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Modular Synthesis of Heparan Sulfate Oligosaccharides Having *N*-Acetyl and *N*-Sulfate Moieties

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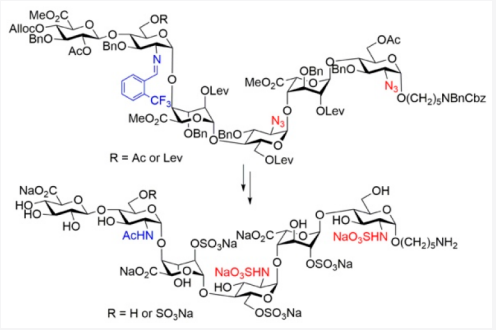
ABSTRACT: Heparan sulfates are structurally diverse sulfated polysaccharides that reside at the surface of all animal cells where they can interact with a multitude of proteins, thereby modulating a wide range of physiological and disease processes. We describe here a modular synthetic methodology that can provide libraries of heparan sulfate oligosaccharides that have glucosamine residues modified by different patterns of *N*-acetyl and *N*-sulfate moieties. It is based on the use of glycosyl donors that are modified at C2 by an azido- or trifluoromethylphenyl-methanimine moiety, which allowed the selective installation of α-glycosides. The amino protecting groups can be selectively unmasked by a reduction or acid treatment, allowing the installation of *N*-acetyl and *N*-sulfate moieties, respectively. In combination with the orthogonal hydroxyl protecting groups levulinic (Lev) ester, thexyldimethylsilyl (TDS) ether, allyloxycarbonate (Alloc), and 9-fluorenylmethyl carbonate (Fmoc), different patterns of *O*-sulfation can be installed. The methodology was applied to prepare four hexasaccharides that differ in the pattern of *N*- and *O*-sulfation. These compounds, together with a number of previously prepared HS oligosaccharides, were printed as a glycan microarray to examine the binding selectivities of several HS-binding proteins.



INTRODUCTION

Heparan sulfates (HSs) are highly sulfated polysaccharides that reside on the surface and in the extracellular matrix of virtually all cells of multicelluar organisms.[1] A large number of endogenous proteins recognize HS, resulting in conformational changes, the stabilization of receptor−ligand complexes, protein oligomerization, sequestration, and protection against degradation. It results in the regulation of many physiological processes, including embryogenesis, angiogenesis, blood coagulation, and inflammation. The binding of proteins to HS has also been implicated in many disease processes, including cancer, viral and bacterial infections, neurological disorders, and several genetic diseases.[1−6]

A lack of large collections of well-defined HS oligosaccharides is a major hurdle in regard to advancing the understanding of the biology of HS-binding proteins.[7−9] Such compounds are needed to establish the ligand requirements of HS-binding proteins, determine the substrate specificities of HS biosynthetic enzymes, and develop methods for HS structure determination. Due to the structural diversity of HS, well-defined compounds cannot be obtained from natural sources. Several laboratories have successfully prepared HS oligosaccharides[10−25] and, although elegant, these approaches are mainly focused on the preparation of compounds composed of the same repeating unit. The enzyme-mediated synthesis of HS oligosaccharides requires significantly fewer steps but cannot provide a wide variety of structures due to the promiscuity of the biosynthetic enzymes.[26−36] As a result, structure−activity relationship studies have employed small numbers of HS oligosaccharides that cannot properly probe the ligand selectivities of HS-binding proteins.[11,20,37−44]

Previously, we described a modular synthetic approach that can provide a wide range of HS oligosaccharides.[12,45−49] It employs common disaccharide building blocks (**1** and **2**, Figure 1) that can easily be converted to glycosyl donors and acceptors for the parallel combinatorial synthesis of HS oligosaccharides. The anomeric center of the building blocks is protected as thexyldimethylsilyl (TDS) ether, which can be removed by treatment with HF, and the resulting lactol can then be converted to a trichloroacetimidate to give glycosyl donors. The C4′ hydroxyl of the modular disaccharide building blocks is protected as 9-fluorenylmethyl carbonate (Fmoc), which can selectively be cleaved by a hindered base, such as triethylamine, to give a glycosyl acceptor. Specific hydroxyls of the building blocks are protected as Lev esters, which can be removed after the oligosaccharide assembly to reveal alcohols for sulfation. The C2 of the glucosamine (GlcN) donors is masked as an azido moiety, which facilitates the installation of

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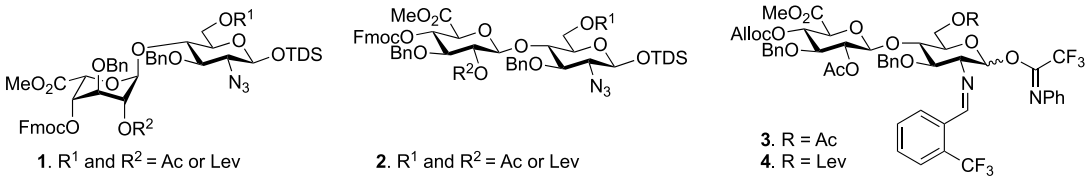
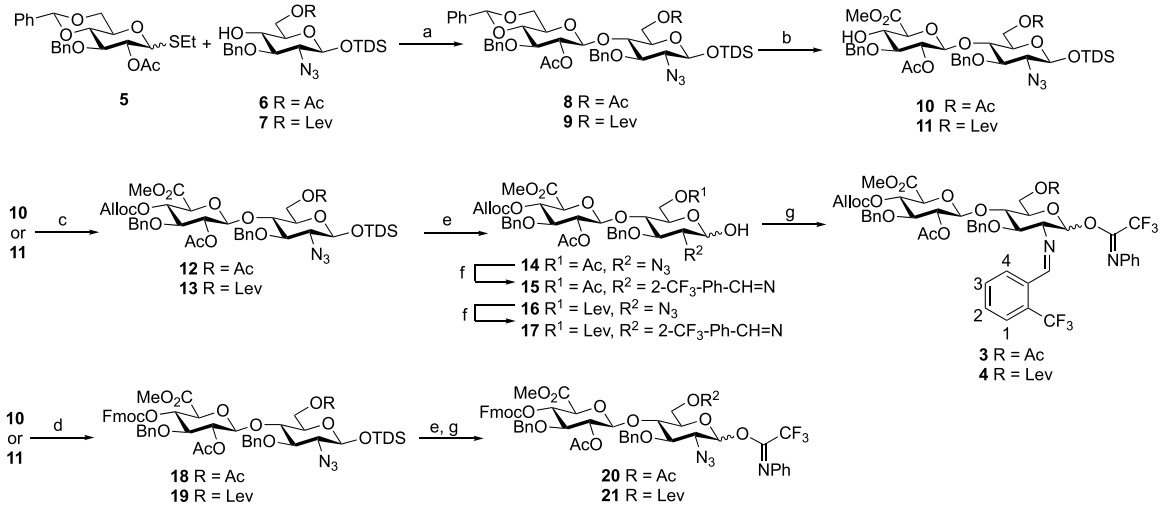


Figure 1. Modular building blocks.

Scheme 1. Synthesis of Disaccharide Building Blocks[a]



[a](a) NIS, TMSOTf, DCM, 4 Å MS, 0 °C, 30 min: **8**, 85%; **9**, 89%. (b) (i) DCM/TFA/H_2O, 30 min; (ii) TEMPO/BAIB, DCM/H_2O, 6 h; and (iii) $TMSCHN_2$, MeOH/toluene, 15 min: **10**, 61% over three steps; **11**, 56% over three steps. (c) AllocCl, TMEDA, DCM, 10 h: **12**, 88%; **13**, 91%. (d) FmocCl, Py: **18**, 89%; **19**, 92%. (e) HF·Py, THF: **14**, 92%; **16**, 88%. (f) PMe_3, THF, H_2O; 2-trifluoromethyl benzaldehyde, DCM/Py, 50 °C: **17**, 64% over two steps. (g) 2,2,2-Trifluoro-*N*-phenylacetimidoyl chloride, K_2CO_3, DCM: **3**, 46% over three steps; **4**, 90%; **20**, 81% over two steps; **21**, 84% over two steps.

1,2-*cis*-glycosides because it does not perform neighboring-group participation during glycosylations. The end stage of the synthesis involves the reduction of the azide to an amine, which can then be acetylated or sulfated. Thus, a limitation of our current approach is that it does not allow the preparation of HS oligosaccharides that have a combination of GlcNS and GlcNAc residues. This shortcoming urgently needs to be addressed because HS has a domain structure in which regions that are extensively modified and highly sulfated are flanked by domains of low or no sulfation and contain GlcNAc residues. It has been suggested that the transition regions of HS are important sites for selective protein binding. As a step toward the synthesis of compounds having a domain structure, it is critical to be able to differentiate amines of GlcN residues of HS precursor oligosaccharides.

We describe here a new set of modular disaccharide building blocks (**3** and **4**, Figure 1) that are modified at C2 by a trifluoromethylphenyl-methanimine moiety to make it possible to prepare HS oligosaccharides with GlcNS and GlcNAc moieties. Previous studies have shown that the nickel triflate-promoted activation of glycosyl donors having trifluoromethylphenyl-methanimine at C2 results in the selective formation of α-glycosides.[50] It has been proposed that these glycosylations proceed through a transition state in which the nickel catalyst chelates the *N*-phenyl trifluoracetimidate at the anomeric center and the methanimine protecting group at C2, thereby controlling the anomeric outcome of the glycosylation. The methanimine-protecting group can be cleaved under mild acidic conditions to reveal an amine that can be acetylated or modified by another derivative, such as a sulfate. We anticipated that trifluoromethylphenyl-methanimine and azido functions can selectively be converted to an amine, allowing the installation of GlcNS and GlcNAc moieties.

RESULTS AND DISCUSSION

To establish the methodology, we prepared disaccharide donors **3** and **4**, which, in combination with previously developed modular disaccharides,[12,51,52] were employed for the synthesis of a series of HS tetra- and hexasaccharides. To minimize the synthetic efforts, we set out to prepare the modular disaccharides from existing building blocks by reducing the azido moiety to give an amine, which can then be protected as a trifluoromethylphenyl-methanimine.

First, we focused on the preparation of the conventional disaccharide building blocks **10** and **11** (Scheme 1). Thus, an NIS/TMSOTf-mediated glycosylation[53] of thioglycosyl donor **5** with acceptors **6** and **7** give disaccharides **8** and **9**, respectively. These compounds were treated with a mixture of DCM/TFA/H_2O to hydrolyze the benzylidene acetal to give a 4,6-diol that was selectively oxidized using 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO)/(diacetoxyiodo)-benzene (BAIB)[54,55] to give carboxylic acids that were protected as methyl esters using trimethylsilyldiazomethane ($TMSCHN_2$), providing target disaccharides **10** and **11**, respectively. The treatment of **10** and **11** with FmocCl resulted in the protection of the C4′ hydroxyl to provide **18** and **19**, respectively, which were converted to donors **20** and **21** first by the removal of the anomeric TDS ether using HF·

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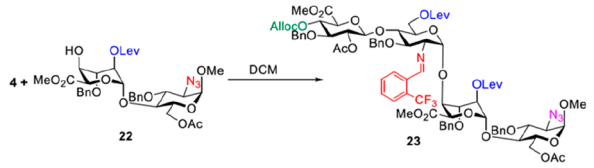
pyridine followed by a reaction with 2,2,2-trifluoro-*N*-phenylacetimidoyl chloride in the presence of K_2CO_3.[56]

Next, attempts were made to reduce the azide of **12** and **13** to an amine for protection as trifluoromethylphenyl-methanimine. Although several conditions were examined, in each case the cleavage of the Fmoc protecting group was observed. Therefore, we opted to protect the C4′ hydroxyl of **10** and **11** as an allyloxycarbonate (Alloc) because it was expected that this protecting group would be more stable and compatible with azide reduction and could be cleaved at a late stage of synthesis using a Pd catalyst without affecting other sensitive functional groups, such as sulfate esters. Thus, **10** and **11** were treated with AllocCl in the presence of *N*,*N*,*N*′,*N*′-tetramethylethylenediamine (TMEDA) to give **12** and **13**, respectively, in high yields. The anomeric TDS esters of **12** and **13** were cleaved with HF in pyridine, which was followed by the reduction of the azido group using a Staudinger reaction with trimethylphosphine (PMe_3) to give an amine that was reacted with 2-trifluoromethyl benzaldehyde in a mixture of dichloromethane and pyridine, installing a 2-CF_3−Ph−CH═N moiety to provide **15** and **17**, respectively.[57] The required trifluoro-*N*-phenylacetimidate donors **3** and **4** were obtained by the treatment of lactols **15** and **17** with 2,2,2-trifluoro-*N*-phenylacetimidoyl chloride in the presence of K_2CO_3.[56] We also attempted another sequence of reactions to prepare **15** and **17** by first reducing the azide to a free amine, followed by the installation of the 2-CF_3−Ph−CH═N moiety and then cleavage of the anomeric TDS protecting group. The latter step was performed by a treatment with HF in pyridine or a TBAF/AcOH complex, but in each case only decomposition was observed.

We examined whether glycosyl donor **4**, having a 2-CF_3−Ph−CH═N moiety at C2, can be employed for the selective installation of 1,2-*cis*-glycosides. For these studies, we used model acceptor **22** that could readily be prepared from our standard building blocks (Table 1 and Scheme S1). Nickel

Table 1. Optimization of Glycosylation Conditions for Donor 4 and Acceptor 22



entry	promotor	equiv	conc. (mM)[a]	4 Å MS	*T* (°C)	*t* (h)	yield (%)[b]
1	$Ni(OTf)_2$[c]	0.15	50	no	35	12	0
2	$Ni(OTf)_2$[d]	0.15	50	no	35	12	0
3	TfOH	0.5	50	yes	−40	1	19
4	TfOH	1.0	50	yes	−40	1	16
5	TfOH	0.5	150	yes	−40	1	24
6	TfOH	0.5	150	yes	−20	12	58

[a]Based on donor **4**. [b]Isolated yield. [c]Commercial. [d]Generated *in situ* with $NiCl_2$ and AgOTf.

triflate [$Ni(OTf)_2$] was employed as the promoter because previous studies have demonstrated it has an α-directing effect by forming a complex with both the anomeric imidate and the C2 benzylidiene.[50] Unfortunately, tetrasaccharide **23** was not formed when commercial (Table 1, entry 1) or *in situ*-synthesized $Ni(OTf)_2$ (from $NiCl_2$ and AgOTf, entry 2) was used. The failure of the glycosylation reactions is probably due to the low reactivity of the disaccharide donor and acceptor. Coupling of **4** with **22** using 0.5 equiv of triflic acid as the promoter in the presence of 4 Å molecular sieves at −40 °C for 1 h resulted in the formation of desired tetrasaccharide **23** but in a low yield of 19% (entry 3). Employing a stochiometric amount of triflic acid did not improve the yield of the glycosylation (entry 4). Increasing the concentration from 50 mM to 150 mM gave a slightly higher yield of 24% (entry 5); however, considerable amounts of glycosyl donor **4** and glycosyl acceptor **22** were recovered (entries 3−5). Tetrasaccharide **23** was isolated in an acceptable yield of 58% as only the α-anomer when the glycosylation was performed at a higher temperature of −20 °C for 12 h (entry 6). A higher temperature and prolonged reaction time were required to consume most of the donor. For each glycosylation, only the α-anomer was observed and isolated.

Next, attention was focused on the conversion of fully protected **23** to HS tetrasaccharide **28**, having GlcNAc and GlcNS moieties (Scheme 2). The Alloc protecting group of **23** was selectively removed using $Pd(PPh_3)_4$, which did not affect the 2-CF_3−Ph−CH═N moiety, providing intermediate **24** in good yield. The 2-*N*-[(2-trifluoromethyl)benzylidene of **24** was removed by a treatment with hydrochloric acid in THF for 15 min, which resulted in the selective formation of a free amine without affecting other functionalities. The resulting intermediate was immediately *N*- and *O*-acetylated using acetic anhydride in pyridine to afford **25**. The latter compound was treated with hydrazine acetate to cleave the Lev esters, which was followed by the *O*-sulfation of the resulting hydroxyls using a sulfur trioxide pyridine complex. Saponification and de-*O*-acetylation of the *O*-sulfated product using a mixture of lithium hydroxide and hydrogen peroxide generated **26** in a yield of 60%. The azido moiety of **26** was reduced by PMe_3 in the presence of NaOH, resulting in the formation of a free amine that was immediately sulfated by adding portions of SO_3·Py every 2 h for 8 h to give **27** in 66% yield over two steps. Finally, the hydrogenation of the benzyl ethers over $Pd(OH)_2$/C gave the target compound **28**, which was purified by size exclusion chromatography over Biogel P2, followed by an exchange to a sodium salt by passing it over a Dowex Na^+ resin.

The new modular donors **3** and **4** and conventional acceptors **20**, **21**, **29**, and **30** were employed to prepare HS hexasaccharides **33**−**36** that resemble sequences spanning NS and NA domains, having various levels of sulfation at the nonreducing GlcA-GlcN moiety. Thus, glycosyl donor **29** was coupled with spacer-modified acceptor **30** using a 0.5 eq of TfOH as the promotor to give tetrasaccharide **31** in a yield of 52% as only the α-anomer (Scheme 3). The Fmoc protecting group of **31** was removed using Et_3N in DCM to give acceptor **32**, which was coupled with **3** and **4**, having the GlcN C2 amine protected as an imine, and **20** and **21**, having the GlcN C2 amine masked as azide, to provide hexasaccharides **33**−**36**, respectively, in moderate yields. The Alloc and 2-CF_3−Ph−CH═N protecting groups of **33** and **34** were removed by a one-pot two-step procedure employing tetrakis-(triphenylphosphine)palladium(0) in a mixture of THF/water, followed by the addition of hydrochloric acid. The resulting free amine of the hexasaccharides was acetylated with acetic anhydride in pyridine and then treated with hydrazine acetate to cleave the Lev esters, which was followed by the *O*-sulfation of the resulting hydroxyls and the saponification of

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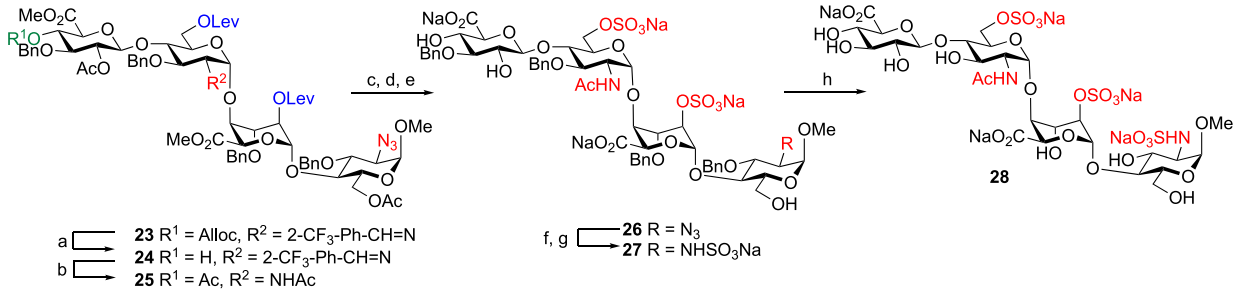
Scheme 2. Deprotection of Tetrasaccharide 23[a]



[a](a) $Pd(PPh_3)_4(0)$, THF/H_2O, 2 h. (b) $HCl/THF/H_2O$, 15 min; Ac_2O, Py, 3 h: **25**,: 90% over two steps. (c) $NH_2NH_2{\cdot}AcOH$, toluene/EtOH, 2 h. (d) $SO_3{\cdot}Py$, DMF, 2 h. (e) 1 M $LiOH/H_2O_2$, THF/H_2O: **26**, 60% over five steps. (f) $PMe_3/NaOH$, THF/H_2O, 2 h. (g) $SO_3{\cdot}Py$, $MeOH/Et_3N$: **27**, 66% over two steps. (h) $Pd(OH)_2/C$, H_2, *t*-BuOH/H_2O, 24 h: **28**, 90%.

the esters to provide hexasaccharides **37** and **38**. In the case of hexasaccharides **35** and **36**, the reaction sequence was simpler and entailed the cleavage of the Lev ester followed by *O*-sulfation and saponification to give compounds **39** and **40**, respectively. The azido moieties of **37**−**40** were reduced using $PMe_3/NaOH$ followed by selective *N*-sulfation using standard conditions to give **41**−**44**, respectively. The latter compounds were subjected to hydrogenation over $Pd(OH)_2/C$ in a mixture of *tert*-butanol/H_2O (1:1 *v*/*v*) to give the target hexasaccharides **45**−**48**. To avoid the methylation of the free amine of the linker, it was important to avoid methanol as the reaction solvent. ^1H NMR spectra of the oligosaccharides were fully assigned by 1D and 2D NMR spectroscopy, such as COSY, HSQC, HMBC, TOCSY, and NOESY. The anomeric configuration was confirmed by $J_{1,2}$ coupling constants ($J_{1,2}$ ∼ 175 Hz for the α-linkage) and ^{13}C chemical shifts of C1 (<100 ppm for the α-linkage).

To probe the effect of the NS/NA substitutions, the uronic acid composition, and the sulfation pattern on HS binding, compounds **45**−**48** along with related HS hexasaccharides[58] (Figure 2, **49**−**55**) were printed on a *N*-hydroxysuccinamide (NHS)-activated glass slide. The HS microarray was exposed to His-tagged IL-8 (1 μg/mL) and His-tagged RANTES (1 μg/mL, Sino Biological), and binding was visualized using the AlexaFluor647 anti-His antibody (5 μg/mL). These chemotactic cytokines play pivotal roles in neutrophil recruitment, activation, and migration to the site of injury and inflammation.[59] This process is orchestrated by cell-surface HS proteoglycans (HSPG's) by engaging with chemokines to generate a concentration gradient.[8] Although HSPG is critically involved in chemokine binding, the structural features of HS important for binding are still ambiguous.

