

1 **Total Synthesis****Short Synthesis of Idraparinux by Applying a 2-O-Methyl-4,6-O-arylmethylene Thioidoside as a 1,2-*trans*- α -Selective Glycosyl Donor**Fruzsina Demeter,^[a] Fanni Veres,^[a] Mihály Herczeg*^[a,b] and Anikó Borbás*^[a]

Abstract: The fully O-sulfated, O-methylated, heparin-related anticoagulant pentasaccharide idraparinux was prepared by a new synthetic pathway in 38 steps using D-glucose and methyl α -D-glucopyranoside as starting materials, with 23 steps for the longest linear route. The L-idose-containing **GH** fragment was obtained by a short and straightforward synthesis whereby a 4,6-cyclic-acetal-protected L-idosyl thioglycoside bearing a C2-

nonparticipating group was used as the α -selective glycosyl donor. The novel L-idose donor was prepared with high chemo- and stereoselectivity by hydroboration-oxidation-based C5 epimerization starting from an orthogonally protected α -thioglycoside. The assembly of the pentasaccharide backbone was achieved by an **F+GH** and **DE+FGH** coupling sequence with full stereoselectivity in each glycosylation step.

Introduction

Heparin polysaccharide and its smaller fragments are invaluable drugs in the prevention and treatment of thromboembolic diseases owing to their anticoagulant properties.^[1] Heparin binds to and activates antithrombin which, in turn, inhibits blood coagulation factors IIa and Xa.^[2] Characterization of the shortest heparin sequence able to activate antithrombin, the **DEFGH** pentasaccharide **1**, along with SAR studies led to the synthetic antithrombotic drug fondaparinux (Arixtra, **2**), possessing selective factor Xa inhibitory activity by means of activation of antithrombin^[3] (Figure 1). The lengthy and demanding synthesis of fondaparinux^[4] spurred research to design simplified analogues that are easier to prepare. The replacement of glucosamine by glucose units and the introduction of methyl ethers to hydroxyls on non-crucial positions resulted in the discovery of non-glycosaminoglycan derivatives such as idraparinux (**3**)^[3,5] which is an extremely potent heparinoid antithrombotic. Idraparinux binds to antithrombin significantly stronger than fondaparinux through the additional interaction of the extra sulfate group of the **H** glucose unit as well as through hydrophobic interactions. The potency of idraparinux is associated with its long half-life which allows a convenient once-a-week administration in humans. However, in the lack of neutralizing agent, the long elimi-

nation half-life proved to be a double-edged sword, and the development of idraparinux was stopped due to major bleeding events during treatment for more than six months.^[6]

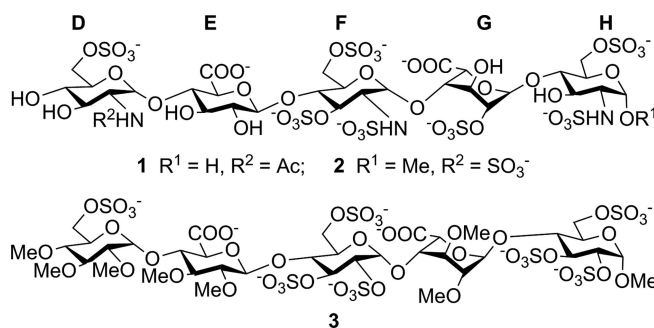


Figure 1. Structure of the AT-binding pentasaccharide domain of heparin (**1**) and the synthetic anticoagulant pentasaccharides fondaparinux (**2**) and idraparinux (**3**).

Recently, new antidotes have emerged in the anticoagulant therapy.^[7] Andexanet alfa, a recombinant protein designed as a specific reversal agent against both direct and indirect factor Xa inhibitors, was approved by FDA in 2018.^[8] Aripazine (ciraparantag), a synthetic small cationic compound is another, clinically investigated reversal agent with promising activity against heparinoid anticoagulants.^[9] These new results might attract renewed interest toward idraparinux.

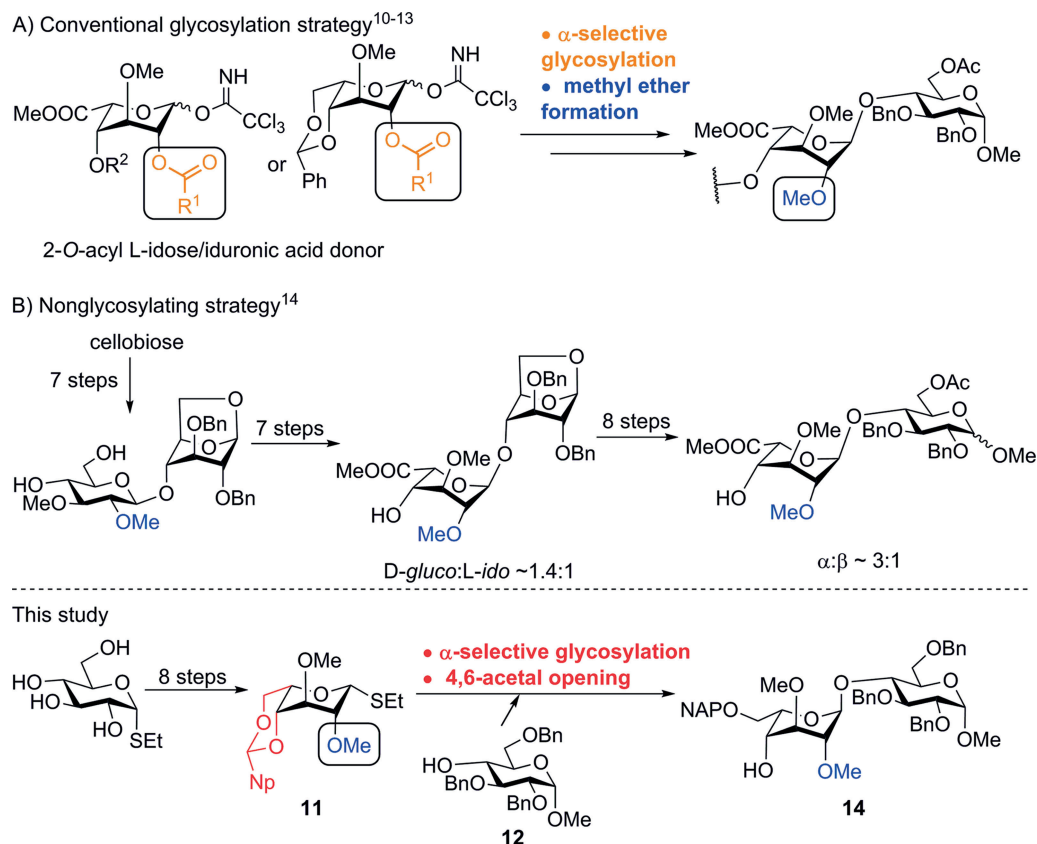
Despite the simplified structure, the synthesis of idraparinux still poses challenges like the efficient synthesis of the L-idosyl building block as well as the introduction of methyl ethers onto the uronic acid residues which are prone to suffer β -elimination under basic conditions of the etherification.

In most syntheses, orthogonally protected 2-O-acyl L-idopyranose or L-iduronic acid building block is prepared from D-glucose via various lengthy procedures^[10] and used as a C2-partici-

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Scheme 1. Synthetic strategies toward the **GH** fragment of idraparinux.

Results and Discussion

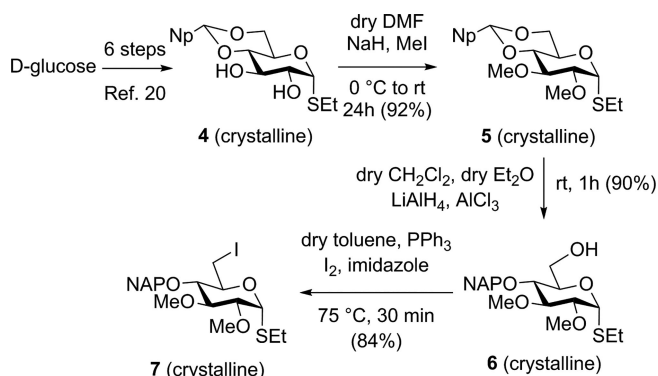
We have developed an efficient synthetic strategy for idraparinux^[14] and related pentasaccharides^[17,18] which was based on the coupling of an **FGH** acceptor and a **DE** donor, both containing a non-oxidized precursor of the hexuronic acid unit, and formation of the uronic acids was performed in one step at the pentasaccharide level. While keeping this post-glycosylation oxidation strategy,^[19] we devised a significantly shortened synthesis for the **GH** building block by utilizing a new, non-participating L-idosyl glycosyl donor which is readily available from a suitably protected α -thioglucoside by our recent method.^[16]

The synthesis of the starting α -thioglucoside **4**^[20] was accomplished by stereoselective introduction of the ethylthio aglycon to 2-acetoxy-D-glucal by photoinduced hydrothiolation^[21,22] followed by deacetylation and 4,6-O-(2-naphthyl)-methylenation. The methyl ether functions of the final product were introduced into positions 2 and 3 at this early stage of synthesis to give **5** in 92 % yield. Next, the regioselective ring opening of the 4,6-O-(2-naphthyl)methylene acetal using the $\text{LiAlH}_4/\text{AlCl}_3$ reagent combination in a 3:1 ratio^[23] resulted in compound **6** in an excellent 90 % yield. Subsequent substitution of the 6-OH group with iodine gave **7** in 84 % yield. It is worth mentioning that each compound of this reaction sequence was obtained in crystalline form (Scheme 2).

Conversion of **7** into the L-idoside derivative **8** was carried out by the well-established C5-epimerization method including

pating glycosyl donor (Scheme 1, A). The 2-O-acyl group ensures the required 1,2-*trans* stereoselectivity upon glycosylation, however, its change into methyl ether further lengthens the synthesis at an oligosaccharide level.^[5,11-14] Recently, Lopatkiwicz and co-workers established a nonglycosylating chemical strategy for the synthesis of idraparinux in which the **GH** and **EF** disaccharide units were prepared from the same cellobiose (Scheme 1, B).^[15] They introduced the needed methyl ethers at an early stage of the synthesis and the functionalized cellobiose was transformed to the **GH** unit via epimerization of C5' by an elimination-addition sequence. The synthesis of fully protected idraparinux was significantly shortened and improved by this imaginative approach which still has weaknesses such as the low efficacy of the C5' epimerization step as well as the low stereoselectivity during conversion of the 1,6-anhydro ring of unit **H** into methyl α -glycoside.

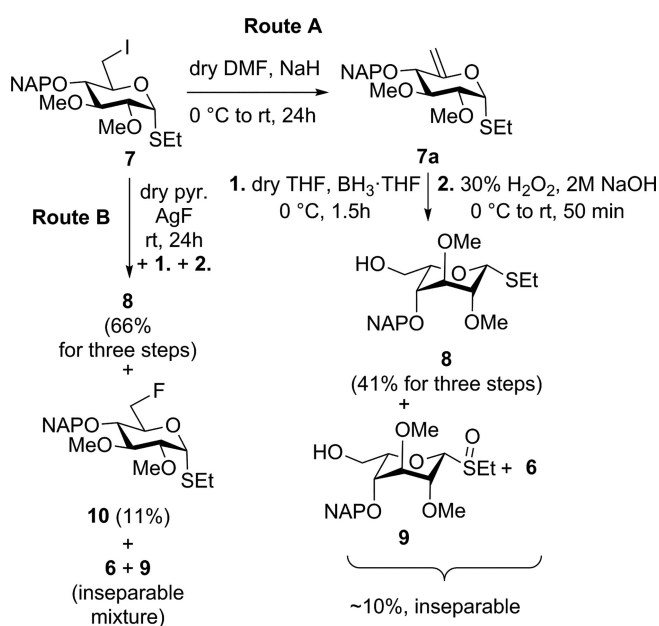
Very recently, we published a straightforward new synthesis of L-idosyl glycosyl donors starting from orthogonally protected α -thioglucosides.^[16] The key steps include C5 epimerization by hydroboration/oxidation of the corresponding 5-enopyranosides followed by a 4,6-O-acetal formation of the obtained L-idosides. We demonstrated in model glycosylations of a GlcNAc acceptor that the 4,6-arylmethylene acetal ensures full 1,2-*trans*- α -selectivity in the absence of a participating group at C2 position. On the basis of these results we envisioned a significantly shortened route to idraparinux by applying a 2,3-di-O-methylated L-idosyl donor for the synthesis of the **GH** fragment.



Scheme 2. Synthesis of the 6-deoxy-6-iodo- α -thioglucoside derivative **7**.

NaH-mediated elimination, hydroboration using $\text{BH}_3\cdot\text{THF}$ and 116 oxidation with H_2O_2 under basic conditions.^[24,25]

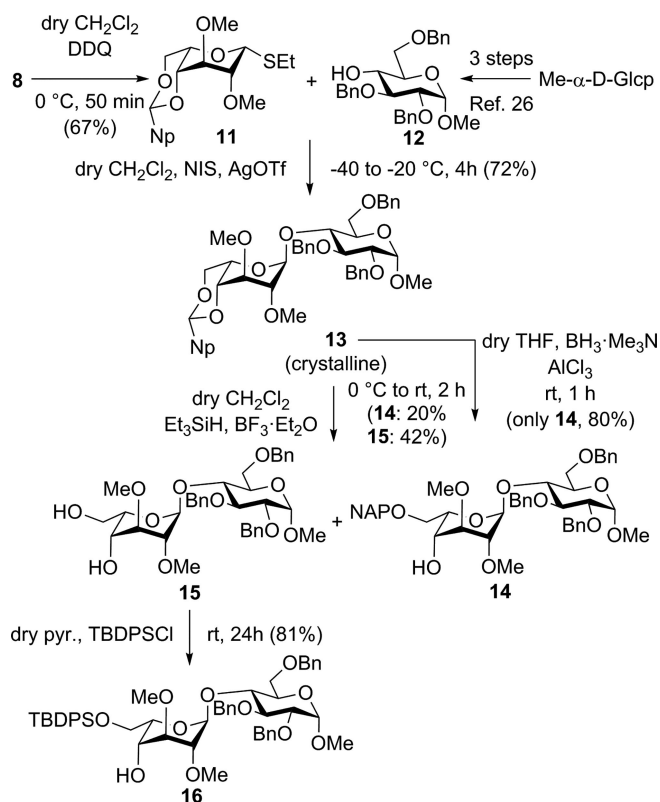
While this reaction sequence had proceeded both in high yield and high stereoselectivity starting from 2,3-di-*O*-benzyl α -thioglucosides,^[16] upon dehydrohalogenation of the 2,3-di-*O*-methylated **7** with sodium hydride a number of byproducts **121** were observed by TLC and, after hydroboration/oxidation, the expected *L*-idose derivative **8** was only formed in low 41 % yield (Scheme 3, Route A). Thus, we attempted to produce the 5,6-unsaturated **7a** derivative by another method using silver fluoride in dry pyridine (Scheme 3, Route B). To our great satisfac-
126 tion, the AgF-mediated elimination provided cleanly the 6-deoxy- α -D-xylo-hex-5-enopyranoside **7a** which was subjected directly to hydroboration-oxidation to produce the desired *L*-idose derivative **8** in a good yield of 66 % over three steps (87 % per step). As we expected, the α -anomeric configuration of **7a**
131 ensured the required high *L*-ido selectivity in the hydroboration step and the *D*-gluco epimer by-product **6** was formed only in a negligible amount. Moreover, the oxidation occurred with high chemoselectivity indicated by the small extent of overoxidized



Scheme 3. The elimination and epimerization reactions of compound **7**.

by-product **9**. (The structure of **6** and **9** was identified on the basis of the MS data and NMR spectra of their inseparable mix- 136 ture.) The observed high stereo- and chemoselectivity of the hydroboration/oxidation of the α -thioglycoside is in line with our previous results.^[16] A third by-product, the 6-fluoro deriva-
141 tive (**10**) of the initial glucose compound was also isolated from the reaction mixture in an 11 % yield. It must have been formed during the elimination reaction, but could not be distinguished by TLC from the 5,6-unsaturated derivative.

