DOI: 10.1002/chem.200900740

From Polymer to Size-Defined Oligomers: A Step Economy Process for the Efficient and Stereocontrolled Construction of Chondroitin Oligosaccharides and Biotinylated Conjugates Thereof: Part 1

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Abstract: Controlled acid hydrolysis of polymeric chondroitin sulfate of bovine origin afforded in good yield a basic disaccharide fragment that was used for the first time as a starting material for the expeditious preparation of a set of building blocks that in turn act as versatile synthons for the efficient and stereocontrolled construction of a collection of size-defined chondroitin oligomers (from di- to octasaccharides). This step economy process allows their preparation as reducing species, fitted with a fluorophore, or as biotinylated conjugates; all useful tools for the preparation of microarrays, or as probes for the study of the biosynthesis of chondroitin sulfate.

Keywords: biotinylated sugars · carbohydrates · chondroitin · glycosylation · oligosaccharides

Introduction

Chondroitin sulfates (CSs) are naturally occurring heteropolysaccharides that belong to a family of complex, polyanionic, linear polymers called glycosaminoglycans (GAGs). They exist predominantly as polysaccharide side chains of proteoglycans (PGs) in extracellular matrixes. They are built from a repeating dimeric unit composed of D-glucuronic acid (GlcA) and 2-acetamido-2-deoxy-D-galactose (GalNAc) arranged in the sequence $[\rightarrow 4)$-β-D-Glc*p*A-$(1\rightarrow 3)$-β-D-Gal*p*-NAc-$(1\rightarrow]_n$, and bearing sulfate groups at various positions.[1] They are widely distributed among various tissues and exhibit a large variety of biological functions.[2] Biosynthesis of chondroitin is catalyzed by specific glycosyltransferases[3] using UDP-GlcA and UDP-GalNAc as glycosyl donors in the Golgi apparatus.[4] Recently, a human chondroitin synthase (ChSy) having both glucuronyltransferase and *N*-acetylgalactosaminyltransferase activity was expressed and cloned,[5] but chondroitin polymerization was not demonstrated. In fact, polymerizing activity requires concomitant expression of a chondroitin polymerizing factor (ChPF).[6] However, the substrate specificity of these enzymes—that is, from which structure polymerization begins—remains a matter of controversy.[7] Therefore, a facile and efficient method for the synthesis of size-defined chondroitin oligomers is urgently required. An in vitro enzymatic synthesis of chondroitin based on the polymerization of an oxazoline derived from the basic disaccharide catalyzed by hyaluronidase has been reported,[8] but this technique did not allow the preparation of size-defined small fragments.

A defect in the biosynthesis of GAGs has been observed in several pathological conditions such as cancer, atherosclerosis, fibrosis, and osteoarthritis (OA), thereby leading, in the latter case, to a progressive loss of cartilage tissue and joint functions. OA is a very common degenerative joint disease and a leading cause of disability with an increasing socioeconomic impact. Current pharmaceutical interventions that address chronic pain are insufficient, and no proven disease-modifying therapy is available to date. Therefore, there is an urgent need to develop new therapies by identifying pharmacological targets to design new drugs. Aggrecan, a CS polymer, is the major component of cartilage matrix, and its anabolism is greatly affected by OA. In this context, the glycosyltransferases involved in the polymerization of CS chains are crucial enzymes whose activity determines the biosynthesis rate.

Within a program devoted to the study of the biosynthetic pathways of CS chains in relation with OA, we recently disclosed the possible chemical synthesis of size-defined chondroitin oligomers by semisynthesis starting from a CS poly-

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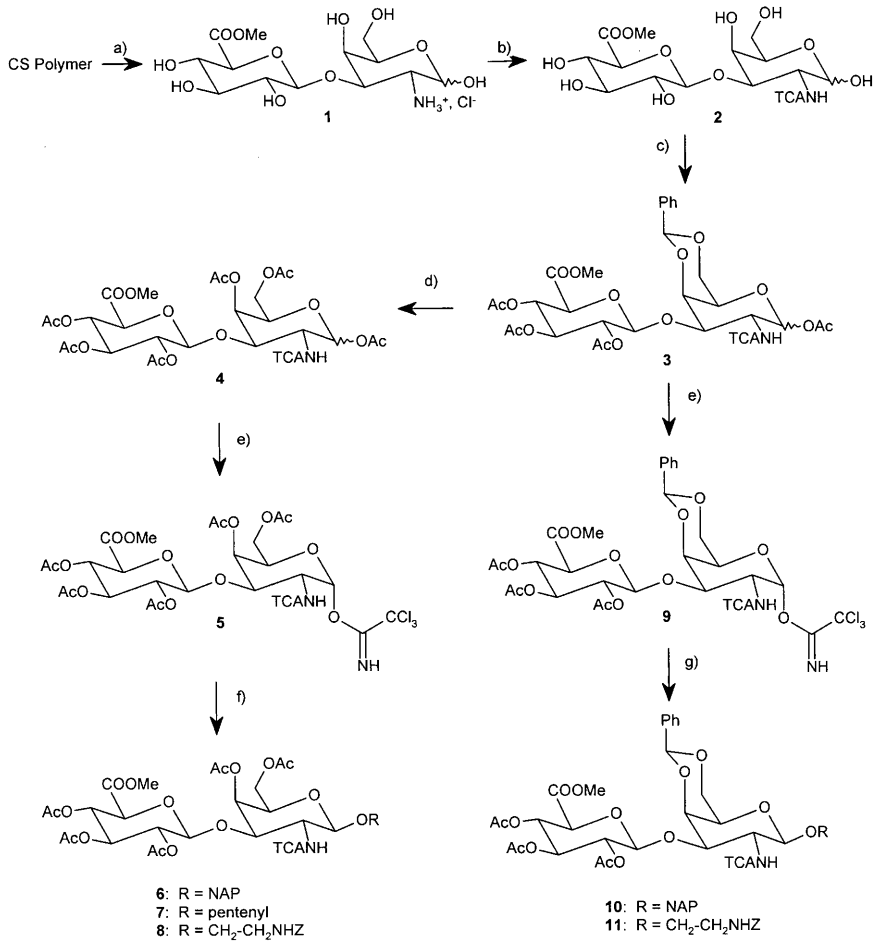
Supporting information for this article is available on the WWW under http://dx.doi.org/10.1002/chem.200900740.

mer.[9] Herein we describe the development of this step economy process for the straightforward construction of nonsulfated chondroitin oligomers and their biotinylated conjugates as probes for the study of the biosynthesis of CS.

Results and Discussion

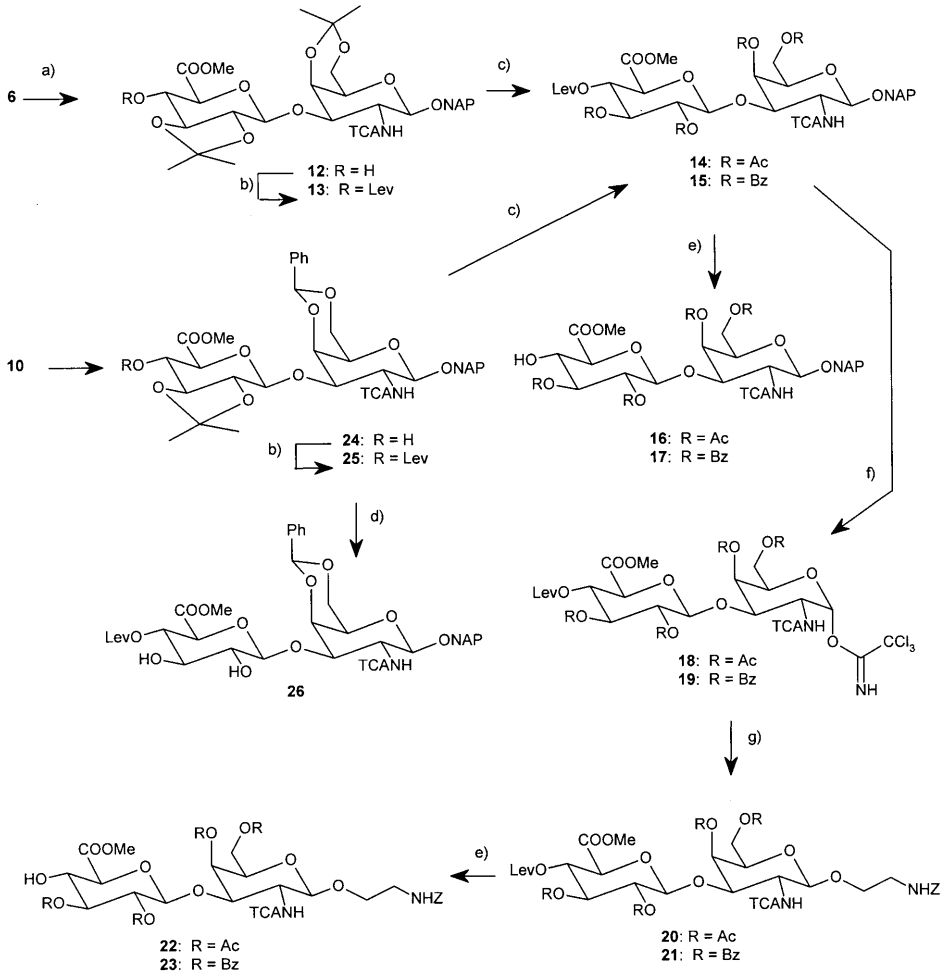
To prepare chondroitin oligomers, synthetic routes should ideally provide ready access to starting materials and involve a limited number of steps. The basic disaccharide repeating unit of CS is composed of D-galactosamine, a rare and expensive sugar, and of D-glucuronic acid, a not easily available species. A practical approach was found in the use of natural CS polymer of bovine origin, now commercially available at reasonable cost. In their seminal studies on the structure of CS, Levene[10] and Meyer and Davidson[11] demonstrated that acid hydrolysis of the native polymer afford the basic disaccharide unit, a process that also results in complete desulfation and N-deacetylation. Thus, starting from a heterogeneously sulfated polymer of variable length, a single synthon that still has the correct backbone of the basic disaccharide can be obtained in good yield in a simple procedure, and is easily transformed into the crystalline methyl ester **1** (Scheme 1). This protocol was reinvestigated and improved, and can be now easily performed on a 50–100 g scale without chromatographic separation. Also relevant in **1** is the possibility to substitute the free amine group with a powerful stereocontrolling auxiliary such as the trichloroacetyl group,[12] a process successfully applied to the highly stereoselective synthesis of 1,2-*trans*-2-amino-2-deoxy-D-glycosides.[13] Consequently, amine **1** was transformed into trichloroacetamide **2**, this latter compound being obtained routinely in a 50–55% overall yield from the polymer. The necessity to lock the D-galactosamine unit in the pyranose conformation through a 4,6-benzylidene acetal before acetylation, thus avoiding the extensive formation of furanose derivatives, is still being discussed.[9] Because crucial coupling reactions were planned to be performed using Schmidt's trichloroacetimidate glycosylation procedure,[14] acetal **3** was transformed in a first route into the crystalline α-imidate **5** by a classical sequence. This easily available glycosyl donor was used systematically to introduce the last disaccharide unit at the nonreducing end in the synthesis of oligomers. Reaction of imidate **5** with a set of alcohols under the catalysis of trimethylsilyl triflate (TMSOTf) afforded exclusively the 1,2-*trans*-linked glycosides **6**–**8** in excellent yields. The 2-naphthylmethyl group[15] in **6** allowed for flexibility because it should either be retained at the end of the syntheses and serve as a fluorophore in biological assays or easily removed to afford reducing species, and the 2-benzyloxycarbonylaminoethyl group in **8** was installed to gain access to biotinylated conjugates, all these species being useful tools for the preparation of microarrays. In an alternative route, and within the scope to reduce the number of steps, acetal **3** was transformed into crystalline α-



Scheme 1. Semisynthesis of building blocks **6**–**8**, **10**, and **11**. a) IR-120 [H^+] resin, H_2O; then 0.5 M H_2SO_4, 100 °C, 6 h; then 0.02 M HCl in MeOH, 0 °C, 4 d; b) Cl_3CCOCl, pyridine, 0 °C, 1 h; then CH_2Cl_2/MeOH/pyridine, 4 h, 52% from the polymer; c) PhCHO, TFA, 24 h; then Ac_2O/pyridine, 16 h, 68%; d) 75% TFA, CH_2Cl_2, 0 °C, 4 h; then Ac_2O/pyridine, 16 h, 80%; e) hydrazine acetate, DMF, 30 min; then Cl_3CCN, DBU, CH_2Cl_2, 30 min, 70% for **5**, 60% for **9**; f) alcohol, TMSOTf, CH_2Cl_2, 30 min, 87% for **6**, 80% for **7** and **8**; g) alcohol, $BF_3{\cdot}OEt_2$, CH_2Cl_2, −60°→−20 °C, 3 h, 79% for **10**, 72% for **11**. TCA = trichloroacetyl, TFA = trifluoroacetic acid, DBU = 1,8-diazabicyclo[5.4.0]undec-7-ene, TMSOTf = trimethylsilyl trifluoromethanesulfonate, NAP = 2-naphthylmethyl, Z = benzyloxycarbonyl.

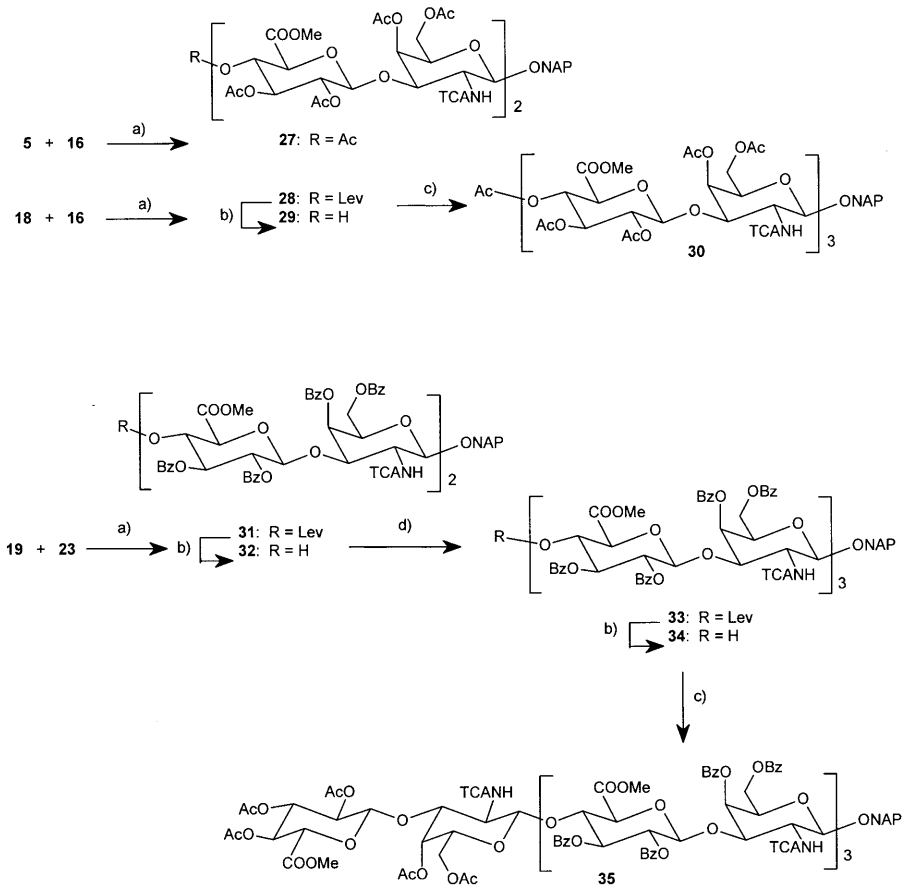
imidate **9**. However, conformationally constrained activated 4,6-benzylidene derivatives in the D-*galacto* series are known to lead to mixtures of glycosides despite the presence of a participating group at C-2.[16] Indeed, attempted glycosylation of **9** with several alcohols under the catalysis of TMSOTf, in various solvents and different temperatures afforded, as expected, α,β mixtures of glycosides. But changing the catalyst for a softer Lewis acid (boron trifluoride ethyl etherate) and lowering the temperature (−60 °C) allowed imidate **9** to react smoothly through an S_N2-like mechanism and to afford the 1,2-*trans*-linked glycosides **10** and **11** in 79 and 72 % yields, respectively.

With building blocks **6** and **10** in hand, we first focused on their transformation into glycosyl donors and acceptors suitable for an expeditious construction of target oligosaccharides (Scheme 2). For comparative reasons, both acetyl- and benzoyl-protected derivatives were prepared. Zemplèn transesterification of **6** and **10** followed by isopropylidenation under kinetic control afforded the acetals **12** and **24**, respectively, as major products. The selectively removable levulinoyl (Lev) group was then installed at the C-4 position of the D-GlcA moiety to allow further elongation at the nonreducing end. Acid hydrolysis of **13** and **25** followed either by acetylation or benzoylation gave the esters **14** and **15**, respectively, which were now ready to be transformed into a set of glycosyl donors and acceptors. Interestingly, the 2,3-isopropylidene acetal in **25** could be selectively removed to give the crystalline diol **26** in 79 % yield. This tailor-made derivative, easily prepared in only 11 steps from the polymer, will be used as a single starting material for the highly divergent chemical synthesis of all known variants (A, C, D, E, K, L, and M) of CS oligomers (see Part 2).[17] Both derivatives **14** and **15** were either transformed into acceptors **16** and **17** through selective cleavage of the levulinoyl group with hydrazine acetate,[18] or into donors **18** and **19** through oxidative removal[19] of the NAP glycoside with 2,3-dichloro-5,6-dicyanobenzoquinone (DDQ) followed by imidoylation. Noticeable was the possibility to install the 2-benzyloxycarbonylaminoethyl group at this point, thus avoiding having to repeat the same sequence of reactions starting from glycoside **11**. Delevulinoylation of **20** and **21** afforded the acceptors **22** and **23**, respectively, in good yields.



Scheme 2. Transformation of building blocks into glycosyl donors and acceptors. a) NaOMe, MeOH; then 2-methoxypropene, CSA, DMF, 2 h, 65 % for **12**, 70 % for **24**; b) LevOH, DCC, DMAP, CH_2Cl_2, 1 h, 90 % for **13**, 92 % for **25**; c) 60 % AcOH, 100 °C, 1 h; then Ac_2O/pyridine, 16 h, 71 % for **14**; or PhCOCl/pyridine, 0 °C, 2 h, 56 % for **15**; d) 80 % AcOH, CH_2Cl_2, 24 h, 79 %; e) hydrazine acetate, pyridine, 8 min, 89 % for **16** and **17**, 80 % for **22**, 75 % for **23**; f) DDQ, CH_2Cl_2/MeOH, 24 h; then Cl_3CCN, DBU, CH_2Cl_2, 30 min, 66 % for **18**, 74 % for **19**; g) 2-benzyloxycarbonylaminoethanol, TMSOTf, CH_2Cl_2, 30 min, 54 % for **20**, 89 % for **21**. LevOH = 4-oxopentanoic acid, DCC = *N*,*N*-dicyclohexylcarbodiimide, DMAP = 4-dimethylaminopyridine, DDQ = 2,3-dichloro-5,6-dicyanobenzoquinone.

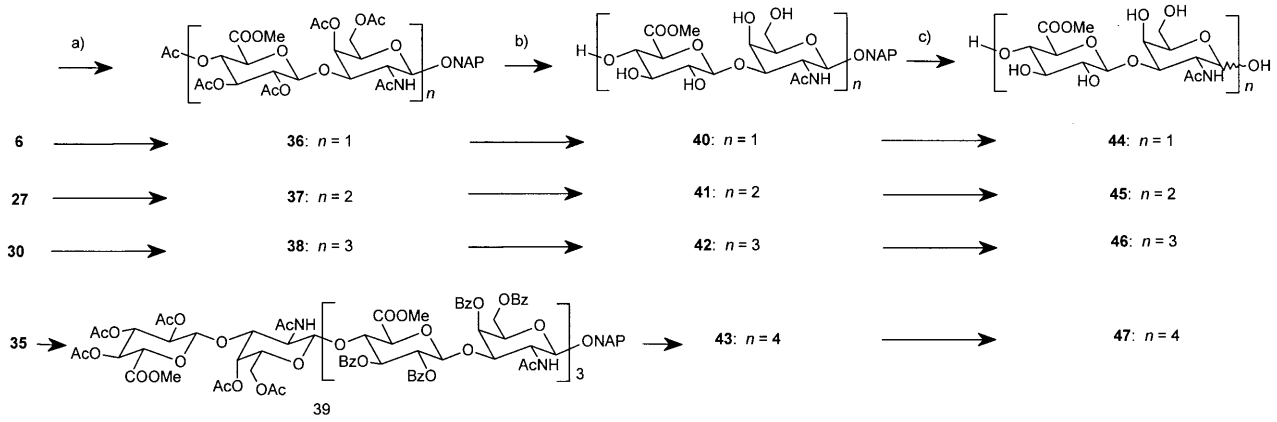
The construction of size-defined reducing chondroitin oligomers was then achieved as follows (Scheme 3). A coupling reaction of acceptor **16** with a moderate excess (1.5 equiv) of imidate **5** under the catalysis of TMSOTf gave the crystalline tetrasaccharide derivative **27**, whereas its reaction with the levulinoylated imidate **18** under similar conditions afforded the corresponding derivative **28**, both in 57 % yield. It is to be noted that no 1,2-*cis*-linked species could be isolated in these and further described coupling reactions, and that characteristic coupling constants ($J_{1,2}$ ≈7.5–8.0 Hz) were observed in the ^{1}H NMR spectra of all oligomers for the newly established 1,2-*trans*-linkages. Delevulinoylation of **28** gave the crystalline



Scheme 3. Construction of the size-defined oligomers. a) TMSOTf, CH_2Cl_2, 30 min, 57% for **27** and **28**, 62% for **31**; b) hydrazine acetate, pyridine, 8 min, 77% for **29**, 69% for **32**, 72% for **34**; c) **5**, TMSOTf, CH_2Cl_2, 30 min, 65% for **30**, 40% for **35**; d) **19**, TMSOTf, CH_2Cl_2, 30 min, 65%.

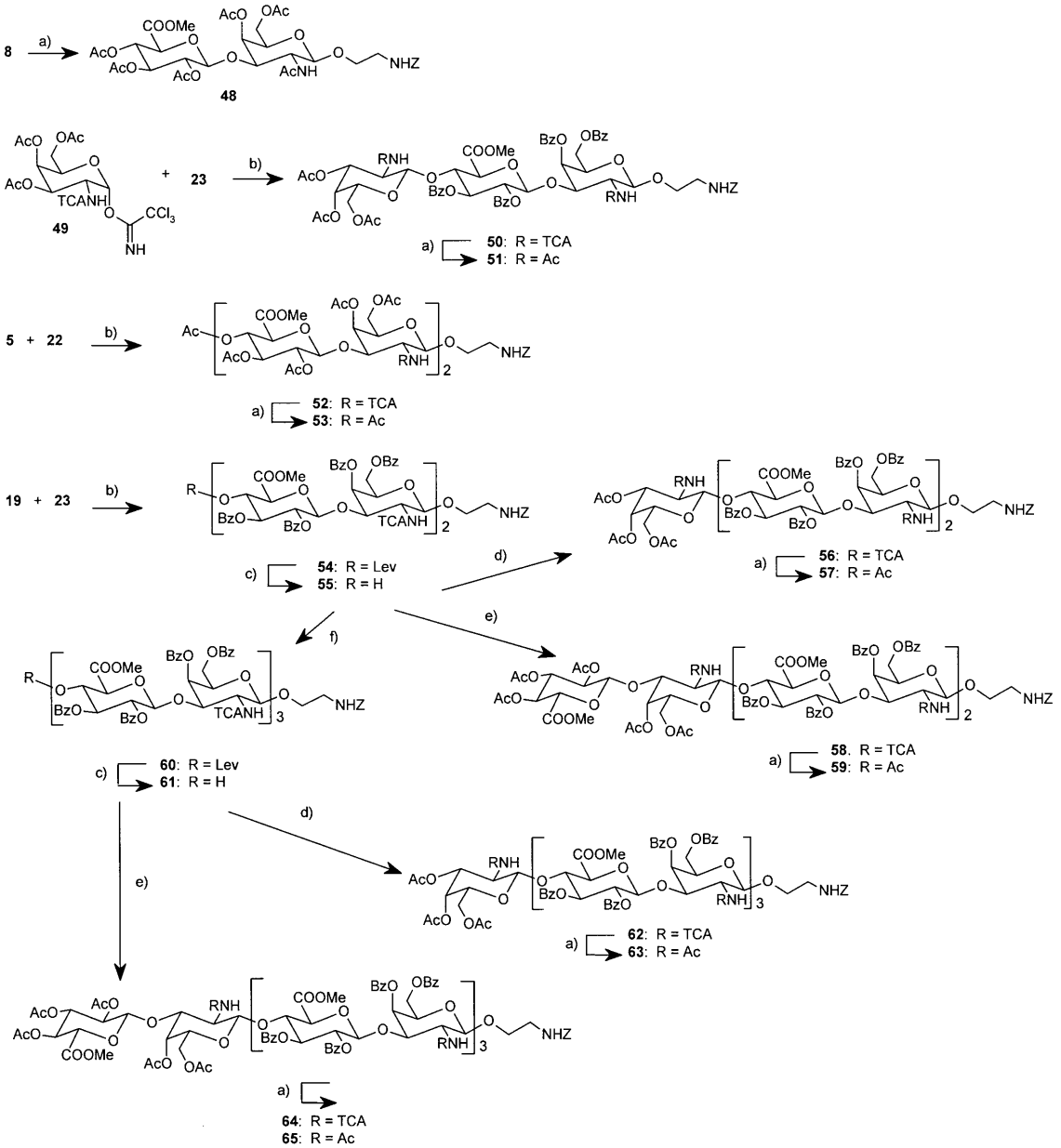
alcohol **29**, which upon further coupling with imidate **5** gave the crystalline hexasaccharide derivative **30** in 65% yield. However, attempted coupling of **29** with the levulinoylated imidate **18** gave low yield of the expected corresponding hexasaccharide derivative. At this point, it became clear that benzoylated species (donors and acceptors) were more suitable in terms of reactivity, stability, and ease of handling than their acetylated congeners. For these reasons, the crystalline hexasaccharide acceptor **34** was readily prepared through a similar sequence starting from the benzoylated acceptor **23** and using imidate **19** in an iterative manner in more than 60% yield for each coupling reaction. Condensation of **34** with imidate **5** afforded the crystalline octasaccharide derivative **35** in a moderate 40% yield (not optimized).

Final deprotection of oligomers **6**, **27**, **30**, and **35** (Scheme 4) was achieved first through transformation of their *N*-trichloroacetyl groups into their *N*-acetyl congeners by radical reduction with tri-*n*-butyl stannane[12] to give the crystalline acetamides **36–39**, followed by a two-step saponification process avoiding an β-elimination reaction at the D-GlcA units with lithium hydroperoxide[20] and sodium hydroxide to afford the target glycosides **40–43**. The ^1H and ^{13}C NMR spectra for **40–43** showed high purity and were in full agreement with the expected structures. Catalytic hydrogenation of **40–43** with 10% palladium on carbon in water smoothly afforded the reducing oligomers **44–47** in excellent yields. It was the first time that these oligomers were obtained as pure species and fully characterized.