Our results confirm that IL-8 preferentially binds to HS having IdoA2S-GlcNS6S sequence (Figure 2B).[60] Compound **55**, bearing three of these units, bound potently, and a gradual decrease of binding was observed when IdoA2S was sequentially replaced by GlcA moieties (**55** vs **54** vs **53**). A complete loss of binding was observed when only GlcA was present in the backbone (**55** vs **49**). Also, IL-8 did not bind to a hexasaccharide in which *N*-sulfate was replaced by *N*-acetyl (e.g., **48** vs **46**). RANTES appears to be more promiscuous but also prefers compounds having IdoA2S in the backbone (e.g., **55**, Figure 2C). A large reduction in binding was observed when either 6-OS was removed (**48** vs **47**) or NHAc was present in the backbone (e.g., **48** vs **46** and **45**). Interestingly, the location of IdoA2S appears to be important and preferably should be present at the nonreducing end (**51** vs **53**).

CONCLUSION

We have developed modular disaccharides that make it possible to assemble HS oligosaccharides with NHAc and NS moieties. It was found that the amino protecting groups trifluoromethylphenyl-methanimine and azide and the hydroxyl protection by Lev ester, TDS ether, Alloc and Fmoc offer the opportunity to selectively manipulate functionalities to prepare high-complex HS oligosaccharides. The methodology will make it possible to prepare panels of compounds for structure−activity relationship studies to better understand the biology of heparan sulfate. A recent paper demonstrated that trifluoromethylphenyl-methanimine can also be employed to make HS oligosaccharides to modulate heparanase activity,[61] which is an enzyme that can remodel HS and has been implicated in cancer. The microarray data highlight key requirements of chemokines to engage with HS. Future studies will focus on synthesizing HS structures bearing high-affinity NS domains that connect to NA domain for binding studies.

EXPERIMENTAL SECTION

General Experimental Procedures. All chemicals were purchased from commercial sources and used without further purification unless otherwise noted. Molecular sieves (4 Å) were flame-dried prior to use. All moisture-sensitive reactions were carried out under an argon atmosphere. All reactions at elevated temperatures were performed in a silicon oil bath unless otherwise specified. Reactions were monitored by thin-layer chromatography (TLC) on silica gel-coated aluminum or glass plates (EMD Chemicals, Inc.). Spots were visualized by UV light (254 nm) when applicable and charring with 10% sulfuric acid in ethanol or a solution of $(NH_4)_6Mo_7O_{24}{\cdot}4H_2O$ (24.0 g, 19.4 mmol) and $Ce(NH_4)_2(NO_3)_6$ (0.50 g, 0.9 mmol) in sulfuric acid (5%, 500 mL). Column chromatography was performed on silica gel G60 (Silicycle 60−200 μm, 60 Å). Fractions or reaction mixtures containing sulfated compounds were concentrated under reduced pressure, with the water bath temperature less than 25 °C. NMR spectra (^1H, ^{13}C, COSY, HSQC, TOCSY, HMBC, and NOESY) were recorded on either an Agilent 400-MR DD2 or a Bruker AVANCE-600 MHz spectrometer at 25 °C. Chemical shifts are reported in parts per million (ppm) relative to tetramethylsilane (TMS δ 0 ppm), deuterium oxide (D_2O δ 0 ppm), or methanol-d_4 (CD_3OD δ 3.31 ppm) as the internal standard. NMR data are presented as follows: chemical shift, multiplicity (s = singlet, bs = broad singlet, d = doublet, bd = broad doublet, t = triplet, dd = doublet of doublet, and m = multiplet or multiple resonances), integration, and coupling constant in Hertz (Hz). All the AB quartets were reported as two doublets due to a large ν_{AB}/J_{AB} ratio (>4). NMR signals were assigned on the basis of ^1H NMR, $^{13}C\{^1H\}$ NMR, COSY, HSQC, HMBC, TOCSY, or NOESY experiments. Due to the small sample size, carbon chemical shifts for compounds **26**, **27**, **28**, **37**, **38**, **39**, **40**, **41**,

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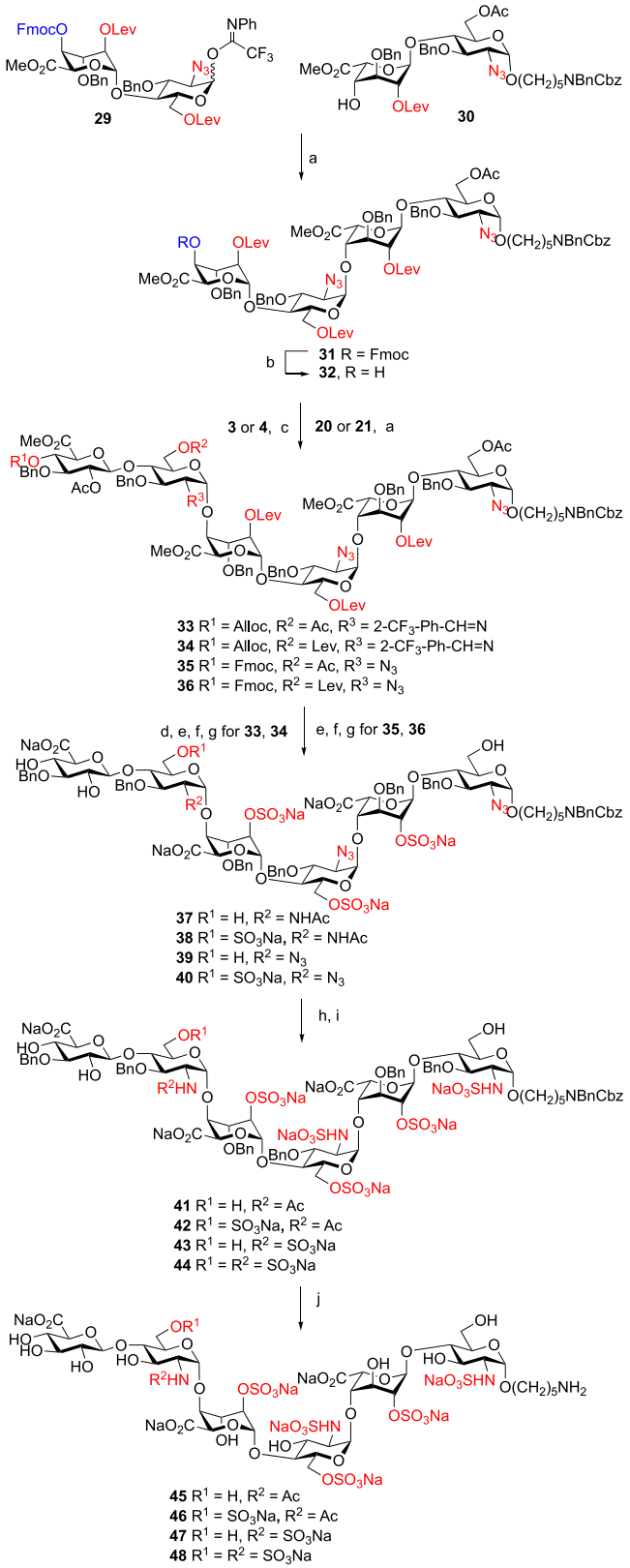
Scheme 3. Synthesis of Hexasaccharide[a]



[a](a) TfOH, DCM, 4 Å MS, −40 °C, 1 h: **31**, 52%; **35**, 55%; **36**, 69%. (b) DCM/Et_3N, 2 h: **32**, 90%. (c) TfOH, DCM, 4 Å MS, −20 °C, 12 h: **33**, 52%; **34**, 48%. (d) (i) $Pd(PPh_3)_4(0)$, THF/H_2O, 2 h; (ii) HCl/THF/H_2O, 15 min; and (iii) Ac_2O, Py, 3 h. (e) NH_2NH_2·AcOH, toluene/EtOH, 2 h. (f) SO_3·Py, DMF, 2 h. (g) 1 M LiOH, 30% H_2O_2, THF/H_2O: **37**, 43% over six steps; **38**, 40% over six steps; **39**, 35% over five steps; **40**, 38% over five steps. (h) PMe_3/NaOH, THF/H_2O, 2 h. (i) SO_3·Py, MeOH/Et_3N; **41**, 60% over two steps; **42**, 40% over two steps; **43**, 46% over two steps; **44**, 49% over two steps. (j)$Pd(OH)_2$/C, H_2, *t*-BuOH/H_2O, 24−48 h: **45**, 92%, **46**, 77%; **47**, 88%; **48**, 90%.

Scheme 3. continued

42, **43**, **44**, **45**, **46**, **47**, and **48** were collected from the F1 dimension in the HSQC spectra. Mass spectra were obtained on a Bruker micrOTOF-QII (ESI LC-MS) or Kratos Analytical Maxima-CFR MALDI-TOF system (using a 2,5-dihydroxybenzoic acid matrix). Reported HRMS data were obtained on an Agilent technologies 6560 ion mobility Q-TOF. Optical rotation was recorded on a Jasco P-1010 polarimeter.

General Procedure for the Cleavage of Lev Esters. Hydrazine acetate (5 equiv per Lev group) was added to a solution of the starting material in a mixture of DCM and MeOH (1:1 *v*/*v*, 0.02 M). The reaction mixture was stirred at room temperature for 2−4 h until TLC analysis (petroleum ether/EtOAc, 1:1 to 1:2 *v*/*v*) indicated the completion of the reaction. The reaction mixture was diluted with DCM (30 mL); washed with water (25 mL), a saturated bicarbonate solution (2 × 25 mL), and brine (25 mL); dried (Na_2SO_4); and filtered. The filtrate was concentrated under reduced pressure, and the residue was purified by silica gel column chromatography using petroleum ether and EtOAc as the eluent (1:1 to 1:2 *v*/*v*) to give pure product.

General Procedure for *O*-Sulfation. To a solution of the starting material in DMF (0.15 M) was added SO_3·Py (10 equiv per OH). The reaction mixture was stirred at room temperature for 2−4 h until TLC (DCM/MeOH, 90:10 *v*/*v*) indicated the completion of the reaction. A mixture of triethylamine and MeOH (1:1 *v*/*v*, 1 mL) was added to the reaction mixture, which continued stirring for 30 min. The reaction mixture was concentrated under reduced pressure, and the residue was applied to a column of Iatrobeads (5 g), which was eluted with a gradient of DCM and MeOH (from 95:5 to 85:15 *v*/*v*). Fractions containing the product were concentrated under reduced pressure, and the residue was passed through a column of Dowex 50 × 8 Na^+ resin (0.6 cm × 5 cm) using MeOH as the eluent to give pure product.

General Procedure for the Saponification of Methyl Esters and De-*O*-acetylation. A premixed solution of a 30% solution of H_2O_2 in H_2O (100 equiv per CO_2Me) and 1 M LiOH (50 equiv per CO_2Me) was added to a solution of the starting material in THF (0.02 M). The reaction mixture was stirred at room temperature for 12 h. Then, a 4 M solution of NaOH was added until pH 14. Stirring continued until LC-MS indicated the completion of the reaction. After adjusting the pH to 8−9 by the careful addition of AcOH, the solvents were removed under reduced pressure. The residue was dissolved in water and applied to a reverse phase C18 column (1.0 cm × 5 cm), which was eluted with a gradient of H_2O and MeOH (from 90:10 to 40:60 *v*/*v*). Fractions containing the product were concentrated under reduced pressure, and the residue was passed through a column of Dowex 50 × 8 Na^+ resin (0.6 cm × 5 cm) using H_2O as the eluent to give pure product.

General Procedure for the Reduction of the Azido Group. To a solution of the starting material in THF (1.0 mL for 0.013 mmol) was added 0.1 M NaOH (10 equiv per azido group). Then, a 1 M solution of PMe_3 in THF (8 equiv per azido group) was added to the solution. The reaction mixture was stirred at room temperature for 1 h until LC-MS indicated the completion of the reaction. After adjusting the pH to 8−9 by the careful addition of AcOH, the solvents were removed under reduced pressure. The residue was dissolved in water and applied to a reverse phase C18 column (1.0 cm × 5 cm), which was eluted with a gradient of H_2O and MeOH (from 90:10 to 40:60 *v*/*v*). Fractions containing the product were concentrated under reduced pressure, and the residue was passed through a column of Dowex 50 × 8 Na^+ resin (0.6 cm × 5 cm) using H_2O as the eluent to give the desired product.

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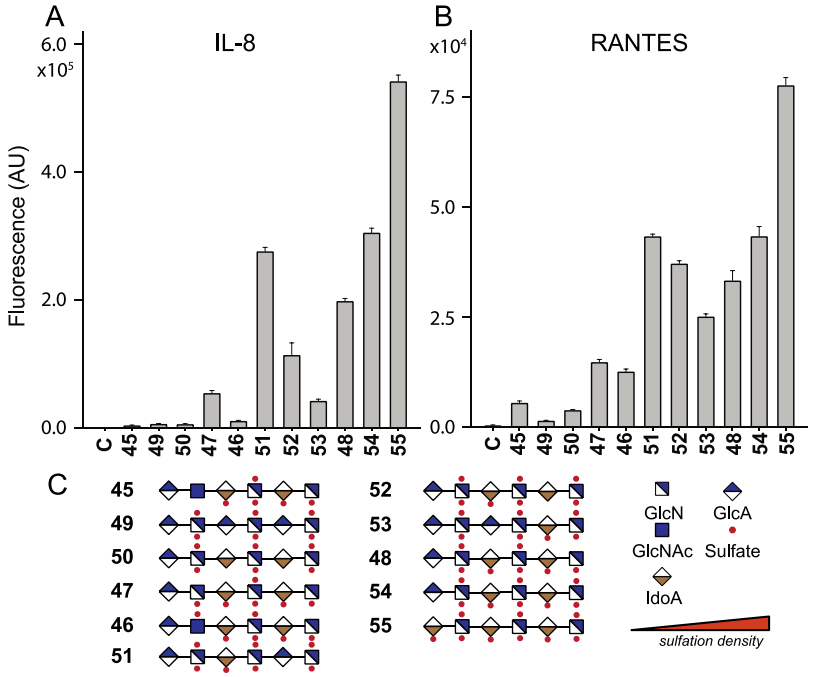

Figure 2. Microarray binding data of synthetic hexasaccharides to chemokines. (A) Interleukin-8/IL-8/CXCL8 (1 μg/mL), (B) chemokine ligand 5/CCL5/RANTES (1 μg/mL), and (C) structures of synthetic hexasaccharides. Each hexasaccharide was printed at 100 μM as replicates of six. The hexasaccharides are arranged according to an increasing number of sulfates. C indicates the blank control. Abbreviations are as follows: GlcN, glucosamine; GlcNAc, *N*-acetyl glucosamine; IdoA, iduronic acid; and GlcA, glucuronic acid. Data are presented as mean ± SD (n = 4).

General Procedure for the Selective *N*-Sulfation Reaction. SO_3·Py (5 equiv per NH_2) was added to a solution of the starting material in a mixture of MeOH (1 mL for 0.006 mmol) and Et_3N (0.3 mL). Then, 1 M NaOH was added to adjust the pH to 11. Three additional portions of SO_3·Py (5 equiv per NH_2) were added to the solution after 30 min, 1 h, and 2 h, followed by adjusting the pH to 11 by the careful addition of 1 M NaOH for each. The progress of the reaction was monitored by TLC (silica gel TLC, EtOAc/pyridine/H_2O/AcOH, 8:5:3:1 $v/v/v/v$). After stirring for an additional 12 h, the reaction mixture was co-evaporated with water, and the residue was passed through a short column of Dowex 50 × 8Na^+ resin (1.0 cm × 5 cm) with H_2O as the eluent. Fractions containing the product were lyophilized, and the residue was dissolved in water and applied to a reverse phase C18 silica gel column (1.0 cm × 5 cm), which was eluted with a gradient of H_2O and acetonitrile (from 98:2 to 85:15 v/v). Appropriate fractions were lyophilized to give the desired product.

General Procedure for Global Debenzylation. Palladium hydroxide on carbon (Degussa type, 20%, 1.5× the weight of the starting material) was added to a solution of the starting material in *tert*-butanol and H_2O (1:1 v/v, 1 mL for 1 mg). The mixture was placed under a hydrogen atmosphere until the completion of the reaction as indicated by ESI-LC-MS. The mixture was filtered through a PTFE syringe filter (Acrodisc, 0.2 μm), and the residue was washed with a *tert*-butanol and H_2O mixture (1:1 v/v, 2 mL). The filtrate was lyophilized to give the final product. Biogel P2 (1.5 cm × 50 cm) was used for purification with 0.1 M ammonium bicarbonate as the eluent, and the fractions containing the compound were lyophilized and passed through a short column of Dowex 50 × 8Na^+ resin (1.0 cm × 5 cm) with H_2O as the eluent. Appropriate fractions were lyophilized to give the desired product.

Glycan Array Screening and Analysis. HS hexasaccharides **45**–**55** were printed on NHS-ester-activated glass slides (Nexterion Slide H, Schott, Inc.) using a Scienion sciFLEXARRAYER S3 instrument. All samples were printed at a concentration of 100 μM in a sodium phosphate buffer (0.225 M, pH 8.5) in replicates of six with a spot volume ~400 pL at 20 °C and 50% relative humidity (each slide has 24 subarrays in a 3 × 8 layout). After printing, the slides were incubated overnight in a saturated NaCl chamber (affording a 75% relative humidity environment); the remaining activated esters were then quenched with ethanolamine (5 mM) in a Tris buffer (pH 9.0, 50 mM) at 50 °C for 1 h. Blocked slides were rinsed with DI water, spun dry, and kept in a desiccator at room temperature for future use. Subarrays were incubated with IL-8 and RANTES (1 μg/mL, His-tagged, Sino Biological). After 1 h, the slide was sequentially washed by dipping in a TSM wash buffer (2 min), a TSM buffer (2 min), and water (2 × 2 min) and spun dry. The subarrays were further incubated with the Alexa Fluor 647 anti-His tag antibody (5 μg/mL) for 1 h in the dark, and the same washing sequence was repeated. The slides were scanned using a GenePix 4000B microarray scanner (Molecular Devices) at the appropriate excitation wavelength with a resolution of 5 μM. Various gains and PMT values were employed in the scanning to ensure that all the signals were within the linear range of the scanner's detector and there was no saturation of the signals. The images were analyzed using GenePix Pro 7 software (ver. 7.2.29.2, Molecular Devices). The data was analyzed with our home-written Excel macro. The highest and the lowest values of the total fluorescence intensity of the six replicates were removed, and the remaining four values were used to calculate the mean value and standard deviation. The data were fitted using Prism software (Prism 8, GraphPad Software), and bars represent the mean ± SD for each compound.

Experimental Procedures and Analytical Data of Products. Compounds **S1**, **5**, **6**, **7**, **8**, **9**, **10**, **11**, **18**, **19**, and **30**;[12] compounds **20**, **21**, and **29**;[52] and compound **S2**[62] were reported previously. For oligosaccharide nomenclature for NMR spectroscopy, the monosaccharide residues of the HS oligosaccharides were labeled from the reducing end to the nonreducing end as A, B, C, D, E, and F; the 2-CF_3−Ph−CH=N moiety was labeled as shown in Scheme 1.

*Dimethylthexylsilyl O-(Methyl 2-O-Acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzyl-6-O-acetyl-2-deoxy-β-D-glucopyranoside (**12**).* To a solution of compound **10** (1.26 g, 1.57 mmol) in anhydrous DCM (6 mL) was added *N*,*N*,*N*′,*N*′-tetramethylethylenediamine (TMEDA) (144 μL, 0.94 mmol). The solution was cooled to 0 °C, followed by the addition of allyl chloroformate (252 μL, 2.36 mmol). The reaction mixture was warmed to room temperature and stirred for 10 h. The reaction mixture was diluted with DCM (25 mL) and washed with a

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saturated bicarbonate solution (25 mL) and brine (25 mL). The organic phase was dried ($MgSO_4$) and filtered, and the filtrate was concentrated *in vacuo*. The residue was purified by silica gel column chromatography using petroleum ether and EtOAc as the eluent (4:1 *v*/*v*) to give disaccharide **12** as a white amorphous solid (1.22 g, 88%). R_f = 0.42 (petroleum ether/EtOAc, 3:1 *v*/*v*). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.39−7.20 (m, 10H, CH aromatic), 5.92−5.84 (m, 1H, CH_2=C*H*CH_2), 5.36−5.24 (m, 2H, CH_2=CHCH_2), 5.04 (dd, *J* = 9.2, 8.0 Hz, 1H, H2^B), 4.99 (t, *J* = 9.2 Hz, 1H, H4^B), 4.96 (d, *J* = 11.5 Hz, 1H, C*H*HBn), 4.83 (d, *J* = 11.5 Hz, 1H, C*H*HBn), 4.68 (d, *J* = 11.5 Hz, 1H, C*H*HBn), 4.62 (d, *J* = 8.0 Hz, 1H, H1^B), 4.60−4.55 (m, 3H, C*H*HBn, CH_2=CHCH_2), 4.47 (d, *J* = 7.7 Hz, 1H, H1^A), 4.35 (dd, *J* = 11.5, 2.0 Hz, 1H, H6a^A), 4.07 (dd, *J* = 11.5, 6.6 Hz, 1H, H6b^A), 3.80 (d, *J* = 9.8 Hz, 1H, H5^B), 3.68 (t, *J* = 9.2 Hz, 1H, H3^B), 3.64 (dd, *J* = 9.5, 8.5 Hz, 1H, H4^A), 3.52 (s, 3H, CO_2CH_3), 3.48−3.44 (m, 1H, H5^A), 3.39 (dd, *J* = 9.5, 8.5 Hz, 1H, H3^A), 3.29 (dd, *J* = 9.5, 7.7 Hz, 1H, H2^A), 2.06 (s, 3H, CH_3 Ac), 1.98 (s, 3H, CH_3 Ac), 1.67−1.61 (m, 1H, C*H*$(CH_3)_2$), 0.89−0.85 (4s, 12H, C$(CH_3)_2$, CH$(CH_3)_2$), 0.18−0.15 (2s, 6H, Si$(CH_3)_2$). ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ 170.6 (CO Ac), 169.2 (CO Ac), 167.1 (CO_2CH_3), 153.8 (CO Alloc), 138.7, 137.5, 131.2 (CH_2=CHCH_2), 128.5, 128.4, 128.0, 127.8, 127.4, 127.2, 119.5 (CH_2=CHCH_2), 101.3 (C1^B), 96.9 (C1^A), 81.0 (C3^A), 79.5 (C3^B), 79.0 (C4^A), 74.9 (C4^B), 74.8 (OCH_2Bn), 74.6 (OCH_2Bn), 72.6 (C5^B, C5^A), 72.5 (C2^B), 69.2 (CH_2=CHCH_2), 68.8 (C2^A), 62.7 (C6^A), 52.8 (CO_2CH_3), 34.0 (C*H*$(CH_3)_2$), 24.9 (C$(CH_3)_2$), 20.9 (CH_3 Ac), 20.8 (CH_3 Ac), 20.0 (CH$(CH_3)_2$), 19.9 (CH$(CH_3)_2$), 18.6 (C$(CH_3)_2$), 18.4 (C$(CH_3)_2$), −2.2 (Si$(CH_3)_2$), −3.2 (Si$(CH_3)_2$). HRMS (ESI): *m*/*z* calcd for $C_{43}H_{63}N_4O_{15}Si$ $[M + NH_4]^+$ 903.4054, found 903.4072.