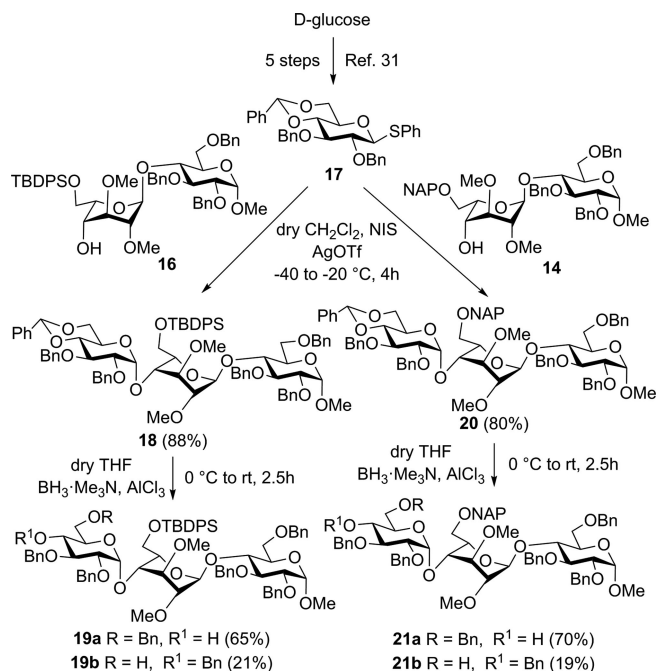
Next, compound **8** was converted into the corresponding 4,6-*O*-(2-naphthyl)methylene derivative **11** by oxidative ring closure with 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) 146 (Scheme 4). It was followed by the key step of the synthesis, glycosylation of monosaccharide acceptor **12**^[26] with the new, non-participating *L*-idosyl donor **11**. We demonstrated earlier that glycosylation reaction between the 2,3-di-*O*-benzyl congener of **11** and a GlcNAc acceptor of low reactivity proceeded 151 with full 1,2-*trans*- α -selectivity.^[16] However, it was questionable whether donor **11** was able to ensure complete stereoselectivity when reacting with an acceptor of higher reactivity. To our great delight, condensation of acceptor **12** and donor **11** upon iodonium ion activation resulted in the desired α -linked **GH** 156 disaccharide with full stereoselectivity in high yield and in crystalline form. The exclusive α -stereoselectivity can be explained by the steric hindrance of the C2-protecting group to prevent nucleophilic attack from the β -face and by the controlling effect^[27,28] of the 4,6-*O*-cyclic protecting group which has been 161 demonstrated to ensure α -selectivity in *D*-glucosylation and *D*-galactosylation reactions.



Scheme 4. Preparation of **GH** disaccharide **13** and its transformations to acceptors **14** and **16**.

Conversion of the fully protected disaccharide **13** to an acceptor by regioselective ring opening reaction was first attempted with a $\text{BF}_3 \cdot \text{Et}_2\text{O} / \text{Et}_3\text{SiH}$ reagent combination. Unfortunately, the main product of the reaction was diol **15** and the expected 6'-ether **14** was only formed in a low 20 % yield. Hence, we turned to the $\text{Me}_3\text{N} \cdot \text{BH}_3 / \text{AlCl}_3$ reagent system which is known to cleave the 4,6-O-acetals with a solvent dependent regioselectivity.^[26,30] In THF, the required 4'-OH/6'-O-ether **14** was isolated as the only product in 80 % yield. Diol **15** was also converted to a disaccharide acceptor building block by regioselective silylation of the primary hydroxyl group. Treatment of **15** with *tert*-butyldiphenylsilyl chloride (TBDPSCl) in dry pyridine provided acceptor **16** in excellent yield.

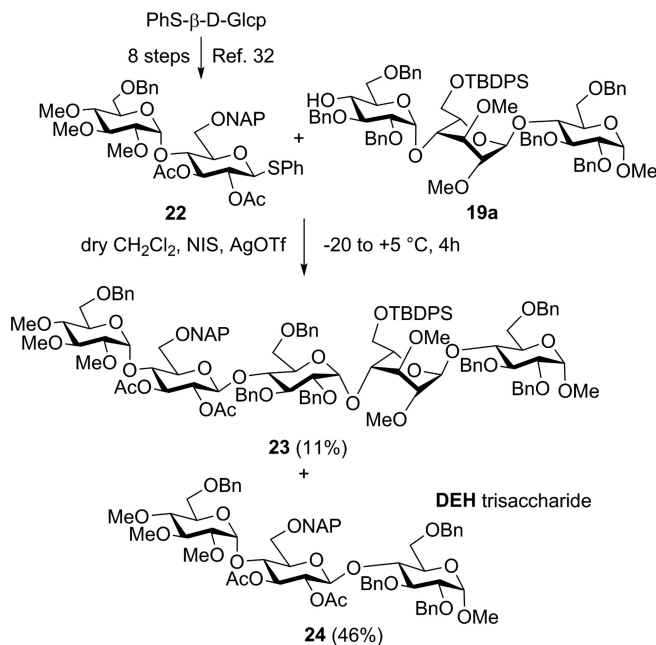
Glycosylation of disaccharide **16** with thioglycoside donor **17**^[31] upon iodonium ion activation resulted in **FGH** trisaccharide **18** with the desired α -interglycosidic linkage in 88 % yield (Scheme 5).



Scheme 5. Synthesis of the **FGH** disaccharide acceptors **19a** and **21a**.

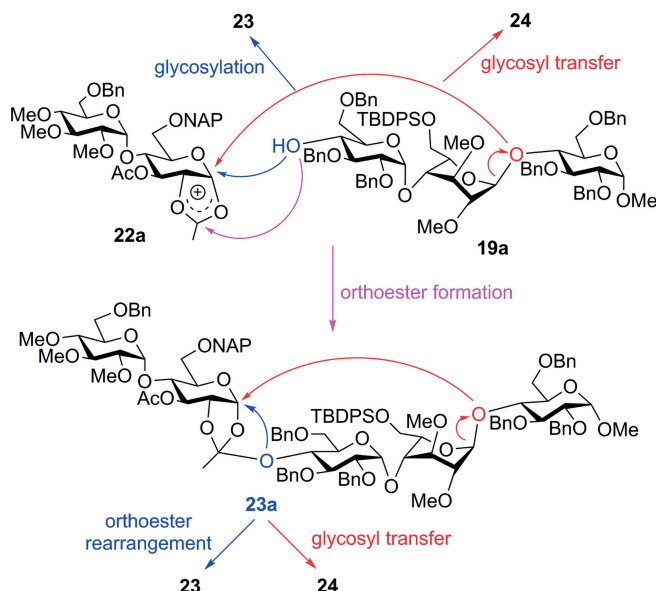
Conversion of **18** to acceptor **19a** was achieved again by a regioselective ring-opening reaction using the $\text{Me}_3\text{N} \cdot \text{BH}_3 / \text{AlCl}_3$ reagent system in THF to produce the desired product in 65 % yield along with the regioisomeric by-product **19b** isolated in 21 %. Following the above reaction path, the 6'-ONAP-containing **14** was converted to another trisaccharide acceptor, compound **21a**, with similar efficacy.

The assembly of the non-oxidized precursor of the final product idraparinux was initially carried out by glycosylation of trisaccharide acceptor **19a** with the non-glucuronide type **DE** disaccharide donor **22**^[32] (Scheme 6). Surprisingly, condensation of disaccharide **22** and trisaccharide **19a** upon NIS-AgOTf activation provided the **DEH** trisaccharide **24** as the major product in 46 % yield, and the needed pentasaccharide **23** was formed in a very low yield of 11 %.



Scheme 6. Synthesis of the protected pentasaccharide **23** by applying the silyl-containing acceptor **19a**.

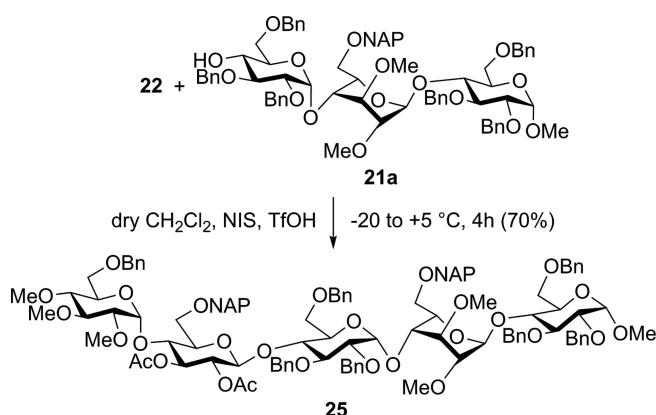
The formation of trisaccharide **24** can be explained either by 196 direct attack of the α -L-idosyl glycosidic oxygen onto the anomeric carbon of the dioxolenium ion formed from **22** or by an intramolecular glycosyl transfer reaction via the orthoester intermediate **23a** (Scheme 7). The intermolecular glycosyl transfer to **22a** could only occur if **19a** adopts a conformation in 201 which the free hydroxyl group is extremely shielded thereby the attack of the interglycosidic oxygen, nucleophilicity of which is enhanced by the surrounding electron-donating ether substituents, becomes dominant. Another, more probable mechanism is the formation of orthoester **23a** which then can undergo 206 either a conventional rearrangement to give the expected



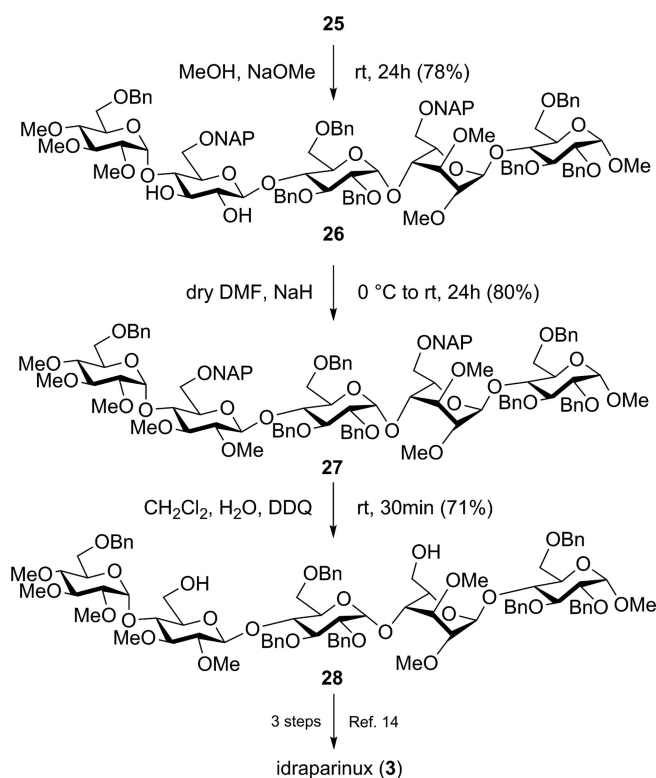
Scheme 7. Plausible mechanism of the formation of **DEH** trisaccharide **24**.

pentasaccharide **23** or can be transformed to trisaccharide **24** by intramolecular transfer of unit **H** onto the glycosidic center of unit **E**.

In the hope of a more efficient synthesis of the protected pentasaccharide skeleton, disaccharide **22** was treated with the NAP-group-containing disaccharide acceptor **21a** upon NIS-TfOH activation. This case the [2+3] coupling reaction proceeded with high efficacy to provide the expected protected pentasaccharide **25** with complete β -stereoselectivity, in 70 % yield (Scheme 8). The significant difference in the **DE**+**FGH** coupling outcome upon changing a remote protecting group in the acceptor **FGH** (**19a** vs. **21a**) can be explained by the different steric and electronic properties of the TBDMS and the NAP



Scheme 8. The [2+3] coupling reaction with the NAP-containing trisaccharide acceptor **21a**.



Scheme 9. The transformation of the 6-O-NAP containing protected pentasaccharide.

protecting group. Another possible reason for the different efficiency of the two glycosylations is that different promoter systems were applied in the two coupling reactions. We hypothesize that under the NIS-AgOTf promotion the orthoester formation may be more preferred compared to the NIS-TfOH promotion. As the formation of the needed pentasaccharide proceeded with high efficacy with acceptor **21a**, we did not study further the intriguing behavior of acceptor **19a**.

