Supplementary Information

Heparan Sulfate Glycomimetics via Iterative Assembly of "Clickable" Disaccharides

Cangjie Yang, †[a] Yu Deng, †[a] Yang Wang,[a] Chaoshuang Xia,[b] Akul Y Mehta,[c] Kelly J. Baker,[c] Anuj Samal,[a] Putthipong Booneimsri,[a,d] Chanthakarn Lertmaneedang,[a,d] Seung Hwang, [a] James Flynn, [a] Muqing Cao, [a] Chao Liu,[a] Alec C. Zhu,[a] Cheng Lin,[b] Richard D. Cummings,[c] Udayan Mohanty,*[a] Jia Niu*[a]

[a]Department of Chemistry, Boston College, Chestnut Hill, Massachusetts 02467, United States.

[b]Center for Biomedical Mass Spectrometry, Boston University School of Medicine, Boston, MA 02118, United States.

[c]Department of Surgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA 02215, United States.

[d]Department of Chemistry, Faculty of Science, Chulalongkorn University, Bangkok, 10330 Thailand.

† These authors have contributed equally to this work.

Correspondence to: udayan.mohanty@bc.edu, jia.niu@bc.edu

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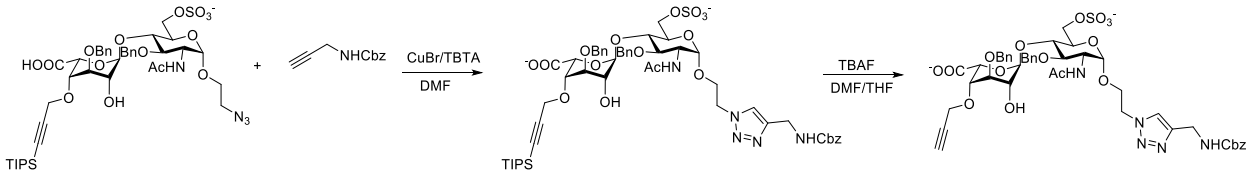
Supplementary Results

Scheme S1. Orthogonality between the sulfated disaccharides with reactions of CuAAC and deprotection



17 94% **S1** 90% **S2**

Figure S2. HPLC trace and LC-ESI-MS spectra of the 6-*O*-sulfated octasaccharide after semi-prep HPLC purification through solution-phase assembly

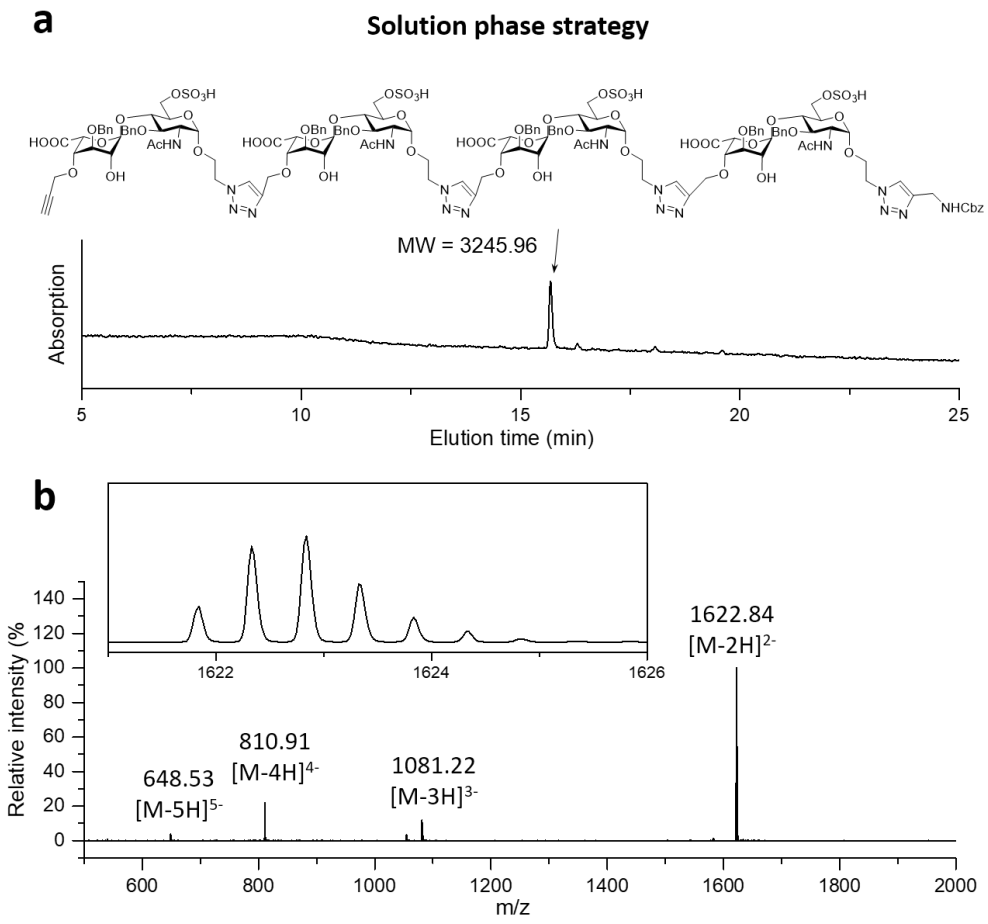


Figure S3. The CID tandem mass spectrum of HS-mimetic oligomer **H** with its cleavage map.

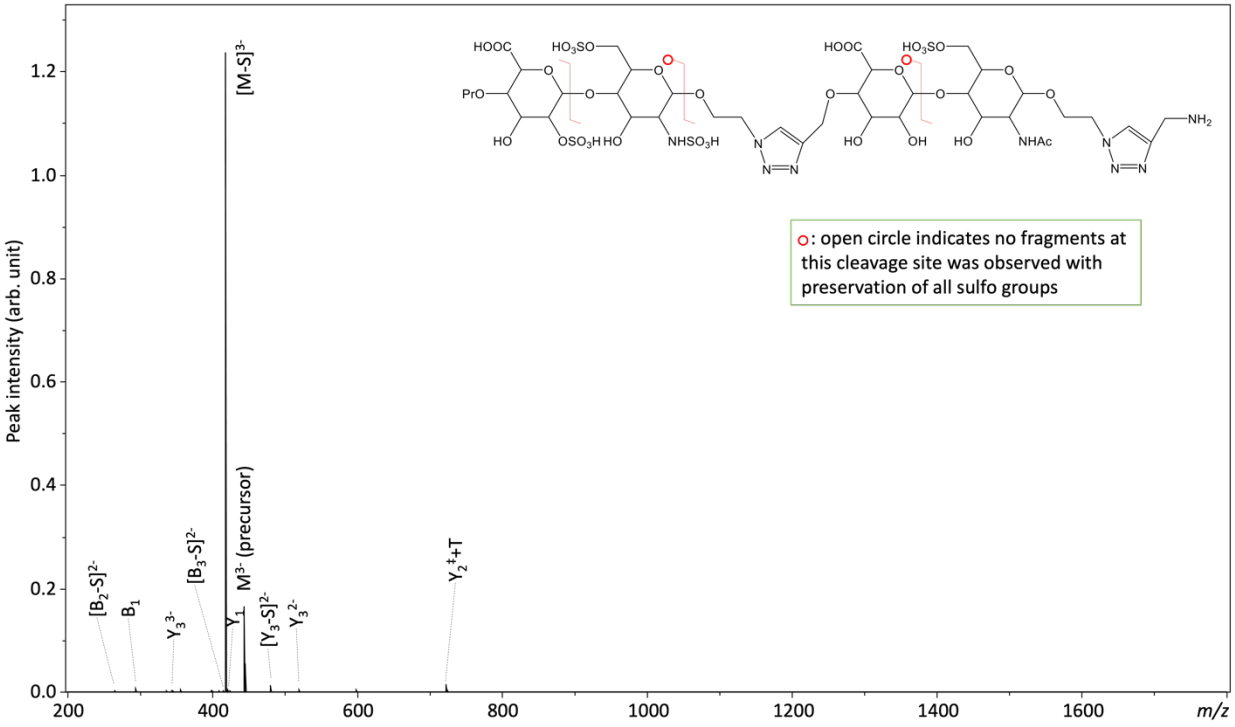


Figure S4. Surface plasmon resonance (SPR) sensorgrams of the sensor-bound heparin in competition with various concentrations of HS-mimetic oligomers (a)C, (b)K, (c)G, (d)T, (e)U, (f)V for FGF2 binding.

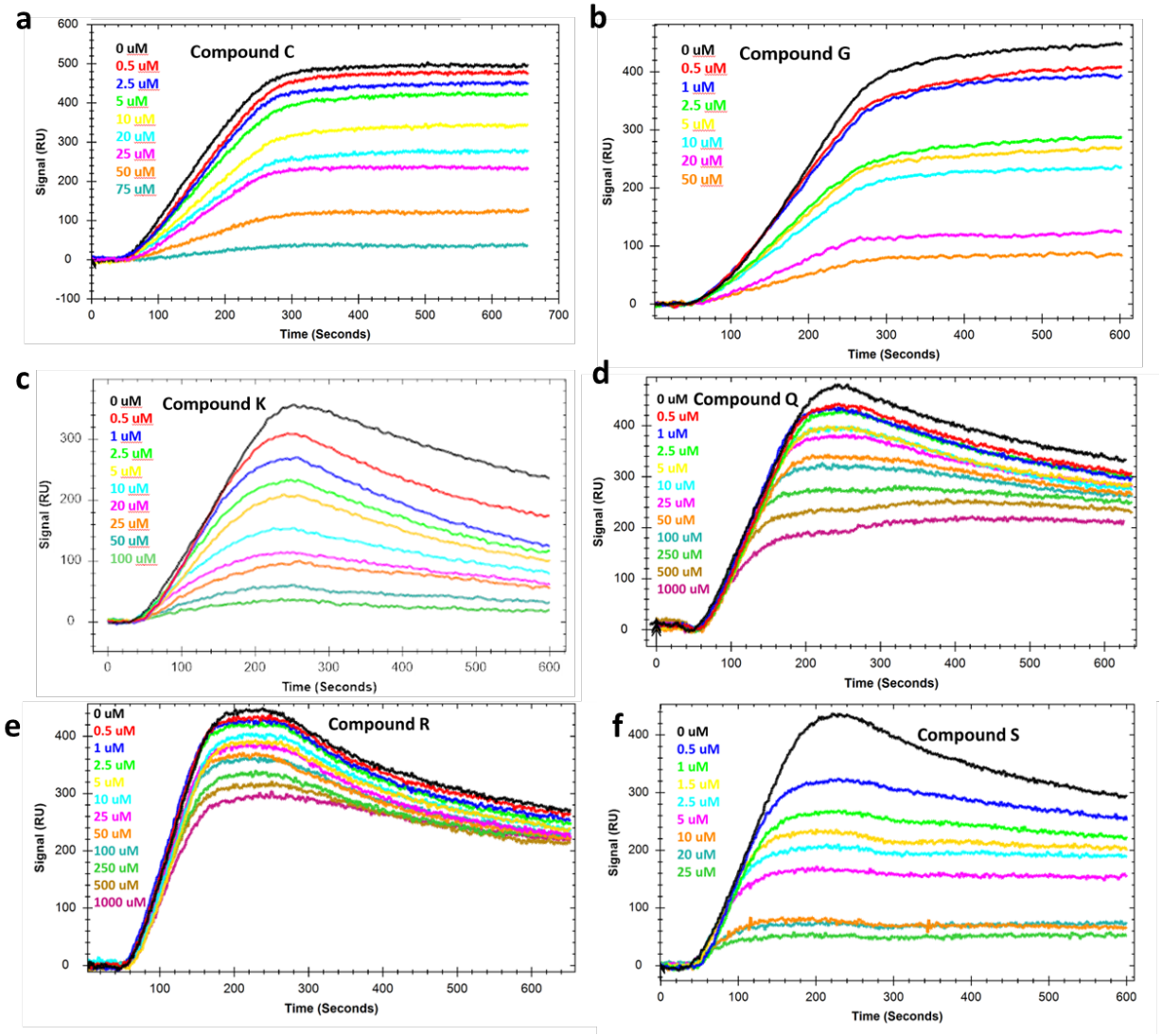
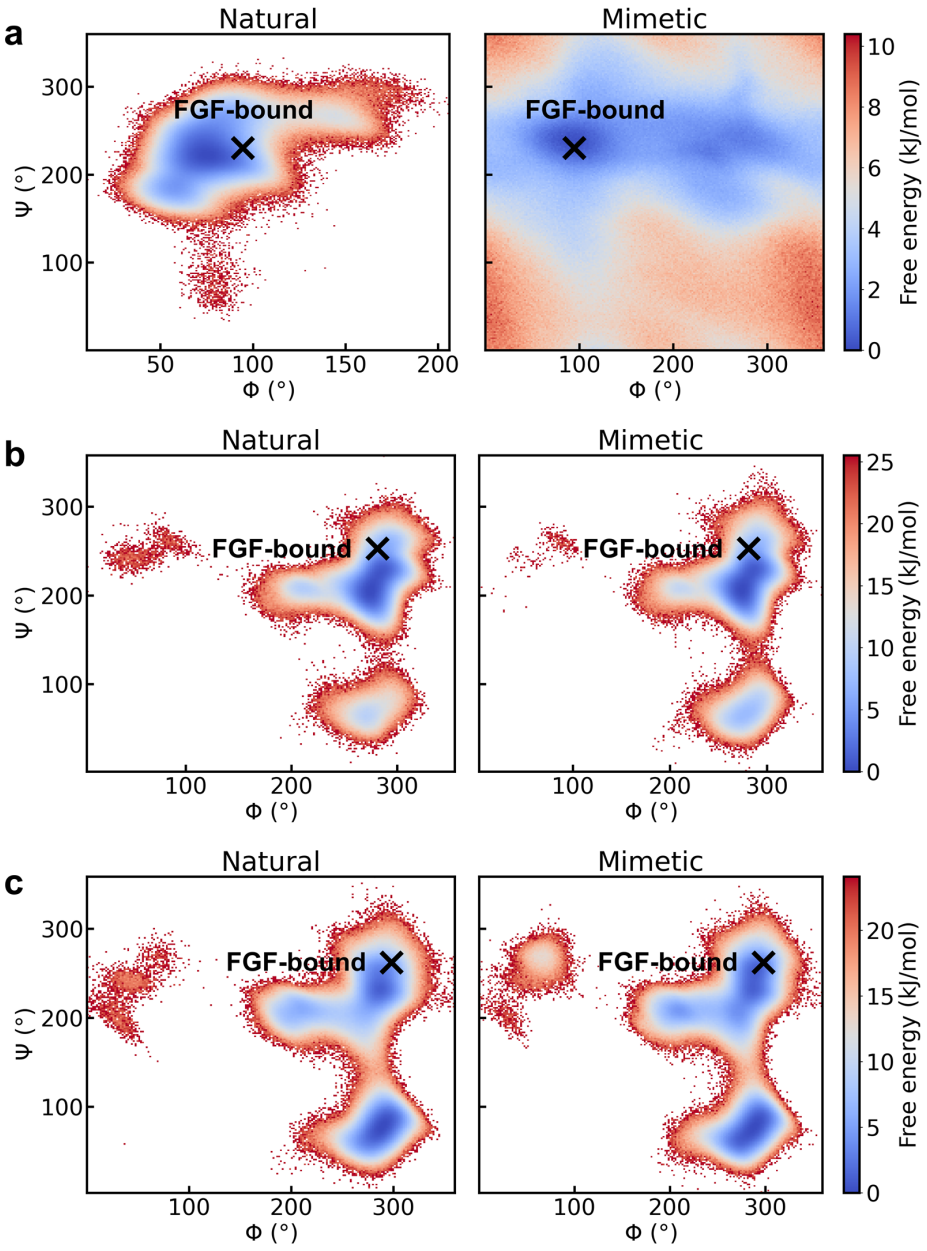
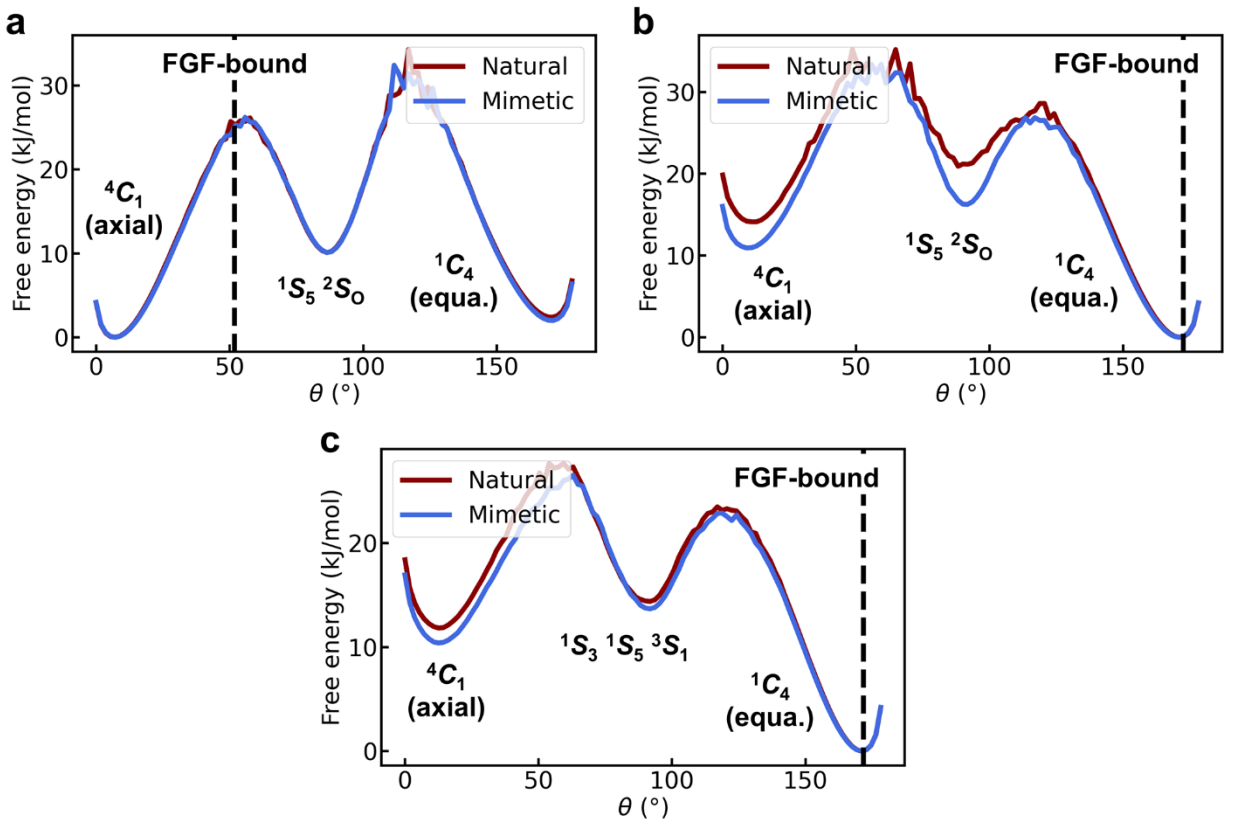


Figure S5. Dihedral bond rotations at glycosidic linkage sites of compound **K** and its analogous native HS tetrasaccharide



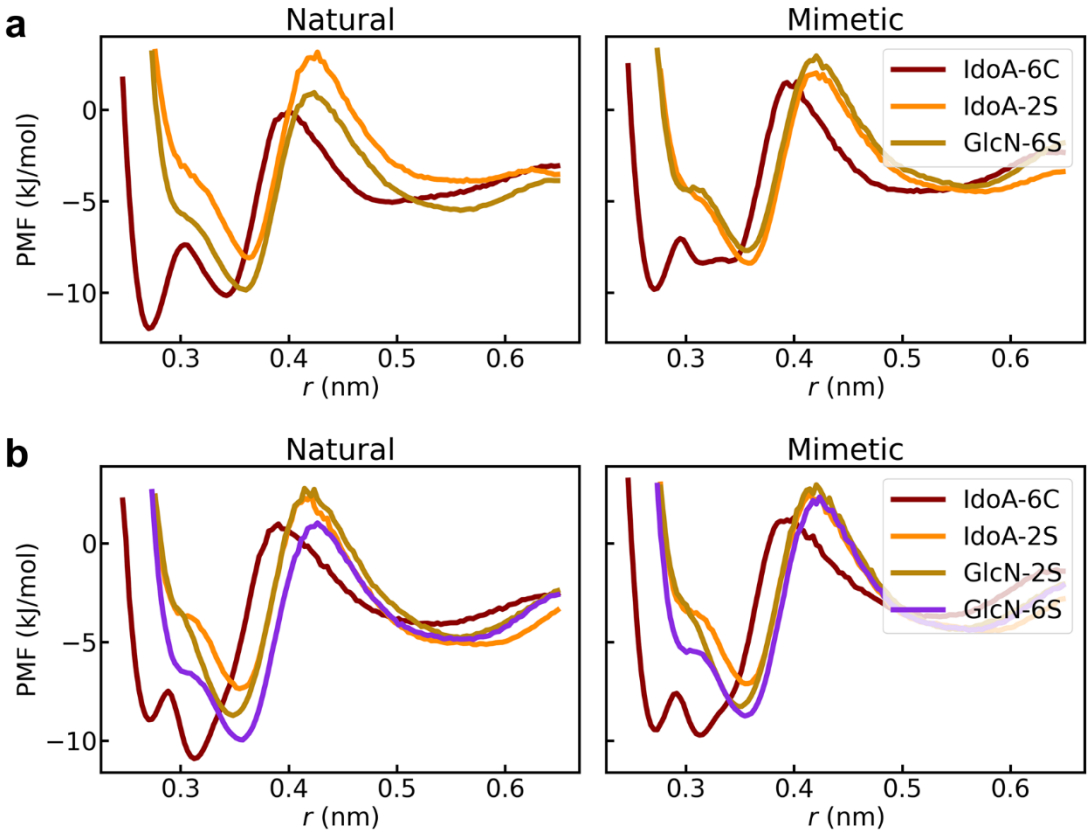
Note: **(a)** GlcNAc(6S)-IdoA(2S), **(b)** IdoA(2S)-GlcNAc(6S), and **(c)** IdoA(2S)-GlcNS(6S) glycosidic linkage sites. GlcNAc(6S)-IdoA(2S) is the addition site of the triazole spacer. Φ and Ψ are dihedral angles corresponding to the O5'-C1'-O4-C4 and C1'-O4-C4-C5 torsions, respectively. FGF-bound indicates the crystallographic configuration of HS tetramer when bound to FGF2 (PDB: 1BFB).

Figure S6. Free energy of ring flipping for terminal IdoA(2S), GlcNAc(6S), and GlcNS(6S) in **K** and its analogous native HS tetrasaccharide



Note: **(a)** Terminal IdoA(2S), **(b)** GlcNAc(6S), and **(c)** GlcNS(6S). θ is the Cremer-Pople angle. Dashed lines indicate the crystallographic configuration of HS tetramer when bound to FGF2 (PDB: 1BFB). $^1C_4$ corresponds to 2-*O*-sulfate of IdoA(2S), acetamide and 6-*O*-sulfate of GlcNAc(6S), and 2- and 6-*O*-sulfate of GlcNS(6S) adopting equatorial geometries, while $^4C_1$ corresponds to these functional groups adopting axial geometries. In GlcNAc(6S) and GlcNS(6S), the $^1C_4$ conformer is favored over $^4C_1$ due to charge repulsion and steric interactions in the axial geometries of $^4C_1$. For GlcNAc(6S), $^4C_1$ is stabilized by the triazole spacer, which mitigates unfavorable interactions of functional groups in the axial geometry.

Figure S7. Na^+ desolvation of negatively charged functional groups on central residues and terminal residues in **K** and its analogous native HS tetrasaccharide



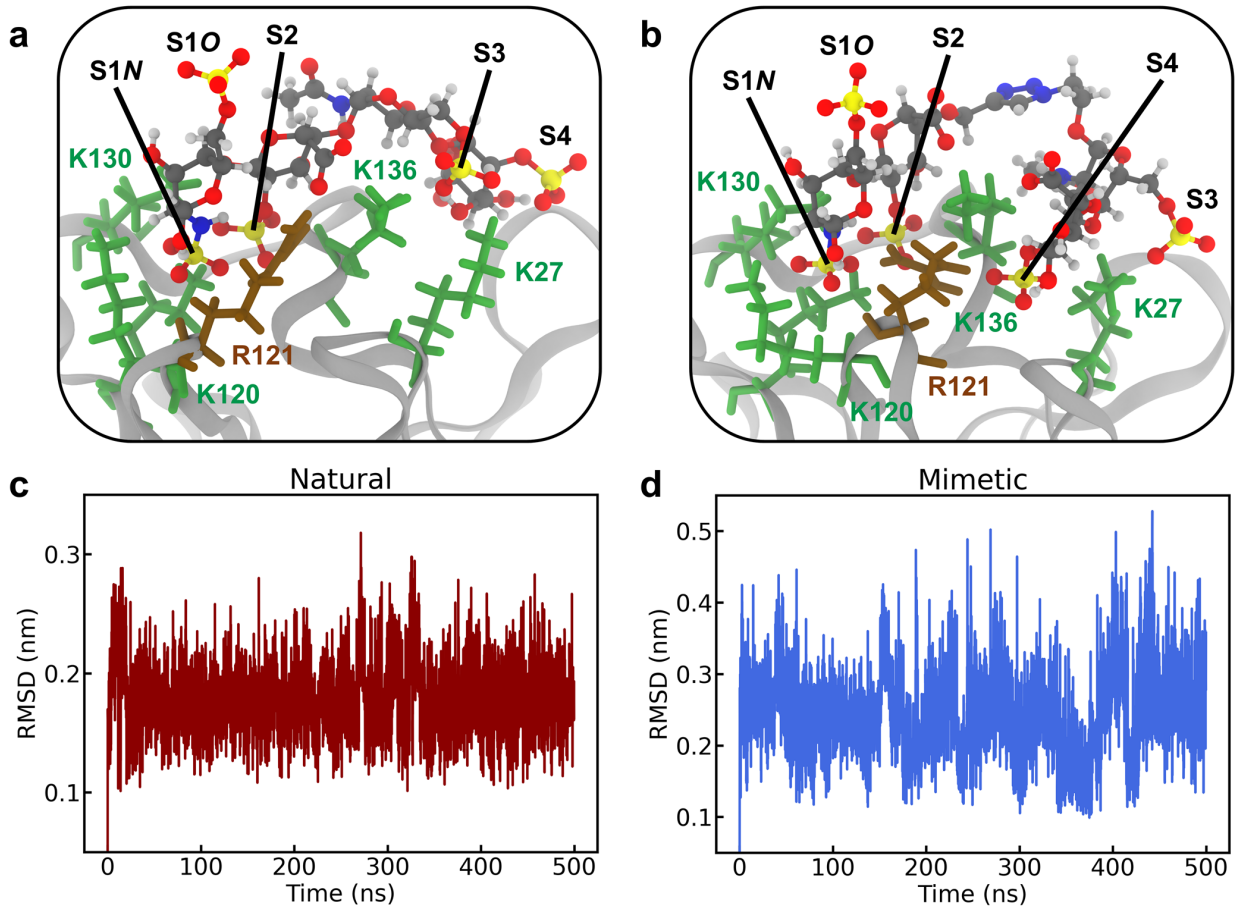
Note: **(a)** Potential of mean force (PMF) for Na^+ solvation around central residues (namely, central IdoA(2S) carboxylate, central IdoA(2S) 2-*O*-sulfate, and GlcNAc(6S) 6-*O*-sulfate) and **(b)** PMF for Na^+ solvation around terminal residues (namely, terminal IdoA(2S) carboxylate, terminal IdoA(2S) 2-*O*-sulfate, GlcNS(6S) 2-*N*-sulfate, and GlcNS(6S) 6-*O*-sulfate).

The negative of the PMF is the free energy required to move an Na^+ ion at distance r from a sulfate group into bulk solution. Accordingly, the PMF is a measure of the interaction strength between a sulfate group and the Na^+ solvation shell surrounding it. Comparing the PMFs for central IdoA(2S) carboxylate between native HS tetrasaccharide and **K** (dark red curve in panel **a**), we find that the PMF value at the first solvation shell ($r \sim 0.27$ nm) to be more negative (by -2 kJ/mol) for the native polymer than for the mimetic. This indicates that the interaction of IdoA(2S) carboxylate with its surrounding Na^+ solvation shell is stronger in native HS than in the mimetic. Similarly, the PMF value at the first solvation shell for GlcNAc(6S) 6-*O*-sulfate (dark yellow curve in panel **a**, $r \sim 0.36$ nm) is more negative (by -2 kJ/mol) for the native HS tetrasaccharide than for **K**. This again indicates a stronger Na^+ solvation interaction in the native polymer compared to the mimetic. For terminal residues, the PMF curves (panel **b**) are closer between native HS and the mimetic, although native HS still exhibits slightly more negative PMF values at the solvation shells.

To further verify the stronger interaction of the native HS tetrasaccharide, compared to **K**, with its surrounding Na^+ ion environment, we computed the monovalent excess ion atmosphere Γ_+. The excess ion atmosphere is a measure of

the extra number of ions in the vicinity of a polymer relative to bulk solution. Γ_+ was found to be 4.1 and 3.7 for the native HS tetrasaccharide and **K**, respectively. This indicates that the average number of Na^+ ions surrounding native HS is greater than that around the mimetic by 0.4. The smaller average number of Na^+ ions around **K** is a result of its decreased linear charge density.

Figure S8. FGF2 binding of compound **K** and its analogous native HS tetrasaccharide



Note: **(a)** Representative snapshot of native HS tetrasaccharide when bound to the positively charged domain of FGF2. S1*N*, S1*O*, S2, S3, and S4 indicate the 2-*N*-sulfate of GlcNS(6S), 6-*O*-sulfate of GlcNS(6S), 2-*O*-sulfate of central IdoA(2S), 6-*O*-sulfate of GlcNAc(6S), and 2-*O*-sulfate of terminal IdoA(2S), respectively. Lys residues are shown in green and Arg in brown. Atom color code: H – white, C – gray, N – blue, O – red, S – yellow. **(b)** Representative snapshot of compound **K** when bound to FGF2. The polymer adopts a partly folded conformation, allowing S3 and S4 to interact with Lys27 and Arg121. **(c)** Root mean squared deviation (RMSD) of native HS tetrasaccharide, showing that it remains stably bound to FGF2 throughout the simulation. **(d)** RMSD of compound **K**, indicating stable binding to FGF2.

Table S1. Comparison of simulation with crystal structure for sulfate-dependent binding to FGF2

Sulfate group	FGF2 residue	Crystal structure (Å)	Native simulation (Å)	Mimetic simulation (Å)
GlcNS(6S) 2-*N*-sulfate	N28	3.3	2.8 ± 0.1	6.8 ± 0.4
GlcNS(6S) 2-*N*-sulfate	R121	3.1	2.9 ± 0.2	2.8 ± 0.1
GlcNS(6S) 2-*N*-sulfate	K126	3.0	2.7 ± 0.1	2.7 ± 0.1
IdoA(2S) 2-*O*-sulfate	K126	2.8	2.7 ± 0.1	2.8 ± 0.1
IdoA(2S) 2-*O*-sulfate	Q135	3.5	2.9 ± 0.1	2.9 ± 0.1
IdoA(2S) 2-*O*-sulfate	K136	3.0	2.9 ± 0.1	2.8 ± 0.1
IdoA(2S) 2-*O*-sulfate	A137	2.9	3.3 ± 0.3	3.7 ± 0.3

Note: Contact distances between FGF2 residues and sulfate groups in the crystal structure of HS tetramer (PDB: 1BFB), simulation of native HS tetrasaccharide, and simulation of compound **K**. Distance is computed for non-hydrogen atoms. For simulation results, error ranges indicate the standard deviations. GlcNS(6S) 2-*N*-sulfate and IdoA(2S) 2-*O*-sulfate correspond to sulfate groups S1*N* and S2, respectively, in **Figure 5** and **S17**. The similarity in contact distances shows that simulations largely reproduce the crystallographic binding configurations of these two sulfates, which interact most extensively with FGF2. For the mimetic simulation, Asn28 is further removed from GlcNS(6S) 2-*N*-sulfate, relative to the crystal structure and native simulation, due to interaction with terminal IdoA(2S) 2-*O*-sulfate (*i.e.*, S4 in **Figure 5** and **S17**).

Supplementary Methods

Materials

Chemicals were purchased from Alfa Aesar, Sigma-Aldrich, Acros, Fisher Scientific, or TCI chemical companies and used as received. Deuterated solvents were purchased from either Cambridge Isotope Laboratories, Inc. or Acros. The organic solvents such as acetonitrile (MeCN), tetrahydrofuran (THF), dichloromethane (DCM), and dimethylformamide (DMF) were purchased from Fisher Scientific and used after the purification by a dry solvent system (Pure Process Technology). Thin layer chromatography was performed on Merck TLC plates (silica gel 60 F254) and visualized by UV irradiation (254 nm) and by charring with sulfuric acid in ethanol. The FGF-Basic (AA 1-155) Recombinant Human Protein (Cat. # PHG0264) and the heparin sodium salt (Cat. # AAA16198MD) were purchased from Fisher Scientific. The related Anti-FGF-2/basic FGF (neutralizing) Antibody (Cat. # 05-117) and biotinylated heparin (Cat. # B9806-10MG) used in SPR were purchased from Sigma-Aldrich. Compound S, a native hexasaccharide was purchased from the Glycan Therapeutics (Cat. # GT77-AZ-014).

Characterization

^{1}H NMR, ^{13}C NMR, gCOSY, and HSQC measurements were conducted in $CDCl_3$, D_2O, CD_3COCD_3, or CD_3OD using a Varian Gemini-600 (600 MHz) or Varian Inova-500 (500 MHz) NMR spectrometer. Chemical shifts are in ppm calibrated using the resonances of the carbon and the residual proton of the deuterated solvent. High-resolution mass spectrometry performed on JEOL AccuTOF DART Micromass LCT ESI-MS and an Agilent 6220 Time-of-Flight LC/MS instruments were used for characterization of small molecules.

The synthetic HS glycomimetics were subjected to liquid chromatography/electrospray ionization mass spectrometry (LC-ESI-MS) analysis. LC-ESI-MS was carried out on an Agilent 6230 LC TOF mass spectrometer monitoring at 210, 254 and 280 nm for mass detection. The mass spectrometer was calibrated in negative ionization mode with spray voltage of 3500 V. Method for reverse phase LC-ESI-MS: Agilent Poroshell 120 EC-C18 (2.7 μm, 2.1× 50 mm) analytical column using mobile phase water (5 mM ammonium acetate)-acetonitrile with a flow rate 0.2 mL/min. Gradient used: isocratic 5% CH_3CN for 5 min, gradient from 5% to 95% CH_3CN over 15 min (5-20 min), then isocratic 95% CH_3CN for 5 min (20-25 min). Method for Hilic LC-ESI-MS: Hilic column (2.7 μm, 2.1× 50 mm) analytical column using mobile phase water (5 mM ammonium acetate)-acetonitrile with a flow rate 0.2 mL/min. Gradient used: isocratic 99% CH_3CN for 3 min, gradient from 99% to 20% CH_3CN over 15 min (3-15 min), then isocratic 20% CH_3CN for 3 min (15-18 min).

Purification of the HS glycomimetics obtained from solution phase ISG was performed on semi-preparative HPLC (Waters Alliance 2695 HPLC). Method for semi-preparative HPLC: Phenomenex C18 (10 μm, 10 × 250 mm) semi-preparative column using water (5 mM ammonium acetate)-acetonitrile mobile phase with a flow rate of 5 mL/min. Gradient used: isocratic 0% CH3CN for 10 min (0-10 min), then gradient from 0 to 45% CH3CN

over 40 minutes (10-50 min).

MS/MS sequencing

All tandem mass spectral analyses were performed on a 12-T hybrid Qh-Fourier transform ion cyclotron resonance (FTICR) mass spectrometer (Bruker Daltonics, Bremen, Germany). Each glycomimetic sample was dissolved in 50/50 water/acetonitrile solution containing 0.1% formic acid to a concentration of 10 pmol/μL, and directly infused into the mass spectrometer using a pulled capillary. CID was performed in the external collision cell with a 4.5 eV collision energy. NETD was performed using the fluoranthene cation radical as the electron transfer reagent, with a reagent accumulation time and a reaction time of 300 ms and 150 ms, respectively. Each tandem mass spectrum was acquired by averaging up to 32 transients for improved S/N. Fragments were manually assigned using the ChemDraw software, with a typical mass accuracy of around 1 ppm, and annotated using the Domon-Costello nomenclature.[1]

Computational methods

Force field: Models of the native HS tetrasaccharide and compound **K** were constructed by combining the GLYCAM06j force field[2], extended for glycosaminoglycans[3], and the generalized Amber force field (GAFF)[4]. Specifically, atoms belonging to HS residues were parameterized using GLYCAM, while those belonging to the 1,2,3-triazole spacer were parameterized using GAFF. Bonds, angles, and dihedrals containing at least one spacer atom were assigned GAFF parameters; otherwise, GLYCAM parameters were assigned. Similarly, 1-4 interactions were scaled according to GAFF if they involved at least one spacer atom; otherwise, GLYCAM scaling was applied. Partial charges on spacer atoms were calculated using the restrained electrostatic potential (RESP) method.[5] Molecular dynamics (MD) simulations were performed using OpenMM v7.6.[6]

Implicit solvent simulations: Explicit solvent models cannot adequately sample HS ring flipping, which occurs on the order of milliseconds in solution. Hence, to study conformational dynamics (**Figure 5b**, **5c**, **S14**, and **S15**), we performed generalized Born implicit solvent simulations using OBC2 parameters, coupled with the solvent accessible surface area (SASA) to account for hydrophobic effects (GBSA-OBC2)[7]. Hydrogen atoms were held fixed, and no cutoff was applied to non-bonded interactions. Dynamics were propagated using the Langevin equation, with a low collision rate of 1 ps^{-1} to accelerate conformational sampling. The integration time step was set to 2 fs. Simulations were performed at 300 K and for 10 μs, with the first 1 μs discarded for equilibration. Due to the accelerated dynamics afforded by implicit solvent, the 10 μs simulation time was sufficient to obtain 17 transitions (on average) for GlcNAc(6S) ring flipping, which was the slowest timescale transition.

Explicit solvent simulations: To study ion solvation effects (**Figure 5d**, **5e**, and **S16**), we performed explicit solvent simulations using TIP3P water[8] and Joung-Cheatham ions[9] in a 6 × 6 × 6 nm periodic box. Hydrogen atoms were held fixed, and the particle mesh Ewald (PME) method with a 1 nm cutoff was applied to calculate non-bonded interactions. The integration time step was 2 fs. Temperature was set to 300 K using Langevin dynamics (1 ps^{-1} collision rate), and pressure was maintained at 1 bar with a Monte Carlo barostat (NPT ensemble). NaCl concentration was set to 137

mM to mimic PBS buffer conditions. The simulation time was set to 1 μs, with the first 100 ns discarded for equilibration. Simulations were initiated with native HS tetrasaccharide and compound **K** close to their free-energy minimum configurations (with respect to glycosidic linkage torsions, ring flipping states, and end-to-end distance), as observed in implicit solvent simulations.

FGF2 binding: MD simulations of native HS tetrasaccharide and compound **K** binding to FGF2 (**Figure 5f**, **5g**, and **S17**) were performed using the implicit solvent protocol described above. FGF2 was modeled with the Amber14sb force field.[10] We used the crystal structure of FGF2 reported by Faham, et al. (PDB: 1BFB[11]), which also contains a bound HS tetramer. Residue protonation states were assigned based on pH = 7. The simulation time was set to 1.5 μs, with the first 1.0 μs discarded for equilibration. The initial configuration of the native HS tetrasaccharide was obtained by aligning two of its adjacent sulfate groups (S1*N* and S2 in **Figure 5a**) to the positions of the bound sulfates of HS tetramer in the crystal structure (PDB: 1BFB[11]); the initial configuration of compound **K** was obtained by the same method. Specifically, the 2-*N*-sulfate of GlcNS(6S) (*i.e.* S1*N*) in native HS/compound **K** was aligned to the bound 2-*N*-sulfate of GlcNS(6S) in the HS tetramer crystal structure; and the 2-*O*-sulfate of central IdoA(2S) (*i.e.* S2) in native HS/compound **K** was aligned to the bound 2-*O*-sulfate of IdoA(2S) in the crystal structure.

Relative free energy: Relative free energy along a coordinate x (**Figure 5b**, **5c**, **S14**, and **S15**) is obtained by taking the Boltzmann inversion of its probability $P(x)$:

$$F(x) = -RT \ln \frac{P(x)}{P(x_0)}$$

where x_0 is some reference value, R is the gas constant, and T is temperature.

Potential of mean force (PMF): PMFs (**Figure S16**) were computed by the taking the Boltzmann inversion of the radial distribution function $g(r)$:

$$\text{PMF} = -RT \ln g(r)$$

where R is the gas constant and T is temperature.

Spatial distribution function (SDF) of ions: SDFs (**Figure 5d** and **e**) were obtained by computing the three-dimensional histogram of ion positions averaged across the entire trajectory. To remove translational and rotational motion, the HS polymer was first aligned to a reference structure. Then the transformation corresponding to the alignment was applied to ion positions. A bin size of 0.6 × 0.6 × 0.6 Å^3 was used to generate the histogram.

Monovalent excess ion atmosphere (Γ_+): Γ_+ (**Figure S16**) was computed based on previous methods[12], according to the equation:

$$\Gamma_+ = N_+ - \rho_+ V$$

where N_+ is the average number of monovalent ions in a region surrounding the macromolecule, V is the volume of

the region, and ρ_+ is the bulk density of monovalent ions outside the region. To calculate Γ_+ for our system, the HS polymer, with ions, was re-centered in the 6 × 6 × 6 nm simulation box for each frame of the trajectory. The region surrounding HS was then defined to be a sphere with radius 2.5 nm and HS at its center. N_+ was obtained by counting the number of monovalent ions inside the sphere while V was set to its volume. Finally, the bulk density ρ_+ was computed from the number of ions outside the sphere.

Contact probability: Contacts between sulfate groups of HS and FGF2 residues (**Figure 5f** and **g**) were computed using a 0.3 nm cutoff for non-hydrogen atoms. The probability of contact formation is estimated by:

$$P_{\text{contact}} = \frac{N_{\text{contact}}}{N_{\text{total}}}$$

where N_{contact} is the number of simulation frames where the residues are in contact and N_{total} is the total number of simulation frames.

Glycan microarray

Printing:
All compounds were printed on Nexterion Slide H NHS slides (Schott) in 100 mM sodium phosphate buffer pH 8.0. To perform the print a sciFLEXARRAYER S11 (Scienion, Phoenix, AZ) was used. Piezo-dispensing capillaries (PDCs) with a modified Type 3 coating (PDC 70 Type 3) were used as sold by the manufacturer. The print layout was designed as 16 sub-arrays printed per slide, and each compound was printed per sub-array in 4 replicates (n = 4) at two concentrations (100 μM and 300 μM) each. In addition to the compounds, controls including heparin, FGF2 (in PBS with 0.02% Tween-20) and buffer alone were also printed. During dispensing, adjustments were made to the voltage and pulse parameters to keep the dispensed volume 330 ± 10 pL per spot. After printing, the slides were kept overnight at 70% relative humidity. The next day the slides were blocked with 50 mM ethanolamine in borate buffer (100 mM sodium tetraborate buffer pH 8.5) for 1 hr, following which slides were taken out of this solution, dip-washed 10X in PBS containing 0.05% Tween-20 and then 10X in water. Slides were dried in a centrifuge and stored at -20°C in a slide tube until use.

Assay:
Assays were performed using a tertiary binding protocol. The following buffers were prepared: TSM buffer (20mM Tris-HCL pH 7.4, 150 mM NaCl, 2 mM CaCl, 2 mM MgCl) TSM wash buffer (TSMW) (TSM buffer + 0.05% Tween 20) and TSM binding buffer (TSMBB) (TSMW + 1% BSA). The slides were removed from the freezer and allowed to come to ambient temperature in a desicator. ProPlate® 16-well chamber (Grace Bio-Labs) were placed on top of the slide to allow partitioning of the sub-arrays. Following this the sub-arrays were rehydrated with TSMW for 5 minutes at ambient temperature. FGF2 was diluted to 5 μg/ml in TSMBB and 100 μL of this solution was applied to one sub-array for 1 hr. Following this, the sub-array was washed 4X with TSMW and then anti-FGF antibody was applied to the the subarray at 5 μg/ml in TSMBB (100 μL) for 1 hr. Following this, the sub-array was washed again

4X with TSMW and then anti-mouse IgG-Alexa-635 antibody was applied to the subarray at 5 μg/ml in TSMBB (100 μL) for 1 hr. The sub-array was washed 4X with TSMW, then 4X with TSM and finally 4X deionized water. Finally, the solution was removed from the sub-array and dried. The slide was then scanned using GenePix 4400A scanner (Molecular Devices) at wavelength 635 nm, laser power 70% and PMT setting of 450. The spots were aligned using the array list file produced by the printer and analyzed. The background subtracted mean values of the 4 spots/probe were averaged to obtain the mean RFU as shown in the charts.

Surface Plasmon Resonance (SPR)

Method:

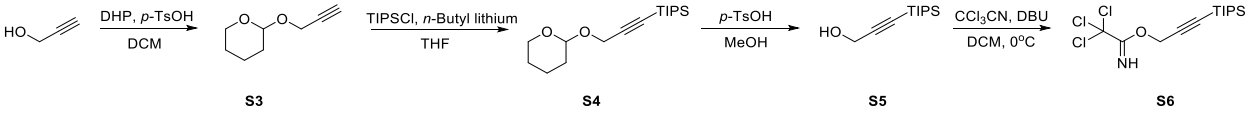
HBS-EP (0.01 M HEPES, 150 mM NaCl, 3 mM EDTA, 0.005% polysorbate 20; pH 7.4) was employed as the running buffer and sample solvent. Briefly, the 0.5 μM streptavidin solution was flowed through the biotin sensor at a flow rate of 20 μl/min, followed by an injection of 0.1 mg/ml of biotinylated heparin at a flow rate of 5 μl/min until a response of 100 RU was obtained. A FGF2 (75 nM) sample was premixed with different concentration of each HS-mimetic (0-0.1 mM) for 1 hour in HBS-EP buffer. Then the mixture was flowed over heparin-streptavidin chip at a flow rate of 20μl/min for 250 sec, followed by dissociation for 350 sec by using HBS-EP buffer at 25 °C. The surface was regenerated by injection of 15 μL of 2 M NaCl at 150 μL/min, until a stable baseline was obtained.

Data Analysis:

To measure the affinity of HS-mimetics to FGF2, a solution competition assay was used to obtain IC50.[13] A stoichiometry of 1:1 was assumed to form for both HS-mimetics and heparin with FGF2 in solution. Before the injection, the FGF2 (P) is pre-mixed with the HS-mimetics (L) and a binding equilibrium was established in solution. The mixture was then flowed through the chips immobilized with heparin. Curve fitting and calculation of IC50 values were performed with the GraphPad Prism program (GraphPad Software, San Diego, CA, USA). The data were fitted to a three parameter, dose-response-inhibition model with a constant slope: Y=Bottom + (Top-Bottom)/(1+(X/IC50)), where X is the concentration of competitor and Y represents free FGF2 concentration(response) that starts at Top and goes to Bottom with a sigmoid shape.

Detailed Synthetic Procedures

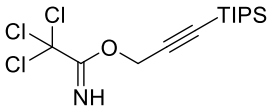
Synthesis of clickable disaccharides



Scheme S2

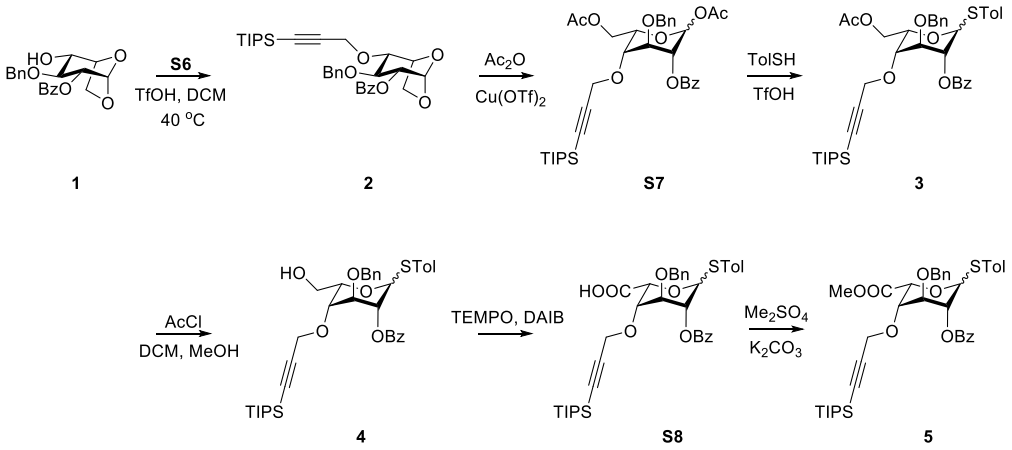
S5

Compound S5 was prepared according the reference.[14] ^{1}H NMR (400 MHz, CDCl3) δ 8.38 – 8.30 (m, 1H), 8.26-8.25 (m, 1H), 7.79 – 7.68 (m, 2H), ^{13}C NMR (126 MHz, $CDCl_3$) δ 105.83, 86.45, 51.48, 18.50, 11.14. Spectral data matched those previously reported.

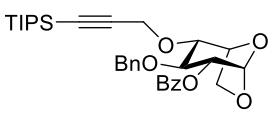


S6

To a solution of compound S5 (5.5 g, 25.89 mmol) and 2,2,2-trichloroacetonitrile (7.48 g, 51.79 mmol, 5.19 mL) in DCM (30 mL), 1,8-Diazabicyclo[5.4.0]undec-7-ene (985.51 mg, 6.47 mmol, 966.19 μL) was added in the ice bath. After warmed up to the room temperature, the solution was stirred for 4 h. The mixture was concentrated under reduced pressure and the crude oil was purified by flash chromatography with eluent hexane: DCM=8:1, give the light yellow oid S6 (yield 98%). ^{1}H NMR (500 MHz, cdcl3) δ 8.47 (s, 1H), 4.95 (s, 2H), 1.06 (d, J = 2.7 Hz, 21H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 161.68, 100.23, 89.25, 57.32, 18.53, 11.12. HRMS (DART) *m/z* $[M+H]^+$ Calcd. For $C_{14}H_{24}Cl_3NOSi$: 356.0771, found 356.0760.



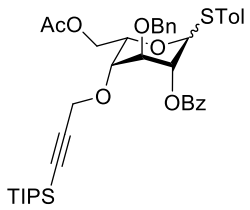
Scheme S3



2

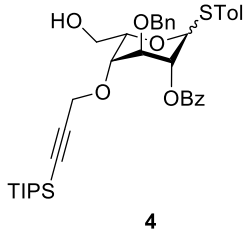
Compound 1 was prepared according the reference.[15] Spectral data matched those previously reported. To a solution of compound S6 (3.00 g, 8.42 mmol), compound 1 (1 g, 2.81 mmol) in DCM (50 mL) were added with pre-dried molecular sieve (500 mg) under N2 atmosphere at 40 °C. After stirred for 30 min, triflic acid (42.11 mg, 280.61

μmol, 24.63 μL) was added. After 2 h, the mixture was filtered through a pad of Celite. The filtrate was concentrated and purified by silica column chromatography by the eluent of hexane:EA=40:1, giving the colourless sticky liquid (0.71 g, yield 46%). $[\alpha]_D^{20}$ = 126.470 (c 0.5, $CHCl_3$). ^1H NMR (600 MHz, $CDCl_3$) δ 8.01 (dd, *J* = 8.3, 1.4 Hz, 2H), 7.59 – 7.53 (m, 1H), 7.45 – 7.39 (m, 2H), 7.24 – 7.17 (m, 5H), 5.51 (d, *J* = 1.8 Hz, 1H), 5.02 (dd, *J* = 8.2, 1.9 Hz, 1H), 4.84 – 4.68 (m, 3H), 4.42 – 4.28 (m, 2H), 4.15 (d, *J* = 7.5 Hz, 1H), 3.95 (m, *J* = 8.1, 4.3, 1.1 Hz, 1H), 3.90 (t, *J* = 8.2 Hz, 1H), 3.74 (dd, *J* = 8.3, 4.5 Hz, 1H), 1.07 (s, 21H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 165.81, 138.14, 133.29, 129.89, 129.54, 128.39, 128.28, 127.83, 127.62, 103.21, 99.28, 88.64, 79.32, 78.86, 76.72, 74.66, 73.56, 65.60, 59.43, 18.57, 18.55, 11.14, 11.14. HRMS (DART) *m/z* $[M+H]^+$ Calcd. For $C_{32}H_{43}O_6Si$: 551.2829, found 551.2823.



3

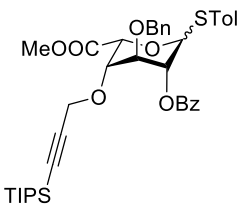
Acetyl anhydride (29.16 g, 285.63 mmol, 27.00 mL) and Copper trifluoromethanesulfonate (88.66 mg, 245.12 μmol) was added to a solution of compound **2** (2.7 g, 4.90 mmol) at room temperature under N_2 atmosphere. After stirring for 24 h, the reaction was quenched with MeOH, and the solvent was evaporated under reduced pressure. Water (5 mL) was added, and the crude target material was extracted with ethyl acetate (3×5 mL). The combined organic layers were sequentially washed with saturated $NaHCO_3$(aq) and brine, dried over Na_2SO_4, filtered and concentrated in vacuo. Purification of this residue via flash column chromatography on silica gel (hexane/ethyl acetate = 10:1) give a colourless oil. Under nitrogen, a solution of obtained product in DCM (80 mL) was added 4-methylbenzenethiol (0.6 g, 4.87 mmol) and trifluoromethanesulfonic acid (69.57 mg, 0.46 mmol, 40.7 μL) at 0 °C. TLC monitoring until reaction completed, triethylamine was added to quench the reaction. After evaporation by reduced pressure, the crude product was purified by column chromatography using hexane: EA = 30:1 as eluent to give a colourless oil (2.7 g, yield 82%). Rf = 0.44 in hexane/EA=5/1. $[\alpha]_D^{20}$ = -11.237 (c 1.0, $CHCl_3$). ^1H NMR (500 MHz, $CDCl_3$) δ 8.12 (ddd, *J* = 50.5, 8.3, 1.4 Hz, 2H), 7.68 – 7.23 (m, 10H), 7.20 – 6.98 (m, 2H), 5.61 – 5.20 (m, 2H), 5.10 – 4.82 (m, 2H), 4.77 – 4.69 (m, 1H), 4.56 – 4.46 (m, 1H), 4.34 (dt, *J* = 11.7, 3.2 Hz, 1H), 4.26 (d, *J* = 16.5 Hz, 0H), 4.12 (d, *J* = 16.6 Hz, 1H), 4.06 – 3.96 (m, 1H), 3.86 (dt, *J* = 48.2, 2.1 Hz, 1H), 2.33 (s, 3H), 2.10 (d, *J* = 15.8 Hz, 3H), 1.06 (d, *J* = 11.1 Hz, 21H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 170.61, 166.04, 165.49, 137.64, 137.26, 133.32, 133.29, 132.56, 131.93, 131.40, 131.22, 130.12, 129.90, 129.61, 129.56, 129.54, 128.52, 128.45, 128.43, 128.40, 128.07, 127.91, 127.70, 127.69, 127.64, 102.25, 102.10, 88.89, 88.86, 86.09, 84.40, 74.65, 72.78, 72.67, 72.40, 71.15, 70.77, 70.68, 69.64, 68.91, 66.58, 64.43, 64.06, 57.60, 57.30, 21.08, 21.05, 20.85, 20.83, 18.56, 18.55, 11.09, 11.06. HRMS (DART) *m/z* $[M+H]^+$ Calcd. For $C_{41}H_{53}O_7SSi$: 717.3281, found 717.3306.



4

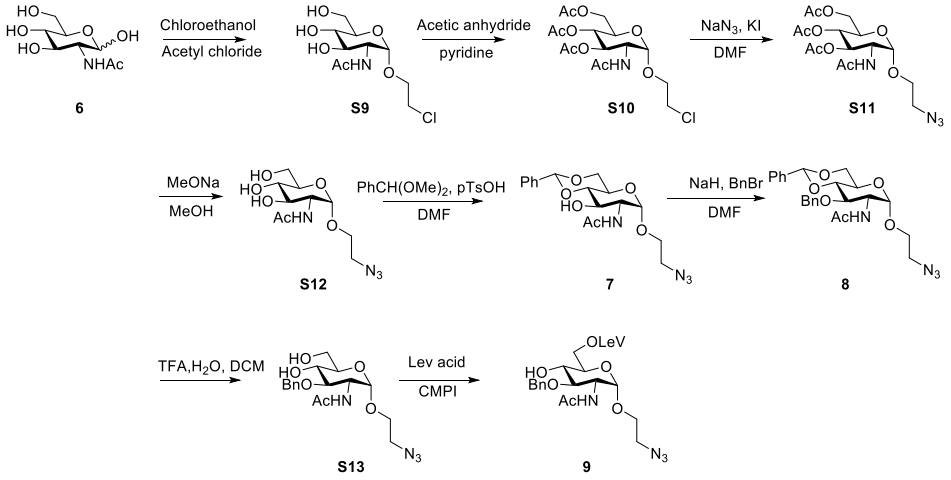
Acetic chloride (1.93 g, 24.55 mmol, 1.49 mL) was added to a solution of compound **3** (8.8 g, 12.27 mmol) in the mixed solvent DCM (40 mL)/MeOH (60 mL) at 0 °C under N_2 protection. The ice bath was removed, and the reaction was kept at RT for 6 h. Saturated $NaHCO_3$ solution was added to quench the reaction. DCM was added to extract the solution twice and the organic phase was dried over Na_2SO_4. The solution was concentrated and purified by silica column Chromatography using EA: hexane = 10:1~5:1 as an eluent, give a colorless oil (7.6 g, yield 92%). $[\alpha]_D^{20}$ = -29.992 (c 0.5, $CHCl_3$). ^1H NMR (600 MHz, Chloroform-*d*) δ 8.15 – 8.12 (m, 0.55 H), 8.09 – 7.98 (m, 1.45 H), 7.61 – 7.27 (m, 11H), 7.10 (dd, *J* = 8.1, 4.2 Hz, 2H), 5.63 – 5.41 (m, 1.45H),

5.41 – 5.22 (m, 0.55H), 4.93 (d, *J* = 11.8 Hz, 1H), 4.85 – 4.77 (m, 1H), 4.73 – 4.64 (m, 1H), 4.30 – 4.09 (m, 1H), 4.08 – 3.96 (m, 2H), 3.95 – 3.73 (m, 3H), 2.31 (s, 3H), 1.10 – 0.93 (m, 21H). ^{13}C NMR (151 MHz, cdcl$_3$) δ 166.05, 165.51, 137.74, 137.53, 137.22, 133.31, 132.49, 131.62, 131.35, 130.06, 129.86, 129.75, 129.58, 128.52, 128.46, 128.43, 128.41, 128.06, 127.92, 127.70, 127.62, 102.30, 88.90, 88.74, 86.19, 84.40, 77.20, 77.04, 76.98, 76.77, 72.92, 72.62, 72.51, 70.95, 70.70, 70.55, 69.98, 69.14, 68.19, 62.71, 62.57, 57.47, 57.14, 21.07, 21.04, 18.52, 18.49, 11.08, 11.05, -0.04. HRMS (DART) ([M+Na]$^+$) Calcd. For $C_{39}H_{50}NaO_6SSi$: 697.2995, found 697.3000.

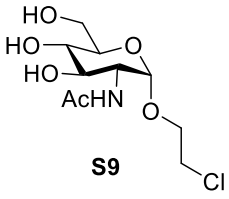


5

To a solution of compound **4** (1.43 g, 2.11 mmol) in mixed water and CH_2Cl_2 [1/2 (v/v), 18 mL] were added TEMPO (66.07 mg, 422.84 μmol) and (diacetoxyiodo)benzene (DAIB, 1.70 g, 5.29 mmol) at room temperature. After stirring for 4 h, the mixture was washed with saturated NH_4Cl solution. It required vigorous stirring. HCl was added into the mixture to tune the pH to 3. DCM was used to dilute and extract the aqueous layer three times. The organic layer was dried over MgSO4, filtered, and concentrated under reduced pressure. The crude product was directly dissolved in DCM/acetone mixture (v/v=1/1, 30 mL) and treated with dimethyl sulfate (400.00 mg, 3.17 mmol, 300.75 μL) and potassium carbonate (584.39 mg, 4.23 mmol) at 0 °C under a nitrogen atmosphere. After 40 min, the mixture was neutralized with 1 N HCl and extracted with DCM by 3 times. The combined organic phases were dried over anhydrous Na_2SO_4, filtered, and evaporated under reduced pressure. The residue was purified by column chromatography (hexane: EA = 30:1~20:1) to afford product as a colourless oil (yield 62%). $[\alpha]_D^{20}$ = -45.489 (c 0.5, $CHCl_3$). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.05 (dd, *J* = 8.3, 1.4 Hz, 2H), 7.57 – 7.51 (m, 1H), 7.43 – 7.22 (m, 9H), 7.07 (d, *J* = 8.1 Hz, 2H), 5.65 (d, *J* = 2.3 Hz, 1H), 5.43 (m, *J* = 3.4, 2.4, 1.0 Hz, 1H), 5.32 (d, *J* = 2.7 Hz, 1H), 4.79 (dd, *J* = 114.2, 11.5 Hz, 1H), 4.29 – 4.25 (m, 1H), 4.22 (d, *J* = 12.1 Hz, 2H), 4.15 (td, *J* = 3.6, 1.1 Hz, 1H), 3.81 (s, 3H), 2.29 (s, 3H), 1.02 (d, *J* = 3.9 Hz, 9H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 169.63, 165.50, 137.58, 137.28, 133.29, 131.95, 131.95, 131.49, 130.03, 129.70, 129.70, 129.51, 128.42, 128.35, 128.34, 127.86, 127.62, 102.04, 88.89, 86.18, 73.20, 72.91, 71.63, 69.12, 68.92, 58.08, 52.19, 21.07, 18.53, 18.51, 11.11, 11.08. HRMS (DART) *m/z* [M+H]$^+$ Calcd. For $C_{40}H_{51}O_7SSi$: 703.3125, found 703.3119.

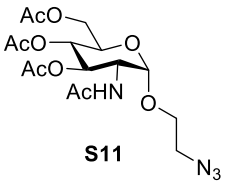


Scheme S4



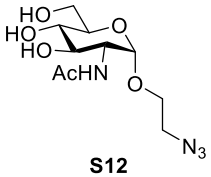
S9

To a solution of N-Acetyl-D-glucosamine (30 g, 135.62 mmol) in 2-chloroethanol (300.00 g, 3.73 mol, 250 mL) was added dropwise acetyl chloride (12.78 g, 162.74 mmol, 9.90 mL) at 0 °C. The reaction mixture was heated at 70°C for 4 h and stirred at room temperature for another 4 h. The solution was concentrated, and the brownish oily residue was dissolved in ethanol. The solution was decolorized using charcoal. The concentrated residue was purified by silica gel chromatography to yield product (DCM: MeOH = 10:1~5:1) to afford light yellow solid (yield 65%, 25.16 g). Rf = 0.6 in DCM: MeOH=2:1. ^{1}H NMR (600 MHz, Deuterium Oxide) δ 4.81 (d, *J* = 3.6 Hz, 1H), 3.87 – 3.81 (m, 1H), 3.78 (dd, *J* = 10.7, 3.6 Hz, 1H), 3.76 – 3.70 (m, 1H), 3.69 – 3.61 (m, 6H), 3.35 (t, *J* = 9.4 Hz, 1H), 1.91 (s, 3H). Spectral data matched those previously reported.[16]



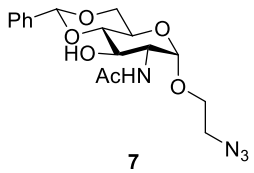
S11

Compound S9 (25.14 g, 88.61 mmol) was added to the mixture of pyridine (10 ml) and acetic anhydride (5 ml), followed by the addition of a catalytic amount of 4-dimethylaminopyridine. The reaction was to be stirred for 2 h. The solution was concentrated under reduced pressure. DCM was added to dilute the solution, which was further washed with 1 N HCl, brine, and dried over Na_2SO_4. The product was purified by silica gel flash column chromatography using EtOAc:hexane (5:3) as an eluent to give the product, which was directly used in the next step. Compound S10 was dissolved in DMF (400 mL) by heating the solution. Sodium azide (28.63 g, 440.44 mmol, 15.48 mL) and potassium iodide (14.62 g, 88.09 mmol, 4.69 mL) were then added. After heated at 60°C overnight, the reaction mixture was concentrated and diluted by DCM. The solution was washed by water for three times. The organic layer was dried over Na_2SO_4 and concentrated, affording a white solid (quantitative, 35.9 g). $[\alpha]_D^{20}$ = 69.581 (c 1.00, $CHCl_3$). ^{1}H NMR (600 MHz, Chloroform-*d*) δ 5.79 (d, *J* = 9.4 Hz, 1H), 5.24 (dd, *J* = 10.8, 9.5 Hz, 1H), 5.14 (t, *J* = 9.8 Hz, 1H), 4.92 (d, *J* = 3.7 Hz, 1H), 4.38 (ddd, *J* = 10.8, 9.5, 3.7 Hz, 1H), 4.24 (dd, *J* = 12.3, 4.5 Hz, 1H), 4.11 (dd, *J* = 12.3, 2.4 Hz, 1H), 3.98 (ddd, *J* = 10.2, 4.5, 2.4 Hz, 1H), 3.92 (ddd, *J* = 10.8, 5.7, 2.9 Hz, 1H), 3.67 (ddd, *J* = 10.7, 7.8, 2.9 Hz, 1H), 3.55 (ddd, *J* = 13.5, 7.7, 2.9 Hz, 1H), 3.38 (ddd, *J* = 13.5, 5.7, 2.9 Hz, 1H), 2.10 (s, 3H), 2.03 (d, *J* = 6.3 Hz, 6H), 1.96 (s, 3H). ^{13}C NMR (151 MHz, cdcl$_3$) δ 171.34, 170.64, 170.11, 169.27, 97.57, 70.95, 68.07, 67.98, 67.49, 61.91, 51.71, 50.35, 23.09, 20.69, 20.68, 20.57. HRMS (DART) ([M+H]$^+$) Calcd. For $C_{16}H_{25}N_4O_9$: 417.1622, found 417.1620.



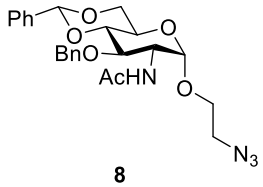
S12

A 25 wt% solution of sodium methoxide in methanol was added to a solution of Compound S11 (35.9 g, 86.22 mmol) in methanol (300 mL). After 0.5 h, the mixture was deionized by the cation exchange resin (H^+), the resin was filtered off and washed with methanol, and the filtrate was concentrated. The cation exchange resin was washed by methanol before use. The product was dried under vacuum at 50 °C before used for next step (yield 99%, 25 g). ^{1}H NMR (500 MHz, Methanol-d_4) δ 4.86 (d, *J* = 3.6 Hz, 1H), 3.93 – 3.79 (m, 3H), 3.73 – 3.56 (m, 4H), 3.46 (t, *J* = 4.9 Hz, 2H), 3.36 (dd, *J* = 9.8, 8.7 Hz, 1H), 3.30 (p, *J* = 1.7 Hz, 4H), 1.98 (s, 3H). Spectral data matched those previously reported.[16]



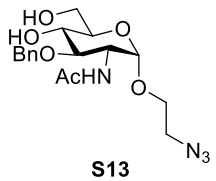
7

Compound **S12** (69.67 mg, 240.00 μmol) was dissolved in DMF (2 mL). dimethoxymethylbenzene (73.05 mg, 480.00 umol, 72.33 μL) and *p*-toluenesulfonic acid monohydrate (2.28 mg, 12.00 umol, 1.84 μL) were added as followed. After stirring overnight at 60 °C, triethylamine was added to quench the reaction. The solution was concentrated and purified by silica chromatography on silica gel (DCM:MeOH = 100:0~100:5), afford a white powder (yield 77%, 70 mg). $[\alpha]_D^{20}$ = 3.399 (c 1, $CHCl_3$). ^{1}H NMR (600 MHz, DMSO-d_6) δ 7.73 (d, *J* = 8.2 Hz, 1H), 7.43 (dd, *J* = 7.0, 2.7 Hz, 2H), 7.40 – 7.31 (m, 3H), 5.60 (s, 1H), 5.15 (d, *J* = 5.8 Hz, 1H), 4.79 (d, *J* = 3.7 Hz, 1H), 4.20 – 4.07 (m, 1H), 3.87 – 3.63 (m, 5H), 3.57 (ddd, *J* = 11.1, 6.2, 3.1 Hz, 1H), 3.52 – 3.43 (m, 2H), 3.41 (ddd, *J* = 13.5, 6.2, 3.2 Hz, 1H). ^{13}C NMR (151 MHz, dmso) δ 170.00, 138.19, 129.32, 128.47, 126.83, 101.31, 98.26, 82.35, 68.46, 67.65, 67.02, 63.27, 54.55, 50.51, 23.09. HRMS (DART) ($[M+H]^+$) Calcd. For C17H22N4O6: 379.1618, found 379.1618.



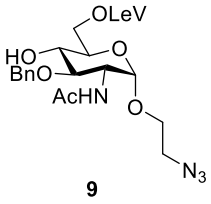
8

A mixture of Compound 7 (200 mg, 528.57 μmol) in anhydrous THF (16 mL) and DMF (3 mL) was cooled to 0 °C under N_2 atmosphere. Sodium hydride (60.76 mg, 1.59 mmol, 60% purity) was added. After stirring for 20 mins, benzyl bromide (108.48 mg, 634.28 umol, 75.34 μL) was added with stirring. The cooling bath was removed. After warming up to room temperature, the reaction mixture was stirred for 40 min (TLC monitoring). Then the mixture was cooled down and MeOH (0.2 mL) was added. The reaction mixture was diluted with EA (20 mL) and washed with water, and the organic layer was dried, concentrated and purified by silica chromatography (DCM and EA). The product 8 was obtained as a white solid (Yield 90%, 223 mg, Rf=0.55, EA). $[\alpha]_D^{20}$ = 34.124 (c 0.5, $CHCl_3$). ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.55 – 7.45 (m, 2H), 7.43 – 7.19 (m, 8H), 5.60 (s, 1H), 5.40 (d, *J* = 9.1 Hz, 1H), 4.93 – 4.86 (m, 2H), 4.64 (d, *J* = 12.1 Hz, 1H), 4.33 – 4.24 (m, 2H), 3.91 – 3.69 (m, 6H), 3.58 (ddd, *J* = 10.8, 8.1, 2.8 Hz, 1H), 3.47 (ddd, *J* = 13.5, 8.1, 3.0 Hz, 1H), 3.26 (ddd, *J* = 13.5, 5.3, 2.8 Hz, 1H), 1.89 (s, 3H). ^{13}C NMR (151 MHz, cdcl$_3$) δ 170.02, 138.32, 137.27, 129.00, 128.41, 128.32, 128.27, 128.05, 127.76, 126.01, 125.99, 101.32, 98.42, 82.60, 77.26, 77.04, 76.83, 75.56, 74.13, 68.88, 67.34, 63.15, 52.32, 50.45, 23.24. HRMS (DART) ($[M+H]^+$) Calcd. For $C_{24}H_{29}N_4O_6$: 469.2087, found 469.2085.



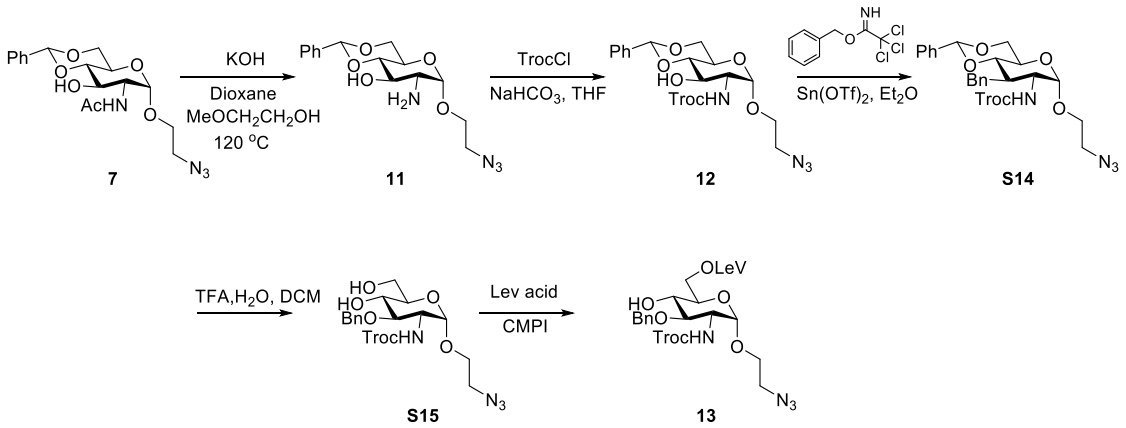
S13

To a solution of compound 8 (0.2 g, 426.89 μmol) in CH_2Cl_2 (5 mL), trifluoroacetic acid (60% aq., 0.2 mL) was added. The resulting mixture was stirred vigorously at 30 °C for 8.5 h and saturated $NaHCO_3$ was added carefully. After phase separation, the aqueous layer was extracted with CH_2Cl_2. The combined organic layers were dried over Na_2SO_4, filtered and the solvents were removed in vacuo. Flash chromatography on silica (EA/MeOH=100:0~10:1) afforded product as a white solid (Rf=0.13 in EA/MeOH=25:1, yield 74%, 120 mg). $[\alpha]_D^{20}$ = 86.977 (c 1.00, $CHCl_3$). ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.44 – 7.16 (m, 5H), 5.48 (d, *J* = 9.2 Hz, 1H), 4.84 (d, *J* = 3.6 Hz, 1H), 4.81 – 4.58 (m, 2H), 4.23 (td, *J* = 10.0, 3.6 Hz, 1H), 3.93 – 3.73 (m, 4H), 3.67 – 3.43 (m, 5H), 3.30 – 3.18 (m, 1H), 2.97 (s, 1H), 1.85 (s, 3H). ^{13}C NMR (151 MHz, cdcl$_3$) δ 170.36, 138.26, 128.62, 128.55, 128.21, 127.98, 97.96, 79.62, 74.29, 72.08, 70.50, 67.17, 61.80, 52.00, 50.47, 23.25. HRMS (DART) ($[M+H]^+$) Calcd. $C_{17}H_{25}N_4O_6$ For: 381.1774, found 381.1788.

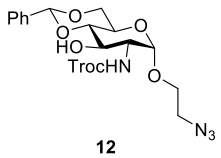


9

To a stirred solution of compound S13 (200 mg, 525.77 umol), N′ -ethylcarbodiimide hydrochloride (EDC, 162.72 mg, 788.65 μmol) and 4-(Dimethylamino)pyridine (DMAP, 32.12 mg, 262.88 μmol) in DCM (8 mL) was added levulinic acid (73.26 mg, 630.92 μmol, 64.83 μL) at room temperature under nitrogen. The reaction was stirred for 4 h at room temperature. The mixture was diluted with dichloromethane (10 mL) and filtered over a pad of Celite®. The solvent was removed in vacuo and the crude product was purified by flash column chromatography. The reaction mixture was directly purified by silica chromatography (EA:MeOH=100:0~100:2), afford the product as white solid (yield 91%, 229 mg). Rf=0.31 in EA:MeOH=25:1. $[\alpha]_D^{20}$ = 64.184 (c 1, $CHCl_3$). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.36 – 7.25 (m, 5H), 5.46 (d, *J* = 9.3 Hz, 1H), 4.83 (d, *J* = 3.7 Hz, 1H), 4.79 – 4.67 (dd, 2H), 4.49 (dd, *J* = 12.2, 4.3 Hz, 1H), 4.23 (dd, *J* = 12.1, 2.3 Hz, 2H), 3.90 (m, *J* = 10.8, 5.5, 2.9 Hz, 1H), 3.75 (m, *J* = 9.5, 4.2, 2.2 Hz, 1H), 3.64 – 3.54 (m, 3H), 3.48 (m, *J* = 13.5, 7.9, 2.8 Hz, 1H), 3.28 (m, *J* = 13.5, 5.4, 2.7 Hz, 1H), 3.02 (s, 1H), 2.76 (td, *J* = 6.2, 2.3 Hz, 1H), 2.60 (t, *J* = 6.0 Hz, 1H), 2.17 (s, 3H), 1.87 (s, 3H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 206.73, 173.30, 170.07, 138.25, 128.61, 128.51, 128.15, 128.12, 127.96, 98.06, 79.25, 74.25, 70.49, 70.26, 67.27, 63.19, 51.85, 50.49, 37.91, 37.81, 29.81, 27.83, 23.27. HRMS (DART) *m/z* $[M+H]^+$ Calcd. For $C_{22}H_{31}N_4O_8$: 479.2142, found 479.2122.



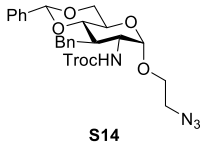
Scheme S5



12

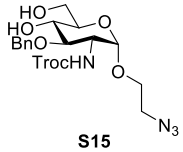
Compound 7 (8.1 g, 21.41 mmol) was dissolved in the mixture of methoxyethanol (91.13 mL) and dioxane (151.88 mL) (25:15, v/v). A 30% KOH Solution (243 mL) was added in the solution. The mixture was refluxed at 120 °C for 48 h. The crude product was extracted with DCM. The organic layer was dried over Na_2SO_4, concentrated under reduced pressure, and further purified by flash column chromatography (DCM:MeOH=15:1) to give product wich was directly used in the next step. Compound 11 (1.72 g, 5.11 mmol) was dispersed in THF (20 mL) and saturated $NaHCO_3$ (20 mL). The solution was cooled to 0°C after which was added 2,2,2-trichloroethyl carbonochloridate (1.30 g, 6.14 mmol, 844.22 μL). After stirring for 4 h, organic mixture was extracted with DCM and dried with sodium sulfate. The crude product was purified using column chromatography with hexane:EA =1:2, affording the product S14 as white solid (yield 86%, 2.25 g). $[\alpha]_D^{20}$ = 22.195 (c 1.0, $CHCl_3$). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.52 – 7.45 (m, 2H), 7.42 – 7.33 (m, 3H), 5.55

(s, 1H), 5.43 (d, *J* = 9.0 Hz, 1H), 4.94 (d, *J* = 3.6 Hz, 1H), 4.75 (dd, *J* = 82.0, 12.0 Hz, 2H), 4.28 (dd, *J* = 10.2, 4.8 Hz, 1H), 4.05 – 3.88 (m, 3H), 3.85 (td, *J* = 9.9, 4.8 Hz, 1H), 3.76 (t, *J* = 10.3 Hz, 1H), 3.65 – 3.55 (m, 2H), 3.48 (m, *J* = 13.4, 7.3, 3.2 Hz, 1H), 3.41 (m, *J* = 13.4, 6.0, 3.2 Hz, 1H), 2.81 (s, 1H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 154.94, 136.90, 129.34, 128.36, 128.27, 126.29, 125.99, 102.01, 98.26, 95.33, 81.69, 74.81, 69.71, 68.72, 67.27, 62.86, 55.64, 50.52. HRMS (DART) *m/z* $[M+Na^+]^+$ Calcd. For $C_{18}H_{22}Cl_3N_4NaO_7$: 533.0374, found 533.0341.



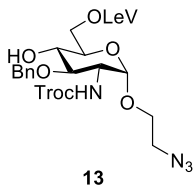
S14

To a solution of compound 12 (19 g, 37.13 mmol) in anhydrous ether (800 mL), benzyl 2,2,2-trichloroacetimidate and molecular seieve were added under N_2 atmosphere. After stirring for 30 min, Tin (II) trifluoromethanesulfonate (3.10 g, 7.43 mmol) was added. After stirring overnight (16 h), the mixture was quenched by addition of saturated aqueous $NaHCO_3$ (200 ml) and extracted with EtOAc. The organic layer was concentrated and purified by colum chromatography Hexane:EA= 6:1 to give product as white solid (13.8 g, 62% yield). $[\alpha]_D^{20}$ = 11.197 (c 1.0, $CHCl_3$). ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.50 (d, *J* = 6.0 Hz, 2H), 7.38 (t, *J* = 7.0 Hz, 3H), 7.32 – 7.23 (m, 5H), 5.60 (s, 1H), 5.12 (d, *J* = 9.7 Hz, 1H), 4.95 – 4.90 (m, 2H), 4.78 (d, *J* = 12.0 Hz, 1H), 4.68 (d, *J* = 11.9 Hz, 2H), 4.29 (dd, *J* = 10.2, 4.6 Hz, 1H), 4.02 (dt, *J* = 9.8, 4.6 Hz, 1H), 3.93 – 3.83 (m, 2H), 3.82 – 3.74 (m, 3H), 3.61 (m, *J* = 10.6, 7.2, 3.4 Hz, 1H), 3.42 (m, *J* = 46.5, 13.4, 6.6, 3.2 Hz, 2H).^{13}C NMR (151 MHz, $CDCl_3$) δ 163.62, 154.44, 138.00, 137.17, 129.04, 128.38, 128.29, 127.88, 127.76, 125.99, 101.34, 98.50, 95.38, 91.82, 82.60, 75.81, 74.70, 74.50, 68.82, 67.23, 63.15, 54.79, 50.47, 29.68. HRMS (DART) *m/z* $[M+H^+]^+$ Calcd. For $C_{25}H_{28}Cl_3N_4O_7$: 601.1024, found 603.0986.



S15

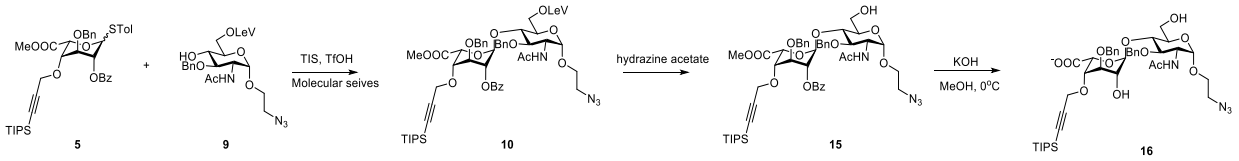
Compound S14 (6.8 g, 11.30 mmol) was dissolved in DCM (375 mL), followed by the addition of trifluoroacetic acid (60% aq., 0.2 mL) at 0 °C. The resulting mixture was stirred vigorously at 30 °C for 6 h. Saturated $NaHCO_3$ was added carefully to quench the reaction. After phase separation, the aqueous layer was extracted with CH_2Cl_2. The combined organic layers were dried over Na_2SO_4, filtered and the solvents were removed in vacuo. Purification by flash chromatography on silica (EA/MeOH=100:0~10:1) afforded product as a white solid (yield 66%, 3.84 g). $[\alpha]_D^{20}$ = 73.115 (c 1.00, $CHCl_3$). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.43 – 7.23 (m, 5H), 5.20 (d, *J* = 9.8 Hz, 1H), 4.88 (d, *J* = 3.7 Hz, 1H), 4.78 (dd, *J* = 11.8, 5.4 Hz, 2H), 4.69 (dd, *J* = 32.9, 11.8 Hz, 2H), 3.97 (td, *J* = 10.1, 3.6 Hz, 1H), 3.89 (ddd, *J* = 10.7, 6.0, 3.3 Hz, 1H), 3.83 (s, 2H), 3.73 (td, *J* = 9.3, 2.9 Hz, 1H), 3.69 – 3.57 (m, 3H), 3.50 – 3.34 (m, 2H), 2.97 (d, *J* = 3.6 Hz, 1H), 2.44 (s, 1H). ^{13}C NMR (126 MHz, cdcl$_3$) δ 154.37, 137.97, 128.63, 128.03, 127.92, 98.14, 95.38, 79.92, 74.70, 74.67, 71.92, 70.58, 67.07, 62.05, 54.62, 50.53. HRMS (DART) ($[M+Na]^+$) Calcd. For $C_{18}H_{23}Cl_3N_4NaO_7$: 535.0530, found 535.0533.



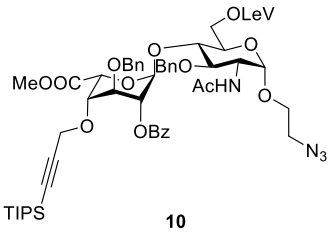
13

To a stirred solution of compound S15 (3.84 g, 7.47 mmol), 4-(Dimethylamino)pyridine (456.57 mg, 3.74 mmol) and N-(3-Dimethylaminopropyl)-N'-ethylcarbodiimide hydrochloride (2.15 g, 11.21 mmol) in the mixture of DCM (25 mL) and THF (25 mL). Levulinic acid (954.67 mg, 8.22 mmol, 844.84 uL) was further added at room temperature under nitrogen. The reaction was stirred for 4 h at the same temperature. The solvent was removed in vacuo and the crude product was purified by column chromatography (EA: Hexane=1:2~1:1) to give the product as wax (yield 76%, 3.84 g). $[\alpha]_D^{20}$

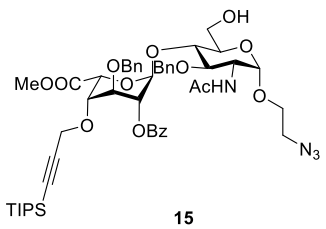
= 63.651 (c 1.0, $CHCl_3$). ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.39 – 7.27 (m, 5H), 5.17 (d, *J* = 9.7 Hz, 1H), 4.88 (d, *J* = 3.7 Hz, 1H), 4.82 – 4.72 (m, 3H), 4.66 (d, *J* = 12.0 Hz, 1H), 4.50 (dd, *J* = 12.2, 4.5 Hz, 1H), 4.26 (dd, *J* = 12.2, 2.2 Hz, 1H), 3.97 (td, *J* = 9.9, 3.8 Hz, 1H), 3.91 (ddd, *J* = 10.7, 6.1, 3.3 Hz, 1H), 3.80 (ddd, *J* = 9.6, 4.5, 2.2 Hz, 1H), 3.67 – 3.55 (m, 3H), 3.47 (ddd, *J* = 13.4, 6.9, 3.3 Hz, 1H), 3.41 (ddd, *J* = 13.4, 6.2, 3.3 Hz, 1H), 2.98 (d, *J* = 3.2 Hz, 1H), 2.81 – 2.72 (m, 2H), 2.61 (t, *J* = 6.4 Hz, 2H), 2.18 (s, 3H). ^{13}C NMR (151 MHz, cdcl$_3$) δ 206.70, 173.28, 154.30, 138.04, 128.56, 128.04, 127.93, 127.90, 98.08, 95.39, 79.40, 74.75, 74.64, 70.49, 70.36, 67.13, 63.18, 54.52, 50.51, 37.90, 37.89, 29.81, 27.82. HRMS (DART) ([M+NH_4]$^+$) Calcd. For$C_{23}H_{33}Cl_3N_5O_9$: 630.1314, found 630.1326.



Scheme S6

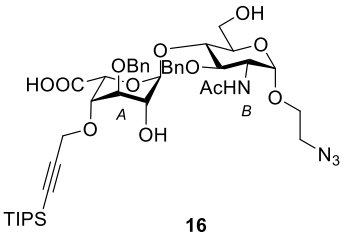


A mixture of compound 5 (65.45 mg, 93.10 μmol) and compound 9 (40.5 mg, 84.64 μmol) was co-evaporated with toluene (3×2mL) in Schlenk tube (10 mL) and placed under vacuum for 1 h. Under N_2 protection, the mixture was dissolved in dry DCM (2 mL) within a reaction flask containing freshly dried 4 Å molecular sieves (400 mg). The mixture was stirred at room temperature for 1 h, and the solution was cooled to –48 °C (acetonitrile/dry ice bath). N-iodosuccinimide (27.42 mg, 121.88 umol) and trifluoromethanesulfonic acid (2.54 mg, 16.93 μmol, 1.49 μL) were added to the reaction flask. After stirring at -48 °C for 30 min, acetonitrile/dry ice bath was removed to warm up to room temperature and the reaction was further kept for 3 h. Et_3N was added to quench the reaction. The whole mixture was filtered through celite followed by washing with CH_2Cl_2, and the filtrate was sequentially washed with aqueous $Na_2S_2O_3$ (10%, 40 mL) and brine. The organic layer was dried over anhydrous $MgSO_4$. The residue was filtered and concentrated in vacuo to get the crude product which was purified by flash column chromatography (ethyl acetate/hexanes = 5:1 v/v) to get the disaccharide 10 (yield 69%, 62 mg). Rf=0.35 in EA. $[\alpha]_D^{20}$ = 13.397 (c 1.0, $CHCl_3$). ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.12 – 8.01 (m, 2H), 7.62 – 7.54 (m, 1H), 7.45 (t, *J* = 7.8 Hz, 2H), 7.33 – 7.14 (m, 10H), 5.37 (d, *J* = 4.3 Hz, 1H), 5.26 (d, *J* = 9.2 Hz, 1H), 5.21 (t, *J* = 4.4 Hz, 1H), 4.89 (d, *J* = 4.2 Hz, 1H), 4.84 – 4.75 (m, 3H), 4.70 (d, *J* = 11.2 Hz, 1H), 4.49 (d, *J* = 11.9 Hz, 1H), 4.36 (dd, *J* = 12.2, 2.2 Hz, 1H), 4.31 – 4.18 (m, 5H), 4.11 (t, *J* = 4.8 Hz, 1H), 4.01 (t, *J* = 9.4 Hz, 1H), 3.84 (m, *J* = 10.6, 5.2, 2.8 Hz, 1H), 3.76 (m, *J* = 9.9, 3.9, 2.2 Hz, 1H), 3.63 (s, 3H), 3.62 – 3.53 (m, 2H), 3.47 (m, *J* = 13.4, 8.2, 2.8 Hz, 1H), 3.24 (m, *J* = 13.4, 5.3, 2.7 Hz, 1H), 2.76 (m, *J* = 6.5 Hz, 2H), 2.69 – 2.53 (m, 2H), 2.17 (s, 3H), 1.74 (s, 3H), 1.03 (d, *J* = 3.3 Hz, 21H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 206.49, 172.37, 169.94, 169.78, 165.51, 138.46, 137.69, 133.37, 130.07, 129.41, 128.50, 128.34, 128.32, 128.06, 127.86, 127.79, 127.48, 102.10, 98.01, 97.72, 88.91, 77.71, 77.31, 75.72, 74.51, 74.27, 73.95, 73.29, 70.35, 70.06, 69.67, 67.39, 62.31, 58.44, 52.05, 51.95, 50.48, 37.98, 29.82, 28.00, 23.18, 18.55, 11.12. HRMS (ESI) *m/z* [M+Na]$^+$ Calcd. For $C_{55}H_{72}N_4O_{15}Si$: 1079.4661, found 1079.4668.



