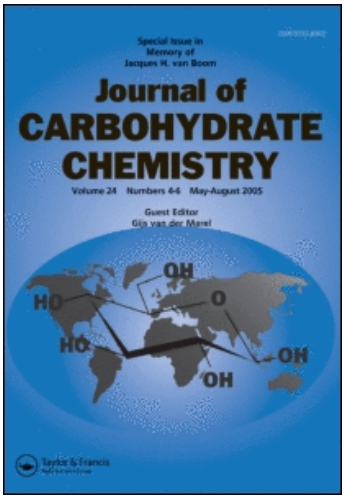

Journal of Carbohydrate Chemistry
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713617200

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To cite this Article Mulard, Laurence A. and Ughetto-Monfrin, Joël(1999) 'Synthesis of a Tri- and Tetrasaccharide Fragment Specific for the *Shigella flexneri* Serotype 5a *O*-Antigen. A Reinvestigation', Journal of Carbohydrate Chemistry, 18: 7, 721 — 753
To link to this Article: DOI: 10.1080/07328309908544033
URL: http://dx.doi.org/10.1080/07328309908544033

J. CARBOHYDRATE CHEMISTRY, 18(7), 721–753 (1999)

SYNTHESIS OF A TRI- AND TETRASACCHARIDE FRAGMENT SPECIFIC FOR THE *Shigella flexneri* SEROTYPE 5a *O*-ANTIGEN. A REINVESTIGATION[1]

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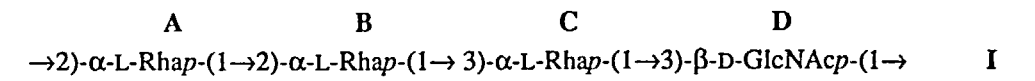
Received February 4, 1999 - Final Form May 18, 1999

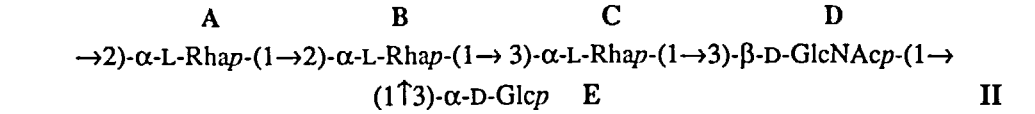
ABSTRACT

Stereocontrolled, stepwise synthesis of methyl α-L-rhamnopyranosyl-(1→2)-[α-D-glucopyranosyl-(1→3)]-α-L-rhamnopyranoside (**A(E)B**, **1**) and methyl 2-acetamido-2-deoxy-β-D-glucopyranosyl-(1→2)-α-L-rhamnopyranosyl-(1→2)-[α-D-glucopyranosyl-(1→3)]-α-L-rhamnopyranoside (**DA(E)B**, **2**) is described; these constitute the methyl glycosides of fragments of the *O*-specific polysaccharide of *Shigella flexneri* serotype 5a. Two routes to trisaccharide **1** were considered. Route 1 involved the coupling of a precursor to residue **A** and a disaccharide **EB**, whereas route 2 was based on the condensation of a precursor to residue **E** and a disaccharide **AB**. Rather surprisingly, the latter afforded the β-anomer of **1**, namely methyl α-L-rhamnopyranosyl-(1→2)-[β-D-glucopyranosyl-(1→3)]-α-L-rhamnopyranoside as the major product. Route 1 was preferred. Overall, several observations made during this study suggested that, for the construction of higher fragments, a suitable precursor to rhamnose **A** would require protecting groups of low bulkiness at position 3 and 4. Therefore, the 2-*O*-acetyl-3,4-di-*O*-allyl-α-L-rhamnopyranosyl trichloroacetimidate (**35**) was the precursor of choice to residue **A** in the synthesis of the tetrasaccharide **2**. The condensation product of **35** and methyl 2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl-4-*O*-benzyl-α-L-rhamnopyranoside was selectively deacylated and condensed to 2-trichloroacetamido-3,4,6-tri-*O*-acetyl-2-deoxy-α-D-glucopyranosyl trichloroacetimidate to afford the corresponding fully protected tetrasaccharide **45**. Controlled stepwise deprotection of the latter proceeded smoothly to afford the target **2**. It should be emphasised that the preparation of **45** was not straightforward, several donors and coupling conditions that were tested resulted only in the complete recovery of the acceptor. Distortion of several signals in the ^{13}C NMR spectra of the fully or partially protected tetrasaccharide intermediates suggested that steric hindrance, added to the known low reactivity of HO-2 of rhamnosyl acceptors, probably played a major role in the outcome of the glycosidation attempts.

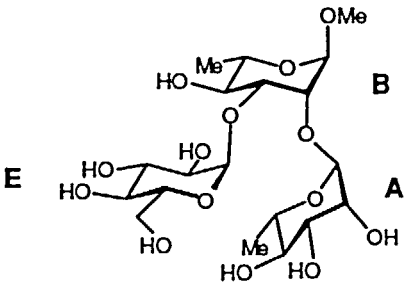
INTRODUCTION

Shigella flexneri is a gram-negative bacillus responsible for the endemic form of shigellosis, a dysenteric syndrome characterised by bacterial invasion of the human colonic mucosa,[2] which causes a high rate of mortality among infants, particularly in developing countries. For these reasons, shigellosis is a priority target as defined by the World Health Organisation (WHO) in its program for the development of vaccines against enteric diseases. Field studies as well as studies on experimental models showed that protection against infection is specific for the serotype of the strain[3,4] which is defined by the structure of the *O*-specific polysaccharide (*O*-SP). Increasing evidences support the hypothesis that serum antibodies against the *O*-SP may confer protective immunity in humans.[5] Furthermore, local anti-LPS secretory IgA antibodies are sufficient to confer protection.[6] Although *O*-SPs are T-cell independent antigens, they may be converted to efficient immunogens through covalent attachment to carrier proteins[7] or possibly T-cell epitope peptides.[8] The former approach has proven successful in adults, in the case of *Shigella sonnei*.[9] Still, optimal features for such conjugates are not well understood. Besides, a parallel approach is underway in our laboratory. In the latter, which is based on encouraging preliminary results obtained on the model bacterium *Shigella flexneri* serotype 5a,[10] vaccine constructs would involve peptide mimics of the antigenic polysaccharides. To help the design of optimal vaccine conjugates, whether of the glyco-type or of the peptide-type, the molecular specificity of the complementarity between the *O*-SP and protective antibodies raised against this pathogen, is under investigation. Our approach is based on the study, at the molecular level, of the interaction between synthetic saccharidic haptens representative of the *O*-SP of *S. flexneri* serotype 5a and homologous protective antibodies. For that reason, several oligosaccharides representative of the *O*-SP of this model bacterium were required in rather large quantities. Thus, in spite of the large amount of synthetic work on fragments of the *O*-SP of various bacteria of the *Shigella flexneri* family reported before by D. R. Bundle's group[11,12] and N. K. Kochetkov's group,[13,14] the synthesis of the required oligosaccharides was undertaken.