The synthesis was continued with the NAP-containing pentasaccharide **25** of which we had a sufficient amount for the remaining transformations (Scheme 9). First, compound **25** was subjected to Zemplén deacetylation to produce diol **26**. Introduction of the methyl ethers to the freed hydroxyls was accomplished by standard alkylation using methyl iodide and sodium hydride to afford the desired compound **27** in 80 % yield. Next, the primary hydroxyls that were to be oxidized in units **E** and **G** were liberated in one step by oxidative cleavage of the NAP groups with DDQ^[33] to provide diol **28**^[14] in 70 % yield. The final transformations of **28** into idraparinux, involving TEMPO-BAIB-mediated oxidation, removal of benzyl ethers by catalytic hydrogenation and O-sulfation using $\text{SO}_3\cdot\text{Et}_3\text{N}$, were performed according to our previous method.^[14]

Conclusions

We have developed a new approach to the synthesis of idraparinux in which the novel and efficient preparation of a 4,6-O-acetal-containing L-idose donor and its utilization for the synthesis of the **GH** disaccharide fragment were the key steps. The synthesis of the new idosyl donor was achieved from a properly protected α -thioglucofuranose in four steps including AgF-mediated elimination, stereoselective hydroboration using $\text{BH}_3\cdot\text{THF}$, chemoselective oxidation with H_2O_2 and DDQ-mediated oxidative acetal ring-closure. By applying this donor, due to the controlling effect of the 4,6-acetal group, the **GH** building block was prepared with full 1,2-*trans*- α -stereoselectivity in the absence of a participating group at C2 position. Typically, L-idose or L-iduronic acid donors with a C2 participating group have been applied for the construction of the α -L-idosyl glycosidic linkage.^[10,34] The demonstrated α -stereodirecting effect of the 4,6-cyclic acetal in the presence of an ether protecting group at C2 position paved the way to designing new, more diverse protecting group strategies for the synthesis of heparin and heparin sulfate oligosaccharides. Another advantage of this new strategy to **GH** unit is that most synthetic intermediates were obtained in crystalline form. The idopyranosyl-containing **GH** unit was successfully incorporated to a late-stage oxidation strategy whereby the non-oxidized pentasaccharide backbone **26** was created by an **F**+**GH** and **DE**+**FGH** coupling sequence, with full stereoselectivity in each glycosylation step, followed by simultaneous formation of two carboxylic functions at the pentasaccharide level.

Applying this new approach the target pentasaccharide **3** could be achieved in a 38-step synthesis starting from D-glucose and methyl α -D-glucopyranoside with 23 steps for the longest linear route. To the best of our knowledge, this is the shortest route to idraparinux yet reported.

276 Experimental Section

General Information: Optical rotations were measured at room temperature on a Perkin–Elmer 241 automatic polarimeter. TLC analysis was performed on Kieselgel 60 F₂₅₄ (Merck) silica-gel plates with visualization by immersing in a sulfuric-acid solution (5 % in EtOH) followed by heating. Column chromatography was performed on silica gel 60 (Merck 0.063–0.200 mm) and Sephadex LH-20 (Sigma–Aldrich, bead size: 25–100 mm). Organic solutions were dried with MgSO₄ and concentrated under vacuum. ¹H and ¹³C NMR spectroscopy (¹H: 400 and 500 MHz; ¹³C: 100.28 and 125.76 MHz) were performed on Bruker DRX-400 and Bruker Avance II 500 spectrometers at 25 °C. Chemical shifts are referenced to SiMe₄ or sodium 3-(trimethylsilyl)-1-propanesulfonate (DSS, δ = 0.00 ppm for ¹H nuclei) and to solvent signals (CDCl₃: δ = 77.00 ppm, CD₃OD: δ = 49.15 ppm for ¹³C nuclei). MALDI-TOF MS analyses of the compounds were carried out in the positive reflection mode using a BIFLEX III mass spectrometer (Bruker, Germany) equipped with delayed-ion extraction. 2,5-Dihydroxybenzoic acid (DHB) was used as matrix and F₃CCOONa as cationising agent in DMF. HRMS measurements were carried out on a maXis II UHR ESI-QTOF MS instrument (Bruker) in positive ionization mode. The following parameters were applied for the electrospray ion source: capillary voltage: 3.6 kV; end plate offset: 500 V; nebulizer pressure: 0.5 bar; dry gas temperature: 200 °C and dry gas flow rate: 4.0 L/min. Constant background correction was applied for each spectrum, the background was recorded before each sample by injecting the blank sample matrix (solvent). Na-formate calibrant was injected after each sample which enabled internal calibration during data evaluation. Mass spectra were recorded by otofControl version 4.1 (build: 3.5, Bruker) and processed by Compass DataAnalysis version 4.4 (build: 200.55.2969).

Ethyl 2,3-Di-O-methyl-4,6-O-(2-naphthyl)methylene-1-thio- α -D-glucopyranoside (5): Compound **4**^[20] (540 mg, 1.766 mmol) was dissolved in dry DMF (8.0 mL) and NaH (60 %, 170 mg, 4.238 mmol, 1.2 equiv./OH) was slowly added to the solution at 0 °C. After stirring for 30 min at 0 °C, MeI (275 μ L, 4.415 mmol, and 1.25 equiv./OH) was added. When complete conversion of the starting material into a main spot had been observed by TLC analysis (24 h at room temperature), CH₃OH (2.5 mL) was added. The reaction mixture was stirred for 5 min and the solvents were evaporated. The residue was dissolved in CH₂Cl₂ (100 mL), and washed with H₂O (2 \times 35 mL), the organic layer was dried, filtered and the solvents evaporated. The crude product was purified by column chromatography (7:3 *n*-hexane/acetone) to give **5** (634 mg, 92 %) as white crystals. [α]_D²⁵ = +203.6 (*c* = 0.14, CHCl₃); m.p.: 145–147 °C (EtOAc/*n*-hexane); *R*_f 0.43 (7:3 *n*-hexane/acetone). ¹H NMR (CDCl₃, 500 MHz): δ = 7.97–7.47 (m, 7 H, arom), 5.70 (s, 1 H, H_{ac}), 5.54 (d, *J* = 4.9 Hz, 1 H, H-1), 4.34–4.28 (m, 2 H, H-5, H-6a), 3.83–3.79 (m, 1 H, H-6b), 3.64 (s, 3 H, OCH₃), 3.61–3.56 (m, 3 H, H-2, H-3, H-4), 3.52 (s, 3 H, OCH₃), 2.65–2.54 (m, 2 H, SCH₂CH₃), 1.31 (t, *J* = 7.4 Hz, 3 H, SCH₂CH₃) ppm. ¹³C NMR (CDCl₃, 125 MHz): δ = 134.8, 133.8, 133.0 (3C, 3 \times C_q arom), 128.5–123.9 (7C, arom), 101.8 (1C, C_{ac}), 83.8 (1C, C-1), 82.4, 81.4, 80.3 (3C, C-2, C-3, C-4), 69.1 (1C, C-6), 62.9 (1C, C-5), 61.3, 58.6 (2C, 2 \times OCH₃), 24.0 (1C, SCH₂CH₃), 14.9 (SCH₂CH₃) ppm. MS (ESI-TOF): *m/z* calcd. for C₂₁H₂₆NaO₅S: 413.1393 [M + Na]⁺, found 413.1403.

Ethyl 2,3-Di-O-methyl-4-O-(2-naphthyl)methyl-1-thio- α -D-glucopyranoside (6): To a stirred solution of the 4,6-O-acetal derivative **5** (1.53 g, 3.918 mmol) in a mixture of dry CH₂Cl₂ (44 mL) and dry Et₂O (18 mL) were added successively LiAlH₄ (669 mg, 17.631 mmol, 4.5 equiv.) and a solution of AlCl₃ (784 mg, 5.877 mmol, 1.5 equiv.) in dry Et₂O (11 mL) under argon at 0 °C. When the TLC (6:4 *n*-hexane/EtOAc) indicated complete disappear-

ance of the starting material (1 h), the reaction mixture was cooled in an ice-bath, and the excess of reagent was decomposed by careful addition of EtOAc (79 mL) followed by H₂O (19 mL), and the stirring was continued for additional 5 min. The mixture obtained, consisting of a grey, non-filterable suspension and a clear organic phase, was poured into a separating funnel and diluted with EtOAc (200 mL). The layers were separated and the organic phase was washed with H₂O (3 \times 50 mL), dried with MgSO₄ and concentrated. The residue was purified by column chromatography (6:4 *n*-hexane/EtOAc) to give **6** (1.38 g, 90 %) as white crystals. [α]_D²⁵ = +230.0 (*c* = 0.10, CHCl₃); m.p.: 103–105 °C (EtOAc/*n*-hexane); *R*_f 0.43 (7:3 *n*-hexane/acetone). ¹H NMR (CDCl₃, 400 MHz): δ = 7.84–7.44 (m, 7 H, arom), 5.48 (d, *J* = 5.1 Hz, 1 H, H-1), 5.03 (d, *J* = 11.4 Hz, 1 H, NAP-CH_{2a}), 4.83 (d, *J* = 11.4 Hz, 1 H, NAP-CH_{2b}), 4.09 (dt, *J* = 3.3, *J* = 351 8.9 Hz, 1 H, H-5), 3.83–3.73 (m, 3 H), 3.66, 3.50 (2 \times s, 6 H, 2 \times OCH₃), 3.57–3.47 (m, 2 H), 2.61–2.50 (m, 2 H, SCH₂CH₃), 1.74 (t, 1 H, H-6-OH), 1.28 (t, *J* = 7.4 Hz, 3 H, SCH₂CH₃) ppm. ¹³C NMR (CDCl₃, 100 MHz): δ = 135.8, 133.4, 133.1 (3C, 3 \times C_q arom), 128.3–126.1 (7C, arom), 84.3 (1C, C-1), 82.8, 82.0, 77.5, 71.1 (4C, skeleton carbons), 75.0 (1C, NAP-CH₂), 62.1 (1C, C-6), 61.3, 58.3 (2C, 2 \times OCH₃), 24.0 (1C, SCH₂CH₃), 14.8 (1C, SCH₂CH₃) ppm. MS (ESI-TOF): *m/z* calcd. for C₂₁H₂₈NaO₅S: 415.1550 [M + Na]⁺, found 415.1574. C₂₁H₂₈KO₅S: 431.1289 [M + Na]⁺, found 431.1286.

Ethyl 6-Deoxy-6-iodo-2,3-di-O-methyl-4-O-(2-naphthyl)methyl-1-thio- α -D-glucopyranoside (7): To the solution of thioglucoside **6** (419 mg, 1.068 mmol) in dry toluene (6.3 mL), triphenylphosphine (420 mmol, 1.602 mmol, 1.5 equiv.), imidazole (218 mg, 3.204 mmol, 3.0 equiv.) and iodine (387 mg, 1.495 mmol, 1.4 equiv.) were added. The reaction mixture was stirred at 75 °C for 30 min then cooled to 366 room temperature. To the stirred mixture NaHCO₃ (210 mg) in water (2.6 mL) was added at room temperature. After 5 min 10 % aqueous solution of Na₂S₂O₃ (5.0 mL) was added and the mixture was diluted with EtOAc (125 mL) and washed with H₂O (2 \times 35 mL). The organic layer was separated, dried with MgSO₄ and concentrated under reduced pressure. The crude product was purified by column chromatography (8:2 *n*-hexane/EtOAc) to give **7** (450 mg, 84 %) as white crystals. [α]_D²⁵ = +146.0 (*c* = 0.40, CHCl₃); m.p.: 82–84 °C (EtOAc/*n*-hexane); *R*_f 0.41 (8:2 *n*-hexane/EtOAc). ¹H NMR (CDCl₃, 400 MHz): δ = 7.85–7.45 (m, 7 H, arom), 5.50 (d, *J* = 4.7 Hz, 1 H, H-376 1), 5.08 (d, *J* = 11.2 Hz, 1 H, NAP-CH_{2a}), 4.88 (d, *J* = 11.2 Hz, 1 H, NAP-CH_{2b}), 3.87–3.83 (m, 1 H, H-5), 3.64, 3.50 (2 \times s, 6 H, 2 \times OCH₃), 3.55–3.53 (m, 2 H, H-2, H-3), 3.49–3.47 (m, 1 H, H-6a), 3.40 (dd, *J* = 5.5, *J* = 10.7 Hz, 1 H, H-6b), 3.34 (t, *J* = 8.8 Hz, 1 H, H-4), 2.69–2.58 (m, 2 H, SCH₂CH₃), 1.29 (t, *J* = 7.4 Hz, 3 H, SCH₂CH₃) ppm. ¹³C NMR (CDCl₃, 100 MHz): δ = 135.7, 133.4, 133.1 (3C, 3 \times C_q arom), 128.4–126.0 (7C, arom), 84.0 (1C, C-2), 82.6 (1C, C-1), 81.9 (1C, C-3), 81.5 (1C, C-4), 75.3 (1C, NAP-CH₂), 69.4 (1C, C-5), 61.2, 58.2 (2C, 2 \times OCH₃), 24.0 (1C, SCH₂CH₃), 14.8 (1C, SCH₂CH₃), 8.2 (1C, C-6) ppm. MS (ESI-TOF): *m/z* calcd. for C₂₁H₂₇INaO₄S: 525.0567 [M + Na]⁺, found 386 525.0567.

Ethyl 2,3-Di-O-methyl-4-O-(2-naphthyl)methyl-1-thio- β -L-idopyranoside (8), Ethyl 2,3-Di-O-methyl-4-O-(2-naphthyl)methyl-1-thio- β -L-idopyranoside Sulfoxide (9) and Ethyl 6-Deoxy-6-fluoro-2,3-di-O-methyl-4-O-(2-naphthyl)methyl-1-thio- α -D-glucopyranoside (10): Method I: A vigorously stirred solution of iodide **7** (1.38 g, 2.746 mmol) in dry DMF (23 mL) was cooled to 0 °C, NaH (132 mg, 5.494 mmol, 2.0 equiv.) was added and the reaction mixture was stirred at room temperature for 24 h. After the complete disappearance of the starting material, MeOH (2.0 mL) was added and the mixture was concentrated. The residue was dissolved in CH₂Cl₂ (250 mL) and washed with H₂O (2 \times 50 mL). The organic layer was separated, dried with MgSO₄ and concentrated under reduced pressure. To a stirred solution of the crude product (954 mg,

2.548 mmol) in anhydrous THF (6.5 mL) a solution of $\text{BH}_3\cdot\text{THF}$ complex in THF (1 M, 25.5 mL, 25.487 mmol, 10.0 equiv.) was added at 0 °C. The reaction mixture was kept at this temperature for 1.5 h. Then H_2O_2 (30 %, 6.5 mL) and an aqueous solution of NaOH (2M, 13.5 mL) were added at 0 °C and the reaction mixture was stirred at room temperature for 50 min. Subsequently, the reaction mixture was diluted with EtOAc (150 mL) and washed with saturated aqueous solution of NH_4Cl (2 × 25 mL), H_2O (25 mL) and brine (25 mL). The organic layer was separated, dried with MgSO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (7:3 *n*-hexane/acetone) to give **8** (411 mg, 41 % for three steps) as a colorless syrup and **6** and **9** (100 mg, ≈ 10 % inseparable mixture, ratio of 6:9 ≈ 3:1) as a colorless syrup.