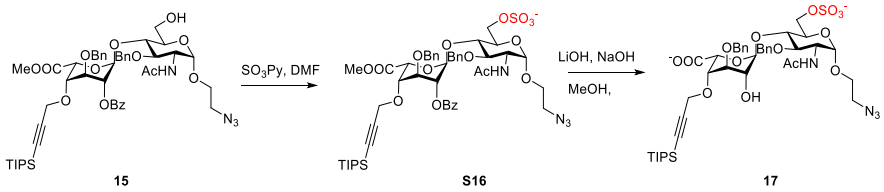
15

To a solution of compound 10 (362 mg, 342.39 μmol) in the mixture of ethanol (8 mL) and toluene (4 mL), hydrazine acetate (315.34 mg, 3.42 mmol, 271.84 μL) was added at room temperature under N_2 atmosphere. After stirring for 2 h, the reaction mixture was evaporated under reduced pressure. The residue was purified by column chromatography (EA: methanol=50:1) to give the product (yield 99%, 327 mg). $[\alpha]_D^{20}$ = 11.997 (c 0.1, $CHCl_3$). ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.05 (dd, *J* = 8.4, 1.3 Hz, 2H), 7.57 (t, *J* = 7.4 Hz, 1H), 7.43 (t, *J* = 7.9 Hz, 2H), 7.35 – 7.21 (m, 8H), 7.17 (d, *J* = 7.0 Hz, 2H), 5.40 (d, *J* = 3.4 Hz, 1H), 5.27 – 5.18 (m, 1H), 4.94 (d, *J* = 3.6 Hz, 1H), 4.85 – 4.67 (m, 3H), 4.46 (d, *J* = 11.9 Hz, 1H), 4.28 (s, 2H), 4.26 – 4.17 (m, 2H), 4.13 (t, *J* = 4.3 Hz, 1H), 4.02 (t, *J* = 9.5 Hz, 1H), 3.88 – 3.79 (m, 4H), 3.68 – 3.63 (m, 1H), 3.62 (d, *J* = 2.7 Hz, 1H), 3.60 (s, 3H), 3.55 (m, *J* = 10.7, 8.1, 2.8 Hz, 1H), 3.46 (m, *J* = 13.3, 8.1, 2.8 Hz, 1H), 3.24 (m, *J* = 13.4, 5.3, 2.7 Hz, 1H), 1.73 (s, 3H), 1.03 (d, *J* = 3.9 Hz, 21H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 169.90, 169.62, 165.64, 138.35, 137.60, 133.38, 130.06, 129.99, 129.40, 128.42, 128.39, 128.36, 128.34, 128.30, 127.97, 127.95, 127.94, 127.89, 127.87, 127.84, 127.43, 102.17, 97.91, 97.77, 88.81, 77.69, 75.13, 74.08, 73.63, 73.61, 72.99, 72.06, 69.56, 69.24, 67.28, 61.31, 58.35, 52.24, 52.02, 50.46, 23.15, 18.79, 18.69, 18.52, 18.50, 11.85, 11.09, 10.85. HRMS (DART) *m/z* $[M+Na]^+$ Calcd. For $C_{50}H_{66}N_4NaO_{13}Si$: 981.4293, found 981.4293.

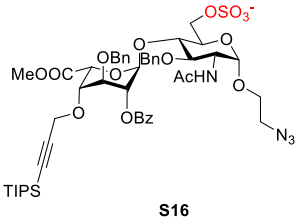


16

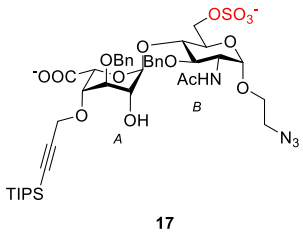
To a solution of compound 15 (614 mg, 640.14 μmol) in the mixture of THF (10 mL) and methanol (5 mL), was added 2 M LiOH (200.00 μL) at –10 °C and the mixture was stirred for 4 h, while the temperature was gradually increased to ambient. The mixture was diluted with MeOH (5 mL), 2 M NaOH (0.4 mL) was added, and the mixture was kept at room temperature for 5 h. After adding H-form resin to tune the pH to 9.5, the mixture was filtered, and the filtrate was concentrated under reduced pressure. Purification by flash column chromatography (EA/MeOH/H2O = 30/2/1~10/2/1, v/v/v) to give the product (yield 80%, 430 mg). $[\alpha]_D^{20}$ = -9.730 (c 1.0, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.40 (d, *J* = 7.2 Hz, 2H, Ar-H), 7.30 (t, *J* = 7.5 Hz, 2H, Ar-H), 7.27 – 7.17 (m, 6H, Ar-H), 5.16 (s, 1H,NH), 4.92 (s, 1H, H-1A), 4.90 (s, 1H, H-1B), 4.76 (t, J = 4.3 Hz, 4H, H-2B, $PhCH_2$, H-6bB, H-2B), 4.68 (d, J = 2.9 Hz, 1H, $PhCH_2$), 4.49 – 4.42 (m, 2H, H-4B, PhCH2), 4.34 (d, J = 16.2 Hz, 1H, $PhCH_2$), 4.21 (t, J = 3.7 Hz, 1H, H-5A), 4.05 (dd, J = 10.7, 3.7 Hz, 1H, H-3A), 3.93 (t, J = 4.8 Hz, 1H, H-2A,), 3.89 (t, J = 9.4 Hz, 1H, H-3B), 3.86 – 3.79 (m, 3H, H-6aB, C≡CCH_2), 3.78 – 3.69 (m, 3H, H-5B, OCH_2*CH_2*), 3.59 – 3.54 (m, 1H, H-4A), 3.44 (t, J = 5.0 Hz, 2H, O*CH_2*CH_2), 1.69 (s, 3H, Ac), 1.06 (m, *J* = 5.3 Hz, 21H, TIPS). ^{13}C NMR (151 MHz, CD_3OD) δ 173.03, 140.10, 139.68, 130.36, 129.06, 129.04, 128.66, 128.35, 128.19, 104.88, 98.67, 88.19, 79.99, 78.88, 78.41, 77.38, 75.64, 73.58, 73.40, 70.04, 67.57, 61.65, 59.99, 54.04, 51.51, 22.52, 18.86, 18.85, 12.21, 12.20. HRMS (DART) ($[M-H]^-$) Calcd. For $C_{42}H_{59}N_4O_{12}Si$: 839.3904, found 839.3900.



Scheme S7

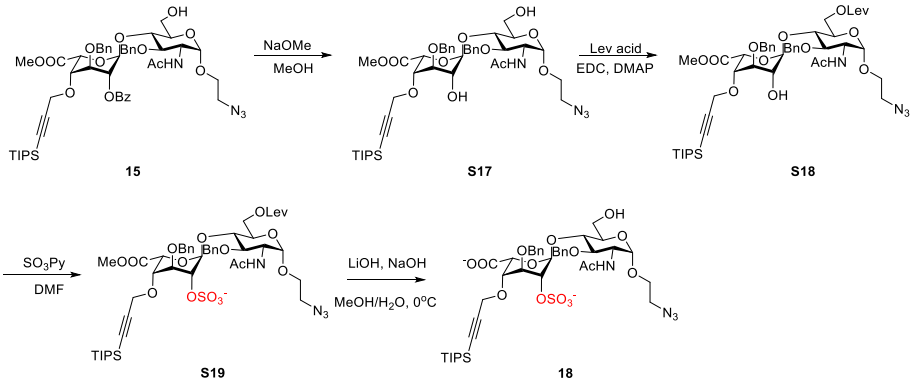


A solution of compound 15 (147 mg, 153.26 umol) and sulfur trioxide pyridine complex (243.93 mg, 1.53 mmol) in DMF (5 mL) was kept stirring at RT for 3 h. $NaHCO_3$ was added, and the dispersion was stirred for 1 h. After filtration, the filtrate was purified by silica gel flash chromatography (MeOH/CH_2Cl_2 = 1/20~1/10, v/v) to give the product (yield 87%, 138 mg). $[\alpha]_D^{20}$ = -0.467 (c 1.0, $CHCl_3$). ^{1}H NMR (600 MHz, acetone) δ 8.11 (dd, *J* = 8.3, 1.3 Hz, 2H), 7.65 – 7.58 (m, 1H), 7.53 – 7.43 (m, 4H), 7.37 – 7.31 (m, 2H), 7.30 – 7.19 (m, 4H), 7.19 – 7.14 (m, 2H), 6.92 (d, *J* = 9.6 Hz, 1H), 5.71 (d, *J* = 2.2 Hz, 1H), 5.34 (m, *J* = 3.3, 2.3, 0.9 Hz, 1H), 5.07 (d, *J* = 2.9 Hz, 1H), 4.93 (d, *J* = 11.2 Hz, 1H), 4.80 (d, *J* = 3.6 Hz, 1H), 4.75 (dd, *J* = 30.1, 11.1 Hz, 1H), 4.52 (d, *J* = 11.0 Hz, 1H), 4.40 – 4.31 (dd, 2H), 4.31 – 4.27 (m, 2H), 4.26 – 4.18 (m, 2H), 4.12 – 4.03 (m, 3H), 3.92 (m, *J* = 11.0, 5.9, 3.8 Hz, 2H), 3.72 (dd, *J* = 10.7, 9.1 Hz, 1H), 3.67 (m, *J* = 11.0, 6.1, 3.8 Hz, 1H), 3.52 (s, 1H), 3.50 (s, 3H), 1.81 (s, 3H), 1.08 (d, *J* = 3.2 Hz, 21H). ^{13}C NMR (151 MHz, acetone) δ 171.62, 170.38, 166.46, 140.13, 139.23, 134.19, 134.17, 131.24, 131.22, 131.15, 129.51, 129.43, 129.39, 129.36, 129.30, 129.20, 128.98, 128.96, 128.95, 128.86, 128.83, 128.69, 128.65, 128.00, 104.04, 99.03, 98.08, 89.00, 79.69, 75.34, 74.23, 74.07, 73.71, 73.50, 71.41, 69.37, 68.80, 67.86, 67.85, 65.86, 58.28, 53.82, 52.81, 51.57, 23.30, 19.43, 19.37, 19.23, 19.22, 12.84, 12.14, 12.13, 11.85. HRMS (DART) *m/z* $[M]^-$ Calcd. For $C_{50}H_{65}N_4O_{13}SSi$: 1037.3891, found 1037.3895.

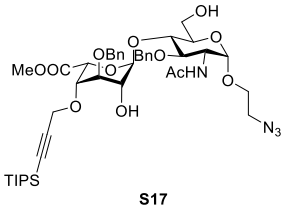


To a solution of compound S16 (130 mg, 125.21 μmol) in aqueous THF/water=10/1 (5 mL) was added 2 M LiOH (2 M, 200.00 uL) at –10 °C and the mixture was stirred for 4 h, while the temperature was gradually increased to ambient. The mixture was diluted with MeOH (5 mL), 2 M NaOH (0.4 mL) was added, and the mixture was kept at room temperature for 5 h. H-form resin was added to neutrilize the solution. After filteration, filtrate was purified by silica gel flash chromatography (MeOH/CH_2Cl_2 = 1/10~1/5, v/v) to give the product (yield 93%, 108 mg). $[\alpha]_D^{20}$ = -17.862 (c 1.0, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.40 (d, *J* = 7.0 Hz, 2H, Ar-H), 7.30 (t, *J* = 7.6 Hz, 2H, Ar-H), 7.27 – 7.16 (m, 6H, Ar-H), 5.15 (s, 1H, H-1A), 4.90 (d, *J* = 12.1 Hz, 1H, H-1B), 4.80 – 4.76 (m, 2H, $PhCH_2$, H-2B), 4.75 – 4.69 (m, 2H, $PhCH_2$, H-5B), 4.44 (d, *J* = 16.3 Hz, 1H, H-5A), 4.40 (d, *J* = 12.2 Hz, 1H, H-4B), 4.36 – 4.28 (m, 2H, O*CH*$_2$$CH_2$), 4.26 – 4.19 (m, 2H, H-6aB, H-3B), 4.05 (dd, *J* = 10.7, 3.7 Hz, 1H, H-2A), 3.97 (td, *J* = 4.2, 1.6 Hz, 1H, H-4B), 3.94 – 3.87 (m, 3H, H-2A, C≡CCH_2), 3.87 – 3.81 (m, 1H, H-6bB), 3.70 (dd, *J* = 10.7, 8.2 Hz, 1H, H-3A), 3.61 – 3.54 (m, 1H, H-4A), 3.44 (t, *J* = 4.9 Hz, 2H, O*CH*$_2$$CH_2$), 1.62 (s, 3H, Ac), 1.07 (d, *J* = 5.6 Hz, 21H, TIPS). ^{13}C NMR (151 MHz, CD_3OD) δ 175.72, 172.94, 140.02, 139.60, 129.10, 129.07, 129.04, 128.59, 128.33, 128.18, 104.78, 103.31, 98.60, 88.22, 80.34, 77.94, 77.90, 77.77, 76.01, 73.25,

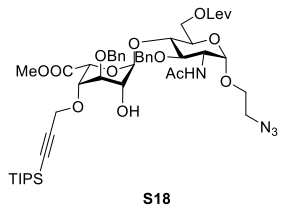
71.27, 70.91, 68.31, 67.70, 67.29, 60.00, 53.96, 51.49, 22.51, 18.86, 12.21. HRMS (DART) *m/z* $[M+H]^-$ Calcd. For $C_{42}H_{59}N_4O_{15}SSi$: 919.3472, found 919.3474.



Scheme S8

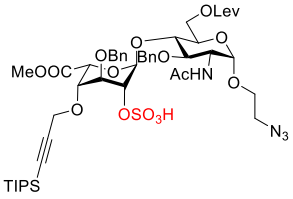

S17

To solution of compound 15 (142 mg, 148.05 μmol) in MeOH (3 mL), NaOMe methanol solution (31.99 mg, 148.05 μmol, 33.02 μL, 25% purity) was added. After stirring at room temperature for 6 h, the reaction was quenched by adding H-form exchange resin to adjust the pH close to 7.0. After filtration, the filtrate was concentrated and purified by a flash column chromatography with eluent (EA:hexane =10:1) to give the product (127 mg, 88% yield). $[\alpha]_D^{20}$ = -2.650 (c 1.0, $CHCl_3$). ^1H NMR (600 MHz, $CDCl_3$) δ 8.19 (s, 1H), 7.35 (m, *J* = 8.8, 7.8, 6.1, 1.3 Hz, 4H), 7.32 – 7.20 (m, 4H), 7.17 – 7.12 (m, 2H), 5.27 (d, *J* = 3.4 Hz, 1H), 4.85 (dd, *J* = 30.7, 3.4 Hz, 2H), 4.69 (d, *J* = 1.9 Hz, 1H), 4.67 (d, *J* = 11.5 Hz, 1H), 4.40 (d, *J* = 11.8 Hz, 1H), 4.31 (d, *J* = 16.3 Hz, 1H), 4.24 (m, *J* = 10.7, 9.2, 3.7 Hz, 1H), 4.19 (d, *J* = 16.2 Hz, 1H), 4.12 (m, *J* = 4.5, 3.1, 1.0 Hz, 1H), 3.98 (t, *J* = 4.7 Hz, 1H), 3.93 (t, *J* = 9.5 Hz, 1H), 3.88 (m, *J* = 10.7, 5.5, 2.9 Hz, 1H), 3.83 (s, 2H), 3.73 – 3.68 (m, 1H), 3.62 (dd, *J* = 10.7, 9.1 Hz, 1H), 3.60 – 3.56 (m, 1H), 3.53 (s, 3H), 3.49 – 3.44 (m, 1H), 3.27 (m, *J* = 13.5, 5.5, 2.8 Hz, 1H), 2.54 – 2.42 (m, 4H), 2.03 (s, 3H), 1.06 (d, *J* = 2.5 Hz, 21H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 169.95, 169.67, 167.01, 152.86, 138.25, 137.77, 128.46, 128.33, 128.10, 127.99, 127.93, 127.75, 127.44, 101.70, 101.05, 97.83, 89.39, 78.19, 75.68, 74.80, 74.62, 74.08, 72.85, 72.17, 68.89, 68.36, 67.25, 61.71, 58.88, 52.31, 52.08, 50.52, 26.05, 25.97, 23.16, 22.85, 18.60, 18.55, 11.11. HRMS (DART) *m/z* $[M+Na]^+$ Calcd. For $C_{43}H_{63}N_4O_{12}NaSi$: 877.4031, found 877.4029.


S18

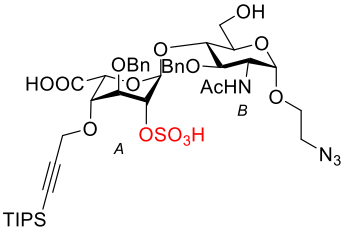
To a solution compound S17 (1.19 g, 1.39 mmol) in DCM (20 mL), levulinic acid (161.46 mg, 1.39 mmol, 142.89 μL) was added. As followed, 4-(Dimethylamino)pyridine (84.94 mg, 695.28 μmol) and N-(3-Dimethylaminopropyl)-N′-ethylcarbodiimide hydrochloride (399.86 mg, 2.09 mmol) were added under N_2 atmosphere. After stirring overnight, the mixture was washed by water twice. The organic layer was dried over Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by silica column chromatography (EA: hexane =5:1), giving the product as a sticky liquid (1.10 g, 83% yield). $[\alpha]_D^{20}$ = -7.665 (c 1.0, $CHCl_3$). ^1H NMR (600 MHz, $CDCl_3$) δ 7.38 – 7.26 (m, 6H), 7.25 – 7.10 (m, 4H), 5.29 (d, *J* = 9.3 Hz, 1H), 4.86 (d, *J*

= 3.0 Hz, 1H), 4.80 (t, *J* = 3.6 Hz, 1H), 4.71 (dd, *J* = 36.9, 11.4 Hz, 3H), 4.45 (dd, *J* = 62.8, 11.1 Hz, 2H), 4.34 – 4.16 (m, 4H), 4.10 (t, *J* = 4.4 Hz, 1H), 4.00 – 3.81 (m, 5H), 3.73 – 3.68 (m, 1H), 3.63 – 3.45 (m, 5H), 3.29 (d, *J* = 8.3 Hz, 1H), 3.19 (d, *J* = 9.0 Hz, 1H), 2.78 (d, *J* = 6.5 Hz, 2H), 2.72 – 2.54 (m, 2H), 2.18 (s, 3H), 1.72 (s, 3H), 1.05 (d, *J* = 4.1 Hz, 21H). ^{13}C NMR (151 MHz, $CDCl_3$) δ 206.63, 172.50, 169.91, 169.74, 138.25, 137.90, 128.40, 128.31, 127.90, 127.88, 127.78, 127.44, 101.74, 101.19, 97.67, 89.31, 78.05, 76.07, 74.97, 74.89, 74.12, 72.94, 69.98, 69.09, 68.45, 67.36, 62.89, 58.91, 52.04, 52.00, 50.54, 37.89, 29.83, 27.92, 23.15, 18.54, 11.10. HRMS (DART) *m/z* $[M+H]^+$ Calcd. For $C_{48}H_{69}N_4O_{14}NaSi$: 975.4399, found 975.4406.



S19

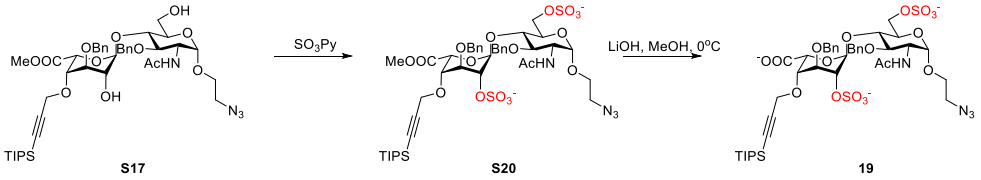
To a solution of S18 (275 mg, 288.52 μmol) in DMF (5 mL), sulfur trioxide pyridine complex (459.21 mg, 2.89 mmol) was added, and the mixture was stirred for 4 h at room temperature. Reactant was not completely consumed. The temperature was further increased to 60 °C and stirred overnight. Solid $NaHCO_3$ (154 mg, 1.84 mmol) was added, and the mixture was stirred for 1 h. After filtration, filtrate was concentrated and further purified by silica gel flash chromatography ($MeOH/CH_2Cl_2$ = 1/20~1/10, v/v), afford the product as white solid (yield 77%, 228 mg). $[\alpha]_D^{20}$ = -6.532 (c 1.0, $CHCl_3$). ^{1}H NMR (600 MHz, acetone) δ 7.43 (d, *J* = 6.9 Hz, 2H), 7.34 (t, *J* = 7.5 Hz, 2H), 7.29 – 7.18 (m, 6H), 5.19 (d, *J* = 4.9 Hz, 1H), 4.85 (dd, *J* = 11.2, 3.9 Hz, 2H), 4.81 (dd, *J* = 4.1, 2.5 Hz, 2H), 4.75 (d, *J* = 11.4 Hz, 1H), 4.59 (d, *J* = 11.2 Hz, 1H), 4.50 (dd, *J* = 12.1, 2.1 Hz, 1H), 4.46 – 4.28 (m, 1H), 4.26 – 4.18 (m, 1H), 4.12 (dd, *J* = 6.1, 4.6 Hz, 1H), 4.04 – 3.83 (m, 6H), 3.78 – 3.61 (m, 3H), 3.54 (s, 3H), 3.53 – 3.49 (m, 1H), 2.82 (m, *J* = 6.7, 2.2 Hz, 2H), 2.69 – 2.56 (m, 2H), 2.15 (s, 3H), 1.81 (s, 3H), 1.08 (d, *J* = 2.5 Hz, 21H). ^{13}C NMR (151 MHz, acetone) δ 206.97, 173.15, 170.65, 170.40, 140.48, 140.06, 129.24, 129.01, 128.99, 128.85, 128.79, 128.64, 128.52, 128.49, 128.41, 128.04, 104.35, 102.31, 98.92, 88.80, 79.55, 79.53, 78.41, 77.69, 76.67, 74.93, 74.24, 71.49, 71.43, 70.74, 67.88, 63.75, 59.36, 59.33, 53.67, 53.58, 52.24, 51.57, 38.60, 28.92, 23.19, 23.14, 19.19, 12.13. HRMS (DART) *m/z* $[M-H]^-$ Calcd. For $C_{48}H_{67}N_4O_{14}SSi$: 1031.3997, found 1031.4051.



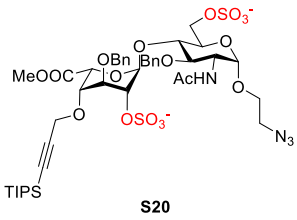
18

To a solution of compound S19 (736.4 mg, 713.42 μmol) in aqueous THF/water=3/2 (16.40 mL) was added 2 M LiOH (2 M, 1.81 mL) at 0 °C and the mixture was stirred overnight. After adding NaOH (2 M, 1.78 mL), it kept stirring for another 2 h. H-form resin was added to tune the pH to 8.0. After filtration, the solvent was removed and the residue was further purified by silica gel flash chromatography ($MeOH/CH_2Cl_2$ = 1/10 (400 mL) ~ EA: MeOH: H_2O=3:1:0.5 (200 mL, v/v) to afford the product as white solid (602 mg, 87% yield) $[\alpha]_D^{20}$ = -3.999 (c 1.0, MeOH). ^{1}H NMR (600 MHz, CD_3OD) δ 7.38 (d, *J* = 6.9 Hz, 2H, Ar-H), 7.28 (t, *J* = 7.6 Hz, 2H, Ar-H), 7.25 – 7.20 (m, 3H, Ar-H), 7.17 (t, *J* = 7.3 Hz, 1H, Ar-H), 7.13 (d, *J* = 6.7 Hz, 2H, Ar-H), 5.31 (s, 1H, NH), 4.88 (d, *J* = 11.6 Hz, 2H, H-1A, H-1B), 4.81 (d, *J* = 11.3 Hz, 1H, $PhCH_2$), 4.74 (d, *J* = 3.7 Hz, 1H, H-2A), 4.67 (d, *J* = 11.2 Hz, 1H, $PhCH_2$), 4.57 (s, 1H, H-4A), 4.47 – 4.37 (m, 2H, $PHCH_2$), 4.37 – 4.33 (m, 2H, $C{\equiv}CCH_2$), 4.25 (s, 1H, H-3A), 4.00 (dd, *J* = 10.7, 3.7 Hz, 1H, H-2B), 3.95 – 3.87 (m, 2H, H-5B, H-6aB), 3.82 (d, *J* = 14.5 Hz, 2H, OCH_2CH_2), 3.75 – 3.67 (m, 2H, H-4B, H-5A), 3.55 (m, *J* =

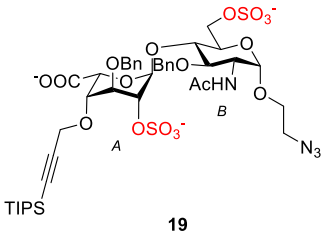
10.7, 5.8, 4.1 Hz, 1H, H-3B), 3.43 (m, *J* = 5.9, 3.9, 2.1 Hz, 2H, O*CH*$_2$CH$_2$), 1.58 (s, 3H, Ac), 1.07 (d, *J* = 5.4 Hz, 21H, TIPS). ^{13}C NMR (151 MHz, CD$_3$OD) δ 175.68, 172.93, 140.17, 139.30, 129.09, 129.06, 129.04, 129.02, 128.65, 128.38, 128.08, 103.99, 100.52, 98.63, 88.87, 80.03, 77.06, 75.80, 74.13, 74.10, 73.30, 73.13, 71.47, 69.67, 67.59, 61.63, 58.30, 54.15, 51.49, 22.49, 18.92, 12.23. HRMS (DART) *m/z* [M-H]$^-$ Calcd. For $C_{42}H_{59}N_4O_{15}SSi$: 919.3472, found 919.3478.



Scheme S9

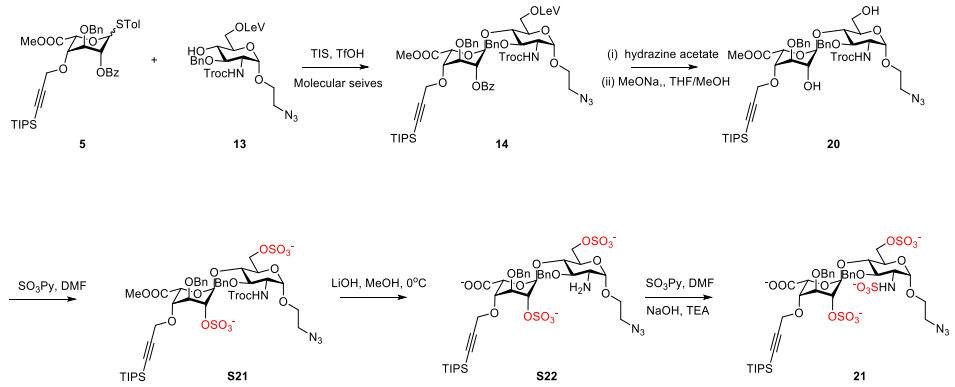


To a solution of compound S17 (102 mg, 119.29 μmol) in DMF (5 mL), sulfur trioxide pyridine complex (189.87 mg, 1.19 mmol) was added. The mixture was stirred for 3 h at room temperature. Solid NaHCO$_3$ (154 mg, 1.84 mmol) was added, the mixture was stirred for 1 h. After filtration, the filtrate was concentrated, and further purify by silica gel flash chromatography (MeOH/CH$_2$Cl$_2$ = 1/10~1/8, v/v) to afford the product as white solid (108.9 mg, 90% yield). $[\alpha]_D^{20}$ = -6.998 (c 1.0, MeOH). ^{1}H NMR (600 MHz, CD$_3$OD) δ 7.45 (d, *J* = 7.1 Hz, 2H), 7.35 (t, *J* = 7.5 Hz, 2H), 7.29 (t, *J* = 7.4 Hz, 1H), 7.22 – 7.14 (m, 3H), 6.99 (dd, *J* = 7.0, 2.6 Hz, 2H), 5.38 (s, 1H), 4.99 (d, *J* = 1.9 Hz, 1H), 4.87 (d, *J* = 10.7 Hz, 1H), 4.77 (d, *J* = 3.7 Hz, 1H), 4.64 (s, 1H), 4.62 (d, *J* = 3.8 Hz, 1H), 4.53 (d, *J* = 11.3 Hz, 1H), 4.43 (d, *J* = 17.0 Hz, 1H), 4.35 – 4.26 (m, 5H), 4.23 (p, *J* = 3.9 Hz, 2H), 4.06 – 3.97 (m, 2H), 3.92 (m, *J* = 10.4, 6.9, 3.2 Hz, 1H), 3.66 (m, *J* = 13.6, 10.5, 5.8 Hz, 2H), 3.57 (m, *J* = 13.5, 7.0, 3.5 Hz, 1H), 3.50 (m, *J* = 13.4, 6.4, 3.2 Hz, 1H), 3.29 (s, 3H), 1.84 (s, 3H), 1.11 (d, *J* = 4.9 Hz, 21H). ^{13}C NMR (151 MHz, CD$_3$OD) δ 180.17, 173.14, 171.96, 139.41, 138.77, 129.55, 129.24, 128.92, 128.83, 128.09, 127.93, 102.82, 98.91, 98.82, 89.96, 79.59, 75.76, 73.45, 73.41, 71.78, 71.46, 70.61, 70.24, 68.12, 67.75, 67.27, 56.47, 54.29, 52.48, 51.58, 24.02, 22.47, 18.95, 18.92, 12.21. HRMS (DART) *m/z* [M+H]$^-$ Calcd. For $C_{43}H_{61}N_4O_{18}S_2Si$: 1013.3202, found 1013.3190.

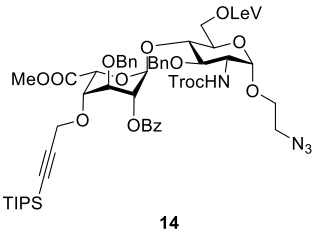


To a solution of compound S18 (69 mg, 68.10 μmol) in mixture of THF/water (3/2, v/v, 5 mL) was added 2 M LiOH (2 M, 108.78 μL) at –10 °C and the mixture was stirred for 4 h. While the temperature was gradually increased to ambient, H-form resin was added to neutralize the solution. After filtration, Na-form resin was added, and the mixture was stirred for 20 mins. The crude product was purified by silica gel flash chromatography (MeOH/CH$_2$Cl$_2$ = 1/10~1/5~1/3, v/v) to afford the product as white solid (67.9 mg, 93% yield). $[\alpha]_D^{20}$ = -3.999 (c 1.0, MeOH). ^{1}H NMR (600 MHz, CD$_3$OD) δ 7.36 (d, *J* = 6.7 Hz, 2H, Ar-H), 7.27 – 7.13 (m, 6H, Ar-H), 7.06 (d, *J* = 6.7 Hz, 2H, Ar-H), 5.41 (s, 1H, H-1A), 4.87 – 4.86 (m, 1H, NH),

4.85 (s, 1H, H-1B), 4.82 (s, 1H, H-6aB), 4.73 (d, J = 3.6 Hz, 1H, $PhCH_2$), 4.66 (d, J = 11.0 Hz, 1H, $PhCH_2$), 4.62 – 4.58 (m, 1H, H-4B), 4.46 – 4.36 (m, 3H, $PhCH_2$, H-5B), 4.34 (dt, J = 2.7, 1.3 Hz, 1H, H-3A), 4.26 (m, J = 1.2 Hz, 2H, $C{\equiv}CCH_2$), 4.25 – 4.22 (m, 1H, H-2A), 4.08 – 3.97 (m, 2H, H-4A, H-2B), 3.92 (m, J = 9.6, 3.9, 1.8 Hz, 1H, OCH_2CH_2), 3.85 (m, J = 11.0, 5.6, 3.9 Hz, 1H, H-5A), 3.66 (dd, J = 10.7, 8.9 Hz, 1H, H-3B), 3.56 (m, J = 11.1, 6.0, 4.1 Hz, 1H, H-6bB), 3.48 – 3.41 (m, 2H, OCH_2CH_2), 1.57 (s, 3H, Ac), 1.07 (d, J = 4.9 Hz, 21H, TIPS). ^{13}C NMR (151 MHz, CD_3OD) δ 175.54, 172.85, 140.13, 139.13, 129.12, 129.09, 129.03, 129.01, 128.96, 128.86, 128.40, 127.98, 104.06, 99.25, 98.45, 88.74, 79.95, 76.13, 74.62, 74.38, 74.30, 73.33, 71.57, 71.28, 69.39, 67.77, 67.73, 58.51, 53.95, 51.49, 49.65, 22.47, 18.93, 18.91, 12.23. HRMS (DART) m/z $[M+H]^-$ Calcd. For $C_{42}H_{59}N_4O_{18}S_2Si$: 999.2968, found 999.2990.



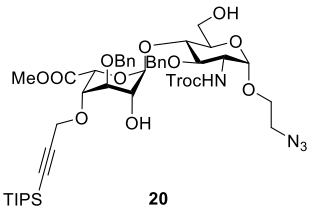
Scheme S10



14

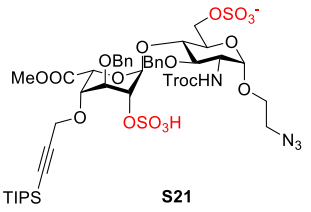
A mixture of compound 5 (0.507 g, 721.23 μmol) and compound 15 (485.42 mg, 793.35 μmol) was co-evaporated with toluene (3×2 mL) in Schlenk tube (10 mL) and placed under vacuum for 1 h. Under N_2 protection, the mixture was dissolved in dry DCM (30 mL) was added to a reaction flask containing freshly dried 4 Å molecular sieves (300 mg). The mixture was stirred at room temperature for 1 h, and the solution was cooled to –48 °C (acetonitrile/dry ice bath). N-Iodosuccinimide (233.66 mg, 1.04 mmol) and trifluoromethanesulfonic acid (21.65 mg, 144.25 μmol, 12.66 μL) were added to the reaction flask. After stirring at -48 °C for 30 min, acetonitrile/dry ice bath was removed. After warmed up to room temperature, the reaction was kept for 3 h. Et_3N was added to quench the reaction. The whole mixture was filtered through celite followed by washing with CH_2Cl_2, and the filtrate was sequentially washed with aqueous $Na_2S_2O_3$ (10%, 40 mL) and brine. The organic layer was dried over anhydrous $MgSO_4$. The residue was filtered and concentrated in vacuo to get the crude product which was purified by flash column chromatography (ethyl acetate/hexanes = 1:3~1:2 v/v) to afford the product as colourless syrup (yield 76%, 0.65 g). $[\alpha]_D^{20}$ = 22.527 (c 1.00, $CHCl_3$). ^{1}H NMR (600 MHz, Chloroform-d) δ 8.11 – 8.01 (m, 2H), 7.60 – 7.51 (m, 1H), 7.46 – 7.38 (m, 2H), 7.32 – 7.15 (m, 10H), 5.33 (d, J = 3.9 Hz, 1H), 5.20 (td, J = 4.1, 0.7 Hz, 1H), 4.99 (d, J = 9.7 Hz, 1H), 4.85 (dd, J = 11.1, 3.8 Hz, 2H), 4.80 (dd, J = 11.4, 7.1 Hz, 2H), 4.69 (d, J = 11.3 Hz, 1H), 4.63 (q, J = 11.9 Hz, 2H), 4.53 (d, J = 11.5 Hz, 1H), 4.39 (dd, J = 12.2, 2.2 Hz, 1H), 4.29 (dd, J = 12.2, 3.9 Hz, 1H), 4.26 (s, 2H), 4.18 (t, J = 4.4 Hz, 1H), 4.10 (t, J = 4.4 Hz, 1H), 4.04 – 3.96 (m, 2H), 3.87 –

3.78 (m, 2H), 3.64 – 3.55 (m, 5H), 3.44 (ddd, *J* = 13.4, 7.1, 3.3 Hz, 1H), 3.37 (ddd, *J* = 13.4, 6.1, 3.3 Hz, 1H), 2.81 – 2.69 (m, 2H), 2.67 – 2.56 (m, 2H), 2.16 (s, 3H), 1.07 – 0.94 (m, 21H). ^{13}C NMR (151 MHz, cdcl$_3$) δ 206.44, 172.31, 169.64, 165.49, 154.15, 138.03, 137.60, 133.34, 130.02, 129.35, 128.43, 128.32, 128.31, 128.12, 127.84, 127.81, 127.60, 127.28, 102.02, 97.82, 97.73, 95.31, 88.87, 77.80, 75.29, 74.57, 74.53, 73.92, 73.56, 73.07, 69.90, 69.68, 69.52, 67.18, 62.26, 58.23, 54.71, 51.85, 50.47, 37.92, 29.77, 27.94, 18.51, 18.44, 18.37, 11.26, 11.17, 11.07, -0.02. HRMS (ESI) ([M+Na]$^+$) Calcd. For $C_{56}H_{71}Cl_3N_4NaO_{16}Si$: 1213.3568, found 1213.3595.



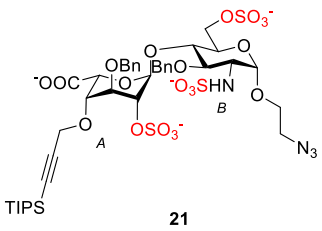
20

To a solution of compound **14** (0.4 g, 335.96 μmol) in the mixture of ethanol (8.06 mL) and toluene (4.10 mL), hydrazine acetate (173.27 mg, 1.88 mmol) was added at room temperature under N_2 atmosphere. After stirring for 2 h, the reaction mixture was filtered and concentrated under reduced pressure. The crude product was dissolved in MeOH (10.04 mL), followed by the addition of sodium methoxide (1732.25 μmol, 163.30 μL, 25% purity). The mixture was stirred for 25 min (monitoring by TLC). The solution was neutralized by H form resin. After filtration, the crude product was concentrated and purified by column chromatography (EA: Hexane=1:1~2:1~3:1) to afford colourless syrup (yield 66%, 240 mg). $[\alpha]_D^{20}$ = -6.998 (c 1.00, $CHCl_3$). ^{1}H NMR (600 MHz, Chloroform-*d*) δ 7.41 – 7.06 (m, 10H), 5.26 (d, *J* = 2.9 Hz, 1H), 5.01 (d, *J* = 9.8 Hz, 1H), 4.85 (dd, *J* = 21.8, 3.4 Hz, 2H), 4.67 (dd, *J* = 11.0, 7.4 Hz, 3H), 4.59 (d, *J* = 1.2 Hz, 2H), 4.46 (d, *J* = 11.5 Hz, 1H), 4.34 – 4.12 (m, 2H), 4.09 (t, *J* = 3.9 Hz, 1H), 4.05 – 3.91 (m, 3H), 3.91 – 3.79 (m, 3H), 3.78 – 3.68 (m, 2H), 3.61 (ddd, *J* = 10.8, 7.8, 3.4 Hz, 2H), 3.49 – 3.37 (m, 5H), 3.25 (d, *J* = 9.4 Hz, 1H), 1.06 (d, *J* = 2.8 Hz, 21H). ^{13}C NMR (151 MHz, cdcl$_3$) δ 169.58, 154.13, 137.94, 137.73, 128.45, 128.30, 128.09, 128.05, 128.01, 127.98, 127.92, 127.19, 101.65, 100.96, 97.91, 95.26, 89.39, 78.38, 75.22, 74.68, 74.53, 74.34, 74.28, 72.72, 72.22, 68.62, 67.98, 67.09, 61.57, 58.78, 55.01, 51.97, 50.54, 18.58, 18.54, 11.10, 11.09. HRMS (ESI) ([M+Na]$^+$) Calcd. For $C_{44}H_{61}Cl_3N_4NaO_{13}Si$: 1011.2938, found 1011.2958.



S21

To a solution of compound S20 (240 mg, 242.81 μmol) in DMF (5 mL) was added sulfur trioxide pyridine complex (386.47 mg, 2.43 mmol). The mixture was stirred for 3 h at room temperature. Solid $NaHCO_3$ (154 mg, 1.84 mmol) was added, the mixture was stirred for 1 h. After filtration, the filtrate was purified by silica gel flash chromatography ($MeOH/CH_2Cl_2$ = 1/20~1/10, v/v) to afford the product of white solid (89%, 247 mg). $[\alpha]_D^{20}$ = -5.465 (c 1.00, $CHCl_3$). ^{1}H NMR (600 MHz, Methanol-*d*$_4$) δ 7.51 – 6.91 (m, 10H), 5.37 (s, 1H), 4.96 (s, 1H), 4.69 – 4.51 (m, 17H), 4.44 – 4.34 (m, 2H), 4.33 – 4.19 (m, 5H), 4.01 (d, *J* = 4.6 Hz, 2H), 3.96 – 3.88 (m, 2H), 3.69 – 3.63 (m, 2H), 3.60 (ddd, *J* = 12.9, 6.6, 3.2 Hz, 1H), 3.50 (ddd, *J* = 13.3, 6.6, 3.4 Hz, 1H), 1.15 – 1.05 (m, 21H). ^{13}C NMR (151 MHz, cd$_3$od) δ 170.60, 155.31, 155.29, 138.15, 137.54, 137.52, 128.38, 128.03, 127.70, 127.49, 127.11, 126.92, 126.60, 101.68, 97.75, 97.67, 95.36, 88.65, 78.31, 74.56, 74.19, 72.24, 72.12, 70.43, 70.17, 69.33, 69.14, 66.92, 66.62, 66.13, 55.67, 55.17, 51.24, 50.41, 17.73, 10.98. HRMS (DART) ([M]$^-$) Calcd. For $C_{44}H_{60}Cl_3N_4O_{19}S_2Si$: 1147.2104, found 1147.2130.



21

To a solution of compound S21 (280 mg, 244.22 μmol) in aqueous THF/water=3/2 (10 mL) was added 2 M LiOH (2 M, 732.65 μL) at –10 °C. The mixture was stirred overnight. While the temperature was gradually increased to ambient. H-form resin was added to neutralize the solution. After filtration, the filtrate was concentrated and the crude product was directly used in the next step. A mixture of compound S22 (220 mg, 214.62 μmol), NaOH (0.1 M, 9.76 mL), triethylamine (7.09 g, 70.02 mmol, 9.76 mL) and sulfur trioxide pyridine complex (341.60 mg, 2.145 mmol) in MeOH (5 mL) were kept stirring at room temperature for 18 h. After the starting material was completely consumed, the solvent was evaporated in vacuo, and the residue was purified by column chromatography (EA: MeOH: water =6:1:0.5) to afford the product as syrup (yield 79%, 217 mg). $[\alpha]_D^{20}$ = -2.799 (c 1.00, MeOH). ^{1}H NMR (600 MHz, Methanol-*d*$_4$) δ 7.31 – 7.25 (m, 2H, Ar-H), 7.23 – 7.19 (m, 2H, Ar-H), 7.17 – 7.12 (m, 2H, Ar-H), 7.12 – 7.06 (m, 3H, Ar-H), 7.06 – 7.01 (m, 1H, Ar-H), 5.31 (s, 1H, NH), 5.10 (d, *J* = 3.6 Hz, 1H, H-1A), 4.77 (d, *J* = 1.8 Hz, 1H, H-1B), 4.73 (s, 1H, H-6aB), 4.61 (dd, *J* = 61.6, 11.0 Hz, 2H, PhCH$_2$), 4.51 (d, *J* = 2.2 Hz, 1H, H-2B), 4.39 – 4.21 (m, 5H, PhCH$_2$, C≡CCH$_2$, H-5A), 4.20 – 4.09 (m, 3H, H-4A, H-3B), 3.90 (t, *J* = 9.3 Hz, 1H, H-2A), 3.83 – 3.72 (m, 2H, OCH$_2$*CH$_2$*), 3.57 (ddd, *J* = 10.6, 5.8, 3.5 Hz, 1H, H-3A), 3.42 (ddd, *J* = 11.5, 8.2, 4.3 Hz, 2H, O*CH$_2$*CH$_2$), 3.32 – 3.26 (m, 2H, H-5B, H-6bB), 1.02 – 0.97 (m, 21H, TIPS). ^{13}C NMR (151 MHz, cd$_3$od) δ 174.27, 137.95, 137.87, 129.01, 127.81, 127.80, 127.73, 127.68, 127.21, 126.86, 102.85, 97.90, 97.74, 87.52, 77.56, 75.15, 73.56, 73.28, 72.81, 72.00, 70.22, 69.80, 68.28, 67.12, 66.73, 57.78, 57.30, 50.40, 49.83, 17.71, 17.55, 17.54, 11.02, 11.01, 10.98. HRMS (ESI) ([M+3H]$^-$) Calcd. For $C_{40}H_{57}N_4O_{20}S_3Si$: 1037.2503, found 1037.2502.

Representative procedure of CuAAC reaction in solution-phase assembly of clickable disaccharides

The synthetic details of the 1st CuAAC coupling in the solution-phase synthesis of all oligosaccharides are similar with that of compound S1. In the following CuAAC couplings for extension, the precursor (1 eq), target sulfated disaccharide (1.2 eq) and TBTA (0.1 eq) was dissolved in DMF (disaccharide concentration ~ 0.02 M). Oxygen was removed from the solution by purging with nitrogen for 15 mins. copper (I) bromide (0.1 eq) was added under a positive nitrogen flow. The Schlenk tube was sealed and stirred at RT for 6 h. The mixture was concentrated and purified by column chromatography affording the product. With the growth of oligosaccharides and sulfate, the eluent varied with the range of EA: MeOH: H_2O= 10:1:0.5~3:1:0.5).

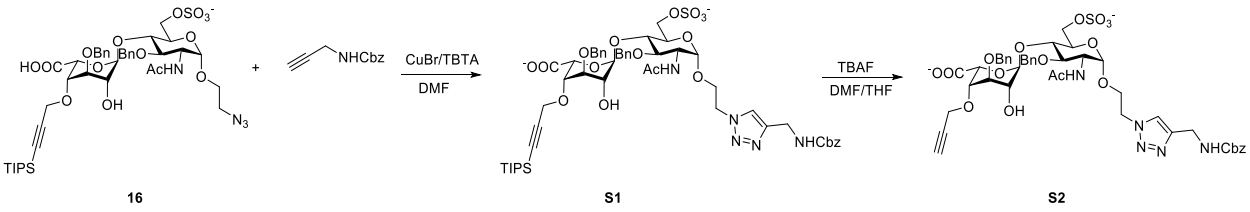
Representative procedure of TBAF deprotection in solution-phase assembly of clickable disaccharides

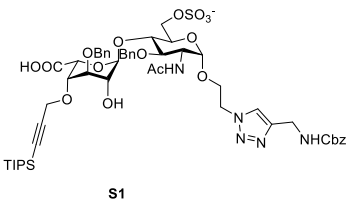
The synthetic details of the TBAF deprotection in the solution-phase synthesis of all oligosaccharides are similar with that of compound **S2**. To a solution of product from CuAAC coupling, TBAF (100~200 eq, 1M solution in THF) was added. The solution was stirred at room temperature for 12 h. After removing the solvent, the crude product was purified by column chromatography to afford the product. With the growth of oligosaccharides and sulfate, the eluent varied with the range of EA: MeOH: H_2O= 10:1:0.5~3:1:0.5).

General procedure for global debenzylation

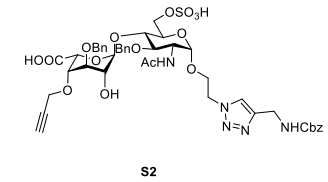
The starting materials and 20% Pd $(OH)_2$ on carbon (1.5 times the weight of starting material) was dispersed in the mixture of tBuOH/water (v/v, 1/1, 2 mL for 5 mg). The solution was equipped with a hydrogen balloon and stirred at room temperature for 24 h. The mixture was filtered through a PTFE syringe filter, and the residue was washed with H_2O (2 mL). The filtrate was mixed with Amberlite™ IR-120 Na ion-exchange resin in water. The residue was freeze dried to provide the final product.

Representative solution-phase assembly of clickable disaccharides

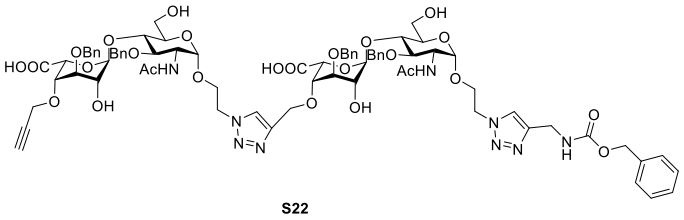




Benzyl prop-2-yn-1-ylcarbamate was prepared according to the reference.[17] In a 10 mL Schlenk tube, compound **16** (30 mg, 32.57 μmol), benzyl N-prop-2-ynylcarbamate (61.63 mg, 325.70 μmol) and TBTA (17.28 mg, 32.57 μmol) was dissolved in DMF (2 mL). Oxygen was removed from the solution by purging with nitrogen for 15 mins. copper (I) bromide (4.67 mg, 32.57 μmol) was added under a positive nitrogen flow. The Schlenk tube was sealed and stirred at RT for 2 h. The mixture was concentrated and purified by column chromatography with EA: MeOH: H_2O (10:1:0.5~6:1:0.5) as eluent, affording the product as a white solid (yield 94%, 34 mg). ***This procedure was applied to all the 1st CuAAC coupling in the following solution-phase assembly section.*** $[\alpha]_D^{20}$ = 9.23 (c 1.00, MeOH). ^{1}H NMR (600 MHz, Methanol-d_4) δ 7.89 (s, 1H), 7.54 – 7.07 (m, 15H), 5.14 – 5.05 (m, 3H), 4.87 (d, *J* = 12.0 Hz, 1H), 4.78 (d, *J* = 11.4 Hz, 1H), 4.74 – 4.67 (m, 2H), 4.67 – 4.50 (m, 3H), 4.48 – 4.27 (m, 5H), 4.24 – 4.12 (m, 3H), 4.07 – 3.97 (m, 2H), 3.97 – 3.91 (m, 1H), 3.91 – 3.74 (m, 3H), 3.60 – 3.51 (m, 1H), 3.51 – 3.44 (m, 1H), 1.63 (s, 3H), 1.14 – 0.94 (m, 21H). ^{13}C NMR (151 MHz, cd$_3$od) δ 174.34, 171.69, 145.67, 138.78, 138.41, 123.12, 103.60, 101.86, 97.12, 86.97, 79.22, 77.07, 76.89, 76.23, 74.71, 72.11, 70.04, 69.95, 67.60, 66.23, 66.04, 65.71, 58.81, 52.61, 49.61, 35.79, 21.37, 17.74, 17.64, 10.98. HRMS (ESI) ([M+H]$^-$) Calcd. For $C_{53}H_{57}N_4O_{20}S_3Si$: 1108.4262, found 1108.8619.

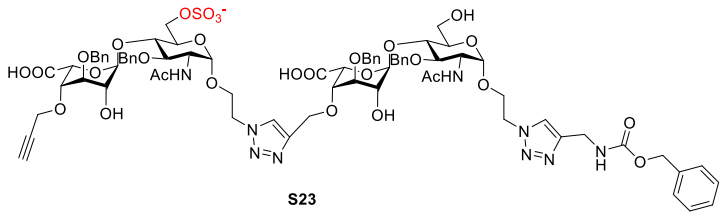


To a solution of compound S1 (34 mg, 30.6 μmol) in DMF (1 mL), TBAF (0.5 mL, 1M solution in THF) was added. The solution was stirred at room temperature for 12 h. After removing the solvent, the crude product was purified by column chromatography with EA: MeOH: H_2O (10:1:0.5~2:1:0.5) as eluent, affording the product as a white solid (yield 90%, 26 mg). ***This procedure was applied to all the 2nd TBAF deprotection in the following solution-phase assembly section.*** $[\alpha]_D^{20}$ = 7.454 (c 1.0, MeOH). ^{1}H NMR (500 MHz, Methanol-d_4) δ 7.91 (s, 1H), 7.46 – 7.16 (m, 15H), 5.12 – 5.04 (m, 3H), 4.92 (d, *J* = 11.8 Hz, 1H), 4.79 – 4.71 (m, 2H), 4.69 (d, *J* = 3.7 Hz, 1H), 4.65 (d, *J* = 2.9 Hz, 1H), 4.63 – 4.54 (m, 2H), 4.50 (d, *J* = 11.8 Hz, 1H), 4.38 (d, *J* = 2.0 Hz, 2H), 4.35 – 4.22 (m, 2H), 4.18 – 4.12 (m, 1H), 4.04 (td, *J* = 10.8, 5.2 Hz, 2H), 3.89 – 3.65 (m, 7H), 2.82 (t, *J* = 2.4 Hz, 1H), 1.72 (s, 3H). ^{13}C NMR (126 MHz, cd$_3$od) δ 174.38, 171.75, 138.91, 138.43, 128.06, 127.90, 127.84, 127.69, 127.68, 127.60, 127.51, 127.21, 126.95, 123.28, 101.05, 97.21, 78.54, 77.36, 77.02, 75.57, 73.94, 72.23, 72.04, 70.78, 69.33, 66.26, 65.58, 60.44, 57.88, 52.64, 49.64, 48.43, 48.21, 48.13, 48.09, 35.82, 21.37. HRMS (ESI) ([M-H]$^-$) Calcd. For $C_{44}H_{50}N_5O_{17}S$: 952.2928, found 952.3024.



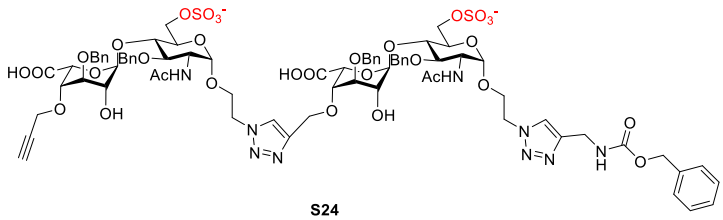
S22

The starting material **16** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S22**. ^{1}H NMR (500 MHz, Methanol-d_4) δ 8.04 (s, 1H), 7.90 (s, 1H), 7.54 – 7.08 (m, 25H), 5.15 – 5.03 (m, 4H), 4.90 (t, J = 11.5 Hz, 3H), 4.81 – 4.75 (m, 2H), 4.76 – 4.63 (m, 8H), 4.63 – 4.52 (m, 4H), 4.52 – 4.43 (m, 2H), 4.38 (d, J = 3.2 Hz, 2H), 4.30 (qd, J = 15.8, 2.3 Hz, 2H), 4.16 – 3.98 (m, 6H), 3.93 – 3.61 (m, 15H), 2.81 (t, J = 2.4 Hz, 1H), 1.71 (d, J = 1.4 Hz, 6H). ^{13}C NMR (151 MHz, cd$_3$od) δ 174.39, 171.86, 171.77, 157.38, 145.01, 138.91, 138.86, 138.42, 138.37, 136.76, 128.06, 127.94, 127.90, 127.88, 127.84, 127.81, 127.77, 127.72, 127.68, 127.67, 127.63, 127.61, 127.50, 127.48, 127.24, 127.20, 126.94, 126.90, 124.36, 123.28, 101.15, 100.97, 97.36, 97.17, 78.72, 78.54, 77.90, 77.38, 77.14, 77.00, 76.83, 75.45, 75.39, 74.21, 73.92, 72.23, 72.22, 72.07, 72.00, 69.48, 68.98, 66.27, 65.88, 65.54, 63.79, 60.43, 60.40, 57.86, 54.83, 52.66, 52.60, 35.80, 21.42, 21.36. HRMS (ESI) ([M-H]$^-$) Calcd. For $C_{77}H_{90}N_9O_{26}$: 1556.60, found 1556.51.



S23

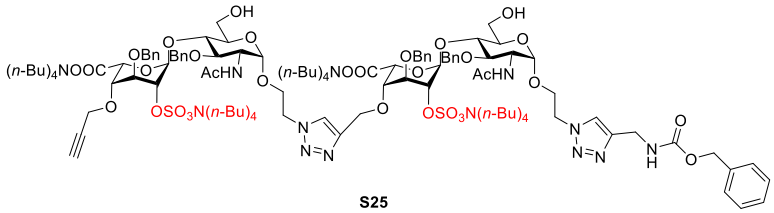
The starting material **16** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S23**. ^{1}H NMR (500 MHz, Methanol-d_4) δ 8.01 (s, 1H), 7.90 (s, 1H), 7.45 – 7.16 (m, 25H), 5.16 – 5.04 (m, 4H), 4.91 (dd, J = 12.0, 8.5 Hz, 2H), 4.82 – 4.63 (m, 11H), 4.63 – 4.51 (m, 4H), 4.48 (d, J = 11.9 Hz, 1H), 4.42 (d, J = 12.1 Hz, 1H), 4.38 (d, J = 2.4 Hz, 2H), 4.33 – 4.22 (m, 3H), 4.20 – 4.12 (m, 2H), 4.08 (t, J = 3.5 Hz, 1H), 4.06 – 3.97 (m, 4H), 3.90 – 3.72 (m, 10H), 3.67 (t, J = 9.8 Hz, 1H), 3.62 (dd, J = 10.6, 9.0 Hz, 1H), 3.57 – 3.51 (m, 1H), 2.81 (t, J = 2.4 Hz, 1H), 1.70 (s, 3H), 1.65 (s, 3H). ^{13}C NMR (126 MHz, cd$_3$od) δ 174.34, 174.17, 171.77, 171.75, 145.03, 138.86, 138.82, 138.41, 128.06, 127.95, 127.92, 127.86, 127.84, 127.77, 127.75, 127.73, 127.72, 127.63, 127.51, 127.24, 127.20, 126.98, 126.92, 124.20, 123.25, 101.76, 101.27, 97.31, 97.21, 79.26, 78.70, 77.81, 77.32, 76.70, 76.22, 76.13, 75.65, 74.64, 74.16, 72.17, 72.07, 71.96, 70.98, 70.06, 69.99, 69.25, 68.04, 66.26, 66.07, 65.96, 65.58, 63.88, 60.41, 57.73, 52.67, 52.63, 49.63, 35.82, 21.44, 21.38. HRMS (ESI) ([M]$^-$) Calcd. For $C_{77}H_{90}N_9O_{29}S^-$: 1636.55, found 1636.46.



S24

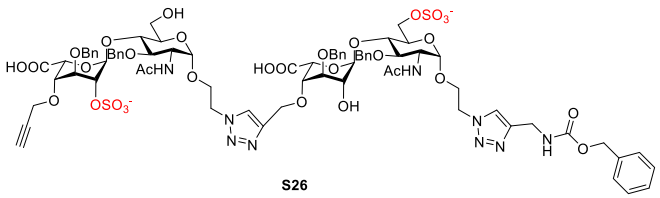
The starting material **17** (98 mg, 106.4 uM) was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S24** (123.5 mg, 67.54% over 4 steps). ^{1}H NMR (500 MHz, Methanol-d_4) δ 8.01 (s, 1H), 7.91 (s, 1H), 7.48 – 7.12 (m, 25H), 5.16 – 5.03 (m, 4H), 4.91 (dd, J = 12.1, 9.2 Hz, 2H), 4.81 – 4.52 (m, 14H), 4.42 (t, J = 11.9 Hz, 2H), 4.38 (s, 2H), 4.33 – 4.20 (m, 5H), 4.20 – 4.13 (m, 2H), 4.10 – 3.99 (m, 5H), 3.93 – 3.74 (m, 8H), 3.65 – 3.57 (m, 2H), 3.54 (d, J = 10.0 Hz, 2H), 2.81 (t, J = 2.4 Hz, 1H), 1.63 (d, J = 1.5 Hz, 6H). ^{13}C NMR (151 MHz, cd$_3$od) δ 174.24, 174.22, 171.71, 145.67, 144.86, 138.82, 138.37, 138.34, 136.82, 128.03, 127.95,

127.91, 127.84, 127.81, 127.72, 127.70, 127.66, 127.56, 127.47, 127.22, 127.19, 126.93, 126.88, 124.18, 123.10, 102.01, 101.59, 97.28, 97.05, 79.31, 79.27, 77.14, 76.42, 76.37, 76.22, 75.95, 74.70, 74.58, 71.89, 71.75, 70.40, 70.10, 69.97, 69.86, 68.12, 67.76, 66.21, 66.10, 66.04, 65.93, 65.64, 63.61, 57.69, 56.32, 56.18, 56.03, 55.89, 52.63, 52.59, 49.59, 35.80, 21.41, 21.34. HRMS (ESI) ([M+H]$^-$) Calcd. For $C_{77}H_{90}N_9O_{32}S_2^-$: 1716.51, found 1716.48.



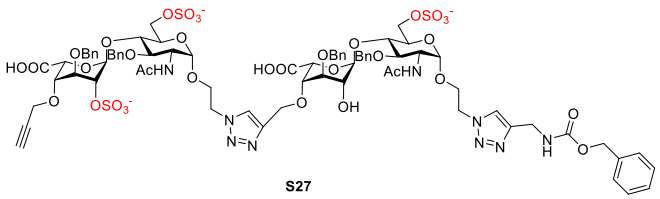
S25

The starting material **18** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S25**. ^{1}H NMR (600 MHz, Methanol-d_4) δ 8.17 (s, 1H), 7.88 (s, 1H), 7.47 – 7.09 (m, 25H), 5.30 (d, J = 12.8 Hz, 2H), 5.04 (s, 2H), 4.90 (t, J = 11.7 Hz, 2H), 4.79 – 4.49 (m, 16H), 4.45 (dd, J = 18.4, 12.1 Hz, 2H), 4.37 (d, J = 2.0 Hz, 2H), 4.24 (d, J = 2.4 Hz, 2H), 4.17 (d, J = 13.9 Hz, 2H), 4.10 – 3.95 (m, 7H), 3.93 – 3.67 (m, 11H), 3.61 (d, J = 10.2 Hz, 1H), 3.43 (d, J = 10.0 Hz, 1H), 3.26 – 3.17 (m, 8H), 2.73 (t, J = 2.5 Hz, 1H), 1.70 – 1.57 (m, 14H), 1.40 (q, J = 7.4 Hz, 8H), 1.01 (t, J = 7.4 Hz, 12H). HRMS (ESI) ([M-4N(n-Bu)$_4$+2H]$^-$) Calcd. For $C_{77}H_{90}N_9O_{32}S_2^{2-}$: 857.75, found 857.76.



S26

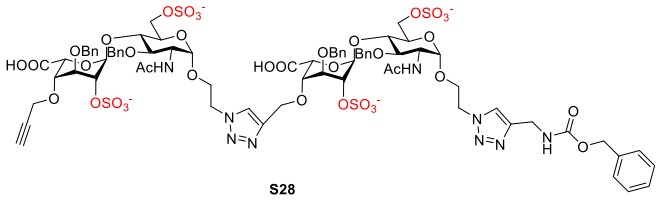
The starting material **17** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S26**. ^{1}H NMR (500 MHz, Methanol-d_4) δ 7.98 (s, 1H), 7.90 (s, 1H), 7.45 – 7.13 (m, 25H), 5.38 – 5.22 (m, 1H), 5.16 – 5.05 (m, 3H), 4.91 (t, J = 12.4 Hz, 2H), 4.83 (d, J = 1.7 Hz, 1H), 4.81 – 4.55 (m, 13H), 4.54 – 4.50 (m, 1H), 4.47 – 4.40 (m, 2H), 4.38 (s, 2H), 4.30 – 4.16 (m, 6H), 4.09 – 3.97 (m, 5H), 3.93 – 3.74 (m, 9H), 3.69 (dd, J = 10.6, 9.1 Hz, 1H), 3.62 (t, J = 9.8 Hz, 1H), 3.55 (d, J = 9.8 Hz, 1H), 3.48 – 3.43 (m, 1H), 1.63 (s, 3H), 1.62 (s, 3H). HRMS (ESI) ([M+H]$^-$) Calcd. For $C_{77}H_{90}N_9O_{32}S_2^-$: 1716.51, found 1716.47.



S27

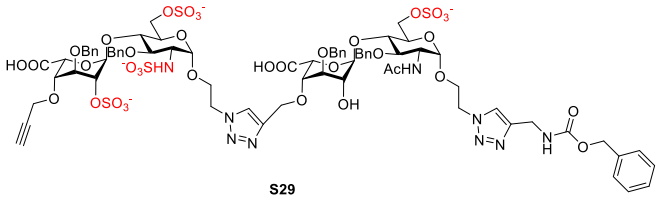
The starting material **17** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S27**. ^{1}H NMR (500 MHz, Methanol-d_4) δ 8.02 (s, 1H), 7.91 (s, 1H), 7.52 – 6.99 (m, 25H), 5.35 (s, 1H), 5.19 – 5.10 (m, 2H), 5.08 (s, 2H), 4.90 (t, J = 12.8 Hz, 2H), 4.81 – 4.70 (m, 5H), 4.70 – 4.52 (m, 9H), 4.44 (d, J = 12.1 Hz, 1H), 4.38 (s, 2H), 4.30 (d, J = 12.3 Hz, 1H), 4.28 – 4.14 (m, 8H), 4.12 – 3.93 (m, 6H), 3.93 – 3.77 (m, 5H), 3.68 – 3.53 (m, 3H), 3.54 – 3.45 (m, 1H), 2.74 (t, J = 2.4 Hz, 1H), 1.62 (d, J = 10.2 Hz, 6H). ^{13}C NMR (126 MHz, MeOD) δ 174.47, 171.84, 171.72, 169.04, 144.98, 138.86, 138.79, 138.30, 137.81, 128.08, 128.01, 127.94, 127.86, 127.78, 127.72, 127.61, 127.49, 127.43, 127.32, 126.95, 126.78, 124.93, 123.34, 101.19, 97.53, 97.42, 97.03, 79.06, 76.89, 76.09, 75.51, 75.46, 75.06, 74.76, 72.70, 71.85, 71.67, 71.57, 70.54, 69.85, 69.75, 69.60, 68.15, 67.38, 66.49, 66.28, 66.21, 65.98, 65.69,

63.25, 57.78, 52.81, 49.69, 48.46, 48.24, 35.85, 21.51, 21.38, 17.96, 17.94, 11.23. HRMS (ESI) ([M+2H]$^-$) Calcd. For $C_{77}H_{90}N_9O_{35}S_3^-$: 1796.47, found 1796.42.



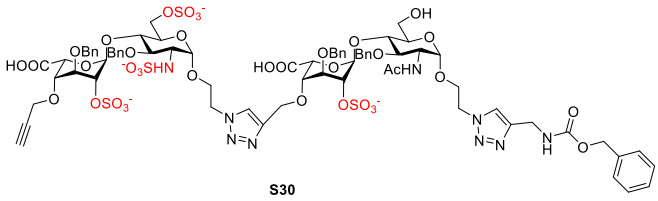
S28

The starting material **19** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S28**. ^{1}H NMR (500 MHz, Methanol-d_4) δ 8.19 (s, 1H), 7.91 (s, 1H), 7.43 – 7.08 (m, 25H), 5.41 (s, 1H), 5.37 (s, 1H), 5.07 (s, 2H), 4.92 (t, J = 12.4 Hz, 2H), 4.83 – 4.74 (m, 4H), 4.73 – 4.52 (m, 12H), 4.46 – 4.23 (m, 10H), 4.21 (s, 1H), 4.16 (s, 1H), 4.14 – 4.07 (m, 3H), 4.06 – 3.98 (m, 5H), 3.88 – 3.76 (m, 3H), 3.72 – 3.56 (m, 3H), 2.73 (t, J = 2.4 Hz, 1H), 1.62 (s, 3H), 1.60 (s, 3H). ^{13}C NMR (126 MHz, MeOD) δ 175.83, 175.72, 173.16, 170.34, 161.49, 158.85, 147.19, 146.40, 140.40, 140.32, 139.27, 138.23, 129.47, 129.42, 129.38, 129.36, 129.18, 129.14, 129.10, 129.00, 128.87, 128.76, 128.33, 128.15, 128.09, 124.64, 99.03, 98.74, 98.36, 80.30, 78.24, 76.31, 76.16, 74.89, 74.36, 73.94, 73.21, 73.04, 72.01, 71.22, 69.55, 67.93, 67.65, 67.37, 67.06, 64.68, 58.02, 56.25, 54.29, 51.07, 49.85, 37.25, 33.06, 30.72, 30.46, 23.73, 22.86, 22.74, 21.65, 19.29. HRMS (ESI) ([M+3H]$^-$) Calcd. For $C_{77}H_{90}N_9O_{38}S_4^-$: 1876.43, found 1876.39.



S29

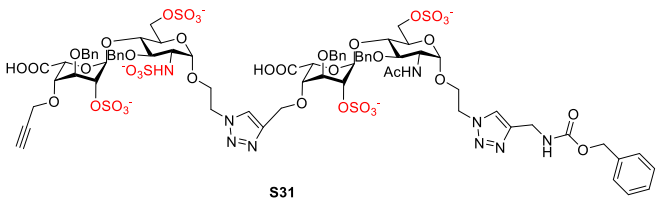
The starting material **17** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S29**. ^{1}H NMR (500 MHz, MeOD) δ 8.08 (s, 1H), 7.92 (s, 1H), 7.46 – 7.15 (m, 25H), 5.35 (s, 1H), 5.23 – 5.06 (m, 5H), 4.82 (d, J = 5.7 Hz, 2H), 4.80 – 4.71 (m, 4H), 4.70 – 4.67 (m, 2H), 4.67 – 4.59 (m, 5H), 4.58 – 4.50 (m, 2H), 4.42 (d, J = 24.9 Hz, 3H), 4.23 (ddd, J = 16.0, 11.3, 4.0 Hz, 6H), 4.18 – 4.01 (m, 7H), 3.99 – 3.79 (m, 8H), 3.71 – 3.58 (m, 4H), 3.51 (d, J = 9.4 Hz, 2H), 3.44 – 3.37 (m, 4H), 3.36 – 3.34 (m, 1H), 2.57 (t, J = 6.5 Hz, 1H), 1.64 (s, 3H). ^{13}C NMR (126 MHz, MeOD) δ 174.74, 174.33, 171.73, 144.75, 138.86, 138.33, 137.89, 128.73, 128.21, 128.08, 127.98, 127.94, 127.93, 127.87, 127.80, 127.72, 127.69, 127.61, 127.51, 127.31, 127.26, 126.94, 123.96, 123.16, 101.62, 97.40, 97.32, 97.14, 79.29, 77.10, 76.56, 76.11, 74.65, 74.53, 73.51, 71.65, 71.46, 70.54, 70.09, 69.48, 69.21, 68.28, 66.99, 66.73, 66.27, 65.74, 63.78, 57.70, 56.57, 52.68, 49.73, 49.64, 48.45, 35.83, 31.67, 29.34, 29.07, 22.34, 21.38. HRMS (ESI) ([M+3H]$^-$) Calcd. For $C_{75}H_{88}N_9O_{37}S_4^-$: 1835.42, found 1835.33.



S30

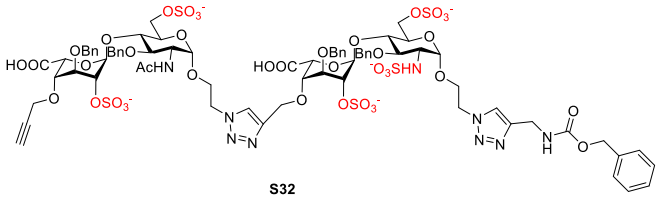
The starting material **18** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S30**. ^{1}H NMR (500 MHz, MeOD) δ 8.09 (s, 1H), 7.94 (d, J = 10.0 Hz, 1H), 7.60 – 7.04 (m, 25H), 5.37 (s, 1H), 5.24 – 5.05 (m, 5H), 4.92 (d, J = 12.1 Hz, 7H), 4.83 – 4.73 (m, 4H), 4.69 (t, J = 11.1 Hz, 4H), 4.63 – 4.54 (m, 5H), 4.39 (s, 3H), 4.27 – 3.99 (m, 7H), 3.98 – 3.62 (m, 10H), 3.45 (ddd, J = 52.2, 8.5, 4.4 Hz, 5H), 3.29 (d, J = 8.9 Hz, 2H), 1.71 – 1.57 (m, 4H).^{13}C NMR (126 MHz, MeOD) δ 174.75, 174.63, 171.83, 169.07, 160.07, 157.42, 145.62, 144.65, 138.76,

138.29, 138.20, 137.82, 136.78, 128.74, 128.23, 128.10, 128.01, 127.96, 127.92, 127.83, 127.79, 127.75, 127.71, 127.65, 127.53, 127.41, 127.33, 127.04, 126.98, 124.06, 123.38, 101.08, 97.40, 97.26, 79.08, 77.37, 76.94, 75.68, 75.21, 75.08, 74.73, 73.74, 73.16, 71.99, 71.97, 71.59, 71.53, 70.65, 69.82, 69.31, 68.40, 67.81, 66.75, 66.31, 65.65, 63.70, 60.32, 57.72, 52.78, 49.75, 49.67, 48.47, 35.80, 29.33, 29.06, 23.90, 22.85, 22.33, 21.46, 17.96, 17.55, 10.78, 4.03. HRMS (ESI) ([M+3H]$^-$) Calcd. For $C_{75}H_{88}N_9O_{37}S_4^-$: 1835.42, found 1835.33.



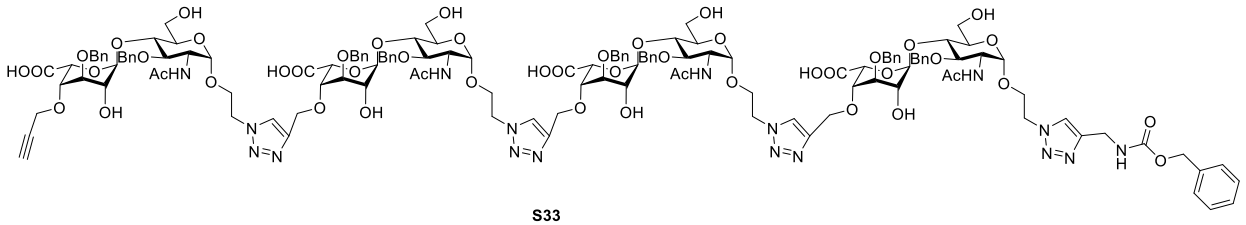
S31

The starting material **19** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S31**. ^{1}H NMR (500 MHz, MeOD) 8.17 (s, 1H), 7.93 (s, 1H), 7.55 – 7.03 (m, 25H), 5.39 (s, 2H), 5.23 (s, 1H), 5.12 (d, J = 25.2 Hz, 2H), 4.85 – 4.73 (m, 10H), 4.72 – 4.52 (m, 10H), 4.44 (s, 2H), 4.38 – 4.17 (m, 8H), 4.17 – 3.93 (m, 10H), 3.82 (dd, J = 24.8, 15.9 Hz, 3H), 3.72 – 3.50 (m, 5H), 3.48 – 3.38 (m, 2H), 3.24 – 3.15 (m, 1H), 2.57 (s, 1H), 1.64 (s, 3H). ^{13}C NMR (126 MHz, MeOD) δ 171.68, 128.77, 128.09, 127.96, 127.77, 127.50, 127.36, 126.76, 97.76, 76.83, 71.63, 66.25, 49.67, 48.45, 48.06, 47.88, 47.71, 47.54, 35.85, 29.06. HRMS (ESI) ([M+4H]$^-$) Calcd. For $C_{75}H_{88}N_9O_{40}S_5^-$: 1915.37, found 1915.32.



S32

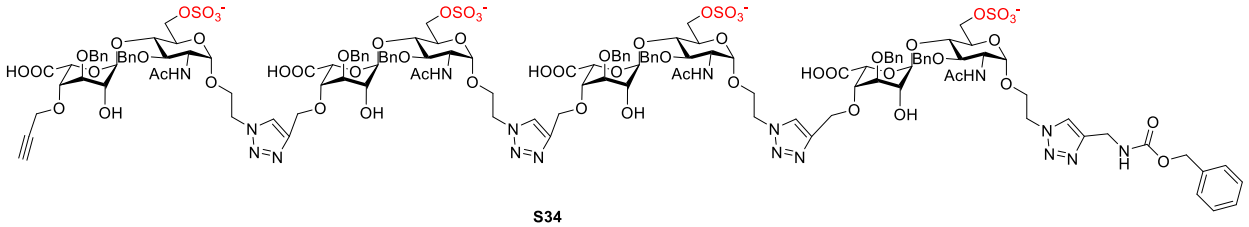
The starting material **21** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S32**. ^{1}H NMR (500 MHz, MeOD) δ 8.19 (s, 1H), 8.04 (s, 1H), 7.56 – 7.00 (m, 25H), 5.42 (s, 2H), 5.20 (d, J = 3.3 Hz, 1H), 5.15 (s, 1H), 5.08 (s, 2H), 4.76 – 4.70 (m, 12H), 4.69 – 4.65 (m, 7H), 4.65 – 4.53 (m, 10H), 4.45 (t, J = 10.5 Hz, 4H), 4.39 – 4.31 (m, 3H), 4.28 (d, J = 10.5 Hz, 3H), 4.20 (d, J = 18.7 Hz, 3H), 4.16 – 4.09 (m, 3H), 4.09 – 3.94 (m, 5H), 3.93 – 3.60 (m, 6H), 3.52 – 3.46 (m, 2H), 3.26 – 3.14 (m, 1H), 2.77 (s, 1H), 1.62 (s, 3H). ^{13}C NMR (126 MHz, MeOD) δ 174.48, 174.39, 171.89, 169.05, 160.09, 145.57, 144.97, 138.89, 138.01, 137.81, 137.78, 128.89, 128.11, 128.06, 128.01, 127.93, 127.80, 127.64, 127.55, 127.49, 127.42, 127.11, 126.80, 123.94, 97.55, 97.33, 78.82, 77.15, 76.96, 74.88, 73.45, 73.14, 72.89, 71.86, 71.71, 71.61, 71.35, 70.69, 70.61, 69.72, 69.56, 66.65, 66.25, 65.97, 63.20, 59.17, 57.59, 56.65, 54.90, 52.85, 51.35, 49.67, 48.48, 48.26, 39.98, 31.65, 29.31, 29.04, 22.87, 22.32, 21.50, 17.91. HRMS (ESI) ([M+3H]$^-$) Calcd. For $C_{75}H_{87}N_9O_{40}S_5^{2-}$: 956.68, found 956.74.



S33

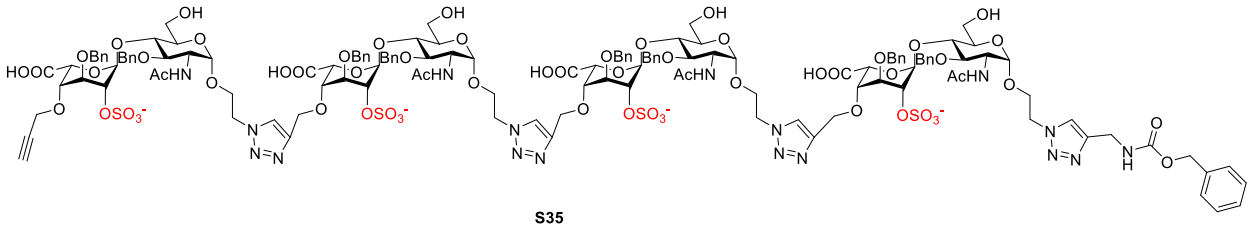
The starting material **16** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S33**.^{1}H NMR (500 MHz, MeOD) δ 8.22 (d, J = 7.8 Hz, 1H), 8.04 (d, J = 9.2 Hz, 2H), 7.95 (s, 1H),

7.69 – 7.05 (m, 45H), 5.36 (t, J = 4.8 Hz, 1H), 5.31 – 5.28 (m, 1H), 5.17 (s, 2H), 5.15 (s, 6H), 5.14 (s, 3H), 4.99 (s, 2H), 4.95 (s, 3H), 4.78 (s, 1H), 4.76 (s, 2H), 4.75 – 4.71 (m, 12H), 4.69 (dd, J = 12.5, 3.8 Hz, 9H), 4.65 – 4.57 (m, 12H), 4.46 – 4.40 (m, 5H), 4.32 – 4.17 (m, 13H), 4.10 – 3.99 (m, 12H), 3.94 – 3.79 (m, 16H), 3.77 – 3.72 (m, 5H), 3.67 (d, J = 2.7 Hz, 6H), 3.63 (d, J = 9.0 Hz, 3H), 3.59 (d, J = 4.7 Hz, 2H), 3.55 (ddd, J = 14.7, 7.6, 4.4 Hz, 5H), 3.51 (s, 2H), 3.47 (p, J = 1.7 Hz, 6H), 3.19 (p, J = 1.7 Hz, 2H), 2.88 (s, 1H), 1.91 (s, 12H). HRMS (ESI) ([M-2H]$^{-}$) Calcd. For $C_{143}H_{169}N_{17}O_{50}^{2-}$: 1462.56, found 1462.49.



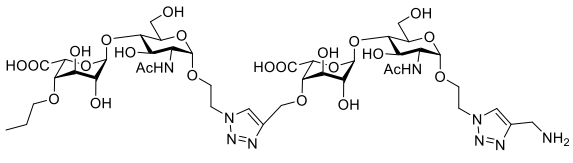
S34

The starting material **17** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S34**. ^{1}H NMR (500 MHz, D2O) δ 7.98 (s, 2H), 7.81 (s, 2H), 7.43 – 6.91 (m, 45H), 5.11 (s, 2H), 5.07 (s, 2H), 4.57 (s, 4H), 4.52 (s, 2H), 4.46 (s, 2H), 4.43 (s, 2H), 4.40 (s, 2H), 4.36 (s, 2H), 4.29 (s, 3H), 4.25 – 4.17 (m, 4H), 4.11 (d, J = 36.9 Hz, 5H), 3.95 (d, J = 17.0 Hz, 8H), 3.76 (s, 19H), 3.63 (d, J = 1.7 Hz, 4H), 3.57 (dt, J = 7.3, 4.0 Hz, 3H), 3.49 – 3.45 (m, 2H), 3.42 (d, J = 8.7 Hz, 2H), 3.32 – 3.28 (m, 3H), 3.11 (t, J = 11.7 Hz, 7H), 2.64 (s, 1H), 1.83 (s, 12H). HRMS (ESI) ([M]$^{4-}$) Calcd. For $C_{143}H_{167}N_{17}O_{62}S_4^{4-}$: 810.99, found 810.96.



S35

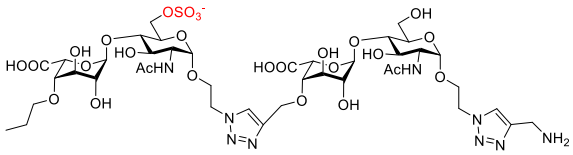
The starting material **18** was treated according to the general procedures of CuAAc reaction and TBAF deprotection to give compound **S35**. ^{1}H NMR (500 MHz, MeOD) δ 8.05 (d, J = 6.2 Hz, 3H), 7.93 (s, 1H), 7.51 – 7.12 (m, 45H), 5.16 (d, J = 13.4 Hz, 4H), 5.09 (s, 3H), 5.01 (s, 2H), 4.78 (d, J = 5.8 Hz, 9H), 4.75 (d, J = 6.7 Hz, 11H), 4.67 (d, J = 8.7 Hz, 8H), 4.42 (d, J = 20.4 Hz, 10H), 4.34 – 4.19 (m, 12H), 4.15 (s, 2H), 4.05 (d, J = 14.0 Hz, 11H), 3.97 – 3.75 (m, 19H), 3.71 – 3.53 (m, 12H), 3.51 (s, 1H), 3.48 – 3.46 (m, 1H), 3.35 (q, J = 1.8 Hz, 3H), 3.22 – 3.15 (m, 3H), 2.63 (s, 1H), 1.67 (d, J = 3.1 Hz, 12H). HRMS (ESI) ([M]$^{4-}$) Calcd. For $C_{143}H_{169}N_{17}O_{62}S_4^{2-}$: 1622.48, found 1682.44.



A

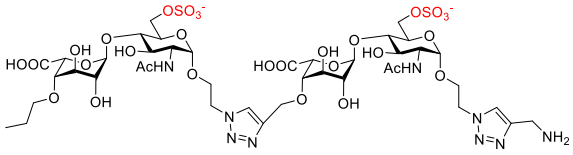
The starting material **S22** was treated according to the general procedures of global debenzylation to give compound **A**. ^{1}H NMR (500 MHz, D2O) δ 8.02 (s, 2H), 4.84 – 4.75 (m, 5H), 4.67 – 4.47 (m, 8H), 4.24 – 3.94 (m, 4H), 3.86 – 3.74 (m, 7H), 3.73 – 3.66 (m, 2H), 3.65 – 3.62 (m, 3H), 3.61 – 3.54 (m, 4H), 3.54 – 3.52 (m, 1H), 3.50 (dt, J = 8.0, 3.0 Hz, 2H), 3.47 – 3.43 (m, 1H), 3.10 – 2.96 (m, 2H), 1.91 (d, J = 8.3 Hz, 6H), 1.46 (q, J = 7.2 Hz, 2H), 0.83 – 0.71 (m, 3H). ^{13}C NMR (126 MHz, D2O) δ 175.29, 175.00, 174.22, 144.43, 132.73,

128.07, 127.95, 125.62, 101.72, 96.31, 79.51, 79.48, 77.35, 77.13, 73.37, 71.24, 70.83, 70.62, 70.56, 69.36, 65.53, 63.55, 59.71, 53.57, 50.24, 49.96, 22.44, 21.87, 21.84, 21.72, 9.79. HRMS (ESI) ([M-H]$^-$) Calcd. For $C_{41}H_{64}N_9O_{24}^-$: 1066.41, found 1066.41.



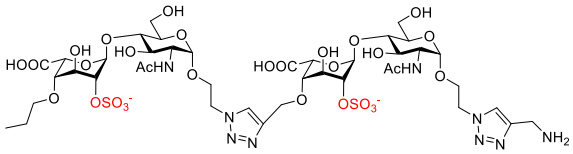
B

The starting material **S23** was treated according to the general procedures of global debenzylation to give compound **B**.^{1}H NMR (500 MHz, D2O) δ 8.14 (d, J = 27.2 Hz, 2H), 4.92 – 4.82 (m, 6H), 4.76 – 4.59 (m, 8H), 4.25 – 4.06 (m, 5H), 3.95 – 3.83 (m, 8H), 3.78 (s, 1H), 3.73 (s, 2H), 3.70 – 3.60 (m, 6H), 3.57 – 3.50 (m, 2H), 3.16 (d, J = 9.4 Hz, 1H), 2.01 – 1.87 (m, 6H), 1.54 (q, J = 7.1 Hz, 2H), 0.87 (t, J = 7.5 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 175.36, 174.97, 174.17, 144.39, 126.07, 125.59, 102.08, 101.76, 96.31, 79.32, 79.22, 77.62, 77.36, 73.30, 70.87, 70.78, 70.68, 70.47, 70.26, 70.01, 69.54, 69.42, 69.25, 68.83, 66.39, 65.66, 63.52, 59.76, 53.55, 53.41, 51.74, 50.08, 49.91, 42.97, 22.43, 21.87, 21.83, 9.79, 6.02. HRMS (ESI) ([M]$^-$) Calcd. For $C_{41}H_{64}N_9O_{27}S^-$: 1146.36, found 1146.33.



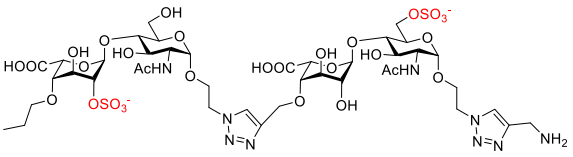
C

The starting material **S24** was treated according to the general procedures of global debenzylation to give compound **C**.^{1}H NMR (500 MHz, D2O) δ 8.03 (d, J = 4.5 Hz, 2H), 4.87 – 4.73 (m, 6H), 4.68 – 4.44 (m, 8H), 4.15 – 4.00 (m, 7H), 3.90 – 3.72 (m, 7H), 3.69 (t, J = 3.7 Hz, 1H), 3.56 (tdd, J = 18.9, 9.9, 4.5 Hz, 7H), 3.48 – 3.38 (m, 2H), 3.28 (d, J = 90.2 Hz, 1H), 1.90 (d, J = 17.8 Hz, 6H), 1.46 (q, J = 7.1 Hz, 2H), 0.78 (t, J = 7.4 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 144.34, 125.65, 124.70, 102.06, 96.31, 79.21, 78.88, 78.04, 77.56, 73.29, 70.58, 70.42, 70.25, 70.00, 69.54, 68.92, 68.83, 66.65, 66.37, 65.67, 63.38, 53.43, 53.29, 50.08, 49.90, 34.67, 22.42, 21.86, 21.83, 9.79, 6.02. HRMS (ESI) ([M+H]$^-$) Calcd. For $C_{41}H_{64}N_9O_{30}S_2^-$: 1226.32, found 1226.29.



