Hz, 1H, H-$2_{Man''}$), 5.15 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 9.8 Hz, 1H, H-$4_{Man'}$), 5.04 (dd, $^3J_{3,4}$ = 9.6 Hz, $^3J_{2,3}$ = 3.5 Hz, 1H, H-$3_{Man'}$), 4.99 (d, $^3J_{1,2}$ = 1.3 Hz, 1H, H-1_{Man}), 4.95 (d, $^3J_{1,2}$ = 1.9 Hz, 1H, H-$1_{Man'}$), 4.86 (dd, $^3J_{2,3}$ = 3.5 Hz, $^3J_{1,2}$ = 1.9 Hz, 1H, H-$2_{Man'}$), 4.81 (d, $^3J_{1,2}$ = 1.8 Hz, 1H, H-$1_{Man''}$), 4.29 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 4.7 Hz, 1H, H-$6a_{Man'}$), 4.26 – 4.21 (m, 3H, H-3_{Man}, H-$5_{Man'}$, H-$6a_{Man''}$), 4.17 (dd, ^2J = 12.2 Hz, $^3J_{5,6b}$ = 2.2 Hz, 1H, H-$6b_{Man'}$), 4.10 (ddd, $^3J_{4,5}$ = 10.0 Hz, $^3J_{5,6a}$ = 5.2 Hz, $^3J_{5,6b}$ = 2.3 Hz, 1H, H-$5_{Man''}$), 4.06 (dd, ^2J = 12.1 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-$6b_{Man''}$), 4.02 – 3.94 (m, 2H, H-5_{Man}, H-$6a_{Man}$), 3.69 (dd, ^2J = 10.3 Hz, $^3J_{5,6b}$ = 1.8 Hz, 1H, H-$6b_{Man}$), 2.13, 2.13, 2.03, 2.02, 2.01, 1.99, 1.82, 1.81 (each s, each 3H, 8 x OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.8 (<u>C</u>(O)CH_3), 170.7 (<u>C</u>(O)CH_3), 170.1 (<u>C</u>(O)CH_3), 170.0 (<u>C</u>(O)CH_3), 169.9 (<u>C</u>(O)CH_3), 169.9 (<u>C</u>(O)CH_3), 169.2 (<u>C</u>(O)CH_3), 169.1 (<u>C</u>(O)CH_3), 166.0 (Ph<u>C</u>O), 165.2 (Ph<u>C</u>O), 133.9 (OBz_{para}), 133.9 (OBz_{para}), 130.3 (OBz), 130.1 (OBz), 129.0 (OBz), 128.9 (OBz), 128.7 (OBz), 128.5 (OBz), 99.8 (C-$1_{Man'}$), 97.3 (C-$1_{Man''}$), 85.8 (C-1_{Man}), 76.7 (C-3_{Man}), 75.7 (C-5_{Man}), 71.0 (C-2_{Man}), 69.7 (C-$5_{Man'}$), 69.4 (C-$2_{Man''}$), 69.2 (C-$3_{Man''}$), 69.2 (C-$2_{Man'}$), 68.7 (C-4_{Man}/$5_{Man''}$), 68.7 (C-4_{Man}/$5_{Man''}$), 68.3 (C-$3_{Man'}$), 66.7 (C-6_{Man}), 66.1 (C-$4_{Man'/Man''}$), 66.0 (C-$4_{Man'/Man''}$), 62.5 (C-$6_{Man'/Man''}$), 62.4 (C-$6_{Man'/Man''}$), 21.0 (CH_3), 20.9 (CH_3), 20.9 (CH_3), 20.8 (CH_3), 20.8 (2 CH_3), 20.6 (CH_3), 20.5 (CH_3) ppm.

ESI-HRMS: *m/z* = 1091.34491 $[M+NH_4]^+$ (calculated *m/z* = 1091.34629).

2.37. α-D-Mannopyranosyl-(1→3)-[α-D-mannopyranosyl-(1→6)]-β-D-mannopyranosyl azide (41)



40 41

The protected trisaccharide **40** (139 mg, 129 µmol, 1 equiv) was suspended in methanol (10 mL) and a solution of sodium methoxide in methanol (50 µL, 250 µmol, 5 M, 1.9 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 23 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 15 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **41** as a lyophilizate (64.6 mg, 122 µmol, 94%).

$[\alpha]_D^{20}$ = +23.9 (*c* = 0.35 in CH_3OH).

IR (ATR): $\tilde{\nu}$ = 3336 (br, m), 2924 (w), 2119 (m), 1637 (w), 1249 (m), 1134 (m), 1052 (s), 1024 (s), 975 (m), 810 (m) cm^{-1}.

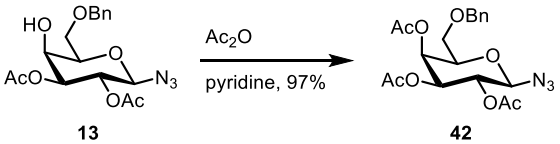
^{1}H NMR (500 MHz, CD_3OD, 298 K) δ = 5.07 (d, $^3J_{1,2}$ = 1.7 Hz, 1H, H-$1_{Man'}$), 4.85 (d, $^3J_{1,2}$ = 1.9 Hz, 1H, H-$1_{Man''}$), 4.56 (d, $^3J_{1,2}$ = 1.1 Hz, 1H, H-1_{Man}), 4.11 (dd, $^3J_{2,3}$ = 3.1 Hz, $^3J_{1,2}$ = 1.1 Hz, 1H, H-2_{Man}), 3.98 – 3.93 (m, 2H, H-$2_{Man'}$, H-$6a_{Man}$), 3.90 – 3.85 (m, 2H, H-$2_{Man''}$, H-$6a_{Man'/Man''}$), 3.84 – 3.62 (m, 10H, H-$3_{Man'}$, H-$3_{Man''}$, H-4_{Man}, H-$4_{Man'/Man''}$, H-$5_{Man'}$, H-$5_{Man''}$, H-$6b_{Man}$, H-$6a_{Man'/Man''}$, H-$6b_{Man'}$, H-$6b_{Man''}$), 3.61 – 3.53 (m, 2H, H-3_{Man}, H-$4_{Man'/Man''}$), 3.47 (ddd, $^3J_{4,5}$ = 9.8 Hz, $^3J_{5,6a}$ = 5.4 Hz, $^3J_{5,6b}$ = 1.8 Hz, 1H, H-5_{Man}) ppm.

^{13}C NMR (151 MHz, CD_3OD, 298 K) δ = 103.9 (C-$1_{Man'}$), 101.6 (C-$1_{Man''}$), 88.3 (C-1_{Man}), 82.6 (C-3_{Man}), 79.1 (C-5_{Man}), 75.1*, 74.4*, 72.7 (C-2_{Man}), 72.5*, 72.5*, 72.0 (C-$2_{Man'}$, C-$2_{Man''}$), 68.9 (C-$4_{Man'/Man''}$), 68.5*, 67.2 (C-6_{Man}), 66.9*, 63.1 (C-$6_{Man'/Man''}$), 62.8 (C-$6_{Man'/Man''}$) ppm.

*Assignment is ambiguous due to signal overlap (C-$3_{Man'}$, C-$3_{Man''}$, C-4_{Man}, C-$4_{Man'/Man''}$, C-$5_{Man'}$, C-$5_{Man''}$).

ESI-HRMS: *m/z* = 547.20836 $[M+NH_4]^+$ (calculated *m/z* = 547.20934).

2.38. 2,3,4-Tri-*O*-acetyl-6-*O*-benzyl-β-D-galactopyranosyl azide (42)



13 42

The partially protected galactosyl azide **13** (169 mg, 444 µmol, 1 equiv) was dissolved in pyridine (2 mL), acetic anhydride (1 mL, 10.6 mmol, 24 equiv) was added and the reaction mixture was

stirred at room temperature for 20 h. The reaction mixture was diluted with ethyl acetate (50 mL) and washed with aq. 1 M HCl solution (3 x 30 mL), satd. aq. $NaHCO_3$ solution (30 mL) and brine (20 mL). The separated organic phase was dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure to yield the product **42** as a colorless oil (182 mg, 432 µmol, 97%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 2:1) = 0.38.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -38.8 (*c* = 1.00 in $CHCl_3$).

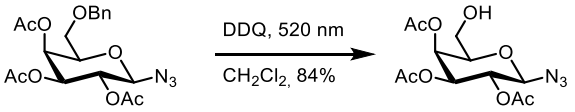
IR (ATR): $\tilde{\nu}$ = 2871 (w), 2116 (m), 1746 (s), 1368 (m), 1211 (s), 1086 (m), 1056 (s), 1017 (m), 952 (m), 900 (m), 740 (m), 699 (m) cm^{-1}.

^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 7.38 – 7.27 (m, 5H, Ar-H), 5.49 (dd, $^3J_{3,4}$ = 3.4 Hz, $^3J_{4,5}$ = 1.2 Hz, 1H, H-4), 5.14 (dd, $^3J_{2,3}$ = 10.3 Hz, $^3J_{1,2}$ = 8.8 Hz, 1H, H-2), 5.03 (dd, $^3J_{2,3}$ = 10.3 Hz, $^3J_{3,4}$ = 3.4 Hz, 1H, H-3), 4.59 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1), 4.57 (d, ^2J = 11.9 Hz, 1H, PhC<u>H</u>H'), 4.44 (d, ^2J = 12.0 Hz, 1H, PhCH<u>H</u>'), 3.99 – 3.92 (m, 1H, H-5), 3.59 (dd, ^2J = 9.7 Hz, $^3J_{5,6a}$ = 6.1 Hz, 1H, H-6a), 3.50 (dd, ^2J = 9.7 Hz, $^3J_{5,6b}$ = 6.6 Hz, 1H, H-6b), 2.08 (s, 3H, OAc), 2.07 (s, 3H, OAc), 1.98 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.1 (<u>C</u>(O)CH_3), 170.0 (<u>C</u>(O)CH_3), 169.4 (<u>C</u>(O)CH_3), 137.3 (OBn_{ipso}), 128.5 (2 Ar-<u>C</u>H), 128.0 (3 Ar-<u>C</u>H), 88.3 (C-1), 74.3 (C-5), 73.6 (Ph<u>C</u>H_2), 70.9 (C-3), 68.3 (C-2), 67.3 (C-4/C-6), 67.2 (C-4/C-6), 20.7 (CH_3), 20.6 (CH_3), 20.6 (CH_3) ppm.

ESI-HRMS: *m/z* = 439.18197 $[M+NH_4]^+$ (calculated *m/z* = 439.18234).

2.39. 2,3,4-Tri-*O*-acetyl-β-D-galactopyranosyl azide (43)



42 **43**

Following the procedure from Cavedon[4] et al., the disaccharide **42** (166 mg, 394 µmol, 1 equiv) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (134 mg, 591 µmol, 1.5 equiv) were dissolved in dry dichloromethane (20 mL) under nitrogen atmosphere and water (200 µL) was added. During strong stirring the reaction mixture was irradiated with 520 nm green light for 4 h at room temperature. The reaction mixture was diluted with dichloromethane (125 mL) and washed with satd. aq. $NaHCO_3$ solution (100 mL). The aq. phase was extracted with dichloromethane (2x50 mL). All organic phases were combined and dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 66:33→40:60) to yield the product **43** as a colorless oil (110 mg, 332 µmol, 84%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:1) = 0.13.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = -5.7 (*c* = 0.65 in $CHCl_3$).

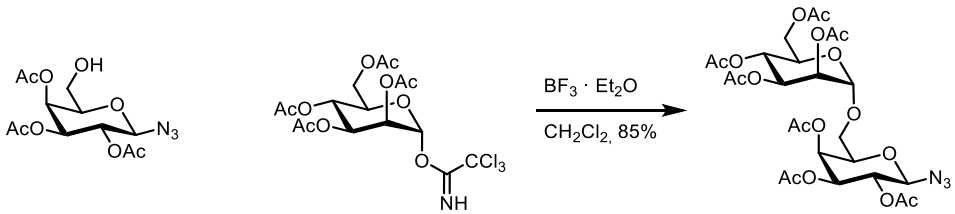
IR (ATR): $\tilde{\nu}$ = 3495 (w), 2118 (m), 1742 (s), 1369 (m), 1245 (s), 1217 (s), 1162 (w), 1112 (m), 1085 (m), 1047 (s), 954 (m) cm^{-1}.

^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 5.41 (dd, $^3J_{3,4}$ = 3.4 Hz, $^3J_{4,5}$ = 1.0 Hz, 1H, H-4), 5.20 (dd, $^3J_{2,3}$ = 10.4 Hz, $^3J_{1,2}$ = 8.8 Hz, 1H, H-2), 5.07 (dd, $^3J_{2,3}$ = 10.3 Hz, $^3J_{3,4}$ = 3.4 Hz, 1H, H-3), 4.62 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1), 3.85 (ddd, $^3J_{5,6b}$ = 7.2 Hz, $^3J_{5,6a}$ = 6.3 Hz, $^3J_{4,5}$ = 1.1 Hz, 1H, H-5), 3.78 (dt, ^2J = 11.7 Hz, $^3J_{5,6a}$ = $^3J_{OH,6a}$ = 6.6 Hz, 1H, H-6a), 3.55 (ddd, ^2J = 11.7 Hz, $^3J_{5,6b}$ = 7.3 Hz, $^3J_{OH,6b}$ = 6.2 Hz, 1H, H-6b), 2.20 (s, 3H, OAc), 2.19 – 2.16 (m, 1H, OH), 2.10 (s, 3H, OAc), 2.01 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 171.2 ($\underline{C}(O)CH_3$), 170.1 ($\underline{C}(O)CH_3$), 169.6 ($\underline{C}(O)CH_3$), 88.6 (C-1), 75.9 (C-5), 70.9 (C-3), 68.6 (C-2), 67.8 (C-4), 60.7 (C-6), 20.8 (CH_3), 20.7 (CH_3) ppm.

ESI-HRMS: *m/z* = 349.13514 $[M+NH_4]^+$ (calculated *m/z* = 349.13539).

2.40. 2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl-(1→6)-2,3,4-tri-*O*-acetyl-β-D-galactopyranosyl azide (44)



43 **Man-TCA** **44**

The acceptor galactosyl azide **43** (44 mg, 133 µmol, 1 equiv) and the mannosyl donor Man-TCA (79 mg, 159 µmol, 1.2 equiv) were dissolved in dry dichloromethane (530 µL) under nitrogen atmosphere, freshly activated molecular sieve (3Å, ~40 mg) was added and the reaction mixture stirred at room temperature for 20 min. At 0 °C boron trifluoride diethyl etherate (5 µL, 39.5 µmol, 0.3 equiv) was added and the reaction mixture was stirred at 0 °C for 2 h, followed by stirring at room temperature for 20 h. The reaction mixture was diluted with dichloromethane (10 mL) and triethylamine (50 µL) was added at room temperature. After filtration over celite® the solvent was removed under reduced pressure. The crude product was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 80:20→45:55) to yield the product **44** as a colorless solid (75 mg, 113 µmol, 85%).

$\boldsymbol{R}_F$ (cyclohexane:ethyl acetate, 1:2) = 0.76.

$[\boldsymbol{\alpha}]_{\boldsymbol{D}}^{\boldsymbol{20}}$ = +28.0 (*c* = 0.48 in $CHCl_3$).

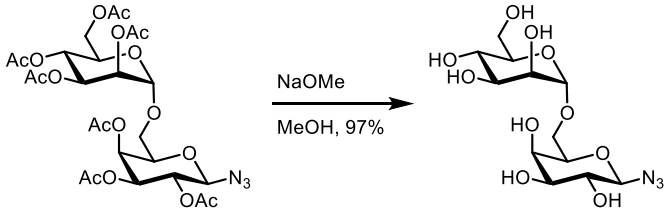
IR (ATR): $\tilde{\nu}$ = 2935 (w), 2122 (m), 1748 (s), 1366 (m), 1217 (s), 1134 (m), 1077 (m), 1054 (s), 1045 (s), 973 (m), 907 (m) cm^{-1}.

^{1}H NMR (600 MHz, $CDCl_3$, 298 K) δ = 5.43 (dd, $^3J_{3,4}$ = 3.3 Hz, $^3J_{4,5}$ = 1.0 Hz, 1H, H-4_{Gal}), 5.34 – 5.26 (m, 2H, H-3_{Man}, H-4_{Man}), 5.21 (dd, $^3J_{2,3}$ = 3.3 Hz, $^3J_{1,2}$ = 1.8 Hz, 1H, H-2), 5.14 (dd, $^3J_{2,3}$ = 10.4 Hz, $^3J_{1,2}$ = 8.7 Hz, 1H, H-2_{Gal}), 5.06 (dd, $^3J_{2,3}$ = 10.4 Hz, $^3J_{3,4}$ = 3.4 Hz, 1H, H-3_{Gal}), 4.77 (d, $^3J_{1,2}$ = 1.8 Hz, 1H, H-1_{Man}), 4.70 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1_{Gal}), 4.28 (dd, ^2J = 12.3 Hz, $^3J_{5,6a}$ = 5.1 Hz, 1H, H-$6a_{Man}$), 4.16 (dd, ^2J = 12.3 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-$6b_{Man}$), 4.07 (ddd, $^3J_{4,5}$ = 9.5 Hz, $^3J_{5,6a}$ = 5.1 Hz, $^3J_{5,6b}$ = 2.4 Hz, 1H, H-5_{Man}), 4.01 (ddd, $^3J_{5,6a}$ = 7.3 Hz, $^3J_{5,6b}$ = 4.3 Hz, $^3J_{4,5}$ = 1.2 Hz, 1H, H-5_{Gal}), 3.84 (dd, ^2J = 10.4 Hz, $^3J_{5,6a}$ = 7.3 Hz, 1H, H-$6a_{Gal}$), 3.54 (dd, ^2J = 10.4 Hz, $^3J_{5,6b}$ = 4.2 Hz, 1H, H-$6b_{Gal}$), 2.17 (s, 3H, OAc), 2.15 (s, 3H, OAc), 2.12 (s, 3H, OAc), 2.10 (s, 3H, OAc), 2.03 (s, 3H, OAc), 2.00 (s, 3H, OAc), 1.99 (s, 3H, OAc) ppm.

^{13}C NMR (151 MHz, $CDCl_3$, 298 K) δ = 170.7 (C(O)CH_3), 170.2 (C(O)CH_3), 170.1 (C(O)CH_3), 170.0 (C(O)CH_3), 170.0 (C(O)CH_3), 169.9 (C(O)CH_3), 169.6 (C(O)CH_3), 97.6 (C-1_{Man}), 88.3 (C-1_{Gal}), 74.2 (C-5_{Gal}), 70.8 (C-3_{Gal}), 69.4 (C-2_{Man}), 69.0 (C-3_{Man}/C-5_{Man}), 69.0 (C-3_{Man}/C-5_{Man}), 68.3 (C-2_{Gal}), 67.7 (C-4_{Gal}), 66.4 (C-6_{Gal}), 66.0 (C-4_{Man}), 62.4 (C-6_{Man}), 21.0 (CH_3), 20.9 (CH_3), 20.9 (CH_3), 20.8 (CH_3), 20.8 (CH_3), 20.7 (CH_3), 20.7 (CH_3) ppm.

ESI-HRMS: *m/z* = 679.22971 $[M+NH_4]^+$ (calculated *m/z* = 679.23047).

2.41. α-D-Mannopyranosyl-(1→6)-β-D-galactopyranosyl azide (45)



44 **45**

The protected disaccharide **44** (68 mg, 103 µmol, 1 equiv) was suspended in methanol (6 mL) and a solution of sodium methoxide in methanol (30 µL, 150 µmol, 5 M, 1.5 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 19 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 20 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **45** as a lyophilizate (36 mg, 99.1 µmol, 97%).

$[\alpha]_D^{20}$ = +47.3 (*c* = 0.41 in CH_3OH).

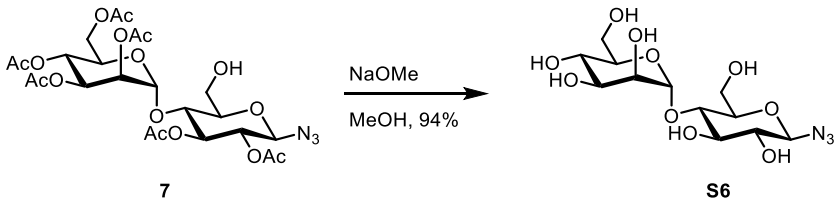
IR (ATR): $\tilde{\nu}$ = 3327 (br, m), 2926 (w), 2118 (m), 1639 (w), 1408 (w), 1368 (m), 1245 (m), 1134 (m), 1047 (s), 1024 (s), 972 (m), 810 (m) cm^{-1}.

^{1}H NMR (600 MHz, D_2O, 298 K) δ = 4.91 (d, $^3J_{1,2}$ = 1.8 Hz, 1H, H-1_{Man}), 4.67 (d, $^3J_{1,2}$ = 8.7 Hz, 1H, H-1_{Gal}), 4.00 – 3.88 (m, 5H, H-2_{Man}, H-4_{Gal}, H-5_{Gal}, H-$6a_{Gal}$, H-$6a_{Man}$), 3.84 – 3.63 (m, 6H, H-3_{Gal}, H-3_{Man}, H-4_{Man}, H-5_{Man}, H-$6b_{Gal}$, H-$6b_{Man}$), 3.54 – 3.50 (m, 1H, H-2_{Gal}) ppm.

^{13}C NMR (151 MHz, D_2O, 298 K) δ = 99.7 (C-1_{Man}), 90.5 (C-1_{Gal}), 74.9, 72.8, 72.6, 70.4, 70.2 (C-2_{Gal}), 69.9, 68.6, 66.7, 66.2 (C-6_{Gal}), 60.8 (C-6_{Man}) ppm.

ESI-HRMS: *m/z* = 385.15637 $[M+NH_4]^+$ (calculated *m/z* = 385.15652).

2.42. α-D-Mannopyranosyl-(1→4)-β-D-glucopyranosyl azide (S6)



7 **S6**

The protected disaccharide **7** (30 mg, 48.4 µmol, 1 equiv) was suspended in methanol (4 mL) and a solution of sodium methoxide in methanol (20 µL, 100 µmol, 5 M, 2 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 18 h. It was neutralized by

addition of Amberlite®-IRC 120 H^+ resin and stirring for 15 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **S6** as a lyophilizate (16.8 mg, 45.7 µmol, 94%).

$[\alpha]_D^{20}$ = +45.4 (*c* = 0.16 in CH_3OH).

IR (ATR): $\tilde{\nu}$ = 3324 (br, m), 2929 (w), 2119 (m), 1248 (m), 1130 (m), 1026 (s), 968 (m), 812 (m) cm^{-1}.

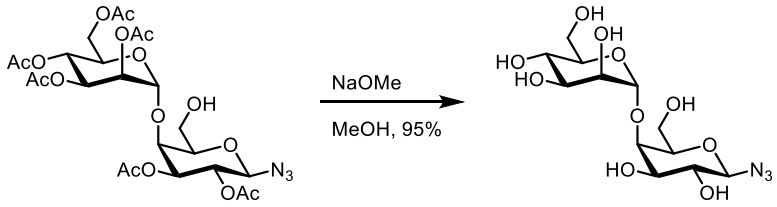
^{1}H NMR (500 MHz, D_2O, 298 K) δ = 5.27 (d, $^3J_{1,2}$ = 1.9 Hz, 1H, H-1_{Man}), 4.71 (d, $^3J_{1,2}$ = 8.8 Hz, 1H, H-1_{Glc}), 4.04 (dd, $^3J_{2,3}$ = 3.3 Hz, $^3J_{1,2}$ = 1.9 Hz, 1H, H-2_{Man}), 3.96 – 3.84 (m, 2H, H-$6a_{Glc}$, H-$6a_{Man}$), 3.82 – 3.57 (m, 8H, H-3_{Glc}, H-3_{Man}, H-4_{Glc}, H-4_{Man}, H-5_{Glc}, H-5_{Man}, H-$6b_{Glc}$, H-$6b_{Man}$), 3.26 (t, $^3J_{1,2}$ = $^3J_{2,3}$ = 8.8 Hz, 1H, H-2_{Glc}) ppm.

^{13}C NMR (126 MHz, D_2O, 298 K) δ = 104.2 (C-1_{Man}), 92.7 (C-1_{Glc}), 79.3*, 79.0*, 78.5*, 76.5*, 75.7 (C-2_{Glc}), 73.1*, 73.0 (C-2_{Man}), 69.3*, 63.7 (C-$6_{Glc/Man}$), 63.4 (C-$6_{Glc/Man}$) ppm.

*Assignment is ambiguous due to signal overlap (C-3_{Glc}, C-3_{Man}, C-4_{Glc}, C-4_{Man}, C-5_{Glc}, C-5_{Man}).

ESI-HRMS: *m/z* = 385.15609 $[M+NH_4]^+$ (calculated *m/z* = 385.15652).

2.43. α-D-Mannopyranosyl-(1→4)-β-D-galactopyranosyl azide (S7)



17 **S7**

The protected disaccharide **17** (91.1 mg, 147 µmol, 1 equiv) was suspended in methanol (6 mL) and a solution of sodium methoxide in methanol (30 µL, 150 µmol, 5 M, 1 equiv) was added at room temperature. The reaction mixture was stirred at room temperature for 18 h. It was neutralized by addition of Amberlite®-IRC 120 H^+ resin and stirring for 15 min. The resin was filtered off and the filtrate was concentrated under reduced pressure. The crude was purified on reversed phase silica gel via automated flash chromatography (H_2O:MeCN, 100:0 1 CV, 100:0 → 0:100 over 16 CV) and lyophilized to obtain the product **S7** as a lyophilizate (51.3 mg, 140 µmol, 95%).

$[\alpha]_D^{20}$ = +30.9 (*c* = 0.53 in CH_3OH).

IR (ATR): $\tilde{\nu}$ = 3342 (br, m), 2930 (w), 2117 (m), 1248 (m), 1091 (s), 1044 (s), 976 (m), 679 (m) cm^{-1}.

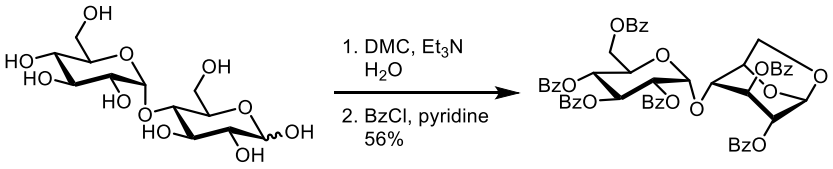
^{1}H NMR (500 MHz, D_2O, 298 K) δ = 4.85 (d, $^3J_{1,2}$ = 1.9 Hz, 1H, H-1_{Man}), 4.76 (d, $^3J_{1,2}$ = 8.6 Hz, 1H, H-1_{Gal}), 4.07 (d, $^3J_{3,4}$ = 3.2 Hz, 1H, H-4_{Gal}), 4.04 – 3.99 (m, 2H, H-2_{Man}, H-$5_{Gal/Man}$), 3.88 – 3.67 (m, 8H, H-3_{Gal}, H-3_{Man}, H-4_{Man}, H-$5_{Gal/Man}$, H-$6a_{Gal}$, H-$6a_{Man}$, H-$6b_{Gal}$, H-$6b_{Man}$), 3.48 (dd, $^3J_{2,3}$ = 10.1 Hz, $^3J_{1,2}$ = 8.6 Hz, 1H, H-2_{Gal}) ppm.

^{13}C NMR (126 MHz, D_2O, 298 K) δ = 104.4 (C-1_{Man}), 93.7 (C-1_{Gal}), 80.0 (C-4_{Gal}), 79.8, 75.9 (C-$5_{Gal/Man}$), 74.9, 73.2 (C-2_{Gal}), 73.1, 72.9 (C-2_{Man}), 69.2, 63.4 (C-$6_{Gal/Man}$), 63.1 (C-$6_{Gal/Man}$) ppm.

*Assignment is ambiguous due to signal overlap (C-3_{Gal}, C-3_{Man}, C-4_{Man}, C-$5_{Gal/Man}$).

ESI-HRMS: *m/z* = 385.15586 $[M+NH_4]^+$ (calculated *m/z* = 385.15652).

2.44. 2,3,4,6-Tetra-*O*-benzoyl-α-D-glucopyranosyl-(1→4)-2,3-di-*O*-benzoyl-1,6-anhydro-β-D-glucopyranose (S9)



S9

Maltose monohydrate (1.06 g, 2.94 mmol, 1 equiv) was dissolved in water (5 mL) and cooled to 0 °C. To the stirred solution triethylamine (3.7 mL, 26.4 mmol, 9 equiv) was added, followed by addition of 2-chloro-1,3-dimethylimidazolinium chloride (DMC, 1.49 g, 8.81 mmol, 3 equiv) and stirred at 0 °C for 1.5 h. The reaction mixture was diluted with water (20 mL) and washed with dichloromethane (3 x 25 mL). The aq. phase was concentrated to dryness and codestilled with toluene (3 x 25 mL). The crude was dissolved in pyridine (15 mL) and cooled to 0 °C. To the stirred solution benzoyl chloride (2.15 mL, 18.4 mmol, 6.3 equiv) was added and stirred for 1 h at 0 °C, then 18 h at room temperature. Methanol (10 mL) was added to the reaction mixture and stirred for 15 min at room temperature. Then, the mixture was diluted with ethyl acetate (100 mL) and washed with aq. 1 M HCl solution (3 x 25 mL), satd. aq. $NaHCO_3$ solution (50 mL) and brine (20 mL). The organic phase was dried over $MgSO_4$, filtrated and the solvent was removed under reduced pressure. The crude was purified on silica gel via automated flash chromatography (cyclohexane:ethyl acetate, 90:10 → 70:30 over 12 CV) to yield the product **S9** as a colorless foam (1.71 g, 1.80 mmol, 61%).

R_F (cyclohexane:ethyl acetate, 4:1) = 0.34.

$[\alpha]_D^{20}$ = +68.0 (*c* = 1.00 in CH_2Cl_2).

IR (ATR): $\tilde{\nu}$ = 2968 (w), 1720 (s), 1602 (m), 1585 (w), 1492 (w), 1451 (m), 1315 (m), 1251 (s), 1092 (s), 1069 (s), 1025 (s), 705 (s) cm^{-1}.

^{1}H NMR (500 MHz, $CDCl_3$, 298 K) δ = 8.36 – 8.30 (m, 2H), 8.12 – 7.85 (m, 10H), 7.64 – 7.26 (m, 17H), 7.15 (dd, J = 8.4, 7.5 Hz, 2H), 6.42 (t, J = 10.0 Hz, 1H), 5.78 – 5.70 (m, 2H), 5.67 (d, J = 3.7 Hz, 1H), 5.44 (dd, J = 10.3, 3.8 Hz, 1H), 5.21 (t, J = 1.5 Hz, 1H), 5.03 (d, J = 1.2 Hz, 1H), 4.99 (d, J = 5.7 Hz, 1H), 4.94 (ddd, J = 10.3, 5.8, 2.6 Hz, 1H), 4.62 (dd, J = 12.3, 2.6 Hz, 1H), 4.52 (dd, J = 12.3, 5.9 Hz, 1H), 4.07 (dd, J = 7.7, 1.0 Hz, 1H), 3.77 – 3.73 (m, 1H), 3.69 (dd, J = 7.7, 5.8 Hz, 1H) ppm.

^{13}C NMR (126 MHz, $CDCl_3$, 298 K) δ = 166.3, 166.1, 165.8, 165.6, 165.5, 164.7, 133.7, 133.7, 133.6, 133.4, 133.3, 133.3, 130.4, 130.2, 130.0, 129.9, 129.9, 129.8, 129.8, 129.4, 129.3, 129.2, 129.1, 128.8, 128.8, 128.7, 128.6, 128.6, 128.5, 128.5, 128.4, 99.1, 98.6, 77.6, 77.4, 77.2, 76.9, 74.8, 71.7, 71.5, 70.4, 69.5, 69.0, 69.0, 65.0, 63.2, 60.5, 14.3 ppm.

ESI-HRMS: *m/z* = 966.29559 $[M+NH_4]^+$ (calculated *m/z* = 966.29676).

3. Biological Testing

Equipment

Test tubes for bacterial cultivation were sterilized in an autoclave before usage. The optical density of the bacterial suspension was measured on a Jenway Spectrophotometer Model 7305. Washing of black 96 well plates was performed on a HyroFlex microplate washer. Fluorescent readout of black 96 well plates was performed on an Infinite M Nano+ plate reader.

Buffer and Bacteria

Following buffers and media were prepared with type 1 water from a Purelab® flex 3 system. The solutions were prepared by following procedures:

LB medium: Luria/Miller powder from Roth® (trypton (10.0 g), sodium chloride (10.0 g), yeast extract (5.00 g)) was dissolved in 1 L type 1 water. The solution was autoclaved and afterwards antibiotics (ampicillin (100 mg), chloramphenicol (50.0 mg)) were added.

PBS: 4 PBS tablets (gibco™) were dissolved in 2 L type 1 water (buffer composition: sodium phosphates 10 mM, potassium chloride 2.68 mM, sodium chloride 140 mM).

PBST: Tween®20 (0.05% v/v) was added to PBS.

Carbonate buffer (pH 9.6): sodium carbonate (1.59 g) and sodium hydrogen carbonate (2.52 g) were dissolved in distilled deionized water (1.00 L).

Bacteria

The GFP-expressing *E. coli* bacteria strain PKL1162, produced in the laboratory of Per Klemm, was used in the adhesion inhibition assays.[9] This *E. coli* strain PKL1162 was constructed by insertion of the plasmid pPKL174 into the strain SAR18[10]. The plasmid pPKL174 contains the *fim* gene cluster, which is responsible for the expression of type 1 fimbriae. The strains SAR18 contains the *gfp* gene in its genome, which is controlled by a constitutive promoter. The final combined bacterial strain PKL1162 expresses type 1 fimbriae as the only fimbriae type in addition to green fluorescence protein (GFP), which allows fluorescence read-out.

Cultivation of bacteria

GFP-expressing *E. coli* bacteria (strain PKL1162) were cultivated in 20 mL LB medium and incubated overnight at 37 °C and 180 rpm. Afterwards, the mixture was centrifuged at 4 °C and 5000 rpm for 10 min. The bacteria pellet was washed twice with PBS (2 mL) and then resuspended in PBS. Finally, the suspension was adjusted to OD_{600} = 0.4.

Mannan coating of microtiter plates

The published assay[9] was adapted and modified as follows: Black 96-well microtiter plates (Nunc™, Maxisorp®) were incubated with a solution of mannan from *Saccharomyces cerevisiae* (1.2 mg/mL in carbonate buffer, 120 µL/well) and desiccated overnight at 37 °C and 160 rpm. Then the plates were washed with PBST (3 x 400 µL/well) and blocked with polyvinyl alcohol (PVA) (1% in PBS, 120 µL/well) at 37 °C and 160 rpm for 2 h. Afterwards, the microtiter plates were washed with PBST (3 x 400 µL/well).

Inhibition assay with GFP-PKL1162 *E. coli* bacteria

Inhibitor solutions of the respective glycans in PBS were prepared and serial dilutions (dilution factor 1:2, 10 steps) of each solution were performed on the mannan-coated microtiter plates (50 µL/well final volume). Next, the prepared bacterial suspension (OD_{600} = 0.4, 50 µL/well) was added and the microtiter plates were incubated at 37 °C and 100 rpm for 45 min. The plates were washed with PBS (3 x 400 µL/well), then the wells were filled with PBS (100 µL/well) and the fluorescence intensity (485 nm/535 nm) was determined. On each individual plate the standard inhibitor methyl α-D-mannopyranoside (MeMan) was tested in parallel as a reference in triplicates and the respective glycans on the same plate in duplicates or triplicates, respectively.

Inhibition curves of adhesion-inhibition assay with GFP expressing *E. coli* bacteria.

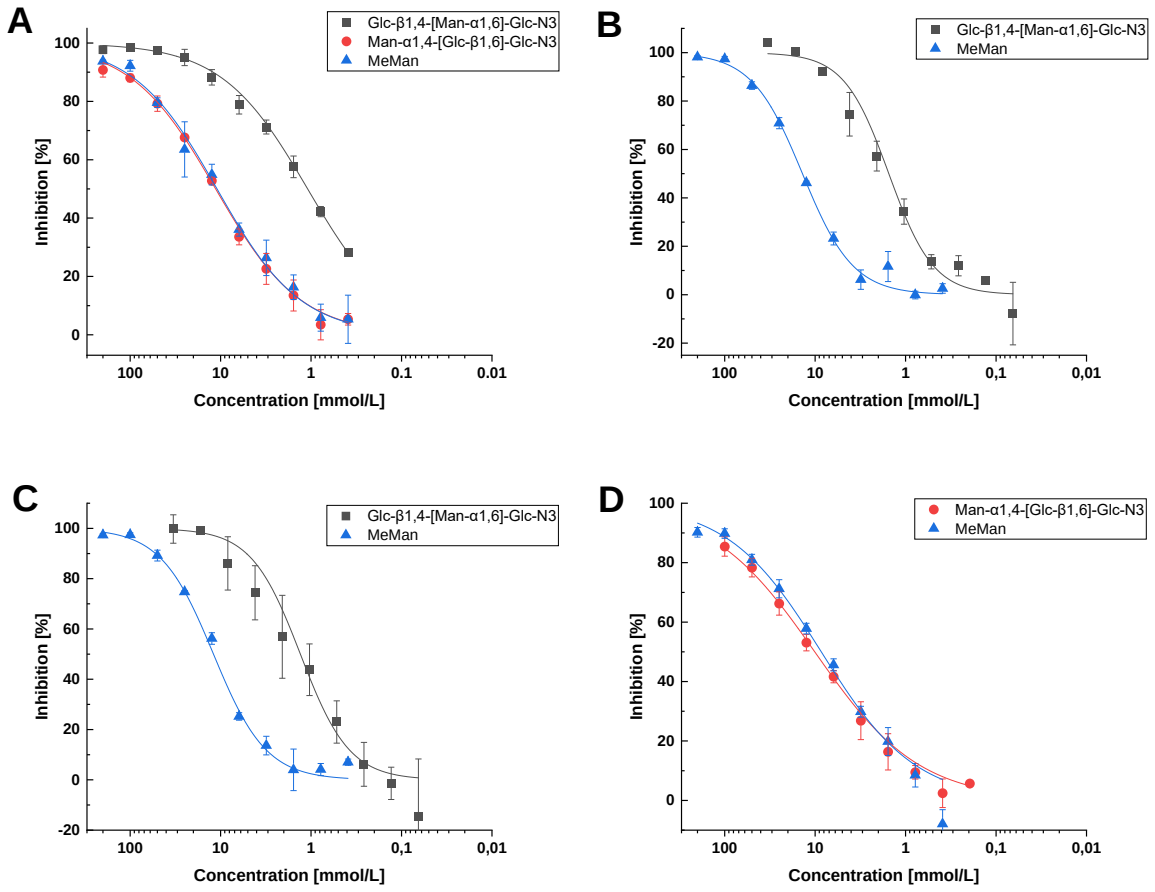


Figure S2. Adhesion-inhibition curves of MeMan, Man-α1,4-[Glc-β1,6]-Glc-βN_3 (**11**), Glc-β1,4-[Man-α1,6]-Glc-βN_3 (**10**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S1 IC_{50} values and corresponding RIP values deduced from the inhibition curves obtained with MeMan, Glc-β1,4-[Man-α1,6]-Glc-βN_3 (**10**) and Man-α1,4-[Glc-β1,6]-Glc-βN_3 (**11**) (Figure S2).

Plate	Entry	MeMan	Glc-β1,4-[Man-α1,6]-Glc-βN_3 (10)	Man-α1,4-[Glc-β1,6]-Glc-βN_3 (11)
A	IC_{50}[a] [mmol]	10.95 (±0.57)	1.09 (±0.02)	11.35 (±0.30)
	RIP[b]	1.00	10.04 (±0.75)	0.97 (±0.08)
B	IC_{50}[a] [mmol]	13.81 (±0.26)	1.53 (±0.44)	-
	RIP[b]	1.00	9.01 (±2.73)	-
C	IC_{50}[a] [mmol]	11.99 (±0.66)	1.31 (±0.15)	-
	RIP[b]	1.00	9.13 (±1.58)	-
D	IC_{50}[a] [mmol]	8.55 (±0.58)	-	10.10 (±0.60)
	RIP[b]	1.00	-	0.85 (±0.11)
	Mean RIP[c]	1.00	9.39 (±1.08)	0.91 (±0.07)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the following formula:

$$\Delta\mathrm{RIP} = \left|\frac{1}{\mathrm{IC_{50}(glycan)}}\cdot \Delta\mathrm{IC_{50}(MeMan)}\right| + \left|-\frac{\mathrm{IC_{50}(MeMan)}}{\mathrm{IC_{50}(glycan)^2}}\cdot \Delta\mathrm{IC_{50}(glycan)}\right|$$

c Mean RIP values of two or three independent experiments with error propagation using the following formula:

$$\Delta\text{Mean RIP} = \frac{1}{3}\sqrt{(\Delta\mathrm{RIP_A})^2 + (\Delta\mathrm{RIP_B})^2 + (\Delta\mathrm{RIP_C})^2} \text{ or } \Delta\text{Mean RIP} = \frac{1}{2}\sqrt{(\Delta\mathrm{RIP_A})^2 + (\Delta\mathrm{RIP_D})^2}$$

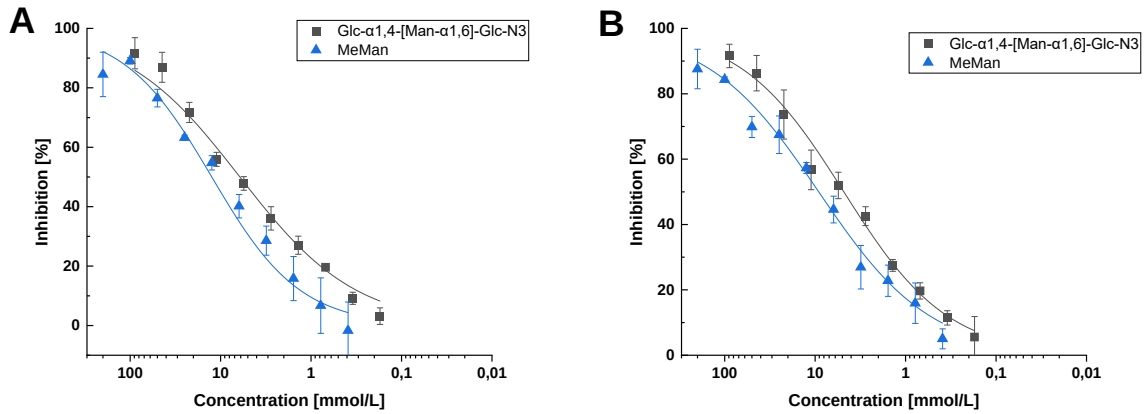


Figure S3. Adhesion-inhibition curves of MeMan, Glc-α1,4-[Man-α1,6]-Glc-βN_3 (**32**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S2 IC_{50} values and corresponding RIP values as deduced from the inhibition curves obtained with MeMan, Glc-α1,4-[Man-α1,6]-Glc-βN_3 (**32**) (Figure S3).

Plate	Entry	MeMan	Glc-α1,4-[Man-α1,6]-Glc-βN_3 (32)
A	IC_{50}[a] [mmol]	12.52 (±1.00)	6.12 (±0.57)
	RIP[b]	1.00	2.04 (±0.35)
B	IC_{50}[a] [mmol]	9.13 (±0.75)	4.82 (±0.31)
	RIP[b]	1.00	1.90 (±0.28)
	Mean RIP[c]	1.00	1.97 (±0.22)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the formula from table S1.

c Mean RIP values of two independent experiments with error propagation using the formula from Table S1.

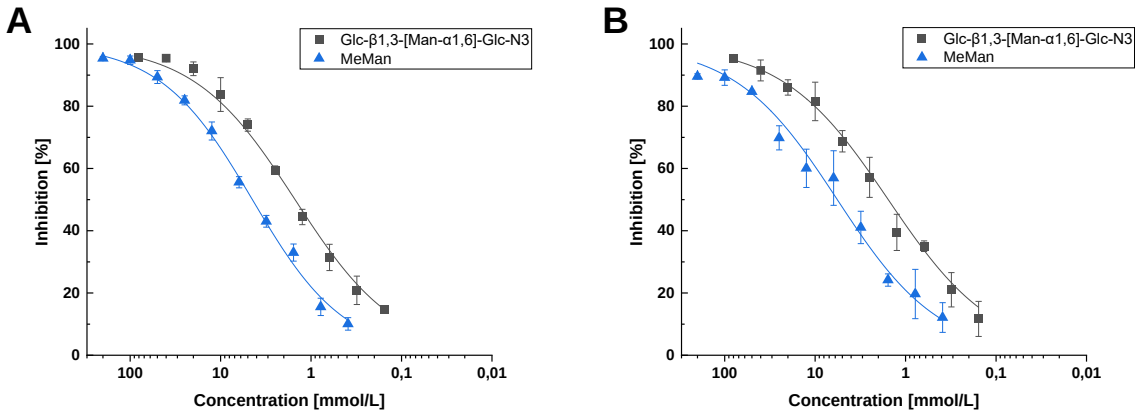


Figure S4. Adhesion-inhibition curves of MeMan, Glc-β1,3-[Man-α1,6]-Glc-βN_3 (**37**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S3 IC_{50} values and corresponding RIP values as deduced from the inhibition curves obtained with MeMan, Glc-β1,3-[Man-α1,6]-Glc-βN_3 (**37**) (Figure S4).

Plate	Entry	MeMan	Glc-β1,3-[Man-α1,6]-Glc-βN_3 (37)
A	IC_{50}[a] [mmol]	4.45 (±0.21)	1.50 (±0.11)
	RIP[b]	1.00	2.96 (±0.35)
B	IC_{50}[a] [mmol]	5.69 (±0.82)	1.56 (±0.08)
	RIP[b]	1.00	3.66 (±0.71)
	Mean RIP[c]	1.00	3.31 (±0.39)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the formula from table S1.

c Mean RIP values of two independent experiments with error propagation using the formula from Table S1.

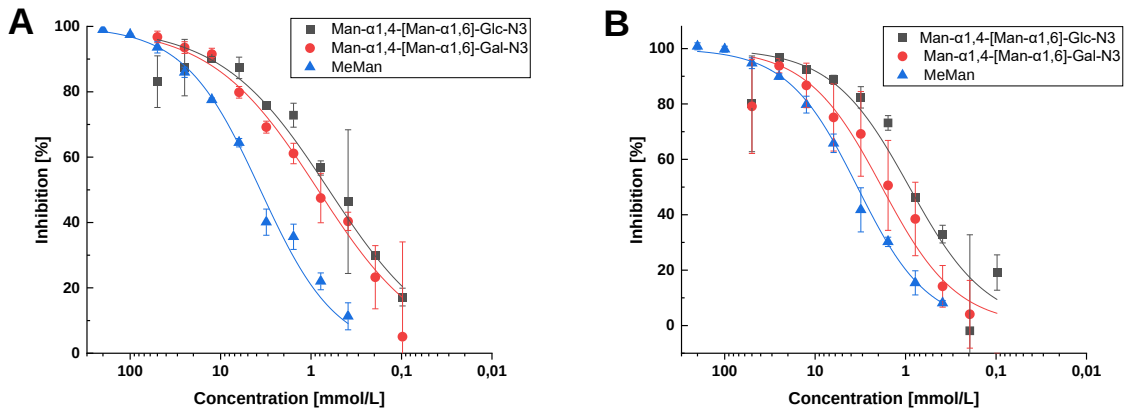


Figure S5. Adhesion-inhibition curves of MeMan, Man-α1,4-[Man-α1,6]-Glc-βN_3 (**26**), Man-α1,4-[Man-α1,6]-Gal-βN_3 (**27**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S4 IC_{50} values and corresponding RIP values as deduced from the inhibition curves obtained with MeMan, Man-α1,4-[Man-α1,6]-Glc-βN_3 (**26**), Man-α1,4-[Man-α1,6]-Gal-βN_3 (**27**) (Figure S5).

Plate	Entry	MeMan	Man-α1,4-[Man-α1,6]-Glc-βN_3 (26)	Man-α1,4-[Man-α1,6]-Gal-βN_3 (27)
A	IC_{50}[a] [mmol]	3.64 (±0.22)	0.63 (±0.02)	0.84 (±0.09)
	RIP[b]	1.00	5.72 (±0.57)	4.34 (±0.76)
B	IC_{50}[a] [mmol]	3.41 (±0.14)	0.91 (±0.01)	1.42 (±0.26)
	RIP[b]	1.00	3.75 (±0.21)	2.41 (±0.55)
	Mean RIP[c]	1.00	4.73 (±0.30)	3.37 (±0.47)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the formula from table S1.

c Mean RIP values of two independent experiments with error propagation using the formula from Table S1.

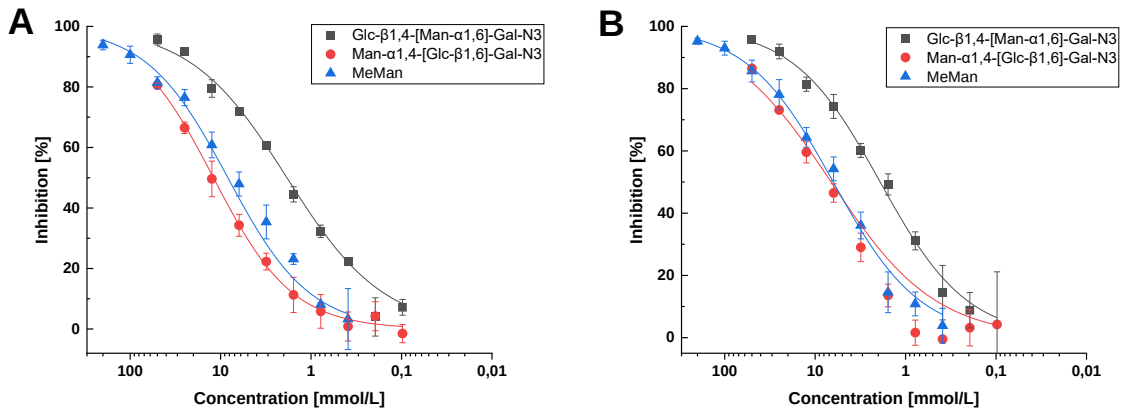


Figure S6. Adhesion-inhibition curves of MeMan, Glc-β1,4-[Man-α1,6]-Gal-βN_3 (**20**), Man-α1,4-[Glc-β1,6]-Gal-βN_3 (**21**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S5 IC_{50} values and corresponding RIP values as deduced from the inhibition curves obtained with MeMan, Glc-β1,4-[Man-α1,6]-Gal-βN_3 (**20**), Man-α1,4-[Glc-β1,6]-Gal-βN_3 (**21**) (Figure S6).

Plate	Entry	MeMan	Glc-β1,4-[Man-α1,6]-Gal-βN_3 (20)	Man-α1,4-[Glc-β1,6]-Gal-βN_3 (21)
A	IC_{50}[a] [mmol]	8.31 (±0.84)	1.85 (±0.04)	11.99 (±0.33)
	RIP[b]	1.00	4.50 (±0.56)	0.69 (±0.09)
B	IC_{50}[a] [mmol]	6.30 (± 0.39)	1.91 (±0.10)	6.65 (±0.64)
	RIP[b]	1.00	3.30 (±0.38)	0.95 (±0.15)
	Mean RIP[c]	1.00	3.90 (±0.34)	0.82 (±0.09)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the formula from table S1.

c Mean RIP values of two independent experiments with error propagation using the formula from Table S1.

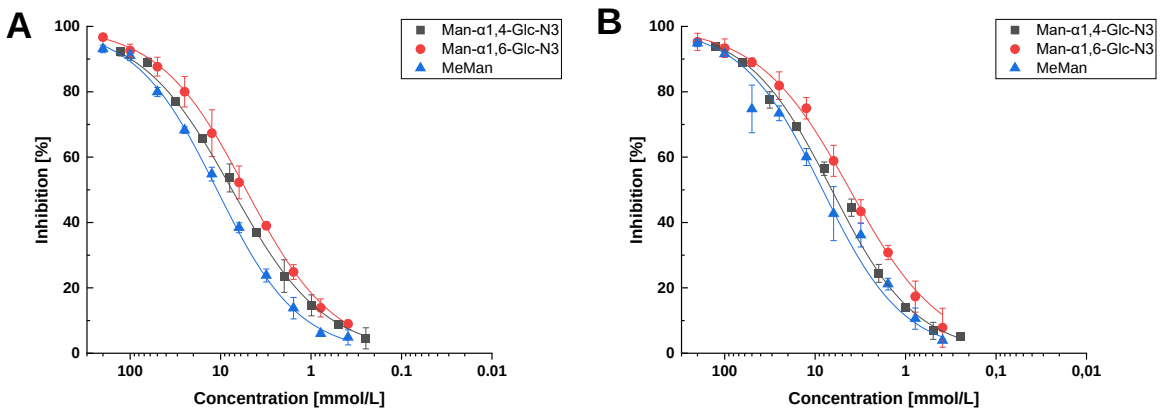


Figure S7. Adhesion-inhibition curves of MeMan, Man-α1,4-Glc-βN_3 (**S6**), Man-α1,6-Glc-βN_3 (**S1**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S6 IC_{50} values and corresponding RIP values as deduced from the inhibition curves obtained with MeMan, Man-α1,4-Glc-βN_3 (**S6**), Man-α1,6-Glc-βN_3 (**S1**) (Figure S7).

Plate	**Entry**	**MeMan**	**Man-α1,4-Glc-βN_3 (S6)**	**Man-α1,6-Glc-βN_3 (S1)**
A	IC_{50}[a] [mmol]	10.95 (±0.34)	7.47 (±0.11)	5.22 (±0.08)
	RIP[b]	1.00	1.47 (±0.07)	2.10 (±0.10)
B	IC_{50}[a] [mmol]	8.26 (±0.62)	6.56 (±0.08)	4.12 (±0.14)
	RIP[b]	1.00	1.26 (±0.11)	2.00 (±0.22)
	Mean RIP[c]	1.00	1.36 (±0.06)	2.05 (±0.12)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the formula from table S1.

c Mean RIP values of two independent experiments with error propagation using the formula from Table S1.

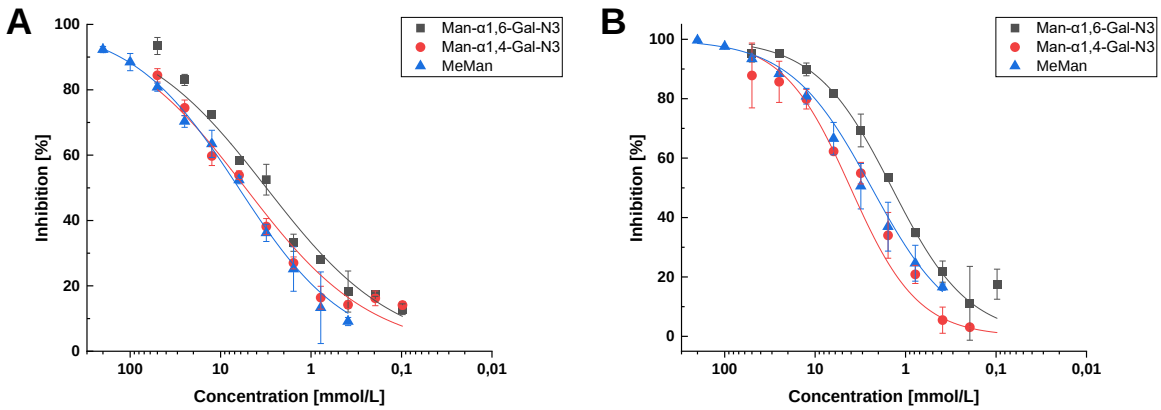


Figure S8. Adhesion-inhibition curves of MeMan, Man-α1,6-Gal-βN_3 (**45**), Man-α1,4-Gal-βN_3 (**S7**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S7. IC_{50} values and corresponding RIP values as deduced from the inhibition curves obtained with MeMan, Man-α1,6-Gal-βN_3 (**45**), Man-α1,4-Gal-βN_3 (**S7**) (Figure S8).

Plate	Entry	MeMan	Man-α1,6-Gal-βN_3 (45)	Man-α1,4-Gal-βN_3 (S7)
A	IC_{50}[a] [mmol]	6.32 (±0.37)	3.12 (±0.22)	5.32 (±0.78)
	RIP[b]	1.00	2.03 (±0.26)	1.19 (±0.24)
B	IC_{50}[a] [mmol]	2.37 (±0.24)	1.41 (±0.04)	4.06 (±0.20)
	RIP[b]	1.00	1.67 (±0.22)	0.58 (±0.09)
	Mean RIP[c]	1.00	1.85 (±0.17)	0.89 (±0.13)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the formula from table S1.

c Mean RIP values of two or three independent experiments with error propagation using the formula from Table S1.

