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New thioglycoside derivatives for use in odourless synthesis of MUXF^3 *N*-glycan fragments related to food allergens

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Abstract

Thioglycosides are valuable tools for complex oligosaccharides' constructions. They present precious advantages due to their stability and crystalline nature. However, their major drawbacks are the repulsive smell of thiols utilised as precursors and, often, their toxicity such as in case of the commonly employed thiophenol and thioethanol. The use of commercially available methyl *tert*-butyl phenyl thiol (MbpSH) avoids these problems and is compatible with gram scale synthesis of thioglycoside donors. In this paper, we describe that Mbp thioglycosides are useful and convenient precursors for odourless oligosaccharide synthesis and we further demonstrate, as a proof of their versatility, their use in the construction of most of the glycosidic linkages found in *N*-glycans.

Keywords: Thioglycosides; Odourless thiol; Allergy; MUXF^3; *N*-Glycan; CCD; Cross-reactive carbohydrate determinants; Oligosaccharides

1. Introduction

Along with trichloroacetimidates, thioglycosides are reliable glycosyl donors for the multi-step construction of complex oligosaccharides.[1] Although introduced about two decades ago, they are yet not surpassed and are widely used. They are reactive enough to be used at low temperature, thus allowing good alpha regioselectivity in the absence of a participating group at position 2, and, moreover, their activation does not require the presence of a heavy metal. Thioglycosides are usually less reactive than imidates but are much more stable at room temperature and are often crystalline and they are, therefore, more convenient for routine oligosaccharide synthesis,[2] both in solution and solid phase. Another precious advantage is that the thioglycoside group can be used for a protection of the anomeric position, while imidate chemistry requires extra protecting groups, such as acetate or trimethylsilylethyl groups, and, thus, more synthetic steps. The major drawback of thioglycoside chemistry is the foul odour of thiol precursors (thioethanol, thiophenol and thiocresol) even far below the toxic concentration, a property for which they find an application as additives for gas odorisation. Hence, despite their great utility in oligosaccharide synthesis, thioglycosides remain an undesirable area of sugar chemistry for many research groups.

Some efforts have been made in this respect to find odourless surrogates for those thiols in glycosylation. One of these is the commercially available methyl thiosalicylate developed by Kobayashi.[3] However, in this case, the thioglycoside reactivity is reduced by the electron-withdrawing groups and, furthermore, ester functions can interfere with multi-step strategies. Node's group[4] prepared phenylmethanethiol derivatives while Huang et al.[5] published non-commercial fluorous thiols for thioglycoside preparation. These thiols are effective, but of high molecular weight and require a multi-step preparation. Some other thiols were proposed as odourless deprotecting reagents,[6] such as dimethylamino ethanethiol,[7] and lastly 2-methyl-5-*tert*-butylthiophenol (MbpSH) (Fig. 1). Kumar et al.[8] used this commercially available thiol as an odourless deprotecting agent for nucleotide chemistry. The complete loss of odour is probably due to the presence of a bulky group next to the thiol group. It is non-volatile (bp 260 °C,

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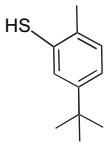


Figure 1. 2-Methyl-5-*tert*-butylthiophenol.

mp −10 °C) and its toxicity (irritant Xi) is largely reduced compared to that of thiophenol (highly toxic T+). This thiol is similar to 2,5-dimethyl phenyl thiol used by Glidersleeve[9] and will, probably, avoid in the same way the glycoside transfer, a major side reaction in deceiving glycosylation reactions.

In the launch of our program on food allergies, which represent a major problem in our society, we were interested in the synthesis of MUXF^3 oligosaccharidic fragments.[10] It is well known that a large part of the population (4% to up to 30%) presents immune reaction to food allergens. This reaction is promoted by the recognition of food glycoproteins by the patient's IgE. In such cases, each patient is a particular case and presents his own recognition pattern of the plant glycoprotein repertoire, a fact which renders the study of allergens rather complicated. In a large number of cases, IgE are directed against the sugar part of the plant or invertebrate protein. In the case of tomato and celery,[11] for example, up to 30% of the allergic patient recognise the *N*-glycan part (Fig. 2). These *N*-glycans are known as 'cross-reactive carbohydrate determinants' CCD.[12] The role of CCD antigens is rather confused in the literature. They are present on glycoprotein but are not harmful,[13] probably due to a generally low density of presented epitopes. The evaluation of their participation to the global allergic response is particularly critical with the recent use of recombinant allergenic protein for diagnosis.[14]

These *N*-glycans are close to the human glycans present on glycoproteins but contain two non-human glycosylation patterns: a *β-D-xylose* in the position 2 of the branched mannose and *α-L-fucose* on the inner chitobioside unit. These two glycosydic linkages, also present in the invertebrate kingdom, are known to be immunogenic.[15]

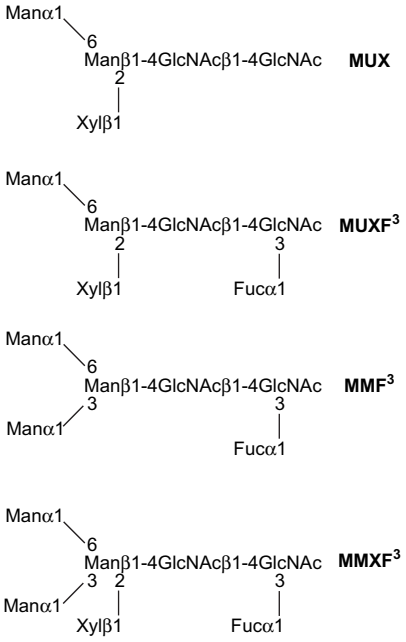


Figure 2. Typical oligosaccharides from plant *N*-glycans.

2. Result and discussion

We thus envisaged a synthetic route towards biotinylated fragments of MUXF^3 oligosaccharides via a novel thiol methodology using MbpSH for the preparation of efficient glycosyl donors required for the synthesis of the two branched trisaccharides **1** (α-Man1→6)[β-Xyl(1→2)]β-Man- and **2** (β-GlcNAc1→4)[α-Fuc(1→3)β-GlcNAc (Fig. 3). These compounds would bear a connector suitable for solid phase diagnosis, whereas, the acid function would be used for bead or plates antigen immobilisation.[16] These syntheses were performed on a large scale, on important sugars (Man, Glc, Fuc, Xyl, GlcNAc) and were based on our previous work and knowledge on mannosides[16] and on glucosamine containing oligosaccharides.[17]

The monosaccharidic building thioglycosides—with or without a participating group in position 2—used in this work are presented in Figure 4.

The syntheses of these building blocks are presented in the following scheme. The glucosyl donor **3** was readily prepared from the corresponding orthoester[18] and MbpSH in presence of catalytic amount of mercuric bromide.[2d] In this reaction, a thiophilic Lewis acid was found to be the optimum choice. Less toxic but more oxophilic Lewis acids, such as TMSOTf, $BF_3 \cdot Et_2O$ or zinc halides, gave less satisfactory results, favouring the formation of the competing ethyl glycoside. Alternatively, a convenient two-step strategy in the absence of mercury salts has also been employed through the 1,2-di-*O*-acetyl analogue **13** (Scheme 1). This method led to a mixture of anomers, which could be used as such for the glycosylation reaction. Due to the fact that a benzoyl group is a better participating group in glycosylations, the acetate group in product **12** was further replaced with a benzoate in high yielding transformations.

The peracyl or perbenzyl thioglycosides were prepared as described in Scheme 2. The key step was the replacement[19]

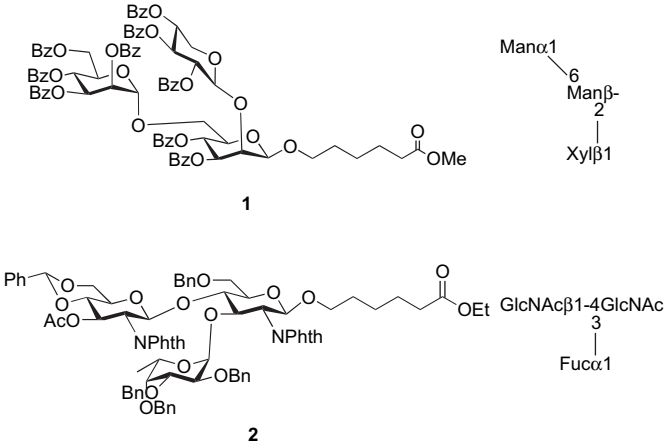


Figure 3. Compounds **1** and **2**.

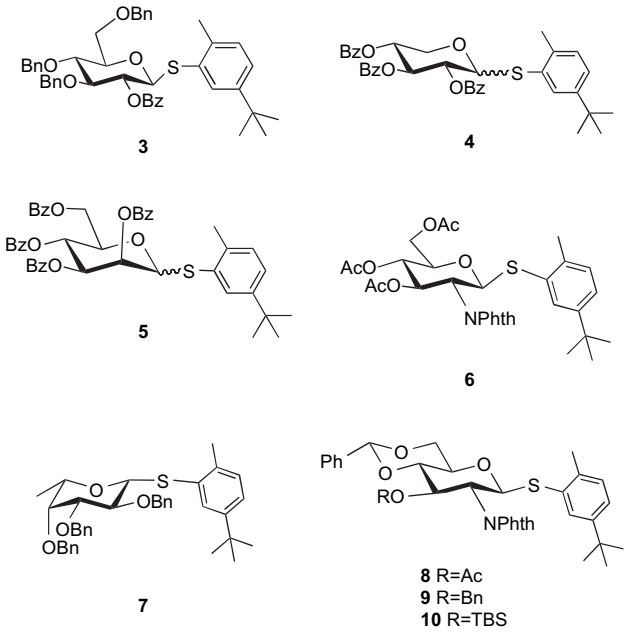
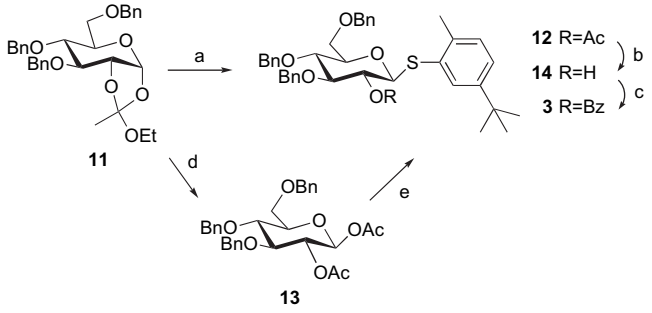
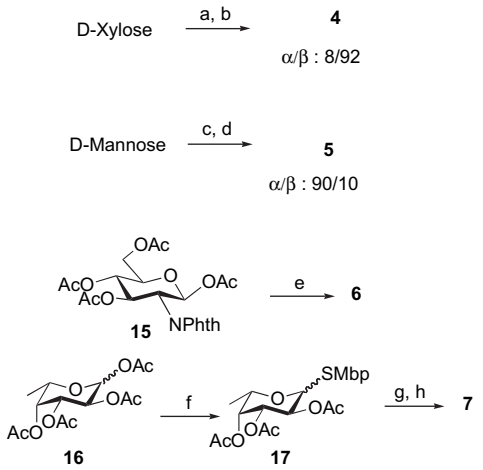


Figure 4. Mbp thioglycosides used in this work.



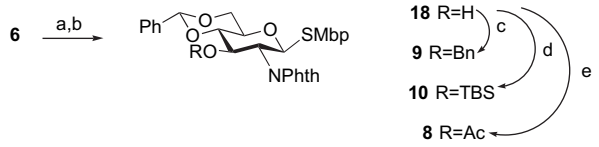
Scheme 1. Reagents and conditions: (a) 2-methyl-5-*tert*-butylthiophenol, $HgBr_2$, toluene, 80 °C, 3 h, 64%; (b) MeONa/MeOH, 40 °C, 12 h, 82%; (c) BzCl, Et_3N, DMAP, CH_2Cl_2, 25 °C, 12 h, 95%; (d) AcOH, rt, 30 min; (e) 2-methyl-5-*tert*-butylthiophenol, $BF_3{\cdot}Et_2O$, toluene, rt, 2 h, 65% (two steps).