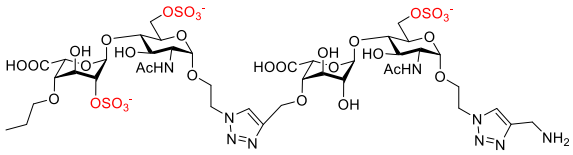
D

The starting material **S25** was treated according to the general procedures of global debenzylation to give compound **D**. ^{1}H NMR (500 MHz, D2O) δ 8.04 (d, J = 6.1 Hz, 2H), 4.97 (d, J = 30.3 Hz, 3H), 4.67 – 4.47 (m, 8H), 4.26 – 3.93 (m, 8H), 3.85 – 3.73 (m, 5H), 3.66 (t, J = 14.2 Hz, 5H), 3.56 (dd, J = 17.5, 9.3 Hz, 5H), 3.51 – 3.07 (m, 3H), 1.90 (d, J = 24.2 Hz, 6H), 1.45 (q, J = 7.1 Hz, 2H), 0.79 (t, J = 7.4 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 176.15, 174.16, 144.56, 125.61, 99.25, 96.34, 77.02, 76.85, 76.22, 74.08, 72.46, 70.95, 70.52, 69.32, 68.64, 68.07, 65.51, 62.92, 59.69, 53.75, 49.93, 22.32, 21.86, 9.85, 6.02. HRMS (ESI) ([M]$^{2-}$) Calcd. For $C_{41}H_{63}N_9O_{30}S_2^{2-}$: 613.16, found 613.21.



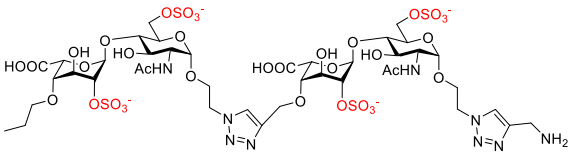
E

The starting material **S26** was treated according to the general procedures of global debenzylation to give compound **E**. ^{1}H NMR (500 MHz, D2O) δ 8.02 (s, 2H), 4.90 (d, J = 96.7 Hz, 5H), 4.68 – 4.40 (m, 7H), 4.20 – 3.96 (m, 7H), 3.78 (d, J = 42.6 Hz, 7H), 3.70 – 3.47 (m, 9H), 3.38 (d, J = 8.5 Hz, 1H), 3.32 – 3.09 (m, 1H), 2.01 – 1.83 (m, 6H), 1.47 – 1.40 (m, 2H), 1.00 (d, J = 6.2 Hz, 2H), 0.79 (t, J = 7.4 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 174.15, 125.62, 99.25, 76.22, 72.46, 70.98, 69.31, 68.09, 65.53, 63.43, 59.70, 53.75, 49.92, 22.32, 21.86, 9.86. HRMS (ESI) ([M+H]$^{-}$) Calcd. For $C_{41}H_{64}N_9O_{30}S_2^{-}$: 1226.32, found 1226.27.



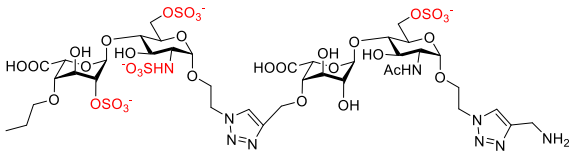
F

The starting material **S27** was treated according to the general procedures of global debenzylation to give compound **F**. ^{1}H NMR (500 MHz, D2O) δ 8.15 – 7.96 (m, 2H), 5.08 – 4.79 (m, 10H), 4.64 – 4.46 (m, 7H), 4.36 – 4.22 (m, 2H), 4.19 – 4.00 (m, 9H), 3.89 – 3.75 (m, 7H), 3.71 – 3.37 (m, 11H), 3.10 – 3.03 (m, 1H), 1.91 (d, J = 32.0 Hz, 6H), 1.45 (q, J = 6.9 Hz, 2H), 1.01 (s, 2H), 0.78 (t, J = 7.4 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 175.50, 175.39, 174.31, 174.17, 144.49, 126.08, 125.84, 125.69, 102.03, 98.04, 96.36, 96.23, 79.19, 77.45, 77.13, 76.13, 74.09, 73.30, 70.43, 70.21, 69.95, 69.51, 68.84, 68.39, 66.33, 65.81, 65.69, 65.60, 62.82, 53.47, 50.29, 49.91, 42.55, 40.88, 38.74, 34.14, 22.43, 21.87, 21.85, 18.23, 18.00, 17.96, 10.72, 9.79. HRMS (ESI) ([M+2H]$^{-}$) Calcd. For $C_{41}H_{64}N_9O_{33}S_3^{-}$: 1306.28, found 1306.25.



G

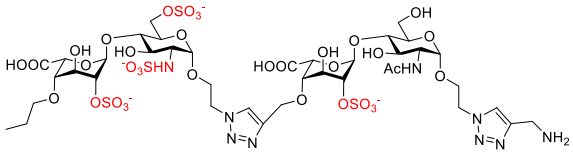
The starting material **S28** was treated according to the general procedures of global debenzylation to give compound **G**. ^{1}H NMR (500 MHz, D2O) δ 8.43 – 7.94 (m, 2H), 5.19 – 4.82 (m, 7H), 4.65 – 4.51 (m, 9H), 4.34 – 4.10 (m, 9H), 4.06 (t, J = 14.4 Hz, 4H), 3.91 – 3.74 (m, 6H), 3.73 – 3.49 (m, 8H), 3.39 (q, J = 7.2 Hz, 1H), 1.90 (d, J = 39.8 Hz, 6H), 1.45 (q, J = 7.1 Hz, 2H), 1.01 (s, 2H), 0.79 (t, J = 7.6 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 174.30, 174.13, 96.30, 77.16, 76.54, 74.22, 72.55, 69.46, 68.92, 68.48, 66.73, 65.60, 53.56, 49.87, 22.32, 21.85, 18.02, 9.84. HRMS (ESI) ([M+3H]$^{-}$) Calcd. For $C_{41}H_{64}N_9O_{36}S_4^{-}$: 1386.23, found 1386.18.



H

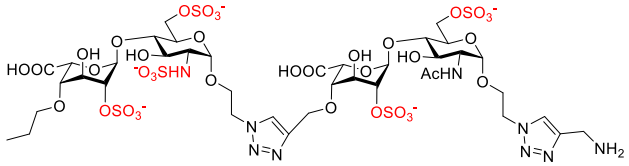
The starting material **S29** was treated according to the general procedures of global debenzylation to give compound **H**. ^{1}H NMR (500 MHz, D2O) δ 8.09 (d, J = 14.5 Hz, 2H), 5.08 – 4.98 (m, 4H), 4.65 – 4.41 (m, 9H), 4.24 – 3.96 (m, 13H), 3.92 – 3.78 (m, 7H), 3.72 – 3.59 (m, 3H), 3.59 – 3.47 (m, 7H), 3.43 – 3.24 (m, 3H), 3.17 (dd, J = 10.3, 3.6 Hz, 3H), 1.93 (s, 3H), 1.45 (q, J = 7.1 Hz, 2H), 0.79 (t, J = 7.4 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 176.01, 175.14, 174.27, 144.15, 125.99, 125.52, 101.67, 99.25, 96.75, 96.17, 78.33, 77.94, 77.00, 76.44, 74.06, 72.51, 70.47, 70.30, 69.91, 69.36, 68.87, 68.74, 68.36, 66.65, 66.05, 65.72, 65.61, 63.20, 57.56,

53.29, 50.17, 49.93, 38.01, 34.16, 22.31, 21.84, 9.85. HRMS (ESI) ([M+3H]$^-$) Calcd. For $C_{39}H_{63}N_9O_{35}S_4^-$: 1344.22, found 1344.16.



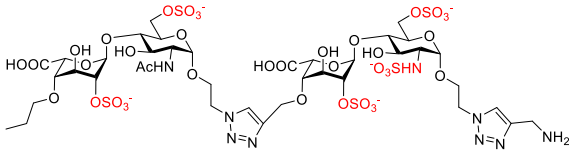
I

The starting material **S30** was treated according to the general procedures of global debenzylation to give compound **I**. ^{1}H NMR (500 MHz, D2O) δ 8.07 (s, 2H), 5.02 (d, J = 4.7 Hz, 4H), 5.00 – 4.98 (m, 1H), 4.64 – 4.63 (m, 6H), 4.62 – 4.61 (m, 3H), 4.61 – 4.58 (m, 6H), 4.18 (s, 2H), 4.10 (s, 5H), 4.04 (s, 1H), 3.87 – 3.79 (m, 6H), 3.70 (d, J = 9.8 Hz, 2H), 3.67 (s, 4H), 3.64 (s, 1H), 3.57 (d, J = 9.7 Hz, 7H), 3.52 (q, J = 8.4 Hz, 4H), 3.45 – 3.33 (m, 4H), 3.27 (s, 2H), 3.15 (d, J = 10.5 Hz, 2H), 1.83 (s, 3H), 1.46 (d, J = 7.1 Hz, 2H), 0.79 (s, 3H). ^{13}C NMR (126 MHz, D2O, obtained from HSQC) δ 179.23, 178.05, 172.59, 125.71, 99.14, 99.14, 97.19, 96.80, 77.27, 76.87, 76.48, 76.09, 74.14, 74.14, 72.58, 72.58, 69.84, 69.06, 68.67, 68.28, 66.72, 65.94, 65.94, 65.55, 65.16, 62.81, 62.81, 59.69, 57.73, 57.73, 53.83, 49.92, 22.18, 21.79, 9.68. HRMS (ESI) ([M+3H]$^-$) Calcd. For $C_{39}H_{62}N_9NaO_{35}S_4^-$: 1366.20, found 1366.15.



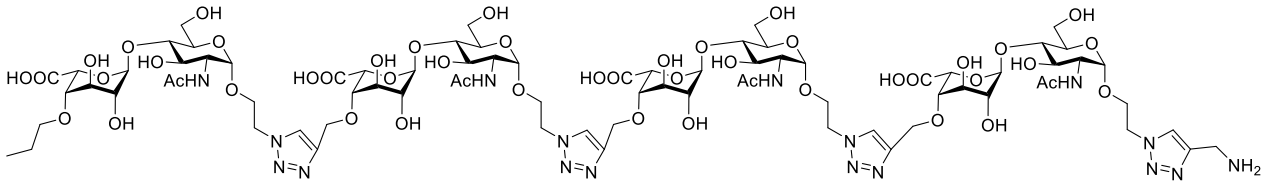
J

The starting material **S31** was treated according to the general procedures of global debenzylation to give compound **J**. ^{1}H NMR (500 MHz, D2O δ 8.09 (d, J = 11.3 Hz, 2H), 5.02 (d, J = 9.4 Hz, 3H), 4.92 (s, 2H), 4.65 – 4.55 (m, 8H), 4.31 (d, J = 14.9 Hz, 1H), 4.23 (d, J = 14.4 Hz, 1H), 4.20 – 4.15 (m, 3H), 4.11 (q, J = 5.4 Hz, 4H), 4.04 (q, J = 7.9 Hz, 3H), 3.82 (ddd, J = 21.3, 10.6, 5.9 Hz, 5H), 3.68 (d, J = 10.3 Hz, 3H), 3.54 (ddd, J = 28.0, 15.1, 7.1 Hz, 5H), 3.39 (q, J = 7.6 Hz, 2H), 3.27 (s, 1H), 3.19 – 3.00 (m, 3H), 1.94 (s, 3H), 1.45 (q, J = 7.1 Hz, 2H), 0.79 (t, J = 7.4 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 175.50, 174.35, 144.37, 125.94, 99.28, 97.50, 96.92, 96.23, 76.94, 74.00, 72.50, 69.90, 68.75, 66.75, 66.19, 65.73, 65.63, 65.51, 62.75, 57.60, 53.52, 50.22, 49.95, 48.85, 34.15, 22.31, 21.85, 9.85. HRMS (ESI) ([M+4H]$^-$) Calcd. For $C_{39}H_{62}N_9O_{38}S_5^-$: 1424.28, found 1424.10.



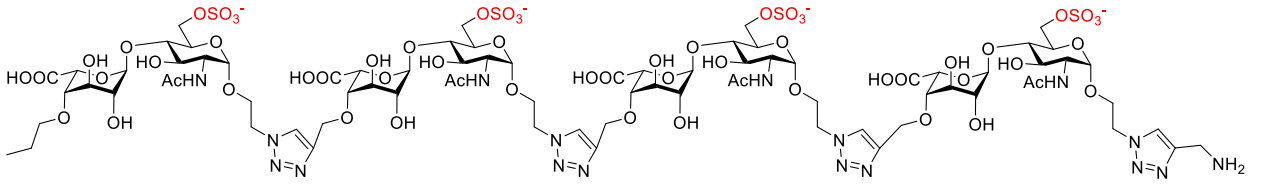
K

The starting material **S32** was treated according to the general procedures of global debenzylation to give compound **K**. ^{1}H NMR (500 MHz, D2O) δ 8.17 (d, J = 41.0 Hz, 2H), 5.14 – 5.00 (m, 5H), 4.70 (d, J = 22.3 Hz, 8H), 4.29 (dt, J = 34.2, 16.4 Hz, 8H), 4.15 (d, J = 11.4 Hz, 4H), 3.97 – 3.82 (m, 5H), 3.77 (d, J = 10.7 Hz, 3H), 3.66 (dt, J = 16.4, 8.4 Hz, 5H), 3.61 – 3.53 (m, 1H), 3.47 (q, J = 7.3 Hz, 1H), 3.34 (d, J = 22.3 Hz, 1H), 1.93 (s, 3H), 1.54 (q, J = 7.0 Hz, 2H), 0.88 (t, J = 7.3 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 175.87, 174.11, 144.31, 125.63, 99.35, 96.76, 96.31, 77.07, 76.55, 74.24, 73.95, 72.55, 72.04, 69.48, 68.91, 68.48, 66.12, 65.93, 65.61, 65.42, 62.71, 62.47, 57.60, 53.55, 50.19, 49.86, 22.32, 21.87, 9.84. HRMS (ESI) ([M+4H]$^-$) Calcd. For $C_{39}H_{62}N_9O_{38}S_5^-$: 1424.28, found 1424.13.



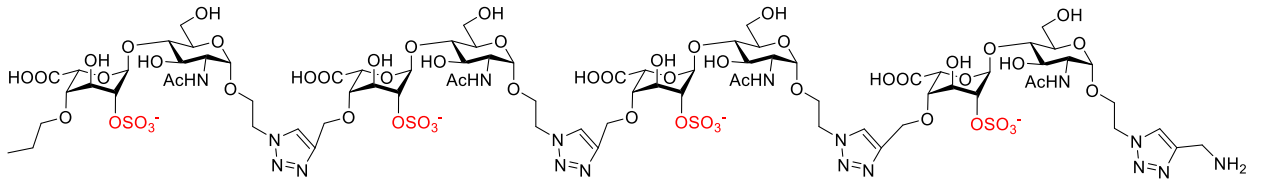
L

The starting material **S33** was treated according to the general procedures of global debenzylation to give compound **L**. ^{1}H NMR (500 MHz, D2O) δ 8.02 (s, 4H), 5.02 (s, 2H), 4.94 (s, 2H), 4.82 (s, 1H), 4.79 (s, 4H), 4.77 (d, J = 5.0 Hz, 4H), 4.74 (s, 2H), 4.73 (s, 2H), 4.67 (s, 2H), 4.67 (s, 1H), 4.63 (d, J = 2.1 Hz, 11H), 4.59 (d, J = 3.9 Hz, 7H), 4.53 (d, J = 2.9 Hz, 2H), 4.45 (d, J = 10.7 Hz, 2H), 4.19 (s, 3H), 4.17 (s, 5H), 4.14 – 4.09 (m, 5H), 4.06 (d, J = 6.5 Hz, 4H), 3.87 – 3.76 (m, 12H), 3.66 (d, J = 11.8 Hz, 6H), 3.61 – 3.54 (m, 8H), 3.51 (d, J = 9.2 Hz, 3H), 3.44 – 3.34 (m, 3H), 3.27 (s, 1H), 2.05 – 1.73 (m, 12H), 1.44 (s, 2H), 0.78 (d, J = 7.6 Hz, 3H). ^{13}C NMR (126 MHz, D2O, obtained from HSQC) δ 178.45, 178.05, 176.88, 176.88, 176.88, 176.88, 176.13, 127.66, 125.32, 124.14, 123.36, 101.88, 99.14, 96.41, 96.41, 78.83, 78.05, 77.27, 76.48, 74.14, 72.58, 72.58, 70.62, 70.62, 70.62, 70.23, 70.23, 69.45, 69.45, 68.67, 67.11, 66.72, 65.94, 65.55, 63.20, 62.42, 62.42, 54.22, 53.44, 52.26, 49.92, 42.89, 42.89, 41.72, 41.33, 40.54, 22.18, 21.79, 21.79, 10.07. HRMS (ESI) ([M-2H]$^{2-}$) Calcd. For $C_{79}H_{119}N_{17}O_{48}^{2-}$: 1036.87, found 1036.86.



M

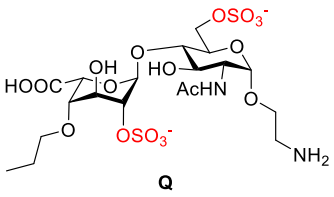
The starting material **S34** was treated according to the general procedures of global debenzylation to give compound **M**. ^{1}H NMR (500 MHz, D2O) δ 8.03 (s, 4H), 4.82 (d, J = 5.1 Hz, 4H), 4.76 (s, 8H), 4.64 (d, J = 7.5 Hz, 6H), 4.61 – 4.58 (m, 6H), 4.57 (s, 2H), 4.55 (s, 2H), 4.47 (d, J = 4.5 Hz, 1H), 4.13 (d, J = 13.8 Hz, 5H), 4.05 (s, 4H), 3.79 (d, J = 22.3 Hz, 10H), 3.69 (s, 1H), 3.63 – 3.50 (m, 9H), 3.47 – 3.42 (m, 2H), 3.27 (d, J = 1.5 Hz, 1H), 1.86 (d, J = 7.5 Hz, 12H), 1.46 (q, J = 7.1 Hz, 2H), 0.78 (t, J = 7.4 Hz, 3H). ^{13}C NMR (126 MHz, D2O, obtained from HSQC) δ 178.05, 178.05, 172.19, 170.02, 169.69, 166.73, 162.04, 161.37, 125.71, 125.71, 102.27, 79.22, 78.83, 77.66, 73.36, 70.62, 70.23, 70.23, 68.67, 66.33, 65.94, 65.55, 63.20, 53.44, 49.92, 22.18, 21.79, 18.28, 9.68. HRMS (ESI) ([M+2H]$^{2-}$) Calcd. For $C_{79}H_{119}N_{17}O_{60}S_4^{2-}$: 1196.78, found 1196.55.



N

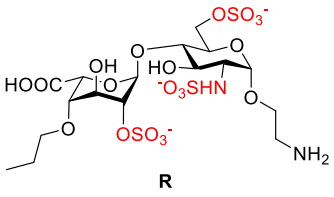
The starting material **S35** was treated according to the general procedures of global debenzylation to give compound **N**. ^{1}H NMR (500 MHz, D2O) δ 8.03 (s, 4H), 4.98 (d, J = 23.5 Hz, 4H), 4.82 – 4.78 (m, 4H), 4.77 (s, 2H), 4.76 (s, 3H),

4.74 (d, J = 1.6 Hz, 8H), 4.68 – 4.66 (m, 14H), 4.64 (d, J = 7.3 Hz, 6H), 4.63 – 4.61 (m, 3H), 4.58 (d, J = 8.5 Hz, 7H), 4.46 (s, 1H), 4.17 – 4.09 (m, 8H), 4.03 (s, 4H), 3.81 (d, J = 19.4 Hz, 7H), 3.77 – 3.68 (m, 10H), 3.67 – 3.62 (m, 5H), 3.56 (dd, J = 18.9, 9.5 Hz, 6H), 3.41 – 3.33 (m, 2H), 1.85 (s, 12H), 1.45 (q, J = 7.1 Hz, 2H), 1.18 (s, 2H), 0.79 (t, J = 7.4 Hz, 3H). ^{13}C NMR (126 MHz, D2O, obtained from HSQC) δ 178.84, 178.84, 178.45, 177.66, 129.61, 125.32, 99.14, 96.41, 76.87, 76.09, 75.70, 73.75, 72.19, 72.19, 71.01, 69.06, 67.89, 65.55, 65.55, 65.16, 62.81, 59.69, 53.83, 49.53, 22.18, 21.79, 9.68. HRMS (ESI) ([M+2H]$^{2-}$) Calcd. For $C_{79}H_{119}N_{17}O_{60}S_4^{2-}$: 1197.28, found 1197.24.



Q

The starting material **19** was treated according to the general debenzylation procedures of global to give compound **Q**. ^{1}H NMR (500 MHz, D2O) δ 5.08 (s, 1H), 4.83 (s, 1H), 4.61 (d, J = 2.7 Hz, 1H), 4.32 (d, J = 11.5 Hz, 1H), 4.22 – 4.14 (m, 3H), 4.08 – 3.74 (m, 5H), 3.66 (d, J = 14.6 Hz, 2H), 3.56 (q, J = 8.0 Hz, 2H), 3.40 (t, J = 7.4 Hz, 1H), 3.14 (d, J = 6.8 Hz, 1H), 1.95 (s, 3H), 1.45 (q, J = 7.2 Hz, 2H), 1.00 (s, 2H), 0.79 (t, J = 7.0 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 175.75, 174.38, 99.25, 96.91, 77.89, 76.69, 74.55, 72.60, 69.55, 69.07, 68.74, 67.21, 66.23, 53.38, 39.24, 22.33, 21.84, 9.84. HRMS (ESI) ([M+H]$^-$) Calcd. For $C_{19}H_{33}N_2O_{18}S_2^-$: 641.12, found 641.18.

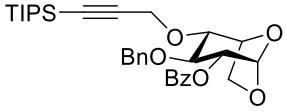


R

The starting material **21** was treated according to the general debenzylation procedures of global to give compound **R**. ^{1}H NMR (500 MHz, D2O) δ 5.14 – 5.08 (m, 2H), 4.65 (s, 2H), 4.33 – 4.14 (m, 4H), 4.02 – 3.87 (m, 2H), 3.70 – 3.53 (m, 5H), 3.39 (d, J = 8.0 Hz, 1H), 3.27 – 3.19 (m, 2H), 1.46 (q, J = 7.1 Hz, 2H), 0.79 (t, J = 7.5 Hz, 3H). ^{13}C NMR (126 MHz, D2O) δ 96.89, 77.72, 76.61, 74.34, 72.59, 69.61, 68.79, 68.65, 67.18, 65.99, 63.86, 57.72, 39.07, 22.32, 9.84. HRMS (ESI) ([M+2H]$^-$) Calcd. For $C_{17}H_{31}N_2O_{20}S_3^-$: 679.06, found 679.13.

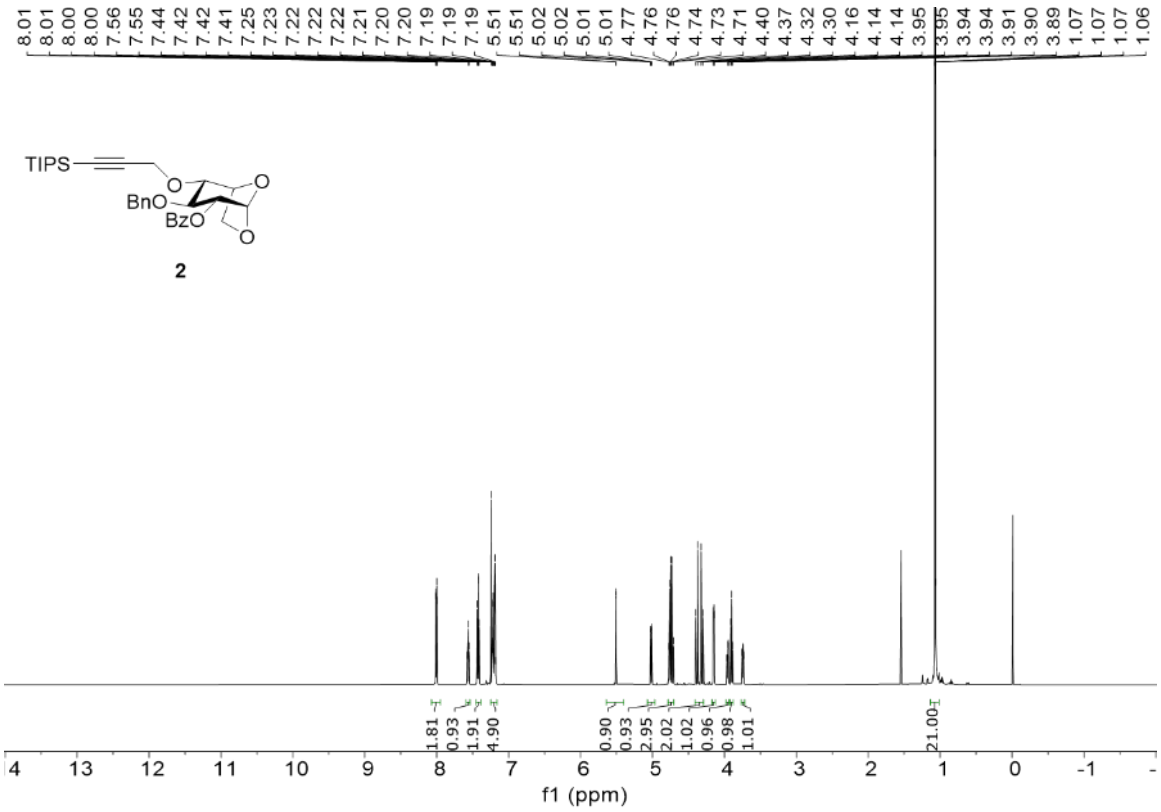
NMR and Mass spectra

Characterization of 2

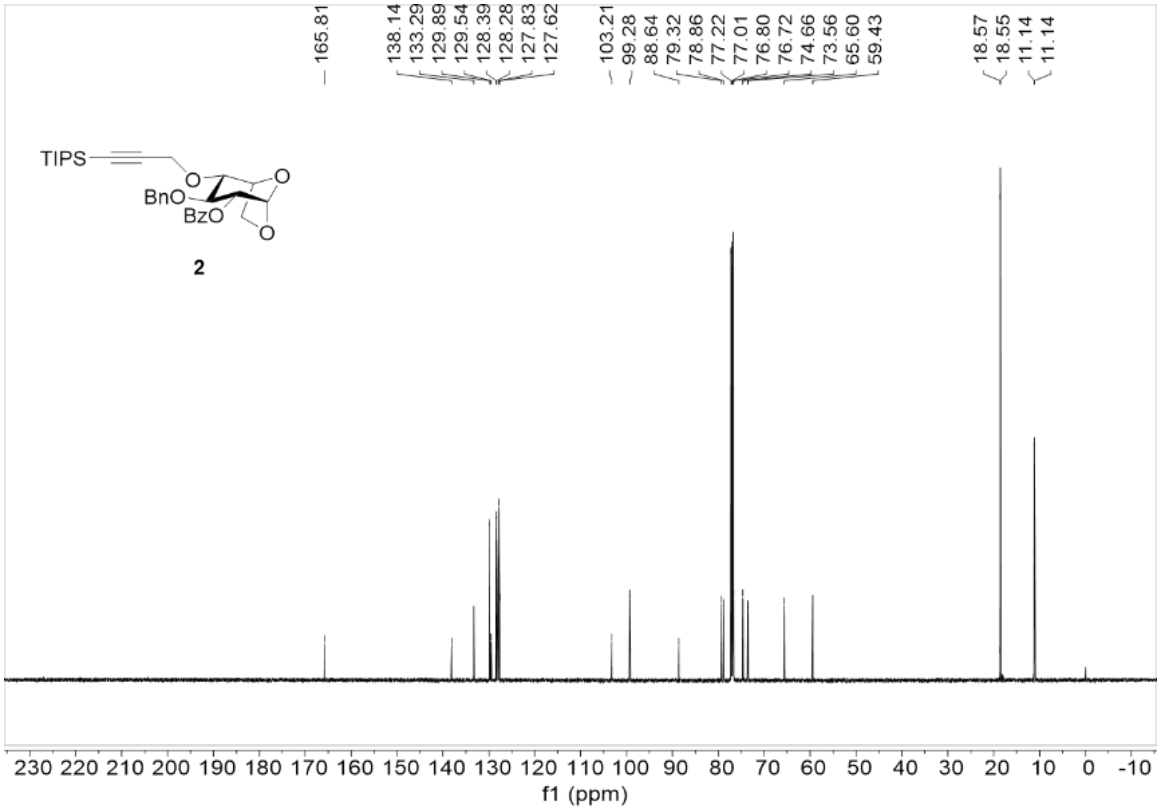


2

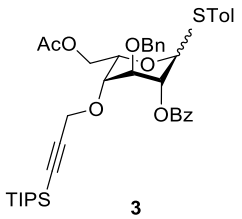
^{1}H NMR of 2



^{13}C NMR of 2

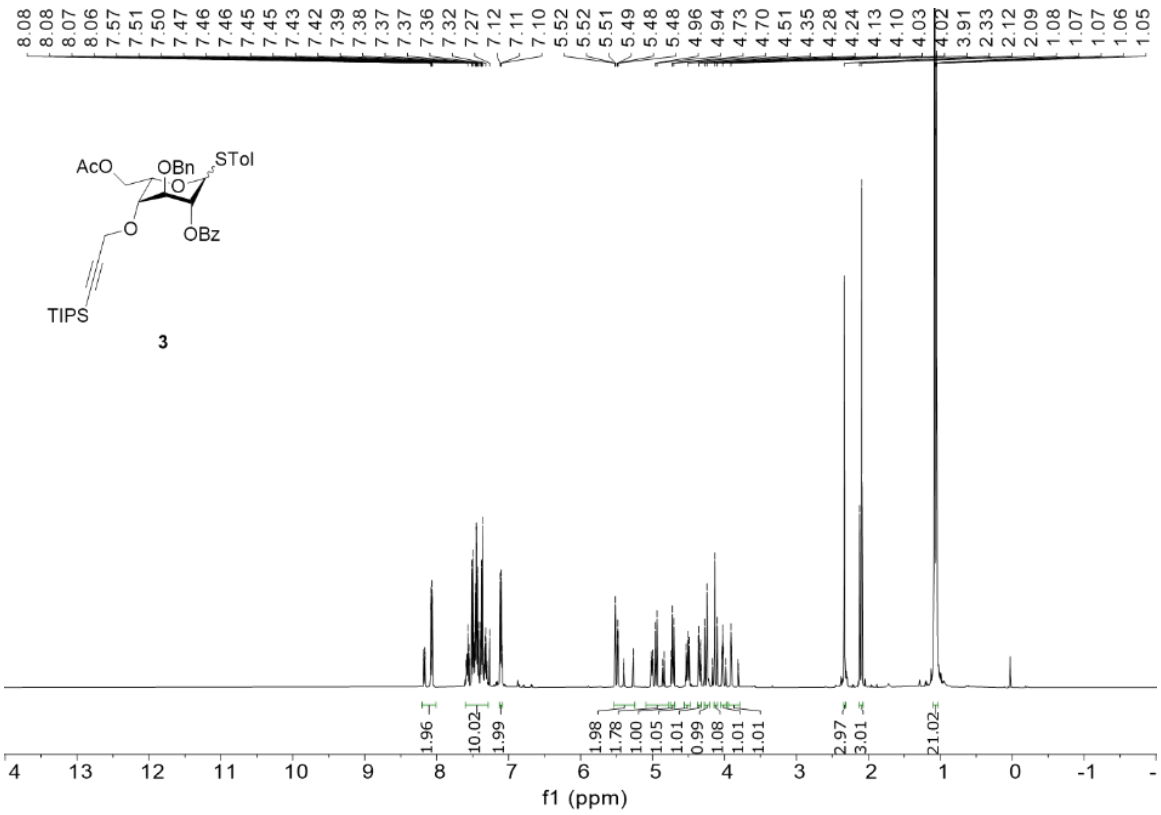

165.81
138.14
133.29
129.89
129.54
128.39
128.28
127.83
127.62
103.21
99.28
88.64
79.32
78.86
77.22
77.01
76.80
76.72
74.66
73.56
65.60
59.43
18.57
18.55
11.14
11.14
TIPS
BnO
BzO
O
O
O
2
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of 3

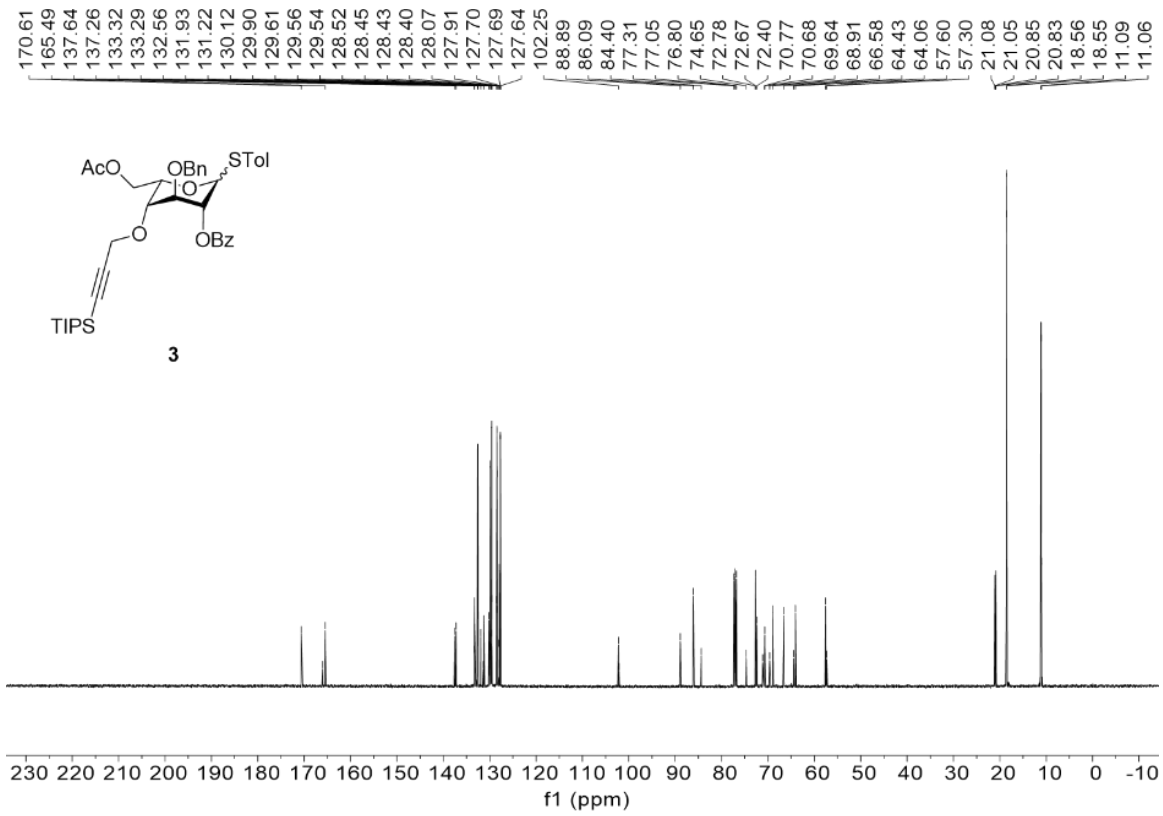


3

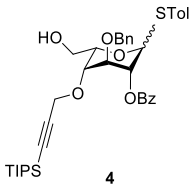
^{1}H NMR of 3



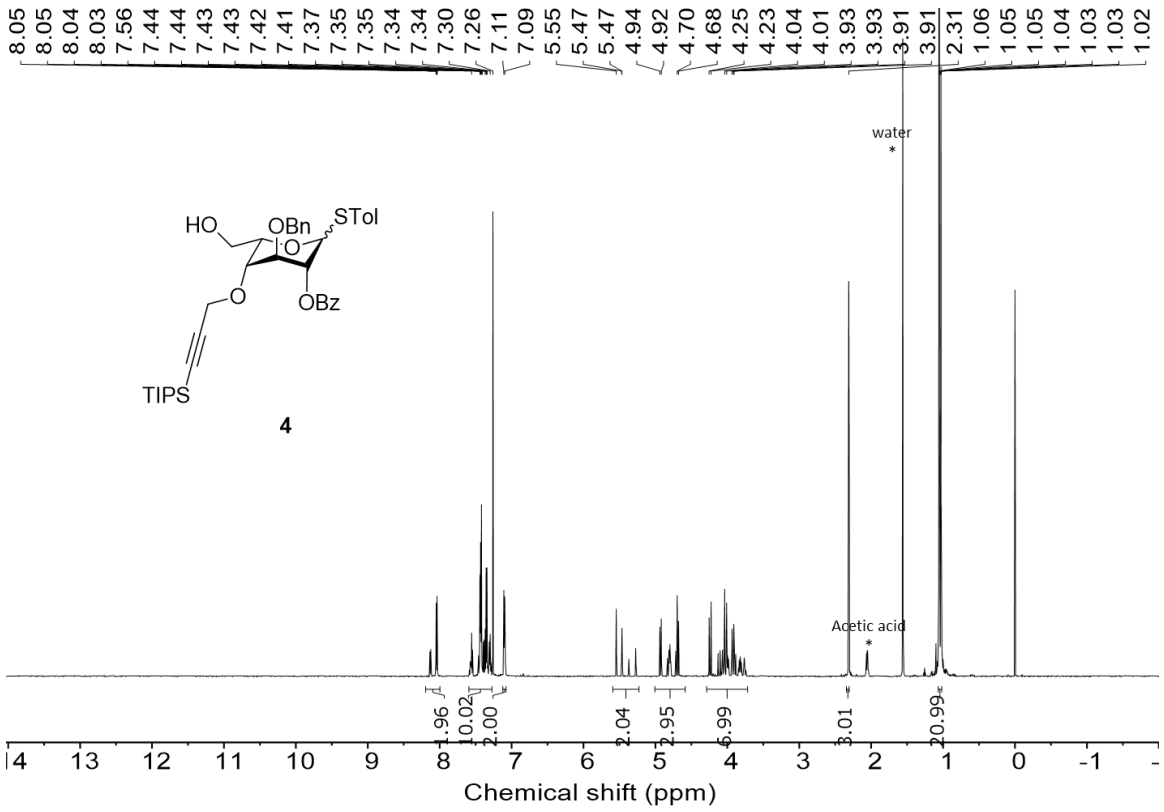
^{13}C NMR of 3


170.61
165.49
137.64
137.26
133.32
133.29
132.56
131.93
131.22
130.12
129.90
129.61
129.56
129.54
128.52
128.45
128.43
128.40
128.07
127.91
127.70
127.69
127.64
102.25
88.89
86.09
84.40
77.31
77.05
76.80
74.65
72.78
72.67
72.40
70.77
70.68
69.64
68.91
66.58
64.43
64.06
57.60
57.30
21.08
21.05
20.85
20.83
18.56
18.55
11.09
11.06
AcO
OBn
STol
O
O
OBz
TIPS
3
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

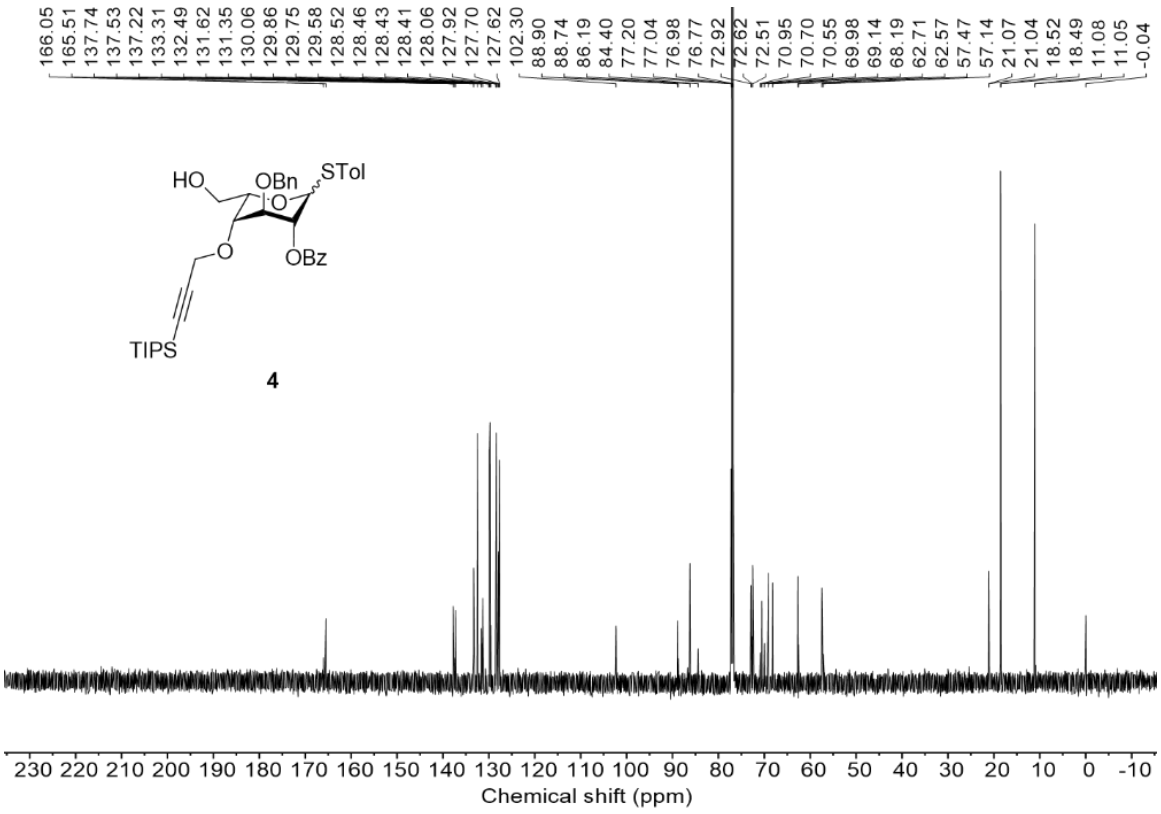
Characterization of 4



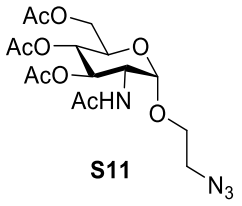
^{1}H NMR of 4



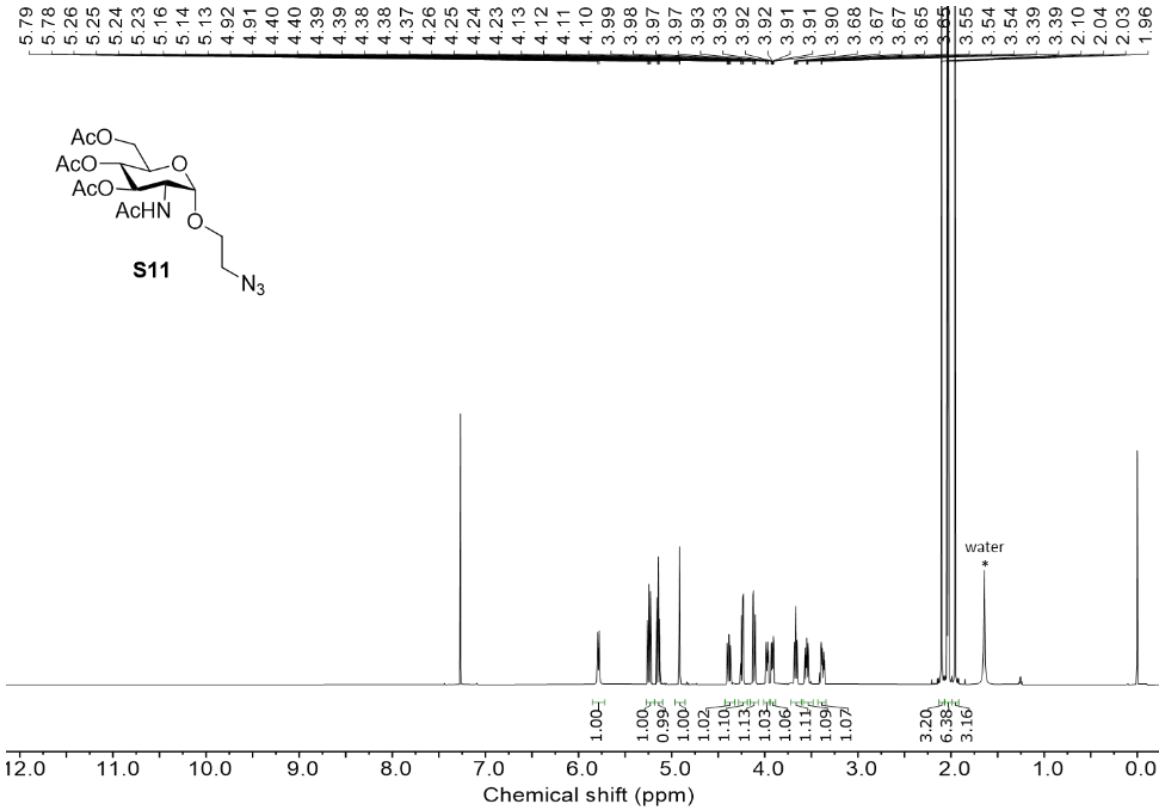
^{13}C NMR of 4


166.05
165.51
137.74
137.53
137.22
133.31
132.49
131.62
131.35
130.06
129.86
129.75
129.58
128.52
128.46
128.43
128.41
128.06
127.92
127.70
127.62
102.30
88.90
88.74
86.19
84.40
77.20
77.04
76.98
76.77
72.92
72.62
72.51
70.95
70.70
70.55
69.98
69.14
68.19
62.71
62.57
57.47
57.14
21.07
21.04
18.52
18.49
11.08
11.05
-0.04
HO
OBn
STol
O
O
OBz
TIPS
4
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

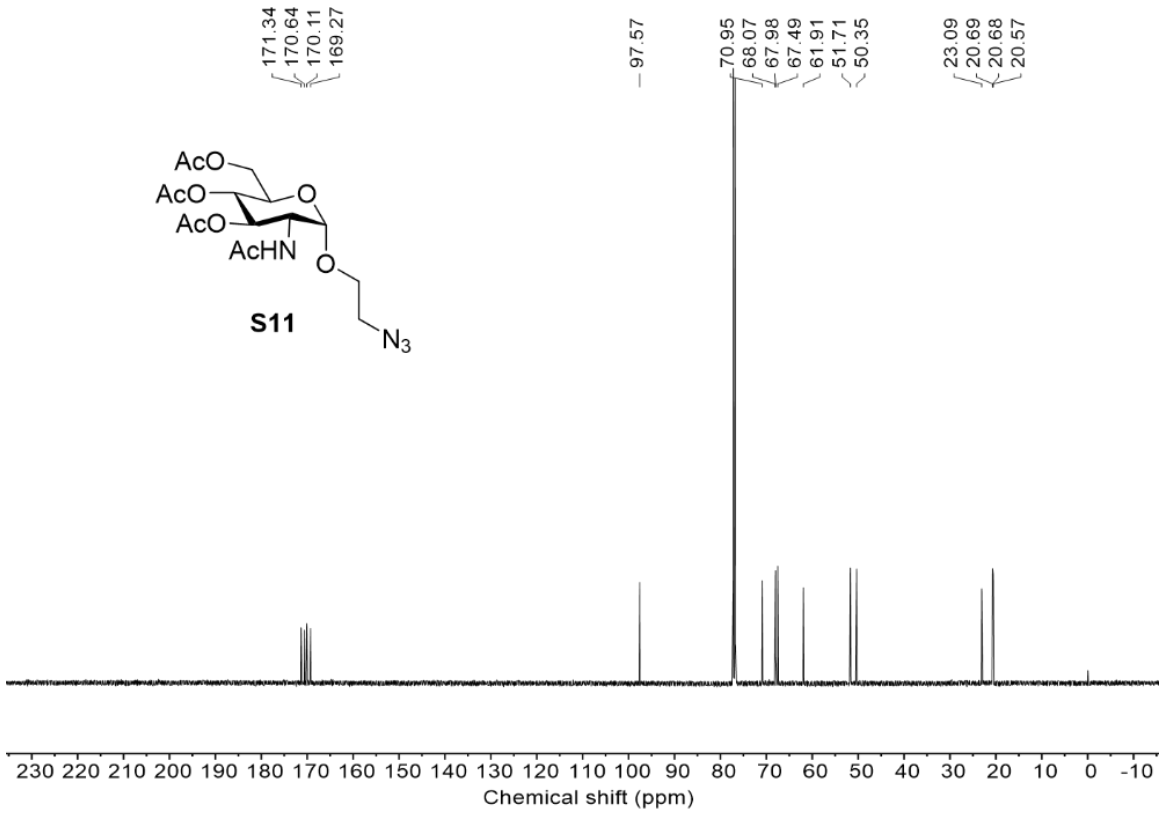
Characterization of S11



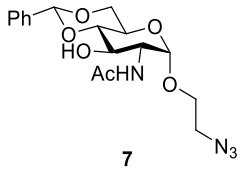
^{1}H NMR of S11



^{13}C NMR of S11

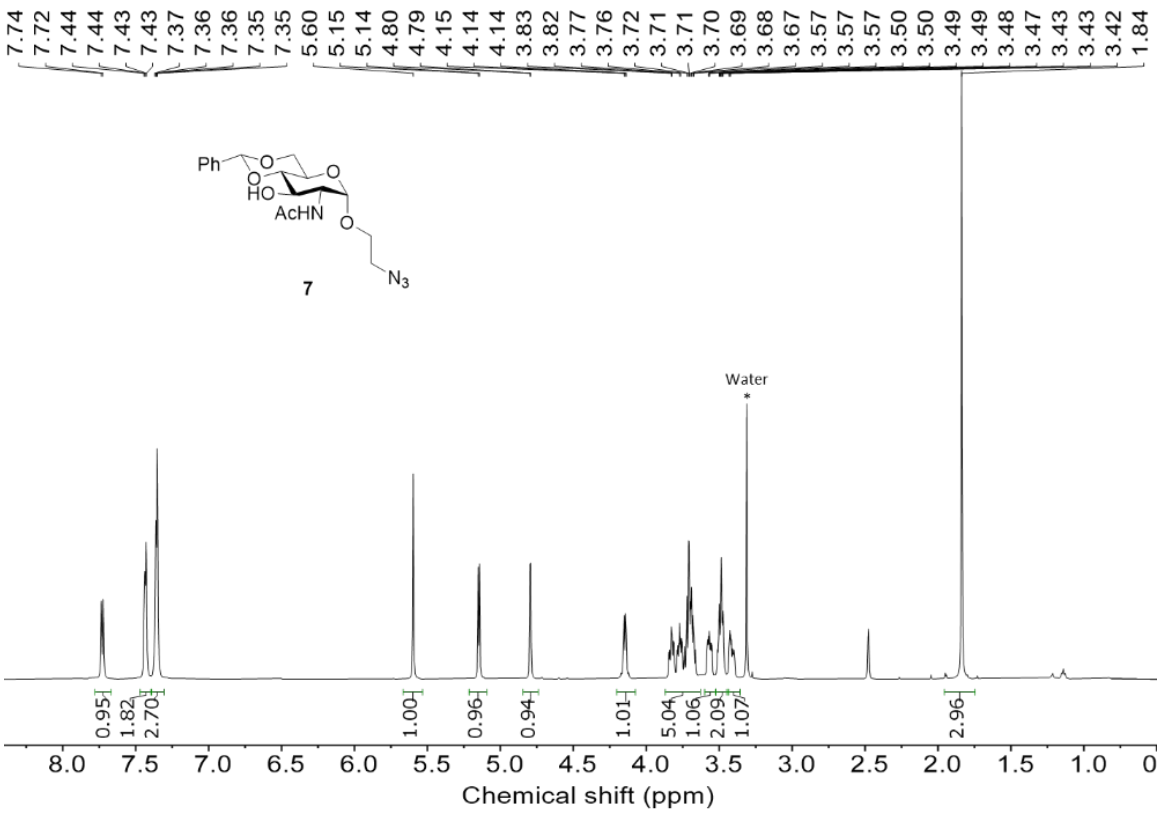

171.34
170.64
170.11
169.27
97.57
70.95
68.07
67.98
67.49
61.91
51.71
50.35
23.09
20.69
20.68
20.57
AcO
AcO
AcO
AcHN
O
O
N3
S11
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of 7

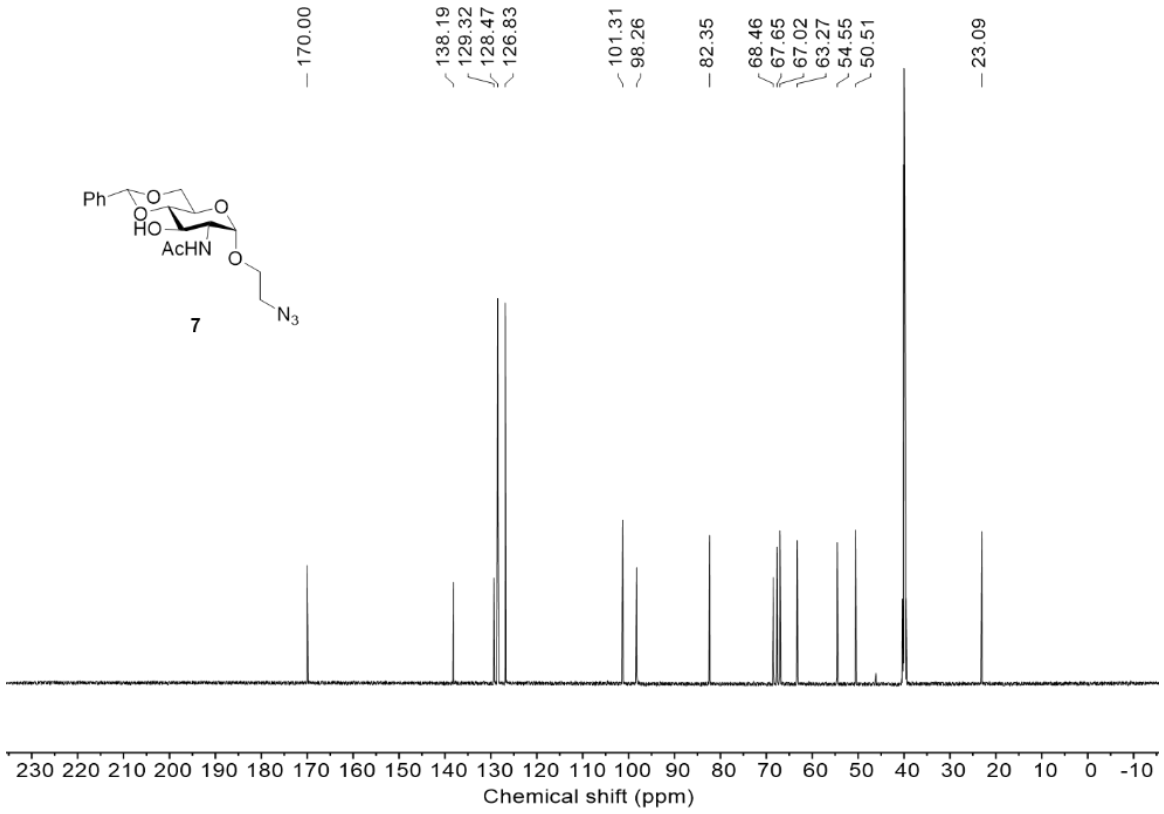


7

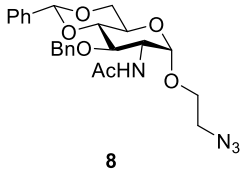
^{1}H NMR of 7



^{13}C NMR of 7

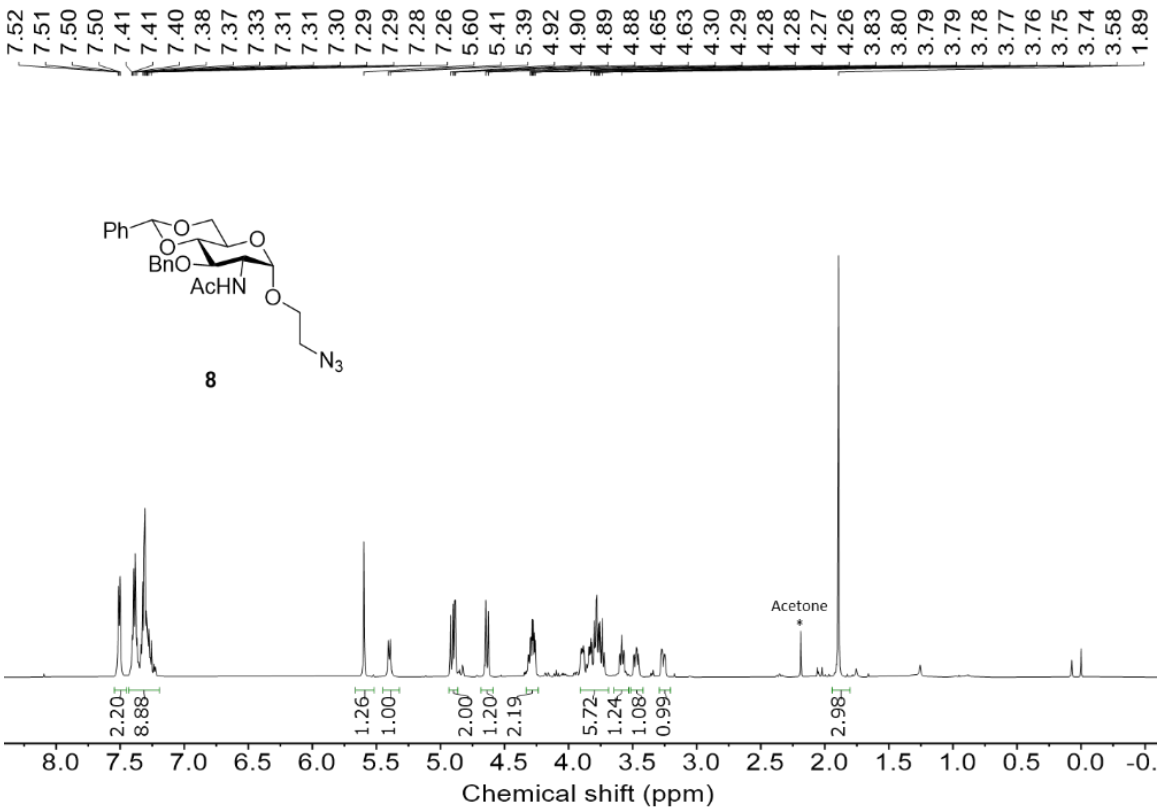

170.00
138.19
129.32
128.47
126.83
101.31
98.26
82.35
68.46
67.65
67.02
63.27
54.55
50.51
23.09
Ph
O
O
HO
AcHN
O
O
N_3
7
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of 8

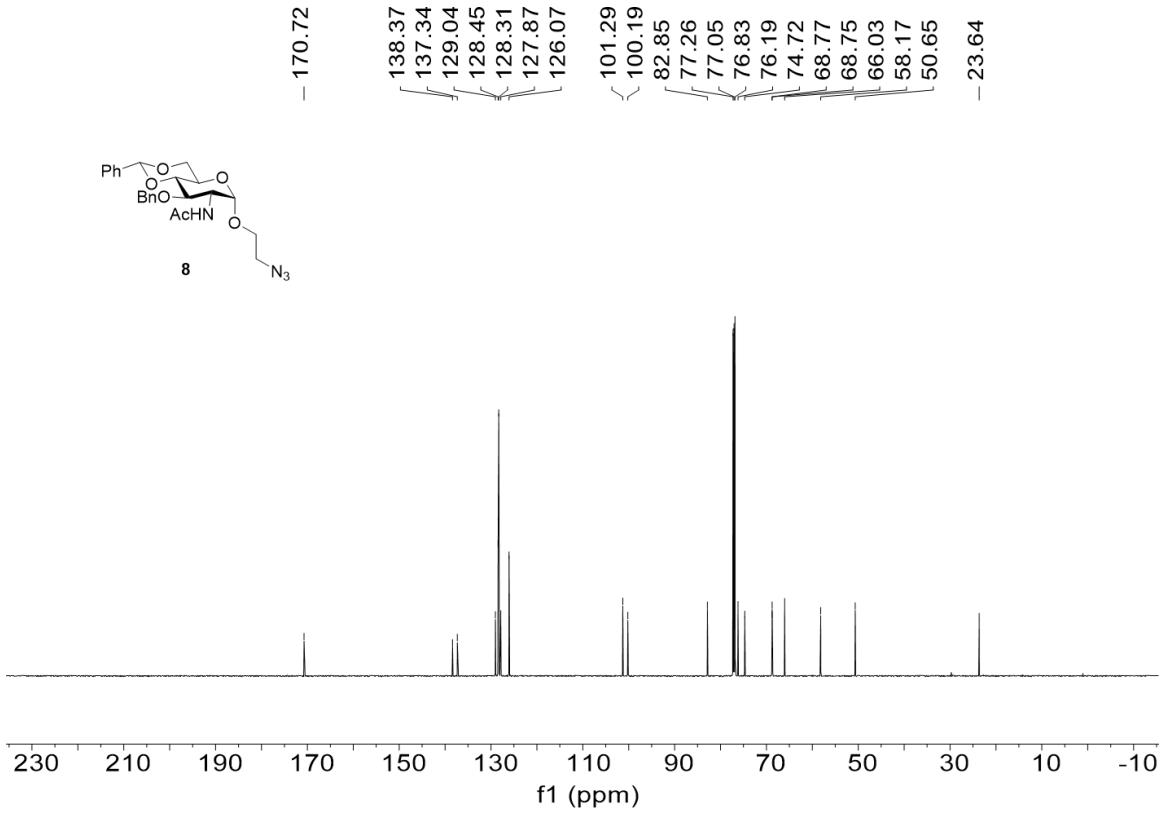


8

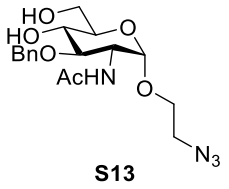
^{1}H NMR of 8



^{13}C NMR of 8

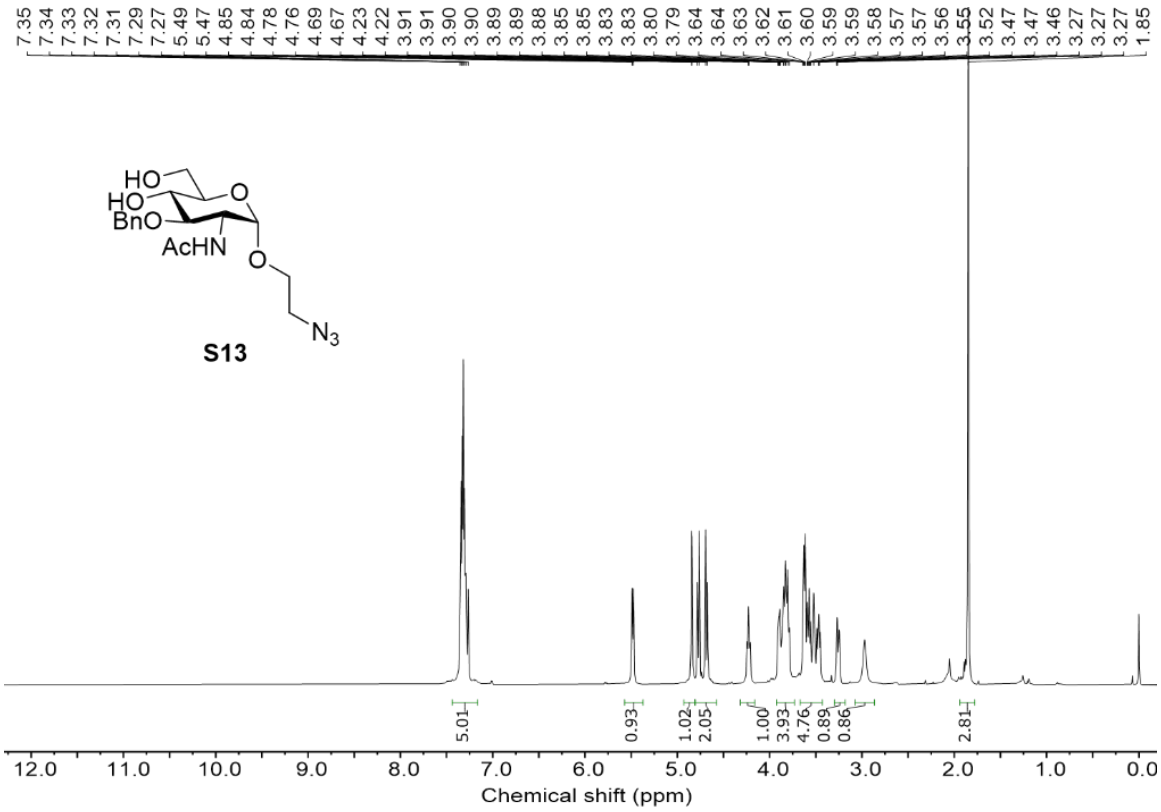

170.72
138.37
137.34
129.04
128.45
128.31
127.87
126.07
101.29
100.19
82.85
77.26
77.05
76.83
76.19
74.72
68.77
68.75
66.03
58.17
50.65
23.64
Ph
BnO
AcHN
N3
8
230
210
190
170
150
130
110
90
70
50
30
10
-10
f1 (ppm)

Characterization of S13

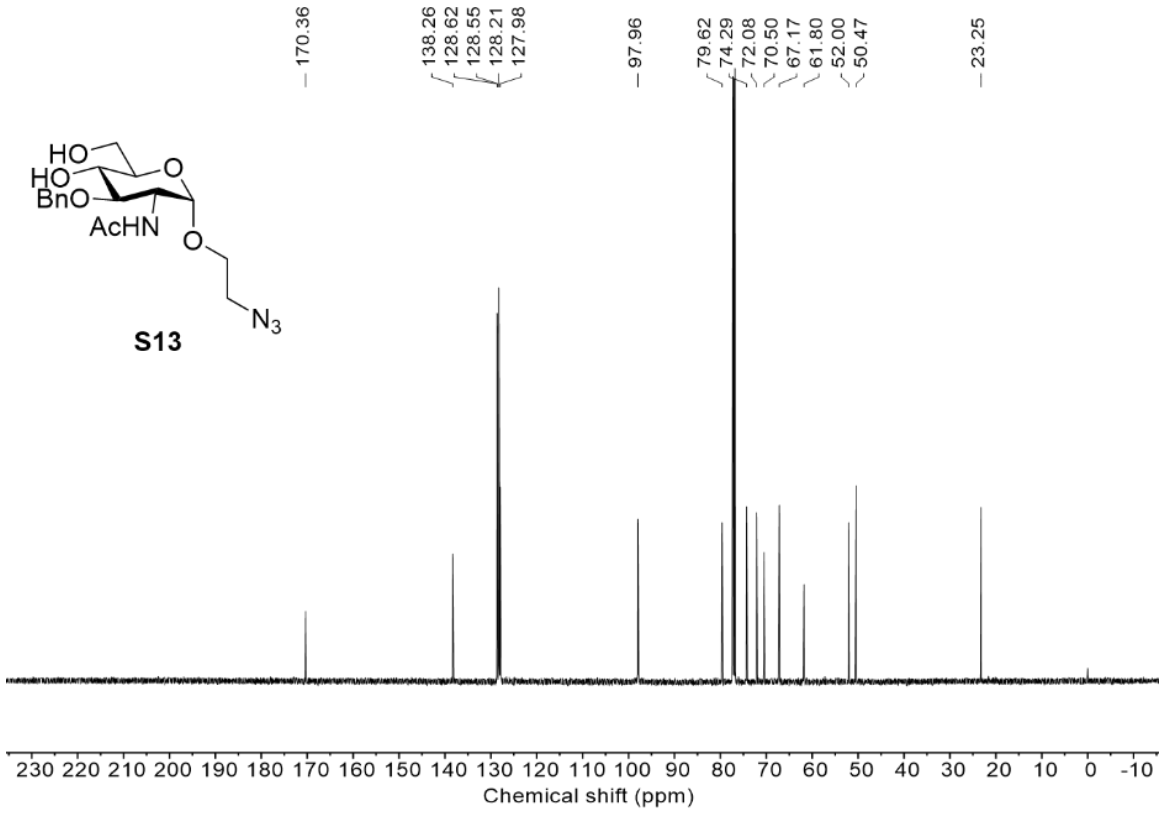


S13

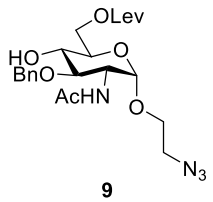
^{1}H NMR of S13



^{13}C NMR of S13

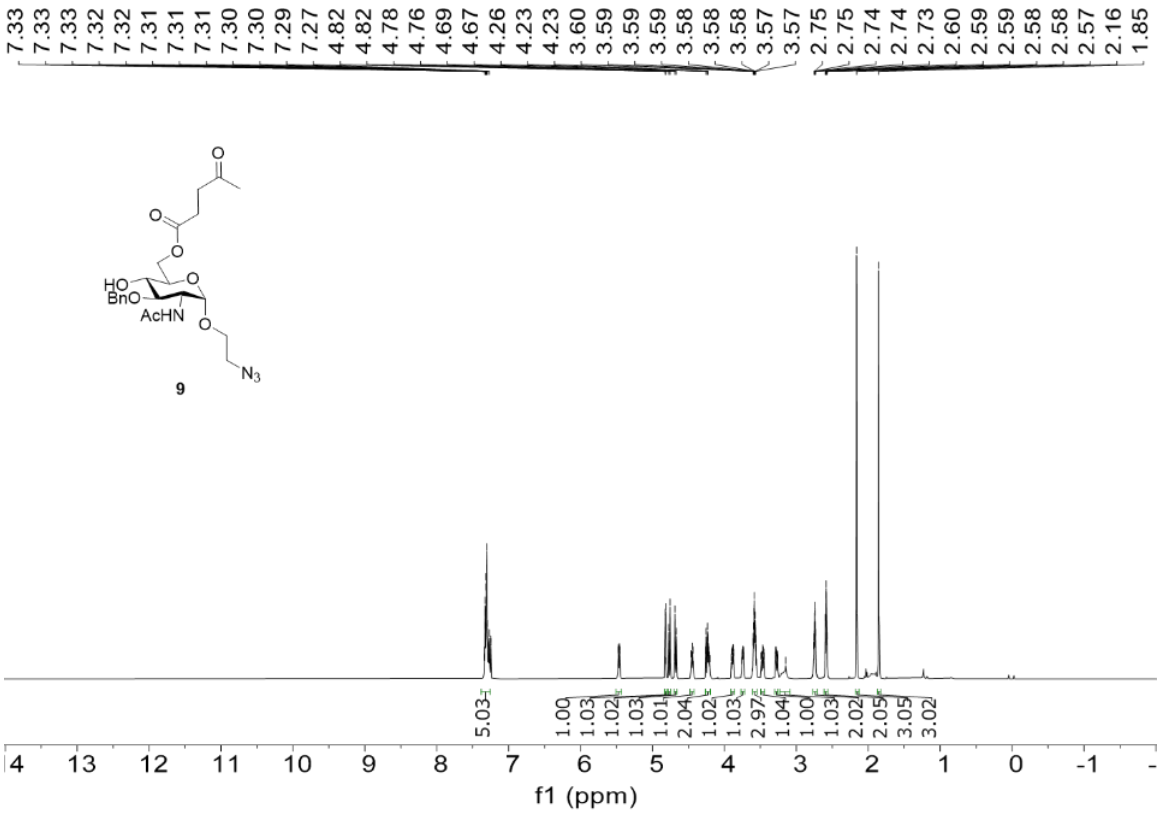

170.36
138.26
128.62
128.55
128.21
127.98
97.96
79.62
74.29
72.08
70.50
67.17
61.80
52.00
50.47
23.25
HO
HO
BnO
AcHN
O
O
N3
S13
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of 9

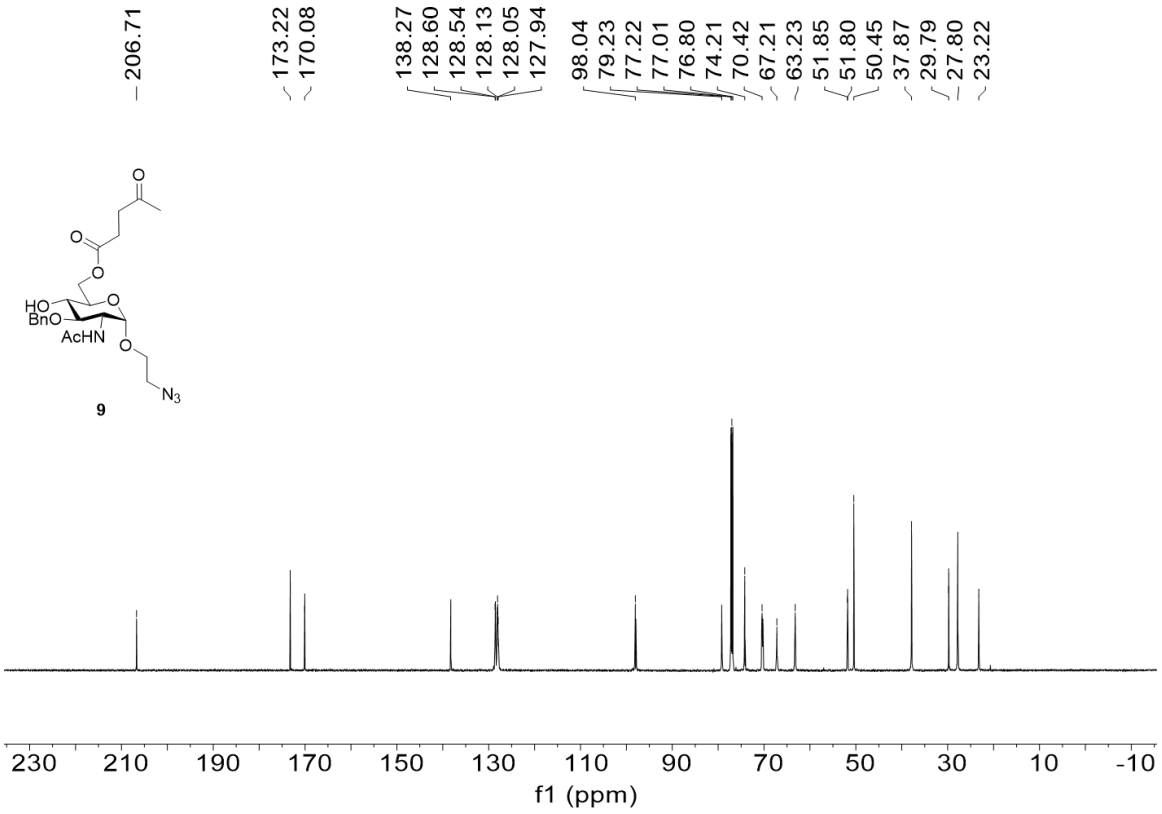


9

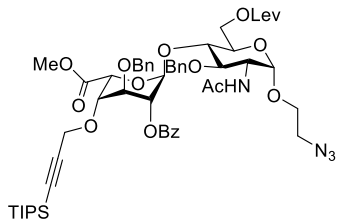
^{1}H NMR of 9



^{13}C NMR of 9

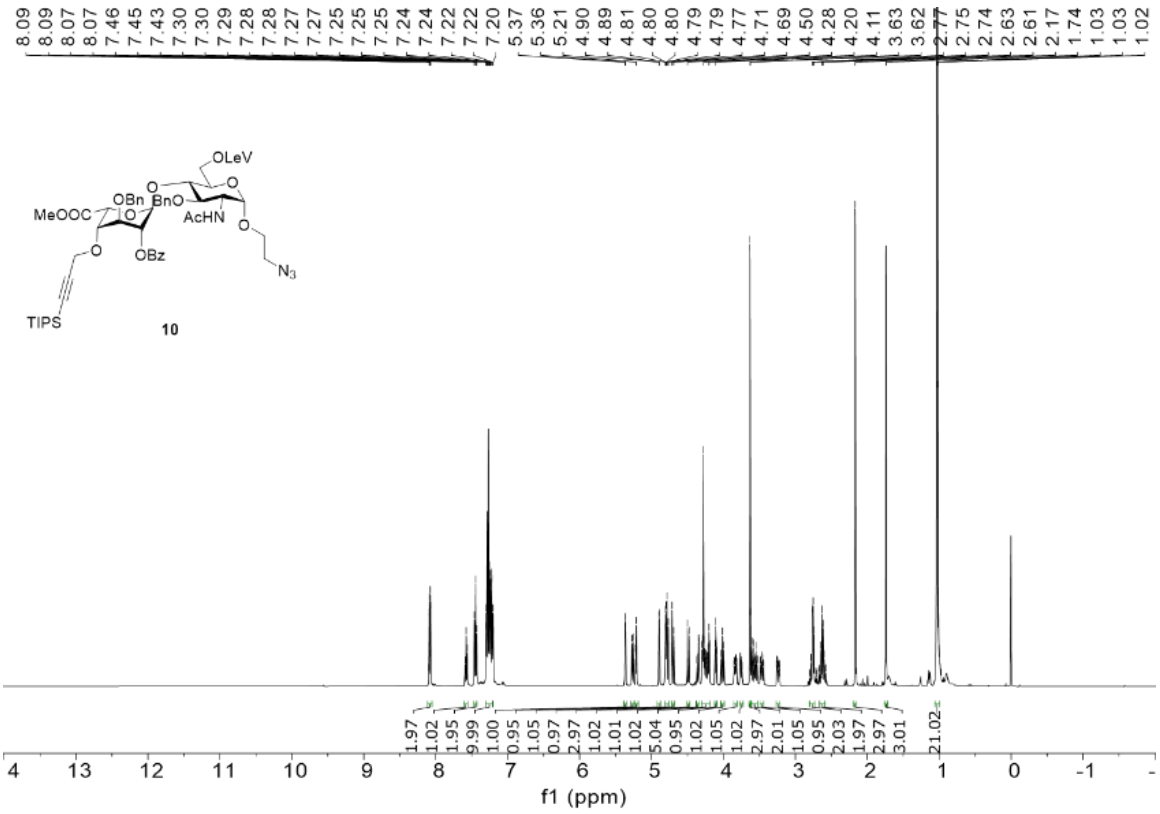

206.71
173.22
170.08
138.27
128.60
128.54
128.13
128.05
127.94
98.04
79.23
77.22
77.01
76.80
74.21
70.42
67.21
63.23
51.85
51.80
50.45
37.87
29.79
27.80
23.22
HO
BnO
AcHN
N3
9
230
210
190
170
150
130
110
90
70
50
30
10
-10
f1 (ppm)

Characterization of 10

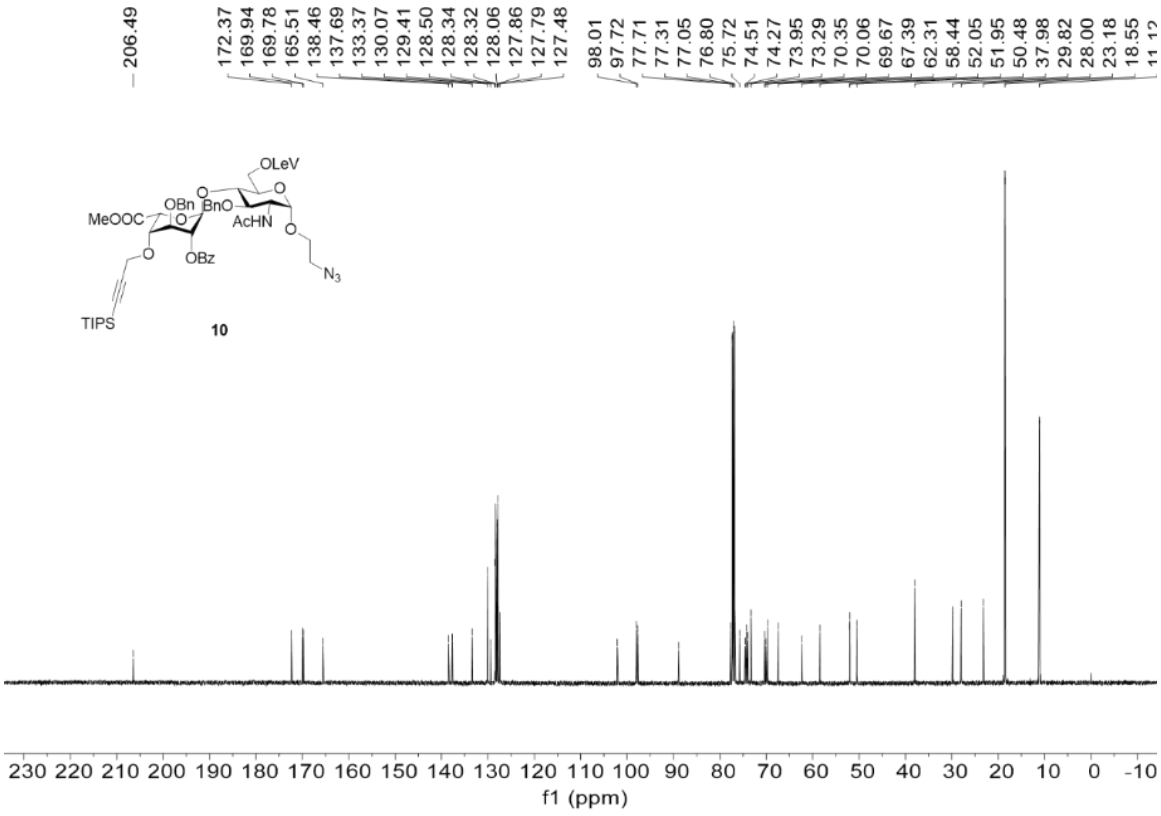


10

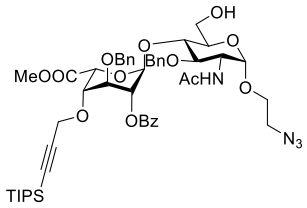
^{1}H NMR of 10



^{13}C NMR of 10

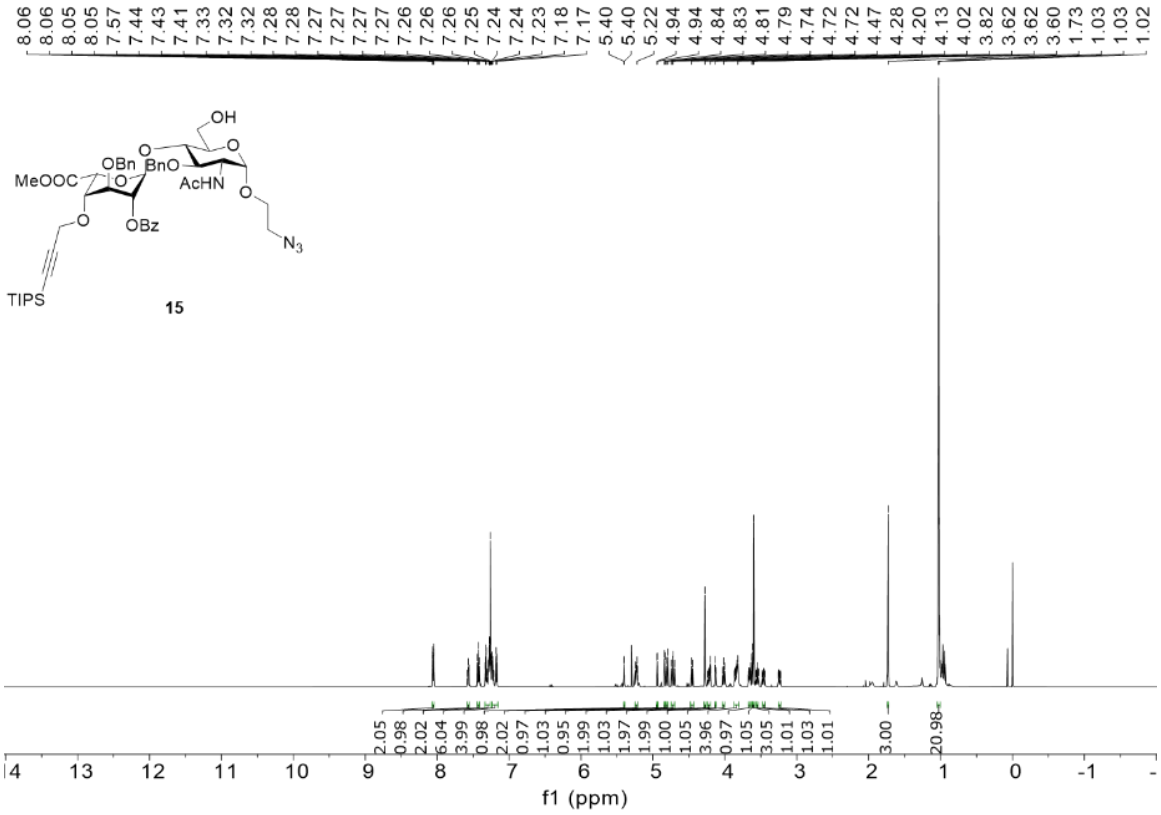

206.49
172.37
169.94
169.78
165.51
138.46
137.69
133.37
130.07
129.41
128.50
128.34
128.32
128.06
127.86
127.79
127.48
98.01
97.72
77.71
77.31
77.05
76.80
75.72
74.51
74.27
73.95
73.29
70.35
70.06
69.67
67.39
62.31
58.44
52.05
51.95
50.48
37.98
29.82
28.00
23.18
18.55
OLeV
OBn
BnO
AcHN
MeOOC
OBz
N3
TIPS
10
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of 15

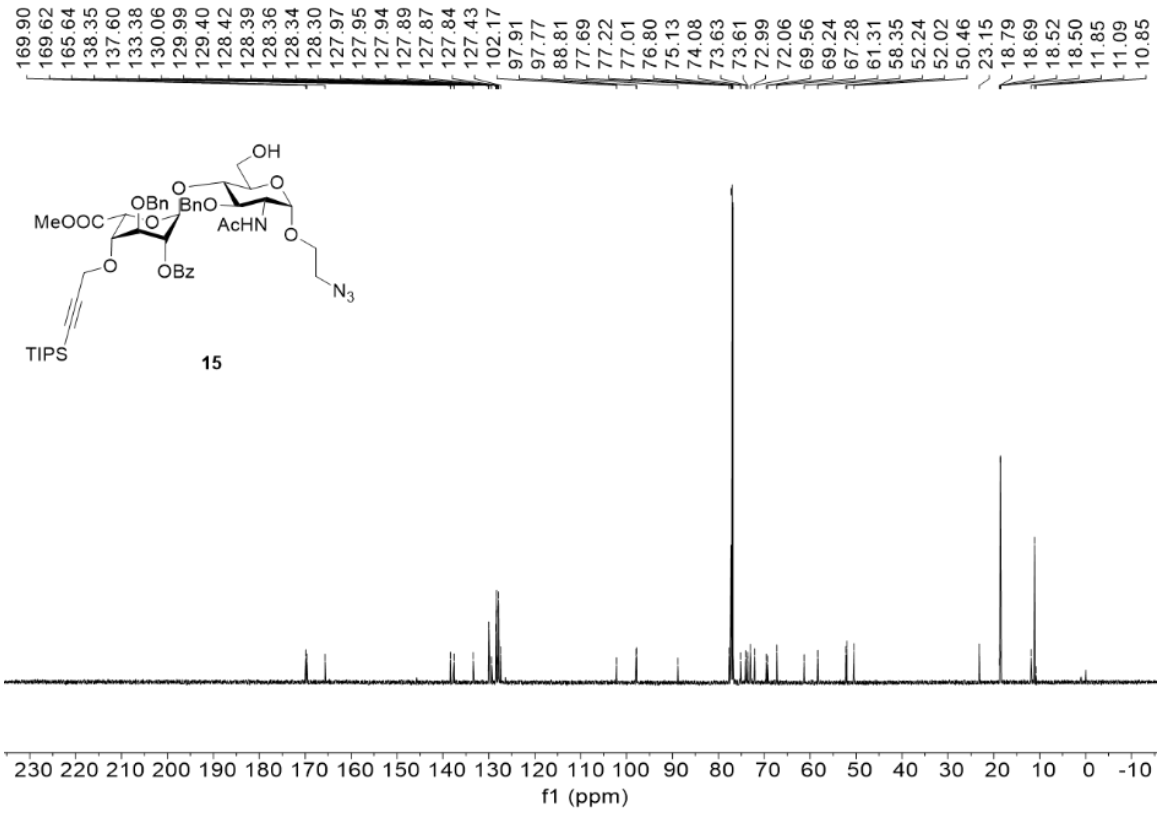


15

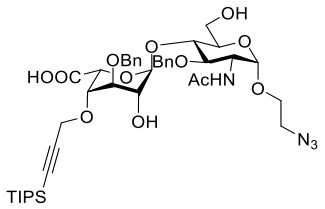
^{1}H NMR of 15



^{13}C NMR of 15

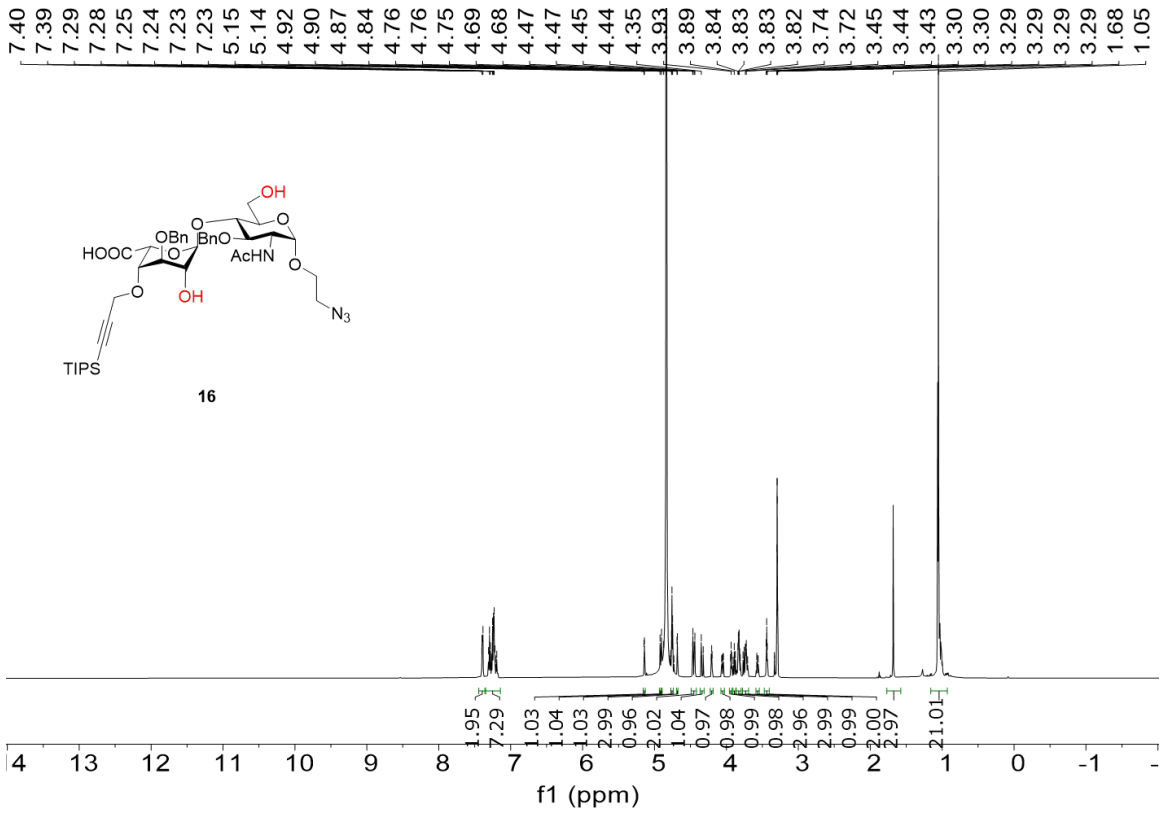

169.90
169.62
165.64
138.35
137.60
133.38
130.06
129.99
129.40
128.42
128.39
128.36
128.34
128.30
127.97
127.95
127.94
127.89
127.87
127.84
127.43
102.17
97.91
97.77
88.81
77.69
77.22
77.01
76.80
75.13
74.08
73.63
73.61
72.99
72.06
69.56
69.24
67.28
61.31
58.35
52.24
52.02
50.46
23.15
18.79
18.69
18.52
18.50
11.85
11.09
10.85
OH
O
OBn
BnO
AcHN
MeOOC
O
O
O
OBz
N3
TIPS
15
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of 16