All members of the *Shigella flexneri* family share the linear heterotetrasaccharide **I**, as a common basis to the repeating unit of their *O*-antigen. Among them, *S. flexneri* serotype 5a is defined by its branched pentasaccharide repeating unit[15,16] **II**, containing α-linked L-rhamnose and D-glucose together with β-linked *N*-acetyl-D-glucosamine as the monosaccharide constituents. As part of this project, we describe herein the synthesis of the branched **A(E)B** and **DA(E)B** fragments. They were synthesised as their known methyl glycoside **1**[17,18] and **2**,[19,20] respectively, to allow binding studies in solution.



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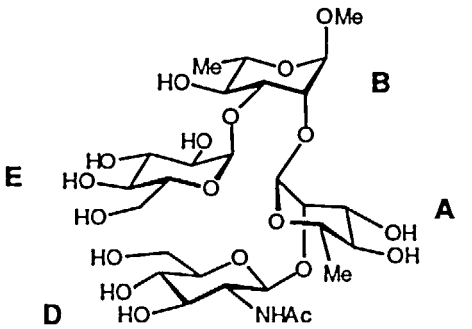

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RESULTS AND DISCUSSION

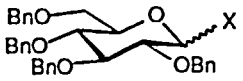
The approach used in this study is based on the synthesis of heterofunctional, monosaccharide intermediates, which were then combined in a stepwise manner.

Study on the A(E)B fragment, synthesis of trisaccharide 1.

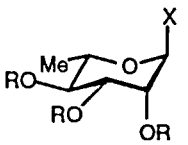
Due to the anticipated crucial importance of the **A(E)B** fragment in the *O*-SP, a careful study of the synthesis of its methyl glycoside[17,18] **1** was undertaken. A retrosynthetic approach showed that two routes to **1** could be considered, namely, the coupling of a donor **A** to a disaccharide **EB** (route 1), or the coupling of a donor **E** to a disaccharide acceptor **AB** (route 2). Both routes were undertaken.

The monosaccharide intermediates.

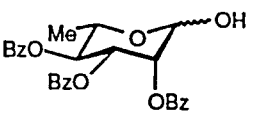
D-Glucose: E unit. 2,3,4,6-Tetra-*O*-benzyl-α/β-D-glucopyranosyl fluoride[21,22] (**3**), is a known convenient donor for the construction of α-D-glucopyranosidic linkages.[23] Having permanent protecting groups at all positions, it was selected as the key precursor to residue **E**. Other precursors tested were the bromide **4**[24] and the trichloroacetimidate **5**.[25,26] All donors were prepared from the commercially available hemiacetal **6**, as described.



X	
F	3
Br	4
$OC(NH)CCl_3$	5
OH	6



R	X	
Bz	Br	7
Ac	$OC(NH)CCl_3$	8
Bz	$OC(NH)CCl_3$	9



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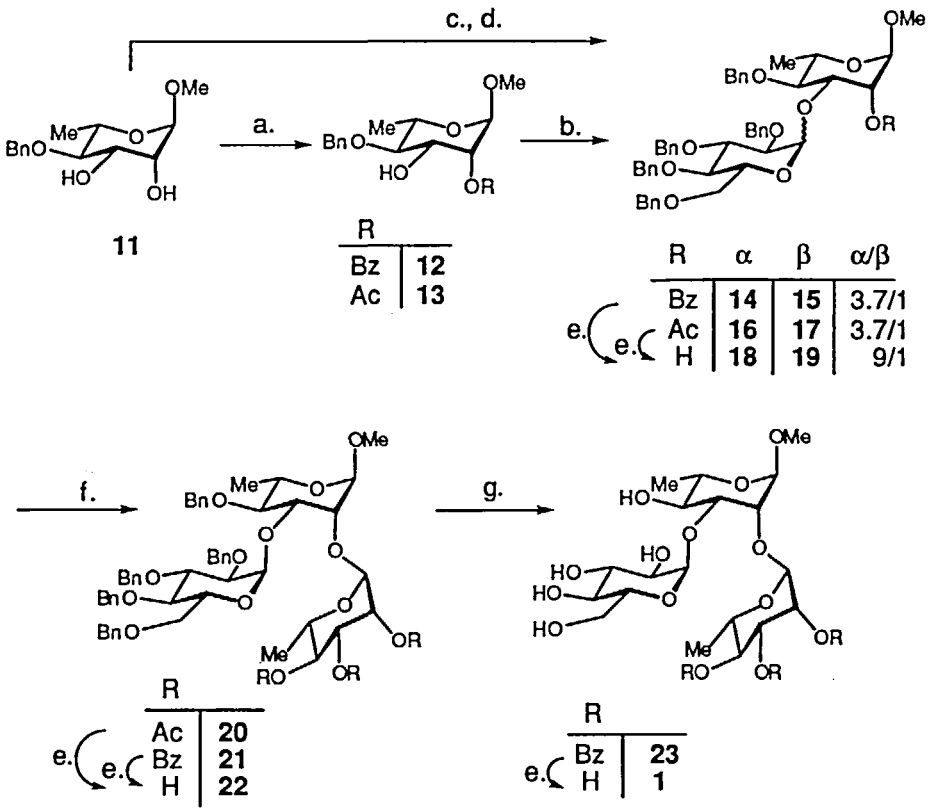
L-Rhamnose: C unit. According to published data,[17,18] a suitable precursor to residue **C** in the synthesis of the trisaccharide **1** is the tri-*O*-benzoylated bromide **7**. The trichloroacetimidate **8**,[27] and the known tri-*O*-benzoylated analogue **9**[28] were tested as well. The latter was preferred. It was prepared from the 1,2,3,4-tetra-*O*-benzoyl-α/β-L-rhamnose[29] via anomeric deprotection upon reaction with hydrazine acetate in DMF to give **10**[29] (90%), followed by treatment with trichloroacetonitrile and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) to give **9** (82% for two steps).