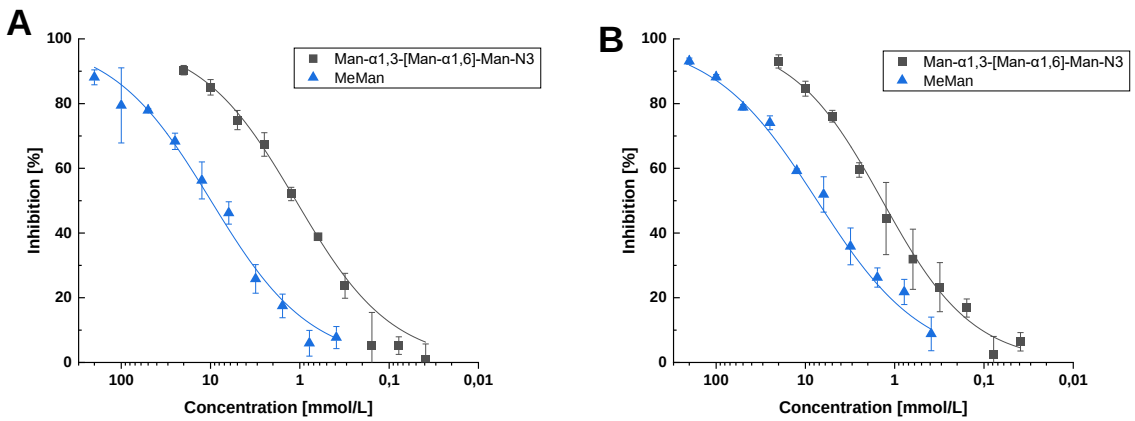


Figure S9. Adhesion-inhibition curves of MeMan, Man-α1,3-[Man-α1,6]-Man-βN_3 (**41**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S8. IC_{50} values and corresponding RIP values as deduced from the inhibition curves obtained with MeMan, Man-α1,3-[Man-α1,6]-Man-βN_3 (**41**) (Figure S9).

Plate	Entry	MeMan	Man-α1,3-[Man-α1,6]-Man-βN_3 (41)
A	IC_{50}[a] [mmol]	9.89 (±0.68)	1.11 (±0.03)
	RIP[b]	1.00	8.95 (±0.88)
B	IC_{50}[a] [mmol]	7.39 (±0.36)	1.38 (±0.10)
	RIP[b]	1.00	5.37 (±0.66)
	Mean RIP[c]	1.00	7.16 (±0.55)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the formula from table S1.

c Mean RIP values of two independent experiments with error propagation using the formula from Table S1.

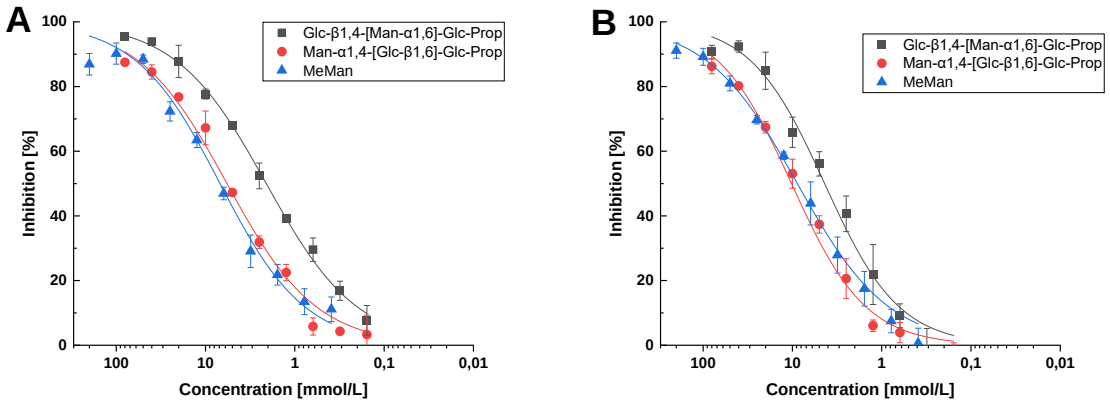


Figure S10. Adhesion-inhibition curves of MeMan, Glc-β1,4-[Man-α1,6]-Glc-βProp (**S3**), Man-α1,4-[Glc-β1,6]-Glc-βProp (**S2**) as inhibitor of type 1 fimbriae-mediated bacterial adhesion of *E. coli* bacteria (PKL1162) to mannan. As a reference MeMan was tested in parallel on the same plate. Sigmoidal dose-responsive inhibition curves were fitted by non-linear regression. Error bars are standard deviations from duplicate or triplicate results on one plate.

Table S9. IC_{50} values and corresponding RIP values as deduced from the inhibition curves obtained with MeMan, Glc-β1,4-[Man-α1,6]-Glc-βProp (**S3**), Man-α1,4-[Glc-β1,6]-Glc-βProp (**S2**) (Figure S10).

Plate	**Entry**	**MeMan**	**Glc-β1,4-[Man-α1,6]-Glc-βProp (S3)**	**Man-α1,4-[Glc-β1,6]-Glc-βProp (S2)**
A	IC_{50}[a] [mmol]	6.88 (±0.52)	2.09 (±0.04)	5.75 (±0.30)
	RIP[b]	1.00	3.29 (±0.31)	1.20 (±0.15)
B	IC_{50}[a] [mmol]	8.81 (±0.41)	4.36 (±0.54)	10.24 (±0.69)
	RIP[b]	1.00	2.02 (±0.35)	0.86 (±0.10)
	Mean RIP[c]	1.00	2.66 (±0.23)	1.03 (±0.09)

[a] IC_{50} values are average values of duplicate or triplicate results on one plate. The fitting error from non-linear regression is given in brackets.

[b] RIP values are based on the inhibitory potency of methyl α-D-mannopyranoside (MeMan) tested on the same 96 well microplate (IP (MeMan) ≡ 1); RIP(glycan) = IC_{50}(MeMan)/IC_{50}(glycan). Fitting errors in brackets are calculated by error propagation using the formula from table S1.

c Mean RIP values of two independent experiments with error propagation using the formula from Table S1.

4. Molecular Modelling

For molecular modelling the Schrödinger software package implementing the Maestro interface was used. Ligands were built using Maestro and prepared for docking using LigPrep and the OPLS4 force field. The crystal structure of FimH in its closed gate (pdb: 1UWF) conformation was constructed using the protein preparation wizard implemented in Maestro.

Induced fit docking

Induced fit docking (IFD) was performed using the standard IFD protocol with the OPLS4 force field. The receptor protein (FimH) was defined as an outer box of 36 Å around the centroid of the ligand as complexed within the binding site of FimH (pdb: 1UWF). A constraint was added to match the mannose core structure of butyl α-D-mannopyranoside in the crystal structure with a tolerance of 1.0 Å during docking. Ligands were set flexible and sampled for ring conformations with an energy window of 2.5 kcal mol^{-1}. Non-planar amide bonds were penalized. Glide redocking was performed with extra precision (XP) for structures within 30 kcal mol^{-1} of the best structure, employing a maximum of 20 top-ranked structures. Results are collected in Table S10.

The top five binding poses according to the IFD score ranking were subjected to a binding pose metadynamics simulation to determine the most stable protein-ligand complex. For each binding pose metadynamics simulations (10 trials of 10 ns) were performed and averaged. Then, the binding pose with the lowest metadynamics composite score was selected as the most stable one. Computed results are collected in Table S11 and in Figure S12 and graphical representations of computed binding poses are represented in Figure S11.

Calculation of binding energies was performed by subjecting the most stable binding poses from binding pose metadynamics simulations to a MM-GBSA (molecular mechanics generalized born surface area) calculation, giving the free binding energy ΔG_{Bind} in kcal mol^{-1}. The MM-GBSA calculations were performed using the VGSB solvation model and the OPLS4 force field. Results are reported in Table S12.

Table S10. Scoring values for IFD docking of glycans into the closed gate conformation of FimH (pdb: 1UWF).

glycan	IFD Score	docking score	XP HBond	glide evdw	glide lipo	glide ecoul	glide energy	glide emodel
Man-α1,4-Glc-βN3	-341.39	-10.215	-7.12	-18.63	-0.32	-33.35	-51.98	-77.23
Man-α1,4-Glc-βN3	-341.39	-10.203	-7.16	-18.05	-0.31	-31.22	-49.27	-76.01
Man-α1,4-Glc-βN3	-341.37	-10.229	-7.13	-16.51	-0.33	-31.37	-47.88	-75.57
Man-α1,4-Glc-βN3	-341.37	-10.180	-7.15	-18.33	-0.32	-35.52	-53.85	-78.22
Man-α1,4-Glc-βN3	-341.27	-9.938	-6.94	-18.35	-0.32	-33.35	-51.70	-78.05
Man-α1,4-Glc-βN3	-341.18	-10.085	-7.10	-19.11	-0.31	-30.60	-49.72	-78.75
Man-α1,4-Glc-βN3	-341.17	-10.048	-7.05	-18.23	-0.31	-28.57	-46.80	-74.05
Man-α1,4-Glc-βN3	-341.17	-10.161	-7.16	-19.09	-0.20	-34.98	-54.07	-78.81
Man-α1,4-Glc-βN3	-341.11	-9.999	-6.93	-19.14	-0.03	-30.50	-49.63	-78.55
Man-α1,4-Glc-βN3	-341.06	-9.982	-6.93	-18.86	-0.31	-32.84	-51.70	-81.31
Man-α1,4-Glc-βN3	-340.78	-9.578	-6.81	-19.69	-0.21	-32.19	-51.88	-73.98

Man-α1,4-Glc-βN3	-340.73	-9.502	-6.98	-14.46	-0.26	-36.64	-51.11	-72.79
Man-α1,4-Glc-βN3	-340.73	-9.749	-6.79	-19.50	-0.31	-37.55	-57.05	-82.80
Man-α1,4-Glc-βN3	-340.63	-9.775	-6.71	-21.61	-0.30	-34.05	-55.66	-73.56
Man-α1,4-Glc-βN3	-340.56	-9.599	-6.63	-17.05	-0.21	-35.56	-52.60	-72.73
Man-α1,4-Glc-βN3	-340.50	-9.353	-6.62	-16.26	-0.32	-35.34	-51.60	-76.86
Man-α1,4-Glc-βN3	-340.47	-9.739	-7.33	-13.24	-0.18	-39.91	-53.15	-81.95
Man-α1,4-Glc-βN3	-340.29	-9.342	-6.81	-15.59	-0.19	-36.18	-51.77	-83.03
Man-α1,4-Glc-βN3	-340.00	-9.368	-6.27	-18.26	-0.33	-36.38	-54.65	-73.73
Man-α1,6-Glc-βN3	-341.97	-10.612	-7.35	-21.89	-0.05	-39.82	-61.72	-92.71
Man-α1,6-Glc-βN3	-341.48	-9.992	-6.73	-21.77	-0.14	-33.72	-55.48	-80.76
Man-α1,6-Glc-βN3	-341.40	-10.168	-7.43	-19.04	-0.10	-37.45	-56.49	-79.31
Man-α1,6-Glc-βN3	-341.10	-9.819	-7.31	-17.57	-0.04	-37.87	-55.45	-77.89
Man-α1,6-Glc-βN3	-341.09	-9.740	-6.90	-20.36	-0.12	-33.33	-53.69	-82.20
Man-α1,6-Glc-βN3	-340.94	-9.446	-6.36	-20.43	-0.41	-34.51	-54.94	-79.59
Man-α1,6-Glc-βN3	-340.84	-9.512	-6.92	-20.29	-0.07	-34.98	-55.27	-79.33
Man-α1,6-Glc-βN3	-340.79	-9.670	-6.61	-22.20	-0.17	-32.67	-54.87	-83.19
Man-α1,6-Glc-βN3	-340.79	-9.671	-7.22	-16.30	-0.42	-38.27	-54.56	-85.59
Man-α1,6-Glc-βN3	-340.74	-9.289	-6.43	-21.51	-0.01	-38.37	-59.88	-93.26
Man-α1,6-Glc-βN3	-340.68	-9.113	-6.25	-16.86	-0.26	-40.01	-56.86	-82.01
Man-α1,6-Glc-βN3	-340.63	-9.328	-6.26	-18.68	-0.16	-38.05	-56.72	-87.35
Man-α1,6-Glc-βN3	-340.61	-9.606	-6.44	-20.47	-0.19	-35.19	-55.66	-81.79
Man-α1,6-Glc-βN3	-340.50	-9.030	-6.21	-19.17	-0.26	-37.23	-56.40	-80.05
Man-α1,6-Glc-βN3	-340.45	-8.952	-6.21	-19.16	-0.08	-37.14	-56.30	-81.88
Man-α1,6-Glc-βN3	-340.17	-9.124	-5.99	-19.32	-0.07	-33.42	-52.74	-80.07
Man-α1,6-Glc-βN3	-340.06	-8.736	-6.13	-23.35	-0.04	-32.92	-56.27	-77.88
Man-α1,6-Glc-βN3	-339.99	-9.169	-5.97	-23.49	-0.25	-34.93	-58.43	-88.24
Man-α1,6-Glc-βN3	-339.99	-9.052	-5.97	-19.26	-0.20	-37.37	-56.63	-81.91
Man-α1,6-Glc-βN3	-339.75	-8.764	-5.96	-17.63	-0.47	-34.68	-52.31	-75.67
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.25	-10.753	-7.40	-22.10	-0.47	-38.86	-60.96	-86.43
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.19	-10.781	-7.96	-20.51	-0.25	-37.19	-57.70	-92.18
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.17	-10.964	-7.46	-25.49	-0.62	-36.44	-61.92	-91.23
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.12	-10.927	-7.89	-25.11	-0.28	-41.18	-66.28	-93.44
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.10	-10.792	-7.34	-26.01	-0.26	-39.81	-65.82	-90.22
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.04	-10.859	-7.45	-25.91	-0.43	-41.38	-67.29	-95.18
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.98	-10.563	-7.20	-25.14	-0.38	-39.82	-64.96	-90.89
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.96	-10.433	-7.07	-22.79	-0.30	-39.17	-61.96	-87.39
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.88	-10.262	-6.73	-28.37	-0.29	-34.75	-63.12	-86.59
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.78	-11.068	-7.55	-27.44	-0.37	-36.48	-63.92	-93.45
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.71	-10.503	-7.27	-24.20	-0.43	-38.65	-62.85	-86.16
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.64	-10.442	-7.62	-19.16	-0.29	-35.48	-54.64	-90.88
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.61	-10.067	-7.30	-20.87	-0.47	-44.56	-65.42	-97.40
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.46	-10.620	-8.07	-21.71	-0.16	-45.23	-66.95	-102.36
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.43	-10.309	-7.42	-20.03	-0.36	-40.82	-60.85	-92.55
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.41	-10.219	-6.80	-28.01	-0.42	-40.74	-68.74	-96.97

Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.38	-9.857	-7.43	-15.45	-0.30	-47.15	-62.60	-95.30
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.31	-10.220	-7.77	-18.10	-0.51	-41.68	-59.78	-90.12
Man-α1,4-[Glc-β1,6]-Glc-βN3	-341.12	-10.431	-7.13	-25.23	-0.07	-36.76	-61.99	-89.11
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.93	-11.218	-8.11	-27.14	-0.02	-47.05	-74.19	-113.72
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.59	-10.944	-8.08	-22.59	-0.02	-49.85	-72.43	-112.35
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.57	-10.465	-7.64	-23.64	-0.30	-40.18	-63.82	-87.91
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.24	-10.117	-7.26	-23.28	-0.30	-42.31	-65.58	-100.53
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.21	-10.410	-7.59	-19.23	-0.27	-37.38	-56.61	-91.22
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.11	-10.012	-7.39	-19.47	-0.63	-41.52	-60.99	-86.46
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.04	-10.003	-7.29	-22.09	-0.58	-41.49	-63.58	-91.62
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.99	-10.423	-7.66	-20.38	-0.03	-49.56	-69.94	-110.78
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.85	-10.002	-6.71	-22.02	-0.30	-39.33	-61.34	-100.26
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.75	-10.320	-7.80	-23.55	-0.32	-35.45	-59.00	-89.67
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.60	-9.953	-7.77	-12.06	-0.30	-43.52	-55.57	-91.69
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.57	-10.407	-7.48	-25.06	-0.15	-35.28	-60.34	-96.89
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.29	-9.604	-6.14	-24.85	-0.43	-34.16	-59.01	-93.80
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.28	-9.987	-6.67	-24.02	-0.20	-35.57	-59.59	-92.26
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.26	-9.923	-6.86	-25.67	-0.02	-40.03	-65.70	-106.77
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.23	-9.486	-6.77	-23.32	-0.25	-37.23	-60.55	-85.36
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.10	-9.358	-6.83	-23.42	-0.22	-38.94	-62.35	-88.27
Glc-β1,4-[Man-α1,6]-Glc-βN3	-341.07	-9.435	-7.14	-15.27	-0.32	-44.75	-60.03	-80.63
Glc-β1,4-[Man-α1,6]-Glc-βN3	-340.88	-9.978	-6.77	-23.23	-0.36	-33.44	-56.67	-93.42
Glc-β1,4-[Man-α1,6]-Glc-βN3	-340.43	-8.879	-5.85	-26.70	-0.21	-39.61	-66.30	-97.88
Man-α1,4-[Man-α1,6]-Glc-βN3	-343.39	-11.958	-9.46	-17.29	-0.21	-47.63	-64.93	-96.78
Man-α1,4-[Man-α1,6]-Glc-βN3	-343.18	-11.479	-8.49	-20.21	-0.17	-42.68	-62.89	-101.86
Man-α1,4-[Man-α1,6]-Glc-βN3	-343.18	-11.160	-7.93	-22.50	-0.09	-40.02	-62.52	-109.14
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.95	-11.287	-8.65	-11.14	-0.49	-37.93	-49.07	-91.86
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.55	-10.636	-7.75	-21.02	-0.06	-44.52	-65.54	-108.28
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.43	-11.137	-8.45	-18.62	-0.32	-37.46	-56.08	-85.37
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.35	-10.676	-7.80	-15.92	-0.52	-36.78	-52.70	-93.88
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.28	-10.635	-7.59	-22.53	-0.15	-39.56	-62.09	-104.90
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.23	-10.905	-7.91	-31.63	-0.25	-40.05	-71.69	-102.81
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.18	-10.588	-7.22	-26.40	-0.10	-38.08	-64.48	-107.38
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.10	-11.041	-8.29	-12.78	-0.34	-38.84	-51.62	-84.77
Man-α1,4-[Man-α1,6]-Glc-βN3	-341.80	-10.432	-7.45	-24.07	-0.23	-36.31	-60.38	-90.96
Man-α1,4-[Man-α1,6]-Glc-βN3	-341.79	-10.393	-7.38	-25.72	0.00	-41.06	-66.78	-121.41
Man-α1,4-[Man-α1,6]-Glc-βN3	-341.77	-9.854	-6.92	-19.27	-0.04	-40.24	-59.50	-107.04
Man-α1,4-[Man-α1,6]-Glc-βN3	-341.62	-9.939	-7.23	-20.82	-0.46	-39.05	-59.88	-91.20
Man-α1,4-[Man-α1,6]-Glc-βN3	-341.59	-9.951	-7.25	-21.59	-0.41	-39.00	-60.59	-94.20
Man-α1,4-[Man-α1,6]-Glc-βN3	-341.46	-9.875	-7.67	-3.79	-0.48	-41.00	-44.79	-98.38
Man-α1,4-[Man-α1,6]-Glc-βN3	-341.09	-9.975	-7.62	-14.78	-0.30	-43.23	-58.01	-88.68
Man-α1,4-[Man-α1,6]-Glc-βN3	-341.00	-9.722	-7.08	-21.88	-0.06	-38.11	-59.99	-104.67
Man-α1,4-Gal-βN3	-341.42	-10.701	-7.73	-20.29	-0.21	-37.84	-58.12	-86.22
Man-α1,4-Gal-βN3	-341.32	-10.151	-7.20	-21.86	-0.22	-32.27	-54.14	-75.31

Man-α1,4-Gal-βN3	-341.25	-10.098	-7.69	-13.31	-0.25	-38.45	-51.76	-78.55
Man-α1,4-Gal-βN3	-341.24	-10.047	-7.54	-16.86	-0.22	-36.43	-53.29	-73.45
Man-α1,4-Gal-βN3	-341.21	-10.028	-7.51	-16.57	-0.20	-37.06	-53.63	-81.08
Man-α1,4-Gal-βN3	-341.12	-9.834	-7.06	-21.14	-0.21	-32.56	-53.70	-77.88
Man-α1,4-Gal-βN3	-341.00	-9.663	-6.97	-16.48	-0.24	-38.58	-55.06	-80.09
Man-α1,4-Gal-βN3	-340.96	-9.786	-7.14	-17.26	-0.24	-32.40	-49.66	-72.41
Man-α1,4-Gal-βN3	-340.95	-9.641	-6.62	-19.78	-0.23	-32.24	-52.02	-72.70
Man-α1,4-Gal-βN3	-340.79	-9.737	-7.20	-14.88	-0.22	-33.71	-48.59	-77.80
Man-α1,4-Gal-βN3	-340.63	-10.041	-6.66	-20.45	-0.17	-30.25	-50.70	-81.29
Man-α1,4-Gal-βN3	-340.50	-9.446	-6.94	-15.24	-0.24	-37.87	-53.11	-78.29
Man-α1,4-Gal-βN3	-340.48	-9.233	-6.55	-17.01	-0.27	-35.78	-52.79	-78.78
Man-α1,4-Gal-βN3	-340.34	-9.568	-6.91	-17.47	-0.16	-35.80	-53.28	-76.05
Man-α1,4-Gal-βN3	-340.30	-8.926	-6.10	-16.93	-0.24	-39.28	-56.21	-80.92
Man-α1,4-Gal-βN3	-340.14	-9.154	-6.54	-17.28	-0.22	-36.47	-53.75	-80.43
Man-α1,4-Gal-βN3	-339.90	-9.467	-6.95	-15.20	-0.21	-37.87	-53.07	-71.51
Man-α1,4-Gal-βN3	-339.14	-8.332	-5.83	-16.84	-0.21	-36.86	-53.70	-75.34
Man-α1,6-Gal-βN3	-341.00	-10.059	-7.36	-23.57	0.00	-37.18	-60.75	-84.12
Man-α1,6-Gal-βN3	-340.65	-9.179	-5.88	-20.96	-0.13	-38.71	-59.67	-95.04
Man-α1,6-Gal-βN3	-340.54	-9.329	-6.85	-16.80	-0.50	-41.08	-57.88	-83.85
Man-α1,6-Gal-βN3	-340.52	-9.207	-6.45	-18.19	-0.26	-33.52	-51.70	-83.49
Man-α1,6-Gal-βN3	-340.52	-9.245	-6.67	-17.89	-0.04	-35.21	-53.11	-78.04
Man-α1,6-Gal-βN3	-340.44	-8.919	-6.14	-16.80	-0.15	-35.95	-52.75	-87.62
Man-α1,6-Gal-βN3	-340.44	-9.221	-6.70	-18.01	-0.04	-38.93	-56.94	-80.62
Man-α1,6-Gal-βN3	-340.35	-8.893	-5.86	-20.97	-0.12	-32.59	-53.57	-80.39
Man-α1,6-Gal-βN3	-340.31	-9.124	-6.58	-18.35	-0.04	-34.99	-53.34	-78.55
Man-α1,6-Gal-βN3	-340.27	-8.940	-5.89	-21.35	-0.50	-32.90	-54.25	-84.91
Man-α1,6-Gal-βN3	-340.26	-9.283	-6.74	-18.60	-0.05	-39.49	-58.08	-82.91
Man-α1,6-Gal-βN3	-340.26	-8.921	-5.96	-19.24	-0.09	-33.19	-52.42	-75.72
Man-α1,6-Gal-βN3	-340.16	-8.937	-6.18	-16.20	-0.01	-38.64	-54.85	-85.03
Man-α1,6-Gal-βN3	-339.92	-8.811	-5.82	-20.39	-0.05	-34.15	-54.54	-78.82
Man-α1,6-Gal-βN3	-339.89	-8.848	-6.45	-15.01	-0.35	-37.69	-52.70	-74.77
Man-α1,6-Gal-βN3	-339.81	-8.504	-5.73	-17.96	-0.34	-37.84	-55.80	-85.11
Man-α1,6-Gal-βN3	-339.68	-8.318	-5.43	-13.99	-0.07	-40.30	-54.29	-79.14
Man-α1,6-Gal-βN3	-339.63	-8.614	-5.84	-16.19	0.00	-37.15	-53.35	-82.01
Man-α1,6-Gal-βN3	-339.58	-8.360	-5.50	-18.11	-0.34	-39.95	-58.06	-94.94
Man-α1,4-[Glc-β1,6]-Gal-βN3	-343.57	-12.437	-9.20	-25.21	-0.32	-39.00	-64.21	-108.11
Man-α1,4-[Glc-β1,6]-Gal-βN3	-343.53	-12.314	-9.44	-24.27	-0.34	-45.37	-69.64	-107.18
Man-α1,4-[Glc-β1,6]-Gal-βN3	-343.13	-12.078	-9.08	-25.18	-0.28	-34.97	-60.15	-91.71
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.86	-11.289	-8.49	-22.85	-0.26	-44.52	-67.37	-100.99
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.86	-11.824	-8.90	-23.28	-0.33	-45.67	-68.95	-97.15
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.85	-11.542	-8.50	-27.60	-0.25	-39.41	-67.01	-99.31
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.82	-11.491	-8.45	-26.11	-0.26	-39.03	-65.15	-100.49
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.79	-11.270	-8.45	-21.57	-0.18	-43.99	-65.56	-95.61
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.51	-11.237	-8.37	-18.81	-0.27	-42.18	-60.99	-103.59

Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.08	-10.983	-8.15	-27.14	-0.26	-34.29	-61.44	-87.72
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.00	-10.794	-7.93	-25.71	-0.27	-43.43	-69.14	-96.14
Man-α1,4-[Glc-β1,6]-Gal-βN3	-341.98	-10.511	-7.83	-18.73	-0.23	-38.09	-56.82	-95.15
Man-α1,4-[Glc-β1,6]-Gal-βN3	-341.95	-10.811	-7.94	-23.70	-0.34	-34.69	-58.39	-87.40
Man-α1,4-[Glc-β1,6]-Gal-βN3	-341.84	-10.877	-8.35	-19.98	-0.35	-45.83	-65.81	-104.18
Man-α1,4-[Glc-β1,6]-Gal-βN3	-341.81	-11.154	-8.08	-24.82	-0.25	-40.81	-65.63	-94.36
Man-α1,4-[Glc-β1,6]-Gal-βN3	-341.70	-10.676	-7.79	-23.63	-0.30	-44.50	-68.13	-97.61
Man-α1,4-[Glc-β1,6]-Gal-βN3	-341.58	-10.079	-7.56	-19.15	-0.30	-38.85	-58.00	-88.12
Man-α1,4-[Glc-β1,6]-Gal-βN3	-341.40	-10.615	-7.62	-24.78	-0.30	-38.21	-62.99	-95.50
Man-α1,4-[Glc-β1,6]-Gal-βN3	-341.37	-10.344	-7.61	-25.48	-0.28	-38.45	-63.93	-86.48
Man-α1,4-[Glc-β1,6]-Gal-βN3	-340.70	-9.684	-7.15	-19.82	-0.28	-42.40	-62.23	-85.50
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.66	-11.042	-8.22	-22.50	-0.46	-38.25	-60.75	-93.05
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.41	-10.544	-7.64	-21.30	-0.14	-40.11	-61.41	-89.85
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.35	-10.314	-7.42	-22.83	-0.39	-47.57	-70.40	-108.69
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.28	-10.411	-7.54	-22.04	-0.30	-46.80	-68.84	-98.46
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.19	-10.791	-8.09	-18.09	-0.46	-38.56	-56.65	-88.75
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.16	-10.304	-7.52	-19.88	-0.47	-43.87	-63.75	-92.94
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.83	-10.429	-7.40	-20.00	-0.17	-42.75	-62.74	-100.29
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.72	-9.890	-7.07	-20.93	-0.21	-44.07	-64.99	-98.45
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.70	-9.963	-7.06	-22.47	-0.53	-39.80	-62.26	-93.20
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.70	-10.386	-7.45	-23.83	-0.21	-39.01	-62.83	-89.57
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.62	-9.724	-6.58	-23.66	-0.34	-37.43	-61.09	-90.91
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.56	-10.424	-7.98	-17.59	-0.06	-44.31	-61.90	-91.96
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.53	-10.125	-7.28	-24.43	-0.06	-37.14	-61.57	-90.54
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.31	-10.195	-7.35	-20.88	-0.33	-39.40	-60.28	-96.88
Glc-β1,4-[Man-α1,6]-Gal-βN3	-341.15	-9.417	-6.07	-26.31	-0.31	-35.98	-62.30	-88.16
Glc-β1,4-[Man-α1,6]-Gal-βN3	-340.95	-9.126	-6.12	-26.26	-0.40	-34.79	-61.05	-87.84
Glc-β1,4-[Man-α1,6]-Gal-βN3	-340.91	-9.542	-7.11	-15.13	-0.44	-42.16	-57.29	-81.51
Glc-β1,4-[Man-α1,6]-Gal-βN3	-340.40	-9.345	-6.44	-26.07	-0.46	-34.94	-61.02	-89.51
Glc-β1,4-[Man-α1,6]-Gal-βN3	-340.04	-9.323	-6.36	-27.08	-0.40	-36.71	-63.79	-83.46
Man-α1,4-[Man-α1,6]-Gal-βN3	-343.99	-12.703	-8.93	-20.75	-0.21	-43.29	-64.04	-99.79
Man-α1,4-[Man-α1,6]-Gal-βN3	-342.26	-10.662	-8.05	-18.30	-0.21	-43.90	-62.20	-98.03
Man-α1,4-[Man-α1,6]-Gal-βN3	-342.24	-11.154	-8.64	-19.92	-0.22	-39.82	-59.74	-102.20
Man-α1,4-[Man-α1,6]-Gal-βN3	-342.09	-10.754	-7.87	-27.92	-0.18	-35.03	-62.95	-95.98
Man-α1,4-[Man-α1,6]-Gal-βN3	-341.83	-10.811	-7.77	-19.58	-0.19	-41.14	-60.72	-100.57
Man-α1,4-[Man-α1,6]-Gal-βN3	-341.80	-10.519	-7.68	-18.29	-0.24	-38.76	-57.04	-98.47
Man-α1,4-[Man-α1,6]-Gal-βN3	-341.66	-10.041	-7.22	-21.69	-0.19	-38.21	-59.90	-95.71
Man-α1,4-[Man-α1,6]-Gal-βN3	-341.34	-10.102	-7.56	-18.84	-0.02	-41.58	-60.42	-85.93
Man-α1,4-[Man-α1,6]-Gal-βN3	-341.20	-9.970	-7.17	-23.27	-0.02	-33.60	-56.88	-91.59
Man-α1,4-[Man-α1,6]-Gal-βN3	-341.08	-9.413	-6.72	-23.74	-0.25	-34.71	-58.45	-95.50
Man-α1,4-[Man-α1,6]-Gal-βN3	-341.08	-9.540	-7.05	-21.30	-0.27	-40.98	-62.28	-88.00
Man-α1,4-[Man-α1,6]-Gal-βN3	-340.97	-9.895	-7.40	-15.33	-0.19	-43.76	-59.09	-103.29
Man-α1,4-[Man-α1,6]-Gal-βN3	-340.97	-9.929	-7.06	-27.05	-0.21	-31.84	-58.90	-97.44
Man-α1,4-[Man-α1,6]-Gal-βN3	-340.91	-9.742	-7.48	-14.60	-0.22	-43.83	-58.42	-95.88

Man-α1,4-[Man-α1,6]-Gal-βN3	-340.90	-9.799	-7.58	-11.27	-0.02	-44.34	-55.61	-83.03
Man-α1,4-[Man-α1,6]-Gal-βN3	-340.77	-9.793	-7.46	-14.66	-0.14	-43.10	-57.76	-99.86
Man-α1,4-[Man-α1,6]-Gal-βN3	-340.72	-9.685	-7.45	-14.81	-0.02	-41.73	-56.54	-94.05
Man-α1,4-[Man-α1,6]-Gal-βN3	-340.70	-9.499	-6.96	-16.67	-0.20	-39.07	-55.74	-96.28
Man-α1,4-[Man-α1,6]-Gal-βN3	-340.64	-9.425	-6.78	-19.18	-0.19	-39.34	-58.53	-97.48
Man-α1,4-[Man-α1,6]-Gal-βN3	-340.56	-9.437	-7.19	-16.40	-0.16	-40.36	-56.76	-92.80
Glc-α1,4-[Man-α1,6]-Glc-βN3	-342.49	-10.838	-7.64	-18.90	-0.25	-49.09	-67.99	-114.86
Glc-α1,4-[Man-α1,6]-Glc-βN3	-342.40	-10.785	-6.85	-23.21	-0.15	-48.13	-71.34	-110.84
Glc-α1,4-[Man-α1,6]-Glc-βN3	-342.16	-10.364	-6.76	-28.26	-0.28	-32.88	-61.14	-81.24
Glc-α1,4-[Man-α1,6]-Glc-βN3	-342.07	-10.678	-5.32	-23.38	-0.54	-32.33	-55.71	-91.42
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.62	-9.923	-5.92	-26.18	-0.31	-30.97	-57.15	-82.17
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.62	-10.033	-5.88	-27.61	-0.43	-29.50	-57.11	-83.44
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.46	-9.924	-6.51	-20.19	-0.27	-41.20	-61.39	-94.00
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.33	-9.676	-5.92	-28.88	-0.37	-28.68	-57.56	-84.06
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.30	-9.983	-5.84	-21.80	-0.43	-37.52	-59.33	-87.49
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.23	-9.588	-5.59	-27.22	-0.56	-30.80	-58.02	-85.92
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.22	-9.517	-6.06	-27.25	-0.24	-30.26	-57.52	-81.10
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.21	-9.523	-5.93	-25.03	-0.63	-27.14	-52.17	-80.18
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.21	-9.863	-5.56	-29.30	-0.40	-30.15	-59.46	-85.26
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.13	-9.863	-5.76	-20.88	-0.46	-34.44	-55.31	-87.37
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.10	-9.410	-5.98	-26.88	-0.66	-31.90	-58.78	-79.69
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.10	-9.452	-6.22	-26.42	-0.43	-28.95	-55.38	-82.36
Glc-α1,4-[Man-α1,6]-Glc-βN3	-340.81	-9.569	-5.62	-27.01	-0.46	-35.00	-62.00	-89.62
Glc-α1,4-[Man-α1,6]-Glc-βN3	-340.71	-9.127	-5.87	-28.40	-0.41	-35.32	-63.71	-90.06
Glc-α1,4-[Man-α1,6]-Glc-βN3	-340.55	-9.708	-7.12	-12.29	-0.62	-34.06	-46.35	-85.61
Glc-α1,4-[Man-α1,6]-Glc-βN3	-340.40	-9.251	-5.06	-25.25	-0.49	-31.86	-57.10	-89.36
Glc-β1,3-[Man-α1,6]-Glc-βN3	-343.11	-11.103	-6.91	-9.73	-0.36	-42.45	-52.18	-96.19
Glc-β1,3-[Man-α1,6]-Glc-βN3	-343.05	-10.850	-7.99	-17.73	-0.37	-49.06	-66.78	-101.98
Glc-β1,3-[Man-α1,6]-Glc-βN3	-342.90	-10.863	-6.90	-16.86	-0.24	-40.43	-57.29	-97.73
Glc-β1,3-[Man-α1,6]-Glc-βN3	-342.44	-10.330	-7.46	-22.12	-0.38	-35.70	-57.82	-96.93
Glc-β1,3-[Man-α1,6]-Glc-βN3	-342.32	-10.635	-6.90	-18.52	-0.11	-34.56	-53.08	-89.78
Glc-β1,3-[Man-α1,6]-Glc-βN3	-342.14	-10.280	-7.36	-17.40	-0.07	-38.12	-55.51	-91.82
Glc-β1,3-[Man-α1,6]-Glc-βN3	-342.02	-10.014	-6.42	-14.59	-0.09	-40.15	-54.73	-97.13
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.90	-10.555	-7.05	-22.20	-0.27	-37.47	-59.67	-96.43
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.90	-10.264	-7.42	-18.02	-0.18	-40.84	-58.86	-95.29
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.87	-10.420	-8.16	-7.00	-0.20	-45.25	-52.26	-87.75
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.84	-10.159	-6.86	-23.93	-0.21	-40.19	-64.12	-103.12
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.76	-9.873	-5.62	-13.16	-0.36	-41.49	-54.66	-96.18
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.62	-10.024	-6.96	-21.33	-0.43	-45.30	-66.63	-99.99
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.60	-9.877	-7.07	-21.40	-0.33	-45.67	-67.08	-98.30
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.48	-10.124	-7.26	-14.36	-0.10	-40.10	-54.46	-96.97
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.40	-10.260	-5.83	-13.57	-0.12	-37.60	-51.17	-89.13
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.38	-9.848	-6.50	-19.61	-0.35	-43.72	-63.33	-90.48
Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.28	-9.590	-6.65	-18.26	-0.15	-39.20	-57.45	-92.36

Glc-β1,3-[Man-α1,6]-Glc-βN3	-341.08	-9.889	-6.98	-14.78	-0.11	-40.90	-55.68	-105.08
Glc-β1,3-[Man-α1,6]-Glc-βN3	-340.20	-8.926	-5.85	-21.65	-0.30	-31.39	-53.04	-90.17
Man-α1,3-[Man-α1,6]-Man-βN3	-342.77	-12.256	-10.10	-18.23	0.00	-56.30	-74.53	-118.94
Man-α1,3-[Man-α1,6]-Man-βN3	-342.76	-12.119	-10.09	-14.93	0.00	-57.73	-72.66	-112.45
Man-α1,3-[Man-α1,6]-Man-βN3	-342.72	-11.061	-8.08	-24.08	-0.19	-39.14	-63.22	-91.00
Man-α1,3-[Man-α1,6]-Man-βN3	-342.59	-11.580	-8.55	-23.38	-0.18	-40.02	-63.40	-96.63
Man-α1,3-[Man-α1,6]-Man-βN3	-342.45	-11.880	-10.07	-9.68	0.00	-58.45	-68.13	-114.82
Man-α1,3-[Man-α1,6]-Man-βN3	-342.34	-11.272	-8.30	-28.33	-0.24	-39.76	-68.09	-110.26
Man-α1,3-[Man-α1,6]-Man-βN3	-342.26	-10.510	-8.36	-18.25	-0.18	-44.37	-62.63	-96.66
Man-α1,3-[Man-α1,6]-Man-βN3	-342.23	-10.554	-8.22	-18.31	-0.24	-37.29	-55.60	-95.94
Man-α1,3-[Man-α1,6]-Man-βN3	-342.10	-10.610	-8.30	-20.60	-0.19	-37.97	-58.58	-91.24
Man-α1,3-[Man-α1,6]-Man-βN3	-342.00	-10.288	-7.73	-14.80	-0.14	-38.94	-53.73	-92.27
Man-α1,3-[Man-α1,6]-Man-βN3	-341.83	-10.852	-7.97	-19.72	-0.18	-44.92	-64.65	-94.87
Man-α1,3-[Man-α1,6]-Man-βN3	-341.74	-10.317	-8.06	-20.58	-0.18	-42.33	-62.92	-90.12
Man-α1,3-[Man-α1,6]-Man-βN3	-341.73	-11.151	-7.96	-24.01	-0.16	-40.93	-64.94	-99.85
Man-α1,3-[Man-α1,6]-Man-βN3	-341.58	-9.790	-7.60	-14.82	-0.11	-42.15	-56.97	-97.79
Man-α1,3-[Man-α1,6]-Man-βN3	-341.56	-10.282	-8.19	-16.44	-0.19	-41.33	-57.77	-92.07
Man-α1,3-[Man-α1,6]-Man-βN3	-341.28	-10.113	-7.80	-17.77	-0.20	-43.57	-61.34	-90.41
Man-α1,3-[Man-α1,6]-Man-βN3	-341.01	-10.219	-7.64	-21.80	-0.20	-37.54	-59.34	-91.40
Man-α1,3-[Man-α1,6]-Man-βN3	-340.96	-10.349	-7.69	-22.59	-0.25	-38.26	-60.85	-84.03
Man-α1,3-[Man-α1,6]-Man-βN3	-340.93	-10.460	-7.36	-28.08	-0.10	-36.67	-64.75	-91.15
Man-α1,3-[Man-α1,6]-Man-βN3	-340.68	-10.375	-7.20	-23.18	-0.29	-40.72	-63.90	-95.63
Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.29	-11.520	-7.66	-30.30	-0.42	-41.26	-71.56	-107.84
Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.06	-11.200	-7.69	-26.46	-0.42	-39.93	-66.39	-99.02
Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.05	-11.175	-8.07	-22.91	-0.58	-37.41	-60.32	-98.37
Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.03	-11.338	-7.66	-29.50	-0.46	-38.78	-68.28	-101.89
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.93	-11.354	-7.58	-27.91	-0.31	-39.00	-66.91	-97.50
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.93	-11.235	-7.41	-29.13	-0.28	-37.24	-66.37	-100.04
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.69	-11.130	-7.74	-25.84	-0.35	-41.76	-67.60	-97.00
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.68	-11.096	-7.56	-23.93	-0.47	-36.11	-60.04	-91.22
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.66	-10.931	-7.69	-23.53	-0.61	-38.83	-62.35	-93.91
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.62	-11.093	-7.48	-25.18	-0.21	-39.72	-64.90	-92.81
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.57	-10.627	-7.65	-21.54	-0.45	-41.05	-62.59	-97.78
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.41	-10.643	-7.64	-21.17	-0.21	-39.30	-60.47	-91.64
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.40	-10.467	-7.43	-21.78	-0.41	-40.94	-62.73	-88.19
Man-α1,4-[Glc-β1,6]-Glc-βProp	-341.93	-10.479	-7.66	-19.77	-0.29	-42.27	-62.04	-95.66
Man-α1,4-[Glc-β1,6]-Glc-βProp	-341.92	-9.730	-7.35	-16.45	-0.57	-41.78	-58.24	-90.85
Man-α1,4-[Glc-β1,6]-Glc-βProp	-341.90	-10.468	-7.03	-26.05	-0.15	-34.68	-60.73	-86.16
Man-α1,4-[Glc-β1,6]-Glc-βProp	-341.82	-9.973	-6.91	-23.21	-0.52	-30.94	-54.15	-82.75
Man-α1,4-[Glc-β1,6]-Glc-βProp	-341.81	-9.791	-6.79	-18.48	-0.62	-42.21	-60.69	-90.57
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.55	-11.484	-8.14	-26.43	-0.13	-42.71	-69.13	-99.49
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.34	-11.535	-7.96	-28.96	-0.12	-42.45	-71.41	-96.23
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.13	-11.045	-7.32	-28.94	-0.08	-40.63	-69.57	-103.43
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.07	-11.058	-8.29	-19.28	-0.58	-45.14	-64.43	-102.10

Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.05	-11.398	-7.63	-31.29	-0.04	-39.97	-71.27	-105.47
Glc-β1,4-[Man-α1,6]-Glc-βProp	-342.49	-9.911	-6.84	-23.16	-0.19	-38.61	-61.76	-87.32
Glc-β1,4-[Man-α1,6]-Glc-βProp	-342.32	-10.702	-6.61	-23.98	-0.47	-37.24	-61.22	-106.56
Glc-β1,4-[Man-α1,6]-Glc-βProp	-342.26	-10.624	-6.58	-23.33	-0.43	-38.02	-61.35	-101.86
Glc-β1,4-[Man-α1,6]-Glc-βProp	-342.24	-10.355	-7.11	-25.46	-0.20	-39.13	-64.59	-97.80
Glc-β1,4-[Man-α1,6]-Glc-βProp	-342.17	-10.331	-6.90	-23.82	-0.04	-42.52	-66.34	-111.25
Glc-β1,4-[Man-α1,6]-Glc-βProp	-342.08	-10.174	-7.31	-22.87	-0.17	-36.45	-59.32	-92.74
Glc-β1,4-[Man-α1,6]-Glc-βProp	-341.98	-9.861	-7.00	-23.44	-0.42	-39.81	-63.25	-90.45
Glc-β1,4-[Man-α1,6]-Glc-βProp	-341.77	-10.430	-7.46	-21.87	-0.18	-43.88	-65.75	-90.65
Glc-β1,4-[Man-α1,6]-Glc-βProp	-341.59	-9.632	-6.98	-21.74	-0.04	-37.63	-59.37	-90.30
Glc-β1,4-[Man-α1,6]-Glc-βProp	-341.54	-9.753	-5.81	-25.06	-0.32	-35.92	-60.98	-93.10
Glc-β1,4-[Man-α1,6]-Glc-βProp	-341.50	-9.790	-7.40	-17.12	-0.36	-39.10	-56.22	-82.19
Glc-β1,4-[Man-α1,6]-Glc-βProp	-341.45	-9.419	-6.58	-20.26	-0.25	-40.01	-60.27	-88.05

Table S11. Scoring values of binding pose metadynamcis calculation for the top five scoring binding poses from IFD. A lower composite (comp.) score correlates to a more stable protein-ligand complex.

Glycan	IFD Score	Comp. Score	Pose Score	Persis-tence	Persis-tence Length	Persis-tence Sum	HBond Persis-tence	HBond Persis-tence Length	HBond Persis-tence Sum
Man-α1,4-Glc-βN3	-341.27	-2.707	1.395	0.820	8.000	6.564	0.820	8.000	6.564
Man-α1,4-Glc-βN3	-341.39	-2.580	1.550	0.826	8.000	6.609	0.826	8.000	6.609
Man-α1,4-Glc-βN3	-341.37	-2.525	1.498	0.805	8.000	6.436	0.805	8.000	6.436
Man-α1,4-Glc-βN3	-341.39	-2.300	1.246	0.709	9.000	6.382	0.709	9.000	6.382
Man-α1,4-Glc-βN3	-341.37	-1.947	1.629	0.715	9.000	6.436	0.715	9.000	6.436
Man-α1,6-Glc-βN3	-341.09	-1.819	2.755	0.915	8.000	7.318	0.915	8.000	7.318
Man-α1,6-Glc-βN3	-341.48	-1.296	2.886	0.836	8.000	6.691	0.836	8.000	6.691
Man-α1,6-Glc-βN3	-341.10	-0.839	3.326	0.833	8.000	6.664	0.833	8.000	6.664
Man-α1,6-Glc-βN3	-341.40	-0.655	3.532	0.838	8.000	6.700	0.838	8.000	6.700
Man-α1,6-Glc-βN3	-341.97	-0.574	2.542	0.623	11.000	6.855	0.623	11.000	6.855
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.25	-1.788	2.235	0.805	8.000	6.436	0.805	8.000	6.436
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.17	-1.220	2.557	0.756	9.000	6.800	0.756	9.000	6.800
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.12	-1.130	2.814	0.789	9.000	7.100	0.789	9.000	7.100
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.19	-0.730	3.043	0.755	9.000	6.791	0.755	9.000	6.791
Man-α1,4-[Glc-β1,6]-Glc-βN3	-342.10	-0.049	3.582	0.726	9.000	6.536	0.726	9.000	6.536
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.21	-1.690	2.237	0.785	10.000	7.855	0.785	10.000	7.855
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.24	-0.731	2.632	0.673	10.000	6.727	0.673	10.000	6.727
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.57	-0.126	3.118	0.649	11.000	7.136	0.649	11.000	7.136
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.59	-0.073	3.191	0.653	11.000	7.182	0.653	11.000	7.182
Glc-β1,4-[Man-α1,6]-Glc-βN3	-342.93	0.350	3.594	0.649	11.000	7.136	0.649	11.000	7.136
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.55	-1.943	1.688	0.726	10.000	7.264	0.726	10.000	7.264
Man-α1,4-[Man-α1,6]-Glc-βN3	-343.39	-0.869	2.370	0.648	11.000	7.127	0.648	11.000	7.127
Man-α1,4-[Man-α1,6]-Glc-βN3	-343.18	-0.845	2.515	0.672	11.000	7.391	0.672	11.000	7.391
Man-α1,4-[Man-α1,6]-Glc-βN3	-343.18	-0.806	2.503	0.662	10.000	6.618	0.662	10.000	6.618

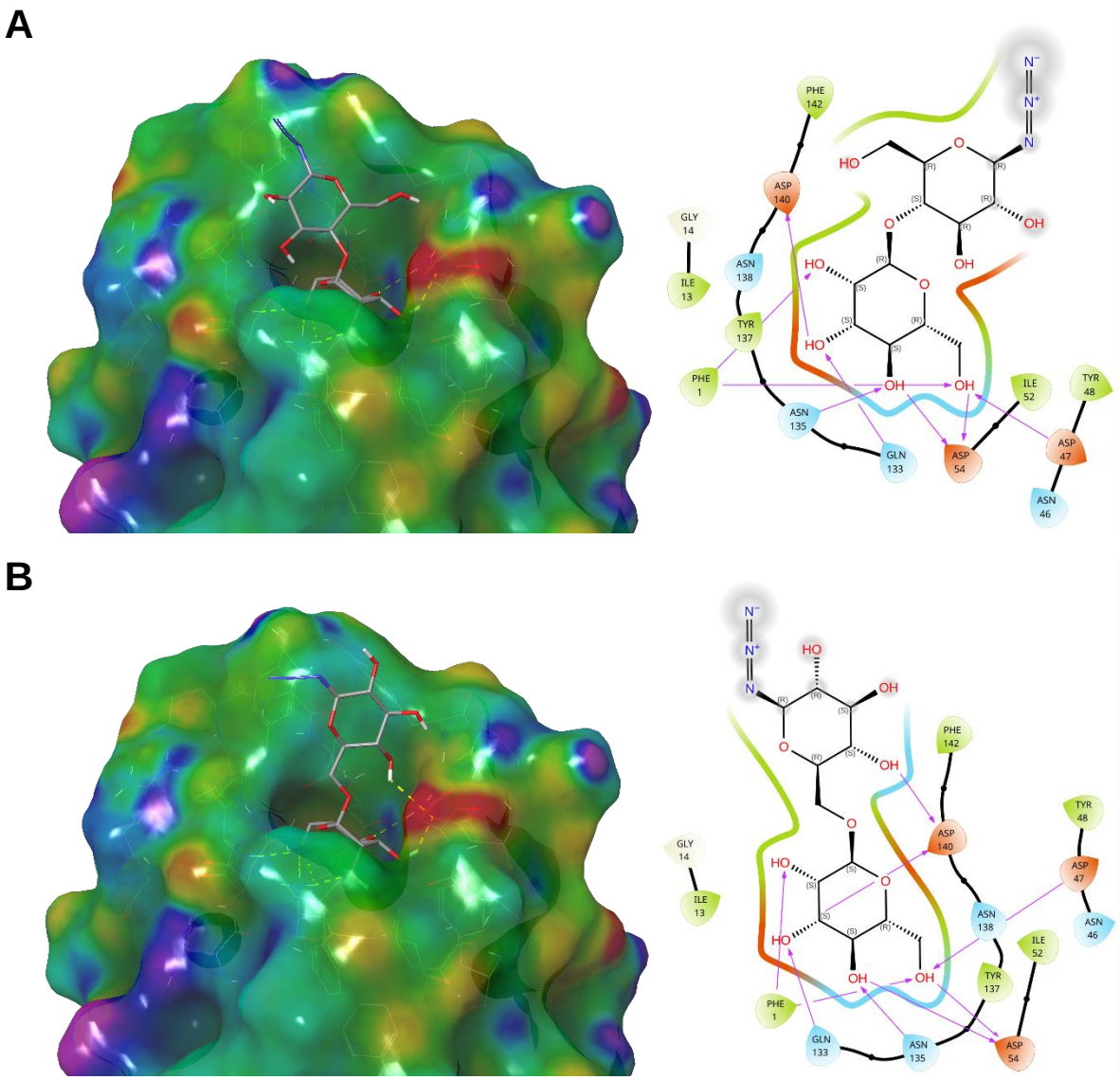
Man-α1,4-[Man-α1,6]-Glc-βN3	-342.95	-0.044	3.206	0.650	8.000	5.200	0.650	8.000	5.200
Man-α1,4-Gal-βN3	-341.24	-2.182	1.585	0.754	9.000	6.782	0.754	9.000	6.782
Man-α1,4-Gal-βN3	-341.25	-2.142	1.585	0.745	9.000	6.709	0.745	9.000	6.709
Man-α1,4-Gal-βN3	-341.32	-2.023	2.136	0.832	8.000	6.655	0.832	8.000	6.655
Man-α1,4-Gal-βN3	-341.21	-1.928	1.743	0.734	9.000	6.609	0.734	9.000	6.609
Man-α1,4-Gal-βN3	-341.42	-1.916	1.847	0.753	9.000	6.773	0.753	9.000	6.773
Man-α1,6-Gal-βN3	-340.52	-2.655	1.549	0.841	8.000	6.727	0.841	8.000	6.727
Man-α1,6-Gal-βN3	-340.65	-2.161	1.738	0.780	9.000	7.018	0.780	9.000	7.018
Man-α1,6-Gal-βN3	-340.54	-0.013	3.830	0.769	9.000	6.918	0.769	9.000	6.918
Man-α1,6-Gal-βN3	-340.52	0.088	3.435	0.669	8.000	5.355	0.669	8.000	5.355
Man-α1,6-Gal-βN3	-341.00	0.447	4.169	0.744	8.000	5.955	0.744	8.000	5.955
Man-α1,4-[Glc-β1,6]-Gal-βN3	-343.13	-0.928	2.688	0.723	9.000	6.509	0.723	9.000	6.509
Man-α1,4-[Glc-β1,6]-Gal-βN3	-343.57	-0.465	2.880	0.669	10.000	6.691	0.669	10.000	6.691
Man-α1,4-[Glc-β1,6]-Gal-βN3	-343.53	-0.195	3.341	0.707	10.000	7.073	0.707	10.000	7.073
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.86	0.156	3.251	0.619	11.000	6.809	0.619	11.000	6.809
Man-α1,4-[Glc-β1,6]-Gal-βN3	-342.86	0.335	3.459	0.625	11.000	6.873	0.625	11.000	6.873
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.35	-3.239	1.564	0.961	9.000	8.645	0.961	9.000	8.645
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.41	-3.001	1.640	0.928	9.000	8.355	0.928	9.000	8.355
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.28	-2.996	1.645	0.928	9.000	8.355	0.928	9.000	8.355
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.19	-2.904	1.641	0.909	9.000	8.182	0.909	9.000	8.182
Glc-β1,4-[Man-α1,6]-Gal-βN3	-342.66	-2.757	1.398	0.831	10.000	8.309	0.831	10.000	8.309
Man-α1,4-[Man-α1,6]-Gal-βN3	-341.83	-2.589	2.133	0.944	9.000	8.500	0.944	9.000	8.500
Man-α1,4-[Man-α1,6]-Gal-βN3	-343.99	-1.540	2.001	0.708	11.000	7.791	0.708	11.000	7.791
Man-α1,4-[Man-α1,6]-Gal-βN3	-342.26	-1.271	2.152	0.685	10.000	6.845	0.685	10.000	6.845
Man-α1,4-[Man-α1,6]-Gal-βN3	-342.24	0.433	3.938	0.701	9.000	6.309	0.701	9.000	6.309
Man-α1,4-[Man-α1,6]-Gal-βN3	-342.09	0.986	4.195	0.642	10.000	6.418	0.642	10.000	6.418
Glc-α1,4-[Man-α1,6]-Glc-βN3	-341.46	-2.680	1.120	0.760	10.000	7.600	0.760	10.000	7.600
Glc-α1,4-[Man-α1,6]-Glc-βN3	-342.49	-1.756	2.224	0.796	9.000	7.164	0.796	9.000	7.164
Glc-α1,4-[Man-α1,6]-Glc-βN3	-342.40	-1.674	1.971	0.729	10.000	7.291	0.729	10.000	7.291
Glc-α1,4-[Man-α1,6]-Glc-βN3	-340.55	-1.259	3.116	0.875	8.000	7.000	0.875	8.000	7.000
Glc-α1,4-[Man-α1,6]-Glc-βN3	-342.07	-0.523	3.326	0.770	9.000	6.927	0.770	9.000	6.927
Glc-β1,3-[Man-α1,6]-Glc-βN3	-342.90	-0.011	3.448	0.692	10.000	6.918	0.692	10.000	6.918
Glc-β1,3-[Man-α1,6]-Glc-βN3	-343.05	0.139	3.205	0.613	11.000	6.745	0.613	11.000	6.745
Glc-β1,3-[Man-α1,6]-Glc-βN3	-342.32	0.437	4.119	0.736	9.000	6.627	0.736	9.000	6.627
Glc-β1,3-[Man-α1,6]-Glc-βN3	-343.11	0.474	3.527	0.611	11.000	6.718	0.611	11.000	6.718
Glc-β1,3-[Man-α1,6]-Glc-βN3	-342.44	1.664	5.037	0.675	10.000	6.745	0.675	10.000	6.745
Man-α1,3-[Man-α1,6]-Man-βN3	-342.59	-1.365	2.736	0.820	9.000	7.382	0.820	9.000	7.382
Man-α1,3-[Man-α1,6]-Man-βN3	-342.72	0.661	4.134	0.695	10.000	6.945	0.695	10.000	6.945
Man-α1,3-[Man-α1,6]-Man-βN3	-342.77	1.233	4.452	0.644	11.000	7.082	0.644	11.000	7.082
Man-α1,3-[Man-α1,6]-Man-βN3	-342.45	1.675	4.902	0.645	11.000	7.100	0.645	11.000	7.100
Man-α1,3-[Man-α1,6]-Man-βN3	-342.76	1.876	5.203	0.665	11.000	7.318	0.665	11.000	7.318
Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.06	-1.483	2.476	0.792	9.000	7.127	0.792	9.000	7.127
Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.29	-1.162	2.727	0.778	9.000	7.000	0.778	9.000	7.000
Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.03	-0.980	2.873	0.771	9.000	6.936	0.771	9.000	6.936

Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.05	-0.919	3.581	0.900	8.000	7.200	0.900	8.000	7.200
Man-α1,4-[Glc-β1,6]-Glc-βProp	-342.93	-0.710	3.083	0.759	9.000	6.827	0.759	9.000	6.827
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.55	-1.899	2.212	0.822	9.000	7.400	0.822	9.000	7.400
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.07	-1.788	2.798	0.917	9.000	8.255	0.917	9.000	8.255
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.05	-0.694	2.922	0.723	9.000	6.509	0.723	9.000	6.509
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.34	-0.555	2.817	0.675	10.000	6.745	0.675	10.000	6.745
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.13	-0.392	2.517	0.582	11.000	6.400	0.582	11.000	6.400

Table S12. Values of computed binding energies ΔG_{Bind} (in kcal mol^{-1}) obtained from MM-GBSA calculations for the respective glycans into the closed gate (pdb: 1UWF) conformation of FimH. Most stable binding poses from IFD ranked by binding pose metadynamics simulations were selected.