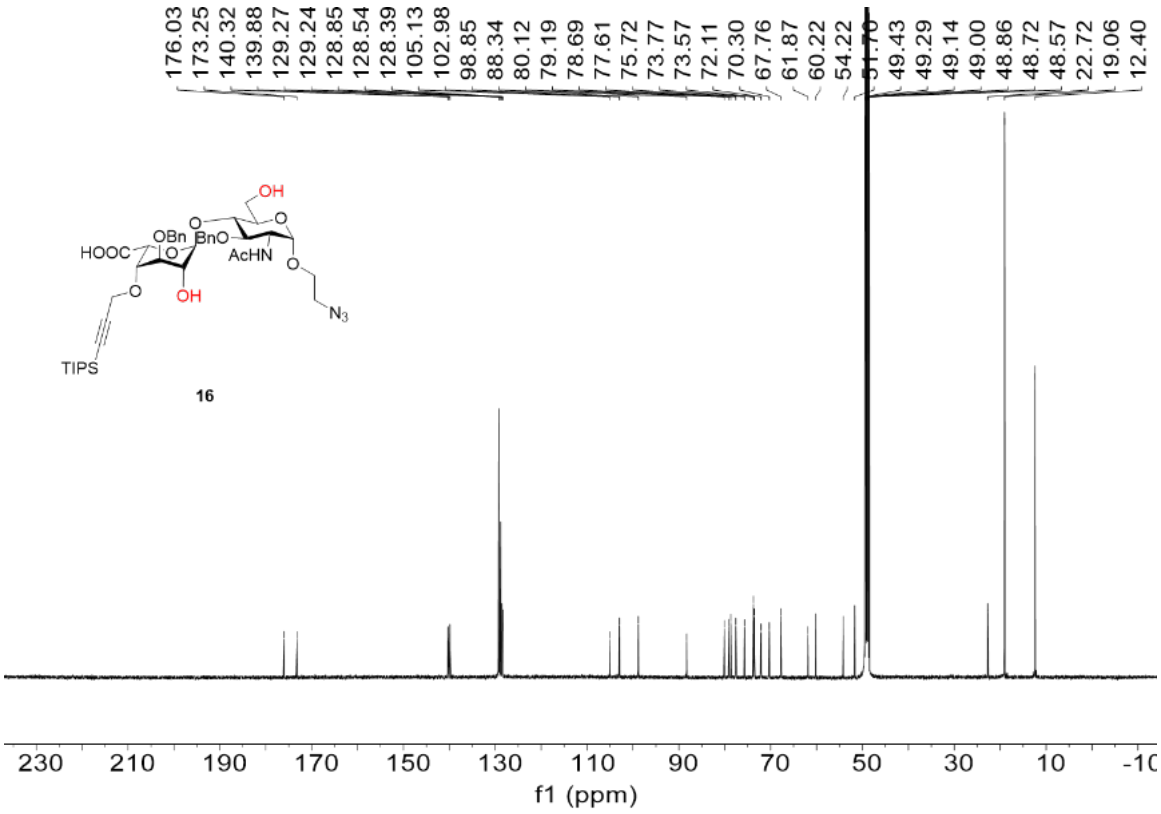


16

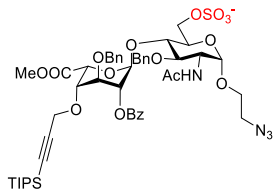
^{1}H NMR of 16



^{13}C NMR of 16

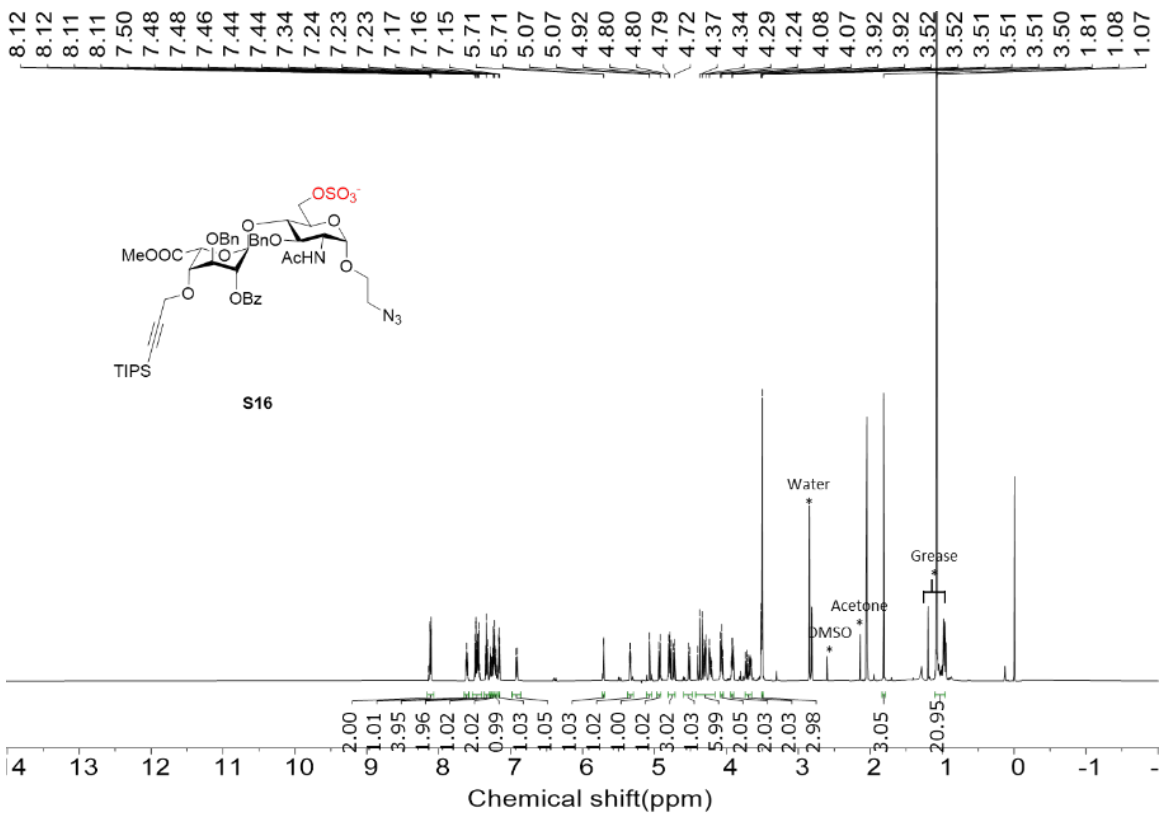

176.03
173.25
140.32
139.88
129.27
129.24
128.85
128.54
128.39
105.13
102.98
98.85
88.34
80.12
79.19
78.69
77.61
75.72
73.77
73.57
72.11
70.30
67.76
61.87
60.22
54.22
51.70
49.43
49.29
49.14
49.00
48.86
48.72
48.57
22.72
19.06
12.40
OH
O
O
OBn
BnO
AcHN
HOOC
O
O
OH
O
N3
TIPS
16
230
210
190
170
150
130
110
90
70
50
30
10
-10
f1 (ppm)

Characterization of S16

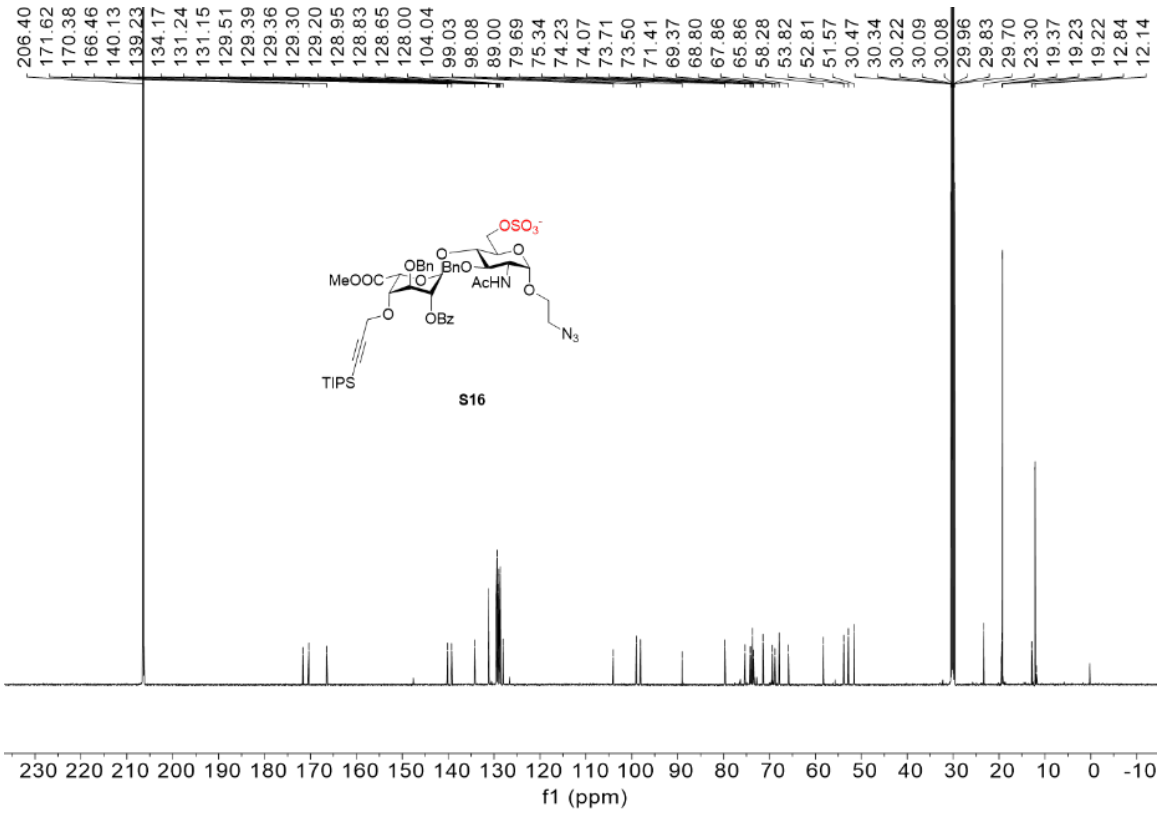


S16

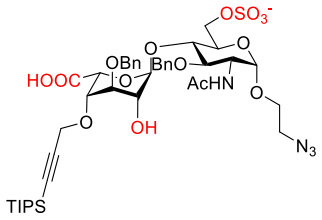
^{1}H NMR of S16



^{13}C NMR of S16

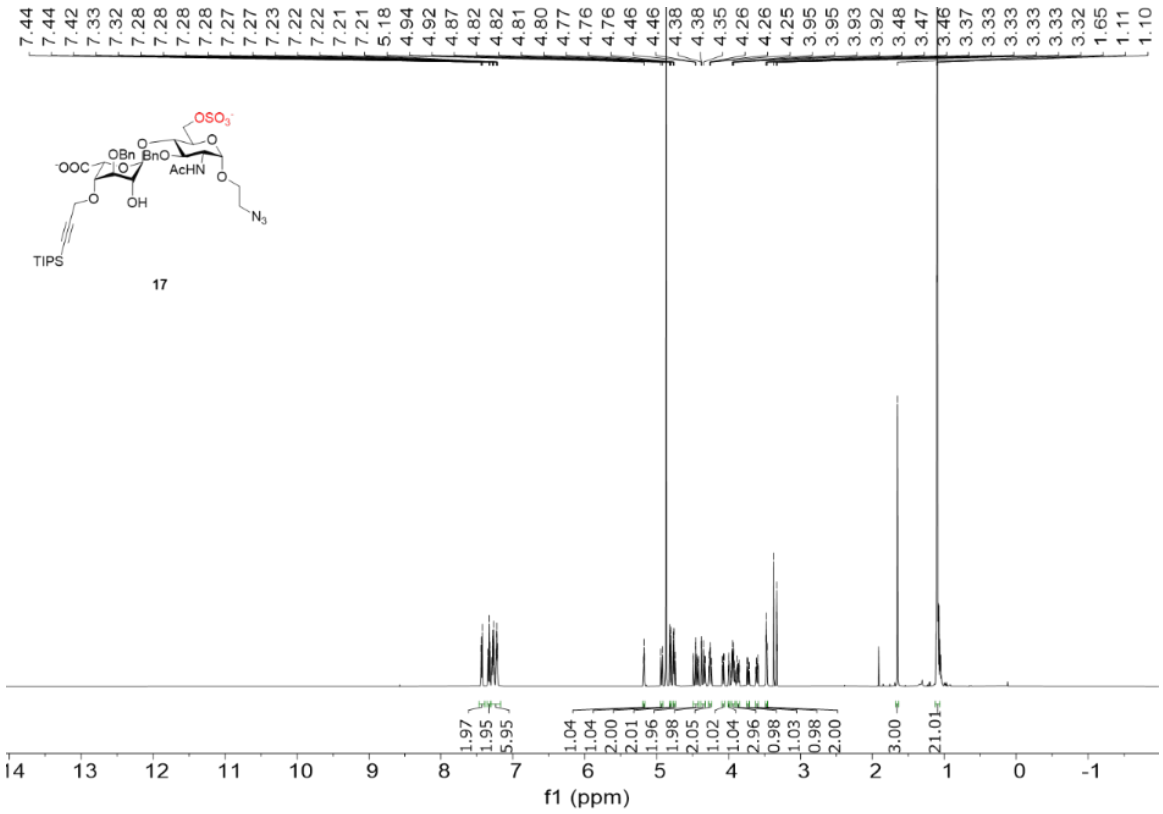

206.40
171.62
170.38
166.46
140.13
139.23
134.17
131.24
131.15
129.51
129.39
129.36
129.30
129.20
128.95
128.83
128.65
128.00
104.04
99.03
98.08
89.00
79.69
75.34
74.23
74.07
73.71
73.50
71.41
69.37
68.80
67.86
65.86
58.28
53.82
52.81
51.57
30.47
30.34
30.22
30.09
30.08
29.96
29.83
29.70
23.30
19.37
19.23
19.22
12.84
12.14
OSO3-
MeOOC
OBn
BnO
AcHN
OBz
N3
TIPS
S16
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of 17



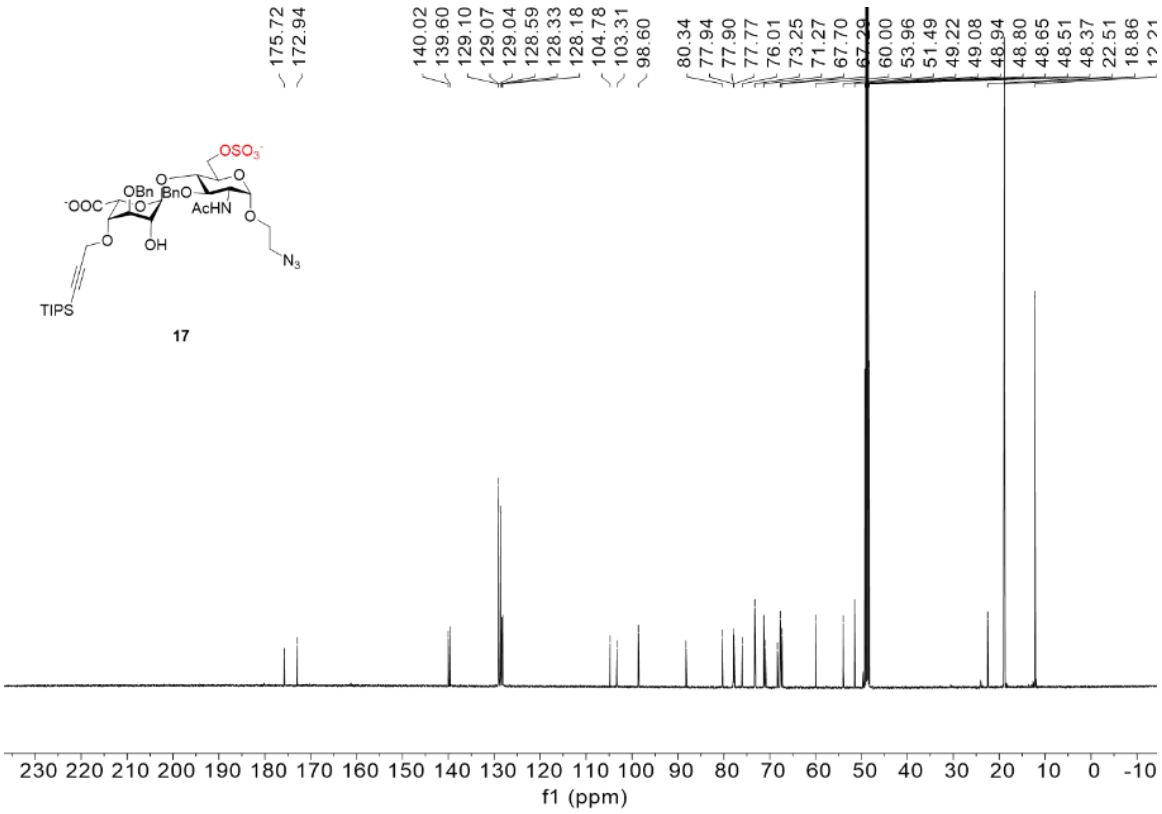
17

^{1}H NMR of 17

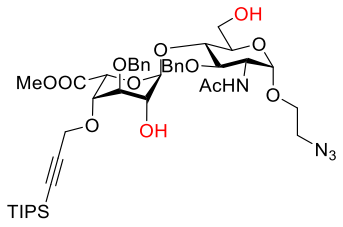


17

^{13}C NMR of 17

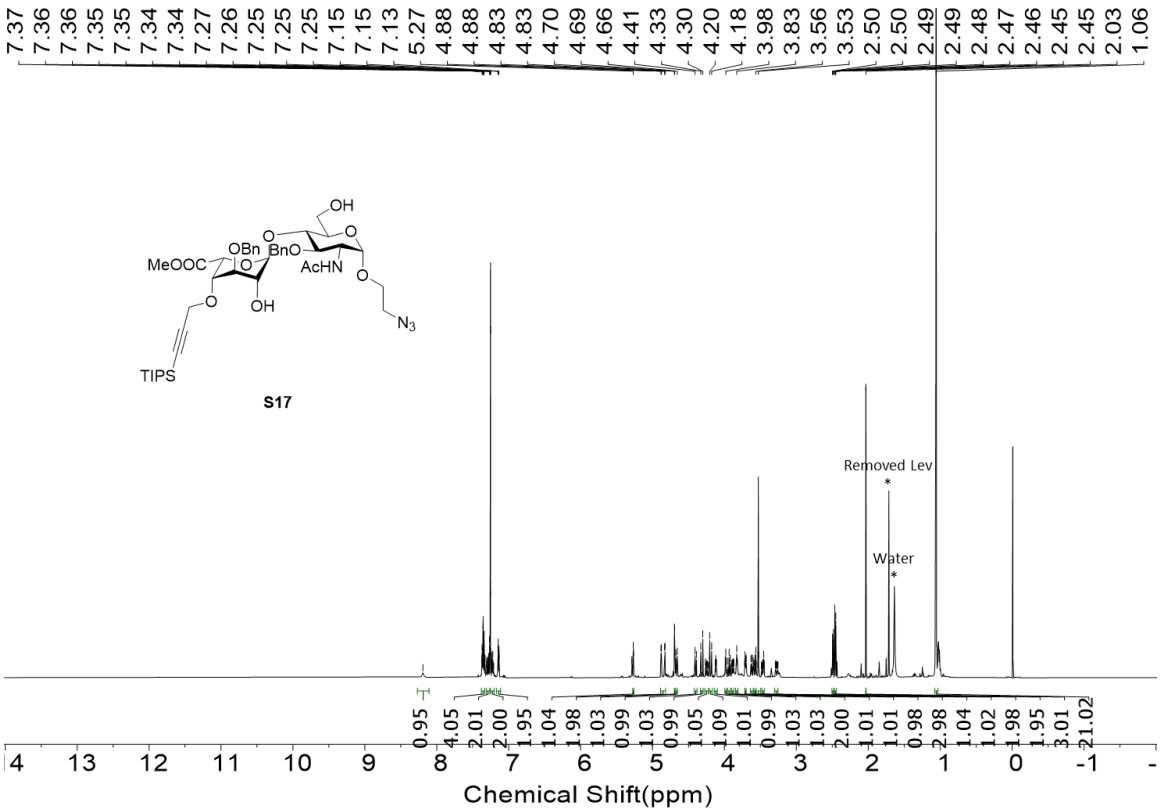

175.72
172.94
140.02
139.60
129.10
129.07
129.04
128.59
128.33
128.18
104.78
103.31
98.60
80.34
77.94
77.90
77.77
76.01
73.25
71.27
67.70
67.29
60.00
53.96
51.49
49.22
49.08
48.94
48.80
48.65
48.51
48.37
22.51
18.86
OSO3-
OBn
BnO
AcHN
-OOC
OH
N3
TIPS
17
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of S17

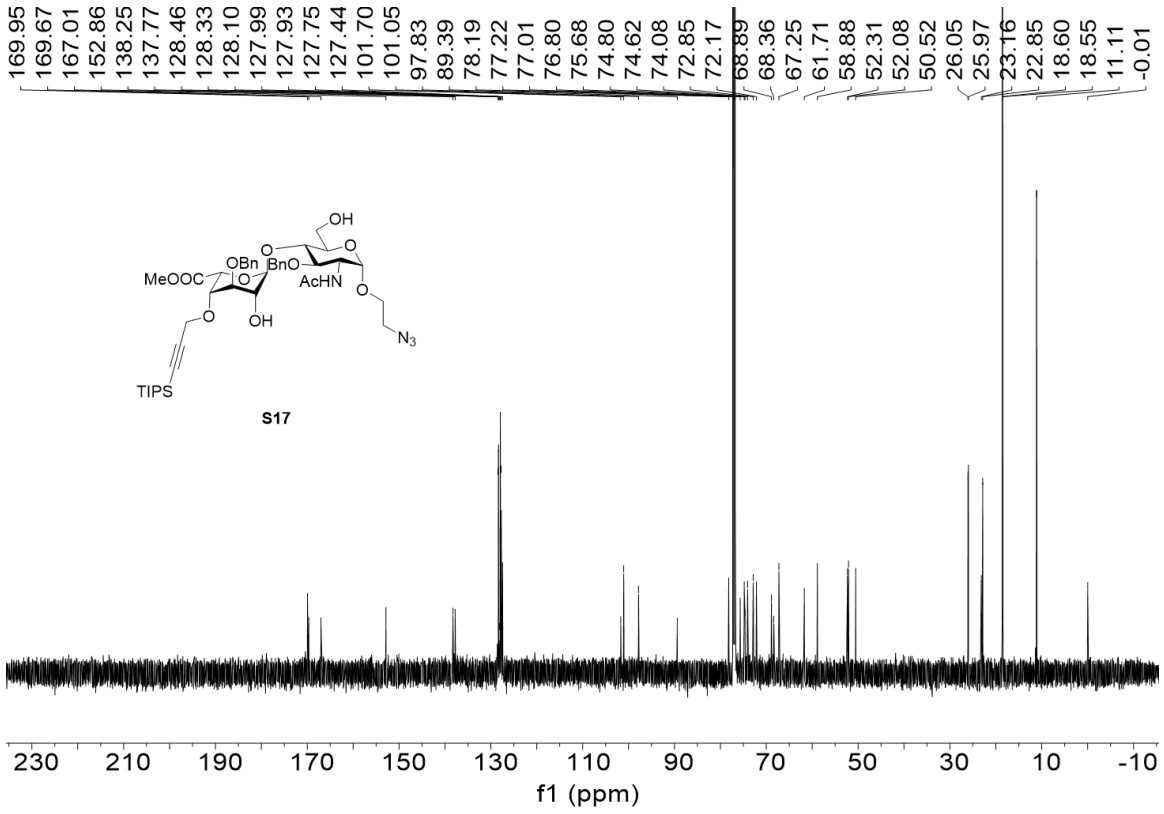


S17

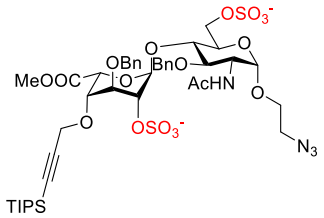
^{1}H NMR of S17



^{13}C NMR of S17

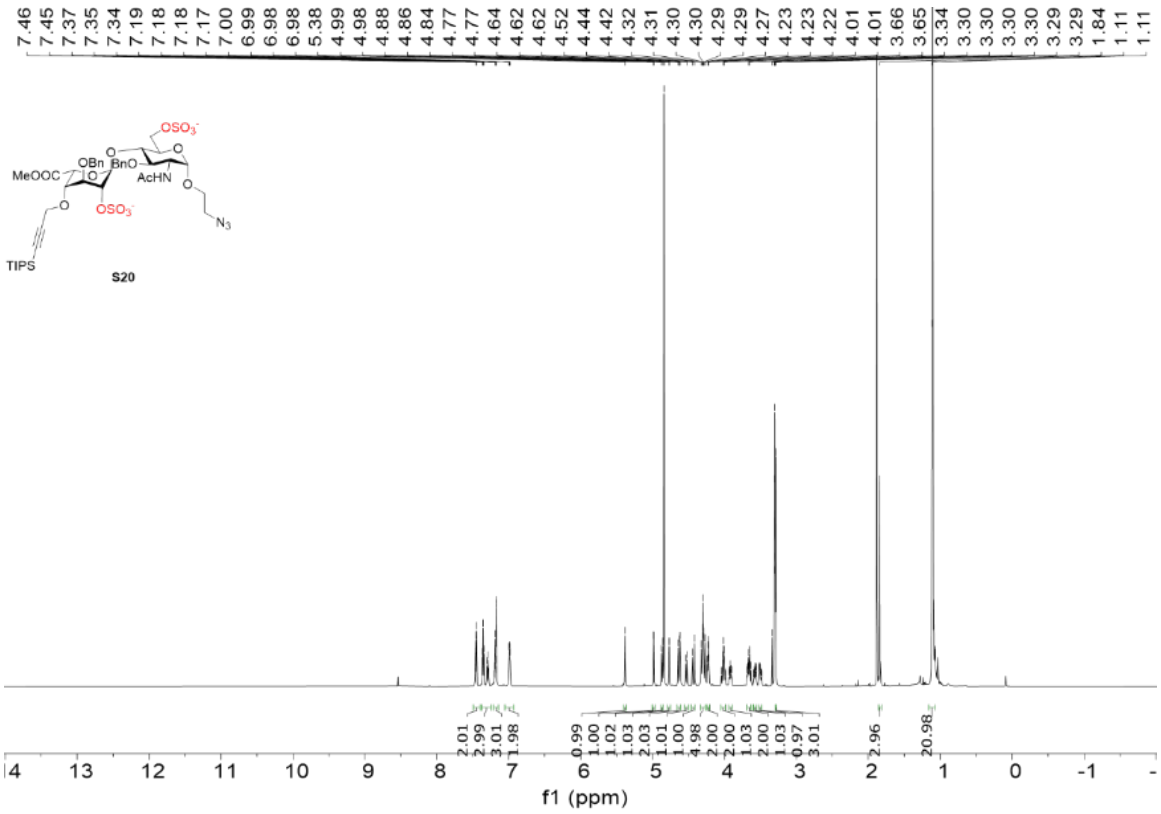

169.95
169.67
167.01
152.86
138.25
137.77
128.46
128.33
128.10
127.99
127.93
127.75
127.44
101.70
101.05
97.83
89.39
78.19
77.22
77.01
76.80
75.68
74.80
74.62
74.08
72.85
72.17
68.89
68.36
67.25
61.71
58.88
52.31
52.08
50.52
26.05
25.97
23.16
22.85
18.60
18.55
11.11
-0.01
OH
O
O
OBn
BnO
MeOOC
O
AcHN
O
O
OH
N3
TIPS
S17
230
210
190
170
150
130
110
90
70
50
30
10
-10
f1 (ppm)

Characterization of S20

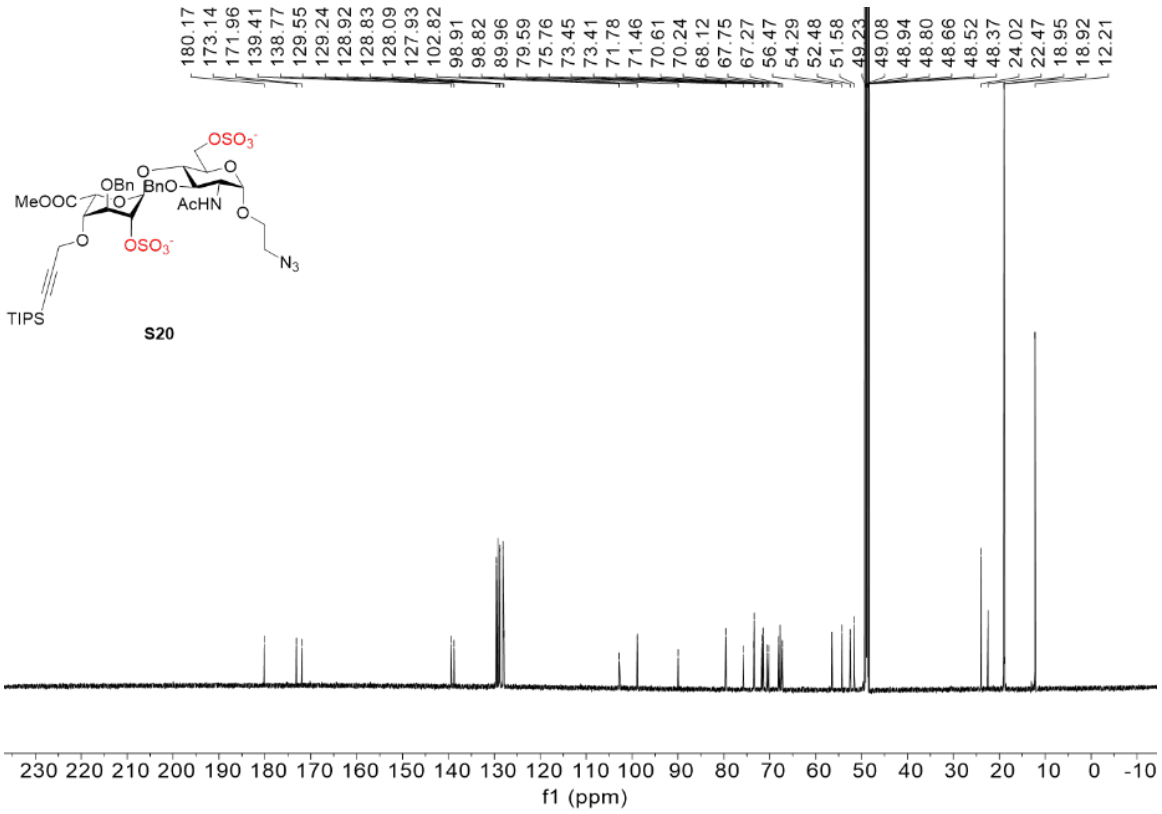


S20

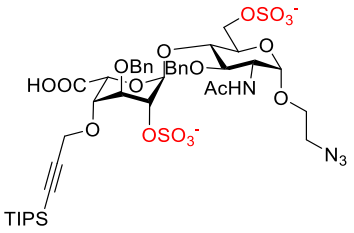
^{1}H NMR of S20



^{13}C NMR of S20

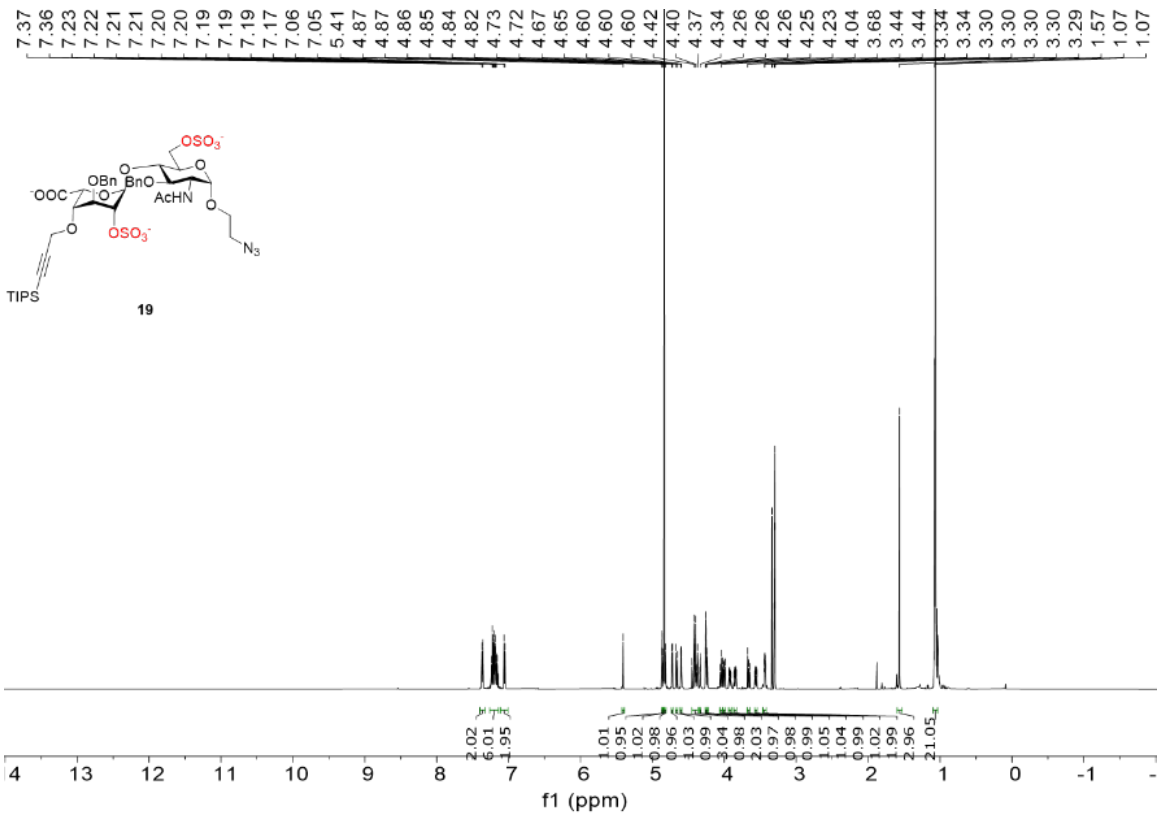

180.17
173.14
171.96
139.41
138.77
129.55
129.24
128.92
128.83
128.09
127.93
102.82
98.91
98.82
89.96
79.59
75.76
73.45
73.41
71.78
71.46
70.61
70.24
68.12
67.75
67.27
56.47
54.29
52.48
51.58
49.23
49.08
48.94
48.80
48.66
48.52
48.37
24.02
22.47
18.95
18.92
12.21
OSO3-
MeOOC
OBn
BnO
AcHN
OSO3-
N3
TIPS
S20
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of 19

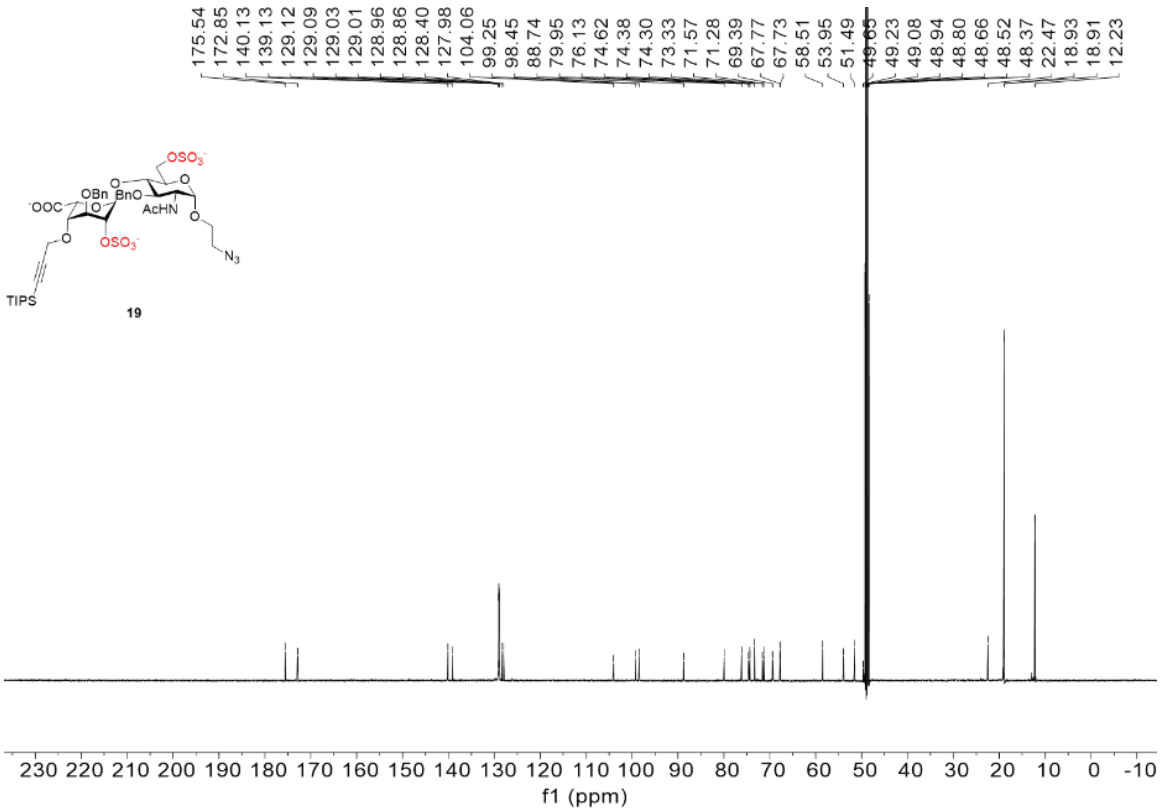


19

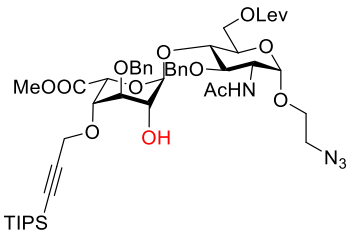
^{1}H NMR of 19



^{13}C NMR of 19

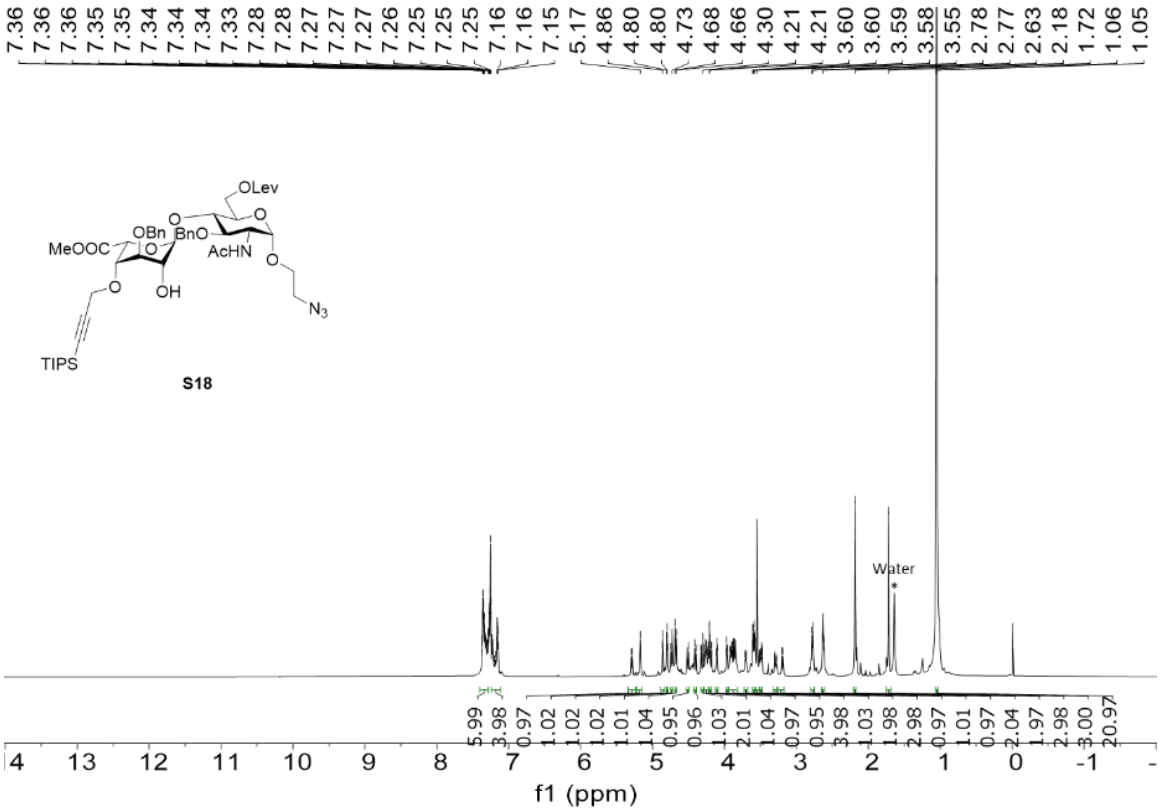

175.54
172.85
140.13
139.13
129.12
129.09
129.03
129.01
128.96
128.86
128.40
127.98
104.06
99.25
98.45
88.74
79.95
76.13
74.62
74.38
74.30
73.33
71.57
71.28
69.39
67.77
67.73
58.51
53.95
51.49
49.23
49.08
48.94
48.80
48.66
48.52
48.37
22.47
18.93
18.91
12.23
OSO3-
OBn
BnO
AcHN
-OOC
OSO3-
N3
TIPS
19
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of S18

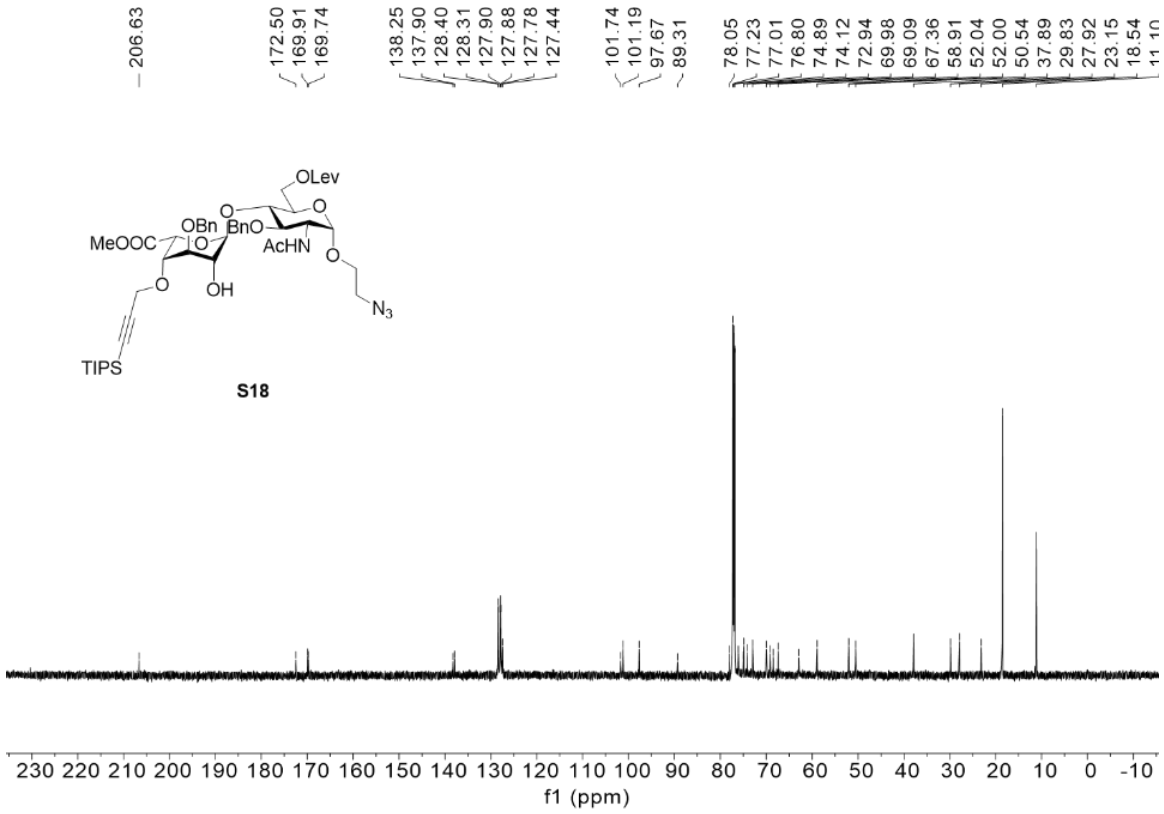


S18

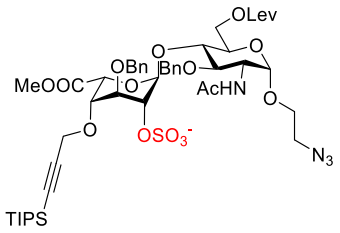
^{1}H NMR of S18



^{13}C NMR of S18

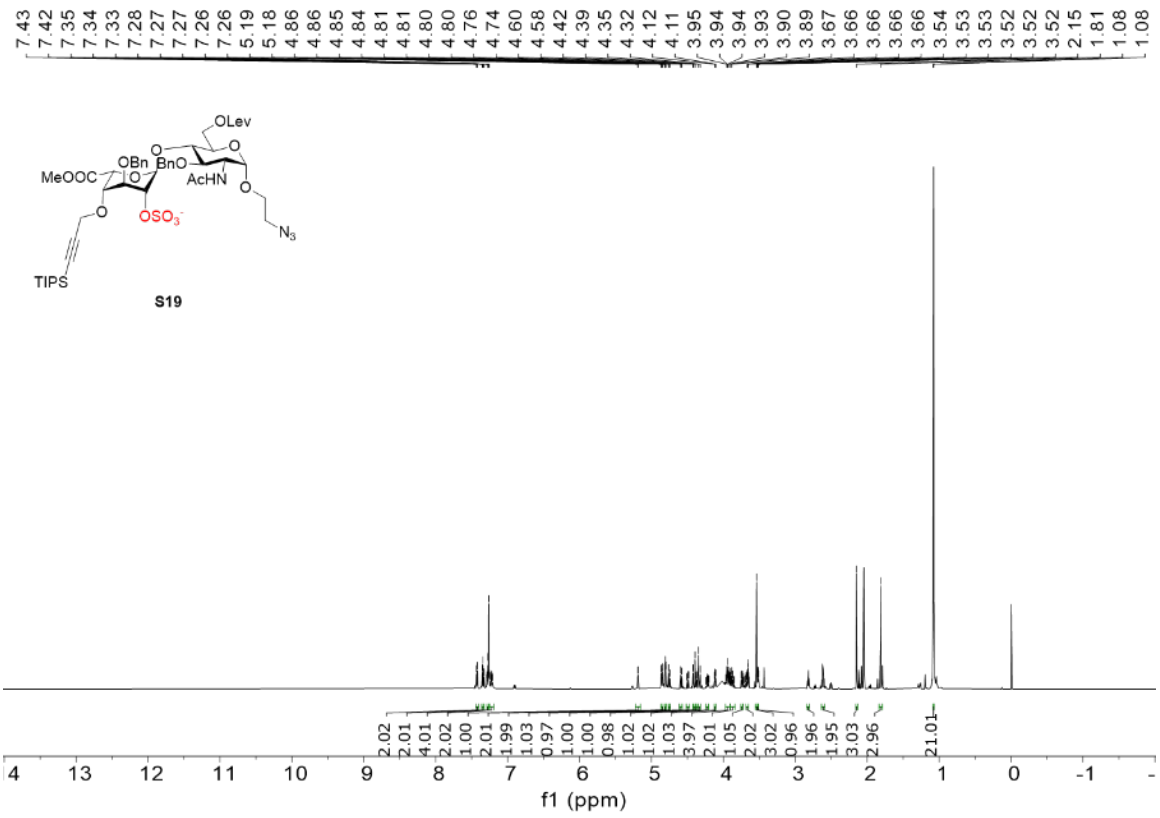

206.63
172.50
169.91
169.74
138.25
137.90
128.40
128.31
127.90
127.88
127.78
127.44
101.74
101.19
97.67
89.31
78.05
77.23
77.01
76.80
74.89
74.12
72.94
69.98
69.09
67.36
58.91
52.04
52.00
50.54
37.89
29.83
27.92
23.15
18.54
OLev
OBn
BnO
MeOOC
AcHN
OH
N3
TIPS
S18
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of S19

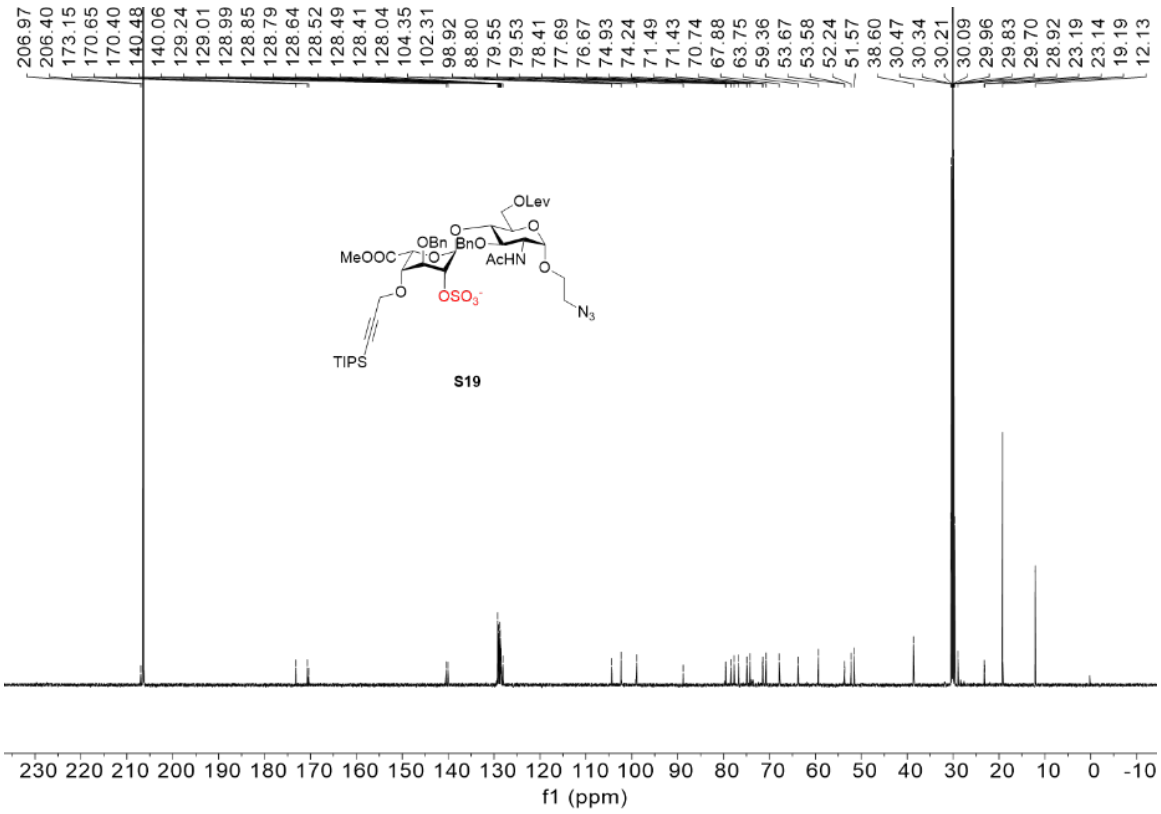


S19

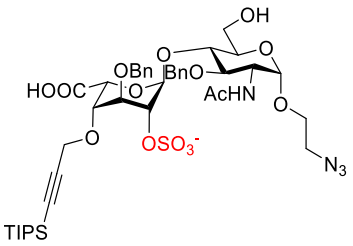
^{1}H NMR of S19



^{13}C NMR of S19

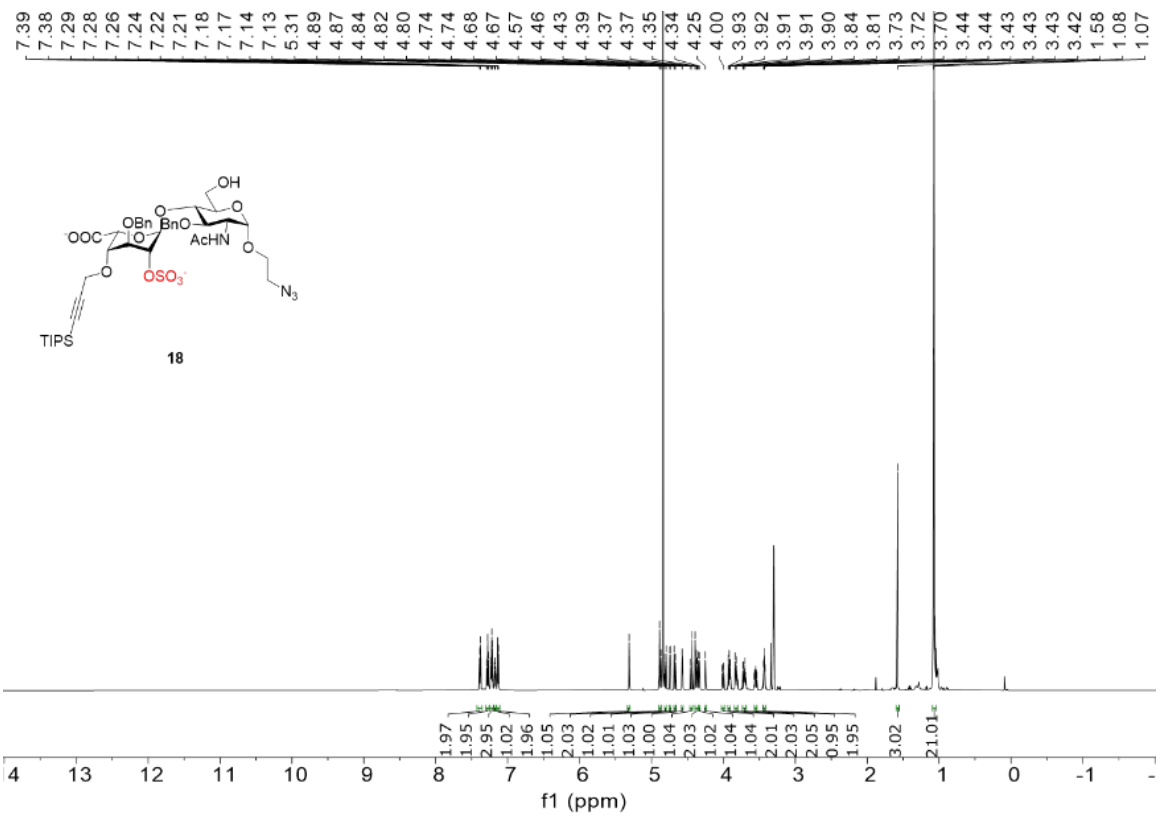

206.97
206.40
173.15
170.65
170.40
140.48
140.06
129.24
129.01
128.99
128.85
128.79
128.64
128.52
128.49
128.41
128.04
104.35
102.31
98.92
88.80
79.55
79.53
78.41
77.69
76.67
74.93
74.24
71.49
71.43
70.74
67.88
63.75
59.36
53.67
53.58
52.24
51.57
38.60
30.47
30.34
30.21
30.09
29.96
29.83
29.70
28.92
23.19
23.14
19.19
12.13
OLev
OBn
BnO
MeOOC
AcHN
OSO3-
N3
TIPS
S19
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of 18

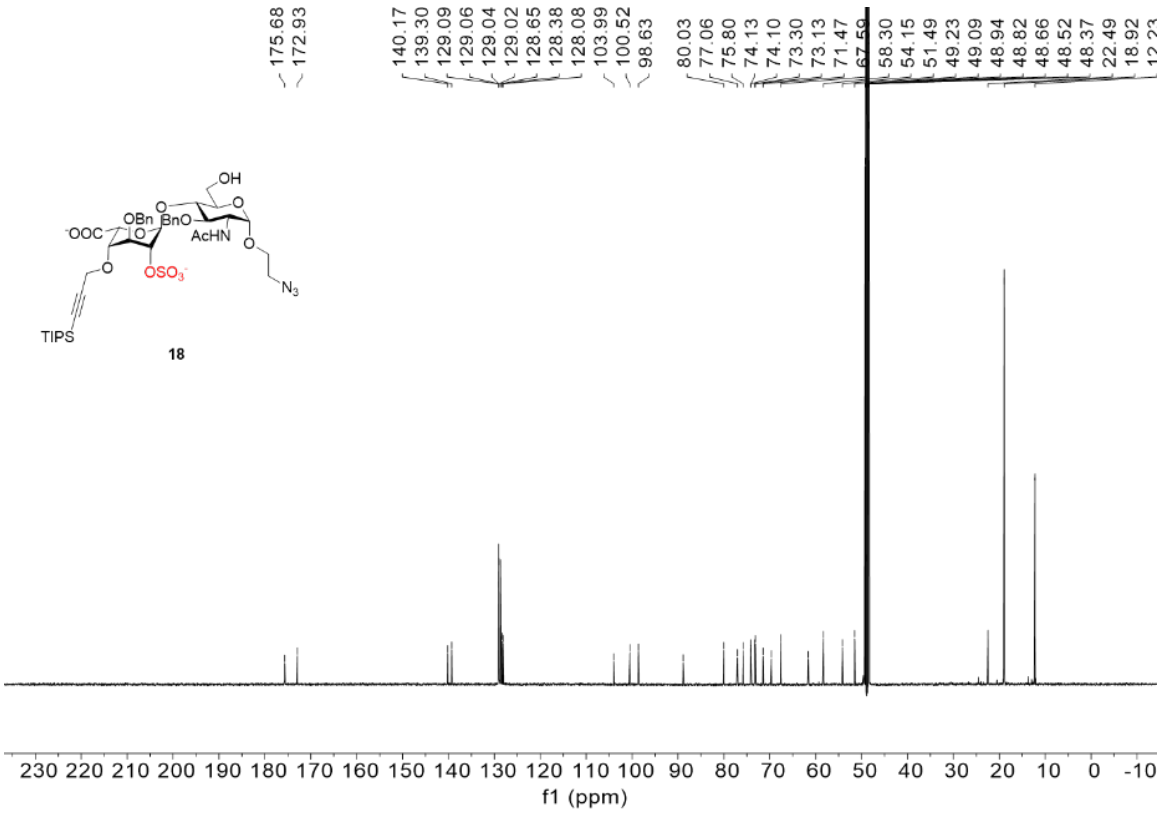


18

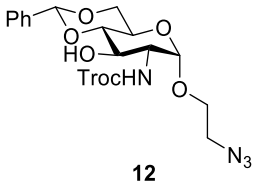
^{1}H NMR of 18



^{13}C NMR of 18

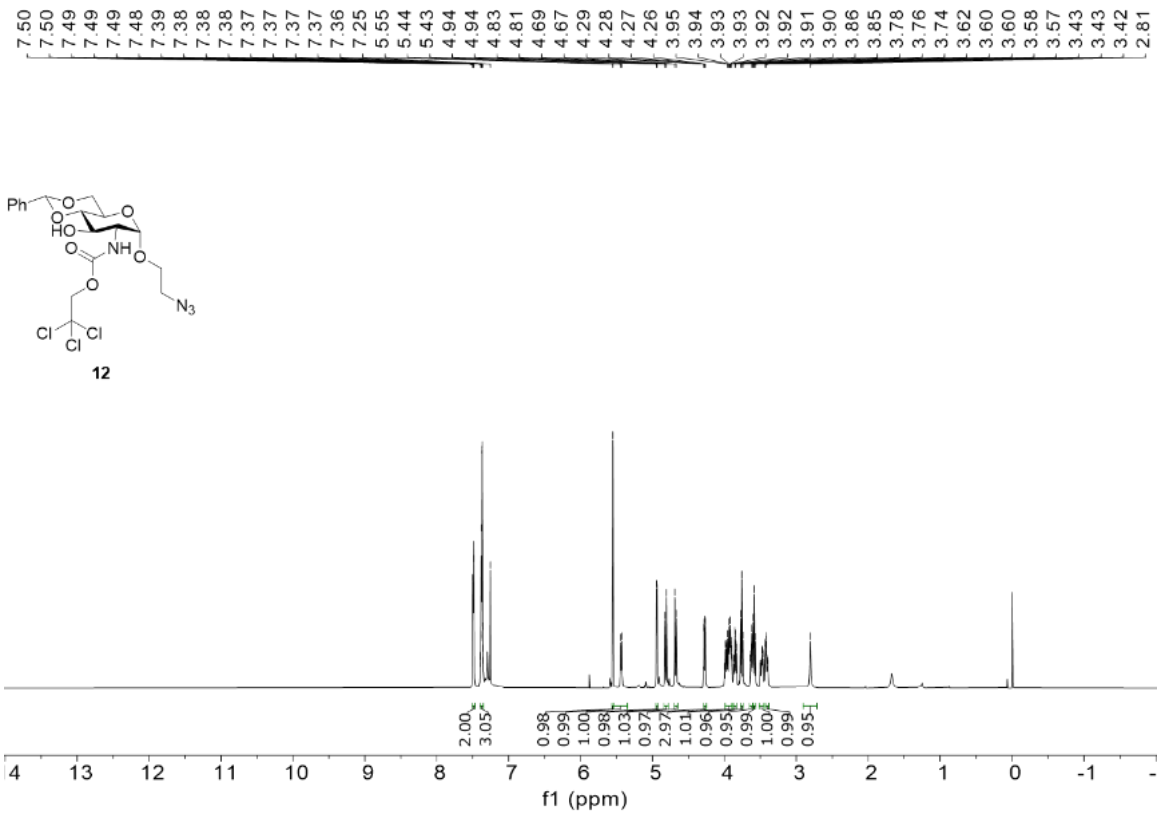

175.68
172.93
140.17
139.30
129.09
129.06
129.04
129.02
128.65
128.38
128.08
103.99
100.52
98.63
80.03
77.06
75.80
74.13
74.10
73.30
73.13
71.47
67.59
58.30
54.15
51.49
49.23
49.09
48.94
48.82
48.66
48.52
48.37
22.49
18.92
OH
OBn
BnO
AcHN
OOC
OSO3-
N3
TIPS
18
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of 12

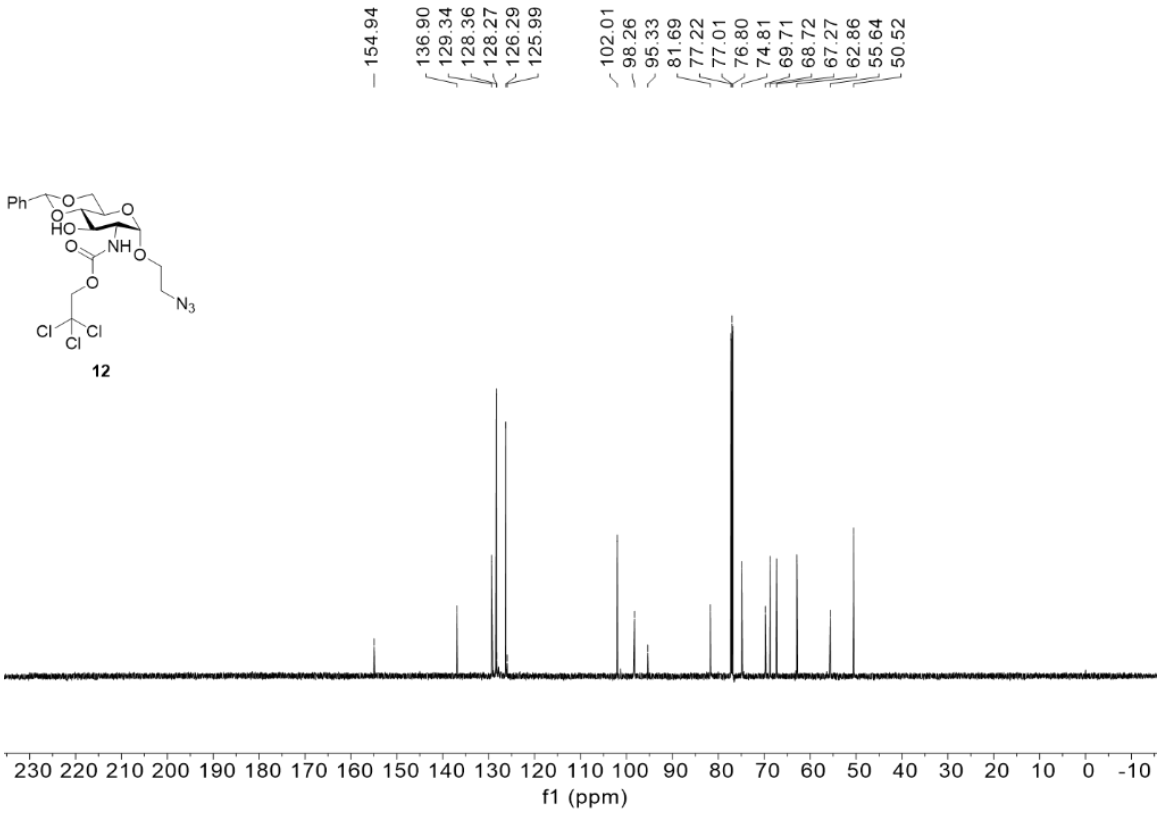


12

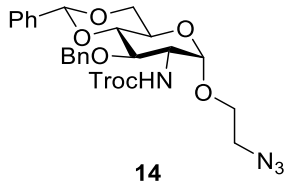
^{1}H NMR of 12



^{13}C NMR of 12

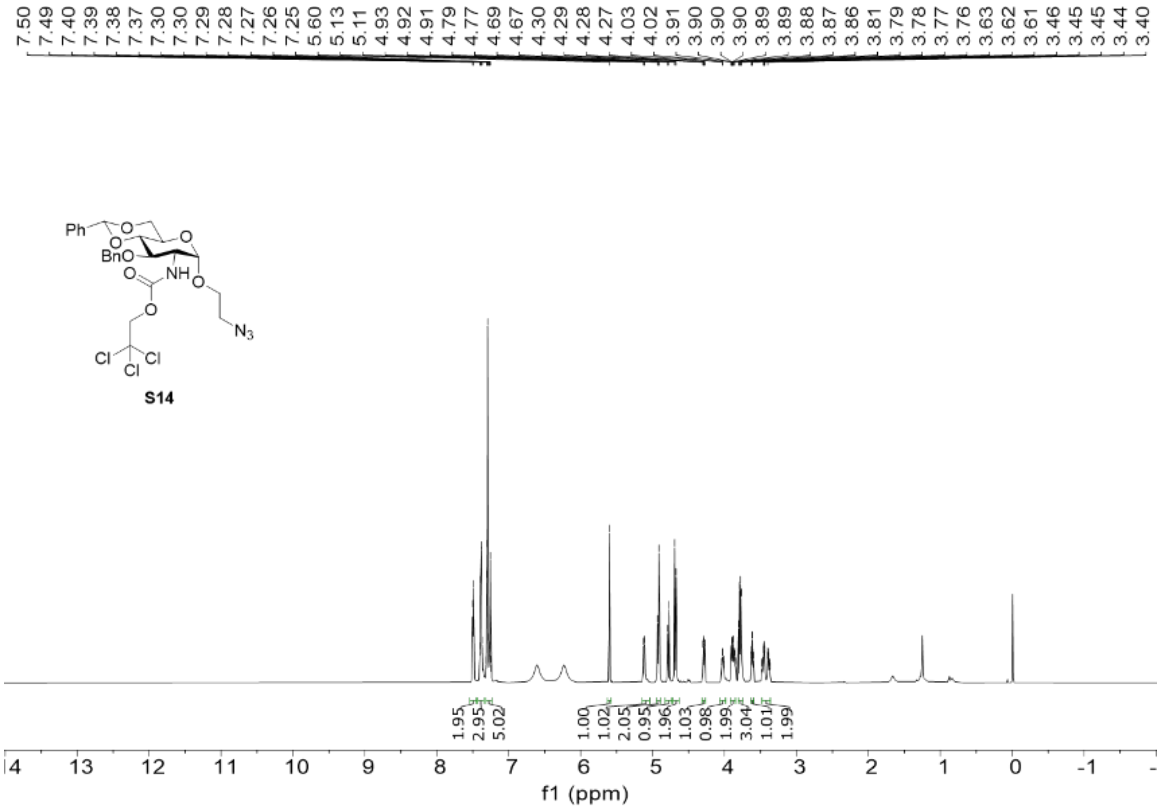

154.94
136.90
129.34
128.36
128.27
126.29
125.99
102.01
98.26
95.33
81.69
77.22
77.01
76.80
74.81
69.71
68.72
67.27
62.86
55.64
50.52
Ph
O
O
HO
O
NH
O
O
N3
Cl
Cl
Cl
12
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of 14

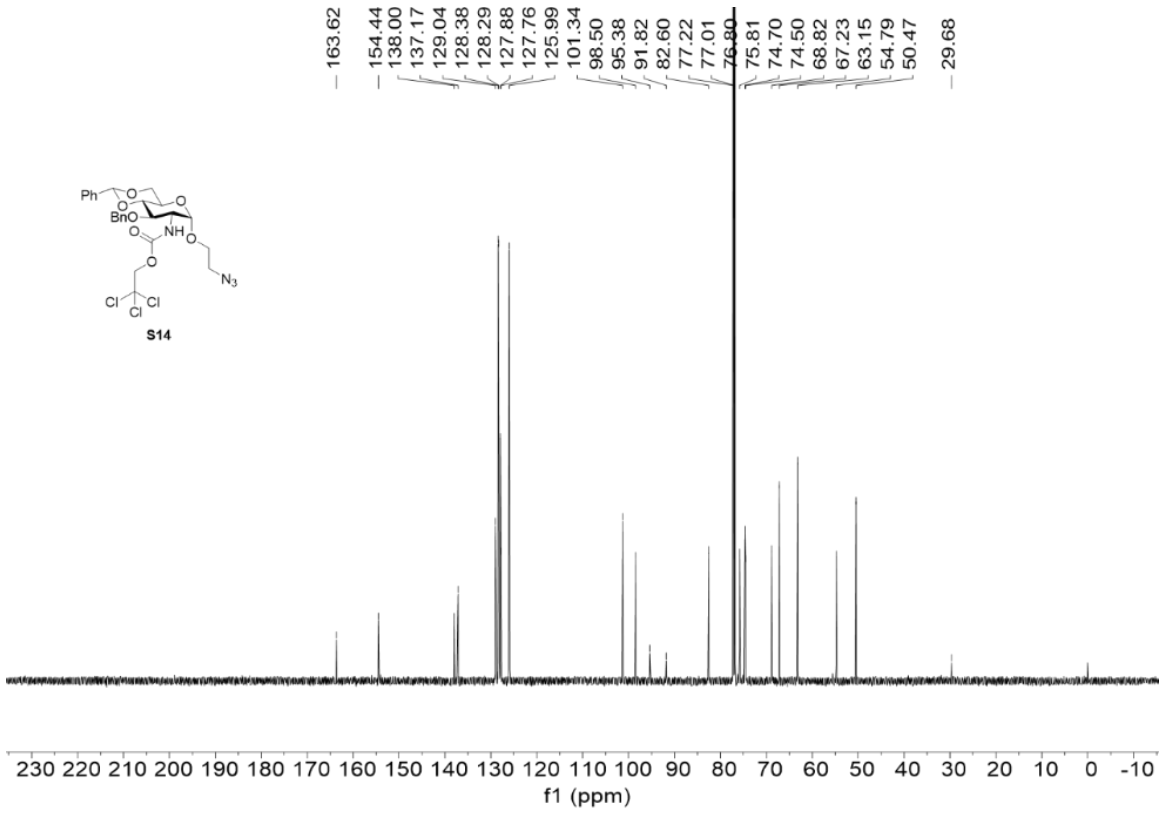


14

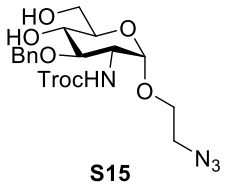
^{1}H NMR of 14



^{13}C NMR of 14

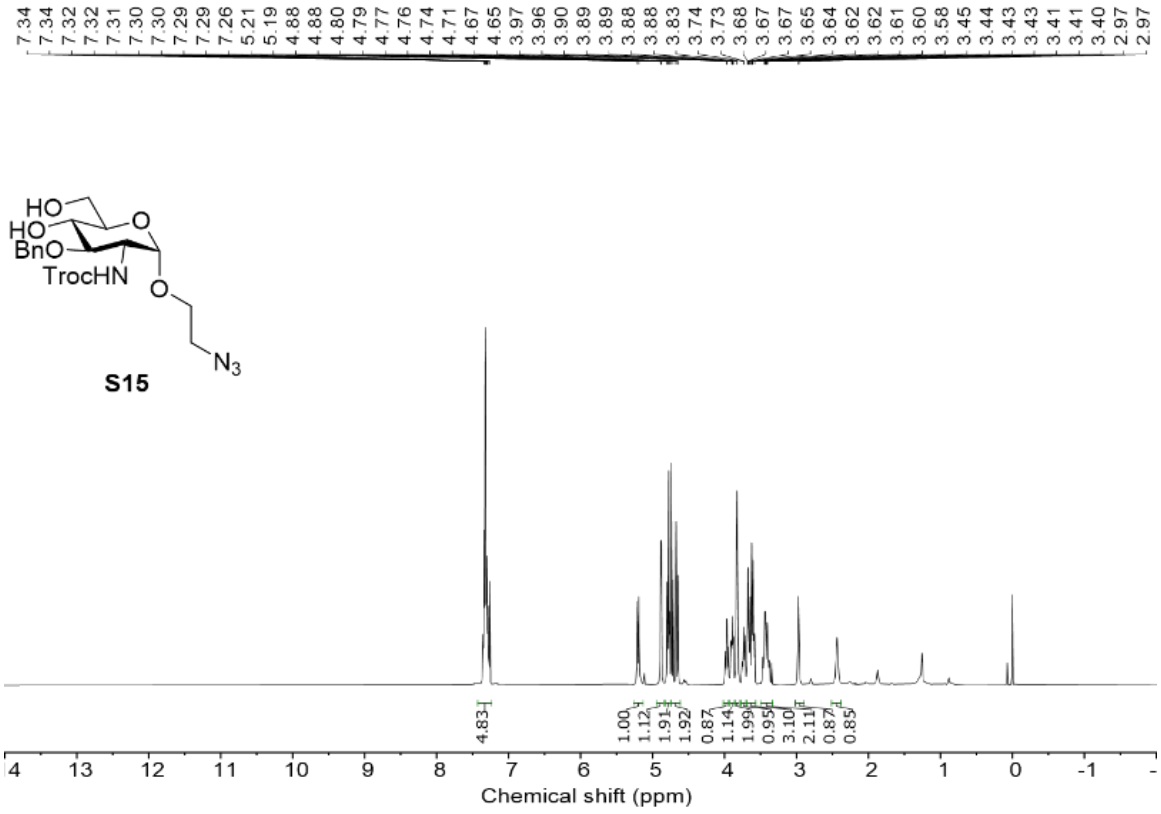

163.62
154.44
138.00
137.17
129.04
128.38
128.29
127.88
127.76
125.99
101.34
98.50
95.38
91.82
82.60
77.22
77.01
76.80
75.81
74.70
74.50
68.82
67.23
63.15
54.79
50.47
29.68
Ph
BnO
NH
N3
Cl
Cl
Cl
S14
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

Characterization of S15

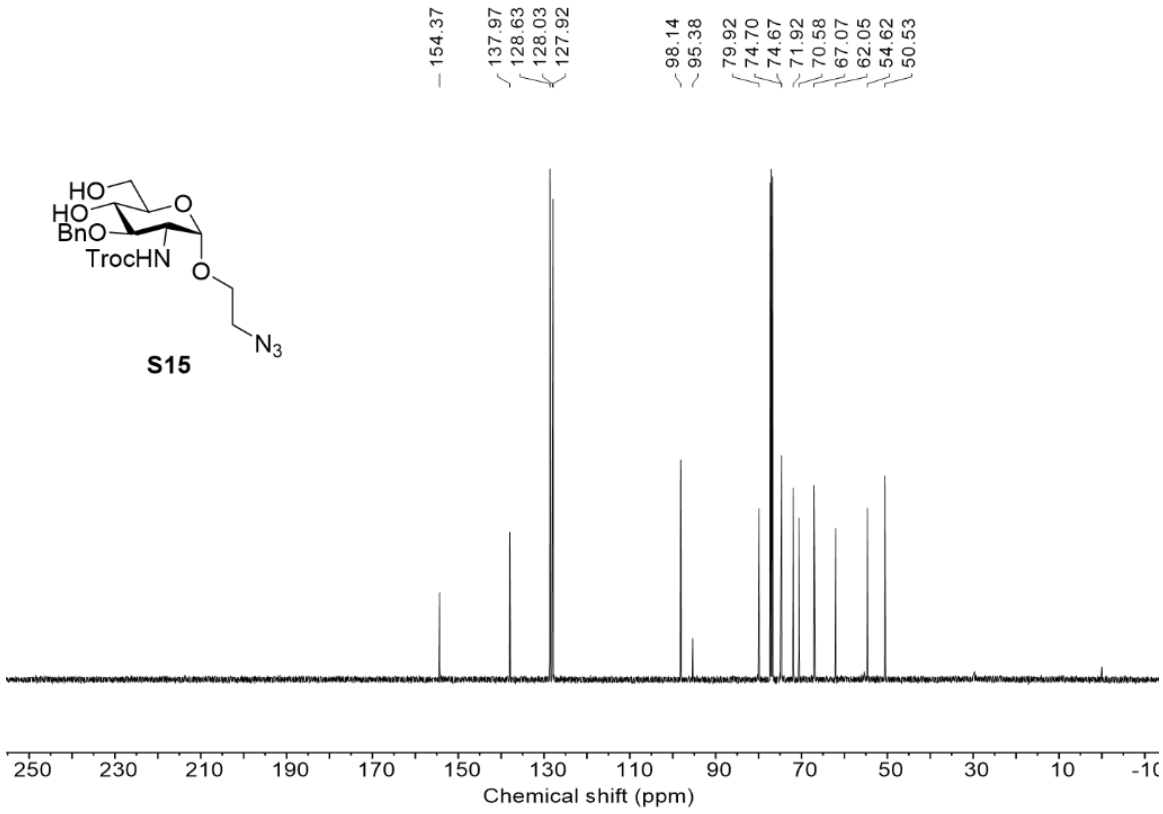


S15

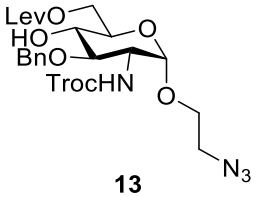
^{1}H NMR of S15



^{13}C NMR of S15

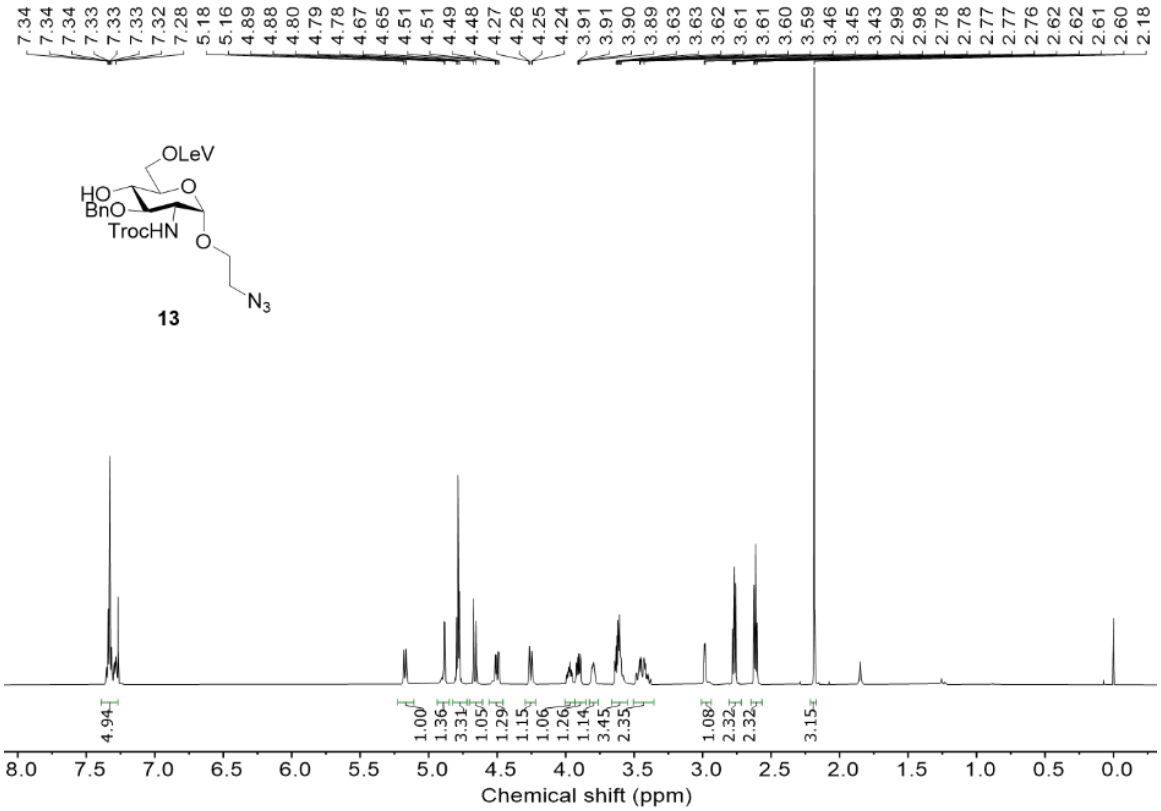

154.37
137.97
128.63
128.03
127.92
98.14
95.38
79.92
74.70
74.67
71.92
70.58
67.07
62.05
54.62
50.53
HO
HO
BnO
TrocHN
O
O
N3
S15
250
230
210
190
170
150
130
110
90
70
50
30
10
Chemical shift (ppm)

Characterization of 13

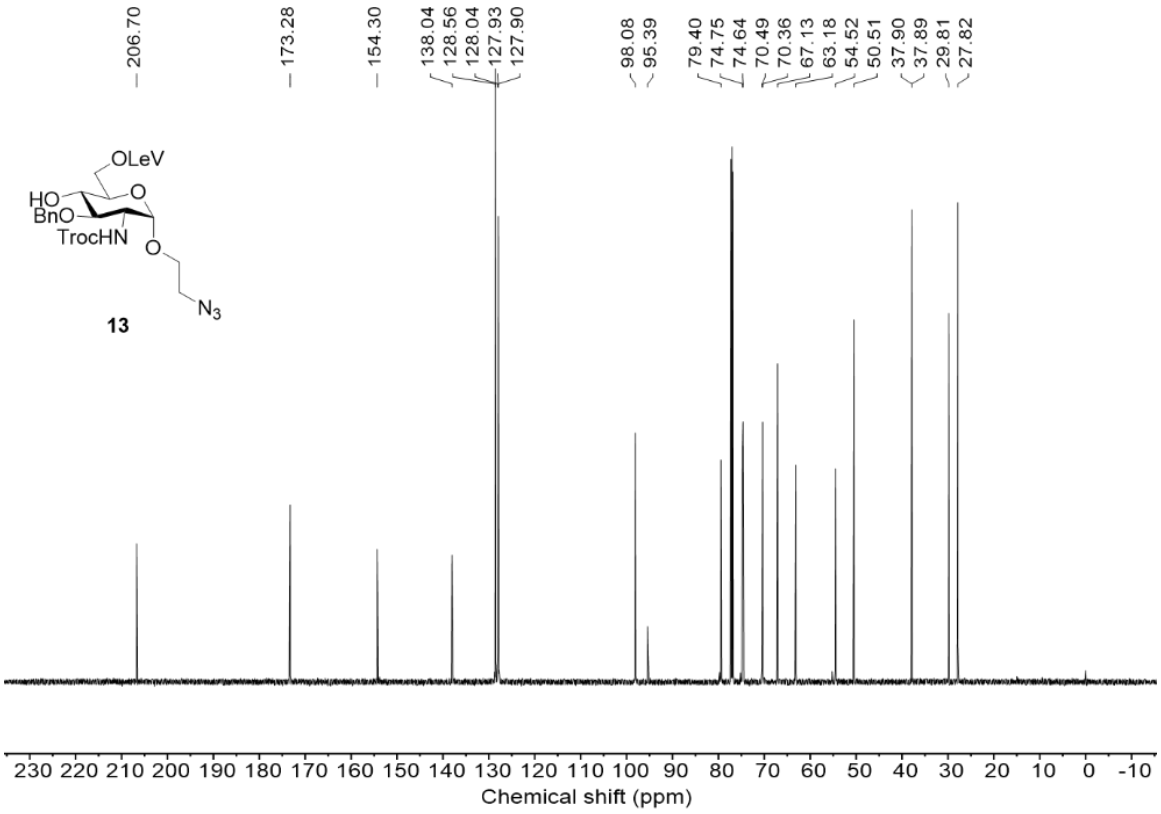


13

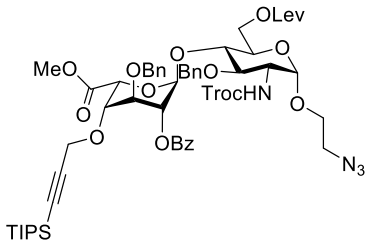
^{1}H NMR of 13



^{13}C NMR of S23

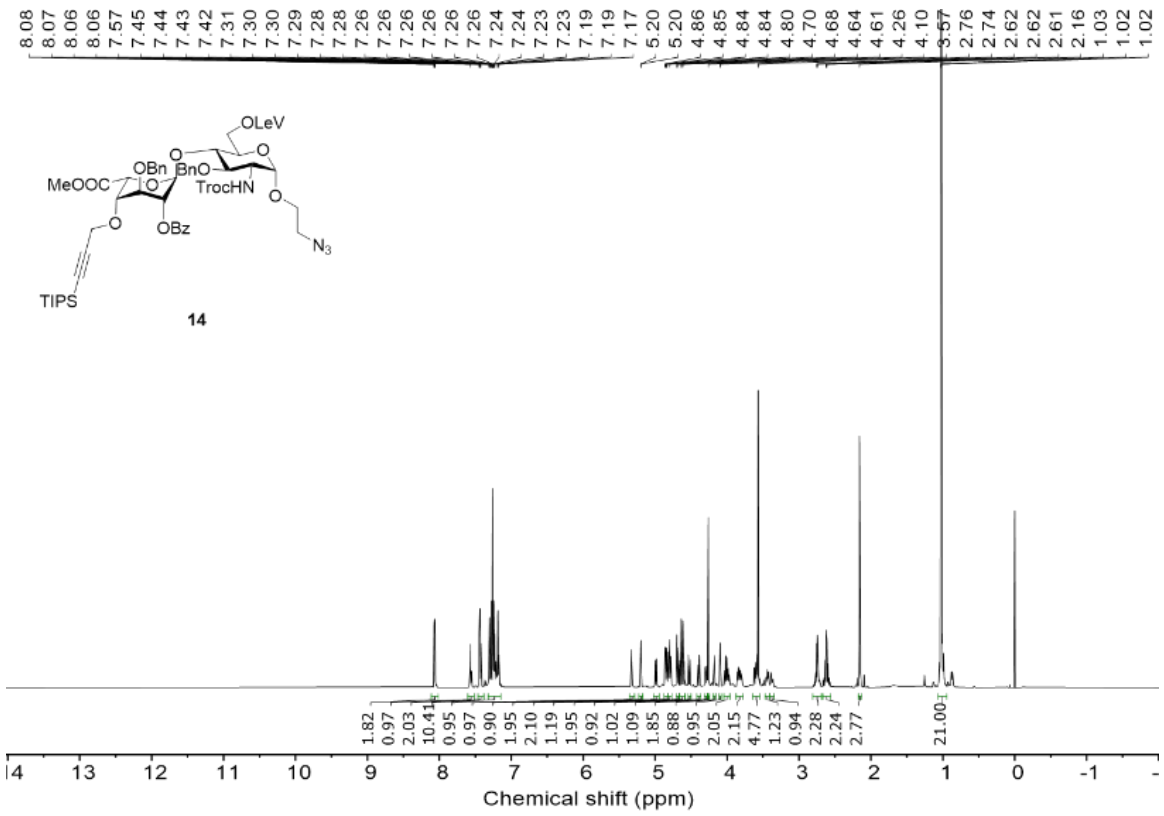

206.70
173.28
154.30
138.04
128.56
128.04
127.93
127.90
98.08
95.39
79.40
74.75
74.64
70.49
70.36
67.13
63.18
54.52
50.51
37.90
37.89
29.81
27.82
OLeV
HO
BnO
TrocHN
O
O
N3
13
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of 14