*(N-Phenyl)-2,2,2-trifluoroacetimidate (Methyl 2-O-Acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-2-N-[(2-trifluoromethyl)benzylidene]-3-O-benzyl-6-O-acetyl-2-deoxy-α/β-D-glucopyranoside (**3**).* To a solution of compound **12** (1.14 g, 1.29 mmol) in THF (26 mL) was added 70% hydrogen fluoride pyridine (3.3 mL) . The reaction mixture was stirred at room temperature for 18 h. The reaction was monitored until TLC analysis showed the completion of the reaction. The mixture was diluted with dichloromethane (50 mL) and washed with a saturated bicarbonate solution (2 × 50 mL) and brine (50 mL). The organic phase was dried ($MgSO_4$) and filtered, and the filtrate was concentrated *in vacuo*. The residue was purified by silica gel column chromatography using petroleum ether and EtOAc (3:1 to 1:1 *v*/*v*) as the eluent to give intermediate **14** as a white amorphous solid (0.88 g, 92%). The resulting intermediate **14** (300 mg, 0.40 mmol) was dissolved in THF (8.0 mL), followed by addition of H_2O (73 μL) and 1 M PMe_3 in THF (0.6 mL). The reaction mixture was stirred at room temperature for 2 h. The presence of amino groups was confirmed using ninhydrin staining. The mixture was concentrated under reduced pressure, and the residue was co-evaporated with toluene (3 × 5 mL). The resulting intermediate was used in the next step without further purification. The amino-containing intermediate was dissolved in anhydrous DCM (4.0 mL) and anhydrous pyridine (0.4 mL). 2-Trifluoromethyl benzaldehyde (64 μL, 0.48 mmol) was added, and the reaction mixture was stirred at 50 °C for 12 h. The reaction mixture was concentrated under reduced pressure, and the residue was dissolved in DCM and cooled to 0 °C, followed by the addition of K_2CO_3 (111 mg, 0.81 mmol) and *N*-phenyl-trifluoroacetimidoyl chloride (129 μL, 0.81 mmol). The reaction mixture was stirred at room temperature for 5 h. The reaction was monitored until TLC analysis showed the completion of the reaction. The mixture was concentrated under reduced pressure, and the residue was purified by silica gel column chromatography using petroleum ether and EtOAc (3:1 *v*/*v*) as the eluent to give disaccharide **3** as a white foam (194 mg, 46% over three steps). R_f = 0.26 (petroleum ether/EtOAc, 3:1 *v*/*v*). ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.64 (s, 1H, N=C*H*PhCF$_3$), 8.05 (d, *J* = 7.4 Hz, 1H, H^4), 7.68 (d, *J* = 7.2 Hz, 1H, H^1), 7.60−7.52 (m, 2H, H^2, H^3), 7.35−6.71 (m, 15H, CH aromatic), 6.10−5.70 (m, 2H, CH_2=C*H*CH_2, H1^A), 5.36−5.32 (m, 1H, CH*H*=CHCH_2), 5.28−5.25 (m, 1H, CH*H*=CHCH_2), 5.09 (t, *J* = 8.5 Hz, 1H, H2^B), 5.02 (t, *J* = 9.5 Hz, 1H, H4^B), 4.95 (d, *J* = 11.5 Hz, 1H, C*H*HBn), 4.69 (d, *J* = 11.6 Hz, 1H, C*H*HBn), 4.64−4.52 (m, 5H, H1^B, C*H*HBn, C*H*HBn, CH_2=CHCH_2), 4.48−4.42 (m, 1H, H6a^A), 4.23−4.14 (m, 1H, H6b^A), 4.01−3.86 (m, 3H, H3^A, H4^A, H5^B), 3.78−3.63 (m, 2H, H3^B, H5^A), 3.63−3.55 (m, 1H, H2^A), 3.54 (s, 3H, CO_2CH_3), 2.10 (s, 3H, CH_3 Lev), 1.99 (s, 3H, CH_3 Ac). ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ 170.7 (CO Ac), 169.2 (CO Ac), 167.2 (CO_2CH_3), 161.9 (N=CHPhCF$_3$), 153.8 (CO Alloc), 143.5, 138.4, 137.6, 133.5, 132.0, 131.2 (CH_2=CHCH_2), 130.8, 128.8, 128.6, 128.5, 128.2, 128.0, 127.9, 127.6, 127.3, 125.8, 125.7, 124.4, 119.5 (CH_2=CHCH_2), 119.4, 101.2 (C1^B), 81.2 (C3^A), 79.6 (C3^B), 78.1 (C4^A), 75.5 (C2^A), 75.0 (C4^B), 74.9 (OCH_2Bn), 74.6 (OCH_2Bn), 73.7 (C5^A), 72.8 (C5^B), 72.5 (C2^B), 69.2 (CH_2=CHCH_2), 62.3 (C6^A), 52.8 (CO_2CH_3), 21.0 (CH_3 Ac), 20.9 (CH_3 Ac). HRMS (ESI): *m*/*z* calcd for $C_{51}H_{51}F_6N_2O_{15}$ $[M + H]^+$ 1045.3188, found 1045.3181; calcd for $C_{43}H_{48}F_3N_2O_{15}$ $[M - [CHPhCF_3] + 3H]^+$ 899.3001, found 899.3006.

*Dimethylthexylsilyl O-(Methyl 2-O-Acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzyl-6-O-levulinoyl-2-deoxy-β-D-glucopyranoside (**13**).* To a solution of compound **11** (0.77 g, 0.90 mmol) in anhydrous DCM (3.6 mL) was added TMEDA (81 μL, 0.54 mmol). The solution was cooled to 0 °C, followed by the addition of allyl chloroformate (144 μL, 1.35 mmol). The reaction mixture was warmed to room temperature and stirred for 10 h. The reaction was monitored by TLC until completion. The reaction mixture was diluted with DCM (25 mL) and washed with a saturated bicarbonate solution (25 mL) and brine (25 mL). The organic phase was dried ($MgSO_4$) and filtered, and the filtrate was concentrated *in vacuo*. The residue was purified by silica gel column chromatography using petroleum ether and EtOAc (4:1 *v*/*v*) as the eluent to give disaccharide **13** as a white amorphous solid (0.77 g, 91%). R_f = 0.55 (petroleum ether/EtOAc, 2:1 *v*/*v*). $[\alpha]_D^{20}$ − 10.9 (*c* = 0.5, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.43−7.19 (m, 10H, CH aromatic), 5.95−5.79 (m, 1H, CH_2=C*H*CH_2), 5.37−5.23 (m, 2H, CH_2=CHCH_2), 5.08−5.00 (m, 3H, C*H*HBn, H2^B, H4^B), 4.78−4.66 (m, 3H, C*H*HBn, H1^B, C*H*HBn), 4.61−4.55 (m, 3H, C*H*HBn, CH_2=CHCH_2), 4.46 (d, *J* = 7.5 Hz, 1H, H1^A), 4.29 (dd, *J* = 11.8, 1.9 Hz, 1H, H6a^A), 4.17 (dd, *J* = 11.8, 5.0 Hz, 1H, H6b^A), 4.03 (d, *J* = 9.8 Hz, 1H, H5^B), 3.86 (t, *J* = 9.3 Hz, 1H, H3^B), 3.76 (dd, *J* = 9.6, 8.6 Hz, 1H, H4^A), 3.51 (s, 3H, CO_2CH_3), 3.44−3.33 (m, 2H, H5^A, H3^A), 3.28 (dd, *J* = 9.9, 7.7 Hz, 1H, H2^A), 2.90−2.47 (m, 4H, 2 × CH_2 Lev), 2.20 (s, 3H, CH_3 Lev), 1.98 (s, 3H, CH_3 Ac), 1.70−1.59 (m, 1H, C*H*$(CH_3)_2$), 0.90−0.83 (4s, 12H, C$(CH_3)_2$, CH$(CH_3)_2$), 0.18−0.13 (2s, 6H, Si$(CH_3)_2$). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 206.6 (CH_3CO Lev), 172.6 (CH_2CO Lev), 169.4 (CO Ac), 167.4 (CO_2CH_3), 153.9 (CO Alloc), 138.8, 137.8, 131.3 (CH_2=CHCH_2), 128.5, 128.4, 127.9, 127.8, 127.6, 127.5, 119.4 (CH_2=CHCH_2), 101.1 (C1^B), 97.0 (C1^A), 81.0 (C3^A), 79.7 (C3^B), 78.5 (C4^A), 75.2 (C4^B, OCH_2Bn), 74.7 (OCH_2Bn), 72.7 (C5^A), 72.6 (C2^B), 72.6 (C5^B), 69.2 (CH_2=CHCH_2), 68.7 (C2^A), 62.6 (C6^A), 52.8 (CO_2CH_3), 38.1 (CH_2 Lev), 34.1 (C*H*$(CH_3)_2$), 30.0 (CH_3 Lev), 28.0 (CH_2 Lev), 25.0 (C$(CH_3)_2$), 20.9 (CH_3 Ac), 20.1 (CH$(CH_3)_2$), 20.0 (CH$(CH_3)_2$), 18.6 (C$(CH_3)_2$), 18.5 (C$(CH_3)_2$), −2.0 (Si$(CH_3)_2$), −3.1 (Si$(CH_3)_2$). HRMS (ESI): *m*/*z* calcd for $C_{46}H_{63}N_3NaO_{16}Si$ $[M + Na]^+$ 964.3870, found 964.3874.

*(Methyl 2-O-Acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzyl-6-O-levulinoyl-2-deoxy-α/β-D-glucopyranoside (**16**).* Hydrogen fluoride pyridine (70%, 2.1 mL) was added to a solution of compound **13** (0.77 g, 0.82 mmol) in THF (16 mL). The reaction mixture was stirred at room temperature for 18 h. The progress of the reaction was monitored by TLC until it showed the completion of the reaction. The mixture was diluted with dichloromethane (30 mL) and washed with a saturated bicarbonate solution (2 × 30 mL) and brine (30 mL). The organic phase was dried ($MgSO_4$) and filtered, the filtrate was concentrated *in vacuo*, and the residue was purified by silica gel column chromatography using petroleum ether and EtOAc (3:1 to 1:1 *v*/*v*) as the eluent to give intermediate **16** as a white amorphous solid (0.58 g, 88%). R_f = 0.18 (petroleum ether/EtOAc, 1:1 *v*/*v*). ^{1}H NMR (600 MHz, $CDCl_3$): δ 7.44−7.10 (m, 10H, CH aromatic), 5.92−5.84 (m,

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1H, CH_2=$CHCH_2$), 5.36−5.30 (m, 1H, CHH=$CHCH_2$), 5.36−5.30 (m, 1H, CHH=$CHCH_2$), 5.29−5.22 (m, 1.55H, CHH=$CHCH_2$, $H1^A\alpha$), 5.21−5.00 (m, 3H, $CHHBn$, $H2^B$, $H4^B$), 4.77−4.66 (m, 3H, $CHHBn$, $H1^B$, $CHHBn$), 4.63−4.55 (m, 3H, $CHHBn$, CH_2=$CHCH_2$), 4.54 (d, J = 8.2 Hz, 0.45H, $H1^A\beta$), 4.31−4.24 (m, 2H, $H6a^A$, $H6b^A$), 4.17 (d, J = 10.0 Hz, 0.55H, $H5^B\alpha$), 4.12 (d, J = 10.0 Hz, 0.45H, $H5^B\beta$), 4.06 (dt, J = 10.0, 2.9 Hz, 0.55H, $H5^A\alpha$), 3.94−3.88 (m, 1.55H, $H3^A\alpha$, $H3^B$), 3.86−3.81 (m, 1H, $H4^A$), 3.52 and 3.51 (2s, 3H, CO_2CH_3), 3.47−3.44 (m, 0.45H, $H5^A\beta$), 3.44−3.41 (m, 0.45H, $H3^A\beta$), 3.37 (dd, J = 10.0, 3.5 Hz, 0.55H, $H2^A\alpha$), 3.37 (dd, J = 9.9, 8.2 Hz, 0.45H, $H2^A\beta$), 3.40−3.33 (m, 1H, $H2^A$), 2.93−2.44 (m, 4H, 2 × CH_2 Lev), 2.20 (s, 3H, CH_3 Lev), 2.00 and 1.98 (2s, 3H, CH_3 Ac). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 207.40 (CH_3CO Lev), 207.38 ($CH_3C'O$ Lev), 172.76 (CH_2CO Lev), 172.73 ($CH_2C'O$ Lev), 169.4 (CO Ac), 167.50 (CO_2CH_3), 167.46 ($C'O_2CH_3$), 153.9 (CO Alloc), 138.5, 138.4, 137.80, 137.76, 131.29 (CH_2=$CHCH_2$), 131.27 (CH_2=$C'HCH_2$), 128.63, 128.55, 128.5, 128.4, 128.3, 128.0, 127.92, 127.88, 127.86, 127.82, 127.77, 127.74, 127.72, 127.67, 127.6, 127.5, 119.4 (CH_2=$CHCH_2$), 119.3 ($C'H_2$=$CHCH_2$), 100.89 ($C1^B\alpha$), 100.87 ($C1^B\beta$), 96.2 ($C1^A\beta$), 91.9 ($C1^A\alpha$), 81.0 ($C3^A\alpha$), 79.60 ($C3^B\alpha$), 79.58 ($C3^B\beta$), 78.6 ($C4^A\beta$), 77.94 ($C4^A\alpha$), 77.92 ($C3^A\alpha$), 75.5 (OCH_2Bn α), 75.4 (OCH_2Bn β), 75.24 ($C4^B\alpha$), 75.22 ($C4^B\beta$), 74.7 (OCH_2Bn β), 74.6 (OCH_2Bn α), 72.8 ($C5^A\beta$), 72.61, 72.60, 72.56, 72.4, 69.1 (CH_2=$CHCH_2$), 68.5 ($C5^A\alpha$), 67.3 ($C2^A\beta$), 63.7 ($C2^A\alpha$), 62.4 ($C6^A\alpha$), 62.2 ($C6^A\beta$), 52.7 (CO_2CH_3), 38.2 (CH_2 Lev α), 38.1 (CH_2 Lev β), 29.95 (CH_3 Lev β), 29.94 (CH_3 Lev α), 28.07 (CH_2 Lev α), 28.04 (CH_2 Lev β), 20.9 (CH_3 Ac). HRMS (ESI): m/z calcd for $C_{38}H_{45}N_3NaO_{16}$ $[M + Na]^+$ 822.2692, found 822.2710.

(Methyl 2-O-Acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-2-N-[(2-trifluoromethyl)benzylidene]-3-O-benzyl-6-O-levulinoyl-2-deoxy-α/β-D-glucopyranoside (17). Compound **16** (575 mg, 0.72 mmol) was dissolved in THF (14.0 mL), followed by the addition of H_2O (130 μL) and 1 M PMe_3 in THF (1.1 mL). The reaction mixture was stirred at room temperature for 2 h. The presence of amino groups was confirmed using ninhydrin staining. The mixture was concentrated under reduced pressure, and the residue was co-evaporated with toluene (3 × 5 mL). The resulting intermediate was used in the next step without further purification. The amino-containing intermediate was dissolved in anhydrous DCM (7.0 mL) and anhydrous pyridine (0.7 mL). 2-Trifluoromethyl benzaldehyde (114 μL, 0.86 mmol) was added, and the reaction mixture was stirred at 50 °C for 12 h. The reaction mixture was concentrated under reduced pressure, and the residue was dissolved in DCM (3.0 mL) and cooled to 0 °C, followed by the addition of K_2CO_3 (127 mg, 0.92 mmol) and *N*-phenyltrifluoroacetimidoyl chloride (147 μL, 0.92 mmol). The reaction mixture was stirred at room temperature for 5 h. The reaction was monitored until TLC analysis showed the completion of the reaction. The mixture was concentrated under reduced pressure, and the residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 v/v) as the eluent to give disaccharide **17** as a white foam (428 mg, 64% over two steps). R_f = 0.20 (petroleum ether/EtOAc, 1:1 v/v). ^1H NMR (600 MHz, $CDCl_3$): δ 8.65−8.50 (m, 1H, N=CHPhCF$_3$), 8.09−7.97 (m, 1H, H^4), 7.69−7.61 (m, 1H, H^1), 7.56−7.46 (m, 2H, H^2, H^3), 7.34−6.96 (m, 10H, CH aromatic), 5.93−5.82 (m, 1H, CH_2=$CHCH_2$), 5.35−5.30 (m, 1H, CHH=$CHCH_2$), 5.27−5.23 (m, 1H, CHH=$CHCH_2$), 5.14−4.98 (m, 3.33H, $H1^A\alpha$, $H2^B$, $CHHBn$, $H4^B$), 4.94 (d, J = 7.7 Hz, 0.67H, $H1^A\beta$), 4.81 (d, J = 8.0 Hz, 1H, $H1^B$), 4.69 (d, J = 11.6 Hz, 1H, $CHHBn$), 4.62−4.55 (m, 3H, $CHHBn$, CH_2=$CHCH_2$), 4.50−4.29 (m, 3H, $CHHBn$, $H6a^A$, $H6b^A$), 4.29−4.17 (m, 1.33H, $H5^B$, $H5^A\alpha$), 4.00−3.91 (m, 2.33H, $H4^A$, $H3^A\alpha$, $H3^B$), 4.17 (d, J = 10.0 Hz, 0.55H, $H5^B\alpha$), 3.86 (t, J = 8.7 Hz, 0.67H, $H3^A\beta$), 3.66−3.62 (m, 0.67H, $H5^A\beta$), 3.53 and 3.51 (2s, 3H, CO_2CH_3), 3.51−3.49 (m, 0.33H, $H2^A\alpha$), 3.30 (t, J = 8.7 Hz, 0.67H, $H2^A\beta$), 2.98−2.46 (m, 4H, 2 × CH_2 Lev), 2.21 (2s, 3H, CH_3 Lev), 2.02 and 2.01 (2s, 3H, CH_3 Ac). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 207.14 (CH_3CO Lev), 207.05 ($CH_3C'O$ Lev), 172.8 (CH_2CO Lev), 169.4 (CO Ac), 167.7 (CO_2CH_3), 167.6 ($C'O_2CH_3$), 161.0 (N=CHPhCF$_3$), 154.0 (CO Alloc), 138.64, 138.59, 138.0, 137.9, 133.8, 133.2, 132.0, 131.4 (CH_2=$CHCH_2$), 130.8, 130.5, 128.5, 128.2, 128.0, 127.8, 127.7, 127.1, 125.7, 125.6, 119.3 (CH_2=$CHCH_2$), 101.02 ($C1^B\alpha$), 100.94 ($C1^B\beta$), 96.0 ($C1^A\beta$), 93.5 ($C1^A\alpha$), 81.0 ($C3^A\beta$), 79.7 ($C3^B$), 78.4, 78.3, 78.0, 77.6 ($C2^A\beta$), 75.6, 75.4, 75.4, 75.2, 74.6 (OCH_2Bn), 74.1 ($C2^A\alpha$), 73.1 ($C5^A\beta$), 72.7 ($C2^B$), 72.5 ($C5^B$), 69.1 (CH_2=$CHCH_2$, $C5^A\alpha$), 62.6 ($C6^A\alpha$), 62.5 ($C6^A\beta$), 52.7 (CO_2CH_3), 38.1 (CH_2 Lev), 30.0 (CH_3 Lev), 28.1 (CH_2 Lev), 20.9 (CH_3 Ac). HRMS (ESI): m/z calcd for $C_{46}H_{51}F_3NO_{16}$ $[M + H]^+$ 930.3154, found 930.3176.