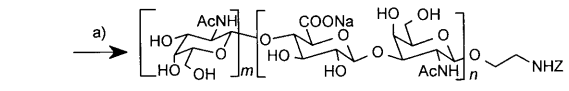
Scheme 4. Access to target chondroitin oligomers. a) Bu_3SnH, AIBN, benzene/DMAC, 80°C, 2 h, 74% for **36**, 81% for **37**, 64% for **38**, 62% for **39**; b) $LiOH/H_2O_2$, THF, −10°C→RT, 16 h; then 4 M NaOH, MeOH, 4 h, 69% for **40**, 71% for **41**, 51% for **42**, 60% for **43**; c) H_2, Pd/C, H_2O, 20 h, 86% for **44**, 87% for **45**, 74% for **46**, 67% for **47**. AIBN = 2,2′-azobis-2-methylpropionitrile, DMAC = *N*,*N*-dimethylacetamide.

In light of the above results, the preparation of size-defined biotinylated chondroitin oligomers was next undertaken (Scheme 5). According to our synthetic plan, a similar strategy should be used for the construction of even-numbered oligomers (from di- to octasaccharides), and several common intermediates should be employed for the preparation of odd-numbered oligomers (tri-, penta-, and heptasaccharides), in which the introduction of a D-GalNAc residue at the nonreducing end should be achieved by the use of known α-imidate **49**.[16] A coupling reaction of imidate **49** with alcohol **23** under the catalysis of TMSOTf afforded the trisaccharide derivative **50** as a single isomer, albeit in a moderate 55% yield due to difficulties in purification of the reaction mixture. The acetylated tetrasaccharide derivative **52** was similarly obtained in 67% yield from imidate **5** and alcohol **22**. For the construction of larger molecules, benzoylated species were previously found to be more efficient. Thus, a coupling reaction between imidate **19** and alcohol **23**, both benzoylated, provided the crystalline tetrasaccharide derivative **54** in 87% yield, which upon delevulinoylation gave the pivotal acceptor **55**. The latter was condensed with imidates **49** and **5**, respectively, to afford the crystalline pentasaccharide **56** and hexasaccharide derivative **58** in 85 and 55% yields, respectively. Further coupling of **55** with

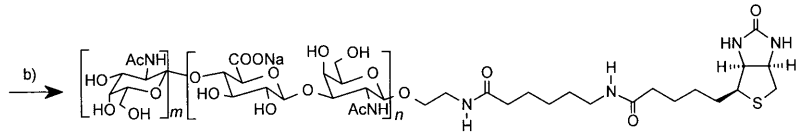


Scheme 5. Preparation of precursors of odd- and even-numbered biotinylated chondroitin oligomers. a) Bu_3SnH, AIBN, benzene/DMAC, 80°C, 4 h, 53% for **48**, 55% for **51**, 65% for **53**, 59% for **57**, 78% for **59**, 77% for **63**, 53% for **65**; b) TMSOTf, CH_2Cl_2, 30 min, 55% for **50**, 67% for **52**, 87% for **54**; c) hydrazine acetate, pyridine, 8 min, 75% for **55**, 83% for **61**; d) **49**, TMSOTf, CH_2Cl_2, 30 min, 85% for **56**, 67% for **62**; e) **5**, TMSOTf, CH_2Cl_2, 30 min, 55% for **58**, 65% for **64**; f) **19**, TMSOTf, CH_2Cl_2, 30 min, 66%.

imidate **19** gave the crystalline hexasaccharide **60** in 66% yield. Delevulinoylation of **60** afforded the crystalline alcohol **61**, which was similarly condensed with imidates **49** and **5**, respectively, to provide the crystalline heptasaccharide **62** and octasaccharide derivative **64** in 67 and 65% yields, respectively. Radical reduction of the *N*-trichloroacetyl groups in oligomers **8**, **50**, **52**, **56**, **58**, **62**, and **64** gave the corresponding crystalline acetamides **48**, **51**, **53**, **57**, **59**, **63**, and **65** in 53–78% yields, depending on the ease of purification of these complex molecules. Saponification of the latter group (Scheme 6), as described above, provided the sodium salts



48 **66**: $m = 0, n = 1$
51 **67**: $m = 1, n = 1$
53 **68**: $m = 0, n = 2$
57 **69**: $m = 1, n = 2$
59 **70**: $m = 0, n = 3$
63 **71**: $m = 1, n = 3$
65 **72**: $m = 0, n = 4$



73: $m = 0, n = 1$
74: $m = 1, n = 1$
75: $m = 0, n = 2$
76: $m = 1, n = 2$
77: $m = 0, n = 3$
78: $m = 1, n = 3$
79: $m = 0, n = 4$

Scheme 6. Access to target biotinylated chondroitin oligomers. a) $LiOH/H_2O_2$, THF, $-10\,^{\circ}C \rightarrow RT$, 16 h; then 4 M NaOH, MeOH, 4 h, 67% for **66**, 68% for **76**, 62% for **68**, 58% for **69**, 71% for **70**, 95% for **71**, 84% for **72**; b) H_2, Pd/C, H_2O, 20 h; then 6-biotinylamidohexanoic acid *N*-hydroxysuccinimidyl ester, NEt_3, DMF/H_2O, 1 h, 67% for **73**, 71% for **74**, 72% for **75** and **77**, 75% for **76**, 85% for **78**, 89% for **79**.

66–72 in good yields. Finally, catalytic hydrogenation of **66–72** led to the corresponding free amine intermediates, which were readily treated with 6-biotinylamidohexanoic acid *N*-hydroxysuccinimidoyl ester and triethylamine in *N*,*N*-dimethylformamide/water to afford, after purification using a Sephadex LH-20 in water, the target molecules **73–79** in 67–89% yields, for which the ^1H and ^{13}C NMR spectroscopic data showed high purity and were in full agreement with the expected structures.

Conclusion

To conclude, we designed a step economy process for the expeditious preparation for the first time of size-defined chondroitin oligomers and their biotinylated conjugates. This semisynthetic route starting from an abundant natural polymer should also be applied to other biologically important members of the GAG family such as dermatan sulfate and hyaluronic acid. The glycosylating efficiency and stereoselectivity exhibited by 2-deoxy-2-trichloroacetamido-D-*galacto* trichloroacetimidate derivatives allowed the straightforward construction in good yields of oligomers up to octasaccharides, and the crystallinity of most intermediates rendered this route very attractive. For the first time, all target compounds, reducing species, and glycosides as well as biotinylated conjugates, were obtained in high purity and fully characterized through ^1H and ^{13}C NMR spectrometry. We do hope that with such a collection of potential probes we shall be able to determine the starting point of the polymerization reaction in the biosynthesis of chondroitin and identify new pharmacological targets. All these structures are currently being investigated in biological assays, the results of which will be reported elsewhere in due course.

Experimental Section

General methods: To prepare chondroitin sulfate, a sodium salt from bovine trachea and 6-biotinylamidohexanoic acid *N*-hydroxysuccinimidyl ester were purchased from Sigma SAFC (St-Quentin-Fallavier, France). Solvents were dried by standard methods, and molecular sieves were activated prior to use by heating for 4 h at 500 °C. Melting points were determined in capillary tubes with a Büchi apparatus and are uncorrected. Optical rotations were measured at 20–25 °C using a Perkin–Elmer 341 polarimeter. ^1H and ^{13}C NMR spectra were recorded at 25 °C with Bruker DPX 250 and Advance II 400 instruments, with Me_4Si as internal standard, unless otherwise stated. Assignments were based on homo- and heteronuclear correlations using the supplier's software. In the NMR data for oligomers, $GlcA^I$ and $GalN^I$ (with roman numeral superscripts) refer to D-glucuronic acid and D-galactosamine residues, respectively, in the reducing disaccharide unit. Low-resolution mass spectra were obtained on a Perkin–Elmer SCIEX API 300 spectrometer operating in the ion-spray mode or on a Micromass Quattro Ultima spectrometer equipped with a Z-spray ionization source operating in the positive or negative mode. HRMS data were obtained from the Centre Regional de Mesure Physique (Université Blaise Pascal,

Clermont-Ferrand, France). Flash-silica chromatography was performed on silica gel 60 (0.040–0.063 mm, Merck, Darmstadt). The reactions were monitored by TLC on coated aluminum sheets (silica gel 60 GF_{254}, Merck), and spots were detected under UV light and by charring with a 95:5 mixture of ethanol and sulfuric acid. Elemental analyses were carried out at the Service Central de Microanalyse du CNRS (Vernaison, France).

***O*-(Methyl β-D-glucopyranosyluronate)-(1→3)-2-amino-2-deoxy-D-galactopyranose hydrochloride (1)**: A solution of chondroitin sulfate A (50 g) in water (500 mL) was brought to pH 1.6 with Amberlite IR-120 [H^+] resin (pH meter monitoring), and was then filtered. The resin was washed with water (4×100 mL), and the volume of the filtrate was adjusted to 970 mL. Concentrated H_2SO_4 (18 M, 27.8 mL, 0.5 M final concentration) was added, and the mixture was stirred for 6 h at 100 °C, then was cooled. Solid $Ba(OH)_2{\cdot}8H_2O$ was added portionwise under vigorous stirring to pH 3.5 (pH meter monitoring), and the slurry was allowed to settle overnight. The solids were filtered off through a Celite pad, washed with water, and the yellow filtrate was concentrated to approximately 500 mL and slowly applied to a column of Amberlite IR-120 [H^+] resin (500 mL, settled volume). The column was washed with water (1 L), AcOH/water (3:1, 1 L), then with aqueous HCl (1 M, 3 L). The fractions containing ninhydrin-positive material were pooled, concentrated, evaporated with water (2×500 mL), and dried under vacuum over P_2O_5. The residue was treated with methanolic HCl (0.02 M, 500 mL) for 4 d at 0 °C, then was concentrated. Repeated additions of absolute EtOH and concentrations gave crude **1** (~38 g). A portion was recrystallized from EtOH to give pure **1**. R_f=0.3 (EtOAc/MeOH/water 1:1:1); m.p. 160–163 °C (ref. [11]: 159–161 °C); $[\alpha]_D^{22}=+40$ (c=1, equil., in water) (ref. [11]: +42 (c=2 in water); ^{1}H NMR (400 MHz, D_2O, internal H_2O, δ_H=4.79): δ=5.48 (d, $J_{1,2}$=3.5 Hz; GalN H-1α), 4.72 (d, $J_{1,2}$=8.0 Hz; GalN H-1β), 4.73, 4.72 (2 d, $J_{1,2}$=7.5 Hz, 1 H; GlcA H-1α,β), 4.30–4.20 (m; GalN H-3α, H-4, GlcA H-5), 4.15–4.06 (m; GalN H-3β, GlcA H-4), 3.82 (s, 3 H; COOCH_3), 3.80–3.70 (m; GalN H-5, 2 H-6), 3.65 (dd, $J_{2,3}$= 11.0 Hz; GalN H-2α), 3.56 (m; GlcA H-3α,β), 3.45 (m; GlcA H-2α,β), 3.34 ppm (dd, $J_{2,3}$=11.0 Hz; GalN H-2β); ^{13}C NMR (100 MHz, D_2O, internal acetone, δ_C=30.83): δ=171.60, 171.54 (GlcA C-6), 104.16, 103.91 (GlcA C-1), 93.46 (GalN C-1β), 89.93 (GalN C-1α), 80.11, 78.01 (GalN C-3), 75.43, 75.36 (GalN C-5), 75.02, 74.96 (GlcA C-5), 73.20, 73.18 (GlcA C-3), 71.67, 71.61 (GlcA C-2), 70.75, 70.71 (GlcA C-4), 68.04, 68.0 (GalN C-4), 61.55, 61.31 (GalN C-6), 53.73 (COO*C*H$_3$), 53.50, 50.40 ppm (GalN C-2).

***O*-(Methyl β-D-glucopyranosyluronate)-(1→3)-2-deoxy-2-trichloroacetamido-D-galactopyranose (2)**: Trichloroacetyl chloride (112 mL, 1 mol) was added slowly at 0 °C to a solution of crude **1** (36.2 g, 89 mmol) in pyridine (400 mL), and the mixture was stirred for 1 h at 0 °C. Water (30 mL) was carefully added dropwise, and the mixture was diluted with CH_2Cl_2 (800 mL), rapidly washed with water, saturated aqueous NaCl, and water, and dried ($MgSO_4$) and concentrated. A solution of the residue in CH_2Cl_2/MeOH/pyridine (1:1:1, 300 mL) was stirred for 4 h at RT, then was concentrated. Flash silica chromatography (CH_2Cl_2/MeOH 4:1) gave the trichloroacetamide **2** (26.85 g, 52% from the polymer) as a pale yellow foam. $[\alpha]_D^{22}=+35$ (c=1 in methanol); ^{1}H NMR (400 MHz, D_2O, internal H_2O, δ_H=4.79): δ=5.30 (d, $J_{1,2}$ 3.5 Hz; GalN H-1α), 4.72 (d, $J_{1,2}$ 8.0 Hz; GalN H-1β), 4.68, 4.59 (2 d, $J_{1,2}$=8.0 Hz, 1 H; GlcA H-1), 4.34 (dd, $J_{2,3}$=11.0 Hz; GalN H-2α), 4.24 (dd, $J_{2,3}$=11.0 Hz, $J_{3,4}$<1.0 Hz; GalN H-3α), 4.12 (m, 1 H; GalN H-4), 4.08–4.0 (m; GalN H-2β, H-3β, H-5, GlcA H-5), 3.82, 3.81 (2 s, 3 H; COOCH_3), 3.80–3.68 (m, 2 H; 2 GalN H-6), 3.54 (dd, $J_{3,4}$=$J_{4,5}$=9.5 Hz, 1 H; GlcAH-4), 3.48, 3.77 (2 dd, $J_{2,3}$= 9.5 Hz,1 H; GlcA H-3), 3.37, 3.35 ppm (2 dd, 1 H; GlcA H-2); MS: m/z: 535 [M+Na]$^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{15}H_{21}Cl_3NO_{12}$: C 35.07, H 4.12, N 2.73; found: C 34.80, H 4.31, N 2.54.

***O*-(Methyl 2,3,4-tri-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-1-*O*-acetyl-4,6-*O*-benzylidene-2-deoxy-2-trichloroacetamido-D-galactopyranose (3)**: A mixture of **2** (26.8 g, 52 mmol), benzaldehyde (200 mL), and TFA (10 mL) was stirred for 24 h at RT under an atmosphere of dry argon. Anhydrous NaOAc (16.4 g, 0.2 mol), pyridine (200 mL), and Ac_2O (120 mL) were added sequentially, and the mixture was stirred overnight, then poured into ice-cold water and stirred for 2 h. The mixture was extracted with CH_2Cl_2 (2×300 mL), and the organic layer was washed with water, saturated aqueous $NaHCO_3$, and water, and dried ($MgSO_4$) and concentrated. Flash silica chromatography (CH_2Cl_2→ CH_2Cl_2/acetone 15:1) gave first the α-acetate **3**α (24.4 g, 60%): m.p. 126–127 °C (from EtOAc/petroleum ether); $[\alpha]_D^{22}=+49$ (c=1 in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): δ=7.50 (m, 5 H; arom. H), 6.78 (d, $J_{2,NH}$= 7.5 Hz, 1 H; GalN N*H*), 6.48 (d, $J_{1,2}$=3.6 Hz,1 H; GalN H-1), 5.54 (s, 1 H; C*H*Ph), 5.24 (m, 2 H; GlcA H-3, H-4), 5.08 (dd, $J_{1,2}$=8.0 Hz, $J_{2,3}$=9.0 Hz, 1 H; GlcA H-2), 4.95 (d, 1 H; GlcA H-1), 4.64 (dd, $J_{2,3}$=11.0 Hz; GalN H-2), 4.51 (dd, $J_{3,4}$=3.5 Hz, $J_{4,5}$<1.0 Hz; GalN H-4), 4.45 (dd, 1 H; GalN H-3), 4.20 (m, 3 H; 2 GalN H-6, GlcA H-5), 3.85 (m, 1 H; GalN H-5), 3.74 (s, 3 H; COOCH_3), 2.18, 2.05 ppm (2 s, 12 H; COCH_3); MS: m/z: 762 [M+Na]$^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{30}H_{34}Cl_3NO_{16}$: C 46.74, H 4.44, N 1.81; found: C 46.50, H 4.33, N 1.78. Next eluted (CH_2Cl_2/acetone 12:1) was the β-acetate **3**β (3.46 g, 8%): m.p. 237–239 °C (from EtOH); $[\alpha]_D^{22}=+25$ (c=1 in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): δ=7.50 (m, 5 H; arom. H), 6.90 (d, $J_{2,NH}$=8.0 Hz, 1 H; GalN N*H*), 6.05 (d, $J_{1,2}$=8.5 Hz; GalN H-1), 5.58 (s, 1 H; PhC*H*), 5.20 (m, 2 H; GlcA H-3,H-4), 5.05 (dd, $J_{1,2}$=7.5 Hz, $J_{2,3}$=9.0 Hz, 1 H; GlcA H-2), 4.93 (d, 1 H; GlcA H-1), 4.55 (dd, $J_{2,3}$=11.0 Hz, $J_{3,4}$=3.5 Hz, 1 H; GalN H-3), 4.47 (dd, $J_{4,5}$<1.0 Hz, 1 H; GalN H-4), 4.32 (dd, $J_{5,6a}$=2.5 Hz, $J_{6a,6b}$= 12.0 Hz, 1 H; GalN H-6a), 4.10 (m, 3 H; GalN H-2, H-6b, GlcA H-5), 3.73 (s, 3 H; COOCH_3), 3.67 (m, 1 H; GalN H-5), 2.16, 2.01 ppm (2 s, 12 H; COCH_3); MS: m/z: 762 [M+Na]$^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{30}H_{34}Cl_3NO_{16}$: C 46.74, H 4.44, N 1.81; found: C 46.60, H 4.51, N 1.81.

***O*-(Methyl 2,3,4-tri-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-1,4,6-tri-*O*-acetyl-2-deoxy-2-trichloroacetamido-D-galactopyranose (4)**: A mixture of **3**α,β (19.25 g, 25 mmol), CH_2Cl_2 (400 mL), and TFA/water (3:1, 15 mL) was stirred for 4 h at 0 °C, then was washed with 10% aqueous NaOAc, saturated aqueous $NaHCO_3$ and water, dried ($MgSO_4$), and concentrated. The solid residue was stirred with pyridine (150 mL) and Ac_2O (100 mL) for 16 h at RT, then was concentrated and evaporated with toluene. Flash-silica chromatography (EtOAc/petroleum ether 3:2) gave the peracetate **4** (15.5 g, 80%) as a white solid. α-anomer **4**α: R_f=0.4 (EtOAc/petroleum ether 2:1); m.p. 181–182 °C (from EtOAc/petroleum ether); $[\alpha]_D^{22}=+41$ (c=1 in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): δ=6.97 (d, $J_{2,NH}$=7.5 Hz, 1 H; GalN N*H*), 6.37 (d, $J_{1,2}$=3.5 Hz, 1 H; GalN H-1), 5.35 (dd, $J_{3,4}$=3.5 Hz, $J_{4,5}$<1.0 Hz, GalN H-4), 5.15 (m, 3 H; GlcA H-2, H-3, H-4), 4.84 (d, $J_{1,2}$=8.0 Hz; GlcA H-1), 4.51 (m, $J_{2,3}$= 11.0 Hz, 1 H; GalN H-2), 4.41 (dd, 1 H; GalN H-3), 4.27 (m, 1 H; GalN H-5), 4.08 (m, 3 H; GalN H-6a,H-6b, GlcA H-5), 3.76 (s, 3 H; COOCH_3), 2.15, 2.12, 2.02 ppm (3 s, 18 H; COCH_3); MS: m/z: 788 [M+Na]$^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{27}H_{34}Cl_3NO_{18}$: C 42.28, H, 4.47, N 1.83; found: C 42.12, H 4.60, N 1.71. β-anomer **4**β: R_f=0.35 (EtOAc/ petroleum ether 2:1); m.p. 228–229 °C (from EtOAc-petroleum ether); $[\alpha]_D^{22}=+10$ (c=1 in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): δ=6.83 (d, $J_{2,NH}$=8.5 Hz, 1 H; GalN N*H*), 5.89 (d, $J_{1,2}$=8.5 Hz, 1 H; GalN H-1), 5.44 (dd, $J_{3,4}$=3.5 Hz, $J_{4,5}$<1.0 Hz, 1 H; GalN H-4), 5.20–5.16 (m, 2 H; GlcA H-3, H-4), 4.97 (dd, $J_{1,2}$=7.5 Hz, $J_{2,3}$=9.0 Hz, 1 H; GlcA H-2), 4.76 (d, 1 H; GlcA H-1), 4.36 (dd, $J_{2,3}$=11.0 Hz, 1 H; GalN H-3), 4.25–4.05 (m, 5 H; GalN H-2,H-5, H-6a,H-6b, GlcA H-5), 3.76 (s, 3 H; COOCH_3), 2.12, 2.08, 1.96 ppm (3 s, 18 H; COCH_3); MS: m/z: 788 [M+Na]$^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{27}H_{34}Cl_3NO_{18}$: C 42.28, H 4.47, N 1.83; found: C 42.30, H 4.56, N 1.77.

***O*-(Methyl 2,3,4-tri-O-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-1-*O*-trichloroacetimidoyl-α-D-galactopyranose (5)**: A mixture of **4**α,β (1.92 g, 2.5 mmol) and hydrazine acetate (0.35 g, 3.75 mmol) in DMF (15 mL) was stirred for 30 min at RT, then was diluted with EtOAc (80 mL), washed with water, saturated aqueous NaCl and water, dried ($MgSO_4$), and concentrated. A mixture of the residue, CCl_3CN (2 mL, 20 mmol), and DBU (57 μL, 0.38 mmol) in CH_2Cl_2 (15 mL) was stirred for 30 min at RT, then was concentrated. Flash-silica chromatography (EtOAc/petroleum ether 1:1, containing 0.1% of Et_3N) and crystallization from EtOAc/petroleum ether gave the imidate **5** (1.52 g, 70%). M.p. 117–118 °C; $[\alpha]_D^{22}=+62$ (c=1 in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): δ=8.78 (s, 1 H; C=N*H*); 6.88 (d, $J_{2,NH}$=8.5 Hz, 1 H; GalN N*H*), 6.54 (d, $J_{1,2}$=3.5 Hz, 1 H; GalN H-1), 5.46 (dd, $J_{3,4}$=3.5 Hz, $J_{4,5}$<1.0 Hz, 1 H; GalN H-4), 5.18 (m, 2 H; GlcA H-3,

H-4), 5.05 (d, $J_{1,2}=8.0$ Hz, $J_{2,3}=9.0$ Hz, 1H; GlcA H-2), 4.81 (d, 1H; GlcA H-1), 4.64 (m, 1H; GalN H-2), 4.30 (m, 2H; GalN H-3, H-5), 4.10 (m, 3H; GalN H-6a, H-6b, GlcA H-5), 3.74 (s, 3H; COOCH_3), 2.15, 2.08, 2.01 ppm (3s, 15H; COCH_3); MS: *m/z*: 885 $[M+NH_4]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{27}H_{32}Cl_6N_2O_{17}$: C 37.31, H 3.71, N 3.12; found: C 37.19, H 3.82, N 3.01.

2-Naphthylmethyl *O*-(methyl 2,3,4-tri-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (6): A mixture of imidate **5** (4.0 g, 4.60 mmol), 2-naphthalenemethanol (1.46 g, 9.2 mmol), and 4 Å powdered molecular sieves (1.0 g) in dry CH_2Cl_2 (40 mL) was stirred for 1 h at RT under dry argon. A solution of TMSOTf in toluene (1 M, 0.69 mL) was added, and the mixture was stirred for 30 min at RT, then was quenched with NEt_3 (0.3 mL), filtered and concentrated. Flash-silica chromatography (EtOAc/petroleum ether 1:1, containing 0.1% of NEt_3) gave the disaccharide **6** (3.46 g, 87%) as a white powder. M.p. 120–122 °C (from 2-propanol); $[\alpha]_D^{22}=-21$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.78$–7.40 (m, 7H; arom. H), 6.91 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN N*H*), 5.45 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.20–5.10 (m, 2H; GlcA H-3, H-4), 4.95 (dd, 1H; GlcA H-2), 4.92 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.91 (ABq, 2H; CH_2Ar), 4.69 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.51 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.20–4.08 (m, 2H; GalN H-6a, H-6b), 3.97 (d, $J_{4,5}=9.5$ Hz, 1H; GlcA H-5), 3.89–3.83 (m, 2H; GalN H-2, H-5), 3.73 (s, 3H; COOCH_3), 2.13, 2.10, 2.02, 1.99, 1.98 ppm (5s, 15H; COCH_3); MS: *m/z*: 886 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{36}H_{40}Cl_3NO_{17}$: C 49.98, H 4.66, N 1.62; found: C 49.84, H 4.82, N 1.55.

4-Pentenyl *O*-(methyl 2,3,4-tri-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (7): From imidate **5** (1.2 g, 1.38 mmol) and 4-penten-1-ol (290 μL, 2.76 mmol) as described for the preparation of disaccharide **6**. Flash-silica chromatography (EtOAc/petroleum ether 1:1, containing 0.1% of NEt_3) afforded the disaccharide **7** (874 mg, 80%) as a white powder. $[\alpha]_D^{20}=+1.5$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.01$ (d, $J_{2,NH}=7.5$ Hz, 1H; GalN N*H*), 5.77 (m, 1H; Pentenyl H-d), 5.47 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.23–5.11 (m, 2H; GlcA H-4, Pentenyl H-e), 5.03–4.90 (m, 3H; GlcA H-2, H-3, Pentenyl H-e), 4.86 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 4.74 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.60 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.16–3.98 (m, 2H; GalN H-6a, H-6b), 4.01 (d, $J_{4,5}=9.5$ Hz, 1H; GlcA H-5), 3.94–3.84 (m, 2H; GalN H-5, Pentenyl H-a), 3.79–3.65 (m, 4H; GalN H-2, COOCH_3), 3.50 (m, 1H; Pentenyl H-a), 2.12, 2.07, 2.04, 2.03, 1.99 (5s, 15H; COCH_3), 2.10–2.00 (m, 2H; Pentenyl H-c), 1.73–1.66 ppm (m, 2H; Pentenyl H-b); MS: *m/z*: 814 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{30}H_{40}Cl_3NO_{17}$: C 45.44, H 5.08, N 1.77; found: C 45.21, H 5.14, N 1.74.

2-Benzyloxycarbonylaminoethyl *O*-(methyl 2,3,4-tri-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (8): From imidate **5** (100 mg, 0.11 mmol) and 2-benzyloxycarbonylaminoethanol (40 mg, 0.21 mmol) as described for the preparation of disaccharide **6**. Flash-silica chromatography (CH_2Cl_2/2-propanol 19:1, containing 0.1% of NEt_3) afforded the disaccharide **8** (83 mg, 80%) as a white powder. $R_f=0.52$ (EtOAc/toluene 3:1); m.p. 192–193 °C (from EtOAc/petroleum ether); $[\alpha]_D^{20}=+6.0$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.35$ (s, 5H; arom. H), 6.85 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN N*H*), 5.44 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.21–5.15 (m, 3H; GlcA H-3, H-4, N*H*COO), 5.08 (s, 2H; CH_2Ph), 4.95 (m, 1H; GlcA H-2), 4.84 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.72 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.50 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.16 (dd, $J_{6a,6b}=11.0$ Hz, $J_{5,6a}=5.0$ Hz, 1H; GalN H-6a), 4.09–3.97 (m, 2H; GalN H-6b, GlcA H-5), 3.91–3.82 (m, 2H; GalN H-5, CH_2-O), 3.76 (s, 3H; COOCH_3), 3.74–3.65 (m, 2H; GalN H-2, CH_2-O), 3.45–3.35 (m, 2H; CH_2-N), 2.12, 2.05, 2.03, 2.01, 1.99 ppm (5s, 15H; COCH_3); MS: *m/z*: 899 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{35}H_{43}Cl_3N_2O_{19}$: C 46.60, H 4.80, N 3.11; found: C 46.44, H 4.92, N 3.15.