Glycan	IFD Score	ΔG_{Bind}	$\Delta G_{Bind\_Coulomb}$	$\Delta G_{Bind\_Covalent}$	ΔG_{Bind_Hbond}	ΔG_{Bind_Lipo}	$\Delta G_{Bind\_Solv\ GB}$	ΔG_{Bind_vdW}	Lig Strain Energy
Man-α1,4-Glc-βN_3	-341.27	-55.65	-55.69	6.86	-6.64	-13.17	38.81	-25.81	11.128
Man-α1,6-Glc-βN_3	-341.09	-58.34	-53.86	4.25	-7.33	-12.58	34.92	-23.74	12.298
Man-α1,4-[Glc-β1,6]-Glc-βN_3	-342.25	-67.51	-56.63	0.86	-6.44	-14.09	39.30	-30.52	7.486
Glc-β1,4-[Man-α1,6]-Glc-βN_3	-342.21	-53.89	-60.21	2.68	-7.67	-11.43	44.90	-22.15	13.803
Man-α1,4-[Man-α1,6]-Glc-βN_3	-343.39	-67.43	-60.19	4.94	-9.22	-16.00	38.54	-25.50	14.303
Man-α1,4-Gal-βN_3	-341.24	-54.14	-55.33	5.97	-6.79	-11.39	34.33	-20.94	11.363
Man-α1,6-Gal-βN_3	-340.52	-61.34	-57.47	3.74	-7.05	-12.38	34.50	-22.69	8.196
Man-α1,4-[Glc-β1,6]-Gal-βN_3	-343.13	-58.13	-53.87	3.98	-8.72	-13.08	44.04	-30.48	14.209
Glc-β1,4-[Man-α1,6]-Gal-βN_3	-342.35	-72.76	-59.09	0.17	-8.71	-15.80	41.72	-31.05	11.684
Man-α1,4-[Man-α1,6]-Gal-βN_3	-341.83	-62.39	-48.41	0.53	-8.04	-16.72	40.30	-30.04	13.362
Glc-α1,4-[Man-α1,6]-Glc-βN_3	-341.46	-62.04	-53.30	1.05	-8.65	-12.29	41.04	-29.89	13.461
Glc-β1,3-[Man-α1,6]-Glc-βN_3	-342.90	-73.04	-66.97	2.02	-7.83	-17.90	44.87	-27.23	10.607
Man-α1,3-[Man-α1,6]-Man-βN_3	-342.59	-54.10	-45.53	5.09	-7.87	-14.30	37.67	-29.17	17.646
Man-α1,4-[Glc-β1,6]-Glc-βProp	-343.06	-64.56	-48.38	6.54	-7.23	-16.81	33.83	-32.51	20.396
Glc-β1,4-[Man-α1,6]-Glc-βProp	-343.55	-61.17	-53.13	11.70	-8.08	-17.68	37.73	-31.71	21.685

Figure S11. FimH-glycan complexes as derived from induced fit docking (IFD) using the closed gate conformation of FimH (pdb: 1UWF). Top scoring poses from binding pose metadynamics simulation (Table S11) were selected. On the left side, Connolly surface representations are shown. Protein coloring represents the electrostatic potential of the surface (positive charges in purple, neutral in green, negative charges in red). Hydrogen bonds are indicated as dashed lines. On the right side, two-dimensional representations of the protein ligand interactions are shown. The hydrogen bond network is shown in magenta, π-cation interactions are shown in red. FimH amino acids are represented teardrop-shaped in feature-related colours: red: negatively charged; light blue: polar; green: hydrophobic. The polypeptide chain is indicated as black line and the mannose binding pocket as multi-coloured line (interruption indicates solvent exposure). Grey shades indicated solvent exposure. A) Man-α1,4-Glc-βN_3 **S6** B) Man-α1,6-Glc-βN_3 **S1** C) Man-α1,4-[Glc-β1,6]-Glc-βN_3 **11** D) Glc-β1,4-[Man-α1,6]-Glc-βN_3 **10** E) Man-α1,4-[Man-α1,6]-Glc-βN_3 **26** F) Man-α1,4-Gal-βN_3 **S7** G) Man-α1,6-Gal-βN_3 **45** H) Man-α1,4-[Glc-β1,6]-Gal-βN_3 **21** I) Glc-β1,4-[Man-α1,6]-Gal-βN_3 **20** J) Man-α1,4-[Man-α1,6]-Gal-βN_3 **27** K) Glc-α1,4-[Man-α1,6]-Glc-βN_3 **32** L) Glc-β1,3-[Man-α1,6]-Glc-βN_3 **37** M) Man-α1,3-[Man-α1,6]-Man-βN_3 **41** N) Man-α1,4-[Glc-β1,6]-Glc-βProp **S2** O) Glc-β1,4-[Man-α1,6]-Glc-βProp **S3**.



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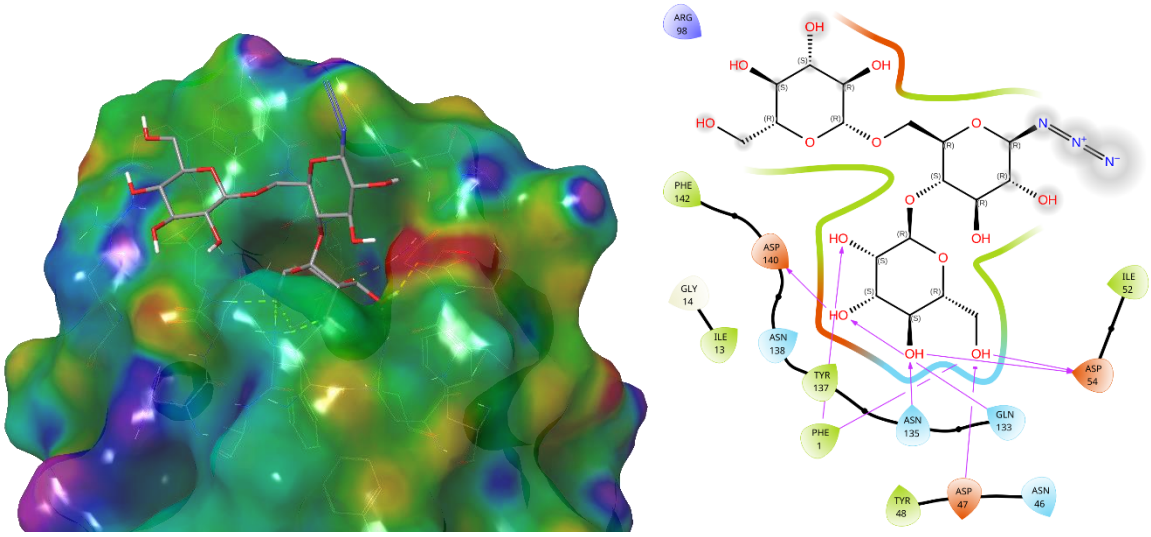
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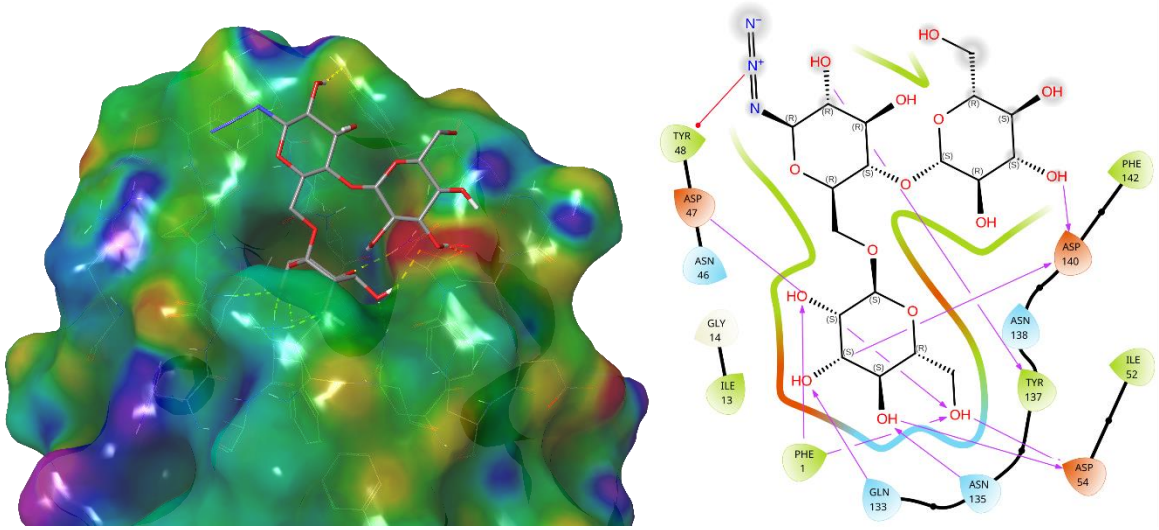
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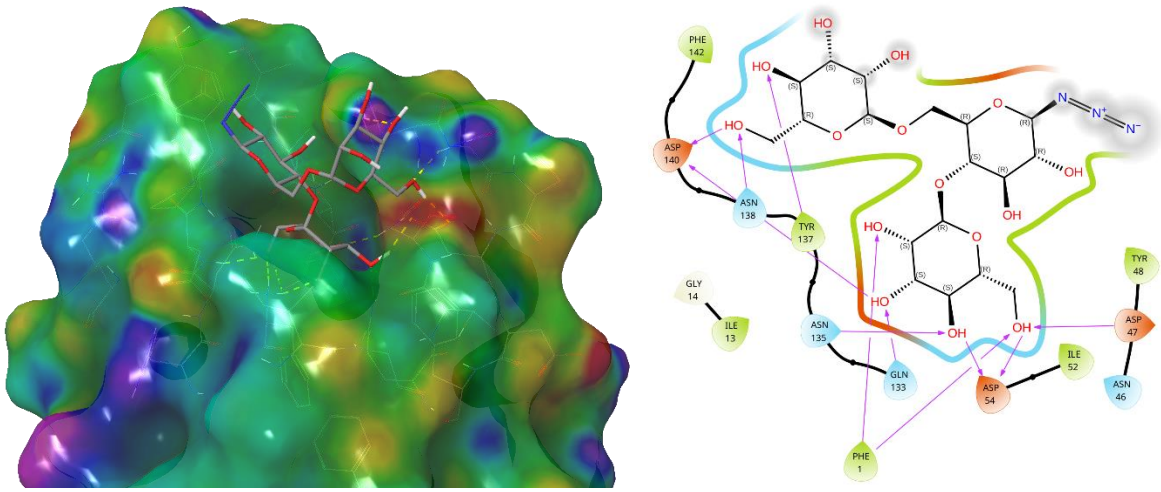
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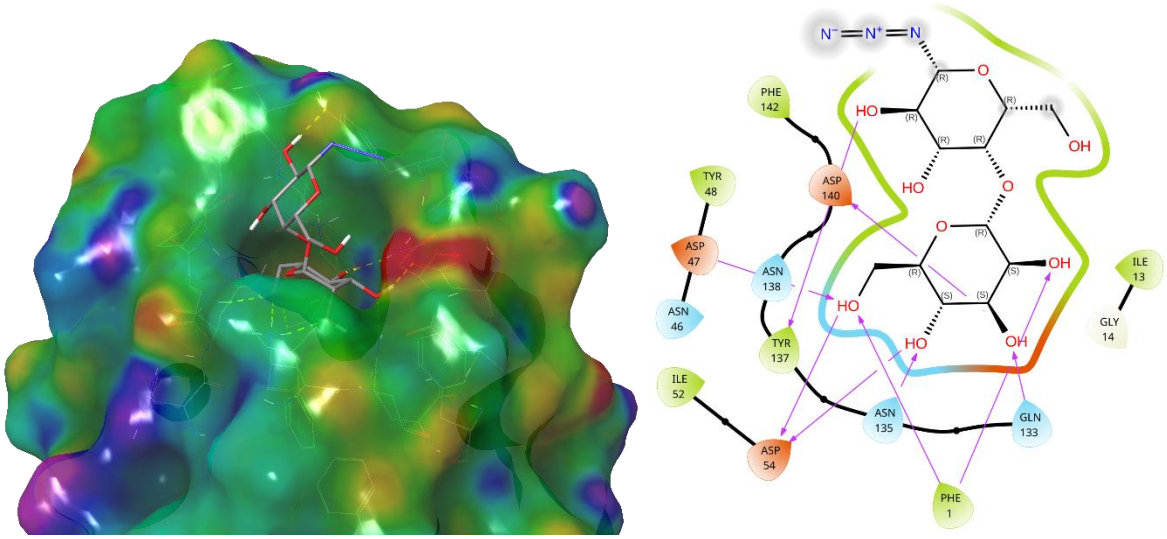
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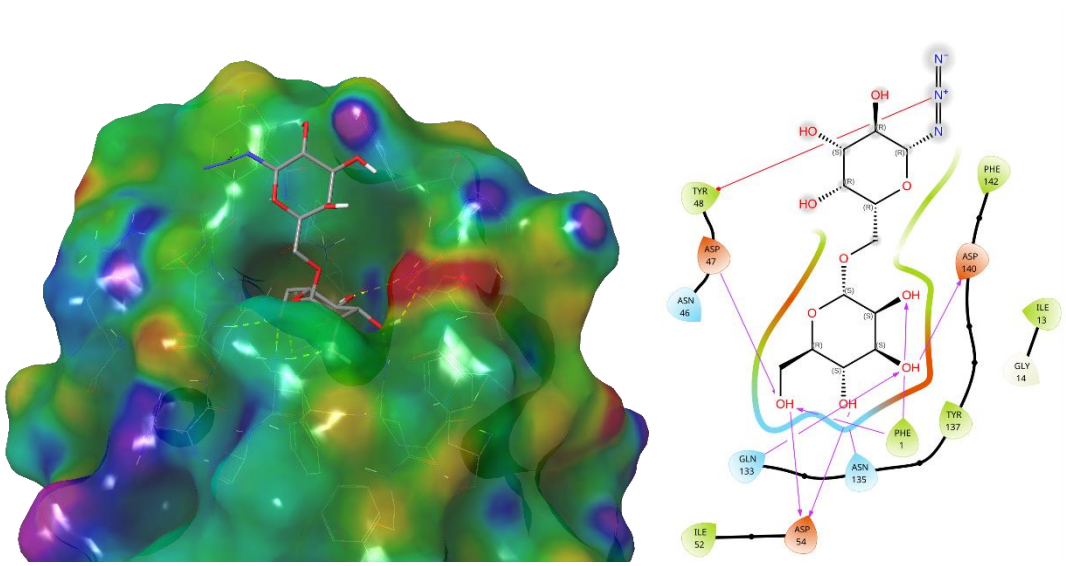
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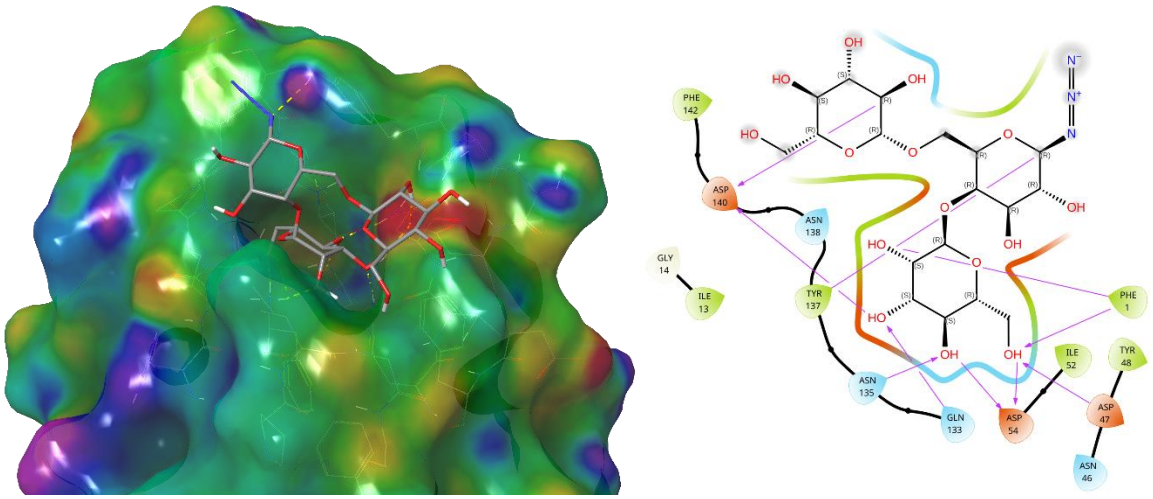
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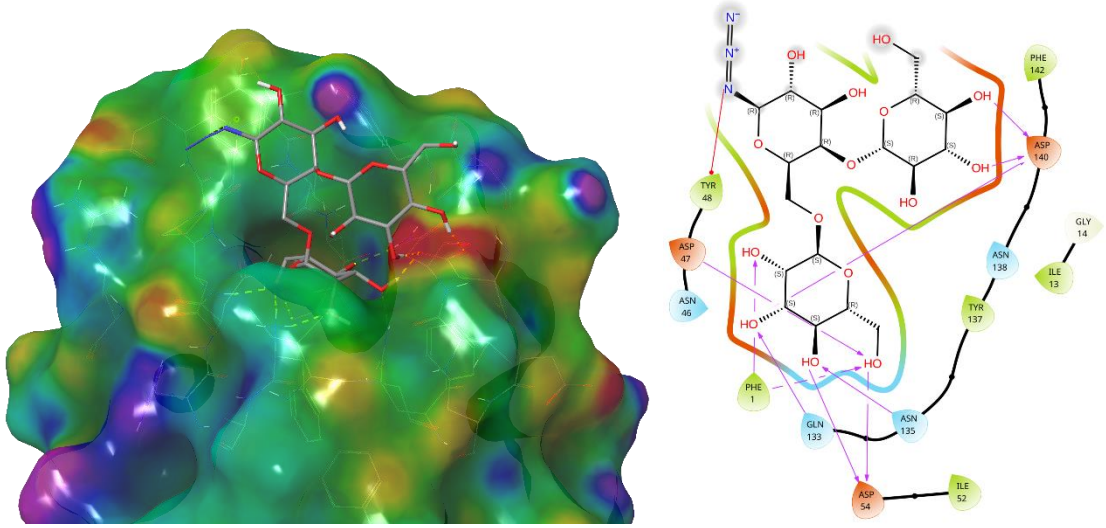
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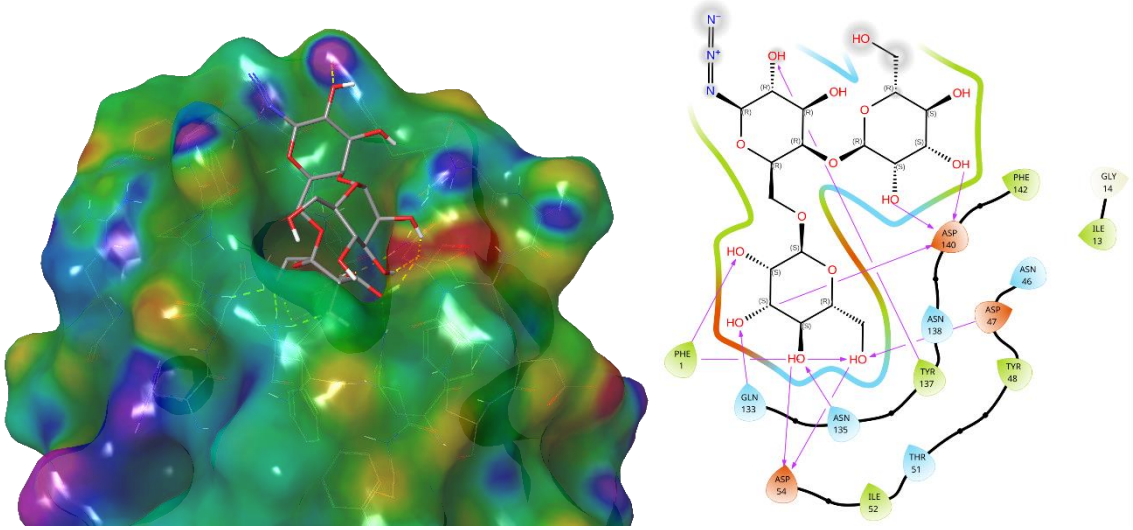
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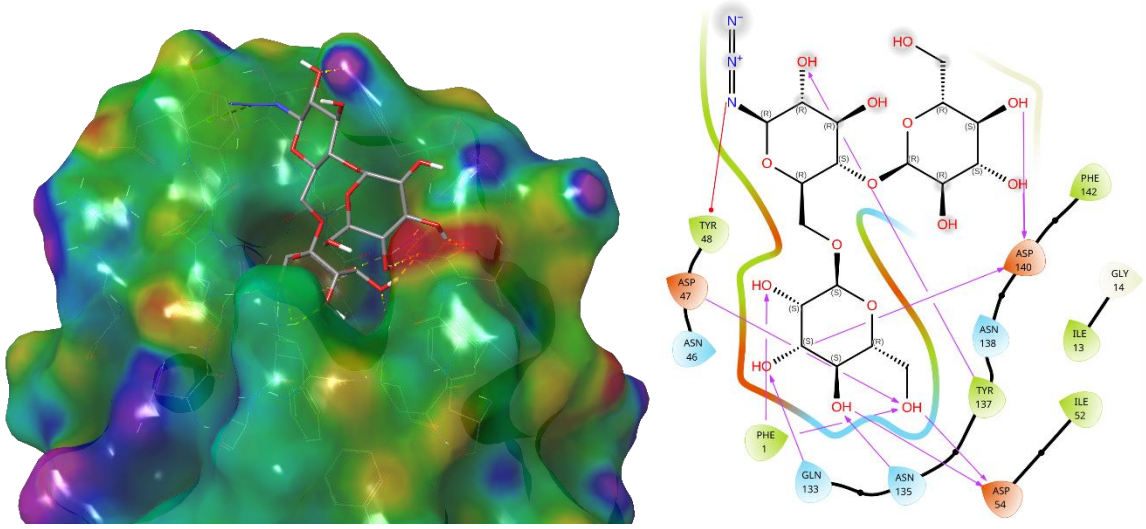
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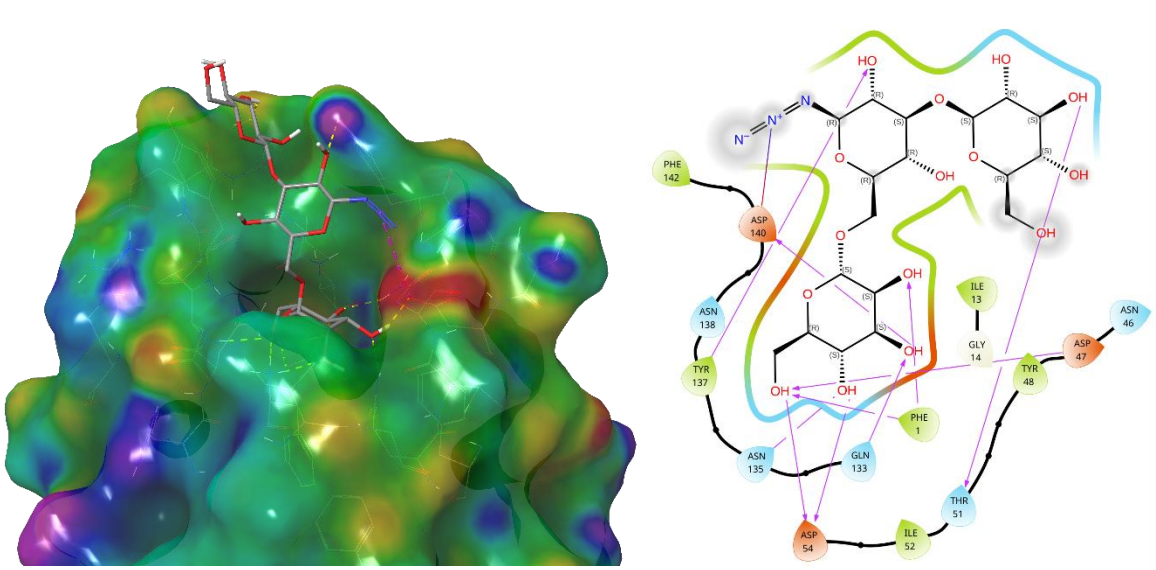
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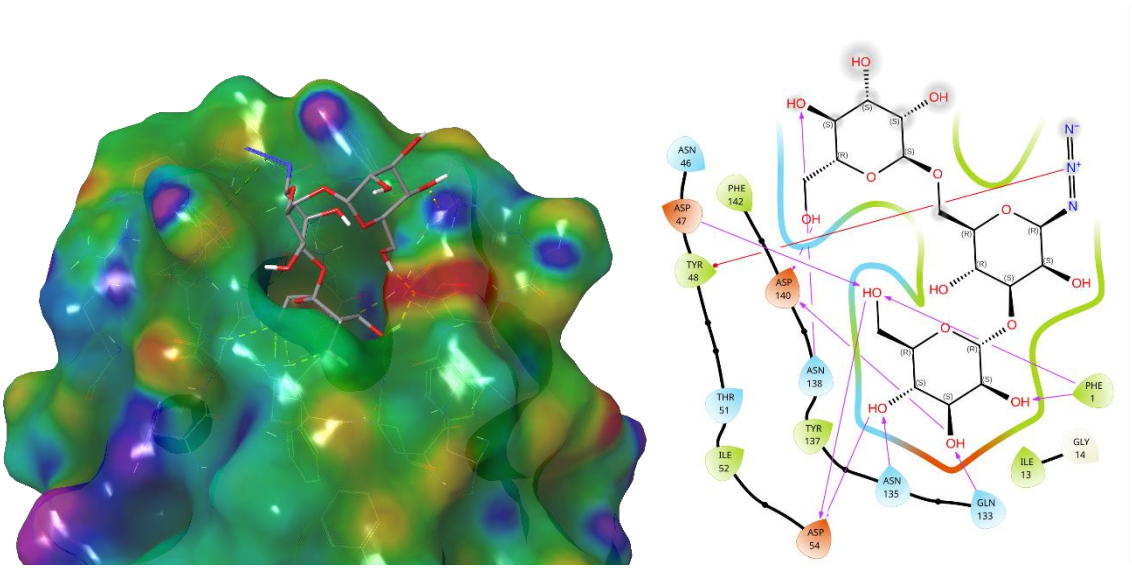
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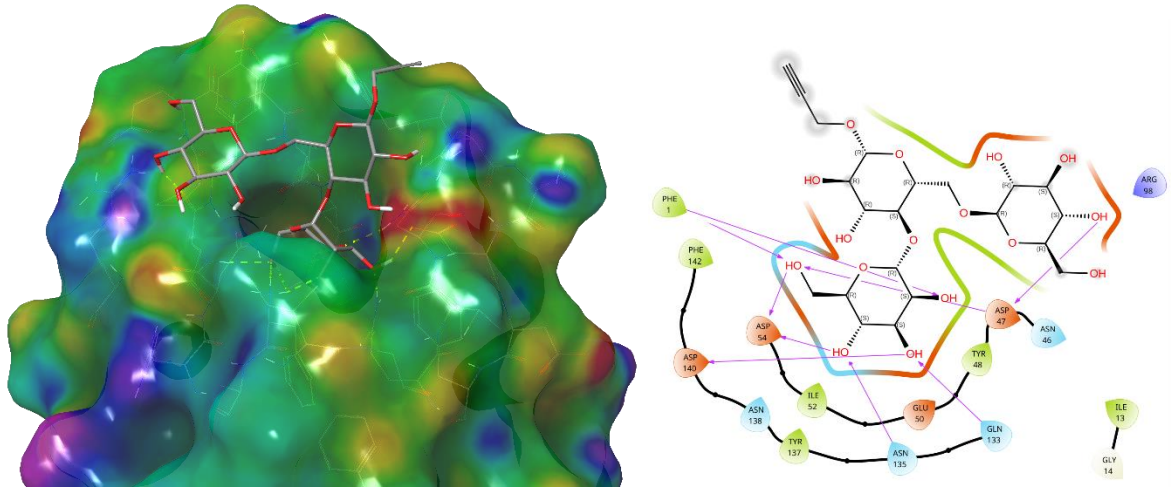
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GLY 14

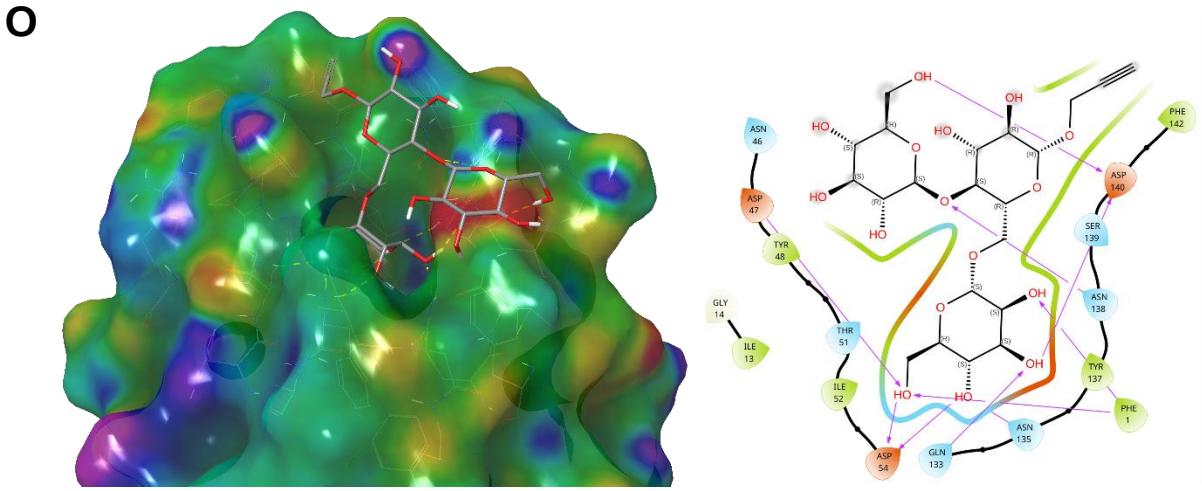
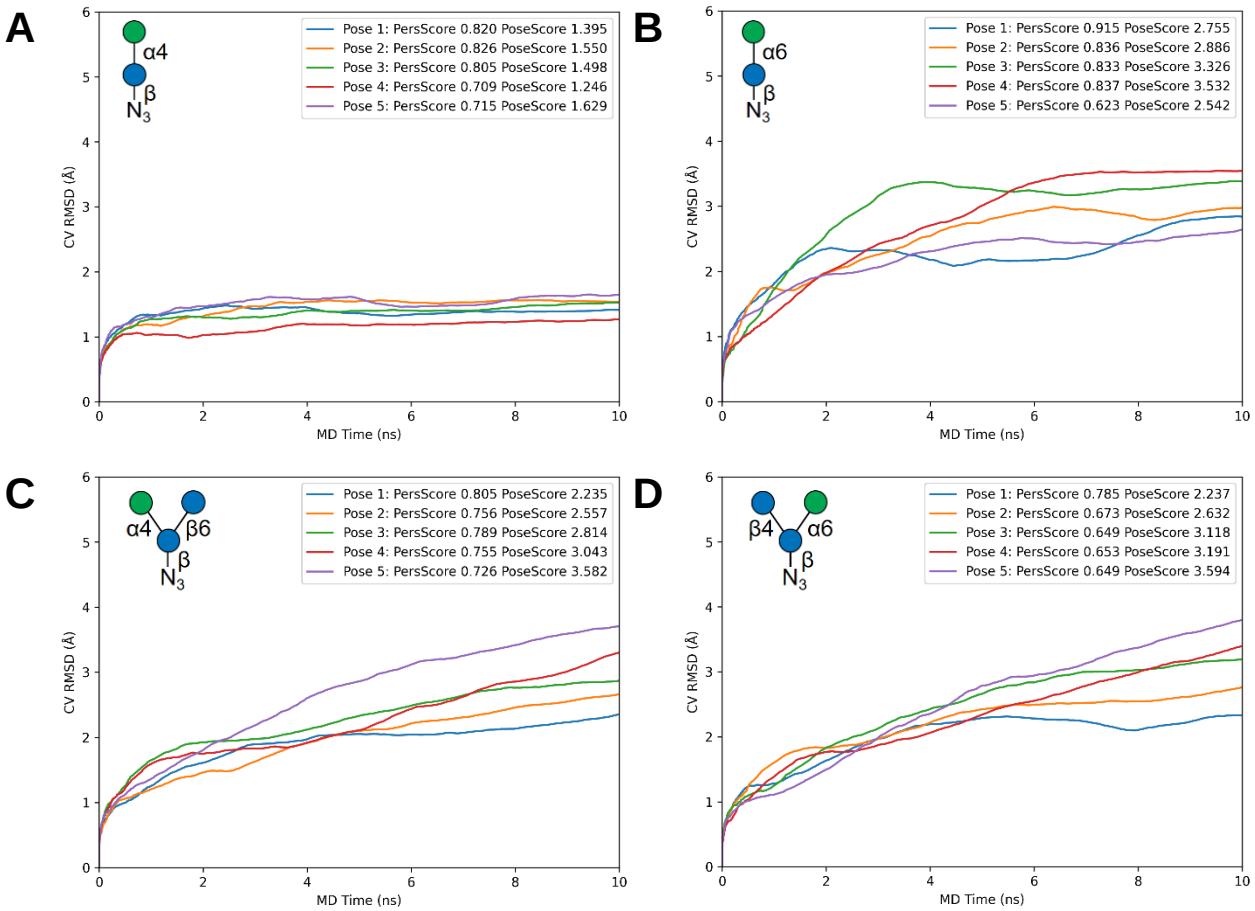
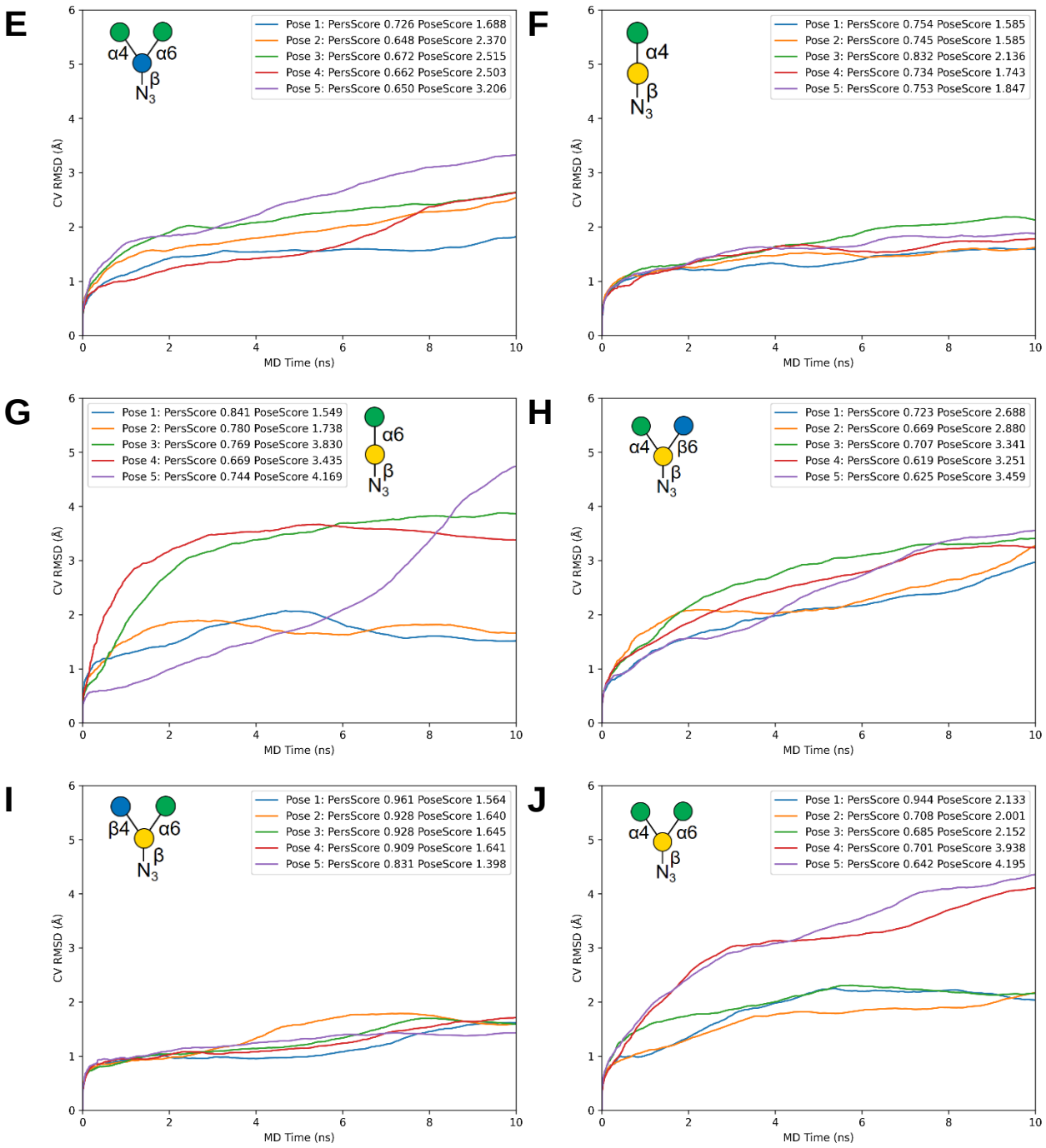


Figure S12. Plots from binding pose metadynamics simulation of averaged RMSD as collective variables (CV) in Å over the duration of the simulation. A) Man-α1,4-Glc-βN$_3$ **S6** B) Man-α1,6-Glc-βN$_3$ **S1** C) Man-α1,4-[Glc-β1,6]-Glc-βN$_3$ **11** D) Glc-β1,4-[Man-α1,6]-Glc-βN$_3$ **10** E) Man-α1,4-[Man-α1,6]-Glc-βN$_3$ **26** F) Man-α1,4-Gal-βN$_3$ **S7** G) Man-α1,6-Gal-βN$_3$ **45** H) Man-α1,4-[Glc-β1,6]-Gal-βN$_3$ **21** I) Glc-β1,4-[Man-α1,6]-Gal-βN$_3$ **20** J) Man-α1,4-[Man-α1,6]-Gal-βN$_3$ **27** K) Glc-α1,4-[Man-α1,6]-Glc-βN$_3$ **32** L) Glc-β1,3-[Man-α1,6]-Glc-βN$_3$ **37** M) Man-α1,3-[Man-α1,6]-Man-βN$_3$ **41** N) Man-α1,4-[Glc-β1,6]-Glc-βProp **S2** O) Glc-β1,4-[Man-α1,6]-Glc-βProp **S3**.




E
α4
α6
β
N3
Pose 1: PersScore 0.726 PoseScore 1.688
Pose 2: PersScore 0.648 PoseScore 2.370
Pose 3: PersScore 0.672 PoseScore 2.515
Pose 4: PersScore 0.662 PoseScore 2.503
Pose 5: PersScore 0.650 PoseScore 3.206
CV RMSD (Å)
MD Time (ns)
F
α4
β
N3
Pose 1: PersScore 0.754 PoseScore 1.585
Pose 2: PersScore 0.745 PoseScore 1.585
Pose 3: PersScore 0.832 PoseScore 2.136
Pose 4: PersScore 0.734 PoseScore 1.743
Pose 5: PersScore 0.753 PoseScore 1.847
CV RMSD (Å)
MD Time (ns)
G
α6
β
N3
Pose 1: PersScore 0.841 PoseScore 1.549
Pose 2: PersScore 0.780 PoseScore 1.738
Pose 3: PersScore 0.769 PoseScore 3.830
Pose 4: PersScore 0.669 PoseScore 3.435
Pose 5: PersScore 0.744 PoseScore 4.169
CV RMSD (Å)
MD Time (ns)
H
α4
β6
β
N3
Pose 1: PersScore 0.723 PoseScore 2.688
Pose 2: PersScore 0.669 PoseScore 2.880
Pose 3: PersScore 0.707 PoseScore 3.341
Pose 4: PersScore 0.619 PoseScore 3.251
Pose 5: PersScore 0.625 PoseScore 3.459
CV RMSD (Å)
MD Time (ns)
I
β4
α6
β
N3
Pose 1: PersScore 0.961 PoseScore 1.564
Pose 2: PersScore 0.928 PoseScore 1.640
Pose 3: PersScore 0.928 PoseScore 1.645
Pose 4: PersScore 0.909 PoseScore 1.641
Pose 5: PersScore 0.831 PoseScore 1.398
CV RMSD (Å)
MD Time (ns)
J
α4
α6
β
N3
Pose 1: PersScore 0.944 PoseScore 2.133
Pose 2: PersScore 0.708 PoseScore 2.001
Pose 3: PersScore 0.685 PoseScore 2.152
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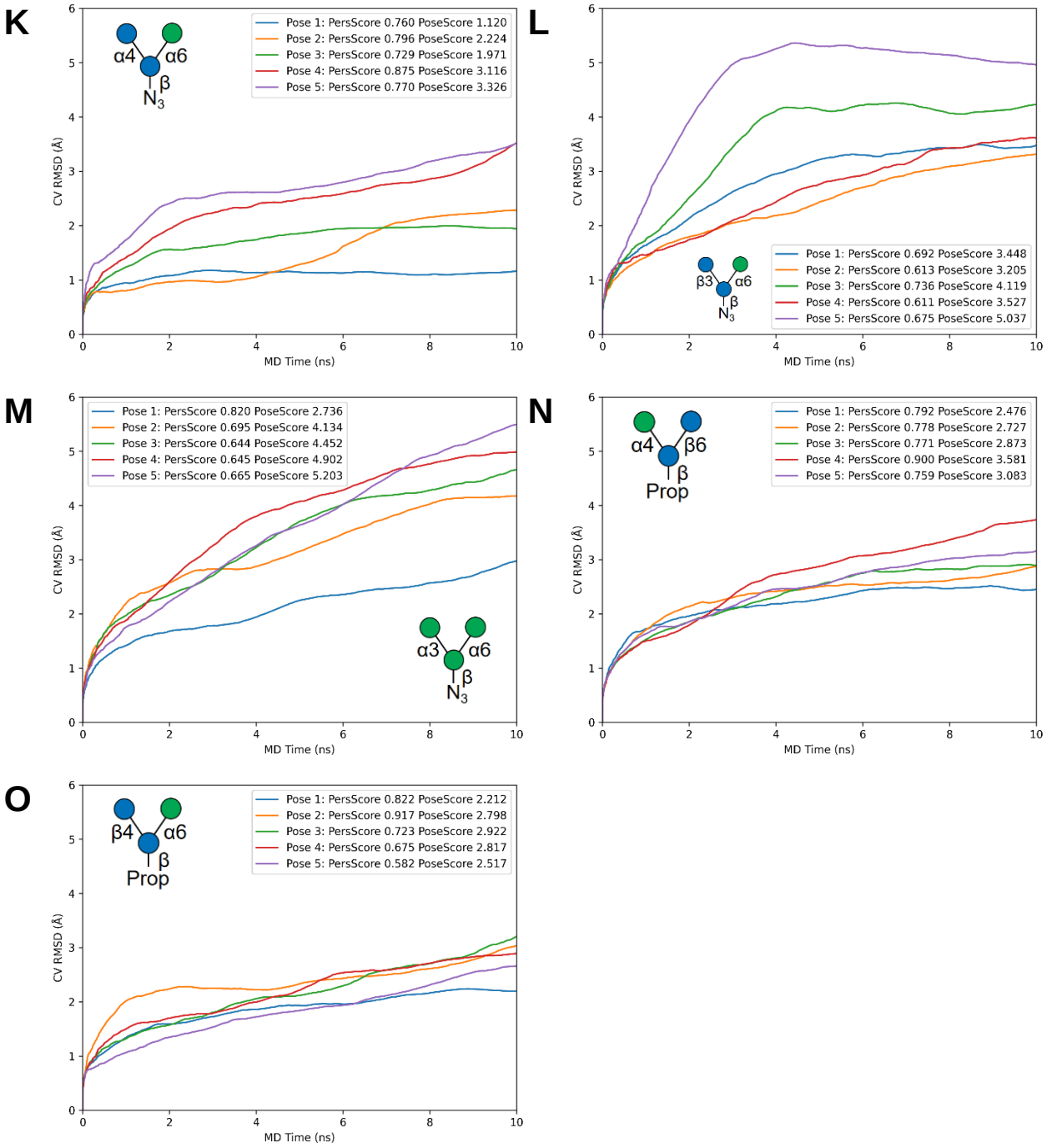
CV RMSD (Å)
MD Time (ns)


K
α4
α6
β
N3
Pose 1: PersScore 0.760 PoseScore 1.120
Pose 2: PersScore 0.796 PoseScore 2.224
Pose 3: PersScore 0.729 PoseScore 1.971
Pose 4: PersScore 0.875 PoseScore 3.116
Pose 5: PersScore 0.770 PoseScore 3.326
CV RMSD (Å)
MD Time (ns)
L
β3
α6
β
N3
Pose 1: PersScore 0.692 PoseScore 3.448
Pose 2: PersScore 0.613 PoseScore 3.205
Pose 3: PersScore 0.736 PoseScore 4.119
Pose 4: PersScore 0.611 PoseScore 3.527
Pose 5: PersScore 0.675 PoseScore 5.037
CV RMSD (Å)
MD Time (ns)
M
Pose 1: PersScore 0.820 PoseScore 2.736
Pose 2: PersScore 0.695 PoseScore 4.134
Pose 3: PersScore 0.644 PoseScore 4.452
Pose 4: PersScore 0.645 PoseScore 4.902
Pose 5: PersScore 0.665 PoseScore 5.203
α3
α6
β
N3
CV RMSD (Å)
MD Time (ns)
N
α4
β6
β
Prop
Pose 1: PersScore 0.792 PoseScore 2.476
Pose 2: PersScore 0.778 PoseScore 2.727
Pose 3: PersScore 0.771 PoseScore 2.873
Pose 4: PersScore 0.900 PoseScore 3.581
Pose 5: PersScore 0.759 PoseScore 3.083
CV RMSD (Å)
MD Time (ns)
O
β4
α6
β
Prop
Pose 1: PersScore 0.822 PoseScore 2.212
Pose 2: PersScore 0.917 PoseScore 2.798
Pose 3: PersScore 0.723 PoseScore 2.922
Pose 4: PersScore 0.675 PoseScore 2.817
Pose 5: PersScore 0.582 PoseScore 2.517
CV RMSD (Å)
MD Time (ns)

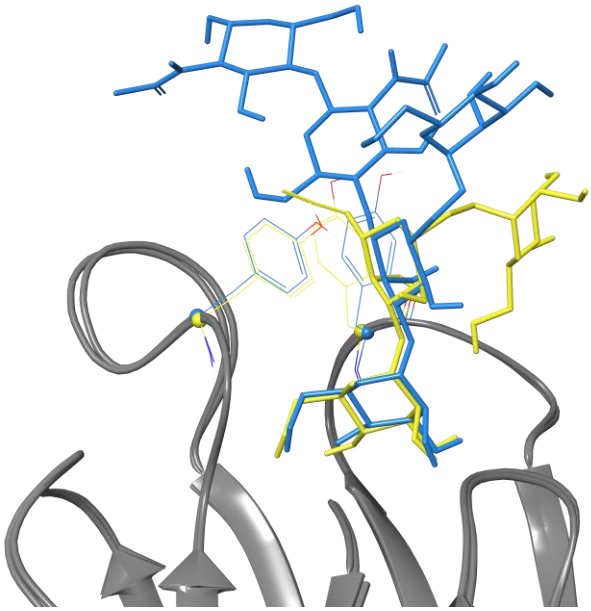


Figure S13. Comparison of the literature-known crystal structure of FimH in complex with oligomannose-3 (blue, pdb: 2VCO)[11] with the resulting binding pose from IFD of Manα1-3[Manα1-6]Man-βN_3 **41** (yellow). The protein structure is represented as ribbons and only Tyr48 and Tyr137 are explicitly shown.

5. NMR Spectra of synthesized saccharides

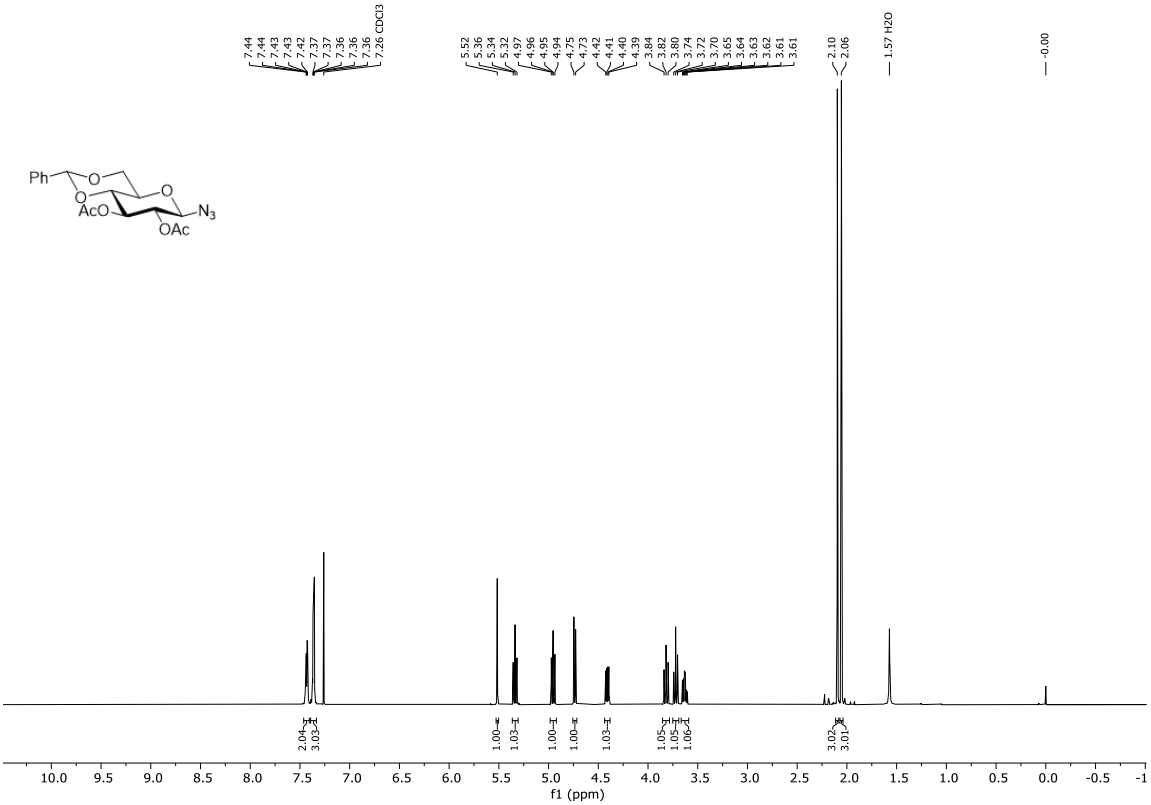


Figure S14. ^{1}H NMR spectrum of compound **2** (500 MHz, $CDCl_3$, 298 K).

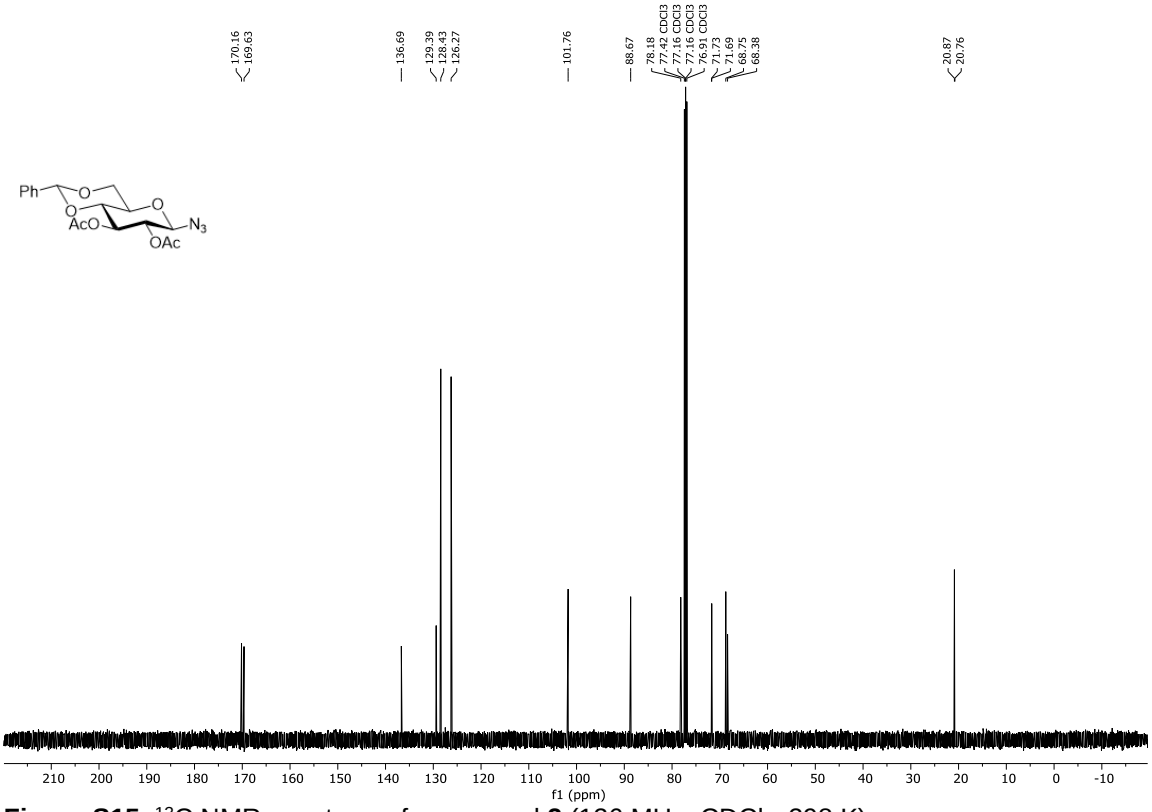


Figure S15. ^{13}C NMR spectrum of compound **2** (126 MHz, $CDCl_3$, 298 K).

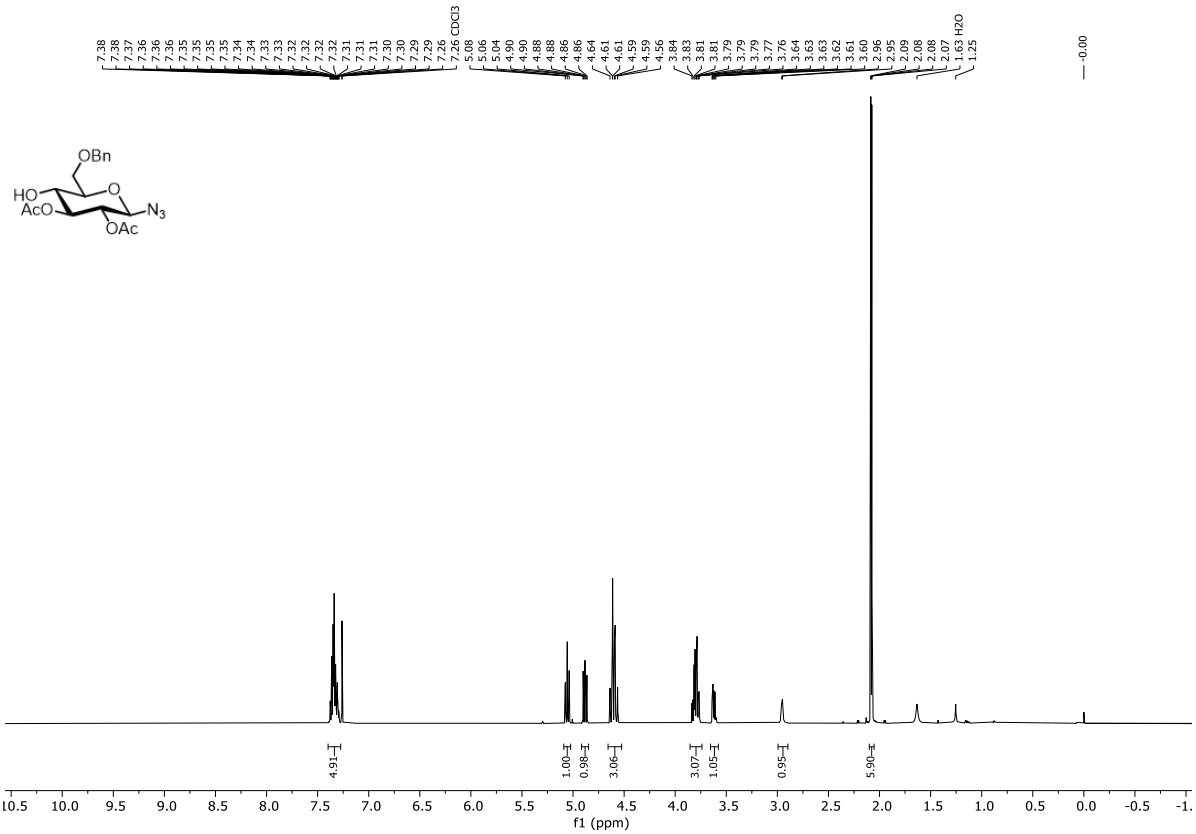


Figure S16. ^{1}H NMR spectrum of compound **3** (500 MHz, $CDCl_3$, 298 K).