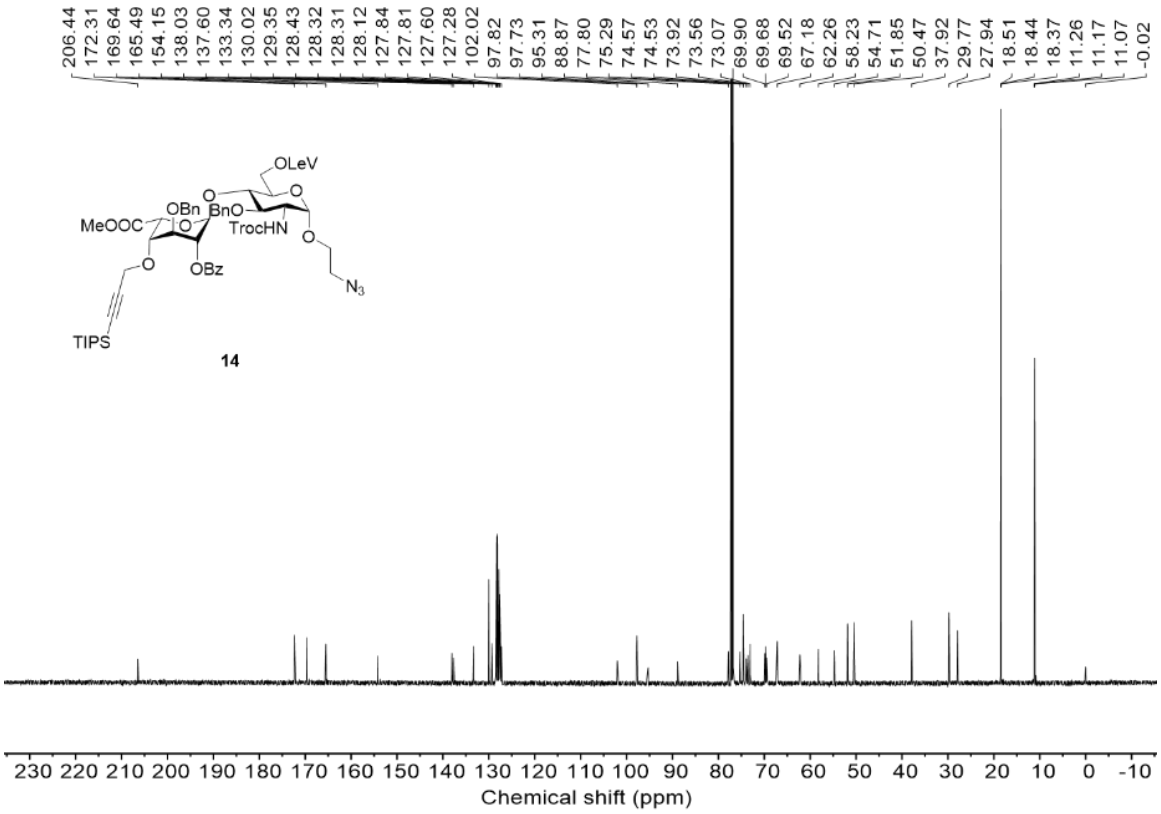


14

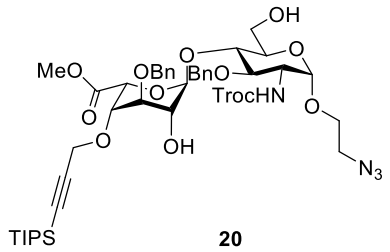
^{1}H NMR of 14



^{13}C NMR of 14

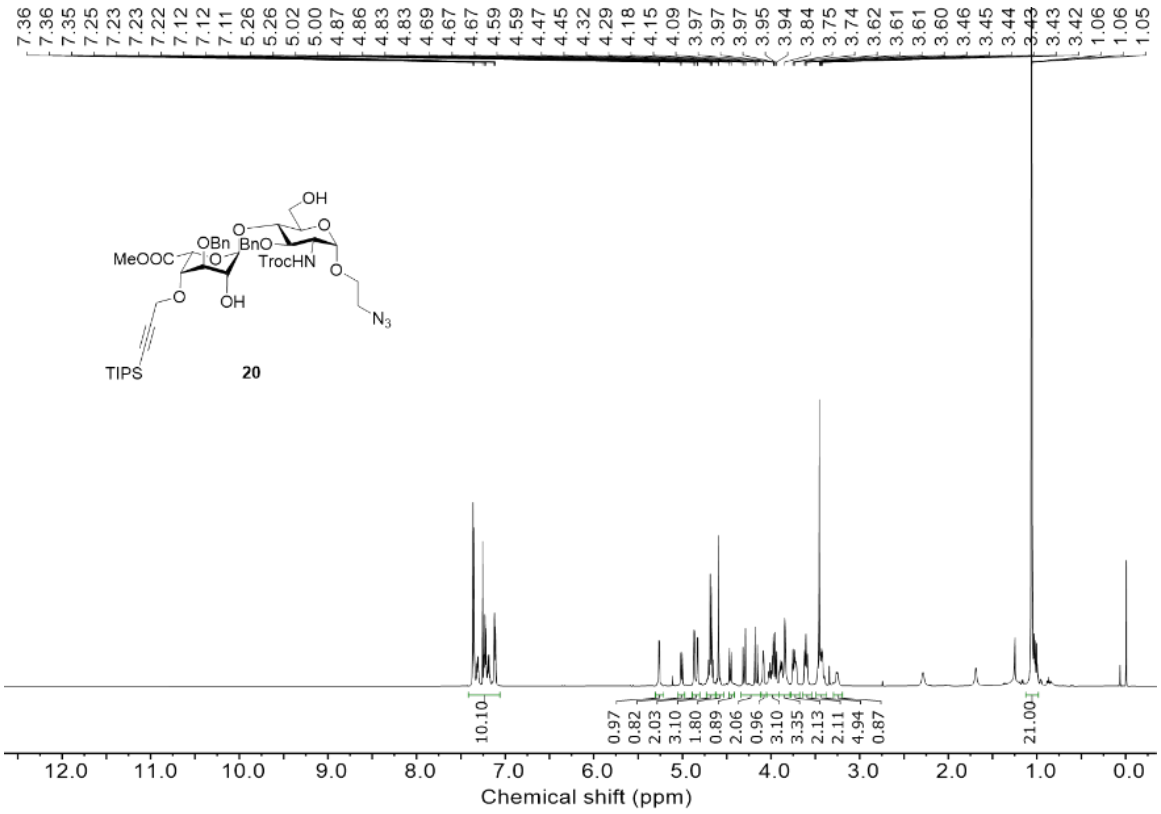

206.44
172.31
169.64
165.49
154.15
138.03
137.60
133.34
130.02
129.35
128.43
128.32
128.31
128.12
127.84
127.81
127.60
127.28
102.02
97.82
97.73
95.31
88.87
77.80
75.29
74.57
74.53
73.92
73.56
73.07
69.90
69.68
69.52
67.18
62.26
58.23
54.71
51.85
50.47
37.92
29.77
27.94
18.51
18.44
18.37
11.26
11.17
11.07
-0.02
OLeV
O
O
OBn
BnO
MeOOC
O
TrocHN
O
O
OBz
N3
TIPS
14
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of 20

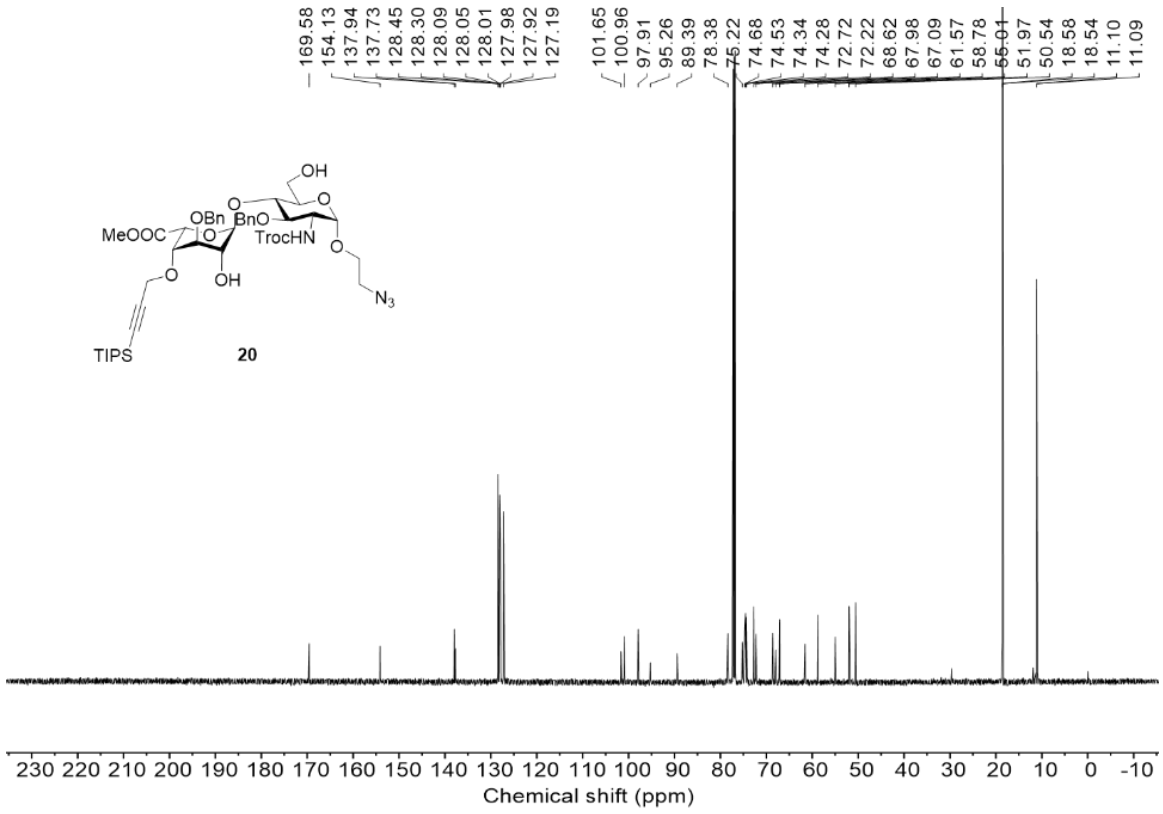


20

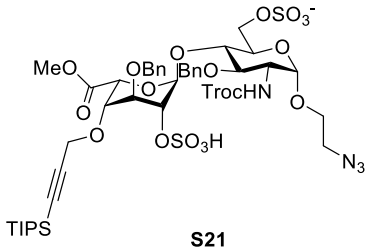
^{1}H NMR of 20



^{13}C NMR of 20

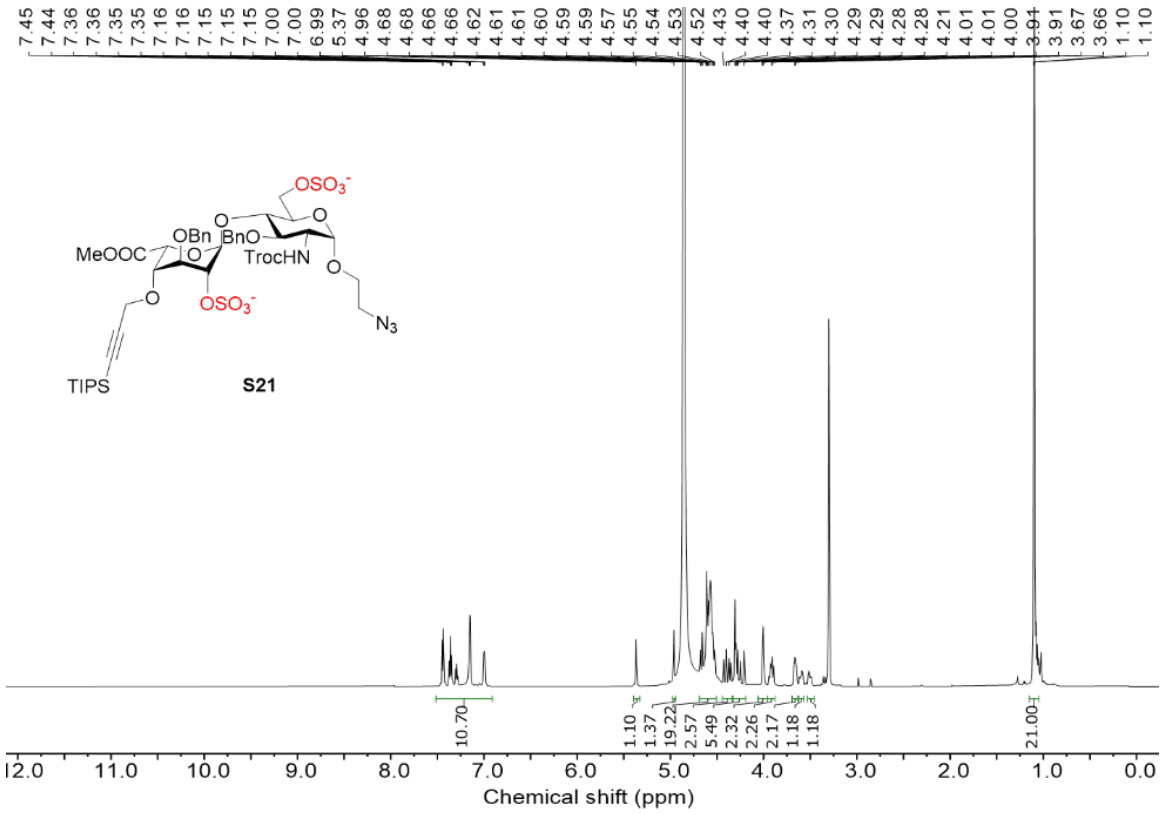

169.58
154.13
137.94
137.73
128.45
128.30
128.09
128.05
128.01
127.98
127.92
127.19
101.65
100.96
97.91
95.26
89.39
78.38
75.22
74.68
74.53
74.34
74.28
72.72
72.22
68.62
67.98
67.09
61.57
58.78
55.01
51.97
50.54
18.58
18.54
11.10
11.09
OH
O
O
OBn
BnO
MeOOC
O
TrocHN
O
O
OH
N3
TIPS
20
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of S21

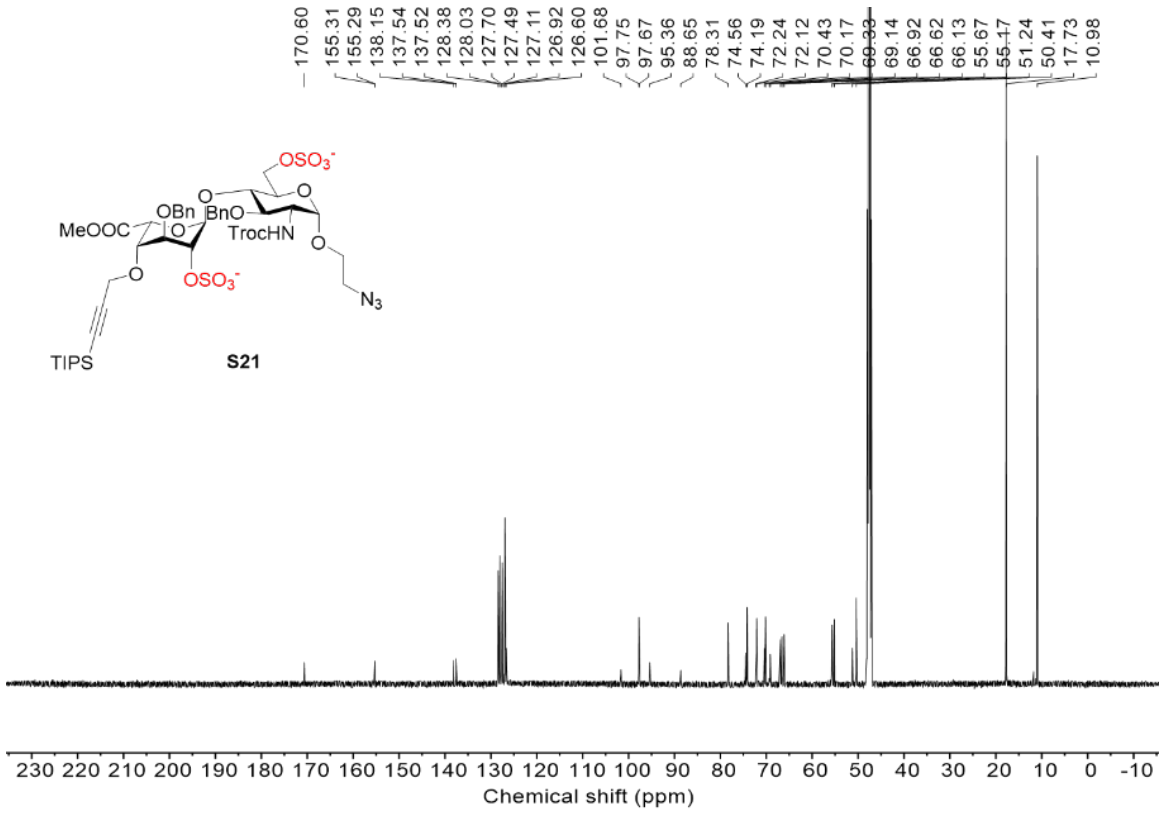


S21

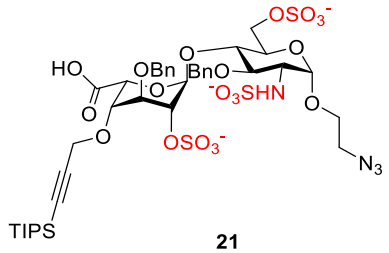
^{1}H NMR of S21



^{13}C NMR of S21

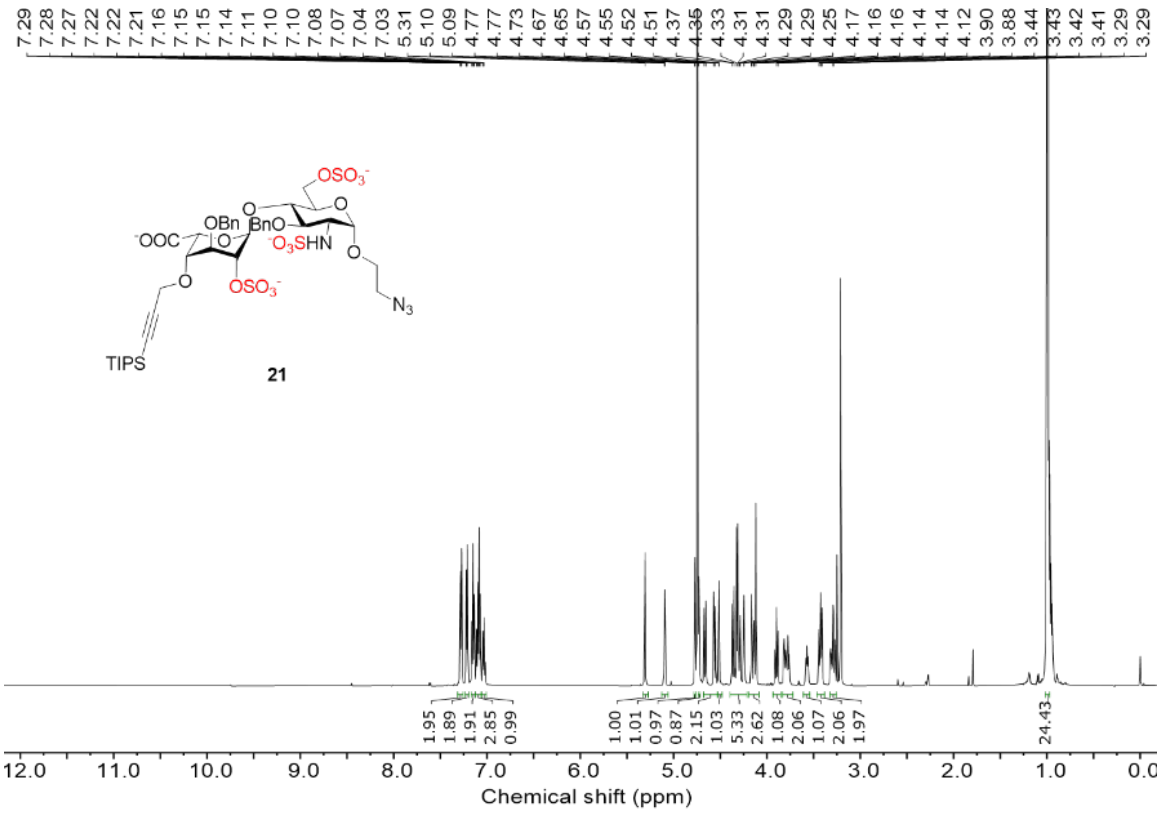

170.60
155.31
155.29
138.15
137.54
137.52
128.38
128.03
127.70
127.49
127.11
126.92
126.60
101.68
97.75
97.67
95.36
88.65
78.31
74.56
74.19
72.24
72.12
70.43
70.17
69.33
69.14
66.92
66.62
66.13
55.67
55.47
51.24
50.41
17.73
10.98
OSO3-
O
O
OBn
BnO
MeOOC
O
TrocHN
O
O
OSO3-
N3
TIPS
S21
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of 21

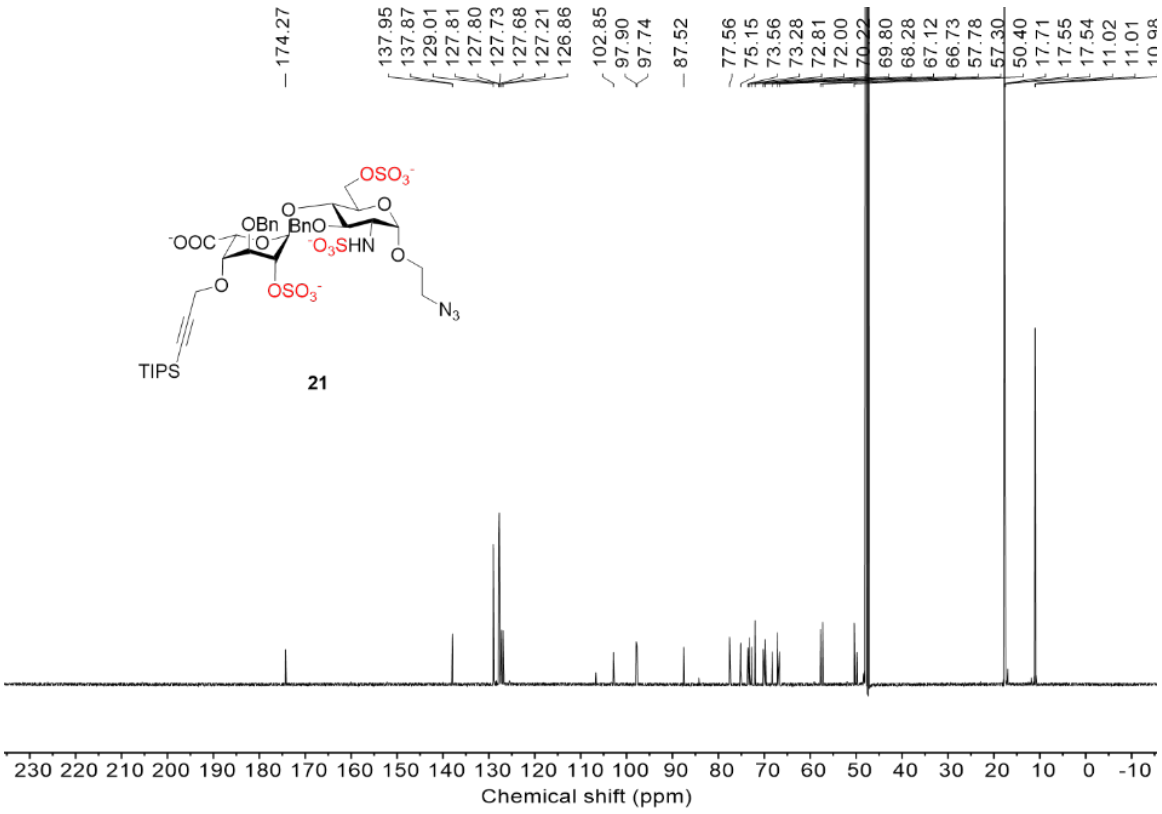


21

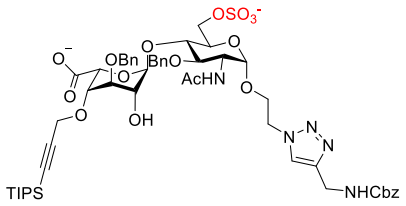
^{1}H NMR of 21



^{13}C NMR of 21

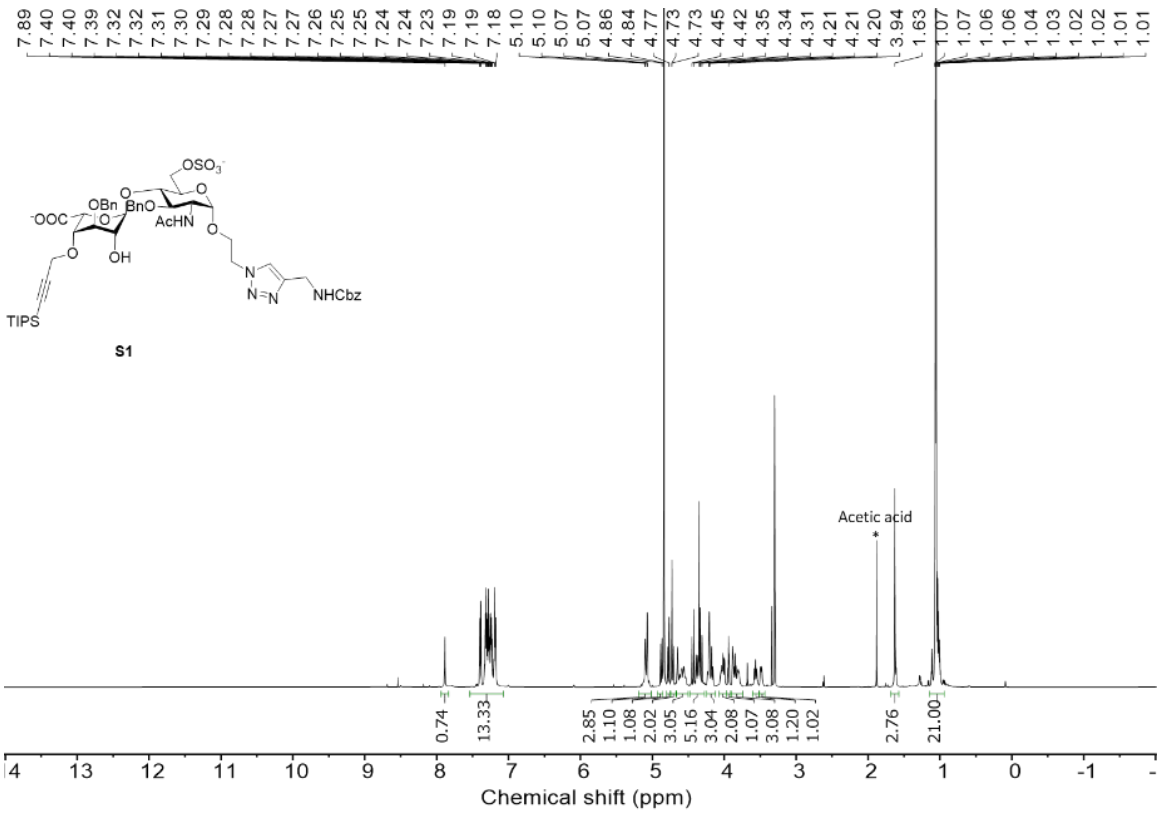

174.27
137.95
137.87
129.01
127.81
127.80
127.73
127.68
127.21
126.86
102.85
97.90
97.74
87.52
77.56
75.15
73.56
73.28
72.81
72.00
70.22
69.80
68.28
67.12
66.73
57.78
57.30
50.40
17.71
17.55
17.54
11.02
11.01
OSO3-
OBn
BnO
-OOC
-O3SHN
OSO3-
N3
TIPS
21
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of S1

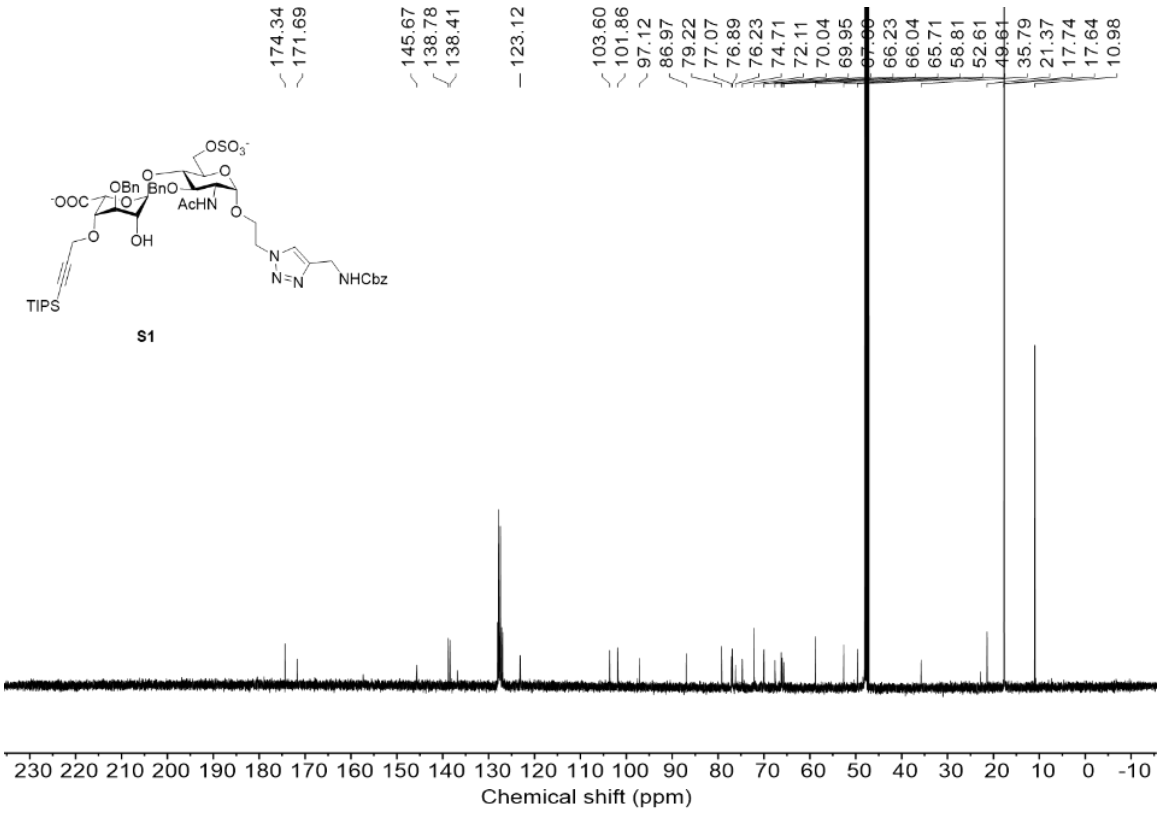


S1

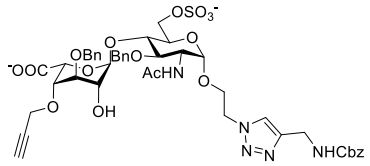
^{1}H NMR of S1



^{13}C NMR of S1

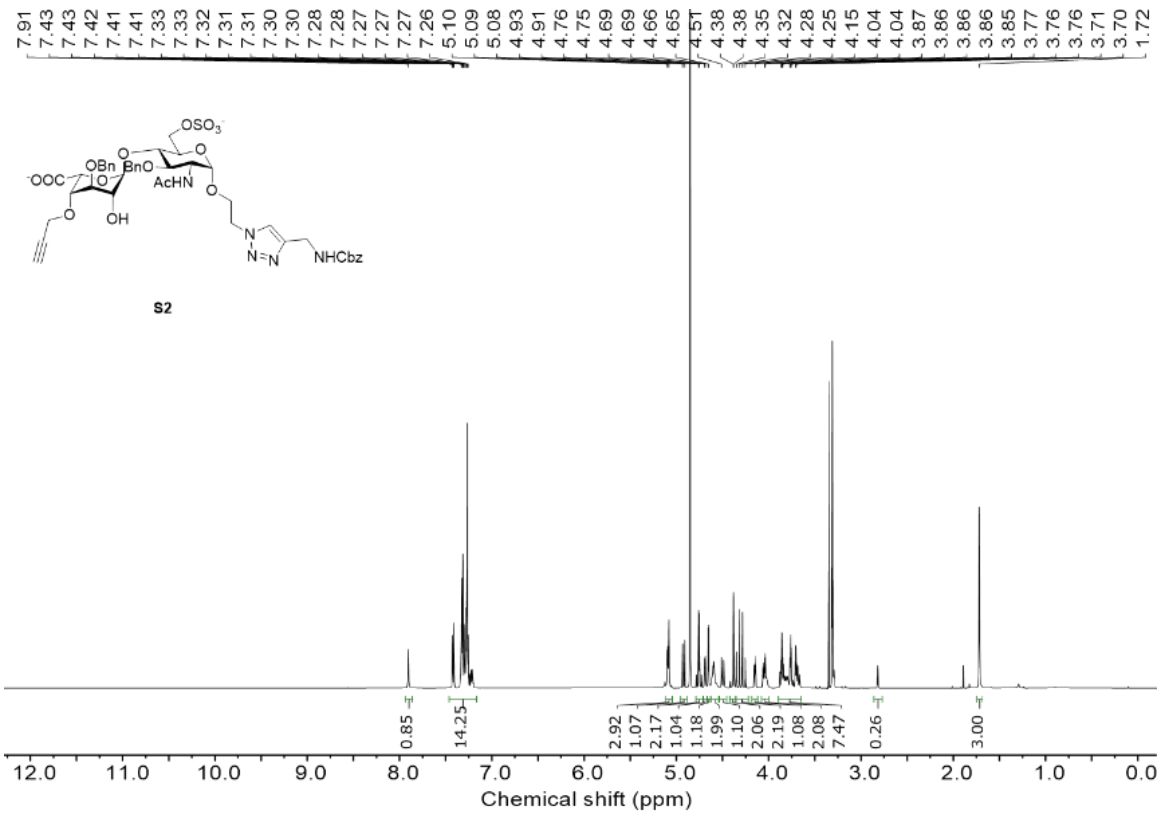

174.34
171.69
145.67
138.78
138.41
123.12
103.60
101.86
97.12
86.97
79.22
77.07
76.89
76.23
74.71
72.11
70.04
69.95
66.23
66.04
65.71
58.81
52.61
49.61
35.79
21.37
17.74
17.64
10.98
OSO3-
OBn
BnO
AcHN
-OOC
OH
TIPS
NHCbz
S1
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of S2

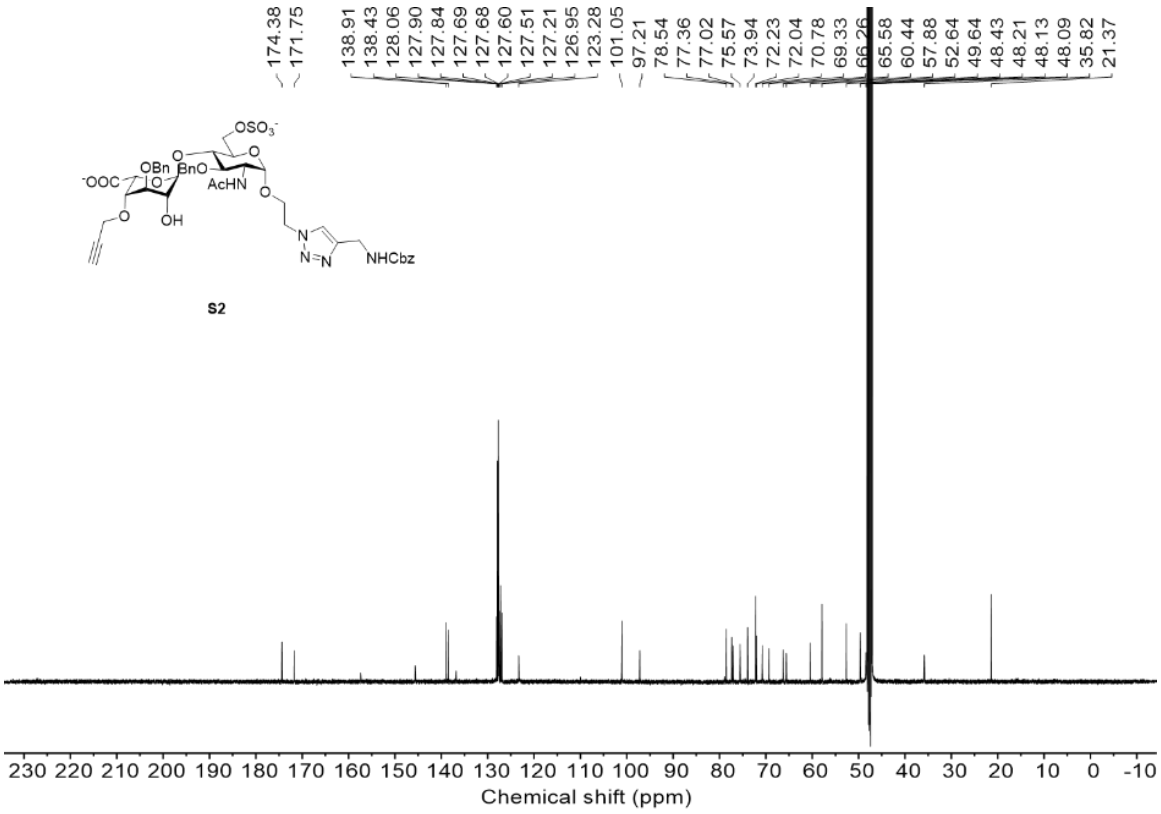


S2

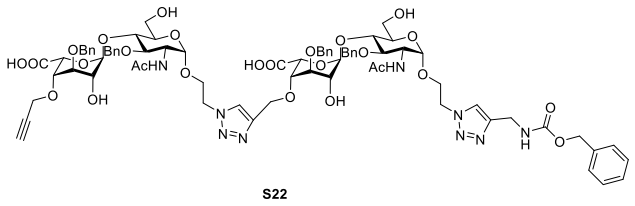
^{1}H NMR of S2



^{13}C NMR of S2

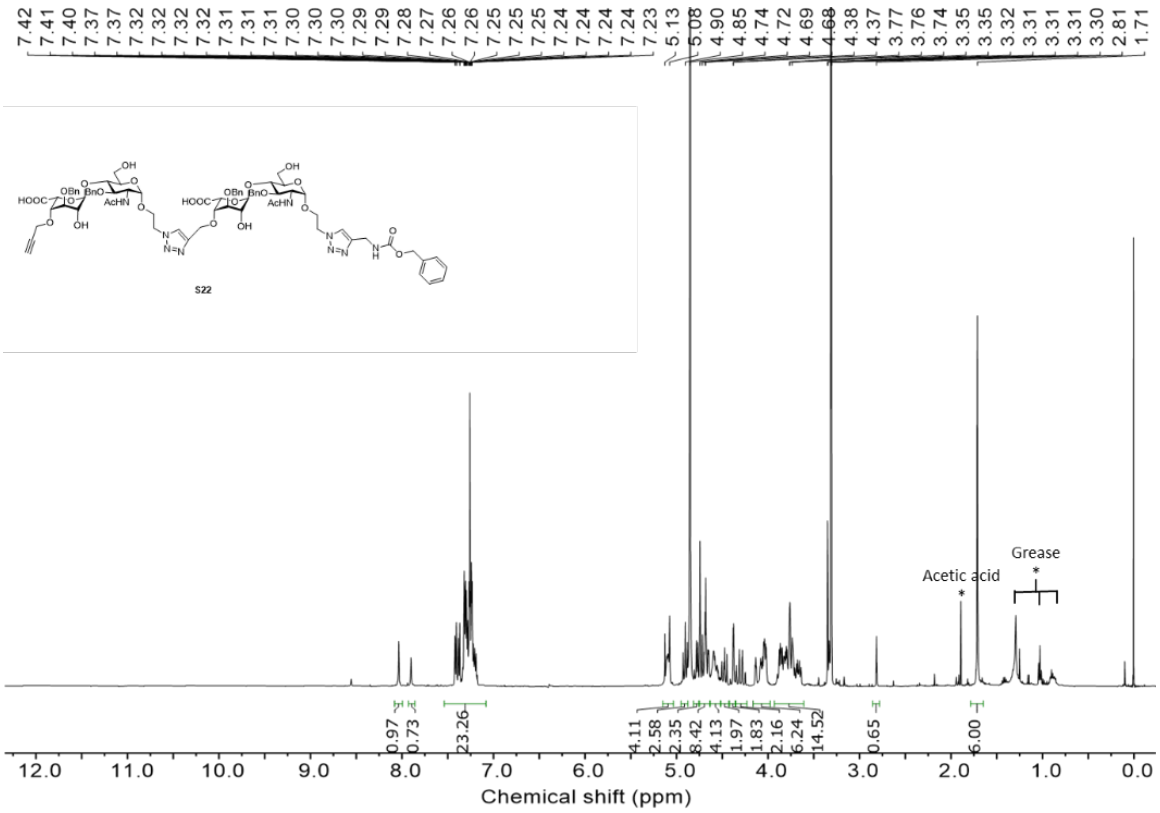

174.38
171.75
138.91
138.43
128.06
127.90
127.84
127.69
127.68
127.60
127.51
127.21
126.95
123.28
101.05
97.21
78.54
77.36
77.02
75.57
73.94
72.23
72.04
70.78
69.33
66.26
65.58
60.44
57.88
52.64
49.64
48.43
48.21
48.13
48.09
35.82
21.37
OSO3-
OBn
BnO
AcHN
-OOC
OH
NHCbz
S2
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
Chemical shift (ppm)

Characterization of S22

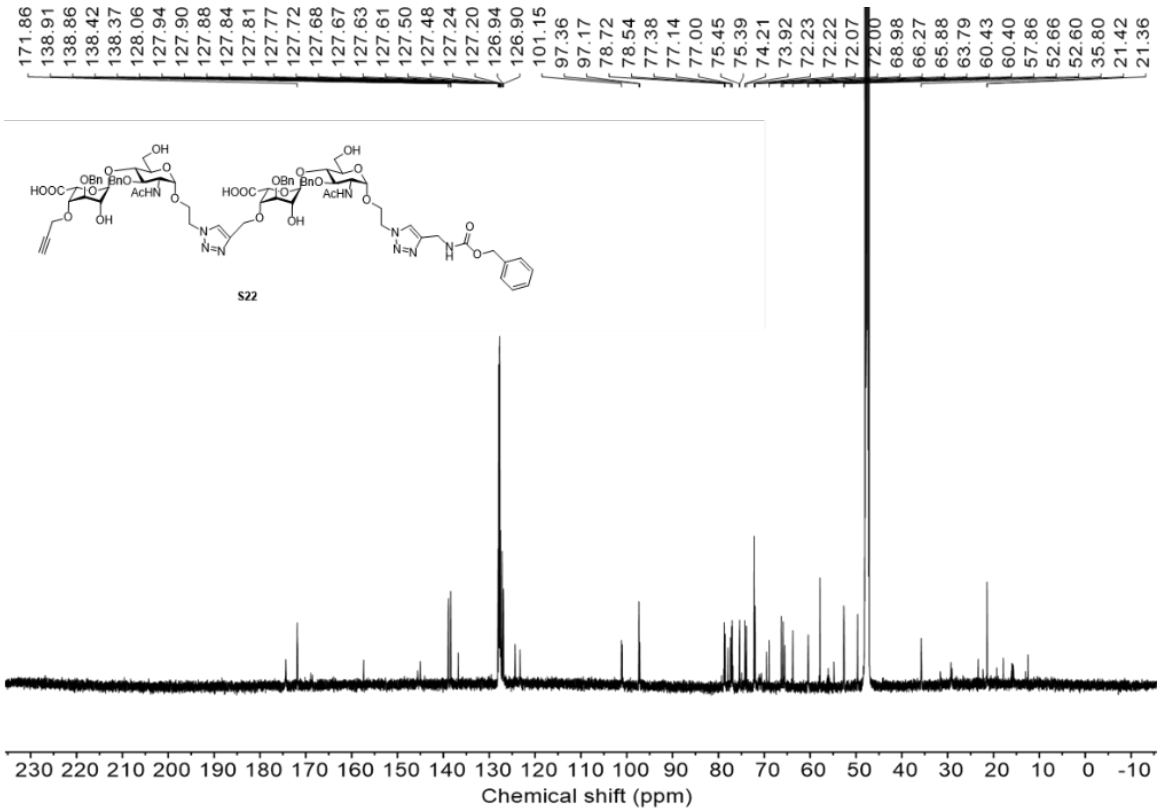


S22

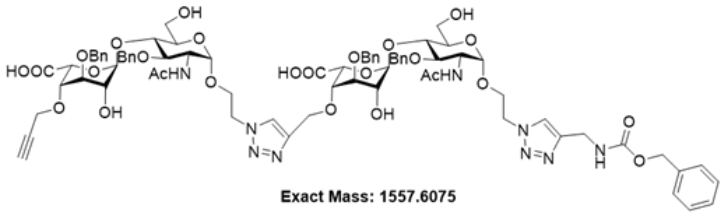
^{1}H NMR of S22

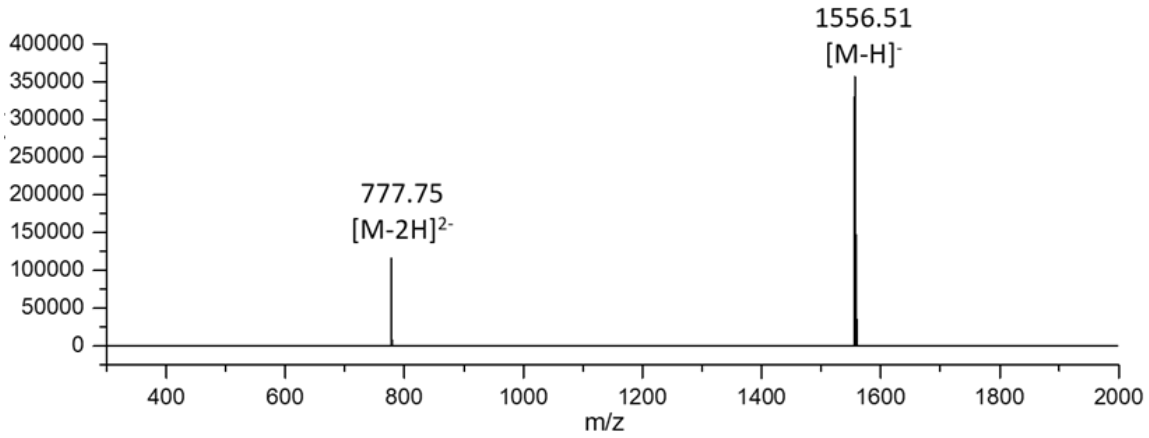


^{13}C NMR of S22

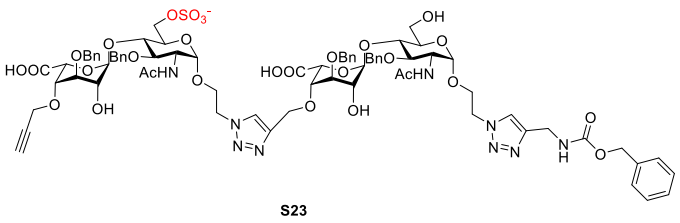


Mass spectra of S22



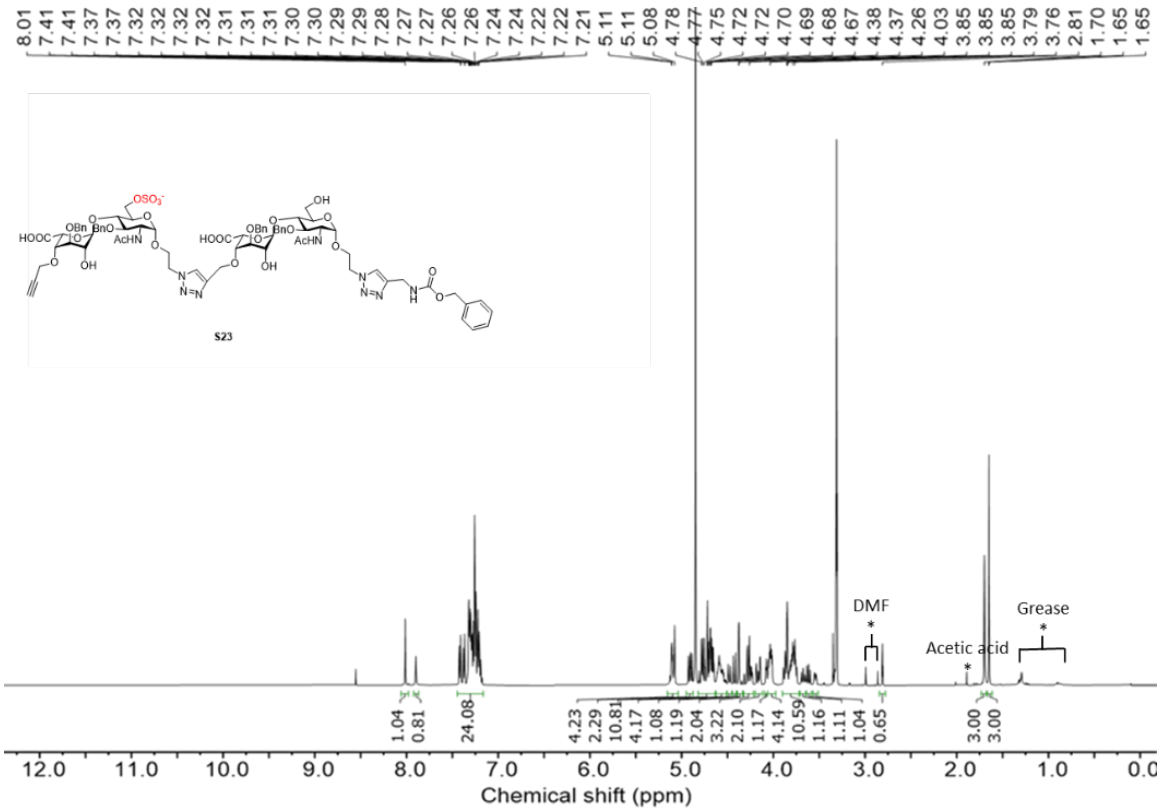


Characterization of S23

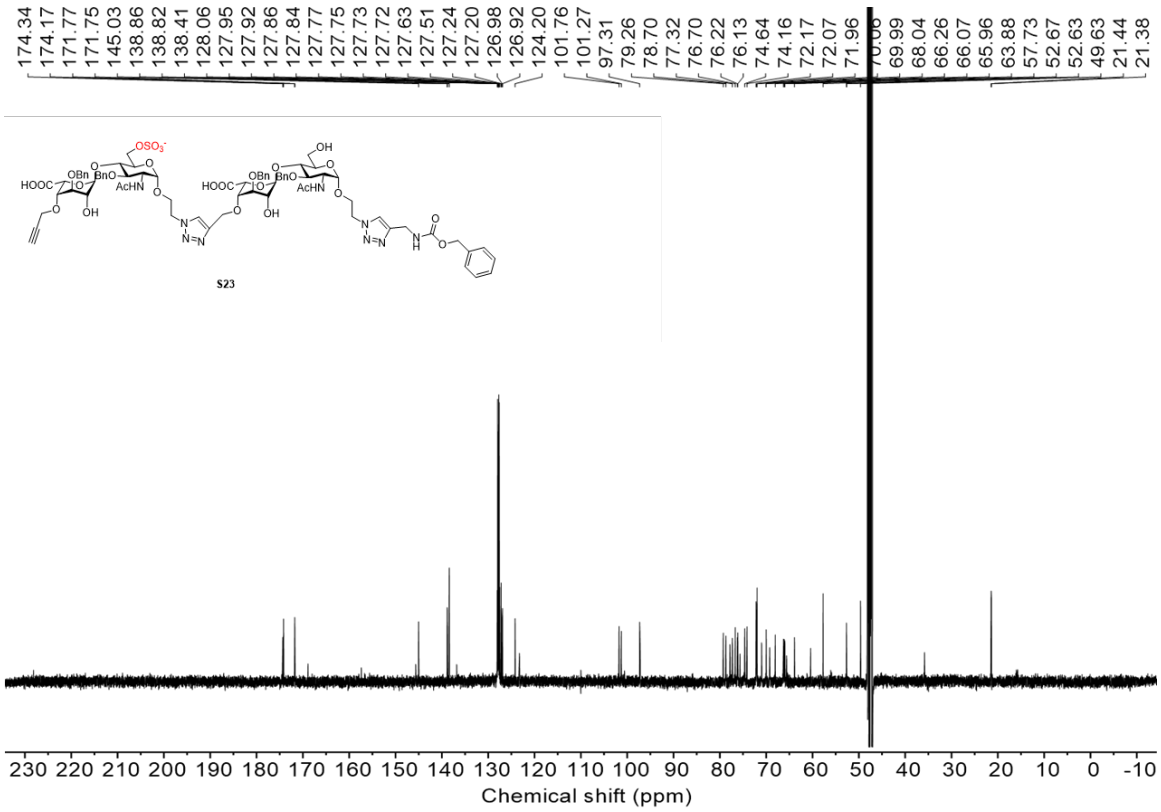


S23

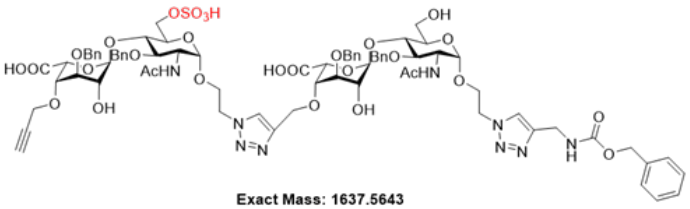
^{1}H NMR of S23

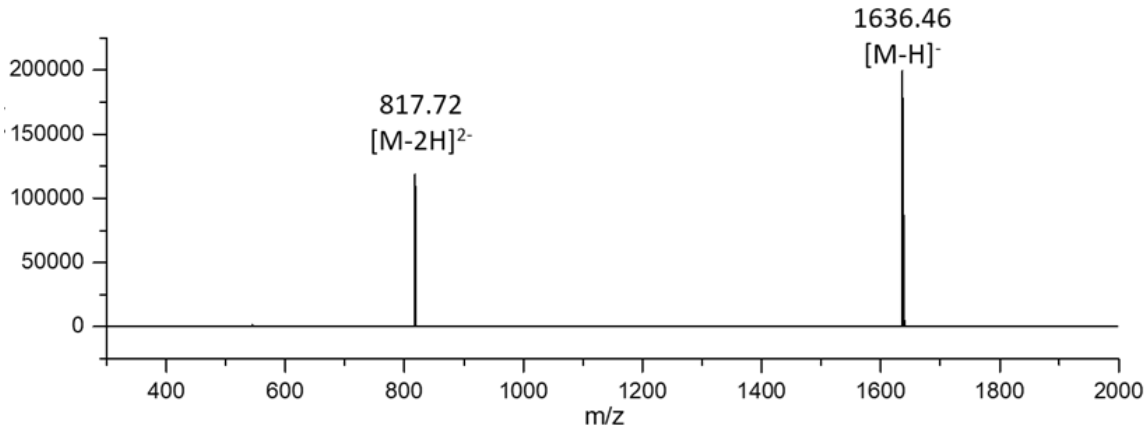


^{13}C NMR of S23

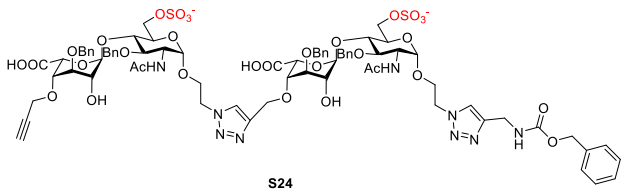


Mass spectra of S23



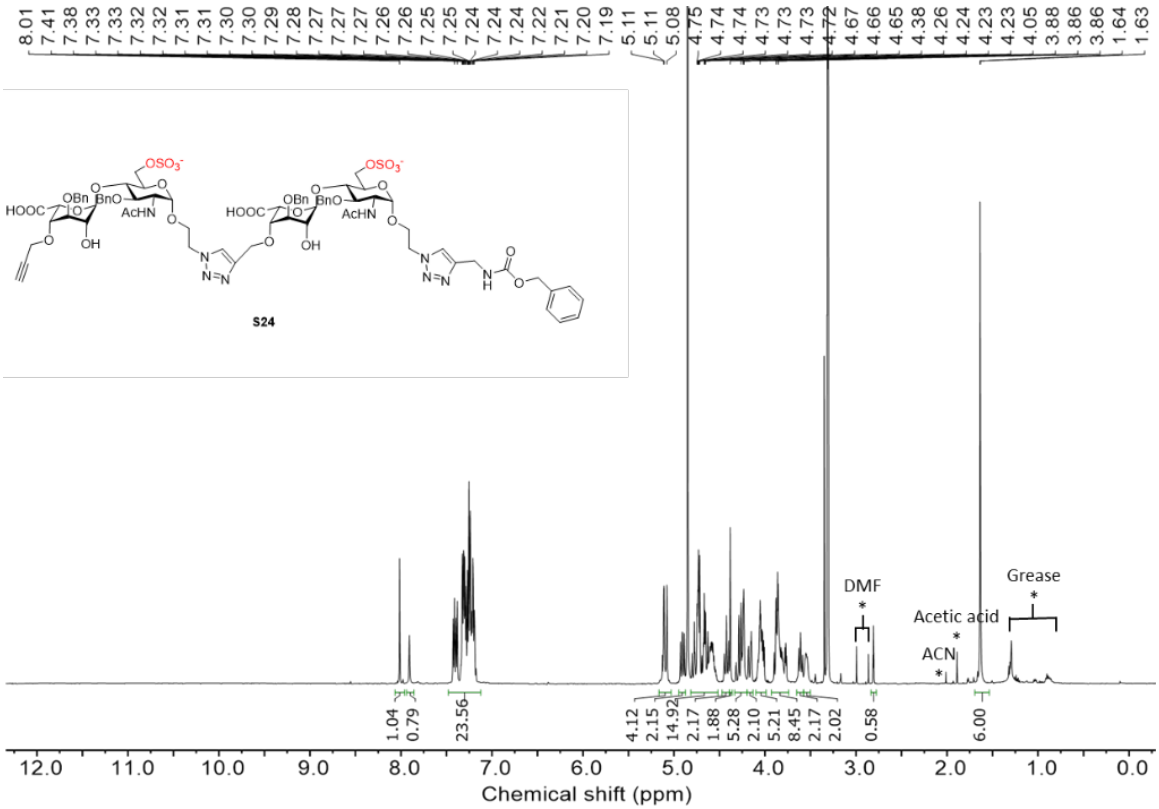


Characterization of S24

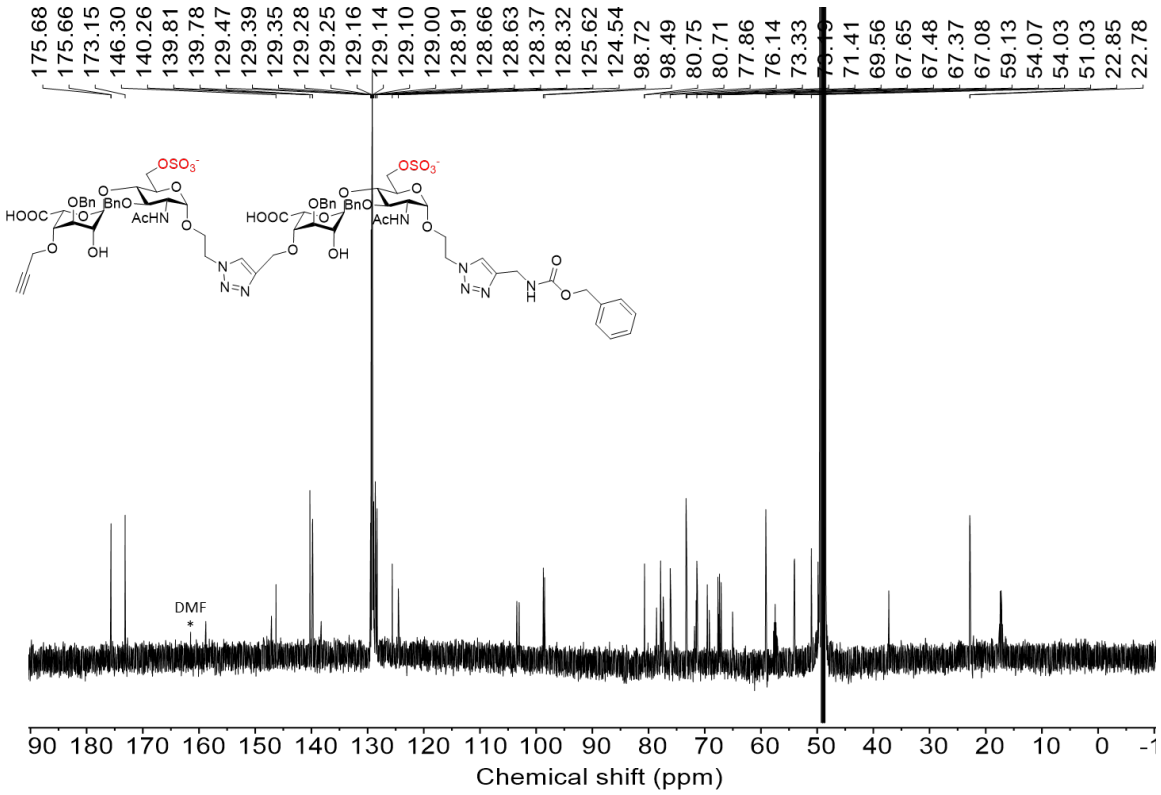


S24

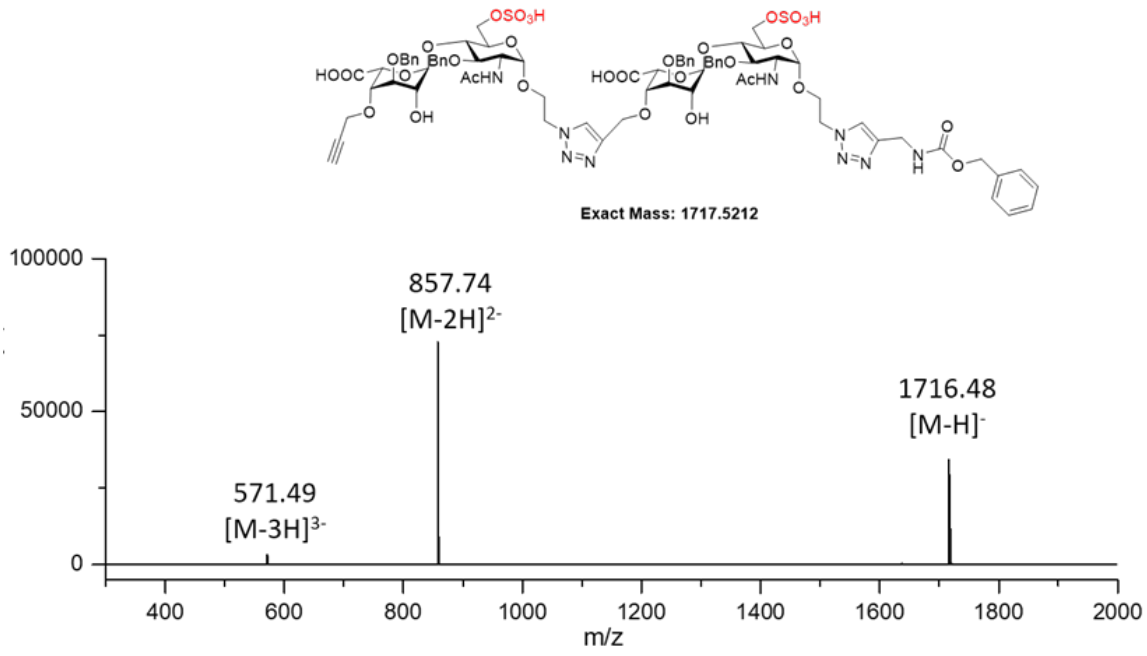
^{1}H NMR of S24



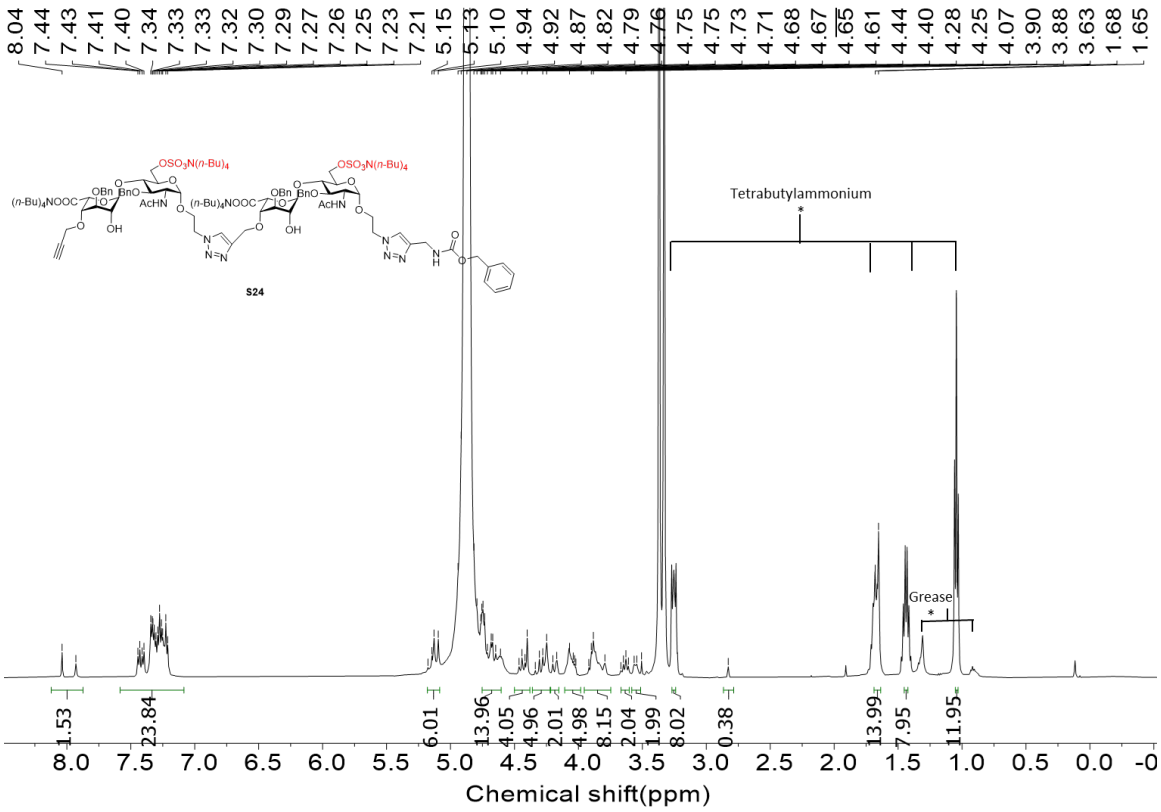
^{13}C NMR of S24



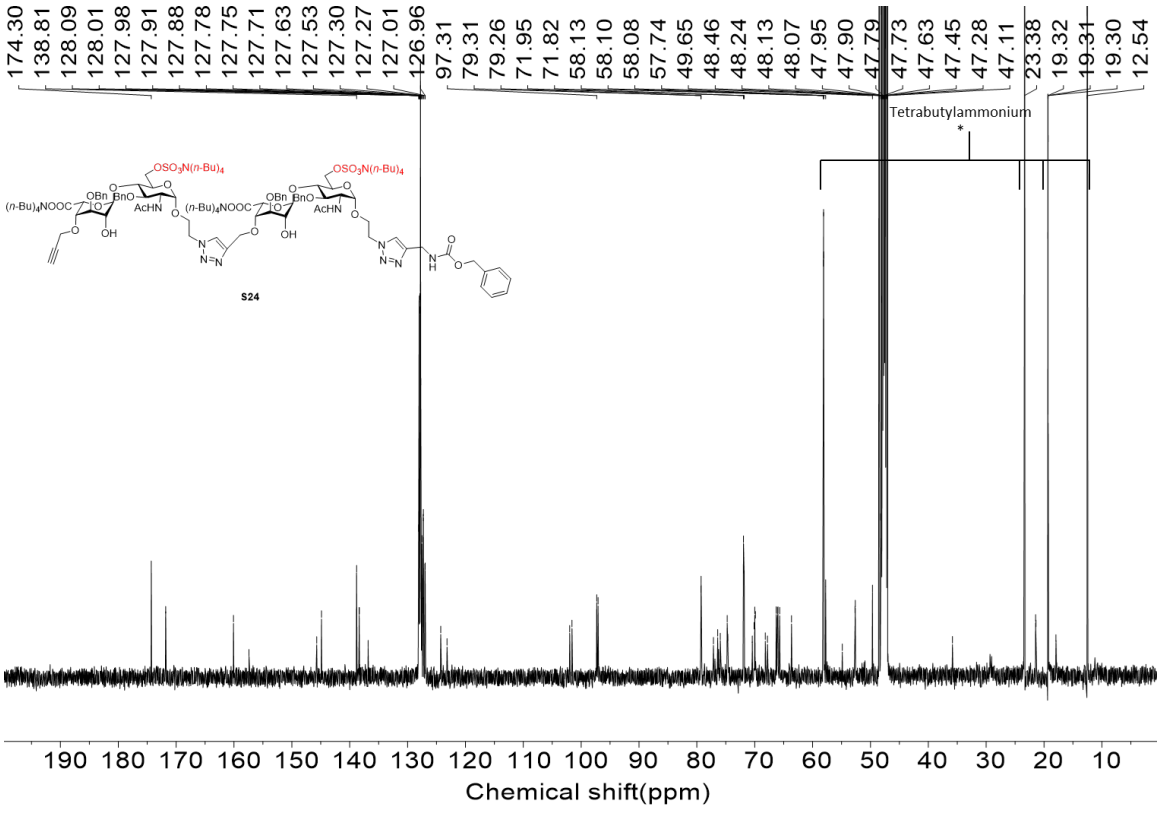
Mass spectra of S24



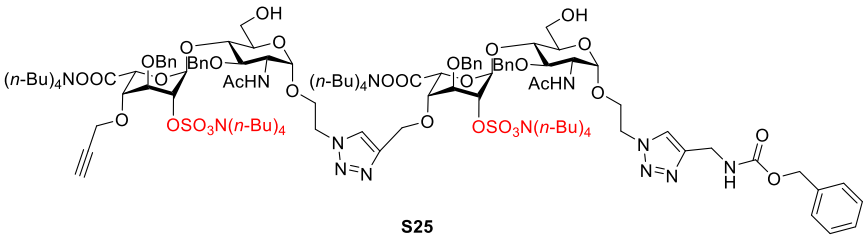
^{1}H NMR of S24 (in large scale)



^{13}C NMR of S24 (in large scale)