***O*-(Methyl 2,3,4-tri-O-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-*O*-benzylidene-2-deoxy-2-trichloroacetamido-1-*O*-trichloroacetimidoyl-α-D-galactopyranose (9)**: From ester **3** (14.82 g, 20 mmol) as described for the preparation of imidate **5**. Flash-silica chromatography (EtOAc/petroleum ether 4:3, containing 0.1% of NEt_3) followed by crystallization from diethyl ether afforded the imidate **9** (10.48 g, 60%). M.p. 131–132 °C; $[\alpha]_D^{20}=+67$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=8.75$ (s, 1H; C=N*H*), 7.50–7.20 (m, 5H; arom. H), 6.79 (d, $J_{2,NH}=8.0$ Hz, 1H; GalN N*H*), 6.62 (d, $J_{1,2}=3.5$ Hz, 1H; GalN H-1), 5.57 (s, 1H; C*H*Ph), 5.26 (dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 1H; GlcA H-3), 5.20 (dd, $J_{4,5}=9.5$ Hz, 1H; GlcA H-4), 5.09 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-2), 4.95 (d, 1H; GlcA H-1), 4.77 (m, $J_{2,3}=11.0$ Hz, 1H; GalN H-2), 4.56 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 4.40–4.30 (m, 2H; GalN H-3, H-6), 4.12–4.08 (m, 2H; GalN H-6, GlcA H-5), 3.92 (m, 1H; GalN H-5), 3.72 (s, 3H; COOCH_3), 2.02 ppm (s, 9H; COCH_3); MS: *m/z*: 893 $[M+H]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{30}H_{32}Cl_6N_2O_{15}$: C 41.26, H 3.69, N 3.21; found: C 41.11, H 3.58, N 3.09.

2-Naphthylmethyl *O*-(methyl 2,3,4-tri-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-*O*-benzylidene-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (10): A mixture of imidate **9** (16.60 g, 19 mmol), 2-naphthalenemethanol (4.75 g, 30 mmol), and 4 Å powdered molecular sieves (2.0 g) in dry CH_2Cl_2 (150 mL) was stirred for 1 h at RT under dry argon, then was cooled to −60 °C. A solution of BF_3·OEt_2 in toluene (1 M, 1.9 mL) was added, and the mixture was stirred from −60 to −20 °C within 3 h, then was quenched with NEt_3 (1 mL), filtered, and concentrated. Flash-silica chromatography (CH_2Cl_2/EtOAc 10:1, containing 0.1% of NEt_3) gave the glycoside **10** (13.05 g, 79%) as a white solid. $R_f=0.35$ (EtOAc/petroleum ether 3:2); m.p. 235–236 °C (from EtOAc/petroleum ether); $[\alpha]_D^{22}=-12$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.70$–7.30 (m, 12H; arom. H), 7.07 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN N*H*), 5.61 (s, 1H; C*H*Ph), 5.22 (dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 1H; GlcA H-3), 5.16 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 5.15 (dd, $J_{4,5}=9.5$ Hz, 1H; GlcA H-4), 5.04 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-2), 4.95 (ABq, 2H; CH_2Ar), 4.90 (d, 1H; GlcA H-1), 4.67 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.5$ Hz, 1H; GalN H-3), 4.46–4.28 (m, 2H; GalN H-4, H-6a), 4.03 (dd, $J_{5,6a}=2.5$ Hz, $J_{6a,6b}=12.0$ Hz, 1H; GalN H-6b), 4.0 (d, 1H; GlcA H-5°, 3.90 (m, 1H; GalN H-2), 3.71 (s, 3H; COOCH_3), 3.54 (m, 1H; GalN H-5), 2.05, 2.03, 2.01 ppm (3s, 9H; COCH_3); MS: *m/z*: 891 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{39}H_{40}Cl_3NO_{15}$: C 53.90, H 4.64, N 1.61; found: C 53.79, H 4.68, N 1.49.

2-Benzyloxycarbonylaminoethyl *O*-(methyl 2,3,4-tri-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-*O*-benzylidene-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (11): From imidate **9** (419 mg, 0.48 mmol) as described for the preparation of **10**. Flash silica chromatography (CH_2Cl_2/2-propanol 19:1, containing 0.1% of NEt_3) afforded the glycoside **11** (312 mg, 72%) as a white powder. M.p. 190–192 °C (from EtOAc/petroleum ether); $[\alpha]_D^{20}=+14$ ($c=1$ in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta=7.54$–7.22 (m, 10H; arom. H), 7.06 (d, $J_{2,NH}=6.5$ Hz, 1H; GalN N*H*), 5.58 (s, 1H; C*H*-Ph), 5.27 (m, 1H; N*H*COO), 5.25 (dd, $J_{3,4}=J_{4,5}=9.5$ Hz, 1H; GlcA H-4), 5.17 (dd, $J_{2,3}=8.5$ Hz, 1H; GlcA H-3), 5.11–5.01 (m, 3H; GlcA H-2, CH_2-Ph), 5.03 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 4.94 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.58 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.5$ Hz, 1H; GalN H-3), 4.44 (dd, $J_{4,5}<1$ Hz, 1H; GalN H-4), 4.31 (d, $J_{5,6a}<1$ Hz, $J_{6a,6b}=12.0$ Hz, 1H; GalN H-6a), 4.07 (dd, $J_{5,6b}<1.0$ Hz, 1H; GalN H-6b), 4.02 (d, 1H; GlcA H-5), 3.93 (m, 1H; CH_2-O), 3.82 (m, 1H; GalN H-2), 3.71 (s, 3H; COOCH_3), 3.69 (m, 1H; CH_2-O), 3.49 (m, 1H; GalN H-5), 3.45–3.33 (m, 2H; CH_2-N), 2.01, 2.00, 1.99 ppm (3s, 9H; COCH_3); MS: *m/z*: 922 $[M+NH_4]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{36}H_{43}Cl_3N_2O_{17}$: C 50.37, H 4.78, N 3.09; found: C 50.45, H 4.96, N 2.95.

2-Naphthylmethyl *O*-(methyl 2,3-*O*-isopropylidene-β-D-glucopyranosyluronate)-(1→3)-2-deoxy-4,6-*O*-isopropylidene-2-trichloroacetamido-β-D-galactopyranoside (12): Methanolic sodium methoxide (1 M, 20 mL) was added to a solution of **6** (8.75 g, 10 mmol) in dry methanol (85 mL), and the mixture was stirred for 3 h at room temperature, then was neutralized with Amberlite IR-120 [H^+] resin, filtered, concentrated, and dried in vacuo. Aliquots of 2-methoxypropene (1.25 mL, 13 mmol, 6 additions) were added every 20 min to a solution of the residue (6.5 g, 9.92 mmol) and CSA (700 mg) in DMF (70 mL). Triethylamine (3.5 mL) was added and the mixture was concentrated. A solution of the residue in EtOAc (100 mL) was washed with saturated aqueous $NaHCO_3$, then several times with saturated aqueous NaCl, dried ($MgSO_4$), and concentrated. Flash-silica chromatography (EtOAc/toluene 3:2, containing 0.2% of

NEt_3) afforded the bis-acetal **12** (4.81 g, 65%) as a white powder. M.p. 218–219°C (from 2-propanol); $[\alpha]_D^{20}=-28$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.86$–7.46 (m, 7H; arom. H), 7.08 (d, $J_{2,NH}=7.0$ Hz, 1H; GalN N*H*), 5.24 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.96 (ABq, 2H; CH_2Ar), 4.85 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.63 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.5$ Hz, 1H; GalN H-3), 4.52 (dd, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 4.20–4.02 (m, 3H; GalN H-6a, H-6b, GlcA H-4), 3.90–3.79 (m, 4H; GalN H-2, COOCH_3), 3.85 (d, $J_{4,5}=9.0$ Hz, 1H; GlcA H-5), 3.59–3.43 (m, 2H; GlcA H-2, H-3), 3.46 (m, 1H; GalN H-5), 3.23 (d, $J_{4,OH}=2.5$ Hz, 1H; O*H*), 1.51, 1.50, 1.43, 1.40 ppm (4s, 12H; C(CH_3)$_2$); MS: *m*/*z*: 732 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{32}H_{38}Cl_3NO_{12}$: C 52.29, H 5.21, N 1.91; found: C 52.47, H 5.32, N 1.78.

2-Naphthylmethyl *O*-(methyl 2,3-*O*-isopropylidene-4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-2-deoxy-4,6-*O*-isopropylidene-2-trichloroacetamido-β-D-galactopyranoside (13): A mixture of **12** (2.78 g, 3.8 mmol), levulinic acid (0.56 g, 4.75 mmol), and DMAP (122 mg, 1 mmol) in anhydrous CH_2Cl_2 (40 mL) was treated portionwise with DCC (0.98 g, 4.75 mmol), and the mixture was stirred for 1 h at RT. The solids were filtered off, washed with CH_2Cl_2, and the filtrate was washed with saturated aqueous $NaHCO_3$ and water, dried ($MgSO_4$), and concentrated. Flash-silica chromatography (EtOAc/toluene 3:2, containing 0.2% of NEt_3) afforded the ester **13** (2.84 g, 90%) as a white powder. M.p. 188–190°C (from EtOAc/petroleum ether); $[\alpha]_D^{20}=-33$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.80$–7.43 (m, 7H; arom. H), 7.22 (d, $J_{2,NH}=7.0$ Hz, 1H; GalN N*H*), 5.27 (m, 1H; GlcA H-4), 5.17 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 4.92 (ABq, 2H; CH_2Ar), 4.83 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.57 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.5$ Hz, 1H; GalN H-3), 4.41 (dd, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 4.15–4.01 (m, 2H; GalN H-6a, H-6b), 3.90 (d, $J_{4,5}=9.0$ Hz, 1H; GlcA H-5), 3.83 (m, 1H; GalN H-2), 3.72 (s, 3H; COOCH_3), 3.61–3.54 (m, 2H; GlcA H-2, H-3), 3.40 (m, 1H; GalN H-5), 2.75–2.60 (m, 4H; CH_2CO), 2.18 (s, 3H; COCH_3), 1.50, 1.47, 1.39, 1.36 ppm (4s, 12H; C(CH_3)$_2$); MS: *m*/*z*: 830 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{37}H_{44}Cl_3NO_{14}$: C 53.34, H 5.32, N 1.68; found: C 53.55, H 5.45, N 1.72.

2-Naphthylmethyl *O*-(methyl 2,3-di-*O*-acetyl-4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (14): A solution of disaccharide **16** (3.16 g, 3.8 mmol) in 60% aqueous AcOH (30 mL) was stirred for 1 h at 100°C, then was cooled, concentrated, evaporated with water (3×30 mL), and dried under vacuum. A solution of the residue and in pyridine (30 mL) and Ac_2O (15 mL) was stirred for 16 h at RT, then was concentrated and evaporated with toluene (3×20 mL). Flash-silica chromatography (EtOAc/petroleum ether 3:2) gave the disaccharide **14** (2.48 g, 71%) as a white powder. M.p. 168–169°C (from 2-propanol); $[\alpha]_D^{20}=-19$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.80$–7.43 (m, 7H; arom. H), 6.85 (d, $J_{2,NH}=8.0$ Hz, 1H; GalN N*H*), 5.47 (d, $J_{3,4}=3.5$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.24–5.12 (m, 3H; GlcA H-2, H-3, H-4), 4.93 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 4.91 (ABq, 2H; CH_2Ar), 4.71 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.52 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.5$ Hz, 1H; GalN H-3), 4.17 (m, 2H; GalN H-6a, H-6b), 3.97 (d, $J_{4,5}=9.0$ Hz, 1H; GlcA H-5), 3.85 (m, 2H; GalN H-2, H-5), 3.74 (s, 3H; COOCH_3), 2.80–2.40 (m, 4H; CH_2CO), 2.14 (s, 3H; COCH_3), 2.13, 2.11, 2.02 ppm (3s, 12H; CO*C*H$_3$); MS: *m*/*z*: 937 $[M+NH_4]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{39}H_{44}Cl_3NO_{18}$: C 50.85, H 4.81, N 1.52; found: C 50.82, H 4.92, N 1.43.

2-Naphthylmethyl *O*-(methyl 2,3-di-*O*-benzoyl-4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-benzoyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (15): From acetal **13** (1.20 g, 1.44 mmol) as described for the preparation of **14**. The solid residue and benzoyl chloride (1.23 mL, 10.6 mmol) in pyridine (12 mL) were stirred for 2 h at 0°C. Methanol (1.2 mL) was added, and the mixture was diluted with CH_2Cl_2 (100 mL), washed with water, saturated aqueous $NaHCO_3$ and water, dried ($MgSO_4$), and concentrated. Flash-silica chromatography (EtOAc/petroleum ether 1:1) afforded the disaccharide **15** (955 mg, 56%) as a white powder. $[\alpha]_D^{20}=+24$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=8.09$–7.26 (m, 27H; arom. H), 6.85 (d, $J_{2,NH}=7.0$ Hz, 1H; GalN N*H*), 5.87 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.56 (dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 1H; GlcA H-3), 5.42 (dd, $J_{4,5}=10.0$ Hz, 1H; GlcA H-4), 5.30 (dd, $J_{1,2}=7.0$ Hz, 1H; GlcA H-2), 5.12 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 4.94 (d, 1H; GlcA H-1), 4.89 (ABq, 2H; CH_2Ar), 4.88 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.58–4.50 (m, 2H; GalN H-6a, H-6b), 4.16 (d, 1H; GlcA H-5), 4.13 (m, 1H; GalN H-5), 3.81 (m, 1H; GalN H-2), 3.71 (s, 3H; COOCH_3), 2.60–2.35 (m, 4H; CH_2CO), 2.10 ppm (s, 3H; COCH_3); MS: *m*/*z*: 1190 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{59}H_{52}Cl_3NO_{18}$: C 60.60, H 4.48, N 1.20; found: C 60.35, H 4.56, N 1.27.

2-Naphthylmethyl *O*-(methyl 2,3-di-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (16): A freshly prepared mixture of pyridine/acetic acid/hydrazine hydrate (6:4:0.5, 17 mL) was added to a solution of disaccharide **14** (748 mg, 0.81 mmol) in pyridine (7.5 mL), and the mixture was stirred for 8 min at RT, then was diluted with CH_2Cl_2 (50 mL), washed with water and saturated aqueous $NaHCO_3$, dried ($MgSO_4$), concentrated, and evaporated with toluene. Flash-silica chromatography (EtOAc/petroleum ether 3:2) afforded the disaccharide **16** (592 mg, 89%) as a white powder. M.p. 183°C (from 2-propanol); $[\alpha]_D^{20}=-30$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.85$–7.35 (m, 7H; arom. H), 6.81 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN N*H*), 5.49 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 4.90 (ABq, 2H; CH_2Ar), 5.01–4.80 (m, 2H; GlcA H-2, H-3), 4.95 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.66 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.52 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.25–4.10 (m, 2H; GalN H-6a, H-6b), 3.92–3.80 (m, 3H; GalN H-5, GlcA H-4, H-5), 3.83 (s, 3H; COOCH_3), 3.80 (m, 1H; GalN H-2), 3.11 (d, $J_{4,OH}=3.0$ Hz, 1H; GlcA *H*O-4), 2.13, 2.10, 2.05, 2.02 ppm (4s, 12H; OCOCH_3); MS: *m*/*z*: 844 $[M+NH_4]^+$, 822 $[M+H]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{34}H_{38}Cl_3NO_{16}$: C 49.62, H 4.65, N 1.70; found: C 49.40, H 4.52, N 1.58.

2-Naphthylmethyl *O*-(methyl 2,3-di-*O*-benzoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-benzoyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (17): From disaccharide **15** (880 mg, 0.75 mmol) as described for the preparation of disaccharide **16**. Flash-silica chromatography (EtOAc/petroleum ether 1:1) afforded the disaccharide **17** (720 mg, 89%) as a white powder. M.p. 179–181°C (from EtOAc/petroleum ether); $[\alpha]_D^{20}=+19$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=8.09$–7.26 (m, 27H; arom. H), 6.86 (d, $J_{2,NH}=7.0$ Hz, 1H; GalN N*H*), 5.88 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz 1H; GalN H-4), 5.43 (dd, $J_{2,3}=J_{3,4}=9.0$ Hz, 1H; GlcA H-3), 5.25 (dd, $J_{1,2}=7.0$ Hz, 1H; GlcA H-2), 5.15 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.91 (d, 1H; GlcA H-1), 4.89 (ABq, 2H; CH_2Ar), 4.88 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.54–4.50 (m, 2H; GalN H-6a, H-6b), 4.19–4.08 (m, 2H; GalN H-5, GlcA H-4), 4.04 (d, $J_{4,5}=10.0$ Hz, 1H; GlcA H-5), 3.80 (m, 1H; GalN H-2), 3.75 (s, 3H; COOCH_3), 3.34 ppm (d, $J_{4,OH}=3.0$ Hz, 1H; GlcA *H*O-4); MS: *m*/*z*: 1092 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{54}H_{46}Cl_3NO_{16}$: C 60.54, H 4.33, N 1.31; found: C 60.70, H 4.21, N 1.24.

***O*-(Methyl 2,3-di-*O*-acetyl-4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-1-*O*-trichloroacetimidoyl-α-D-galactopyranose (18)**: DDQ (480 mg, 2.12 mmol) was added to a solution of disaccharide **14** (651 mg, 0.71 mmol) in CH_2Cl_2/MeOH (9:1, 7 mL), and the mixture was stirred for 24 h at RT under dry argon, then was diluted with CH_2Cl_2 (40 mL), washed with saturated aqueous $NaHCO_3$ and water, dried ($MgSO_4$), and concentrated. Flash-silica chromatography (CH_2Cl_2/acetone 9:1) gave the corresponding free hemiacetal (471 mg, 85%) as a pale yellow powder. A mixture of the above isolated hemiacetal (471 mg, 0.60 mmol), CCl_3CN (0.61 mL, 6 mmol), and DBU (18 μL, 0.12 mmol) in dry CH_2Cl_2 (5 mL) was stirred for 30 min at RT, then was concentrated. Flash-silica chromatography (EtOAc/petroleum ether 1:1, containing 0.1% of NEt_3) and crystallization from EtOAc/petroleum ether gave the imidate **18** (368 mg, 66%). M.p. 100–101°C; $[\alpha]_D^{22}=+55$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=8.75$ (s, 1H; C=N*H*), 6.87 (d, $J_{2,NH}=8.2$ Hz, 1H; N*H*), 6.52 (d, $J_{1,2}=3.5$ Hz, 1H; GalN H-1), 5.42 (dd, $J_{3,4}=3.5$ Hz, $J_{4,5}=0.8$ Hz, 1H; GalN H-4), 5.17 (m, 2H; GlcA H-3, H-4), 5.05 (m, 1H; GlcA H-2), 4.78 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 4.60 (m, $J_{2,3}=11.0$ Hz, 1H; GalN H-2), 4.31 (m, 1H; GalN H-5), 4.30 (dd, 1H; GalN H-3), 4.16 (dd, $J_{5,6a}=6.0$ Hz, $J_{6a,6b}=11.5$ Hz, 1H; GalN H-6a), 4.00 (d, $J_{4,5}=9.5$ Hz, 1H; GlcA H-5), 3.97 (dd, $J_{5,6b}=7.0$ Hz, 1H; GalN H-6b), 3.72 (s, 3H; COOCH_3), 2.68, 2.45 (2 m, 4H; CH_2CO), 2.14, 2.13, 2.05, 2.03, 2.01 ppm (5s, 15H; COCH_3,

CH_3CO); ISMS: m/z: 940 $[M+NH_4]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{30}H_{36}Cl_6N_2O_{18}$: C 38.94, H 3.92, N 3.03; found: C 38.76, H 3.78, N, 2.88.

***O*-(Methyl 2,3-di-*O*-benzoyl-4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-benzoyl-2-deoxy-2-trichloroacetamido-1-*O*-trichloroacetimidoyl-α-D-galactopyranose (19)**: From disaccharide **17** (3.91 g, 3.34 mmol) as described for the preparation of **18**. Flash-silica chromatography (petroleum ether/EtOAc 3:2, containing 0.1% of NEt_3) afforded the imidate **19** (2.15 g, 74%) as a white powder. M.p. 112–115°C (from petroleum ether/diethyl ether); $[\alpha]_D^{20}=+89$ ($c=1$ in chloroform); ^1H NMR (250 MHz, $CDCl_3$): $\delta=8.72$ (s, 1H; C=N*H*), 8.01–7.26 (m, 20H; arom. H), 6.95 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN N*H*), 6.69 (d, $J_{1,2}=3.5$ Hz, 1H; GalN H-1), 5.99 (dd, $J_{3,4}=2.5$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.64 (dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 1H; GlcA H-3), 5.45 (dd, $J_{1,2}=8.0$ Hz, 1H; GlcA H-2), 5.39 (dd, $J_{4,5}=9.5$ Hz, 1H; GlcA H-4), 5.16 (d, 1H; GlcA H-1), 4.81 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-2), 4.62–4.58 (m, 2H; GalN H-3, H-6a), 4.44–4.38 (m, 2H; GalN H-5, H-6b), 4.25 (d, 1H; GlcA H-5), 3.67 (s, 3H; $COOCH_3$), 2.62–234 (m, 4H; CH_2 CO), 2.03 ppm (s, 3H; $COCH_3$); MS: m/z: 1026 $[M-C(NH)CCl_3]^+$(for ^{35}Cl); elemental analysis calcd (%) for $C_{50}H_{44}Cl_6N_2O_{18}$: C 51.17, H 3.78, N 2.39; found: C 51.06, H 4.04, N 2.39.

2-Benzyloxycarbonylaminoethyl *O*-(methyl 2,3-di-*O*-acetyl-4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (20): From imidate **18** (262 mg, 0.28 mmol) as described for the preparation of **8**. Flash-silica chromatography (EtOAc/acetone 12:1, containing 0.1% of NEt_3) afforded the disaccharide **20** (147 mg, 54%) as a white powder. $R_f=0.22$ (CH_2Cl_2/acetone 12:1); $[\alpha]_D^{20}=+8$ ($c=1$ in chloroform); ^1H NMR (250 MHz, $CDCl_3$): $\delta=$ 7.33–7.21 (m, 5H; arom. H), 7.09 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN N*H*), 5.33 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.10–4.97 (m, 5H; GlcA H-3, H-4, CH_2Ph, N*H*COO), 4.85 (m, 1H; GlcA H-2), 4.71 (d, $J_{1,2}=$ 8.0 Hz, 1H; GalN H-1), 4.64 (d, $J_{1,2}=8.0$ Hz, 1H; GlcA H-1), 4.39 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.08 (dd, $J_{6a,6b}=11.5$ Hz, $J_{5,6a}=6.0$ Hz, 1H; GalN H-6a), 3.99–3.95 (m, 2H; GalN H-6b, GlcA H-5), 3.81–3.71 (m, 2H; GalN H-5, CH_2O), 3.63 (s, 3H; $COOCH_3$), 3.62–3.57 (m, 2H; GalN H-2, CH_2O), 3.31–3.21 (m, 2H; CH_2N), 2.63–2.59 (m, 2H; CH_2CO), 2.42–2.33 (m, 2H; CH_2CO), 2.07, 2.03, 1.96, 1.95 ppm (4s, 15H; $OCOCH_3$); MS: m/z: 955 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{38}H_{47}Cl_3N_2O_{20}$: C 47.64, H 4.94, N 2.92; found: C 47.56, H 5.02, N, 2.85.

2-Benzyloxycarbonylaminoethyl *O*-(methyl 2,3-di-*O*-benzoyl-4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-benzoyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (21): From imidate **19** (1.0 g, 0.85 mmol) as described for the preparation of **8**. Flash-silica chromatography (toluene/EtOAc 1:1, containing 0.1% of NEt_3) afforded the disaccharide **21** (918 mg, 89%) as a white powder. $[\alpha]_D^{20}=+44$ ($c=1$ in chloroform); ^1H NMR (250 MHz, $CDCl_3$): $\delta=8.09$–7.31 (m, 25H; arom. H), 6.88 (d, $J_{2,NH}=6.5$ Hz, 1H; GalN N*H*), 5.88 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.58 (dd, $J_{2,3}=10.0$ Hz, $J_{3,4}=9.5$ Hz, 1H; GlcA H-3), 5.42 (dd, $J_{4,5}=10.0$ Hz, 1H; GlcA H-4), 5.21 (dd, $J_{1,2}=7.5$ Hz, 1H; GlcA H-2), 5.14 (m, 1H; N*H*COO), 5.08 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 5.04 (s, 2H; CH_2Ph), 4.98 (d, 1H; GlcA H-1), 4.82 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.45–4.40 (m, 2H; GalN H-6a, H-6b), 4.21 (d, 1H; GlcA H-5), 4.11 (m, 1H; GalN H-5), 3.89–3.71 (m, 2H; GalN H-2, CH_2O), 3.72 (s, 3H; $COOCH_3$), 3.67 (m, 1H; CH_2O), 3.41–3.29 (m, 2H; CH_2N), 2.62–2.37 (m, 4H; CH_2CO), 2.02 ppm (s, 3H; $COCH_3$); MS: m/z: 1227 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{58}H_{55}Cl_3N_2O_{20}$: C 57.74, H 4.60, N 2.32; found: C 57.87, H 4.09, N 2.55.

2-Benzyloxycarbonylaminoethyl *O*-(methyl 2,3-di-*O*-acetyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (22): From disaccharide **20** (365 mg, 0.38 mmol) as described for the preparation of **8**. Flash-silica chromatography (EtOAc/toluene 2:1) afforded the alcohol **22** (263 mg, 80%) as a white powder. $[\alpha]_D^{20}=+1$ ($c=1$ in chloroform); ^1H NMR (250 MHz, $CDCl_3$): $\delta=7.39$–7.32 (m, 5H; arom. H), 6.72 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN N*H*), 5.49 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.19 (m, 1H; N*H*COO), 5.18 (s, 2H; CH_2Ph), 5.00 (m, 1H; GlcA H-3), 4.91–4.83 (m, 2H; GalN H-1, GlcA H-2), 4.69 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.39 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.20–3.99 (m, 3H; GalN H-6a, H-6b, GlcA H-5), 3.92–3.82 (m, 3H; GalN H-5, GlcA H-4, CH_2O), 3.79 (s, 3H; $COOCH_3$), 3.78–3.67 (m, 2H; GalN H-2, CH_2O), 3.45–3.31 (m, 2H; CH_2N), 3.13 (d, $J_{4,OH}=3.0$ Hz, 1H; GlcA *H*O-4), 2.11, 2.05, 2.04, 2.02 ppm (4s, 12H; $OCOCH_3$); MS: m/z: 857 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{33}H_{41}Cl_3N_2O_{18}$: C 46.09, H 4.81, N 3.26; found: C 46.39, H 4.81, N 3.19.