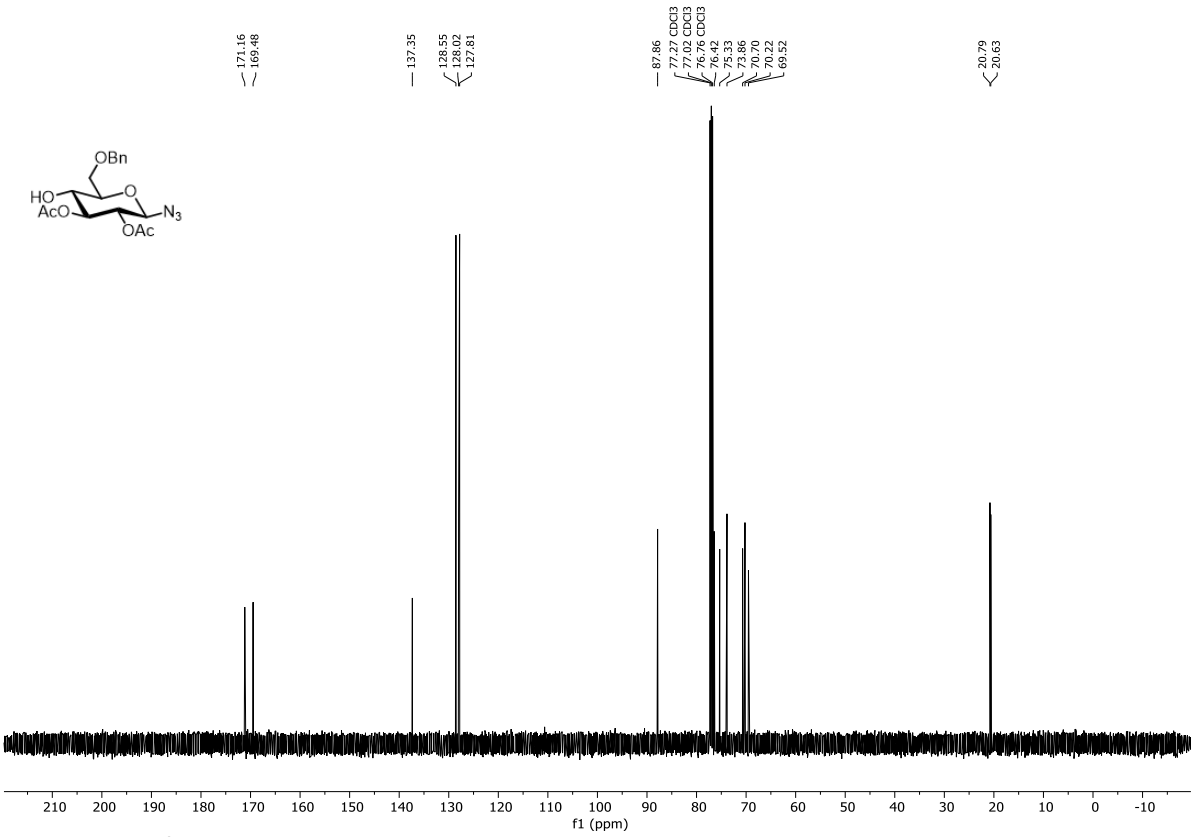


Figure S17. ^{13}C NMR spectrum of compound **3** (126 MHz, $CDCl_3$, 298 K).

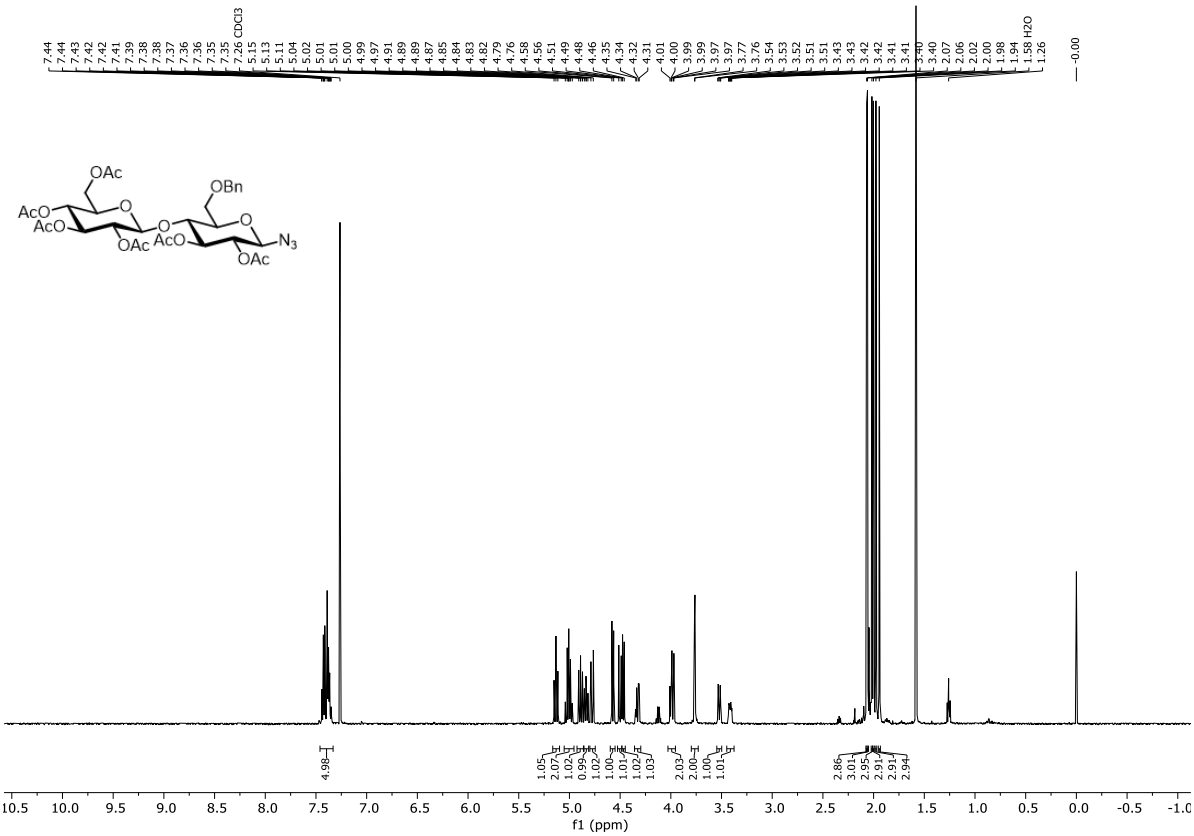


Figure S18. ^{1}H NMR spectrum of compound **4** (500 MHz, $CDCl_3$, 298 K).

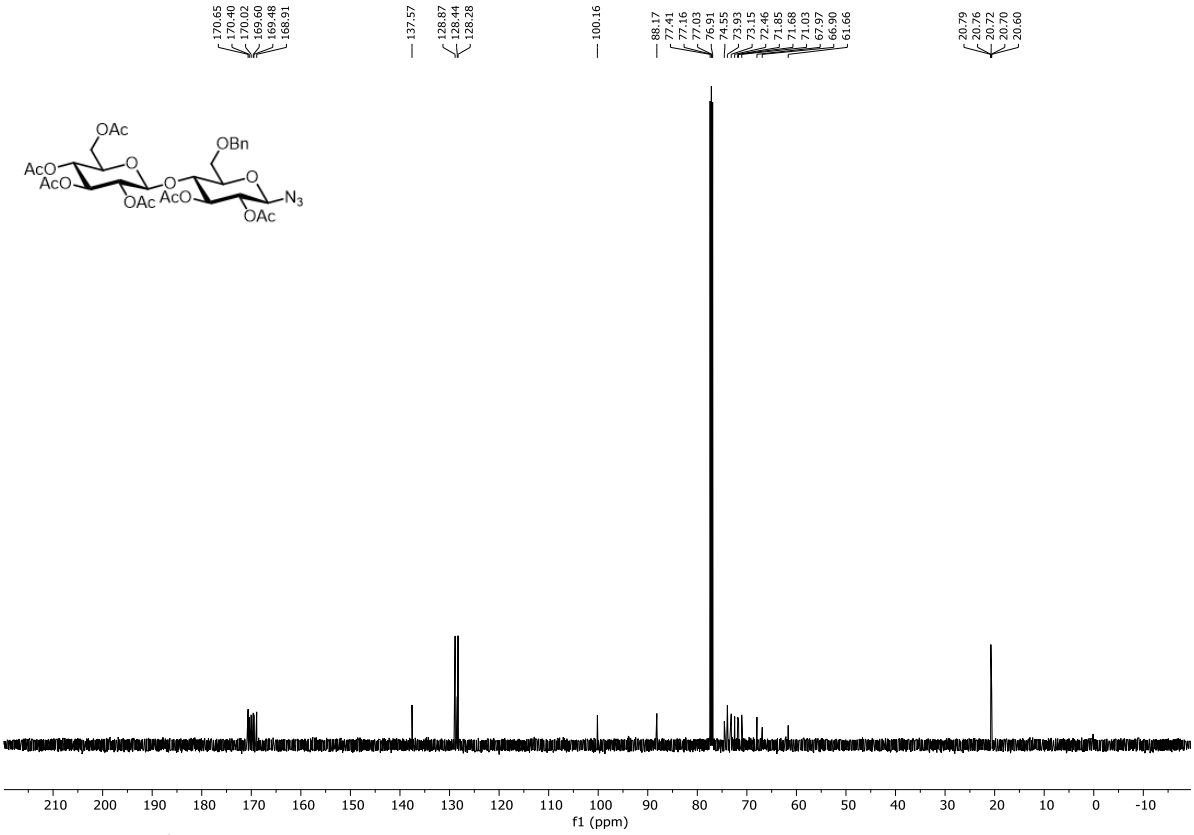


Figure S19. ^{13}C NMR spectrum of compound **4** (126 MHz, $CDCl_3$, 298 K).

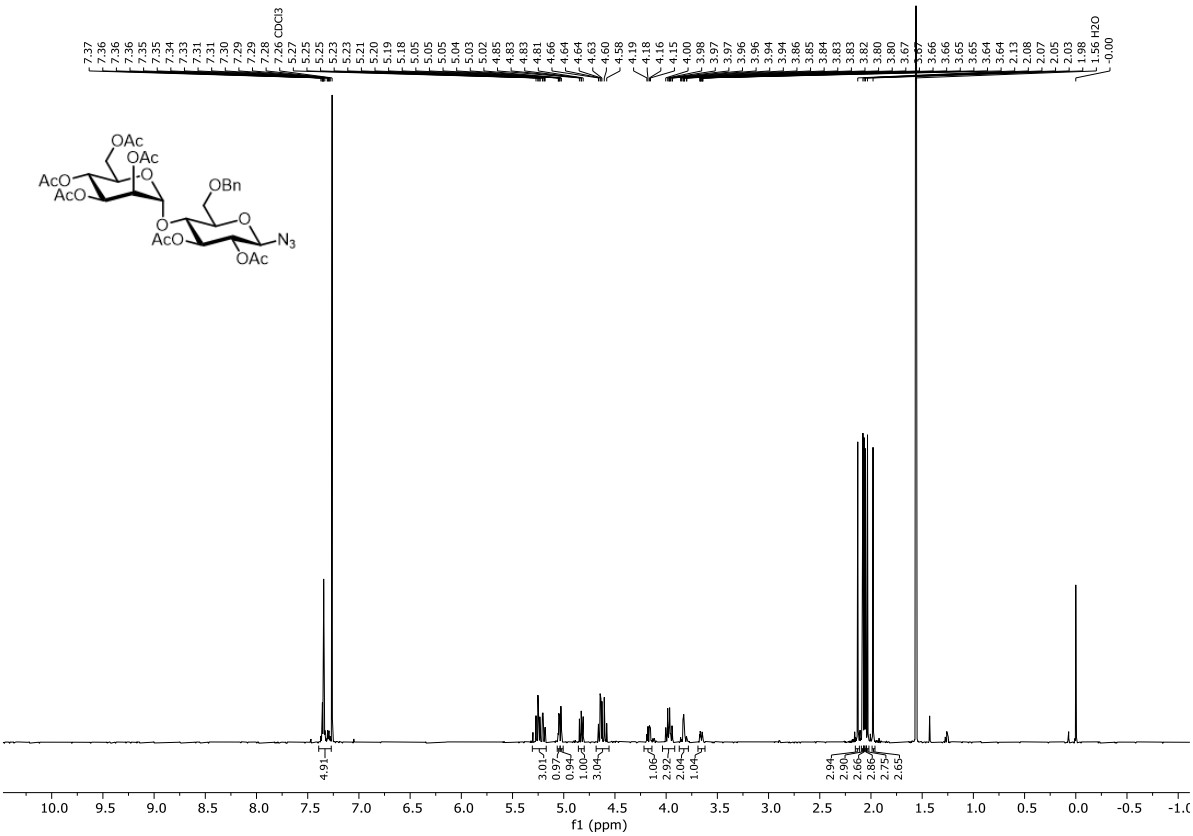


Figure S20. ^{1}H NMR spectrum of compound **5** (500 MHz, $CDCl_3$, 298 K).

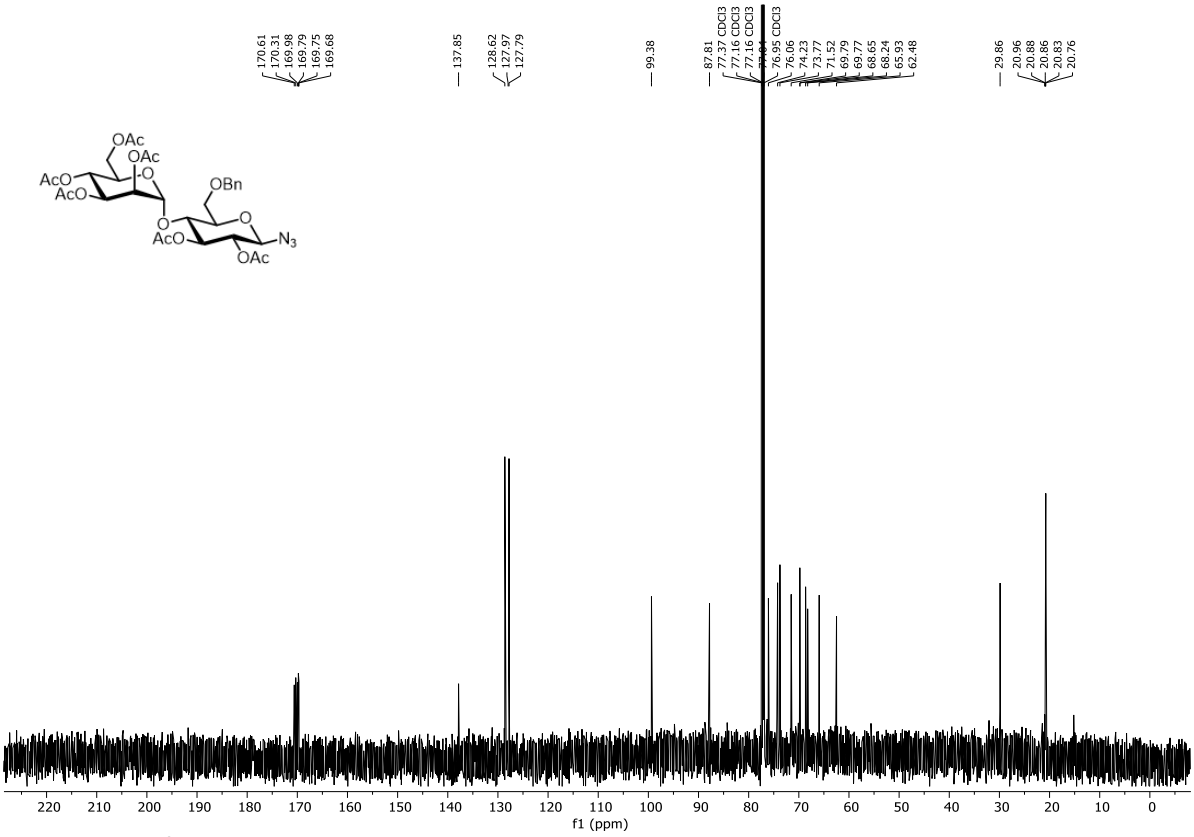


Figure S21. ^{13}C NMR spectrum of compound **5** (151 MHz, $CDCl_3$, 298 K).

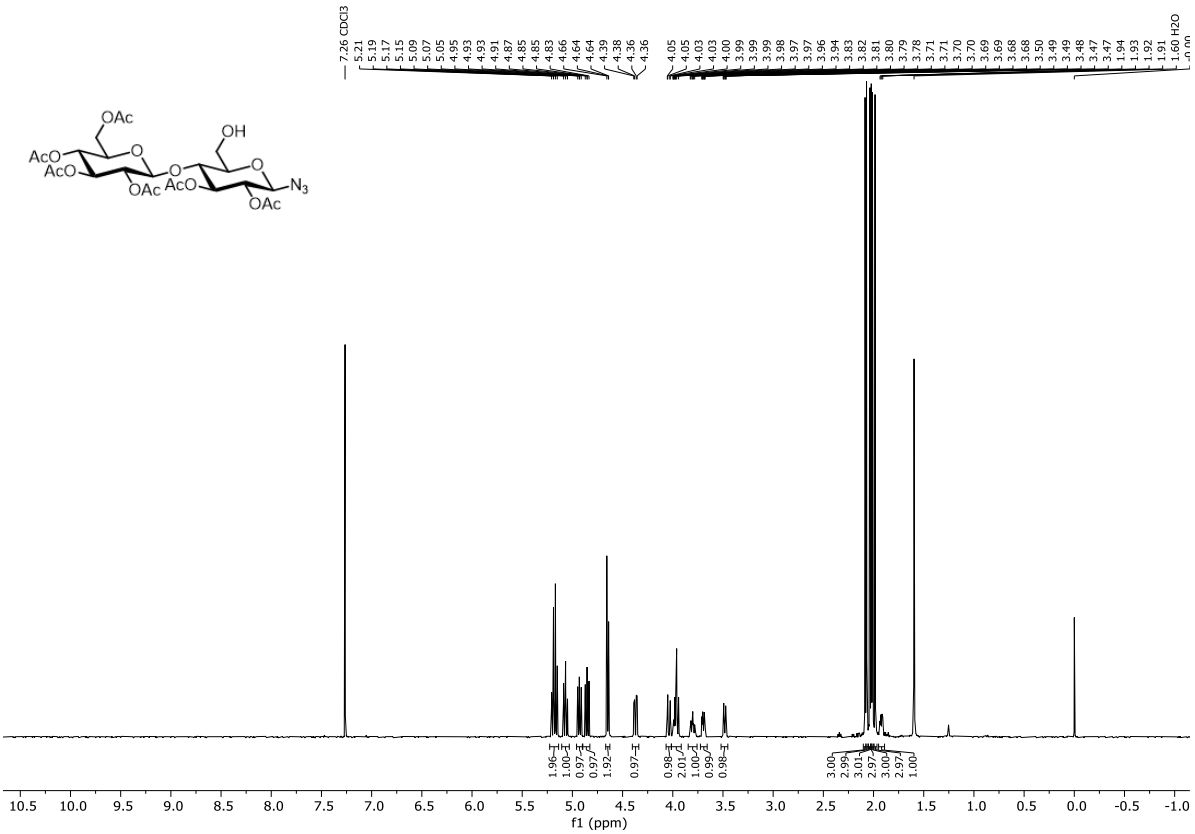


Figure S22. ^{1}H NMR spectrum of compound **6** (500 MHz, $CDCl_3$, 298 K).

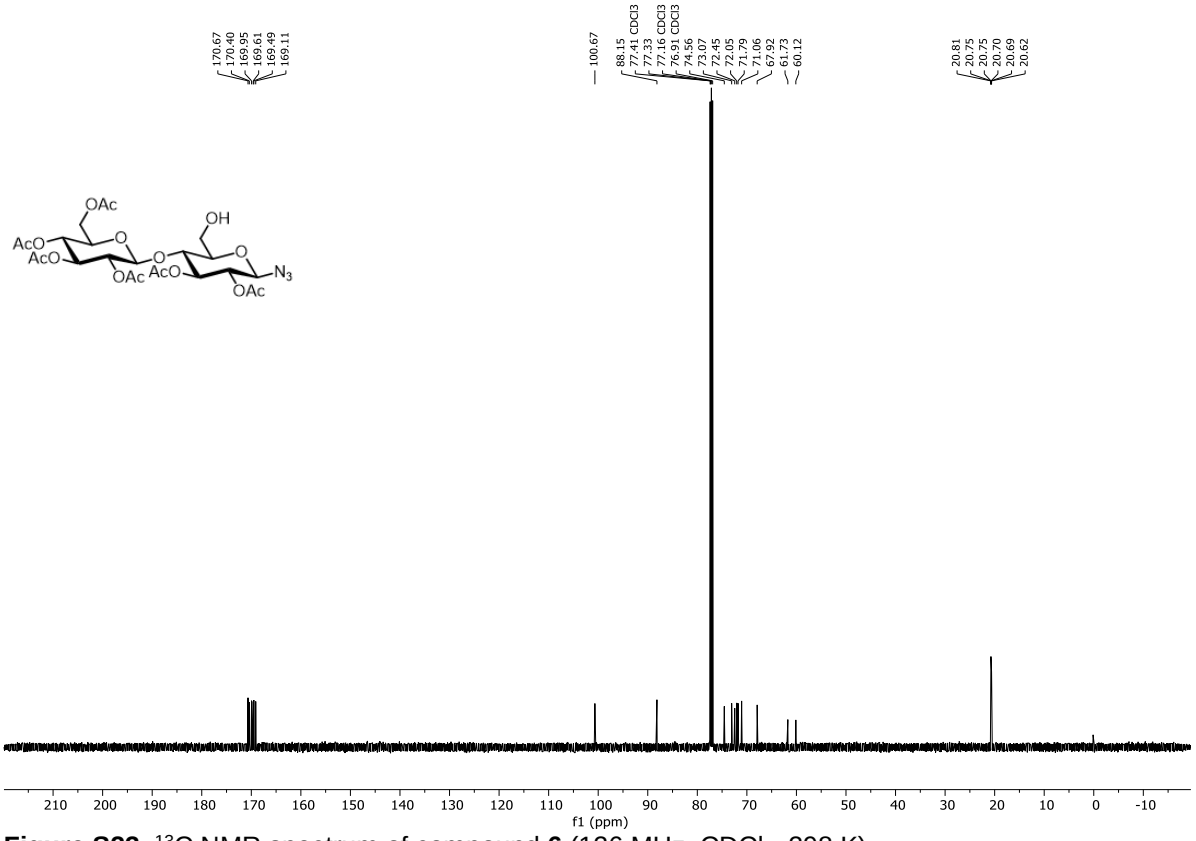


Figure S23. ^{13}C NMR spectrum of compound **6** (126 MHz, $CDCl_3$, 298 K).

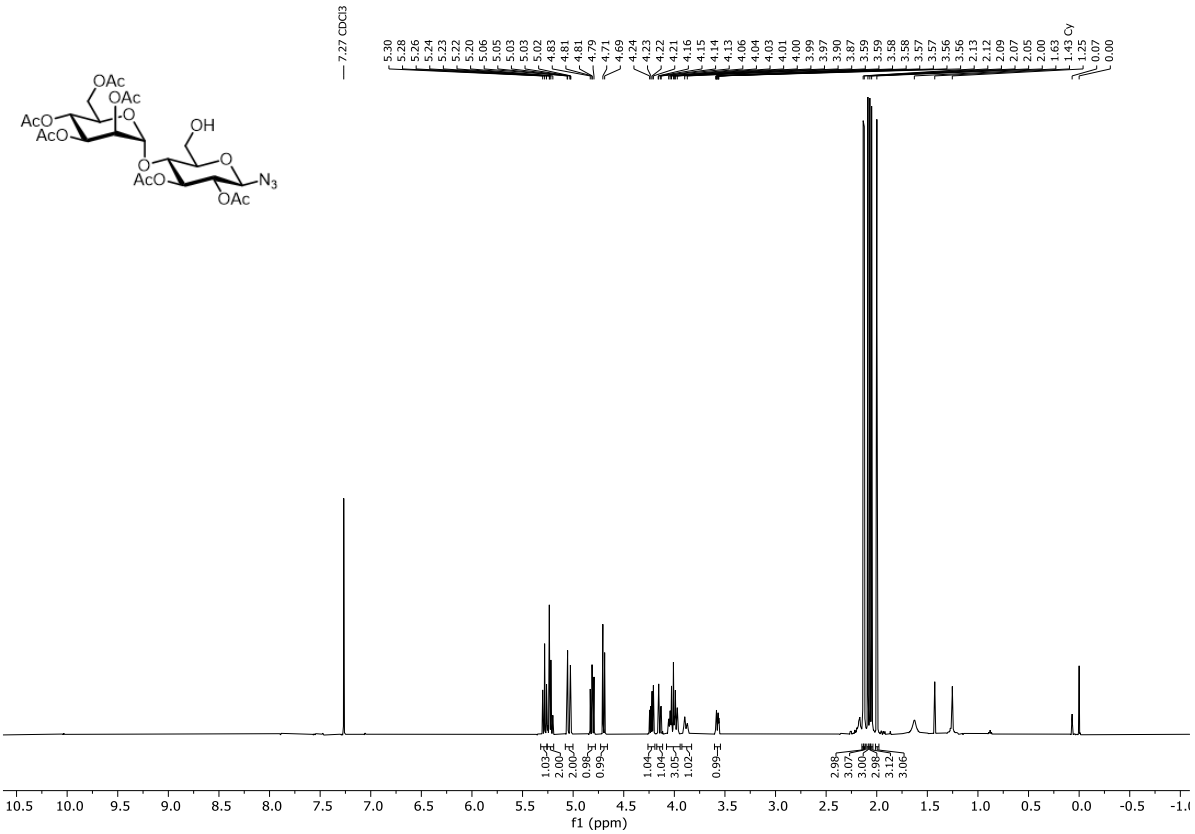


Figure S24. ^{1}H NMR spectrum of compound **7** (500 MHz, $CDCl_3$, 298 K).

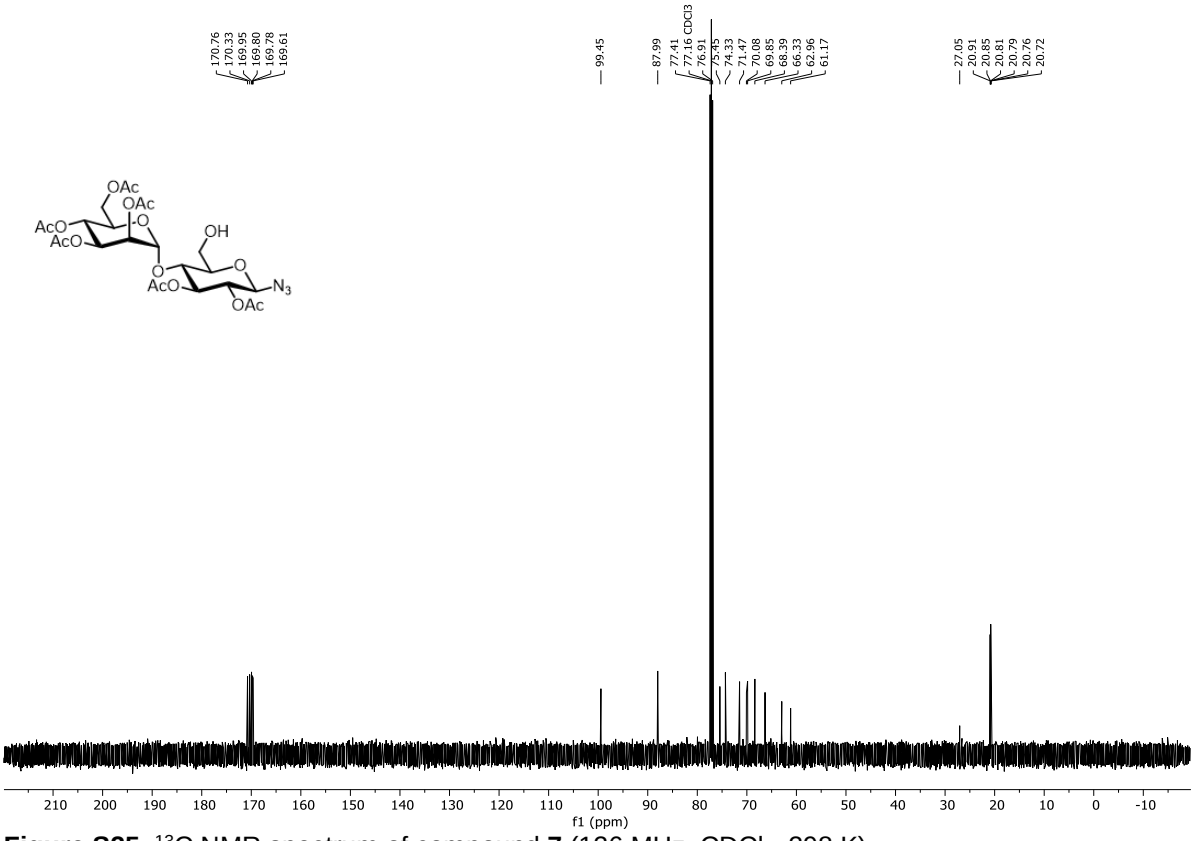


Figure S25. ^{13}C NMR spectrum of compound **7** (126 MHz, $CDCl_3$, 298 K).

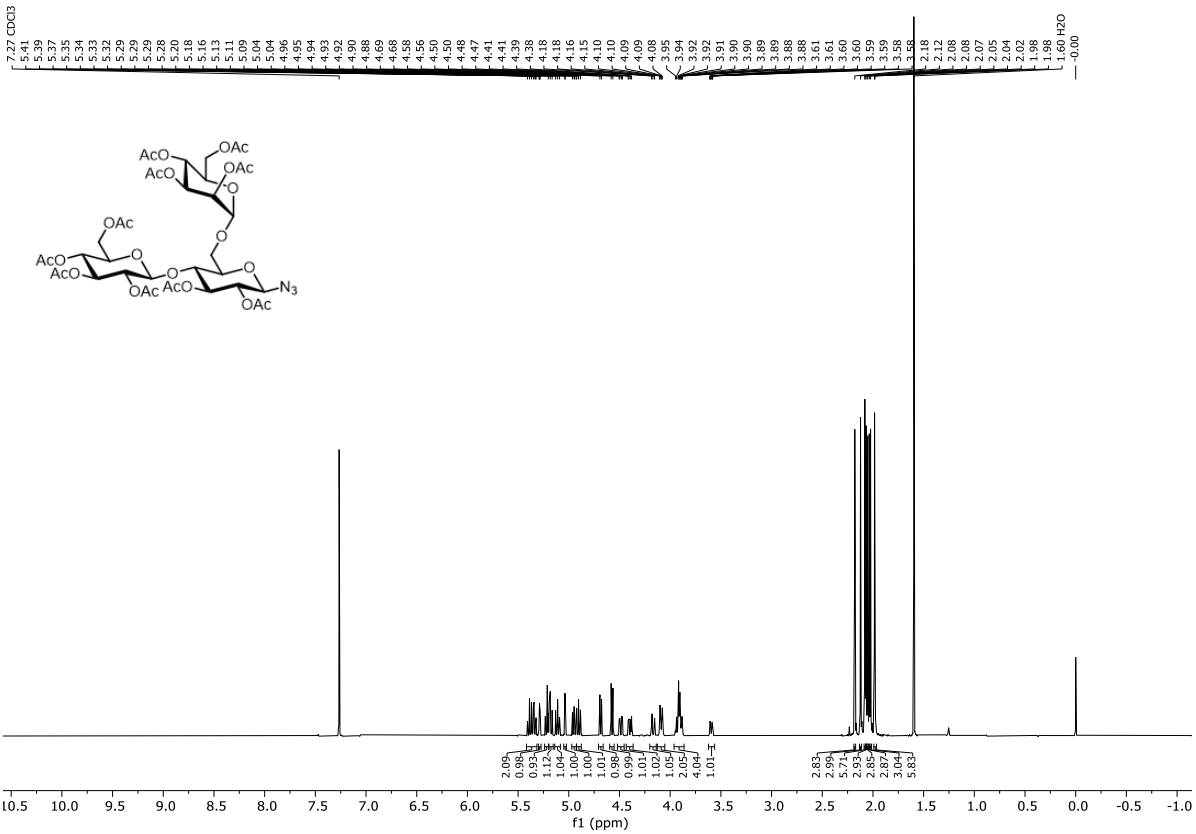


Figure S26. ^{1}H NMR spectrum of compound **8** (500 MHz, $CDCl_3$, 298 K).

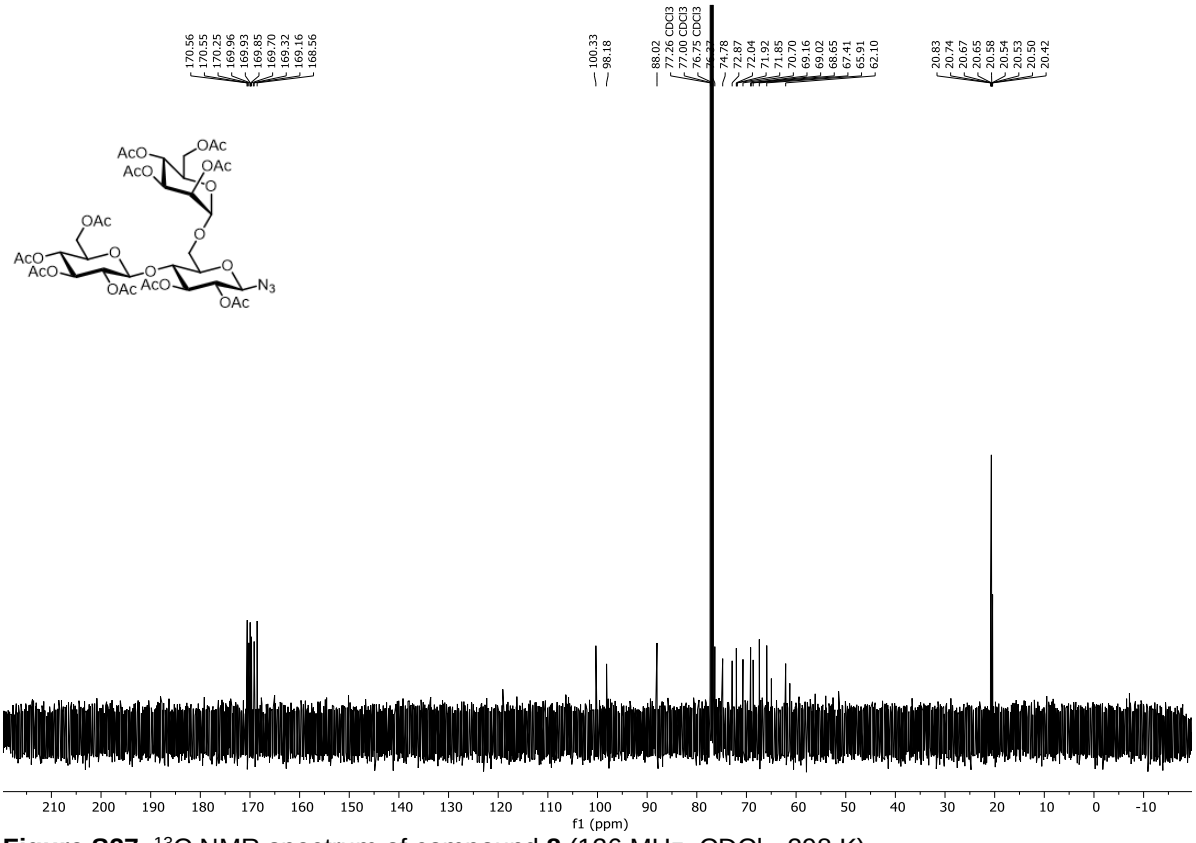


Figure S27. ^{13}C NMR spectrum of compound **8** (126 MHz, $CDCl_3$, 298 K).

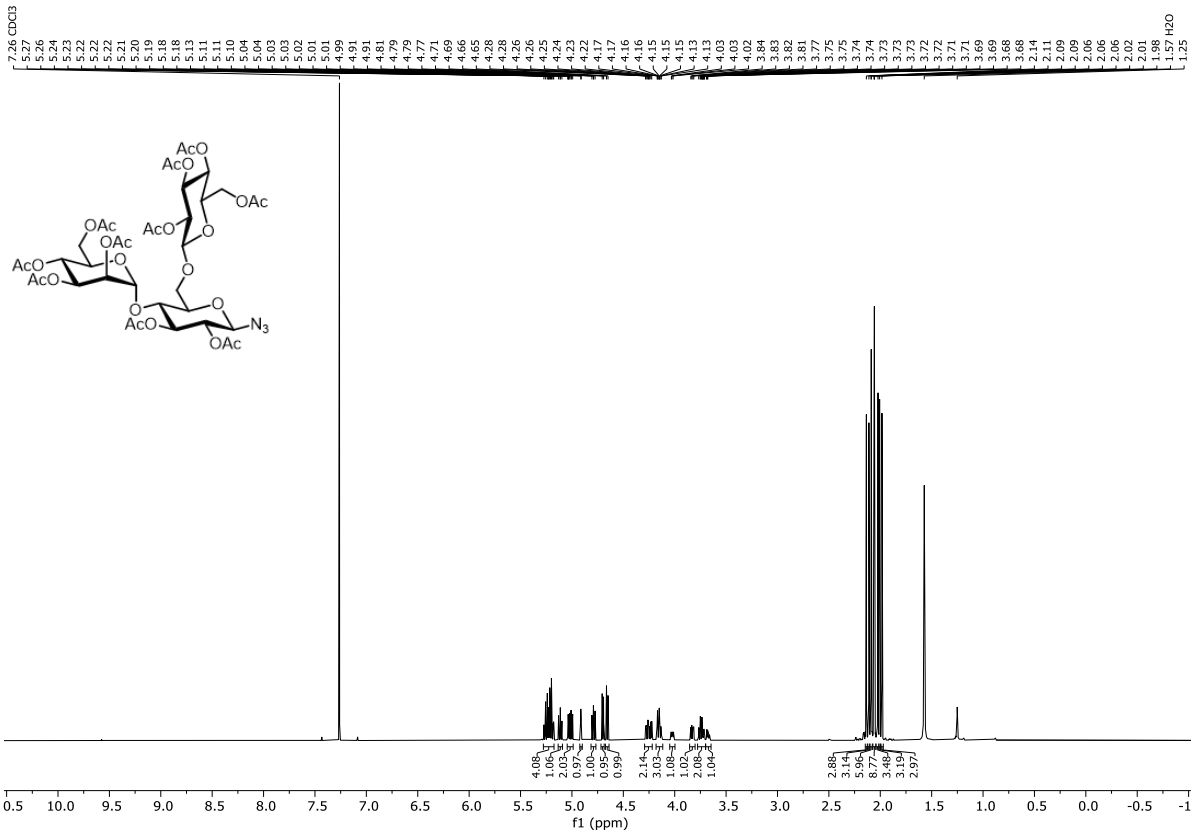


Figure S28. ^{1}H NMR spectrum of compound **9** (600 MHz, $CDCl_3$, 298 K).

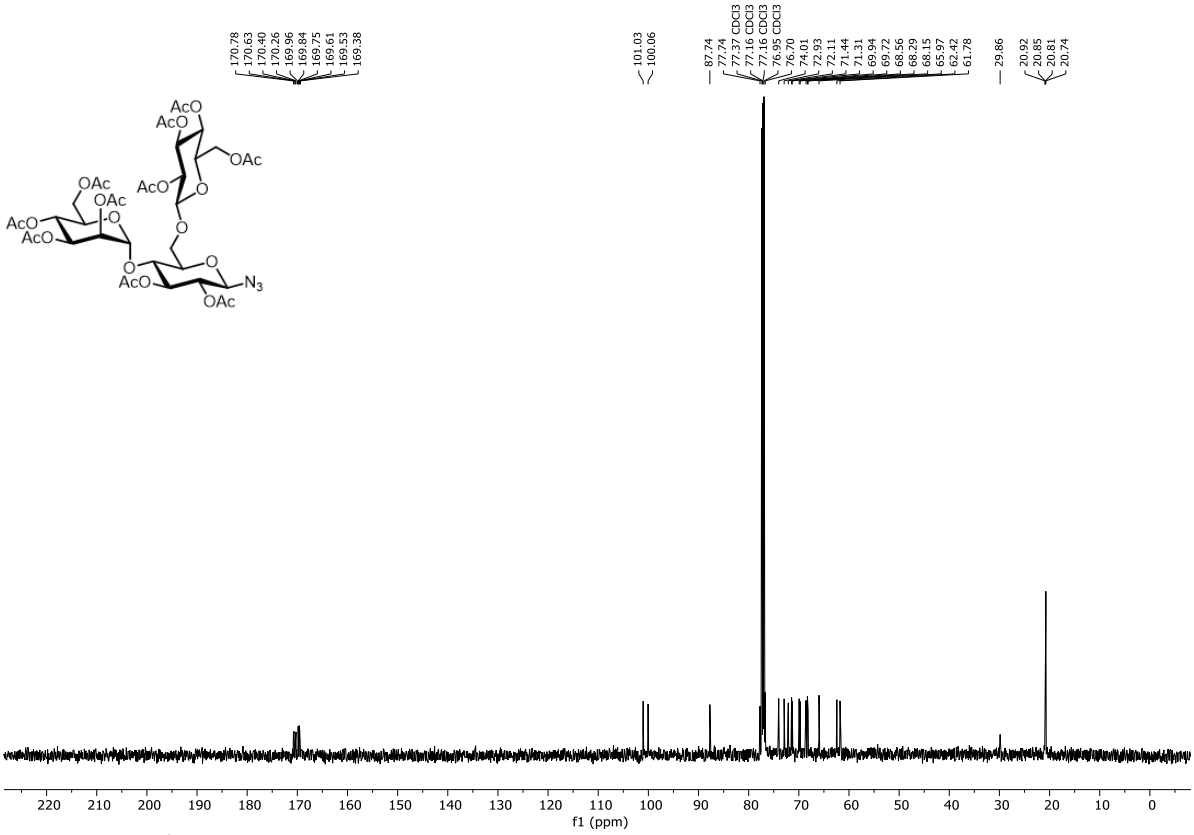


Figure S29. ^{13}C NMR spectrum of compound **9** (151 MHz, $CDCl_3$, 298 K).

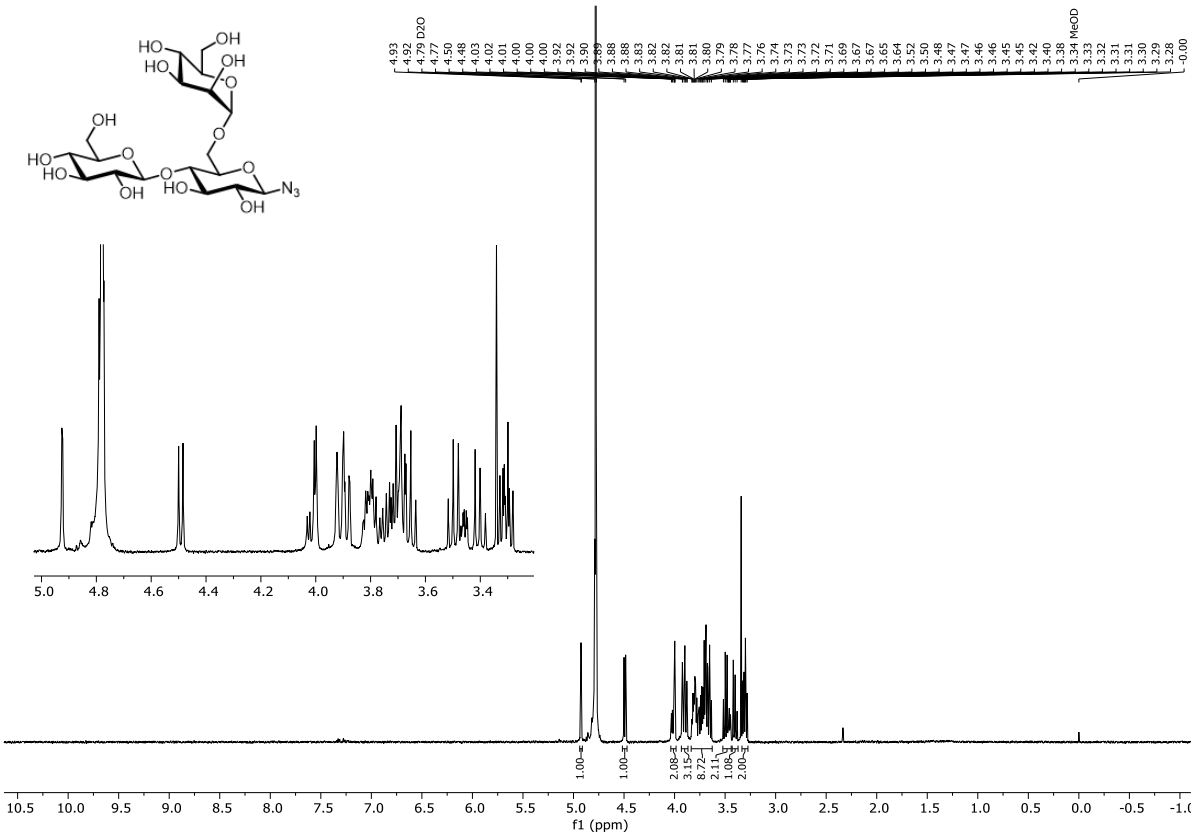


Figure S30. ^{1}H NMR spectrum of compound **10** (500 MHz, D_2O, 298 K).

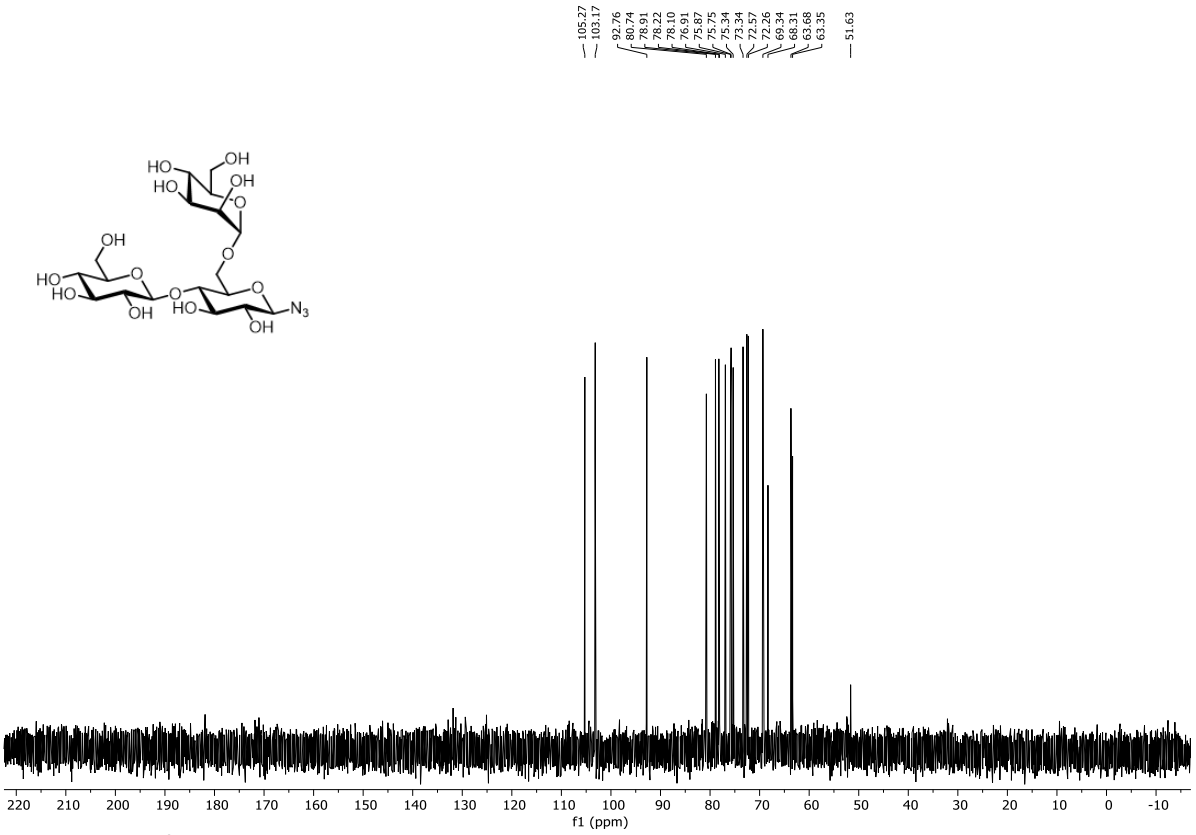


Figure S31. ^{13}C NMR spectrum of compound **10** (126 MHz, D_2O, 298 K).

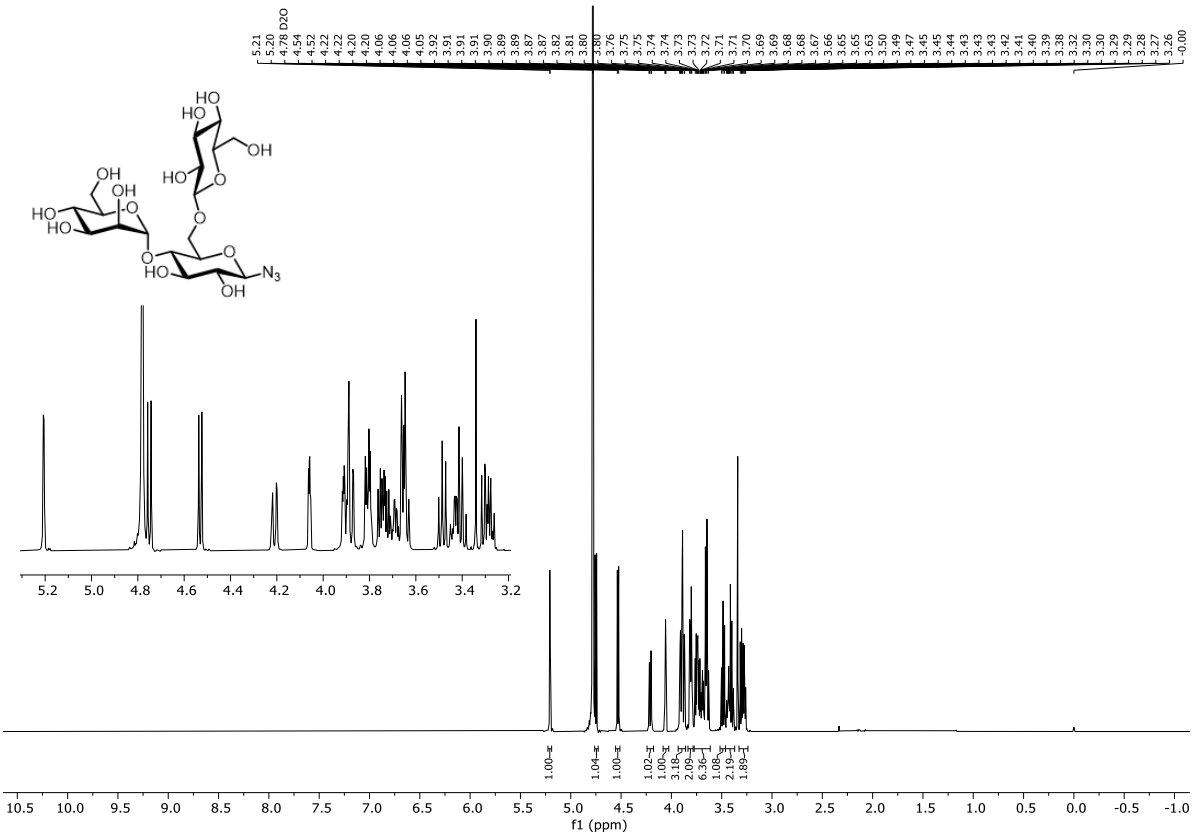


Figure S32. ^{1}H NMR spectrum of compound **11** (600 MHz, H_2O, 298 K).

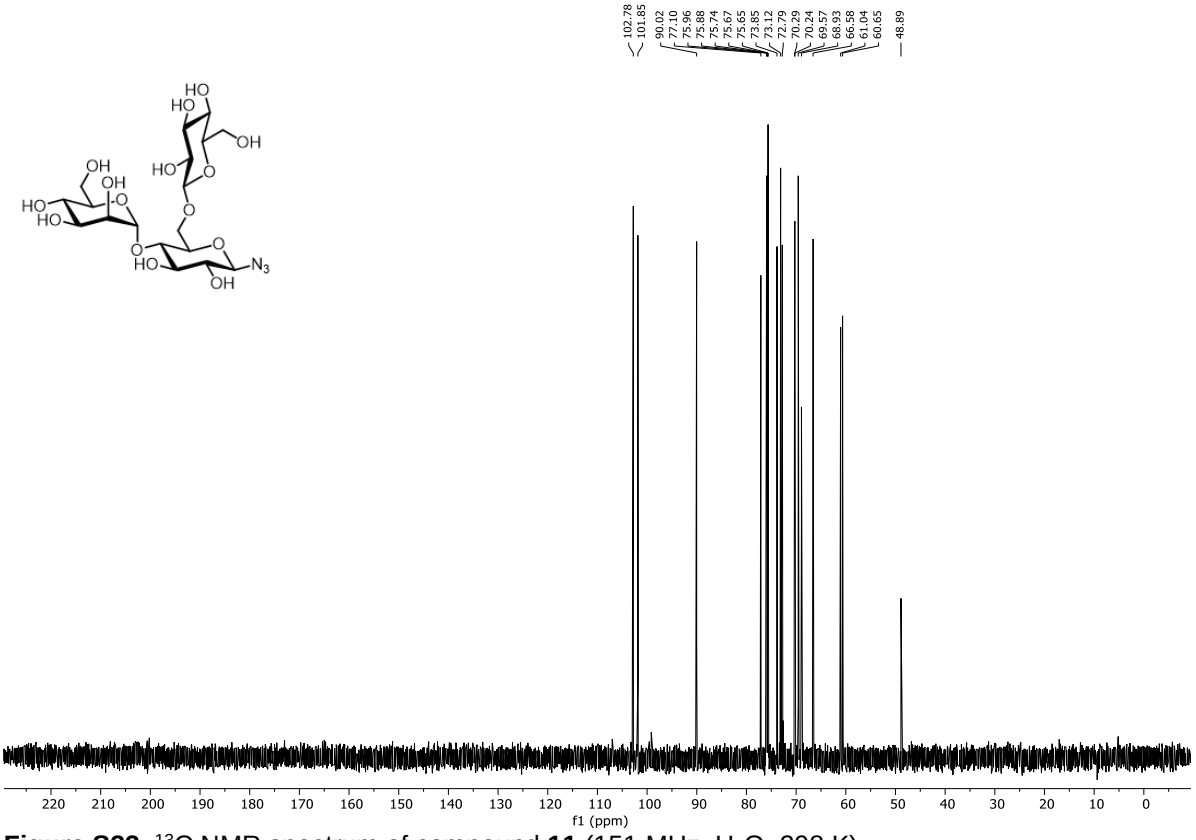


Figure S33. ^{13}C NMR spectrum of compound **11** (151 MHz, H_2O, 298 K).

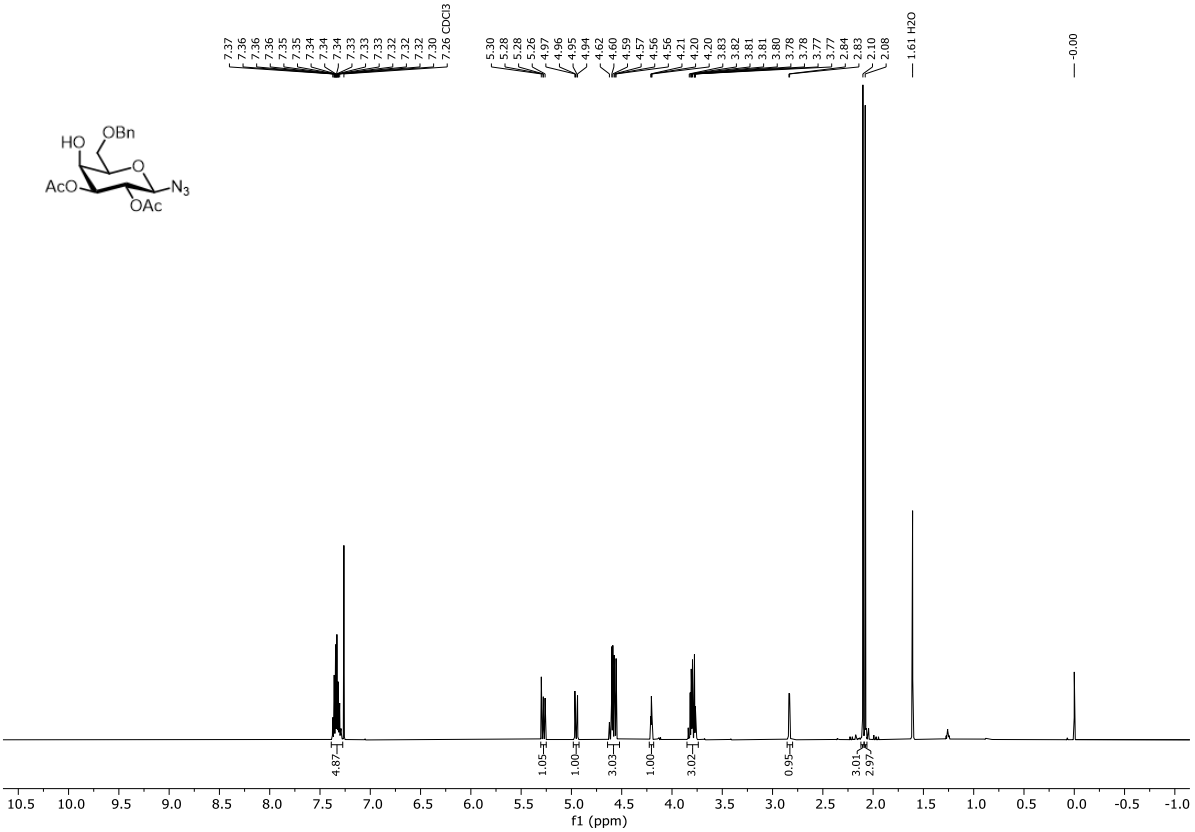


Figure S34. ^{1}H NMR spectrum of compound **13** (500 MHz, $CDCl_3$, 298 K).