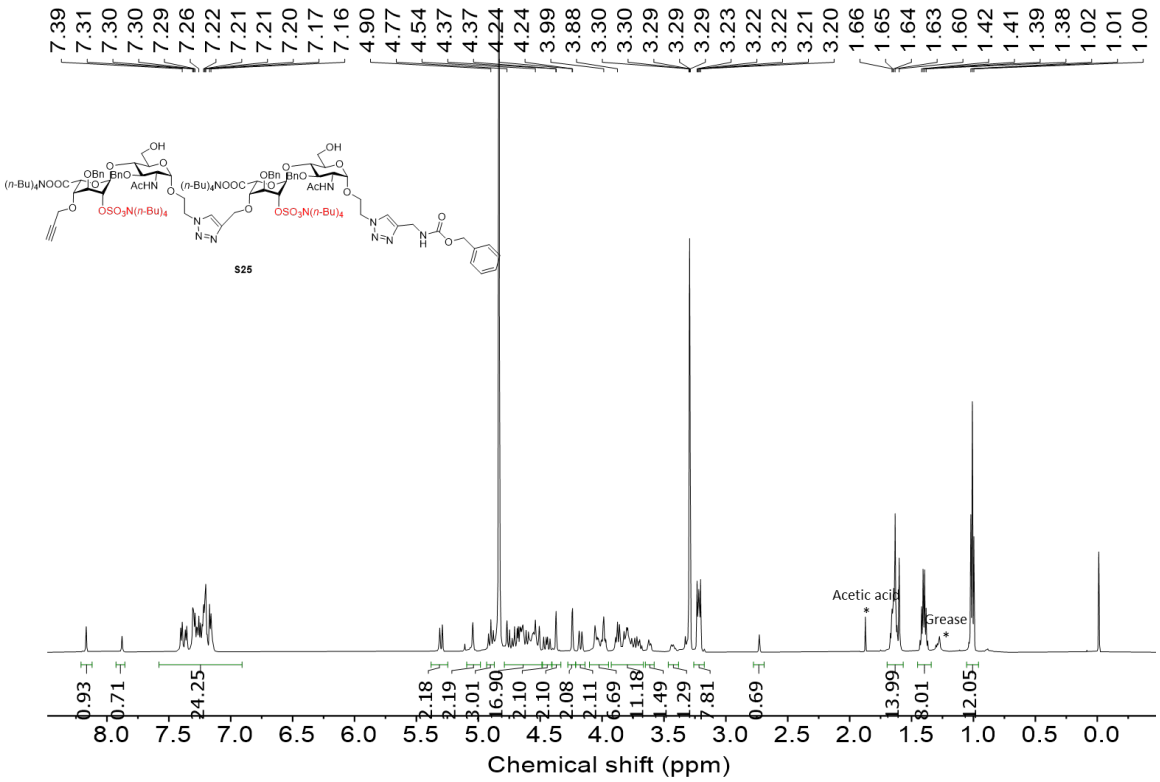


Characterization of S25

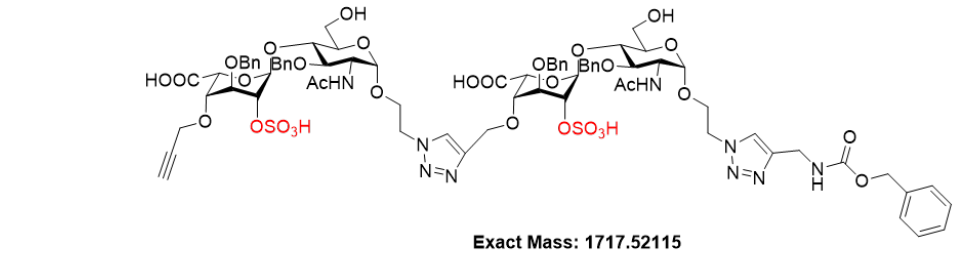


S25

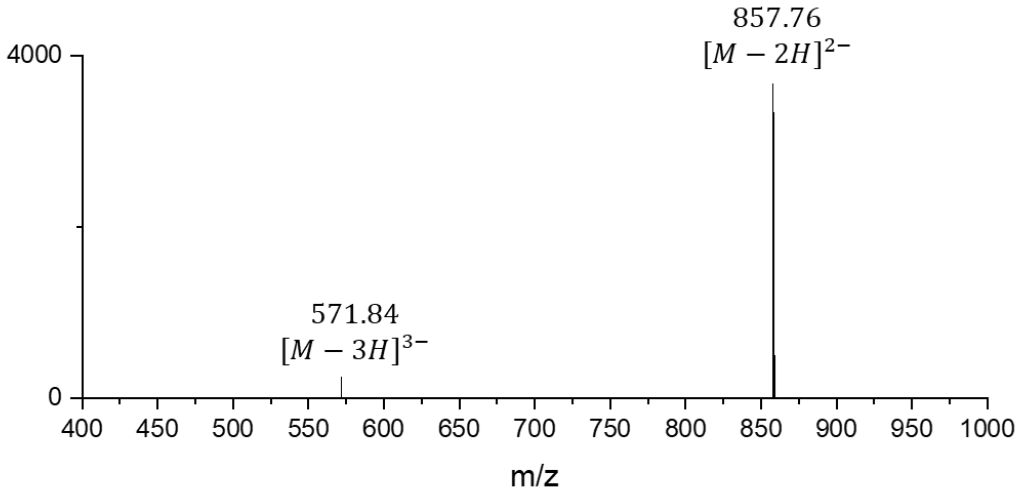
^{1}H NMR of S25



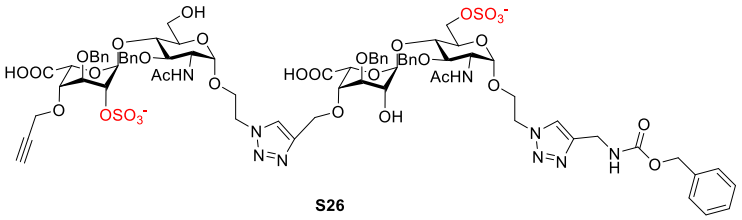
Mass spectra of S25



Exact Mass: 1717.52115

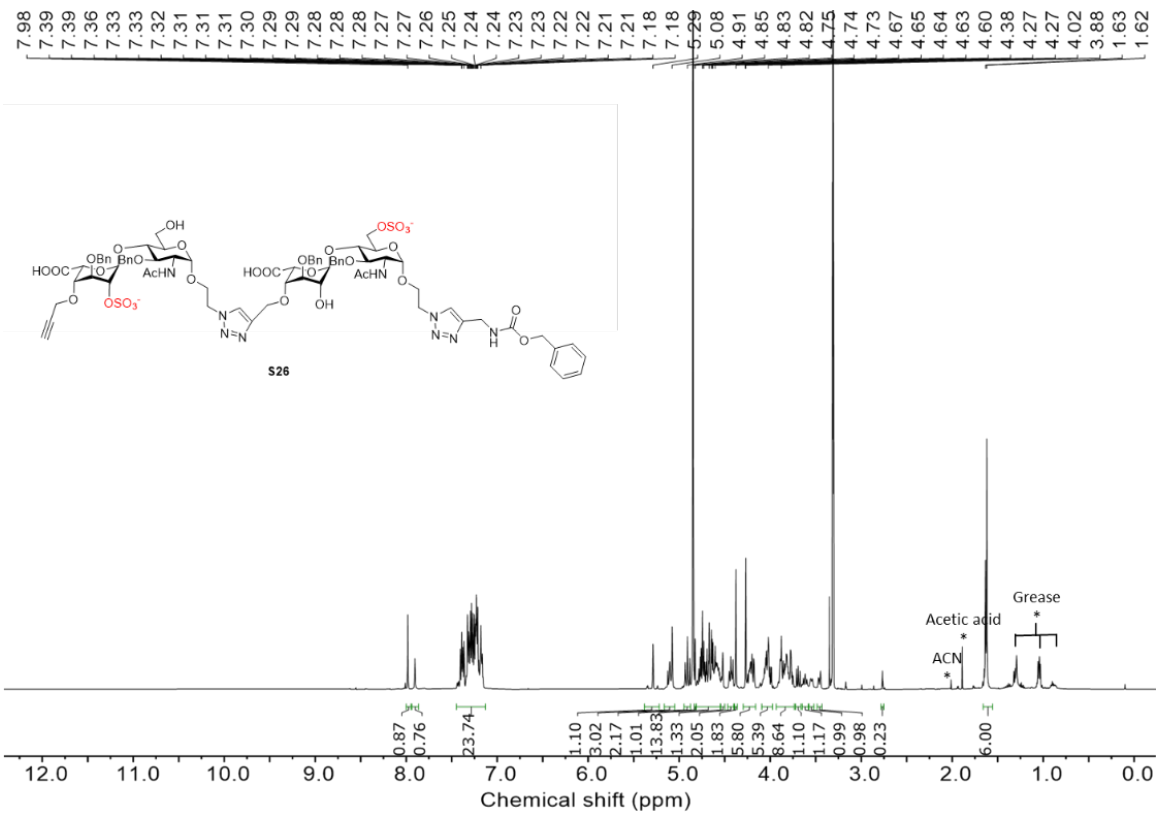


Characterization of S26

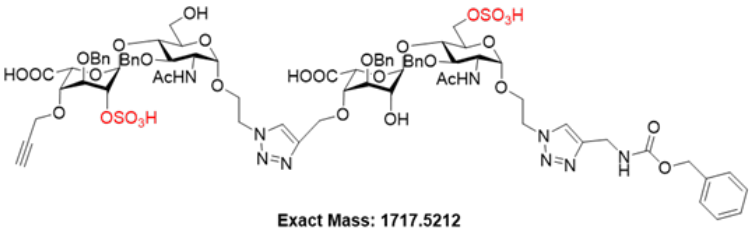


S26

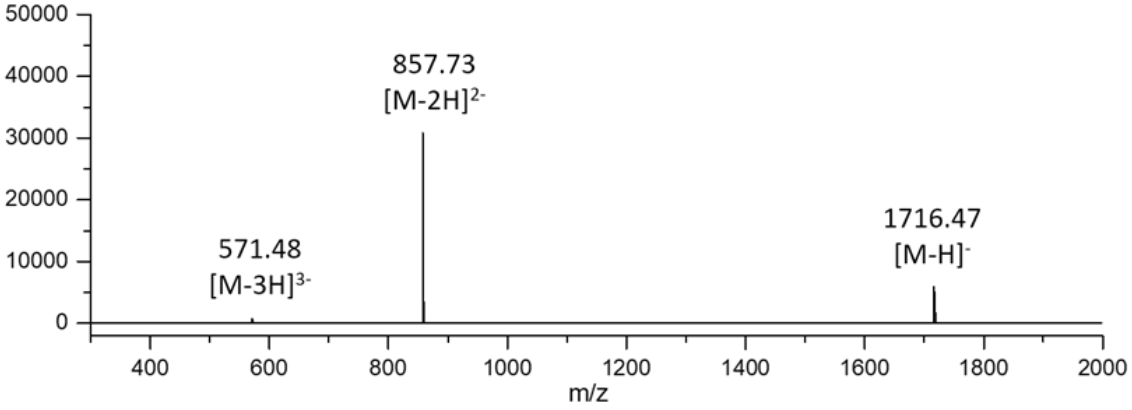
^{1}H NMR of S26



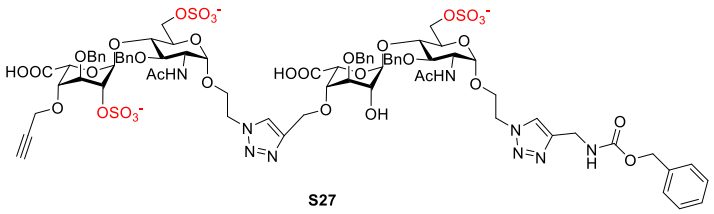
Mass spectra of S26



Exact Mass: 1717.5212

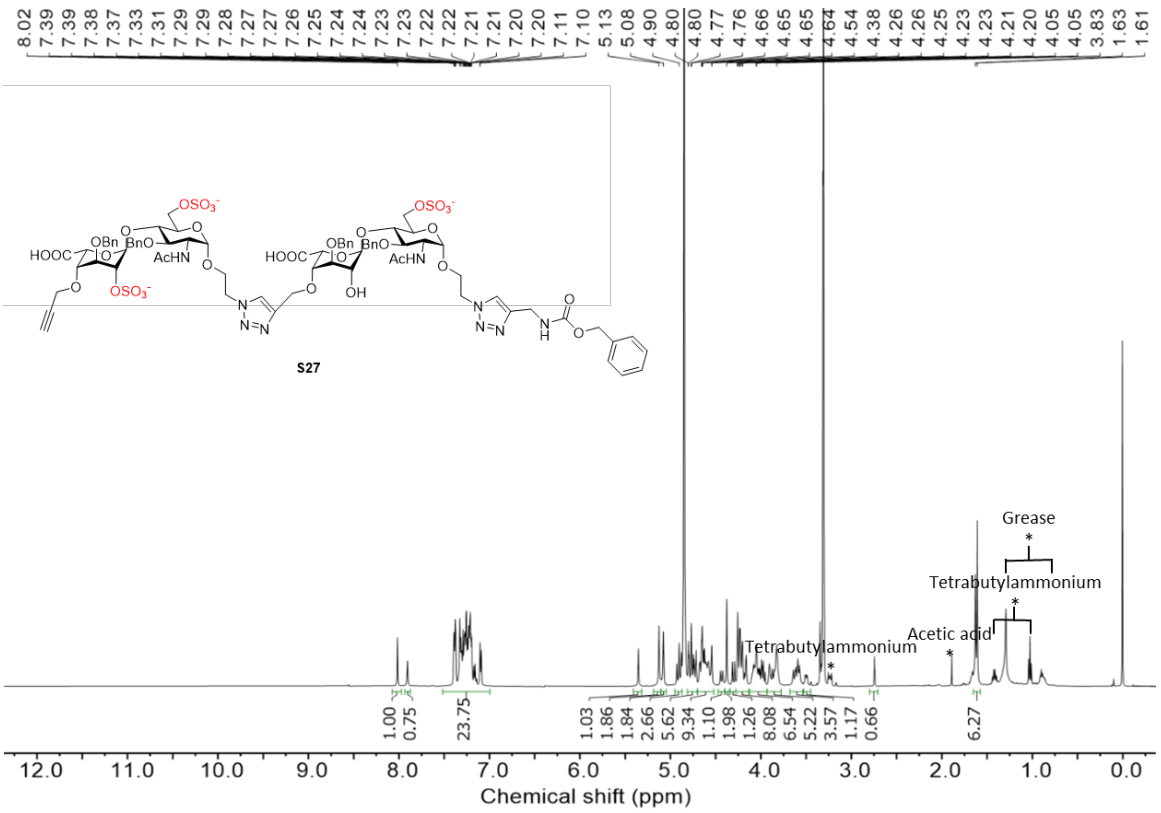


Characterization of S27

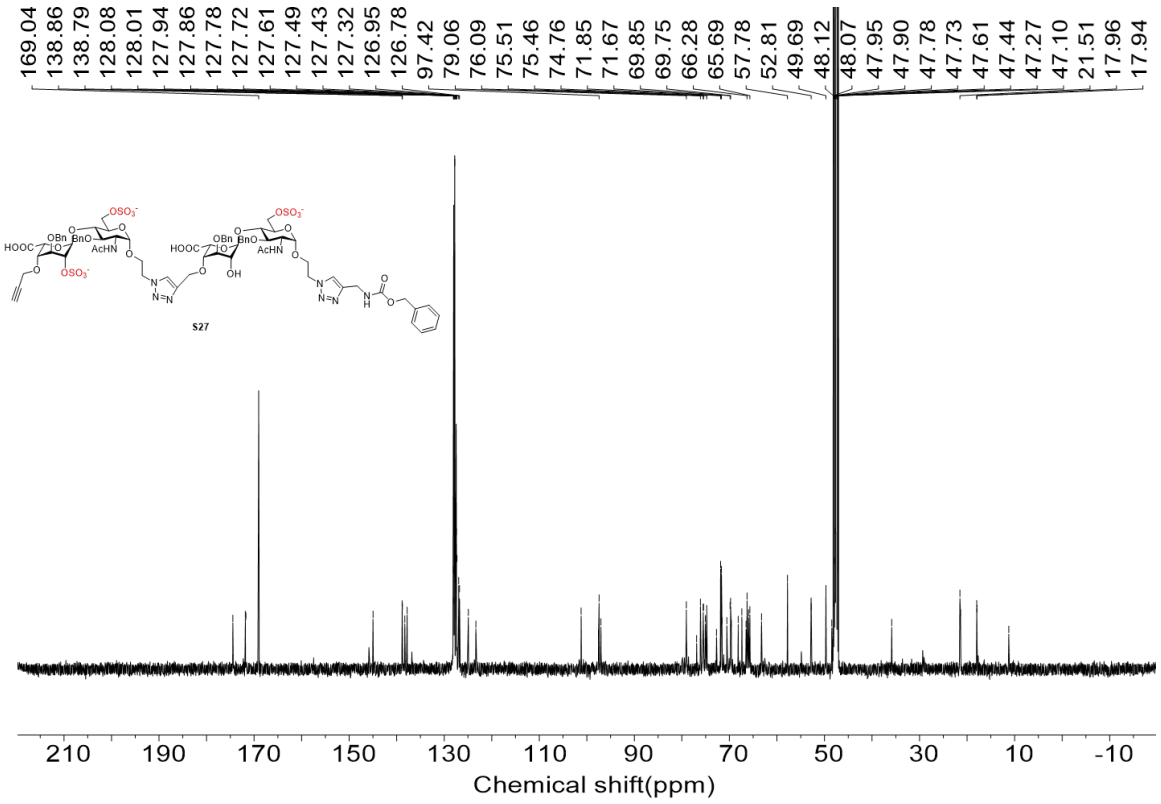


S27

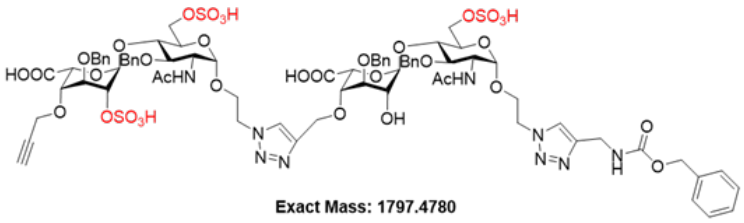
^{1}H NMR of S27

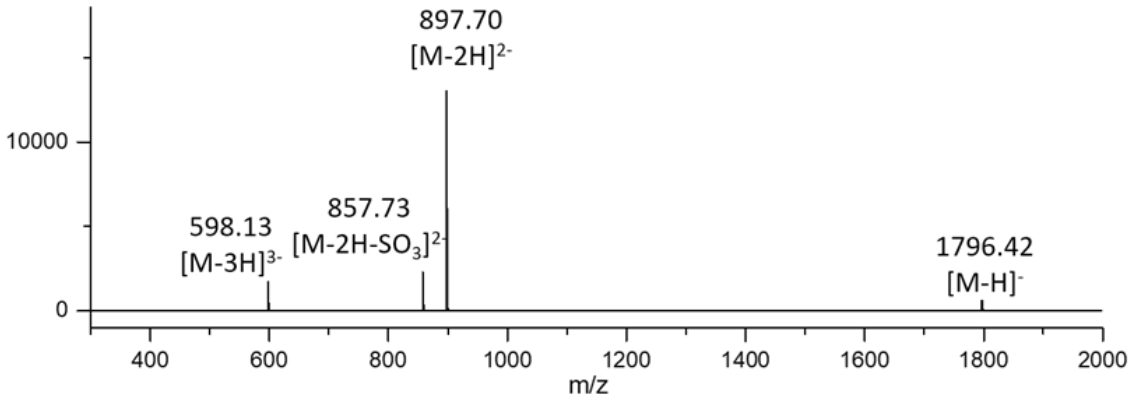


^{13}C NMR of S27

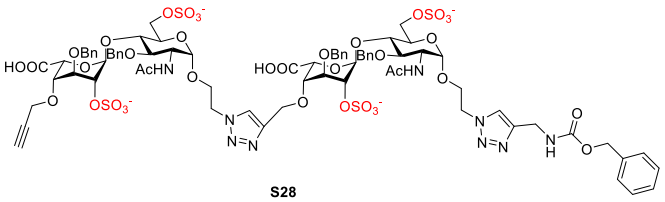


Mass spectra of S27



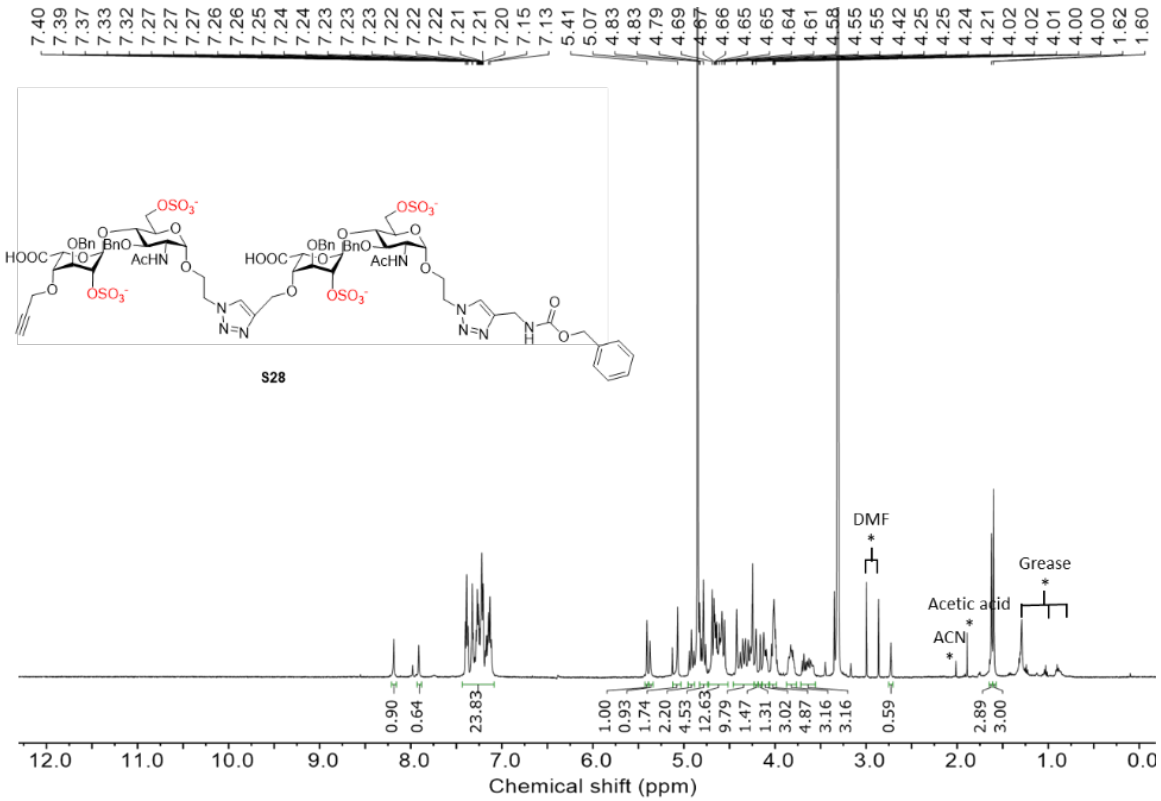


Characterization of S28



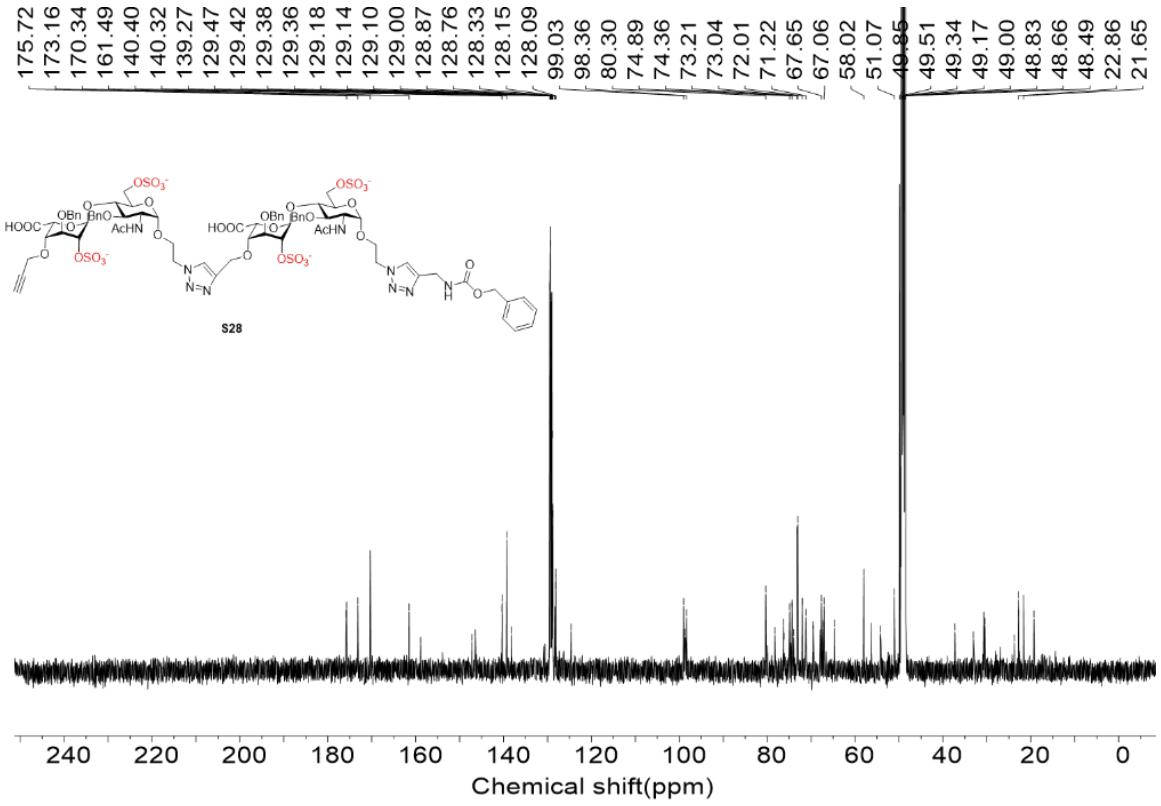
S28

^{1}H NMR of S28

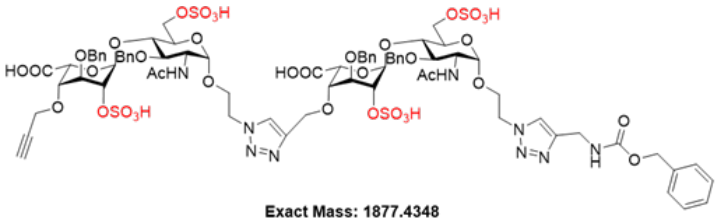


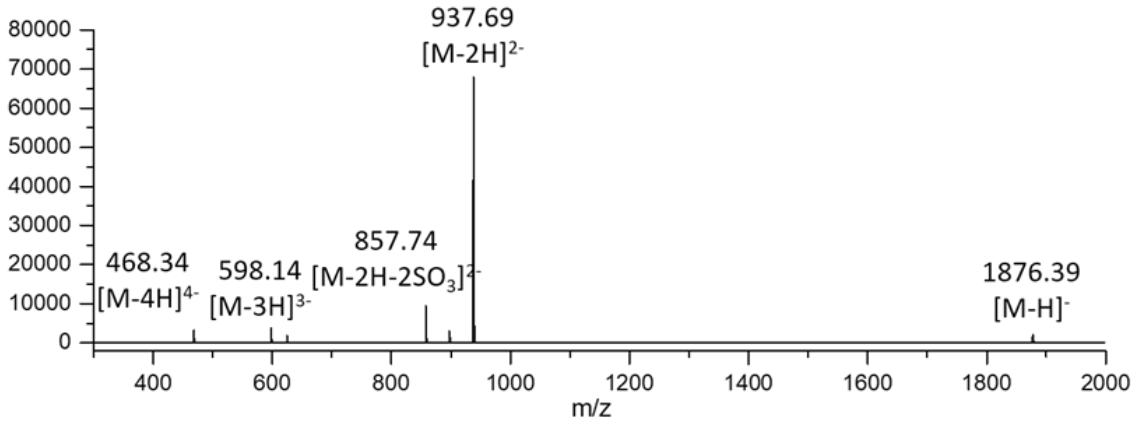
S28

^{13}C NMR of S28

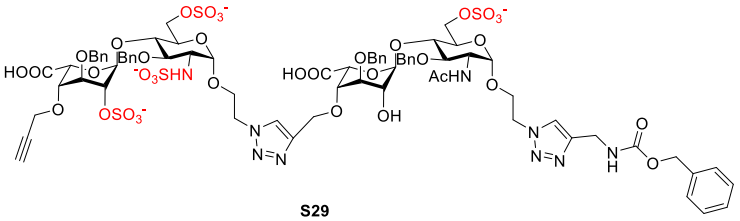


Mass spectra of S28



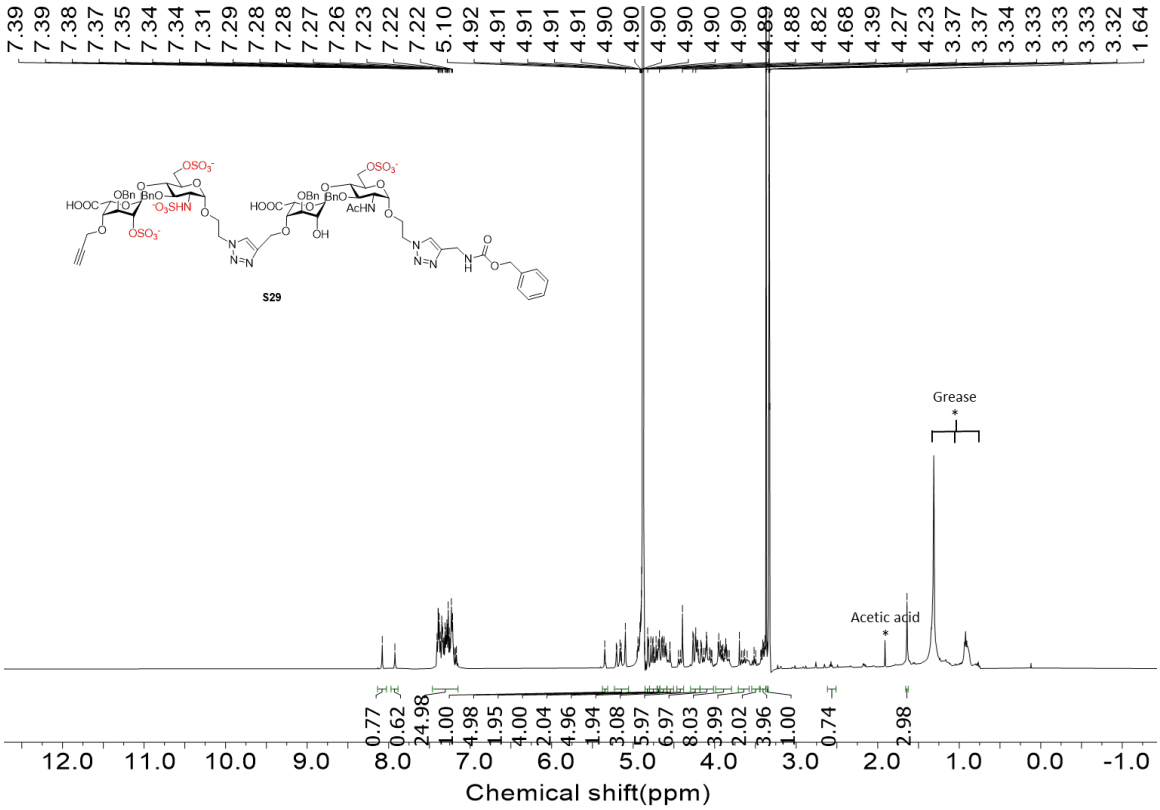


Characterization of S29

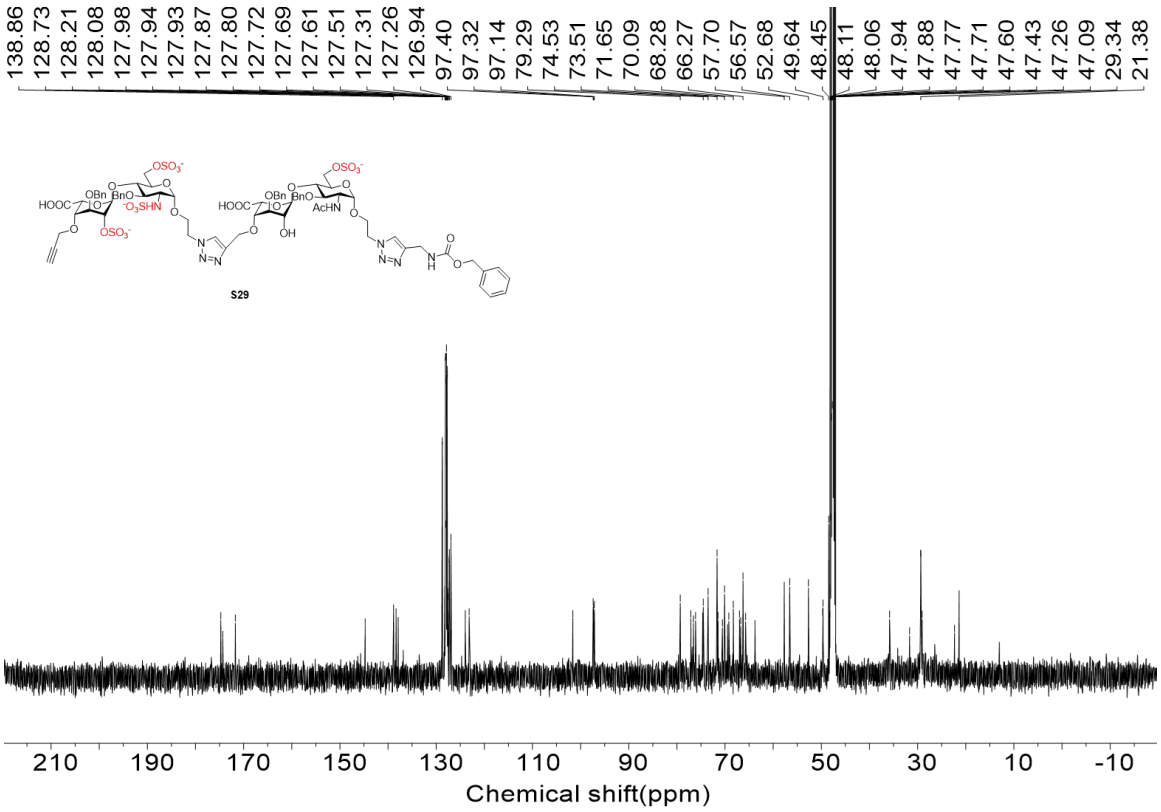


S29

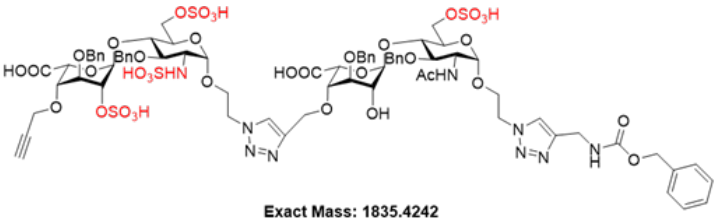
^{1}H NMR of S29

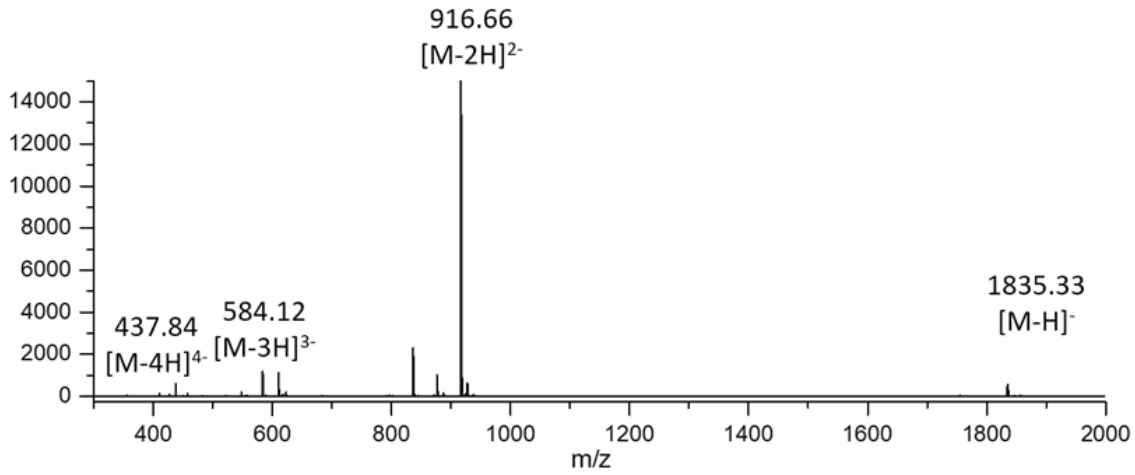


^{13}C NMR of S29

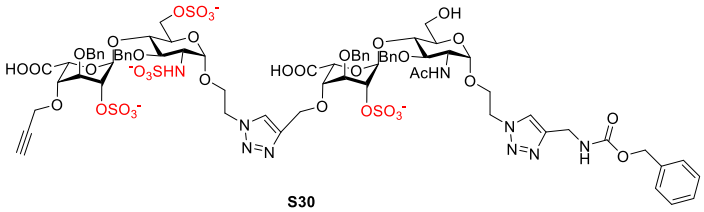


Mass spectra of S29



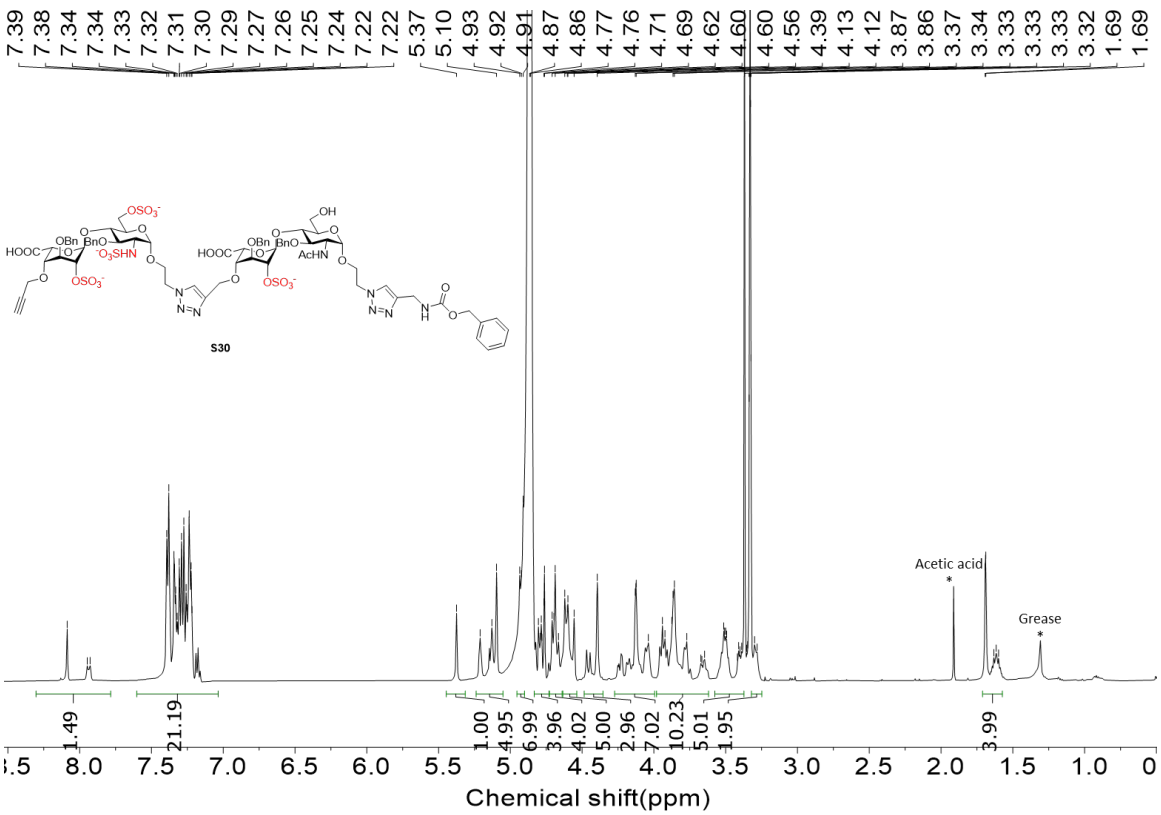


Characterization of S30



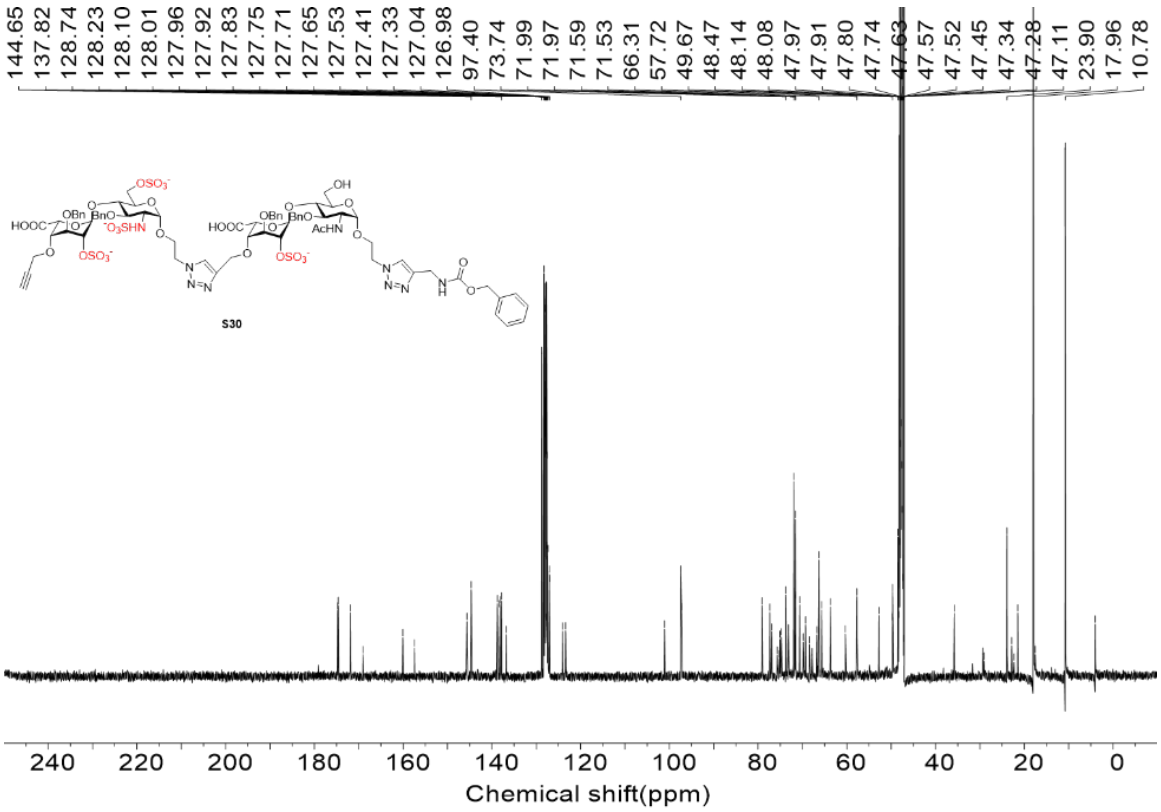
S30

^{1}H NMR of S30

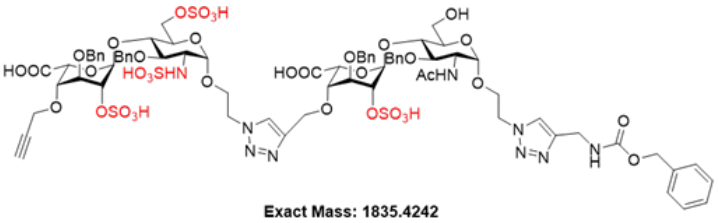


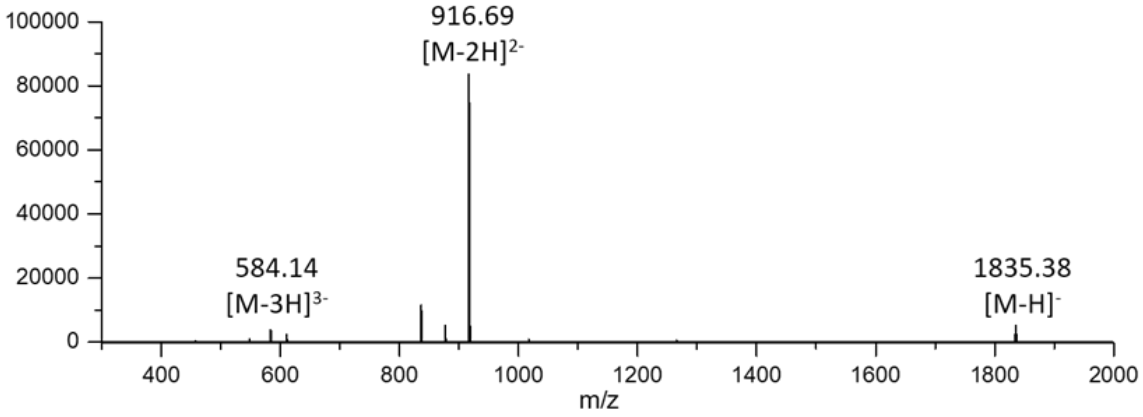
S30

^{13}C NMR of S30

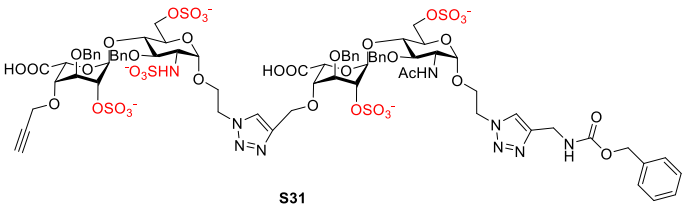


Mass spectra of S30



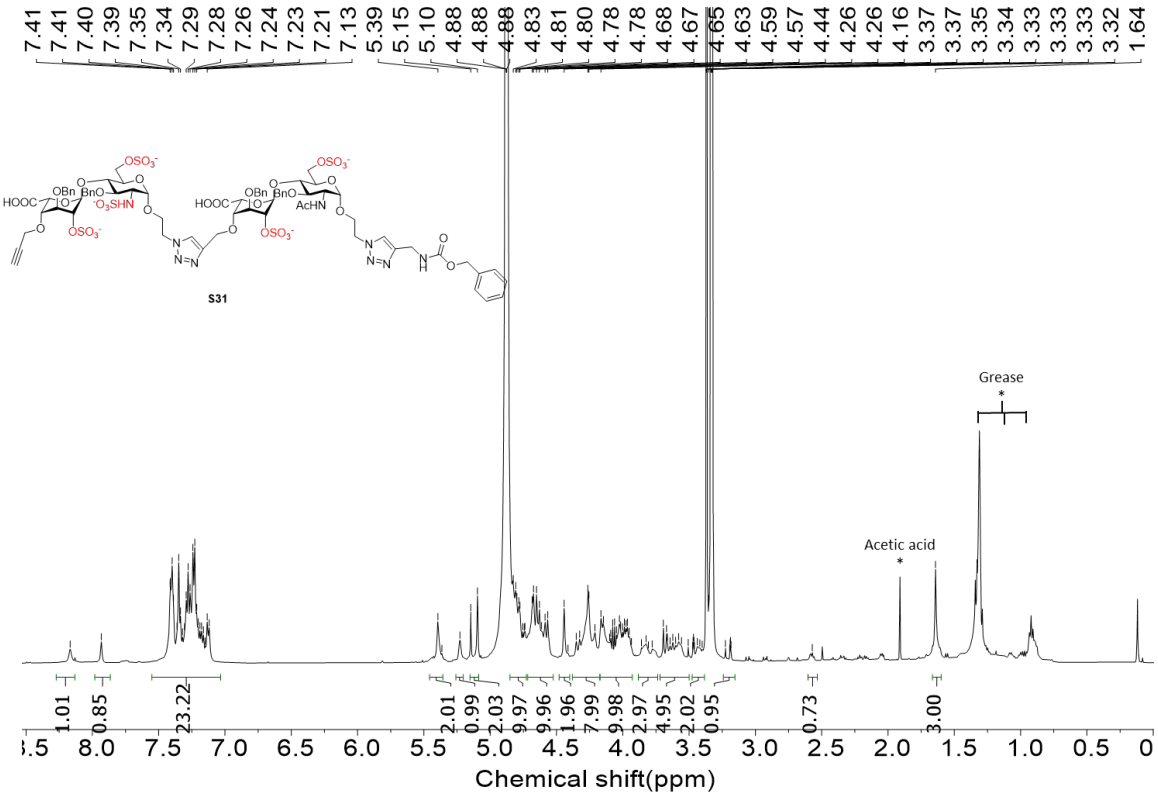


Characterization of S31



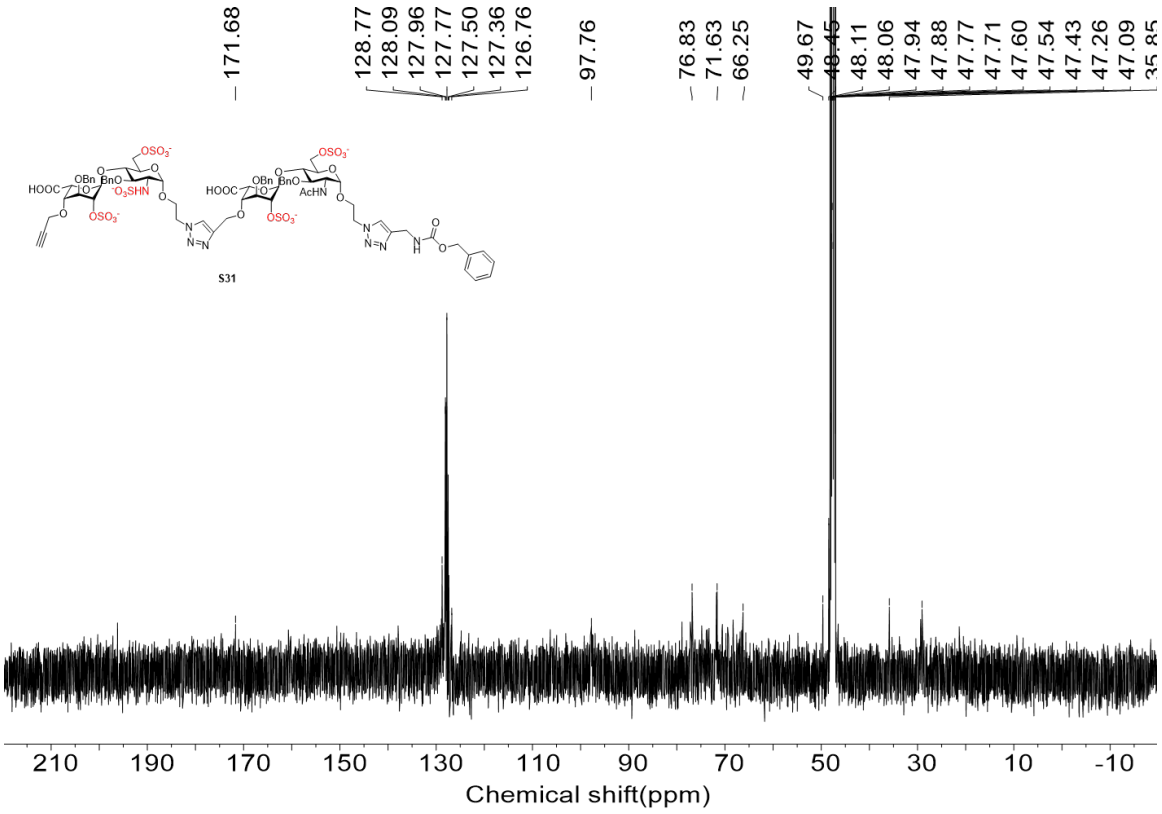
S31

^{1}H NMR of S31

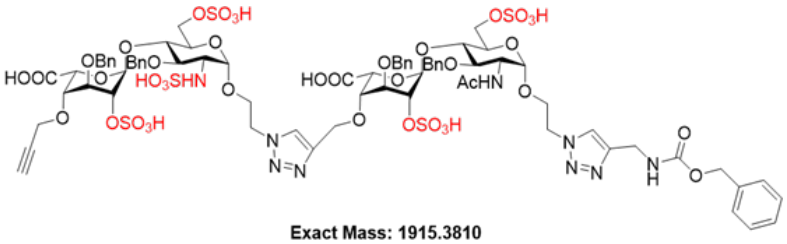


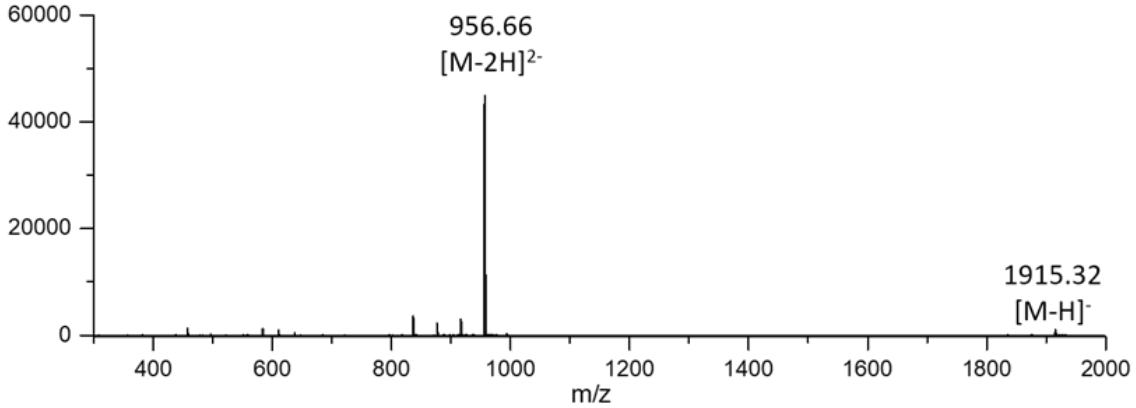
S31

^{13}C NMR of S31

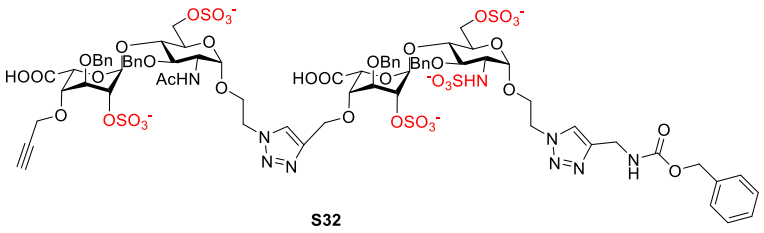


Mass spectra of S31

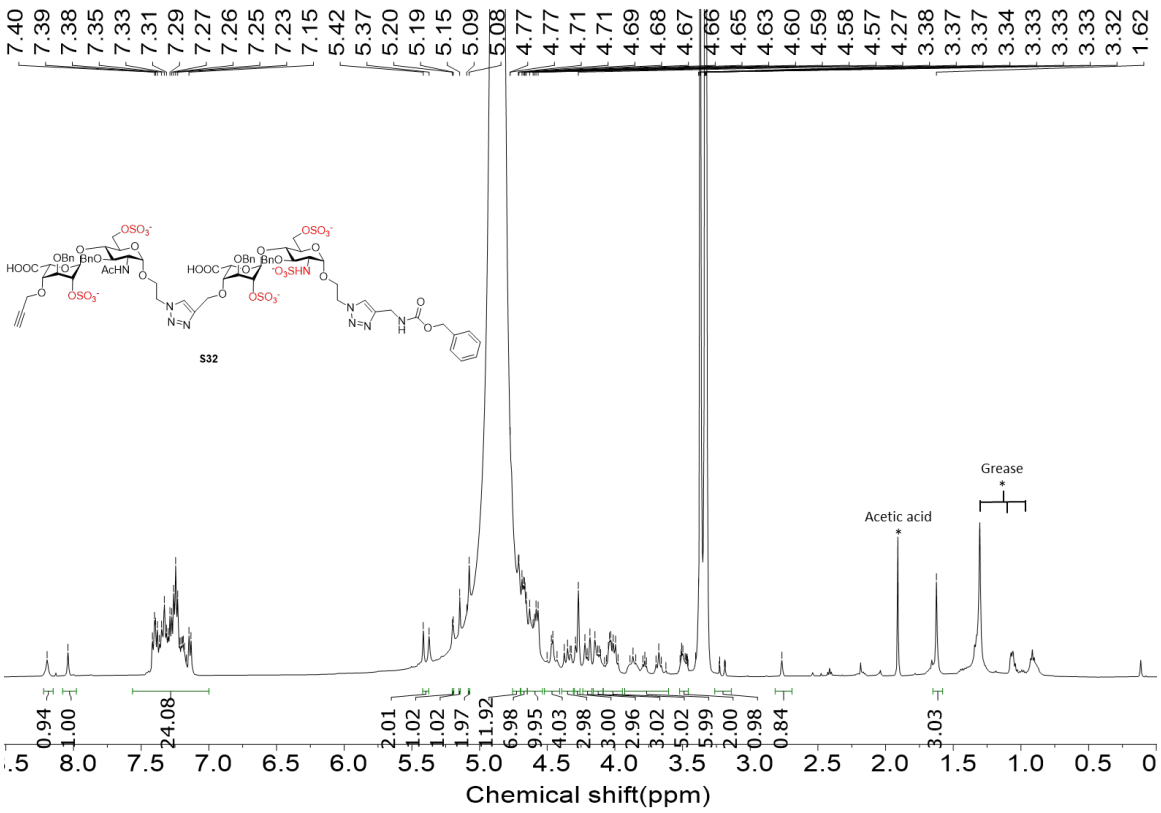




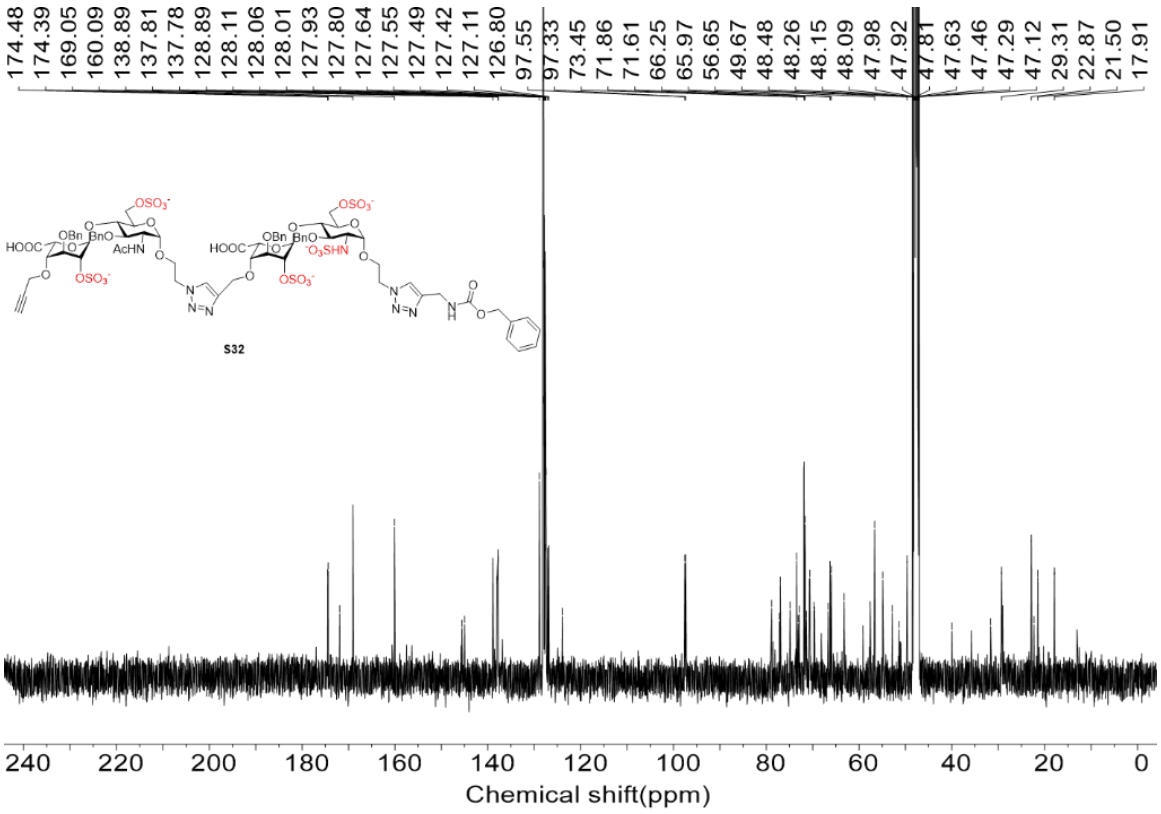
Characterization of S32



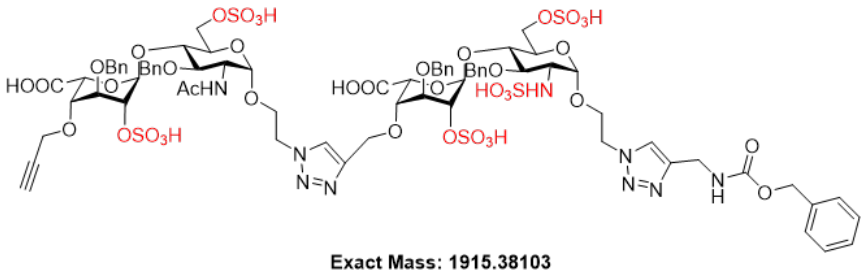
^{1}H NMR of S32

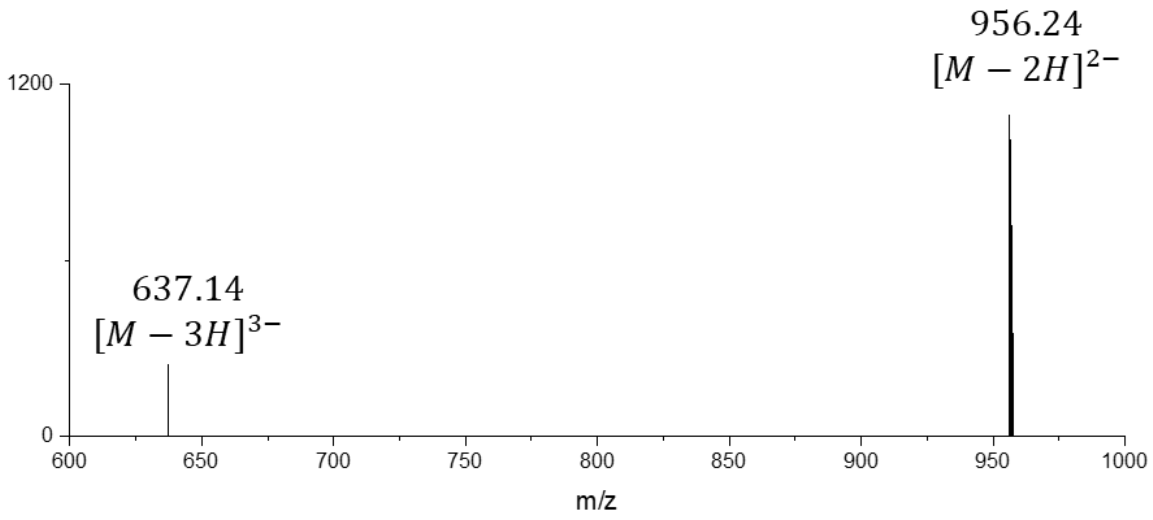


^{13}C NMR of S32

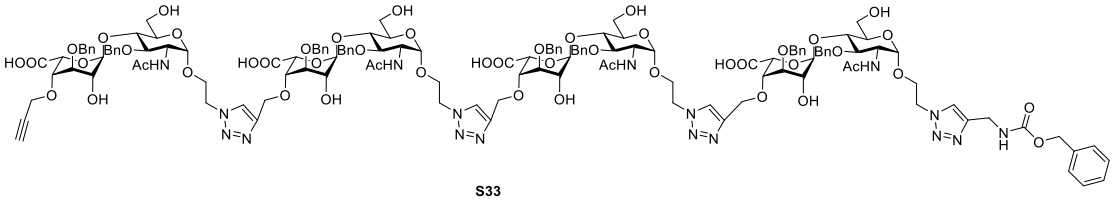


Mass spectra of S32



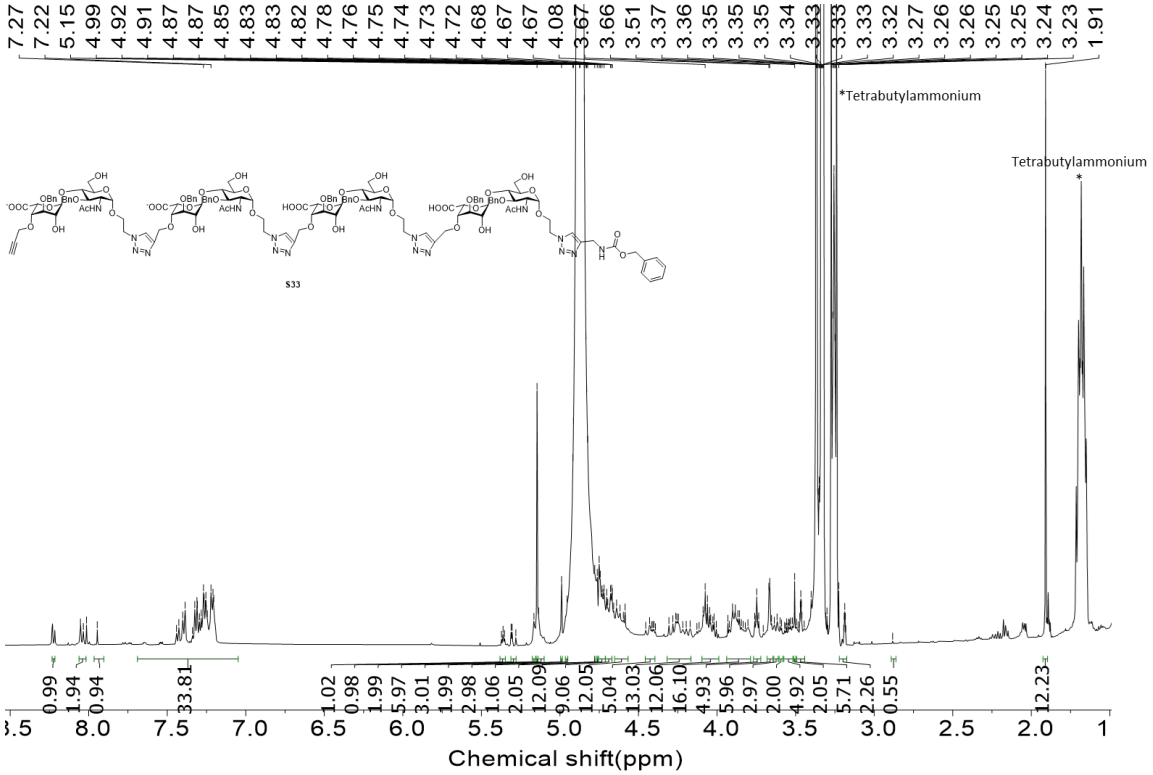


Characterization of S33

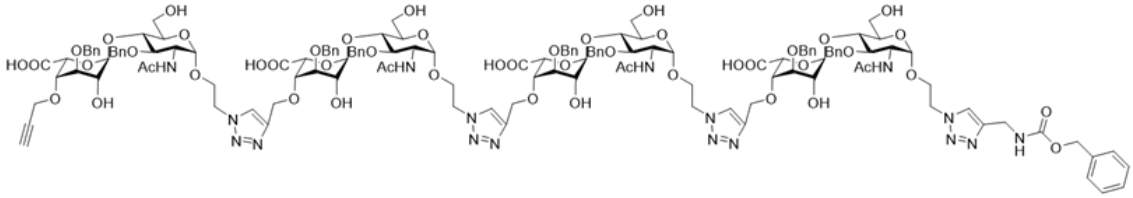


S33

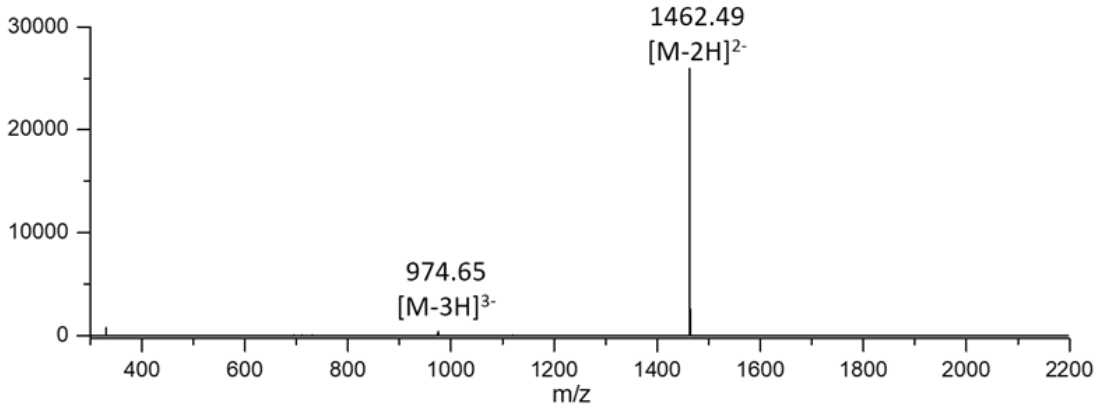
^{1}H NMR of S33



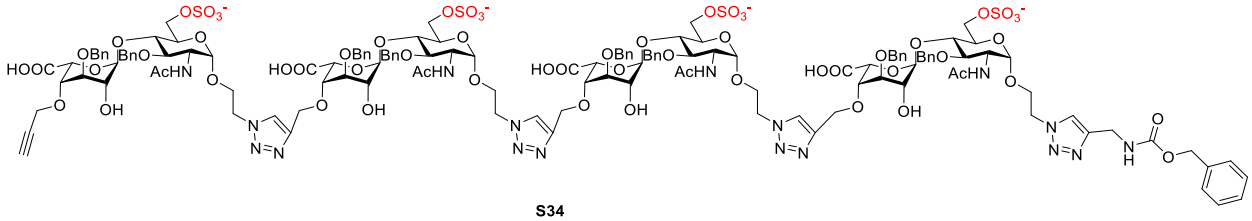
Mass spectra of S33



Exact Mass: 2926.1361

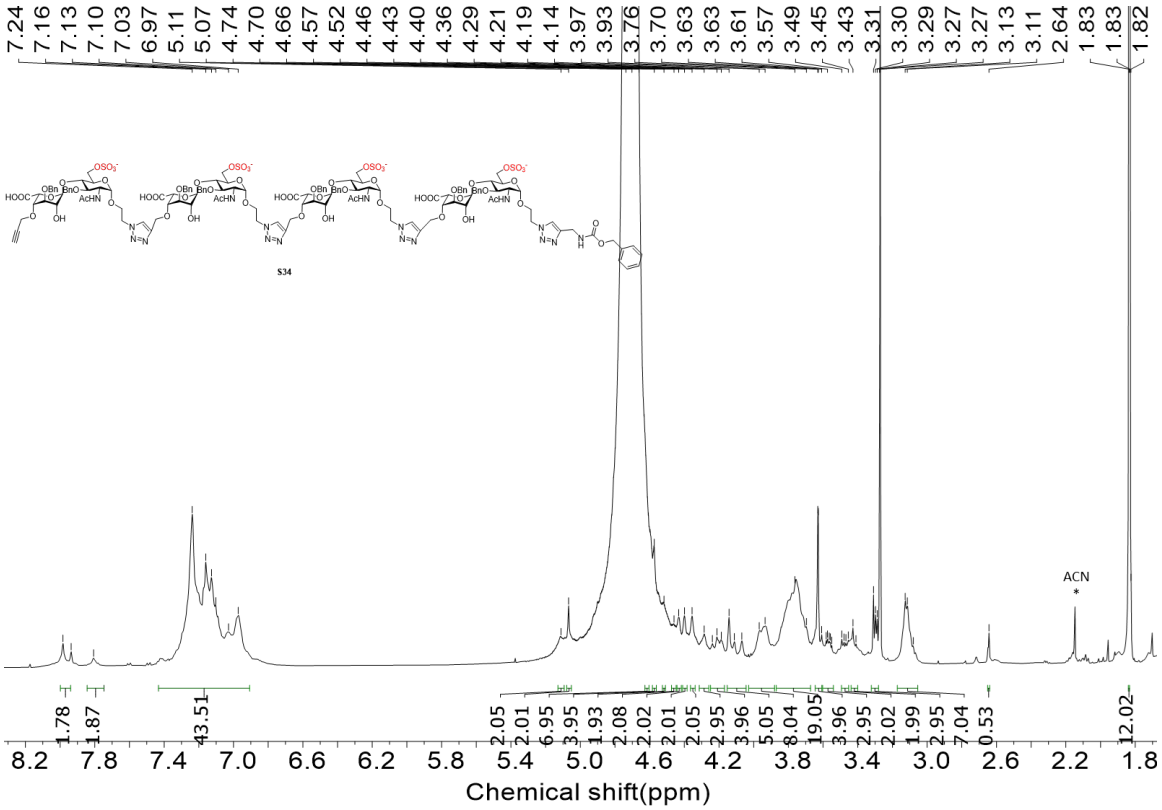


Characterization of S34

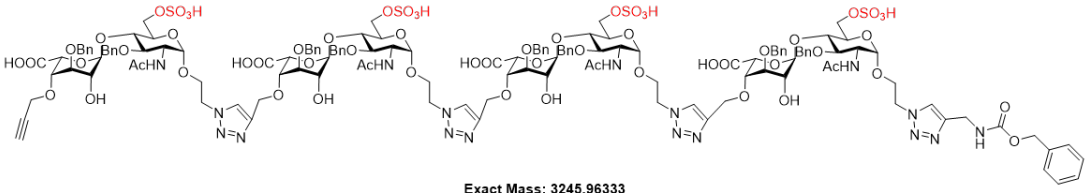


S34

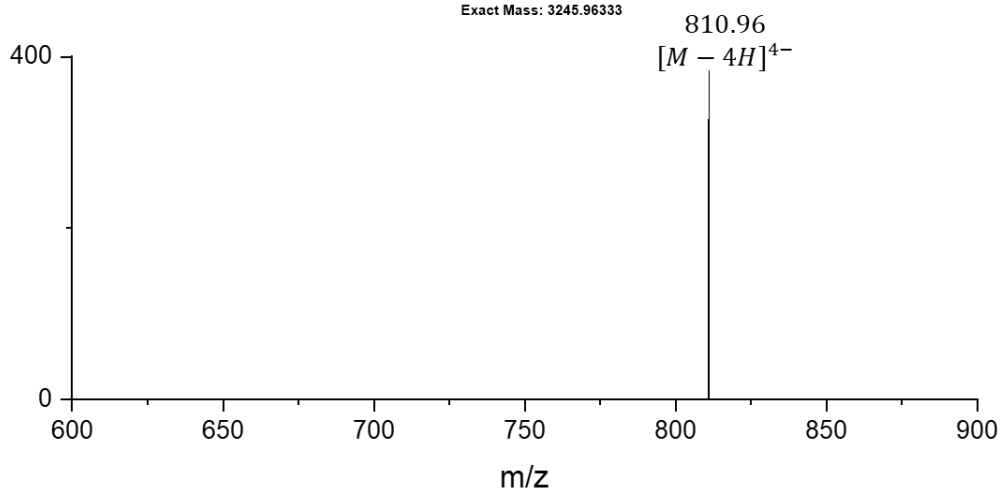
^{1}H NMR of S34



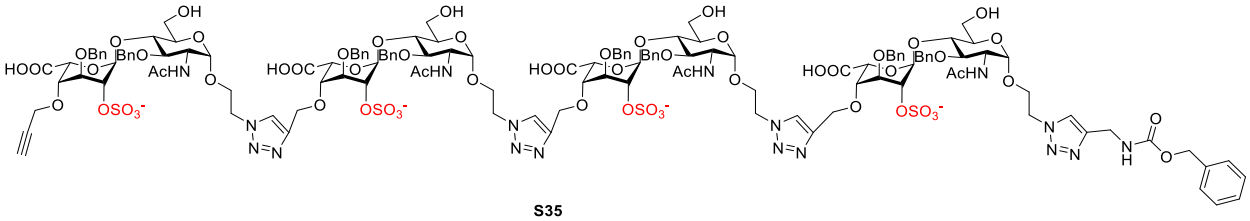
Mass spectra of S34



Exact Mass: 3245.96333

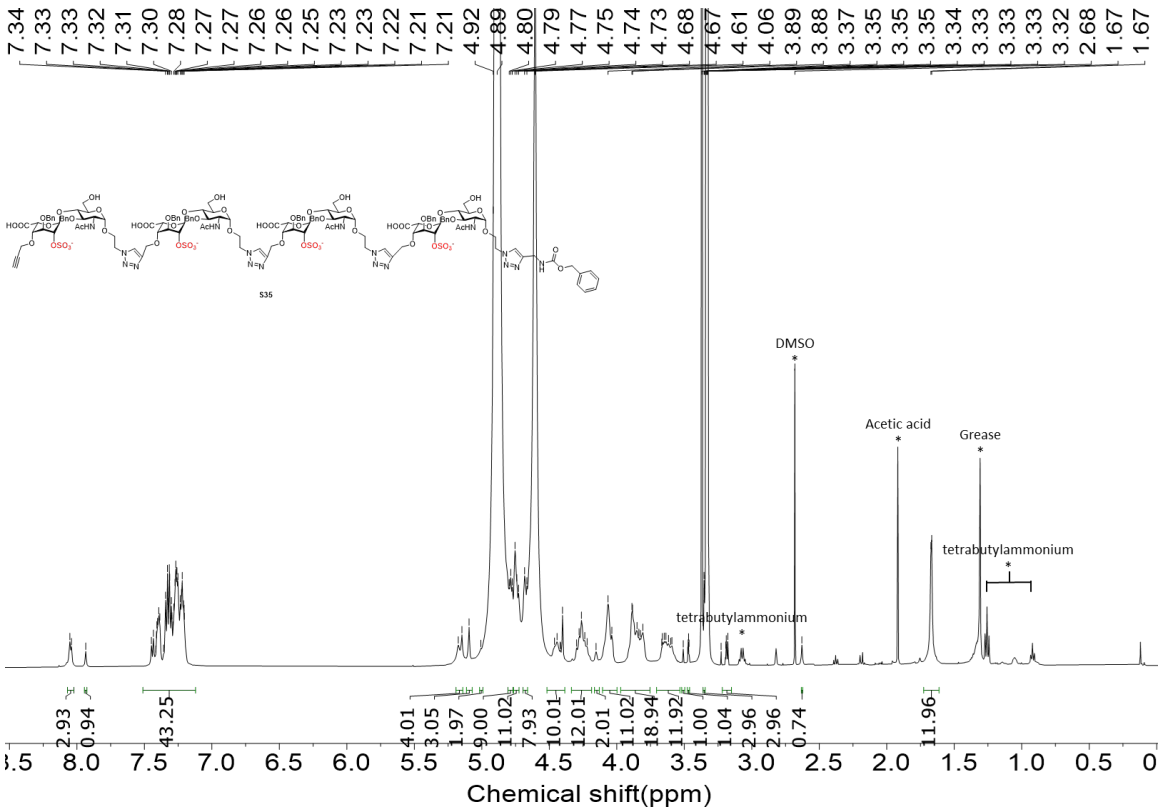


Characterization of S35

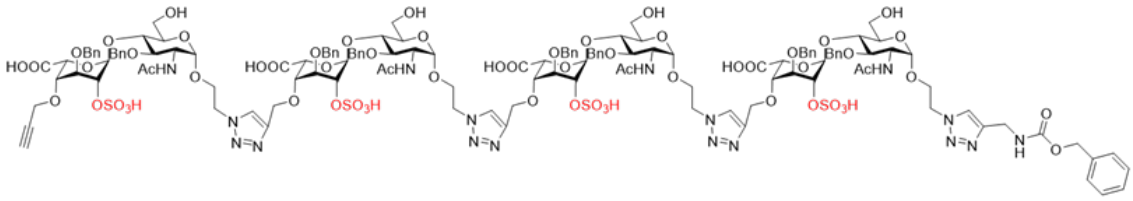


S35

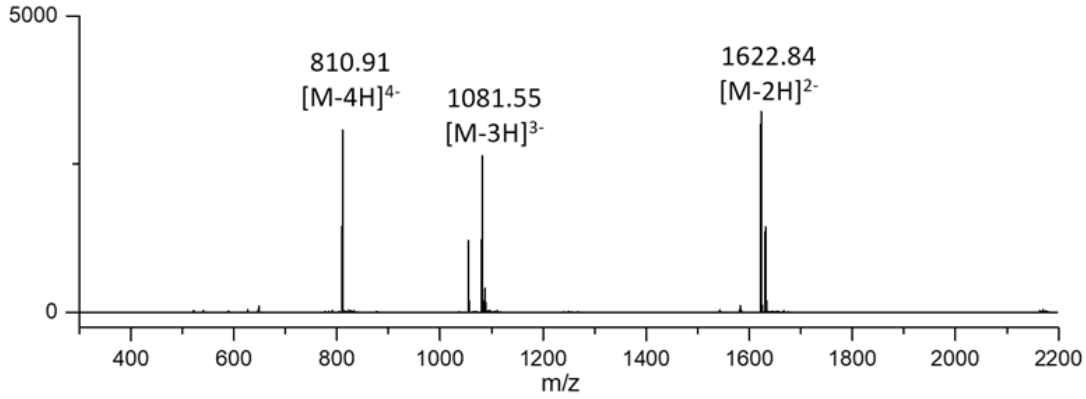
^{1}H NMR of S35



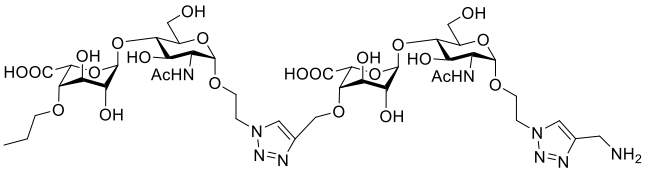
Mass spectra of S35



Exact Mass: 3245.9633

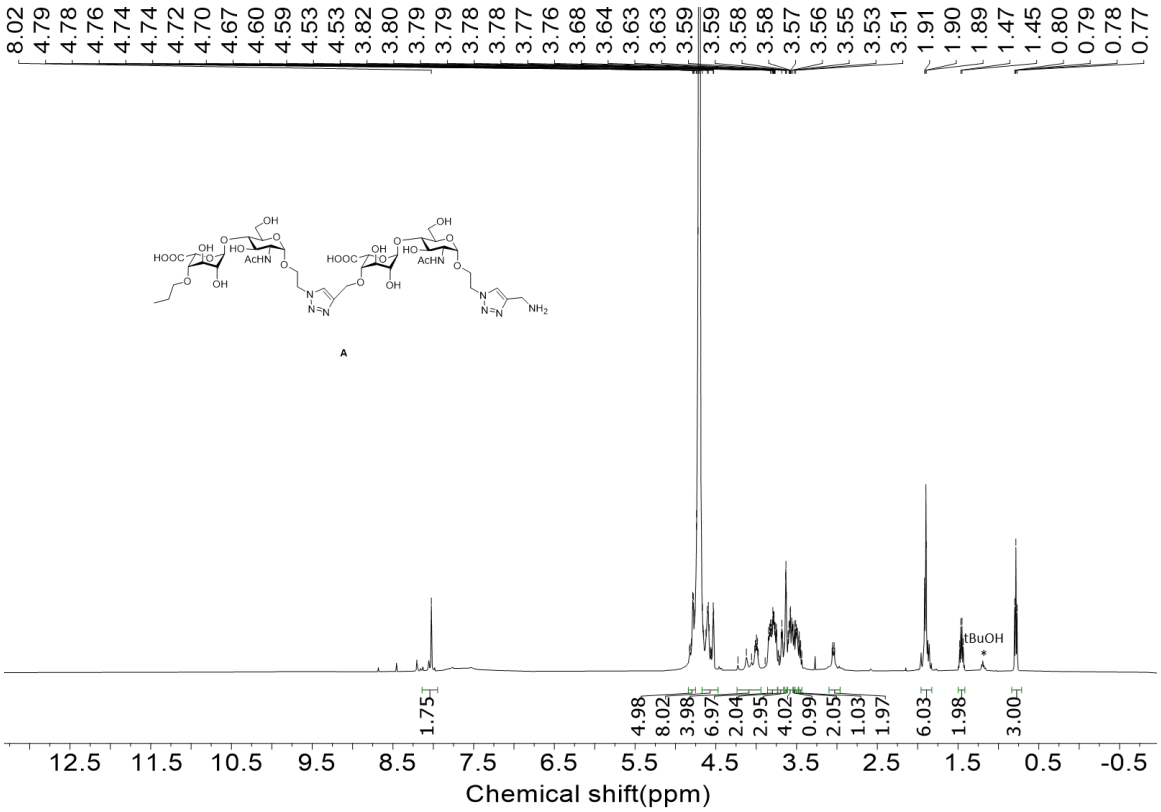


Characterization of A

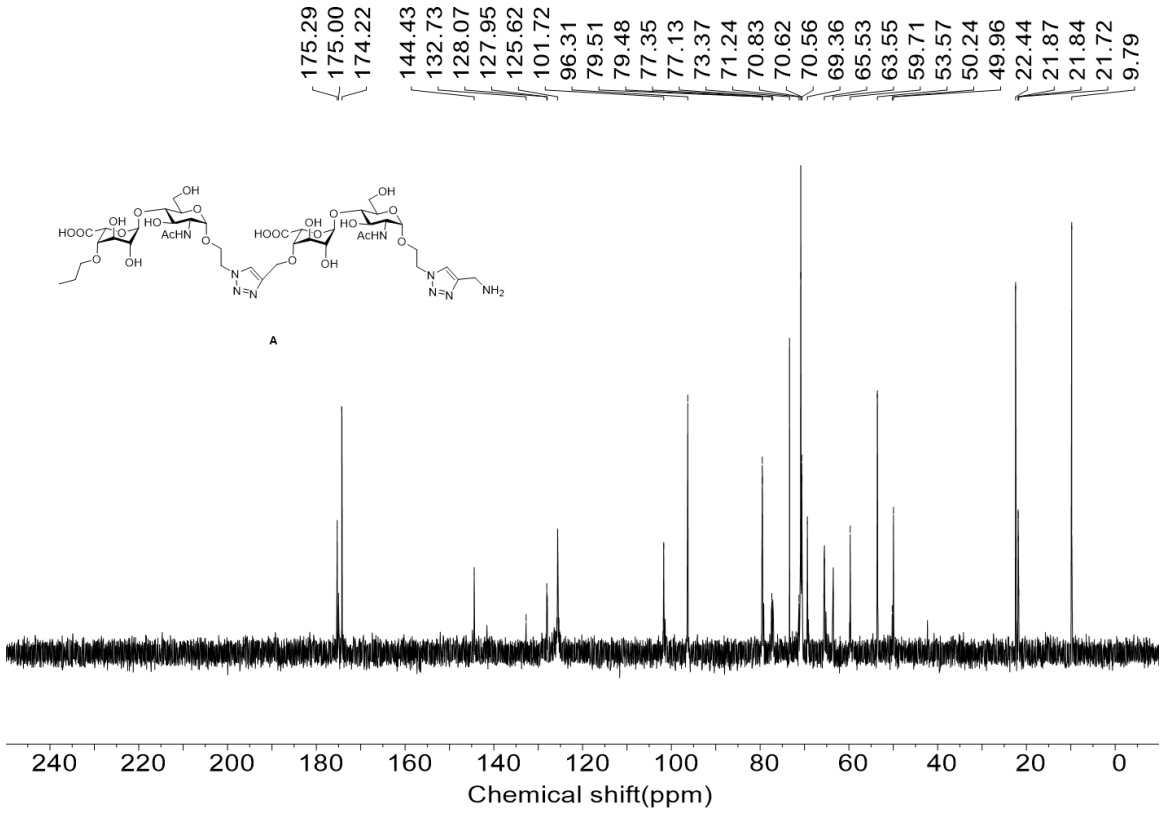


A

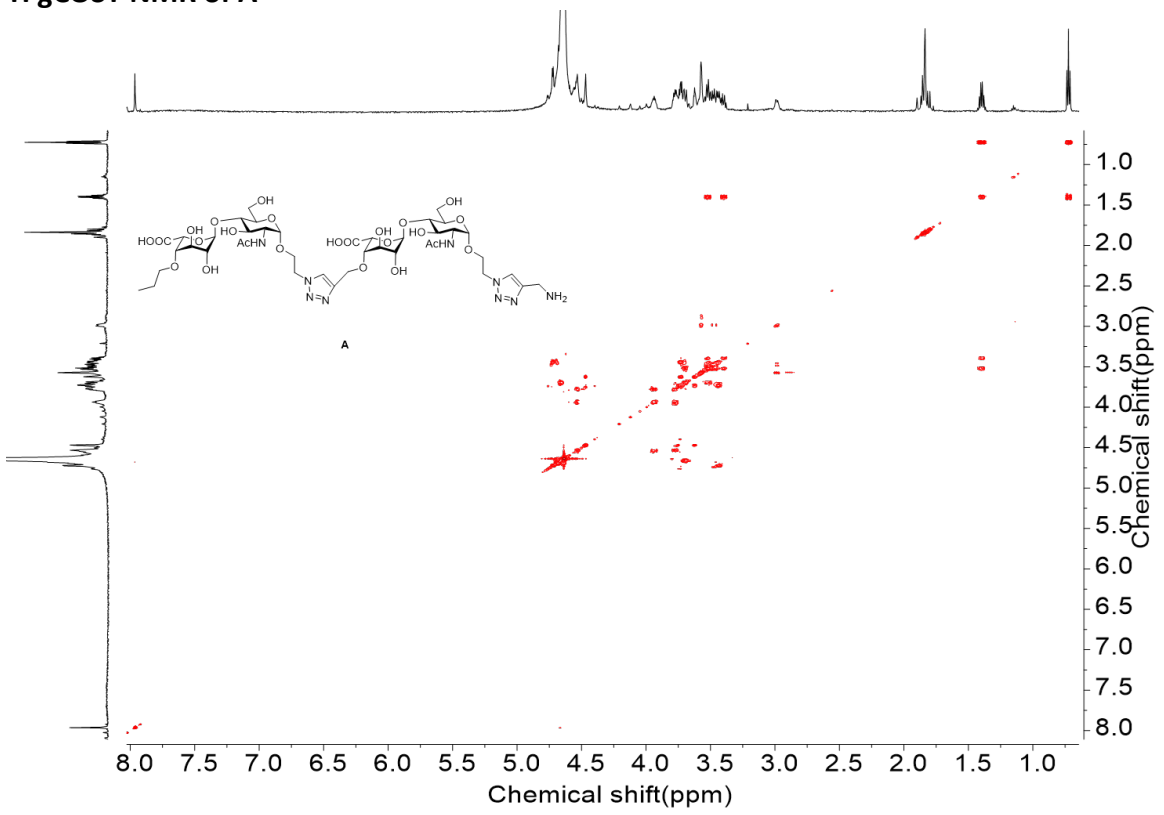