Scheme 2. Reagents and conditions: (a) BzCl, pyridine, 85%; (b) MbpSH, $BF_3{\cdot}OEt_2$, CH_2Cl_2, 85%; (c) BzCl, pyridine, 95%; (d) MbpSH, $BF_3{\cdot}OEt_2$, CH_2Cl_2, 88%; (e) MbpSH, $BF_3{\cdot}OEt_2$, CH_2Cl_2, 98%; (f) MbpSH, $BF_3{\cdot}OEt_2$, CH_2Cl_2, 97% (α/β 7:1); (g) MeONa, MeOH, 45 min, rt; then NaH, BnBr, DMF, 2 h, rt, 84% (two steps, pure β anomer).

of the anomeric acyloxy group by the MbpS group in the presence of $BF_3{\cdot}OEt_2$ in D-xylose perbenzoate,[20] D-mannose perbenzoate,[21] 1,3,4,6-tetra-*O* acetyl-2-deoxy-2-phthalimido glucose **15**[22] and L-fucose peracetate **16**.[23]

Compound **6** was deacetylated and was subsequently reacted with benzylaldehyde dimethyl acetal to yield **18**. Three different protecting groups were then used (Ac, Bn, TBS) for the position 3 to give compounds **8**, **9** and **10**, respectively (Scheme 3).



Scheme 3. Reagents and conditions: (a) MeONa, MeOH, 2 h, rt; (b) benzaldehyde dimethylacetal, CSA, CH_3CN, 1 h, 90% (two steps); (c) NaH, BnBr, THF, 3 h, reflux, 63%;[10b] (d) TBSOTf, pyridine, 1 h, rt, 94%; (e) Ac_2O, pyridine, 15 h, rt, 93%.

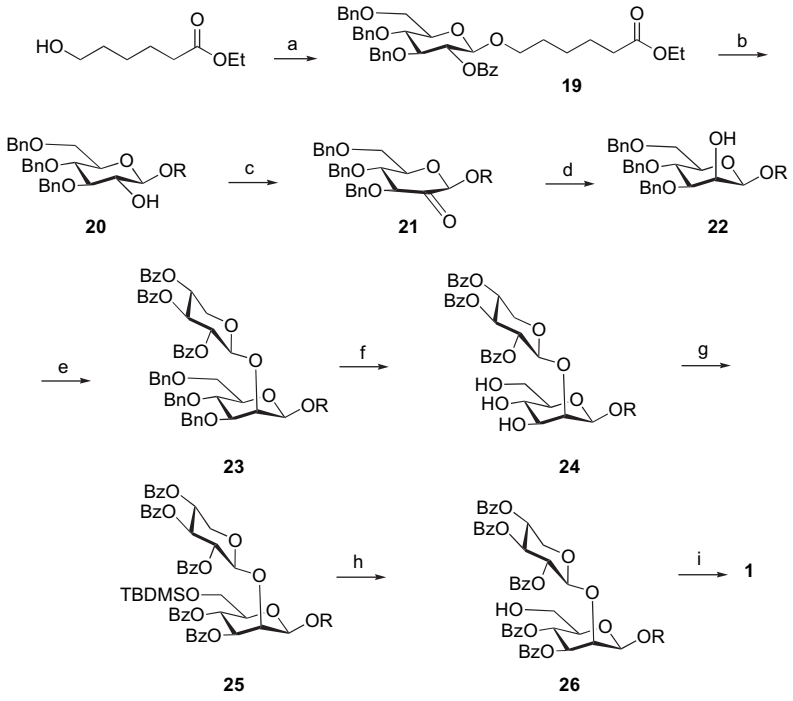
Having all these blocks in hand, we started building up the trisaccharides **1** and **2**. The synthesis of the trisaccharide **1** is depicted in Scheme 4. The β-mannosidic linkage is usually considered to be difficult to construct starting with a mannosyl derivative. In our case, it was quite straightforward to be obtained from a β-glucosyl analogue through an oxidation–reduction sequence, since, upon this process the hydride comes from the less hindered face of the keto group (such as in compound **21**). This strategy is practically convenient when the position 2 is to be glycosylated in the next step as already described for the β(1→2) oligomannoside synthesis.[24] Subsequently, a β-xylopyranosyl unit was introduced on position 2, and the benzyl groups were removed to give compound **24**.

To differentiate the position 6 of the β-manno unit, we decided to selectively silylate this position and to benzoylate in a one-pot method the 3- and 4-positions of this fragment. Using TBAF in THF for the desilylation step of **25**, a complete migration of the 4-benzoate to the 6-position to give compound **27** was observed (Fig. 5). This migration is rather frequent with acetate groups but less frequent with benzoate. Nevertheless, this unwanted reaction was avoided using an acidic fluorine source (aq HF) to afford compound **26**, which was then mannosylated with compound **5** to give trisaccharide **1** in a high yield.

Alternatively, the acetylated glycosyl donor **12** was coupled with ethyl 6-hydroxy hexanoate to give **28** (Fig. 5). As expected, the yield was moderate (69%) compared to the benzoylated donor **3** (97%), validating our choice for the benzoyl group at position 2.

The synthesis of **2**, shown in Scheme 5, illustrates the use of glucosamine **6** and **8** and of the benzylated fucose donors **7**.

The ethyl 6-hydroxy hexanoate was glycosylated (NBS, TfOH) with **6** in a very high yield to give **29**. The acetate groups were removed and an acetal was selected to protect the positions 4 and 6 to give **30**. L-Fucose was subsequently introduced using the glycosyl donor **7** to give **31** (83%) as an α/β mixture, non-separable at this stage (α/β 85:15). The



Scheme 4. Reagents and conditions: (a) **3**, NIS, cat TfOH, CH_2Cl_2, 4 Å MS, rt, 97%; (b) MeONa, MeOH, THF, 2 h, 60 °C, 89%; (c) $(COCl)_2$, DMSO, Et_3N, 45 min, −78 °C; (d) $NaBH_4$, MeOH, CH_2Cl_2, 12 h, rt, 74% (two steps); (e) **4**, NIS, cat. TfOH, CH_2Cl_2, 4 Å MS, rt, 84%; (f) H_2 (1.2 bar), 10% Pd/C, AcOEt, MeOH, 48 h, rt, 92%; (g) TBDMSCl, DMAP, pyridine, 2 h, rt then BzCl, pyridine, 2 h, rt, 70% (two steps, one pot); (g) aq HF, CH_3CN, 12 h, rt, 94%; (i) **5**, NIS, cat. TfOH, CH_2Cl_2, 4 Å MS, rt, 98%. [R=$(CH_2)_5$–CO_2Me].

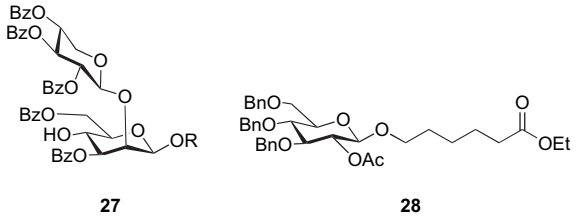


Figure 5. Compounds **27** and **28**.

reductive ring-opening of the benzylidene[25] afforded the pure α-L-fucoside **32**.

The compound **32** was then glycosylated with β-glucosamine donors **8**, **9**, **10**. Like others,[10a] we noticed the low reactivity of acceptors such as compound **32**. We tried different donors with various substituents in position 3 (**8**, **9**, **10**) in order to increase the reactivity with electron donating protecting groups. The yields obtained were rather disappointing and the acetate **8** activated with NIS was found the optimum system (66% yield, 8 g scale). In those glycosylations, elimination reaction was favoured, instead, and the glycal **33**[26] (Fig. 6) was isolated as a major side product.

3. Conclusion

We have described herein a very convenient alternative of usual thioglycosides in glycosylation reactions for the construction of oligosaccharidic fragments **1** and **2**. These carbohydrate units are ready to be then coupled to an amine

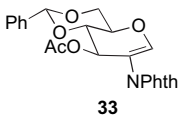
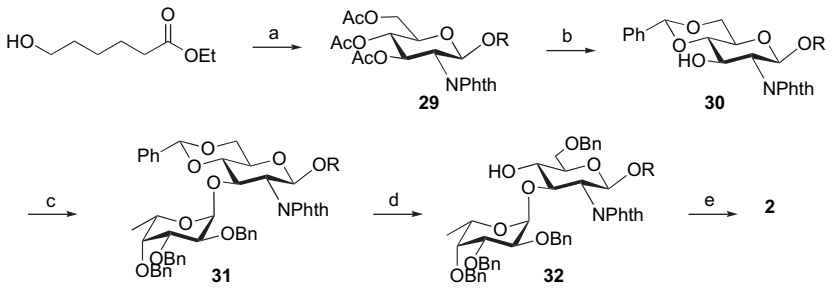


Figure 6. Compound **33**.



Scheme 5. Reagents and conditions: (a) **6**, NBS, TfOH, 4 Å MS, CH_2Cl_2, 99%; (b) EtONa/EtOH; then benzaldehyde dimethylacetal, CSA, CH_3CN, 73% (two steps); (c) **7**, NIS, TfOH, 4 Å MS, CH_2Cl_2, 83% (mixture of α and β fucosides); (d) Et_3SiH, TfOH, 4 Å MS, CH_2Cl_2, −78 °C, 79% (pure α fucoside); (e) **8**, NIS, TfOH, 4 Å MS, CH_2Cl_2, 66%. [R=$(CH_2)_5$–CO_2Et].

derived from biotin (such as biotin hydrazide) and evaluated as synthetic antigen in allergy diagnosis. The Mbp donors, used in our synthesis, are stable and often crystalline compounds. Their handling does not require special equipment nor special expertise in thiol manipulation. We are currently exploiting this novel thiol methodology in solution and solid phase synthesis of oligosaccharides.

4. Experimental section

4.1. General procedures

All compounds were homogeneous by TLC analysis and had spectral properties consistent with their assigned structures. Melting points were determined in capillary tubes in a Büchi 510 apparatus. Optical rotations were measured with a Perkin–Elmer Model 241 digital polarimeter at 22±3 °C. Compound purity was checked by TLC on Silica gel 60 F_{254} (E. Merck) with detection by charring with sulfuric acid. Column chromatography was performed on Silica gel 60 (E. Merck). ^{1}H and ^{13}C NMR spectra were recorded with Brüker AM 250, AM 400 instruments. Chemical ionisation and FAB mass spectrometry were recorded with Jeol MS700: CI (gas: ammonia); FAB (matrix: NBA, NaI). NIS was purchased from Fluka [ref. 58070]. Carboxypentyl chain was numbered 7 (OCH_2) to 11 in NMR assignments.

4.1.1. 5-Methoxycarbonylpentyl 2-O-(2,3,4-tri-O-benzoyl-β-D-xylopyranosyl)-3,4-di-O-benzoyl-6-O-(2,3,4,6-tetra-O-benzoyl-α-D-mannopyranosyl)-β-D-mannopyranoside (1)