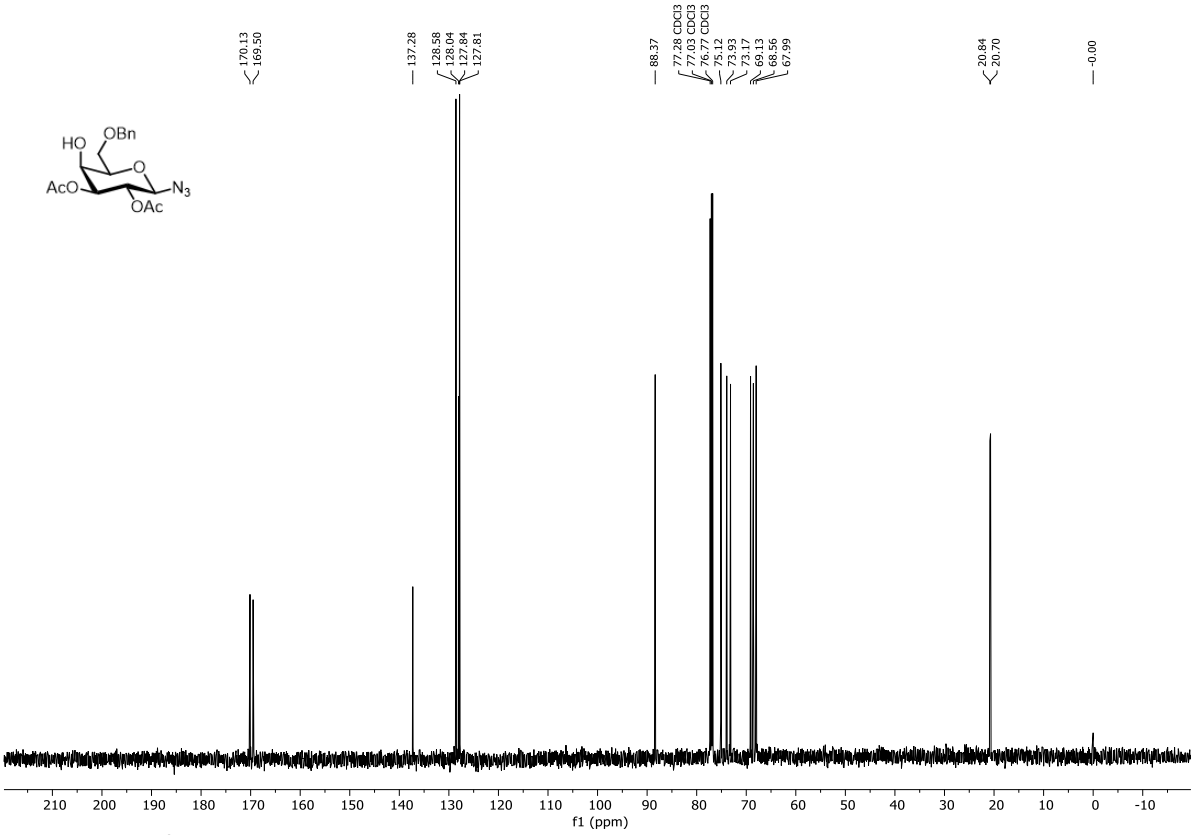


Figure S35. ^{13}C NMR spectrum of compound **13** (126 MHz, $CDCl_3$, 298 K).

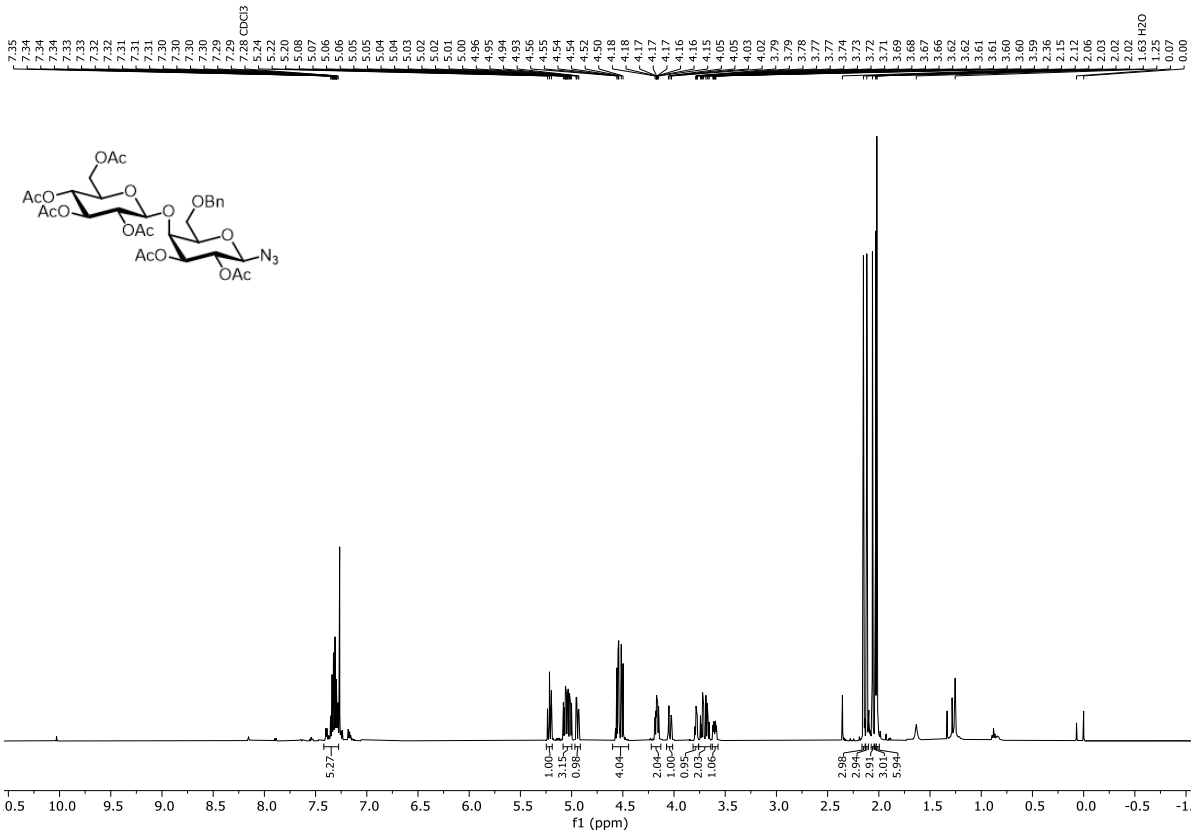


Figure S36. ^{1}H NMR spectrum of compound **14** (500 MHz, $CDCl_3$, 298 K).

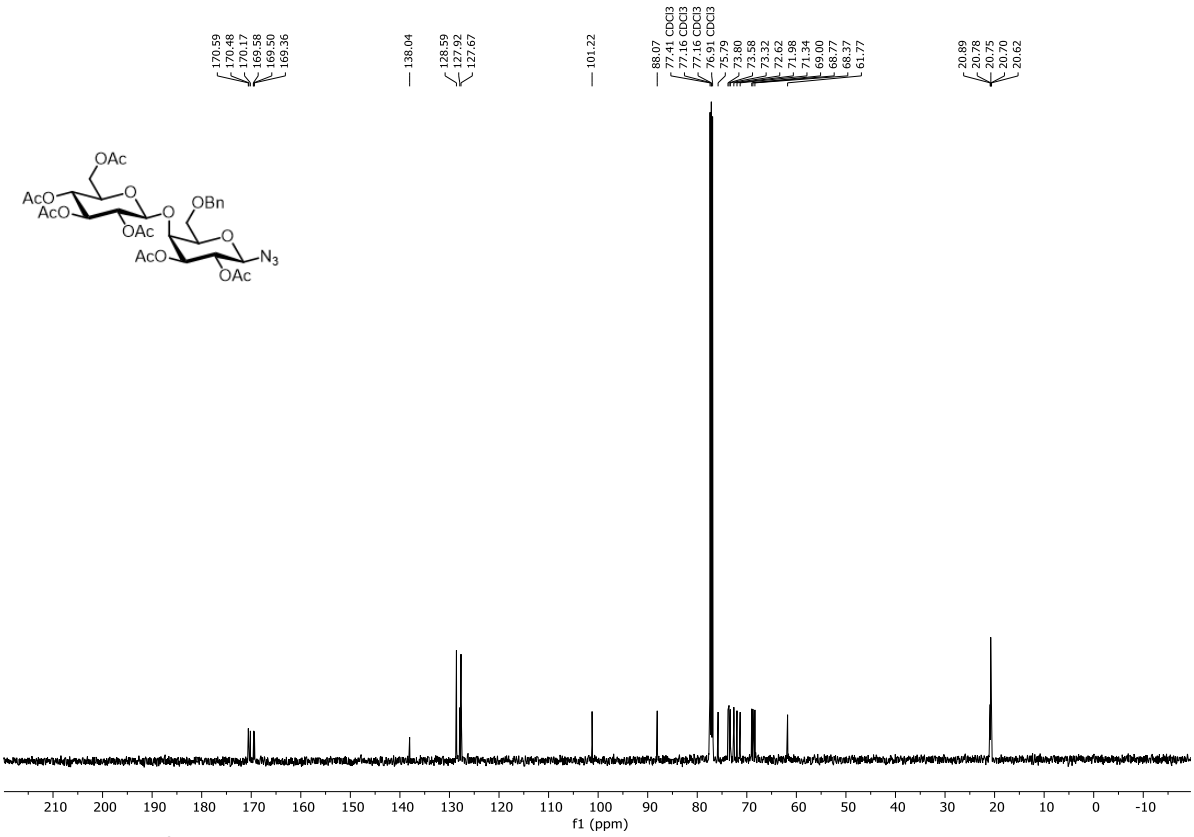


Figure S37. ^{13}C NMR spectrum of compound **14** (126 MHz, $CDCl_3$, 298 K).

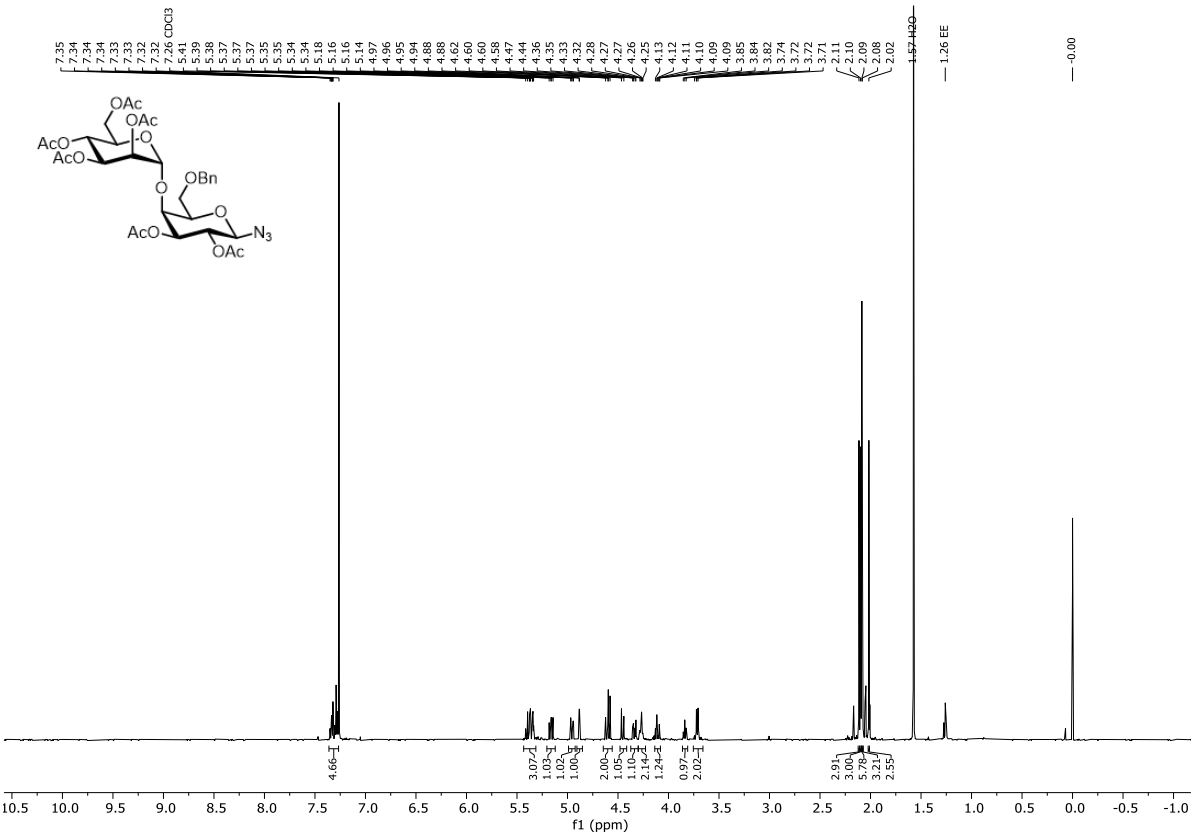


Figure S38. ^{1}H NMR spectrum of compound **15** (500 MHz, $CDCl_3$, 298 K).

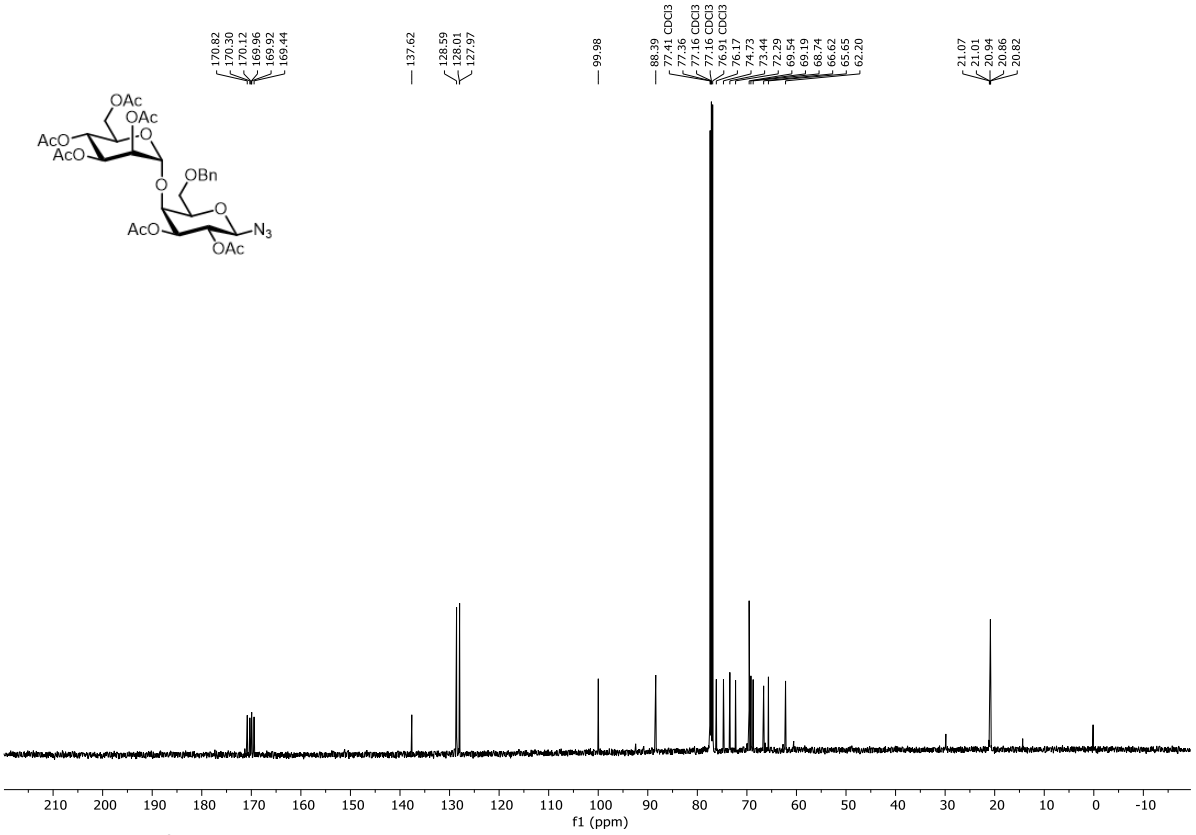


Figure S39. ^{13}C NMR spectrum of compound **15** (126 MHz, $CDCl_3$, 298 K).

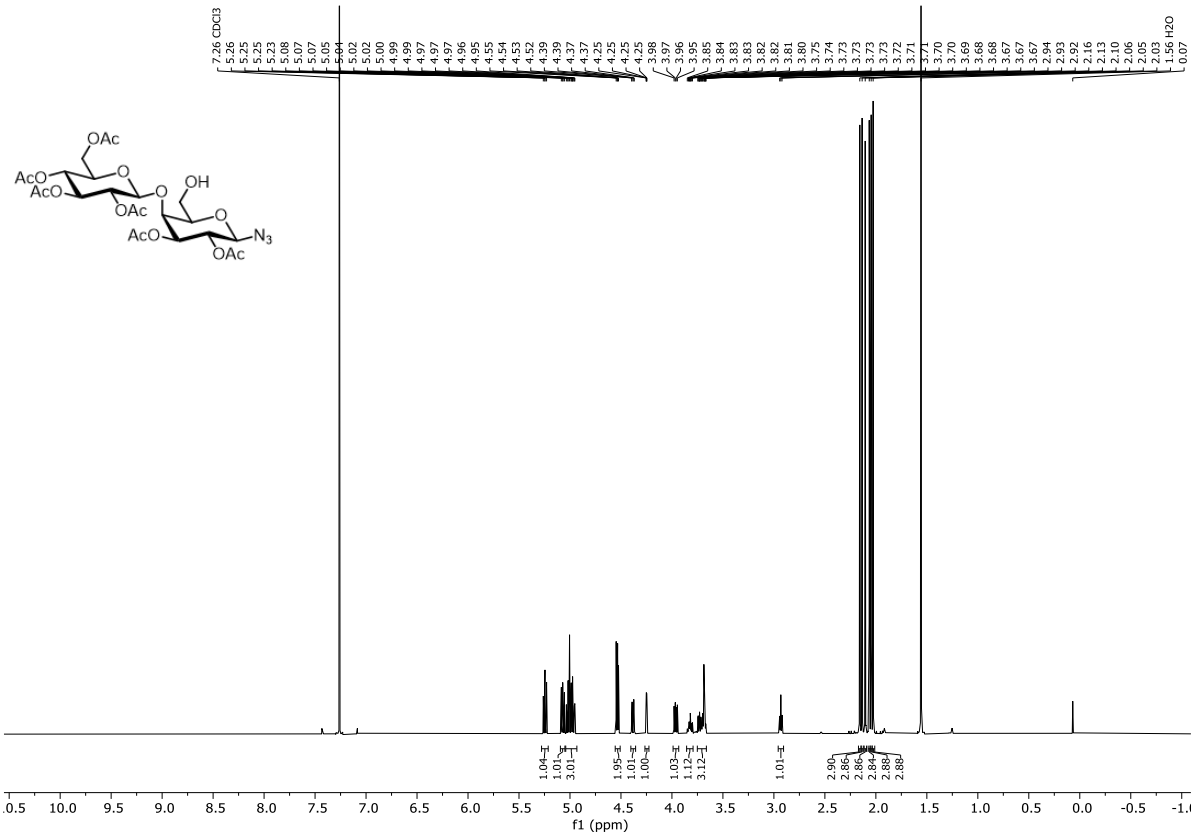


Figure S40. ^{1}H NMR spectrum of compound **16** (600 MHz, $CDCl_3$, 298 K).

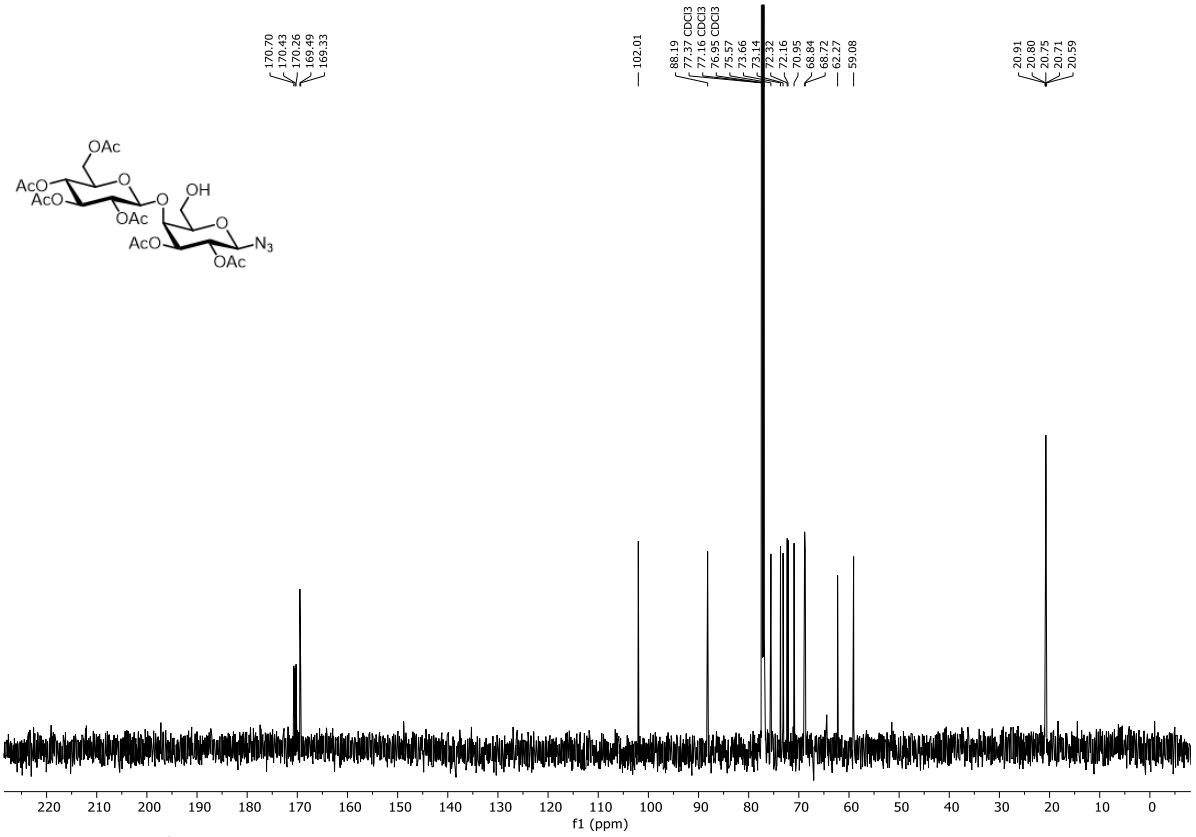


Figure S41. ^{13}C NMR spectrum of compound **16** (151 MHz, $CDCl_3$, 298 K).

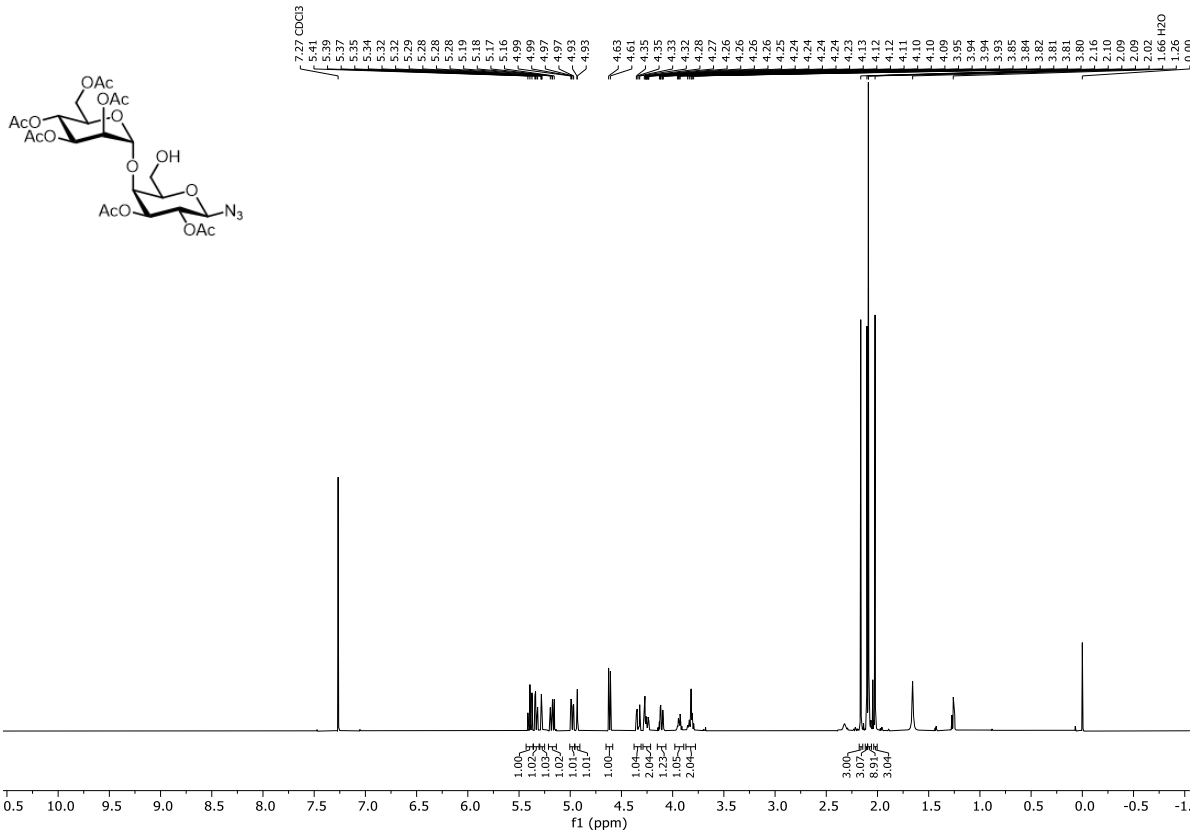


Figure S42. ^{1}H NMR spectrum of compound **17** (500 MHz, $CDCl_3$, 298 K).

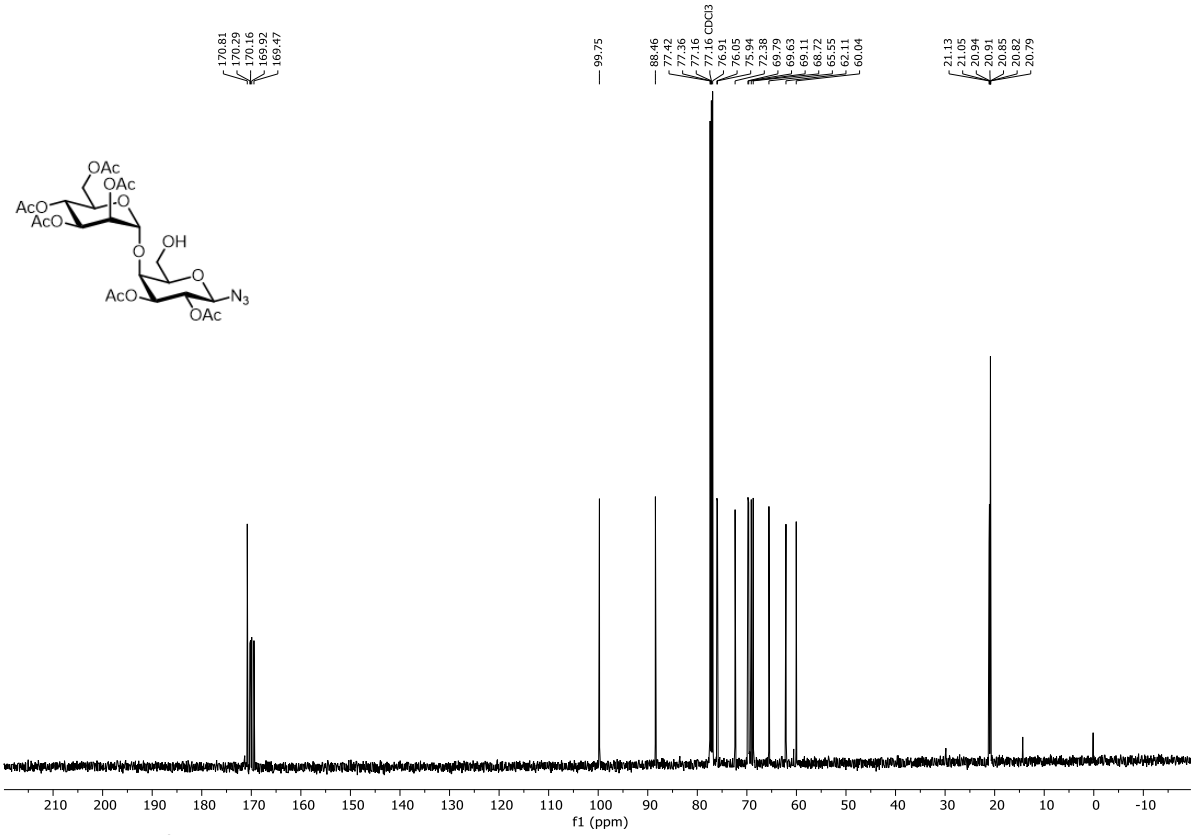


Figure S43. ^{13}C NMR spectrum of compound **17** (126 MHz, $CDCl_3$, 298 K).

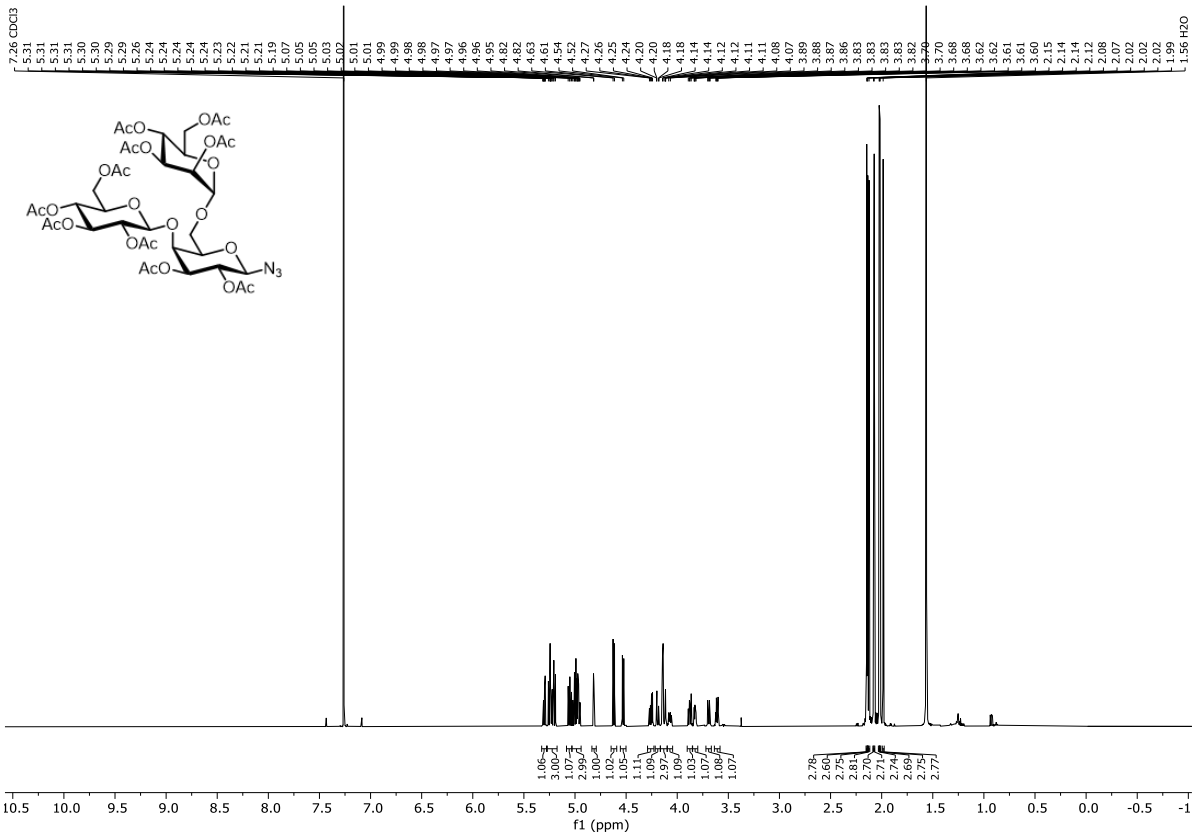


Figure S44. ^{1}H NMR spectrum of compound **18** (600 MHz, $CDCl_3$, 298 K).

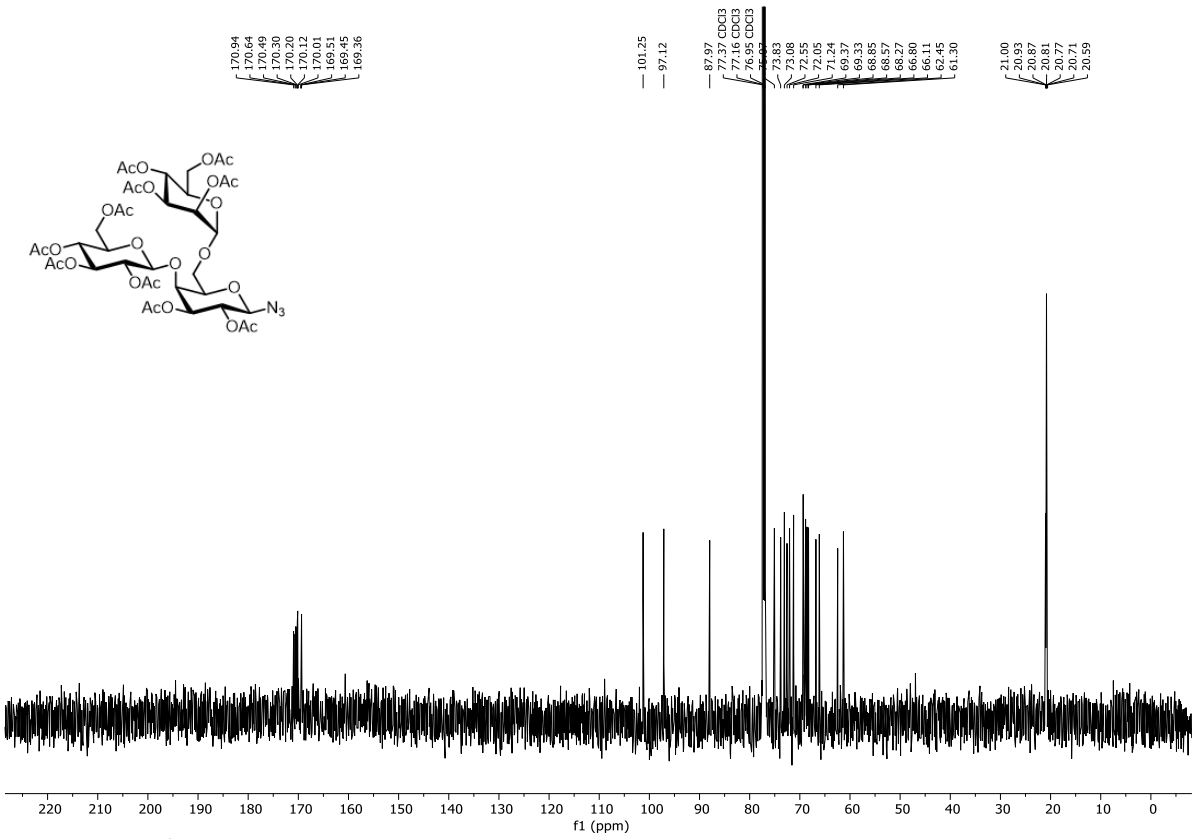


Figure S45. ^{13}C NMR spectrum of compound **18** (151 MHz, $CDCl_3$, 298 K).

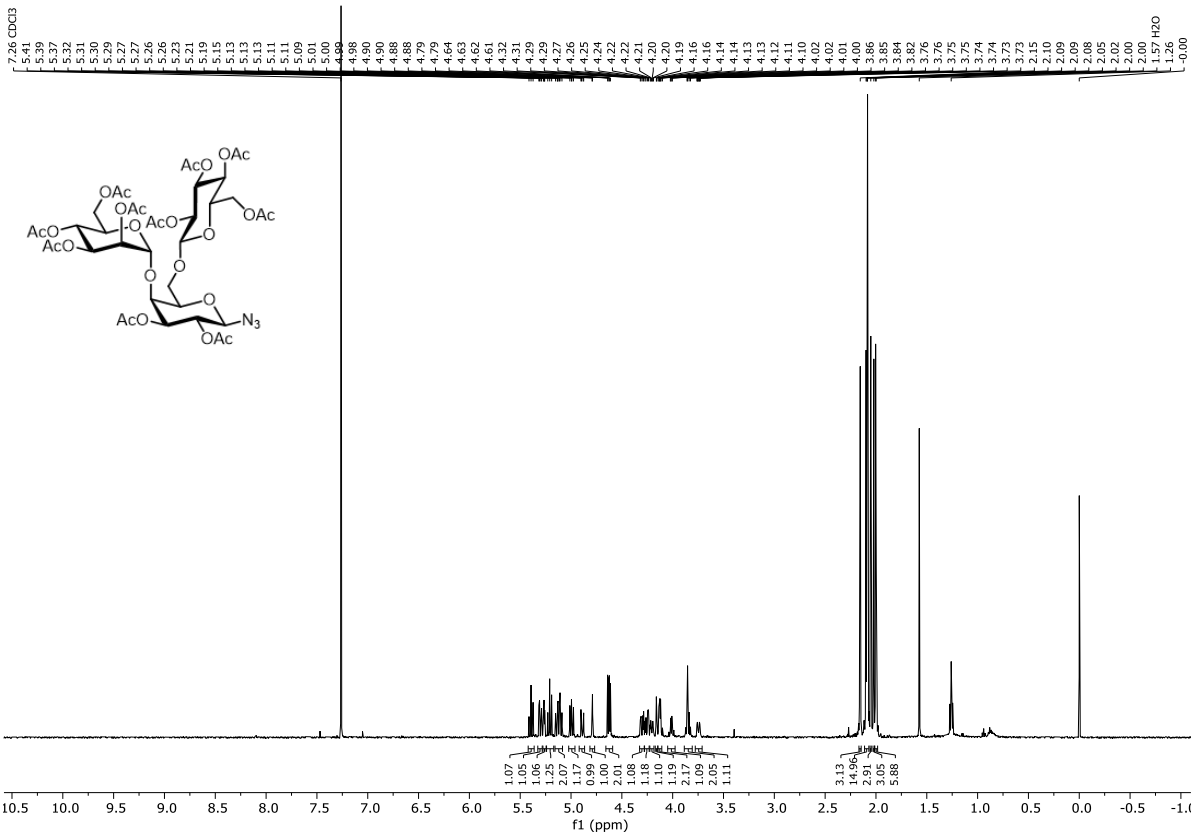


Figure S46. ^{1}H NMR spectrum of compound **19** (500 MHz, $CDCl_3$, 298 K).

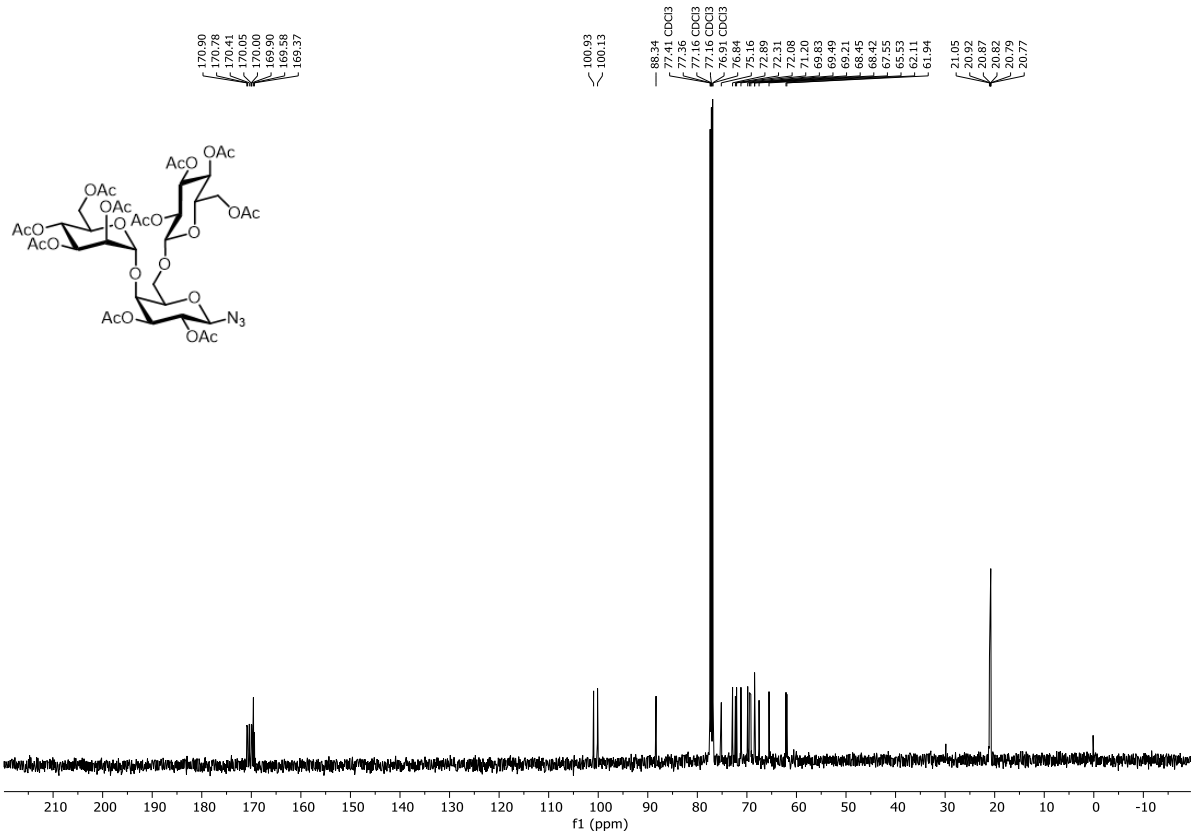


Figure S47. ^{13}C NMR spectrum of compound **19** (126 MHz, $CDCl_3$, 298 K).

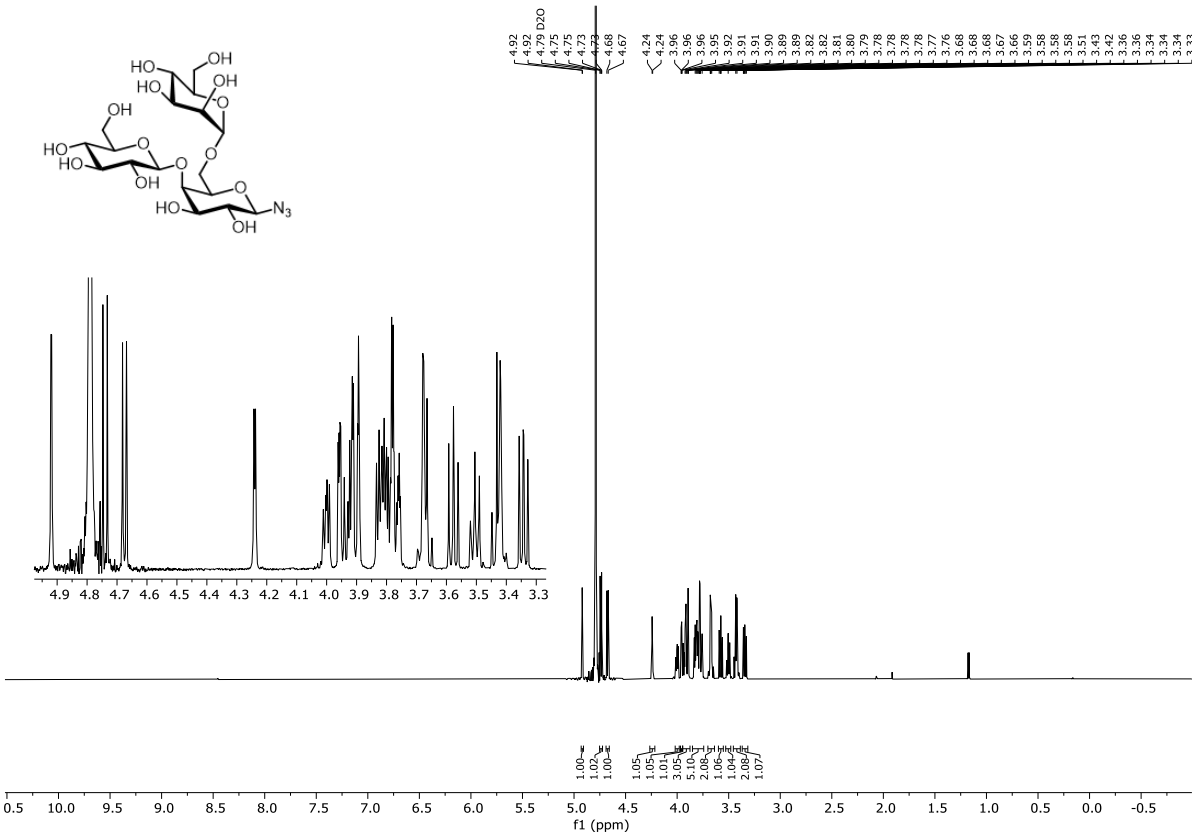


Figure S48. ^{1}H NMR spectrum of compound **20** (600 MHz, D_2O, 298 K).

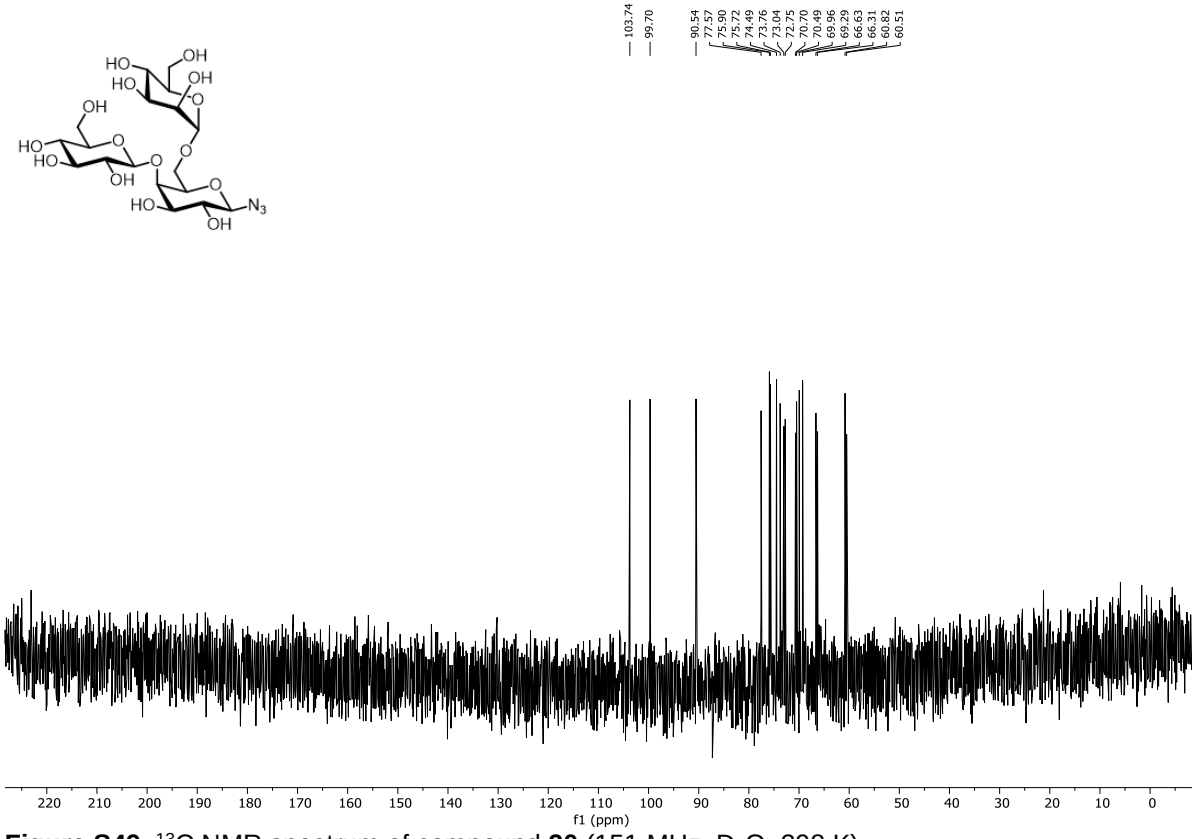


Figure S49. ^{13}C NMR spectrum of compound **20** (151 MHz, D_2O, 298 K).

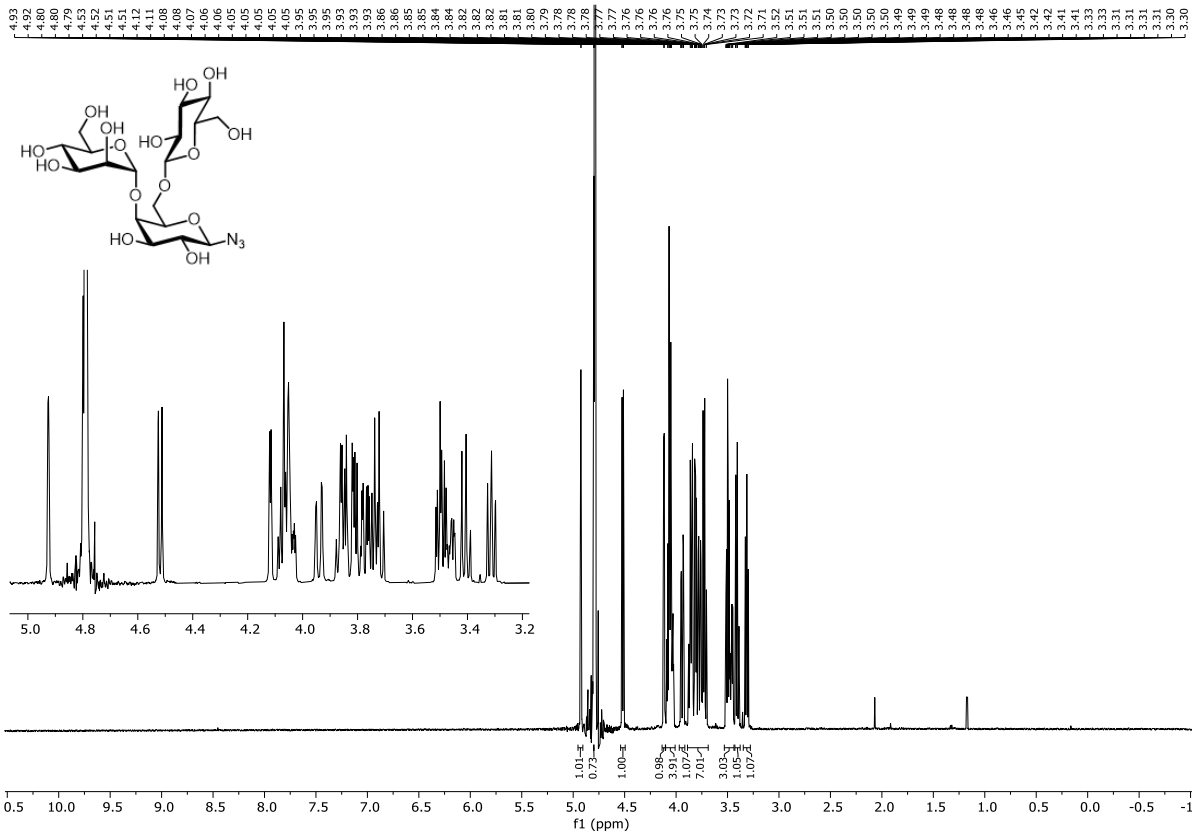


Figure S50. ^{1}H NMR spectrum of compound **21** (600 MHz, D_2O, 298 K).

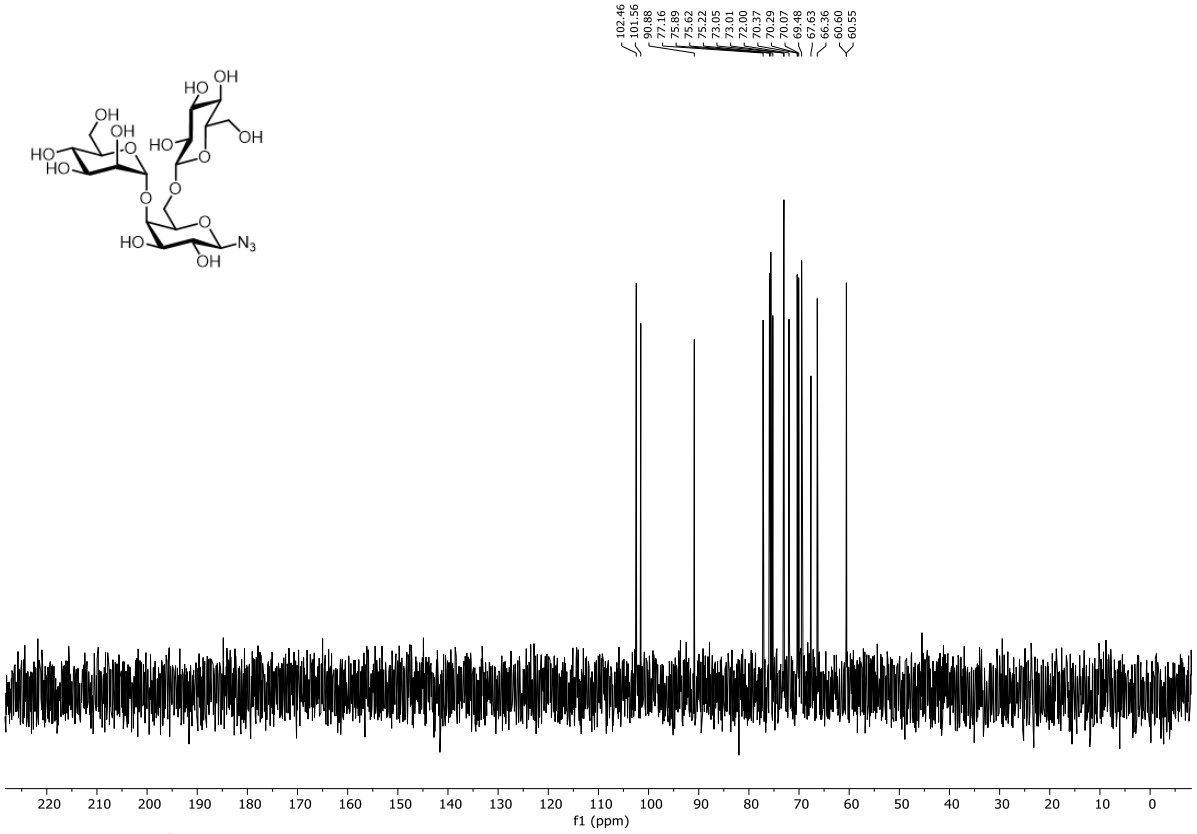


Figure S51. ^{13}C NMR spectrum of compound **21** (151 MHz, D_2O, 298 K).

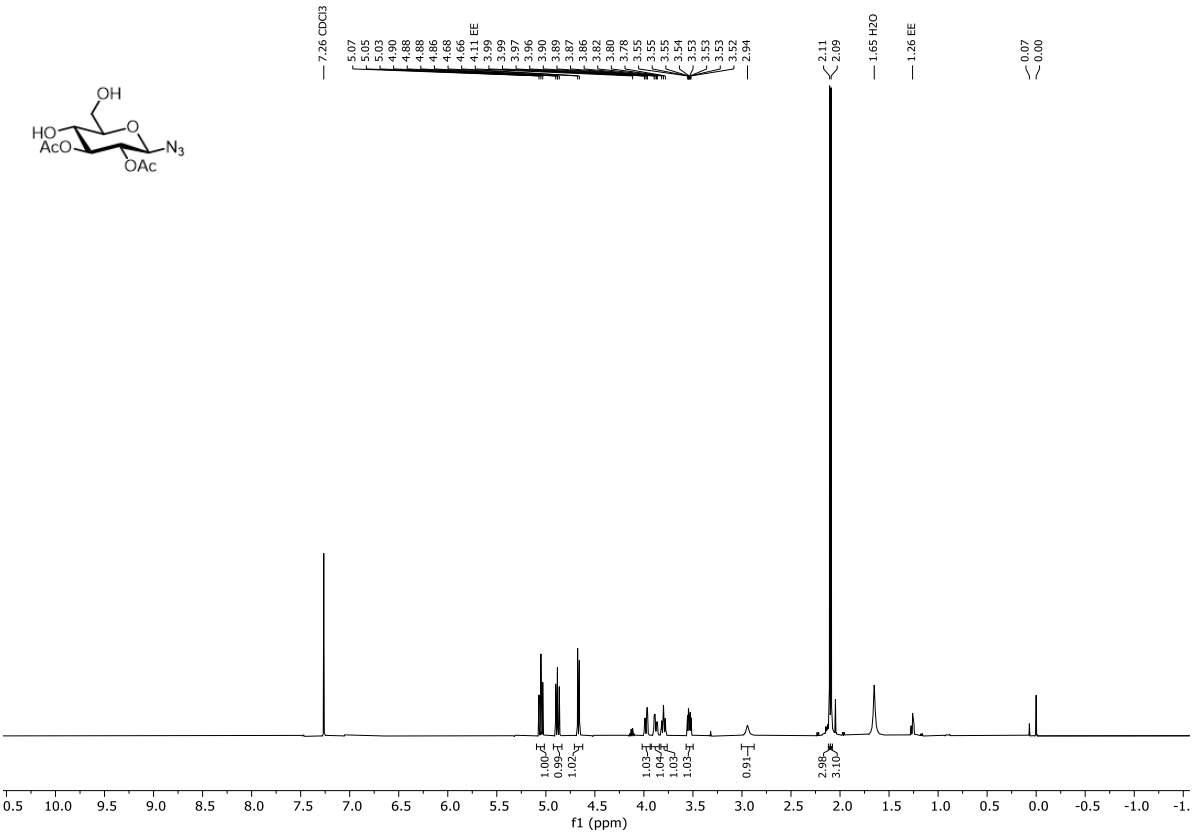


Figure S52. ^{1}H NMR spectrum of compound **22** (500 MHz, $CDCl_3$, 298 K).