2-Benzyloxycarbonylaminoethyl *O*-(methyl 2,3-di-*O*-benzoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-di-*O*-benzoyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (23): From disaccharide **21** (882 mg, 0.73 mmol) as described for the preparation of **8**. Flash-silica chromatography (petroleum ether/EtOAc 1:1) afforded the alcohol **23** (621 mg, 75%) as a white powder. $[\alpha]_D^{20}=+39$ ($c=1$ in chloroform); ^1H NMR (250 MHz, $CDCl_3$): $\delta=8.09$–7.71 (m, 25H; arom. H), 6.88 (d, $J_{2,NH}=$ 7.0 Hz, 1H; GalN N*H*), 5.89 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.43 (dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 1H; GlcA H-3), 5.26 (m, 1H; GlcA H-2), 5.12–5.09 (m, 1H; N*H*COO), 5.09 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 5.01 (s, 2H; CH_2Ph), 4.96 (d, $J_{1,2}=7.0$ Hz, 1H; GlcA H-1), 4.84 (dd, $J_{2,3}=$ 11.0 Hz, 1H; GalN H-3), 4.49–4.38 (m, 2H; GalN H-6a, H-6b), 4.57–4.51 (m, 2H; GalN H-5, GlcA H-4), 4.08 (d, $J_{4,5}=9.5$ Hz, 1H; GlcA H-5), 3.91–3.80 (m, 1H; CH_2O), 3.77 (s, 3H; $COOCH_3$), 3.72–3.61 (m, 2H; GalN H-2, CH_2O), 3.42–3.34 (m, 2H; CH_2N), 3.33 ppm (d, $J_{4,OH}=3.0$ Hz, 1H; GlcA *H*O-4); MS: m/z: 1129 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{53}H_{49}Cl_3N_2O_{18}$: C 57.44, H 4.46, N 2.53; found: C 57.79, H 4.62, N 2.45.

2-Naphthylmethyl *O*-(methyl 2,3-*O*-isopropylidene-β-D-glucopyranosyluronate)-(1→3)-4,6-*O*-benzylidene-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (24): From disaccharide **10** (8.69 g, 10 mmol) as described for the preparation of **12**. Flash-silica chromatography (CH_2Cl_2/acetone 9:1, containing 0.2% of Et_3N) gave the alcohol **24** (5.49 g, 70%) as a white powder. $R_f=0.27$ (toluene/EtOAc 3:2 containing 0.2% of NEt_3); m.p. 188–190°C (from petroleum ether/EtOAc); $[\alpha]_D^{20}=-8.5$ ($c=1$ in chloroform); ^1H NMR (250 MHz, $CDCl_3$): $\delta=7.83$–7.27 (m, 12H; arom. H), 7.24 (d, $J_{2,NH}=6.5$ Hz, 1H; GalN N*H*), 5.61 (s, 1H; C*H*Ph), 5.34 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.96 (ABq, 2H; CH_2Ar), 4.93 (d, $J_{1,2}=$ 7.5 Hz, 1H; GlcA H-1), 4.75 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.0$ Hz, 1H; GalN H-3), 4.48 (dd, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 4.42 (d, $J_{6a,6b}=12.5$ Hz, 1H; GalN H-6a), 4.15–4.05 (m, 2H; GalN H-6b, GlcA H-4), 3.96–3.83 (m, 5H; GalN H-2, GlcA H-5, $COOCH_3$), 3.57 (m, 1H; GalN H-5), 3.58–3.39 (m, 2H; GlcA H-2, H-3), 3.24 (d, $J_{4,OH}=2.5$ Hz, 1H; GlcA *H*O-4), 1.42, 1.39 ppm (2s, 6H; $C(CH_3)_2$); MS: m/z: 799 $[M+NH_4]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{36}H_{38}Cl_3NO_{12}$: C 55.22, H 4.89, N 1.79; found: C 54.97, H 4.96, N 1.70.

2-Naphthylmethyl *O*-(methyl 2,3-*O*-isopropylidene-4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-*O*-benzylidene-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (25): From disaccharide **24** (5.02 g, 6.4 mmol) as described for the preparation of **13**. Flash-silica chromatography (CH_2Cl_2/acetone 12:1, containing 0.2% of NEt_3) gave the disaccharide **25** (5.19 g, 92%) as a white powder. $R_f=0.25$ (toluene/EtOAc 3:2 containing 0.2% of NEt_3); m.p. 200–203°C (from EtOAc); $[\alpha]_D^{20}=-10$ ($c=1$ in chloroform); ^1H NMR (250 MHz, $CDCl_3$): $\delta=7.82$–7.35 (m, 12H; arom. H), 7.22 (d, $J_{2,NH}=7.0$ Hz, 1H; GalN N*H*), 5.63 (s, 1H; C*H*Ph), 5.30 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 5.28 (m, 1H; GlcA H-4), 4.95 (ABq, 2H; CH_2Ar), 4.91 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.72 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.5$ Hz, 1H; GalN H-3), 4.44 (dd, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 4.40 (m, 1H; GalN H-6a), 4.13 (m, 1H; GalN H-6b), 3.93 (d, $J_{4,5}=8.0$ Hz, 1H; GlcA H-5), 3.91 (m, 1H; GalN H-2), 3.71 (s, 3H; $COOCH_3$), 3.62–3.56 (m, 3H; GalN H-5, GlcA H-2, H-3), 2.85–2.55 (m, 4H; CH_2CO), 2.18 (s, 3H; $COCH_3$), 1.40, 1.37 ppm (2s, 6H; $C(CH_3)_2$); MS: m/z: 897 $[M+NH_4]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{41}H_{44}Cl_3NO_{14}$: C 55.89, H 5.03, N 1.59; found: C 55.63, H 5.07, N 1.52.

2-Naphthylmethyl *O*-(methyl 4-*O*-levulinoyl-β-D-glucopyranosyluronate)-(1→3)-4,6-*O*-benzylidene-2-deoxy-2-trichloroacetamido-β-D-galactopyranoside (26): A solution of **25** (4.05 g, 4.6 mmol) in CH_2Cl_2/AcOH/water (5:4:1, 80 mL) was stirred for 24 h at RT, then was concentrated, evaporated with water (3×20 mL), and dried in vacuo. Flash-silica chromatography (CH_2Cl_2/MeOH 19:1→12:1) gave the diol **26** (3.06 g, 79%) as a white solid. $R_f=0.40$ (CH_2Cl_2/MeOH 12:1); m.p. 194–195°C (from

EtOAc); $[\alpha]_D^{20}=-8.5$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, CD_3OD/$CDCl_3$ 3:1): $\delta=7.83$–7.30 (m, 12H; arom. H), 5.63 (s, 1H; C*H*Ph), 4.95 (ABq, 2H; CH_2Ar), 4.93 (d, $J_{1,2}=7.5$ Hz, 1H; GalN H-1), 4.85 (dd, $J_{3,4}=9.5$ Hz, $J_{4,5}=10.0$ Hz, 1H; GlcA H-4), 4.45 (m, 2H; GlcA H-1, GalN H-4), 4.24 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.5$ Hz; GalN H-3), 4.20–4.10 (m, 3H; GalN H-2, H-6a, H-6b), 3.94 (d, 1H; GlcA H-5), 3.69 (s, 3H; COOCH_3), 3.55 (m, 2H; GalN H-5, GlcA H-3), 3.35 (dd, $J_{1,2}=7.5$ Hz, $J_{2,3}=9.5$ Hz; GlcA H-2), 2.87–2.55 (m, 4H; CH_2CO), 2.16 ppm (s, 3H; COCH_3); MS: *m*/*z*: 862 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{38}H_{40}Cl_3NO_{14}$: C 54.26, H 4.79, N 1.66; found: C 54.19, H 4.86, N 1.52.

Tetrasaccharide 27: From imidate **5** (480 mg, 0.55 mmol) and alcohol **16** (300 mg, 0.36 mmol) as described for the preparation of **6**. Flash-silica chromatography (EtOAc/petroleum ether 2:1, containing 0.1% of NEt_3) afforded the tetrasaccharide **27** (316 mg, 57%) as a white powder. M.p. 140°C (from 2-propanol); $[\alpha]_D^{20}=-9.5$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.70$–7.21 (m, 7H; arom. H), 6.98, 6.91 (2d, $J_{2,NH}=7.0$ Hz, 2H; 2GalN N*H*), 5.44, 5.39 (2dd, $J_{3,4}=3.5$ Hz, $J_{4,5}<1.0$ Hz, 2H; 2GalN H-4), 5.14 (dd, $J_{3,4}=8.0$ Hz, $J_{4,5}=8.5$ Hz, 1H; GlcA^{II} H-4), 5.05–4.96 (m, 2H; 2GlcA H-3), 4.91, 4.90 (2d, $J_{1,2}=8.5$ Hz, 2H; 2GalN H-1), 4.89 (ABq, 2H; CH_2Ar), 4.88–4.83 (m, 2H; 2GlcA H-2), 4.66, 4.63 (2d, $J_{1,2}=7.5$ Hz, 2H; 2GlcA H-1), 4.46, 4.28 (2dd, $J_{2,3}=11.0$ Hz, 2H; 2GalN H-3), 4.17–4.07 (m, 5H; 2GalN H-6a, H-6b, GlcA^{I} H-4), 3.96 (d, 1H; GlcA^{II} H-5), 3.90 (d, $J_{4,5}=9.5$ Hz, 1H; GlcA^{I} H-5), 3.87–3.80 (m, 2H; 2GalN H-5), 3.82, 3.75 (2s, 6H; COOCH_3), 3.80–3.65 (m, 2H; 2GalN H-2), 2.09, 2.02, 2.00, 1.99, 1.98, 1.97 ppm (6s, 27H; OCOCH_3); MS: *m*/*z*: 1525 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{59}H_{68}Cl_6N_2O_{32}$: C 46.32, H 4.48, N 1.83; found: C 46.19, H 4.44, N 1.82.

Tetrasaccharide 28: From imidate **18** (168 mg, 0.18 mmol) and alcohol **16** (100 mg, 0.12 mmol) as described for the preparation of disaccharide **6**. Flash-silica chromatography (EtOAc/petroleum ether 2:1, containing 0.1% of NEt_3) afforded the tetrasaccharide **28** (110 mg, 57%) as a white powder. M.p. 143–145°C (from 2-propanol); $[\alpha]_D^{20}=-6$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.80$–7.31 (m, 7H; arom. H), 6.97, 6.92 (2d, $J_{2,NH}=7.5$ Hz, 2H; 2GalN N*H*), 5.44, 5.39 (2dd, $J_{3,4}=3.5$ Hz, $J_{4,5}<1.0$ Hz, 2H; 2GalN H-4), 5.19 (dd, $J_{3,4}=8.0$ Hz, $J_{4,5}=9.5$ Hz, 1H; GlcA^{II} H-4), 5.20–5.10 (m, 2H; 2GlcA H-3), 4.91 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 4.90 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.89 (ABq, 2H; CH_2Ar), 4.86–4.82 (m, 2H; 2GlcA H-2), 4.67 (d, $J_{1,2}=7.0$ Hz, 1H; GlcA H-1), 4.64 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.47, 4.28 (2dd, $J_{2,3}=11.0$ Hz, 2H; 2GalN H-3), 4.17–4.00 (m, 5H; 2GalN H-6a, H-6b, GlcA^{I} H-4), 3.96, 3.91 (2d, $J_{4,5}=9.5$ Hz, 2H; 2GlcA H-5), 3.89–3.81 (m, 2H; 2GalN H-5), 3.83, 3.75 (2s, 6H; COOCH_3), 3.80–3.68 (m, 2H; 2GalN H-2), 2.75–2.68, 2.50–2.40 (2m, 4H; CH_2CO), 2.11 (s, 3H; COCH_3), 2.09, 2.07, 2.05, 2.04, 2.03, 2.02, 2.00 ppm (8s, 24H; OCOCH_3); MS: *m*/*z*: 1581 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{62}H_{72}Cl_6N_2O_{33}$: C 46.95, H 4.58, N 1.77; found: C 46.75, H 4.72, N 1.70.

Tetrasaccharide acceptor 29: From tetrasaccharide **28** (152 mg, 90 μmol) as described for the preparation of disaccharide **16**. Flash-silica chromatography (EtOAc/petroleum ether 3:1) afforded the alcohol **29** (110 mg, 77%) as a white powder. M.p. 142°C (from 2-propanol); $[\alpha]_D^{20}=-13$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.80$–7.35 (m, 7H; arom. H), 6.80, 6.78 (2d, $J_{2,NH}=7.5$ Hz, 2H; 2GalN N*H*), 5.45, 5.44 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 2H; 2GalN H-4), 5.15–5.05 (m, 2H; 2GlcA H-3), 4.93, 4.91 (2d, $J_{1,2}=8.5$ Hz, 2H; 2GalN H-1), 4.89 (ABq, 2H; CH_2Ar), 4.86–4.82 (m, 2H; 2GlcA H-2), 4.64, 4.60 (2d, $J_{1,2}=7.5$ Hz, 2H; 2GlcA H-1), 4.51, 4.26 (2dd, $J_{2,3}=11.0$ Hz, 2H; 2GalN H-3), 4.19–4.00 (m, 5H; 2GalN H-6a, 2H-6b, GlcA^{I} H-4), 3.95–3.70 (m, 5H; 2GalN H-5, GlcA^{II} H-4, 2GlcA H-5), 3.86, 3.84 (2s, 6H; COOCH_3), 3.75–3.65 (m, 2H; 2GalN H-2), 3.14 (d, $J_{4,OH}=3.0$ Hz, 1H; GlcA^{II} *H*O-4), 2.35, 2.12, 2.10, 2.05, 2.04, 2.00, 1.98 ppm (7s, 24H; OCOCH_3); MS: *m*/*z*: 1485 $[M+H]^+$, 1502 $[M+NH_4]^+$, 1507 $[M+Na]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{57}H_{66}Cl_6N_2O_{31}$: C 46.01, H 4.47, N 1.88; found: C 46.17, H 4.38, N 1.78.

Hexasaccharide 30: From imidate **5** (116 mg, 0.13 mmol) and alcohol **29** (100 mg, 70 μmol) as described for the preparation of disaccharide **6**. Flash-silica chromatography (EtOAc/toluene 3:1, containing 0.1% of NEt_3) afforded the hexasaccharide **30** (100 mg, 65%) as a white powder. M.p. 157–158°C (from 2-propanol); $[\alpha]_D^{20}=-7$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.85$–7.35 (m, 7H; arom. H), 6.98, 6.91, 6.90 (3d, $J_{2,NH}=7.0$ Hz, 3H; 3GalN N*H*), 5.45, 5.41, 5.38 (3dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 3H; 3GalN H-4), 5.23–5.12 (m, 3H; 3GlcA H-3), 5.03–4.85 (m, 4H; GlcA^{III} H-4, 3GlcA H-2), 4.94, 4.92, 4.91 (3d, $J_{1,2}=8.0$ Hz, 3H; 3GalN H-1), 4.91 (ABq, 2H; CH_2Ar), 4.68, 4.66, 4.65 (3d, $J_{1,2}=7.5$ Hz, 3H; 3GlcA H-1), 4.48, 4.27, 4.23 (3dd, $J_{2,3}=11.0$ Hz, 3H; 3GalN H-3), 4.15–3.80 (m, 14H; 3GalN H-5, H-6a, H-6b, GlcA^{I} H-4, GlcA^{II} H-4, 3GlcA H-5), 3.85, 3.83, 3.76 (3s, 9H; COOCH_3), 3.78–3.68 (m, 3H; 3GalN H-2), 2.35, 2.11, 2.09, 2.04, 2.01, 2.00, 1.99 ppm (7s, 39H; OCOCH_3); MS: *m*/*z*: 2188 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{82}H_{95}Cl_9N_3O_{47}$: C 44.88, H 4.41, N 1.91; found: C 44.61, H 4.47, N 1.91.

Tetrasaccharide 31: From imidate **19** (1.01 g, 0.86 mmol) and alcohol **23** (710 mg, 0.66 mmol) as described for the preparation of disaccharide **6**. Flash-silica chromatography (toluene/EtOAc 3:1, containing 0.1% of NEt_3) afforded the tetrasaccharide **31** (850 mg, 62%) as a white powder. M.p. 163–165°C (from 2-propanol); $[\alpha]_D^{20}=+12$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=8.12$–7.10 (m, 47H; arom. H), 6.87, 6.80 (2d, $J_{2,NH}=8.0$ Hz, 2H; 2GalN N*H*), 5.82 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4), 5.61 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{II} H-4), 5.53 (dd, $J_{2,3}=J_{3,4}=9.0$ Hz, 1H; GlcA^{I} H-3), 5.46 (dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 1H; GlcA^{II} H-3), 5.38 (dd, $J_{4,5}=10.0$ Hz, 1H; GlcA^{II} H-4), 5.27–5.20 (m, 2H; 2GlcA H-2), 5.15, 5.13 (2d, $J_{1,2}=8.0$ Hz, 2H; 2GalN H-1), 4.89 (d, $J_{1,2}=7.0$ Hz, 1H; GlcA H-1), 4.87 (ABq, 2H; CH_2Ar), 4.86 (d, $J_{1,2}=7.0$ Hz, 1H; GlcA H-1), 4.84 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN^{I} H-3), 4.68 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN^{II} H-3), 4.54–4.49 (m, 2H; GalN^{I} H-6a, H-6b), 4.31 (dd, $J_{4,5}=9.5$ Hz, 1H; GlcA^{I} H-4), 4.15–4.08 (m, 2H; GalN^{I} H-5, GlcA^{II} H-5), 4.02 (d, 1H; GlcA^{I} H-5), 3.88 (m, 1H; GalN^{II} H-5), 3.78 (m, 1H; GalN^{I} H-2), 3.72, 3.65 (2s, 6H; COOCH_3), 3.70–350 (m, 2H; GalN^{II} H-2, H-6a), 3.32 (dd, $J_{6a,6b}=11.0$ Hz, $J_{5,6b}=7.0$ Hz, 1H; GalN^{II} H-6b), 2.42 (m, 4H; CH_2CO), 2.00 ppm (s, 3H; COCH_3); MS: *m*/*z*: 2077 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{102}H_{88}Cl_6N_2O_{33}$: C 58.83, H 4.26, N 1.35; found: C 58.56, H 4.43, N 1.34.

Tetrasaccharide acceptor 32: From tetrasaccharide **31** (634 mg, 0.31 mmol) as described for the preparation of disaccharide **16**. Flash-silica chromatography (petroleum ether/EtOAc 1:1) afforded the alcohol **38** (415 mg, 69%) as a white powder. M.p. 173–175°C (from 2-propanol); $[\alpha]_D^{20}=+2$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=8.20$–7.25 (m, 47H; arom. H), 6.86 (d, $J_{2,NH}=8.0$ Hz, 1H; GalN^{I} N*H*), 6.74 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN^{II} N*H*), 5.82 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4), 5.63 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{II} H-4), 5.47 (dd, $J_{2,3}=J_{3,4}=9.0$ Hz, 1H; GlcA^{I} H-3), 5.38 (dd, $J_{2,3}=J_{3,4}=9.0$ Hz, 1H; GlcA^{II} H-3), 5.20 (m, 2H; 2GlcA H-2), 5.16 (d, $J_{1,2}=8.0$ Hz, 1H; GalN H-1), 5.14 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.90 (d, $J_{1,2}=7.0$ Hz, 1H; GlcA H-1), 4.88 (ABq, 2H; CH_2Ar), 4.87 (m, 1H; GalN^{I} H-3), 4.84 (d, $J_{1,2}=7.0$ Hz, 1H; GlcA H-1), 4.69 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN^{II} H-3), 4.55–4.45 (m, 2H; GalN^{I} H-6a, H-6b), 4.32 (dd, $J_{4,5}=9.5$ Hz, 1H; GlcA^{I} H-4), 4.15–4.05 (m, 2H; GalN^{I} H-5, GlcA^{II} H-4), 4.02, 3.99 (2d, $J_{4,5}=9.5$ Hz, 2H; 2GlcA H-5), 3.90 (m, 1H; GalN^{II} H-5), 3.74 (m, 1H; GalN^{I} H-2), 3.72, 3.69 (2s, 6H; COOCH_3), 3.68–3.52 (m, 2H; GalN^{II} H-2, H-6a), 3.34 (d, $J_{4,OH}=3.0$ Hz, 1H; GlcA^{II} *H*O-4), 3.30 ppm (dd, $J_{6a,6b}=11.0$ Hz, $J_{5,6b}=7.0$ Hz, 1H; GalN^{II} H-6b); MS: *m*/*z*: 1979 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{97}H_{82}Cl_6N_2O_{31}$: C 58.71, H 4.17, N 1.41; found: C 58.72, H 4.37, N 1.36.

Hexasaccharide 33: From imidate **19** (270 mg, 0.23 mmol) and alcohol **32** (283 mg, 0.14 mmol) as described for the preparation of disaccharide **6**. Flash-silica chromatography (toluene/EtOAc 1:1, containing 0.1% of NEt_3) afforded the hexasaccharide **33** (277 mg, 65%) as a white powder. M.p. 184–186°C (from CH_2Cl_2/diethyl ether/petroleum ether); $[\alpha]_D^{20}=-1$ ($c=1$ in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta=8.10$–7.05 (m, 67H; arom. H), 6.84, 6.81, 6.72 (3d, $J_{2,NH}=7.5$ Hz, 3H; 3GalN N*H*), 5.81 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4), 5.60, 5.55 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 2H; GalN^{II} H-4, GalN^{III} H-4), 5.52 (dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 1H; GlcA^{I} H-3), 5.45, 5.42 (2dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 2H; GlcA^{II} H-3, GlcA^{III} H-3), 5.37 (dd, $J_{4,5}=10.0$ Hz, 1H; GlcA^{III} H-4), 5.22 (dd, $J_{1,2}=7.5$ Hz, 1H; GlcA^{I} H-2), 5.21 (dd, $J_{1,2}=7.5$ Hz, 1H; GlcA H-2), 5.15 (m, 1H; GlcA H-2), 5.14, 5.13, 5.10 (3d, $J_{1,2}=8.0$ Hz, 3H; 3GalN H-1), 4.88 (d, $J_{1,2}=7.5$ Hz, 1H; GlcA H-1), 4.87 (ABq, 2H; CH_2Ar), 4.86 (m, 1H;

GalN^{I} H-3), 4.85, 4.81 (2 d, $J_{1,2}$ = 7.5 Hz, 2 H; 2GlcA H-1), 4.68, 4.65 (2 dd, $J_{2,3}$ = 11.0 Hz, 2 H; GalN^{II} H-3, GalN^{III} H-3), 4.51–4.49 (m, 2 H; GalN^{I} H-6a, H-6b), 4.31, 4.26 (2 dd, $J_{4,5}$ = 9.5 Hz, 2 H; GlcA^{I} H-4, GlcA^{II} H-4), 4.12 (m, 1 H; GalN^{I} H-5), 4.10 (d, 1 H; GlcA^{III} H-5), 4.00, 3.96 (2 d, 2 H; GlcA^{I} H-5, GlcA^{II} H-5), 3.86–3.83 (m, 2 H; GalN^{II} H-5, GalN^{III} H-5), 3.75 (m, 1 H; GalN^{I} H-2), 3.71, 3.64, 3.63 (3 s, 9 H; COOCH_3), 3.66–3.50 (m, 4 H; GalN^{II} H-2, H-6a, GalN^{III} H-2, H-6a), 3.30–3.22 (m, 2 H; GalN^{II} H-6b, GalN^{III} H-6b), 2.57–2.33 (m, 4 H; CH_2CO), 2.00 ppm (s, 3 H; COCH_3); MS: *m/z*: 2988 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{145}H_{124}Cl_9N_3O_{48}$: C 58.14, H 4.17, N 1.40; found: C 57.99, H 4.37, N 1.33.

Hexasaccharide acceptor 34: From hexasaccharide **33** (285 mg, 95 μmol) as described for the preparation of disaccharide **16**. Flash-silica chromatography (petroleum ether/EtOAc 1:1) afforded the hexasaccharide **34** (198 mg, 72%) as a white powder. M.p. 163–165 °C (from 2-propanol); $[\alpha]_D^{20} = -5$ (c = 1 in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.10–7.10 (m, 67 H; arom. H), 6.82, 6.73, 6.72 (3d, $J_{2,NH}$ = 7.5 Hz, 3 H; 3GalN N*H*), 5.81 (dd, $J_{3,4}$ = 3.5 Hz, $J_{4,5}$ < 1.0 Hz, 1 H; GalN^{I} H-4), 5.61, 5.55 (2dd, $J_{3,4}$ = 3.0 Hz, $J_{4,5}$ < 1.0 Hz, 2 H; GalN^{II} H-4, GalN^{III} H-4), 5.45, 5.43, 5.37 (3 dd, $J_{2,3}$ = $J_{3,4}$ = 9.5 Hz, 3 H; 3GlcA H-3), 5.24–5.19 (m, 3 H; 3GlcA H-2), 5.16, 5.14, 5.12 (3 d, $J_{1,2}$ = 8.0 Hz, 3 H; 3GalN H-1), 4.88 (d, $J_{1,2}$ = 7.5 Hz, 1 H; GlcA H-1), 4.87 (ABq, 2 H; CH_2Ar), 4.85 (m, 1 H; GalN^{I} H-3), 4.82, 4.81 (2d, $J_{1,2}$ = 7.5 Hz, 2 H; 2GlcA H-1), 4.68, 4.65 (2 dd, $J_{2,3}$ = 11.0 Hz, 2 H; GalN^{II} H-3, GalN^{III} H-3), 4.51–4.49 (m, 2 H; GalN^{I} H-6a, H-6b), 4.30, 4.26 (2dd, $J_{4,5}$ = 9.5 Hz, 2 H; GlcA^{I} H-4, GlcA^{II} H-4), 4.14–4.08 (m, 2 H; GalN^{I} H-5, GlcA^{III} H-4), 4.0, 3.99, 3.96 (3d, $J_{4,5}$ = 9.5 Hz, 3 H; 3GlcA H-5), 3.89–3.83 (m, 2 H; GalN^{II} H-5, GalN^{III} H-5), 3.76 (m, 1 H; GalN^{I} H-2), 3.71, 3.69, 3.67 (3 s, 9 H; COOCH_3), 3.60–3.52 (m, 4 H; GalN^{II} H-2, H-6a, GalN^{III} H-2, H-6a), 3.29 (d, $J_{4,OH}$ = 3.0 Hz, 1 H; GlcA^{III} *H*O-4), 3.28–3.23 ppm (m, 2 H; GalN^{II} H-6b, GalN^{III} H-6b); MS: *m/z*: 2890 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{140}H_{118}Cl_9N_3O_{46}$: C 58.03, H 4.10, N 1.45; found: C 58.03, H 4.10, N 1.39.