(N-Phenyl)-2,2,2-trifluoroacetimidate (Methyl 2-O-Acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-2-N-[(2-trifluoromethyl)benzylidene]-3-O-benzyl-6-O-levulinoyl-2-deoxy-α/β-D-glucopyranoside (4). Compound **17** (428 mg, 0.46 mmol) was dissolved in DCM (3.0 mL) and cooled to 0 °C, followed by the addition of K_2CO_3 (127 mg, 0.92 mmol) and *N*-phenyltrifluoroacetimidoyl chloride (147 μL, 0.92 mmol). The reaction mixture was stirred at room temperature for 5 h. The reaction was monitored until TLC analysis showed the completion of the reaction. The mixture was concentrated under reduced pressure, and the residue was purified by silica gel column chromatography using petroleum ether and EtOAc (3:1 v/v) as the eluent to give disaccharide **4** as a white foam (456 mg, 90%). R_f = 0.60 (petroleum ether/EtOAc, 1:1 v/v). ^1H NMR (600 MHz, $CDCl_3$): δ 8.63 (s, 1H, N=CHPhCF$_3$), 8.03−8.00 (m, 1H, ArH^4), 7.70−7.65 (m, 1H, H^1), 7.58−7.52 (m, 2H, H^2, H^3), 7.33−6.66 (m, 15H, CH aromatic), 6.09−5.66 (m, 2H, CH_2=$CHCH_2$, $H1^A$), 5.36−5.30 (m, 1H, CHH=$CHCH_2$), 5.27−5.23 (m, 1H, CHH=$CHCH_2$), 5.11 (t, J = 8.7 Hz, 1H, $H2^B$), 5.08−5.01 (m, 2H, $CHHBn$, $H4^B$), 4.81 (d, J = 8.0 Hz, 1H, $H1^B$), 4.69 (d, J = 11.6 Hz, 1H, $CHHBn$), 4.62−4.51 (m, 4H, $CHHBn$, $CHHBn$, CH_2=$CHCH_2$), 4.41−4.26 (m, 2H, $H6a^A$, $H6b^A$), 4.24 (d, J = 9.8 Hz, 1H, $H5^B$), 4.08−3.85 (m, 3H, $H4^A$, $H3^B$, $H3^A$), 3.82−3.54 (m, 2H, $H5^A$, $H2^A$), 3.52 (s, 3H, CO_2CH_3), 2.97−2.47 (m, 4H, 2 × CH_2 Lev), 2.21 (s, 3H, CH_3 Lev), 2.00 (s, 3H, CH_3 Ac). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 207.0 (CH_3CO Lev), 172.7 (CH_2CO Lev), 169.3 (CO Ac), 167.6 (CO_2CH_3), 161.9 (N=CHPhCF$_3$), 154.0 (CO Alloc), 143.5, 138.5, 137.9, 133.6, 132.0, 131.4 (CH_2=$CHCH_2$), 130.7, 129.7, 129.5, 128.8, 128.6, 128.5, 128.11, 128.05, 127.9, 127.7, 127.3, 125.73, 125.70, 125.0, 124.4, 119.4 (CH_2=$CHCH_2$), 100.9 ($C1^B$), 81.0 ($C3^A$), 80.0 ($C3^B$), 77.7 ($C4^A$), 75.4 (OCH_2Bn), 75.34 ($C4^B$), 75.28 ($C2^A$), 74.7 (OCH_2Bn), 73.7 ($C5^A$), 72.6 ($C2^B$), 72.5 ($C5^B$), 69.1 (CH_2=$CHCH_2$), 62.1 ($C6^A$), 52.7 (CO_2CH_3), 38.1 (CH_2 Lev), 30.0 (CH_3 Lev), 28.1 (CH_2 Lev), 20.9 (CH_3 Ac). HRMS (ESI): m/z calcd for $C_{54}H_{54}F_6N_2NaO_{16}$ $[M + Na]^+$ 1123.3270, found 1123.3259.

Methyl O-(2-O-Levulinoyl-3-O-benzyl-4,6-O-benzylidene-α-L-idopyranosyl)-(1 → 4)-O-2-azido-3-O-benzyl-6-O-acetyl-2-deoxy-α-D-glucopyranoside (S3). Freshly activated 4 Å molecular sieves were added to a solution of glycosyl donor **S1** (0.85 g, 1.71 mmol) and glycosyl acceptor **S2** (0.50 g, 1.42 mmol) in anhydrous DCM (86 mL, 0.02 M based on the glycosyl donor) (see Scheme S1). After stirring for 30 min at room temperature, the solution was cooled to 0 °C, followed by the addition of NIS (0.38 g, 1.71 mmol) and TMSOTf (25 μL, 0.14 mmol). The reaction mixture was stirred for 30 min, followed by quenching with Et_3N. The mixture was filtered, and the filtrate was concentrated *in vacuo*. The residue was purified by silica gel column chromatography using a stepwise gradient of petroleum ether and EtOAc (3:1 to 2:1 v/v, 0.1% Et_3N) as the eluent to give disaccharide **S3** as a white amorphous solid (0.77 g, 69%). R_f = 0.39 (petroleum ether/EtOAc, 3:1 v/v). $[\alpha]_D^{20}$ + 22.8 (c = 0.5, $CHCl_3$). ^1H NMR (600 MHz, $CDCl_3$): δ 7.46−7.24 (m, 15H, CH aromatic), 5.29 (s, 1H, CH benzylidene), 5.00 (t, J = 2.9 Hz, 1H, $H2^B$), 4.95 (bs, 1H, $H1^B$), 4.84−4.80 (m, 2H, $CHHBn$, $H1^A$), 4.77 (d, J = 11.5 Hz, 1H, $CHHBn$), 4.66−4.62 (m, 2H, $CHHBn$, $CHHBn$), 4.49 (d, J = 12.3 Hz, 1H, $H6a^A$), 4.18 (dd, J = 12.3, 2.3 Hz, 1H, $H6b^A$), 3.89−3.79 (m, 5H, $H5^A$, $H5^B$, $H4^A$, $H4^B$, $H3^A$), 3.77 (d, J = 12.8 Hz, 1H, $H6a^B$), 3.69 (t, J = 3.2 Hz, 1H, $H3^B$), 3.48 (dd, J = 10.0, 3.6 Hz, 1H, $H2^A$), 3.45 (s, 3H, OCH_3), 3.08 (dd, J = 12.8, 1.5 Hz, 1H, $H6b^B$), 2.66−2.51 (m, 4H, 2 × CH_2 Lev), 2.10 (s, 3H, CH_3 Ac), 2.03 (s, 3H, CH_3 Lev). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 206.5 (CH_3CO Lev), 172.1 (CH_2CO Lev), 170.8 (CO Ac), 138.2, 138.1,

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137.8, 129.1, 128.6, 128.2, 127.8, 127.5, 126.3, 100.6 (CH benzylidene), 98.6 ($C1^A$), 98.1 ($C1^B$), 79.1 ($C3^A$), 75.1 ($C3^B$), 75.0 (OCH_2Bn), 74.1 ($C4^A$), 73.9 ($C4^B$), 72.3 (OCH_2Bn), 69.5 ($C5^A$), 69.2 ($C6^B$), 67.2 ($C2^B$), 64.1 ($C2^A$), 62.4 ($C6^A$), 60.4 ($C5^B$), 55.5 (OCH_3), 37.9 (CH_2 Lev), 29.8 (CH_3 Lev), 28.3 (CH_2 Lev), 21.1 (CH_3 Ac). HRMS (ESI): *m/z* calcd for $C_{41}H_{47}N_3NaO_{13}$ $[M + Na]^+$ 812.3001, found 812.3026.

*Methyl O-(Methyl 2-O-Levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzyl-6-O-acetyl-2-deoxy-α-D-glucopyranoside (**22**).* A solution of a disaccharide **S3** (0.74 g, 0.94 mmol) in a mixture of DCM/TFA/H_2O (0.06 M, 16.0 mL, 10:1:0.1 *v/v/v*) was stirred at room temperature for 30 min. The reaction mixture was diluted with DCM (25 mL); washed with water (30 mL), saturated bicarbonate (30 mL), and brine (30 mL); dried ($MgSO_4$); and filtered. The filtrate was concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 *v/v*) as the eluent to give the pure product, which was dissolved in a mixture of DCM/H_2O (3.75 mL, 2:1 *v/v*), followed by the addition of TEMPO (33.2 mg, 0.21 mmol) and (diacetoxyiodo)benzene (0.82 g, 2.55 mmol). The reaction mixture was stirred at room temperature for 6 h. The progress of the reaction was monitored by TLC until completion. The reaction mixture was quenched by the addition of aqueous $Na_2S_2O_3$ (10%, 10 mL) and extracted with EtOAc (2 × 10 mL). The combined organic layers were dried ($MgSO_4$) and filtered, and the filtrate was concentrated *in vacuo*. The residue was dissolved in MeOH and toluene (10 mL, 1:4 *v/v*) and cooled to 0 °C. An excess of trimethylsilyldiazomethane (2 M in diethyl ether, 1.0 mL) was added to the solution slowly until the reaction mixture stayed yellow. Stirring was continued for 15 min, and the excess trimethylsilyldiazomethane was quenched by the addition of AcOH until the reaction mixture became colorless. The mixture was concentrated under reduced pressure and co-evaporated with toluene (3 × 5 mL), and the residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 *v/v*) as the eluent to afford compound **22** as a light yellow amorphous solid (0.40 g, 58% over three steps). R_f = 0.25 (petroleum ether/EtOAc, 1:2 *v/v*). $[\alpha]_D^{20}$ + 21.3 (*c* = 3.3, $CHCl_3$). ^1H NMR (600 MHz, $CDCl_3$): δ 7.39−7.22 (m, 10H, CH aromatic), 5.06 (bs, 1H, $H1^B$), 4.93 (bs, 1H, $H2^B$), 4.87 (bs, 1H, $H5^B$), 4.79 (d, *J* = 3.6 Hz, 1H, $H1^A$), 4.77−4.74 (m, 2H, C*H*HBn, C*H*HBn), 4.66 (d, *J* = 10.8 Hz, 1H, C*H*HBn), 4.63 (d, *J* = 11.5 Hz, 1H, C*H*HBn), 4.41 (dd, *J* = 12.3, 1.3 Hz, 1H, $H6a^A$), 4.23 (dd, *J* = 12.7, 3.6 Hz, 1H, $H6b^A$), 3.98−3.95 (m, 1H, $H4^B$), 3.93−3.89 (m, 1H, $H4^A$), 3.86−3.83 (m, 1H, $H5^A$), 3.80 (t, *J* = 9.5 Hz, 1H, $H3^A$), 3.74 (t, *J* = 2.6 Hz, 1H, $H3^B$), 3.47 (s, 3H, CO_2CH_3), 3.45−3.42 (m, 4H, OCH_3 at 3.44, $H2^A$), 2.76−2.73 (m, 2H, CH_2 Lev), 2.62 (d, *J* = 10.5 Hz, 1H, O*H*), 2.58−2.54 (m, 2H, CH_2 Lev), 2.18 (s, 3H, CH_3 Lev), 2.11 (s, 3H, CH_3 Ac). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 206.3 (CH_3CO Lev), 171.4 (CH_2CO Lev), 170.7 (CO Ac), 169.6 (CO_2CH_3), 137.8, 137.4, 128.5, 128.2, 128.1, 128.1, 127.5, 127.4, 98.5 ($C1^A$), 97.9 ($C1^B$), 78.6 ($C3^A$), 75.0 ($C4^A$), 74.8 (OCH_2Bn), 74.7 ($C3^B$), 72.5 (OCH_2Bn), 69.0 ($C5^A$), 68.8 ($C5^B$), 67.7 ($C4^B$), 67.6 ($C2^B$), 63.7 ($C2^A$), 62.2 ($C6^A$), 55.4 (OCH_3), 52.0 (CO_2CH_3), 37.8 (CH_2 Lev), 29.7 (CH_3 Lev), 27.9 (CH_2 Lev), 20.9 (CH_3 Ac). HRMS (ESI): *m/z* calcd for $C_{35}H_{43}N_3NaO_{14}$ $[M + Na]^+$ 752.2637, found 752.2662.

*Methyl O-(Methyl-2-O-acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-N-[(2-trifluoromethyl)-benzylidene]-3-O-benzyl-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-6-O-acetyl-2-deoxy-α-D-glucopyranoside (**23**).* Freshly activated 4 Å molecular sieves were added to a solution of glycosyl donor **4** (73 mg, 66 μmol) and glycosyl acceptor **22** (40 mg, 55 μmol) in anhydrous DCM (0.44 mL, 0.15 M based on the glycosyl donor). After stirring for 15 min at room temperature, the solution was cooled to −20 °C, followed by the addition of TfOH (2.5 μL, 27 μmol). The reaction mixture was stirred for 12 h and quenched by the addition of Et_3N. The reaction mixture was filtered, and the filtrate was concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 *v/v*, 0.1% Et_3N) as the eluent to give tetrasaccharide **23** as a white foam (52 mg, 58%). R_f = 0.36 (petroleum ether/EtOAc, 1:1 *v/v*). ^1H NMR (600 MHz, $CDCl_3$): δ 8.51 (d, *J* = 1.8 Hz, 1H, N=C*H*PhCF$_3$), 8.16 (d, *J* = 7.8 Hz, 1H, H^4), 7.59 (dd, *J* = 7.2, 1.5 Hz, 1H, H^1), 7.50−7.43 (m, 2H, H^2, H^3), 7.39−6.80 (m, 20H, 4 × Bn CH aromatic), 5.91−5.84 (m, 1H, CH_2=C*H*CH_2), 5.40 (d, *J* = 5.9 Hz, 1H, $H1^B$), 5.35−5.30 (m, 1H, C*H*H=$CHCH_2$), 5.26−5.23 (m, 1H, CH*H*=$CHCH_2$), 5.10 (dd, *J* = 9.6, 8.0 Hz, 1H, $H2^D$), 5.02 (t, *J* = 9.5 Hz, 1H, $H4^D$), 5.00 (d, *J* = 12.0 Hz, 1H, C*H*HBn), 4.98 (d, *J* = 3.0 Hz, 1H, $H1^C$), 4.96−4.91 (m, 1H, $H2^B$), 4.85 (d, *J* = 12.0 Hz, 1H, C*H*HBn), 4.79 (d, *J* = 8.0 Hz, 1H, $H1^D$), 4.76 (d, *J* = 3.0 Hz, 1H, $H1^A$), 4.70 (d, *J* = 10.5 Hz, 1H, C*H*HBn), 4.68 (d, *J* = 12.0 Hz, 1H, C*H*HBn), 4.61 (d, *J* = 12.0 Hz, 1H, C*H*HBn), 4.58 (t, *J* = 6.2 Hz, 2H, CH_2=CHCH_2), 4.53 (d, *J* = 12.0 Hz, 1H, C*H*HBn), 4.48−4.31 (m, 6H, $H5^B$, C*H*HBn, $H6a^C$, $H6a^A$, $H6b^A$, C*H*HBn), 4.26 (bd, *J* = 10.0 Hz, 1H, $H5^D$), 4.24 (dd, *J* = 12.0, 1.7 Hz, 1H, $H6b^C$), 4.17−4.13 (m, 1H, $H5^C$), 4.04−3.99 (m, 2H, $H3^B$, $H4^B$), 3.98−3.93 (m, 2H, $H4^C$, $H3^D$), 3.92−3.81 (m, 4H, $H5^A$, $H4^A$, $H3^C$, $H3^A$), 3.64 (s, 3H, CO_2CH_3), 3.52−3.41 (m, 8H, $H2^C$, $H2^A$, including 2 × CO_2CH_3 at 3.48 and 3.41), 2.98−2.90 (m, 1H, C*H*H Lev), 2.71−2.59 (m, 3H, C*H*H Lev, CH_2 Lev), 2.55−2.44 (m, 3H, C*H*H Lev, CH_2 Lev), 2.25−2.16 (m, 1H, C*H*H Lev,), 2.21 (s, 3H, CH_3 Lev), 2.17 (s, 3H, CH_3 Ac), 2.09 (s, 3H, CH_3 Lev), 1.99 (s, 3H, CH_3 Ac). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 206.9 (CH_3CO Lev), 206.1 (CH_3CO Lev), 172.8 (CH_2CO Lev), 171.9 (CH_2CO Lev), 171.1 (CO Ac), 170.3 (CO_2CH_3), 169.3 (CO Ac), 167.7 (CO_2CH_3), 160.7 (N=CHPhCF$_3$), 154.1 (CO Alloc), 138.6, 138.2, 138.0, 137.9, 133.49, 132.0, 131.4 (CH_2=C*H*CH_2), 130.6, 129.5, 129.3, 129.2, 129.1, 128.5, 128.4, 128.3, 128.2, 128.1, 128.0, 127.9, 127.74, 127.68, 127.3, 127.1, 126.8, 125.6, 119.3 (CH_2=$CHCH_2$), 100.9 ($C1^C$, $C1^D$), 98.6 ($C1^A$), 97.9 ($C1^B$), 79.7 ($C3^D$), 78.5 ($C3^A$), 78.3 ($C4^C$), 77.9 ($C3^C$), 77.3 ($C3^B$), 76.4 ($C4^A$), 75.5 ($C4^D$), 75.4 (OCH_2Bn), 75.2 (OCH_2Bn, $C4^B$), 74.7 (OCH_2Bn), 74.6 ($C2^C$), 74.2 (OCH_2Bn), 72.6 ($C2^D$), 72.5 ($C5^D$), 71.8 ($C5^B$), 71.4 ($C2^B$), 69.8 ($C5^C$), 69.1 (CH_2=$CHCH_2$), 68.9 ($C5^A$), 63.4 ($C2^A$), 62.3 ($C6^A$), 62.3 ($C6^C$), 55.4 (OCH_3), 52.6 (CO_2CH_3), 52.2 (CO_2CH_3), 38.2 (CH_2 Lev), 37.7 (CH_2 Lev), 30.0 (CH_3 Lev), 29.8 (CH_3 Lev), 28.1 (CH_2 Lev), 27.8 (CH_2 Lev), 21.1 (CH_3 Ac), 20.9 (CH_3 Ac). ^{19}F NMR (565 MHz, $CDCl_3$): δ −57.00. HRMS (ESI): *m/z* calcd for $C_{81}H_{92}F_3N_4O_{29}$ $[M + H]^+$ 1641.5794, found 1641.5823.

*Methyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-acetylamino-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-2-deoxy-α-D-glucopyranoside (**26**).* Tetrakis(triphenylphosphine)palladium(0) (6.6 mg, 5.8 μmol) was added to a solution of protected tetrasaccharide **23** (9.5 mg, 5.8 μmol) in THF and H_2O (1.1 mL, 10:1 *v/v*, 5 mM). The reaction mixture was stirred at room temperature for 1 h. After TLC analysis indicated the completion of the reaction, a 2 M hydrochloric acid solution (58 μL, 116 μmol) was added to the reaction mixture, and stirring was continued for 15 min. The progress of the reaction was monitored by TLC until it showed the completion of the reaction. The reaction mixture was co-evaporated with toluene (2 × 3 mL), and the residue was dissolved in pyridine (0.5 mL), followed by the addition of Ac_2O (0.2 mL). After stirring for another 3 h at room temperature, the reaction mixture was concentrated under reduced pressure, and the residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 *v/v*) as the eluent to give compound **25** as a colorless amorphous solid (7.7 mg, 90%). Compound **25** (7.7 mg, 5.2 μmol) was subjected to Lev ester removal, *O*-sulfation, saponification, and de-*O*-acetylation reactions according to the general procedures to provide compound **26** as a white-powder sodium salt (4.3 mg, 60% over three steps). ^1H NMR (600 MHz, D_2O): δ 7.84 (d, *J* = 10.2 Hz, 1H, N*H*$COCH_3$), 7.56−7.33 (m, 20H, CH aromatic), 5.28 (s, 1H, $H1^B$), 4.98−4.71 (m, 9H, 2 × CH_2Bn, 2 × C*H*HBn, $H1^A$ at 4.92, $H1^C$ at 4.86, $H5^B$ at 4.79), 4.68 (d, *J* = 7.9 Hz, 1H, $H1^D$), 4.61 (d, *J* = 11.4 Hz, 1H, C*H*HBn), 4.59 (d, *J* = 11.4 Hz, 1H, C*H*HBn), 4.52 (dd, *J* = 11.2, 2.4 Hz, 1H, $H6a^C$), 4.45 (s, 1H, $H2^B$), 4.31−4.26 (m, 1H, $H6b^C$), 4.14−4.02 (m, 4H, $H4^B$, $H5^C$, $H3^B$, $H2^C$), 3.99−3.85 (m, 4H, $H4^C$, $H4^A$, $H6a^A$, $H6b^A$), 3.85−3.70 (m, 5H, $H3^A$, $H3^C$, $H5^A$, $H5^D$, $H4^D$), 3.68−3.58 (m, 2H,

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$H2^A$, $H3^D$), 3.50 (bt, J = 8.6 Hz, 1H, $H2^D$), 3 0.42 (s, 3H, OCH_3), 1.84 (s, 3H, $NHCOCH_3$). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 129.0, 128.8, 128.67, 128.66, 102.6 ($C1^D$), 98.3 ($C1^B$), 97.8 ($C1^A$), 93.8 ($C1^C$), 83.7 ($C3^D$), 78.6 ($C3^C$, $C3^A$), 76.7 ($C5^D$), 76.0 ($C4^C$), 75.3 (OCH_2Bn), 74.9 (OCH_2Bn), 74.8 ($C4^A$), 74.6 (OCH_2Bn), 73.3 ($C2^D$), 72.3 (OCH_2Bn), 71.7 ($C4^D$), 71.4 ($C2^B$), 71.3 ($C5^A$), 69.4 ($C5^C$, $C3^B$), 68.8 ($C4^B$), 67.9 ($C5^B$), 66.0 ($C6^C$), 63.5 ($C2^A$), 59.9 ($C6^A$), 54.9 (OCH_3), 51.9 ($C2^C$), 22.4 ($NHCOCH_3$). HRMS (ESI): m/z calcd for $C_{55}H_{65}N_4O_{28}S_2$ $[M - 4Na + 3H]^-$ 1293.3232, found 1293.3221.

*Methyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-acetylamino-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-3-O-benzy-2-deoxy-α-D-glucopyranoside (**27**).* The azido group of compound **26** (4.3 mg, 3.1 μmol) was reduced to a free amine, followed by *N*-sulfation, according to the general procedure to give compound **27** as a white powder sodium salt (3.0 mg, 66% over two steps). ^1H NMR (600 MHz, D_2O): δ 7.89 (d, J = 10.2 Hz, 1H, $NHCOCH_3$), 7.55−7.34 (m, 20H, CH aromatic), 5.28 (s, 1H, $H1^B$), 5.02 (d, J = 3.6 Hz, 1H, $H1^A$), 4.95 (d, J = 11.4 Hz, 1H, $CHHBn$), 4.90 (s, 2H, CH_2Bn), 4.85−4.70 (m, 6H, CH_2Bn, 2 × $CHHBn$, $H1^C$ at 4.80, $H5^B$ at 4.77), 4.68 (d, J = 7.8 Hz, 1H, $H1^D$), 4.58 (d, J = 12.0 Hz, 1H, $CHHBn$), 4.53 (dd, J = 11.2, 2.4 Hz, 1H, $H6a^C$), 4.41 (s, 1H, $H2^B$), 4.30−4.26 (m, 1H, $H6b^C$), 4.12−4.09 (m, 2H, $H4^B$, $H5^C$), 4.06−4.01 (m, 2H, $H3^B$, $H2^C$), 3.95 (t, J = 9.3 Hz, 1H, $H4^C$), 3.92−3.87 (m, 2H, $H6a^A$, $H4^A$), 3.85 (dd, J = 12.5, 3.9 Hz, 1H, $H6b^A$), 3.81−3.66 (m, 5H, $H5^A$, $H3^C$, $H5^D$, $H3^A$, $H4^D$), 3.63 (t, J = 8.8 Hz, 1H, $H3^D$), 3.53−3.49 (m, 1H, $H2^D$), 3 0.43 (s, 3H, OCH_3), 3.39 (dd, J = 10.4, 3.7 Hz, 1H, $H2^A$), 1.83 (s, 3H, $NHCOCH_3$). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 128.9, 128.79, 128.77, 128.48, 128.46, 102.4 ($C1^D$), 98.23 ($C1^B$), 98.17 ($C1^A$), 93.4 ($C1^C$), 83.6 ($C3^D$), 78.6 ($C3^C$), 76.7 ($C5^D$, $C3^A$), 75.81 ($C4^A$), 75.76 ($C4^C$), 74.7 (OCH_2Bn), 74.5 (OCH_2Bn), 74.3 (OCH_2Bn), 73.2 ($C2^D$), 72.1 (OCH_2Bn), 71.8 ($C4^D$), 71.5 ($C2^B$), 70.6 ($C5^A$), 68.9 ($C3^B$), 68.7 ($C4^B$, $C5^C$), 68.0 ($C5^B$), 65.9 ($C6^C$), 60.2 ($C6^A$), 57.3 ($C2^A$), 55.2 (OCH_3), 51.7 ($C2^C$), 22.2 ($NHCOCH_3$). HRMS (ESI): m/z calcd for $C_{55}H_{67}N_2O_{31}S_3$ $[M - 5Na + 4H]^-$ 1347.2895, found 1347.2885.

*Methyl O-(β-D-Glucopyranosyluronate)-(1 → 4)-O-(2-acetylamino-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-2-deoxy-α-D-glucopyranoside (**28**).* Compound **27** (3.0 mg, 2.1 μmol) was subjected to global deprotection according to the general procedure to give compound **28** as a white-powder sodium salt (2.0 mg, 90%). ^1H NMR (600 MHz, D_2O): δ 5.23 (bs, 2H, $H1^B$, $H5^B$), 5.12 (d, J = 3.6 Hz, 1H, $H1^C$), 5.03 (d, J = 3.4 Hz, 1H, $H1^A$), 4.64 (d, J = 8.2 Hz, 1H, $H1^D$), 4.43 (dd, J = 11.2, 3.0 Hz, 1H, $H6a^C$), 4.31−4.26 (m, 2H, $H2^B$, $H6b^C$), 4.24 (t, J = 2.6 Hz, 1H, $H3^B$), 4.09 (bs, 1H, $H4^B$), 4.06 (dd, J = 10.2, 3.5 Hz, 1H, $H2^C$), 4.04−4.01 (m, 1H, $H5^D$), 3.95−3.88 (m, 2H, $H5^C$, $H6a^A$), 3.85 (dd, J = 12.0, 4.4 Hz, 1H, $H6b^A$), 3.82−3.76 (m, 3H, $H3^C$, $H5^A$, $H4^C$), 3.73−3.66 (m, 2H, $H4^A$, $H3^A$), 3.61−3.56 (m, 2H, $H4^D$, $H3^D$), 3 0.42 (s, 3H, OCH_3), 3.40−3.36 (m, 1H, $H2^D$), 3.26 (dd, J = 9.9, 3.5 Hz, 1H, $H2^A$), 2.09 (s, 3H, $NHCOCH_3$). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 101.9 ($C1^D$), 99.2 ($C1^B$), 98.2 ($C1^A$), 94.9 ($C1^C$), 77.6 ($C4^C$, $C4^A$), 74.9 ($C3^D$), 74.5 ($C5^D$), 73.2 ($C2^B$), 72.8 ($C2^D$), 72.0 ($C4^B$), 71.4 ($C4^D$), 70.3 ($C5^A$), 69.7 ($C3^A$), 69.5 ($C3^C$), 69.2 ($C5^C$), 66.4 ($C5^B$), 65.8 ($C6^C$), 64.2 ($C3^B$), 59.8 ($C6^A$), 58.1 ($C2^A$), 55.3 (OCH_3), 52.8 ($C2^C$), 22.2 ($NHCOCH_3$). HRMS (ESI): m/z calcd for $C_{27}H_{42}N_2O_{31}S_3$ $[M - 5Na + 3H]^{2-}$ 493.0472, found 493.0489.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-[Methyl-2-O-levulinoyl-3-O-benzyl-4-O-(9-fluorenylmethyloxycarbonyl)-α-L-idopyranosyluronate]-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-6-O-acetyl-2-deoxy-α-D-glucopyranoside (**31**).* Freshly activated 4 Å molecular sieves were added to a solution of glycosyl donor **29** (353 mg, 0.30 mmol) and glycosyl acceptor **30** (259 mg, 0.25 mmol) in anhydrous DCM (6 mL, 0.05 M based on the glycosyl acceptor). After stirring for 30 min at room temperature, the solution was cooled to −40 °C, followed by the addition of TfOH (13 μL, 0.15 mmol). The reaction mixture was stirred for 1 h and quenched with pyridine. The reaction mixture was filtered, and the filtrate was concentrated *in vacuo*. The residue was purified by silica gel column chromatography using a stepwise gradient of petroleum ether and EtOAc (3:2 to 1:1 *v*/*v*) as the eluent to give disaccharide **31** (264 mg, 52%). R_f = 0.24 (petroleum ether/EtOAc, 1:1 *v*/*v*). $[\alpha]_D^{20}$ +16.6 (c = 2.3, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$): δ 7.82−7.05 (m, 38H, CH aromatic), 5.25 (d, J = 3.9 Hz, 1H, $H1^B$), 5.17 (bd, J = 9.5 Hz, 2H, CH_2Cbz), 5.09−5.04 (m, 2H, $H1^C$, $H1^D$), 4.98−4.93 (m, 2H, $H4^D$, $H2^B$), 4.89−4.68 (m, 10H, $H5^D$, $H2^D$, $H1^A$, $H5^B$, 2 × CH_2Bn, 2 × $CHHBn$), 4.66 (d, J = 10.7 Hz, 1H, $CHHBn$), 4.60 (d, J = 10.7 Hz, 1H, $CHHBn$), 4.53−4.35 (m, 6H, NCH_2Bn, $H6a^C$, $H6a^A$, CH_2 Fmoc), 4.29 (d, J = 12.0 Hz, 1H, $H6b^A$), 4.23−4.14 (m, 2H, CH Fmoc, $H6b^C$), 4.03 (t, J = 4.6 Hz, 1H, $H4^B$), 3.98−3.79 (m, 7H, $H3^B$, $H4^C$, $H5^A$, $H4^A$, $H3^D$, $H3^A$, $H5^C$), 3.68−3.59 (m, 2H, $H3^C$, OCH*H* linker), 3.47 (s, 3H, CO_2CH_3), 3.44 (s, 3H, CO_2CH_3), 3.42−3.16 (m, 5H, OCH*H* linker, $H2^A$, $H2^C$, CH_2N linker), 2.86−2.46 (m, 12H, 6 O) × CH_2 Lev), 2.17 (s, 3H, CH_3 Lev), 2.11 (s, 6H, CH_3 Ac, CH_3 Lev), 2.04 (s, 3H, CH_3 Lev), 1.70−1.20 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 207.0 (CH_3CO Lev), 206.4 (CH_3CO Lev), 206.2 (CH_3CO Lev), 172.3 (CH_2CO Lev), 172.2 (CH_2CO Lev), 171.8 (CH_2CO Lev), 170.9 (CO Ac), 169.5 (CO_2CH_3), 168.6 (CO_2CH_3), 154.4, 143.3, 143.2, 141.43, 141.41, 138.2, 138.1, 137.7, 137.6, 137.3, 128.7, 128.62, 128.59, 128.35, 128.33, 128.27, 128.1, 128.02, 127.98, 127.9, 127.64, 127.61, 127.29, 127.27, 125.18, 125.13, 120.2, 98.2 ($C1^B$), 97.7 ($C1^A$), 97.4 ($C1^D$), 96.9 ($C1^C$), 78.4 ($C3^A$), 78.2 ($C3^C$), 76.0 ($C4^A$), 74.9 (OCH_2Bn), 74.8 (OCH_2Bn), 74.3 ($C3^B$, $C4^C$), 73.6 (OCH_2Bn), 73.51 (OCH_2Bn), 73.45 ($C3^D$), 72.0 ($C4^B$), 71.5 ($C4^D$), 70.3 (CH_2 Fmoc), 69.7 ($C5^C$, $C5^B$, $C2^B$), 69.1 ($C5^A$), 68.3 (OCH_2 linker), 68.2 ($C2^D$), 67.3 (CH_2Cbz), 67.2 ($C5^D$), 63.4 ($C2^A$), 63.3 ($C2^C$), 62.5 ($C6^A$), 62.1 ($C6^C$), 52.3 (CO_2CH_3), 51.9 (CO_2CH_3), 50.7 (NCH_2Bn), 50.4 (NCH_2Bn), 47.2 (CH_2N linker), 46.8 (CH Fmoc), 46.3 (CH_2N linker), 38.1 (CH_2 Lev), 37.8 (CH_2 Lev), 37.7 (CH_2 Lev), 29.9 (CH_3 Lev), 29.8 (CH_3 Lev), 29.6 (CH_3 Lev), 29.1 (CH_2 linker), 28.3 (CH_2 Lev), 28.0 (CH_2 Lev), 27.8 (CH_2 Lev), 27.6 (CH_2 linker), 23.4 (CH_2 linker), 21.0 (CH_3 Ac). HRMS (ESI): m/z calcd for $C_{106}H_{117}N_7NaO_{32}$ $[M + Na]^+$ 2022.7635, found 2022.7706.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(Methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-6-O-acetyl-2-deoxy-α-D-glucopyranoside (**32**).* A solution of a tetrasaccharide **31** (264 mg, 0.13 mmol) in a mixture of DCM and Et_3N (2.5 mL, 4:1 *v*/*v*, 50 mM) was stirred at ambient temperature for 2 h until TLC analysis indicated completion of the reaction. The mixture was concentrated under reduced pressure, and the residue was purified by silica gel column chromatography with petroleum ether and EtOAc (1:1 *v*/*v*) as the eluent to give the pure product **32** as a white amorphous solid (211 mg, 90%). R_f = 0.36 (petroleum ether/EtOAc, 1:3 *v*/*v*). $[\alpha]_D^{20}$ +21.4 (c = 2.6, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$): δ 7.77−6.56 (m, 30H, CH aromatic), 5.24 (d, J = 3.5 Hz, 1H, $H1^B$), 5.17 (bd, J = 10.5 Hz, 2H, CH_2Cbz), 5.05 (d, J = 3.5 Hz, 1H, $H1^C$), 4.99 (bs, 1H, $H1^D$), 4.95 (t, J = 3.5 Hz, 1H, $H2^B$), 4.90−4.55 (m, 12H, $H2^D$, $H1^A$, $H5^D$, $H5^B$, 4 × CH_2 Bn), 4.49 (bs, 2H, NCH_2Bn), 4.39 (d, J = 12.5 Hz, 2H, $H6a^A$, $H6a^C$), 4.28 (d, J = 12.2 Hz, 1H, $H6b^A$), 4.19 (d, J = 12.5 Hz, 1H, $H6b^C$), 4.73 (t, J = 3.3 Hz, 1H, $H3^D$), 4.04−3.77 (m, 8H, $H4^B$, $H4^D$, $H3^B$, $H5^A$, $H4^C$, $H4^A$, $H3^A$, $H5^C$), 3.68−3.60 (m, 2H, $H3^C$, OCH*H* linker), 3.48 (s, 3H, CO_2CH_3), 3.44 (s, 3H, CO_2CH_3), 3.41−3.17 (m, 5H, $H2^A$, $H2^C$, OCH*H* linker, CH_2N linker), 2.78−2.46 (m, 12H, 6 × CH_2 Lev), 2.17 (s, 3H, CH_3 Lev), 2.15 (s, 3H, CH_3 Lev), 2.10 (s, 6H, CH_3 Lev, CH_3 Ac), 1.65−1.26 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$): δ 206.8 (CH_3CO Lev), 206.5 (CH_3CO Lev), 206.1 (CH_3CO Lev), 172.3 (CH_2CO Lev), 172.2 (CH_2CO Lev), 171.5 (CH_2CO Lev), 170.9 (CO Ac), 169.6 (CO_2CH_3), 169.4 (CO_2CH_3), 138.1, 138.0, 137.8, 137.5, 137.3, 128.69, 128.65, 128.6, 128.29, 128.27, 128.10, 127.97, 127.95, 127.9, 127.6, 127.5, 127.4, 127.3, 98.2 ($C1^B$), 97.9 ($C1^D$), 97.7 ($C1^A$), 96.9 ($C1^C$), 78.3 ($C3^A$), 78.2 ($C3^C$), 75.9 ($C4^A$), 75.3 ($C3^D$), 74.8 (OCH_2Bn), 74.6 (OCH_2Bn), 74.4 ($C5^A$), 73.8 ($C3^B$), 73.5