L-Rhamnose: B unit. Methyl 4-*O*-benzyl-α-L-rhamnopyranoside[30] (**11**) has a permanent benzyl group at position 4 that should increase the acceptor reactivity of HO-3. It was selected as a common precursor to the 2-*O*-benzoate[19] **12**, and the 2-*O*-acetate[31] **13** (route 1, Scheme 1). In order to prevent acyl migration, which was observed upon column chromatography, the latter was used as a crude material (2-*O*-acetyl/3-*O*-acetyl ratio: 97/3 as extracted from the ^{1}H NMR spectrum) in the glycosylation process. Besides, selective *p*-methoxybenzylation, or allylation, of the hydroxyl group at position 3 of the diol **11** (route 2, Scheme 2) using the dibutyltin oxide methodology[32,33] gave compounds **24**[34] (87%) and **25**[19,35] (80%), respectively.

Assembly of the trisaccharide.

Route 1 (scheme 1) mainly followed the one described earlier.[18] The α-D-glucopyranosyl linkage, the stereochemistry of which is the most difficult to control, was introduced first. As the 2-*O*-benzoyl group is less prone to migrate to the *cis*-oriented HO-3 group than its 2-*O*-acetyl counterpart, the benzoate **12** was expected to be the nucleophile of choice for the construction of the **EB** linkage. Thus, condensation of the alcohol **12** was attempted with several precursors to residue **E**, such as the fluoride **3**,[23,36] the bromide **4**,[18,37] and the trichloroacetimidate **5**,[38] following known protocols as described in the cited references. In our hands, the fluoride donor **3** when used in combination with titanium tetrafluoride (TiF_4) as the promoter and dry diethyl ether as the solvent was found the most satisfactory. As the condensation products were of close mobility on TLC plates,



a. i. $MeC(OMe)_3$ or $PhC(OMe)_3$, APTS, CH_3CN; ii. CF_3CO_2H 50% aq CH_2Cl_2; b. **3**, TiF_4, MS 4Å, Et_2O; c. Bu_2SnO, $PhCH_3$; d. **5**, Et_4NI, iPr_2NEt; e. MeONa, MeOH; f. **8** or **9**, TMSOTf, Et_2O; g. H_2, Pd/C.

Scheme 1

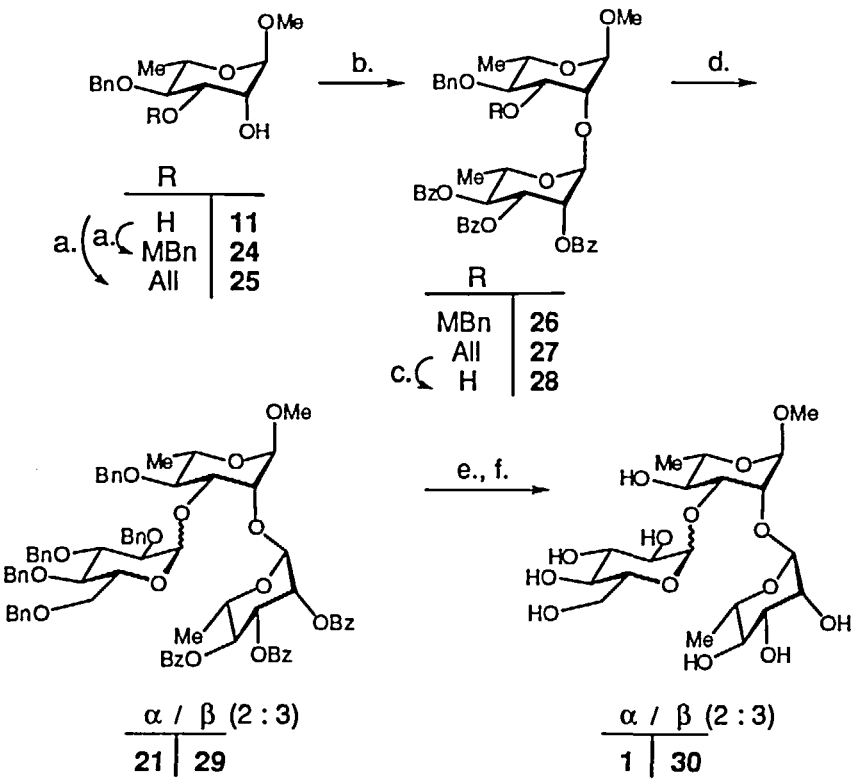
only analytical samples of **14** and **15** were retrieved. Thus, compounds **14** and **15** were *O*-debenzoylated as an α/β mixture to give **18**[18] (56%) and **19**[17,18,39] (17%). The α/β anomeric configuration for residue **E** in **14**, **15**, **18** and **19** was indicated by the $^3J_{H\text{-}1,H\text{-}2}$ coupling constant for this residue (see Experimental). With the aim of improving the yield of **18**, the crude 2-*O*-acetylated acceptor **13** was condensed to **3** following a similar two-step procedure. Yields of **16**[17] and **17** were 59% and 16% starting from **11**, respectively, corresponding to an α/β ratio of 3.7 to 1. Zemplén deacylation of the condensation products (MeONa 1 eq, CH_2Cl_2/MeOH: 1/2) was unusually slow as seen by ^1H NMR kinetic measurements. Typically, deacetylation of **16** was achieved within 1.5 h, whereas debenzoylation of **14** necessitated at least 24 h. Besides, selective deblocking of the β-

anomers **15** (8 h) and **17** (30 min) was always much faster than that of the corresponding α-anomers **14** and **16**, respectively. In fact, in both cases deacylation of the α-anomer would require more or less three times the duration needed for the corresponding β-anomer. The limited access to HO-2, as pointed out by the above data, probably results from the steric hindrance caused by the presence of the 2,3,4,6-tetra-*O*-benzyl-D-glucopyranose at *O*-3. Overall, masking of *O*-2 by the α-linked glucopyranose is much more pronounced than by its β-linked counterpart.