Octasaccharide 35: From imidate **5** (160 mg, 180 μmol) and acceptor **34** (260 mg, 90 μmol) as described for the preparation of disaccharide **6**. Flash-silica chromatography (toluene/EtOAc 1:1, containing 0.1% of NEt_3) afforded the octasaccharide **35** (130 mg, 40%) as a white powder. M.p. 170–172 °C (from 2-propanol); $[\alpha]_D^{20} = -7$ (c = 1 in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.10–7.05 (m, 67 H; arom. H), 6.83, 6.77, 6.72, 6.70 (4 d, $J_{2,NH}$ = 7.5 Hz, 4 H; 4GalN N*H*), 5.81 (dd, $J_{3,4}$ = 3.5 Hz, $J_{4,5}$ < 1.0 Hz, 1 H; GalN^{I} H-4), 5.57, 5.54 (2 dd, $J_{3,4}$ = 3.0, $J_{4,5}$ < 1.0 Hz, 2 H; GalN^{II} H-4, GalN^{III} H-4), 5.46, 5.45, 5.43 (3 dd, $J_{2,3}$ = $J_{3,4}$ = 9.5 Hz, 3 H; GlcA^{I} H-3, GlcA^{II} H-3, GlcA^{III} H-3), 5.22 (dd, $J_{1,2}$ = 7.5 Hz, 1 H; GlcA^{I} H-2), 5.18 (dd, $J_{3,4}$ = 3.5 Hz, $J_{4,5}$ < 1.0 Hz, 1 H; GalN^{IV} H-4), 5.17–5.06 (m, 7 H; GalN^{I} H-1, GalN^{II} H-1, GalN^{III} H-1, GlcA^{II} H-2, GlcA^{III} H-2, GlcA^{IV} H-3, H-4), 4.89 (d, $J_{1,2}$ = 8.5 Hz, 1 H; GalN^{IV} H-1), 4.88 (d, 1 H; GlcA^{I} H-1), 4.87 (ABq, 2 H; CH_2Ar), 4.87–4.83 (m, 2 H; GalN^{I} H-3, GlcA^{IV} H-2), 4.83, 4.82 (2 d, $J_{1,2}$ = 7.5 Hz, 2 H; GlcA^{II} H-1, GlcA^{III} H-1), 4.65, 4.64 (2 dd, $J_{2,3}$ = 11.0 Hz, 2 H; GalN^{II} H-3, GalN^{III} H-3), 4.58 (d, $J_{1,2}$ = 8.0 Hz, 1 H; GlcA^{IV} H-1), 4.51–4.49 (m, 2 H; GalN^{I} H-6a, H-6b), 4.31, 4.26, 4.22 (3 dd, $J_{4,5}$ = 9.5 Hz, 3 H; GlcA^{I} H-4, GlcA^{II} H-4, GlcA^{III} H-4), 4.20 (m, 1 H; GalN^{IV} H-3), 4.12 (m, 1 H; GalN^{I} H-5), 4.01, 3.99, 3.96 (3 d, 3 H; GlcA^{I} H-5, GlcA^{II} H-5, GlcA^{III} H-5), 3.92, (d, $J_{4,5}$ = 9.5 Hz, 1 H; GlcA^{IV} H-5), 3.87–3.83 (m, 2 H; GalN^{II} H-5, GalN^{III} H-5), 3.75 (m, 1 H; GalN^{I} H-2), 3.71, 3.64, 3.63 (3 s, 12 H; COOCH_3), 3.64–3.52 (m, 6 H; GalN^{II} H-2, H-6a, GalN^{III} H-2, H-6a, GalN^{IV} H-2, H-5), 3.37 (dd, $J_{6a,6b}$ = 11.5 Hz, $J_{5,6a}$ = 6.5 Hz, 1 H; GalN^{IV} H-6a), 3.28–3.19 (m, 2 H; GalN^{II} H-6b, GalN^{III} H-6b), 3.09 (dd, $J_{5,6b}$ = 6.5 Hz, 1 H; GalN^{IV} H-6b), 2.02, 1.99, 1.97, 1.96, 1.82 ppm (5 s, 15 H; OCOCH_3); MS: *m/z*: 3595 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{165}H_{148}Cl_{12}N_4O_{62}$: C 54.98, H 4.14, N 1.55; found: C 54.78, H 4.23, N 1.49.

Disaccharide acetamide 36: A mixture of disaccharide **6** (210 mg, 0.24 mmol), tributylstannane (400 μL, 1.46 mmol), and AIBN (22 mg) in benzene (4.5 mL) and *N,N*-dimethylacetamide (1 mL) was stirred for 1 h at RT under a flow of dry argon, then was heated for 2 h at 80 °C, cooled and concentrated. The residue was stirred at 0 °C with petroleum ether (20 mL) and the resulting solids were filtered off. Flash-silica chromatography (EtOAc/petroleum ether 2:1) afforded the acetamide **36** (137 mg, 74%) as a white powder. M.p. 206–207 °C (from MeOH); $[\alpha]_D^{20} = -22$ (c = 1 in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.85–7.42 (m, 7 H; arom. H), 5.72 (d, $J_{2,NH}$ = 7.0 Hz, 1 H; GalN N*H*), 5.41 (dd, $J_{3,4}$ = 3.0 Hz, $J_{4,5}$ < 1.0 Hz, 1 H; GalN H-4), 5.21–5.17 (m, 2 H; GlcA H-3, H-4), 5.07 (d, $J_{1,2}$ = 8.0 Hz, 1 H; GalN H-1), 4.97 (m, 1 H; GlcA H-2), 4.91 (ABq, 2 H; CH_2Ar), 4.72 (d, $J_{1,2}$ = 7.5 Hz, 1 H; GlcA H-1), 4.65 (dd, $J_{2,3}$ = 11.0 Hz, 1 H; GalN H-3), 4.19 (dd, $J_{6a,6b}$ = 11.5 Hz, $J_{5,6a}$ = 6.0 Hz, 1 H; GalN H-6a), 4.11 (dd, $J_{5,6b}$ = 7.0 Hz, 1 H; GalN H-6b), 3.99 (d, $J_{4,5}$ = 9.5 Hz, 1 H; GlcA H-5), 3.89 (m, 1 H; GalN H-5), 3.75 (s, 3 H; COOCH_3), 3.52 (m, 1 H; GalN H-2), 2.10, 2.09, 2.04, 2.02, 2.00 (5 s, 15 H; OCOCH_3), 1.89 ppm (s, 3 H; NHCOCH_3); MS: *m/z*: 784 $[M+Na]^+$; elemental analysis calcd (%) for $C_{36}H_{43}NO_{17}$: C 56.76, H 5.69, N 1.84; found: C 56.88, H 5.67, N 1.77.

Tetrasaccharide acetamide 37: From tetrasaccharide **27** (495 mg, 0.32 mmol) in *N,N*-dimethylacetamide (10 mL) as described for the preparation of the disaccharide **36**. Flash-silica chromatography (CH_2Cl_2/MeOH 13:1) afforded the acetamide **37** (345 mg, 81%) as a white powder. M.p. 145–146 °C (from 2-propanol); $[\alpha]_D^{20} = -8.5$ (c = 1 in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.75–7.20 (m, 7 H; arom. H), 5.92, 5.86 (2 d, $J_{2,NH}$ = 7.0 Hz, 2 H; 2GalN N*H*), 5.40, 5.34 (2 dd, $J_{3,4}$ = 3.0 Hz, $J_{4,5}$ < 1.0 Hz, 2 H; 2GalN H-4), 5.24–5.17 (m, 2 H; 2GlcA H-3), 5.06 (d, $J_{1,2}$ = 8.0 Hz, 1 H; GalN^{I} H-1), 5.05 (m, 1 H; GlcA^{II} H-4), 4.97–4.84 (m, 2 H; 2GlcA H-2), 4.89 (ABq, 2 H; CH_2Ar), 4.76 (d, $J_{1,2}$ = 8.0 Hz, 1 H; GalN^{II} H-1), 4.76, 4.68 (2 d, $J_{1,2}$ = 7.5 Hz, 2 H; 2GlcA H-1), 4.61, 4.56 (2 dd, $J_{2,3}$ = 11.0 Hz, 2 H; 2GalN H-3), 4.20–3.95 (m, 9 H; 2GalN H-5, H-6a, H-6b, GlcA^{I} H-4, 2GlcA H-5), 3.85, 3.75 (2 s, 6 H; COOCH_3), 3.56–3.30 (m, 2 H; 2GalN H-2), 2.10, 2.07, 2.05, 2.03, 2.02, 2.01, 1.94, 1.89 ppm (8 s, 33 H; OCOCH_3, NHCOCH_3); MS: *m/z*: 1323 $[M+H]^+$; elemental analysis calcd (%) for $C_{59}H_{74}N_2O_{32}$: C 53.55, H 5.64, N 2.12; found: C 53.28, H 5.60, N 2.05.

Hexasaccharide acetamide 38: From hexasaccharide **30** (200 mg, 90 μmol) in *N,N*-dimethylacetamide (5 mL) as described for the preparation of the disaccharide **36**. Flash-silica chromatography (CH_2Cl_2/MeOH 13:1) afforded the acetamide **38** (110 mg, 64%) as a white powder. M.p. 159–160 °C (from 2-propanol); $[\alpha]_D^{20} = -1.5$ (c = 1 in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.80–6.90 (m, 7 H; arom. H), 5.86, 5.84, 5.78 (3 d, $J_{2,NH}$ = 7.0 Hz, 3 H; 3GalN N*H*), 5.43, 5.40 (2 dd, $J_{3,4}$ = 3.0 Hz, $J_{4,5}$ < 1.0 Hz, 3 H; 3GalN H-4), 5.10–5.04 (m, 3 H; 3GlcA H-3), 5.07 (d, $J_{1,2}$ = 8.0 Hz, 1 H; GalN^{I} H-1), 5.04 (m, 1 H; GlcA^{III} H-4), 4.89 (ABq, 2 H; CH_2Ar), 4.97–4.80 (m, 3 H; 3GlcA H-2), 4.75, 4.74 (2 d, $J_{1,2}$ = 7.5 Hz, 2 H; GalN^{II} H-1, GalN^{III} H-1), 4.68, 4.65, 4.63 (3 d, $J_{1,2}$ = 7.5 Hz, 3 H; 3GlcA H-1), 4.63–4.50 (m, 3 H; 3GalN H-3), 4.20–3.75 (m, 14 H; 3GalN H-5, H-6a, H-6b, GlcA^{I} H-4, GlcA^{II} H-4, 3GlcA H-5), 3.86, 3.84, 3.74 (3 s, 9 H; COOCH_3), 3.45–3.25 (m, 3 H; 3GalN H-2), 2.10, 2.09, 2.07, 2.05, 2.03, 2.02, 2.00, 1.97 ppm (8 s, 48 H; OCOCH_3, NHCOCH_3); MS: *m/z*: 1882 $[M-H]^-$; elemental analysis calcd (%) for $C_{82}H_{105}N_3O_{47}$: C 52.26, H 5.62, N 2.23; found: C 52.33, H 5.80, N 2.09.

Octasaccharide acetamide 39: From octasaccharide **35** (124 mg, 34 μmol), in benzene (3.5 mL) and *N,N*-dimethylacetamide (1.5 mL) as described for the preparation of **36**, except that more tributylstannane (110 μL, 0.41 mmol) and AIBN (50 mg) were added after 2 h and 4 h. Flash-silica chromatography (CH_2Cl_2/acetone 3:1, then CH_2Cl_2/MeOH 12:1) afforded the acetamide **39** (85 mg, 62%) as a white powder. R_f = 0.25 (dichloromethane/acetone 3:1); m.p. 176–178 °C (from 2-propanol); $[\alpha]_D^{20} = -9$ (c = 1 in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.10–6.90 (m, 67 H; arom. H), 5.72 (dd, $J_{3,4}$ = 3.0 Hz, $J_{4,5}$ < 1.0 Hz, 1 H; GalN^{I} H-4), 5.68 (d, $J_{2,NH}$ = 7.5 Hz, 1 H; GalN^{IV} N*H*), 5.52, 5.45 (2dd, $J_{3,4}$ = 3.5 Hz, $J_{4,5}$ < 1.0 Hz, 2 H; GalN^{II} H-4, GalN^{III} H-4), 5.49–5.41 (m, 3 H; GlcA^{I} H-3, GlcA^{II} H-3, GlcA^{III} H-3), 5.40, 5.37, 5.35 (3 d, $J_{2,NH}$ = 7.0 Hz, 3 H; GalN^{I} N*H*, GalN^{II} N*H*, GalN^{III} N*H*), 5.30–5.13 (m, 6 H; GalN^{I} H-1, GlcA^{I} H-2, GlcA^{II} H-2, GlcA^{III} H-2, GlcA^{IV} H-3, H-4), 5.10 (dd, $J_{3,4}$ = 3.0 Hz, $J_{4,5}$ < 1.0 Hz, 1 H; GalN^{IV} H-4), 4.92–4.75(m, 9 H; GalN^{I} H-3, GalN^{II} H-1, H-3, GalN^{III} H-1, H-3, GlcA^{I} H-1, GlcA^{II} H-1, GlcA^{III} H-1, GlcA^{IV} H-2), 4.82 (ABq, 2 H; CH_2Ar), 4.71 (d, $J_{1,2}$ = 8.5 Hz, 1 H; GalN^{IV} H-1), 4.58 (d, $J_{1,2}$ = 7.5 Hz, 1 H; GlcA^{IV} H-1), 4.52–4.40 (m, 3 H; GalN^{I} H-6a, H-6b, GalN^{IV} H-3), 4.22, 4.16, 4.13 (3 dd, $J_{3,4}$ = $J_{4,}$ = 9.5 Hz, 3 H; GlcA^{I} H-4, GlcA^{II} H-4, GlcA^{III} H-4), 4.12 (m, 1 H; GalN^{I} H-5), 4.01, 4.00, 3.94 (3 d, 3 H; GlcA^{I} H-5, GlcA^{II} H-5, GlcA^{III} H-5), 3.92, (d, $J_{4,5}$ = 9.5 Hz, 1 H; GlcA^{IV} H-5), 3.68, 3.67, 3.66, 3.61 (4 s, 12 H; COOCH_3), 3.69–3.51 (m, 5 H; GalN^{II} H-5, H-6a, GalN^{III} H-5, H-6a, GalN^{IV} H-5), 3.40 (m, 1 H; GalN^{I} H-2), 3.20–3.00 (m, 7 H;

GalN^{II} H-2, H-6b, GalN^{III} H-2, H-6b, GalN^{IV} H-2, H-6a, H-6b), 2.01, 1.98, 1.97, 1.95, 1.92, 1.89, 1.79 ppm (6s, 27H; OCOCH_3, NHCOCH_3); elemental analysis calcd (%) for $C_{165}H_{160}N_4O_{62}$: C 62.11, H 5.05, N 1.76; found: C 61.90, H 4.95, N 1.57.

Disaccharide glycoside 40: A solution of ester **36** (245 mg, 0.32 mmol) in THF (6 mL) was treated at −10 °C with a freshly prepared solution of hydrogen peroxide (30 wt % solution in water, 0.8 mL) and lithium hydroxide (1 M, 1.6 mL), and the mixture was stirred for 1 h at −10 °C and 16 h at RT, then was cooled to 0 °C. Methanol (4 mL) and sodium hydroxide (4 M, 2 mL) were added, and the mixture was stirred for 4 h at RT, then was concentrated and diluted with water (10 mL). The mixture was adjusted to pH 3 (pH meter monitoring) with Amberlite IR-120 [H$^+$] resin, filtered, concentrated, and dried to afford the acid (136 mg, 79 %) as a white powder. The solid was dissolved in water (5 mL), the solution was adjusted to pH 7 (pH meter monitoring) with diluted aqueous NaOH, and was then eluted from a column (3×80 cm) of Sephadex LH-20 with water and lyophilized to afford the sodium salt **40** (121 mg, 69 % from **36**) as a white powder. R_f=0.37 (EtOAc/MeOH/water 6:2:1); m.p. 261–263 °C (from MeOH); $[\alpha]_D^{20}=-38$ (c=1 in water); ^{1}H NMR (250 MHz, D_2O, internal HOD, δ_H=4.79): δ=7.79–7.28 (m, 7H; arom. H), 4.76 (ABq, 2H; CH_2Ar), 4.38 (d, $J_{1,2}$=8.5 Hz, 1H; GalN H-1), 4.30 (d, $J_{1,2}$=8.0 Hz, 1H; GlcA H-1), 4.03 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN H-4), 3.90 (dd, $J_{2,3}$=11.0 Hz, 1H; GalN H-2), 3.77–3.62 (m, 2H; GalN H-6a, H-6b), 3.55 (d, $J_{4,5}$=9.0 Hz, 1H; GlcA H-5), 3.57–3.47 (m, 2H; GalN H-3, H-5), 3.41–3.29 (m, 2H; GlcA H-3, H-4), 3.20 (m, 1H; GlcA H-2), 1.78 ppm (s, 3H; NHCOCH_3); MS: m/z: 536 [M−Na]$^-$; HRMS: m/z: calcd for $C_{25}H_{31}NO_{12}Na$ [M+H]$^+$: 560.1744; found: 560.1747.

Tetrasaccharide glycoside 41: From ester **37** (310 mg, 0.23 mmol) as described for the preparation of **40** to afford the sodium salt **41** (160 mg, 71 %) as a white powder. R_f=0.26 (EtOAc/MeOH/water 4:2:1); $[\alpha]_D^{20}=-32$ (c=1 in water); ^{1}H NMR (250 MHz, D_2O, internal HOD, δ_H=4.79): δ=7.84–7.32 (m, 7H; arom. H), 4.79 (ABq, 2H; CH_2Ar), 4.52, 4.50 (2d, $J_{1,2}$=8.5 Hz, 2H; 2GalN H-1), 4.48, 4.42 (2d, $J_{1,2}$=7.5 Hz, 2H; 2GlcA H-1), 4.16, 4.10 (2dd, $J_{3,}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 2H; 2GalN H-4), 4.04–3.96 (m, 2H; 2GalN H-2), 3.83–3.57 (m, 11H; 2GalN H-3, H-5, H-6a, H-6b GlcA^I H-4, 2GlcA H-5), 3.56 (m, 1H; GlcA^I H-3), 3.54–3.45 (m, 2H; GlcA^{II} H-3, H-4), 3.34, 3.32 (2dd, $J_{2,3}$=9.0 Hz, 2H; 2GlcA H-2), 2.02, 1.81 ppm (2s, 6H; NHCOCH_3); MS: m/z: 937 [M−Na]$^-$, 915 [M−Na+H]$^-$, 457 [M−2Na]$^{2-}$; HRMS: m/z: calcd for $C_{39}H_{52}N_2O_{23}Na$ [M−Na+2H]$^+$: 939.2859; found: 939.2873.

Hexasaccharide glycoside 42: From ester **38** (82 mg, 40 μmol) as described for the preparation of **40** to afford the sodium salt **42** (30 mg, 51 %) as a white powder. R_f=0.29 (EtOAc/MeOH/water 3:2:1); $[\alpha]_D^{20}=-22.5$ (c=1 in water); ^{1}H NMR (250 MHz, D_2O, internal HOD, δ_H=4.79): δ=7.93–7.47 (m, 7H; arom. H), 4.94 (ABq, 2H; CH_2Ar), 4.54, 4.51, 4.50 (3d, $J_{1,2}$=8.5 Hz, 3H; 3GalN H-1), 4.49, 4.48, 4.43 (3d, $J_{1,2}$=7.5 Hz, 3H; 3GlcA H-1), 4.16, 4.10 (2dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 3H; 3GalN H-4), 4.05–3.95 (m, 3H; 3GalN H-2), 3.87–3.63 (m, 17H; 3GalN H-3, H-5, H-6a, H-6b, GlcA^I H-4, GlcA^{II} H-4, 3GlcA H-5), 3.59–3.49 (m, 2H; GlcA^I H-3, GlcA^{II} H-3), 3.52–3.46 (m, 2H; GlcA^{III} H-3, H-4), 3.36, 3.34, 3.33 (3dd, $J_{2,3}$=9.0 Hz, 3H; 3GlcA H-2), 2.03, 2.00, 1.81 ppm (3s, 9H; NHCOCH_3); MS: m/z: 1294 [M−3Na+2H]$^-$, 647 [M−3Na+H]$^{2-}$, 430.5 [M−3Na]$^{3-}$; HRMS: m/z: calcd for $C_{53}H_{73}N_3O_{34}Na$ [M−2Na+3H]$^+$: 1318.3973; found: 1318.3994.

Octasaccharide glycoside 43: From ester **39** (78 mg, 25 μmol) as described for the preparation of **26** to afford the sodium salt **43** (26 mg, 60 %) as a white powder. $[\alpha]_D^{20}=-23.5$ (c=1 in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, δ_H=4.79): δ=8.05–7.21 (m, 7H; arom. H), 4.95 (ABq, 2H; CH_2Ar), 4.56–4.50 (m, 4H; 4GalN H-1), 4.50–4.42 (m, 4H; 4GlcA H-1), 4.17, 4.11 (2dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 4H; 4GalN H-4), 4.03–3.97 (m, 4H; 4GalN H-2), 3.86–3.67 (m, 23H; 4GalN H-3, H-5, H-6a, H-6b, GlcA^I H-4, GlcA^{II} H-4, GlcA^{III} H-4, 4GlcA H-5), 3.62–3.55 (m, 3H; GlcA^I H-3, GlcA^{II} H-3, GlcA^{III} H-3), 3.50–3.48 (m, 2H; GlcA^{IV} H-3, H-4), 3.30–3.40 (m, 4H; 4GlcA H-2), 2.03, 2.00, 1.81 ppm (3s, 12H; NHCOCH_3); HRMS: m/z: calcd for $C_{67}H_{94}N_4O_{45}$ [M−4Na+4H]$^{2-}$: 836.2517; found: 836.2535.

Disaccharide 44: A solution of the glycoside **40** (30 mg, 50 μmol) in water (5 mL) was hydrogenated in the presence of 10 % Pd/C catalyst (25 mg) for 20 h at RT. The catalyst was removed by filtration through a Celite pad and the filtrate was concentrated. The residue was eluted from a column (3×80 cm) of Sephadex LH-20 with water and lyophilized to afford the target molecule **44** (19 mg, 86 %) as a white powder. R_f= 0.17 (EtOAc/MeOH/water 6:2:1); $[\alpha]_D^{20}=-7$ (c=1, equil., in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, δ_H=4.79): δ=5.22 (d, $J_{1,2}$= 3.5 Hz; GalN H-1α), 4.68 (d, $J_{1,2}$=8.5 Hz; GalN H-1β), 4.56 (d, $J_{1,2}$= 8.0 Hz; GlcA H-1α), 4.50 (d, $J_{1,2}$=8.0 Hz; GlcA H-1β), 4.29 (dd, $J_{2,3}$= 11.0 Hz; GalN H-2α), 4.25 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz; GalN H-4α), 4.18 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz; GalN H-4β), 4.12 (m; GalN H-5α), 4.01 (dd; GalN H-3α), 3.99 (dd, $J_{2,3}$=11.0 Hz; GalN H-2β), 3.82 (dd; GalN H-3β), 3.78–3.67 (m; GalN H-5β, H-6a, H-6b, GlcA H-5), 3.49–3.47 (m, 2H; GlcA H-3, H-4), 3.34 (m, 1H; GlcA H-2), 2.04 ppm (s, 3H; NHCOCH_3); HRMS: m/z: calcd for $C_{14}H_{23}NO_{12}Na$ [M+H]$^+$: 420.1118; found: 420.1114.

Tetrasaccharide 45: From glycoside **41** (31 mg, 30 μmol) as described for the preparation of **44** to afford the target molecule **45** (23 mg, 87 %) as a white powder. R_f=0.20 (EtOAc/MeOH/water 4:2:1); $[\alpha]_D^{20}=-15$ (c=1, equil., in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, δ_H=4.79): δ= 5.22 (d, $J_{1,2}$=3.5 Hz; GalN^I H-1α), 4.69 (d, $J_{1,2}$=8.5 Hz; GalN^I H-1β), 4.57 (d, $J_{1,2}$=8.0 Hz; GlcA^I H-1α), 4.52, 4.51, 4.50 (3d, $J_{1,2}$=7.5 Hz; GlcA^I H-1β, GlcA^{II} H-1), 4.50 (d, $J_{1,2}$=8.5 Hz, 1H; GalN^{II} H-1), 4.29 (dd, $J_{2,3}$=11.0 Hz; GalN^I H-2α), 4.20 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz; GalN^I H-4α), 4.19, 4.13 (2dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz; GalN^I H-4β, GalN^{II} H-4), 4.11 (m; GalN^I H-5α), 4.04–3.98 (m, 2H; GalN^I H-2β, H-3α, GalN^{II} H-2), 3.84–3.70 (m; GalN^I H-3β, H-5β, H-6a, H-6b, GalN^{II} H-3, H-5, H-6a, H-6b, GlcA^I H-4, 2GlcA H-5), 3.60, 3.59 (2dd, $J_{2,3}$=$J_{3,4}$=9.0 Hz, 1H; GlcA^I H-3α, GlcA^I H-3β), 3.52–3.46 (m, 2H; GlcA^{II} H-3, H-4), 3.38–3.31 (m, 2H; 2GlcA H-2), 2.04, 2.02 ppm (2s, 6H; NHCOCH_3); HRMS: m/z: calcd for $C_{28}H_{44}N_2O_{23}Na$ [M−Na+2H]$^+$: 799.2233; found: 799.2221.

Hexasaccharide 46: From glycoside **42** (30 mg, 20 μmol) as described for the preparation of **44** to afford the target molecule **46** (20 mg, 74 %) as a white powder. R_f=0.23 (EtOAc/MeOH/water 3:2:1); $[\alpha]_D^{20}=-10$ (c=1, equil., in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, δ_H=4.79): δ= 5.22 (d, $J_{1,2}$=3.5 Hz; GalN^I H-1α), 4.69 (d, $J_{1,2}$=8.5 Hz; GalN^I H-1β), 4.57 (d, $J_{1,2}$=8.0 Hz; GlcA^I H-1α), 4.55–4.48 (m; GalN^{II} H-1, GalN^{III} H-1, GlcA^I H-1β, GlcA^{II} H-1, GlcA^{III} H-1), 4.29 (dd, $J_{2,3}$=11.0 Hz; GalN^I H-2α), 4.21 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz; GalN^I H-4α), 4.18, 4.13, 4.12 (3dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz; GalN^I H-4β, GalN^{II} H-4, GalN^{III} H-4), 4.12 (m; GalN^I H-5α), 4.03–3.97 (m, 3H; GalN^I H-2β, H-3α, GalN^{II} H-2, GalN^{III} H-2), 3.84–3.68 (m; GalN^I H-3β, H-5β, GalN^{II} H-3, H-5, GalN^{III} H-3, H-5, 3GalN H-6a, H-6b, GlcA^I H-4, GlcA^{II} H-4, 3GlcA H-5), 3.62–3.57 (m, 2H; GlcA^I H-3, GlcA^{II} H-3), 3.51–3.48 (m, 2H; GlcA^{III} H-3, H-4), 3.40–3.31 (m, 3H; 3GlcA H-2), 2.04, 2.03 ppm (2s, 9H; NHCOCH_3); HRMS: m/z: calcd for $C_{42}H_{65}N_3O_{34}Na$ [M−2Na+3H]$^+$: 1178.3347; found: 1178.3365; calcd for $C_{42}H_{65}N_3O_{34}$ [M−3Na+3H]$^{2-}$: 576.6646; found: 576.6630.