Method II: A vigorously stirred solution of iodide **7** (440 mg, 0.876 mmol) in dry pyridine (8.8 mL) AgF (556 mg, 4.379 mmol, 5.0 equiv.) was added and the reaction mixture was stirred in the dark at room temperature for 24 h. After the complete disappearance of the starting material the mixture was diluted with EtOAc (15 mL), filtered through a pad of Celite® and concentrated under reduced pressure. To a stirred solution of the crude product (300 mg, 0.801 mmol) in anhydrous THF (2.0 mL) a solution of $\text{BH}_3\cdot\text{THF}$ complex in THF (1M, 8.0 mL, 8.011 mmol, 10.0 equiv.) was added at 0 °C. The reaction mixture was kept at this temperature for 1.5 h. Then H_2O_2 (30 %, 2.0 mL) and an aqueous solution of NaOH (2M, 4.25 mL) were added at 0 °C and the reaction mixture was stirred at room temperature for 50 min. Subsequently, the reaction mixture was diluted with EtOAc (100 mL) and washed with saturated aqueous solution of NH_4Cl (2 × 15 mL), H_2O (15 mL) and brine (15 mL). The organic layer was separated, dried with MgSO_4 and concentrated under reduced pressure. The residue was purified by column chromatography (6:4 *n*-hexane/acetone) to give **8** (204 mg, 66 % for three steps) as a colorless syrup and **6** and **9** (34 mg, ≈ 11 % inseparable mixture, ratio of 6:9 ≈ 2:1) as a colorless syrup and **10** (34 mg, 11 %).

Data of the Mixture of 6 and 9: Characteristic NMR signals: ^1H NMR (CDCl_3 , 400 MHz): δ = 5.45 (d, J = 5.1 Hz, 1 H, H-1 *D-gluc*), 5.12 (d, J = 2.2 Hz, 0.5 H, H-1 *L-ido*-sulfoxide). MS (MALDI-TOF): m/z calcd. for $\text{C}_{21}\text{H}_{28}\text{NaO}_5\text{S}$ (**6**): 415.155 [M + Na] $^+$, found 415.292; m/z calcd. for $\text{C}_{21}\text{H}_{28}\text{NaO}_6\text{S}$ (**9**): 431.151 [M + Na] $^+$, found 431.246.

Data of 8: $[\alpha]_D^{25}$ = +52.0 (c = 0.55, CHCl_3); R_f 0.25 (7:3 *n*-hexane/acetone). ^1H NMR (CDCl_3 , 400 MHz): δ = 7.85–7.47 (m, 7 H, arom), 4.81 (d, J = 12.4 Hz, 1 H, NAP- CH_{2a}), 4.80 (d, J = 1.6 Hz, 1 H, H-1), 4.70 (d, J = 12.5 Hz, 1 H, NAP- CH_{2b}), 4.02 (dd, J = 7.9, J = 11.5 Hz, 1 H, H-6a), 3.78 (ddd, J = 1.9, J = 4.3, J = 6.6 Hz, 1 H, H-5), 3.60–3.57 (m, 2 H, H-3, H-6b), 3.51 (s, 3 H, OCH_3), 3.41 (s, 1 H, H-4), 3.30 (s, 4 H, H-2, OCH_3), 2.71 (qd, J = 2.8, J = 7.4 Hz, 2 H, SCH_2CH_3), 1.99 (s, 1 H, H-6-OH), 1.28 (t, J = 7.4 Hz, 3 H, SCH_2CH_3) ppm. ^{13}C NMR (CDCl_3 , 100 MHz): δ = 135.4, 133.2, 133.1 (3C, 3 × C_q arom), 128.5–126.2 (7C, arom), 83.4 (1C, C-1), 78.5 (1C, C-2), 77.3 (1C, C-5), 73.3 (1C, C-3), 72.4 (1C, NAP- CH_2), 71.4 (1C, C-4), 62.8 (1C, C-6), 59.2, 58.1 (2C, 2 × OCH_3), 25.8 (1C, SCH_2CH_3), 15.5 (1C, SCH_2CH_3) ppm. MS (ESI-TOF): m/z calcd. for $\text{C}_{21}\text{H}_{28}\text{NaO}_5\text{S}$: 415.1550 [M + Na] $^+$, found 415.1552.

Data of 10: $[\alpha]_D^{25}$ = +184.0 (c = 0.20, CHCl_3); R_f 0.64 (6:4 *n*-hexane/acetone). ^1H NMR (CDCl_3 , 400 MHz): δ = 7.85–7.44 (m, 7 H, arom), 5.51 (d, J = 4.0 Hz, 1 H, H-1), 5.05 (d, J = 11.3 Hz, 1 H, NAP- CH_{2a}), 4.80 (d, J = 11.3 Hz, 1 H, NAP- CH_{2b}), 4.67 (ddd, J = 3.3, J = 10.3 Hz, J = 47.2 Hz, 1 H, H-6a), 4.55 (ddd, J = 1.5, J = 10.3, J = 47.3 Hz, 1 H, H-6b), 4.24–4.14 (m, H-5), 3.66 (s, 3 H, OCH_3), 3.55–3.52 (m, 3 H, H-2, H-3, H-4), 3.51 (s, 3 H, OCH_3), 2.57 (tdd, J = 5.4, J = 7.4, J = 12.8 Hz, 2 H, SCH_2CH_3), 1.29 (t, J = 7.4 Hz, 3 H, SCH_2CH_3) ppm. ^{13}C NMR (CDCl_3 , 100 MHz): δ = 135.7, 133.4, 133.2 (3C, 3 × C_q arom), 128.4–

126.0 (7C, arom), 84.3 (1C, C-1), 82.3 (d, J = 172 Hz, 1C, C-6), 83.0, 81.8 (2C, C-2, C-3), 76.7 (d, J = 5.9 Hz, 1C, C-4), 75.3 (1C, NAP- CH_2), 70.2 (d, J = 18.1 Hz, 1C, C-5), 61.3, 58.3 (2C, 2 × OCH_3), 24.1 (1C, SCH_2CH_3), 14.8 (1C, SCH_2CH_3) ppm. MS (ESI-TOF): m/z calcd. for $\text{C}_{21}\text{H}_{27}\text{FNaO}_4\text{S}$: 417.1506 [M + Na] $^+$, found 417.1506.

Ethyl 2,3-Di-O-methyl-4,6-O-(2-naphthyl)methylene-1-thio-β-L-idopyranoside (11): To a vigorously stirred solution of **8** (160 mg, 0.407 mmol) in dry CH_2Cl_2 (11 mL) DDQ (139 mg, 0.611 mmol, 1.5 equiv.) and 4 Å MS (115 mg) were added. After 50 min the 471 mixture was diluted with CH_2Cl_2 (100 mL), filtered, extracted with a saturated aqueous solution of NaHCO_3 (2 × 25 mL) and H_2O (2 × 25 mL), dried and concentrated. The crude product was purified by silica gel chromatography (7:3 *n*-hexane/acetone) to give **11** (106 mg, 67 %) as a colorless syrup. $[\alpha]_D^{25}$ = +55.7 (c = 0.21, CHCl_3); 476 R_f 0.35 (7:3 *n*-hexane/acetone). ^1H NMR (CDCl_3 , 400 MHz): δ = 7.96–7.44 (m, 7 H, arom), 5.62 (s, 1 H, H_{ac}), 4.87 (d, J = 1.3 Hz, 1 H, H-1), 4.36 (d, J = 12.5 Hz, 1 H, NAP- CH_{2a}), 4.07 (dd, J = 2.0, J = 12.5 Hz, 1 H, NAP- CH_{2b}), 3.97 (s, 1 H, H-4), 3.70 (t, J = 2.2 Hz, 1 H, H-3), 3.58 (d, J = 1.1 Hz, 1 H, H-5), 3.49, 3.47 (2 × s, 6 H, 2 × OCH_3), 3.36 (s, 1 481 H, H-2), 2.76 (q, J = 7.4 Hz, 2 H, SCH_2CH_3), 1.31 (t, J = 7.4 Hz, 3 H, SCH_2CH_3) ppm. ^{13}C NMR (CDCl_3 , 100 MHz): δ = 135.8, 133.8, 133.0 (3C, 3 × C_q arom), 128.4–124.6 (7C, arom), 101.6 (1C, C_{ac}), 82.3 (1C, C-1), 77.2 (1C, C-2), 75.4 (1C, C-3), 71.7 (1C, C-4), 70.1 (1C, C-6), 68.6 (1C, C-5), 58.4, 58.2 (2C, 2 × OCH_3), 25.6 (1C, SCH_2CH_3), 15.1 (1C, 486 SCH_2CH_3) ppm. MS (ESI-TOF): m/z calcd. for $\text{C}_{21}\text{H}_{26}\text{NaO}_5\text{S}$: 413.1393 [M + Na] $^+$, found 413.1393.

Methyl [2,3-Di-O-methyl-4,6-O-(2-naphthyl)methylene-α-L-idopyranosyl]-(1→4)-2,3,6-tri-O-benzyl-α-D-glucopyranoside (13): To a solution of compound **11** (200 mg, 0.512 mmol) and compound **12**^[26] (357 mg, 0.768 mmol, 1.5 equiv.) in dry CH_2Cl_2 (6.0 mL) 4 Å molecular sieves (0.25 g) were added. After stirring at room temperature for 30 min, the mixture was cooled to –40 °C and solutions of NIS (173 mg, 0.768 mmol, 1.5 equiv.) in dry THF (240 μL) and AgOTf (32 mg, 0.123 mmol, 0.24 equiv.) in dry toluene (240 μL) 496 were added. After stirring at –40 °C to –20 °C for 4 h, TLC analysis (6:4 *n*-hexane/EtOAc) showed complete consumption of the donor. The reaction mixture was neutralized with Et_3N (50 μL), diluted with CH_2Cl_2 (150 mL), and filtered. The filtrate was washed with an aqueous solution of $\text{Na}_2\text{S}_2\text{O}_3$ (10 %, 25 mL), a saturated aqueous solution 501 of NaHCO_3 (2 × 25 mL), and water (2 × 25 mL), dried, and concentrated. The crude product was purified by column chromatography on silica gel (6:4 *n*-hexane/EtOAc) to give compound **13** (294 mg, 72 %) as white crystals. $[\alpha]_D^{25}$ = +1.1 (c = 0.09, CHCl_3); R_f 0.36 (6:4 *n*-hexane/EtOAc); m.p.: 162–164 °C (EtOAc/*n*-hexane). ^1H NMR (CDCl_3 , 506 400 MHz): δ = 7.91–7.22 (m, 22 H, arom), 5.43 (s, 1 H, H_{ac}), 5.05 (d, J = 11.2 Hz, 1 H, Bn- CH_{2a}), 4.85 (d, J = 4.9 Hz, 1 H, H-1'), 4.78–4.56 (m, 6 H, Bn- CH_{2b} , 2 × Bn- CH_2 , H-1), 3.98–3.77 (m, 5 H, H-3, H-4, H-4', H-5', H-6'a), 3.70–3.69 (m, 2 H, H-6a,b), 3.59 (dd, J = 3.6, J = 9.5 Hz, 1 H, H-2), 3.54 (s, 1 H, H-5), 3.51 (s, 3 H, OCH_3), 3.46–3.43 (m, 511 1 H, H-3'), 3.44, 3.38 (2 × s, 6 H, 2 × OCH_3), 3.20 (dd, J = 4.9, J = 9.1 Hz, 1 H, H-2'), 3.16 (dd, J = 2.2, J = 13.2 Hz, 1 H, H-6'b) ppm. ^{13}C NMR (CDCl_3 , 100 MHz): δ = 139.2, 138.1, 137.8, 135.5, 133.6, 132.9 (6C, 6 × C_q arom), 128.5–124.0 (22C, arom), 100.4, (1C, C-1'), 100.0 (1C, C_{ac}), 98.1 (1C, C-1), 82.3 (1C, C-3), 80.6 (1C, C-2), 80.3, 80.2 516 (2C, C-2', C-3'), 78.2 (1C, C-4'), 75.7, 73.5, 73.4 (3C, 3 × Bn- CH_2), 73.0 (1C, C-4), 70.6 (1C, C-5), 68.7 (1C, C-6'), 68.5 (1C, C-6), 62.0 (1C, C-5'), 59.8, 58.6 (2C, 2 × OCH_3), 55.2 (1C, C-1- OCH_3) ppm. MS (ESI-TOF): m/z calcd. for $\text{C}_{47}\text{H}_{52}\text{NaO}_{11}$: 815.3402 [M + Na] $^+$, found 815.3399.

Methyl [2,3-Di-O-methyl-6-O-(2-naphthyl)methyl-α-L-idopyranosyl]-(1→4)-2,3,6-tri-O-benzyl-α-D-glucopyranoside (14) and Methyl [2,3-Di-O-methyl-α-L-idopyranosyl]-(1→4)-2,3,6-tri-O-benzyl-α-D-glucopyranoside (15)

Method I: To a solution of compound **13** (250 mg, 0.315 mmol) in anhydrous CH_2Cl_2 (3.2 mL) at 0 °C Et_3SiH (604 μL , 3.784 mmol, 12.0 equiv.) and $\text{BF}_3 \cdot \text{Et}_2\text{O}$ (80 μL , 0.631 mmol, 2.0 equiv.) were added. The reaction mixture was stirred for 2 h at 0 °C. Then the mixture was diluted with CH_2Cl_2 (100 mL), washed with saturated aqueous solution of NaHCO_3 (2 \times 20 mL), dried with MgSO_4 and concentrated. The crude product was purified by column chromatography on silica gel (1:1 *n*-hexane/EtOAc) to give compound **14** (52 mg, 20 %) as a colorless syrup and compound **15** (105 mg, 42 %) as a colorless syrup.