An attempted deviation from this synthetic pathway involved the use of the *cis*-diol **11** as the acceptor. Thus, the cyclic stannylidene obtained by reacting **11** with dibutyltin oxide was tentatively glycosylated with the bromide donor **4** according to Garegg's procedure.[40] Despite a slightly better stereoselectivity of the condensation (α/β, 90:10), the yield of **18** (36%) could not be improved using this methodology. As an example, running the reaction in the presence of mercuric cyanide, afforded **18** in 25% yield. Overall, the use of the acetylated precursor **13** as the acceptor was found much more convenient in terms of time and number of purification steps.

Next, the disaccharide intermediate **18** was rhamnosylated with the trichloroacetimidate **8**, under promotion by trimethylsilyl triflate (TMSOTf), to give the trisaccharide **20** in 59% yield. Deacetylation of **20** under Zemplén conditions resulted in the triol **22** (94%). Using the tri-*O*-benzoylated precursor **9** as the donor, the condensation proceeded smoothly, and the glycosylation product **21** was isolated in 92% yield. Conventional hydrogenolysis of the latter gave **23** (91%) and subsequent Zemplén debenzoylation afforded the target trisaccharide **1** (92%).

In route 2 (Scheme 2), residue **E** was introduced last. Condensation of the alcohols **24** and **25** with the bromide donor **7** was achieved under base-deficient conditions using silver triflate (AgOTf) as the promoter and *sym*-collidine as the acid scavenger.[41] Under such conditions, the fully protected disaccharides **26** and **27** were obtained in 66% and 76% yield, respectively. Selective deallylation of **27**, achieved by isomerisation of the allyl ether to the 1-propenyl ether using [1,5-cyclooctadiene-bis(methyldiphenylphosphine)-iridium] hexafluorophosphate as the promoter[42] and subsequent hydrolysis, afforded the disaccharide **28** bearing a free hydroxyl group at position 3 in 85% yield. The latter was trimethylsilylated and condensed to the glucosyl donor **3** in the presence of TiF_4 as described above to give a 2:3 α/β mixture of the glycosylation products **21** and **29** in 81% yield. Isolation of the pure anomers at this stage was not possible except for analytical purpose, nor at any of the partially protected stages. Nevertheless, the mixture of the fully protected trisaccharides **21** and **29** resulting from the condensation of **28** and **4** was submitted to conventional hydrogenolysis and subsequent Zemplén debenzoylation to give the target **1** (26%) and its β**E** isomer **30** (39%). The all α stereochemistry of the glycosidic



a. i. Bu_2SnO, $PhCH_3$; ii. *p*MBnCl or AllBr, Bu_4NI, dioxane; b. **7**, AgOTf, *sym*-collidine, CH_2Cl_2; c. i. "Ir", THF, ii. HgO, $HgBr_2$, acetone/H_2O; d. i. Me_3SiCl, pyridine, ii. **4**, Tf_2O, MS 4Å, Et_2O; e. H_2, Pd/C, EtOH/AcOH; f. MeONa, MeOH.

Scheme 2

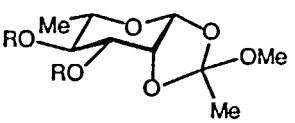
linkages in **21** and **1** was established by measuring the $^1J_{C\text{-}1,H\text{-}1}$ heteronuclear coupling constants, whereas a similar analysis conducted for compound **30** clearly established the β stereochemistry of its **EB** glycosidic linkage (see Experimental). Comparison of the ^1H and ^{13}C NMR data obtained for the free trisaccharides to those from the literature[18] further ascertained the anomeric configuration of residue **E** in compounds **1** and **30**. Our results show that even though the condensation of the **AB** precursor **28** to the **E** precursor **4** was performed under conditions known to favour the formation of the α-D-glucopyranosidic linkage, the β-anomer **29** was obtained as the major compound. A possible explanation for this fact is steric hindrance, which would occur in a 2-α-L/3-α-D cis-vicinal branched rhamnopyranosyl system, but would be negligible in the corresponding 2-α-L/3-β-D cis-vicinal branched rhamnopyranosyl system. Interestingly, analysis of the ^1H NMR spectrum of the fully protected trisaccharide **21** showed several distorted resonance

signals. The most apparent distortion was that of the doublet corresponding to H-6_B, showing a $^3J_{H\text{-}5,H\text{-}6}$ homonuclear coupling constant of 5.1 Hz, thus reflecting an apparent distorted conformation of rhamnose **B**. No such distorted resonance signals could be seen in the ^{1}H NMR spectrum of the corresponding βE anomer **29**. Neither were they observed in the ^{1}H NMR spectra of any of the trisaccharides, once partially (**22**, **23**) or fully deprotected (**1**, **30**). These structural observations correlate well with the previous discussion on the slow kinetics of debenzoylation of the fully protected **21** (see above). Therefore, steric hindrance appears as one of the major factors to be taken into account when constructing fragments bearing the A(E)B sequence. In this respect, it should be added that the fully protected trisaccharide **20**, bearing a 2,3,4-tri-*O*-acetyl-α-L-rhamnopyranosyl residue, does not show any apparent conformational constraint as deduced from the analysis of its ^{1}H and ^{13}C NMR spectra. These observations may help the choice of the various precursors necessary to build higher fragments of the *O*-SP of *Shigella flexneri* serotype 5a. In particular, the use of precursors to rhamnose **A** bearing low bulkiness protecting groups at position 3 and 4 is recommended.

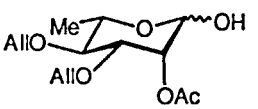
Study on the DA(E)B fragment, synthesis of tetrasaccharide 2.

In the present study, the linear strategy designed for the preparation of the target tetrasaccharide[19,20] **2** took advantage of the observations made during the preparation of **1**. Route 1 was undertaken, and the alcohol **18** was selected as the crucial synthetic intermediate for disaccharide **EB**.

The monosaccharide intermediates.