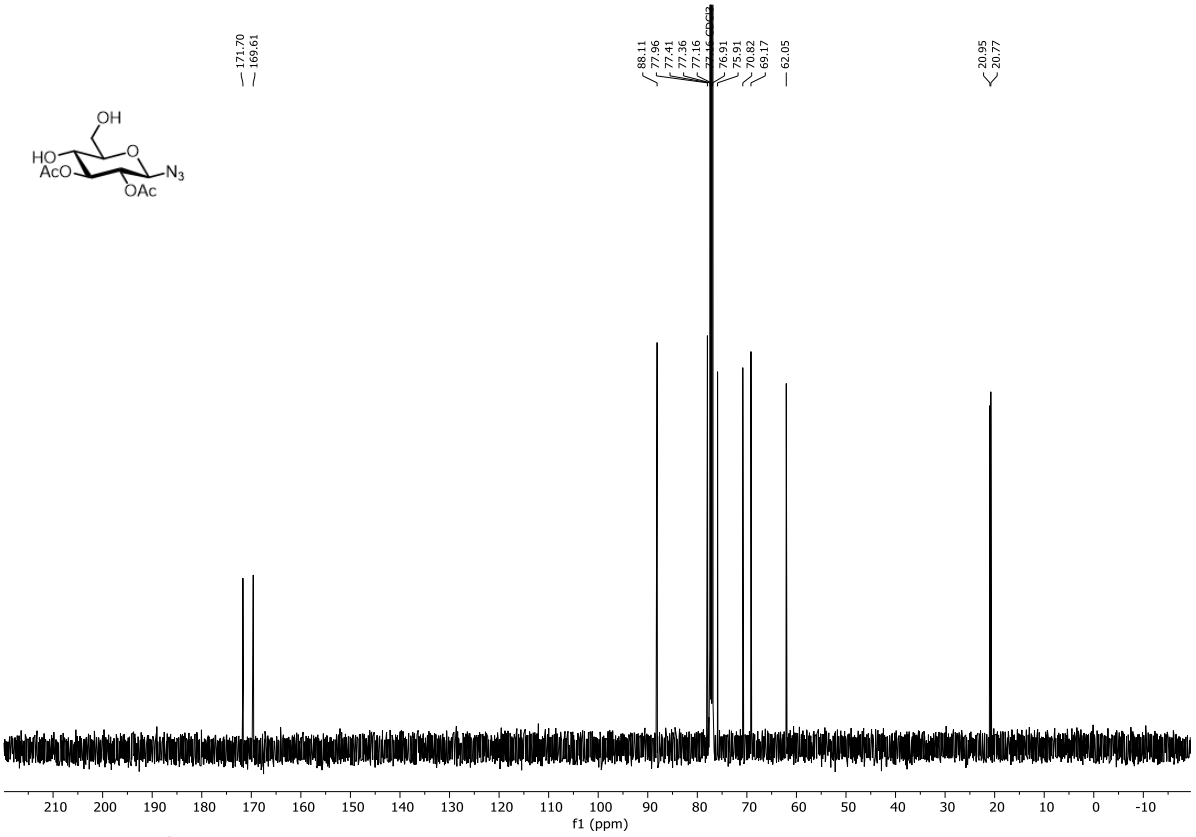


Figure S53. ^{13}C NMR spectrum of compound **22** (126 MHz, $CDCl_3$, 298 K).

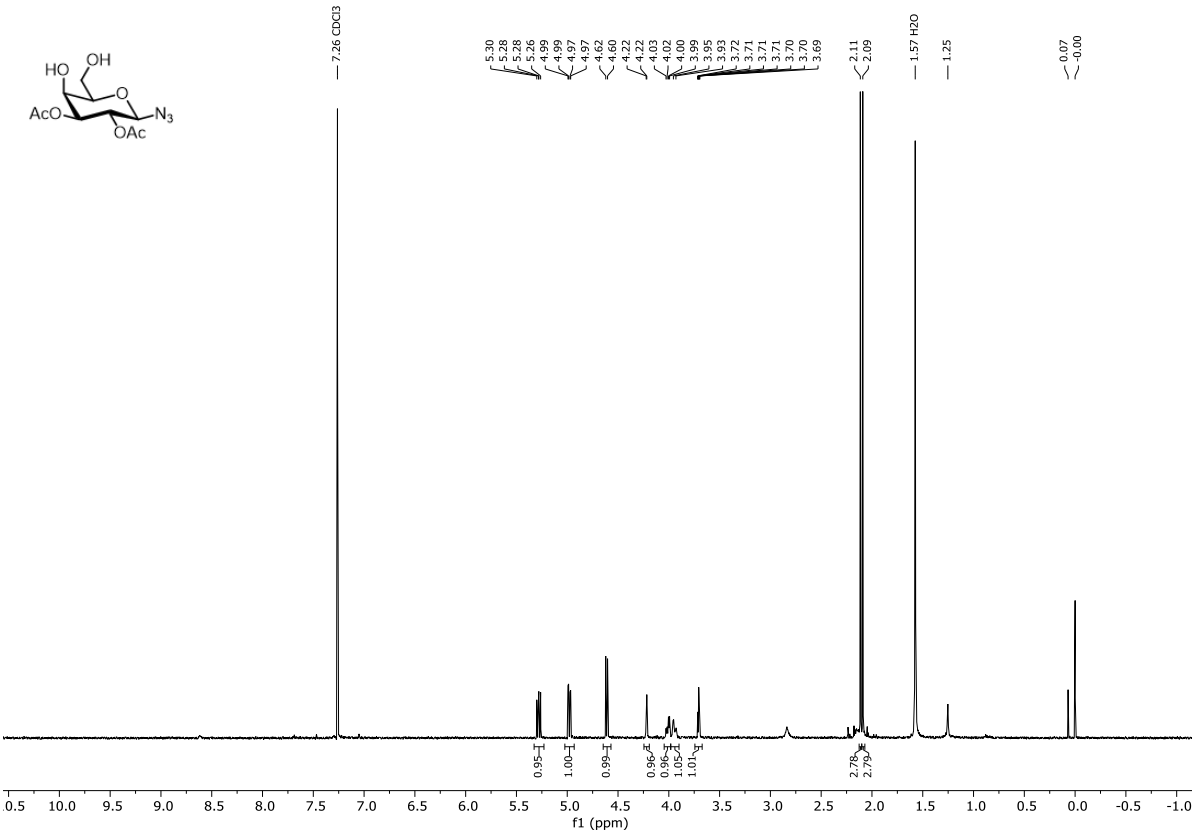


Figure S54. ^{1}H NMR spectrum of compound **23** (500 MHz, $CDCl_3$, 298 K).

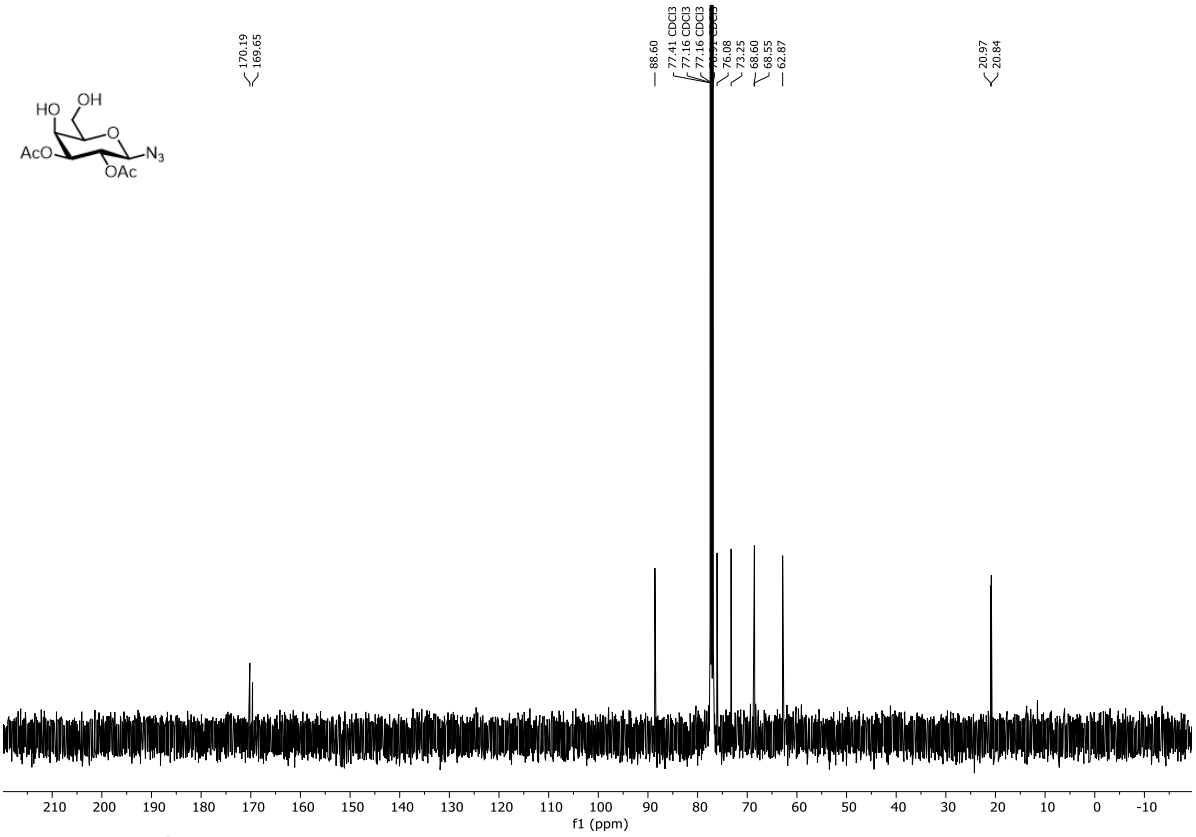


Figure S55. ^{13}C NMR spectrum of compound **23** (126 MHz, $CDCl_3$, 298 K).

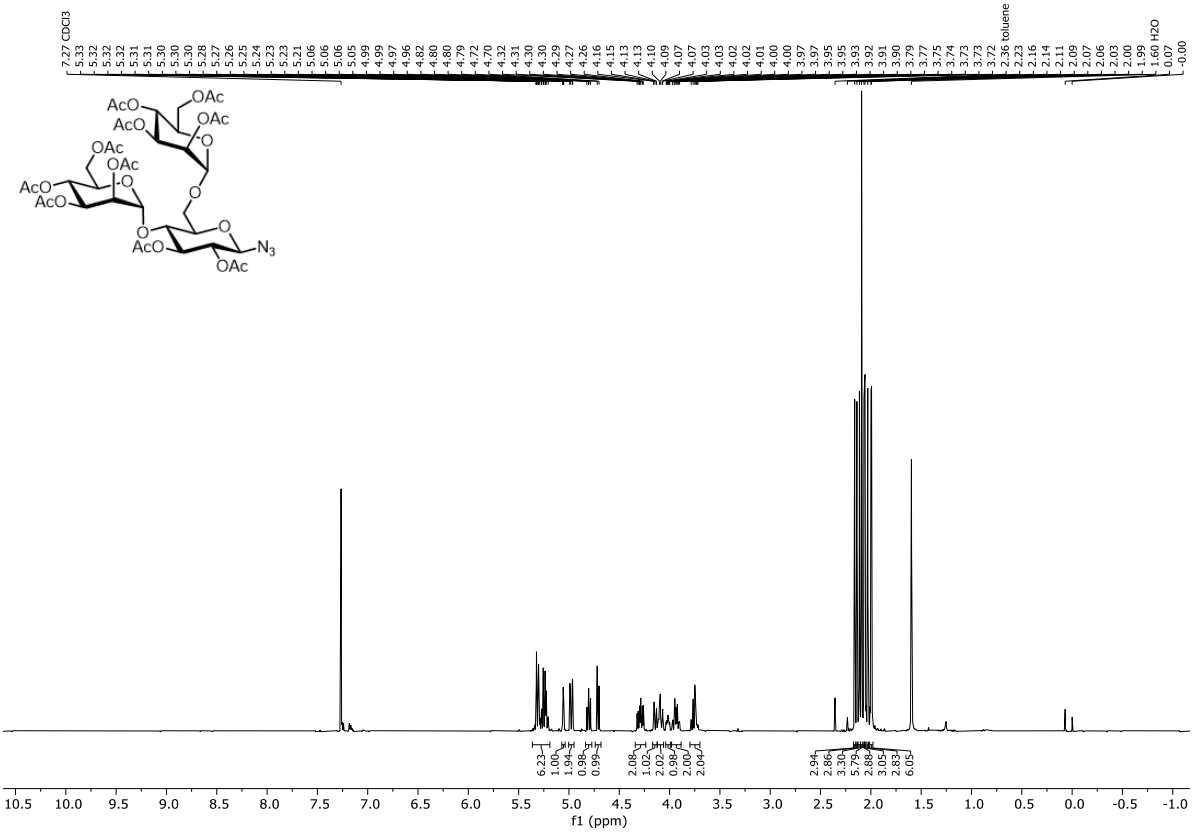


Figure S56. ^{1}H NMR spectrum of compound **24** (500 MHz, $CDCl_3$, 298 K).

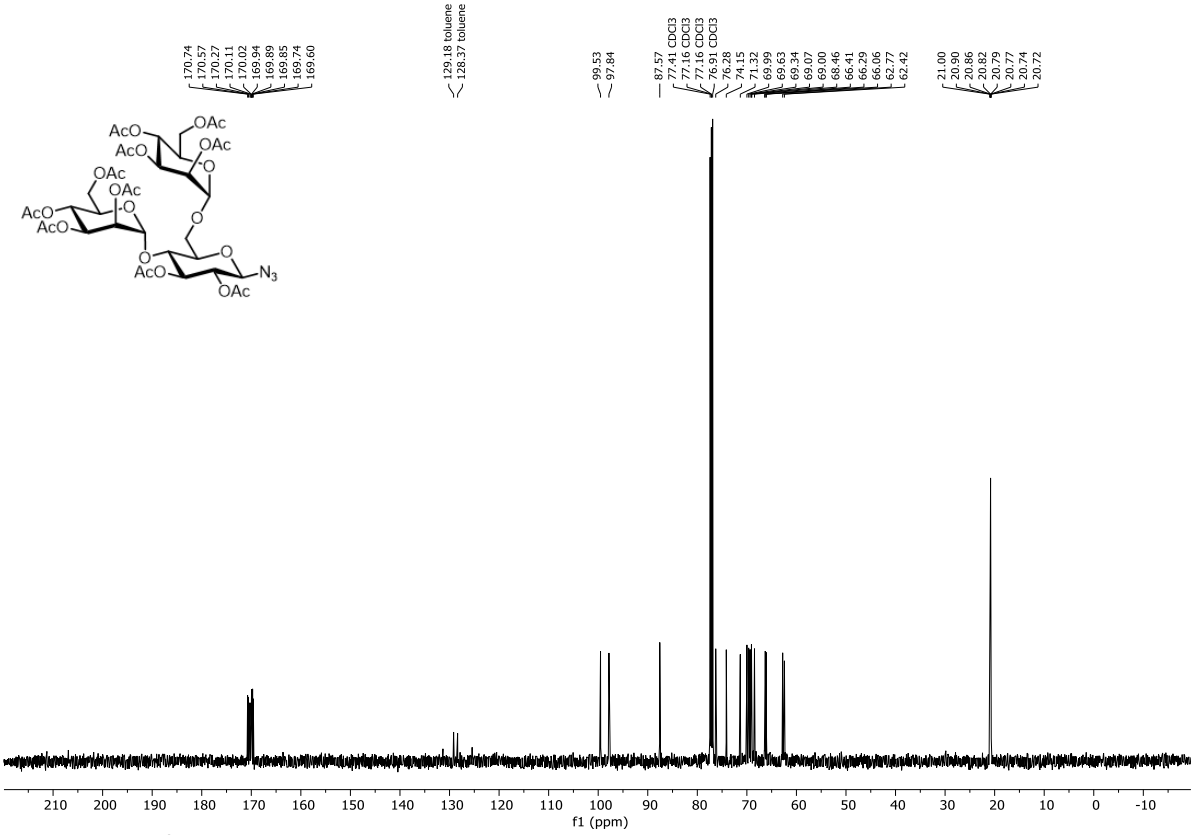


Figure S57. ^{13}C NMR spectrum of compound **24** (126 MHz, $CDCl_3$, 298 K).

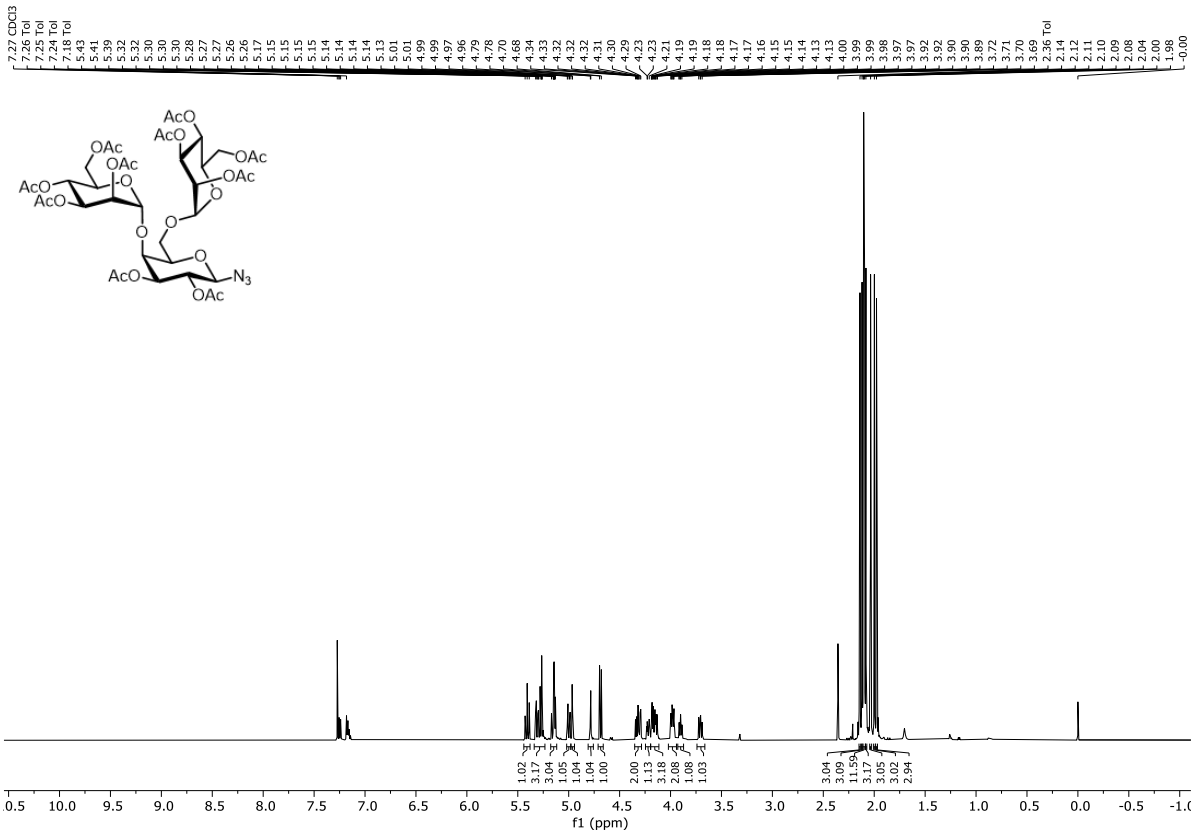


Figure S58. ^{1}H NMR spectrum of compound **25** (500 MHz, $CDCl_3$, 298 K).

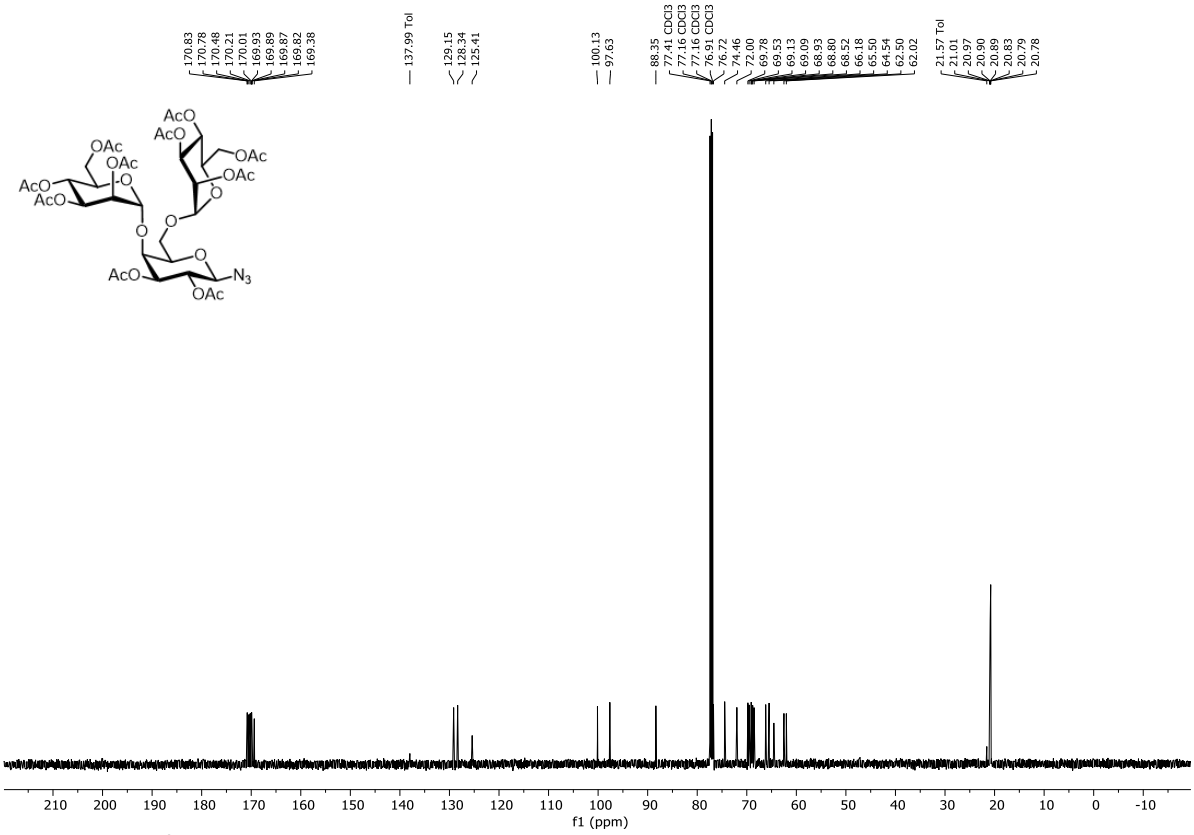


Figure S59. ^{13}C NMR spectrum of compound **25** (126 MHz, $CDCl_3$, 298 K).

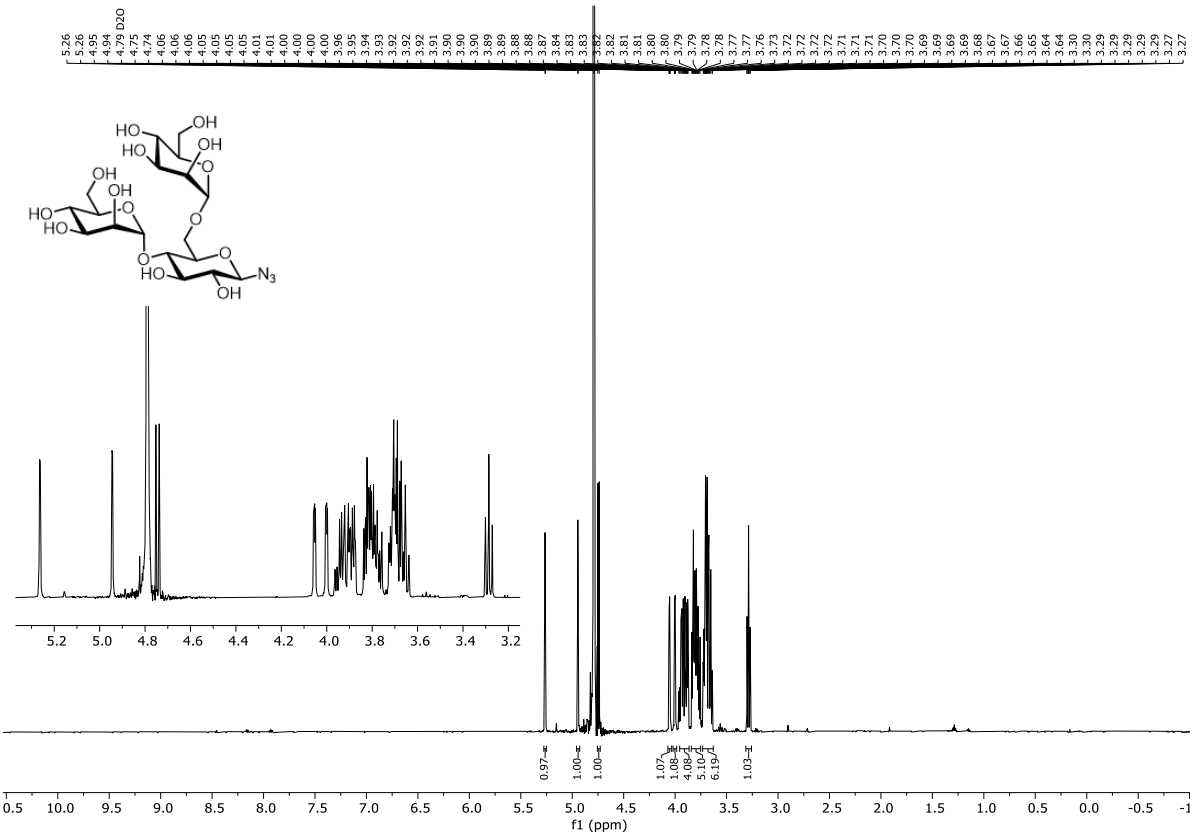


Figure S60. ^{1}H NMR spectrum of compound **26** (600 MHz, D_2O, 298 K).

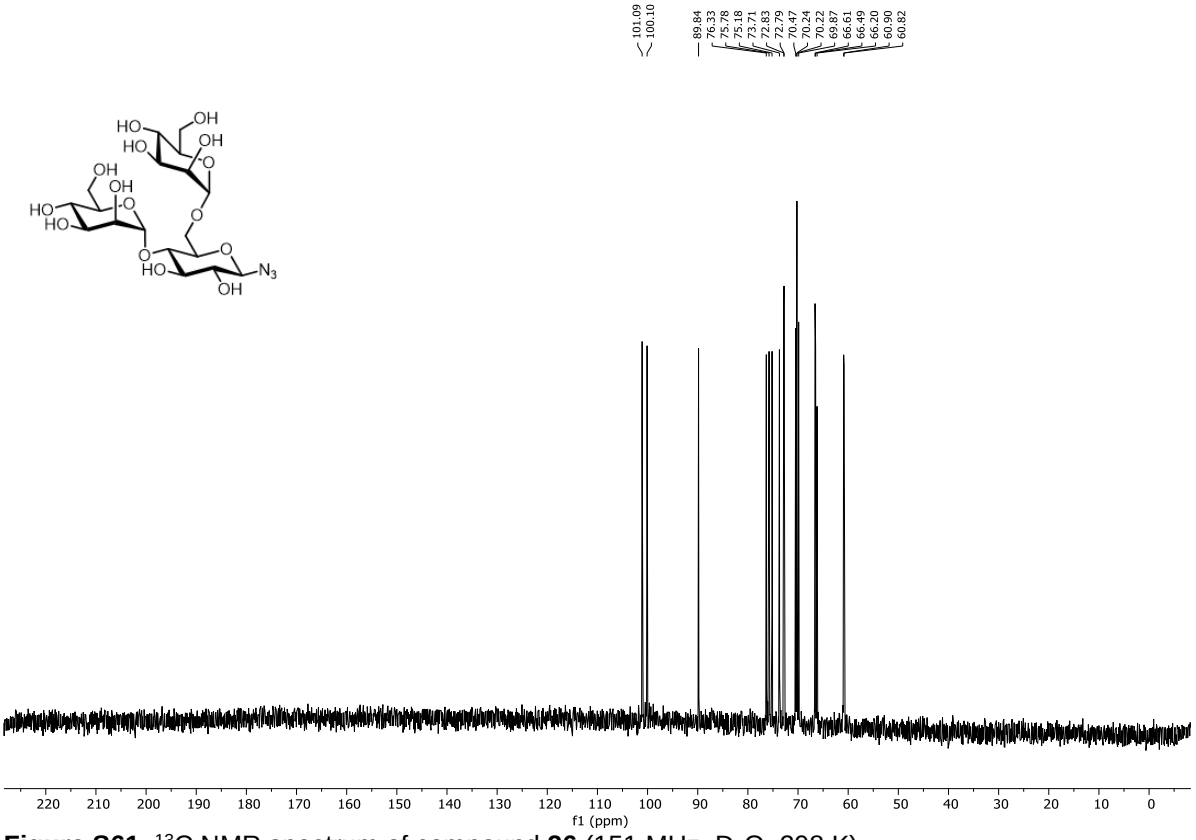


Figure S61. ^{13}C NMR spectrum of compound **26** (151 MHz, D_2O, 298 K).

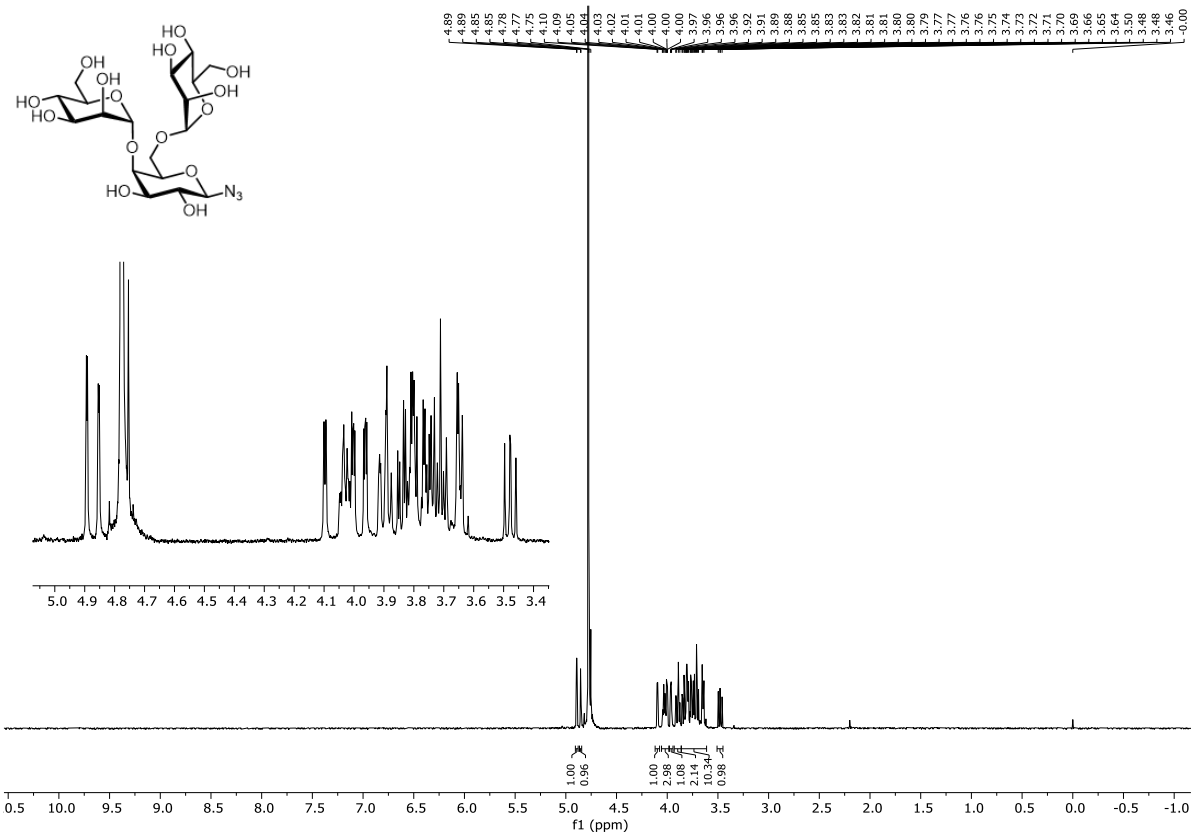


Figure S62. ^{1}H NMR spectrum of compound **27** (500 MHz, D_2O, 298 K).

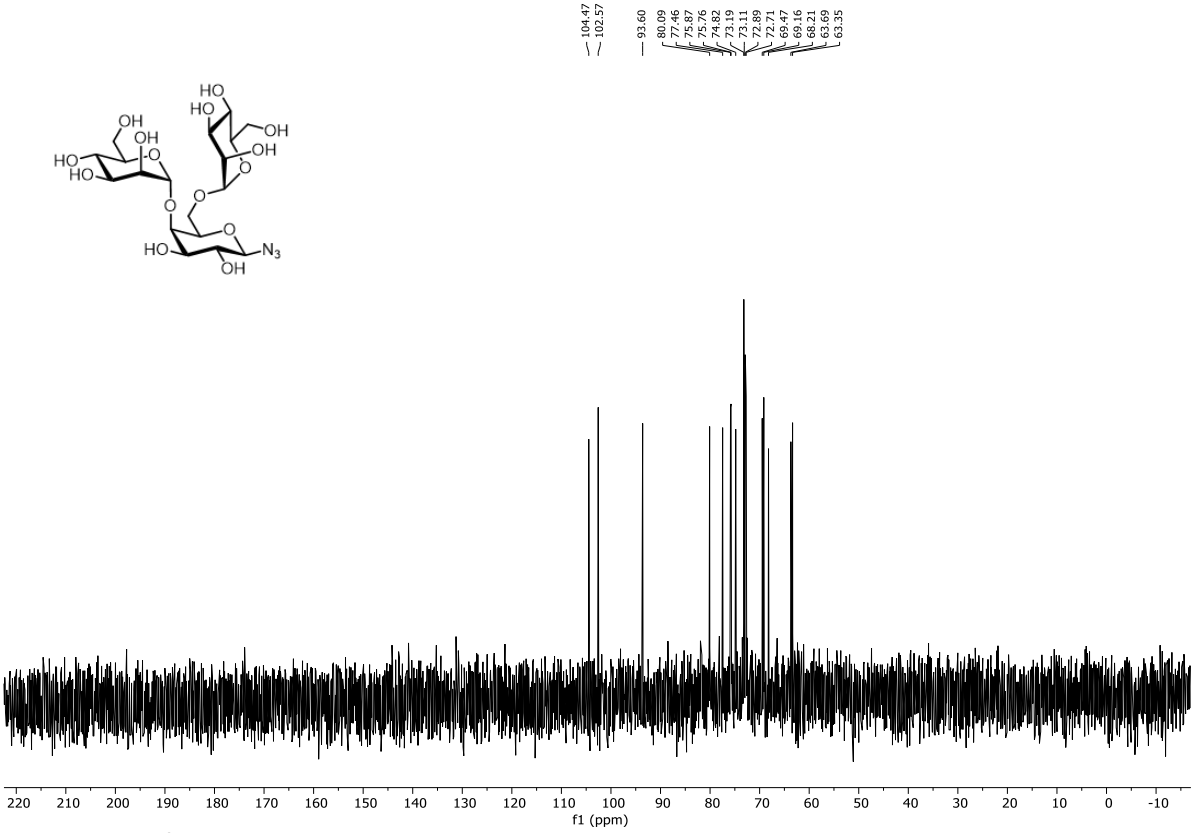


Figure S63. ^{13}C NMR spectrum of compound **27** (126 MHz, D_2O, 298 K).

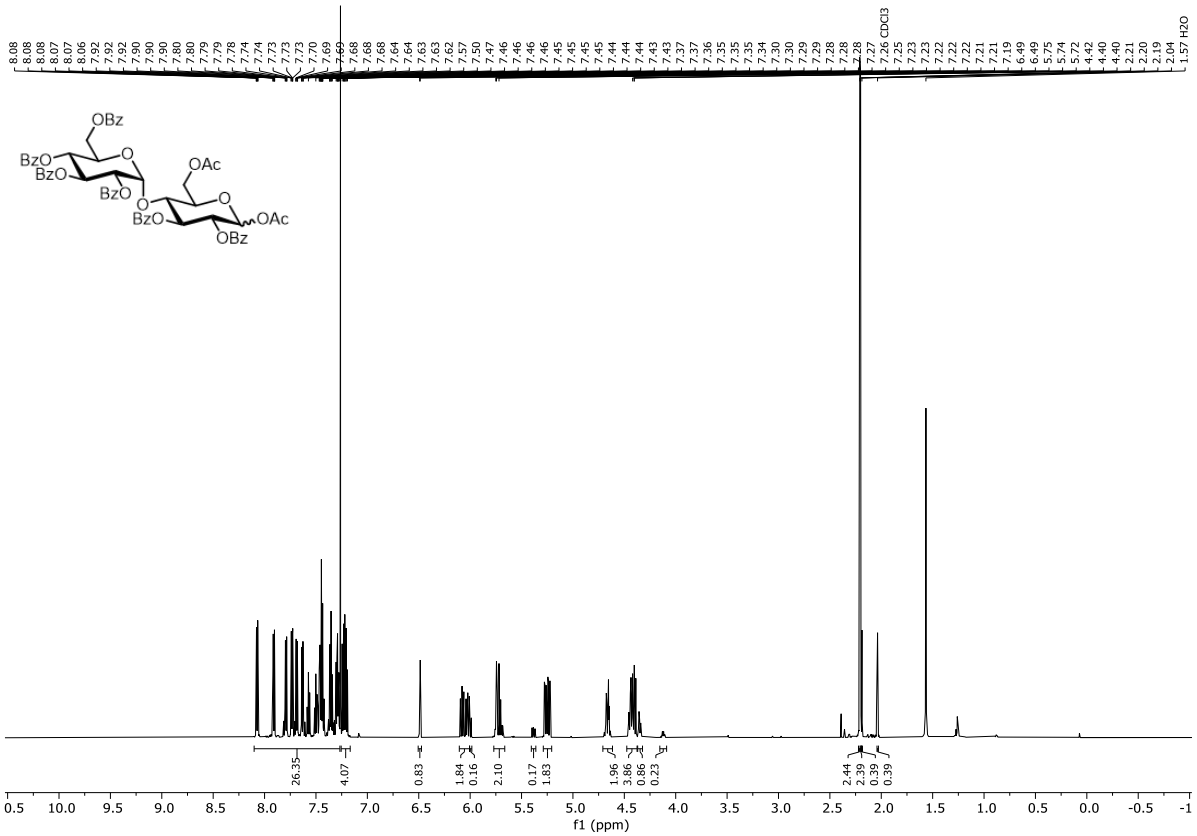


Figure S64. ^{1}H NMR spectrum of compound **28** (600 MHz, $CDCl_3$, 298 K).

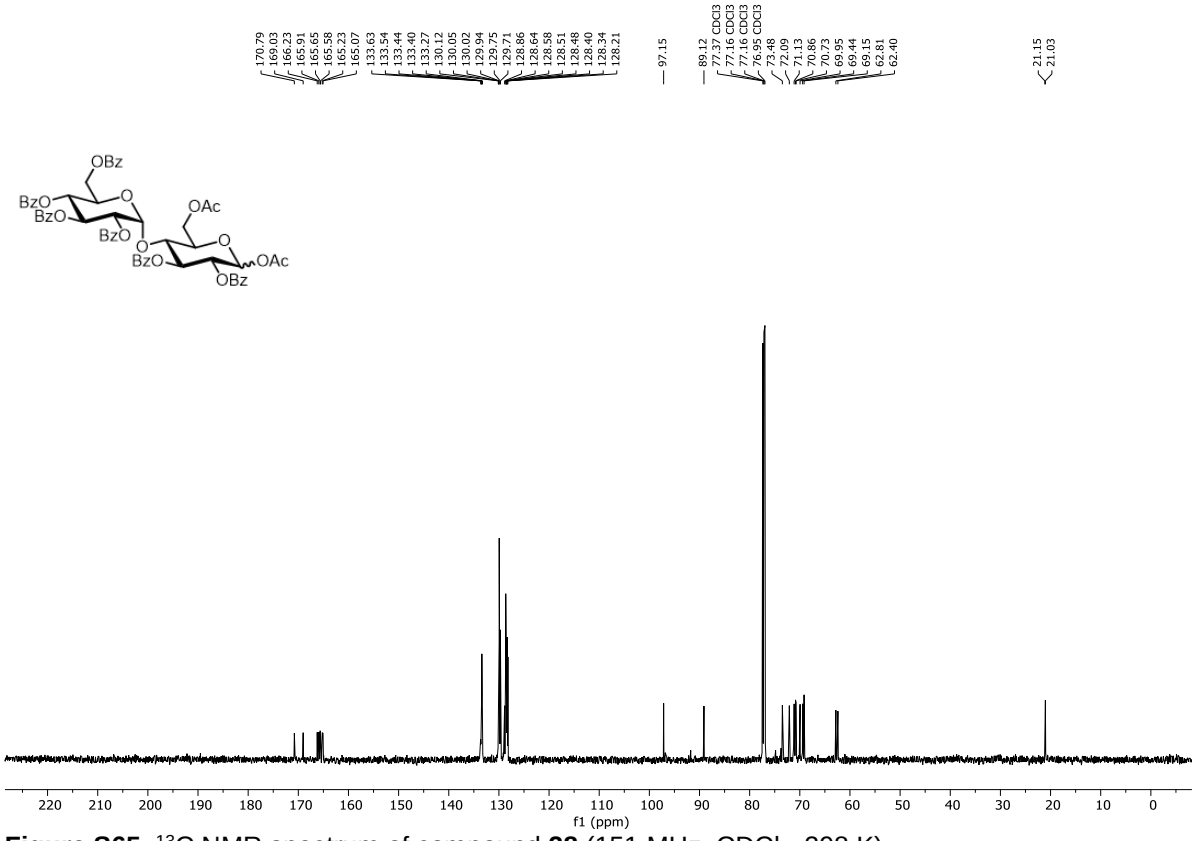


Figure S65. ^{13}C NMR spectrum of compound **28** (151 MHz, $CDCl_3$, 298 K).

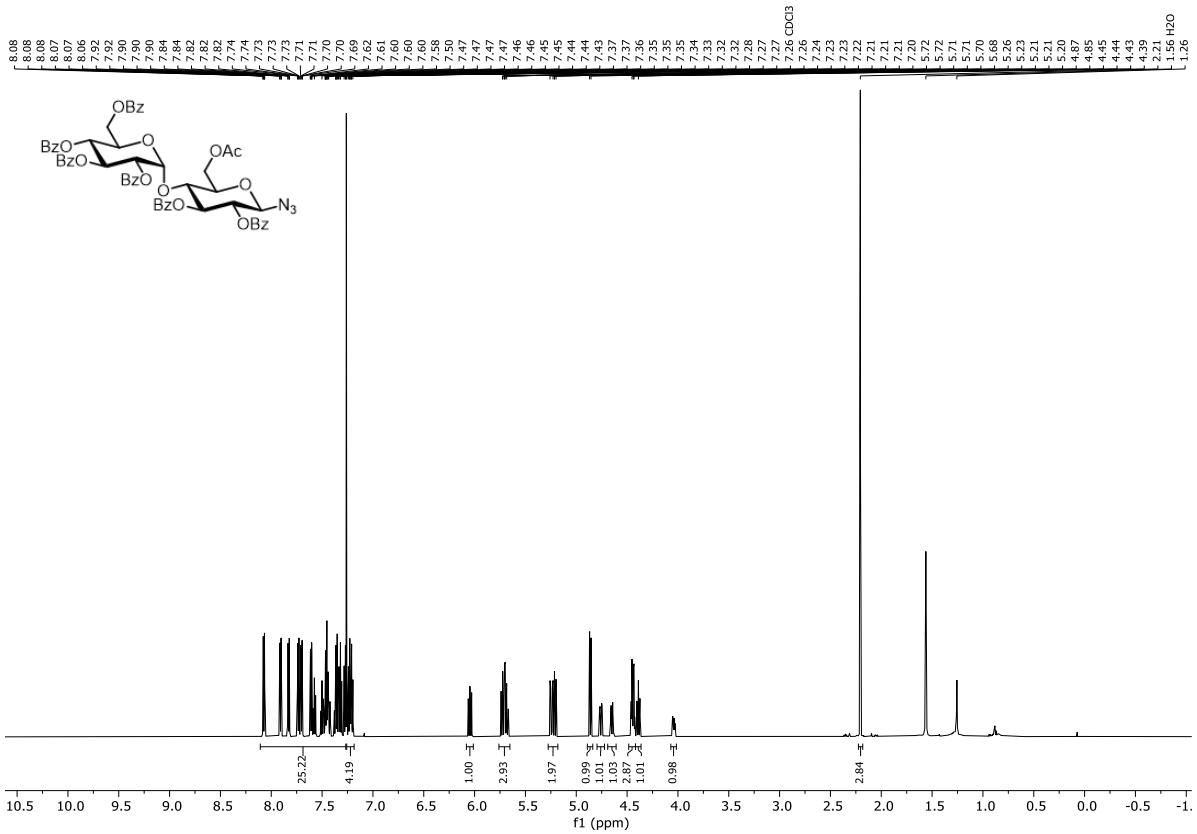


Figure S66. ^{1}H NMR spectrum of compound **29** (600 MHz, $CDCl_3$, 298 K).

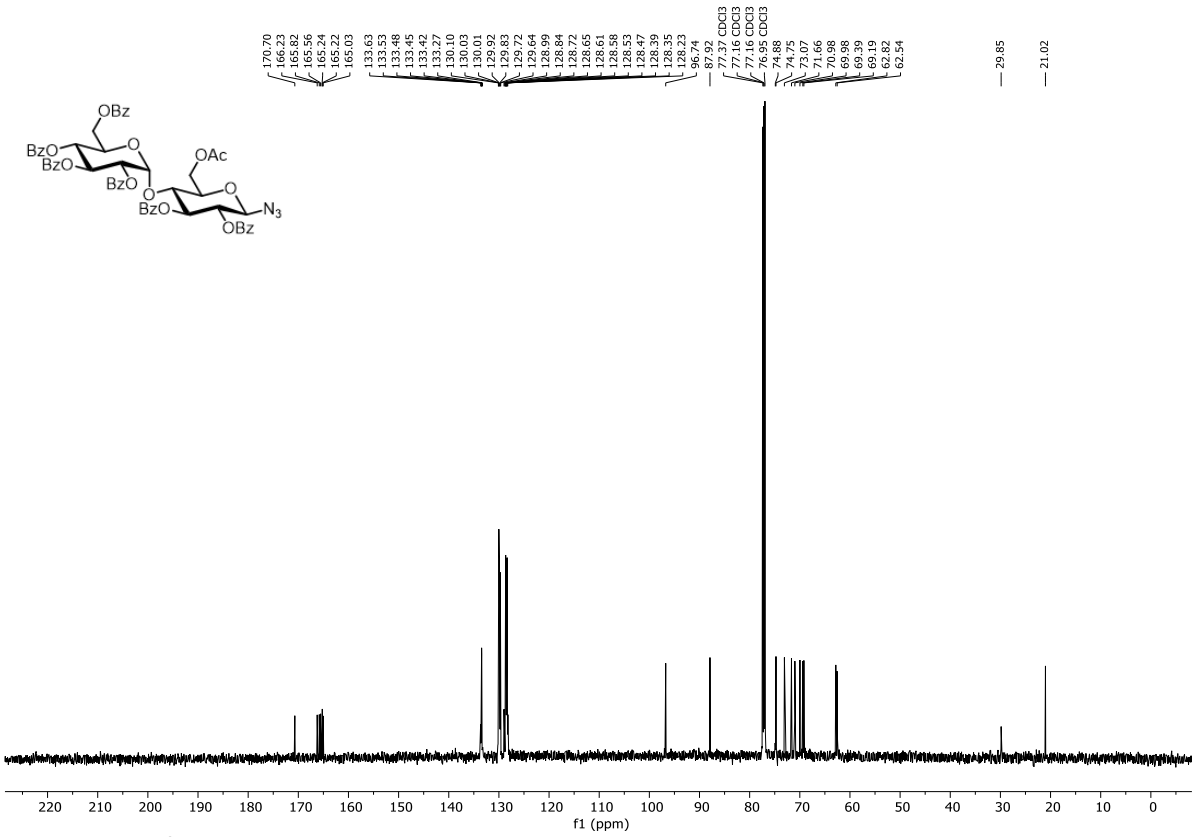


Figure S67. ^{13}C NMR spectrum of compound **29** (151 MHz, $CDCl_3$, 298 K).

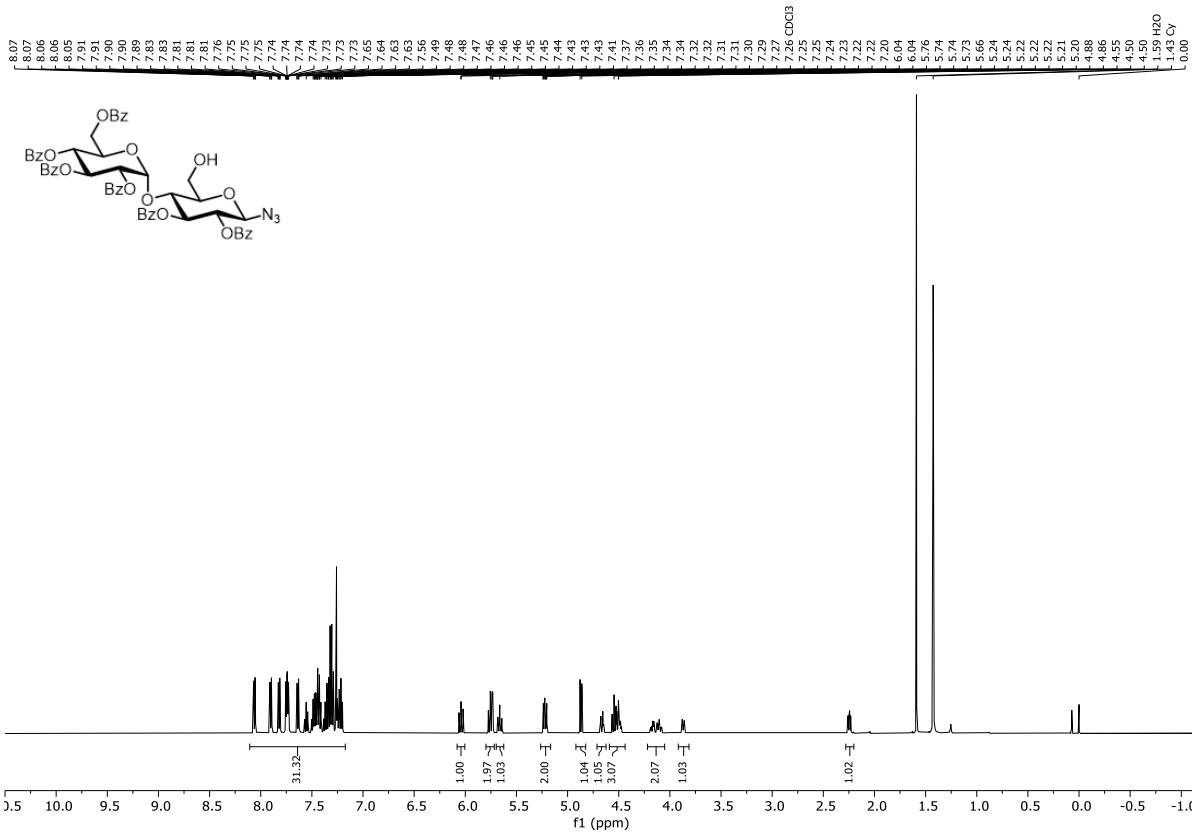


Figure S68. ^{1}H NMR spectrum of compound **30** (500 MHz, $CDCl_3$, 298 K).

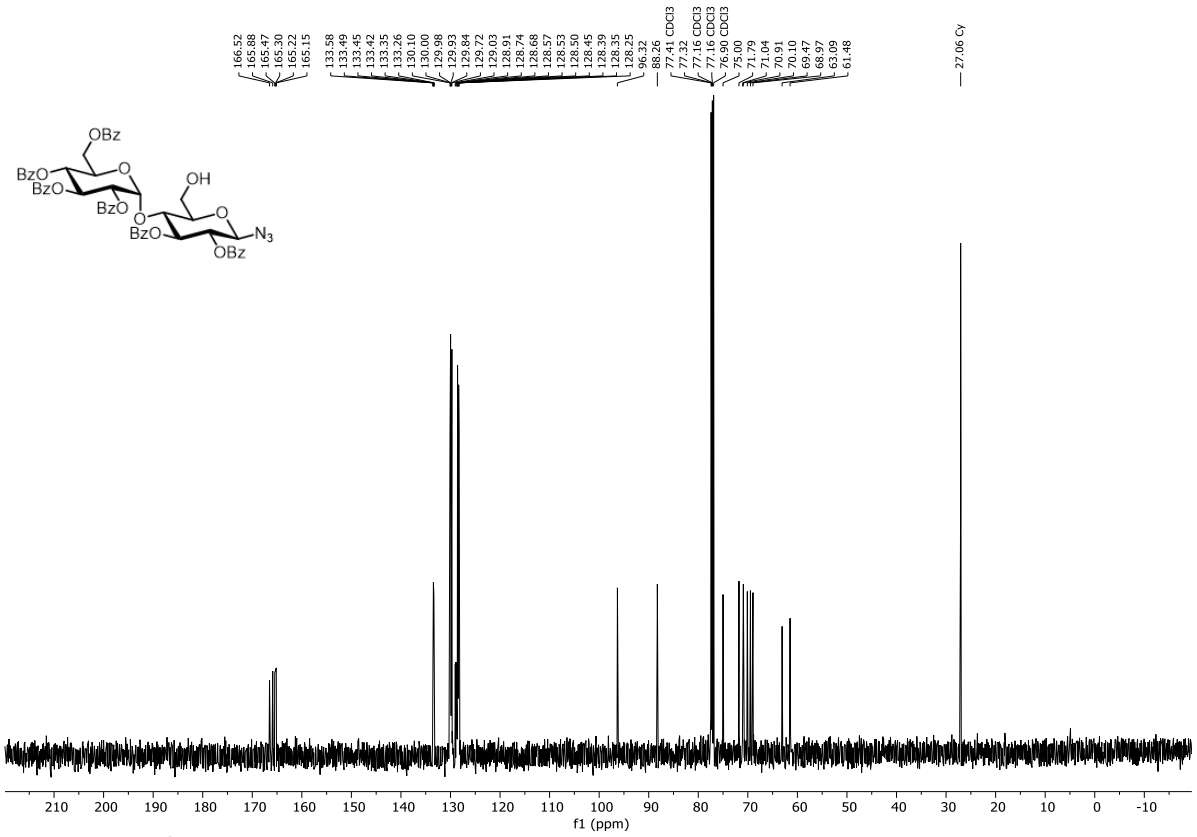


Figure S69. ^{13}C NMR spectrum of compound **30** (126 MHz, $CDCl_3$, 298 K).