^{1}H NMR of A



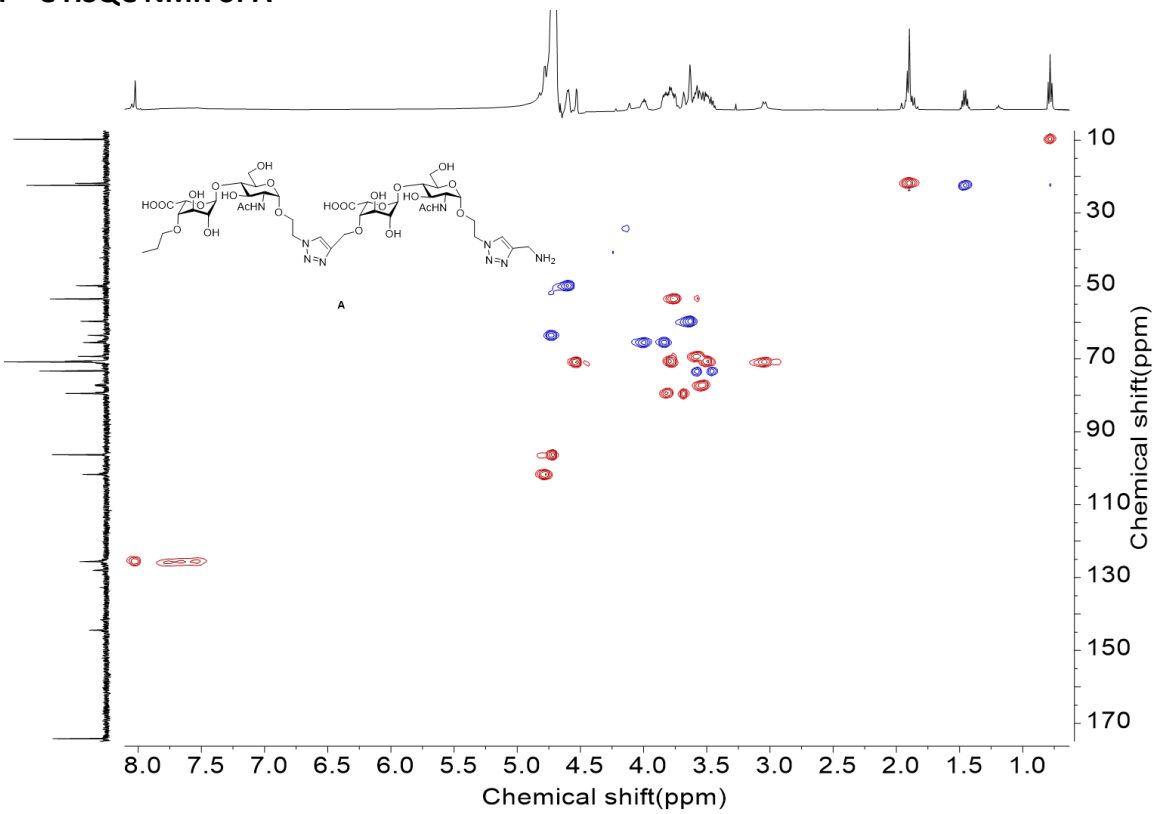
^{13}C NMR of A



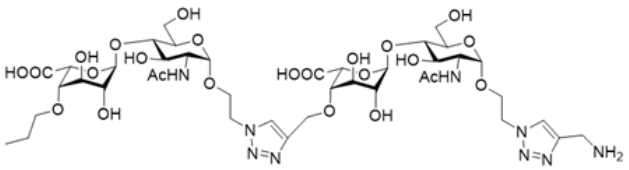
^{1}H-^{1}H gCOSY NMR of A



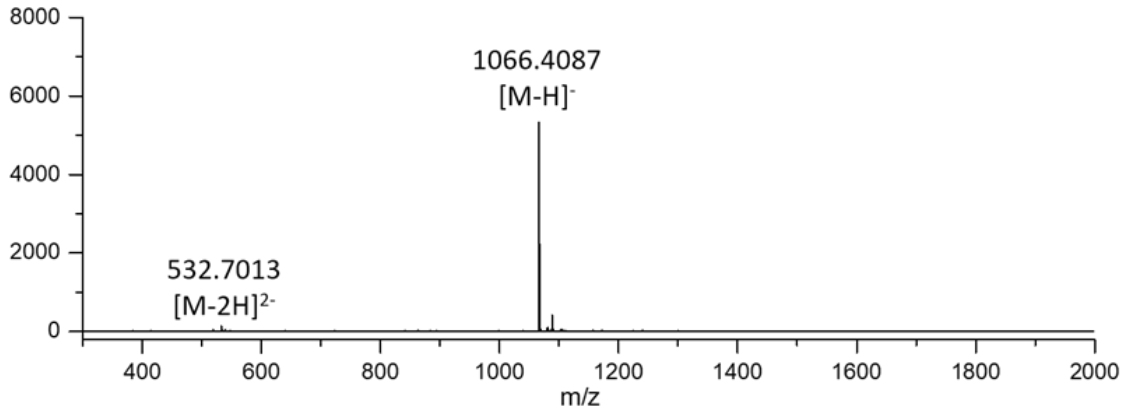
^{1}H-^{13}C HSQC NMR of A



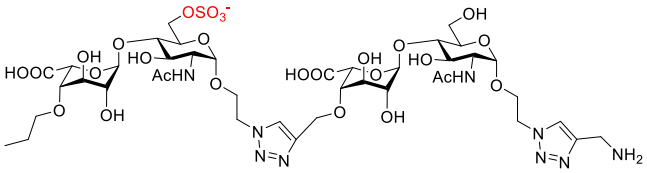
Mass spectra of A



Exact Mass: 1067.4142

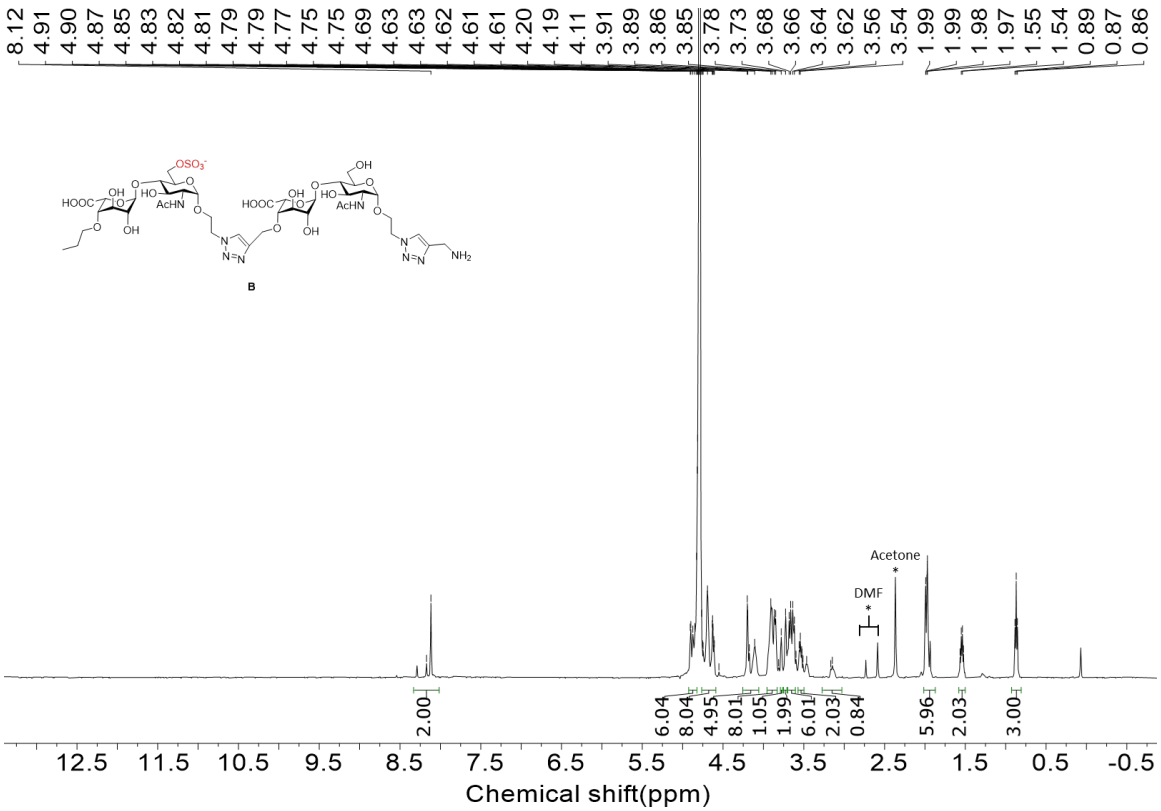


Characterization of B

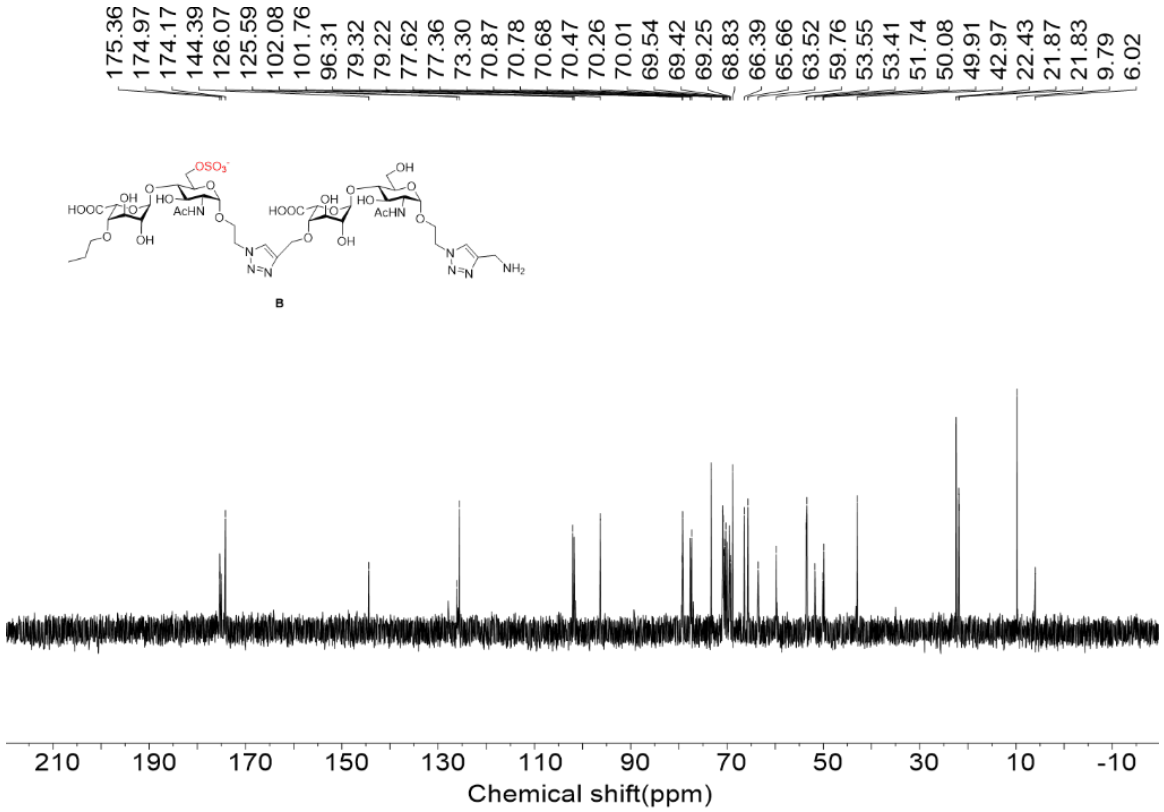


B

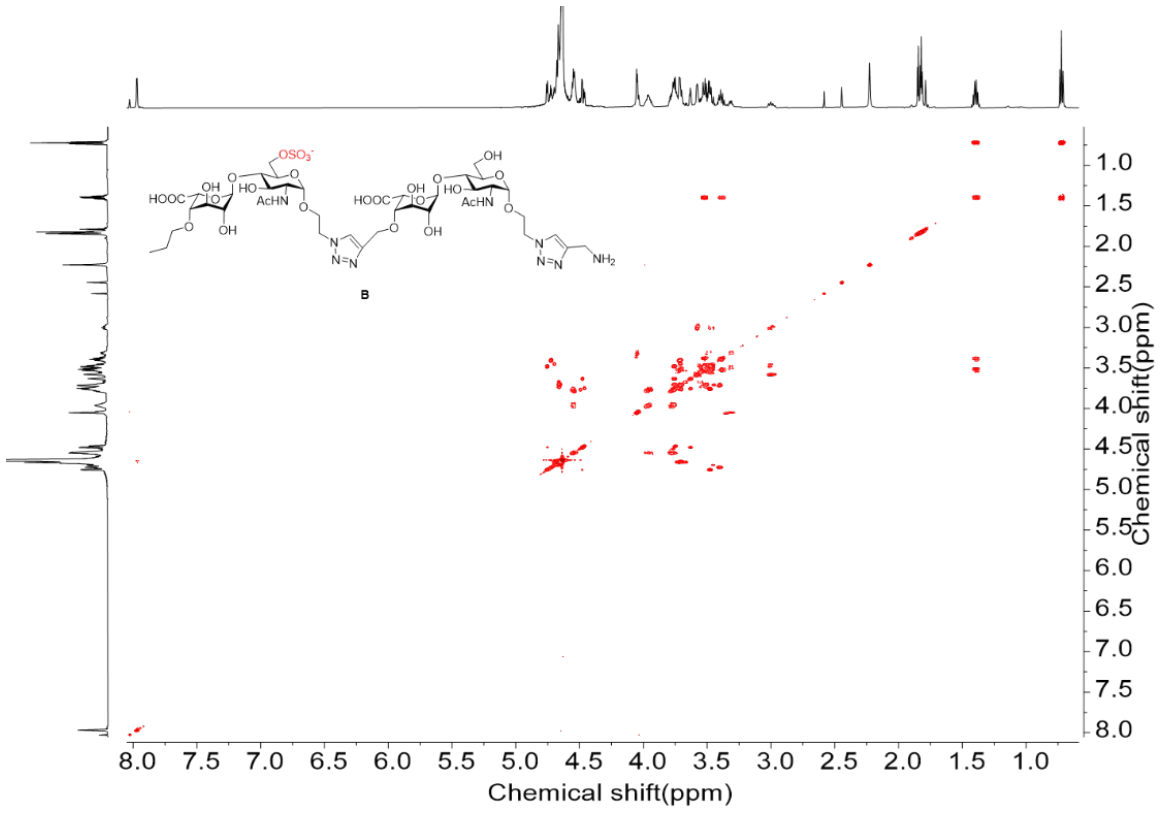
^{1}H NMR of B



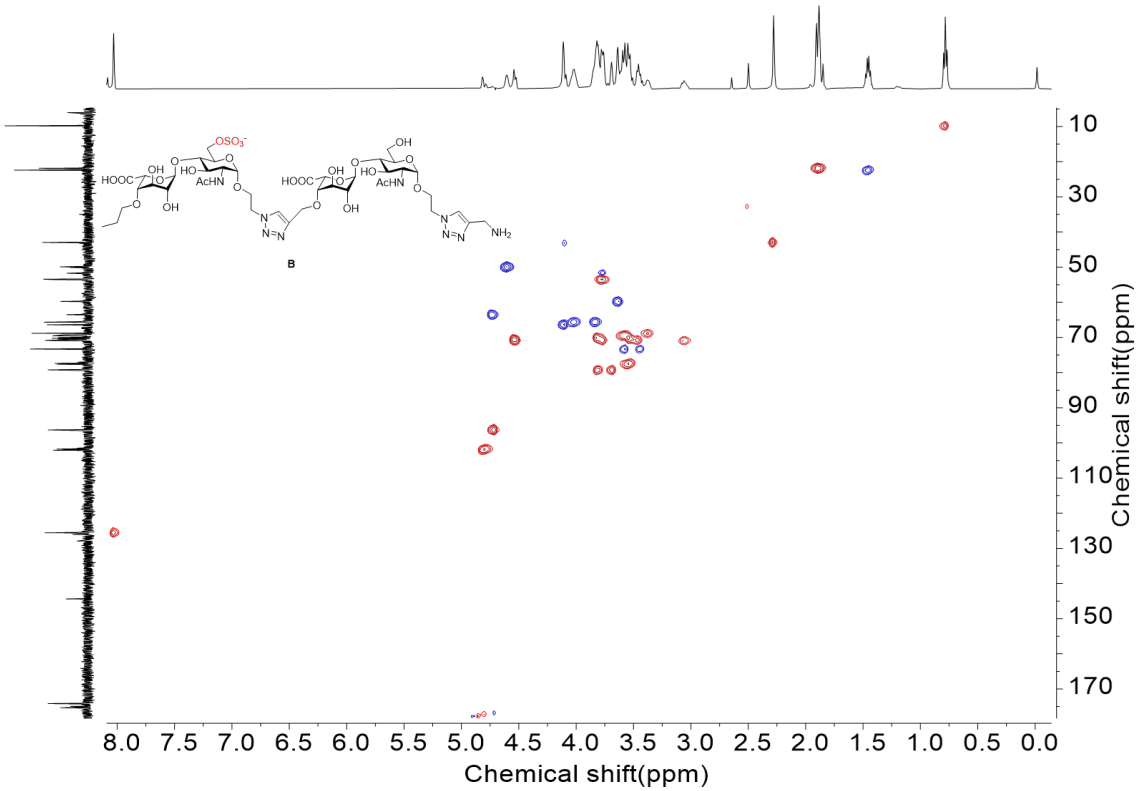
^{13}C NMR of B



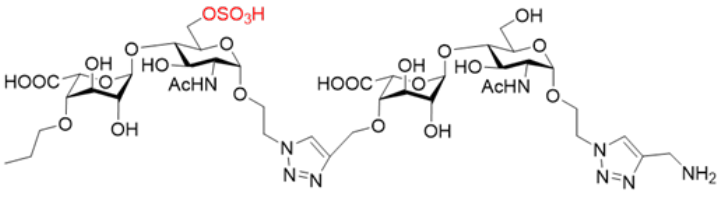
^{1}H-^{1}H gCOSY NMR of 8



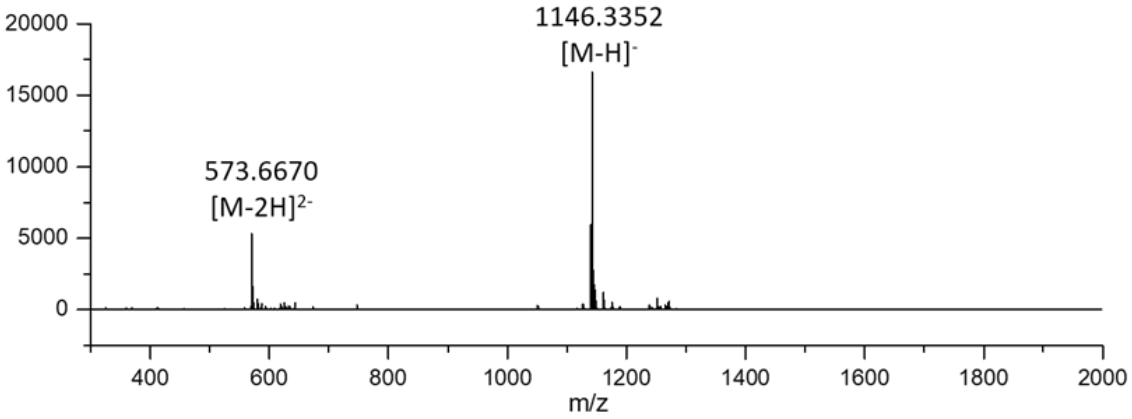
^{1}H-^{13}C HSQC NMR of B



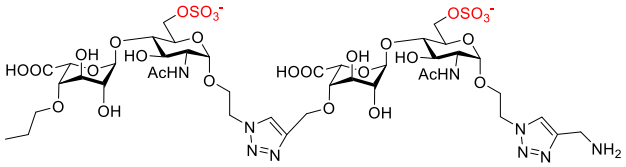
Mass spectra of B



Exact Mass: 1147.3711

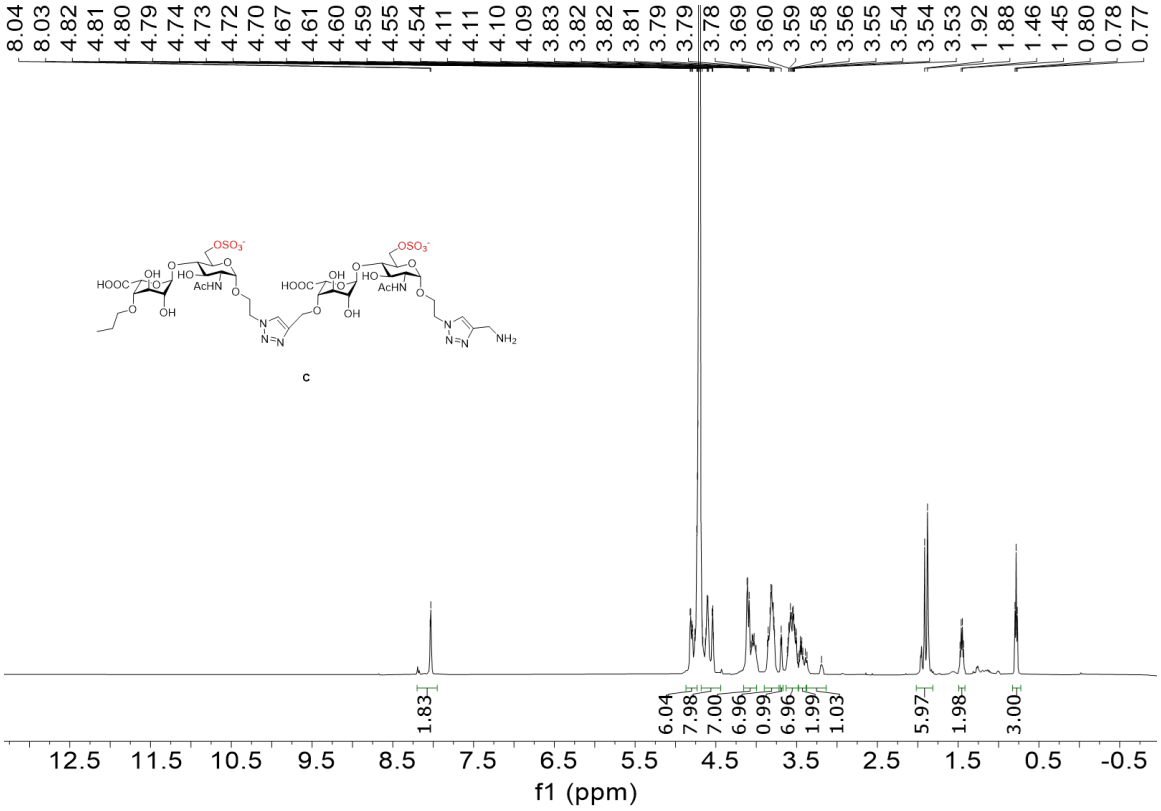


Characterization of C



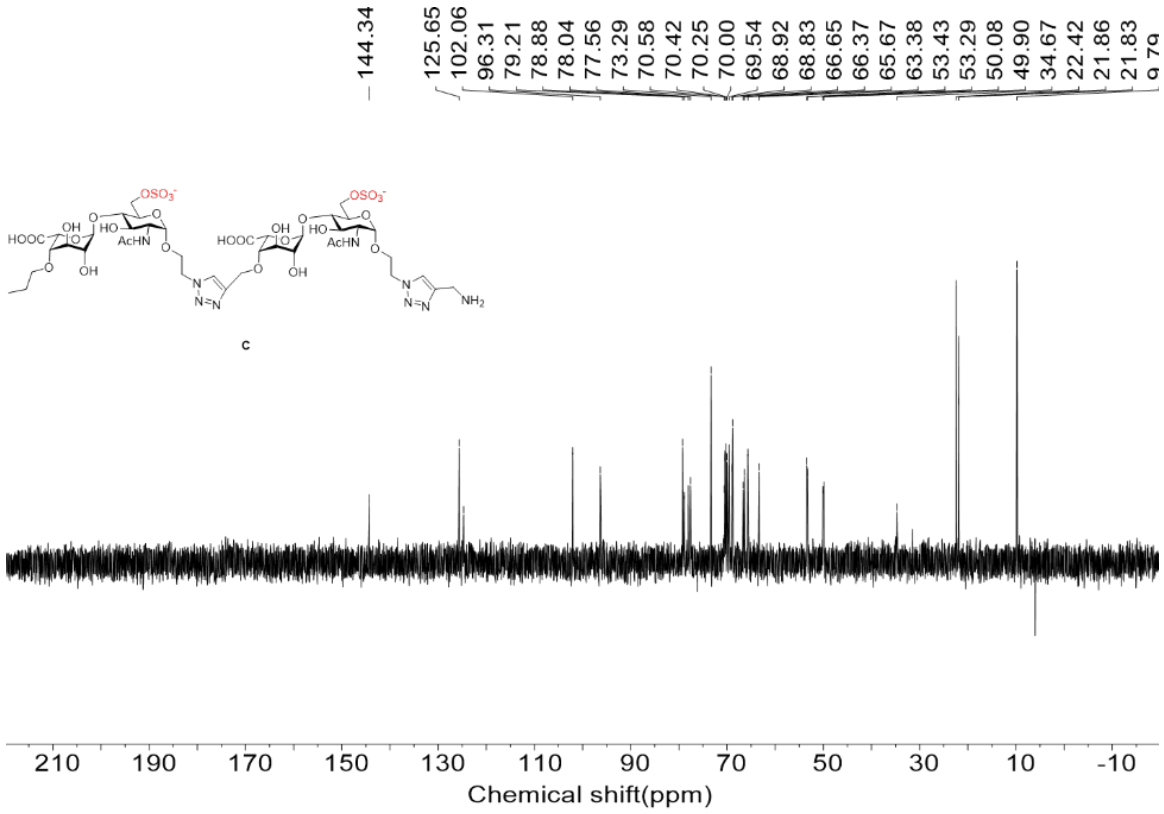
c

^{1}H NMR of C

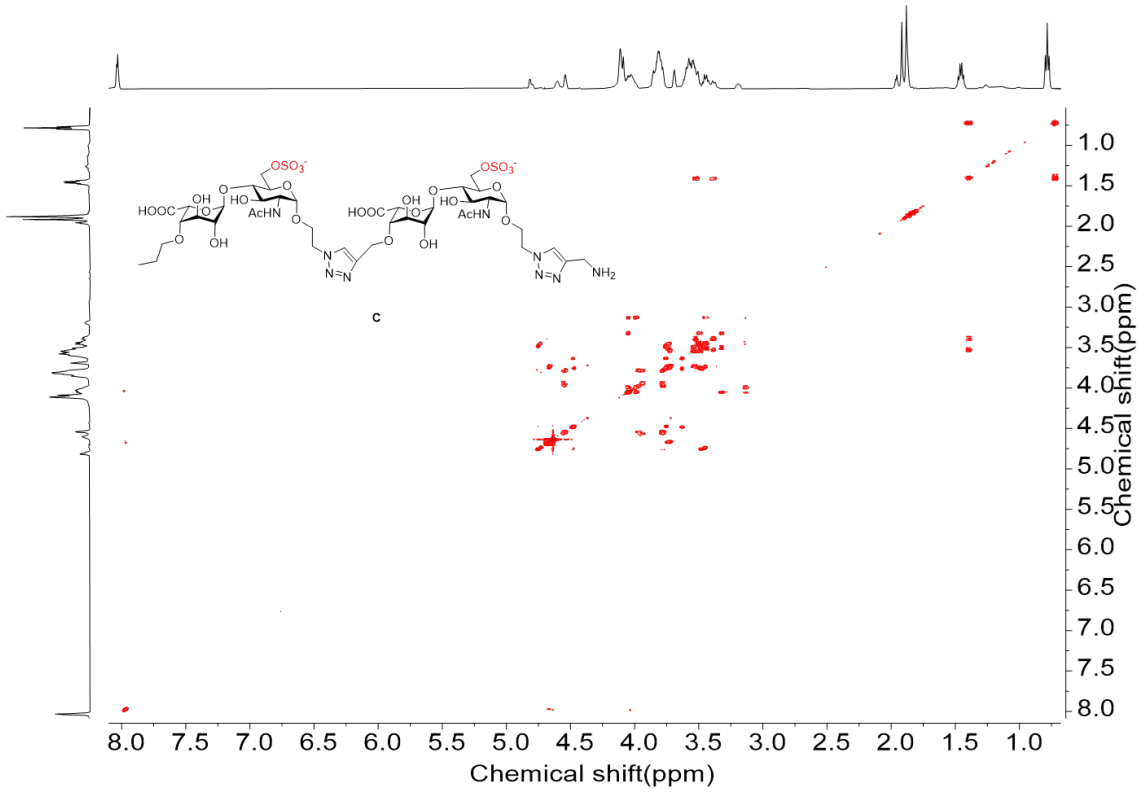


c

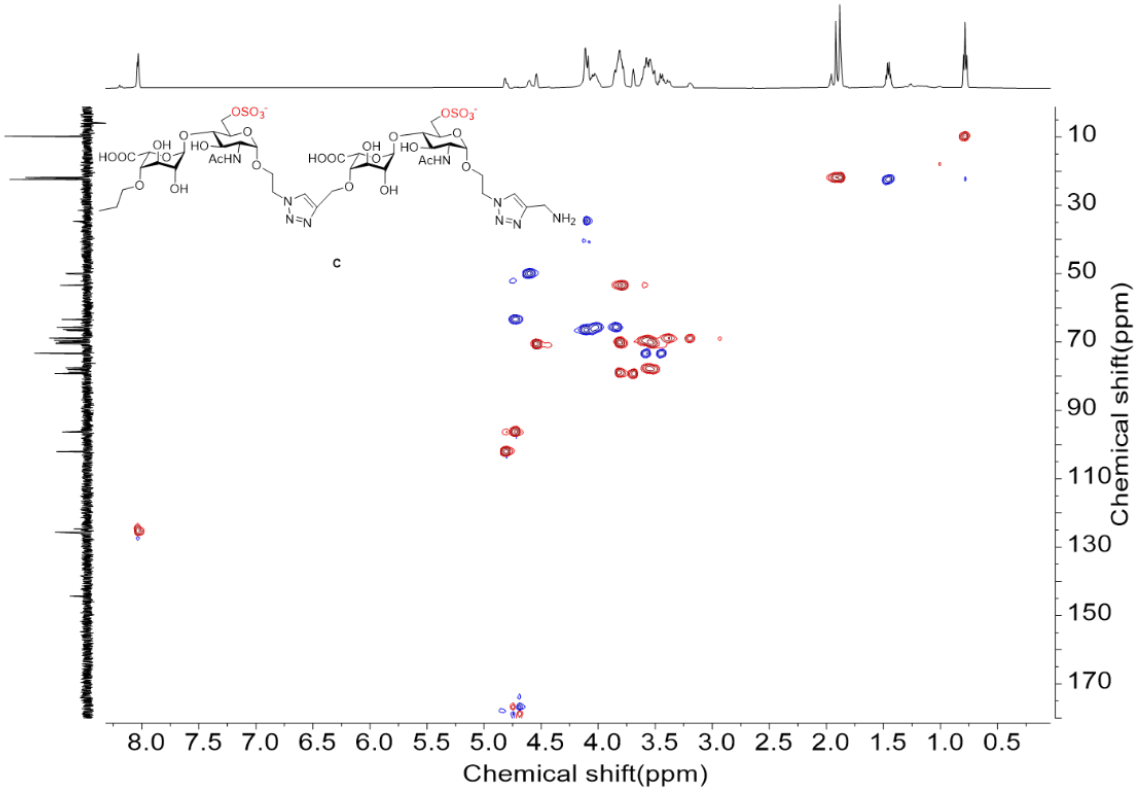
^{13}C NMR of C



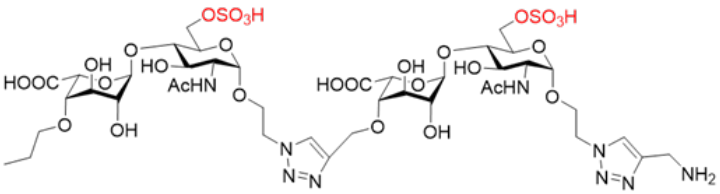
^{1}H-^{1}H gCOSY NMR of C



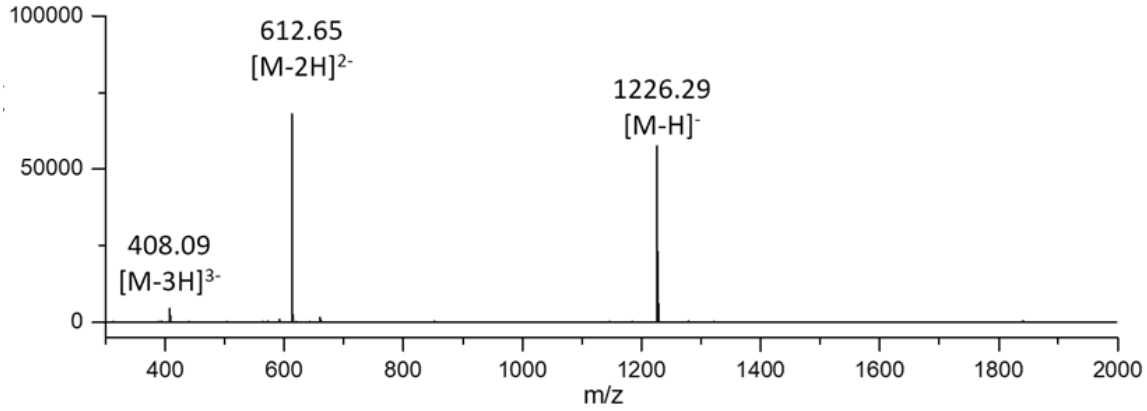
^{1}H-^{13}C HSQC NMR of C



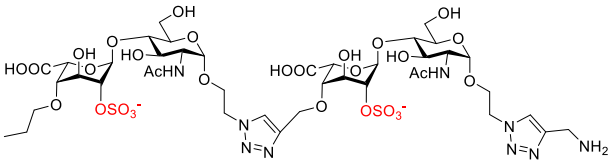
Mass spectra of C



Exact Mass: 1227.3279

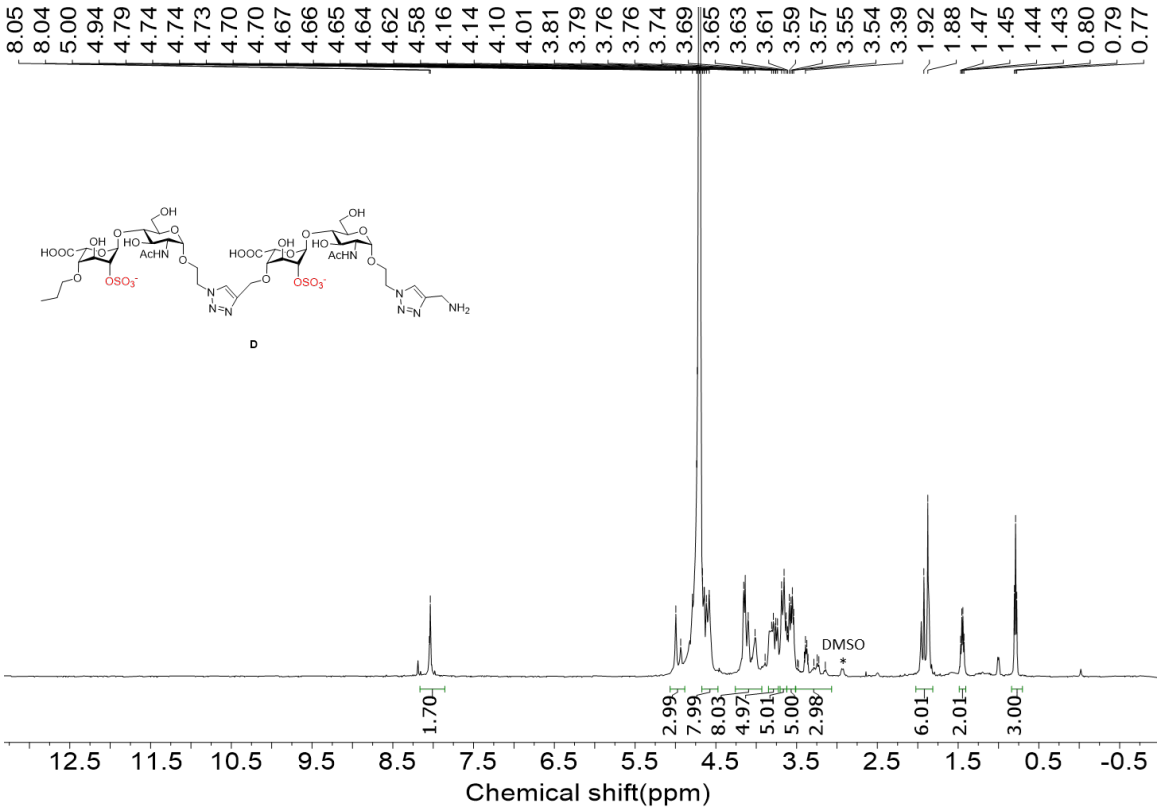


Characterization of D



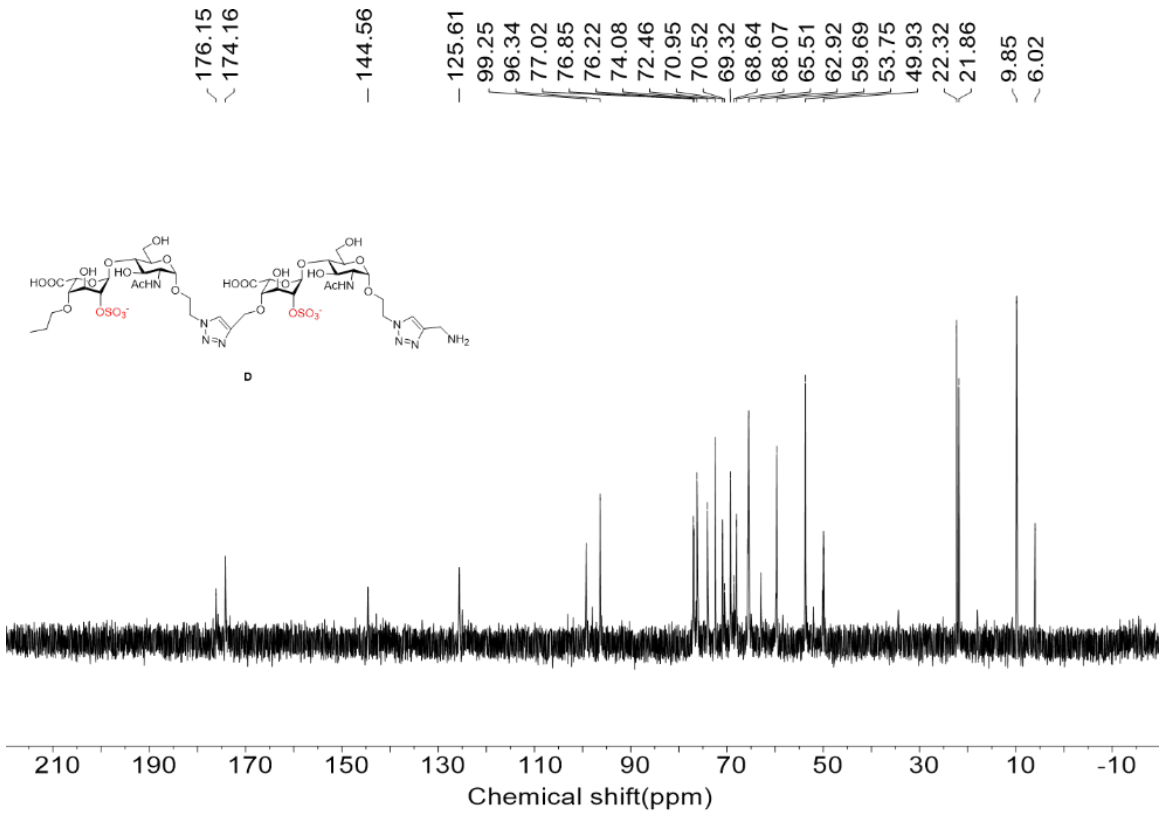
D

^{1}H NMR of D

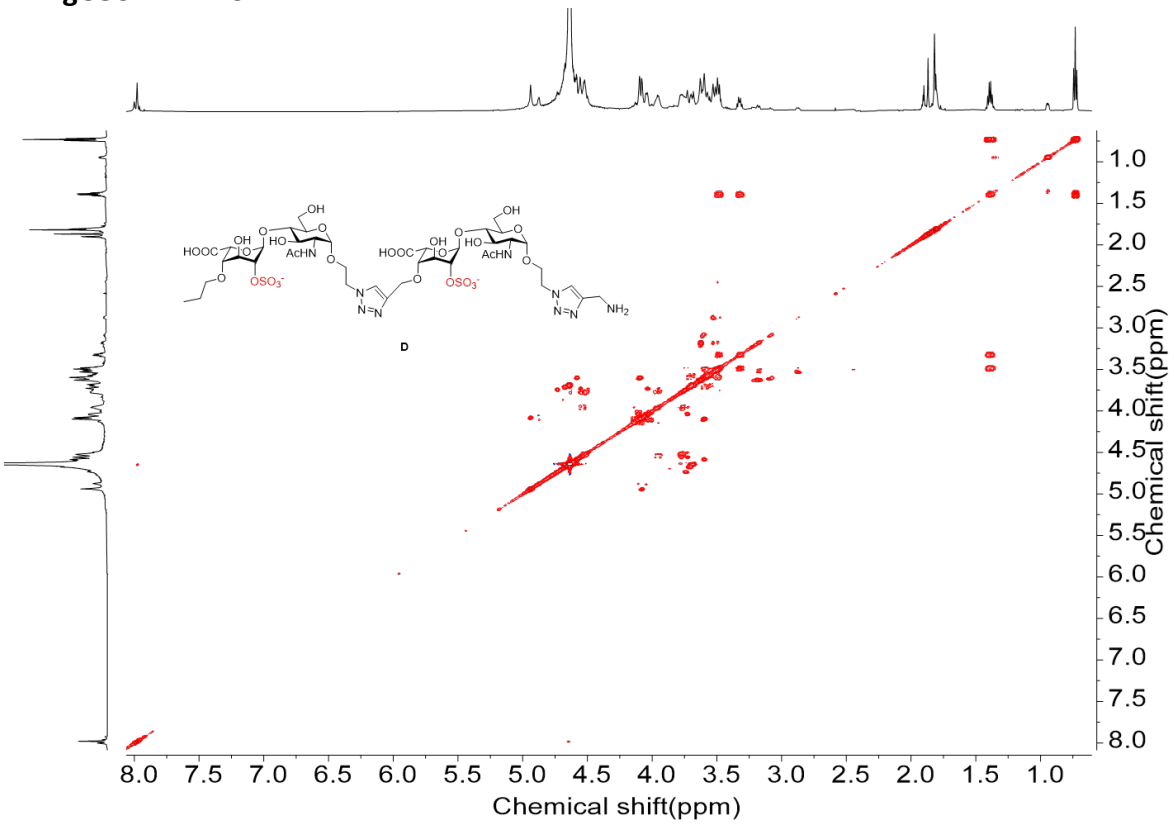


D

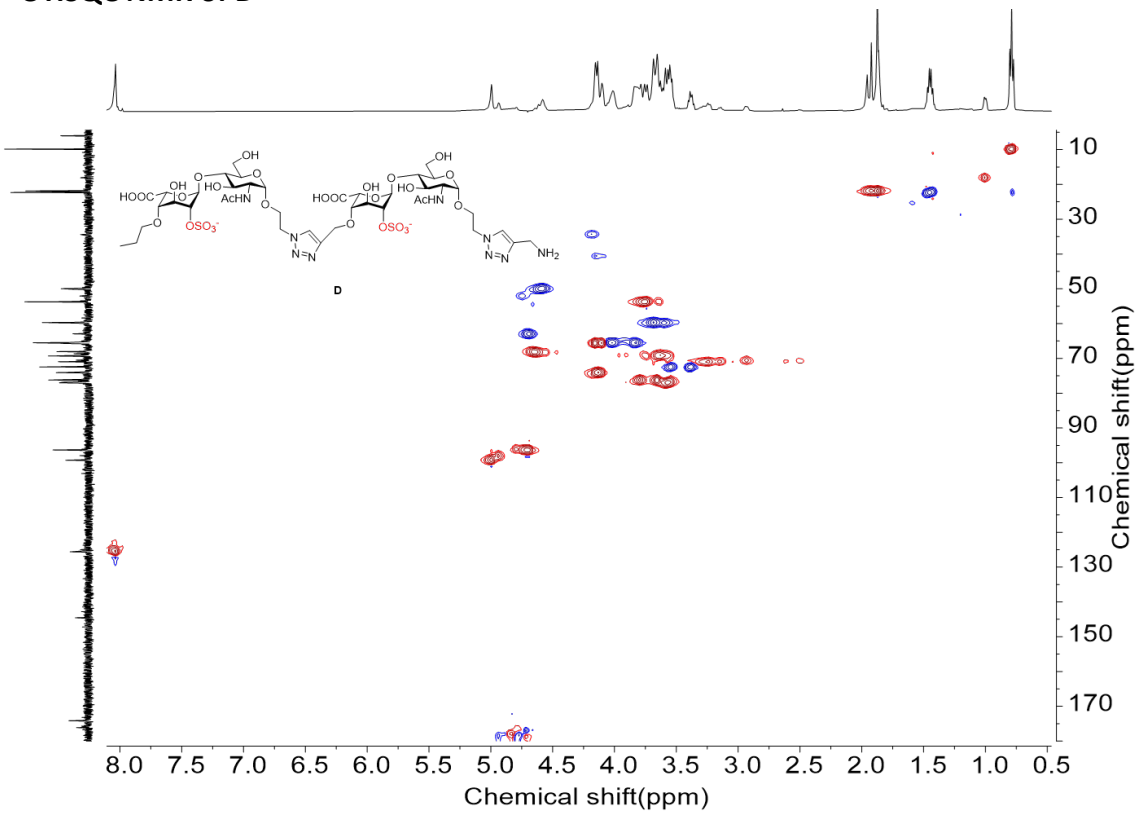
^{13}C NMR of D



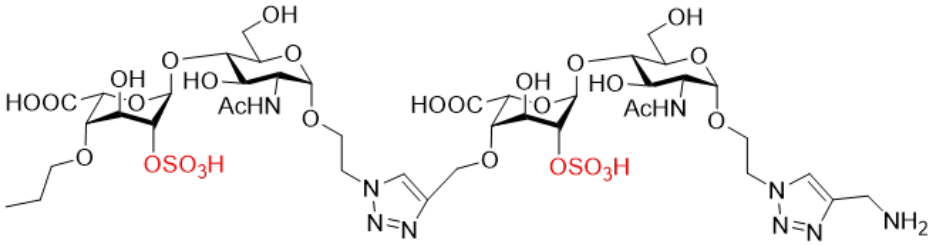
^{1}H-^{1}H gCOSY NMR of D



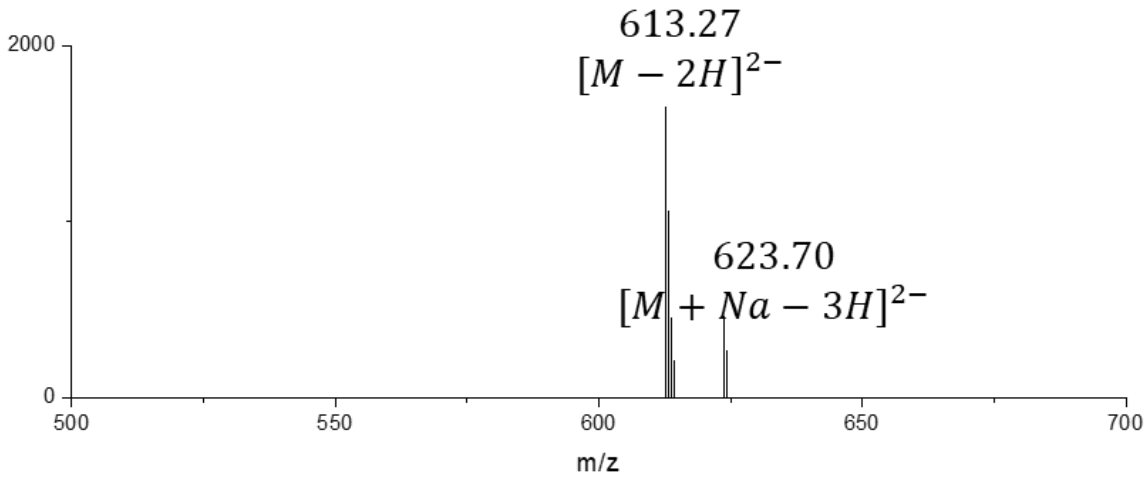
^{1}H-^{13}C HSQC NMR of D



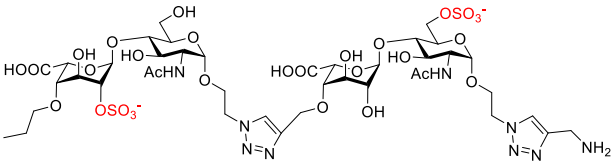
Mass spectra of D



Exact Mass: 1227.32787

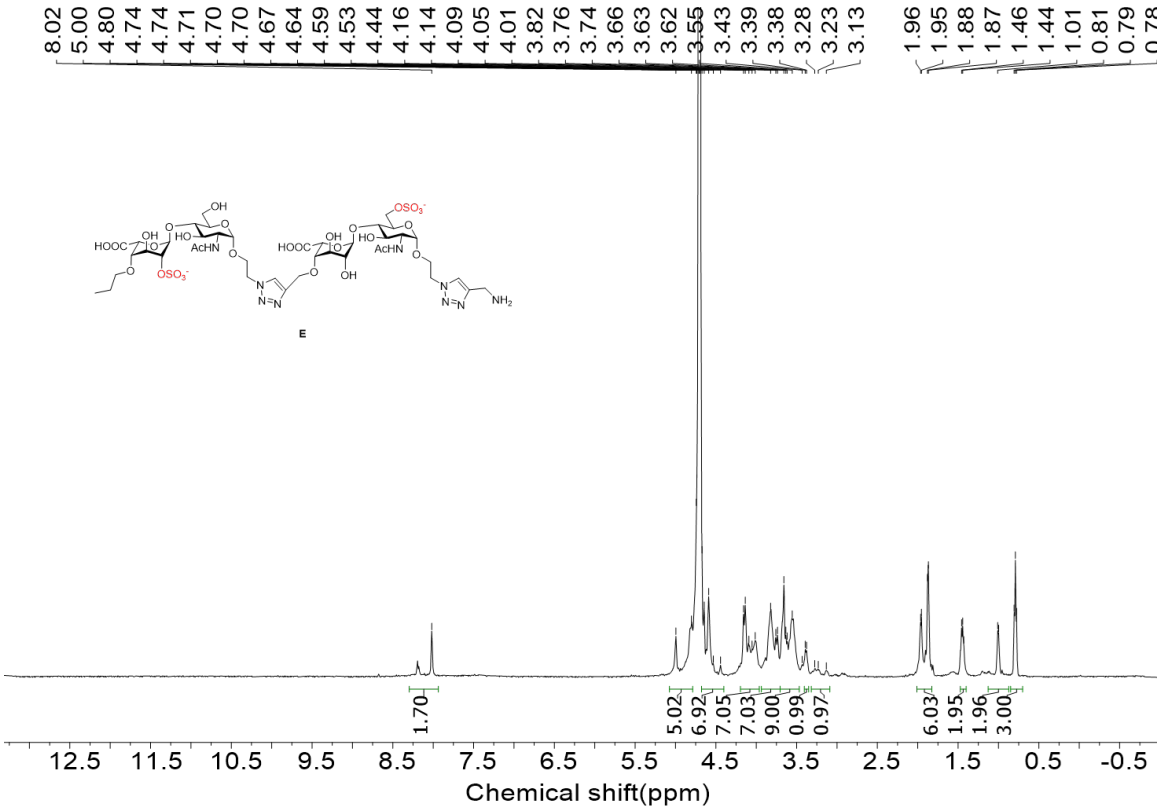


Characterization of E

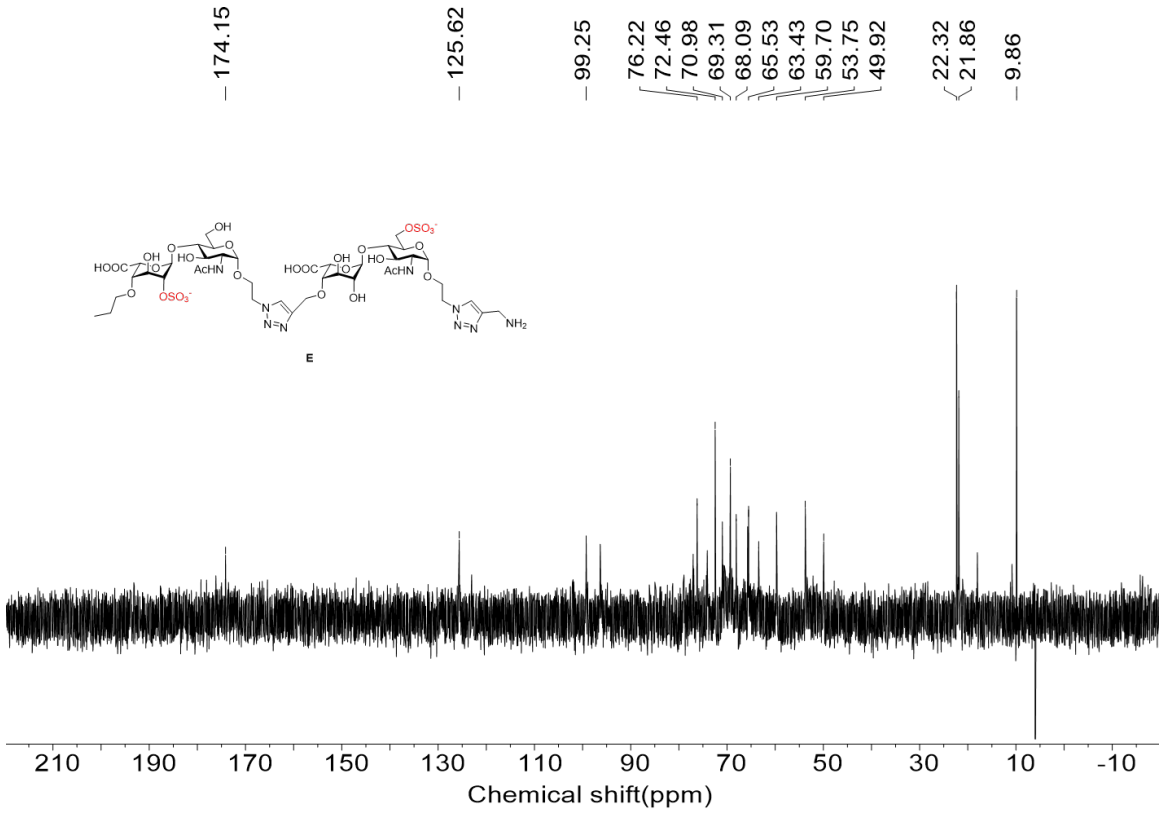


E

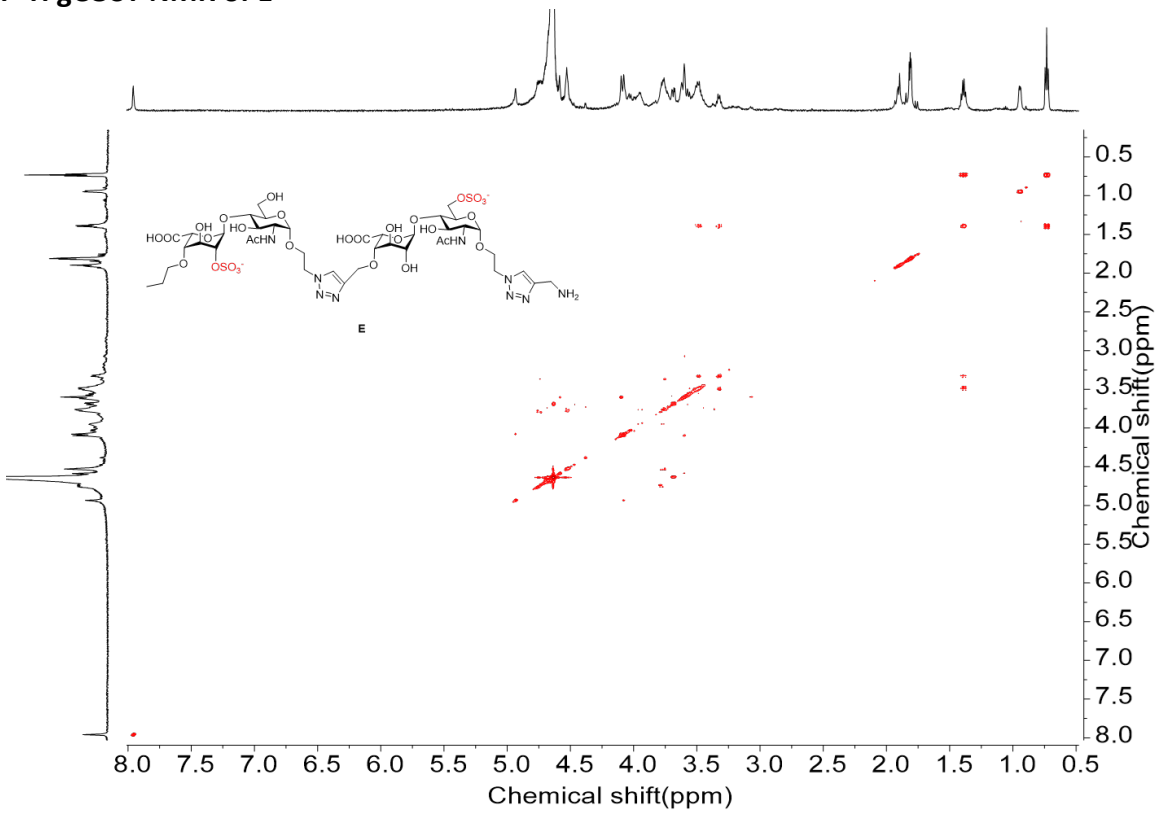
^{1}H NMR of E



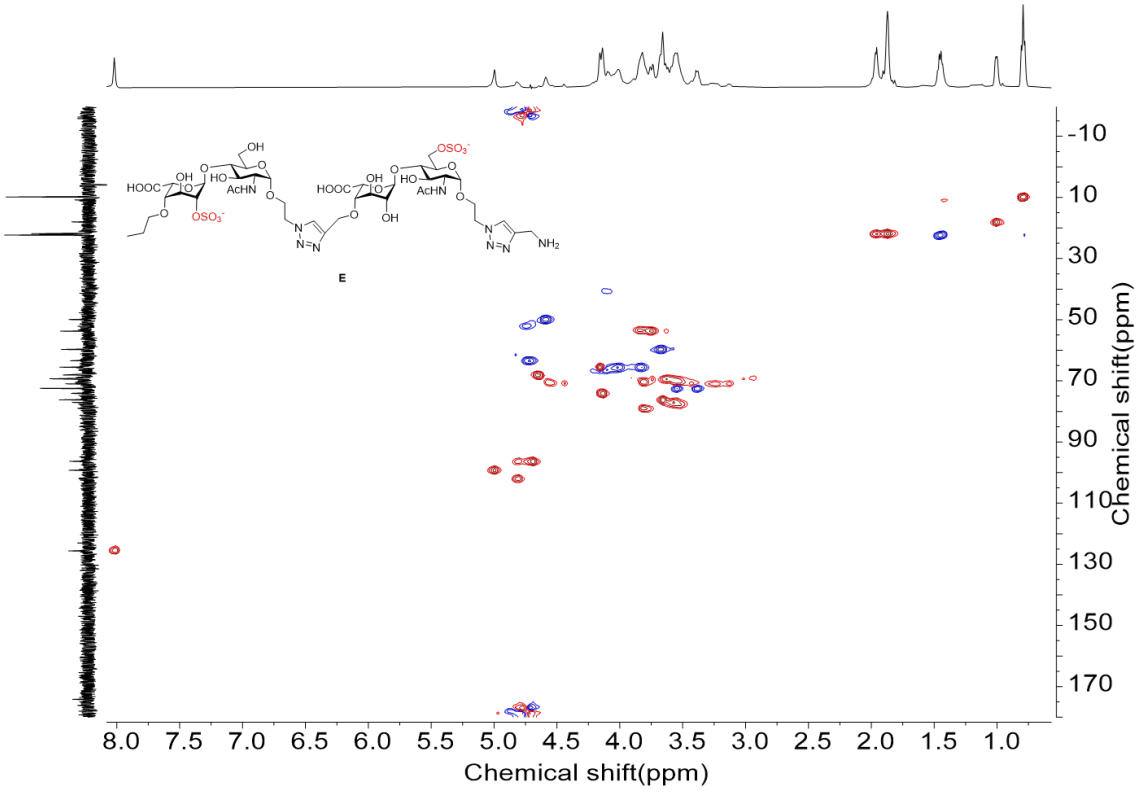
^{13}C NMR of E



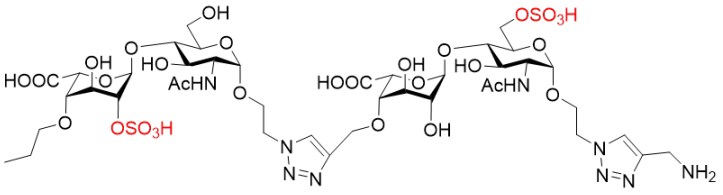
^{1}H-^{1}H gCOSY NMR of E



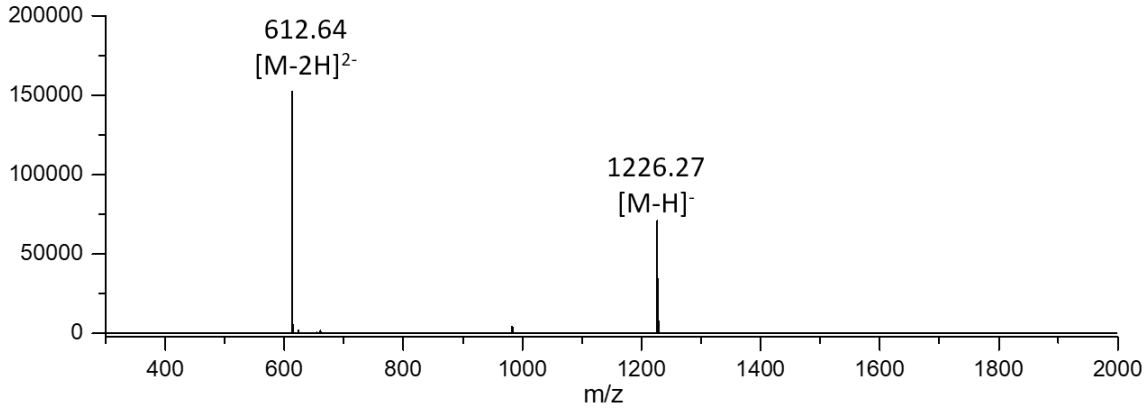
^{1}H-^{13}C HSQC NMR of E



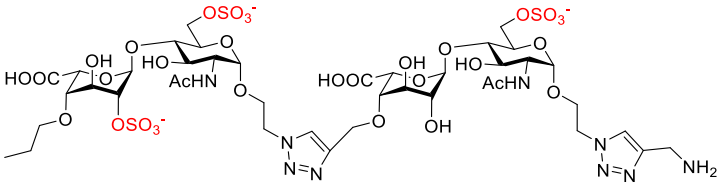
Mass spectra of E



Exact Mass: 1227.3279

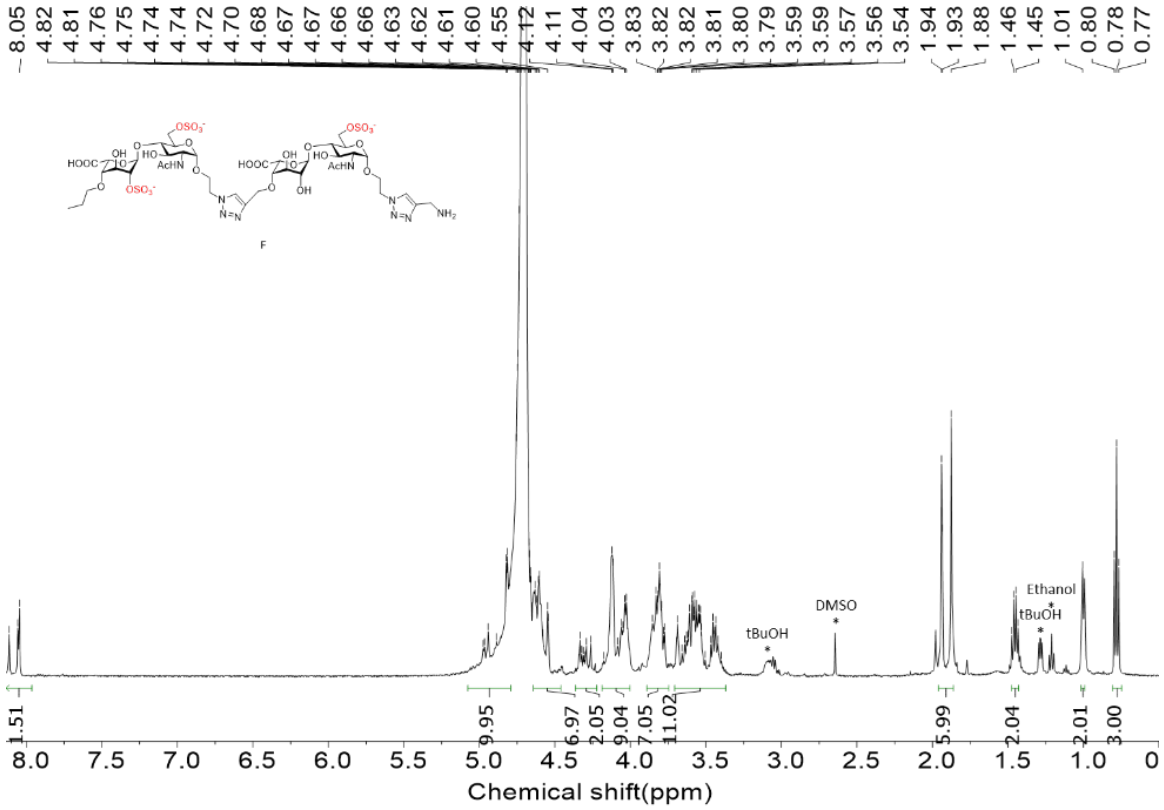


Characterization of F

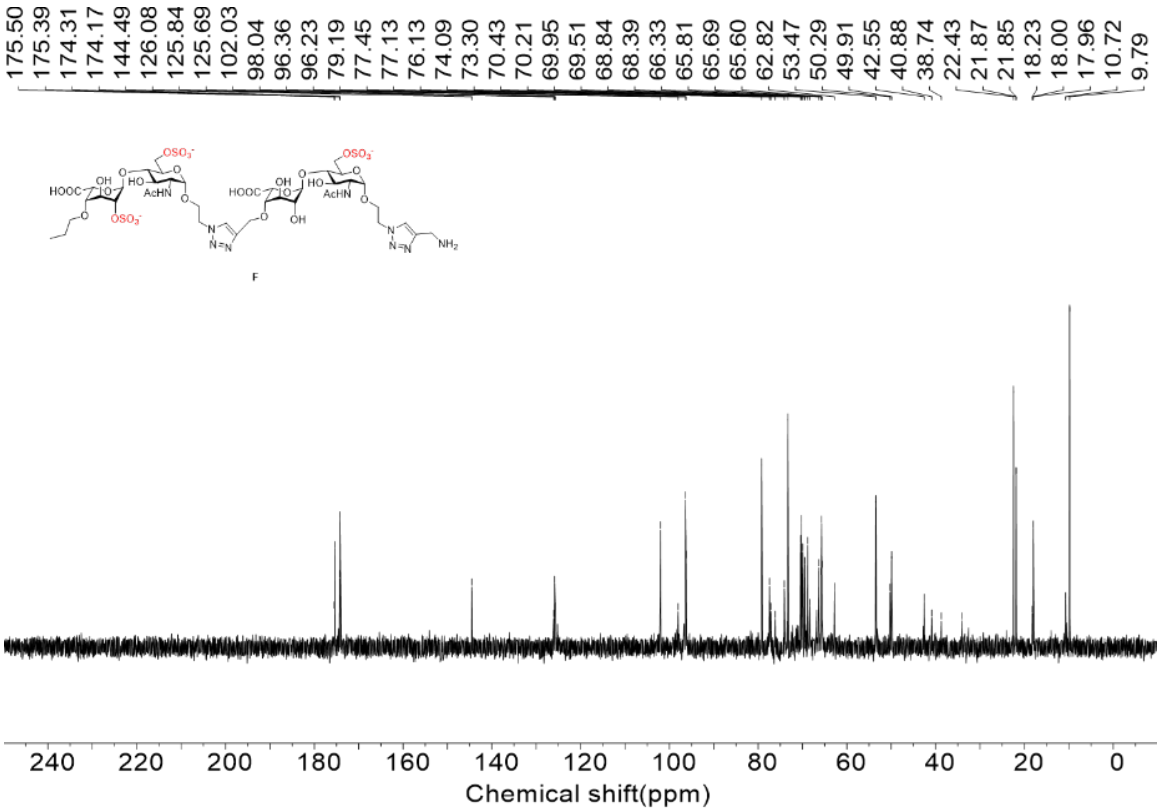


F

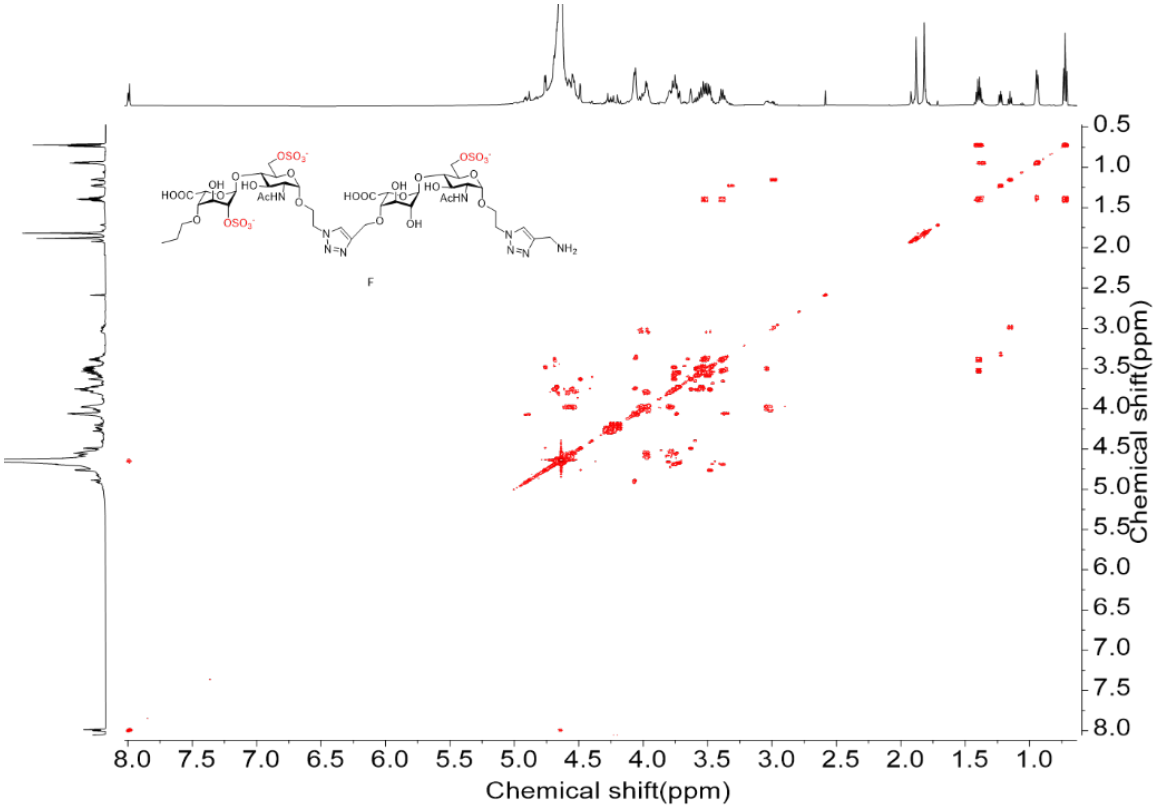
^{1}H NMR of F



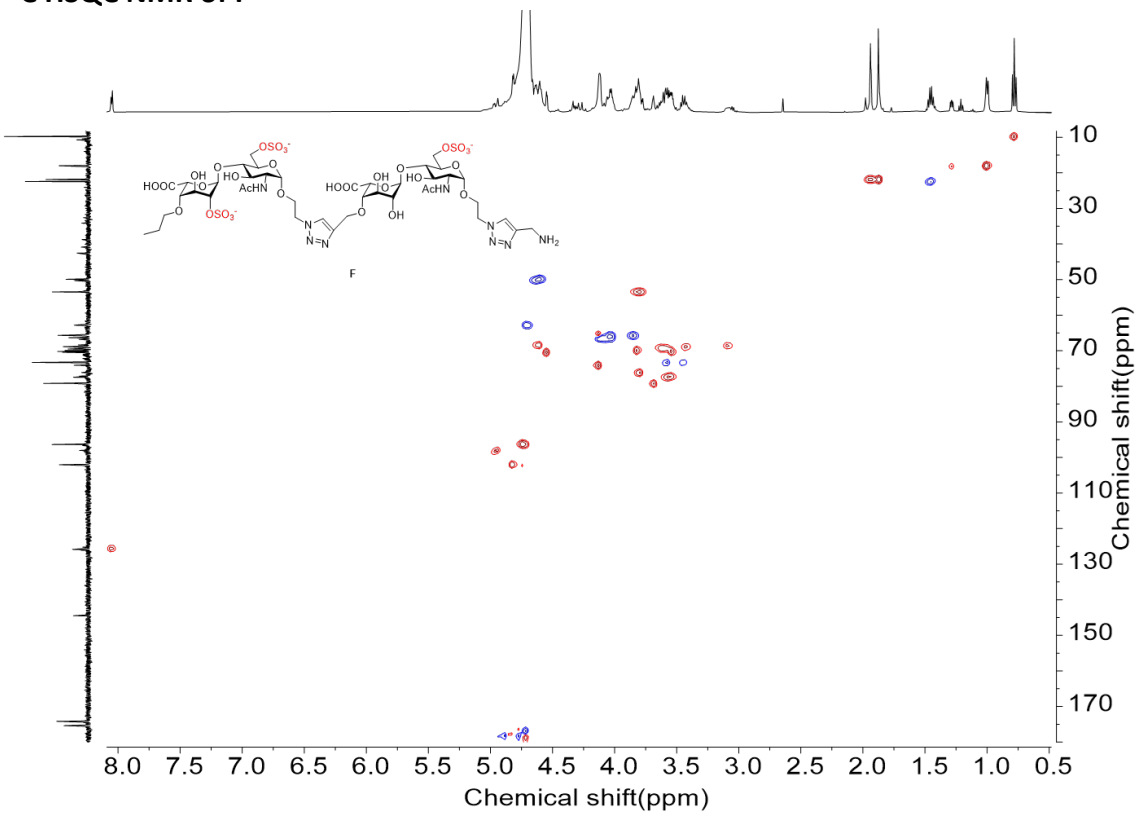
^{13}C NMR of F



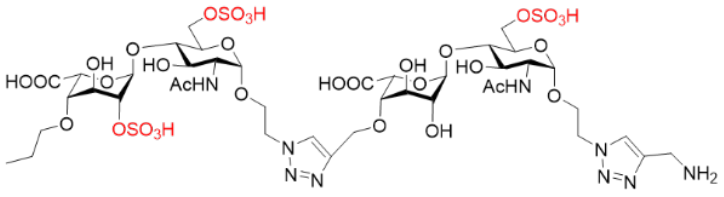
^{1}H-^{1}H gCOSY NMR of F

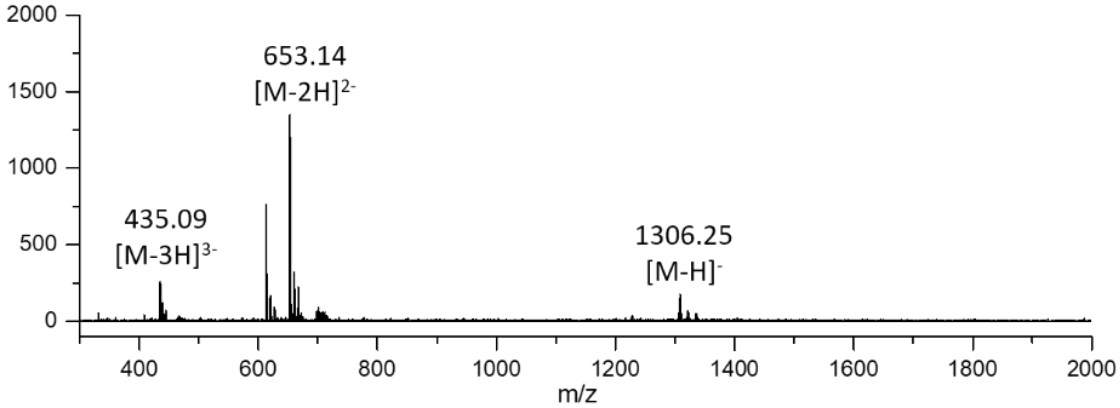


^{1}H-^{13}C HSQC NMR of F

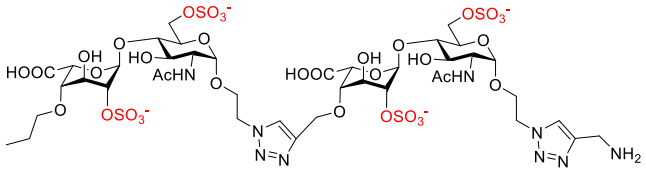


Mass spectra of F



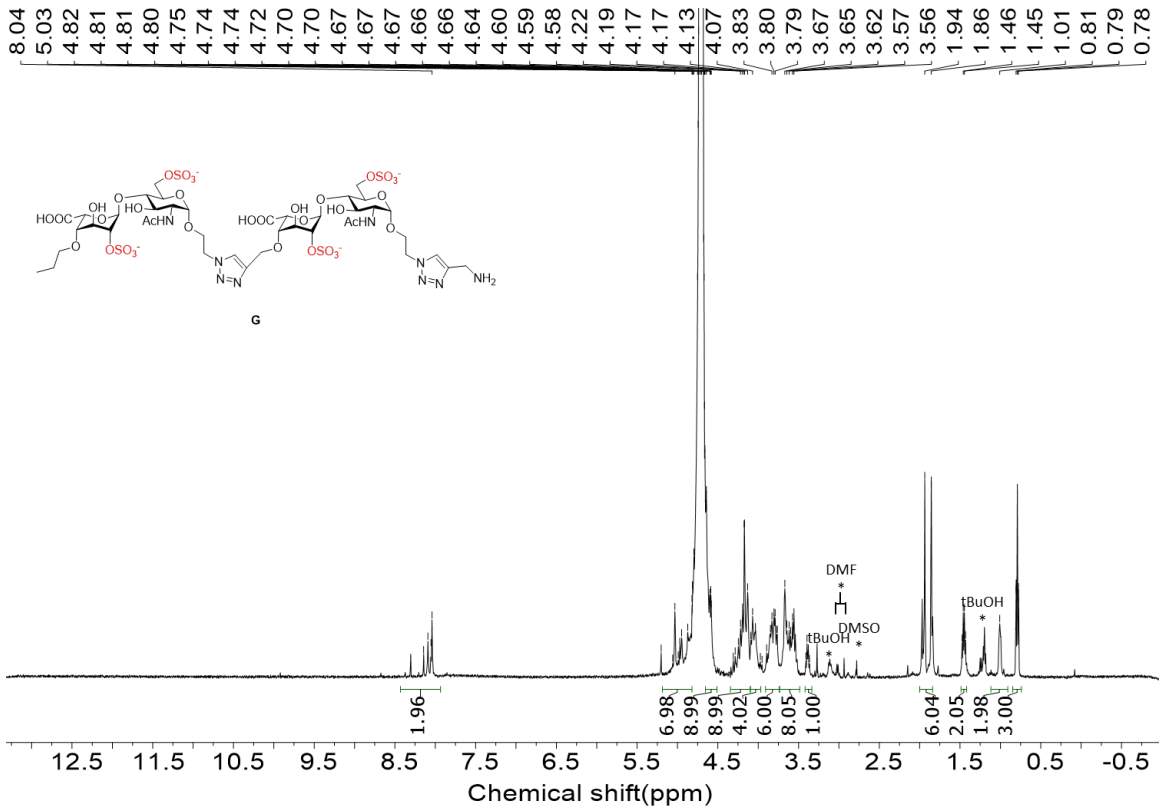


Characterization of G



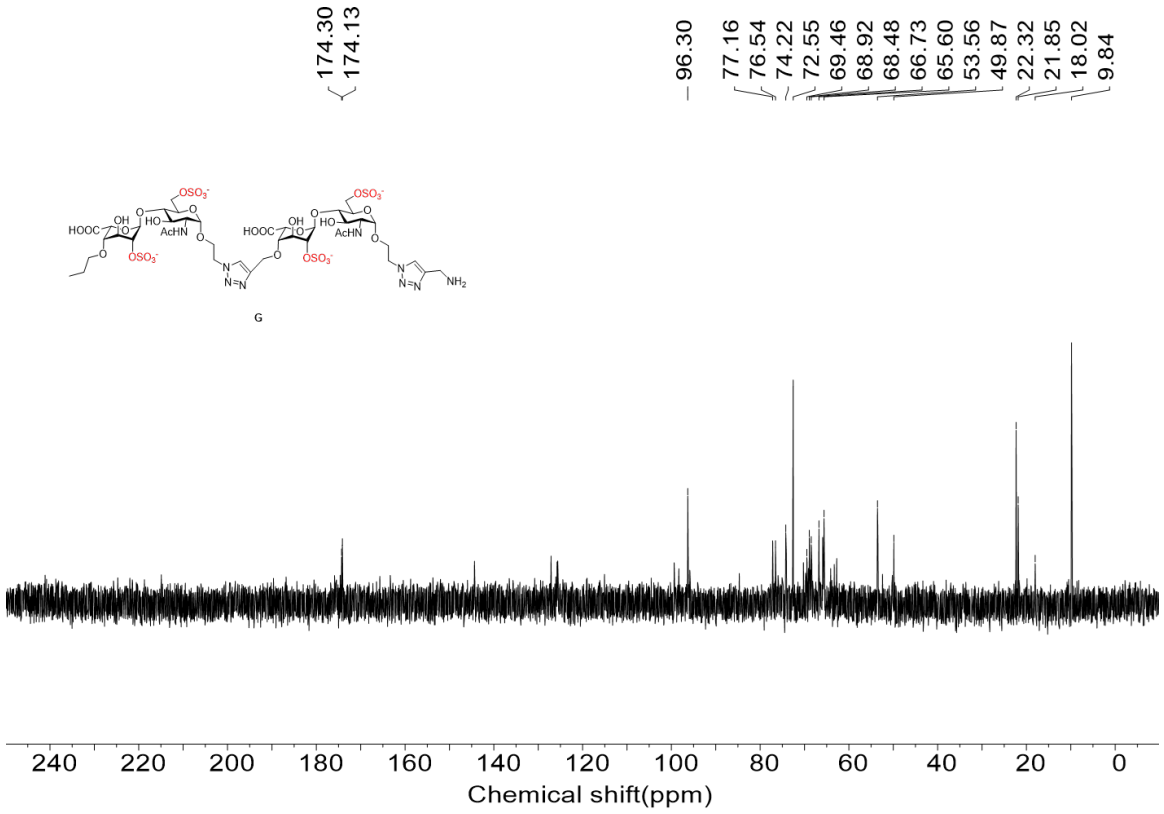
G

^{1}H NMR of G

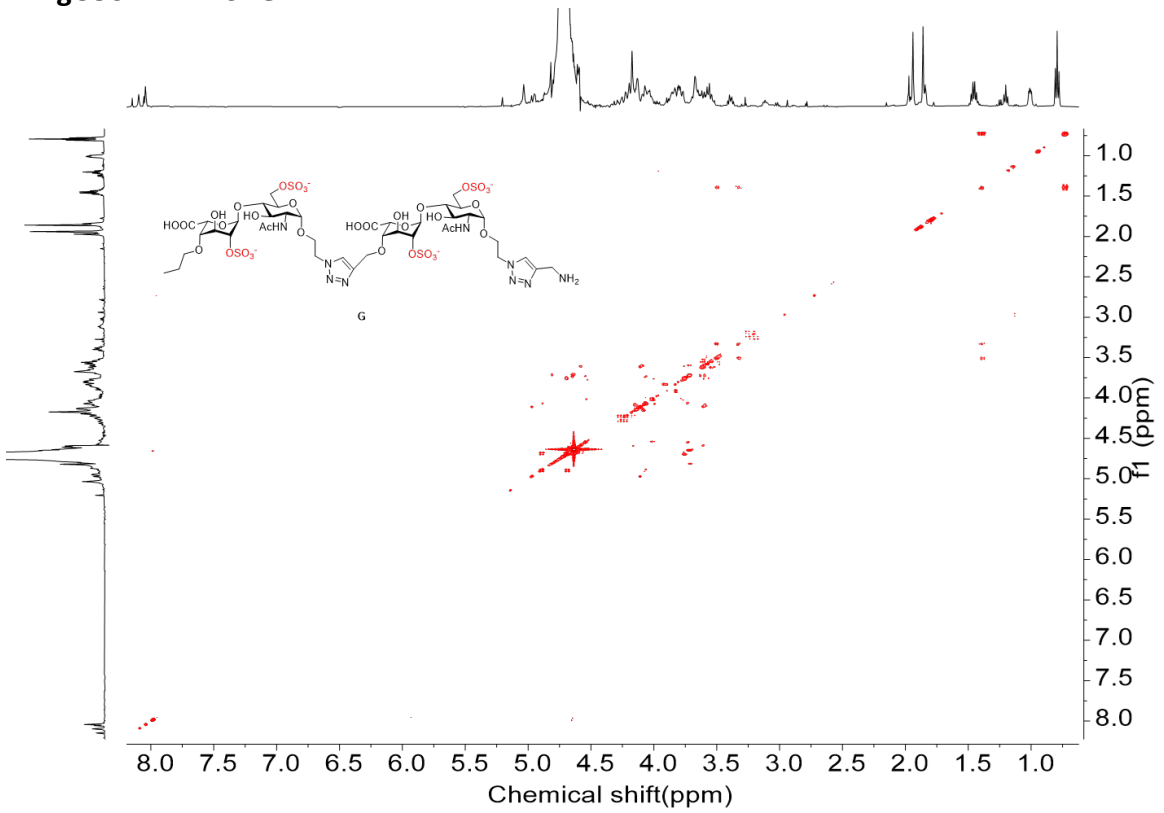


G

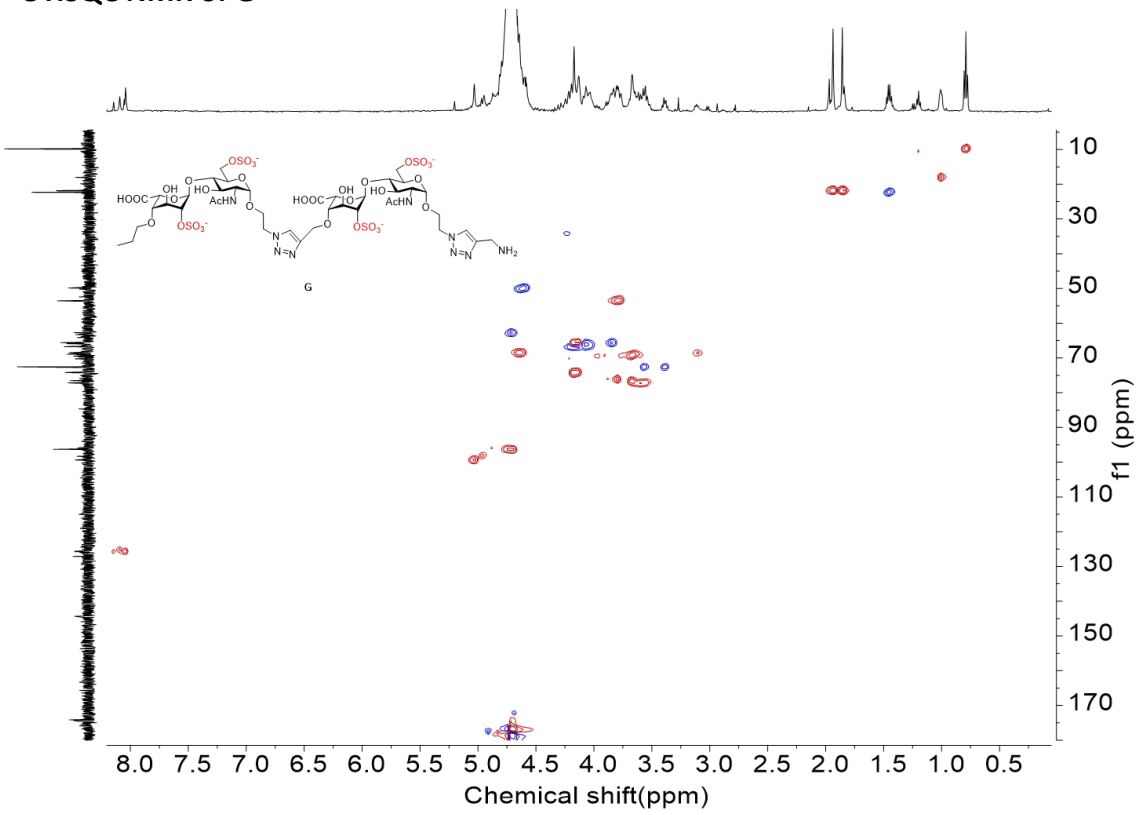
^{13}C NMR of G



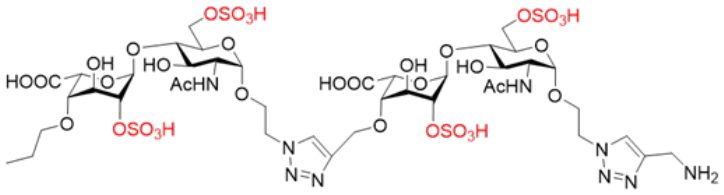
^{1}H-^{1}H gCOSY NMR of G

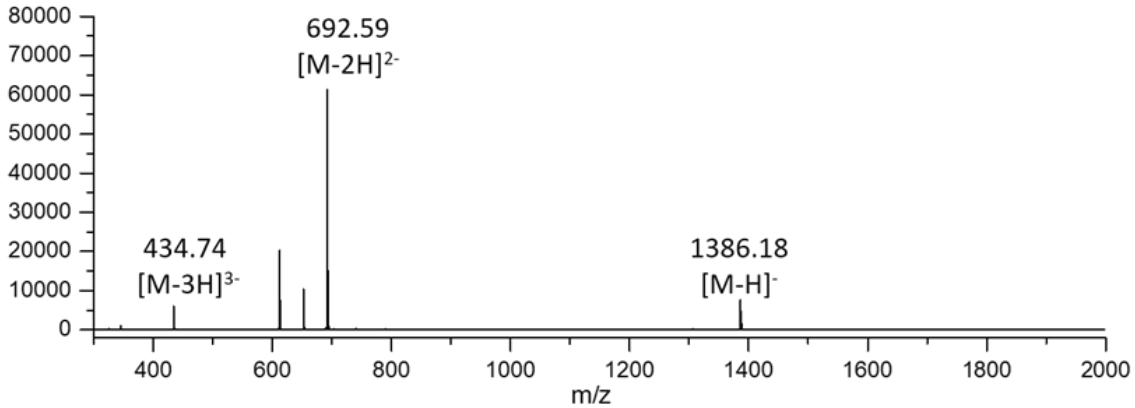


^{1}H-^{13}C HSQC NMR of G

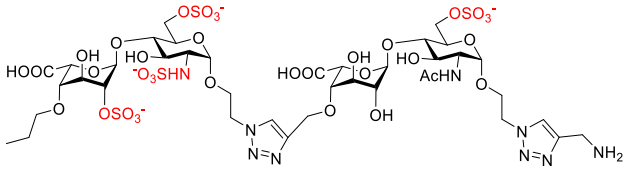


Mass spectra of G



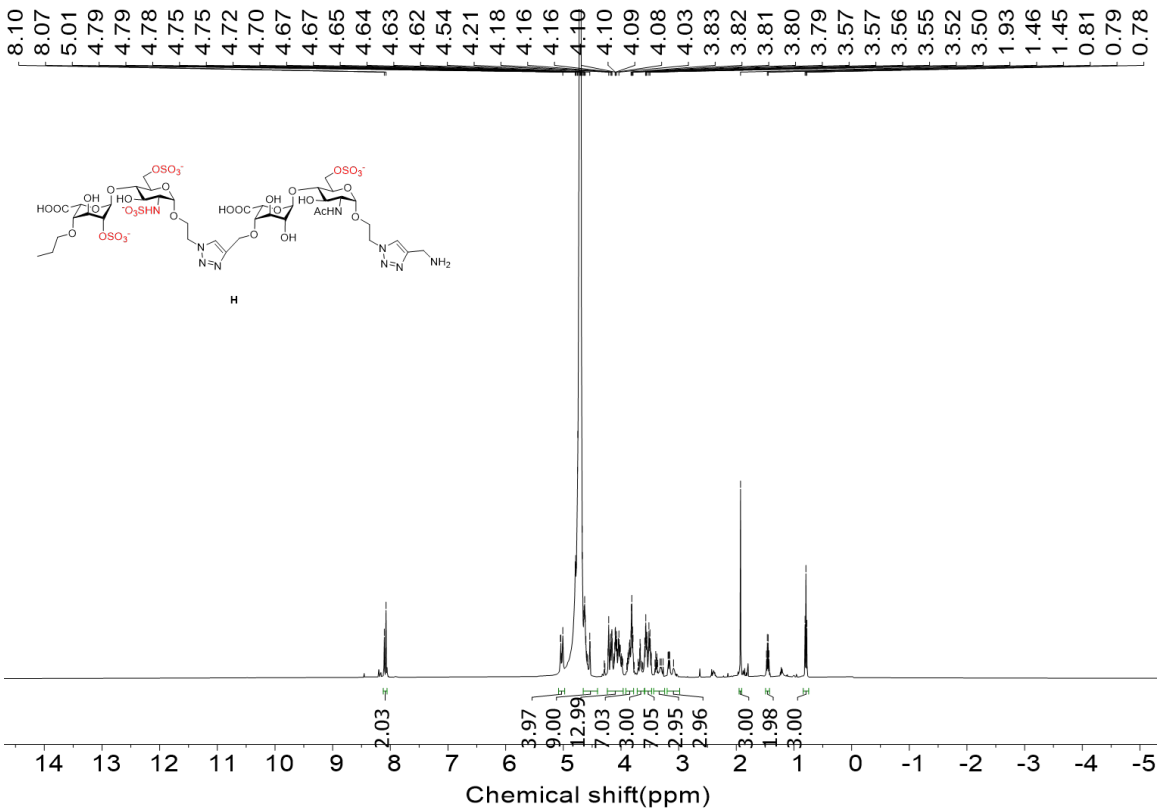


Characterization of H



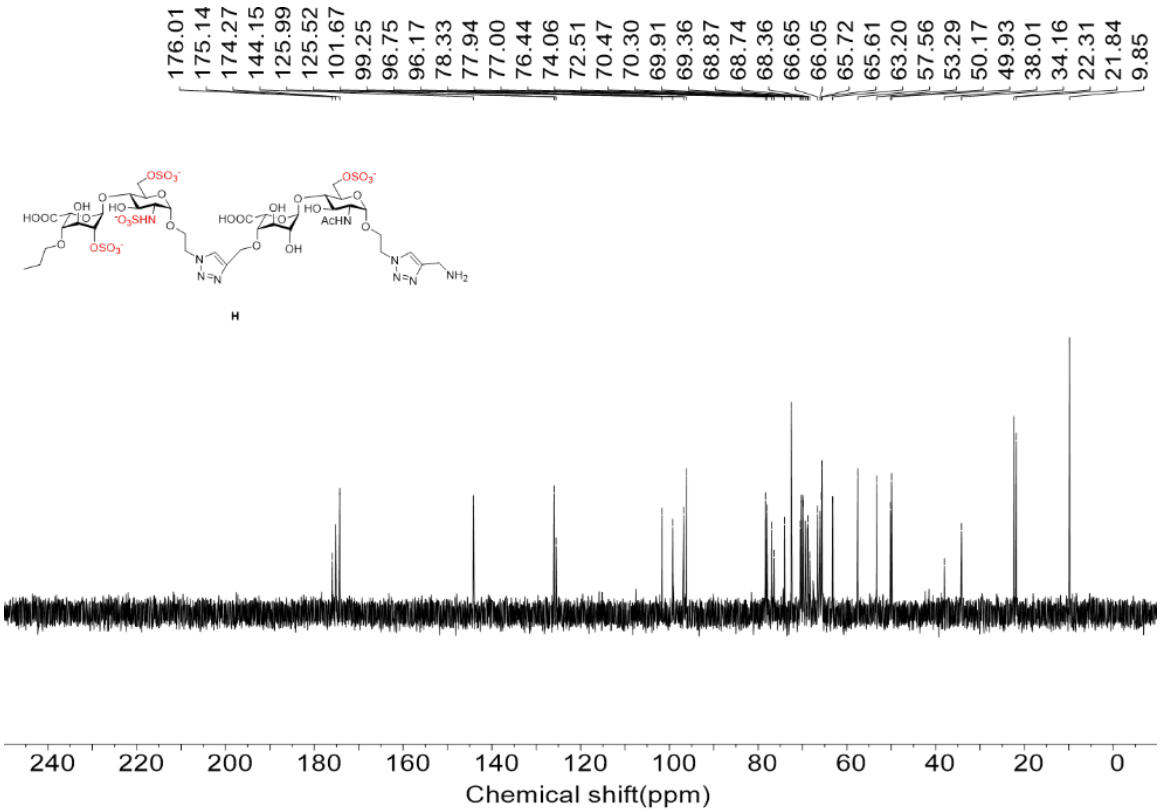
H

^{1}H NMR of H

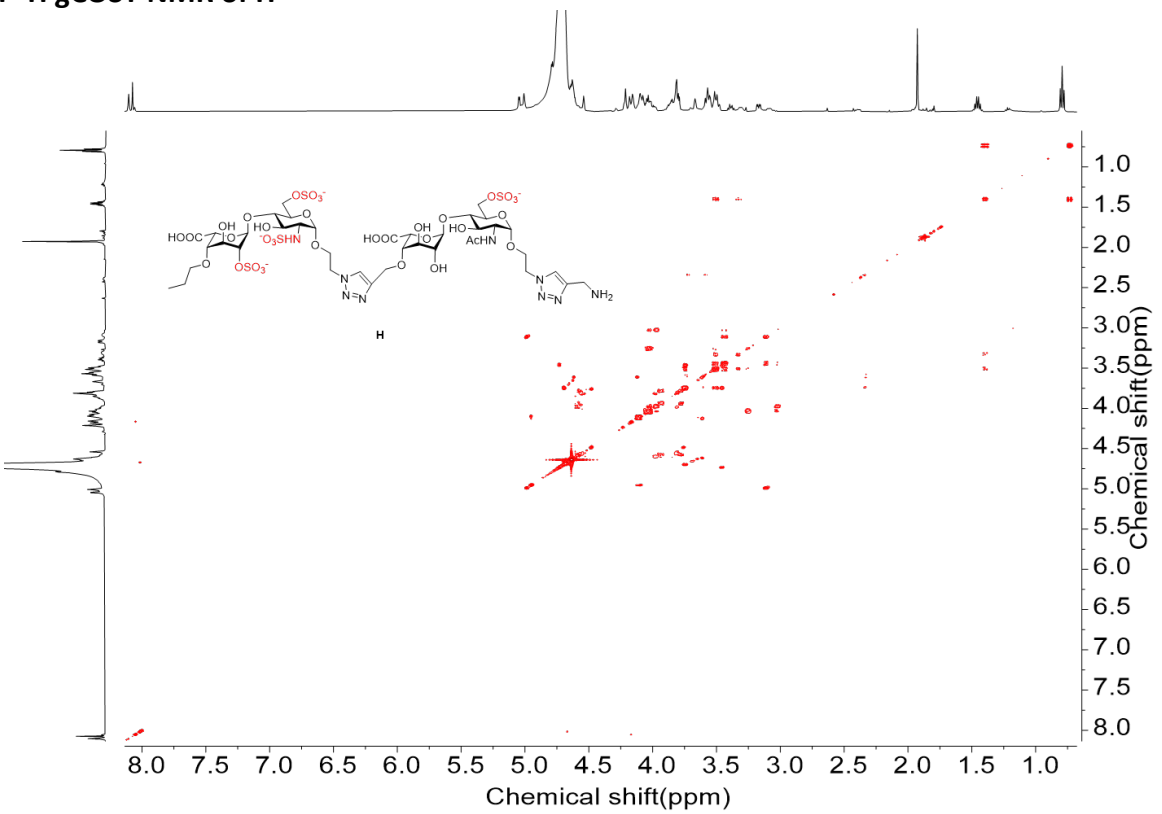


H

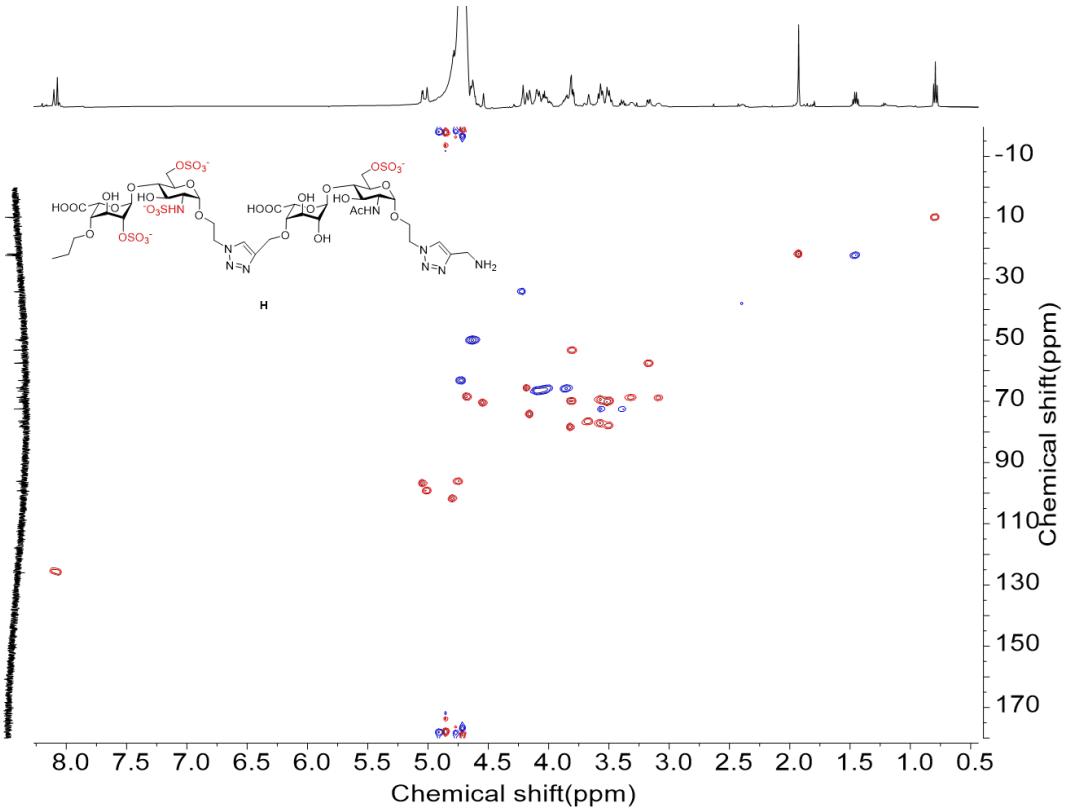
^{13}C NMR of H



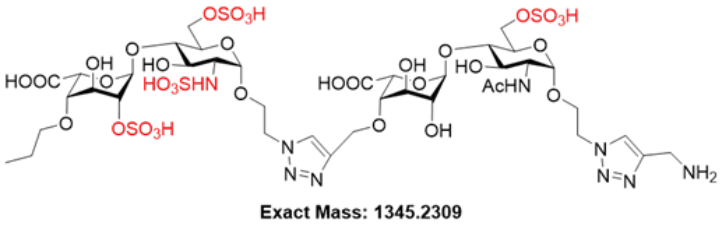
^{1}H-^{1}H gCOSY NMR of H