R	
Ac	**31**
All	**32**



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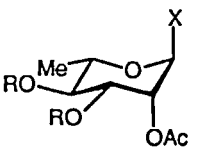
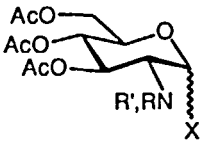


R	X	
Bn	Cl	**34**
All	$OC(NH)CCl_3$	**35**

L-Rhamnose: C unit. The known chloride[43] **34** and the trichloroacetimidate **35** were selected as the rhamnose donors for residue **C** in the tetrasaccharide **2**. The precursor to **35** was the 1,2-ortho ester[44] **31**. It was submitted to deacetylation followed by conventional alkylation with allyl bromide to afford **32** (94%). Acid hydrolysis of the latter afforded **33** and subsequent treatment of the resulting hemiacetal with trichloroacetonitrile and DBU gave **35** (81%). This intermediate can function both as a glycosyl donor and as a glycosyl acceptor after removal of the temporary-protecting group from O-2. In this

respect, the acetyl group is ideally suited since it is the only ester functionality present on the expected condensation product when coupling **18** and **35**.

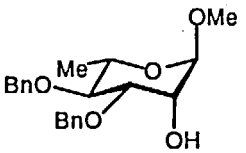


R, R'	X	
ClPhth	Br	**36**
ClPhth	$OC(NH)CCl_3$	**37**
H, $C(O)OCH_2CCl_3$	$OC(NH)CCl_3$	**38**
H, $C(O)CCl_3$	$OC(NH)CCl_3$	**39**

2-Acetamido-2-deoxy-D-glucose: D unit. Recently, several glucosamine donors possessing modified amino functionalities have been proposed in order to overcome the problems associated to the widely spread phthalimido procedure[45] when introducing a 2-acetamido-2-deoxy-β-D-glucopyranosidic linkage. Amongst those investigated, the tetrachlorophthalimides[46] **36** and **37**,[47] the carbamate **38**,[48] and the trichloroacetamide[49] **39** were selected as potential precursors to residue **D**.

Assembly of the tetrasaccharide.

When the disaccharide **18** and the chloride donor **34** were condensed in anhydrous dichloromethane under base-deficient conditions, using AgOTf as the promoter and *sym*-collidine as the acid scavenger, no glycosylation product was isolated and the **EB** precursor was totally recovered. The poor reactivity of HO-2 of a 3-*O*-glycosylated rhamnopyranosyl intermediate was noticed earlier, and the major influence of steric hindrance on the outcome of the glycosylation reaction was outlined.[50] Besides, previous failure of attempted glycosylation at O-2 of **18** have been reported,[19] they were attributed to the steric bulk of the glycosyl donor and the relatively low reactivity of the O-2 position



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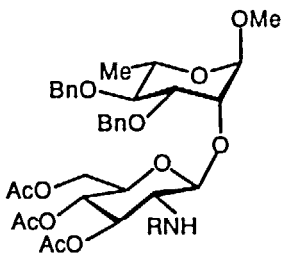
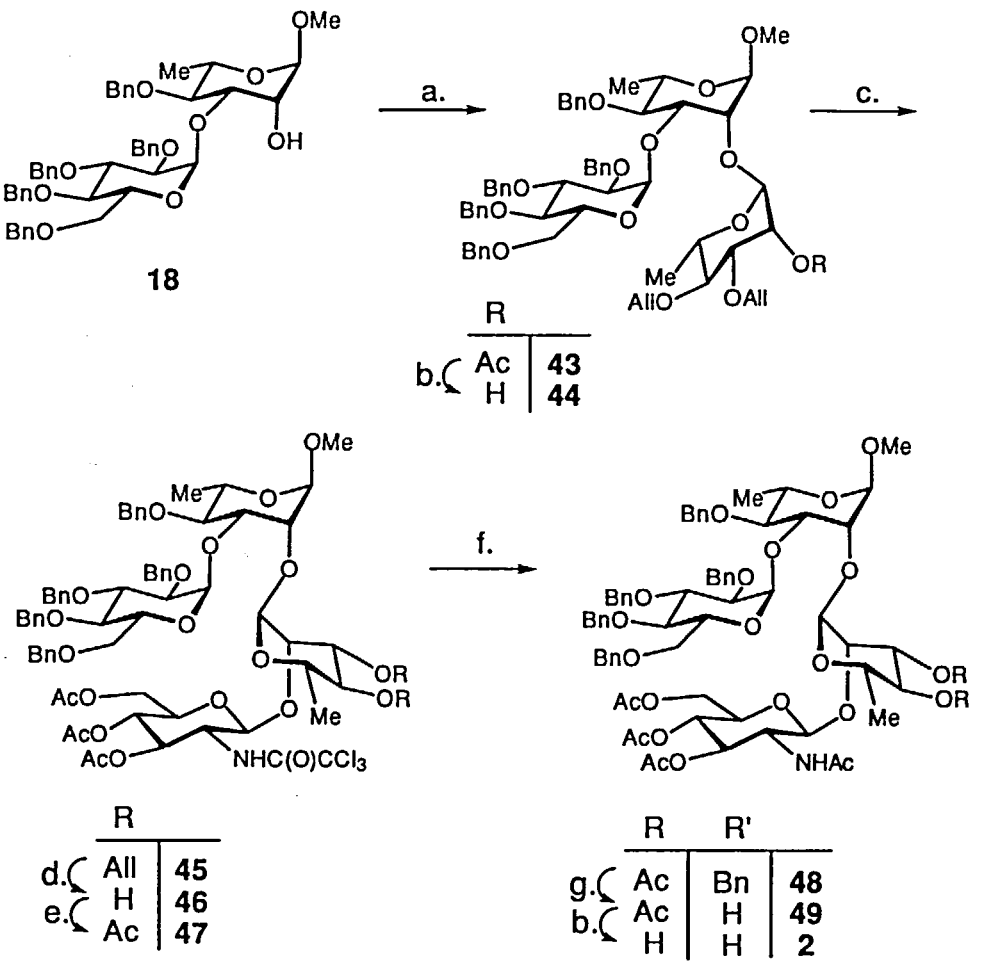


R	
$C(O)OCH_2CCl_3$	**41**
$C(O)CCl_3$	**42**

of the acceptor. Based on this suggestion and on our observations made during the synthesis of **1**, a new rhamnopyranosyl donor was designed, namely the trichloroacetimidate **35**. Condensation of **18** and **35** was achieved in diethyl ether in the presence of a catalytic amount of TMSOTf to afford the fully protected trisaccharide **43** in 96% yield (scheme 3). Next, transesterification of **43** provided the intermediate **44** (98%) ready for further chain elongation. As anticipated by the choice of the protecting groups at position 3 and 4 of rhamnose A, no distortion at all could be seen in the ^{1}H and ^{13}C NMR spectra of trisaccharides **43** and **44**.