Octasaccharide 47: From glycoside **43** (15 mg, 8 μmol) as described for the preparation of **44** to afford the target molecule **47** (9.5 mg, 67 %) as a white powder. R_f=0.25 (EtOAc/MeOH/water 2:2:1); $[\alpha]_D^{20}=-16$ (c=1, equil., in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, δ_H=4.79): δ= 5.22 (d, $J_{1,2}$=3.5 Hz; GalN^I H-1α), 4.68 (d, $J_{1,2}$=8.5 Hz; GalN^I H-1β), 4.56 (d, $J_{1,2}$=8.0 Hz; GlcA^I H-1α), 4.52–4.47 (m; GalN^{II} H-1, GalN^{III} H-1, GalN^{IV} H-1, GlcA^I H-1β, GlcA^{II} H-1, GlcA^{III} H-1, GlcA^{IV} H-1), 4.29 (dd, $J_{2,3}$=11.0 Hz; GalN^I H-2α), 4.21 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz; GalN^I H-4α), 4.18–4.17, 4.14–4.13 (2m, 4H; GalN^I H-4β, H-5α, GalN^{II} H-4, GalN^{III} H-4, GalN^{IV} H-4), 4.04–3.98 (m, 4H; GalN^I H-2β, H-3α, GalN^{II} H-2, GalN^{III} H-2, GalN^{IV} H-2), 3.85–3.65 (m; GalN^I H-3β, H-5β, GalN^{II} H-3, H-5, GalN^{III} H-3, H-5, GalN^{IV} H-3, H-5, 4GalN H-6a, H-6b, GlcA^I H-4, GlcA^{II} H-4, GlcA^{III} H-4, 4GlcA H-5), 3.62–3.53 (m, 3H; GlcA^I H-3, GlcA^{II} H-3, GlcA^{III} H-3), 3.51–3.48 (m, 2H; GlcA^{IV} H-3, H-4), 3.39–3.31 (m, 4H; 4GlcA H-2), 2.04, 2.03 ppm (2s, 12H; NHCOCH_3); ^{13}C NMR (100 MHz, D_2O, internal acetone, δ_C=30.83): δ=175.61, 175.19, 175.17 (4GlcA C-6, NH$COCH_3$), 104.97, 104.79, 101.51, 101.47 (4GalN C-1, 4GlcA C-1), 81.02, 80.98, 80.36, 80.33, 80.31 (4GalN C-3, GlcA^I C-4, GlcA^{II} C-4, GlcA^{III} C-4), 77.06, 77.04, 77.02, 76.76, 75.95, 75.62, 74.34, 73.38, 73.13, 73.09, 72.46, 68.39, 68.35 (4GalN C-4, C-5, GlcA^{IV} C-4, 4GlcA C-2, C-3, C-5), 61.74 (4GalN C-6), 51.68, 51.64 (4GalN C-2),

23.17, 23.15 ppm ($NHCOCH_3$); MS: *m/z*: 788 $[M-2Na]^{2-}$, 777 $[M-3Na+H]^{2-}$, 767 $[M-4Na+2H]^{2-}$.

Disaccharide acetamide 48: From disaccharide **8** (186 mg, 0.21 mmol) in *N,N*-dimethylacetamide (2 mL) as described for the preparation of **39**. Flash-silica chromatography (CH_2Cl_2/MeOH 19:1) afforded the acetamide **48** (88 mg, 53%) as a white powder. M.p. 124°C (diethyl ether/EtOH); $[\alpha]_D^{20}=+5$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.35$ (s, 5H; arom. H), 6.07 (d, $J_{2,NH}=7.0$ Hz, 1H; GalN N*H*), 5.35 (m, 1H; N*H*COO), 5.33 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 5.22–5.12 (m, 2H; GlcA H-3, H-4), 5.09 (s, 2H; C*H*$_2$Ph), 4.97 (m, 1H; GlcA H-2), 4.85 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.73 (d, $J_{1,2}=8.0$ Hz, 1H; GlcA H-1), 4.47 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-3), 4.12 (dd, $J_{6a,6b}=11.5$ Hz, $J_{5,6a}=6.0$ Hz, 1H; GalN H-6a), 4.03–3.99 (m, 2H; GalN H-6b, GlcA H-5), 3.40–3.30 (m, 2H; GalN H-5, C*H*$_2$O), 3.74 (s, 3H; COOC*H*$_3$), 3.69–3.61 (m, 2H; GalN H-2, C*H*$_2$O), 3.38–3.32 (m, 2H; C*H*$_2$N), 2.07, 2.04, 2.02, 2.01, 1.99 ppm (5s, 18H; OCOC*H*$_3$, NHCOC*H*$_3$); MS: *m/z*: 821 $[M+Na]^+$; elemental analysis (%) calcd for $C_{35}H_{46}N_2O_{19}$: C 52.63, H 5.80, N 3.51; found: C 52.65, H 5.61, N 3.89.

Trisaccharide 50: From alcohol **23** (200 mg, 0.18 mmol) and 3,4,6-tri-*O*-acetyl-2-deoxy-2-trichloroacetamido-1-*O*-trichloroacetimidoyl-α-D-galactopyranose[16] (193 mg, 0.33 mmol) as described for the preparation of **6**. Flash-silica chromatography (EtOAc/petroleum ether 3:2, containing 0.1% of NEt_3) afforded the trisaccharide **50** (64 mg, 55%) as a white powder. $[\alpha]_D^{20}=+10$ ($c=1$ in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta=8.12$–7.25 (m, 25H; arom. H), 6.98 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN^I N*H*), 6.83 (d, $J_{2,NH}=7.5$ Hz, 1H; GalN^{II} N*H*), 5.88 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^I H-4), 5.54 (dd, $J_{2,3}=J_{3,4}=9.0$ Hz, 1H; GlcA H-3), 5.54 (dd, $J_{1,2}=7.0$ Hz, 1H; GlcA H-2), 5.17 (m, 1H; N*H*COO), 5.12 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{II} H-4), 5.07 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN^{II} H-3), 5.07 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^I H-1), 5.02 (s, 2H; C*H*$_2$Ph), 4.97 (d, $J_{1,2}=7.0$ Hz, 1H; GlcA H-1), 4.89 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^{II} H-1), 4.82 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN^I H-3), 4.48 (dd, $J_{6a,6b}=12.0$ Hz, $J_{5,6a}=5.0$ Hz, 1H; GalN^I H-6a), 4.40 (dd, $J_{5,6b}=7.0$ Hz, 1H; GalN^I H-6b), 4.29 (dd, $J_{4,5}=10.0$ Hz, 1H; GlcA H-4), 4.16–4.09 (m, 2H; GalN^I H-5, GlcA H-5), 4.01 (m, 1H; GalN^{II} H-2), 3.88 (m, 1H; C*H*$_2$O), 3.79–3.62 (m, 3H; GalN^I H-2, GalN^{II} H-5, C*H*$_2$O), 3.72 (s, 3H; COOC*H*$_3$), 3.44–3.31 (m, 2H; C*H*$_2$N), 3.27 (dd, $J_{6a,6b}=12.0$ Hz, $J_{5,6a}=8.0$ Hz, 1H; GalN^{II} H-6a), 3.21 (dd, $J_{5,6b}=6.0$ Hz, 1H; GalN^{II} H-6b), 1.95, 1.94, 1.93 ppm (3s, 9H; OCOC*H*$_3$); MS: *m/z*: 1536 $[M-H]^-$ (for ^{35}Cl); elemental analysis (%) calcd for $C_{67}H_{65}Cl_6N_3O_{26}$: C 52.22, H 4.25, N 2.73; found: C 51.95, H 4.38, N 2.63.

Trisaccharide acetamide 51: From trisaccharide **50** (135 mg, 90 μmol) in benzene (3 mL) and *N,N*-dimethylacetamide (1 mL) as described for the preparation of **39**. Flash-silica chromatography (CH_2Cl_2/acetone 2:1) afforded the acetamide **51** (64 mg, 55%) as a white powder. M.p. 130–131°C (diethyl ether/petroleum ether); $[\alpha]_D^{20}=+24$ ($c=1$ in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta=8.12$–7.17 (m, 25H; arom. H), 6.03 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^I H-4), 6.98 (d, $J_{2,NH}=9.0$ Hz, 1H; GalN^{II} N*H*), 5.63 (d, $J_{2,NH}=7.0$ Hz, 1H; GalN^I N*H*), 5.52 (dd, $J_{3,4}=9.0$ Hz, $J_{2,3}=7.0$ Hz, 1H; GlcA H-3), 5.25 (m, 1H; N*H*COO), 5.23 (dd, $J_{1,2}=6.0$ Hz, 1H; GlcA H-2), 5.18 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^I H-1), 5.07 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{II} H-4), 5.03 (s, 2H; C*H*$_2$Ph), 4.99 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN^{II} H-3), 4.97 (d, 1H; GlcA H-1), 4.86 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN^I H-3), 4.60 (d, $J_{1,2}=8.5$ Hz, 1H; GalN^{II} H-1), 4.51 (dd, $J_{4,5}=10.0$ Hz, 1H; GlcA H-4), 4.46 (dd, $J_{6a,6b}=12.0$ Hz, $J_{5,6a}=5.0$ Hz, 1H; GalN^I H-6a), 4.35 (dd, $J_{5,6b}=5.0$ Hz, 1H; GalN^I H-6b), 4.24 (d, 1H; GlcA H-5), 4.13 (dd, 1H; GalN^I H-5), 3.94 (m, 1H; GalN^{II} H-2), 3.83 (m, 1H; C*H*$_2$O), 3.78–3.66 (m, 2H; GalN^{II} H-5, C*H*$_2$O), 3.77 (s, 3H; COOC*H*$_3$), 3.48–3.31 (m, 4H; GalN^I H-2, GalN^{II} H-6a, C*H*$_2$N), 3.21 (dd, $J_{6a,6b}=12.0$ Hz, $J_{5,6b}=6.0$ Hz, 1H; GalN^{II} H-6b), 1.97, 1.95 (2s, 9H; OCOC*H*$_3$), 1.90, 1.89 ppm (2s, 6H; NHCOC*H*$_3$); MS: *m/z*: 1334 $[M+H]^+$; elemental analysis (%) calcd for $C_{67}H_{71}N_3O_{26}$: C 60.31, H 5.36, N 3.15; found: C 60.15, H 5.39, N 3.14.

Tetrasaccharide 52: From alcohol **22** (150 mg, 0.17 mmol) and imidate **5** (212 mg, 0.24 mmol) as described for the preparation of **6**. Flash-silica chromatography (EtOAc/toluene 3:1, containing 0.1% of NEt_3) afforded the tetrasaccharide **52** (181 mg, 67%) as a white powder. $[\alpha]_D^{20}=+6$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.33$–7.29 (m, 5H; arom. H), 6.87, 6.78 (2d, $J_{2,NH}=8.0$ Hz, 2H; 2GalN N*H*), 5.46 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^I H-4), 5.41 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{II} H-4), 5.23 (m, 1H; N*H*COO), 5.19–5.01 (m, 5H; 2GlcA H-3, GlcA^{II} H-4, C*H*$_2$Ph), 4.92 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^{II} H-1), 4.90–4.82 (m, 3H; GalN^I H-1, 2GlcA H-2), 4.69–4.61 (m, 2H; 2GlcA H-1), 4.49, 4.28 (2dd, $J_{2,3}=11.0$ Hz, 2H; 2GalN H-3), 4.20–3.70 (m, 7H; 2GalN H-6a, 2H-6b, GlcA^I H-4, 2GlcA H-5), 3.82–3.79 (m, 4H; GalN H-2, 2GalN H-5, C*H*$_2$O), 3.82, 3.78 (2s, 6H; COOC*H*$_3$), 3.77–3.65 (m, 2H; GalN H-2, C*H*$_2$O), 3.47–3.36 (m, 2H; C*H*$_2$N), 2.11, 2.04, 2.01, 2.00, 1.99, 1.98 ppm (6s, 27H; OCOC*H*$_3$); MS: *m/z*: 1562 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{58}H_{71}Cl_6N_3O_{34}$: C 44.46, H 4.57, N 2.68; found: C 44.22, H 4.47, N 2.48.

Tetrasaccharide acetamide 53: From tetrasaccharide **52** (313 mg, 0.2 mmol) as described for the preparation of **39**. Flash-silica chromatography (CH_2Cl_2/MeOH 15:1) afforded the acetamide **53** (175 mg, 65%) as a white powder. M.p. 159–160°C (EtOAc/petroleum ether); $[\alpha]_D^{20}=+8.5$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=7.35$ (s, 5H; arom. H), 5.91, 5.81 (2d, $J_{2,NH}=7.0$ Hz, 2H; 2GalN N*H*), 5.39–5.26 (m, 3H; 2GalN H-4, N*H*COO), 5.25–5.11 (m, 4H; GlcA^{II} H-3, H-4, C*H*$_2$Ph), 5.03 (dd, $J_{2,3}=J_{3,4}=9.0$ Hz, 1H; GlcA^I H-3), 4.93–4.80 (m, 3H; GalN H-1, 2GlcA H-2), 4.75 (d, $J_{1,2}=8.5$ Hz, 1H; GalN H-1), 4.68–4.62 (m, 2H; 2GlcA H-1), 4.57–4.42 (m, 2H; 2GalN H-3), 4.09–3.64 (m, 11H; 2GalN H-5, 2H-6a, 2H-6b, GlcA^I H-4, 2GlcA H-5, C*H*$_2$O), 3.73, 3.66 (2s, 6H; COOC*H*$_3$), 3.54–3.41 (m, 4H; 2GalN H-2, C*H*$_2$N), 2.11, 2.04, 2.01, 2.00, 1.99, 1.98 ppm (6s, 33H; OCOC*H*$_3$, NHCOC*H*$_3$); MS: *m/z*: 1359 $[M+2H]^+$; elemental analysis calcd (%) for $C_{58}H_{77}N_3O_{34}$: C 51.21, H 5.71, N 3.09; found: C 51.45, H 5.74, N 2.99.

Tetrasaccharide 54: From alcohol **23** (650 mg, 0.59 mmol) and imidate **19** (895 mg, 0.76 mmol) as described for the preparation of **6**. Flash-silica chromatography (CH_2Cl_2/acetone 12:1, containing 0.1% of NEt_3) afforded the tetrasaccharide **54** (1.07 g, 87%) as a white powder. M.p. 149–151°C (from 2-propanol/petroleum ether); $[\alpha]_D^{20}=+18.5$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=8.12$–7.10 (m, 45H; arom. H), 6.80, 6.78 (2d, $J_{2,NH}=8.0$ Hz, 2H; 2GalN N*H*), 5.83 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^I H-4), 5.67 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{II} H-4), 5.53–5.42 (m, 2H; 2GlcA H-3), 5.32 (dd, $J_{3,4}=J_{4,5}=10.0$ Hz, 1H; GlcA^{II} H-4), 5.38–5.24 (m, 2H; 2GlcA H-2), 5.20 (m, 1H; N*H*COO), 5.14 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^I H-1), 5.06 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^{II} H-1), 5.02 (s, 2H; C*H*$_2$Ph), 4.92, 4.87 (2d, $J_{1,2}=7.0$ Hz, 2H; GlcA^I H-1, GlcA^{II} H-1), 4.80, 4.69 (2dd, $J_{2,3}=11.0$ Hz, 2H; 2GalN H-3), 4.47 (dd, $J_{6a,6b}=12.0$ Hz, $J_{5,6a}=6.0$ Hz, 1H; GalN^I H-6a), 4.43 (dd, $J_{5,6b}=7.0$ Hz, 1H; GalN^I H-6b), 4.32 (dd, $J_{3,4}=9.5$ Hz $J_{4,5}=10.0$ Hz, 1H; GlcA^I H-4), 4.16–4.09 (m, 2H; GalN^I H-5, GlcA^{II} H-5), 4.05 (d, 1H; GlcA^I H-5), 3.91–3.82 (m, 2H; GalN^{II} H-6a, C*H*$_2$O), 3.73, 3.66 (2s, 6H; COOC*H*$_3$), 3.69–3.52 (m, 4H; GalN^{II} H-6b, 2GalN H-2, C*H*$_2$O), 3.42–3.29 (m, 3H; GalN^{II} H-5, C*H*$_2$N), 3.42–3.29 (m, 4H; C*H*$_2$CO), 2.00 ppm (s, 3H; COC*H*$_3$); MS: *m/z*: 2144 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{101}H_{91}Cl_6N_3O_{35}$: C 57.23, H 4.33, N 1.98; found: C 57.04, H 4.13, N 1.82.

Tetrasaccharide acceptor 55: From tetrasaccharide **54** (1.06 g, 0.50 mmol) as described for the preparation of **16**. Flash-silica chromatography (CH_2Cl_2/acetone 12:1) afforded the alcohol **55** (759 mg, 75%) as a white powder. $[\alpha]_D^{20}=+9.5$ ($c=1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta=8.12$–7.09 (m, 43H; arom. H), 6.88–6.71 (m, 4H; 2arom. H, 2GalN N*H*), 5.69, 5.59 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 2H; 2GalN H-4), 5.46, 5.34 (2dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 2H; 2GlcA H-3), 5.27–5.09 (m, 4H; GalN^{II} H-1, 2GlcA H-2, N*H*COO), 5.03 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^I H-1), 4.98 (s, 2H; C*H*$_2$Ph), 4.89, 4.82 (2d, $J_{1,2}=7.0$ Hz, 2H; 2GlcA H-1), 4.76, 4.67 (2dd, $J_{2,3}=11.0$ Hz, 2H; 2GalN H-3), 4.47–4.31 (m, 2H; GalN^I H-6a, H-6b), 4.26 (dd, $J_{4,5}=9.5$ Hz, 1H; GlcA^I H-4), 4.09–3.93 (m, 2H; GalN^I H-5, GlcA^{II} H-4), 4.02, 3.97 (2d, 2H; 2GlcA H-5), 3.89–3.78 (m, 2H; GalN^{II} H-6a, C*H*$_2$O), 3.68, 3.61 (2s, 6H; COOC*H*$_3$), 3.60–3.50 (m, 4H; GalN^{II} H-6b, 2GalN H-2, C*H*$_2$O), 3.34–3.23 ppm (m, 4H; GalN^{II} H-5, GlcA^{II} *H*O-4, C*H*$_2$N); MS: *m/z*: 2018 $[M+H]^+$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{96}H_{85}Cl_6N_3O_{33}$: C 57.04, H 4.24, N 2.08; found: C 57.02, H 4.11, N 2.05.

Pentasaccharide 56: From alcohol **55** (650 mg, 0.59 mmol) and imidate **49** (119 mg, 0.20 mmol) as described for the preparation of **6**. Flash-silica

chromatography (CH_2Cl_2/acetone 10:1, containing 0.1% of NEt_3; then toluene/EtOAc 3:2) afforded the pentasaccharide **56** (210 mg, 85%) as a white powder. M.p. 144–145°C (from 2-propanol/petroleum ether); $[\alpha]_D^{20} = -3$ ($c = 1$ in chloroform); ^{1}H NMR (400 MHz, CDCl $_3$): $\delta = 8.09$–7.11 (m, 43H; arom. H), 6.88–6.82 (m, 3H; 2 arom. H, GalN^I N*H*), 6.78 (d, $J_{2,NH} = 7.0$ Hz, 1H; GalN^{III} N*H*), 6.71 (d, $J_{2,NH} = 7.0$ Hz, 1H; GalN^{II} N*H*), 5.81, 5.62 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^I H-4), 5.62 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^{II} H-4), 5.51, 5.49 (2dd, $J_{2,3} = J_{3,4} = 9.0$ Hz, 2H; 2GlcA H-3), 5.27–5.02 (m, 3H; 2GlcA H-2, N*H*COO), 5.18 (d, $J_{1,2} = 8.5$ Hz, 1H; GalN^I H-1), 5.11 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^{III} H-4), 5.06 (d, $J_{1,2} = 8.5$ Hz, 1H; GalN^{II} H-1), 5.11 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^{III} H-3), 5.01 (s, 2H; C*H*$_2$Ph), 4.93 (d, $J_{1,2} = 7.5$ Hz, 1H; GlcA^I H-1), 4.86 (d, $J_{1,2} = 8.5$ Hz, 1H; GlcA^{II} H-1), 4.85 (d, $J_{1,2} = 7.0$ Hz, 1H; GalN^{III} H-1), 4.80 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^I H-3), 4.67 (dd, $J_{2,3} = 1.0$ Hz, 1H; GalN^{II} H-3), 4.47 (dd, $J_{6a,6b} = 12.0$ Hz, $J_{5,6a} = 5.0$ Hz, 1H; GalN^I H-6a), 4.39 (dd, $J_{5,6b} = 7.0$ Hz, 1H; GalN^I H-6b), 4.32, 4.23 (2dd, 2H; $J_{4,5} = 10.0$ Hz, 2GlcA H-4), 4.09 (m, 1H; GalN^I H-5), 4.05 (d, 2H; 2GlcA H-5), 4.05 (m, 1H; GalN^{III} H-2), 3.92–3.81 (m, 2H; GalN^{II} H-5, C*H*$_2$O), 3.73, 3.61 (2s, 6H; COOC*H*$_3$), 3.75–3.54 (m, 5H; GalN^I H-2, GalN^{II} H-2, H-6a, GalN^{III} H-5, C*H*$_2$O), 3.44–3.20 (m, 4H; GalN^{II} H-6b, GalN^{III} H-6a, C*H*$_2$N), 3.09 (dd, $J_{6a,6b} = 12.0$ Hz, $J_{5,6b} = 6.0$ Hz, 1H; GalN^{III} H-6b), 1.95, 1.94, 1.92 ppm (3s, 9H; OCOC*H*$_3$); MS: *m*/*z*: 2447 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{110}H_{101}Cl_9N_4O_{41}$: C 53.84, H 4.15, N 2.28; found: C 53.60, H 4.10, N 2.19.

Pentasaccharide acetamide 57: From pentasaccharide **56** (103 mg, 40 μmol) in benzene (3 mL) and *N*,*N*-dimethylacetamide (0.75 mL) as described for the preparation of **39**. Flash-silica chromatography (CH_2Cl_2/acetone 2:1) afforded the acetamide **57** (53 mg, 59%) as a white powder. M.p. 159–160°C (from petroleum ether/diethyl ether); $[\alpha]_D^{20} = +5.5$ ($c = 1$ in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 8.07$–6.81 (m, 45H; arom. H), 5.88 (d, $J_{2,NH} = 9.0$ Hz, 1H; GalN^{III} N*H*), 5.82 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^I H-4), 5.73 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^{II} H-4), 5.52 (d, $J_{2,NH} = 9.0$ Hz, 1H; GalN^I N*H*), 5.51 (dd, $J_{2,3} = J_{3,4} = 9.0$ Hz, 1H; GlcA^I H-3), 5.49–5.44 (m, 2H; GalN^{II} N*H*, GlcA^{II} H-3), 5.29 (dd, $J_{1,2} = 8.0$ Hz, 1H; GlcA^I H-2), 5.18 (m, 1H; N*H*COO), 5.14–5.10 (m, 2H; GalN^{II} H-1, GlcA^{II} H-2), 5.04 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^{III} H-4), 5.01 (s, 2H; C*H*$_2$Ph), 4.98 (d, $J_{1,2} = 8.0$ Hz, 1H; GalN^I H-1), 4.92 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^{III} H-3), 4.91–4.86 (m, 2H; GalN^I H-3, GlcA^I H-1), 4.86 (d, $J_{1,2} = 8.0$ Hz, 1H; GlcA^{II} H-1), 4.79 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^{II} H-3), 4.51 (d, $J_{1,2} = 8.5$ Hz, 1H; GalN^{III} H-1), 4.50–4.44 (m, 2H; GalN^I H-6a, GlcA H-4), 4.31 (dd, $J_{6b,6a} = 11.0$ Hz, $J_{5,6b} = 5.0$ Hz, 1H; GalN^I H-6b), 4.23 (dd, $J_{4,5} = 10.0$ Hz, 1H; GlcA H-4), 4.16 (dd, 1H; GlcA H-5), 4.09–4.05 (m, 2H; GalN^I H-5, GlcA H-5), 3.94 (m, 1H; GalN^{III} H-2), 3.85–3.75 (m, 2H; GalN^{II} H-5, C*H*$_2$O), 3.72, 3.67 (2s, 6H; COOC*H*$_3$), 3.75–3.68 (m, 2H; GalN^{III} H-5, C*H*$_2$O), 3.53 (m, 1H; GalN^{II} H-6a), 3.46–3.40 (m, 1H; GalN^{II} H-6b), 3.44–3.20 (m, 7H; GalN^I H-2, GalN^{II} H-2, GalN^{III} H-2, H-6a, H-6b, C*H*$_2$N), 1.96, 1.93, 1.87 (3s, 9H; OCOC*H*$_3$), 1.76, 1.63, 1.25 ppm (3s, 9H; NHCOC*H*$_3$); HRMS: *m*/*z*: calcd for $C_{110}H_{110}N_4O_{41}$ $[M]^{2+}$: 1072.3401; found: 1072.3434.

Hexasaccharide 58: From alcohol **55** (209 mg, 0.10 mmol) and imidate **5** (162 mg, 0.19 mmol) as described for the preparation of **6**. Flash-silica chromatography (toluene/EtOAc 3:2, containing 0.1% of NEt_3) afforded the hexasaccharide **58** (154 mg, 55%) as a white powder. M.p. 177–179°C (from 2-propanol/petroleum ether); $[\alpha]_D^{20} = +2.5$ ($c = 1$ in chloroform); ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 8.09$–6.92 (m, 45H; arom. H), 6.85 (d, $J_{2,NH} = 7.0$ Hz, 1H; GalN^I N*H*), 6.84 (d, $J_{2,NH} = 7.0$ Hz, 1H; GalN^{III} N*H*), 6.83 (d, $J_{2,NH} = 7.0$ Hz, 1H; GalN^{II} N*H*), 5.82 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^I H-4), 5.59 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^{II} H-4), 5.49, 5.47 (2dd, $J_{2,3} = 9.0$ Hz, $J_{3,4} = 10.0$ Hz, 2H; GlcA^I H-3, GlcA^{II} H-3), 5.28–5.01 (m, 10H; GalN^I H-1, GalN^{II} H-1, GalN^{III} H-4, GlcA^I H-2, GlcA^{II} H-2, GlcA^{III} H-3, H-4, C*H*$_2$PH; N*H*COO), 4.94–4.78 (m, 3H; GlcA^I H-1, GlcA^{II} H-1, GlcA^{III} H-2), 4.81 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^I H-3), 4.89 (d, $J_{1,2} = 8.5$ Hz, 1H; GalN^{III} H-1), 4.68 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^{II} H-3), 4.58 (d, $J_{1,2} = 8.0$ Hz, 1H; GlcA^{III} H-1), 4.47–4.31 (m, 2H; GalN^I H-6a, H-6b), 4.30–4.16 (m, 3H; GalN^{III} H-3, GlcA^I H-4, GlcA^{II} H-4), 4.11 (m, 1H; GalN^I H-5), 4.02, 3.97 (2d, $J_{4,5} = 10.0$ Hz, 2H; GlcA^I H-5, GlcA^{II} H-5), 3.96–3.78 (m, 3H; GalN^{II} H-5, GlcA^{III} H-5, C*H*$_2$O), 3.74, 3.71, 3.64 (3s, 9H; COOC*H*$_3$), 3.79–3.51 (m, 6H; GalN^{II} H-6a, GalN^{III} H-5, 3GalN H-2, C*H*$_2$O), 3.41–3.22 (m, 4H; GalN^{II} H-6b, GalN^{III} H-6a, C*H*$_2$N), 3.09 ppm (dd, $J_{6a,6b} = 12.0$ Hz, $J_{5,6b} = 6.0$ Hz, 1H; GalN^{III} H-6b); MS: *m*/*z*: 2721 $[M-H]^-$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{121}H_{115}Cl_9N_4O_{49}$: C 53.27, H 4.25, N 2.05; found: C 53.08, H 4.26, N 1.91.