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(OCH_2Bn), 72.8 (OCH_2Bn), 72.1 ($C4^B$), 69.7 ($C5^C$), 69.6 ($C5^B$), 69.5 ($C2^B$), 69.1 ($C4^C$), 69.0 ($C5^D$), 68.3 (OCH_2 linker, $C2^D$), 67.8 ($C4^D$), 67.3 (CH_2Cbz), 63.4 ($C2^A$), 63.3 ($C2^C$), 62.5 ($C6^A$), 62.2 ($C6^C$), 52.1 (CO_2CH_3), 51.9 (CO_2CH_3), 50.7 (NCH_2Bn), 50.4 (NCH_2Bn), 47.2 (CH_2N linker), 46.3 (CH_2N linker), 38.0 (CH_2 Lev), 37.9 (CH_2 Lev), 37.8 (CH_2 Lev), 29.9 (CH_3 Lev), 29.8 (2 × CH_3 Lev), 29.1 (CH_2 linker), 28.08 (CH_2 Lev), 28.05 (CH_2 Lev), 27.8 (CH_2 linker), 23.4 (CH_2 linker), 21.0 (CH_3 Ac). HRMS (ESI): m/z calcd for $C_{91}H_{107}N_7NaO_{30}$ $[M + Na]^+$ 1800.6955, found 1800.7026.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(Methyl-2-O-acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-2-N-[(2-trifluoromethyl)benzylidene]-3-O-benzyl-6-O-acetyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzy-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-6-O-acetyl-2-deoxy-α-D-glucopyranoside (**33**).* Freshly activated 4 Å molecular sieves were added to a solution of glycosyl donor **3** (67.0 mg, 64 μmol) and glycosyl acceptor **32** (95.0 mg, 53 μmol) in anhydrous DCM (0.25 mL, 0.13 M based on the glycosyl donor). After stirring for 15 min at room temperature, the solution was cooled to −20 °C, followed by the addition of TfOH (2.4 μL, 27 μmol). After stirring the reaction mixture for 12 h, the reaction was quenched by the addition of Et_3N. The reaction mixture was filtered, and the filtrate was concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 v/v, 0.1% Et_3N) as the eluent to give hexasaccharide **33** as a white foam (73.2 mg, 52%). $[\alpha]_D^{20}$ +42.0 (c = 1.2, $CHCl_3$).^{1}H NMR (600 MHz, $CDCl_3$): δ 8.50 (d, J = 1.8 Hz, 1H, N=C*H*PhCF$_3$), 8.18 (d, J = 7.6 Hz, 1H, *Ar*H^4), 7.58 (d, J = 7.7 Hz, 1H, H^1), 7.51−7.44 (m, 2H, H^2, H^3), 7.41−6.77 (m, 40H, 7 × Bn, Cbz CH aromatic), 5.91−5.84 (m, 1H, CH_2=C*H*CH_2), 5.38 (d, J = 5.9 Hz, 1H, H1^D), 5.36−5.30 (m, 2H, C*H*H=$CHCH_2$, H1^B), 5.28−5.25 (m, 1H, CH*H*=$CHCH_2$), 5.19−5.15 (m, 2H, CH_2Cbz), 5.08 (dd, J = 9.3, 8.0 Hz, 1H, H2^F), 5.06 (d, J = 3.4 Hz, 1H, H1^C), 5.02−4.99 (m, 1H, H4^F), 4.97 (d, J = 3.4 Hz, 1H, H1^E), 4.94 (t, J = 5.1 Hz, 1H, H2^B), 4.91−4.87 (m, 3H, H2^D, C*H*HBn, C*H*HBn), 4.84−4.78 (m, 2H, H1^A, H5^B), 4.76−4.47 (m, 14H, 3 × CH_2 Bn, C*H*HBn, H1^F at 4.59, CH_2=CHCH_2, C*H*HBn, H5^D, NCH_2Bn), 4.45 (d, J = 11.8 Hz, 2H, C*H*HBn, H6a^C), 4.41 (dd, J = 11.9, 1.6 Hz, 1H, H6a^E), 4.37 (d, J = 11.6 Hz, 2H, C*H*HBn, H6a^A), 4.31 (dd, J = 12.0, 2.6 Hz, 1H, H6b^A), 4.26 (dd, J = 12.6, 2.6 Hz, 1H, H6b^C), 4.23 (dd, J = 12.0, 3.4 Hz, 1H, H6b^E), 4.14−4.10 (m, 1H, H5^E), 4.07 (t, J = 5.1 Hz, 1H, H4^B), 4.02−3.98 (m, 2H, H4^D, H3^D), 3.95−3.80 (m, 9H, H3^B, H5^C, H5^A, H3^E, H5^F, H4^C, H4^A, H3^A, H4^E), 3.71 (t, J = 9.3 Hz, 1H, H3^F), 3.70−3.59 (m, 5H, H3^C, OCH*H* linker, CO_2CH_3), 3.52 (s, 3H, CO_2CH_3), 3.48 (s, 3H, CO_2CH_3), 3.44 (dd, J = 9.6, 3.1 Hz, 1H, H2^E), 3.42−3.31 (m, 1H, OCH*H* linker), 3.31−3.18 (m, 4H, H2^C, H2^A, CH_2N linker), 2.85−2.39 (m, 12H, 6 × CH_2 Lev), 2.21 (s, 3H, CH_3 Lev), 2.11 (s, 6H, CH_3 Ac, CH_3 Lev), 2.07 (s, 3H, CH_3 Ac), 1.98 (s, 3H, CH_3 Ac), 1.97 (s, 3H, CH_3 Lev), 1.67−1.26 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 206.7 (CH_3CO Lev), 206.2 (CH_3CO Lev), 206.1 (CH_3CO Lev), 172.6 (CH_2CO Lev), 172.1 (CH_2CO Lev), 171.8 (CH_2CO Lev), 171.0 (*C*O Ac), 170.7 (*C*O Ac), 170.3 (CO_2CH_3), 169.9 (CO_2CH_3), 169.1 (*C*O Ac), 167.2 (CO_2CH_3), 160.6 (N=CHPhCF$_3$), 153.9 (*C*O Alloc), 138.4, 138.2, 138.03, 137.98, 137.8, 137.74, 137.66, 132.0, 131.2 (CH_2=*C*HCH_2), 130.7, 129.2, 129.1, 128.7, 128.6, 128.4, 128.3, 128.1, 128.1, 128.03, 127.98, 127.9, 127.8, 127.6, 127.5, 127.3, 127.2, 126.7, 119.5 (CH_2=CHCH_2), 101.2 (C1^F), 100.8 (C1^E), 98.2 (C1^B), 97.9 (C1^D), 97.7 (C1^A), 97.2 (C1^C), 79.7 (C3^F), 78.5 (C3^A), 78.3 (C4^E), 78.0 (C3^E), 77.9 (C3^C), 77.4 (C3^D), 76.3 (C4^A), 76.0 (C4^C), 75.2 (C3^B), 75.2 (C4^F, OCH_2Bn), 75.1 (C4^D, OCH_2Bn), 74.8 (C2^E, OCH_2Bn), 74.7 (OCH_2Bn), 74.2 (OCH_2Bn), 73.9 (OCH_2Bn), 72.8 (C5^F), 72.5 (C2^F), 72.3 (C4^B), 71.8 (C5^D), 71.5 (C2^D), 70.2 (C2^B, C5^B), 69.9 (C5^E), 69.8 (C5^C), 69.2 (CH_2=CHCH_2), 69.0 (C5^A), 68.3 (OCH_2 linker), 67.3 (CH_2Cbz), 63.3 (C2^A), 63.0 (C2^C), 62.5 (C6^A), 62.11 (C6^E), 62.08 (C6^C), 52.8 (CO_2CH_3), 52.3 (CO_2CH_3), 52.0 (CO_2CH_3), 50.7 (NCH_2Bn), 50.4 (NCH_2Bn), 47.2 (CH_2N linker), 46.3 (CH_2N linker), 38.1 (CH_2 Lev), 37.8 (CH_2 Lev), 37.6 (CH_2 Lev), 30.0 (CH_3 Lev), 29.8 (CH_3 Lev), 29.5 (CH_3 Lev), 29.1 (CH_2 linker), 28.1 (CH_2 Lev, CH_2 linker), 27.8 (CH_2 Lev), 27.6 (CH_2 Lev), 23.4 (CH_2 linker), 21.0 (2 × CH_3 Ac), 20.8 (CH_3 Ac). HRMS (ESI): m/z calcd for $C_{134}H_{156}F_3N_9O_{44}$ $[M + H + NH_4]^{2+}$ 1326.5110, found 1326.5123.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(Methyl-2-O-acetyl-3-O-benzyl-4-O-allyloxycarbonyl-β-D-glucopyranosyluronate)-(1 → 4)-O-2-N-[(2-trifluoromethyl)benzylidene]-3-O-benzyl-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzy-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-6-O-acetyl-2-deoxy-α-D-glucopyranoside (**34**).* Freshly activated 4 Å molecular sieves were added to a solution of glycosyl donor **4** (36.0 mg, 33 μmol) and glycosyl acceptor **32** (48.2 mg, 27 μmol) in anhydrous DCM (0.25 mL, 0.13 M based on the glycosyl donor). After stirring for 15 min at room temperature, the solution was cooled to −20 °C, followed by the addition of TfOH (1.2 μL, 14 μmol). The reaction mixture was stirred for 12 h, after which the reaction was quenched by the addition of Et_3N. The mixture was filtered, and the filtrate was concentrated under reduced pressure. The residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 v/v, 0.1% Et_3N) as the eluent to give hexasaccharide **34** as a white foam (35.0 mg, 48%). R_f = 0.36 (petroleum ether/EtOAc, 1:2 v/v). ^{1}H NMR (600 MHz, $CDCl_3$): δ 8.50 (d, J = 1.8 Hz, 1H, N=C*H*PhCF$_3$), 8.15 (d, J = 6.7 Hz, 1H, H^4), 7.58 (d, J = 7.7 Hz, 1H, H^1), 7.49−7.43 (m, 2H, H^2, H^3), 7.38−6.75 (m, 40H, 7 × Bn, Cbz CH aromatic), 5.91−5.83 (m, 1H, CH_2=C*H*CH_2), 5.38 (d, J = 6.2 Hz, 1H, H1^D), 5.34−5.31 (m, 2H, C*H*H=$CHCH_2$, H1^B), 5.26−5.22 (m, 1H, CH*H*=CHCH_2), 5.21−5.13 (m, 2H, CH_2Cbz), 5.10 (dd, J = 9.4, 8.4 Hz, 1H, H2^F), 5.05 (d, J = 3.4 Hz, 1H, H1^C), 5.04−4.96 (m, 3H, H4^F, C*H*HBn, H1^E), 4.94 (t, J = 4.9 Hz, 1H, H2^B), 4.92−4.84 (m, 3H, H2^D, C*H*HBn, C*H*HBn), 4.84−4.77 (m, 3H, H1^A, H5^B, H1^F), 4.77−4.51 (m, 9H, 2 × CH_2 Bn, C*H*HBn, C*H*HBn, CH_2=CHCH_2, C*H*HBn), 4.51−4.47 (m, 2H, NCH_2Bn), 4.46−4.20 (m, 10H, H6a^C, H5^D, C*H*HBn, H6a^E, C*H*HBn, H6a^A, H6b^A, H6b^C, H5^F, H6b^E), 4.16−4.12 (m, 1H, H5^E), 4.07 (t, J = 5.3 Hz, 1H, H4^B), 4.01−3.82 (m, 11H, H4^D, H3^D, H4^E, H3^F, H3^B, H5^C, H5^A, H4^A, H4^C, H3^E, H3^A), 3.69−3.58 (m, 5H, H3^C, OCH*H* linker, CO_2CH_3), 3.52 (s, 3H, CO_2CH_3), 3.50−3.30 (m, 5H, CO_2CH_3, H2^E, OCH*H* linker), 3.30−3.17 (m, 4H, H2^C, H2^A, CH_2N linker), 2.97−2.38 (m, 16H, 8 × CH_2 Lev), 2.21 (s, 3H, CH_3 Lev), 2.20 (s, 3H, CH_3 Lev), 2.11 (s, 6H, CH_3 Ac, CH_3 Lev), 1.98 (s, 3H, CH_3 Ac), 1.97 (s, 3H, CH_3 Lev), 1.67−1.26 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, $CDCl_3$): δ 206.9 (CH_3CO Lev), 206.6 (CH_3CO Lev), 206.2 (CH_3CO Lev), 206.0 (CH_3CO Lev), 172.8 (CH_2CO Lev), 172.6 (CH_2CO Lev), 172.1 (CH_2CO Lev), 171.8 (CH_2CO Lev), 171.0 (*C*O Ac), 170.3 (CO_2CH_3), 170.0 (CO_2CH_3), 169.2 (*C*O Ac), 167.7 (CO_2CH_3), 160.7 (N=CHPhCF$_3$), 154.1 (*C*O Alloc), 138.6, 138.3, 138.03, 137.97, 137.9, 137.8, 132.0, 131.4 (CH_2=*C*HCH_2), 130.6, 130.2, 129.9, 128.7, 128.6, 128.4, 128.1, 128.0, 127.91, 127.87, 127.7, 127.5, 127.4, 127.3, 127.1, 126.7, 125.61, 125.57, 119.3 (CH_2=CHCH_2), 101.01 (C1^E), 100.95 (C1^F), 98.2 (C1^B), 97.9 (C1^D), 97.8 (C1^A), 97.2 (C1^C), 79.7 (C3^F), 78.3 (C3^A, C4^E), 77.9 (C3^E, C3^C), 77.6 (C3^D), 76.4 (C4^A), 76.2 (C4^C), 75.5 (C4^F), 75.3 (C4^D, C3^B, OCH_2Bn), 75.2 (OCH_2Bn), 75.1 (OCH_2Bn), 74.7 (C2^E), 74.5 (OCH_2Bn), 74.3 (OCH_2Bn), 73.9 (OCH_2Bn), 72.6 (C2^F), 72.5 (C5^F), 72.4 (C4^B), 72.0 (C5^D), 71.8 (C2^D), 70.3 (C2^B, C5^B), 69.8 (C5^E, C5^C), 69.1 (CH_2=CHCH_2), 69.0 (C5^A), 68.3 (OCH_2 linker), 67.3 (CH_2Cbz), 63.3 (C2^A), 63.0 (C2^C), 62.5 (C6^A), 62.3 (C6^E), 62.1 (C6^C), 52.6 (CO_2CH_3), 52.3 (CO_2CH_3), 52.0 (CO_2CH_3), 50.7 (NCH_2Bn), 50.4 (NCH_2Bn), 47.2 (CH_2N linker), 46.3 (CH_2N linker), 38.2 (CH_2 Lev), 38.1 (CH_2 Lev), 37.8 (CH_2 Lev), 37.6 (CH_2 Lev), 30.0 (CH_3 Lev), 29.8 (2 × CH_3 Lev), 29.5 (CH_3 Lev), 29.1 (CH_2 linker), 28.1 (CH_2 Lev, CH_2 linker), 27.8 (CH_2 Lev), 27.6 (CH_2 Lev), 27.4 (CH_2 Lev), 23.4 (CH_2 linker), 21.0 (CH_3 Ac), 20.9 (CH_3 Ac). HRMS (ESI): m/z calcd for $C_{137}H_{159}F_3N_9NaO_{45}$ $[M + Na + NH_4]^{2+}$ 1365.5151, found 1365.5145.

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*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-[Methyl-2-O-acetyl-3-O-benzyl-4-O-(9-fluorenylmethyloxycarbonyl)-β-D-glucopyranosyluronate]-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-acetyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-6-O-acetyl-2-deoxy-α-D-glucopyranoside (**35**).* Freshly activated 4 Å molecular sieves were added to a solution of glycosyl donor **20** (47.5 mg, 36 μmol) and glycosyl acceptor **32** (53.5 mg, 30 μmol) in anhydrous DCM (1 mL). After stirring for 30 min at room temperature, the solution was cooled to −40 °C, followed by the addition of TfOH (2.3 μL, 15 μmol). The reaction mixture was stirred for 1 h, after which the reaction was quenched with pyridine. The reaction mixture was filtered, and the filtrate was concentrated *in vacuo*. The residue was purified by silica gel column chromatography using a stepwise gradient of petroleum ether and EtOAc (3:1 to 1:1 *v*/*v*) as the eluent to give hexasaccharide **35** as a white foam (43.8 mg, 55%). R_f = 0.54 (petroleum ether/EtOAc, 1:2 *v*/*v*). $[\alpha]_D^{20}$ +33.6 (*c* = 2.7, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.26−6.64 (m, 48H, CH aromatic), 5.29 (d, *J* = 4.5 Hz, 1H, H1^B), 5.27 (d, *J* = 4.9 Hz, 1H, H1^D), 5.17 (bd, *J* = 9.5 Hz, 2H, CH_2Cbz), 5.12 (d, *J* = 11.0 Hz, 1H, C*H*HBn), 5.10−5.00 (m, 4H, H2^F, H4^F, H1^E, H1^C), 5.00−4.52 (m, 17H, H2^B, H2^D, C*H*HBn, H1^A at 4.82, H5^B, 5 × CH_2 Bn, H5^D, H1^F at 4.53), 4.50 (bs, 2H, NCH_2Bn), 4.47−4.12 (m, 9H, H6a^C, H6a^E, H6a^A, H6b^A, H6b^E, H6b^C, CH_2 Fmoc, C*H* Fmoc), 4.06 (t, *J* = 4.9 Hz, 1H, H4^B), 4.03−3.64 (m, 15H, H4^D, H3^B, H3^D, H5^F, H5^E, H5^C, H5^A, H4^C, H4^E, H3^A, H4^A, H3^F, H3^E, H3^C, OCH*H* linker), 3.59 (s, 3H, CO_2CH_3), 3.51 (s, 3H, CO_2CH_3), 3.46 (s, 3H, CO_2CH_3), 3.44−3.18 (m, 6H, OCH*H* linker, CH_2N linker, H2^C, H2^E, H2^A), 2.82−2.42 (m, 12H, 6 × CH_2 Lev), 2.17 (s, 3H, CH_3 Lev), 2.11 (s, 6H, CH_3 Lev, CH_3 Ac), 2.07 (s, 3H, CH_3 Lev), 2.05 (s, 3H, CH_3 Ac), 1.95 (s, 6H, CH_3 Ac), 1.64−1.26 (m, 6H, 3 × CH_2 linker). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$): δ 206.6 (CH_3CO Lev), 206.2 (CH_3CO Lev), 206.1 (CH_3CO Lev), 172.5 (CH_2CO Lev), 172.1 (CH_2CO Lev), 172.0 (CH_2CO Lev), 170.9 (CO Ac), 170.5 (CO Ac), 169.8 (CO_2CH_3), 169.7 (CO_2CH_3), 169.0 (CO Ac), 167.0 (CO_2CH_3), 154.0, 143.4, 143.1, 141.43, 141.39, 138.2, 138.04, 137.99, 137.7, 137.63, 137.55, 128.7, 128.59, 128.55, 128.53, 128.4, 128.32, 128.30, 128.11, 128.09, 128.02, 128.00, 127.96, 127.91, 127.89, 127.77, 127.74, 127.68, 127.65, 127.6, 127.3, 125.2, 125.1, 120.2, 100.9 (C1^F), 98.2 (C1^D), 98.1 (C1^B), 97.7 (C1^A), 97.5 (C1^E), 97.0 (C1^C), 79.5 (C3^F), 78.4, 78.1, 77.9, 77.6, 76.2, 75.7, 75.3 (OCH$_2$Bn), 75.2 (C4^F), 75.0 (C3^B, C3^D, OCH$_2$Bn), 74.6 (OCH$_2$Bn), 74.1 (OCH$_2$Bn), 73.7 (OCH$_2$Bn), 72.9, 72.8 (C4^D), 72.4 (C2^F), 72.2 (C4^B), 70.6 (C5^D, CH$_2$ Fmoc), 70.5 (C2^D), 70.0 (C2^B, C5^B), 69.7, 69.3, 69.1, 68.3 (OCH$_2$ linker), 67.3 (CH$_2$Cbz), 63.3 (C2^C), 63.1 (C2^A), 62.8 (C2^E), 62.5 (C6^A), 62.1 (C6^E), 61.7 (C6^C), 52.8 (CO_2CH_3), 52.3 (CO_2CH_3), 52.0 (CO_2CH_3), 50.7 (NCH$_2$Bn), 50.4 (NCH$_2$Bn), 47.2 (CH$_2$N linker), 46.7 (CH Fmoc), 46.3 (CH$_2$N linker), 38.0 (CH$_2$ Lev), 37.8 (CH$_2$ Lev), 37.7 (CH$_2$ Lev), 29.9 (CH$_3$ Lev), 29.8 (CH$_3$ Lev), 29.6 (CH$_3$ Lev), 29.1 (CH$_2$ linker), 28.0 (CH$_2$ Lev), 27.8 (CH$_2$ Lev), 27.6 (CH$_2$ linker), 23.4 (CH$_2$ linker), 21.0 (CH$_3$ Ac), 21.0 (CH$_3$ Ac), 20.7 (CH$_3$ Ac). HRMS (ESI): *m*/*z* calcd for $C_{137}H_{160}N_{12}O_{44}$ $[M + 2NH_4]^{2+}$ 1339.0337, found 1339.0395.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-[Methyl-2-O-acetyl-3-O-benzyl-4-O-(9-fluorenylmethyloxycarbonyl)-β-D-glucopyranosyluronate]-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-levulinoyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(methyl-2-O-levulinoyl-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-6-O-acetyl-2-deoxy-α-D-glucopyranoside (**36**).* Freshly activated 4 Å molecular sieves were added to a solution of glycosyl donor **21** (65.0 mg, 59 μmol) and glycosyl acceptor **32** (86.0 mg, 48 μmol) in anhydrous DCM (0.4 mL, 0.15 M based on the glycosyl donor). After stirring for 30 min at room temperature, the solution was cooled to −40 °C, followed by the addition of TfOH (2.1 μL, 24 μmol). The reaction mixture was stirred for 1 h, after which the reaction was quenched with pyridine. The mixture was filtered, and the filtrate was concentrated *in vacuo*. The residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 *v*/*v*) as the eluent to give hexasaccharide **36** as a white foam. (90 mg, 69%). $[\alpha]_D^{20}$ +25.1 (*c* = 1.4, $CHCl_3$) ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.78−7.11 (m, 48H, CH aromatic), 5.30−5.26 (m, 2H, H1^B, H1^D), 5.22 (d, *J* = 11.3 Hz, 1H, C*H*HBn), 5.30−5.26 (m, 2H, CH_2Cbz), 5.13−5.07 (m, 2H, H2^F, H4^F), 5.06−5.04 (m, 2H, H1^C, H1^E), 4.95 (d, *J* = 4.6 Hz, 1H, H2^B), 4.91−4.78 (m, 5H, H2^D, C*H*HBn, C*H*HBn, H1^A at 4.83, H5^B), 4.77−4.62 (m, 9H, H1^F at 4.76, 2 × CH_2 Bn, C*H*HBn, C*H*HBn, C*H*HBn, C*H*HBn), 4.59 (d, *J* = 11.8 Hz, 1H, C*H*HBn), 4.52−4.47 (m, 3H, NCH_2Bn, H5^D), 4.44−4.27 (m, 7H, H6a^C, H6a^A, H6a^E, H6b^A, CH_2 Fmoc, H5^F), 4.26−4.19 (m, 2H, H6b^C, C*H* Fmoc), 4.17 (dd, *J* = 12.7, 2.0 Hz, 1H, H6b^E), 4.06 (t, *J* = 4.9 Hz, 1H, H4^B), 4.02−3.82 (m, 11H, H3^F at 4.00, H3^D, H4^D, H3^B, H4^E, H5^A, H5^C, H5^E, H4^A, H4^C, H3^A), 3.69−3.59 (m, 3H, H3^C, H3^E, OCH*H* linker), 3.58 (s, 3H, CO_2CH_3), 3.50 (s, 3H, CO_2CH_3), 3.45 (s, 3H, CO_2CH_3), 3.41−3.18 (m, 6H, OCH*H* linker, CH_2N linker, H2^C, H2^A, H2^E), 2.99−2.40 (m, 16H, 8 × CH_2 Lev), 2.22 (s, 3H, CH_3 Lev), 2.17 (s, 3H, CH_3 Lev), 2.12 (s, 6H, CH_3 Lev, CH_3 Ac), 2.06 (s, 3H, CH_3 Lev), 1.97 (s, 6H, CH_3 Ac), 1.64−1.26 (m, 6H, 3 × CH_2 linker). ^{13}C{^{1}H} NMR (151 MHz, $CDCl_3$): δ 207.0 (CH_3CO Lev), 206.6 (CH_3CO Lev), 206.2 (CH_3CO Lev), 206.2 (CH_3CO Lev), 172.7 (CH_2CO Lev), 172.5 (CH_2CO Lev), 172.1 (CH_2CO Lev), 172.0 (CH_2CO Lev), 171.0 (CO Ac), 169.9 (CO_2CH_3), 169.8 (CO_2CH_3), 169.2 (CO Ac), 167.6 (CO_2CH_3), 154.2 (CO Fmoc), 143.5, 143.2, 141.41, 141.39, 138.3, 138.2, 138.0, 137.8, 137.7, 137.0, 136.9, 129.2, 128.7, 128.6, 128.5, 128.4, 128.3, 128.2, 128.0, 127.92, 127.87, 127.8, 127.7, 127.6, 127.5, 127.4, 127.29, 125.28, 125.2, 120.2, 100.6 (C1^F), 98.2 (C1^D), 98.1 (C1^B), 97.7 (C1^A, C1^E), 97.0 (C1^C), 79.4 (C3^F), 78.4 (C3^A), 78.1 (C3^C), 77.7 (C4^E), 77.6 (C3^E), 76.2 (C4^A), 75.8 (C4^C), 75.5, 75.0, 74.6, 74.2, 73.7, 73.1, 72.5 (C2^F), 72.4 (C5^F), 72.2 (C4^B), 70.7 (C5^D, C2^D), 70.5 (CH$_2$ Fmoc), 70.0 (C5^B), 69.7 (C2^B), 69.2 (C5^E), 69.0 (C5^C), 68.3 (OCH$_2$ linker), 67.3 (CH$_2$Cbz), 63.3 (C2^C), 63.1 (C2^A), 62.7 (C2^E), 62.5 (C6^A), 62.1 (C6^C), 61.9 (C6^E), 52.7 (CO_2CH_3), 52.4 (CO_2CH_3), 52.0 (CO_2CH_3), 50.7 (NCH$_2$Bn), 50.4 (NCH$_2$Bn), 47.2 (CH$_2$N linker), 46.7 (CH Fmoc), 46.3 (CH$_2$N linker), 38.2 (CH$_2$ Lev), 38.0 (CH$_2$ Lev), 37.8 (CH$_2$ Lev), 37.7 (CH$_2$ Lev), 30.0 (CH$_3$ Lev), 29.9 (CH$_3$ Lev), 29.8 (CH$_3$ Lev), 29.6 (CH$_3$ Lev), 29.1 (CH$_2$ linker), 28.1 (CH$_2$ Lev), 28.0 (CH$_2$ Lev), 27.8 (CH$_2$ Lev, CH$_2$ linker), 27.6 (CH$_2$ Lev), 23.4 (CH$_2$ linker), 21.0 (CH$_3$ Ac), 20.8 (CH$_3$ Ac). HRMS (ESI): *m*/*z* calcd for $C_{140}H_{164}N_{12}O_{45}$ $[M + 2NH_4]^{2+}$ 1367.0468, found 1367.0444.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-acetamino-3-O-benzyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzy-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-2-deoxy-α-D-glucopyranoside (**37**).* Tetrakis(triphenylphosphine)palladium(0) (30.0 mg, 27 μmol) was added to a solution of protected hexasaccharide **33** (70.0 mg, 27 μmol) in THF and H_2O (5.5 mL, 10:1 *v*/*v*, 5 mM). The reaction mixture was stirred at room temperature for 1 h. After TLC analysis indicated the completion of the reaction, 2 M hydrochloric acid (0.27 mL, 0.53 mmol) was added to the reaction mixture. Stirring continued for 15 min. The reaction was monitored by TLC until completion. The reaction mixture was co-evaporated with toluene (2 × 3 mL), and the residue was dissolved in pyridine (1.0 mL), followed by the addition of Ac_2O (0.5 mL). After stirring for another 3 h at room temperature, the reaction mixture was concentrated under reduced pressure, and the residue was purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 *v*/*v*) as the eluent to afford a hexasaccharide intermediate as a white amorphous solid (57.3 mg, 87%). The resulting compound (42.0 mg, 17 μmol) was subjected to the Lev ester removal, *O*-sulfation, saponification, and de-*O*-acetylation reactions according to the general procedures to provide compound **37** as a white-powder sodium salt (19.8 mg, 50% over three steps). ^{1}H NMR (600 MHz, D_2O): δ 7.56−7.16 (m, 40H, CH aromatic), 5.30 (s, 1H, H1^D), 5.27 (s, 1H, H1^B), 5.17−5.06 (m, 3H, H1^C, CH_2Cbz), 4.95−4.73 (m, 10H, C*H*HBn, 2 × CH_2Bn, C*H*HBn,