To a mixture of **26** (0.895 g, 0.932 mmol), **5** (0.848 g, 1.118 mmol, 1.2 equiv) and 4 Å molecular sieves (1 g) in anhydrous dichloromethane (6 mL) under argon, were added NIS (0.419 g, 1.864 mmol, 2 equiv) and TfOH (0.016 mL, 0.184 mmol, 0.2 equiv). The mixture was allowed to stir for 10 min and was then filtered, extracted with dichloromethane and washed with saturated $NaHCO_3$ and $Na_2S_2O_3$ solutions. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 1.409 g of **1** (98%) as white solid. R_f: 0.32 (cyclohexane/EtOAc 7:3). Mp: 98 °C. $[\alpha]_D^{25}$ −110 (*c* 1.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.18–7.30 (m, 45H, H Ar), 6.18 (t, 1H, $J_{H4''-H3''}=J_{H4''-H5''}=10.0$ Hz, $H_{4''}$), 5.90 (dd, 1H, $J_{H3''-H2''}=3.2$ Hz, $J_{H3''-H4''}=10.0$ Hz, $H_{3''}$), 5.84 (t, 1H, $J_{H4-H3}=J_{H4-H5}=10.1$ Hz, H_4), 5.70 (t, 1H, $J_{H3'-H4'}=J_{H3'-H2'}=4.7$ Hz, $H_{3'}$), 5.62–5.59 (m, 2H, $H_{2'}$, $H_{2''}$), 5.38 (dd, 1H, $J_{H3-H4}=10.1$ Hz, $J_{H3-H2}=3.2$ Hz, H_3), 5.28 (d, 1H, $J_{H1'-H2'}=3.0$ Hz, $H_{1'}$), 5.17 (m, 1H, $H_{4'}$), 5.06 (d, 1H, $J_{H1''-H2''}=1.8$ Hz, $H_{1''}$), 4.83 (s, 1H, H_1), 4.82–4.60 (m, 2H, H_2, $H_{6a''}$), 4.48 (dd, 1H, $J_{gem}=12.9$ Hz, $J_{H5a'-H4'}=2.9$ Hz, $H_{5a'}$), 4.46–4.41 (m, 2H, $H_{5''}$, $H_{6b''}$), 4.03–3.93 (m, 2H, H_5, H_{7a}), 3.76 (dd, 1H, $J_{gem}=12.0$ Hz, $J_{H6a-H5}=7.1$ Hz, H_{6a}), 3.67 (dd, 1H, $J_{gem}=12.8$ Hz, $J_{H6b-H5}=2.6$ Hz, H_{6b}), 3.65 (s, 3H, OMe), 3.59 (dt, 1H, $J_{gem}=9.3$ Hz, $J_{H7b-H8}=6.5$ Hz, H_{7b}), 3.42 (dd, 1H, $J_{gem}=12.7$ Hz, $J_{H5b'-H4'}=2.9$ Hz, $H_{5b'}$), 2.20 (t, 2H, $J_{H11-H10}=7.8$ Hz, H_{11}), 1.69–1.52 (m, 2H, H_8 or H_{10}), 1.38–1.30 (m, 2H, H_9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.9 (CO COOMe), 165.9 (2CO Bz), 165.4 (CO Bz), 165.3 (CO Bz), 165.2 (CO Bz), 165.2 (CO Bz), 165.1 (CO Bz), 165.0 (CO Bz), 164.4 (CO Bz), 133.3–128.0 (54C, C Ar), 100.0 ($C_{1'}$), 99.9 (C_1), 97.2 ($C_{1''}$), 75.3 (C_2), 73.4 (C_3), 73.3 (C_5), 70.2 ($C_{2''}$), 69.7 ($C_{3''}$), 69.6 (C_7), 68.7 ($C_{5''}$), 68.5 ($C_{2'}$), 68.1 ($C_{4'}$), 68.0 ($C_{3'}$), 67.7 (C_6), 67.3 (C_4), 66.5 ($C_{4''}$), 62.2 ($C_{6''}$), 59.3 ($C_{5'}$), 51.2 (OMe), 33.6 (C_{11}), 29.0 (C_8), 25.6 (C_9), 24.5 (C_{10}). MS FAB$^+$-HRMS *m/z* $[M+Na]^+$ calcd for $C_{87}H_{78}O_{26}Na$ 1561.4679, found 1561.4692.

4.1.2. 5-Ethoxycarbonylpentyl 4-O-(3-O-acetyl-4,6-O-benzylidene-2-deoxy-2-phthalimido-β-D-glucopyranosyl)-3-O-(2,3,4-tri-O-benzyl-α-L-fucopyranosyl)-6-O-benzyl-2-deoxy-2-phthalimido-β-D-glucopyranoside (2)

To a mixture of **32** (8.860 g, 9.240 mmol), **8** (11.11 g, 18.49 mmol, 2.0 equiv) and 4 Å molecular sieves (15 g) in anhydrous dichloromethane (90 mL), were added under argon, NIS (1.951 g, 8.672 mmol, 2.0 equiv) and TfOH (0.082 mL, 0.924 mmol, 0.1 equiv). After 2 min the mixture was filtered, extracted with dichloromethane and washed with saturated $NaHCO_3$ and $Na_2S_2O_3$ solutions. The organic layer was dried ($MgSO_4$), filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give a mixture of **2** and **33**. This mixture was purified by column chromatography on silica gel (dichloromethane) to give 8.39 g of **2** (66%) as a white amorphous solid. R_f: 0.22 (cyclohexane/EtOAc 7:3). $[\alpha]_D^{25}$ −36 (*c* 1.9, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.00–7.22 (m, 33H, H Ar), 5.86 (dd, 1H, $J_{H3''-H2''}=J_{H3''-H4''}=9.6$ Hz, $H_{3''}$), 5.65 (d, 1H, $J_{H1''-H2''}=8.3$ Hz, $H_{1''}$), 5.35 (s, 1H, H benzylidene), 5.11 (d, 1H, $J_{H1-H2}=8.5$ Hz, H_1), 5.07 (d, 1H, $J_{H1'-H2'}=2.8$ Hz, $H_{1'}$), 4.92 (d, 1H, $J_{gem}=11.4$ Hz, CHPh), 4.71 (m, 2H, 2CHPh), 4.63 (d, 1H, $J_{gem}=11.4$ Hz, CHPh), 4.58–4.48 (m, 3H, 2CHPh, 1H), 4.43–4.25 (m, 6H, H_2, $H_{2''}$, 2CHPh, $H_{5'}$, 1H), 4.16–4.06 (m, 3H, $1H_6$, CH_2 OEt), 3.87–3.73 (m, 5H, $H_{2'}$, $1H_6$, H_7, 2H), 3.68–3.56 (m, 3H, $2H_6$, 1H), 3.44–3.32 (m, 3H, H_7, 2H), 1.98 (m, 2H, H_{11}), 1.91 (s, 3H, CH_3 OAc), 1.44–1.37 (m, 4H, H_8, H_{10}), 1.30 (d, 3H, $J_{H6'-H5'}=6.4$ Hz, $H_{6'}$), 1.25 (t, 3H, $J=7.2$ Hz, CH_3 OEt), 1.10 (m, 2H, H_9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.2 (CO COOEt), 170.0 (CO OAc), 168.6 (CO Phth), 167.8 (CO Phth), 138.6–123.1 (C Ar), 101.3 (C benzylidene), 97.9 (C_1), 97.6 ($C_{1'}$), 96.1 ($C_{1''}$), 79.4, 79.0, 78.2, 75.8, 74.9, 74.8 (CH_2Ph), 74.4, 73.9, 72.6 (CH_2Ph), 72.5 ($2CH_2$Ph), 69.7 ($C_{3''}$), 68.9 (C_7), 68.4 ($1C_6$), 68.3 ($1C_6$), 66.9, 65.8, 59.9 (CH_2 OEt), 55.8 (C_2 or $C_{2''}$), 55.6 (C_2 or $C_{2''}$), 33.8 (C_{11}), 28.7 (C_8 or C_{10}), 25.2 (C_9), 24.3 (C_8 or C_{10}), 20.4 (CH_3 OAc), 16.9 ($C_{6'}$), 14.1 (CH_3 OEt). MS FAB$^+$-HRMS *m/z* $[M+Na]^+$ calcd for $C_{79}H_{82}N_2O_{20}Na$ 1401.5359, found 1401.5370.

4.1.3. (2-Methyl-5-tert-butylphenyl) 2-O-benzoyl-3,4,6-tri-O-benzyl-1-thio-β-D-glucopyranoside (3)

To a mixture of **14** (16.20 g, 26.47 mmol), DMAP (0.640 g, 5.294 mmol, 0.2 equiv) in anhydrous dichloromethane (100 mL) were added at 0 °C, under argon, triethylamine (26.0 mL, 185.3 mmol, 7 equiv) and benzoyl chloride

(9.22 mL, 79.41 mmol, 3 equiv). The mixture was heated with stirring at 40 °C for 12 h. The mixture was allowed to cool down to room temperature, the product was extracted with dichloromethane, washed with HCl (1 M) and neutralised with a saturated $NaHCO_3$ solution. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 9:1) to give 18.10 g of **3** (95%) as a white solid. R_f: 0.43 (cyclohexane/EtOAc 9:1). Mp: 72 °C. $[\alpha]_D^{25}$ −42 (*c* 1.5, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 8.19–7.19 (m, 23H, H Ar), 5.51 (dd, 1H, J_{H2-H1}=10.0 Hz, J_{H2-H3}=9.0 Hz, H_2), 4.96 (d, 1H, J_{gem}=10.0 Hz, CHPh), 4.89 (d, 1H, J_{H1-H2}=10.0 Hz, H_1), 4.87 (d, 1H, J_{gem}=11.0 Hz, CHPh), 4.81 (d, 1H, J_{gem}=11.0 Hz, CHPh), 4.75 (d, 1H, J_{gem}=12.0 Hz, CHPh), 4.72 (d, 1H, J_{gem}=11.0 Hz, CHPh), 4.70 (d, 1H, J_{gem}=12.0 Hz, CHPh), 3.99 (t, 1H, J_{H3-H2}=J_{H3-H4}=9.0 Hz, H_3), 3.88 (m, 1H, H_4), 3.92 (m, 2H, H_{6a}, H_{6b}), 3.73 (m, 1H, H_5), 2.33 (s, 3H, CH_3), 1.39 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 165.1 (CO Bz), 149.4–124.6 (30C, C Ar), 87.2 (C_1), 84.2 (C_3), 79.2 (C_5), 77.6 (C_4), 75.1 (CH_2Ph), 74.9 (CH_2Ph), 73.3 (CH_2Ph), 72.4 (C_2), 68.6 (C_6), 34.2 (Cq *t*-Bu), 31.1 (*t*-Bu), 20.1 (CH_3). MS FAB$^+$-HRMS *m/z* $[M+Na]^+$ calcd for $C_{45}H_{48}O_6SNa$ 739.3069, found 739.3055.

4.1.4. (2-Methyl-5-tert-butylphenyl) 2,3,4-tri-O-benzoyl-1-thio-β-D-xylopyranoside (4)

Benzoyl chloride (17.0 mL, 146.6 mmol, 4.4 equiv) was added dropwise to a cooled (0 °C) solution of D-xylose (5 g, 33.3 mmol, 1 equiv) in pyridine (30 mL). The reaction mixture was stirred for 12 h at room temperature and concentrated. A solution of the residue in dichloromethane was washed with aq HCl, water and sodium hydrogen carbonate, dried over $MgSO_4$ and concentrated. The residue was crystallised in ethanol to give pentabenzoyl α,β-D-xylopyranose (16.0 g, 85%; α/β 85:15). To a solution of 1,2,3,4-tetra-*O*-benzoyl-D-xylopyranose (2.000 g, 3.533 mmol, 1 equiv) in anhydrous dichloromethane (23 mL), were added under argon, 2-methyl-5-*tert*-butylthiophenol (0.973 mL, 5.30 mmol, 1.5 equiv) and $BF_3 \cdot Et_2O$ (2.20 mL, 17.66 mmol, 5 equiv). The mixture was allowed to stir overnight and was neutralised with a saturated $NaHCO_3$ solution at 0 °C. The product was extracted with dichloromethane, the organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 1.870 g of **4** (85%) as a white foam containing 2 anomers (α/β 8:92). R_f: 0.42 (cyclohexane/EtOAc 7:3). β anomer: ^1H NMR (400 MHz, $CDCl_3$) δ: 8.08–7.40 (m, 18H, H Ar), 5.88 (t, 1H, J_{H3-H2}=J_{H3-H4}=6.5 Hz, H_3), 5.63 (t, 1H, J_{H2-H3}=J_{H2-H1}=6.5 Hz, H_2), 5.41 (ddd, 1H, J_{H4-H3}=6.5 Hz, J_{H4-H5b}=7.0 Hz, J_{H4-H5a}=4.0 Hz, H_4), 5.54 (d, 1H, J_{H1-H2}=6.5 Hz, H_1), 4.80 (dd, 1H, J_{gem}=12.1 Hz, J_{H5a-H4}=4.0 Hz, H_{5a}), 3.87 (dd, 1H, J_{gem}=12.1 Hz, J_{H5b-H4}=7.0 Hz, H_{5b}), 2.42 (s, 3H, CH_3), 1.37 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 165.4 (CO Bz), 165.1 (CO Bz), 165.0 (CO Bz), 149.4–124.6 (24C, C Ar), 86.8 (C_1), 70.6 (C_3), 70.2 (C_5), 77.6 (C_2), 68.7 (C_4), 63.6 (C_5), 34.3 (Cq *t*-Bu), 31.2 (*t*-Bu), 20.2 (CH_3). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{37}H_{40}NO_7S$ 642.2524, found 642.2529.