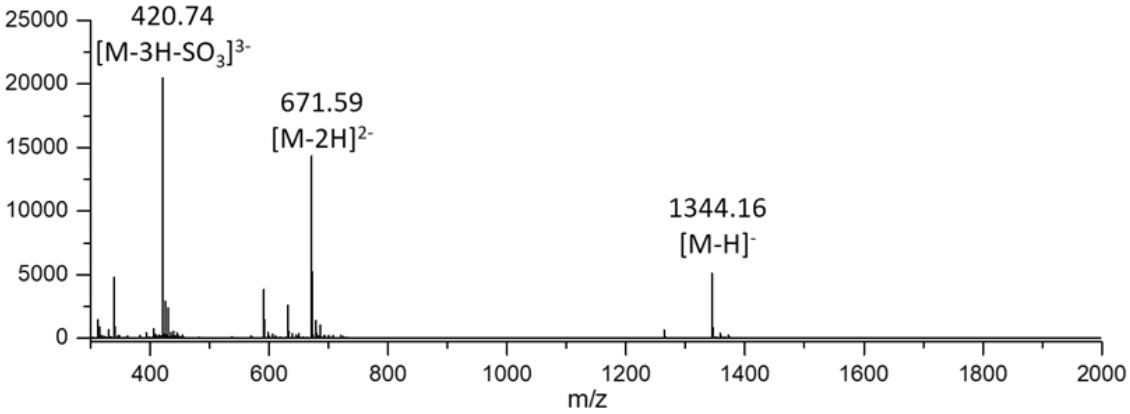
^{1}H-^{13}C HSQC NMR of H



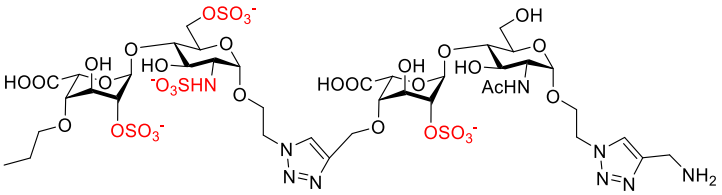
Mass spectra of H



Exact Mass: 1345.2309

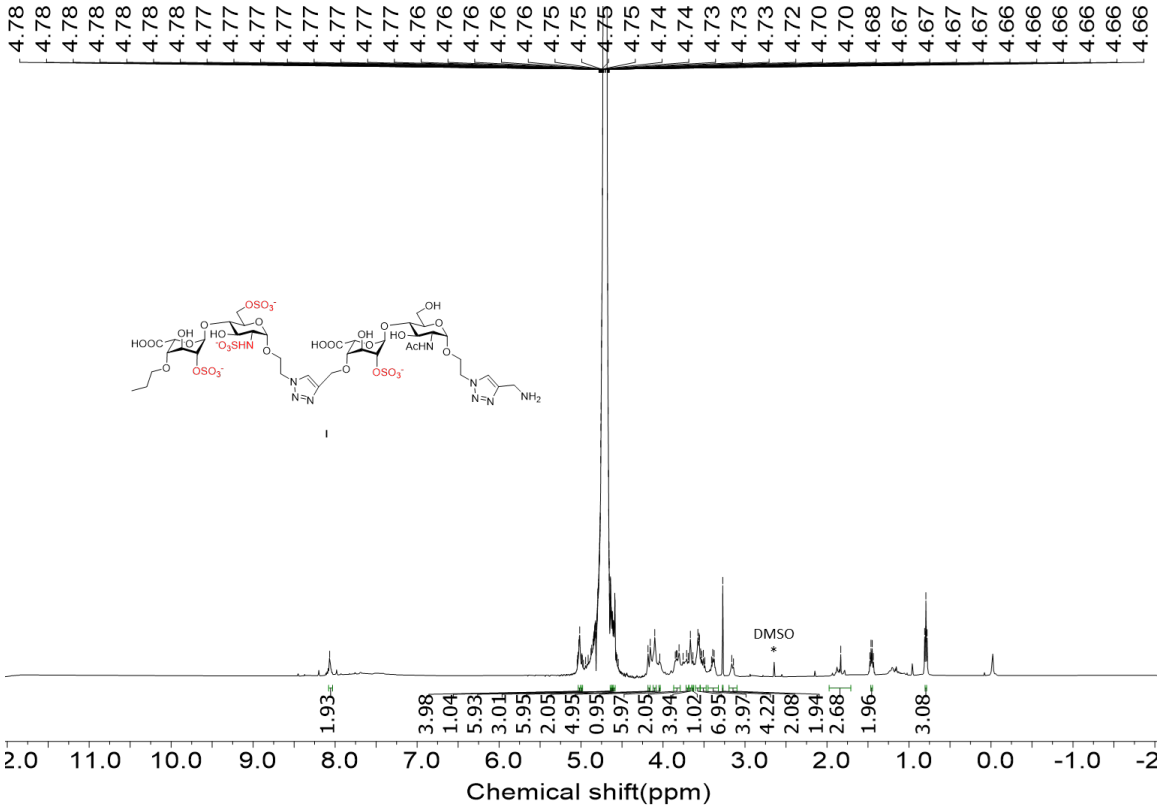


Characterization of I



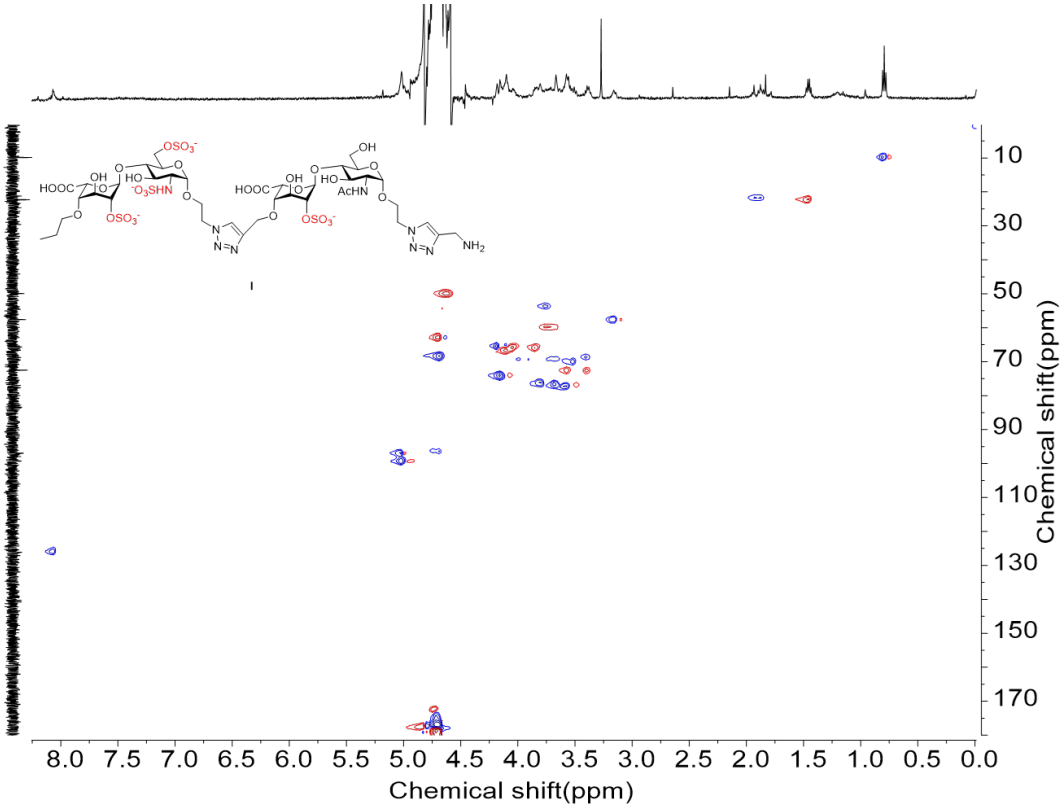
I

^{1}H NMR of I

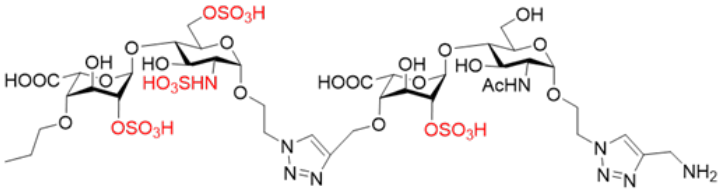


I

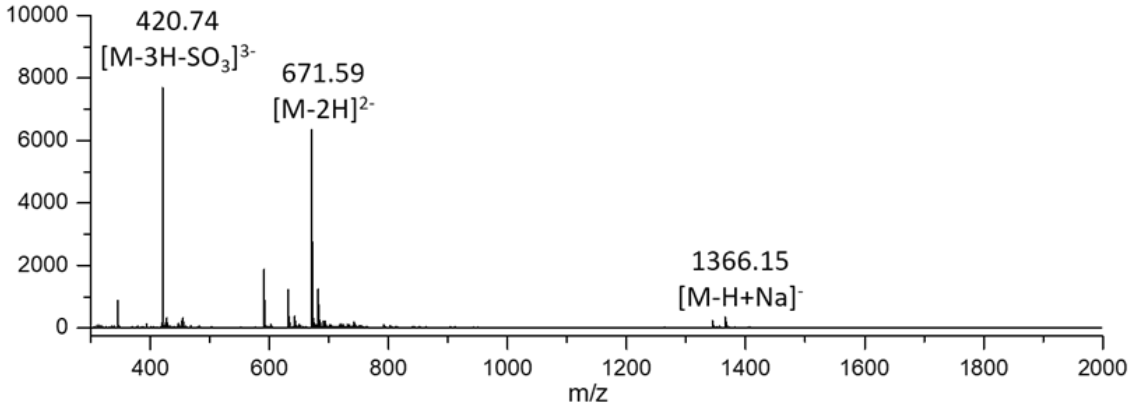
^{1}H-^{13}C HSQC NMR of I



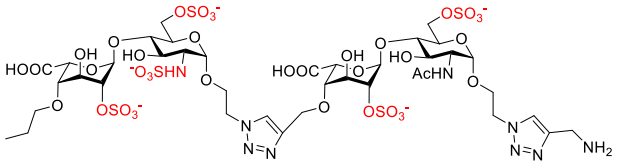
Mass spectra of I



Exact Mass: 1345.2309

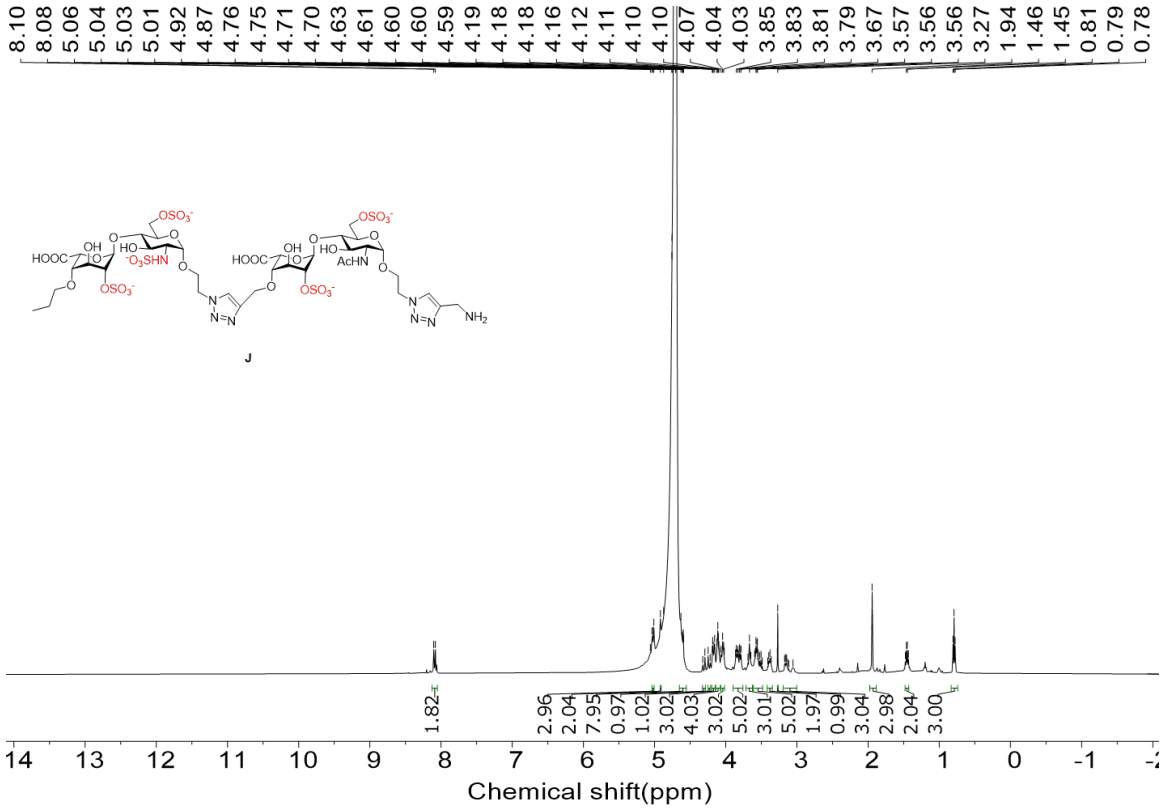


Characterization of J



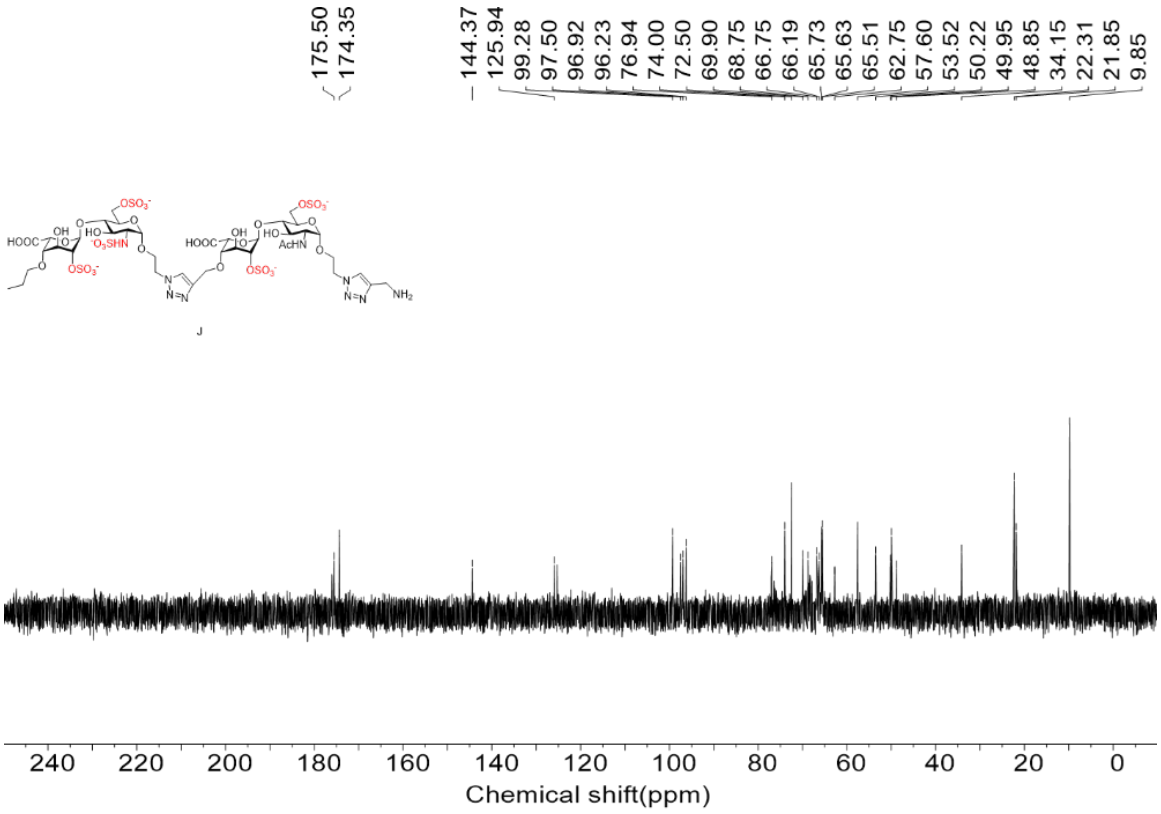
J

^{1}H NMR of J

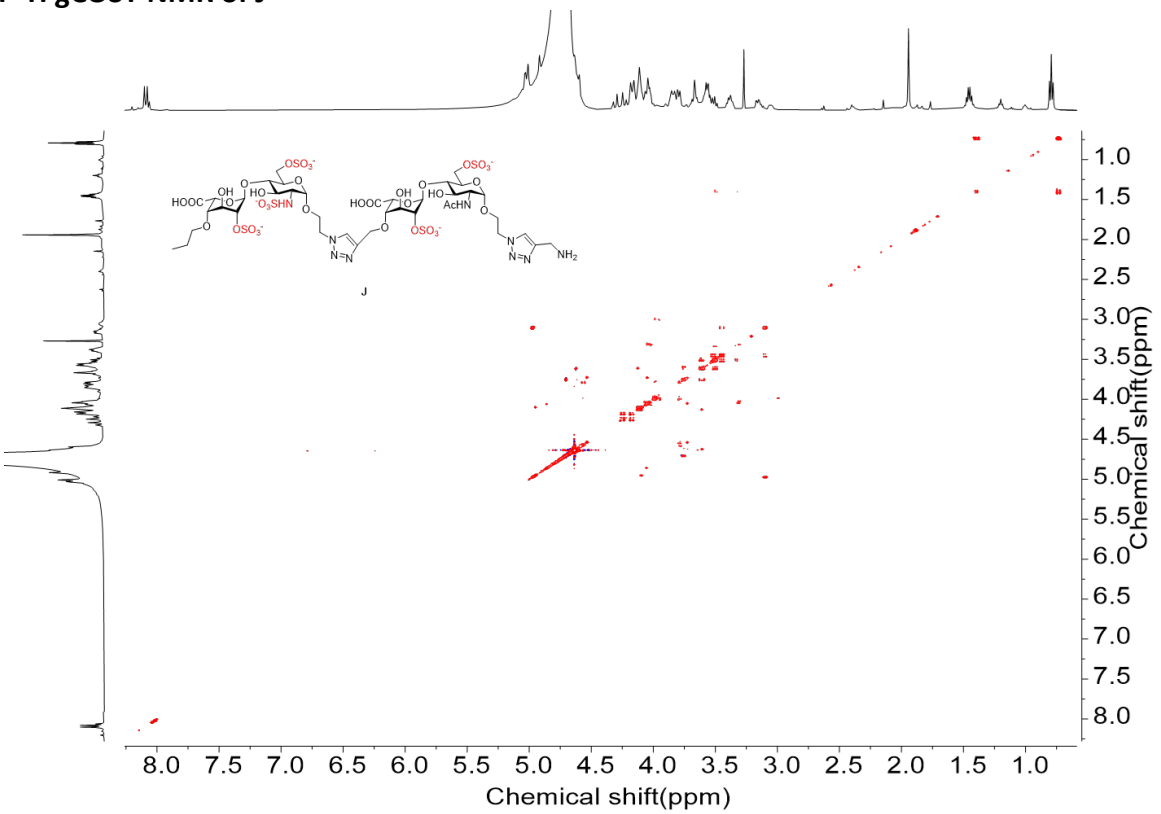


J

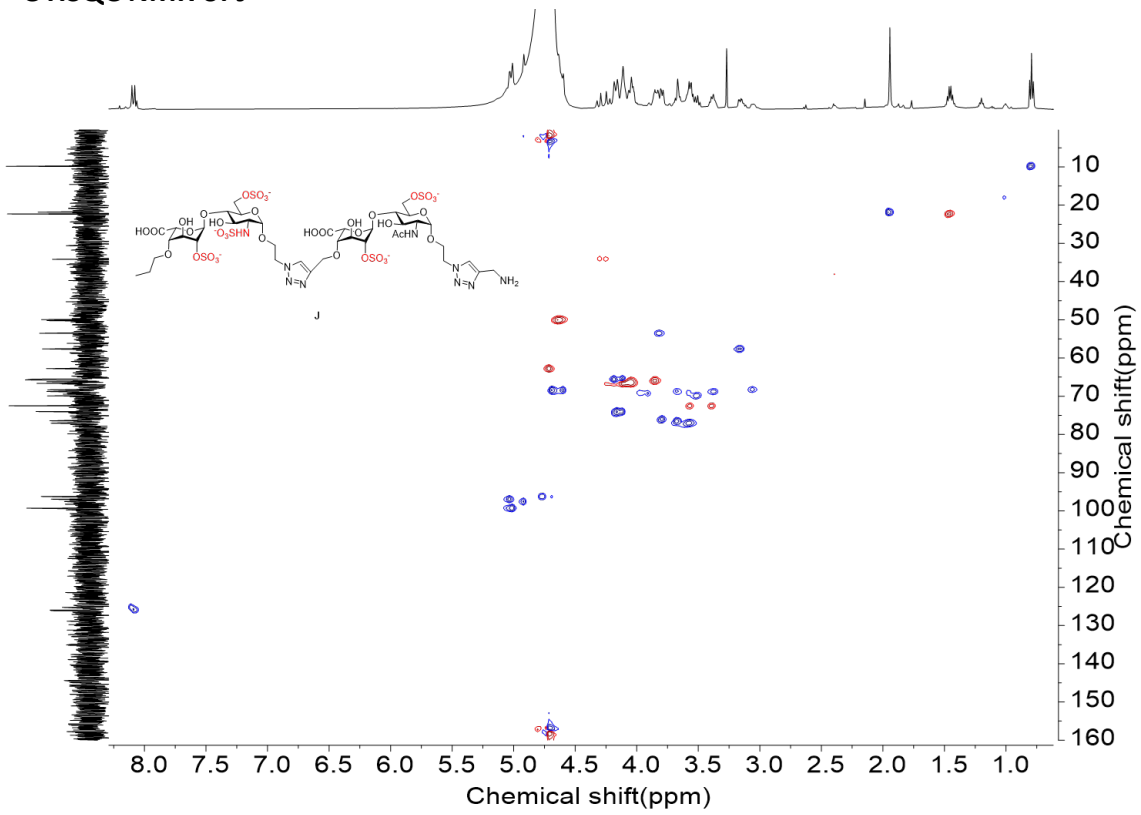
^{13}C NMR of J



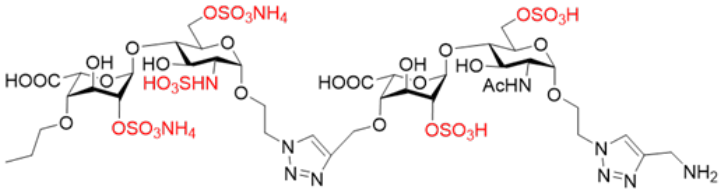
^{1}H-^{1}H gCOSY NMR of J



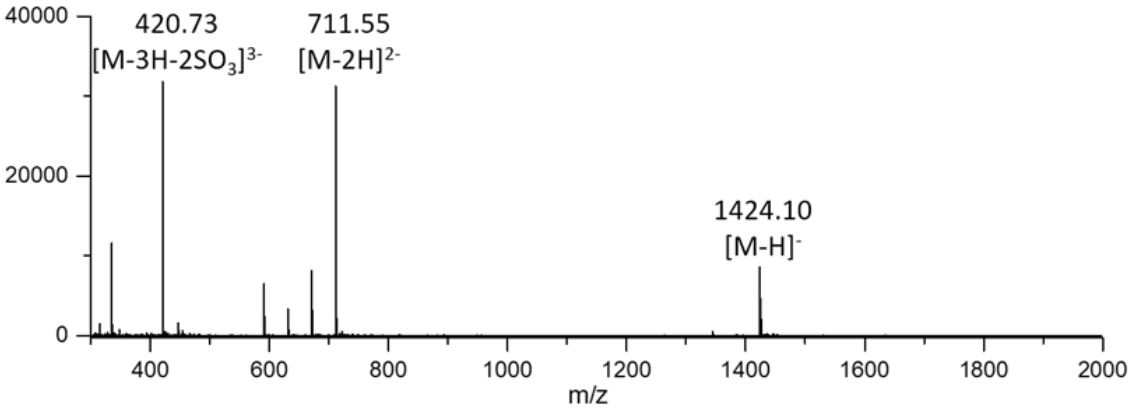
^{1}H-^{13}C HSQC NMR of J



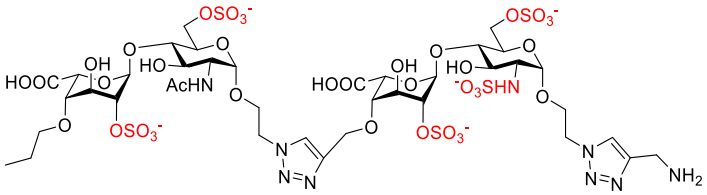
Mass spectra of J



Exact Mass: 1459.2409

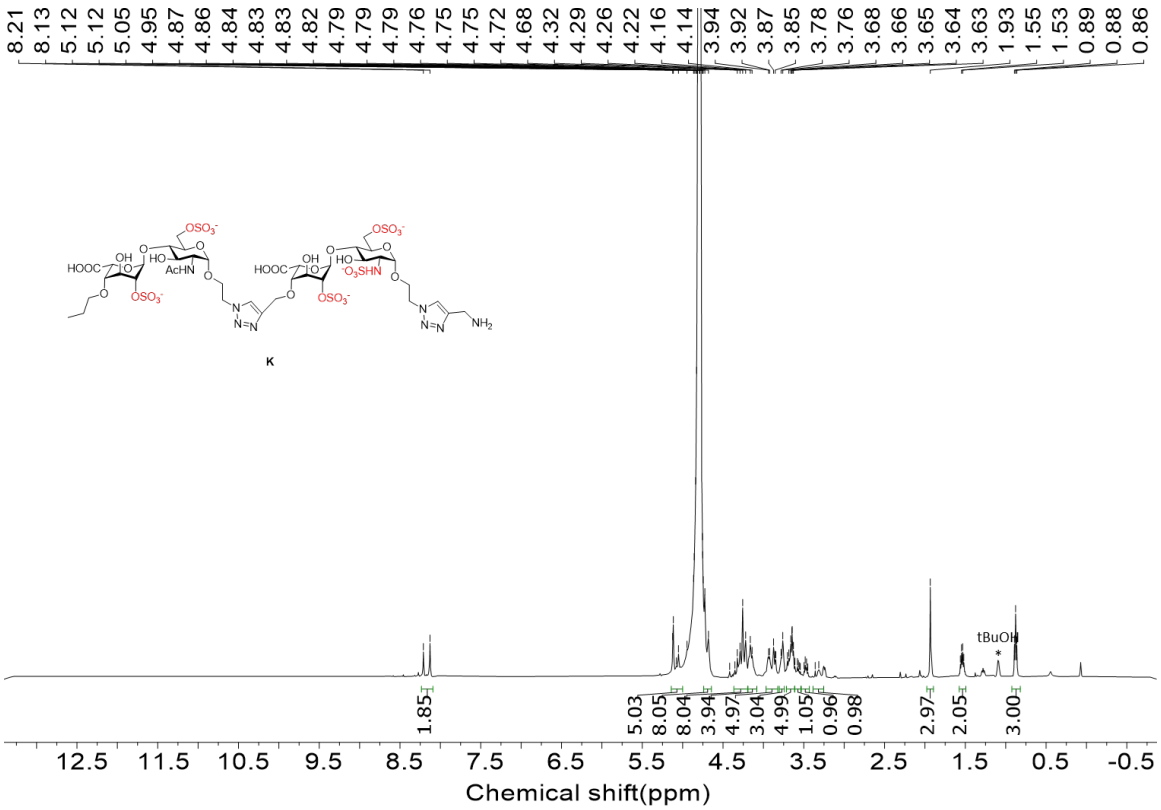


Characterization of K



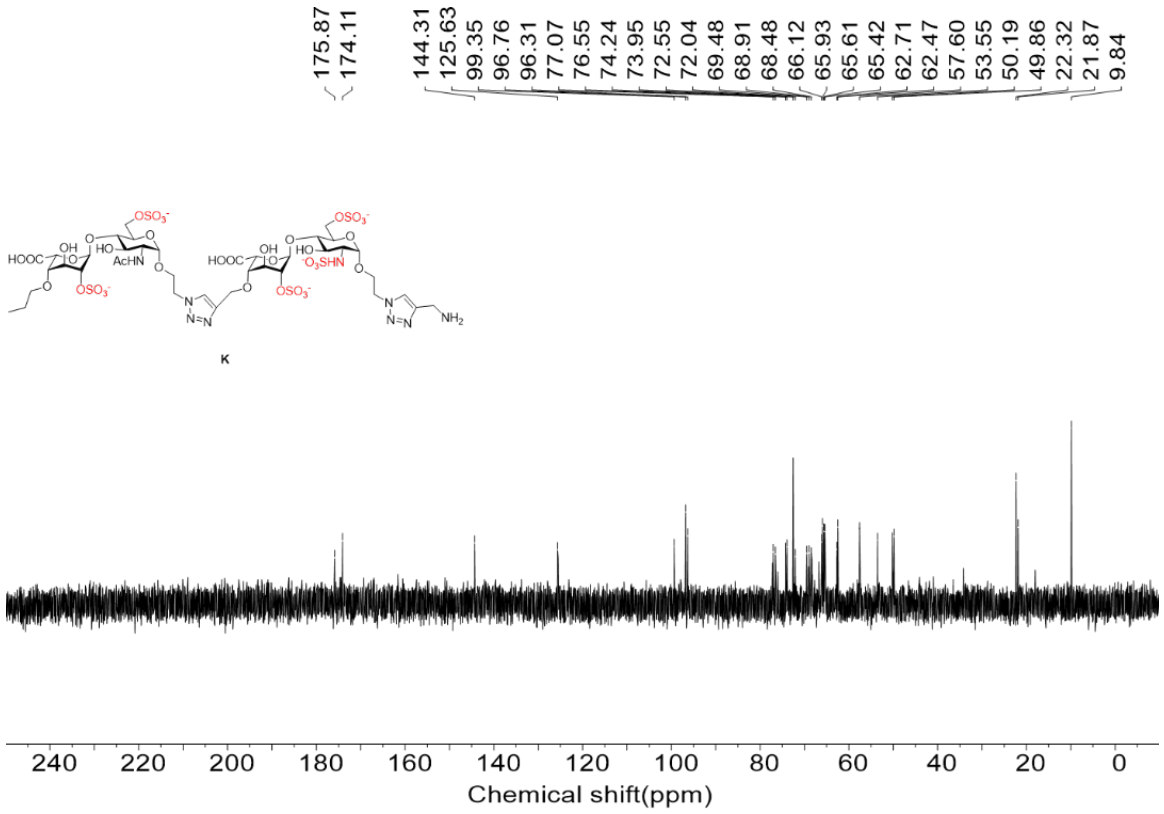
K

^{1}H NMR of K

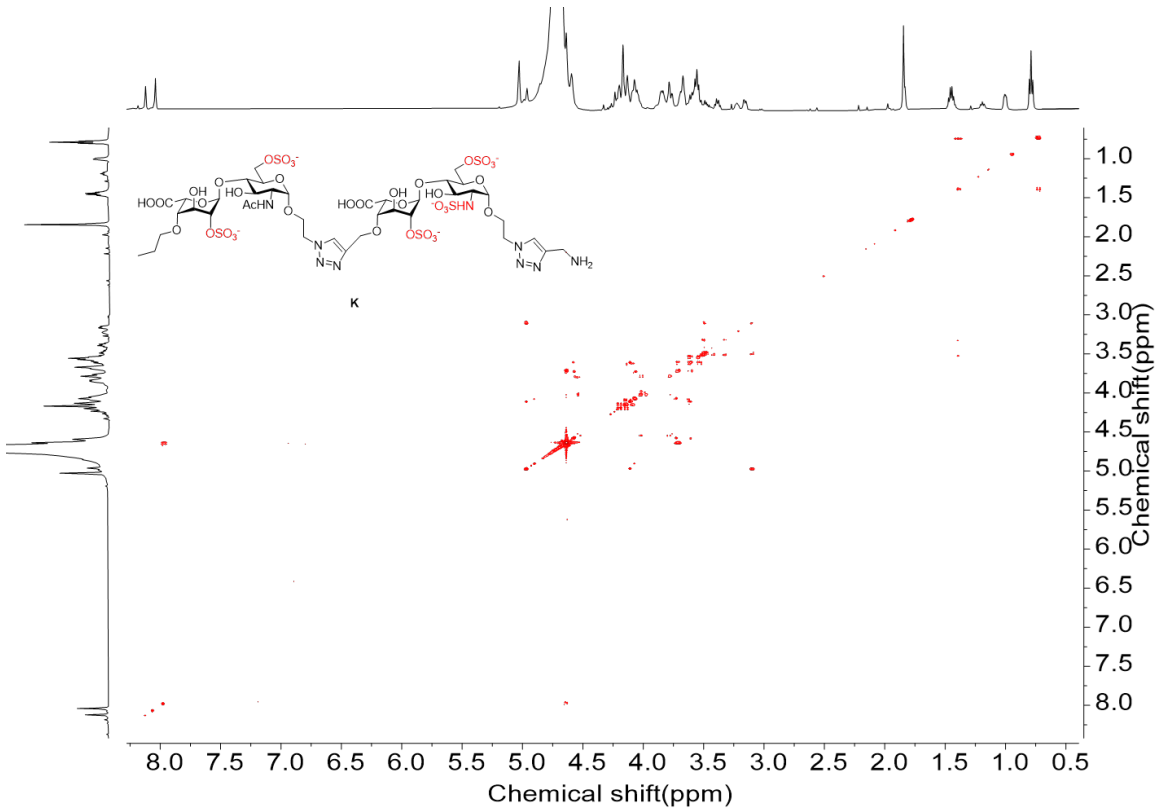


K

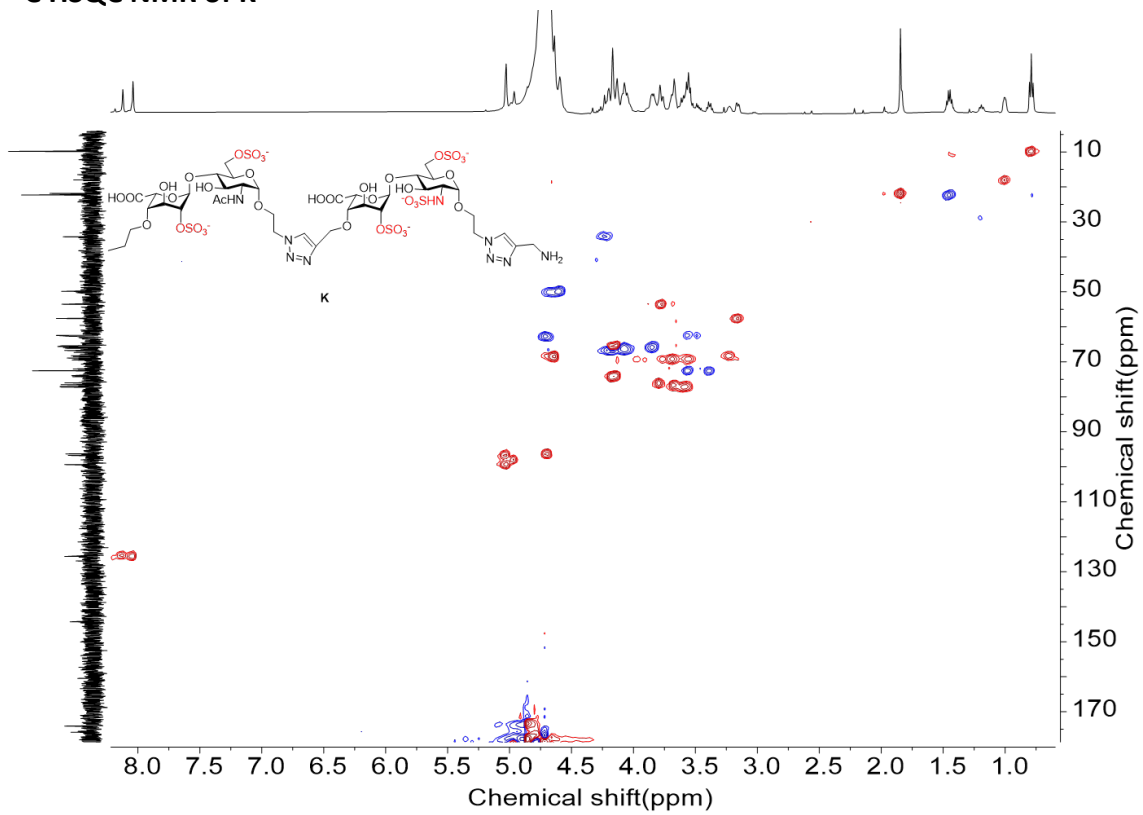
^{13}C NMR of K



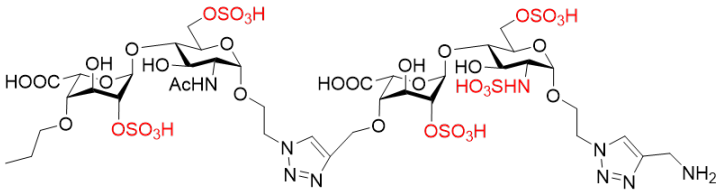
^{1}H-^{1}H gCOSY NMR of K



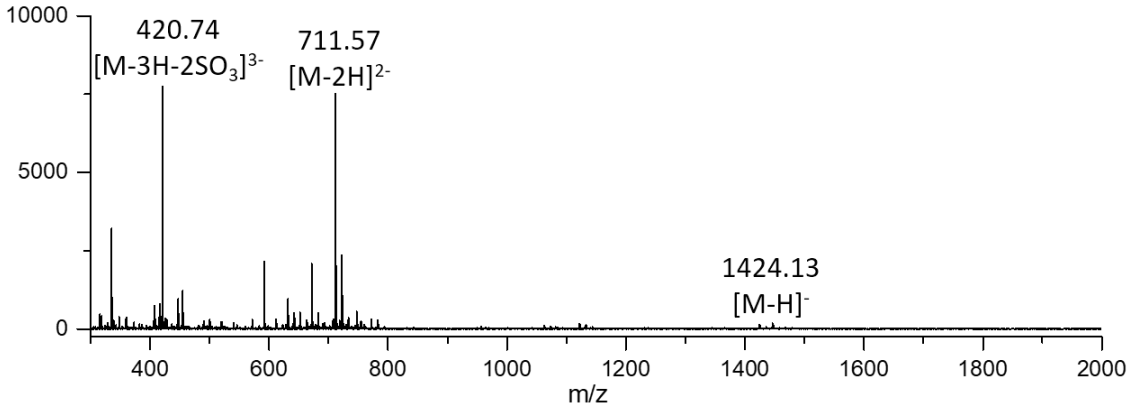
^{1}H-^{13}C HSQC NMR of K



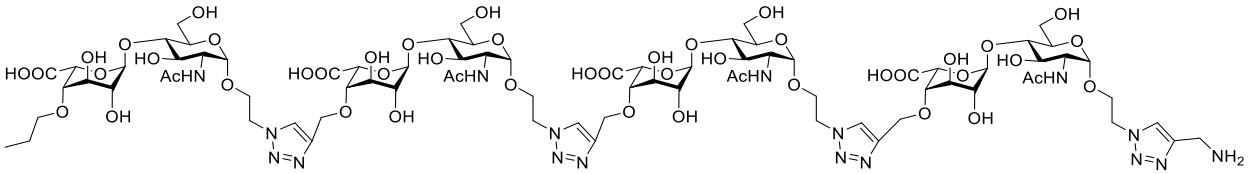
Mass spectra of K



Exact Mass: 1425.1878

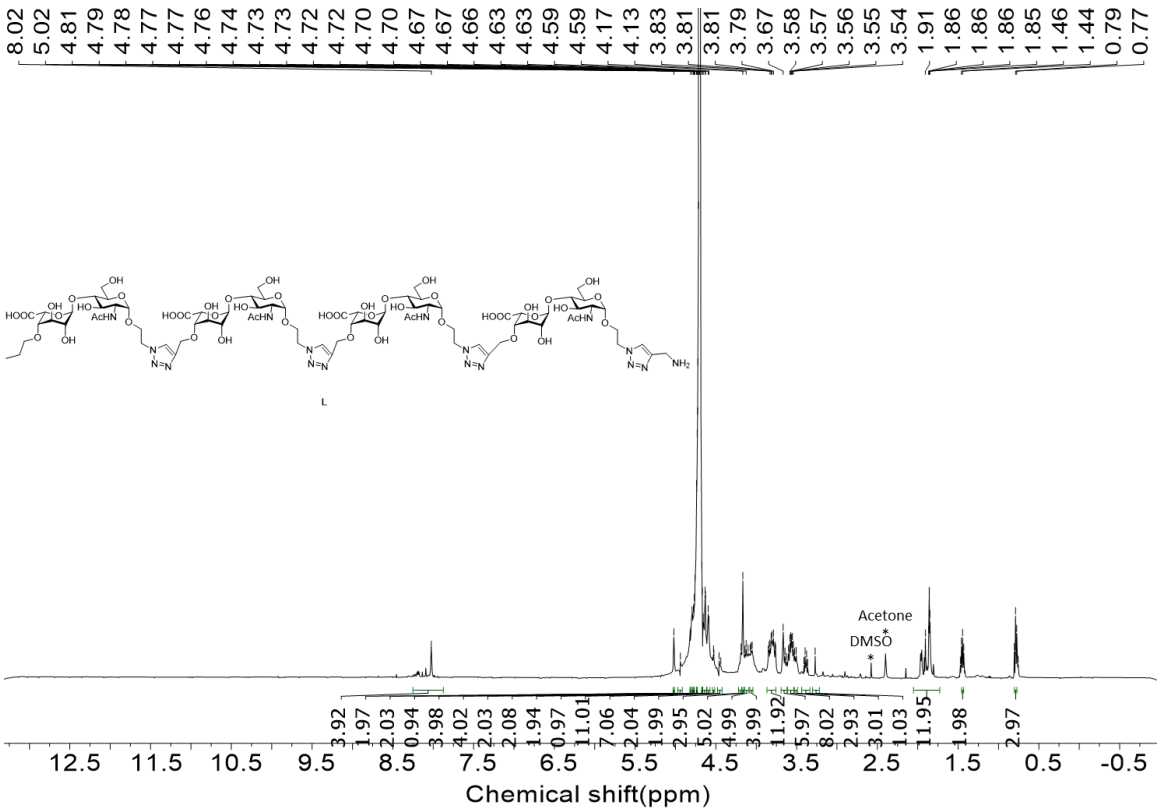


Characterization of L

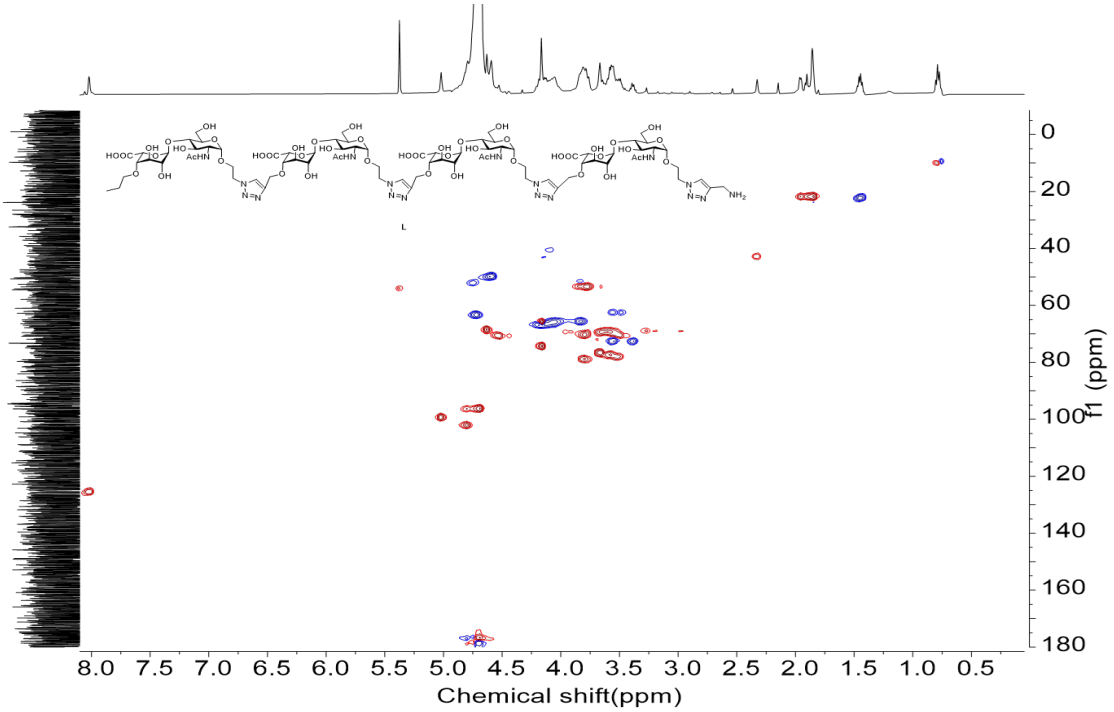


L

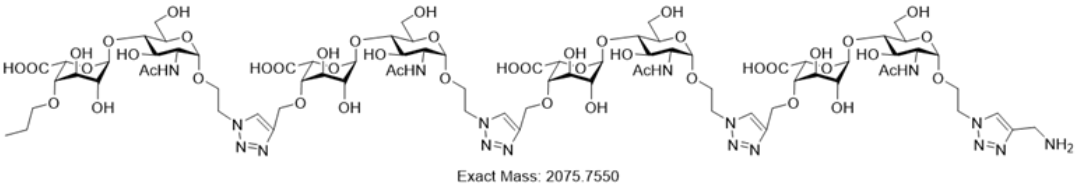
^{1}H NMR of L

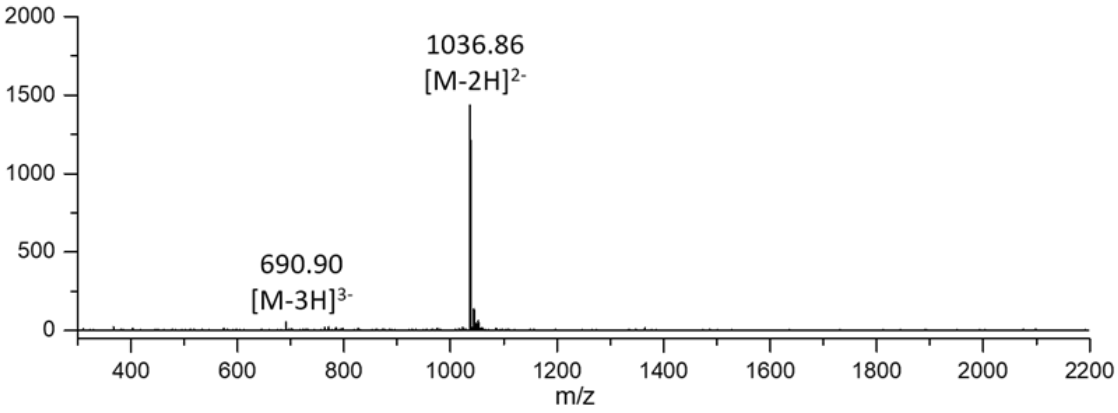


^{1}H-^{13}C HSQC NMR of L

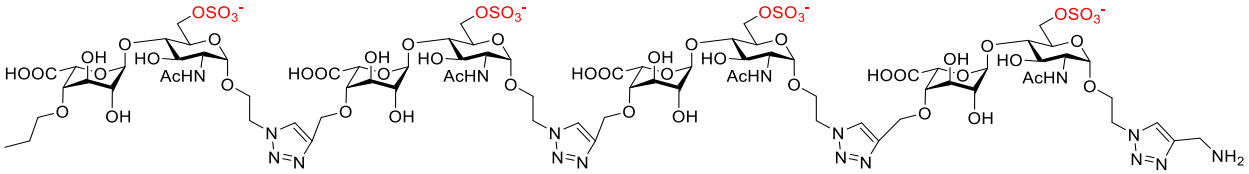


Mass spectra of L



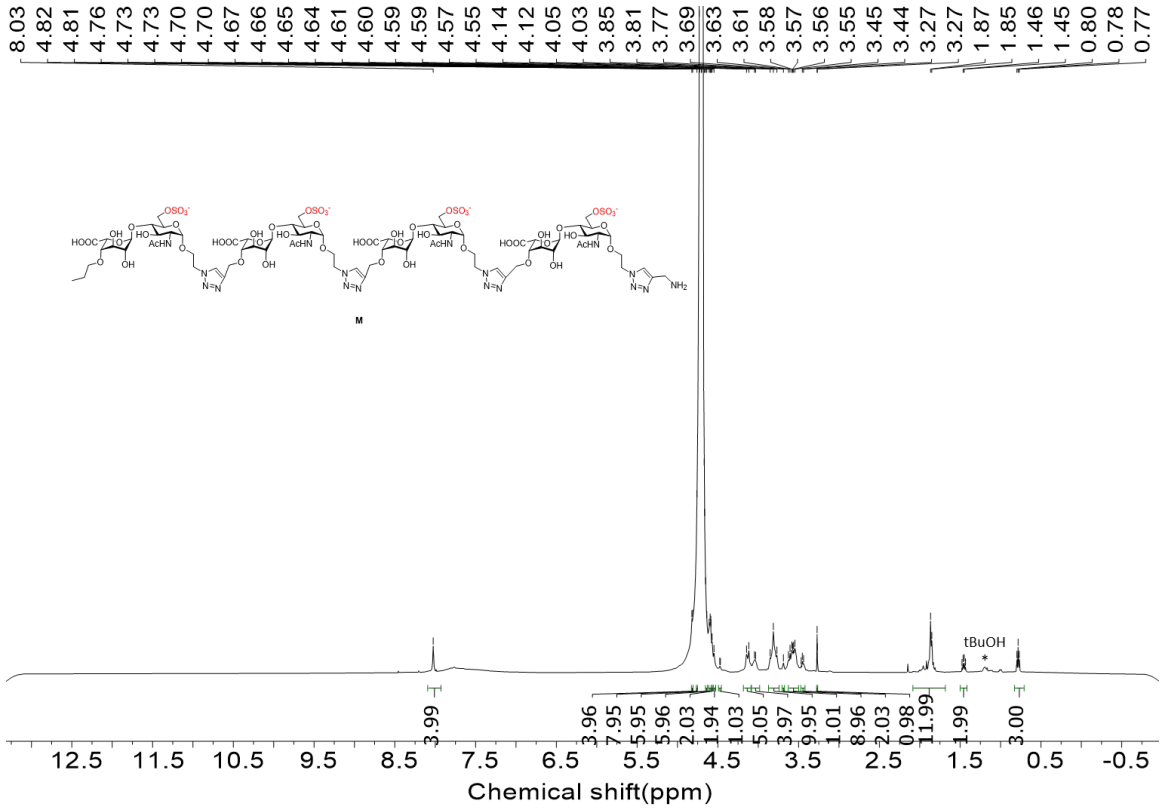


Characterization of M



M

^{1}H NMR of M



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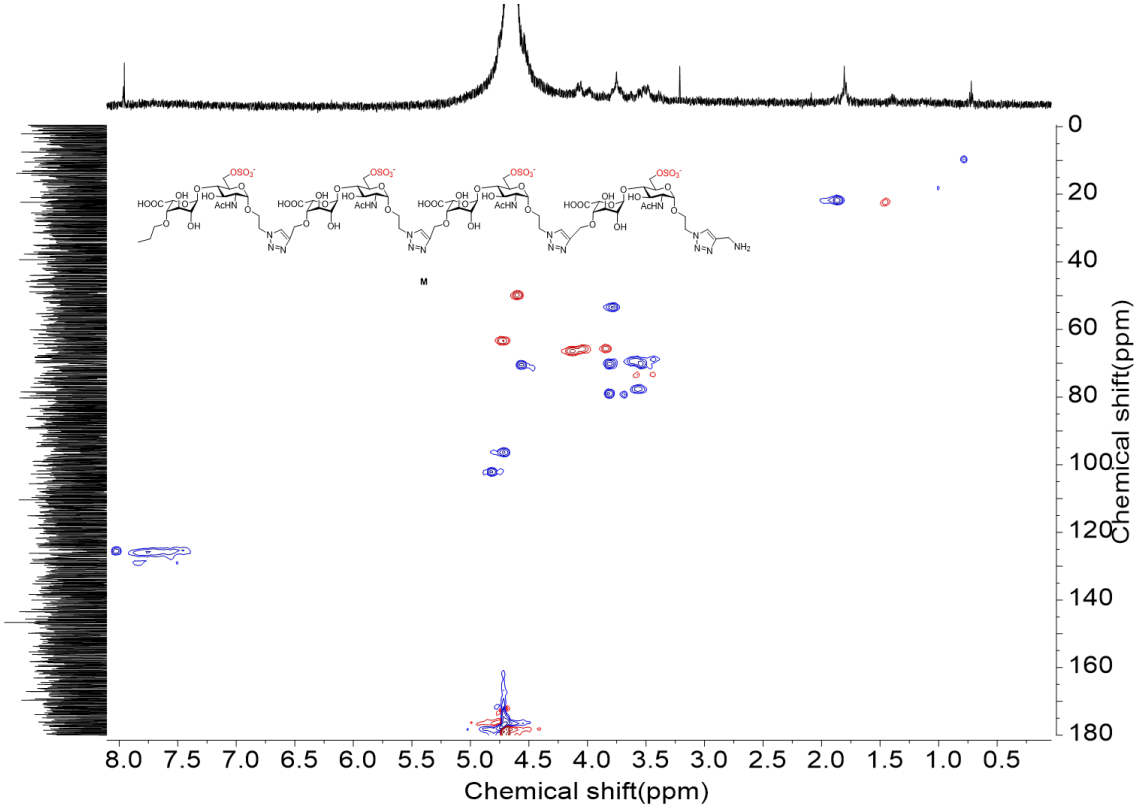
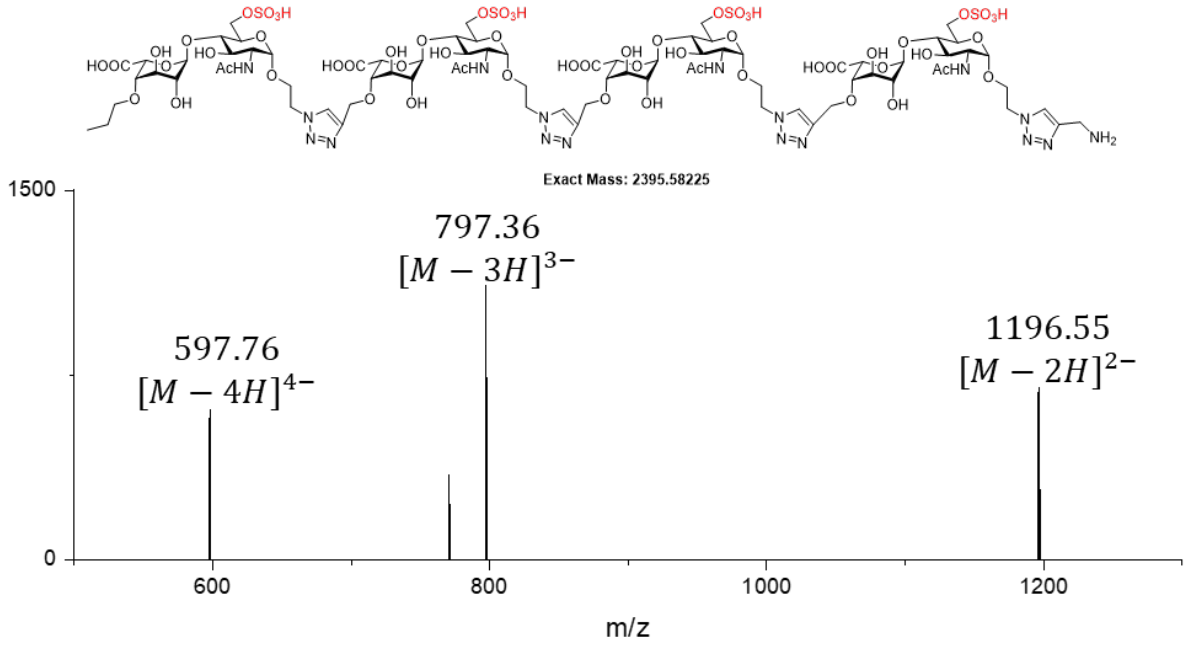
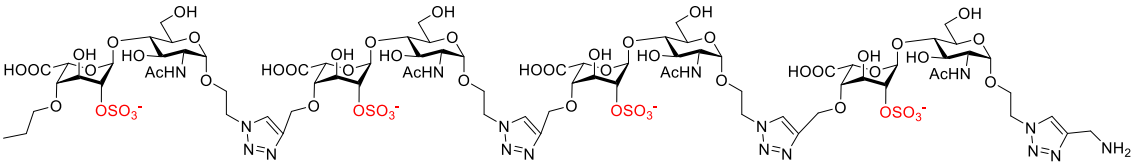


Mass spectra of M

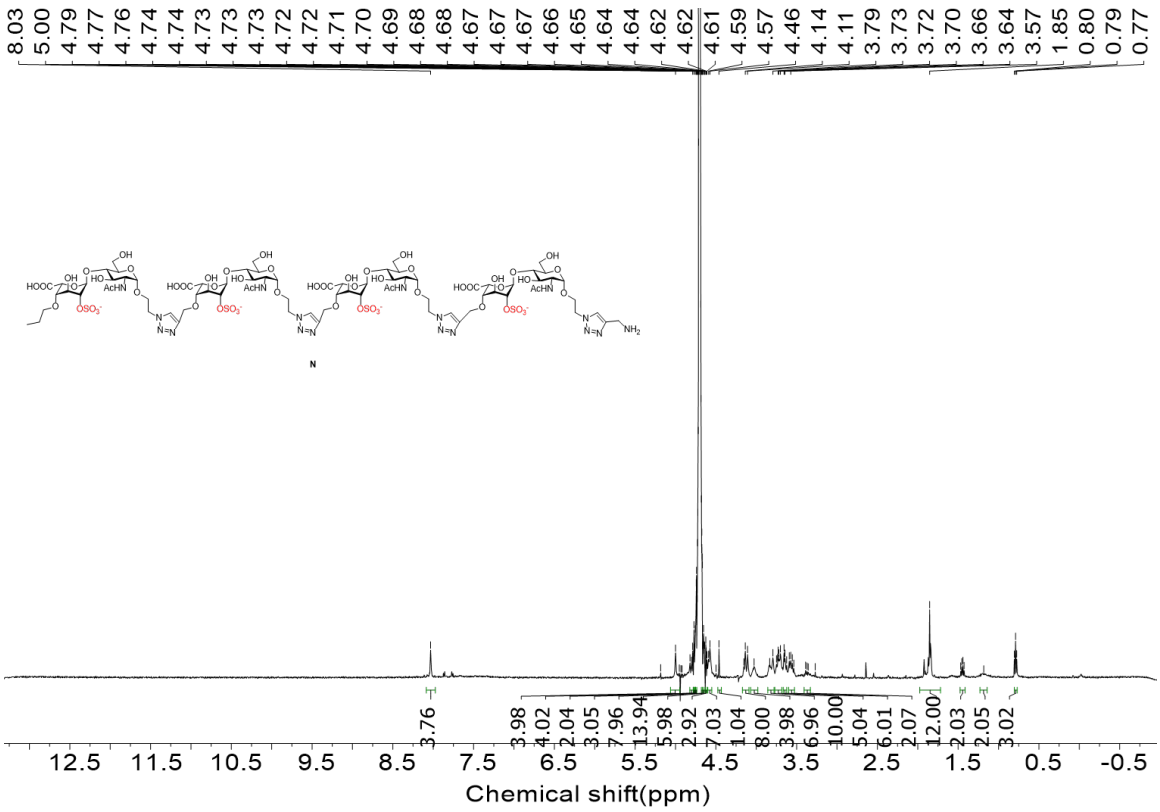


Characterization of N



N

^{1}H NMR of N



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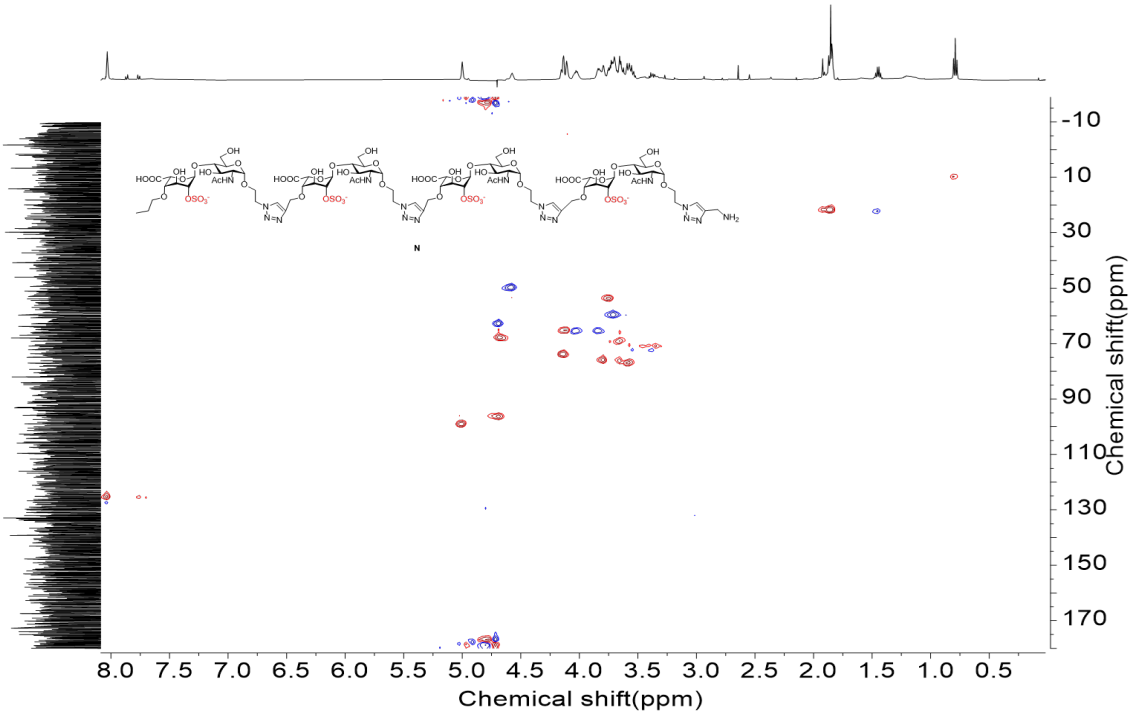
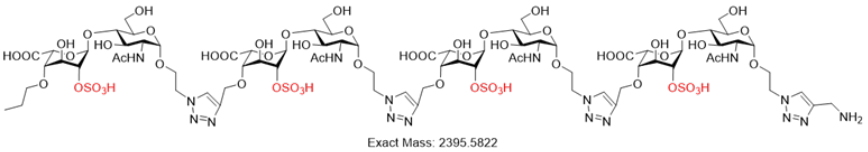
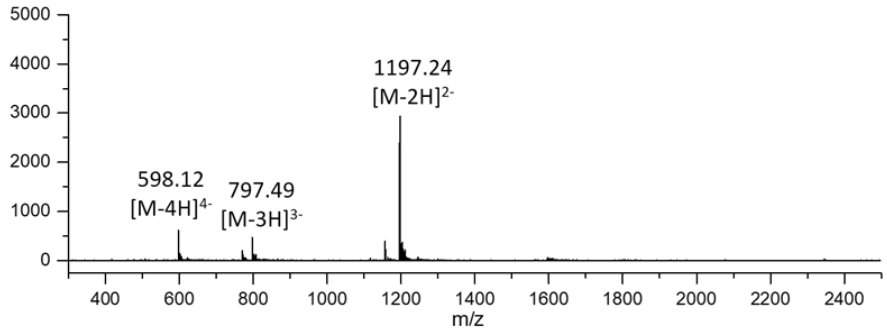
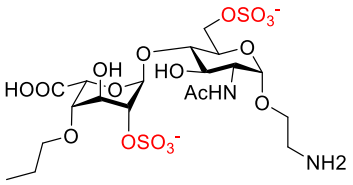


Mass spectra of N



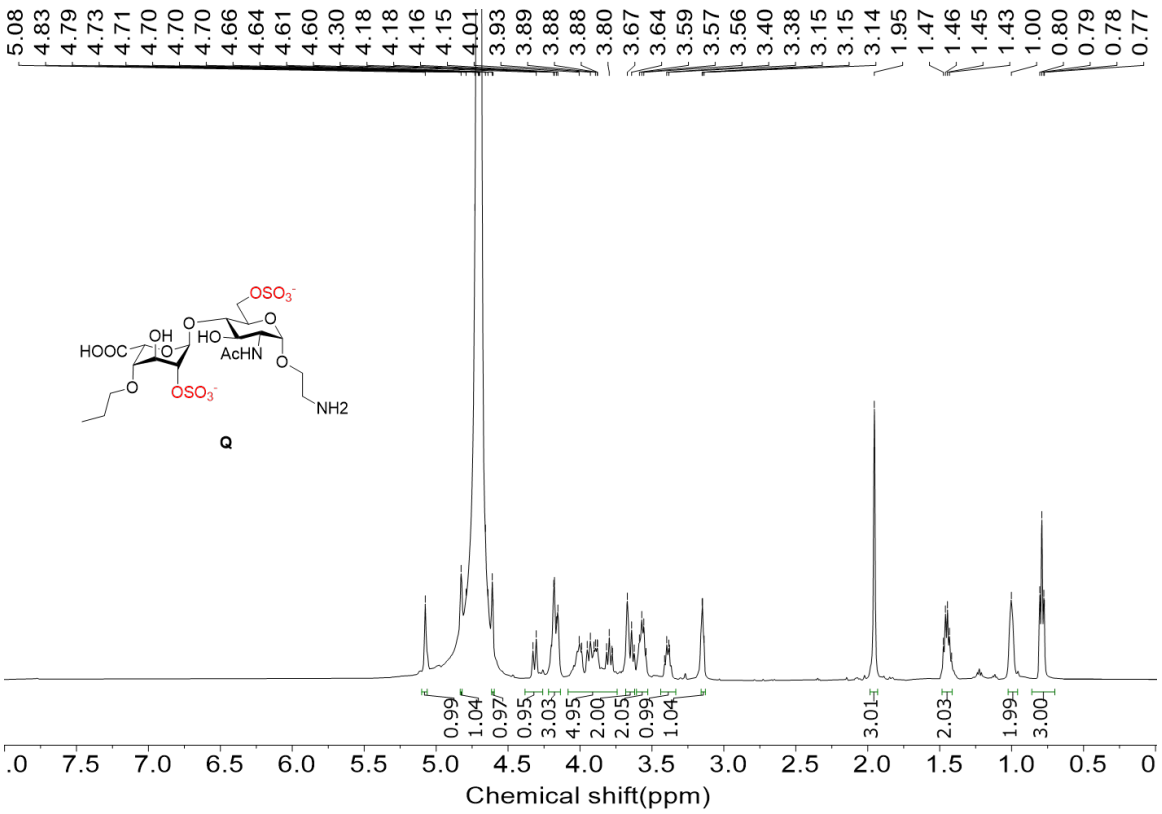


Characterization of Q



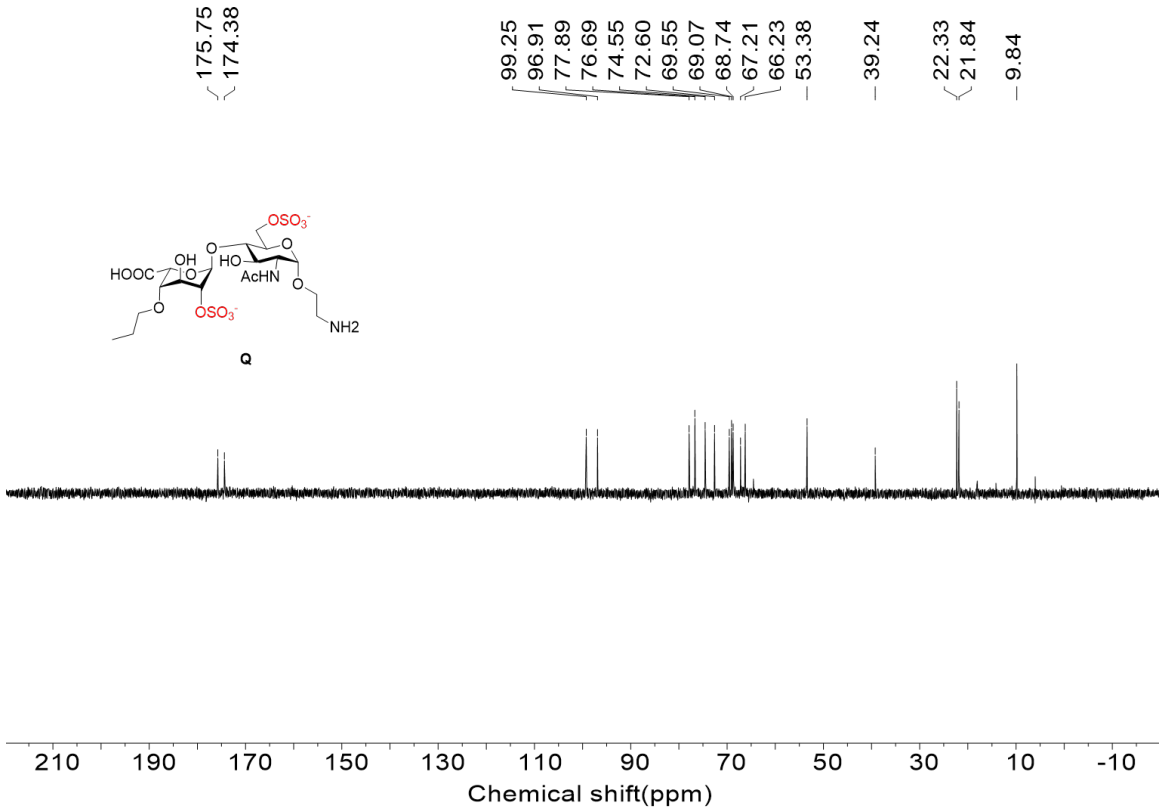
Q

^{1}H NMR of Q

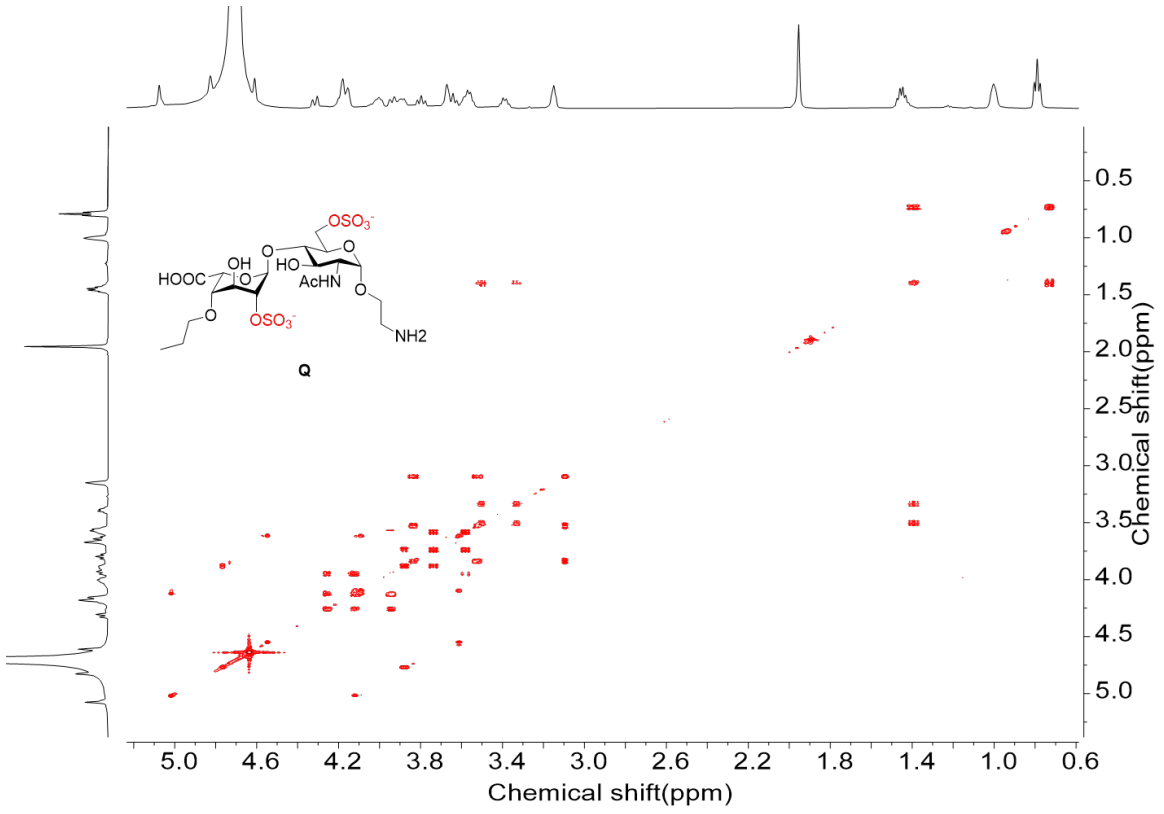


Q

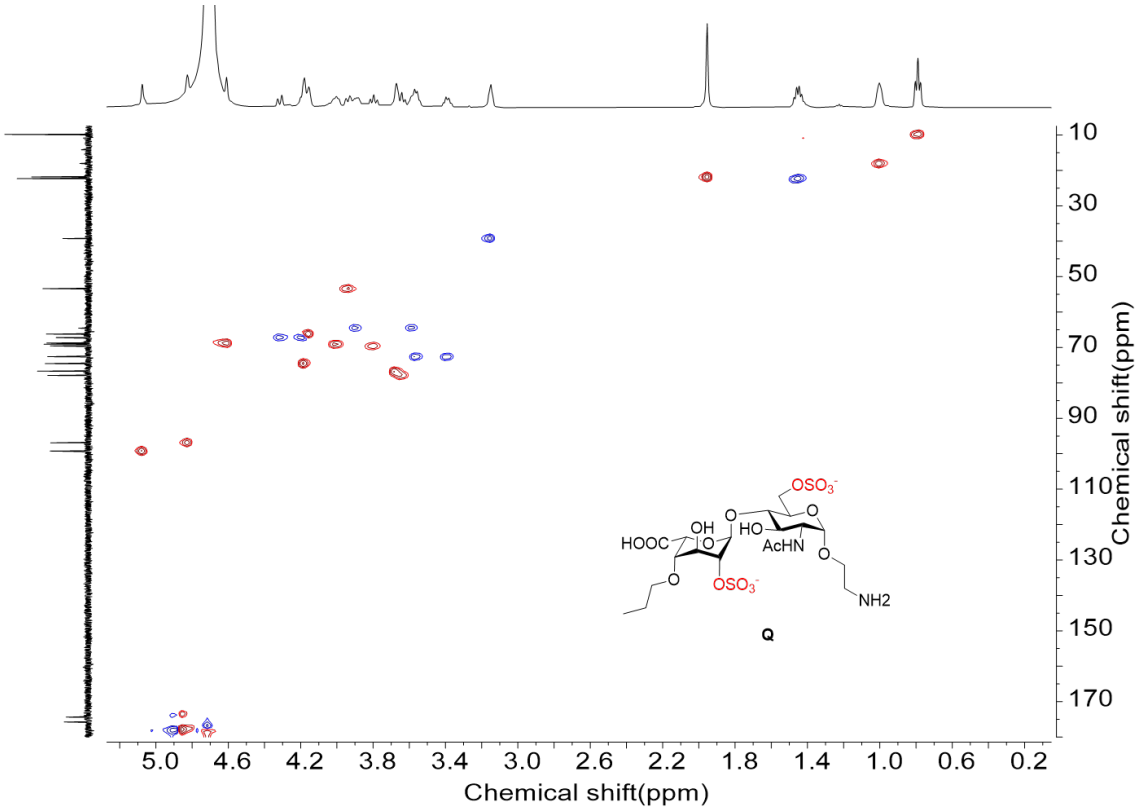
^{13}C NMR of Q



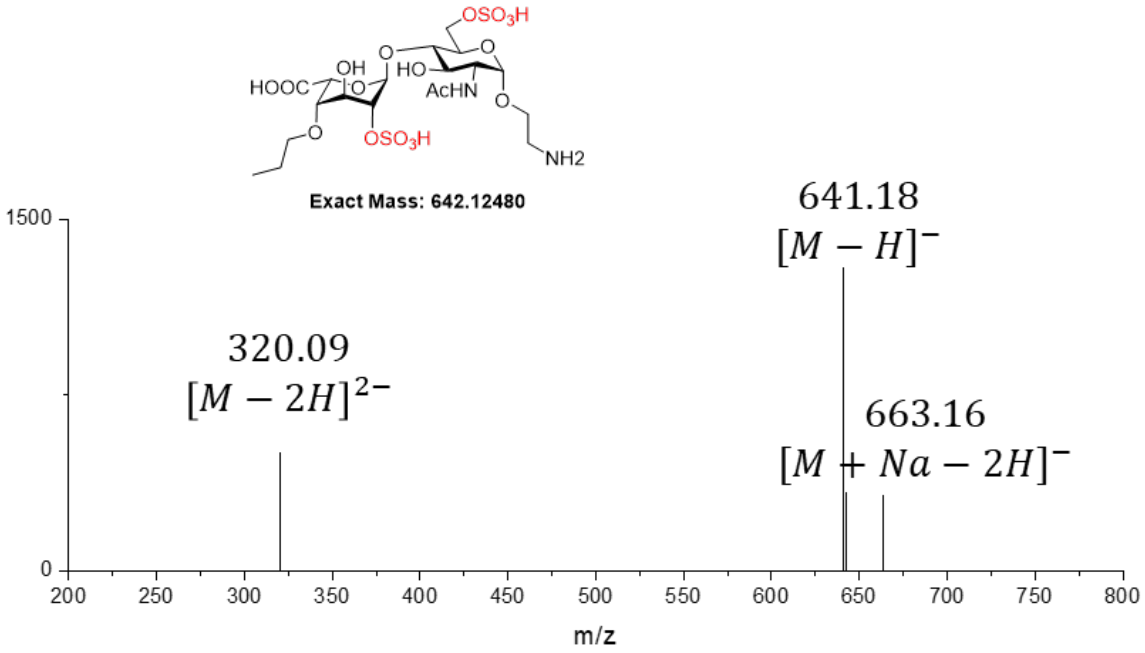
^{1}H-^{1}H gCOSY NMR of Q



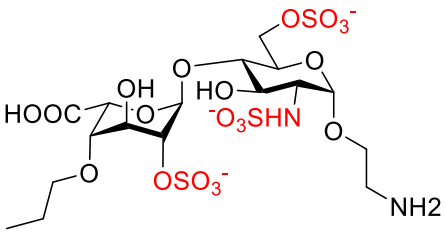
^{1}H-^{13}C HSQC NMR of Q



Mass spectra of Q

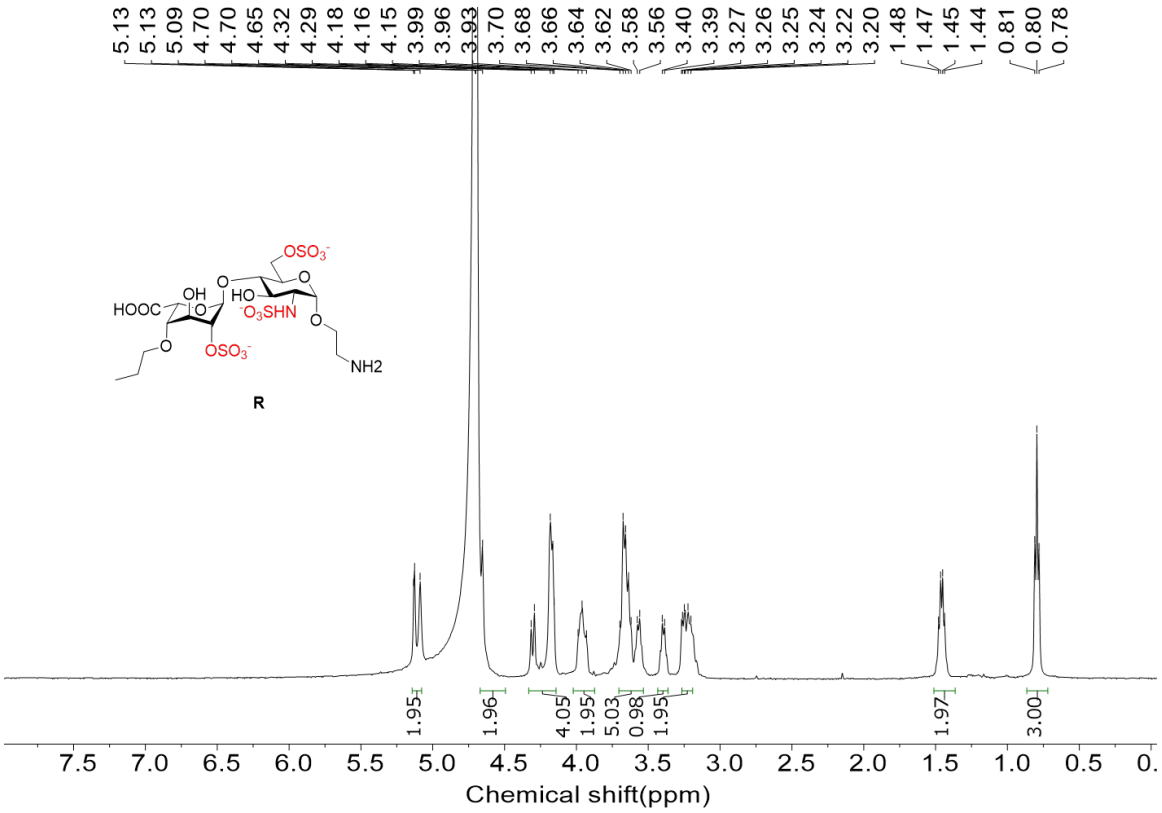

OSO3H
OH
HO
HOOC
AcHN
NH2
OSO3H
Exact Mass: 642.12480
641.18
[M − H]−
320.09
[M − 2H]2−
663.16
[M + Na − 2H]−
1500
0
200
250
300
350
400
450
500
550
600
650
700
750
800
m/z

Characterization of R

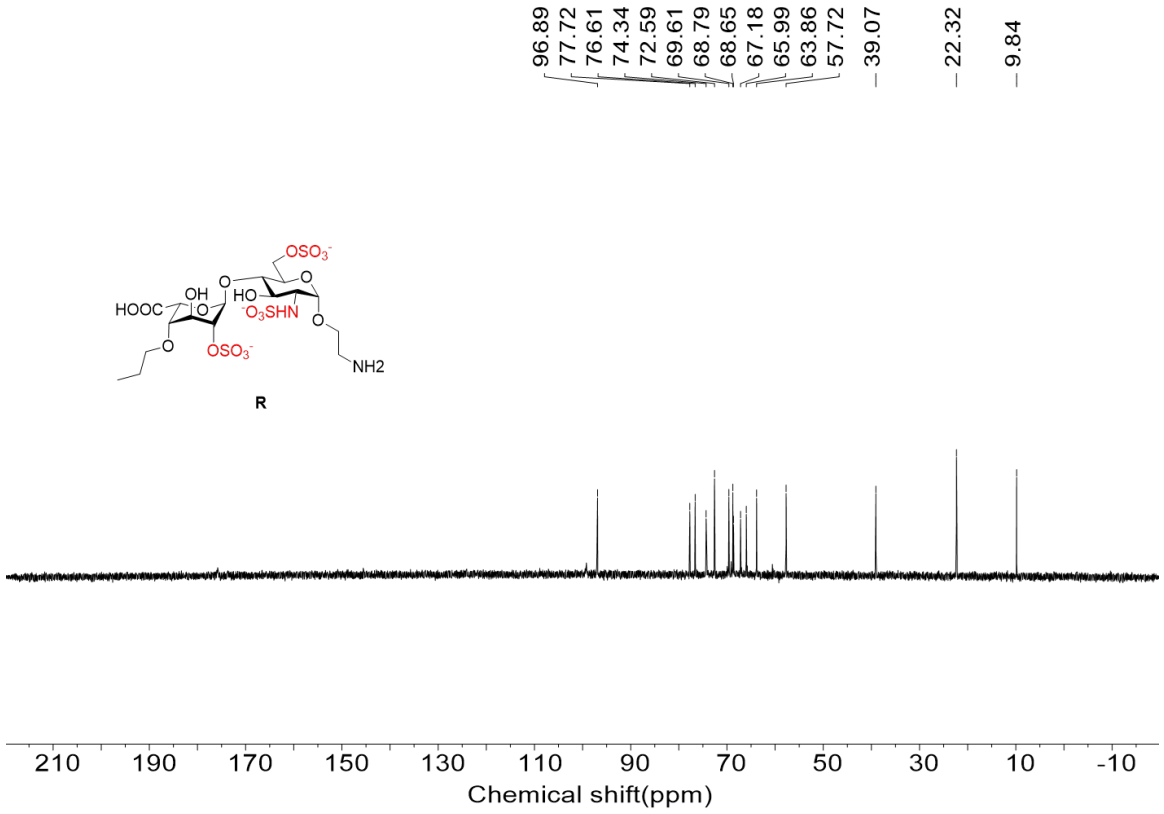


R

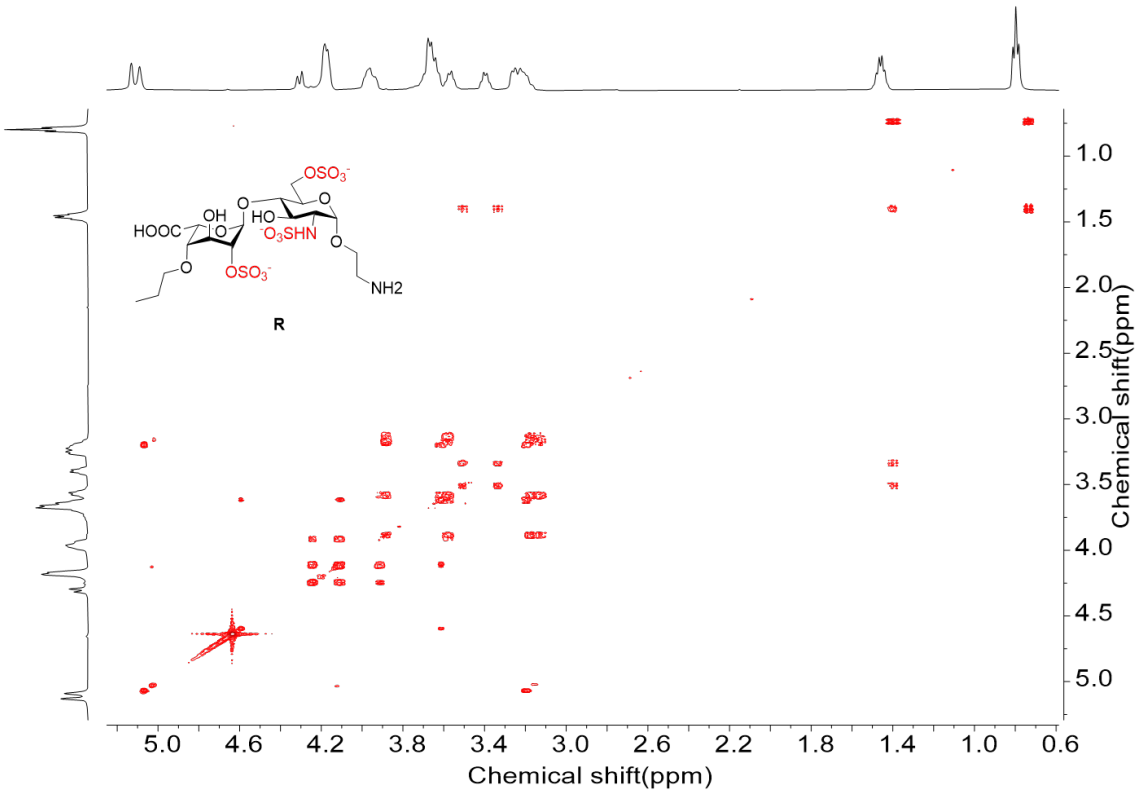
^{1}H NMR of R



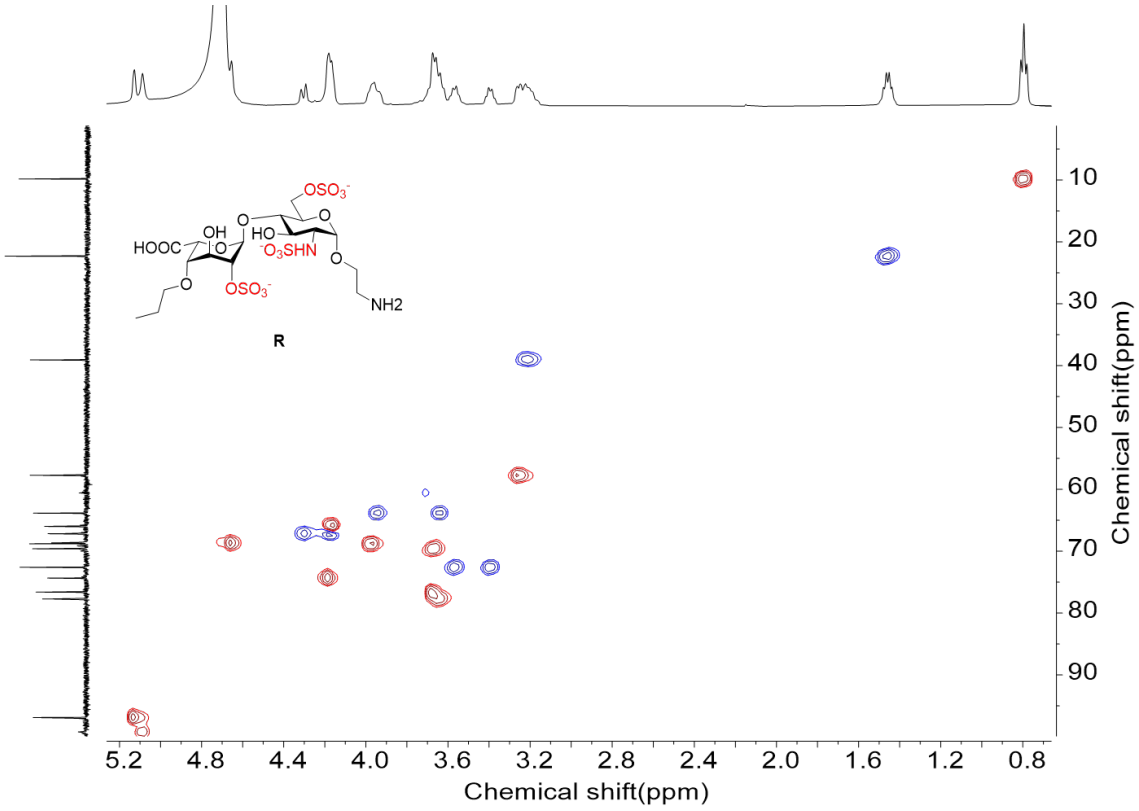
^{13}C NMR of R



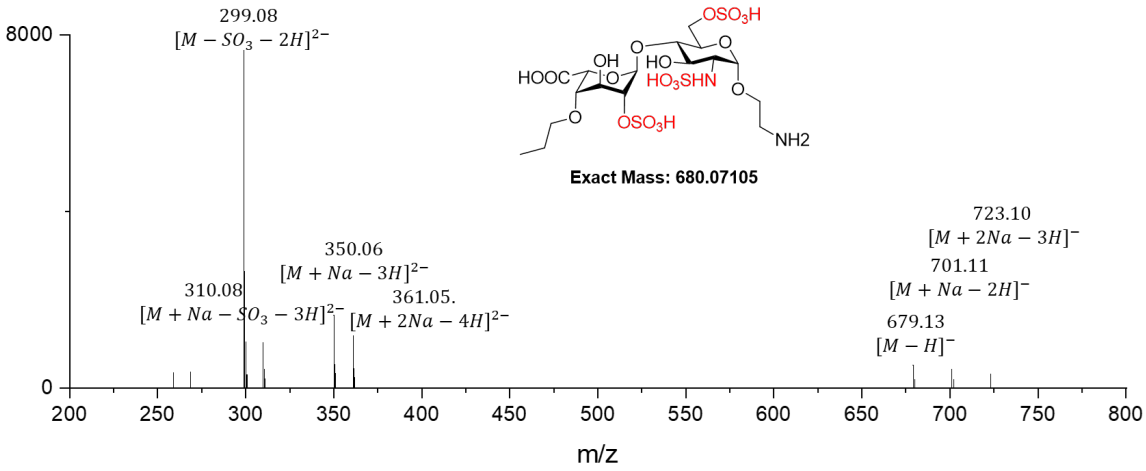
^{1}H-^{1}H gCOSY NMR of R



^{1}H-^{13}C HSQC NMR of R



Mass spectra of R



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