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$H5^B$, $H5^D$, $H1^E$), 4.73−4.38 (m, 11H, 2 × CH_2Bn, C*H*HBn, C*H*HBn, $H1^F$, $H2^B$, $H2^D$, NCH_2Bn), 4.35 (d, J = 10.6 Hz, 1H, $H6a^C$), 4.30 (d, J = 10.6 Hz, 1H, $H6b^C$), 4.25 (s, 1H, $H3^B$), 4.20−4.13 (m, 1H, $H4^B$), 4.10−4.04 (m, 2H, $H5^C$, $H4^D$), 4.02−3.34 (m, 22H, $H3^D$, $H4^C$, $H2^E$, $H4^A$, $H5^E$, $H3^C$, $H4^E$, $H6a^A$, $H6b^A$, $H6a^E$, $H6b^E$, $H3^A$, $H5^A$, $H4^F$, $H3^E$, $H5^F$, $H3^F$, $H2^F$, OCH_2 linker, $H2^C$, $H2^A$), 3.30−3.11 (m, 2H, CH_2N linker), 1.82 (s, 3H, CH_3 NHAc), 1.60−1.20 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 128.8, 128.7, 128.6, 128.53, 128.45, 102.8 ($C1^F$), 98.3 ($C1^B$), 97.9 ($C1^D$), 96.8 ($C1^A$), 94.0 ($C1^C$), 93.9 ($C1^E$), 83.5 ($C3^F$), 79.0 ($C3^E$), 78.9 ($C3^C$), 77.8 ($C3^A$), 76.6 ($C5^F$), 76.2 ($C4^E$), 75.4 (OCH_2Bn), 75.2 (OCH_2Bn), 75.2 (OCH_2Bn), 74.6 (OCH_2Bn), 74.5 ($C4^A$), 73.2 ($C2^F$), 72.4 ($C4^C$), 72.1 (OCH_2Bn), 71.9 (OCH_2Bn, $C5^A$), 71.5 ($C2^D$, $C4^F$), 71.1 ($C2^B$), 70.9 ($C5^E$), 70.5 ($C4^B$), 69.7 ($C3^D$), 69.4 ($C3^B$, $C5^C$, $C4^D$), 67.9 ($C5^B$, $C5^D$), 67.6 (CH_2Cbz), 67.6 (OCH_2 linker), 66.5 ($C6^C$), 63.3 ($C2^C$), 62.9 ($C2^A$), 59.7 ($C6^A$, $C6^E$), 52.2 ($C2^E$), 50.5 (NCH_2Bn), 46.9 (NCH_2 linker), 27.5 (CH_2 linker), 27.1 (CH_2 linker), 23.0 (CH_2 linker), 22.2 (CH_3 NHAc). HRMS (ESI): m/z calcd for $C_{100}H_{114}N_8O_{43}S_3$ $[M - 6Na + 4H]^{2-}$ 1105.8093, found 1105.8076.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-acetamino-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzy-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-2-deoxy-α-D-glucopyranoside (**38**).* Tetrakis-(triphenylphosphine)palladium(0) (13.7 mg, 12 μmol) was added to a solution of protected hexasaccharide **34** (32.0 mg, 12 μmol) in THF and H_2O (5.5 mL, 10:1 v/v). The reaction mixture was stirred at room temperature for 1 h. After TLC analysis indicated the completion of the reaction, a 2 M hydrochloric acid solution (0.12 mL, 0.24 mmol) was added directly to the reaction mixture. Stirring continued for 15 min. The progress of the reaction was monitored by TLC until it showed the completion of the reaction. The mixture was co-evaporated with toluene (2 × 3 mL), and the residue was dissolved in pyridine (1.0 mL), followed by the addition of Ac_2O (0.5 mL). After stirring for another 3 h at room temperature, the reaction mixture was concentrated under reduced pressure and purified by silica gel column chromatography using petroleum ether and EtOAc (1:1 v/v) as the eluent to afford the hexasaccharide intermediate as a white amorphous solid (25.6 mg, 85%). The resulting compound (25.6 mg, 10 μmol) was subjected to the Lev ester removal, *O*-sulfation, saponification, and de-*O*-acetylation reactions according to the general procedures to provide compound **38** as a white powder sodium salt (11.6 mg, 47% over three steps). ^1H NMR (600 MHz, D_2O): δ 7.56−7.18 (m, 40H, CH aromatic), 5.33 (s, 1H, $H1^D$), 5.31 (s, 1H, $H1^B$), 5.21−5.08 (m, 3H, $H1^C$, CH_2Cbz), 5.04−4.83 (m, 7H, C*H*HBn, 2 × CH_2Bn, C*H*HBn, $H1^A$), 4.82−4.78 (m, 2H, $H5^B$, $H5^D$), 4.75 (d, J = 2.7 Hz, 1H, $H1^E$), 4.73−4.66 (m, 3H, CH_2Bn, $H1^F$), 4.65−4.40 (m, 9H, CH_2Bn, C*H*HBn, C*H*HBn, $H6a^E$, $H2^B$, $H2^D$, NCH_2Bn), 4.38 (d, J = 10.6 Hz, 1H, $H6a^C$), 4.33 (d, J = 10.6 Hz, 1H, $H6b^C$), 4.28 (s, 1H, $H3^B$), 4.25−4.16 (m, 2H, $H6b^E$, $H4^B$), 4.14−3.84 (m, 11H, $H5^C$, $H5^E$, $H4^D$, $H3^D$, $H4^C$, $H2^E$, $H4^A$, $H4^E$, $H3^C$, $H6a^A$, $H6b^A$), 3.82−3.56 (m, 8H, $H3^E$, $H3^A$, $H5^F$, $H5^A$, $H4^F$, $H3^F$, OC*H*H linker, $H2^C$), 3.49 (d, J = 8.3 Hz, 1H, $H2^F$), 3.45−3.24 (m, 4H, OC*H*H linker, $H2^A$, CH_2N linker), 1.85 (s, 3H, CH_3 NHAc), 1.60−1.26 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 128.7, 128.60, 128.55, 128.47, 128.45, 128.4, 102.3 ($C1^F$), 98.3 ($C1^B$), 97.9 ($C1^D$), 96.9 ($C1^A$), 93.9 ($C1^C$), 93.5 ($C1^E$), 83.6 ($C3^F$), 78.8 ($C3^A$, $C3^C$, $C3^E$), 76.6 ($C5^F$), 75.5 (OCH_2Bn), 75.3 (OCH_2Bn), 75.2 ($C4^E$), 74.6 (2 × OCH_2Bn, $C4^A$), 73.1 ($C2^F$), 72.6 ($C4^C$), 72.1 (2 × OCH_2Bn), 71.6 ($C2^D$, $C5^A$, $C4^F$), 71.0 ($C2^B$), 70.5 ($C4^B$), 69.5 ($C3^D$, $C3^B$, $C5^C$, $C5^E$), 67.9 ($C5^B$, $C5^D$), 67.7 (CH_2Cbz), 67.6 (OCH_2 linker), 66.5 ($C6^C$), 65.9 ($C6^E$), 63.3 ($C2^C$), 62.7 ($C2^A$), 59.8 ($C6^A$), 51.8 ($C2^E$), 50.4 (NCH_2Bn), 47.0 (NCH_2 linker), 27.3 (CH_2 linker), 23.0 (CH_2 linker), 22.9 (CH_2 linker), 22.2 (CH_3 NHAc). HRMS (ESI): m/z calcd for $C_{100}H_{114}N_8O_{46}S_4$ $[M - 7Na + 5H]^{2-}$ 1145.7877, found 1145.7866.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-2-deoxy-α-D-glucopyranoside (**39**).* A solution of a hexasaccharide **35** (43.8 mg, 17 μmol) in a mixture of DCM and Et_3N (3 mL, 4:1 v/v, 10 mM) was stirred at ambient temperature for 2 h. The reaction was monitored until TLC analysis indicated the completion of the reaction. The reaction mixture was concentrated under reduced pressure, and the residue was dissolved in pyridine (2.0 mL), followed by the addition of acetic anhydride (0.5 mL). Stirring continued for 3 h until TLC analysis indicated the completion of the reaction. The reaction mixture was concentrated under reduced pressure, and the residue was dissolved in EtOAc (25 mL); washed with water (25 mL), a 1 N HCl solution (25 mL); water (25 mL); saturated bicarbonate (25 mL); and brine (25 mL), dried (Na_2SO_4), and filtered, and the filtrate was concentrated under reduced pressure. The residue was subjected to the Lev ester removal, *O*-sulfation, saponification, and de-*O*-acetylation reactions according to the general procedures to provide compound **39** as a white-powder sodium salt (13.4 mg, 35% over five steps). ^1H NMR (600 MHz, D_2O): δ 7.59−7.17 (m, 40H, CH aromatic), 5.30 (s, 2H, $H1^B$, $H1^D$), 5.21−5.10 (m, 3H, CH_2Cbz, $H1^C$), 5.08 (d, J = 10.8 Hz, 1H, C*H*HBn), 5.02−4.84 (m, 6H, CH_2Bn, C*H*HBn, C*H*HBn, $H1^A$, $H1^E$), 4.84−4.66 (m, 6H, $H5^B$, C*H*HBn, $H5^D$, C*H*HBn, C*H*HBn, C*H*HBn), 4.65−4.40 (m, 8H, C*H*HBn, $H1^F$ at 4.58, C*H*HBn, $H2^B$, $H2^D$, C*H*HBn, NCH_2Bn), 4.39−4.31 (m, 2H, $H6a^C$, $H6b^C$), 4.28−4.13 (m, 4H, $H4^B$, $H3^B$, $H4^D$, $H3^D$), 4.10−4.06 (m, 1H, $H5^C$), 4.02−3.70 (m, 14H, $H3^E$, $H4^C$, $H4^A$, $H4^E$, $H5^E$, $H3^C$, $H6a^A$, $H6b^A$, $H6a^E$, $H6b^E$, $H3^A$, $H4^F$, $H5^F$, $H5^A$), 3.70−3.24 (m, 9H, OC*H*H linker, $H3^F$, $H2^C$, $H2^F$, $H2^A$, $H2^E$, OC*H*H linker, CH_2N linker), 1.63−1.29 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 129.0, 128.7, 129.6, 128.5, 128.4, 102.7 ($C1^F$), 98.3 ($C1^B$, $C1^D$), 96.9 ($C1^A$), 94.4 ($C1^E$), 94.0 ($C1^C$), 83.6 ($C3^F$), 78.7 ($C3^C$, $C3^E$), 77.6 ($C3^A$), 76.8 ($C5^F$), 75.7 ($C4^E$), 75.5 (3 × OCH_2Bn), 74.6 (OCH_2Bn), 74.5 ($C4^A$), 73.3 ($C2^F$), 72.8 ($C4^C$), 72.3 (2 × OCH_2Bn), 71.6 ($C5^A$, $C4^F$), 71.4 ($C2^D$), 71.2 ($C5^E$), 71.0 ($C2^B$), 70.6 ($C4^D$), 70.2 ($C3^B$, $C3^D$), 69.7 ($C5^C$), 69.3 ($C4^B$), 67.9 ($C5^D$), 67.8 (OCH_2 linker), 67.74 ($C5^B$), 67.73 (CH_2Cbz), 66.5 ($C6^C$), 63.2 ($C2^C$), 62.9 ($C2^A$, $C2^E$), 59.6 ($C6^A$, $C6^E$), 50.5 (NCH_2Bn), 47.1 (NCH_2 linker), 27.3 (CH_2 linker), 23.0 (CH_2 linker). HRMS (ESI): m/z calcd for $C_{98}H_{112}N_{10}O_{42}S_3$ $[M - 6Na^+ + 4H^+]^{2-}$ 1097.7993, found 1097.7996.

*N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-azido-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-azido-3-O-benzy-2-deoxy-α-D-glucopyranoside (**40**).* A solution of a hexasaccharide **36** (80.0 mg, 30 μmol) in a mixture of DCM and Et_3N (3 mL, 4:1 v/v, 10 mM) was stirred at ambient temperature for 2 h. The reaction was monitored until TLC analysis indicated the completion of the reaction. The reaction mixture was concentrated under reduced pressure, and the residue was dissolved in pyridine (2 mL), followed by the addition of acetic anhydride (0.5 mL). Stirring was continued for 3 h until TLC analysis indicated the completion of the reaction. The mixture was concentrated under reduced pressure, and the residue was dissolved in EtOAc (25 mL); washed with water (25 mL), a 1 N HCl solution (25 mL), water (25 mL), saturated bicarbonate (25 mL), and brine (25 mL); dried (Na_2SO_4); and filtered, and the filtrate was concentrated under reduced pressure, the residue was subjected to Lev ester removal, *O*-sulfation, saponification, and de-*O*-acetylation reactions according to the general procedures to provide compound **40** as a white powder sodium salt (27.3 mg, 38% over five steps). ^1H NMR (600 MHz, D_2O): δ 7.54−7.17 (m, 40H, CH aromatic), 5.26 (s, 2H, $H1^B$, $H1^D$), 5.18−5.07 (m, 3H, CH_2Cbz, $H1^C$), 5.05 (d, J = 10.8 Hz, 1H, C*H*HBn), 4.95−4.79 (m, 8H, CH_2Bn, C*H*HBn, C*H*HBn, C*H*HBn, $H1^A$, $H1^E$, $H5^B$), 4.73 (s, 1H, $H5^D$), 4.71−4.39 (m, 13H, C*H*HBn, C*H*HBn, $H1^F$ at 4.64,

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CH_2Bn, CHHBn, NCH_2Bn, CHHBn, H6a^E, H2^B, H2^D, CHHBn), 4.36−4.29 (m, 2H, H6a^C, H6b^C), 4.26 (s, 1H, H4^B), 4.20−4.12 (m, 3H, H6b^E, H3^B, H4^D), 4.10−4.02 (m, 3H, H3^D, H5^C, H5^E), 4.00−3.82 (m, 7H, H4^C, H3^E, H4^A, H4^E, H3^C, H6a^A, H6b^A), 3.80−3.21 (m, 13H, H3^A, H4^F, H5^F, H5^A, OCHH linker, H3^F, H2^C, H2^F, H2^A, H2^E, OCHH linker, CH_2N linker), 1.60−1.20 (m, 6H, 3 × CH_2 linker). ^{13}C{^{1}H} NMR (151 MHz, D_2O): δ 128.9, 128.60, 128.55, 128.5, 128.4, 102.1 (C1^F), 98.3 (C1^B, C1^D), 96.8 (C1^A), 93.84 (C1^C), 93.76 (C1^E), 83.6 (C3^F), 78.9 (C3^C), 78.4 (C3^E), 77.6 (C3^A), 76.8 (C5^F), 75.5 (OCH_2Bn), 75.3 (2 × OCH_2Bn), 74.9 (C4^A, C4^E), 74.6 (OCH_2Bn), 73.1 (C2^F), 72.7 (C4^C), 72.3 (OCH_2Bn), 72.0 (OCH_2Bn), 71.7 (C5^A, C4^F), 71.5 (C2^D), 71.2 (C2^B), 70.4 (C3^B), 69.8 (C4^D), 69.7 (C3^D), 69.4 (C5^C, C5^E), 69.3 (C4^B), 68.0 (C5^B), 67.8 (C5^D), 67.6 (CH_2Cbz), 67.5 (OCH$_2$ linker), 66.4 (C6^C), 65.8 (C6^E), 63.2 (C2^C), 62.4 (C2^A, C2^E), 59.8 (C6^A), 50.5 (NCH_2Bn), 47.0 (NCH$_2$ linker), 27.3 (CH$_2$ linker), 23.0 (CH$_2$ linker). HRMS (ESI): m/z calcd for $C_{98}H_{110}N_{10}O_{45}S_4$ $[M - 7Na + 5H]^{2-}$ 1137.7777, found 1137.7744.

N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-acetamino-3-O-benzyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-sulfamino-3-O-benzy-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-3-O-benzy-2-deoxy-α-D-glucopyranoside (**41**). The azido group of compound **37** (14.1 mg, 6.0 μmol) was reduced to a free amine, followed by *N*-sulfation according to the general procedures, to give compound **41** as a white-powder sodium salt (8.9 mg, 60% over two steps). ^{1}H NMR (600 MHz, D_2O): δ 7.49−7.16 (m, 40H, CH aromatic), 5.46 (s, 1H, H1^D), 5.31 (s, 1H, H1^C), 5.29 (s, 1H, H1^B), 5.18−5.08 (m, 2H, CH_2Cbz), 5.00 (bd, 1H, H1^A), 4.92 (d, J = 11.4 Hz, 1H, CHHBn), 4.87−4.61 (m, 12H, 4 × CH_2Bn, CHHBn, H5^B at 4.77, H1^E at 4.75, H5^D at 4.71), 4.56−4.41 (m, 6H, H1^F at 4.53, CH_2Bn, NCH_2Bn, H2^D at 4.48), 4.39−4.27 (m, 3H, H6a^C, H6b^C, H3^B), 4.25 (s, 1H, H4^B), 4.12−4.07 (m, 1H, H5^C), 4.03 (s, 2H, H3^D, H4^D), 3.96−3.50 (m, 17H, H2^E, H4^C, H5^E, H4^A, H4^E, H6a^A, H6b^A, H6a^E, H6b^E, H5^A, H3^E, H3^C, H4^F, H5^F, H3^A, H3^F, OCHH linker), 3.48 (t, J = 8.6 Hz, 1H, H2^F), 3.44−3.31 (m, 2H, OCHH linker, H2^C), 3.30−3.20 (m, 3H, CH_2N linker, H2^A), 1.81 (s, 3H, CH_3 NHAc), 1.60−1.20 (m, 6H, 3 × CH_2 linker). ^{13}C{^{1}H} NMR (151 MHz, D_2O): δ 129.0, 128.60, 128.59, 128.5, 102.9 (C1^F), 98.6 (C1^C), 98.1 (C1^D), 97.8 (C1^B), 97.1 (C1^A), 93.8 (C1^E), 83.6 (C3^F), 79.2 (C3^E), 77.9 (C3^C), 76.81 (C3^A), 76.75 (C5^F), 76.3 (C4^E), 75.2 (C4^B), 75.1 (OCH_2Bn, C4^A), 75.01 (OCH_2Bn), 74.98 (OCH_2Bn), 74.9 (C3^B), 74.6 (OCH_2Bn), 73.5 (C4^C), 73.2 (C2^F), 72.5 (OCH_2Bn), 72.0 (C2^B), 71.8 (OCH_2Bn), 71.5 (C5^A, C4^F), 71.2 (C2^D, C5^E), 69.7 (C5^C), 69.3 (C3^D, C4^D), 68.3 (C5^B), 68.1 (OCH$_2$ linker), 68.0 (C5^D), 67.6 (CH_2Cbz), 66.7 (C6^C), 59.9 (C6^A, C6^E), 58.3 (C2^C), 57.5 (C2^A), 52.3 (C2^E), 50.5 (NCH_2Bn), 47.2 (NCH$_2$ linker), 27.3 (CH$_2$ linker), 22.9 (CH$_2$ linker), 22.3 (CH$_3$ NHAc). HRMS (ESI): m/z calcd for $C_{100}H_{118}N_4O_{49}S_5$ $[M - 8Na + 6H]^{2-}$ 1159.7756, found 1159.7742.

N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-acetamino-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-sulfamino-3-O-benzy-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-3-O-benzy-2-deoxy-α-D-glucopyranoside (**42**). The azido group of compound **38** (9.4 mg, 3.8 μmol) was reduced to a free amine, followed by *N*-sulfation according to the general procedures, to give compound **42** as a white-powder sodium salt (4.0 mg, 40% over two steps). ^{1}H NMR (600 MHz, D_2O): δ 7.56−7.11 (m, 40H, CH aromatic), 5.46 (s, 1H, H1^D), 5.31 (s, 1H, H1^C), 5.26 (s, 1H, H1^B), 5.17−5.08 (m, 2H, CH_2Cbz), 5.04−4.98 (m, 1H, H1^A), 4.92−4.61 (m, 15H, 5 × CH_2Bn, CHHBn, H5^B, H5^D, H1^E at 4.73, H1^F at 4.64), 4.59 (s, 1H, H2^B), 4.55−4.44 (m, 5H, CHHBn, H6a^E, H2^D, NCH_2Bn), 4.37−4.27 (m, 3H, H6a^C, H6b^C, H3^B), 4.24 (s, 1H, H4^B), 4.20 (d, J = 11.0 Hz, 1H, H6b^E), 4.12−4.02 (m, 3H, H5^C, H5^E, H3^D), 3.99−3.81 (m, 7H, H4^D, H2^E, H4^C, H4^A, H4^E, H6a^A, H6b^A), 3.78−3.22 (m, 14H, H5^A, H3^E, H3^C, H4^F, H5^F, H3^A, H3^F, OCHH linker, H2^F, H2^C, OCHH linker, H2^A, CH_2N linker), 1.80 (s, 3H, CH_3 NHAc), 1.54−1.20 (m, 6H, 3 × CH_2 linker). ^{13}C{^{1}H} NMR (151 MHz, D_2O): δ 129.0, 128.47, 128.46, 128.4, 127.7, 102.2 (C1^F), 98.7 (C1^C), 97.8 (C1^D, C1^B), 97.0 (C1^A), 93.3 (C1^E), 83.6 (C3^F), 78.7 (C3^E), 77.2 (C3^C), 77.0 (C3^A), 76.6 (C5^F), 75.2 (OCH_2Bn), 75.0 (OCH_2Bn, C4^A, C4^B), 74.6 (2 × OCH_2Bn, C3^B), 73.1 (C4^C, C2^F), 72.4 (OCH_2Bn), 71.8 (C2^B, OCH_2Bn), 71.6 (C5^A, C4^F), 71.0 (C2^D), 69.5 (C3^D), 68.9 (C4^D), 68.2 (C5^C, C5^E), 68.0 (OCH$_2$ linker), 67.6 (C5^D, C5^B, CH_2Cbz), 66.5 (C6^C), 65.7 (C6^E), 60.2 (C6^A), 58.3 (C2^C), 57.4 (C2^A), 51.7 (C2^E), 50.5 (NCH_2Bn), 47.1 (NCH$_2$ linker), 28.0 (CH$_2$ linker), 27.0 (CH$_2$ linker), 22.8 (CH$_2$ linker), 22.2 (CH$_3$ NHAc). HRMS (ESI): m/z calcd for $C_{100}H_{118}N_4Na_2O_{52}S_6$ $[M - 7Na + 5H]^{2-}$ 1221.7360, found 1221.7337.