4.1.5. (2-Methyl-5-tert-butylphenyl) 2,3,4,6-tetra-O-benzoyl-1-thio-α-D-mannopyranoside (5)

Benzoyl chloride (17 mL, 146.6 mmol, 4.4 equiv) was added dropwise to a cooled (0 °C) solution of D-mannose (5 g, 27.8 mmol, 1 equiv) in pyridine (30 mL). The reaction mixture was stirred for 12 h at room temperature and concentrated. A solution of the residue in dichloromethane was washed with aq HCl, water, a saturated $NaHCO_3$ solution, dried over $MgSO_4$ and concentrated. The reside was crystallised in ethanol to give pentabenzoyl α-D-mannopyranose (18.5 g, 95%) To a solution of 1,2,3,4,6-penta-*O*-benzoyl-D-mannopyranose (5.000 g, 7.142 mmol) in anhydrous dichloromethane (10 mL), were added under argon, 2-methyl-5-*tert*-butylthiophenol (1.97 mL, 10.71 mmol, 1.5 equiv) and $BF_3 \cdot Et_2O$ (4.52 mL, 35.71 mmol, 5 equiv). The mixture was allowed to stir overnight and was neutralised with a saturated $NaHCO_3$ solution at 0 °C. The product was extracted with dichloromethane, the organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 9:1) to give 4.780 g of **5** (88%) as a white foam containing 2 anomers (α/β 8.4:1). α anomer: R_f: 0.26 (cyclohexane/EtOAc 9:1). ^1H NMR (400 MHz, $CDCl_3$) δ: 8.16–7.40 (m, 23H, H Ar), 6.35 (t, 1H, J_{H3-H4}=10.1 Hz, J_{H4-H5}=10.0 Hz, H_4), 6.12 (dd, 1H, J_{H2-H3}=3.2 Hz, J_{H2-H1}=1.6 Hz, H_2), 6.04 (dd, 1H, J_{H3-H4}=10.1 Hz, J_{H2-H3}=3.2 Hz, H_3), 5.80 (d, 1H, J_{H1-H2}=1.6 Hz, H_1), 4.78 (dd, 1H, $J_{H6a-H6b}$=12.0 Hz, J_{H5-H6a}=2.6 Hz, H_{6a}), 4.64 (dd, 1H, $J_{H6a-H6b}$=12.0 Hz, J_{H5-H6b}=3.7 Hz, H_{6b}), 2.58 (s, 3H, CH_3), 1.47 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 166.0 (CO Bz), 165.4 (CO Bz), 165.3 (CO Bz), 165.2 (CO Bz), 149.9–123.0 (30C, C Ar), 86.0 (C_1), 72.3 (C_2), 70.4 (C_3), 70.1 (C_5), 66.8 (C_4), 62.7 (C_6), 34.3 (Cq *t*-Bu), 31.2 (3C, *t*-Bu), 20.4 (CH_3). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{45}H_{46}NO_9S$ 776.2893, found 776.2896.

4.1.6. (2-Methyl-5-tert-butylphenyl) 3,4,6-tri-O-acetyl-2-deoxy-2-phthalimido-1-thio-β-D-glucopyranoside (6)

To a mixture of 1,3,4,6-tetra-*O*-acetyl-2-deoxy-2-phthalimido-D-glucopyranose **15** (4.010 g, 8.400 mmol) and 2-methyl-5-*tert*-butylthiophenol (2.32 mL, 12.61 mmol, 1.5 equiv) in anhydrous dichloromethane under argon was added $BF_3 \cdot Et_2O$ (5.33 mL, 25.20 mmol, 5 equiv). The mixture was stirred overnight at room temperature and excess $BF_3 \cdot Et_2O$ was neutralised with a saturated $NaHCO_3$ solution at 0 °C. The product was extracted with dichloromethane. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 4.95 g of **6** (98%) as a white solid. R_f: 0.61 (cyclohexane/EtOAc 5:5). Mp: 69 °C. $[\alpha]_D^{25}$ +54 (*c* 1.1, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 7.86 (br m, 2H, H Phth), 7.75 (m, 2H, H Phth), 7.47 (d, 1H, J_{a-c}=1.9 Hz, H_a), 7.21 (dd, 1H, J_{c-b}=8.0 Hz, H_c), 7.06 (d, 1H, H_b), 5.82 (dd, 1H, J_{H3-H2}=J_{H3-H4}=

9.7 Hz, H_3), 5.65 (d, 1H, J_{H1-H2}=10.6 Hz, H_1), 5.20 (dd, 1H, J_{H4-H5}=9.6 Hz, H_4), 4.42 (dd, 1H, H_2), 4.34 (dd, 1H, J_{gem}=12.3 Hz, J_{H6-H5}=4.6 Hz, H_6), 4.16 (dd, 1H, J_{H6-H5}= 1.9 Hz, H_6), 3.88 (m, 1H, H_5), 2.15 (s, 3H, CH_3), 2.09 (s, 3H, CH_3 OAc), 2.01 (s, 3H, CH_3 OAc), 1.84 (s, 3H, CH_3 OAc), 1.27 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 170.4 (CO OAc), 169.8 (CO OAc), 169.1 (CO OAc), 167.5 (CO Phth), 166.7 (CO Phth), 149.3, 137.4, 134.2, 134.1, 131.3, 130.9, 130.8, 130.2, 129.8, 125.5, 123.5, 123.4 (C Ar), 84.1 (C_1), 75.6 (C_5), 71.4 (C_3), 68.4 (C_4), 62.0 (C_6), 53.5 (C_2), 34.1 (Cq *t*-Bu), 31.0 (*t*-Bu), 20.5 (CH_3), 20.4 (CH_3), 20.2 (CH_3), 20.0 (CH_3). MS FAB$^+$-HRMS *m/z* $[M+Na]^+$ calcd for $C_{31}H_{35}NO_9SNa$ 620.1930, found 620.1935.

4.1.7. (2-Methyl-5-tert-butylphenyl) 2,3,4-tri-O-benzyl-1-thio-β-L-fucopyranoside (7)

Compound **17** (19.21 g, 41.04 mmol) was dissolved in anhydrous methanol (80 mL) under argon. Sodium (0.188 g, 0.2 equiv) was added. After 45 min, the mixture was neutralised (IR 120H$^+$), filtered and the solvent was evaporated to give a white foam. [R_f: 0.55 (dichloromethane/methanol 9:1)]. The crude product was dissolved in anhydrous DMF (140 mL) under argon and benzyl bromide was added (3.91 mL, 117.1 mmol, 3.5 equiv). The mixture was cooled at 0 °C and NaH (60% dispersion in mineral oil, 5.35 g, 133.8 mmol, 4 equiv) was added slowly portionwise. The mixture allowed warming up to room temperature overnight. The excess benzyl bromide and NaH was quenched with methanol. The solvent was evaporated and the residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 95:5) to give 17.33 g of **7** (84%, β anomer only) as a white solid. R_f: 0.46 (cyclohexane/EtOAc 9:1). Mp: 62–63 °C. $[\alpha]_D^{25}$ +1.6 (*c* 2.1, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.99–7.32 (m, 18H, H Ar), 5.22 (d, 1H, J_{gem}=11.8 Hz, CHPh), 5.13 (d, 1H, J_{gem}=10.3 Hz, CHPh), 5.05 (d, 1H, J_{gem}=10.3 Hz, CHPh), 4.96 (m, 3H, 3CHPh), 4.82 (d, 1H, J_{H1-H2}=9.8 Hz, H_1), 4.20 (dd, 1H, J_{H1-H2}=J_{H2-H3}=9.8 Hz, H_2), 3.85 (d, 1H, J_{H4-H3}=2.7 Hz, H_4), 3.80 (dd, 1H, H_3), 3.69 (q, 1H, J_{H5-H6}=6.3 Hz, H_5), 2.63 (s, 3H, CH_3 thio), 1.50 (s, 9H, *t*-Bu), 1.46 (d, 3H, *J*=6.3 Hz, H_6). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 148.9 (Cq Ar), 138.3 (Cq Ar), 138.2 (Cq Ar), 138.1 (Cq Ar), 135.4 (Cq Ar), 133.5 (Cq Ar), 129.4–123.8 (C Ar), 87.7 (C_1), 84.4 (C_3), 77.3 (C_2), 76.0 (C_4), 75.4 (CHPh), 74.3 (CHPh), 74.2 (C_5), 72.7 (CHPh), 34.2 (Cq *t*-Bu), 31.0 (*t*-Bu), 20.1 (CH_3 thio), 17.1 (C_6). MS FAB$^+$-HRMS *m/z* $[M+Na]^+$ calcd for $C_{38}H_{44}O_4SNa$ 619.2859, found 619.2862.

4.1.8. (2-Methyl-5-tert-butylphenyl) 3-O-acetyl-4,6-O-benzylidene-2-deoxy-2-phthalimido-1-thio-β-D-glucopyranoside (8)

To a solution of **18** (1.600 g, 2.857 mmol) in anhydrous pyridine (10 mL) was added acetic anhydride (0.9 mL) under argon and the mixture was allowed to stir overnight. The solvents were evaporated and the residue was extracted with dichloromethane, washed with an aq HCl solution (1 M) and neutralised with a saturated $NaHCO_3$ solution. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 1.60 g of **8** (93%) as a white solid. R_f: 0.47 (cyclohexane/EtOAc 7:3). Mp: 173–174 °C. $[\alpha]_D^{25}$ +46 (*c* 1.1, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.00–7.20 (m, 12H, H Ar), 5.99 (dd, 1H, J_{H3-H2}= J_{H3-H4}=9.4 Hz, H_3), 5.81 (d, 1H, J_{H1-H2}=10.6 Hz, H_1), 5.61 (s, 1H, H benzylidene), 4.49 (dd, 1H, H_2), 4.45 (dd, 1H, J_{gem}=10.1 Hz, J_{H6-H5}=4.2 Hz, H_6), 3.95–3.80 (m, 3H, H_4, H_5, $H_{6'}$), 2.21 (s, 3H, CH_3 thio), 1.94 (s, 3H, CH_3 OAc), 1.33 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 170.0 (CO OAc), 167.6 (CO Phth), 167.1 (CO Phth), 149.5–123.5 (C Ar), 101.5 (C benzylidene), 84.6 (C_1), 79.0, 70.5 (C_3), 70.3, 68.5 (C_6), 54.3 (C_2), 34.3 (Cq *t*-Bu), 31.1 (*t*-Bu), 20.5 (CH_3 OAc), 20.1 (CH_3 thio). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{34}H_{39}N_2O_7S$ 619.2478, found 619.2474.

4.1.9. (2-Methyl-5-tert-butylphenyl) 3-O-benzyl-4,6-O-benzylidene-2-deoxy-2-phthalimido-1-thio-β-D-glucopyranoside (9)

Compound **18** (1.000 g, 1.788 mmol) was dissolved in anhydrous THF (10 mL) under argon. Benzyl bromide (0.32 mL, 2.680 mmol, 1.5 equiv) was added and NaH (60% dispersion in mineral oil, 0.085 g, 3.576 mmol, 2.0 equiv) was added slowly portionwise. The mixture was then heated at reflux for 3 h, after this time, the mixture was allowed to cool down at room temperature and the excess benzyl bromide and NaH was destroyed with methanol. The solvents were evaporated. The product was extracted with dichloromethane and washed with water. The organic layer was dried over $MgSO_4$, filtered and evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 8:2) to give 0.731 g of **9** (63%) as a white foam. R_f: 0.66 (cyclohexane/EtOAc 7:3). $[\alpha]_D^{25}$ +57 (*c* 1.9, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.56–6.91 (17H, H Ar), 5.68 (s, 1H, H benzylidene), 5.59 (d, 1H, J_{H1-H2}=10.5 Hz, H_1), 4.83 (d, 1H, J_{gem}=12.3 Hz, CHPh), 4.57–4.38 (m, 4H, CHPh, H_2, H_4, H_6), 3.94 (m, 2H, H_3, $H_{6'}$), 3.74 (m, 1H, H_5), 2.15 (s, 3H, CH_3), 1.30 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149–123 (C Ar), 101.7 (C benzylidene), 85.2 (C_1), 83.3 (C_3), 75.9 (C_4), 74.6 (CHPh), 70.7 (C_5), 69.1 (C_6), 55.3 (C_2), 34.8 (Cq *t*-Bu), 31.6 (*t*-Bu), 20.5 (CH_3). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{39}H_{43}N_2O_6S$ 667.2842, found 667.2836.