Method II: To a solution of compound **13** (126 mg, 0.159 mmol) in anhydrous THF (500 μL) 4 Å MS (121 mg) and $\text{Me}_3\text{N} \cdot \text{BH}_3$ (70 mg, 0.953 mmol, 6.0 equiv.) were added and stirred for 30 min at room temperature. After 30 min AlCl_3 (127 mg, 0.953 mmol, 6.0 equiv.) was added and the reaction mixture was stirred at room temperature for 30 min. The mixture was diluted with CH_2Cl_2 (100 mL), washed with water (2 \times 20 mL), dried with MgSO_4 and concentrated. The crude product was purified by column chromatography on silica gel (1:1 *n*-hexane/EtOAc) to give compound **14** (101 mg, 80 %) as a colorless syrup.

Data of 14: $[\alpha]_D^{25} = +3.3$ ($c = 0.12$, CHCl_3); R_f 0.40 (1:1 *n*-hexane/EtOAc). ^1H NMR (CDCl_3 , 400 MHz): $\delta = 7.80\text{--}7.20$ (m, 22 H, arom), 5.08 (s, 1 H, H-1'), 4.95–4.43 (m, 9 H, NAP- CH_2 , 3 \times Bn- CH_2 , H-1), 4.39 (td, $J = 1.3$, $J = 5.7$ Hz, 1 H, H-5'), 3.94–3.86 (m, 2 H), 3.79–3.57 (m, 5 H), 3.52–3.46 (m, 3 H), 3.40, 3.34, 3.27 (3 \times s, 9 H, 3 \times OCH₃), 3.20 (s, 1 H), 3.14 (d, $J = 9.3$ Hz, 1 H, C-4-OH) ppm. ^{13}C NMR (CDCl_3 , 100 MHz): $\delta = 139.2$, 138.2, 138.0, 135.9, 133.3, 132.9 (6C, 6 \times C_q arom), 128.4–125.7 (22C, arom), 98.1 (2C, C-1, C-1'), 80.4, 80.3, 77.5, 77.4, 74.6, 70.1, 66.9, 66.8 (8C, skeleton carbons), 75.4, 73.5, 73.3 (4C, NAP- CH_2 , 3 \times Bn- CH_2), 69.8, 68.9 (2C, C-6, C-6'), 58.5, 58.3 (2C, 2 \times OCH₃), 55.2 (1C, C-1-OCH₃) ppm. MS (MALDI-TOF): m/z calcd. for $\text{C}_{47}\text{H}_{54}\text{NaO}_{11}$: 817.356 [M + Na]⁺, found 817.381.

Data of 15: $[\alpha]_D^{25} = -5.5$ ($c = 0.20$, CHCl_3); R_f 0.13 (1:1 *n*-hexane/EtOAc). ^1H NMR (CDCl_3 , 400 MHz): $\delta = 7.27\text{--}7.18$ (m, 15 H, arom), 4.96 (d, $J = 10.5$ Hz, 1 H, Bn- CH_2), 4.89 (s, 1 H, H-1'), 4.72–4.45 (m, 6 H, Bn- CH_2 , 2 \times Bn- CH_2 , H-1), 4.08–4.06 (m, 1 H, H-5'), 3.84–3.78 (m, 2 H, H-3, H-3'), 3.72–3.70 (m, 1 H, H-4), 3.56 (s, 2 H, H-6a,b), 3.51 (dd, $J = 3.3$, $J = 8.8$ Hz, 1 H, H-2), 3.45–3.40 (m, 1 H, H-5), 3.37 (s, 3 H, OCH₃), 3.35–3.31 (m, 1 H, H-4'), 3.29, 3.17 (2 \times s, 6 H, 2 \times OCH₃), 3.28–3.12 (m, 2 H, H-6'a,b), 3.07–3.05 (m, 1 H, H-2'), 1.83 (s, 1 H, C-6'-OH), 1.24 (s, 1 H, C-4'-OH) ppm. ^{13}C NMR (CDCl_3 , 100 MHz): $\delta = 138.5$, 138.0, 137.7 (3C, 3 \times C_q arom), 128.5–127.7 (15C, arom), 98.0, (1C, C-1), 97.0 (1C, C-1), 80.3 (1C, C-2), 80.1 (1C, C-3), 76.9, 76.8 (2C, C-2', C-4'), 75.8, 73.6 (2C, 2 \times Bn- CH_2), 73.5 (1C, C-3'), 73.4 (1C, Bn- CH_2), 70.2 (1C, C-4), 68.9 (1C, C-6), 67.1, 67.0 (2C, C-5, C-5'), 63.0 (1C, C-6'), 58.4, 58.2 (2C, 2 \times OCH₃), 55.2 (1C, C-1-OCH₃) ppm. MS (MALDI-TOF): m/z calcd. for $\text{C}_{36}\text{H}_{46}\text{NaO}_{11}$: 667.293 [M + Na]⁺, found 667.344.

Methyl (6-*O*-*tert*-Butyldiphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (16): To a solution of **15** (103 mg, 0.157 mmol) in dry pyridine (540 μL), *tert*-butyldiphenylsilyl chloride (81 μL , 0.314 mmol, 2 equiv.) was added. The mixture was stirred for 24 h at room temperature. After the complete disappearance of the starting material, the mixture was concentrated. The residue was dissolved in EtOAc (75 mL), washed with 1 M aqueous solution of HCl (2 \times 10 mL), water (10 mL), saturated aqueous solution of NaHCO_3 (2 \times 10 mL), and water (2 \times 10 mL), dried, and concentrated. The crude product was purified by column chromatography on silica gel (7:3 *n*-hexane/acetone) to give compound **16** (114 mg, 81 %) as a colorless syrup. $[\alpha]_D^{25} = +5.4$ ($c = 0.13$, CHCl_3); R_f 0.41 (7:3 *n*-hexane/acetone). ^1H NMR (CDCl_3 , 400 MHz): $\delta = 7.69\text{--}7.15$ (m, 25 H, arom), 5.08 (s, 1 H, H-1'), 4.88–

4.49 (m, 7 H, 3 \times Bn- CH_2 , H-1), 4.26 (t, $J = 5.1$ Hz, 1 H, H-5'), 3.93–3.84 (m, 2 H), 3.83–3.75 (m, 4 H), 3.69–3.61 (m, 2 H), 3.51–3.47 (m, 2 H), 3.41, 3.36, 3.24 (3 \times s, 9 H, 3 \times OCH₃), 3.18 (s, 1 H), 1.26 (s, 1 H, C-4'-OH), 1.02 (s, 9 H, 3 \times *t*Bu- CH_3) ppm. ^{13}C NMR (CDCl_3 , 100 MHz): $\delta = 139.0$, 138.3, 138.1, 133.4, 133.3 (5C, 5 \times C_q arom), 129.6–127.3 (25C, arom), 98.4, 98.3 (2C, C-1, C-1'), 80.8, 80.2, 77.8, 77.6, 74.4, 70.0, 68.1, 66.7 (8C, skeleton carbons), 75.6, 73.6 (2C, 2 \times Bn- CH_2), 69.0 (1C, C-6), 63.5 (1C, C-6'), 58.4, 58.3 (2C, 2 \times OCH₃), 55.2 (1C, C-1-OCH₃), 26.9 (3C, 3 \times *t*Bu- CH_3), 19.2 (1C, C_q *t*Bu) ppm. MS (MALDI-TOF): m/z calcd. for $\text{C}_{52}\text{H}_{64}\text{NaO}_{11}\text{Si}$: 915.411 [M + Na]⁺, 596 found 915.550.

Methyl (2,3-Di-*O*-benzyl-4,6-*O*-benzylidene- α -D-glucopyranosyl)-(1 \rightarrow 4)-(6-*O*-*tert*-butyldiphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (18):

To a solution of compound **16** (54 mg, 0.060 mmol) and compound **601** 17^[31] (52 mg, 0.096 mmol, 1.6 equiv.) in dry CH_2Cl_2 (708 μL) 4 Å molecular sieves (50 mg) were added. After stirring at room temperature for 30 min, the mixture was cooled to –40 °C and solutions of NIS (33 mg, 0.145 mmol, 1.5 equiv.) in dry THF (45 μL) and AgOTf (6.0 mg, 0.023 mmol, 0.24 equiv.) in dry toluene (45 μL) were added. 606 After stirring at –40 °C to –20 °C for 4 h, TLC analysis (7:3 *n*-hexane/EtOAc) showed complete consumption of the donor. The reaction mixture was neutralized with Et_3N (25 μL), diluted with CH_2Cl_2 (75 mL), and filtered. The filtrate was washed with an aqueous solution of $\text{Na}_2\text{S}_2\text{O}_3$ (10 %, 10 mL), a saturated aqueous solution of NaHCO₃ (2 \times 10 mL), and water (2 \times 10 mL), dried, and concentrated. The crude product was purified by column chromatography on silica gel (7:3 *n*-hexane/EtOAc) to give compound **18** (70 mg, 88 %) as a colorless syrup. $[\alpha]_D^{25} = -1.8$ ($c = 0.11$, CHCl_3); R_f 0.30 (7:3 *n*-hexane/EtOAc). ^1H NMR (CDCl_3 , 500 MHz): $\delta = 7.74\text{--}7.19$ (m, 40 H, 616 arom), 5.50 (s, 1 H, H_{ac}), 5.28 (d, $J = 3.9$ Hz, 1 H, H-1'), 5.01 (d, $J = 7.2$ Hz, 1 H, H-1'), 4.99–4.62 (m, 8 H, 4 \times Bn- CH_2), 4.62 (d, $J = 3.6$ Hz, 1 H, H-1), 4.49 (q, $J = 12.2$ Hz, 2 H, Bn- CH_2), 4.01 (dd, $J = 4.5$, $J = 10.1$ Hz, 1 H, H-6'a), 3.93–3.84 (m, 7 H, H-3, H-3', H-3'', H-4', H-5, H-6a, H-6'a), 3.77–3.75 (m, 2 H, H-5', H-6'b), 3.65–3.56 (m, 5 H, H-2'', 621 H-4, H-4'', H-6b, H-6'b), 3.55–3.52 (m, 1 H, H-5''), 3.51 (s, 3 H, C-3'-OCH₃), 3.49–3.48 (m, 1 H, H-2), 3.46 (s, 3 H, C-2'-OCH₃), 3.42 (s, 3 H, C-1-OCH₃), 3.00 (t, $J = 7.7$ Hz, 1 H, H-2'), 1.03 (s, 9 H, 3 \times *t*Bu- CH_3) ppm. ^{13}C NMR (CDCl_3 , 125 MHz): $\delta = 139.5$, 139.0, 138.6, 138.5, 138.3, 137.5, 132.9, 132.7 (8C, 8 \times C_q arom), 129.9–126.2 (40C, arom), 626 101.2 (1C, C_{ac}), 101.0 (1C, C-1'), 99.4 (1C, C-1''), 98.1 (1C, C-1), 85.5 (1C, C-2'), 82.5 (1C, C-3'), 82.4 (1C, C-4'), 80.6 (1C, C-3), 79.2 (1C, C-2), 79.1 (1C, C-2''), 78.9 (1C, C-4), 78.7 (1C, C-3''), 75.9 (1C, C-4'), 75.6, 75.2 (2C, 2 \times Bn- CH_2), 73.8 (1C, C-5'), 73.7, 73.4 (3C, 3 \times Cn- CH_2), 70.8 (1C, C-5), 69.4 (1C, C-6), 68.8 (1C, C-6'), 63.2 (1C, C-5''), 62.8 631 (1C, C-6'), 60.6, 60.5 (2C, 2 \times OCH₃), 55.3 (1C, C-1-OCH₃), 27.1 (3C, 3 \times *t*Bu- CH_3), 19.1 (1C, C_q *t*Bu) ppm. MS (MALDI-TOF): m/z calcd. for $\text{C}_{79}\text{H}_{90}\text{NaO}_{16}\text{Si}$: 1345.589 [M + Na]⁺, found 1345.662.

Methyl (2,3,6-Tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(6-*O*-*tert*-butyldiphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)- 636 2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (19a) and Methyl (2,3,4-Tri-*O*-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-(6-*O*-*tert*-butyldiphenylsilyl-2,3-di-*O*-methyl- α -L-idopyranosyl)-(1 \rightarrow 4)-2,3,6-tri-*O*-benzyl- α -D-glucopyranoside (19b): To a solution of **18** (63 mg, 0.048 mmol) in dry THF (144 μL) 4 Å MS (36 mg) and $\text{Me}_3\text{N} \cdot \text{BH}_3$ 641 (21 mg, 0.286 mmol, 6 equiv.) were added and the reaction mixture was stirred for 30 min at room temperature. After 30 min AlCl_3 (38 mg, 0.286 mmol, 6 equiv.) was added and the mixture was stirred at room temperature for 2 h. After 2.5 h the reaction mixture was diluted with CH_2Cl_2 (5.0 mL), and washed with H₂O (2 \times 5 mL). 646 The organic layer was dried with MgSO_4 and concentrated. The crude product was purified by silica gel chromatography (7:3 *n*-

hexane/acetone) to give **19a** (40 mg, 65 %) as a colorless syrup and **19b** (13 mg, 21 %) as a colorless syrup.