N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-sulfamino-3-O-benzyl-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-sulfamino-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-3-O-benzy-2-deoxy-α-D-glucopyranoside (**43**). The azido group of compound **39** (13.4 mg, 5.8 μmol) was reduced to a free amine, followed by *N*-sulfation according to the general procedures, to give compound **43** as a white-powder sodium salt (6.8 mg, 46% over two steps). ^{1}H NMR (600 MHz, D_2O): δ 7.58−7.14 (m, 40H, CH aromatic), 5.49 (s, 1H, H1^B), 5.39 (s, 1H, H1^D), 5.32−5.27 (m, 2H, H1^C, H1^E), 5.20−5.09 (m, 2H, CH_2Cbz), 5.00 (bd, 1H, H1^A), 4.91−4.64 (m, 11H, H5^B, H5^D, 4 × CH_2 Bn, CHHBn), 4.60 (s, 2H, H2^B, H2^D), 4.56−4.42 (m, 7H, H1^F at 4.54, NCH_2Bn, CH_2Bn, CHHBn, H6a^C), 4.36−4.22 (m, 4H, H6b^C, H3^B, H4^B, H3^D), 4.18 (s, 1H, H4^D), 4.12−4.08 (m, 1H, H5^C), 3.97−3.49 (m, 16H, H4^C, H5^E, H4^E, H4^A, H6a^A, H6b^A, H3^E, H6a^E, H6b^E, H5^A, H3^C, H4^F, H5^F, H3^A, H3^F, OCHH linker), 3.44−3.30 (m, 4H, OCHH linker, H2^C, H2^E, H2^F), 3.30−3.20 (m, 3H, CH_2N linker, H2^A), 1.60−1.18 (m, 6H, 3 × CH_2 linker). ^{13}C{^{1}H} NMR (151 MHz, D_2O): δ 129.3, 129.2, 128.79, 128.75, 128.7, 128.60, 128.3, 102.7 (C1^F), 98.5 (C1^E, C1^C), 97.9 (C1^B), 97.4 (C1^D), 97.1 (C1^A), 83.6 (C3^F), 78.0 (C3^E), 77.7 (C3^C), 76.5 (C5^F, C3^A), 75.5 (C4^A, C4^E), 75.4 (OCH_2Bn), 75.14 (C3^D), 75.06 (OCH_2Bn, C4^D), 75.0 (C3^B, C4^B), 74.5 (OCH_2Bn), 73.3, 72.62 (C4^C), 72.56 (OCH_2Bn), 72.3 (C2^B, C2^D), 71.5 (C5^A, C4^F), 71.2 (C5^E), 69.8 (C5^C), 68.6 (C5^D), 68.3 (C5^B), 68.1 (OCH$_2$ linker), 67.7 (CH_2Cbz), 66.9 (C6^C), 60.2 (C6^A or C6^E), 59.9 (C6^A or C6^E), 58.1 (C2^C, C2^E), 57.4 (C2^A), 50.6 (NCH_2Bn), 47.2 (NCH$_2$ linker), 27.3 (CH$_2$ linker), 23.0 (CH$_2$ linker). HRMS (ESI): m/z calcd for $C_{98}H_{116}N_4O_{51}S_6$ $[M - 9Na^+ + 7H^+]^{2-}$ 1178.7488, found 1178.7486.

N-(Benzyl)-benzyloxycarbonyl-5-aminopentyl O-(3-O-Benzyl-β-D-glucopyranosyluronate)-(1 → 4)-O-(2-sulfamino-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-(2-sulfamino-3-O-benzyl-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-3-O-benzyl-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-3-O-benzy-2-deoxy-α-D-glucopyranoside (**44**). The azido group of compound **40** (22.0 mg, 9.1 μmol) was reduced to a free amine, followed by *N*-sulfation according to the general procedures, to give compound **44** as a white-powder sodium salt (11.9 mg, 49% over two steps). ^{1}H NMR (600 MHz, D_2O): δ 7.62−7.14 (m, 40H, CH aromatic), 5.48 (s, 1H, H1^B), 5.39 (s, 1H, H1^D), 5.29 (d, J = 3.0 Hz, 2H, H1^C, H1^E), 5.17−5.09 (m, 2H, CH_2Cbz), 5.00 (bd, 1H, H1^A), 4.88−4.65 (m, 11H, 4 × CH_2 Bn, CHHBn, H5^B, H5^D), 4.64 (d, J = 7.3 Hz, 1H, H1^F), 4.60 (s, 2H, H2^D, H2^B), 4.56−4.40 (m, 7H, NCH_2Bn, CH_2Bn, CHHBn, H6a^E, H6a^C), 4.34−4.16 (m, 6H, H6b^C, H3^B, H4^B, H3^D, H4^D, H6b^E), 4.08 (d, J = 9.0 Hz, 1H, H5^C), 4.05 (d, J = 9.6 Hz, 1H, H5^E), 3.97−3.77 (m, 6H, H4^E, H4^C, H4^A, H3^E, H6a^A, H6b^A), 3.74−3.51 (m, 7H, H4^A, H4^F, H5^F, H3^C, H3^A, H3^F, OCHH linker), 3.44 (dd, J = 10.8, 3.3 Hz, 1H, H2^E), 3.42−3.31 (m, 4H, OCHH linker, H2^C, H2^F), 3.30−3.19 (m, 3H, CH_2N linker, H2^A), 1.60−1.18 (m, 6H, 3 × CH_2 linker). ^{13}C{^{1}H} NMR (151 MHz, D_2O): δ 129.2, 129.0, 128.61, 128.58, 128.4, 128.1, 102.0 (C1^F), 98.1 (C1^E, C1^C), 97.7 (C1^B), 97.3 (C1^D), 96.9 (C1^A), 83.6 (C3^F), 77.6 (C5^F), 77.4 (C3^E), 76.5 (C3^C), 76.4 (C3^A), 75.4 (OCH_2Bn), 75.0 (OCH_2Bn), 74.9 (C4^A), 74.78 (C4^B, C3^D), 74.75 (C4^D), 74.71 (C3^B), 74.65 (C4^E), 74.5 (OCH_2Bn), 73.7 (OCH_2Bn), 73.1 (C2^F), 72.5 (OCH_2Bn), 72.39 (OCH_2Bn), 72.38 (C4^C), 72.1 (C2^B, C2^D),

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71.5 ($C5^A$, $C4^F$), 69.6 ($C5^C$), 69.4 ($C5^E$), 68.3 ($C5^D$), 68.1 ($C5^B$), 67.9 (OCH_2 linker), 67.6 (CH_2Cbz), 66.7 ($C6^C$), 60.1 ($C6^E$, $C6^A$), 58.2 ($C2^C$), 57.3 ($C2^A$), 57.2 ($C2^E$), 50.4 (NCH_2Bn), 47.1 (NCH_2 linker), 27.1 (CH_2 linker), 22.9 (CH_2 linker). HRMS (ESI): m/z calcd for $C_{98}H_{114}N_4Na_2O_{54}S_7$ $[M - 8Na + 6H]^{2-}$ 1240.7091, found 1240.7044.

*5-Aminopentyl O-(β-D-Glucopyranosyluronate)-(1 → 4)-O-(2-acetamino-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-(2-sulfamino-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-2-deoxy-α-D-glucopyranoside (**45**).* Compound **41** (5.2 mg, 2.1 μmol) was subjected to global deprotection according to the general procedure to give the title compound **45** as a white-powder sodium salt (3.3 mg, 92%). ^{1}H NMR (600 MHz, D_2O): δ 5.43 (s, 1H, $H1^C$), 5.26 (s, 1H, $H1^B$), 5.16 (s, 1H, $H1^D$), 5.12 (d, J = 3.0 Hz, 2H, $H1^A$, $H1^E$), 4.91 (s, 1H, $H5^D$), 4.67 (bs, 1H, $H5^B$), 4.47 (d, J = 7.7 Hz, 1H, $H1^F$), 4.32−4.23 (m, 5H, $H2^D$, $H2^B$, $H6a^C$, $H6b^C$, $H3^D$), 4.17−4.14 (m, 1H, $H3^B$), 4.09 (t, J = 3.3 Hz, 1H, $H4^B$), 4.04−3.96 (m, 3H, $H5^C$, $H4^D$, $H2^E$), 3.92−3.66 (m, 13H, $H6a^A$, $H6b^A$, $H6a^E$, $H6b^E$, $H5^E$, $H3^A$, $H3^E$, $H4^C$, $H5^A$, $H5^F$, $H4^A$, $H4^E$, OCH*H* linker), 3.66−3.61 (m, 1H, $H3^C$), 3.55−3.47 (m, 3H, OCH*H* linker, $H4^F$, $H3^F$), 3.39−3.35 (m, 1H, $H2^F$), 3.32−3.22 (m, 2H, $H2^C$, $H2^A$), 3.01 (t, J = 7.1 Hz, 2H, CH_2N linker), 2.03 (s, 3H, CH_3 NHAc), 1.76−1.42 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 102.1 ($C1^F$), 98.9 ($C1^D$), 97.8 ($C1^B$), 96.9 ($C1^A$), 95.7 ($C1^C$), 93.2 ($C1^E$), 77.4 ($C4^A$, $C4^E$), 76.9 ($C2^B$), 75.8 ($C5^A$, $C4^C$, $C5^F$), 75.7 ($C4^B$), 75.1 ($C3^F$), 73.7 ($C2^D$), 72.8 ($C2^F$), 71.7 ($C4^F$), 70.8 ($C4^D$), 70.5 ($C5^E$), 69.8 ($C3^E$), 69.7 ($C5^B$), 69.6 ($C3^B$), 69.5 ($C3^C$), 69.2 ($C5^C$), 68.3 ($C3^A$), 67.8 ($C5^D$), 67.6 (OCH_2 linker), 66.3 ($C6^C$), 64.1 ($C3^D$), 59.4 ($C6^A$, $C6^E$), 57.9 ($C2^C$, $C2^A$), 52.9 ($C2^E$), 39.5 (CH_2N linker), 28.0 (CH_2 linker), 26.4 (CH_2 linker), 22.6 (CH_2 linker), 22.1 (CH_3 NHAc). HRMS (ESI): m/z calcd for $C_{43}H_{69}N_4NaO_{47}S_5$ $[M - 7Na + 5H]^{2-}$ 788.0822, found 788.0804.

*5-Aminopentyl O-(β-D-Glucopyranosyluronate)-(1 → 4)-O-(2-acetamino-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-(2-sulfamino-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-2-deoxy-α-D-glucopyranoside (**46**).* Compound **42** (2.4 mg, 0.9 μmol) was subjected to global deprotection according to the general procedure to give the title compound **46** as a white-powder sodium salt (1.3 mg, 77%). ^{1}H NMR (600 MHz, D_2O): δ 5.42 (bs, 1H, $H1^C$), 5.26 (s, 1H, $H1^B$), 5.16 (s, 1H, $H1^D$), 5.14−5.10 (m, 2H, $H1^E$, $H1^A$), 4.92 (s, 1H, $H5^D$), 4.68 (s, 1H, $H5^B$), 4.56 (d, J = 7.9 Hz, 1H, $H1^F$), 4.44 (d, J = 10.7 Hz, 1H, $H6a^E$), 4.33−4.21 (m, 6H, $H2^D$, $H2^B$, $H6a^C$, $H6b^C$, $H6b^E$, $H3^D$), 4.18−4.15 (m, 1H, $H3^B$), 4.11−4.07 (m, 2H, $H4^B$, $H5^E$), 4.04−3.99 (m, 3H, $H4^D$, $H5^C$, $H2^E$), 3.88−3.66 (m, 10H, $H6a^A$, $H6b^A$, $H4^A$, $H3^A$, $H3^E$, $H4^C$, $H4^E$, $H5^F$, $H5^A$, OCH*H* linker), 3.66−3.60 (m, 1H, $H3^C$), 3.55−3.46 (m, 3H, OCH*H* linker, $H3^F$, $H4^F$), 3.34 (t, J = 8.4 Hz, 1H, $H2^F$), 3.26 (dd, J = 10.0, 3.1 Hz, 1H, $H2^C$), 3.22 (dd, J = 10.1, 3.1 Hz, 1H, $H2^A$), 3.01 (t, J = 7.1 Hz, 2H, CH_2N linker), 2.04 (s, 3H, CH_3 NHAc), 1.77−1.42 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 101.8 ($C1^F$), 99.0 ($C1^D$), 97.7 ($C1^B$), 96.9 ($C1^A$), 95.9 ($C1^C$), 93.4 ($C1^E$), 77.1 ($C5^A$), 76.8 ($C2^B$), 76.5 ($C4^C$, $C4^E$), 75.9 ($C5^F$), 75.7 ($C4^B$), 74.9 ($C3^F$), 73.8 ($C2^D$), 72.9 ($C2^F$), 71.9 ($C4^F$), 71.1 ($C4^D$), 70.4 ($C4^A$), 69.70 ($C5^B$), 69.65 ($C3^E$), 69.6 ($C3^C$), 69.4 ($C3^B$), 69.2 ($C5^C$), 68.8 ($C5^E$), 68.5 ($C3^A$), 67.8 ($C5^D$), 67.6 (OCH_2 linker), 66.3 ($C6^C$), 65.8 ($C6^E$), 64.2 ($C3^D$), 60.2 ($C6^A$), 57.9 ($C2^C$, $C2^A$), 52.8 ($C2^E$), 39.5 (CH_2N linker), 28.0 (CH_2 linker), 26.4 (CH_2 linker), 22.7 (CH_2 linker), 22.2 (CH_3 NHAc). HRMS (ESI): m/z calcd for $C_{43}H_{69}N_4NaO_{50}S_6$ $[M - 8Na + 6H]^{2-}$ 828.0606, found 828.0595.

*5-Aminopentyl O-(β-D-Glucopyranosyluronate)-(1 → 4)-O-(2-sulfamino-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-(2-sulfamino-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-2-deoxy-α-D-glucopyranoside (**47**).* Compound **43** (6.8 mg, 2.7 μmol) was subjected to global deprotection according to the general procedure to give the title compound **47** as a white-powder sodium salt (4.2 mg, 88%).^{1}H NMR (600 MHz, D_2O): δ 5.45 (d, J = 3.6 Hz, 1H, $H1^C$), 5.41 (d, J = 3.5 Hz, 1H, $H1^E$), 5.29 (d, J = 3.6 Hz, 1H, $H1^B$), 5.22 (d, J = 3.0 Hz, 1H, $H1^D$), 5.14 (d, J = 3.5 Hz, 1H, $H1^A$), 4.82 (1H, $H5^D$), 4.70 (d, J = 2.9 Hz, 1H, $H5^B$), 4.52 (d, J = 7.9 Hz, 1H, $H1^F$), 4.40 (dd, J = 11.5, 2.9 Hz, 1H, $H6a^C$), 4.35−4.30 (m, 2H, $H2^D$, $H2^B$), 4.28 (dd, J = 11.5, 2.2 Hz, 1H, $H6b^C$), 4.22 (dd, J = 5.8, 3.7 Hz, 1H, $H3^D$), 4.19 (dd, J = 6.6, 3.9 Hz, 1H, $H3^B$), 4.12 (t, J = 3.6 Hz, 1H, $H4^B$), 4.09 (t, J = 3.3 Hz, 1H, $H4^D$), 4.03−4.00 (m, 1H, $H5^C$), 3.97−3.69 (m, 13H, $H6a^A$, $H6b^A$, $H6a^E$, $H6b^E$, $H5^E$, $H5^A$, $H3^A$, $H4^C$, $H5^F$, $H3^E$, $H4^A$, $H4^E$, OCH*H* linker), 3.66−3.61 (m, 1H, $H3^C$), 3.58−3.49 (m, 3H, OCH*H* linker, $H4^F$, $H3^F$), 3.44−3.38 (m, 1H, $H2^F$), 3.32−3.22 (m, 3H, $H2^C$, $H2^E$, $H2^A$), 3.05 (t, J = 7.3 Hz, 2H, CH_2N linker), 1.77−1.47 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 102.2 ($C1^F$), 99.2 ($C1^D$), 97.8 ($C1^B$), 96.9 ($C1^A$), 96.5 ($C1^E$), 96.1 ($C1^C$), 77.5 ($C4^E$, $C4^A$), 76.7 ($C2^B$), 75.9 ($C2^D$), 75.9 ($C4^B$), 75.8 ($C4^D$), 75.8 ($C4^C$, $C5^F$), 75.1 ($C4^F$), 72.8 ($C2^F$), 71.8 ($C3^F$), 70.6 ($C5^E$), 70.4 ($C5^A$), 69.8 ($C5^B$), 69.6 ($C3^C$), 69.5 ($C3^E$), 69.4 ($C3^B$), 69.3 ($C5^C$), 69.2 ($C5^D$), 69.1 ($C3^D$), 68.5 ($C3^A$), 67.7 (OCH_2 linker), 66.4 ($C6^C$), 59.6 ($C6^A$, $C6^E$), 57.9 ($C2^C$, $C2^E$, $C2^A$), 39.5 (NCH_2 linker), 28.0 (CH_2 linker), 26.4 (CH_2 linker), 22.6 (CH_2 linker). HRMS (ESI): m/z calcd for $C_{41}H_{68}N_4O_{49}S_6$ $[M - 9Na + 7H]^{2-}$ 796.0644, found 796.0635.

*5-Aminopentyl O-(β-D-Glucopyranosyluronate)-(1 → 4)-O-(2-sulfamino-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-(2-sulfamino-6-O-sulfate-2-deoxy-α-D-glucopyranosyl)-(1 → 4)-O-(2-O-sulfate-α-L-idopyranosyluronate)-(1 → 4)-O-2-sulfamino-2-deoxy-α-D-glucopyranoside (**48**).* Compound **44** (6.2 mg, 2.3 μmol) was subjected to global deprotection according to the general procedure to give the title compound as a white-powder sodium salt (4.0 mg, 90%). ^{1}H NMR (600 MHz, D_2O): δ 5.43−5.38 (m, 2H, $H1^C$, $H1^E$), 5.26 (bs, 1H, $H1^B$), 5.20 (s, 1H, $H1^D$), 5.11 (d, J = 3.2 Hz, 1H, $H1^A$), 4.80 (s, 1H, $H5^D$), 4.68 (s, 1H, $H5^B$), 4.58 (d, J = 7.9 Hz, 1H, $H1^F$), 4.46 (d, J = 11.0 Hz, 1H, $H6a^E$), 4.38 (d, J = 10.4 Hz, 1H, $H6a^C$), 4.33−4.27 (m, 2H, $H2^D$, $H2^B$), 4.25 (d, J = 10.5 Hz, 1H, $H6b^C$), 4.21 (d, J = 10.5 Hz, 1H, $H6b^E$), 4.19−4.15 (m, 2H, $H3^D$, $H3^B$), 4.11−4.05 (m, 3H, $H4^B$, $H4^D$, $H5^C$), 4.01−3.97 (m, 1H, $H5^E$), 3.89−3.65 (m, 10H, $H6a^A$, $H6b^A$, $H4^A$, $H3^A$, $H4^C$, $H4^E$, $H5^F$, $H3^C$, $H5^A$, OCH*H* linker), 3.65−3.58 (m, 1H, $H3^E$), 3.55−3.46 (m, 3H, OCH*H* linker, $H3^F$, $H4^F$), 3.33 (bt, J = 8.5 Hz, 1H, $H2^F$), 3.26 (dd, J = 10.4, 3.0 Hz, 2H, $H2^C$, $H2^E$), 3.22 (dd, J = 10.1, 3.1 Hz, 1H, $H2^A$), 3.01 (t, J = 7.1 Hz, 2H, CH_2N linker), 1.78−1.42 (m, 6H, 3 × CH_2 linker). $^{13}C\{^1H\}$ NMR (151 MHz, D_2O): δ 101.8 ($C1^F$), 99.1 ($C1^D$), 97.7 ($C1^B$), 96.9 ($C1^A$), 96.4 ($C1^C$), 96.2 ($C1^E$), 77.1 ($C5^A$), 76.6 ($C2^B$), 75.80 ($C2^D$, $C4^C$, $C4^E$, $C5^F$), 75.77 ($C4^B$, $C4^D$), 75.0 ($C3^F$), 72.9 ($C2^F$), 71.9 ($C4^F$), 70.4 ($C4^A$), 69.6 ($C5^B$), 69.5 ($C3^E$), 69.3 ($C3^C$), 69.2 ($C5^E$), 69.1 ($C5^D$, $C3^B$, $C3^D$), 68.7 ($C5^C$), 68.5 ($C3^A$), 67.7 (OCH_2 linker), 66.4 ($C6^C$), 65.8 ($C6^E$), 60.2 ($C6^A$), 57.7 ($C2^C$, $C2^E$, $C2^A$), 39.5 (CH_2N linker), 28.0 (CH_2 linker), 26.3 (CH_2 linker), 22.6 (CH_2 linker). HRMS (ESI): m/z calcd for $C_{41}H_{68}N_4O_{52}S_7$ $[M - 10Na + 8H]^{2-}$ 836.0428, found 836.0469.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge at https://pubs.acs.org/doi/10.1021/acs.joc.0c01881.

Copies of NMR spectra (PDF)

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Notes

The authors declare no competing financial interest.

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