4.1.10. (2-Methyl-5-tert-butylphenyl) 4,6-O-benzylidene-3-O-tert-butyldimethylsilyl-2-deoxy-2-phthalimido-1-thio-β-D-glucopyranoside (10)

Compound **18** (3.080 g, 5.510 mmol) was dissolved in anhydrous pyridine (6 mL) and TBDMSOTf (2.53 mL, 11.02 mmol, 2 equiv) was added at room temperature under argon. The mixture was stirred for 1 h, the solvent was evaporated and the residue was extracted with dichloromethane, washed with a HCl solution (1 M) and neutralised with a saturated $NaHCO_3$ solution. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 9:1) to give 3.49 g of **10** (94%) as a white foam. R_f: 0.44

(cyclohexane/EtOAc 9:1). $[\alpha]_D^{25}$ +51 (*c* 2.4, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 8.00–7.07 (m, 12H, H Ar), 5.63 (d, 1H, J_{H1-H2}=10.7 Hz, H_1), 5.60 (s, 1H, H benzylidene), 4.74 (dd, 1H, J_{H3-H4}=J_{H3-H2}=9.0 Hz, H_3), 4.46 (dd, 1H, H_2), 4.41 (dd, 1H, J_{gem}=10.4 Hz, J_{H6-H5}=4.8 Hz, H_6), 3.90 (dd, 1H, J_{gem}=10.4 Hz, J_{H6-H5}=10.0 Hz, $H_{6'}$), 3.75 (ddd, 1H, J_{H5-H4}= 9.2 Hz, H_5), 3.68 (dd, 1H, H_4), 2.18 (s, 3H, CH_3 thio), 1.32 (s, 9H, *t*-Bu), 0.65 (s, 9H, *t*-Bu TBS), −0.06 (s, 3H, CH_3 TBS), −0.23 (s, 3H, CH_3 TBS). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.2, 167.3 (CO Phth), 149.0–123.0 (C Ar), 101.9 (C benzylidene), 85.0 (C_1), 82.5 (C_4), 70.6 (C_3), 70.3 (C_5), 68.6 (C_6), 56.8 (C_2), 34.3 (Cq *t*-Bu), 31.1 (*t*-Bu), 25.3 (*t*-Bu TBS), 20.1 (CH_3 thio), 17.6 (Cq *t*-Bu TBS), −4.2 (CH_3 TBS), −5.3 (CH_3 TBS). MS DCI^+-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{38}H_{51}N_2O_6SSi$ 691.3237, found 691.3232.

4.1.11. (2-Methyl-5-tert-butylphenyl) 2-O-acetyl-3,4,6-tri-O-benzyl-1-thio-β-D-glucopyranoside (12)

To a mixture of 1,2-*O*-(1-ethoxyethylene) 3,4,6-*O*-benzyl-β-D-glucopyranose **11** (0.490 g, 0.970 mmol) and 2-methyl-5-*tert*-butylthiophenol (0.356 mL, 1.940 mmol, 2 equiv) in anhydrous toluene (5 mL) was added under argon, mercury bromide (0.035 g, 0.097 mmol, 0.1 equiv). The mixture was stirred at 80 °C overnight and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 9:1) to give 410 mg of **12** (64%) as a white foam. R_f: 0.40 (cyclohexane/EtOAc 9:1). *Alternative preparation*: A solution of the 1,2-*O*-(1-ethoxyethylene) 3,4,6-*O*-benzyl-β-D-glucopyranose **11** (10.6 g, 20.98 mmol) in acetic acid (20 mL) was stirred for 30 min at room temperature and was concentrated. 2-Methyl-5-*tert*-butylthiophenol (4.63 mL, 25.18 mmol, 1.2 equiv) and $BF_3{\cdot}Et_2O$ (5.3 ml, 41.96 mmol, 2 equiv) were added to a solution of the residue in toluene (20 mL). The solution was stirred for 2 h, neutralised with aq hydrogen carbonate (200 mL) and diluted with dichloromethane. The organic layer was separated, dried over $MgSO_4$ and concentrated. The residue was purified by column chromatography on silica gel to give 8.9 g of **12** (65%). $[\alpha]_D^{25}$ +15 (*c* 2.2, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 8.29–7.30 (m, 18H, H Ar), 5.38 (t, 1H, J_{H2-H1}=J_{H2-H3}=10.0 Hz, H_2), 5.04 (d, 1H, J_{gem}=11.4 Hz, CHPh), 5.02 (d, 1H, J_{gem}=10.7 Hz, CHPh), 4.92 (d, 1H, J_{gem}=10.7 Hz, CHPh), 4.83 (d, 1H, H_1), 4.78 (d, 1H, J_{gem}=10.7 Hz, CHPh), 4.76 (d, 1H, J_{gem}=12.7 Hz, CHPh), 4.72 (d, 1H, J_{gem}=12.7 Hz, CHPh), 3.99–3.95 (m, 3H, H_4, H_{6a}, H_{6b}), 3.94 (t, 1H, J_{H3-H2}=J_{H3-H4}=10.0 Hz, H_3), 3.73 (m, 1H, H_5), 2.69 (s, 3H, CH_3 thio), 2.20 (s, 3H, CH_3 OAc), 1.52 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 169.0 (CO OAc), 149.2–124.3 (24C, C Ar), 86.5 (C_1), 84.1 (C_3), 78.9 (C_5), 77.4 (C_4), 74.8 (CH_2Ph), 73.6 (CH_2Ph), 73.0 (CH_2Ph), 71.5 (C_2), 68.3 (C_6), 34.0 (Cq *t*-Bu), 30.9 (*t*-Bu), 20.5 (CH_3 OAc), 19.9 (CH_3 thio). MS DCI^+ *m/z* $[M+NH_4]^+$ calcd for $C_{40}H_{50}NO_6S$ 672.3, found 672.3.

4.1.12. (2-Methyl-5-tert-butylphenyl) 3,4,6-tri-O-benzyl-1-thio-β-D-glucopyranoside (14)

Compound **12** (3.370 g, 5.153 mmol) was dissolved in anhydrous methanol (25 mL) and anhydrous THF (5 mL) under argon. Sodium (0.059 g, 2.565 mmol, 0.5 equiv) was added. After 12 h, the mixture was neutralised (IR $120H^+$), filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 9:1) to give 2.580 g of **14** (82%) as a white solid. R_f: 0.4 (cyclohexane/EtOAc 9:1). Mp: 94 °C. $[\alpha]_D^{25}$ −24 (*c* 1.0, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 7.83–7.27 (m, 18H, H Ar), 5.10 (d, 1H, J_{gem}=11.0 Hz, CHPh), 5.00 (d, 1H, J_{gem}= 11.0 Hz, CHPh), 4.99 (d, 1H, J_{gem}=10.0 Hz, CHPh), 4.76–4.69 (m, 3H, CHPh), 4.68 (d, 1H, J_{H1-H2}=12.0 Hz, H_1), 3.92–3.85 (m, 2H, $H_{6a,}$ H_{6b}), 3.81–3.73 (m, 3H, H_4, H_3, H_2), 3.67 (m, 1H, H_5), 2.68 (d, 1H, J_{OH-H2}=1.5 Hz, OH C_2), 2.56 (s, 3H, CH_3), 1.43 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.4–124.7 (24C, C Ar), 88.6 (C_1), 85.9 (C_2), 78.1 (C_5), 77.3 (C_4), 75.1 (CH_2Ph), 74.9 (CH_2Ph), 73.3 (CH_2Ph), 72.9 (C_3), 68.7 (C_6), 34.3 (Cq *t*-Bu), 31.1 (*t*-Bu), 20.3 (CH_3). MS FAB^+-HRMS *m/z* $[M+K]^+$ calcd for $C_{38}H_{44}O_5SK$ 651.2547, found 651.2535.

4.1.13. (2-Methyl-5-tert-butylphenyl) 2,3,4-tri-O-acetyl-1-thio-L-fucopyranoside (17)

To a mixture of 1,2,3,4-tetra-*O*-acetyl-L-fucopyranose **16** (10.30 g, 30.48 mmol) in anhydrous dichloromethane (60 mL) under argon, were added, 2-methyl-5-*tert*-butylthiophenol (8.35 mL, 45.72 mmol, 1.5 equiv) and $BF_3{\cdot}Et_2O$ (19.3 mL, 152.4 mmol, 5 equiv). The mixture was allowed to stir overnight and was neutralised with a saturated $NaHCO_3$ solution at 0 °C. The product was extracted with dichloromethane. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 2:1) to give 13.36 g of **17** (97%) as a white foam consisting of 2 anomers (α/β 1:7). α anomer: R_f: 0.47 (cyclohexane/EtOAc 2:1). $[\alpha]_D^{25}$ −143 (*c* 1.7, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 7.52–7.17 (3H, H Ar), 5.90 (m, 1H, H_1), 5.38 (m, 3H, H_2, H_3, H_4), 4.69 (q, 1H, J_{H5-H6}=6.6 Hz, H_5), 2.39 (s, 3H, CH_3 thio), 2.21 (s, 3H, CH_3 OAc), 2.14 (s, 3H, CH_3 OAc), 2.06 (s, 3H, CH_3 OAc), 1.32 (s, 9H, *t*-Bu), 1.18 (d, 3H, *J*=6.6 Hz, H_6). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 170.5 (CO OAc), 170.2 (CO OAc), 169.5 (CO OAc), 149.6 (Cq Ar), 136.4 (Cq Ar), 132.0 (Cq Ar), 129.9 (C Ar), 129.5 (C Ar), 124.7 (C Ar), 85.0 (C_1), 70.9, 68.5, 68.2 (C_2, C_3, C_4), 65.5 (C_5), 34.4 (Cq *t*-Bu), 31.2 (*t*-Bu), 20.8 (CH_3 OAc), 20.7 (CH_3 OAc), 20.6 (CH_3 OAc), 20.0 (CH_3 thio), 15.8 (C_6). MS DCI^+-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{23}H_{36}NO_7S$ 470.2212, found 470.2207. β anomer: R_f: 0.54 (cyclohexane/EtOAc 2:1). $[\alpha]_D^{25}$ −10 (*c* 3.4, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 7.64, 7.24, 7.16 (H Ar), 5.31 (m, 2H, H_2, H_4), 5.09 (dd, 1H, J_{H3-H2}=9.0 Hz, J_{H3-H4}=3.4 Hz, H_3), 4.67 (d, 1H, J_{H1-H2}=10.0 Hz, H_1), 3.85 (qd, 1H, J_{H5-H4}=1.0 Hz, J_{H5-H6}=6.7 Hz, H_5), 2.39 (s, 3H, CH_3 thio), 2.21 (s, 3H, OAc), 2.13 (s, 3H, OAc), 2.02 (s, 3H, OAc), 1.34 (s, 9H, *t*-Bu), 1.28 (d, 3H, *J*=6.7 Hz, H_6). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 170.6 (CO OAc), 170.0 (CO OAc), 169.5 (CO OAc), 149.4 (Cq Ar), 136.5 (Cq Ar), 132.3 (Cq Ar), 129.8 (CH Ar), 129.7 (CH Ar), 125.1 (CH Ar), 86.9 (C_1), 73.0 (C_5), 72.3 (C_3), 70.2 (C_4), 67.4 (C_2), 34.3 (Cq *t*-Bu), 31.2

(*t*-Bu), 20.7 (CH_3 OAc), 20.6 (CH_3 OAc), 20.5 (CH_3 OAc), 20.1 (CH_3 thio), 16.4 (C_6).

4.1.14. (2-Methyl-5-tert-butylphenyl) 4,6-O-benzylidene-2-deoxy-2-phthalimido-1-thio-β-D-glucopyranoside (**18**)

Compound **6** (2.000 g, 3.35 mmol) was dissolved in anhydrous methanol (10 mL) and anhydrous THF (3 mL) under argon. Sodium (0.015 g, 0.670 mmol, 0.2 equiv) was added. After 2 h, the mixture was neutralised (IR $120H^+$), filtered and the solvent was evaporated to give a white foam. [R_f: 0.46 (dichloromethane/methanol 9:1)]. The crude product was dissolved in anhydrous acetonitrile (60 mL) under argon. To the solution was added successively: benzaldehyde dimethyl acetal (1.00 mL, 6.700 mmol, 2 equiv) and camphorsulphonic acid (0.232 g, 1.000 mmol, 0.3 equiv). After 1 h a saturated $NaHCO_3$ solution was added and the product was extracted with dichloromethane. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 1.69 g of **18** (90%) as a white solid. R_f: 0.29 (cyclohexane/EtOAc 7:3). Mp: 104 °C. $[\alpha]_D^{25}$ +46 (*c* 1.2, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.00–7.09 (m, 12H, H Ar), 5.62 (m, 2H, H_1, H benzylidene), 4.67 (m, 1H, H_3), 4.42 (dd, 1H, $J_{H2-H1}=J_{H2-H3}=10.4$ Hz, H_2), 4.39 (m, 1H, H_6), 3.89 (m, 1H, $H_{6'}$), 3.66 (m, 2H, H_4, H_5), 2.89 (d, 1H, $J_{OH-H3}=3.6$ Hz, OH), 2.20 (s, 3H, CH_3), 1.32 (s, 9H, *t*-Bu). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 168.1, 167.5 (CO Phth), 149.4, 136.8, 134.1–128.1 (C Ar), 101.8 (C benzylidene), 85.0 (C_1), 81.8 (C_4), 70.1 (C_5), 69.5 (C_3), 68.5 (C_6), 55.6 (C_2), 34.3 (Cq *t*-Bu), 31.1 (*t*-Bu), 20.1 (CH_3). MS DCI^+-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{32}H_{37}N_2O_6S$ 577.2372, found 577.2377.