Whether performed with donor **36** under AgOTf-promoted Königs-Knorr conditions in which *sym*-collidine was the proton acceptor, or with donors **37**, **38**, and **39** under catalysis with TMSOTf, attempted glycosylation of **44** in dichloromethane failed, leading to complete recovery of the starting acceptor. The use of **37** in acetonitrile was still unsuccessful, even though the combination of a trichloroacetimidate donor and trichloroacetonitrile was reported, on several occasions, to be highly suitable for the preparation of β-glycosidic linkages.[47,51] As a test, the rhamnoside[34] **40** was condensed to donors **38** and **39** using the exact conditions that failed in the case of **43**. Glycosidation went smoothly in both cases, leading to disaccharides **41** (91%) and **42** (97%), respectively. To overcome the repeatedly observed total absence of reaction of **44**, the latter was reacted with the *N*-trichloroacetamide donor **39** in acetonitrile in the presence of a catalytic amount of TMSOTf. Under such conditions, the fully protected tetrasaccharide **45** was isolated in 89% yield after repeated column chromatography to avoid contamination by a side-product of close mobility. The β interglycosidic linkage for residue **D** is indicated by the $^{1}J_{C\text{-}1,H\text{-}1}$ heteronuclear coupling constant for the glucosamine unit of 162 Hz. Values of 169-170 Hz were obtained for the other residues, which ascertained their α-anomeric orientation. Next, tetrasaccharide **45** was submitted to stepwise deprotection. Although tributylstannane mediated reduction of the *N*-trichloroacetyl group into the corresponding *N*-acetyl group has been reported for a compound bearing an allyl protecting group,[49] several side-products were formed when **45** was treated with tributylstannane in the presence of a catalytic amount of 2,2'-azobis(2-methylpropionitrile) (AIBN), as described. Thus, deallylation of **45** was performed first. Conventional removal of the allyl ethers from **45** following a two-step process[42] using the cationic iridium complex, as described for the preparation of **28**, gave the diol **46** in 71% yield. Acetylation of the latter led to **47** (98%) and subsequent dehydrohalogenation using tributyltin hydride in combination with a catalytic amount of AIBN gave the *N*-acetylated tetrasaccharide **48** in 88% yield. It should be noted that the addition of *N*,*N*-dimethyl acetamide (DMA) to the reaction mixture is of great importance for the reaction to go to completion. Next, compound **48** was fully deprotected by (i) hydrogenolysis [H_2, Pd-C]



a. 32, TMSOTf, Et_2O; b. MeONa, MeOH; c. 39, TMSOTf, CH_3CN; d. i. "Ir", THF, ii. HgO, $HgBr_2$, acetone/H_2O; e. Ac_2O, pyridine; f. Bu_3SnH, DMA/$PhCH_3$; g. H_2, Pd/C.

Scheme 3

to give **49** (92%) and (ii) transesterification (MeONa-MeOH) into the free tetrasaccharide **2** (89%). In $CDCl_3$, NMR data showed that two average conformers of **49** were present in solution, but only one was seen in DMSO-d_6. Measurement of the magnitude of the one-bond $^1J_{C,H}$ coupling constants for the anomeric carbon atoms of the target **2** gave values of 172-173 Hz for the rhamnosyl and glucosyl residues, whereas the glucosaminyl unit had a $^1J_{C,H}$ coupling constant of 164 Hz. The former values are consistent with the presence of α-L-rhamnosyl and α-D-glucosyl residues while the latter is in total agreement with the

expected β configuration of the glucosaminyl residue, thus confirming the stereochemical integrity of the glycosidic linkages of **2**.

Interestingly, analysis of the ^{13}C NMR spectrum of the protected, whether fully or partially, tetrasaccharides **45-48** showed the presence of several repeated distorted resonance signals. The most apparent distortions were those of the signals attributed to C-1_A, C-1_E, C-4_B, and to a lesser extent those of the signals associated with C-2_B, and C-3_B. These observations show that the addition of a protected *N*-acetyl-D-glucosamine residue disrupts the overall conformation of the starting **A(E)B** portion, most probably generating a steric constraint at the branching point. They may explain the negative outcome of several of the attempted condensations of fragment **A(E)B** and residue **D**. This apparent steric constraint only disappeared upon debenzylation of the intermediate **48**. As expected, no distortion subsisted in the NMR spectra of the free tetrasaccharide **2**.

The reaction products were characterised by fully assigned ^1H and ^{13}C NMR spectra. Assignment of the ^1H NMR spectra was made possible by analysis of the experimental subspectra generated when running selective TOCSY experiments[52] to identify sets of signals attributable to individual rings, followed by unambiguous identification of one of the signals for each residue in one particular compound. Following the assignment of the ^1H NMR spectra, the assignment of the $^{13}C\{^1H\}$ NMR signals followed directly from the analysis of the ^{13}C-^1H chemical shift correlated spectrum. The anomeric configurations of the newly formed glycosidic linkages were established by measurement of anomeric $^1J_{C,H}$ coupling constants.[53,54]

EXPERIMENTAL

General Methods. Melting points were determined in capillary tubes with an electrothermal apparatus and are uncorrected. Optical rotations were measured for $CHCl_3$ solutions at 25 °C, except where indicated otherwise, with a Perkin-Elmer automatic polarimeter, Model 241 MC. TLC on precoated slides of Silica Gel 60 F_{254} (Merck) was performed with solvent mixtures of appropriately adjusted polarity consisting of *A*, dichloromethane-methanol; *B*, cyclohexane-ethyl acetate; *C*, cyclohexane-acetone; *D*, toluene-acetone; *E*, toluene-EtOAc; *F*, dichloromethane-diethyl ether; *G*, water-acetonitrile. Detection was effected when applicable, with UV light, and/or by charring with orcinol (35 mM) in aqueous H_2SO_4 (4N). Preparative chromatography was performed by elution from columns of Silica Gel 60 (particle size 0.040-0.063 mm). The NMR spectra were recorded at 25 °C for solutions in $CDCl_3$, unless stated otherwise, on a Bruker AC 300P spectrometer (300 MHz for ^1H, 75 MHz for ^{13}C). External references: for solutions in $CDCl_3$, TMS (0.00 ppm for both ^1H ^{13}C); for solutions in D_2O, dioxane (67.4 ppm for