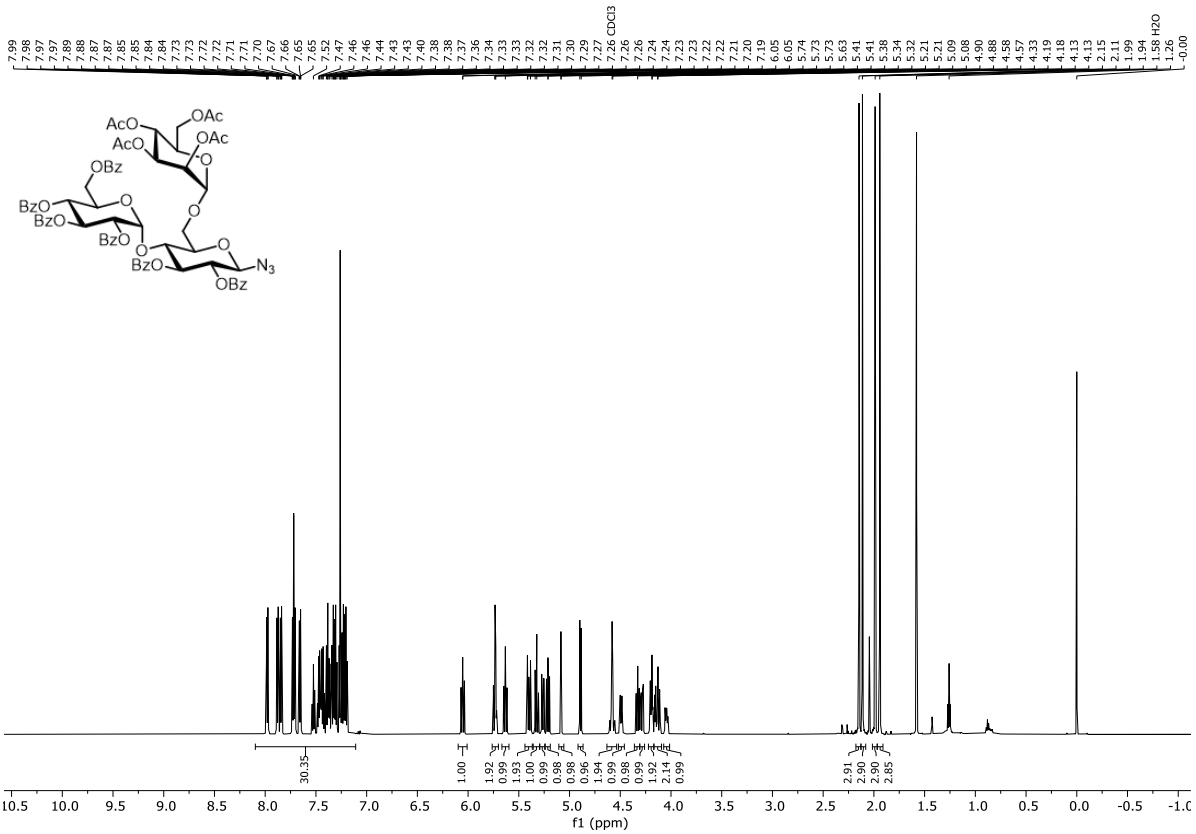


Figure S70. ^{1}H NMR spectrum of compound **31** (600 MHz, $CDCl_3$, 298 K).

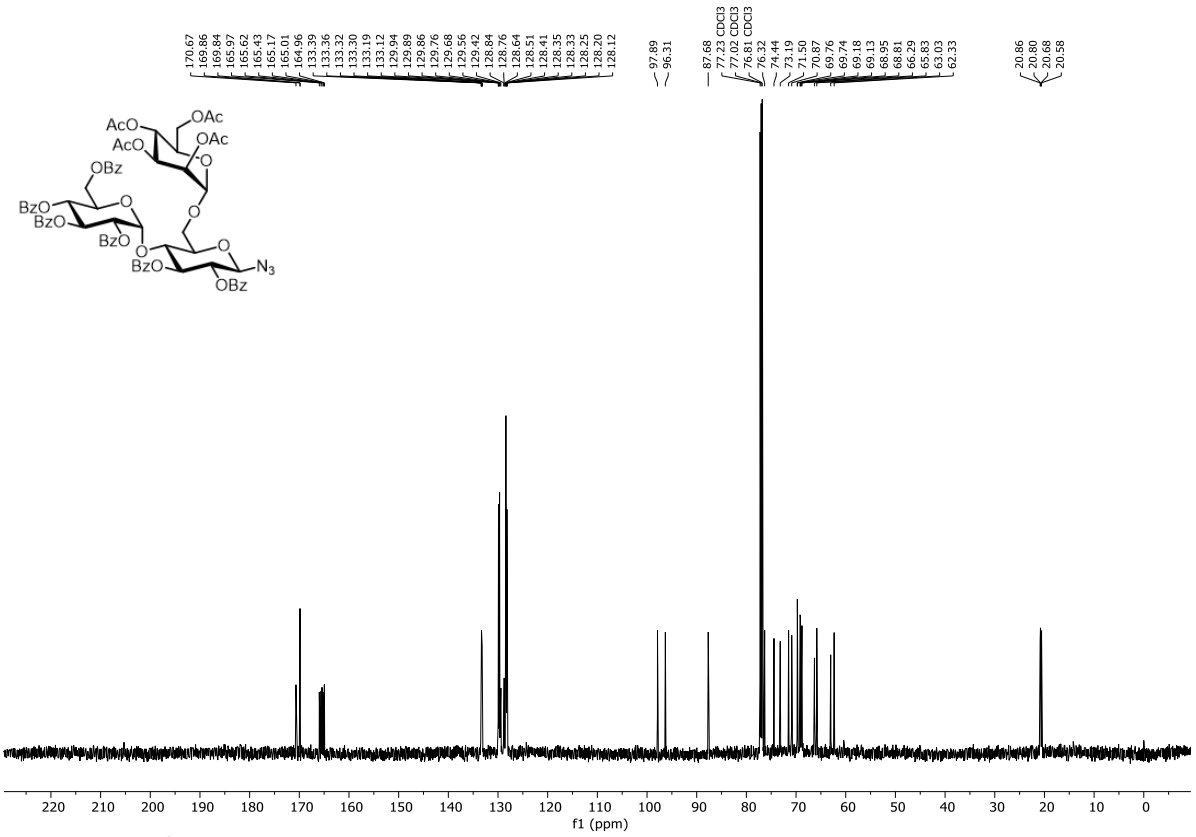


Figure S71. ^{13}C NMR spectrum of compound **31** (151 MHz, $CDCl_3$, 298 K).

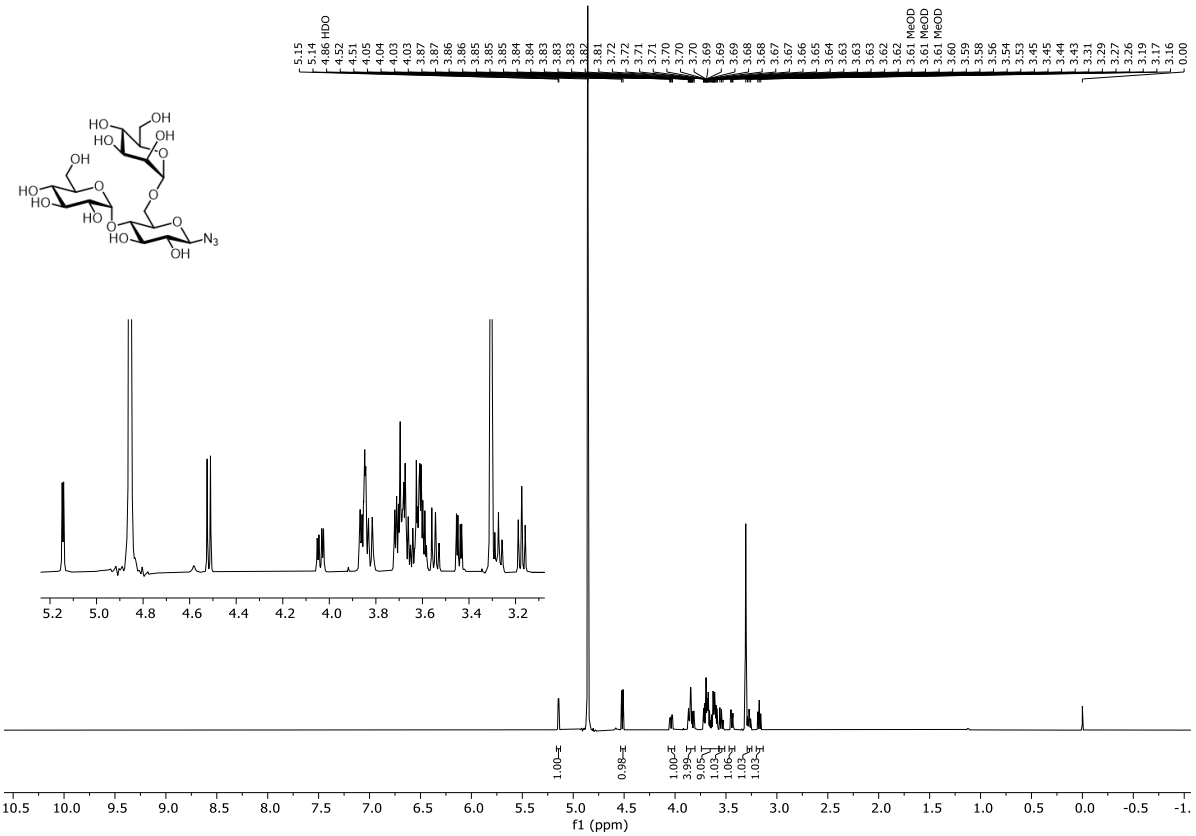


Figure S72. ^{1}H NMR spectrum of compound **32** (600 MHz, CD_3OD, 298 K).

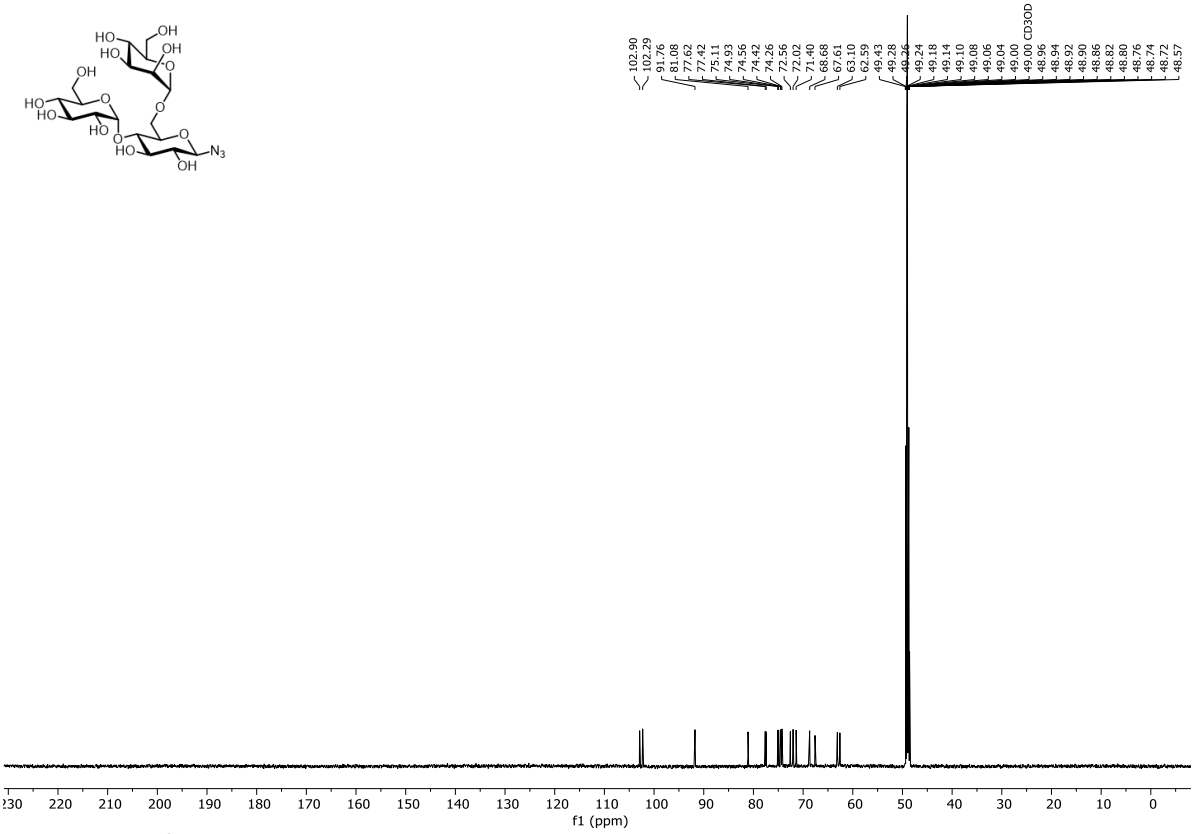


Figure S73. ^{13}C NMR spectrum of compound **32** (151 MHz, CD_3OD, 298 K).

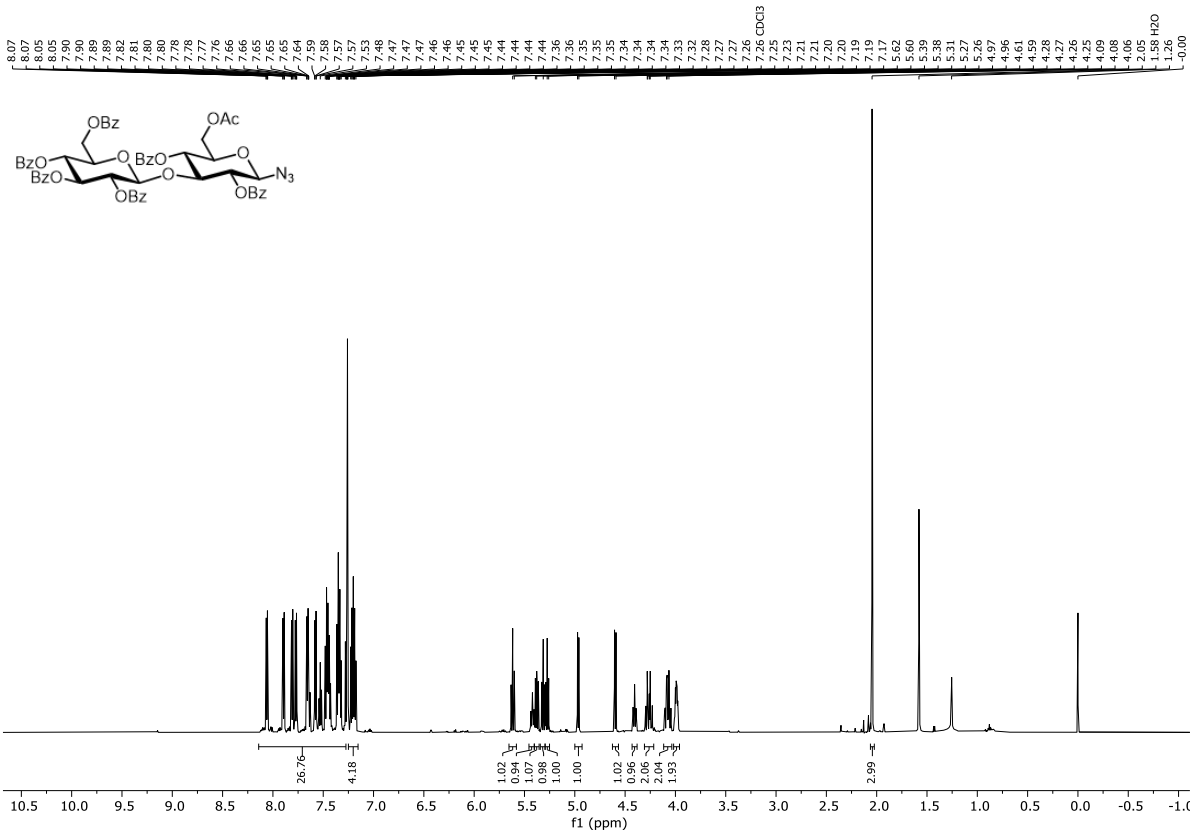


Figure S74. ^{1}H NMR spectrum of compound **34** (600 MHz, $CDCl_3$, 298 K).

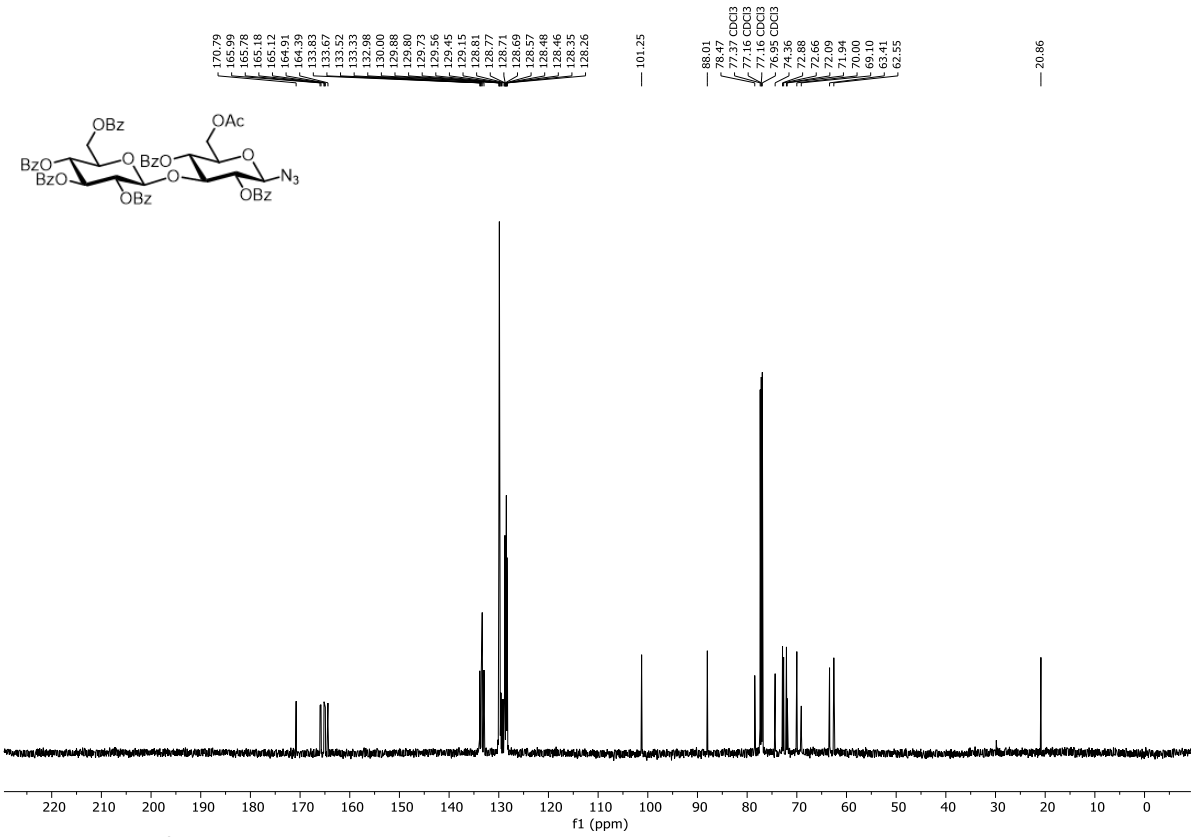


Figure S75. ^{13}C NMR spectrum of compound **34** (151 MHz, $CDCl_3$, 298 K).

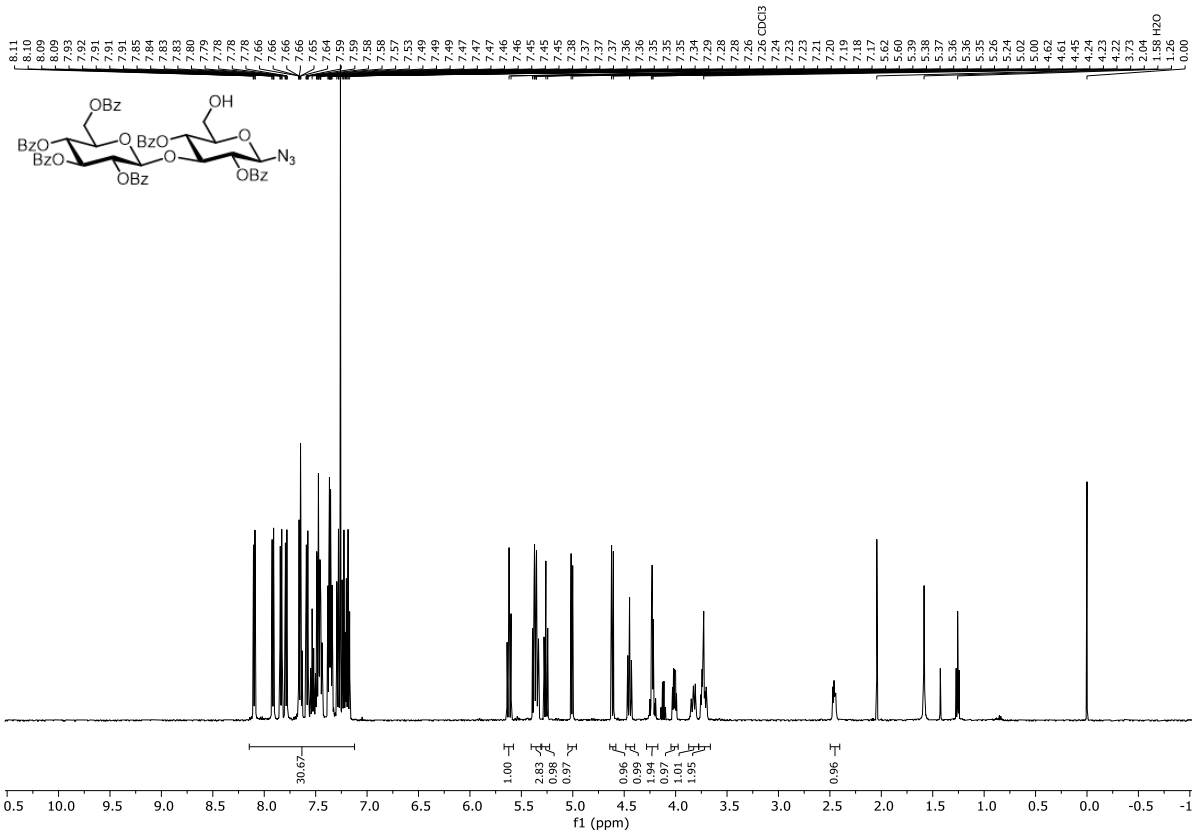


Figure S76. ^{1}H NMR spectrum of compound **35** (500 MHz, $CDCl_3$, 298 K).

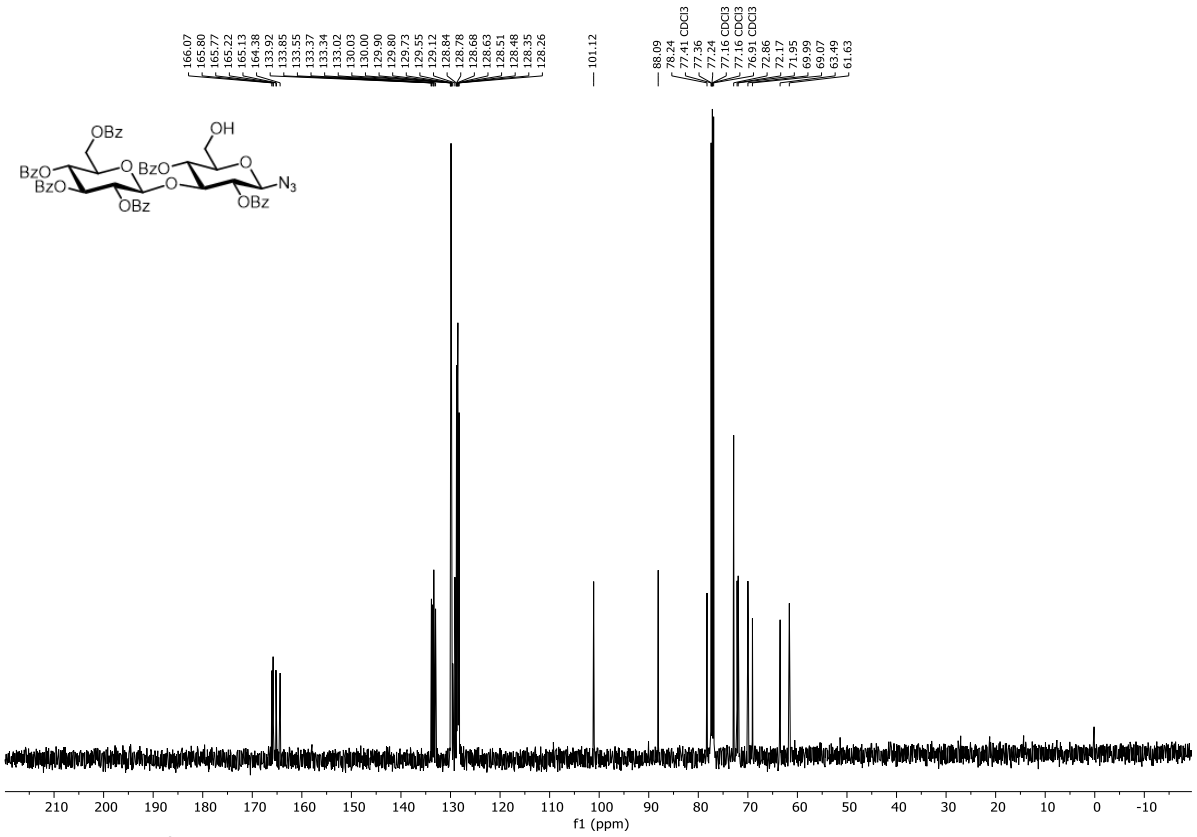


Figure S77. ^{13}C NMR spectrum of compound **35** (126 MHz, $CDCl_3$, 298 K).

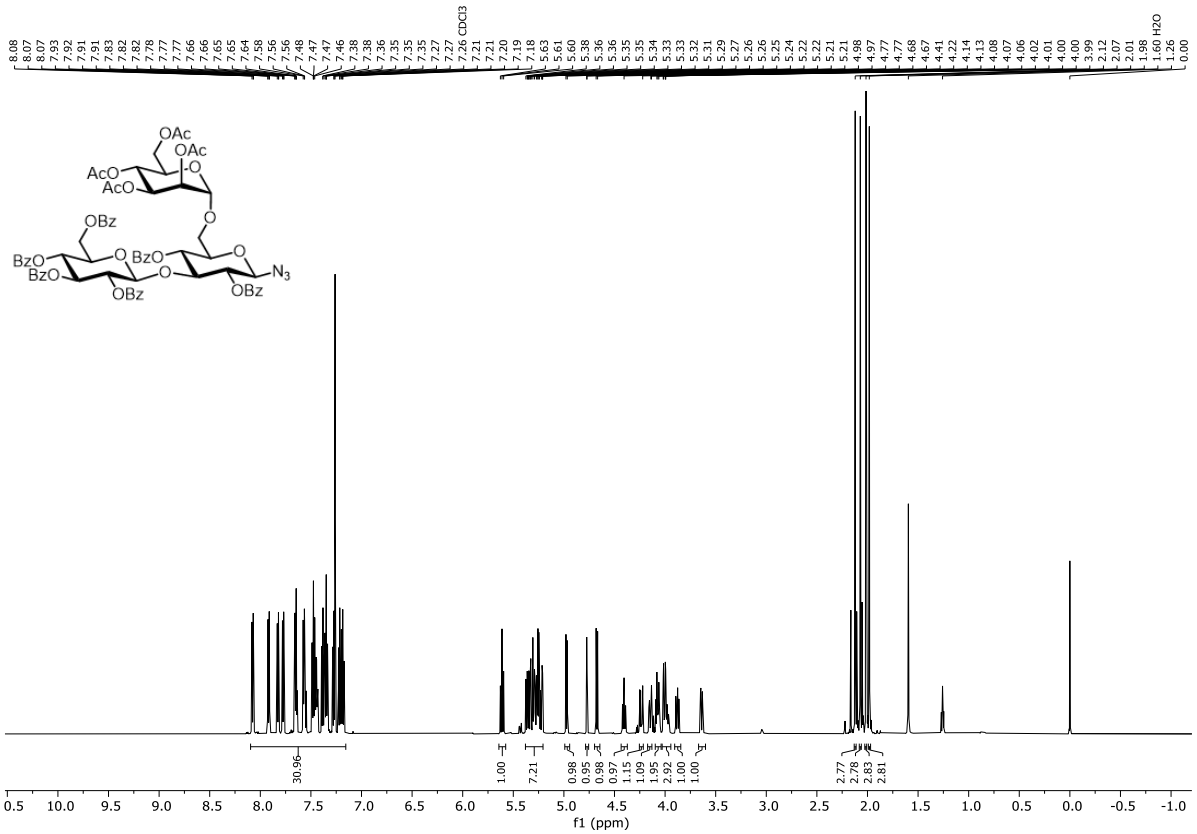


Figure S78. ^{1}H NMR spectrum of compound **36** (600 MHz, $CDCl_3$, 298 K).

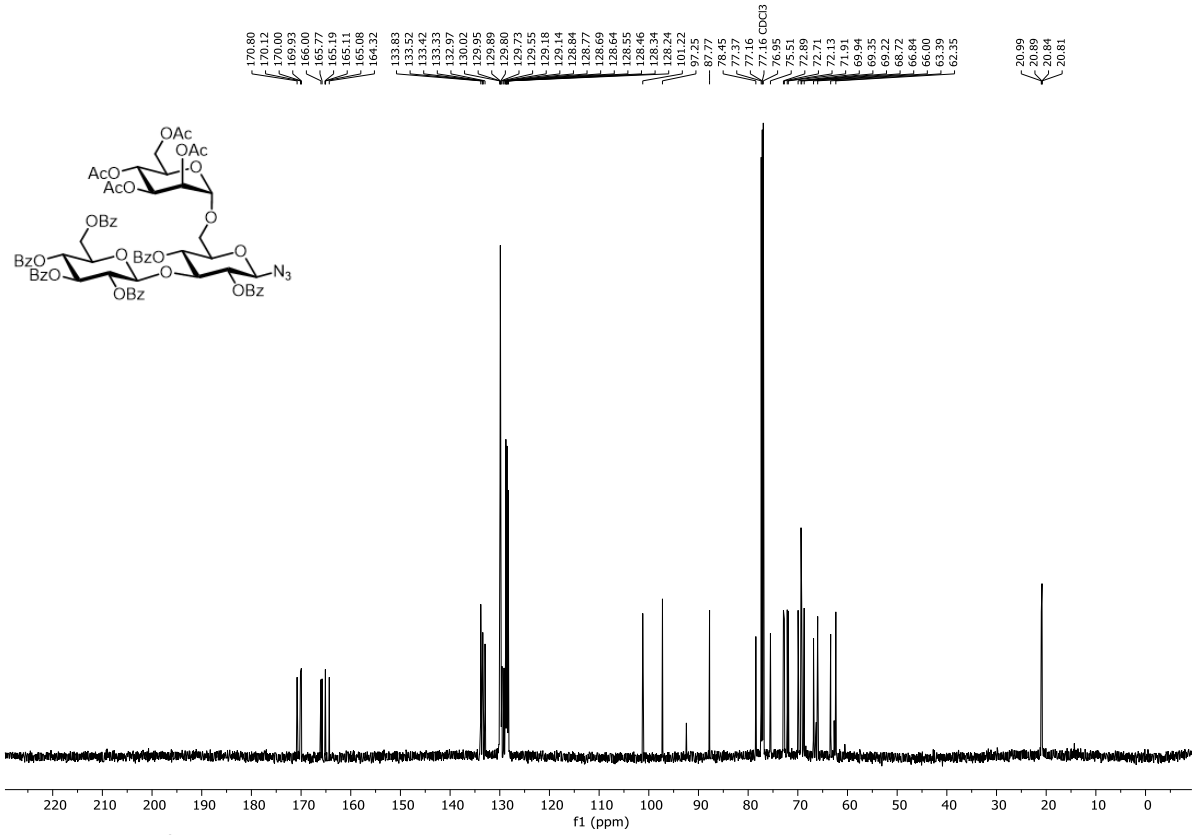


Figure S79. ^{13}C NMR spectrum of compound **36** (151 MHz, $CDCl_3$, 298 K).

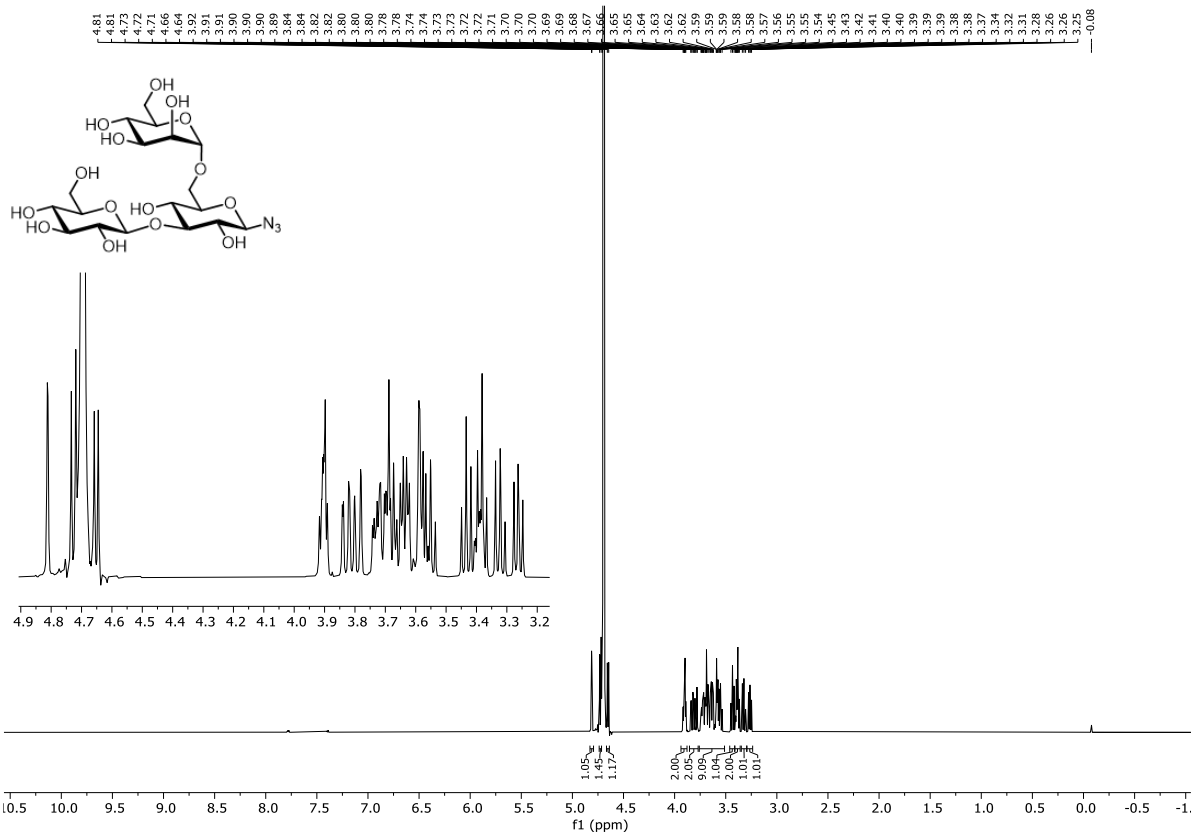


Figure S80. ^{1}H NMR spectrum of compound **37** (600 MHz, D_2O, 298 K).

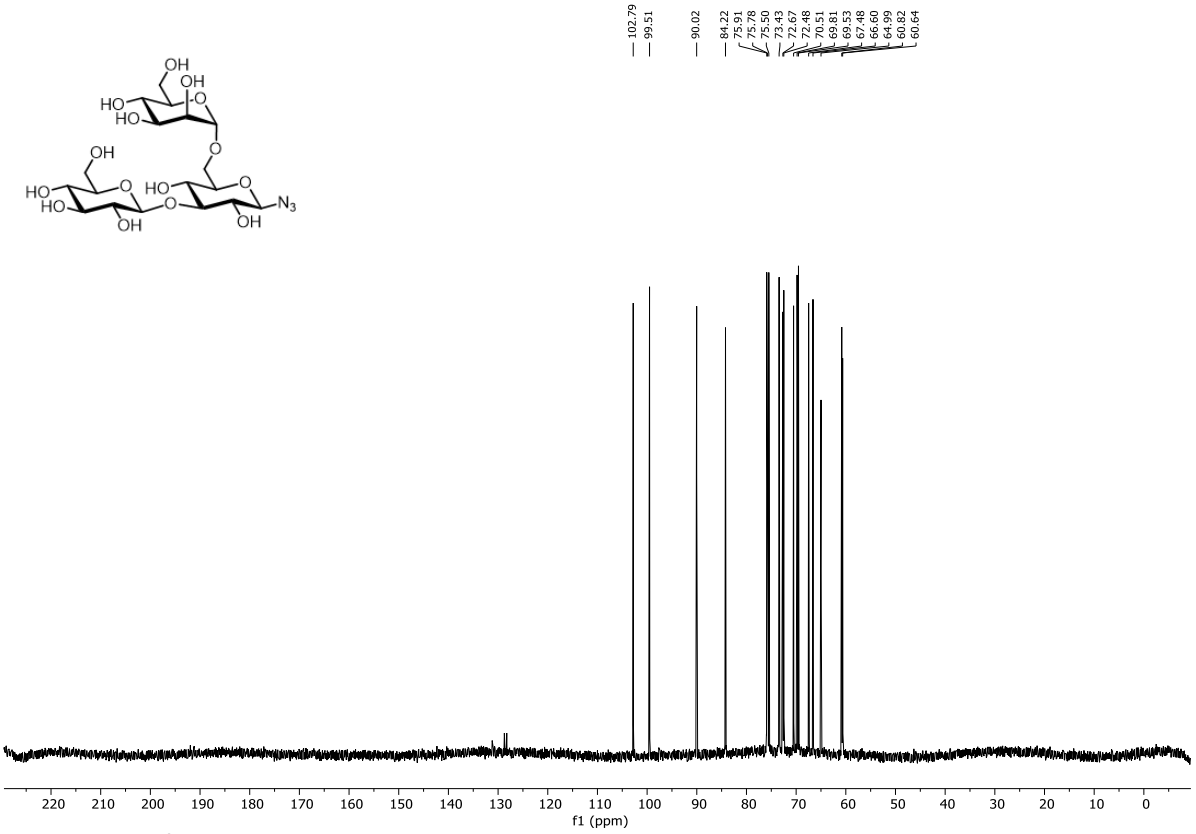


Figure S81. ^{13}C NMR spectrum of compound **37** (151 MHz, D_2O, 298 K).

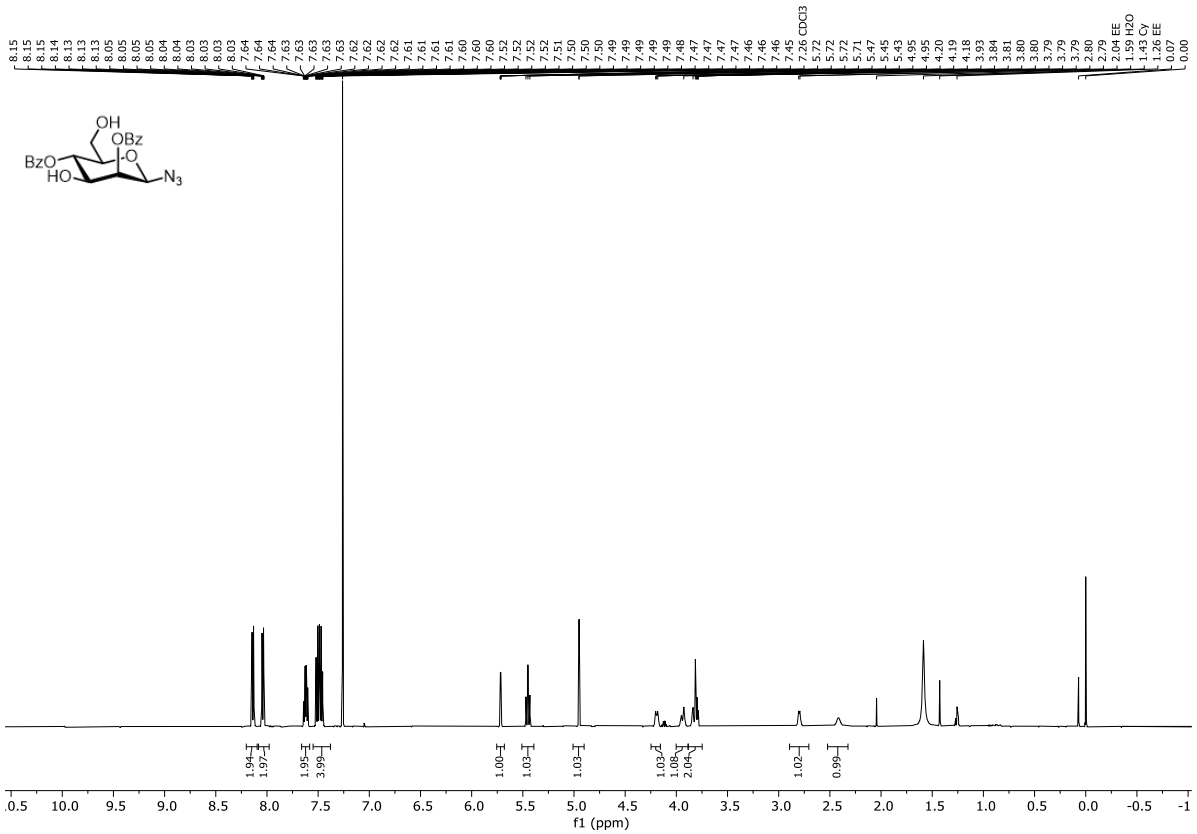


Figure S82. ^{1}H NMR spectrum of compound **39** (500 MHz, $CDCl_3$, 298 K).

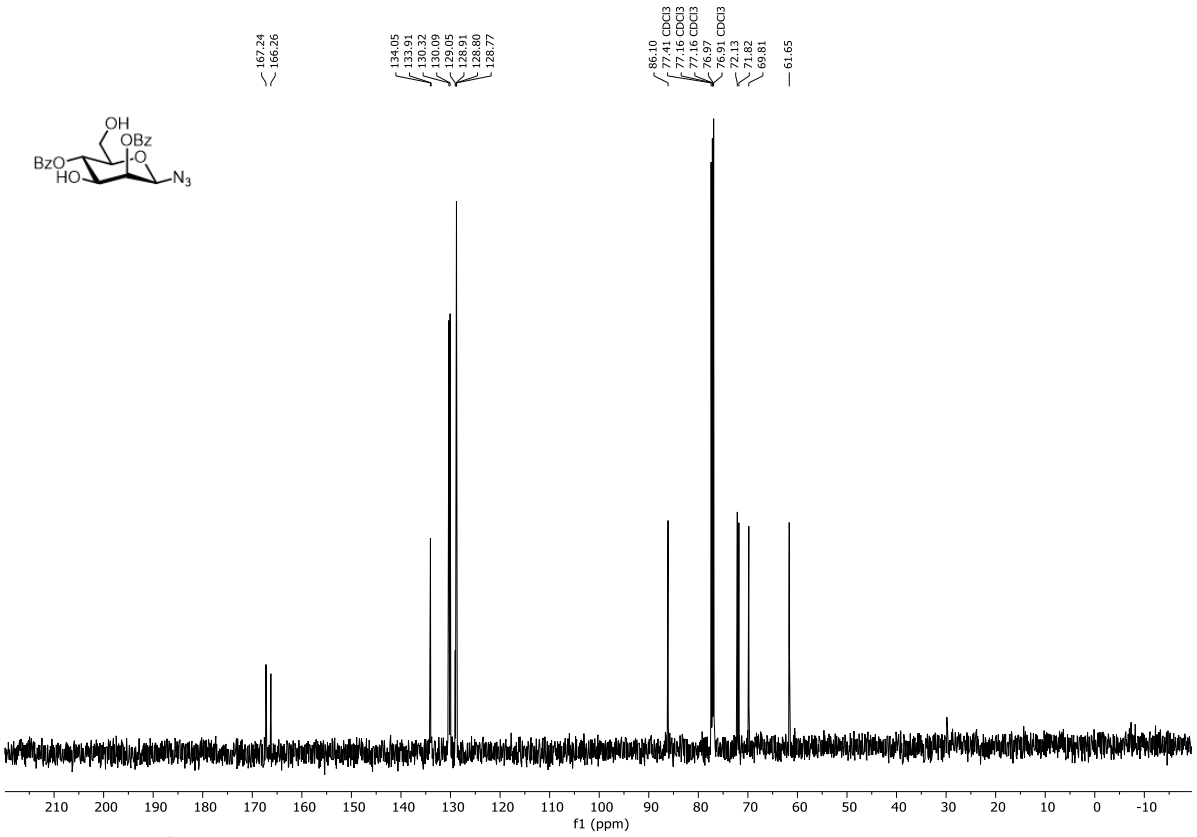


Figure S83. ^{13}C NMR spectrum of compound **39** (126 MHz, $CDCl_3$, 298 K).

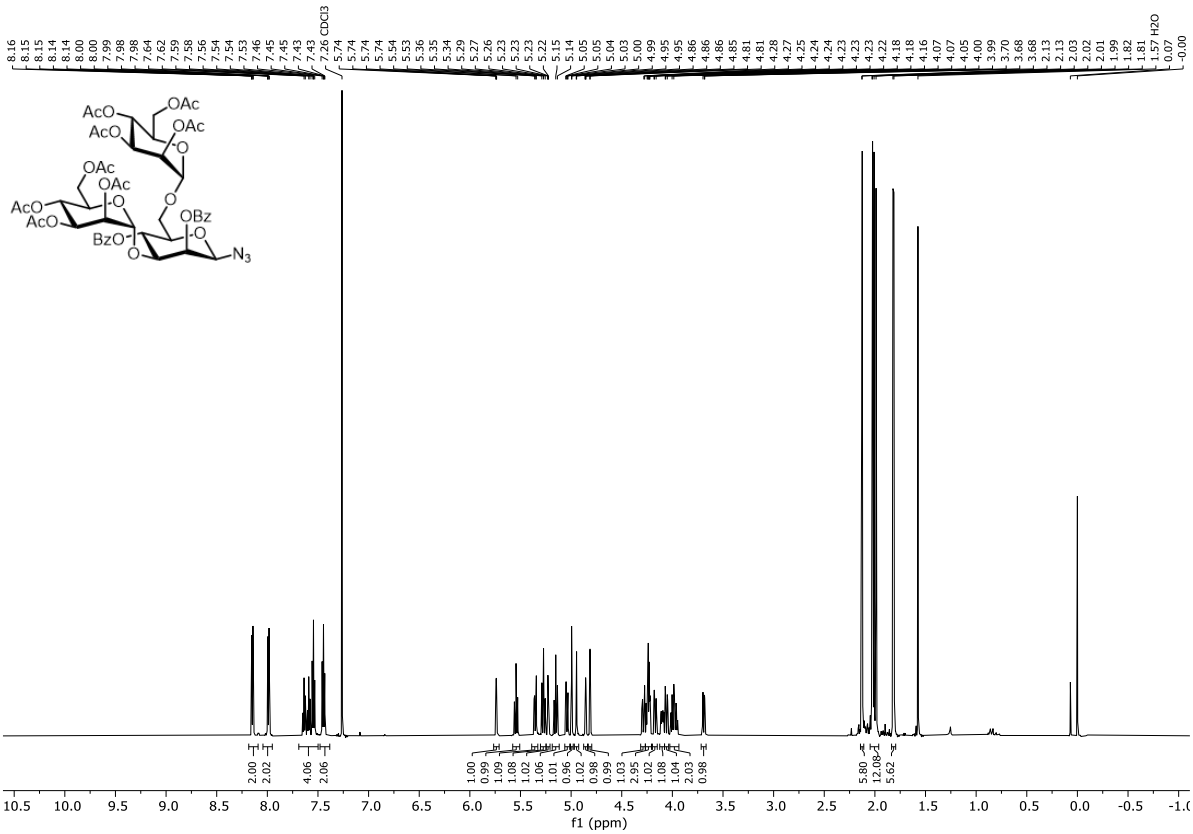


Figure S84. ^{1}H NMR spectrum of compound **40** (600 MHz, $CDCl_3$, 298 K).

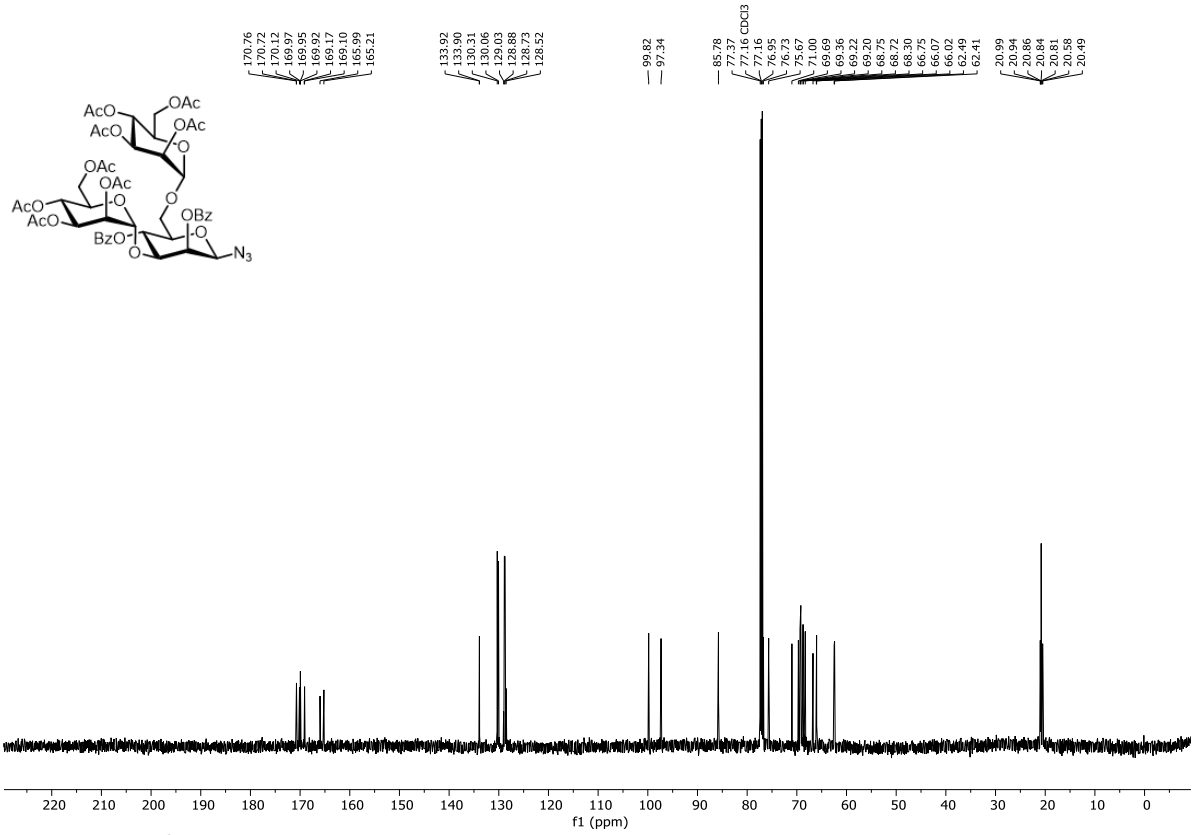


Figure S85. ^{13}C NMR spectrum of compound **40** (151 MHz, $CDCl_3$, 298 K).

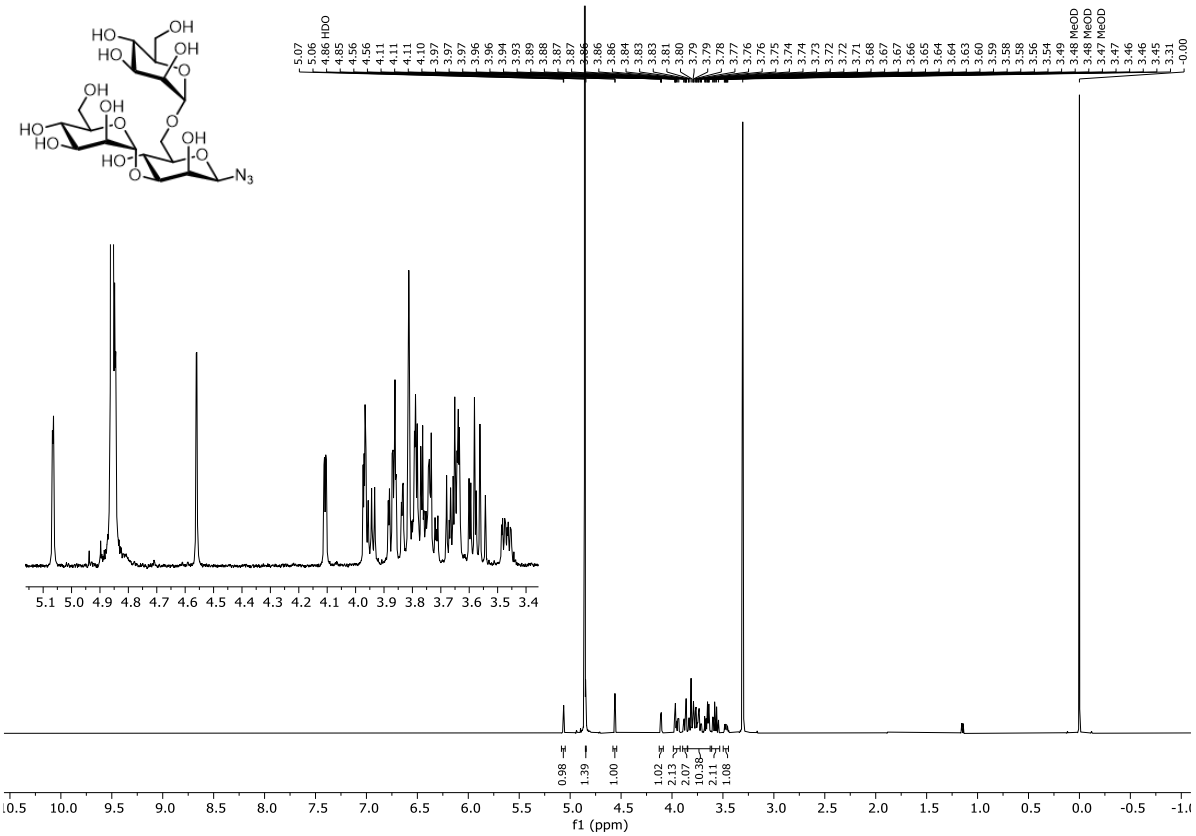


Figure S86. ^{1}H NMR spectrum of compound **41** (500 MHz, CD_3OD, 298 K).

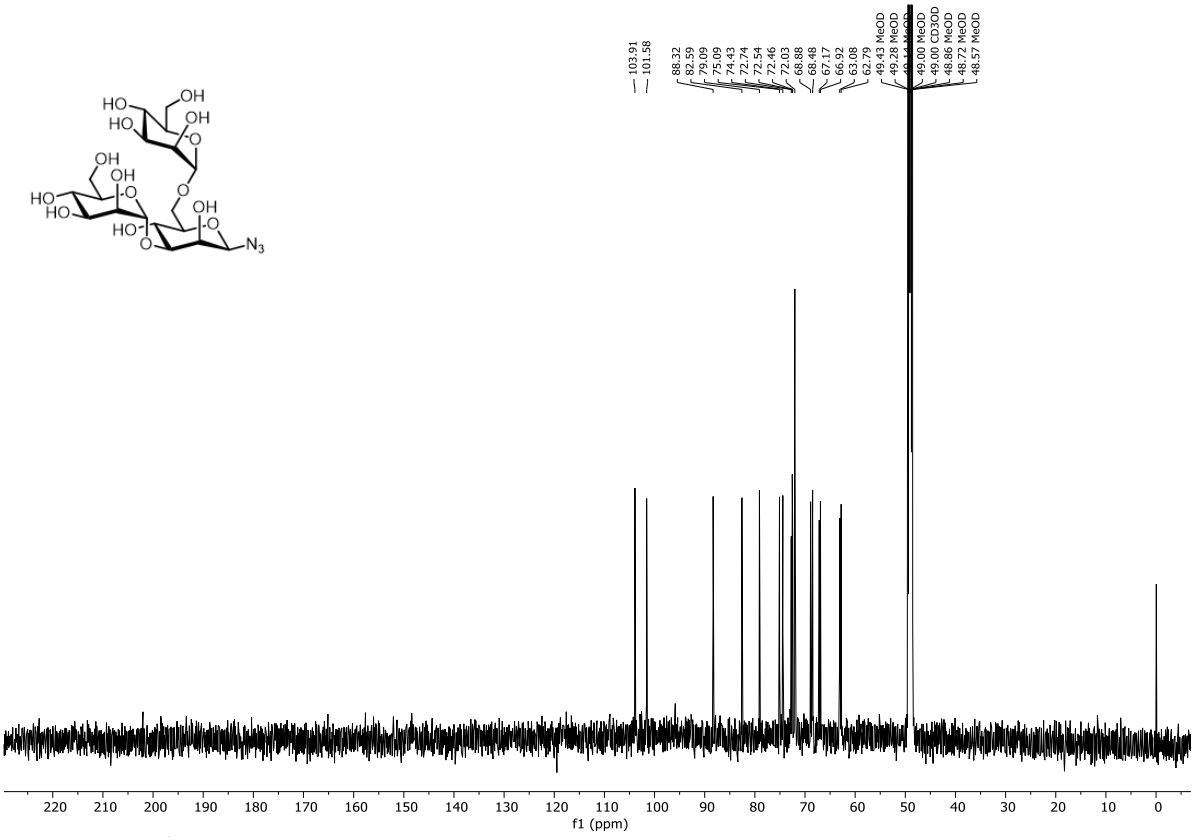


Figure S87. ^{13}C NMR spectrum of compound **41** (151 MHz, CD_3OD, 298 K).