4.1.15. 5-Ethoxycarbonylpentyl 2-O-benzoyl-3,4,6-tri-O-benzyl-β-D-glucopyranoside (**19**)

To a mixture of **3** (0.192 g, 0.268 mmol), ethyl 6-hydroxyhexanoate (0.052 mL, 0.321 mmol, 1.2 equiv) and 4 Å molecular sieves (200 mg) in anhydrous dichloromethane (3 mL) were added under argon, NIS (0.122 g, 0.536 mmol, 2 equiv) and TfOH (0.005 mL, 0.053 mmol, 0.2 equiv). The mixture was stirred for 5 min and was then filtered, extracted with dichloromethane and washed with saturated $Na_2S_2O_3$ and $NaHCO_3$ solutions. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 9:1) to give 182 mg of **19** (97%) as a syrup. R_f: 0.43 (cyclohexane/EtOAc 8:2). $[\alpha]_D^{25}$ +21 (*c* 1.3, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.14–7.19 (m, 20H, H Ar), 5.42 (t, 1H, $J_{H2-H1}=J_{H2-H3}=8.0$ Hz, H_2), 4.92 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.85 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.78 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.73 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.68 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.65 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.62 (d, 1H, H_1), 4.13 (q, 2H, $J=7.0$ Hz, CH_2 OEt), 4.01–3.82 (m, 5H, H_{7a}, H_{6a}, H_{6b}, H_4, H_3), 3.68 (m, 1H, H_5), 3.57 (m, 1H, H_{7b}), 2.08 (m, 2H, H_{11}), 1.66–1.47 (m, 4H, H_{10}, H_8), 1.37–1.24 (m, 2H, H_9), 1.30 (t, 3H, $J=7.0$ Hz, CH_3 OEt). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.1 (CO COOEt), 169.0 (CO Bz), 137.8–127.2 (24C, C Ar), 100.8 (C_1), 82.3 (C_3), 76.6 (C_4), 74.8 (C_5), 74.6 (CH_2Ph), 74.6 (CH_2Ph), 73.5 (C_2), 73.1 (CH_2Ph), 69.0 (C_7), 68.4 (C_6), 59.7 (CH_2 OEt), 33.6 (C_{11}), 28.7 (C_8 or C_{10}), 25.0 (C_9), 24.1 (C_8 or C_{10}), 13.9 (CH_3 OEt). MS FAB^+-HRMS *m/z* $[M+Na]^+$ calcd for $C_{42}H_{48}O_9Na$ 719.3196, found 719.3190.

4.1.16. 5-Methoxycarbonylpentyl 3,4,6-tri-O-benzyl-β-D-glucopyranoside (**20**)

Compound **19** (1.820 g, 2.615 mmol) was dissolved in anhydrous methanol (15 mL) under argon. Sodium (0.030 g, 1.307 mmol, 0.5 equiv) was added. The mixture was heated at 60 °C for 2 h, allowed to cool down to room temperature, neutralised (IR $120H^+$), filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 8:2) to give 1.350 g of **20** (89%) as a white solid. R_f: 0.40 (cyclohexane/EtOAc 8:2). Mp: 39 °C. $[\alpha]_D^{25}$ −9 (*c* 0.7, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.46–7.22 (m, 15H, H Ar), 5.04 (d, 1H, $J_{gem}=11.3$ Hz, CHPh), 4.92 (m, 2H, CHPh), 4.71 (d, 1H, $J_{gem}=12.0$ Hz, CHPh), 4.60 (d, 1H, $J_{gem}=12.0$ Hz, CHPh), 4.59 (d, 1H, $J_{gem}=10.8$ Hz, CHPh), 4.31 (d, 1H, $J_{H1-H2}=7.3$ Hz, H_1), 4.00 (m, 1H, H_{7a}), 3.88–3.74 (m, 2H, H_{6a}, H_{6b}), 3.72 (s, 3H, OMe), 3.67 (dd, 1H, $J=8.1$, 5.6 Hz, H_3), 3.64–3.53 (m, 4H, H_{7b}, H_5, H_4, H_2), 2.68 (d, 1H, $J_{OH-H2}=2.0$ Hz, OH C_2), 2.28 (t, 2H, $J_{H11-H10}=7.0$ Hz, H_{11}), 1.78–1.66 (m, 4H, H_{10}, H_8), 1.37–1.24 (m, 2H, H_9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.1 (CO COOMe), 137.9–127.5 (18C, C Ar), 102.6 (C_1), 84.4 (C_3), 77.4 (C_2), 75.0 (CH_2Ph), 74.9 (CH_2Ph), 74.9 (C_5), 74.6 (C_4), 73.3 (CH_2Ph), 69.5 (C_7), 68.7 (C_6), 51.4 (OMe), 33.7 (C_{11}), 28.9 (C_8 or C_{10}), 25.4 (C_9), 24.4 (C_8 or C_{10}). MS DCI^+-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{34}H_{46}NO_8$ 596.3223, found 596.3217.

4.1.17. 5-Methoxycarbonylpentyl 3,4,6-tri-O-benzyl-β-D-mannopyranoside (**22**)

To a solution of oxalyl chloride (3.66 mL, 42.62 mmol, 3 equiv) in anhydrous dichloromethane (20 mL), cooled at −78 °C, was added dropwise DMSO (6.0 mL, 85.25 mmol, 6 equiv) under argon. After 15 min, a solution of **20** (8.213 g, 14.20 mmol, 1 equiv) in dichloromethane (20 mL) was added dropwise and the mixture was left stirring for a further 45 min at −78 °C. Triethylamine (12.0 mL, 85.25 mmol, 6 equiv) was then added dropwise and the mixture was allowed to warm up to room temperature. After 30 min the mixture was extracted with dichloromethane and washed with water. The organic layer was dried over $MgSO_4$, filtered, and an equivalent volume of methanol was poured into the solution. Sodium borohydride (2.148 g, 56.83 mmol, 4 equiv) was then added. The mixture was left stirring overnight at room temperature and the solvents were evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 6.140 g of **22** (74%) as a syrup. R_f: 0.35 (cyclohexane/EtOAc 7:3). $[\alpha]_D^{25}$ −15 (*c* 2.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.42–7.27 (m, 15H, H Ar), 4.95 (d, 1H, $J_{gem}=10.8$ Hz, CHPh), 4.82 (d, 1H, $J_{gem}=11.8$ Hz, CHPh), 4.69 (d, 1H, $J_{gem}=11.5$ Hz, CHPh),

4.67–4.59 (m, 3H, CHPh), 4.44 (s, 1H, H_1), 4.14 (br s, 1H, H_2), 3.99 (dt, 1H, J_{gem}=9.4 Hz, J_{H7a-H8}=6.6 Hz, H_{7a}), 3.94 (t, 1H, J_{H4-H5}=J_{H4-H3}=9.5 Hz, H_4), 3.84 (dd, 1H, J_{gem}=10.8 Hz, J_{H6a-H5}=2.1 Hz, H_{6a}), 6.78 (dd, 1H, J_{gem}=10.8 Hz, J_{H6b-H5}=5.0 Hz, H_{6b}), 3.68 (s, 3H, OMe), 3.64 (d, 1H, J_{H3-H4}=9.1 Hz, H_3), 3.55 (dt, 1H, J_{gem}=9.4 Hz, J_{H7b-H8}=6.9 Hz, H_{7b}), 3.48 (m, 1H, H_5), 2.69 (s, 1H, OH C_2), 2.35 (t, 2H, $J_{H11-H10}$=7.4 Hz, H_{11}), 2.48–1.67 (m, 4H, H_{10}, H_8), 1.48–1.40 (m, 2H, H_9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.5 (CO COOMe), 137.8–127.0 (18C, C Ar), 99.3 (C_1), 81.1 (C_3), 74.8 (C_5), 74.6 (CH_2Ph), 73.8 (C_4), 72.9 (CH_2Ph), 70.7 (CH_2Ph), 68.9 (C_7), 68.8 (C_6), 67.7 (C_2), 50.9 (OMe), 33.4 (C_{11}), 28.7 (C_8 or C_{10}), 25.1 (C_9), 24.2 (C_8 or C_{10}). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{34}H_{46}NO_8$ 596.3223, found 596.3223.

*4.1.18. 5-Methoxycarbonylpentyl 2-O-(2,3,4-tri-O-benzoyl-β-D-xylopyranosyl)-3,4,6-tri-O-benzyl-β-D-mannopyranoside (**23**)*

To a mixture of **22** (0.400 g, 0.691 mmol), **4** (0.518 g, 0.829 mmol, 1.2 equiv) and 4 Å molecular sieves (400 mg) in anhydrous dichloromethane (3 mL), was added under argon, NIS (0.311 g, 1.382 mmol, 2 equiv) and TfOH (0.012 mL, 0.138 mmol, 0.2 equiv). The mixture was allowed to stir for 10 min and was then filtered, extracted with dichloromethane and washed with saturated $NaHCO_3$ and $Na_2S_2O_3$ solutions. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 8:2) to give 604 mg of **23** (84%) as a syrup. R_f: 0.38 (cyclohexane/EtOAc 8:2). $[\alpha]_D^{25}$ −16 (*c* 1.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.16–7.29 (m, 30H, H Ar), 5.78 (t, 1H, $J_{H3'-H2'}$=6.1 Hz, $J_{H3'-H4'}$=6.0 Hz, $H_{3'}$), 5.66 (dd, 1H, $J_{H2'-H3'}$=6.1 Hz, $J_{H1'-H2'}$=4.2 Hz, $H_{2'}$), 5.48 (d, 1H, $H_{1'}$), 5.37 (dt, 1H, $J_{H4'-H5b'}$=9.0 Hz, $H_{4'}$), 4.99 (d, 1H, J_{gem}=11.2 Hz, CHPh), 4.94 (d, 1H, J_{gem}=12.0 Hz, CHPh), 4.81 (dd, 1H, J_{gem}=8.9 Hz, $J_{H5a'-H4}$=3.5 Hz, $H_{5a'}$), 4.72 (d, 1H, J_{gem}=12.0 Hz, CHPh), 4.53 (d, 1H, J_{gem}=11.2 Hz, CHPh), 4.50 (d, 1H, J_{gem}=12.9 Hz, CHPh), 4.42–4.37 (m, 3H, H_1, H_2, CHPh), 3.88–3.81 (m, 2H, H_{7a}, $H_{5b'}$), 3.76–3.71 (m, 2H, H_4 H_{6a}), 3.72 (s, 3H, OMe), 3.64 (dd, 1H, J_{H3-H4}=10.0 Hz, J_{H3-H2}=3.0 Hz, H_3), 3.49–3.37 (m, 3H, H_{7b}, H_{6b}, H_5), 2.28 (t, 2H, $J_{H11-H10}$=7.0 Hz, H_{11}), 1.68–1.52 (m, 4H, H_{10}, H_8), 1.42–1.35 (m, 2H, H_9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.9 (CO COOMe), 165.4 (CO Bz), 165.0 (CO Bz), 164.7 (CO Bz), 138.2–127.2 (36C, C Ar), 100.4 (C_1), 99.6 ($C_{1'}$), 80.6 (C_3), 74.0 (CH_2Ph), 74.8 (C_4), 73.0 (CH_2Ph), 69.6 (C_2), 69.2 (CH_2Ph), 69.1 (C_6), 68.8 ($C_{2'}$, $C_{3'}$), 68.7 (C_7), 68.7 ($C_{4'}$), 60.2 ($C_{5'}$), 51.2 (OMe), 33.6 (C_{11}), 29.0 (C_8 or C_{10}), 25.5 (C_9), 24.5 (C_8 or C_{10}). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{60}H_{66}NO_{15}$ 1040.4432, found 1040.4445.