^{13}C) and trimethylsilyl-3 propionic acid sodium salt (0.00 ppm for ^{1}H). Proton-signal assignments were made by first-order analysis of the spectra, as well as analysis of two-dimensional ^{1}H-^{1}H correlation maps (COSY) and selective TOCSY experiments. Of the two magnetically non-equivalent geminal protons at C-6, the one resonating at lower field is denoted H-6a and the one at higher field is denoted H-6b. The ^{13}C NMR assignments were supported by two-dimensional ^{13}C-^{1}H correlation maps (HETCOR). Interchangeable assignments are marked with an asterisk in the listing of signal assignments. Sugar residues in oligosaccharides are serially lettered according to the lettering of the repeating unit of the *O*-SP and identified by a subscript in the listing of signal assignments. Low-resolution chemical ionisation mass spectra (CIMS) were obtained using NH_3 as the ionising gas. Before use, AgOTf was dried at 133 Pa/50 °C for 2 h, CH_2Cl_2 was distilled over P_2O_5, Et_2O and THF were distilled over sodium/benzophenone. CH_3CN suitable for DNA synthesis and kept on Trap-Pack molecular sieves bags was used as such. Solutions in organic solvents were dried by passing through phase separator filters.

2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyl Trichloroacetimidate (9). The crude hemiacetal **10** obtained by selective anomeric debenzoylation of 1,2,3,4-tetra-*O*-benzoyl-L-rhamnopyranose[29] (4.14 g, 7.14 mmol) was dissolved in dry CH_2Cl_2 (30 mL). Trichloroacetonitrile (7.2 mL, 71.4 mmol) and DBU (105 μL, 0.7 mmol) were added and the solution was stirred for 30 min. The volatiles were evaporated, and the crude material was coevaporated twice with toluene. The residue was chromatographed on a short column of silica gel (solvent *B*, 95:5, containing 0.1% of Et_3N) to give pure α anomer **9** (3.63 g, 82%) as a colourless foam, $[\alpha]_D$ +118° (*c* 1.0); lit.[28] $[\alpha]_D$ +97.5° (*c* 1.0); ^{1}H and ^{13}C NMR data differ slightly from those described.[28] NMR: ^{1}H, δ 8.84 (s, 1H, NH), 8.14-7.25 (m, 15H, Ph), 6.51 (d, 1H, $J_{1,2}$ = 1.5 Hz, H-1), 5.90 (m, 2H, H-2, 3), 5.80 (ddd, 1H, $J_{3,4}$ = 9.9 Hz, H-4), 5.30 (s, 3H, CH_3), 4.43 (dq, 1H, $J_{4,5}$ = 9.6 Hz, H-5), 1.44 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6); ^{13}C, δ 165.7, 165.5, 165.3 (3C, C=O), 160.1 (C=N), 133.7-128.4 (Ph), 94.8 (C-1), 90.6 (CCl_3), 71.1 (C-4), 69.7 (2C, C-3*, 5), 69.2 (C-2*), 17.8 (C-6).

Methyl [2,3,4,6-Tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-2-*O*-benzoyl-4-*O*-benzyl-α-L-rhamnopyranoside (14) and **Methyl [2,3,4,6-Tetra-*O*- benzyl-β-D-glucopyranosyl-(1→3)]-2-*O*- benzoyl-4-*O*- benzyl-α-L-rhamnopyranoside (15).** A mixture of crude α-L-rhamnopyranoside **12**[55] (372 mg, 1.0 mmol) and molecular sieves 4Å in Et_2O (20 mL) was stirred for 30 min under Ar. The glycosyl fluoride[21] **3** (940 mg, 2 mmol) was added and stirring was continued for 30 min at 0 °C, at which time, TiF_4 (1.0 g, 8.1 mmol) was added. The mixture was stirred overnight at rt when TLC (solvent *D*, 8.4:1.6) showed that no starting material remained.

The mixture was diluted with Et_2O and filtered through a pad of Celite. Et_3N was slowly added to neutralise the filtrate, and volatiles were evaporated. The residue, taken up in CH_2Cl_2 was washed with cold 5% aq $NaHCO_3$, water and satd aq NaCl, then dried and concentrated. Chromatography of the residue (solvent *F*, 9.8:0.2) gave a mixture of compounds (727 mg, 75 %) from which analytical samples of amorphous **14** and amorphous **15** were retrieved.

Compound **14** had $[\alpha]_D$ +33° (*c* 1.0); NMR: ^1H, δ 8.07-7.05 (m, 30H, Ph), 5.60 (dd, 1H, $J_{1,2}$ = 2.1 Hz, H-2_B), 5.23 (d, 1H, $J_{1,2}$ = 3.5 Hz, H-1_E), 4.96 (d, 1H, J = 10.2 Hz, CH_2PhA), 4.82 (d, 1H, J = 10.9 Hz, CH_2PhB), 4.81 (d, 1H, J = 10.9 Hz, CH_2PhC), 4.77 (d, 1H, H-1_B), 4.71 (d, 1H, J = 10.9 Hz, CH_2PhB'), 4.65 (d, 1H, J = 10.2 Hz, CH_2PhA'), 4.58 (d, 1H, J = 12.0 Hz, CH_2PhD), 4.52 (d, 1H, J = 12.1 Hz, CH_2PhE), 4.43 (d, 1H, J = 10.9 Hz, CH_2PhC'), 4.40 (d, 1H, J = 12.1 Hz, CH_2PhE'), 4.35 (d, 1H, J = 12.1 Hz, CH_2PhD'), 4.31 (d, 1H, $J_{2,3}$ = 3.2, $J_{3,4}$ = 9.3 Hz, H-3_B), 4.00 (m, 2H, H-3_E, 5_E), 3.79 (dq, 1H, $J_{4,5}$ = 9.5 Hz, H-5_B), 3.46 (dd, 2H, J = 9.8 Hz, H-4_B, 4_E), 3.63 (dd, 1H, $J_{5,6a}$ = 3.2 Hz, H-$6a_E$), 3.59 (dd, 1H, H-2_E), 3.55 (dd, 1H, $J_{5,6b}$ = 1.7, $J_{6a,6b}$ = 12.9 Hz, H-$6b_E$), 3.35 (s, 3H, CH_3), 1.42 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_B); ^{13}C, δ 166.1 (C=O), 133.2-127.3 (Ph), 98.5 (C-1_B, $J_{C,H}$ = 169.7 Hz), 92.6 (C-1_E, $J_{C,H}$ = 168.7 Hz), 82.0 (C-3_E), 79.8 (C-4_B*), 79.0 (C-2_E), 77.6 (C-4_E*), 76.1, 75.4, 74.9, 73.3, (4C, CH_2Ph), 72.5 (C-3_B), 72.2 (CH_2Ph), 70.2 (C-5_E), 68.4 (C-2_B), 68.2 (C-6_E), 67.7 (C-5_B), 54.9 (CH_3), 18.1 (C-6_B); ES: *m/z* 895.6 ($[M+H]^+$), 917.5 ($[M+Na]^+$).