Hexasaccharide acetamide 59: From **58** (154 mg, 60 μmol) in *N*,*N*-dimethylacetamide (2 mL) and benzene (1.5 mL) as described for the preparation of **39**. Flash-silica chromatography (CH_2Cl_2/MeOH 19:1) afforded the acetamide **59** (106 mg, 78%) as a white powder. $[\alpha]_D^{20} = +4$ ($c = 1$ in chloroform); m.p. 161–162°C (from CH_2Cl_2/petroleum ether/diethyl ether); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 8.09$–6.77 (m, 45H; arom. H), 5.72 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^I H-4), 5.67 (d, $J_{2,NH} = 7.0$ Hz, 1H; GalN^{III} N*H*), 5.54 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^{II} H-4), 5.49–5.43 (m, 3H; GalN^I N*H*, GlcA^I H-3, GlcA^{II} H-3), 5.38 (d, $J_{2,NH} = 7.0$ Hz, 1H; GalN^{II} N*H*), 5.28 (dd, $J_{1,2} = 7.0$ Hz, $J_{2,3} = 9.0$ Hz, 1H; GlcA H-2), 5.22–5.08 (m, 6H; GalN^I H-1, GalN^{III} H-4, GlcA^{III} H-3, H-4, GlcA H-2, N*H*COO), 5.01 (s, 2H; C*H*$_2$Ph), 4.94 (d, $J_{1,2} = 8.0$ Hz, 1H; GalN^{II} H-1), 4.89–4.81 (m, 3H; GalN^{II} H-3, GlcA^{II} H-2, GlcA H-1), 4.77 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^I H-3), 4.76 (d, $J_{1,2} = 7.0$ Hz, 1H; GlcA H-1), 4.71 (d, $J_{1,2} = 8.0$ Hz, 1H; GalN^{III} H-1), 4.60 (d, $J_{1,2} = 8.0$ Hz, 1H; GlcA^{III} H-1), 4.51–4.45 (m, 2H; GalN^I H-6a, GalN^{III} H-3), 4.33 (dd, $J_{6a,6b} = 11.5$ Hz, $J_{5,6b} = 7.0$ Hz, 1H; GalN^I H-6b), 4.22, 4.18 (2dd, $J_{3,4} = 9.5$ Hz, $J_{4,5} = 10.0$ Hz, 2H; GlcA^I H-4, GlcA^{II} H-4), 4.09–3.99 (m, 3H; GalN^I H-5, GlcA^I H-5, GlcA^{II} H-5), 3.93 (m, 1H; GlcA^{III} H-5), 3.82–3.59 (m, 3H; GalN^{II} H-5, GalN^{III} H-5, C*H*$_2$O), 3.68, 3.61 (2s, 9H; COOC*H*$_3$), 3.53 (dd, $J_{6a,6b} = 12.0$ Hz, $J_{5,6a} = 6.0$ Hz, 1H; GalN^{II} H-6a), 3.48–3.23 (m, 5H; GalN^{II} H-6b, GalN^{III} H-6a, C*H*$_2$N, C*H*$_2$O), 3.21–3.08 (m, 4H; 3GalN H-2, GalN^{III} H-6b), 2.01, 1.98, 1.97, 1.96, 1.89 (5s, 15H; OCOC*H*$_3$), 1.78, 1.40, 1.30 ppm (3s, 9H; NHCOC*H*$_3$); HRMS: *m*/*z*: calcd for $C_{121}H_{124}N_4O_{49}$ $[M]^{2+}$: 1209.3745; found: 1209.3773.

Hexasaccharide 60: From alcohol **55** (759 mg, 0.34 mmol) and imidate **19** (705 mg, 0.60 mmol) as described for the preparation of **6**. Flash-silica chromatography (CH_2Cl_2/acetone 12:1, containing 0.1% of NEt_3) afforded the hexasaccharide **60** (754 mg, 66%) as a white powder. M.p. 150–155°C (from 2-propanol/petroleum ether); $[\alpha]_D^{20} = +5.5$ ($c = 1$ in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 8.08$–7.12 (m, 61H; arom. H), 6.86–6.80 (m, 5H; 4 arom. H; GalN^I N*H*), 6.74 (2d, $J_{2,NH} = 7.0$ Hz, 2H; GalN^{II} N*H*, GalN^{III} N*H*), 5.81 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^I H-4), 5.59, 5.55 (2dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 2H; GalN^{II} H-4, GalN^{III} H-4), 5.51, 5.48, 5.42 (3dd, $J_{2,3} = J_{3,4} = 9.5$ Hz, 3H; 3GlcA H-3), 5.37 (dd, $J_{4,5} = 10.0$ Hz, 1H; GlcA^{III} H-4), 5.18, 5.10 (2d, $J_{1,2} = 8.0$ Hz, 2H; GalN^{II} H-1, GalN^{III} H-1), 5.24–5.09 (m, 4H; 3GlcA H-2, N*H*COO), 5.07 (d, $J_{1,2} = 8.0$ Hz, 1H; GalN^I H-1), 5.01 (s, 2H; C*H*$_2$Ph), 4.91 (d, $J_{1,2} = 7.5$ Hz, 1H; GlcA^{III} H-1), 4.87, 4.81 (2d, $J_{1,2} = 7.5$ Hz, 2H; GlcA^I H-1, GlcA^{II} H-1), 4.79 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^I H-3), 4.68, 4.65 (2dd, $J_{2,3} = 11.0$ Hz, 2H; GalN^{II} H-3, GalN^{III} H-3), 4.47 (dd, $J_{6a,6b} = 11.5$ Hz, $J_{5,6a} = 5.0$ Hz, 1H; GalN^I H-6a), 4.39 (dd, $J_{5,6b} = 7.0$ Hz, 1H; GalN^I H-6b), 4.31, 4.25 (2dd, $J_{4,5} = 9.5$ Hz, 2H; GlcA^I H-4, GlcA^{II} H-4), 4.10 (d, 1H; GlcA^{III} H-5), 4.12–4.07 (m, 1H; GalN^I H-5), 4.03, 3.96 (2d, 2H; GlcA^I H-5, GlcA^{II} H-5), 3.89–3.82 (m, 3H; GalN^{II} H-5, GalN^{III} H-5, C*H*$_2$O), 3.73, 3.64, 3.63 (3s, 9H; COOC*H*$_3$), 3.74–3.50 (m, 6H; GalN^{II} H-6a, H-6b, 3GalN H-2, C*H*$_2$O), 3.42–3.24 (m, 4H; GalN^{III} H-6a, H-6b, C*H*$_2$N), 2.60–2.31 (m, 4H; C*H*$_2$CO), 2.01 ppm (s, 3H; COC*H*$_3$); MS: *m*/*z*: 1512 $[M-2H]^{2-}$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{144}H_{127}Cl_9N_4O_{50}$: C 57.03, H 4.22, N 1.85; found: C 56.95, H 4.25, N 1.73.

Hexasaccharide acceptor 61: From hexasaccharide **60** (754 mg, 0.25 mmol) as described for the preparation of **16**. Flash-silica chromatography (CH_2Cl_2/acetone 12:1) afforded the alcohol **61** (604 mg, 83%) as a white powder. M.p. 161–162°C (from 2-propanol); $[\alpha]_D^{20} = +1$ ($c = 1$ in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): $\delta = 8.08$–7.12 (m, 62H; arom. H), 6.91 (d, $J_{2,NH} = 7.0$ Hz, 1H; GalN^I N*H*), 6.87–6.76 (m, 5H; GalN^{II} N*H*, GalN^{III} N*H*, 3 arom. H), 5.81 (dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 1H; GalN^I H-4), 5.61, 5.56 (2dd, $J_{3,4} = 3.0$ Hz, $J_{4,5} < 1.0$ Hz, 2H; GalN^{II} H-4, GalN^{III} H-4), 5.49, 5.42, 5.38 (3dd, $J_{2,3} = J_{3,4} = 9.5$ Hz, 3H; 3GlcA H-3), 5.25–5.09 (m, 6H; GalN^{II} H-1, GalN^{III} H-1, 3GlcA H-2, N*H*COO), 5.06 (d, $J_{1,2} = 8.0$ Hz, 1H; GalN^I H-1), 5.00 (s, 2H; C*H*$_2$Ph), 4.92, 4.84, 4.81 (3d, $J_{1,2} = 7.5$ Hz, 3H; 3GlcA H-1), 4.79 (dd, $J_{2,3} = 11.0$ Hz, 1H; GalN^I H-3), 4.68, 4.63 (2dd, $J_{2,3} = 11.0$ Hz, 2H; GalN^{II} H-3, GalN^{III} H-3), 4.45 (dd, $J_{6a,6b} = 11.5$ Hz, $J_{5,6a} = 5.0$ Hz, 1H; GalN^I H-6a), 4.38 (dd, $J_{5,6b} = 7.0$ Hz, 1H; GalN^I H-6b), 4.30, 4.26 (2dd, $J_{3,4} = 8.0$ Hz, $J_{4,5} = 9.5$ Hz, 2H; GlcA^I

H-4, GlcA^{II} H-4), 4.12–3.95 (m, 5H; GalN^{I} H-5, 3GlcA H-5, GlcA^{III} H-4), 3.89–3.81 (m, 3H; GalN^{II} H-5, GalN^{III} H-5, CH_2O), 3.72, 3.67, 3.63 (3s, 9H; COOCH_3), 3.72–3.52 (m, 6H; GalN^{II} H-6a, H-6b, 3GalN H-2, CH_2O), 3.40 (d, $J_{4,OH}$=3.0 Hz, 1H; GlcA^{III} *H*O-4), 3.42–3.22 ppm (m, 4H; GalN^{III} H-6a, H-6b, CH_2N); MS: *m*/*z*: 2927 [*M*−H]$^-$, 1463 [*M*−H]$^{2-}$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{139}H_{121}Cl_9N_4O_{48}$: C 56.89, H 4.16, N 1.91; found: C 56.65, H 4.29, N 1.82.

Heptasaccharide 62: From alcohol **61** (250 mg, 85 μmol) and imidate **49** (91 mg, 150 μmol) as described for the preparation of **6**. Flash-silica chromatography (CH_2Cl_2/acetone 12:1, containing 0.1% of NEt_3) afforded the heptasaccharide **62** (183 mg, 67%) as a white powder. M.p. 160–162°C (from 2-propanol); $[\alpha]_D^{20}=-6$ (*c*=1 in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): δ=8.09–7.55 (m, 63H; arom. H), 7.19 (d, $J_{2,NH}$= 6.5 Hz, 1H; GalN^{I} N*H*), 6.98–6.95 (m, 2H; arom. H), 6.98–6.95 (m, 3H; GalN^{II} N*H*, GalN^{III} N*H*, GalN^{IV} N*H*), 5.82 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN^{I} H-4), 5.59, 5.56 (2dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 2H; GalN^{II} H-4, GalN^{III} H-4), 5.51, 5.49, 5.45 (3dd, $J_{2,3}$=$J_{3,4}$=9.0 Hz, 3H; 3GlcA H-3), 5.26–5.19 (m, 2H; 2GlcA H-2), 5.18, 5.13 (2d, $J_{1,2}$=8.5 Hz, 2H; GalN^{II} H-1, GalN^{III} H-1), 5.15–4.97 (m, 6H; GalN^{I} H-1, GalN^{IV} H-1, GlcA H-2, CH_2Ph, N*H*COO), 5.10 (d, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN^{IV} H-4), 4.95, 4.89, 4.86 (3d, $J_{1,2}$=7.5 Hz, 3H; 3GlcA H-1), 4.85 (m, 1H; GalN^{VI} H-3), 4.78 (dd, $J_{2,3}$=11.0 Hz, 1H; GalN^{I} H-3), 4.59 (2dd, $J_{2,3}$=11.0 Hz, 2H; GalN^{II} H-3, GalN^{III} H-3), 4.46 (dd, $J_{6a,6b}$=12.0 Hz, $J_{5,6a}$=5.0 Hz, 1H; GalN^{I} H-6a), 4.39 (dd, $J_{5,6b}$=7.0 Hz, 1H; GalN^{I} H-6b), 4.31, 4.27, 4.24 (3dd, $J_{4,5}$=10.0 Hz, 3H; 3GlcA H-4), 4.11–4.03 (m, 2H; GalN^{I} H-5, GlcA H-5), 4.04, 4.01 (2d, 2H; 2GlcA H-5), 3.98 (m, 1H; GalN^{IV} H-2), 3.90–3.78 (m, 4H; GalN^{I} H-2, GalN^{II} H-5, GalN^{III} H-5, CH_2O), 3.72, 3.61 (2s, 9H; COOCH_3), 3.74–3.52 (m, 6H; GalN^{II} H-2, H-6a, GalN^{III} H-2, H-6a, GalN^{IV} H-5, CH_2O), 3.48–3.19 (m, 4H; GalN^{II} H-6b, GalN^{III} H-6b, CH_2N), 3.17 (dd, $J_{6a,6b}$=11.0 Hz, $J_{5,6a}$=6.0 Hz, 1H; GalN^{IV} H-6a), 3.13 (dd, $J_{5,6b}$=5.0 Hz, 1H; GalN^{IV} H-6b), 1.95, 1.93, 1.92 ppm (3s, 9H; OCOCH_3); MS: *m*/*z*: 3358 [*M*−H]$^-$, 1679 [*M*−H]$^{2-}$ (for ^{35}Cl); elemental analysis calcd (%) for $C_{153}H_{137}Cl_{12}N_5O_{56}$: C 54.58, H 4.10, N 2.08; found: C 54.45, H 4.18, N 1.99.

Heptasaccharide acetamide 63: From **62** (193 mg, 60 μmol) in benzene (2 mL) and *N*,*N*-dimethylacetamide (3 mL) as described for the preparation of **39**. Flash-silica chromatography (CH_2Cl_2/methanol 19:1) afforded the acetamide **63** (130 mg, 77%) as a white powder. M.p. 168–170°C (from petroleum ether/diethyl ether); $[\alpha]_D^{20}=-5.5$ (*c*=1 in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): δ=8.02–7.73 (m, 65H; arom. H), 5.88 (d, $J_{2,NH}$=9.0 Hz, 1H; GalN^{IV} N*H*), 5.81 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN^{I} H-4), 5.69 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN H-4), 5.52–5.41 (m, 6H; GalN^{I} N*H*, GalN N*H*, GalN H-4, 3GlcA H-3), 5.37 (d, $J_{2,NH}$= 9.0 Hz, 1H; GalN N*H*), 5.28–5.13 (m, 3H; 2GlcA H-2, N*H*COO), 5.10 (d, $J_{1,2}$=8.5 Hz, 1H; GalN H-1), 5.10 (dd, 1H; GlcA H-2), 5.02 (dd, $J_{3,4}$= 3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN^{IV} H-4), 4.98 (s, 2H; CH_2Ph), 4.93 (d, $J_{1,2}$= 8.0 Hz, 1H; GalN^{I} H-1), 4.91 (d, $J_{1,2}$=8.0 Hz, 1H; GalN H-1), 4.77 (dd, $J_{2,3}$=11.0 Hz, $J_{3,4}$=3.0 Hz, 1H; GalN H-3), 4.92–4.80 (m, 5H; GalN^{I} H-3, GalN^{IV} H-3, GalN H-3, GlcA^{I} H-1, GlcA^{II} H-1), 4.74 (d, $J_{1,2}$=8.0 Hz, 1H; GlcA H-1), 4.51 (d, $J_{1,2}$=8.5 Hz, 1H; GalN^{IV} H-1), 4.49–4.45 (m, 2H; GalN^{I} H-6a, GlcA H-4), 4.31 (dd, $J_{6b,6a}$=11.0 Hz, $J_{5,6b}$=7.0 Hz, 1H; GalN^{I} H-6b), 4.21–4.13 (m, 2H; 2GlcA H-4), 4.16 (dd, $J_{4,5}$=10.0 Hz, 1H; GlcA H-5), 4.06–3.90 (m, 2H; GalN^{I} H-5, GalN^{IV} H-2), 4.02, 3.99 (2d, $J_{4,5}$=10.0 Hz, 2H; 2GlcA H-5), 3.81–3.58 (m, 5H; GalN^{II} H-5, GalN^{III} H-5, GalN^{IV} H-5, CH_2O), 3.68, 3.65, 3.63 (3s, 9H; COOCH_3), 3.55–3.39 (m, 4H; GalN^{II} H-6a, H-6b, GalN^{III} H-6a, H-6b), 3.44–3.20 (m, 7H; GalN^{I} H-2, GalN^{II} H-2, GalN^{III} H-2, GalN^{IV} H-6a, H-6b, CH_2N), 1.96, 1.93, 1.87 (3s, 9H; OCOCH_3), 1.34, 130, 1.25 ppm (3s, 12H; NHCOCH_3); elemental analysis calcd (%) for $C_{153}H_{149}N_5O_{56}$: C 62.21, H 5.08, N 2.37; found: C 62.01, H 5.18, N 2.11.

Octasaccharide 64: From alcohol **61** (321 mg, 0.11 mmol) and imidate **5** (256 mg, 0.22 mmol) as described for the preparation of **6**. Flash-silica chromatography (toluene/EtOAc 3:2, containing 0.1% of NEt_3) afforded the octasaccharide **64** (260 mg, 65%) as a white powder. M.p. 164–165°C (from diethyl ether); $[\alpha]_D^{20}=-4.5$ (*c*=1 in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): δ=8.06–7.12 (m, 43H; arom. H), 6.86 (d, $J_{2,NH}$= 6.5 Hz, 1H; GalN^{I} N*H*), 6.86–6.77 (m, 2H; arom. H), 6.78 (d, $J_{2,NH}$= 7.0 Hz, 1H; GalN^{IV} N*H*), 6.74, 6.71 (2d, $J_{2,NH}$=7.0 Hz, 2H; GalN^{II} N*H*, GalN^{III} N*H*), 5.81 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN^{I} H-4), 5.57, 5.54 (2dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 2H; GalN^{II} H-4, GalN^{III} H-4), 5.47, 5.46, 5.43 (3dd, $J_{2,3}$=$J_{3,4}$=9.5 Hz, 3H; GlcA^{I} H-3, GlcA^{II} H-3, GlcA^{III} H-3), 5.18 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN^{IV} H-4), 5.07 (d, $J_{1,2}$= 8.0 Hz, 1H; GalN^{I} H-1), 5.25–5.05 (m, 8H; GalN^{II} H-1, GalN^{III} H-1, GlcA^{I} H-2, GlcA^{II} H-2, GlcA^{III} H-2, GlcA^{IV} H-3, H-4, N*H*COO), 5.02 (s, 2H; CH_2Ph), 4.91 (d, $J_{1,2}$=7.5 Hz, 1H; GlcA H-1), 4.89 (d, $J_{1,2}$=8.5 Hz, 1H; GalN^{IV} H-1), 4.87–4.77 (m, 4H; GalN^{I} H-3, GlcA^{IV} H-2, 2GlcA H-1), 4.65 (2dd, $J_{2,3}$=11.0 Hz, 2H; GalN^{II} H-3, GalN^{III} H-3), 4.57 (d, $J_{1,2}$= 8.0 Hz, 1H; GlcA^{IV} H-1), 4.47 (dd, $J_{6a,6b}$=11.5 Hz, $J_{5,6a}$=5.0 Hz, 1H; GalN^{I} H-6a), 4.38 (dd, 1H; $J_{5,6b}$=7.0 Hz, GalN^{I} H-6b), 4.30, 4.26, 4.22 (3dd, $J_{4,5}$=9.5 Hz, 3H; GlcA^{I} H-4, GlcA^{II} H-4, GlcA^{III} H-4), 4.21 (dd, $J_{2,3}$=11.0 Hz, 1H; GalN^{IV} H-3), 4.10 (m, 1H; GalN^{I} H-5), 4.03, 3.99, 3.92 (3d, 3H; GlcA^{I} H-5, GlcA^{II} H-5, GlcA^{III} H-5), 3.96 (d, $J_{4,5}$=10.0 Hz, 1H; GlcA^{IV} H-5), 3.89–3.82 (m, 3H; GalN^{II} H-5, GalN^{III} H-5, CH_2O), 3.73, 3.71, 3.64, 3.62 (4s, 12H; COOCH_3), 3.74–3.53 (m, 8H; 4GalN H-2, GalN^{II} H-6a, GalN^{III} H-6a, GalN^{IV} H-5, CH_2O), 3.36 (dd, $J_{6a,6b}$=11.0 Hz, $J_{5,6a}$=6.0 Hz, 1H; GalN^{IV} H-6a), 3.29, 3.21 (2dd, $J_{6a,6b}$=11.0 Hz, $J_{5,6b}$= 7.0 Hz, 2H; 2GalN H-6b), 3.40–3.26 (m, 2H; CH_2NH), 3.09 (dd, $J_{6a,6b}$= 11.0 Hz, $J_{5,6b}$=7.0 Hz, 1H; GalN^{IV} H-6b), 2.02, 1.99, 1.98, 1.96, 1.82 ppm (5s, 15H; OCOCH_3); MS: *m*/*z*: 1815 [*M*−2H]$^{2-}$; HRMS: *m*/*z*: calcd for $C_{68}H_{108}N_8O_{42}S$ [*M*−3Na+3H]$^{2-}$: 869.3063; found: 869.3078.

Octasaccharide acetamide 65: From **64** (214 mg, 60 μmol) in benzene (2 mL) and *N*,*N*-dimethylacetamide (3 mL) as described for the preparation of **39**. Flash-silica chromatography (CH_2Cl_2/methanol 19:1) afforded the acetamide **65** (100 mg, 53%) as a white powder. M.p. 181–182°C (EtOAc/petroleum ether); $[\alpha]_D^{20}=-7$ (*c*=1 in chloroform); ^{1}H NMR (400 MHz, $CDCl_3$): δ=8.02–6.74 (m, 65H; arom. H), 5.71 (dd, $J_{3,4}$= 3.5 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN^{I} H-4), 5.69 (d, $J_{2,NH}$=6.5 Hz, 1H; GalN^{I} N*H*), 5.51, 5.45 (2dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 2H; GalN^{II} H-4, GalN^{III} H-4), 5.49–5.41 (m, 4H; GalN^{IV} N*H*, GlcA^{I} H-3, GlcA^{II} H-3, GlcA^{III} H-3), 5.40–5.35 (m, 2H; GalN^{II} N*H*, GalN^{III} N*H*), 5.30–5.11 (m, 6H; GlcA^{I} H-2, GlcA^{II} H-2, GlcA^{III} H-2, GlcA^{IV} H-3, H-4, N*H*COO), 5.11 (d, $J_{1,2}$= 7.5 Hz, 1H; GalN^{I} H-1), 5.09 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H; GalN^{IV} H-4), 5.00 (s, 2H; CH_2Ph), 4.91, 4.89 (2d, $J_{1,2}$=8.0 Hz, 2H; GalN^{II} H-1, GalN^{III} H-1), 4.82, 4.76 (2d, $J_{1,2}$=7.5 Hz, 2H; 2GlcA H-1), 4.92–4.74 (m, 4H; GalN^{I} H-3, GalN^{II} H-3, GalN^{III} H-3, GlcA^{IV} H-2), 4.72 (d, $J_{1,2}$= 7.5 Hz, 1H; GlcA H-1), 4.70 (d, $J_{1,2}$=8.5 Hz, 1H; GalN^{IV} H-1), 4.58 (d, $J_{1,2}$=8.0 Hz, 1H; GlcA^{IV} H-1),4.49–4.43 (m, 2H; GalN^{I} H-6a, GalN^{IV} H-3), 4.31 (dd, $J_{5,6b}$=7.0 Hz, 1H; GalN^{I} H-6b), 4.23, 4.16, 4.13 (3dd, $J_{3,4}$= $J_{4,5}$=9.5 Hz, 3H; GlcA^{I} H-4, GlcA^{II} H-4, GlcA^{III} H-4), 4.03 (m, 1H; GalN^{I} H-5), 4.02, 4.01, 3.93 (3d, 3H; GlcA^{I} H-5, GlcA^{II} H-5, GlcA^{III} H-5), 3.92 (d, $J_{4,5}$=10.0 Hz, 1H; GlcA^{IV} H-5), 3.81–3.58 (m, 5H; GalN^{II} H-5, GalN^{III} H-5, GalN^{IV} H-5, CH_2O), 3.69, 3.67, 3.66, 3.61 (4s, 12H; COOCH_3), 3.57–3.06 (m, 12H; GalN^{II} H-6a, H-6b, GalN^{III} H-6a, H-6b, GalN^{IV} H-6a, H-6b, 4GalN H-2, CH_2N), 2.01, 1.98, 1.97, 1.96, 1.89, 1.78, 1.38, 1.33, 1.29 ppm (9s, 27H; OCOCH_3, NHCOCH_3); MS: *m*/*z*: 1613 [*M*+2H]$^{2+}$; HRMS: *m*/*z*: calcd for $C_{68}H_{108}N_8O_{42}S$ [*M*−3Na+3H]$^{2-}$: 869.3063; found: 869.3078.

Disaccharide 66: From disaccharide **48** (80 mg, 25 μmol) as described for the preparation of **40** to afford the sodium salt **66** (45 mg, 67%) as a white powder. R_f=0.53 (EtOAc/MeOH/water 4:2:1); $[\alpha]_D^{20}=-29$ (*c*=1 in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, δ_H=4.79): δ=7.45 (s, 5H; arom. H), 5.14 (s, 2H; CH_2Ph), 4.50 (d, $J_{1,2}$=8.0 Hz, 1H; GlcA H-1), 4.47 (d, $J_{1,2}$=8.5 Hz, 1H; GalN H-1), 4.17 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$< 1.0 Hz, 1H; GalN H-4), 4.01 (dd, $J_{2,3}$=11.0 Hz, 1H; GalN H-2), 3.99 (m, 1H; CH_2O), 3.91 (dd, 1H; GalN H-3), 3.79–3.68 (m, 2H; GalN H-6a, H-6b), 3.71 (m, 1H; GalN H-5), 3.70 (d, $J_{4,5}$=10.0 Hz, 1H; GlcA H-5), 3.65 (m, 1H; CH_2O), 3.53–3.46 (m, 2H; GlcA H-3, H-4), 3.38–3.31 (m, 3H; GlcA H-2, CH_2N), 1.96 ppm (s, 3H; NHCOCH_3); MS: *m*/*z*: 574 [*M*−Na+H]$^-$; elemental analysis calcd (%) for $C_{24}H_{33}N_2NaO_{12}$: C 48.32, H 5.58, N 4.70; found: C 48.13, H 5.59, N 4.38.

Trisaccharide 67: From trisaccharide **51** (37 mg, 20 μmol) as described for the preparation of **40** to afford the sodium salt **67** (23 mg, 68%) as a white powder. R_f=0.32 (EtOAc/MeOH/water 4:2:1); $[\alpha]_D^{20}=-7$ (*c*=1 in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, δ_H=4.79): δ=7.42 (s, 5H; arom. H), 5.12 (s, 2H; CH_2Ph), 4.51–4.43 (m, 2H; 2GalN H-1), 4.50 (d, $J_{1,2}$=8.0 Hz, 1H; GlcA H-1), 4.11 (dd, $J_{3,4}$=3.0 Hz, $J_{4,5}$<1.0 Hz, 1H;

GalN^{I} H-4), 4.01 (dd, $J_{1,2}=8.5$ Hz, $J_{2,3}=9.5$ Hz, 1H; GalN^{I} H-2), 3.95–3.61 (m, 15H; GalN^{II} H-2, H-4, 2GalN H-3, H-5, H-6a, H-6b, GlcA H-4, H-5, N*H*COO, CH_2O), 3.59 (dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 1H; GlcA H-3), 3.38 (dd, 1H; GlcA H-2), 3.35–3.29 (m, 2H; CH_2N), 2.06, 1.96 ppm (2s, 6H; NHCOCH_3); HRMS: *m/z*: calcd for $C_{32}H_{47}N_3NaO_{19}$ $[M+H]^+$: 800.2701; found: 800.2691.