*4.1.19. 5-Methoxycarbonylpentyl 2-O-(2,3,4-tri-O-benzoyl-β-D-xylopyranosyl)-β-D-mannopyranoside (**24**)*

Compound **23** (1.560 g, 1.524 mmol) was dissolved in a mixture of EtOAc/methanol (1:1, 30 mL). Pd/C (10%) (800 mg) was added. The mixture was stirred at room temperature overnight under H_2 (1.2 bar). The mixture was filtered off Celite and the solvent was evaporated. The residue was purified by column chromatography on silica gel (EtOAc) to give 1.060 g of **24** (92%) as a white foam. R_f: 0.44 (EtOAc). Mp: 67–69 °C. $[\alpha]_D^{25}$ −25 (*c* 1.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.04–7.27 (m, 15H, H Ar), 5.95 (dd, 1H, $J_{H3'-H2'}$=8.9 Hz, $J_{H3'-H4'}$=9.0 Hz, $H_{3'}$), 5.55 (dd, 1H, $J_{H2'-H1'}$=7.0 Hz, $H_{2'}$), 5.47 (dt, 1H, $J_{H4'-H3'}$=9.0 Hz, $J_{H4'-H5a'}$=5.1 Hz, $H_{4'}$), 5.13 (d, 1H, $H_{1'}$), 4.53 (dd, 1H, J_{gem}=12.1 Hz, $J_{H4'-H5a'}$=5.1 Hz, $H_{5a'}$), 4.43 (s, 1H, H_1), 4.19 (s, 1H, H_2), 3.87 (m, 1H, H_4), 3.81–3.56 (m, 4H, H_{7a}, H_{7b}, $H_{5b'}$, H_3), 3.70 (s, 3H, OMe), 3.33 (m, 1H, H_{6a}), 3.24–3.23 (m, 2H, H_5, H_{6b}), 2.74 (s, 1H, OH), 2.30 (t, 2H, $J_{H11-H10}$=7.5 Hz, H_{11}), 1.59 (m, 2H, H_{10}), 1.45–1.17 (m, 5H, H_8, H_9, OH). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.8 (CO COOMe), 165.5 (CO Bz), 165.5 (CO Bz), 165.3 (CO Bz), 133.2–128.1 (18C, C Ar), 101.4 (C_1), 100.1 ($C_{1'}$), 77.5 (C_2), 75.5 (C_5), 72.9 (C_3), 71.7 ($C_{2'}$), 71.3 ($C_{3'}$), 69.9 ($C_{4'}$), 69.2 (C_7), 67.8 (C_4), 62.3 ($C_{5'}$), 62.0 (C_6), 51.3 (OMe), 33.7 (C_{11}), 28.8 (C_8), 25.2 (C_9), 24.4 (C_{10}). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{39}H_{48}NO_{15}$ 770.3024, found 770.3021.

*4.1.20. 5-Methoxycarbonylpentyl 2-O-(2,3,4-tri-O-benzoyl-β-D-xylopyranosyl)-3,4-di-O-benzoyl-6-O-tert-butyl-dimethylsilyl-β-D-mannopyranoside (**25**)*

To a mixture of **24** (1.060 g, 1.409 mmol), DMAP (0.020 g, 0.160 mmol, 0.1 equiv) in anhydrous pyridine (3 mL) was added under argon TBDMSCl (0.660 g, 4.227 mmol, 3 equiv). The mixture turned cloudy and was allowed to stir overnight. Benzoyl chloride (1.00 mL, 8.612 mmol, 6 equiv) was added and after 2 h the solvent was evaporated. The product was extracted with dichloromethane, washed with HCl (1 M) and neutralised with a saturated $NaHCO_3$ solution. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 8:2) to give 1.072 g of **25** (70%) as a white solid. R_f: 0.38 (cyclohexane/EtOAc 8:2). Mp: 58 °C. $[\alpha]_D^{25}$ −109 (*c* 1.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.28–7.31 (m, 25H, H Ar), 5.76 (t, 1H, J_{H4-H3}=J_{H4-H5}=10.0 Hz, H_4), 5.70 (t, 1H, $J_{H3'-H2'}$=4.3 Hz, $J_{H3'-H4'}$=4.6 Hz, $H_{3'}$), 5.10 (dd, 1H, $J_{H2'-H3'}$=4.3 Hz, $J_{H2'-H1'}$=3.0 Hz, $H_{2'}$), 5.28 (dd, 1H, J_{H3-H4}=10.0 Hz, J_{H3-H2}=3.3 Hz, H_3), 5.23 (d, 1H, $J_{H1'-H2'}$=3.0 Hz, $H_{1'}$), 5.09 (m, 1H, $H_{4'}$), 4.69 (s, 1H, H_1), 4.55 (d, 1H, J_{H2-H3}=3.3 Hz, H_2), 4.41 (dd, 1H, J_{gem}=12.8 Hz, $J_{H5a'-H4'}$=2.9 Hz, $H_{5a'}$), 3.80 (m, 1H, H_{7a}), 3.73–3.69 (m, 2H, H_5, H_{6a}), 3.68 (s, 3H, OMe), 3.54 (m, 2H, H_{7b}, H_{6b}), 3.37 (dd, 1H, J_{gem}=12.8 Hz, $J_{H5b'-H4'}$=3.7 Hz, $H_{5b'}$), 2.24 (t, 2H, $J_{H11-H10}$=7.4 Hz, H_{11}), 1.62–1.52 (m, 4H, H_8, H_{10}), 1.52–1.51 (m, 2H, H_9), 1.46 (s, 9H, *t*-Bu), −0.068 (s, 3H, CH_3 TBS), −0.071 (s, 3H, CH_3 TBS). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.0 (CO COOMe), 166.0 (CO Bz), 165.3 (CO Bz), 165.3 (CO Bz), 165.0 (CO Bz), 164.5 (CO Bz), 133.5–128.1 (30C, C Ar), 99.9 ($C_{1'}$), 99.8 (C_1), 75.5 (C_5), 75.4 (C_2), 73.7 (C_3), 69.4 (C_7), 68.5 ($C_{2'}$), 68.1 (C_4), 67.9 ($C_{3'}$), 67.4 ($C_{4'}$), 63.3 (C_6), 59.1 ($C_{5'}$), 51.3 (OMe), 33.7 (C_{11}), 29.0 (C_8 or C_{10}), 25.6 (*t*-Bu), 25.5 (C_9),

24.4 (C_8 or C_{10}), 18.1 (Cq *t*-Bu), −5.4 (CH_3 TBS), −5.5 (CH_3 TBS). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{59}H_{70}NO_{17}Si$ 1092.4413, found 1092.4401.

4.1.21. 5-Methoxycarbonylpentyl 2-O-(2,3,4-tri-O-benzoyl-β-D-xylopyranosyl)-3,4-di-O-benzoyl-β-D-mannopyranoside (26)

Compound **25** (0.550 g, 0.510 mmol) was dissolved in acetonitrile (3 mL) in a Teflon flask. HF (40% aq, 0.44 mL, 8.850 mmol, 17 equiv) was added and the mixture was allowed to stir overnight. The mixture was diluted with dichloromethane and washed with a saturated $NaHCO_3$ solution. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 6:4) to give 0.461 g of **26** (94%) as a white solid. R_f: 0.35 (cyclohexane/EtOAc 6:4). Mp: 79 °C. $[\alpha]_D^{25}$ −160 (*c* 1.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.18−7.34 (m, 25H, H Ar), 5.91 (t, 1H, $J_{H4-H3}=J_{H4-H5}=9.9$ Hz, H_4), 5.76 (t, 1H, $J_{H3'-H2'}=J_{H3'-H4'}=6.1$ Hz, $H_{3'}$), 5.82 (dd, 1H, $J_{H2'-H3'}=6.1$ Hz, $J_{H2'-H1'}=4.3$ Hz, $H_{2'}$), 5.32 (dd, 1H, $J_{H3-H2}=3.1$ Hz, H_3), 5.21−5.16 (m, 2H, $H_{1'}$, $H_{4'}$), 4.69 (s, 1H, H_1), 4.54 (d, 1H, $J_{H2-H3}=3.1$ Hz, H_2), 4.33 (dd, 1H, $J_{gem}=12.6$ Hz, $J_{H5a'-H4'}=3.5$ Hz, $H_{5a'}$), 3.77−3.70 (m, 2H, H_5, H_{6a}), 3.68 (s, 3H, OMe), 3.67−3.61 (m, 1H, H_{7a}), 3.58−3.54 (m, 1H, H_{6b}), 3.40−3.35 (m, 2H, $H_{5b'}$, H_{7b}), 2.55 (s, 1H, OH C_6), 2.26 (t, 2H, $J_{H11-H10}=7.5$ Hz, H_{11}), 1.61−1.53 (m, 2H, H_{10}), 1.49−1.41 (m, 2H, H_8), 1.33−1.21 (m, 2H, H_9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.9 (CO COOMe), 166.0 (CO Bz), 165.2 (CO Bz), 165.2 (CO Bz), 165.2 (CO Bz), 164.8 (CO Bz), 133.3−128.1 (30C, C Ar), 100.5 ($C_{1'}$), 100.0 (C_1), 75.2 (C_2), 74.5 (C_5), 73.3 (C_3), 69.6 ($C_{2'}$), 69.5 (C_7), 68.1 (C_4), 68.9 ($C_{3'}$), 68.7 ($C_{4'}$), 66.4 (C_4), 61.6 (C_6), 60.1 ($C_{5'}$), 51.3 (OMe), 33.6 (C_{11}), 28.8 (C_8), 25.3 (C_9), 24.3 (C_{10}). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{53}H_{56}NO_{17}$ 978.3548, found 978.3563.

4.1.22. 5-Methoxycarbonylpentyl 2-O-(2,3,4-tri-O-benzoyl-β-D-xylopyranosyl)-3,6-di-O-benzoyl-β-D-mannopyranoside (27)

Compound **25** (1.250 g, 1.162 mmol) was dissolved in anhydrous THF (6 mL) under argon. A solution of TBAF (1 M in THF, 3.5 mL, 3.500 mmol, 3 equiv) was added and the mixture was stirred for 2 h. The solvent was evaporated and the residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 0.836 g of **27** (72%) as a white solid. R_f: 0.27 (cyclohexane/EtOAc 7:3). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.28−7.31 (m, 25H, H Ar), 5.72 (t, 1H, $J_{H3'-H2'}=6.6$ Hz, $J_{H3'-H4'}=6.4$ Hz, $H_{3'}$), 5.46 (dd, 1H, $J_{H2'-H3'}=6.6$ Hz, $J_{H2'-H1'}=4.8$ Hz, $H_{2'}$), 5.30 (d, 1H, $J_{H1'-H2'}=4.8$ Hz, $H_{1'}$), 5.16 (ddd, 1H, $J_{H4'-H3'}=6.3$ Hz, $J_{H4'-H5'}=4.0$ Hz, $J_{H4'-H5'}=10.3$ Hz, $H_{4'}$), 5.10 (dd, 1H, $J_{H3-H4}=10.0$ Hz, $J_{H3-H2}=3.0$ Hz, H_3), 4.64 (s, 1H, H_1), 4.54−4.48 (m, 3H, H_2, H_{6a}, H_{6b}), 4.23−4.16 (m, 2H, $H_{5a'}$, H_4), 3.74−3.65 (m, 1H, H_{7a}), 3.65 (s, 3H, OMe), 3.66−3.60 (m, 1H, H_5), 3.51−3.47 (m, 1H, $H_{5b'}$), 3.43−3.34 (m, 1H, H_{7b}), 2.26 (t, 2H, $J_{H10-H11}=7.5$ Hz, H_{11}), 1.62−1.49 (m, 4H, H_8, H_{10}), 1.38−1.24 (m, 2H, H_9). MS DCI$^+$-HRMS *m/z* $[M+NH_4]^+$ calcd for $C_{53}H_{56}NO_{17}$ 978.3548, found 978.3563.