Data of 19a: $[\alpha]_D^{25} = +13.0$ ($c = 0.13$, CHCl_3); R_f 0.36 (7:3 *n*-hexane/acetone). ^1H NMR (CDCl_3 , 500 MHz): $\delta = 7.72\text{--}7.12$ (m, 40 H, arom), 5.27 (d, $J = 3.5$ Hz, 1 H, H-1''), 4.99 (d, $J = 7.2$ Hz, 1 H, H-1'), 4.97–4.62 (m, 8 H, 4 \times Bn-CH₂), 4.60 (d, $J = 3.6$ Hz, 1 H, H-1), 4.52–4.40 (m, 4 H, 2 \times Bn-CH₂), 3.93 (dd, $J = 4.7$, $J = 11.3$ Hz, 1 H, H-6'a), 3.89–3.83 (m, 6 H, H-3, H-3', H-4, H-4', H-5', H-6a), 3.81–3.79 (m, 1 H, H-6'b), 3.67–3.56 (m, 4 H, H-3'', H-4'', H-5, H-6b), 3.54–3.49 (m, 2 H, H-2'', H-6''a), 3.50 (s, 3 H, C-3'-OCH₃), 3.47–3.46 (m, 1 H, H-2), 3.45 (s, 3 H, C-2'-OCH₃), 3.41 (s, 3 H, C-1-OCH₃), 3.42–3.35 (m, 2 H, H-5'', H-6''b), 3.01 (t, $J = 7.2$ Hz, 1 H, H-2'), 2.24 (d, $J = 2.5$ Hz, 1 H, C-4''-OH), 1.04 (s, 9 H, 3 \times tBu-CH₃) ppm. ^{13}C NMR (CDCl_3 , 125 MHz): $\delta = 139.6$, 139.0, 138.6, 138.5, 138.3, 138.0, 133.2, 132.9 (8C, 8 \times C_q arom), 129.9–127.2 (40C, arom), 100.8 (1C, C-1'), 98.6 (1C, C-1''), 98.2 (1C, C-1), 85.1 (1C, C-2'), 82.1 (1C, C-3'), 81.4 (1C, C-3''), 80.6 (1C, C-3), 79.2 (1C, C-2), 79.1 (1C, C-2''), 78.8 (1C, C-4''), 76.0 (1C, C-4'), 75.6, 75.3, 73.8, 73.7 (4C, 4 \times Bn-CH₂), 73.6 (1C, C-4), 73.4, 72.5 (2C, 2 \times Bn-CH₂), 70.9, 70.8, 70.7 (3C, C-5, C-5', C-5''), 69.3 (1C, C-6), 69.1 (1C, C-6''), 62.8 (1C, C-6'), 60.5, 60.4 (2C, 2 \times OCH₃), 55.3 (1C, C-1-OCH₃), 27.1 (3C, 3 \times tBu-CH₃), 19.3 (1C, C_q tBu) ppm. MS (ESI-TOF): m/z calcd. for C₇₉H₉₂NaO₁₆Si: 1347.6047 [M + Na]⁺, found 1347.6037.

Data of 19b: $[\alpha]_D^{25} = +17.2$ ($c = 0.97$, CHCl_3); R_f 0.31 (7:3 *n*-hexane/acetone). ^1H NMR (CDCl_3 , 500 MHz): $\delta = 7.70\text{--}7.18$ (m, 40 H, arom), 5.24 (d, $J = 3.6$ Hz, 1 H, H-1''), 4.99 (d, $J = 10.6$ Hz, 1 H, Bn-CH_{2a}), 4.96 (d, $J = 7.0$ Hz, 1 H, H-1'), 4.91–4.61 (m, 9 H, Bn-CH_{2b}, 4 \times Bn-CH₂), 4.60 (d, $J = 3.0$ Hz, 1 H, H-1), 4.47 (q, $J = 12.2$ Hz, 2 H, Bn-CH₂), 3.91 (dd, $J = 4.9$, $J = 11.3$ Hz, 1 H, H-6'a), 3.88–3.76 (m, 8 H, H-3, H-3', H-3'', H-4', H-5, H-5', H-6a, H-6'b), 3.65 (t, $J = 9.4$ Hz, 1 H, H-4), 3.58 (dd, $J = 7.0$, $J = 10.8$ Hz, 1 H, H-6b), 3.53–3.46 (m, 5 H, H-2, H-2'', H-4'', H-6''a,b), 3.50 (s, 3 H, C-3'-OCH₃), 3.46 (s, 3 H, C-2'-OCH₃), 3.41 (s, 3 H, C-1-OCH₃), 3.38–3.36 (m, 1 H, H-5''), 3.00 (t, $J = 7.2$ Hz, 1 H, H-2'), 1.48–1.45 (m, 1 H, C-6''-OH), 1.04 (s, 9 H, 3 \times tBu-CH₃) ppm. ^{13}C NMR (CDCl_3 , 125 MHz): $\delta = 139.6$, 138.5, 138.4, 133.2, 132.8, 131.2 (8C, 8 \times C_q arom), 128.5–127.2 (40C, arom), 100.7 (1C, C-1'), 98.6 (1C, C-1''), 98.2 (1C, C-1), 85.2 (1C, C-2'), 82.3 (1C, C-3'), 80.6 (1C, C-3''), 80.6 (1C, C-3), 79.7 (1C, C-2''), 79.2 (1C, C-2), 78.8 (1C, C-4), 77.5 (1C, C-4''), 76.2 (1C, C-4'), 75.6, 75.2 (4C, 4 \times Bn-CH₂), 74.2 (1C, C-5'), 73.4, 72.8 (2C, 2 \times Bn-CH₂), 71.8 (1C, C-5''), 70.8 (1C, C-5), 69.3 (1C, C-6), 62.6 (1C, C-6'), 61.8 (1C, C-6''), 60.5, 60.4 (2C, 2 \times OCH₃), 55.3 (1C, C-1-OCH₃), 27.1 (3C, 3 \times tBu-CH₃), 19.2 (1C, C_q tBu) ppm. MS (MALDI-TOF): m/z calcd. for C₇₉H₉₂NaO₁₆Si: 1347.605 [M + Na]⁺, found 1347.877.

Methyl (2,3-Di-O-benzyl-4,6-O-benzylidene- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-O-methyl-6-O-(2-naphthyl)methyl- α -L-idopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-O-benzyl- α -D-glucopyranoside (20**):** To a solution of compound **14** (90 mg, 0.113 mmol) and compound **17**^[31] (98 mg, 0.181 mmol, 1.6 equiv.) in dry CH₂Cl₂ (1320 μ L) 4 \AA molecular sieves (80 mg) were added. After stirring at room temperature for 30 min, the mixture was cooled to -40°C and solutions of NIS (61 mg, 0.272 mmol, 1.5 equiv.) in dry THF (84 μ L) and AgOTf (11 mg, 0.043 mmol, 0.24 equiv.) in dry toluene (84 μ L) were added. After stirring at -40°C to -20°C for 4 h, TLC analysis (7:3 *n*-hexane/EtOAc) showed complete consumption of the donor. The reaction mixture was neutralized with Et₃N (200 μ L), diluted with CH₂Cl₂ (100 mL), and filtered. The filtrate was washed with an aqueous solution of Na₂S₂O₃ (10 %, 20 mL), a saturated aqueous solution of NaHCO₃ (2 \times 20 mL), and water (2 \times 20 mL), dried, and concentrated. The crude product was purified by column chromatography on silica gel (65:35 *n*-hexane/EtOAc) to give compound **20** (111 mg, 80 %) as a colorless syrup. $[\alpha]_D^{25} = +11.0$ ($c = 0.10$, CHCl_3); R_f 0.50

(6:4 *n*-hexane/EtOAc). ^1H NMR (CDCl_3 , 500 MHz): $\delta = 7.72\text{--}7.19$ (m, 711 37 H, arom), 5.52 (s, 1 H, H_{ac}), 5.25 (d, $J = 3.8$ Hz, 1 H, H-1''), 4.98 (d, $J = 6.9$ Hz, 1 H, H-1'), 4.98–4.60 (m, 8 H, 4 \times Bn-CH₂), 4.58 (d, $J = 4.0$ Hz, 1 H, H-1), 4.48–4.38 (m, 4 H, NAP-CH₂, Bn-CH₂), 4.15 (dd, $J = 4.7$, $J = 10.1$ Hz, 1 H, H-6''a), 4.04 (dd, $J = 4.6$ Hz, $J = 9.5$ Hz, 1 H, H-5'), 3.93–3.88 (m, 4 H, H-3, H-3'', H-4, H-4'), 3.79–3.74 (m, 5 H, H-3', 716 H-5, H-5'', H-6a, H-6'a), 3.71–3.64 (m, 3 H, H-6b, H-6'b, H-6''b), 3.60 (t, $J = 9.4$ Hz, 1 H, H-4''), 3.58 (dd, $J = 3.8$, $J = 9.4$ Hz, 1 H, H-2''), 3.52 (s, 3 H, C-3'-OCH₃), 3.50–3.47 (m, 1 H, H-2), 3.49 (s, 3 H, C-2'-OCH₃), 3.36 (s, 3 H, C-1-OCH₃), 3.05 (t, $J = 7.4$ Hz, 1 H, H-2') ppm. ^{13}C NMR (CDCl_3 , 125 MHz): $\delta = 139.4$, 138.8, 138.5, 138.3, 137.5, 721 135.8, 133.3, 132.8 (9C, 9 \times C_q arom), 129.9–125.6 (37C, arom), 101.2 (1C, C_{ac}), 100.0 (1C, C-1'), 99.1 (1C, C-1''), 98.4 (1C, C-1), 84.8 (1C, C-2'), 82.5 (1C, C-3'), 82.3 (1C, C-4''), 80.2 (1C, C-3), 79.4 (1C, C-2), 79.0 (1C, C-2''), 78.3 (1C, C-4'), 76.6 (1C, C-4), 76.3 (1C, C-3''), 75.3, 75.0, 73.6, 73.2 (6C, NAP-CH₂, 5 \times Bn-CH₂), 72.2 (1C, C-5'), 70.4 (1C, C-5), 726 69.1 (1C, C-6'), 68.9 (1C, C-6''), 68.3 (1C, C-6), 63.3 (1C, C-5''), 60.4, 60.3 (2C, 2 \times OCH₃), 55.3 (1C, C-1-OCH₃) ppm. MS (ESI-TOF): m/z calcd. for C₇₄H₈₀NaO₁₆: 1247.5339 [M + Na]⁺, found 1247.5331.

Methyl (2,3,6-Tri-O-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-O-methyl-6-O-(2-naphthyl)methyl- α -L-idopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-O-benzyl- α -D-glucopyranoside (21a**) and Methyl (2,3,4-Tri-O-benzyl- α -D-glucopyranosyl)-(1 \rightarrow 4)-[2,3-di-O-methyl-6-O-(2-naphthyl)methyl- α -L-idopyranosyl]-(1 \rightarrow 4)-2,3,6-tri-O-benzyl- α -D-glucopyranoside (**21b**):** To a solution of **20** (95 mg, 0.077 mmol) in dry THF (235 μ L) 4 \AA MS (60 mg) and Me₃N-BH₃ 736 (34 mg, 0.465 mmol, 6 equiv.) were added and the reaction mixture was stirred for 30 min at room temperature. After 30 min AlCl₃ (62 mg, 0.465 mmol, 6 equiv.) was added and the mixture was stirred at room temperature for 2 h. After 2 h the reaction mixture was diluted with CH₂Cl₂ (50 mL), and washed with H₂O (2 \times 15 mL). 741 The organic layer was dried with MgSO₄ and concentrated. The crude product was purified by silica gel chromatography (6:4 *n*-hexane/EtOAc) to give **21a** (66 mg, 70 %) as a colorless syrup and **21b** (18 mg, 19 %) as a colorless syrup.

Data of 21a: $[\alpha]_D^{25} = +26.7$ ($c = 0.12$, CHCl_3); R_f 0.66 (1:1 *n*-hexane/EtOAc). ^1H NMR (CDCl_3 , 500 MHz): $\delta = 7.74\text{--}7.16$ (m, 37 H, arom), 5.27 (d, $J = 3.5$ Hz, 1 H, H-1''), 4.98 (d, $J = 7.4$ Hz, 1 H, H-1'), 4.96–4.60 (m, 8 H, 4 \times Bn-CH₂), 4.58 (d, $J = 4.3$ Hz, 1 H, H-1), 4.49–4.36 (m, 6 H, NAP-CH₂, 2 \times Bn-CH₂), 4.10 (dd, $J = 4.8$, $J = 9.8$ Hz, 1 H, H-5'), 3.94–3.86 (m, 3 H, H-3, H-4, H-4'), 3.80 (dd, $J = 3.7$, $J = 10.7$ Hz, 751 1 H, H-6a), 3.77–3.73 (m, 3 H, H-3', H-5, H-6'a), 3.69–3.60 (m, 5 H, H-3'', H-4'', H-5'', H-6b, H-6'b), 3.55–3.50 (m, 2 H, H-2'', H-6''a), 3.51 (s, 3 H, C-3'-OCH₃), 3.49–3.44 (m, 2 H, H-2, H-6''b), 3.47 (s, 3 H, C-2'-OCH₃), 3.36 (s, 3 H, C-1-OCH₃), 3.06 (t, $J = 7.3$ Hz, 1 H, H-2'), 2.23 (s, 1 H, C-4''-OH) ppm. ^{13}C NMR (CDCl_3 , 125 MHz): $\delta = 139.4$, 138.8, 756 138.6, 138.4, 138.0, 135.9, 133.4, 132.9 (9C, 9 \times C_q arom), 128.6–125.8 (37C, arom), 100.0 (1C, C-1'), 98.4 (1C, C-1''), 98.0 (1C, C-1''), 84.5 (1C, C-2'), 82.2 (1C, C-3'), 80.9 (1C, C-3''), 80.3 (1C, C-3), 79.5 (1C, C-2), 79.3 (1C, C-2''), 76.6 (1C, C-4), 76.0 (1C, C-4'), 75.5, 75.2, 73.7, 73.6, 73.3, 72.4 (7C, NAP-CH₂, 6 \times Bn-CH₂), 71.9 (1C, C-5'), 70.9, 761 70.8 (2C, C-4'', C-5''), 70.5 (1C, C-5), 69.4 (1C, C-6'), 69.2 (1C, C-6''), 68.4 (1C, C-6), 60.3, 60.2 (2C, 2 \times OCH₃), 55.4 (1C, C-1-OCH₃) ppm. MS (ESI-TOF): m/z calcd. for C₇₄H₈₂NaO₁₆: 1249.5495 [M + Na]⁺, found 1249.5487.