Tetrasaccharide 68: From tetrasaccharide **53** (173 mg, 0.13 mmol) as described for the preparation of **40** to afford the sodium salt **68** (78 mg, 62%) as a white powder. $R_f=0.64$ (EtOAc/MeOH/water 3:2:1); $[\alpha]_D^{20}=+17$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=7.44$ (s, 5H; arom. H), 5.11 (s, 2H; CH_2Ph), 4.53 (d, $J_{1,2}=8.5$ Hz, 1H; GalN^{I} H-1), 4.51 (2d, $J_{1,2}=8.0$ Hz, 2H; 2GlcA H-1), 4.49 (d, $J_{1,2}=8.5$ Hz, 1H; GalN^{II} H-1), 4.17 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4), 4.11 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{II} H-4), 4.02, 3.99 (2dd, $J_{2,3}=11.0$ Hz, 2H; 2GalN H-2), 3.92 (m, 1H; CH_2O), 3.84–3.68 (m, 11H; 2GalN H-3, H-5, H-6a, H-6b, GlcA^{I} H-4, 2GlcA H-5), 3.60 (dd, $J_{2,3}=8.5$ Hz, $J_{3,4}=9.0$ Hz, 1H; GlcA^{I} H-3), 3.53–3.46 (m, 2H; GlcA^{II} H-3, H-4), 3.38 (2dd, 2H; 2GlcA H-2), 3.36–3.30 (m, 2H; CH_2N), 2.04, 1.96 ppm (2s, 6H; NHCOCH_3); MS: *m/z*: 952 $[M-2Na+H]^-$; HRMS: *m/z*: calcd for $C_{38}H_{55}N_3NaO_{25}$ $[M-Na+2H]^+$: 976.3022; found: 976.3004.

Pentasaccharide 69: From pentasaccharide **57** (37 mg, 20 μmol) as described for the preparation of **40** to afford the sodium salt **69** (12 mg, 58%) as a white powder. $R_f=0.24$ (EtOAc/MeOH/water 2:2:1); $[\alpha]_D^{20}=-9$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=7.41$ (s, 5H; arom. H), 5.14 (s, 2H; CH_2Ph), 4.54–4.47 (m, 5H; 3GalN H-1, 2GlcA H-1), 4.13, 4.11 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 2H; GalN^{I} H-4, GalN^{II} H-4), 4.04–3.98 (m, 2H; GalN^{I} H-2, GalN^{II} H-2), 3.93 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{III} H-4), 3.92–3.56 (m, 21H; GalN^{III} H-2, 3GalN H-3, H-5, H-6a, H-6b, 2GlcA H-3, H-4, H-5, CH_2O), 3.42–3.31 (m, 4H; 2GlcA H-2, CH_2N), 2.06, 2.04, 1.96 ppm (3s, 9H; NHCOCH_3); HRMS: *m/z*: calcd for $C_{46}H_{68}N_4O_{30}Na$ $[M-Na+2H]^+$: 1179.3816; found: 1179.3839; calcd for $C_{46}H_{68}N_4O_{30}$ $[M-2Na+2H]^{2-}$: 577.1181; found: 577.1880.

Octasaccharide 70: From hexasaccharide **59** (41 mg, 20 μmol) as described for the preparation of **40** to afford the sodium salt **70** (17 mg, 71%) as a white powder. $R_f=0.53$ (EtOAc/MeOH/water 2:2:1); $[\alpha]_D^{20}=-21.5$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=7.81$–7.30 (m, 5H; arom. H), 5.15 (s, 2H; CH_2Ph), 4.52–4.42 (m, 6H; 3GalN H-1, 3GlcA H-1), 4.16 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4), 4.11, 4.10 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 2H; GalN^{II} H-4, GalN^{III} H-4), 4.04–3.95 (m, 3H; 3GalN H-2), 3.94–3.54 (m, 22H; 3GalN H-3, H-5, H-6a, H-6b, GlcA^{I} H-3, H-4, GlcA^{II} H-3, H-4, 3GlcA H-5, CH_2O), 3.50–3.46 (m, 2H; GlcA^{III} H-3, H-4), 3.39–3.25 (m, 5H; 3GlcA H-2, CH_2N), 2.03, 2.02, 1.95 ppm (3s; NHCOCH_3); HRMS: *m/z*: calcd for $C_{52}H_{76}N_4O_{36}$ $[M-3Na+3H]^{2-}$: 665.2041; found: 665.2032.

Heptasaccharide 71: From heptasaccharide **63** (140 mg, 50 μmol) as described for the preparation of **40** to afford the sodium salt **71** (71 mg, 95%) as a white powder. $R_f=0.55$ (EtOAc/MeOH/water 1:1:1); $[\alpha]_D^{20}=-4$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=7.45$ (s, 5H; arom. H), 5.13 (s, 2H; CH_2Ph), 4.51–4.49 (m, 7H; 4GalN H-1, 3GlcA H-1), 4.12, 4.11 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 3H; 3GalN H-4), 4.00, 3.99 (2dd, $J_{1,2}=8.0$ Hz, $J_{2,3}=11.0$ Hz, 3H; 3GalN H-2), 3.88 (dd, $J_{1,2}=8.0$ Hz, $J_{2,3}=11.0$ Hz, 1H; GaN^{IV} H-2), 3.94–3.67 (m, 23H; GalN^{IV} H-4, 4GalN H-3, H-5, H-6a, H-6b, 3GlcA H-4, H-5, CH_2O), 3.63 (m, 1H; CH_2O), 3.58 (dd, $J_{2,3}=11.0$ Hz, $J_{3,4}=3.0$ Hz, 3H; 3GlcA H-3), 3.41–3.30 (m, 5H; 3GlcA H-2, CH_2N), 2.06, 2.03, 1.96 ppm (3s, 12H; NHCOCH_3); HRMS: *m/z*: calcd for $C_{153}H_{148}N_5NaO_{56}$ $[M-2Na+3H]^+$: 1558.4931; found: 1558.4933.

Octasaccharide 72: From octasaccharide **65** (80 mg, 25 μmol) as described for the preparation of **40** to afford the sodium salt **72** (37 mg, 84%) as a white powder. $R_f=0.38$ (EtOAc/MeOH/water 1:2:2); $[\alpha]_D^{20}=-24.5$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=7.45$ (s, 5H; arom. H), 5.13 (s, 2H; CH_2Ph), 4.52–4.45 (m, 8H; 4GalN H-1, 4GlcA H-1), 4.18 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4),4.12, 4.11 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 3H; 3GalN H-4), 4.04–3.97 (m, 4H; 4GalN H-2), 3.92 (m, 1H; CH_2O), 3.83–3.55 (m, 24H; 4GalN H-3, H-5, H-6a, H-6b, GlcA^{I} H-4, GlcA^{II} H-4, GlcA^{III} H-4, 4GlcA H-5, CH_2O), 3.48 (dd, $J_{2,3}=9.0$ Hz, $J_{3,4}=10.0$ Hz, 3H; GlcA^{I} H-3, GlcA^{II} H-3, GlcA^{III} H-3), 3.51–3.45 (m, 2H; GlcA^{IV} H-3, H-4), 3.41–3.30 (m, 6H; 4GlcA H-2, CH_2N), 2.04, 2.03, 1.96 ppm (3s, 12H; NHCOCH_3); HRMS: *m/z*: calcd for $C_{66}H_{97}N_5O_{47}$ $[M-4Na+4H]^{2-}$: 854.7599; found: 854.7588.

Biotinylated disaccharide 73: From **48** (19 mg, 30 μmol) as described for the preparation of **44** to give the intermediate amine. A solution of the amine and 6-biotinylamidohexanoic acid *N*-hydroxysuccinimidoyl ester (58 mg, 130 μmol) in DMF (675 μL), NEt_3 (75 μL), and water (750 μL) was stirred for 1 h at room temperature, then was concentrated. The resulting solid was washed with absolute EtOH, and the residue was eluted from a column (3×80 cm) of Sephadex LH-20 with water and lyophilized to afford the biotinylated disaccharide **73** (17 mg, 67%) as a white powder. $R_f=0.48$ (EtOAc/MeOH/water 3:2:1); $[\alpha]_D^{20}=-0.5$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=4.62$ (ddd, $J_{b,c}=8.0$ Hz, $J_{c,d'}=5.0$ Hz, $J_{c,d}<1.0$ Hz, 1H; H-c), 4.52 (d, $J_{1,2}=7.0$ Hz, 1H; GalN H-1), 4.51 (d, $J_{1,2}=8.0$ Hz, 1H; GlcA H-1), 4.43 (dd, $J_{b,e}=5.0$ Hz, 1H; H-b), 4.19 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN H-4), 4.03 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN H-2), 3.93 (m, 1H; CH_2-r), 3.84 (dd, 1H; GalN H-3), 3.82–3.67 (m, 6H; GalN H-5, H-6a, H-6b, GlcA H-5, CH_2-r), 3.53–3.46 (m, 2H; GlcA H-3, H-4), 3.40–3.32 (m, 4H; GlcA H-2, H-e, CH_2-q), 3.19 (dd, $J_{k,k'}=J_{k,l}=7.0$ Hz, 2H; CH_2-k), 3.01 (dd, $J_{d,d'}=13.0$ Hz, 1H; H-d′), 2.80 (dd, 1H; H-d), 2.29–2.23 (m, 4H; CH_2-i, CH_2-o), 2.03 (s, 3H; NHCOCH_3), 1.80–1.30 ppm (m, 12H; CH_2-f, CH_2-g, CH_2-h, CH_2-l, CH_2-m, CH_2-n); MS: *m/z*: 778 $[M-Na]^-$; HRMS: *m/z*: calcd for $C_{32}H_{53}Na\,N_5O_{15}S$ $[M+H]^+$: 802.3157; found: 802.3149.

Biotinylated trisaccharide 74: From **67** (20 mg, 25 μmol) as described for the preparation of **73** to afford the biotinylated trisaccharide **74** (15 mg, 71%) as a white powder. $R_f=0.63$ (EtOAc/MeOH/water 1:1:1); $[\alpha]_D^{20}=+10$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=4.63$ (ddd, $J_{b,c}=8.0$ Hz, $J_{c,d'}=5.0$ Hz, $J_{c,d}<1.0$ Hz, 1H; H-c), 4.51 (d, $J_{1,2}=8.0$ Hz, 1H; GlcA H-1), 4.50 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^{I} H-1), 4.48 (d, $J_{1,2}=8.0$ Hz, 1H; GalN^{II} H-1), 4.44 (dd, $J_{b,e}=5.0$ Hz, 1H; H-b), 4.13 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4), 4.02 (dd, $J_{2,3}=11.0$ Hz, 1H; GalN^{I} H-2), 3.96–3.68 (m, 14H; GalN^{II} H-2, H-4, 2GalN H-3, H-5, H-6a, H-6b, GlcA H-4, H-5, CH_2-r), 3.59 (dd, $J_{2,3}=J_{3,4}=9.0$ Hz, 1H; GlcA H-3), 3.41–3.32 (m, 4H; GlcA H-2, H-e, CH_2-q), 3.19 (dd, $J_{k,k'}=J_{k,l}=7.0$ Hz, 2H; CH_2-k), 3.01 (dd, $J_{d,d'}=13.0$ Hz, 1H; H-d′), 2.80 (dd, 1H; H-d), 2.29–2.23 (m, 4H; CH_2-i, CH_2-o), 2.06, 2.02 (2s, 6H; NHCOCH_3), 1.80–1.28 ppm (m, 12H; CH_2-f, CH_2-g, CH_2-h, CH_2-l, CH_2-m, CH_2-n); HRMS: *m/z*: calcd for $C_{40}H_{66}NaN_6O_{20}S$ $[M+H]^+$: 1005.3950; found: 1005.3953.

Biotinylated tetrasaccharide 75: From **68** (20 mg, 20 μmol) as described for the preparation of **73** to afford the biotinylated tetrasaccharide **75** (17 mg, 72%) as a white powder. $R_f=0.60$ (EtOAc/MeOH/water 1:1:1); $[\alpha]_D^{20}=-2.5$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=4.63$ (ddd, $J_{b,c}=8.0$ Hz, $J_{c,d'}=5.0$ Hz, $J_{c,d}<1.0$ Hz, 1H; H-c), 4.58–4.48 (m, 4H; 2GalN H-1, 2GlcA H-1), 4.44 (dd, $J_{b,e}=5.0$ Hz, 1H; H-b), 4.19 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4), 4.16 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{II} H-4), 4.02 (2dd, $J_{1,2}=8.5$ Hz, $J_{2,3}=11.0$ Hz, 2H; 2GalN H-2), 3.93 (m, 1H; CH_2-r), 3.85–3.67 (m, 12H; 2GalN H-3, H-5, H-6a, H-6b, GlcA^{I} H-4, 2GlcA H-5, CH_2-r), 3.59 (dd, $J_{2,3}=J_{3,4}=9.0$ Hz, 1H; GlcA^{I} H-3), 3.52–3.47 (m, 2H; GlcA^{II} H-3, H-4), 3.41–3.31 (m, 5H; 2GlcA H-2, H-e, CH_2-q), 3.19 (dd, 1H; $J_{k,k'}=J_{k,l}=7.0$ Hz, 2H; CH_2-k), 3.01 (dd, $J_{d,d'}=13.0$ Hz, 1H; H-d′), 2.80 (dd, 1H; H-d), 2.29–2.23 (m, 4H; CH_2-i, CH_2-o), 2.04, 2.02 (2s, 6H; NHCOCH_3), 1.81–1.32 ppm (m, 12H; CH_2-f, CH_2-g, CH_2-h, CH_2-l, CH_2-m, CH_2-n); HRMS: *m/z*: calcd for $C_{46}H_{74}NaN_6O_{26}S$ $[M-Na+2H]^+$: 1181.4271; found: 1181.4279; calcd for $C_{46}H_{74}N_6O_{26}S$ $[M-2Na+2H]^{2-}$: 578.2108; found: 578.2097.

Biotinylated pentasaccharide 76: From **69** (15 mg, 10 μmol) as described for the preparation of **73** to afford the biotinylated pentasaccharide **76** (10 mg, 75%) as a white powder. $R_f=0.78$ (EtOAc/MeOH/water 1:1:1); $[\alpha]_D^{20}=-2.5$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=4.62$ (ddd, $J_{b,c}=8.0$ Hz, $J_{c,d'}=5.0$ Hz, $J_{c,d}<1.0$ Hz, 1H; H-c), 4.53–4.51 (m, 5H; 3GalN H-1, 2GlcA H-1), 4.43 (dd, $J_{b,e}=5.0$ Hz, 1H; H-b), 4.13, 4.11 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 2H; GalN^{I} H-4, GalN^{II} H-4), 4.04–3.97 (m, 2H; GalN^{I} H-2, GalN^{II} H-2), 3.95–3.68 (m, 20H; GalN^{III} H-2, H-4, 3GalN H-3, H-5, H-6a, H-6b, 2GlcA H-4, H-5, CH_2-r), 3.59, 3.58 (2dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 2H; 2GlcA H-3), 3.41–3.32 (m, 5H;

2GlcA H-2, H-e, CH_2-q), 3.19 (dd, $J_{k,k'}=J_{k,l}=7.0$ Hz, 1H; CH_2-k), 3.01 (dd, $J_{d,d'}=13.0$ Hz, 1H; H-d′), 2.80 (dd, 1H; H-d), 2.28–2.21 (m, 4H; CH_2-i, CH_2-o), 2.02, 2.02, 2.01 (3s, 9H; NHCOCH_3), 1.78–1.22 ppm (m, 12H; CH_2-f, CH_2-g, CH_2-h, CH_2-l, CH_2-m, CH_2-n); HRMS: *m*/*z*: calcd for $C_{54}H_{87}N_7O_{31}NaS$ $[M-Na+2H]^+$: 1384.5065; found: 1384.5046; calcd for $C_{54}H_{87}N_7O_{31}S$ $[M-2Na+2H]^{2-}$: 679.7505; found: 679.7482.

Biotinylated hexasaccharide 77: From **70** (20 mg, 20 μmol) as described for the preparation of **73** to afford the biotinylated hexasaccharide **77** (17 mg, 72%) as a white powder. $R_f=0.88$ (EtOAc/MeOH/water1:1:1); $[\alpha]_D^{20}=-8.5$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=4.60$ (ddd, $J_{b,c}=8.0$ Hz, $J_{c,d'}=5.0$ Hz, $J_{c,d}<1.0$ Hz, 1H; H-c), 4.53–4.48 (m, 6H; 3GalN H-1, 3GlcA H-1), 4.43 (dd, $J_{b,e}=5.0$ Hz, 1H; H-b), 4.16 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<11.0$ Hz, 1H; GalN^{I} H-4), 4.12, 4.11 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 2H; GalN^{II} H-4, GalN^{III} H-4), 4.04–3.96 (m, 3H; 3GalN H-2), 3.95–3.67 (20H; 3GalN H-3, H-5, H-6a, H-6b, GlcA^{I} H-4, GlcA^{II} H-4, 3GlcA H-5, CH_2-r), 3.59 (dd, $J_{3,4}=9.0$ Hz, $J_{2,3}=8.0$ Hz, 2H; GlcA^{I} H-3, GlcA^{II} H-3), 3.53–3.45 (m, 2H; GlcA^{III} H-3, H-4), 3.39–3.26 (6H; 3GlcA H-2, H-e, CH_2-q), 3.18 (dd, $J_{k,k'}=J_{k,l}=7.0$ Hz, 1H; CH_2-k), 3.00 (dd, $J_{d,d'}=13.0$ Hz, 1H; H-d′), 2.79 (dd, 1H; H-d), 2.28–2.21 (m, 4H; CH_2-i, CH_2-o), 2.02, 2.02, 2.01 (3s, 9H; NHCOCH_3), 1.78–1.22 ppm (m, 12H; CH_2-f, CH_2-g, CH_2-h, CH_2-l, CH_2-m, CH_2-n); HRMS: *m*/*z*: calcd for $C_{60}H_{94}N_7O_{37}S$ $[M-3Na+2H]^-$: 1536.5410; found: 1536.5398.

Biotinylated heptasaccharide 78: From **71** (30 mg, 20 μmol) as described for the preparation of **73** to afford the biotinylated heptasaccharide **78** (29 mg, 85%) as a white powder. $R_f=0.78$ (EtOAc/MeOH/water1:1:1); $[\alpha]_D^{20}=-12.5$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=4.62$ (ddd, $J_{b,c}=8.0$ Hz, $J_{c,d'}=5.0$ Hz, $J_{c,d}<1.0$ Hz, 1H; H-c), 4.54–4.45 (m, 7H; 4GalN H-1, 3GlcA H-1), 4.43 (dd, $J_{b,e}=5.0$ Hz, 1H; H-b), 4.12, 4.11 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 3H; 3GalN H-4), 4.04–3.97 (m, 3H; 3GalN H-2), 3.95–3.88 (m, 2H; GalN^{IV} H-2, CH_2-r), 3.95–3.63 (m, 24H; GalN^{IV} H-4, 4GalN H-3, H-5, H-6a, H-6b, 3GlcA H-4, H-5, CH_2-r), 3.59, 3.58 (2dd, $J_{2,3}=J_{3,4}=9.5$ Hz, 3H; 3GlcA H-3), 3.41–3.31 (m, 6H; 3GlcA H-2, H-e, CH_2-q), 3.19 (dd, $J_{k,k'}=J_{k,l}=7.0$ Hz, 1H; CH_2-k), 3.01 (dd, $J_{d,d'}=13.0$ Hz, 1H; H-d′), 2.80 (dd, 1H; H-d), 2.28–2.21 (m, 4H; CH_2-i, CH_2-o), 2.06, 2.03, 2.02 (3s, 12H; NHCOCH_3), 1.78–1.28 ppm (m, 12H; CH_2-f, CH_2-g, CH_2-h, CH_2-l, CH_2-m, CH_2-n); HRMS: *m*/*z*: calcd for $C_{68}H_{108}N_8O_{42}S$ $[M-3Na+3H]^{2-}$: 869.3063; found: 869.3078.

Biotinylated octasaccharide 79: From **72** (36 mg, 20 μmol) as described for the preparation of **73** to afford the biotinylated octasaccharide **79** (33 mg, 89%) as a white powder. $R_f=0.71$ (EtOAc/MeOH/water 1:1:1); $[\alpha]_D^{20}=-13$ ($c=1$ in water); ^{1}H NMR (400 MHz, D_2O, internal HOD, $\delta_H=4.79$): $\delta=4.62$ (ddd, $J_{b,c}=8.0$ Hz, $J_{c,d'}=5.0$ Hz, $J_{c,d'}<1.0$ Hz, 1H; H-c), 4.54–4.45 (m, 8H; 4GalN H-1, 4GlcA H-1), 4.43 (dd, $J_{b,e}=5.0$ Hz, 1H; H-b), 4.17 (dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 1H; GalN^{I} H-4), 4.12, 4.11 (2dd, $J_{3,4}=3.0$ Hz, $J_{4,5}<1.0$ Hz, 3H; GalN^{II} H-4, GalN^{III} H-4, GalN^{IV} H-4), 4.03–3.94 (m, 4H; 4GalN H-2), 3.91 (m, 1H; CH_2-r), 3.85–3.62 (m, 24H; 4GalN H-3, H-5, H-6a, H-6b, 3GlcA H-4, 4GlcA H-5, CH_2-r), 3.61–3.55 (m, 3H; GlcA^{I} H-3, GlcA^{II} H-3, GlcA^{III} H-3), 3.52–3.46 (m, 2H; GlcA^{IV} H-3, H-4), 3.40–3.29 (m, 7H; 4GlcA H-2, H-e, CH_2-q), 3.18 (dd, $J_{k,k'}=J_{k,l}=7.0$ Hz, 1H; C*H2*-k), 2.99 (dd, $J_{d,d'}=13.0$ Hz, 1H; H-d‘), 2.79 (dd, 1H; H-d), 2.28–2.21 (m, 4H; CH_2-i, CH_2-o), 2.02, 2.01, 2.00 (3s, 12H; NHCOCH_3), 1.78–1.28 ppm (m, 12H; CH_2-f, CH_2-g, CH_2-h, CH_2-l, CH_2-m, CH_2-n); ^{13}C NMR (100 MHz, D_2O, internal acetone, $\delta_C=30.83$): $\delta=177.60$, 177.27, 175.63, 175.35, 175.27, 175.25 (10C; 4GlcA C-6, *C*=O), 165.99 (1C; C-a), 104.95, 104.77 (4C; 4GlcA C-1), 102.00, 101.47 (4C; 4GalN C-1), 80.96, 80.85, 80.40, 80.35 (7C; 4GalN C-3, GlcA^{I} C-4, GlcA^{II} C-4, GlcA^{III} C-4), 77.06, 77.04, 76.77, 75.96, 75.63, 75.54, 74.39, 74.35, 73.38, 73.12, 72.46 (17C; 4GalN C-5, GlcA^{IV} C-4, 4GlcA C-2, C-3, C-5), 68.77 (1C; C-r), 68.41, 68.35 (4C; 4GalN C-4), 62.76 (1C; C-b), 61.74 (4C; 4GalN C-6), 60.91 (1C; C-c), 56.06 (1C; C-e), 51.78, 51.69, 51.65 (4C; 4GalN C-2), 40.37 (1C; *C*-d), 39.93, 39.74 (2C; C-k, C-q), 36.30, 36.19 (2C; C-o, C-i), 28.69, 28.51, 28.35, 26.25, 25.88, 25.66 (6C; C-f, C-g, C-h, C-l, C-m, C-n), 23.17, 22.94 ppm (4C; NHCO*C*H$_3$); HRMS: *m*/*z*: calcd for $C_{74}H_{116}N_8O_{48}S$ $[M-4Na+4H]^{2-}$: 957.3223; found: 957.3259.

Acknowledgements

This research was supported by the Programme ANR-05-BLAN-0198–02 "GT-GAG." We are grateful for support by the Ministère de l'Enseignement Supérieur et de le Recherche through a studentship to A.V.

[1] L. Kjellen, U. Lindahl, *Annu. Rev. Biochem.* **1991**, *60*, 443–475.
[2] a) R. V. Iozzo, *Annu. Rev. Biochem.* **1998**, *67*, 609–652; b) K. Sugahara, S. Yamada, *Trends Glycosci. Glycotechnol.* **2000**, *12*, 321–349.
[3] K. Sugahara, H. Kitagawa, *Curr. Opin. Struct. Biol.* **2000**, *10*, 518–527.
[4] K. Prydz, K. T. Dalen, *J. Cell Sci.* **2000**, *113*, 193–205.
[5] H. Kitagawa, T. Uyama, K. Sugahara, *J. Biol. Chem.* **2001**, *276*, 38721–38726.
[6] H. Kitagawa, T. Izumikawa, T. Uyama, K. Sugahara, *J. Biol. Chem.* **2003**, *278*, 23666–23671.
[7] T. Ninomiya, N. Sugiura, A. Tawada, K. Sugimoto, H. Watanabe, K. Kimata, *J. Biol. Chem.* **2002**, *277*, 21567–21575.
[8] S. Kobayashi, S. Fujikawa, M. Ohmae, *J. Am. Chem. Soc.* **2003**, *125*, 14357–14369.
[9] C. Lopin, J.-C. Jacquinet, *Angew. Chem.* **2006**, *118*, 2636–2640; *Angew. Chem. Int. Ed.* **2006**, *45*, 2574–2578.
[10] P. A. Levene, *J. Biol. Chem.* **1941**, *140*, 267–277.
[11] E. A. Davidson, K. Meyer, *J. Am. Chem. Soc.* **1954**, *76*, 5686–5689.
[12] G. Blatter, J.-M. Beau, J.-C. Jacquinet, *Carbohydr. Res.* **1994**, *260*, 189–202.
[13] a) C. Coutant, J.-C. Jacquinet, *J. Chem. Soc. Perkin Trans. 1* **1995**, 1573–1581; b) G. Blatter, J.-C. Jacquinet, *Carbohydr. Res.* **1996**, *288*, 109–125; c) F. Belot, J.-C. Jacquinet, *Carbohydr. Res.* **2000**, *326*, 88–97; d) N. Karst, J.-C. Jacquinet, *Eur. J. Org. Chem.* **2002**, 815–825.
[14] R. R. Schmidt, *Angew. Chem.* **1986**, *98*, 213–236; *Angew. Chem. Int. Ed. Engl.* **1986**, *25*, 212–235.
[15] M. J. Gaunt, J. Yu, J. B. Spencer, *J. Org. Chem.* **1998**, *63*, 4172–4173.
[16] F. Bélot, J.-C. Jacquinet, *Carbohydr. Res.* **2000**, *325*, 93–106.
[17] J.-C. Jacquinet, C. Lopin-Bon, A. Vibert, *Chem. Eur. J.* **2009**, *15*, 9579–9595.
[18] H. J. Koeners, J. Verhoeven, J. H. van Boom, *Tetrahedron Lett.* **1980**, *21*, 381–382.
[19] J. Xia, S. A. Abbas, R. D. Locke, C. F. Piskorz, J. L. Alderfer, K. L. Matta, *Tetrahedron Lett.* **2000**, *41*, 169–173.
[20] H. Lucas, J. E. M. Basten, T. G. van Dinther, D. G. Meulemen, S. F. van Aelst, C. A. A. van Boeckel, *Tetrahedron* **1990**, *46*, 8207–8228.

Received: March 23, 2009
Published online: July 2, 2009