4.1.23. 5-Ethoxycarbonylpentyl 2-O-acetyl-3,4,6-tri-O-benzyl-β-D-glucopyranoside (28)

To a mixture of **12** (0.932 g, 1.420 mmol), ethyl 6-hydroxy-hexanoate (280 μL, 1.710 mmol, 1.2 equiv) and powdered 4 Å molecular sieves (1 g) in anhydrous dichloromethane (14 mL) were added under argon, NIS (0.641 g, 2.840 mmol, 2 equiv) and TfOH (0.025 mL, 0.142 mmol, 0.1 equiv). The mixture was allowed to stir for 15 min and was then filtered, extracted with dichloromethane and washed with saturated $Na_2S_2O_3$ and $NaHCO_3$ solutions. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 8:2) to give 620 mg of **28** (69%) as a syrup. R_f: 0.44 (cyclohexane/EtOAc 8:2). $[\alpha]_D^{25}$ +2 (*c* 1.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.43−7.25 (m, 15H, H Ar), 5.09 (t, 1H, $J_{H2-H1}=J_{H2-H3}=8.0$ Hz, H_2), 4.88 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.86 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.76 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.68 (d, 1H, $J_{gem}=12.0$ Hz, CHPh), 4.63 (d, 1H, $J_{gem}=11.0$ Hz, CHPh), 4.62 (d, 1H, $J_{gem}=12.0$ Hz, CHPh), 4.43 (d, 1H, $J_{H1-H2}=8.0$ Hz, H_1), 4.17 (q, 2H, $J=7.0$ Hz, CH_2 OEt), 3.95 (m, 1H, H_{7a}), 3.84−3.72 (m, 4H, H_4 H_{6a}, H_{6b}, H_3), 3.56 (m, 1H, H_5), 3.52 (m, 1H, H_{7b}), 2.34 (t, 2H, $J_{H11-H10}=7.0$ Hz, H_{11}), 2.03 (s, 3H, CH_3 OAc), 1.74−1.61 (m, 4H, H_{10}, H_8), 1.47−1.39 (m, 2H, H_9), 1.30 (t, 3H, $J=7.0$ Hz, CH_3 OEt). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.1 (CO COOEt), 169.0 (CO OAc), 137.9−127.2 (18C, C Ar), 100.6 (C_1), 82.6 (C_3), 77.7 (C_4), 74.8 (C_5), 74.6 (2C, CH_2Ph), 73.1 (CH_2Ph), 72.0 (C_2), 68.9 (C_7), 68.8 (C_6), 59.8 (CH_2 OEt), 33.8 (C_{11}), 28.8 (C_8), 25.1 (C_9), 24.2 (C_{10}), 20.5 (CH_3 OAc), 13.9 (CH_3 OEt). MS FAB$^+$-HRMS *m/z* $[M+K]^+$ calcd for $C_{37}H_{46}O_9K$ 673.2779, found 673.2773.

4.1.24. 5-Ethoxycarbonylpentyl 3,4,6-tri-O-acetyl-2-deoxy-2-phthalimido-β-D-glucopyranoside (29)

To a mixture of compound **6** (8.350 g, 13.98 mmol), ethyl 6-hydroxy-hexanoate (3.40 mL, 20.98 mmol, 1.5 equiv) and 4 Å molecular sieves (4 g) in anhydrous dichloromethane (100 mL) were added under argon, NBS (6.221 g, 34.95 mmol, 2.5 equiv) and TfOH (0.620 mL, 6.99 mmol, 0.5 equiv). After 10 min the mixture was filtered, extracted with dichloromethane and washed with saturated $Na_2S_2O_3$ and $NaHCO_3$ solutions. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 5:5) to give 8.06 g of **29** (100%) as a syrup. R_f: 0.48 (cyclohexane/EtOAc 5:5). $[\alpha]_D^{25}$ +18 (*c* 3.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.78−7.66 (m, 4H, H Phth), 5.69 (dd, 1H, $J_{H3-H2}=10.7$ Hz, $J_{H3-H4}=9.3$ Hz, H_3), 5.27 (d, 1H, $J_{H1-H2}=8.5$ Hz, H_1), 5.07 (dd, 1H, $J_{H4-H5}=9.8$ Hz, H_4), 4.24 (dd, 1H, $J_{gem}=12.3$ Hz, $J_{H6-H5}=4.6$ Hz, H_6), 4.20 (dd, 1H, H_2), 4.07 (dd, 1H, $J_{H6'-H5}=2.2$ Hz, $H_{6'}$), 3.95 (q, 2H, $J=7.2$ Hz, CH_2 OEt), 3.79 (ddd, 1H, H_5), 3.73 (dt, 1H, $J_{H7-H7'}=9.3$ Hz, $J_{H7-H8}=6.2$ Hz, H_7), 3.36 (dt, 1H, $J_{H7'-H8}=6.3$ Hz, $H_{7'}$), 2.00 (s, 3H, CH_3 OAc), 1.93 (s, 3H, CH_3 OAc),

1.88 (m, 2H, H_{11}), 1.76 (s, 3H, CH_3 OAc), 1.31 (m, 4H, H_8, H_{10}), 1.11 (t, 3H, CH_3 OEt), 1.01 (m, 2H, H_9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 172.9 (CO COOEt), 170.2 (CO OAc), 169.7 (CO OAc), 169.1 (CO OAc), 134.0 (CH Phth), 130.9 (Cq Phth), 123.2 (CH Phth), 97.7 (C_1), 71.4 (C_5), 70.3 (C_3), 69.3 (C_7), 68.6 (C_4), 61.6 (C_6), 59.7 (CH_2 OEt), 54.2 (C_2), 33.5 (C_{11}), 28.5 (C_8 or C_{10}), 24.8 (C_9), 23.9 (C_8 or C_{10}), 20.3 (CH_3 OAc), 20.2 (CH_3 OAc), 20.0 (CH_3 OAc), 13.8 (CH_3 OEt). MS FAB$^+$-HRMS *m/z* $[M+Na]^+$ calcd for $C_{28}H_{35}NO_{12}Na$ 600.2057, found 600.2031.

*4.1.25. 5-Ethoxycarbonylpentyl 4,6-O-benzylidene-2-deoxy-2-phthalimido-β-D-glucopyranoside (**30**)*

Compound **29** (5.570 g, 9.65 mmol) was dissolved in anhydrous ethanol (20 mL) and anhydrous THF (20 mL) under argon. Sodium (0.044 g, 1.93 mmol, 0.2 equiv) was added. After 15 min the mixture was neutralised (IR 120H$^+$), filtered and the solvent was evaporated to give a white foam. [R_f: 0.44 (dichloromethane/methanol 9:1)]. The crude product was dissolved in anhydrous acetonitrile (80 mL) under argon. To the solution were added successively, benzaldehyde dimethyl acetal (2.90 mL, 19.30 mmol, 2 equiv) and camphorsulphonic acid (0.671 g, 2.890 mmol, 0.3 equiv). After 1 h a saturated $NaHCO_3$ solution was added and the product was extracted with dichloromethane. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 3.83 g of **30** (73% over two steps) as a white foam. R_f: 0.19 (cyclohexane/EtOAc 7:3). $[\alpha]_D^{25}$ −30 (*c* 1.5, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 7.76−7.26 (m, 9H, H Ar), 5.50 (s, 1H, H benzylidene), 5.15 (d, 1H, J_{H1-H2}=8.5 Hz, H_1), 4.52 (t, 1H, J_{H3-H2}=J_{H3-H4}=8.4 Hz, H_3), 4.30 (dd, 1H, J_{gem}=10.1 Hz, J_{H6-H5}=3.6 Hz, H_6), 4.14 (dd, 1H, H_2), 3.98 (q, 2H, *J*=7.2 Hz, CH_2 OEt), 3.73 (m, 3H, OH, H_7, $H_{6'}$), 3.52 (m, 2H, H_4, H_5), 3.35 (dt, 1H, $J_{H7'-H7}$=9.8 Hz, $J_{H7'-H8}$=6.3 Hz, $H_{7'}$), 1.88 (m, 2H, H_{11}), 1.31 (m, 4H, H_8, H_{10}), 1.14 (t, 3H, CH_3 OEt), 1.02 (m, 2H, H_9). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.1 (CO COOEt), 136.8, 133.7, 131.1, 128.7, 127.8, 125.9 (C Ar), 101.2 (C benzylidene), 98.4 (C_1), 81.7 (C_4), 69.2 (C_7), 68.2 (C_6), 67.9 (C_3), 65.8 (C_5), 59.7 (CH_2 OEt), 56.6 (C_2), 33.5 (C_{11}), 28.5 (C_8 or C_{10}), 24.8 (C_9), 23.9 (C_8 or C_{10}), 13.8 (CH_3 OEt). MS FAB$^+$-HRMS *m/z* $[M+Na]^+$ calcd for $C_{29}H_{33}NO_9Na$ 562.2053, found 562.2048.

*4.1.26. 5-Ethoxycarbonylpentyl 3-O-(2,3,4-tri-O-benzyl-α-L-fucopyranosyl)-4,6-O-benzylidene-2-deoxy-2-phthalimido-β-D-glucopyranoside (**31**)*

To a mixture of **30** (2.340 g, 4.336 mmol), **7** (3.100 g, 5.203 mmol, 1.2 equiv) and 4 Å molecular sieves (2 g) in anhydrous dichloromethane (15 mL), were added under argon, NIS (1.951 g, 8.672 mmol, 2 equiv) and TfOH (0.038 mL, 0.433 mmol, 0.1 equiv). After 20 min the mixture was filtered, extracted with dichloromethane and washed with saturated $NaHCO_3$ and $Na_2S_2O_3$ solutions. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 8:2) to give 3.48 g of **31** (83%) as a syrup containing 2 anomers (α/β 85:15 estimated by ^1H NMR). R_f: 0.46 (cyclohexane/EtOAc 7:3).

*4.1.27. 5-Ethoxycarbonylpentyl 3-O-(2,3,4-tri-O-benzyl-α-L-fucopyranosyl)-6-O-benzyl-2-deoxy-2-phthalimido-β-D-glucopyranoside (**32**)*

To a mixture of **31** (0.286 g, 0.299 mmol), 4 Å molecular sieves (400 mg), triethylsilane (0.154 mL, 0.956 mmol, 3.2 equiv) in anhydrous dichloromethane (4 mL) was added under argon at −78 °C, TfOH (0.077 mL, 0.867 mmol, 2.9 equiv). After 30 min triethylamine (1 mL) and methanol (1 mL) were added dropwise. The mixture was allowed to warm up to room temperature, filtered and concentrated. The crude product was extracted with dichloromethane and washed with water. The organic layer was dried over $MgSO_4$, filtered and the solvent was evaporated. The residue was purified by column chromatography on silica gel (cyclohexane/EtOAc 7:3) to give 0.228 g of **32** (79%) as a syrup. R_f: 0.34 (cyclohexane/EtOAc 7:3). $[\alpha]_D^{25}$ +21 (*c* 1.0, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$) δ: 7.90−7.03 (m, 24H, H Ar), 5.41 (d, 1H, J_{H1-H2}=8.4 Hz, H_1), 4.93 (d, 1H, J_{gem}=11.4 Hz, CHPh), 4.75−4.67 (m, 4H, 3CHPh, $H_{1'}$), 4.62 (d, 1H, J_{gem}=11.9 Hz, CHPh), 4.60 (d, 1H, J_{gem}=11.4 Hz, CHPh), 4.35 (dd, 1H, J_{H2-H3}=10.8 Hz, H_2), 4.32 (s, 1H, OH), 4.25 (dd, 1H, J_{H3-H4}=8.1 Hz, H_3), 4.20 (d, 1H, J_{gem}=13.0 Hz, CHPh), 4.16−4.10 (m, 3H, $H_{5'}$, CH_2 OEt), 3.96 (m, 2H, H_6, H_7), 3.84 (m, 3H, $H_{2'}$, $H_{3'}$, H_6), 3.74 (m, 1H, H_5), 3.65−3.58 (m, 3H, H_4, $H_{4'}$, $H_{7'}$), 3.53 (d, 1H, J_{gem}=13.0 Hz, CHPh), 2.11 (m, 2H, H_{11}), 1.56 (m, 4H, H_8, H_{10}), 1.27 (m, 5H, CH_3 OEt, H_9), 1.14 (d, 3H, $J_{H6'-H5'}$=6.5 Hz, $H_{6'}$). The regioselectivity was demonstrated by addition of trichloroacetyl isocyanate and ^1H NMR analysis: H_4 deshielding δ: 5.08 (t, *J*=9.3 Hz). ^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.2 (CO COOEt), 168.6 (CO Phth), 167.8 (CO Phth), 138.5, 138.2, 138.0, 137.9 (Cq Bn), 133.4, 132.2, 131.6 (CH Phth), 128.2−122.6 (C Ar), 100.5 ($C_{1'}$), 98.0 (C_1), 83.0 (C_3), 78.5 ($C_{3'}$), 77.6 ($C_{4'}$), 75.0 (C_5), 74.5 (CH_2Ph), 73.7 ($C_{2'}$), 73.2 (CH_2Ph), 73.1 (CH_2Ph), 72.1 (CH_2Ph), 71.0 (C_4), 69.1 (C_6, C_7), 68.2 ($C_{5'}$), 59.8 (CH_2 OEt), 54.4 (C_2), 33.8 (C_{11}), 28.8 (C_8 or C_{10}), 25.1 (C_9), 24.1 (C_8 or C_{10}), 16.2 ($C_{6'}$), 14.0 (CH_3 OEt). MS FAB$^+$-HRMS *m/z* $[M+Na]^+$ calcd for $C_{56}H_{63}NO_{13}Na$ 980.4197, found 980.4183.

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