Data of 21b: $[\alpha]_D^{25} = +31.8$ ($c = 2.70$, CHCl_3); R_f 0.46 (1:1 *n*-hexane/EtOAc). ^1H NMR (CDCl_3 , 500 MHz): $\delta = 7.72\text{--}7.19$ (m, 37 H, arom), 5.24 (d, $J = 3.6$ Hz, 1 H, H-1''), 4.97 (d, $J = 10.8$ Hz, 1 H, Bn-CH_{2a}), 4.98 (d, $J = 6.9$ Hz, 1 H, H-1'), 4.89–4.69 (m, 7 H, Bn-CH_{2b}, 3 \times Bn-CH₂), 4.60–4.58 (m, 2 H, Bn-CH₂), 4.57 (d, $J = 4.6$ Hz, 1 H, H-1), 4.49–4.36 (m, 4 H, NAP-CH₂, Bn-CH₂), 4.06 (dd, $J = 4.6$, $J = 9.6$ Hz, 1 H, H-771 5'), 3.93–3.84 (m, 4 H, H-3, H-3'', H-4, H-4'), 3.79 (dd, $J = 3.7$, $J =$

10.7 Hz, 1 H, H-6a), 3.76–3.72 (m, 3 H, H-3', H-5, H-6'a), 3.69–3.66 (m, 2 H, H-6b, H-6'b), 3.60–3.55 (m, 3 H, H-5'', H-6''a,b), 3.52–3.46 (m, 3 H, H-2, H-2'', H-4''), 3.51 (s, 3 H, C-3'-OCH₃), 3.48 (s, 3 H, C-2'-OCH₃), 3.37 (s, 3 H, C-1-OCH₃), 3.05 (t, *J* = 7.3 Hz, 1 H, H-2'), 1.70 (s, 1 H, C-6''-OH) ppm. ¹³C NMR (CDCl₃, 125 MHz): δ = 139.4, 138.8, 138.6, 138.4, 138.3, 135.9, 133.4, 132.9 (9C, 9 × C_q arom), 128.6–125.7 (37C, arom), 100.1 (1C, C-1'), 98.5 (1C, C-1), 98.0 (1C, C-1''), 84.7 (1C, C-2'), 82.5 (1C, C-3'), 81.7 (1C, C-3''), 80.3 (1C, C-3), 79.9 (1C, C-2''), 79.5 (1C, C-2), 77.3 (1C, C-4''), 76.7 (1C, C-4), 76.1 (1C, C-4'), 75.5, 75.4, 75.2, 73.7, 73.3, 72.8 (7C, NAP-CH₂, 6 × Bn-CH₂), 72.0 (1C, C-5'), 71.7 (1C, C-5''), 70.5 (1C, C-5), 69.2 (1C, C-6'), 68.4 (1C, C-6), 61.7 (1C, C-6''), 60.4 (2C, 2 × OCH₃), 55.4 (1C, C-1-OCH₃) ppm. MS (ESI-TOF): *m/z* calcd. for C₇₄H₈₂NaO₁₆: 1249.5495 [M + Na]⁺, found 1249.5483.

Methyl (6-O-Benzyl-2,3,4-tri-O-methyl-α-D-glucopyranosyl)-(1→4)-[2,3-di-O-acetyl-6-O-(2-naphthyl)methyl-β-D-glucopyranosyl]-(1→4)-(2,3,6-tri-O-benzyl-α-D-glucopyranosyl)-(1→4)-(6-O-tert-butylidiphenylsilyl-2,3-di-O-methyl-α-L-idopyranosyl)-(1→4)-2,3,6-tri-O-benzyl-α-D-glucopyranoside (23) and Methyl (6-O-Benzyl-2,3,4-tri-O-methyl-α-D-glucopyranosyl)-(1→4)-[2,3-di-O-acetyl-6-O-(2-naphthyl)methyl-β-D-glucopyranosyl]-(1→4)-2,3,6-tri-O-benzyl-α-D-glucopyranoside (24): To a solution of trisaccharide acceptor 19a (32 mg, 0.024 mmol) and disaccharide donor 22^[32] (28.6 mg, 0.036 mmol, 1.5 equiv.) in dry CH₂Cl₂ (1.2 mL) 4 Å MS (150 mg) were added and the reaction mixture was stirred at room temperature. After 30 min the stirred mixture was cooled to –20 °C under argon. After at this temperature, NIS (12 mg, 0.054 mmol, 1.5 equiv. to the donor) was dissolved in dry THF (30 μL) and AgOTf (2 mg, 0.009 mmol, 0.24 equiv. to the donor) dissolved in dry toluene (30 μL) were added. The temperature was warmed up to +5 °C and the reaction mixture was stirred for 4 h. After 4 h the reaction mixture was quenched with Et₃N (150 μL), diluted with CH₂Cl₂ (25 mL), filtered and the mixture was washed with saturated aqueous solution of Na₂S₂O₃ (2 × 5 mL), saturated aqueous solution of NaHCO₃ (5 mL) and with H₂O (2 × 5 mL) until neutral pH. The organic layer was dried on MgSO₄ and concentrated. The crude product was purified by silica gel chromatography (6:4 *n*-hexane/EtOAc to 1:1 *n*-hexane/EtOAc) to give **23** (5 mg, 11 %) as a colorless syrup and **24** (22 mg, 46 %) as a colorless syrup.

Data of 23: [α]_D²⁵ = +27.0 (*c* = 0.10, CHCl₃); *R*_f 0.48 (1:1 *n*-hexane/EtOAc). ¹H NMR (CDCl₃, 500 MHz): δ = 7.80–7.10 (m, 52 H, arom), 5.27 (d, *J* = 3.8 Hz, 1 H, H-1'), 5.12–4.25 (m, 22 H, 7 × Bn-CH₂, NAP-CH₂, 4 × H-1, H-2-E, H-3-E), 3.96–2.98 (m, 46 H, 6 × OCH₃, 28 skeleton hydrogen), 2.02, 1.95 (2 × s, 6 H, 2 × Ac-CH₃), 1.03 (s, 9 H, *t*Bu-CH₃) ppm. ¹³C NMR (CDCl₃, 125 MHz): δ = 148.7, 147.5, 144.8, 143.8, 143.5, 139.5, 138.3, 137.6, 133.3, 133.2, 132.9, 132.8 (12C, 12 × C_q arom), 135.7–125.6 (52C, arom), 101.1, 100.0, 98.9, 98.2, 98.0 (5C, 5 × C-1), 85.0, 83.4, 82.0, 80.6, 80.4, 79.4, 79.2, 76.8, 75.6, 75.3, 75.2, 73.0, 71.4, 71.1, 69.0, 68.5, 67.7 (20C, skeleton carbons), 75.1, 73.5, 73.1 (9C, 7 × Bn-CH₂, 2 × NAP-CH₂), 70.9, 70.8, 70.7 (3C, C-5, C-5', C-5''), 67.7, 68.5, 68.7, 69.0 (4C, 4 × C-6), 63.2 (1C, C-6-G), 60.9, 60.5, 59.4 (5C, 5 × OCH₃), 55.4 (1C, C-1-OCH₃), 21.2, 20.9 (2C, 2 × Ac-CH₃), 27.1 (3C, 3 × *t*Bu-CH₃), 19.2 (1C, C_q *t*Bu) ppm. MS (MALDI-TOF): *m/z* calcd. for C₁₁₆H₁₃₆NaO₂₈Si: 2027.888 [M + Na]⁺, found 2027.809.

Data of 24: [α]_D²⁵ = +25.8 (*c* = 0.12, CHCl₃); *R*_f 0.35 (1:1 *n*-hexane/EtOAc). ¹H NMR (CDCl₃, 500 MHz): δ = 7.81–7.13 (m, 27 H, arom), 5.11 (t, *J* = 9.1 Hz, 1 H, H-3'), 5.07 (d, *J* = 3.5 Hz, 1 H, H-1''), 5.02 (d, *J* = 11.6 Hz, 1 H, Bn-CH_{2a}), 4.85 (dd, *J* = 9.4 Hz, *J* = 8.2 Hz, 1 H, H-2'), 4.77–4.58 (m, 5 H, Bn-CH_{2b}, 2 × Bn-CH₂), 4.56–4.52 (m, 2 H, H-1, H-1'), 4.48–4.27 (m, 4 H, NAP-CH₂, Bn-CH₂), 3.92 (t, *J* = 9.2 Hz, 1 H, H-4'), 3.90–3.85 (m, 2 H, H-3, H-4), 3.75 (dd, *J* = 10.7, *J* = 3.2 Hz, 1 H, H-6a), 3.69–3.60 (m, 5 H, H-5, H-5'', H-6b, H-6'a,b), 3.58 (s, 3 H,

C-3'-OCH₃), 3.44 (dd, *J* = 10.1, *J* = 3.3 Hz, 1 H, H-6''a), 3.42–3.37 (m, 3 H, H-2, H-3'', H-6''b), 3.41, 3.40 (2 × s, 6 H, C-4''-OCH₃, C-2''-OCH₃), 3.34 (s, 3 H, C-1-OCH₃), 3.23–3.21 (m, 1 H, H-5'), 3.17 (t, *J* = 9.5 Hz, 1 H, H-4''), 3.05 (dd, *J* = 9.8, *J* = 3.5 Hz, 1 H, H-2''), 2.01, 1.94 (2 × s, 6 H, 2 Ac-CH₃) ppm. ¹³C NMR (CDCl₃, 125 MHz): δ = 170.1, 169.8 (2C, 2 × C_q Ac), 139.6, 138.4, 138.2, 137.8, 136.2, 133.4, 133.0 (7C, 7 × C_q arom), 128.8–125.8 (27C, arom), 100.0 (1C, C-1'), 98.5 (1C, C-41), 97.9 (1C, C-1''), 83.3 (1C, C-3''), 81.9 (1C, C-2''), 80.3 (1C, C-3), 79.4 (1C, C-4''), 79.3 (1C, C-2), 77.1 (1C, C-4), 75.3 (1C, C-3'), 75.2 (1C, C-5'), 75.0 (1C, C-4'), 74.0, 73.8, 73.4 (5C, 4 × Bn-CH₂, NAP-CH₂), 73.0 (1C, C-2'), 71.3 (1C, C-5''), 70.0 (1C, C-5), 68.8 (1C, C-6'), 68.5 (1C, C-6''), 67.9 (1C, C-6), 60.8 (1C, C-3''-OCH₃), 60.5 (1C, C-4''-OCH₃), 59.4 846 (1C, C-2''-OCH₃), 55.4 (1C, C-1-OCH₃), 21.2, 20.9 (2C, 2 × Ac-CH₃) ppm. MS (ESI-TOF): *m/z* calcd. for C₆₅H₇₆NaO₁₈: 1167.4924 [M + Na]⁺, found 1167.4885.

Methyl (6-O-Benzyl-2,3,4-tri-O-methyl-α-D-glucopyranosyl)-(1→4)-[2,3-di-O-acetyl-6-O-(2-naphthyl)methyl-β-D-glucopyranosyl]-(1→4)-(2,3,6-tri-O-benzyl-α-D-glucopyranosyl)-(1→4)-[2,3-di-O-methyl-6-O-(2-naphthyl)methyl-α-L-idopyranosyl]-(1→4)-2,3,6-tri-O-benzyl-α-D-glucopyranoside (25): To a solution of trisaccharide acceptor 21a (38 mg, 0.031 mmol) and disaccharide donor 22^[32] (37 mg, 0.047 mmol, 1.5 equiv.) in dry CH₂Cl₂ (1.2 mL) 4 Å MS (250 mg) were added and the reaction mixture was stirred at room temperature. After 30 min the stirred mixture was cooled to –20 °C under argon. After at this temperature, NIS (16 mg, 0.070 mmol, 1.5 equiv. to the donor) and TfOH (2.0 μL, 0.020 mmol, 0.3 equiv. to the NIS) dissolved in dry THF (28 μL) were added. The 861 temperature was warmed up to +5 °C and the reaction mixture was stirred for 4 h. Than reaction mixture was quenched with Et₃N (150 μL), diluted with CH₂Cl₂ (25 mL), filtered and the mixture was washed with saturated aqueous solution of Na₂S₂O₃ (2 × 5 mL), saturated aqueous solution of NaHCO₃ (5 mL) and H₂O (2 × 5 mL) 866 until neutral pH. The organic layer was dried on MgSO₄ and concentrated. The crude product was purified by silica gel chromatography (55:45 *n*-hexane/EtOAc to 1:1 *n*-hexane/EtOAc) to give **25** (41 mg, 70 %) as a colorless syrup. [α]_D²⁵ = +60.0 (*c* = 0.10, CHCl₃); *R*_f 0.45 (1:1 *n*-hexane/EtOAc). ¹H NMR (CDCl₃, 500 MHz): δ = 7.77–7.07 (m, 871 49 H, arom), 5.22 (d, *J* = 3.7 Hz, 1 H, H-1-F), 5.09–5.05 (m, 2 H, H-1-D, H-3-E), 4.97–4.95 (m, 2 H, 2 × Bn-CH_{2a}), 4.89 (d, *J* = 6.9 Hz, 1 H, H-1-G), 4.82 (t, *J* = 8.3 Hz, 1 H, H-2-E), 4.80–4.25 (m, 18 H, H-1-H, H-1-E, 2 × NAP-CH₂, 2 × Bn-CH_{2b}, 5 × Bn-CH₂), 4.05 (dd, *J* = 5.0, *J* = 9.7 Hz, 1 H, H-5-G), 3.95–3.84 (m, 5 H, H-3-H, H-4-E, H-4-F, H-4-G, H-876 4-H), 3.79–3.68 (m, 7 H, H-3-F, H-5-F, H-5-H, H-6a-F, H-6a-G, H-6a,b-H), 3.67–3.61 (m, 4 H, H-3-G, H-6b-G, H-6a,b-E), 3.60–3.55 (m, 4 H, H-5-D, C-3-D-OCH₃), 3.50–3.44 (m, 10 H, H-2-F, H-2-H, H-6b-F, H-6a-D, C-2-G-OCH₃, C-3-G-OCH₃), 3.43–3.39 (m, 8 H, H-3-D, H-6b-D, C-2-D-OCH₃, C-3-D-OCH₃), 3.34 (s, 3 H, C-1-H-OCH₃), 3.20–3.15 (m, 2 H, 881 H-4-D, H-5-E), 3.06–3.00 (m, 2 H, C-2-D, H-2-G), 2.00, 1.82 (2 × s, 6 H, 2 × Ac-CH₃) ppm. ¹³C NMR (CDCl₃, 125 MHz): δ = 170.1, 169.7 (2C, 2 × Ac-CH₃), 139.6, 139.5, 138.6, 138.5, 138.3, 138.2, 137.7, 136.2, 135.9, 133.4, 133.9 (13C, 13 × C_q arom), 128.9–125.8 (49C, arom), 100.0 (1C, C-1-E), 99.8 (1C, C-1-G), 98.6 (1C, C-1-F), 98.4 (1C, 886 C-1-H), 97.9 (1C, C-1-D), 84.5 (1C, C-2-G), 83.3 (1C, C-3-D), 82.2 (1C, C-3-G), 81.9 (1C, C-2-D), 80.3 (1C, C-3-H), 80.0 (1C, C-3-F), 79.5 (1C, C-2-H), 79.4 (1C, C-4-D), 79.0 (1C, C-2-F), 76.8 (1C, C-4-F), 76.6 (1C, C-4-H), 76.5 (1C, C-4-G), 75.5 (1C, NAP-CH₂), 75.3, (1C, C-3-E), 75.2 (1C, C-5-E), 75.0 (1C, NAP-CH₂), 74.9 (1C, C-4-E), 73.8, 73.7, 73.4, 73.3, 891 73.1 (7C, 7 × Bn-CH₂), 72.9 (1C, C-5-E), 72.2 (1C, C-5-G), 71.3 (1C, C-5-D), 71.0 (1C, C-5-F), 70.5 (1C, C-5-H), 68.9 (1C, C-6-G), 68.8 (1C, C-6-E), 68.5 (1C, C-6-D), 68.3 (1C, C-6-H), 67.6 (1C, C-6-F), 60.8 (1C, C-3-D-OCH₃), 60.5 (2C, C-3-G-OCH₃, C-4-D-OCH₃), 60.3 (1C, C-2-G-OCH₃), 59.3 (1C, C-2-D-OCH₃), 55.4 (1C, C-1-H-OCH₃), 21.1, 20.8 (2C, 896

2 × Ac-CH₃) ppm. MS (MALDI-TOF): *m/z* calcd. for C₁₁₁H₁₂₆NaO₂₆: 1931.190 [M + Na]⁺, found 1931.124.