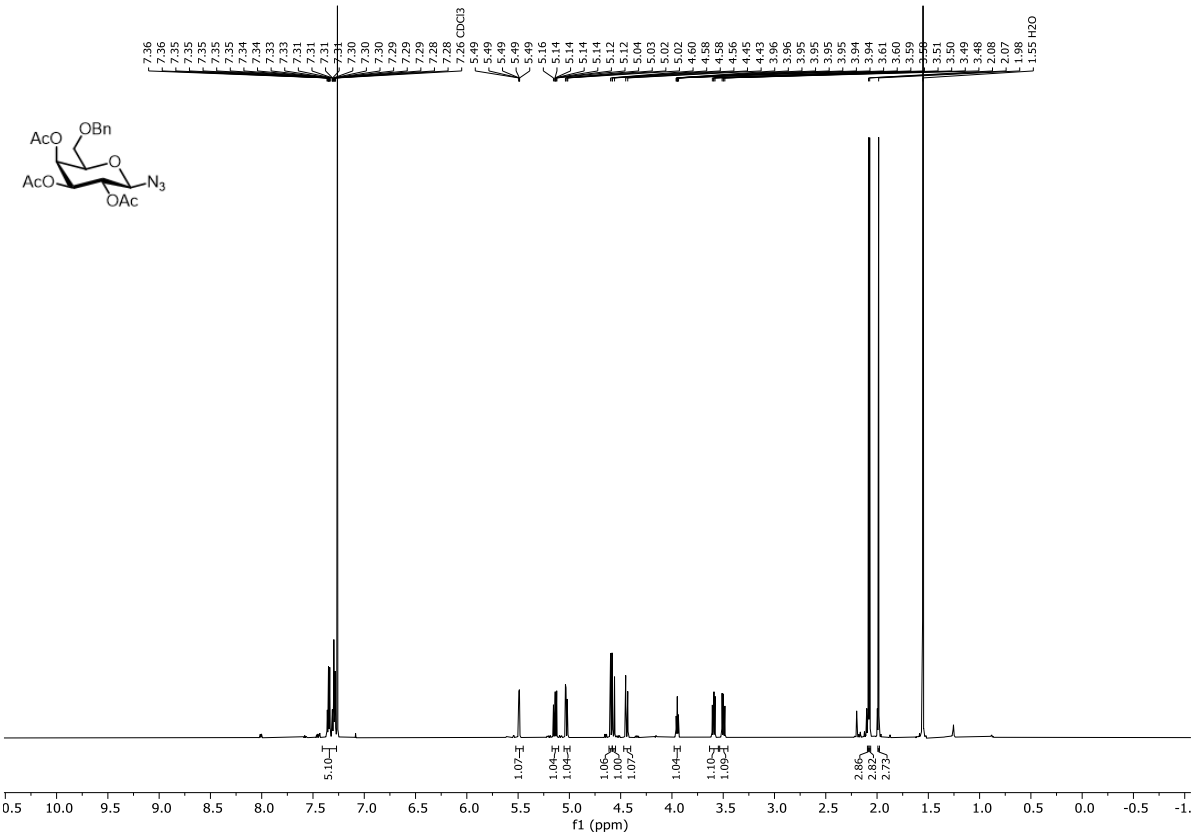


Figure S88. ^{1}H NMR spectrum of compound **42** (600 MHz, $CDCl_3$, 298 K).

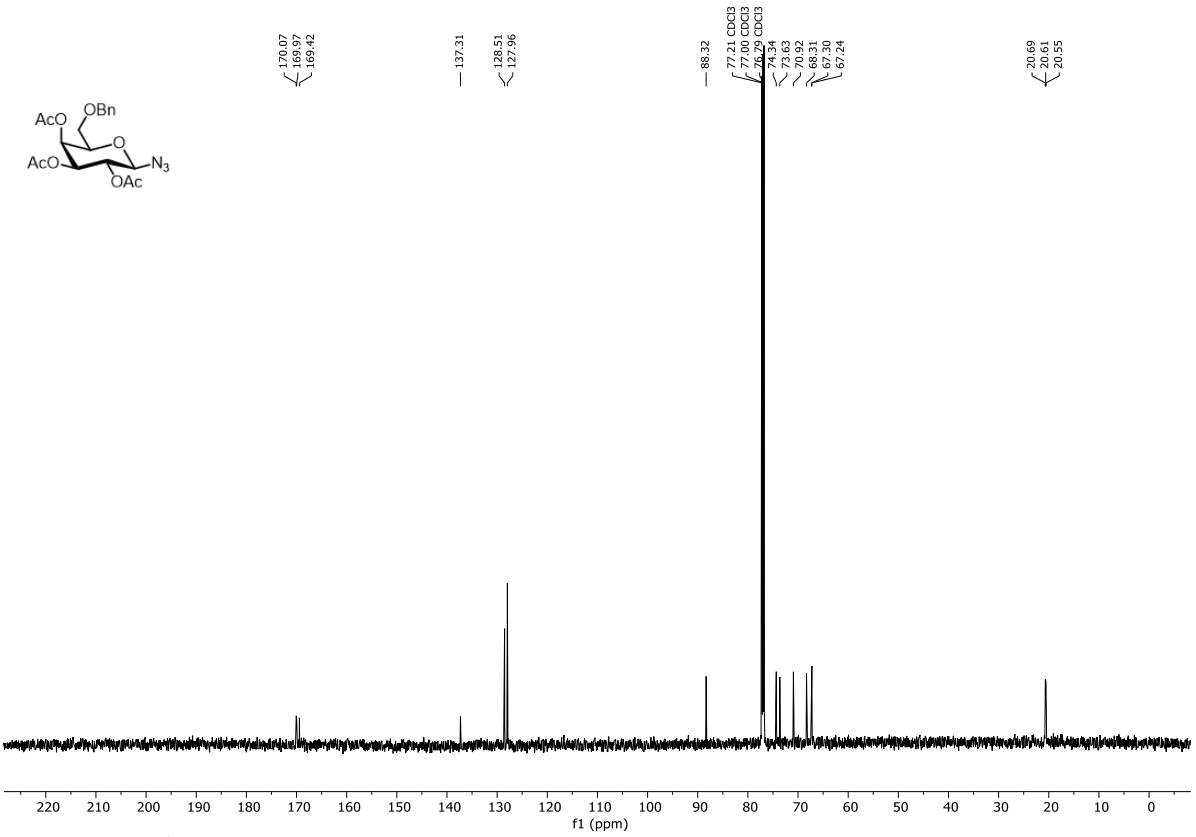


Figure S89. ^{13}C NMR spectrum of compound **42** (151 MHz, $CDCl_3$, 298 K).

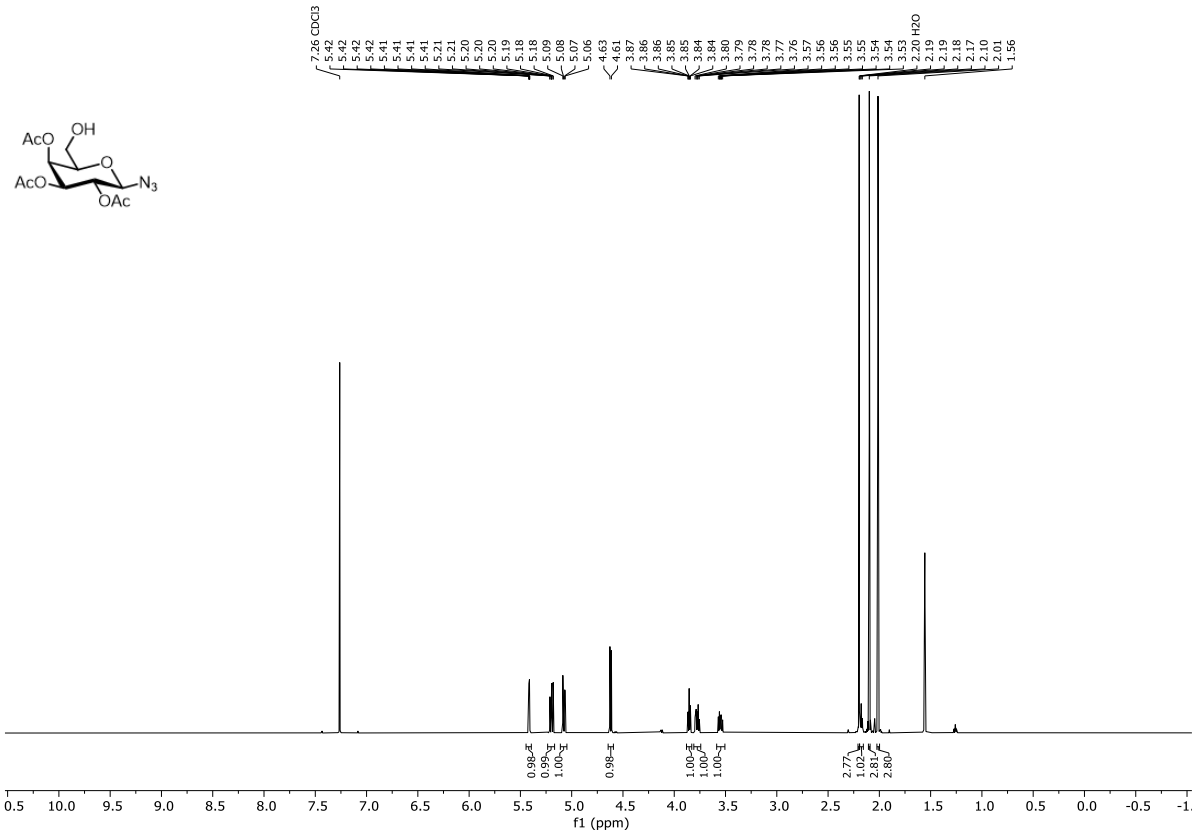


Figure S90. ^{1}H NMR spectrum of compound **43** (600 MHz, $CDCl_3$, 298 K).

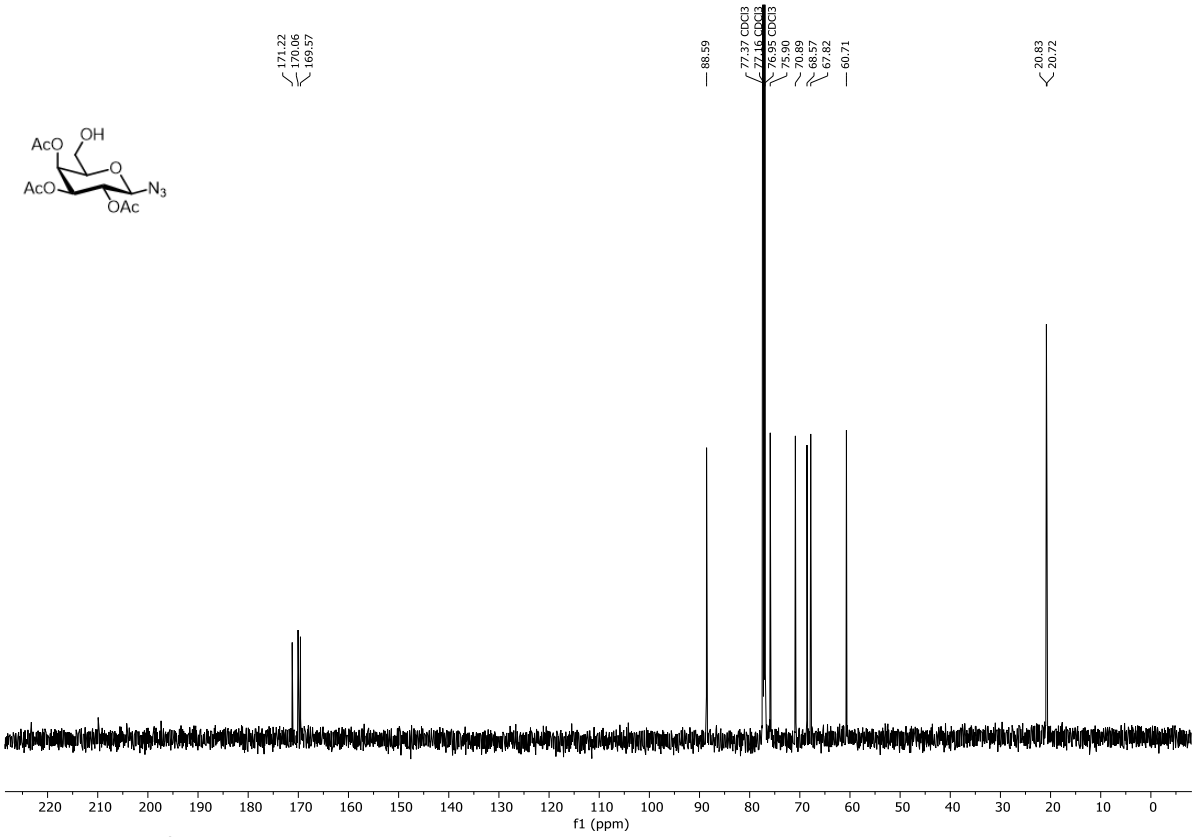


Figure S91. ^{13}C NMR spectrum of compound **43** (151 MHz, $CDCl_3$, 298 K).

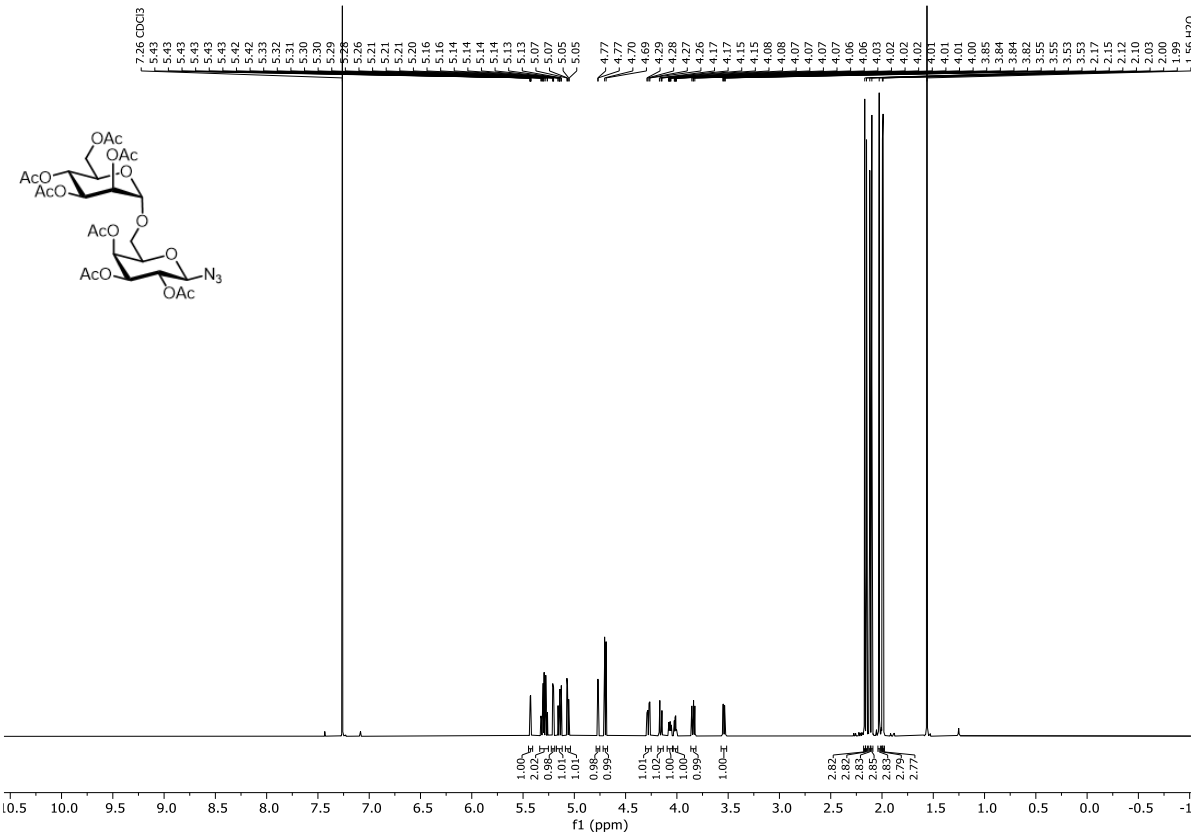


Figure S92. ^{1}H NMR spectrum of compound **44** (600 MHz, $CDCl_3$, 298 K).

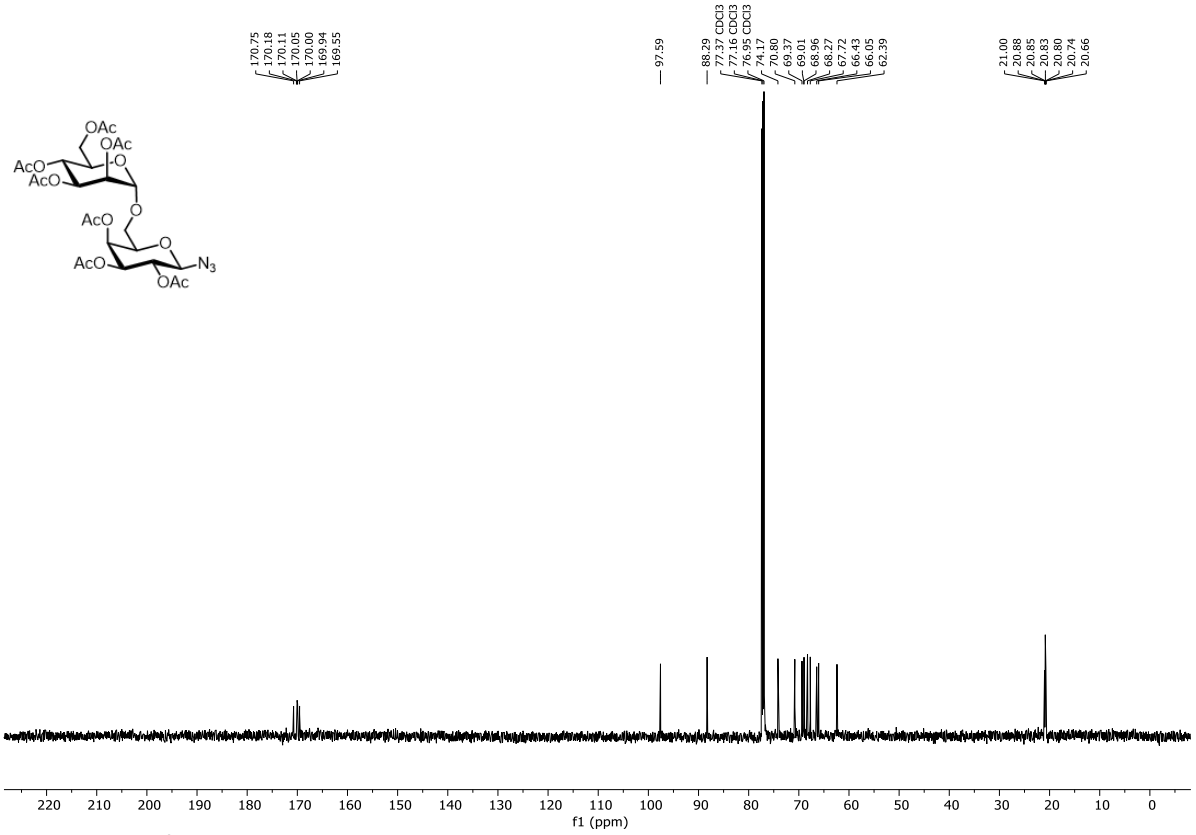


Figure S93. ^{13}C NMR spectrum of compound **44** (151 MHz, $CDCl_3$, 298 K).

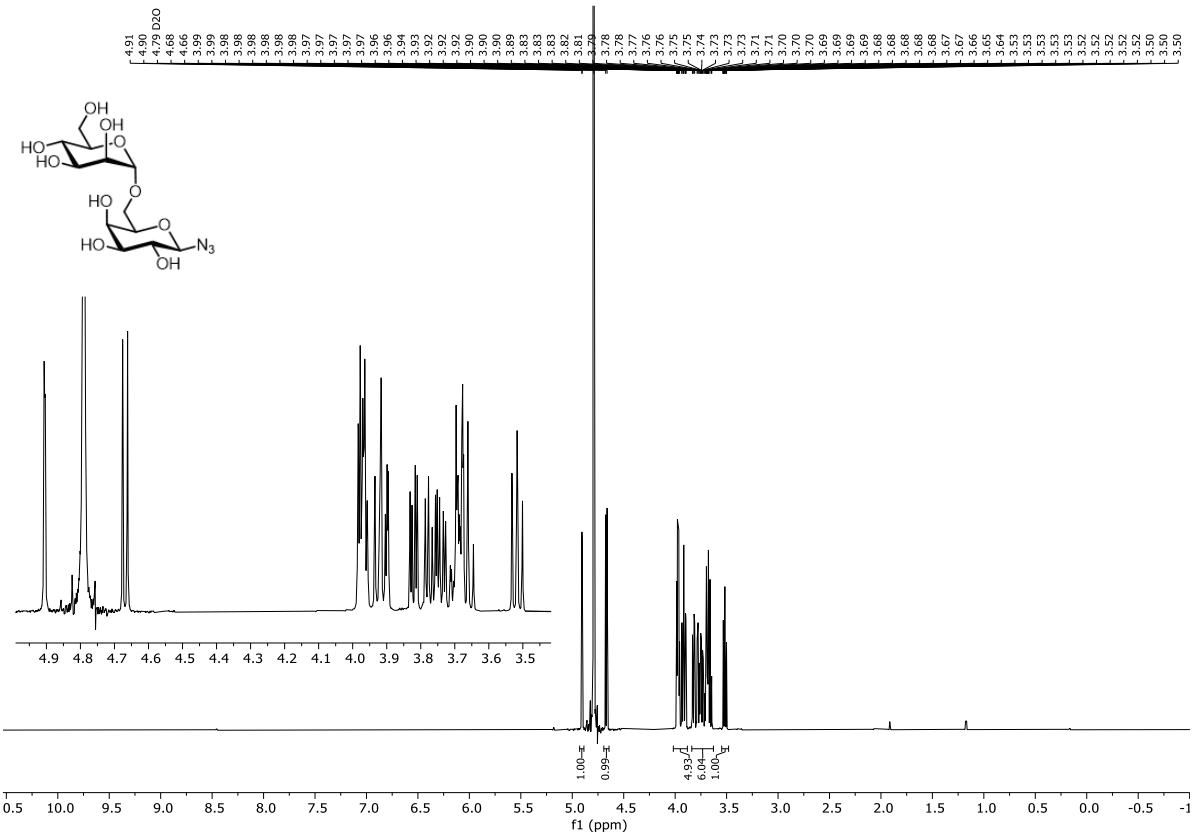


Figure S94. ^{1}H NMR spectrum of compound **45** (600 MHz, D_2O, 298 K).

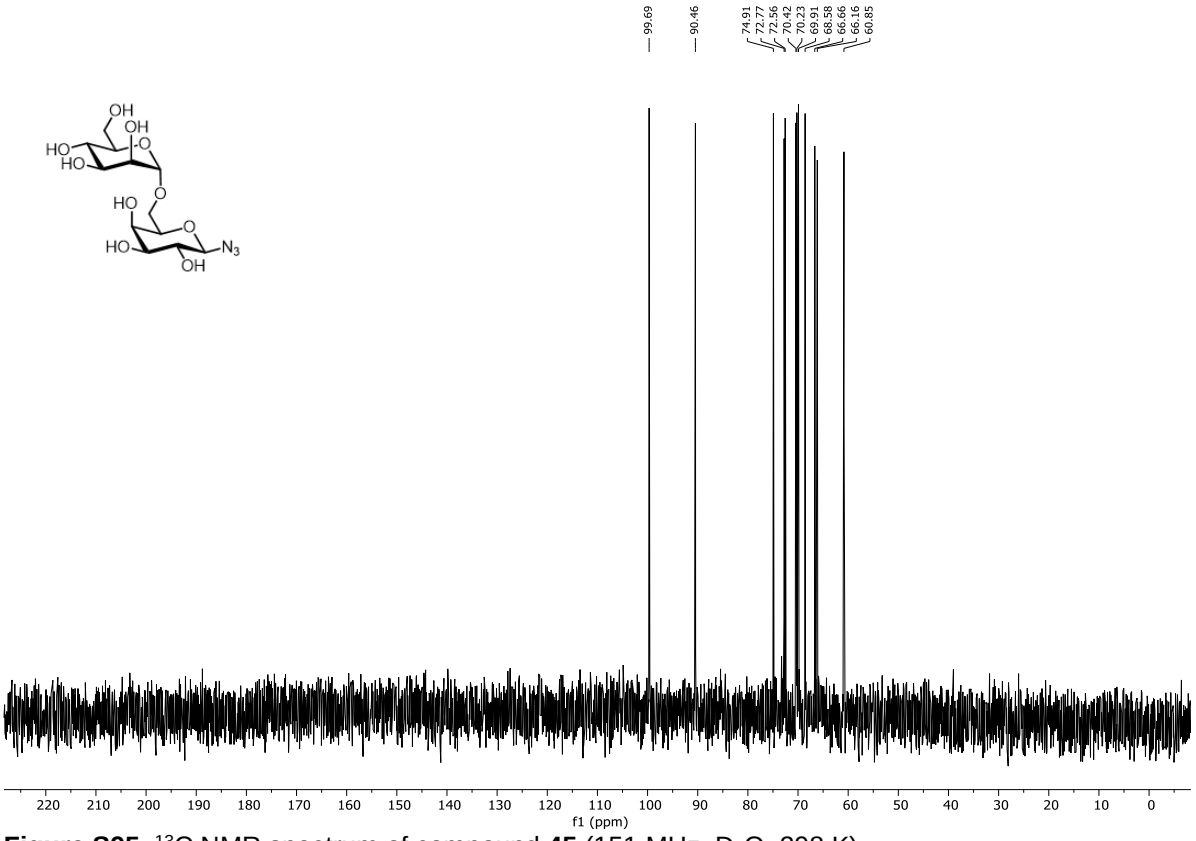


Figure S95. ^{13}C NMR spectrum of compound **45** (151 MHz, D_2O, 298 K).

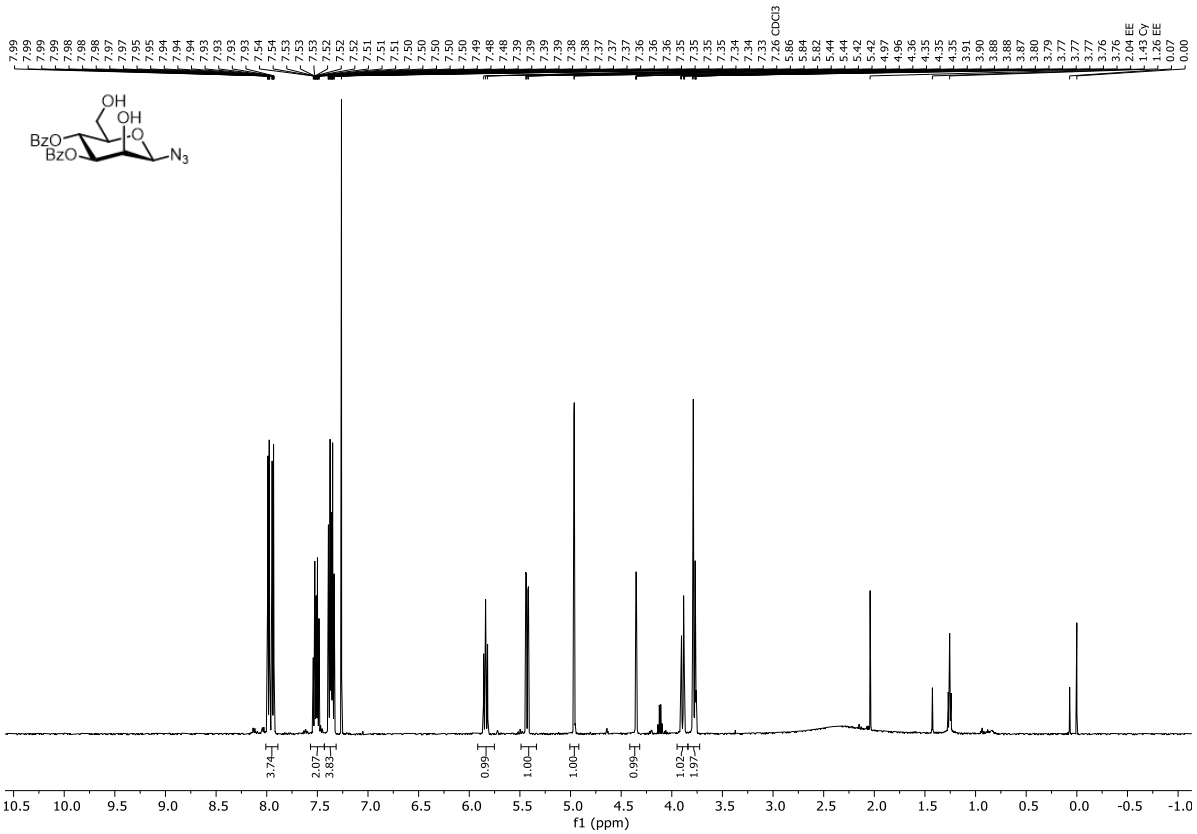


Figure S96. ^{1}H NMR spectrum of compound **S4** (500 MHz, $CDCl_3$, 298 K).

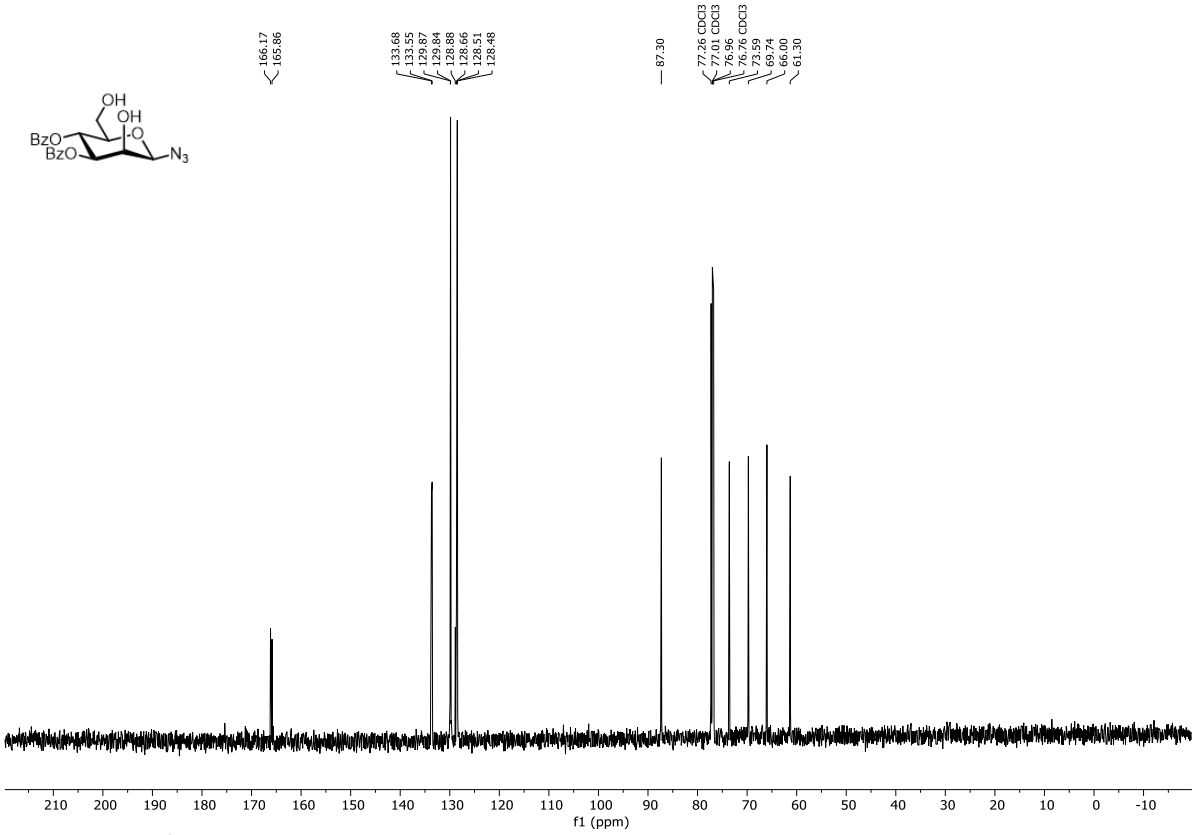


Figure S97. ^{13}C NMR spectrum of compound **S4** (126 MHz, $CDCl_3$, 298 K).

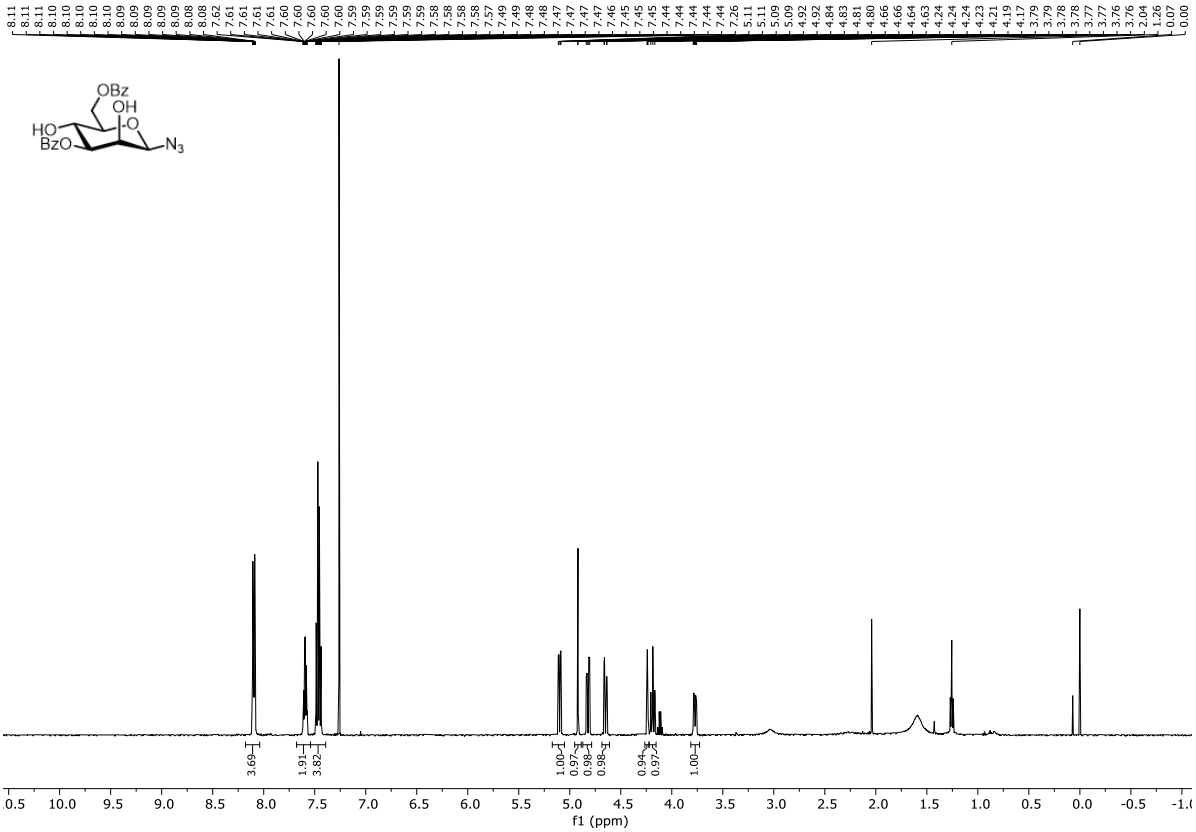


Figure S98. ^{1}H NMR spectrum of compound **S5** (500 MHz, $CDCl_3$, 298 K).

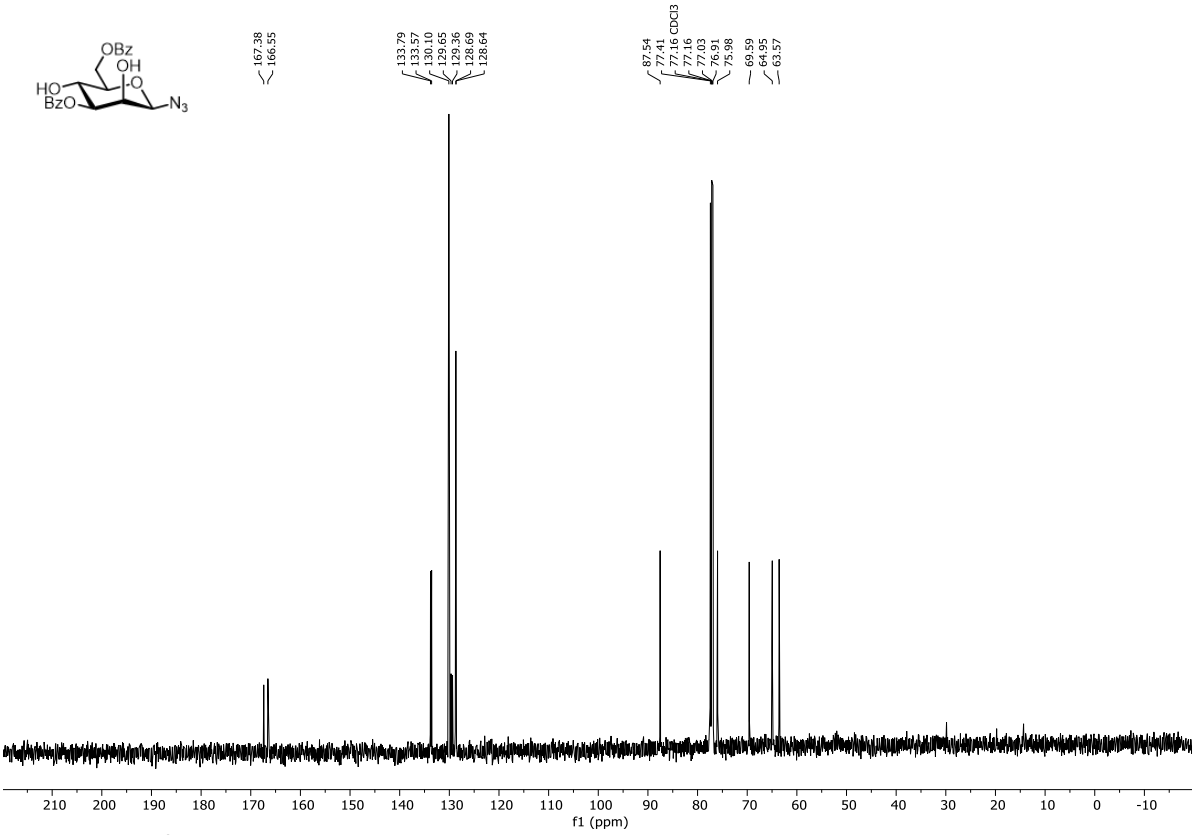


Figure S99. ^{13}C NMR spectrum of compound **S5** (126 MHz, $CDCl_3$, 298 K).

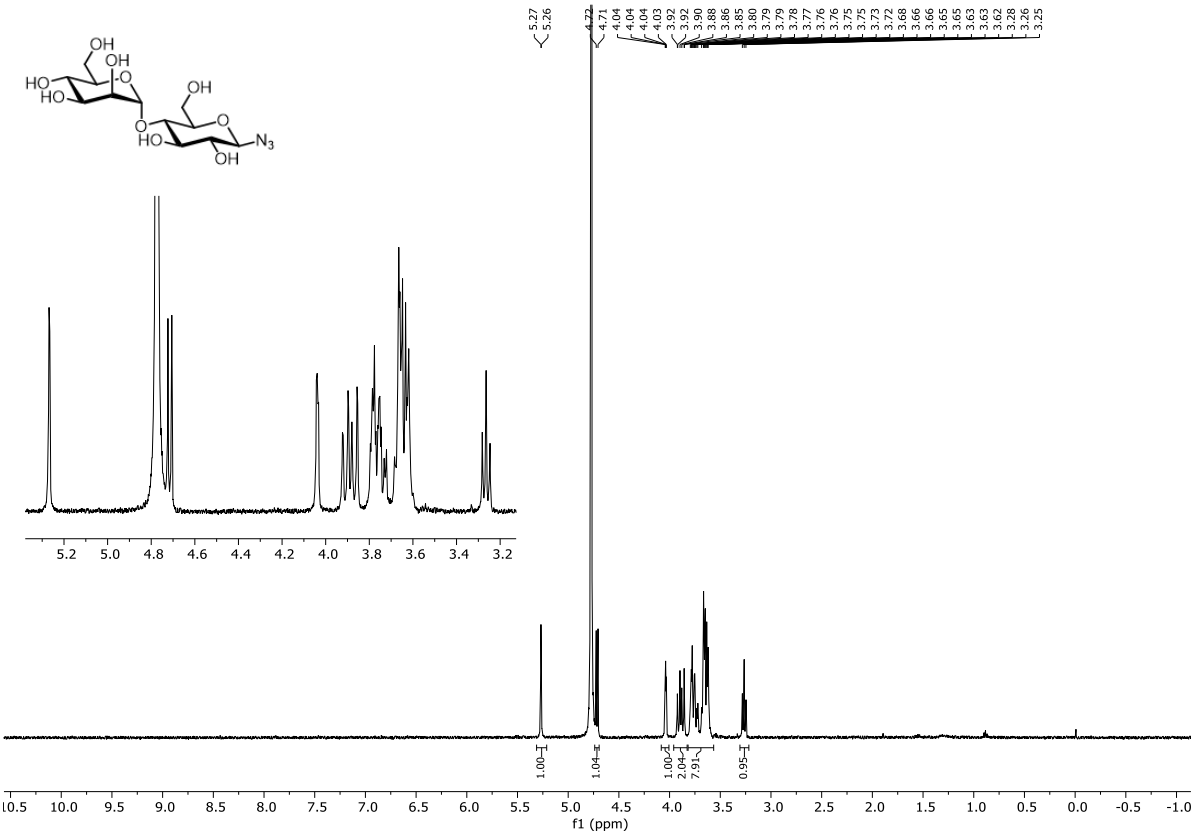


Figure S100. ^{1}H NMR spectrum of compound **S6** (500 MHz, D_2O, 298 K).

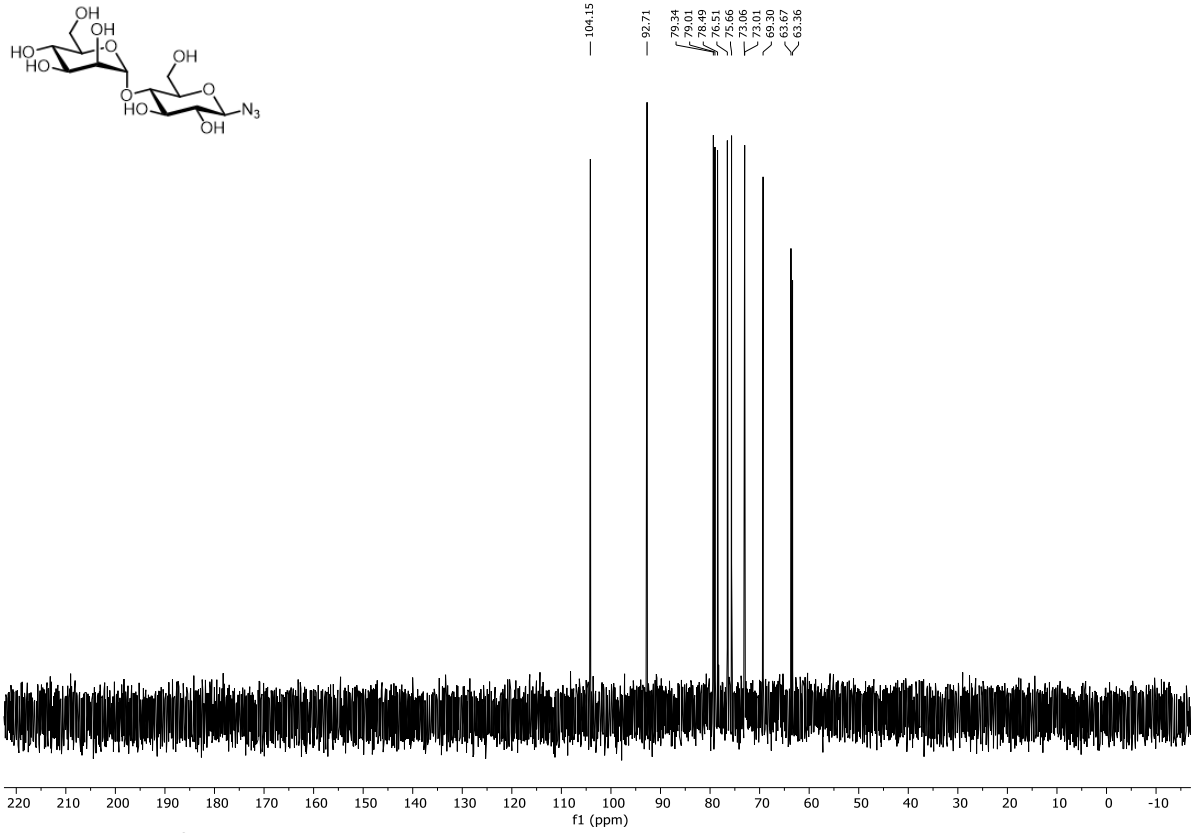


Figure S101. ^{13}C NMR spectrum of compound **S6** (126 MHz, D_2O, 298 K).

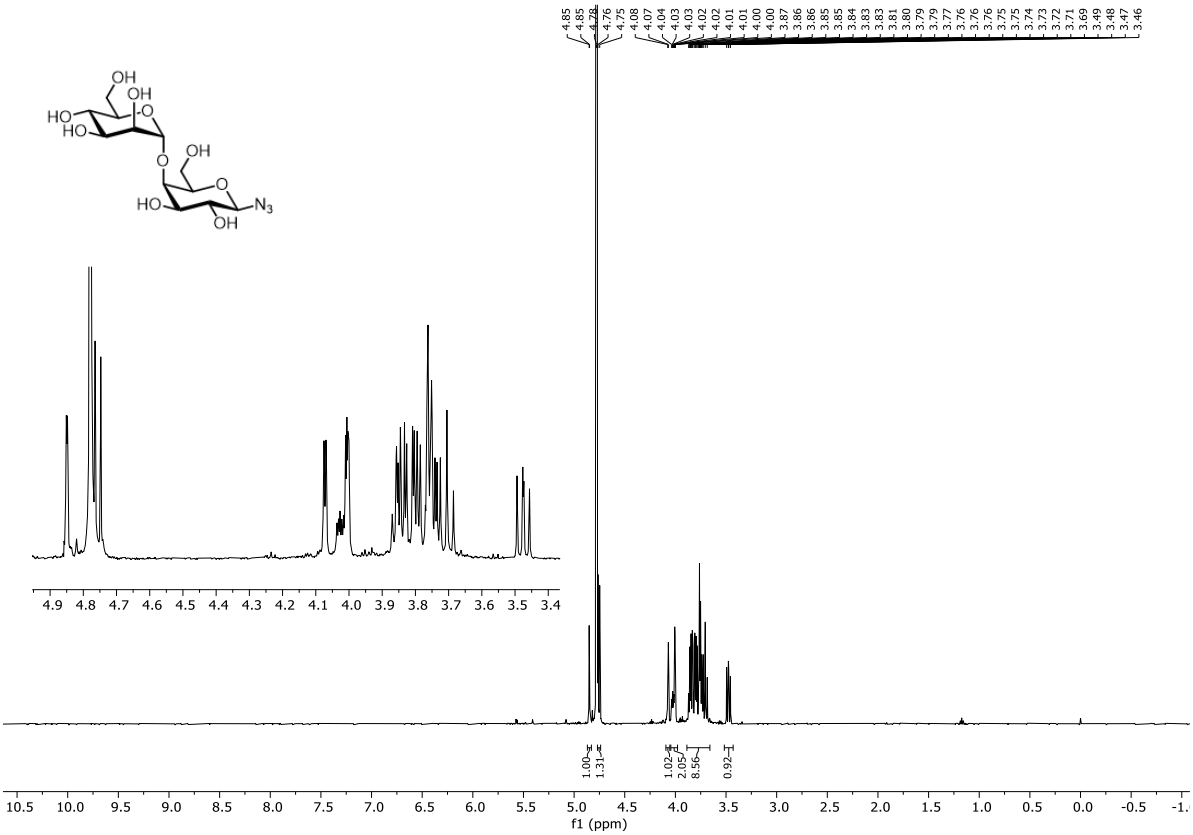


Figure S102. ^{1}H NMR spectrum of compound **S7** (500 MHz, D_2O, 298 K).

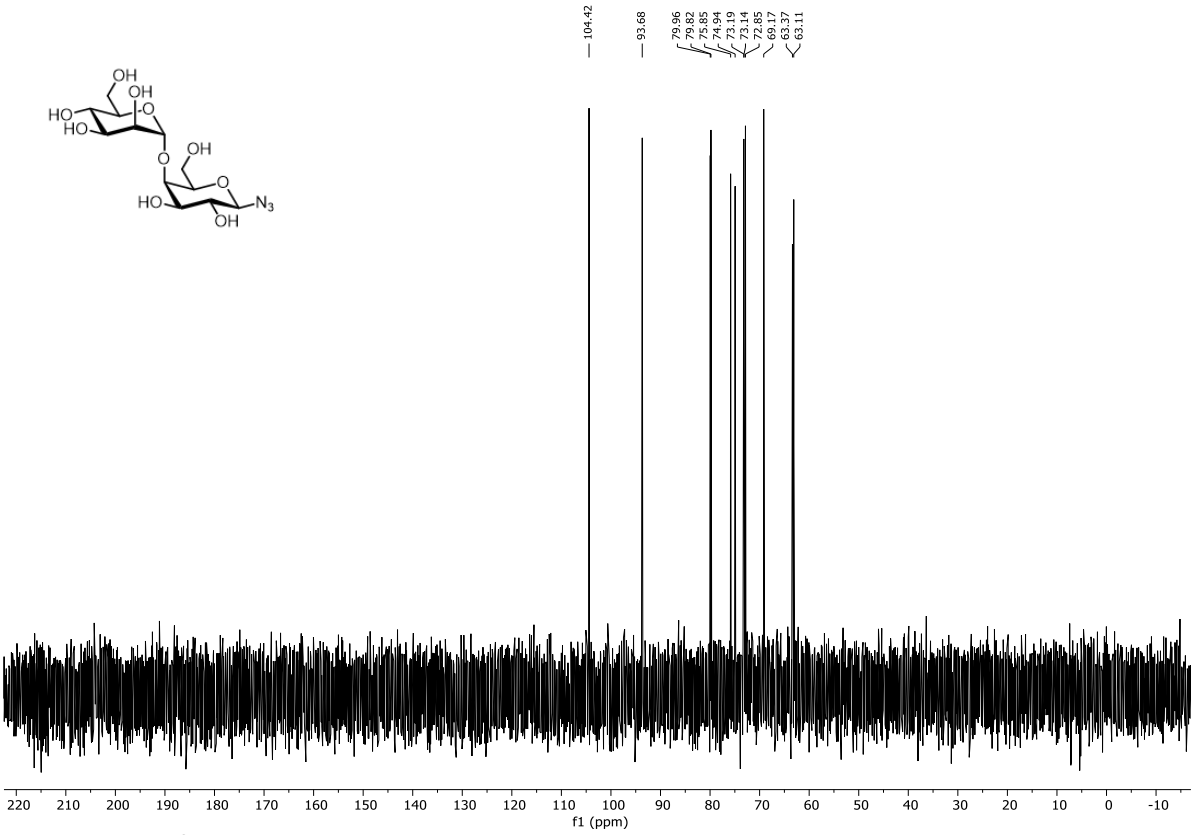


Figure S103. ^{13}C NMR spectrum of compound **S7** (126 MHz, D_2O, 298 K).

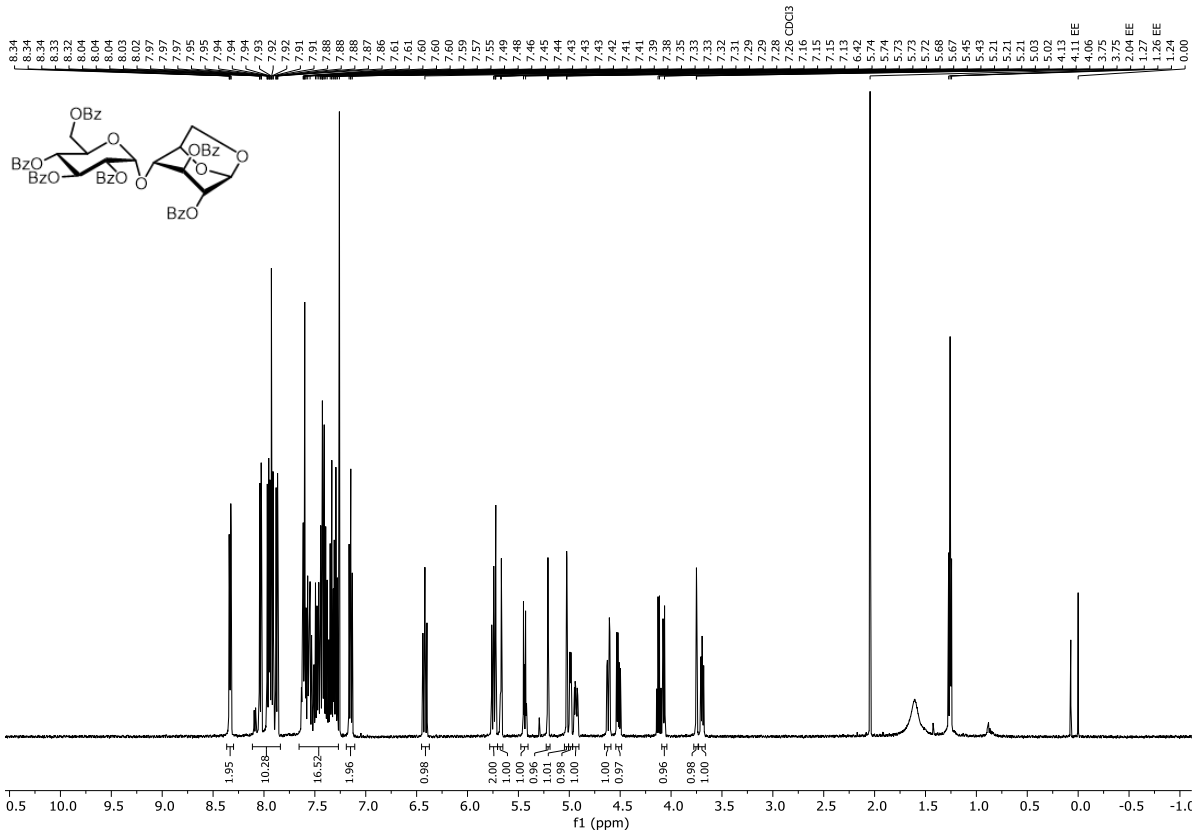


Figure S104. ^{1}H NMR spectrum of compound **S9** (500 MHz, $CDCl_3$, 298 K).

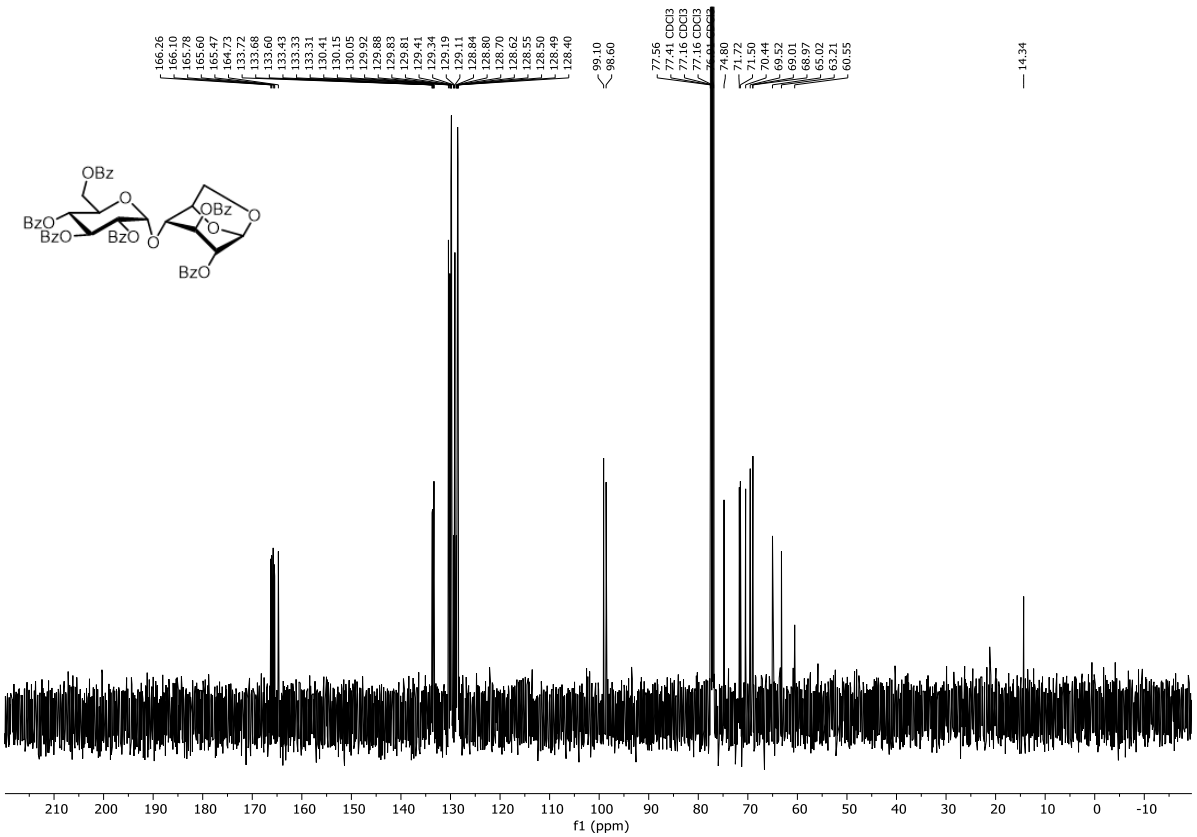


Figure S105. ^{13}C NMR spectrum of compound **S9** (126 MHz, $CDCl_3$, 298 K).

6. Literature

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