Methyl (6-O-Benzyl-2,3,4-tri-O-methyl-α-D-glucopyranosyl)-(1→4)-[6-O-(2-naphthyl)methyl-β-D-glucopyranosyl]-(1→4)-
(2,3,6-tri-O-benzyl-α-D-glucopyranosyl)-(1→4)-[2,3-di-O-
methyl-6-O-(2-naphthyl)methyl-α-L-idopyranosyl]-(1→4)-2,3,6-
tri-O-benzyl-α-D-glucopyranoside (26): Compound 25 (33 mg,
 0.017 mmol) was dissolved in MeOH (1.0 mL) and NaOMe was
 added (5 mg, 0.092 mmol, pH ≈ 10) and the reaction mixture was
 stirred at room temperature for 24 h. Then the reaction mixture was
 neutralized by Amberlite IR-120 (H⁺) ion-exchange resin, filtered,
 washed with MeOH and concentrated. The crude product was purified
 by column chromatography (65:35 = *n*-hexane/acetone) to give
 26 (25 mg, 78 %) as a colorless syrup. [α]_D²⁵ = +55.0 (*c* = 0.06, CHCl₃);
*R*_f 0.29 (7:3 *n*-hexane/acetone). ¹H NMR (CDCl₃, 500 MHz): δ = 7.77–
 7.13 (m, 49 H, arom), 5.22 (d, *J* = 3.7 Hz, 1 H, H-1-F), 5.03 (d, *J* =
 3.5 Hz, 1 H, H-1-D), 4.96 (d, *J* = 5.9 Hz, 1 H, H-1-G), 4.95–4.28 (m, 20
 H, H-1-H, H-1-E, 2 × NAP-CH₂, 7 × Bn-CH₂), 4.00–3.96 (m, 2 H, H-4-F,
 H-5-G), 3.90–3.82 (m, 3 H, H-3-F, H-4-G, H-6a-F), 3.79–3.65 (m, 9 H,
 H-3-H, H-3-G, H-4-H, H-5-H, H-5-F, H-6a,b-H, H-6a,b-G), 3.61 (s, 3 H,
 C-3-D-OCH₃), 3.59–3.57 (m, 1 H, H-5-D), 3.56 (s, 3 H, C-2-D-OCH₃),
 3.54–3.50 (m, 2 H, H-3-E-OH, H-6a-E), 3.48 (s, 4 H, H-2-F, C-3-G-OCH₃),
 3.47–3.40 (m, 13 H, H-2-H, H-3-D, H-3-E, H-4-E, H-6a-D, H-6b-F, H-
 6b-E, C-2-G-OCH₃, C-4-D-OCH₃), 3.36 (s, 3 H, C-1-H-OCH₃), 3.33–3.29
 (m, 2 H, H-2-E, H-6b-D), 3.22 (s, 1 H, C-2-E-OH), 3.19–3.13 (m, 3 H,
 H-2-D, H-4-D, H-5-E), 3.05–3.02 (m, 1 H, H-2-G) ppm. ¹³C NMR (CDCl₃,
 125 MHz): δ = 139.5, 138.6, 138.4, 138.1, 137.7, 136.4, 136.0, 133.4,
 133.0, 132.9 (13C, 13 × C_q arom), 128.6–125.8 (49C, arom), 103.1 (1C,
 C-1-E), 100.6 (1C, C-1-D), 100.0 (1C, C-1-G), 98.5 (1C, C-1-H), 98.3 (1C,
 C-1-F), 84.7 (1C, C-2-G), 84.1 (1C, C-3-D), 82.9 (1C, C-2-D), 82.5 (1C,
 C-3-G), 82.0 (1C, C-4-E), 80.6 (1C, C-3-F), 80.3 (1C, C-3-H), 79.5 (2C,
 C-2-H, C-4-D), 79.4 (1C, C-2-F), 76.7 (2C, C-4-F, C-4-H), 76.3 (1C, C-4-
 G), 76.1 (1C, C-3-E), 75.3, 74.8 (2C, 2 × NAP-CH₂), 74.7, (1C, C-5-E),
 74.0 (1C, C-2-E), 73.7, 73.6, 73.4, 73.3, 72.9 (7C, 7 × Bn-CH₂), 72.0
 (1C, C-5-G), 71.4 (1C, C-5-D), 70.8 (1C, C-5-F), 70.5 (1C, C-5-H), 69.3
 (1C, C-6-G), 69.0 (1C, C-6-E), 68.5 (2C, C-6-D, C-6-H), 68.3 (1C, C-6-F),
 60.9 (1C, C-3-D-OCH₃), 60.6 (1C, C-4-D-OCH₃), 60.3 (3C, C-2-G-OCH₃,
 C-3-G-OCH₃, C-2-D-OCH₃), 55.4 (1C, C-1-H-OCH₃) ppm. MS (MALDI-
 TOF): *m/z* calcd. for C₁₀₇H₁₂₂NaO₂₆: 1845.812 [M + Na]⁺, found
 1845.714.

Methyl (6-O-Benzyl-2,3,4-tri-O-methyl-α-D-glucopyranosyl)-(1→4)-[2,3-di-O-methyl-6-O-(2-naphthyl)methyl-β-D-glucopyr-
anosyl]-(1→4)-(2,3,6-tri-O-benzyl-α-D-glucopyranosyl)-(1→4)-
[2,3-di-O-methyl-6-O-(2-naphthyl)methyl-α-L-idopyranosyl]-(1→4)-2,3,6-tri-O-benzyl-α-D-glucopyranoside (27): To a solution
 of 26 (21 mg, 0.0115 mmol) in dry DMF (250 μL) was added NaH
 (60 %, 10 mg, 0.250 mmol) at 0 °C. After stirring for 30 min at 0 °C,
 MeI (20 μL, 0.321 mmol) was added and stirred for 24 h at room
 temperature. When complete conversion of the starting material
 into a main spot had been observed by TLC analysis, CH₃OH
 (500 μL) was added. The reaction mixture was stirred for 5 min and
 the solvents were evaporated. The residue was dissolved in CH₂Cl₂
 (25 mL), and washed with H₂O (2 × 5.0 mL), the organic layer was
 filtered, dried and the solvents evaporated. The crude product was
 purified by silica gel chromatography (6:4 = *n*-hexane/acetone) to
 give 27 (16 mg, 80 %) as a colorless syrup. [α]_D²⁵ = +45.7 (*c* = 0.07,
 CHCl₃); *R*_f 0.58 (6:4 *n*-hexane/acetone). ¹H NMR (CDCl₃, 500 MHz):
 δ = 7.78–7.08 (m, 49 H, arom), 5.58 (d, *J* = 3.7 Hz, 1 H), 5.23 (d, *J* =
 3.6 Hz, 1 H), 5.02–4.06 (m, 21 H, 3 × H-1, 7 × Bn-CH₂, 2 × NAP-CH₂),
 4.06 (dd, *J* = 4.7, *J* = 9.6 Hz, 1 H), 3.98 (t, *J* = 9.4 Hz, 1 H), 3.89–3.62
 (m, 17 H), 3.62–3.32 (m, 4 H), 3.60, 3.54, 3.48, 3.45, 3.38, 3.36, 3.33
 (7 × s, 24 H, 8 × OCH₃), 3.29–3.21 (m, 4 H), 3.15 (dd, *J* = 3.7, *J* =
 9.8 Hz, 1 H), 3.04–3.00 (m, 1 H), 2.94–2.91 (m, 1 H) ppm. ¹³C NMR

(CDCl₃, 125 MHz): δ = 139.7, 139.4, 138.6, 138.4, 138.2, 138.0, 136.5,
 135.9, 133.4, 133.0, 132.9 (13C, 13 × C_q arom), 128.7–125.7 (49C, 961
 arom), 102.9, 100.0, 98.5, 96.3 (5C, 5 × C-1), 86.7, 84.7, 84.6, 83.6,
 82.4, 81.9, 80.4, 79.9, 79.5, 79.4, 79.0, 77.0, 76.7, 76.2, 74.8, 72.4, 72.2,
 71.4, 70.9, 70.5 (20C skeleton carbons), 75.6, 74.9, 73.8, 73.5, 73.4,
 73.3, 73.2 (9C, 2 × NAP-CH₂, 7 × Bn-CH₂), 69.4, 68.3, 68.2, 67.8 (5C,
 5 × C-6), 60.9, 60.5, 60.3, 59.8, 59.6 (7C, 7 × OCH₃), 55.4 (1C, C-1-H-
 OCH₃) ppm. MS (MALDI-TOF): *m/z* calcd. for C₁₀₉H₁₂₆NaO₂₆:
 1873.843 [M + Na]⁺, found 1873.749.

Methyl (6-O-Benzyl-2,3,4-tri-O-methyl-α-D-glucopyranosyl)-(1→4)-(2,3-di-O-methyl-β-D-glucopyranosyl)-(1→4)-(2,3,6-tri-O-
benzyl-α-D-glucopyranosyl)-(1→4)-(2,3-di-O-methyl-α-L-idopyr-
anosyl)-(1→4)-2,3,6-tri-O-benzyl-α-D-glucopyranoside (28): To a
 vigorously stirred solution of 27 (14 mg, 0.007 mmol) in CH₂Cl₂
 (2.0 mL) and H₂O (250 μL), DDQ (5.0 mg, 0.021 mmol) was added.
 After 30 min the mixture was diluted with CH₂Cl₂ (20 mL) and ex-
 tracted with saturated aqueous NaHCO₃ (2 × 5 mL) and H₂O (2 × 976
 5 mL), dried and concentrated. The crude product was purified by
 silica gel chromatography (6:4 *n*-hexane/acetone) to give 28 (8 mg,
 71 %) as a colorless syrup. [α]_D²⁵ = +61.4 (*c* = 0.08, CH₂Cl₂); *R*_f 0.52
 (6:4 *n*-hexane/acetone). ¹H NMR (CDCl₃, 360 MHz): δ = 7.39–7.18
 (m, 35 H, arom), 5.52 (d, *J* = 3.7 Hz, 1 H), 5.15 (d, *J* = 3.4 Hz, 1 H), 981
 4.93–4.50 (m, 16 H, 7 × Bn-CH₂, 2 × H-1), 4.28 (d, *J* = 7.8 Hz, 1 H),
 3.93–3.63 (m, 15 H), 3.62–3.15 (m, 12 H), 3.61, 3.58, 3.54, 3.49, 3.44,
 3.42, 3.39, 3.35 (8 × s, 24 H, 8 × OCH₃), 3.03–2.94 (m, 3 H), 2.36, 2.08
 (2 × s, 2 H, 2 × OH) ppm. ¹³C NMR (CDCl₃, 90 MHz): δ = 138.7, 138.4,
 138.0, 137.8, 137.7, 137.5, 137.4 (7C, 7 × C_q arom), 128.2–127.3 (35C, 986
 arom), 102.3, 98.6, 97.8, 97.0, 96.3 (5C, 5 × C-1), 86.1, 84.4, 83.1, 82.6,
 81.5, 81.4, 80.1, 79.6, 79.2, 78.4, 75.2, 74.1, 73.9, 71.2, 70.8, 70.6, 70.1
 (20C, skeleton carbons), 75.5, 74.9, 73.2, 73.1, 72.7 (7C, 7 × Bn-CH₂),
 68.1, 68.0, 67.4, 61.6 (5C, 5 × C-6), 60.4, 60.1, 60.0, 59.6, 59.4, 59.3,
 59.2 (7C, 7 × OCH₃), 54.9 (C-1-H-OCH₃) ppm. MS (ESI-TOF): *m/z* calcd. 991
 for C₈₇H₁₁₀NaO₂₆: 1593.7178 [M + Na]⁺, found 1593.7163.

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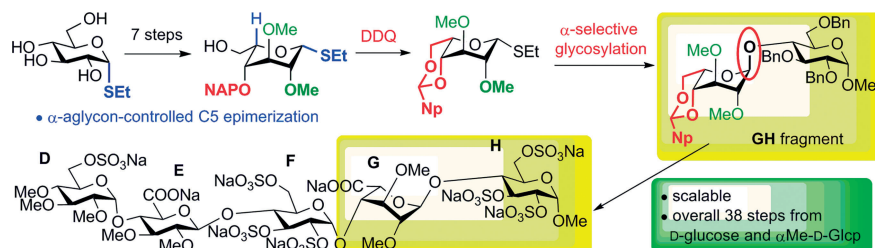
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Total Synthesis

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Short Synthesis of Idraparinux by Applying a 2-O-Methyl-4,6-O-aryl-methylene Thiodiside as a 1,2-trans- α -Selective Glycosyl Donor



Our new route to idraparinux is based on a short and straightforward synthesis of a 4,6-cyclic-acetal-protected L-idosyl thioglycoside bearing a C2-non-participating group, which can be used directly as an α -selective glycosyl

donor building block. The assembly of idraparinux was achieved by an **F+GH** and **DE+FGH** coupling sequence with full stereoselectivity in each glycosylation step.

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