Anal. Calcd for $C_{55}H_{58}O_{11}$: C, 73.81; H, 6.53. Found: C, 73.63; H, 6.59.

Compound **15** had $[\alpha]_D$ +58° (*c* 1.0); NMR: ^1H, δ 8.18-6.92 (m, 30H, Ph), 5.50 (dd, 1H, $J_{1,2}$ = 1.7 Hz, H-2_B), 4.94 (d, 1H, J = 10.6 Hz, CH_2PhA), 4.92 (2 d, 2H, J = 10.7 Hz, CH_2PhB, CH_2PhC), 4.84 (s, 1H, H-1_B), 4.82 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1_E), 4.80 (d, 1H, J = 11.0 Hz, CH_2PhD), 4.79 (d, 1H, J = 10.7 Hz, CH_2PhC'), 4.69 (d, 1H, J = 11.5 Hz, CH_2PhB'), 4.61 (d, 1H, J = 12.2 Hz, CH_2PhE), 4.56 (d, 2H, J = 10.7 Hz, CH_2PhA', CH_2PhD'), 4.54 (d, 1H, J = 12.2 Hz, CH_2PhE'), 4.45 (dd, 1H, $J_{2,3}$ = 3.4, $J_{3,4}$ = 9.4 Hz, H-3_B), 3.85 (dq, 1H, $J_{4,5}$ = 9.5 Hz, H-5_B), 3.76 (dd, 1H, $J_{5,6a}$ = 2.1, $J_{6a,6b}$ = 11.4 Hz, H-$6a_E$), 3.70 (bd, 1H, H-$6b_E$), 3.68 (t, partially overlapped, 1H, H-4_B), 3.63-3.57 (m, 2H, H-3_E, 5_E), 3.45-3.38 (m, 2H, H-2_E, 4_E), 3.38 (s, 3H, OCH_3), 1.41 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_B); ^{13}C, δ 165.8 (C=O), 138.6-127.3 (Ph), 103.3 (C-1_E, $J_{C,H}$ = 161.7 Hz), 98.3 (C-1_B, $J_{C,H}$ = 170.2 Hz), 84.5 (C-3_E), 82.3 (C-2_E), 81.5 (C-4_B), 77.9 (C-5_E), 75.5 (CH_2Ph), 75.3 (C-4_E), 75.2 (C-3_B), 75.0, 74.9, 74.6, 73.5, (4C, CH_2Ph), 73.5 (C-2_B), 68.7 (C-6_E), 67.5 (C-5_B), 54.9 (CH_3), 18.0 (C-6_B); ES: *m/z* 895.6 ($[M+H]^+$), 917.5 ($[M+Na]^+$).

Anal. Calcd for $C_{55}H_{58}O_{11}$: C, 73.81; H, 6.53. Found: C, 73.68; H, 6.59.

Methyl [2,3,4,6-Tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-2-*O*-acetyl-4-*O*-benzyl-α-L-rhamnopyranoside (16) and **Methyl [2,3,4,6-Tetra-*O*-benzyl-β-D-glucopyranosyl-(1→3)]-2-*O*-acetyl-4-*O*-benzyl-α-L-rhamnopyranoside (17).** A mixture of crude α-L-rhamnopyranoside **13** prepared as described[31] from methyl 4-*O*-benzyl-α-L-rhamnopyranoside[30] (**11**, 2.95 g, 11.0 mmol), and molecular sieves 4Å in Et_2O (20 mL) was stirred for 30 min under Ar. The glycosyl fluoride[21] **3** (12.0 g, 22.1 mmol) and TiF_4 (8.2 g, 66.1 mmol) were added sequentially as described for the preparation of **14** and **15** and the reaction mixture was processed as above. Chromatography of the residue (solvent *B*, 8.75:1.25) gave a mixture of compounds **16** and **17** (12.5 g). Analytical samples of both **16** and **17** were tentatively retrieved. The faster moving product, isolated as a colourless oil, was the β anomer **17**, $[\alpha]_D$ +10° (*c* 1.0); NMR: ^{1}H, δ 7.40–6.92 (m, 25H, Ph), 5.23 (dd, 1H, $J_{1,2}$ = 1.7, $J_{2,3}$ = 3.5 Hz, H-2_B), 5.00-4.46 (m, 10H, CH_2Ph), 4.73 (d, 1H, $J_{1,2}$ = 7.7 Hz, H-1_E), 4.67 (bs, 1H, H-1_B), 4.29 (d, 1H, $J_{3,4}$ = 9.4 Hz, H-3_B), 3.77 (dq, 1H, $J_{4,5}$ = 9.5 Hz, H-5_B), 3.72 (bd, 1H, H-$6a_E$), 3.69 (dd, 1H, $J_{5,6b}$ = 4.1, $J_{6a,6b}$ = 11.0 Hz, H-$6b_E$), 3.62 (dd, 1H, $J_{4,5}$ = 8.6 Hz, H-4_E), 3.59 (dd, 1H, $J_{3,4}$ = 8.8 Hz, H-3_E), 3.55 (dd, 1H, H-4_B), 3.46 (dd, 1H, $J_{2,3}$ = 8.7 Hz, H-2_E), 3.39 (m, 1H, H-5_E), 3.30 (s, 3H, OCH_3), 2.16 (s, 3H, C(=O)CH_3), 1.49 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_B); ^{13}C, δ 170.3 (C=O), 138.6-127.5 (Ph), 103.2 (C-1_E), 98.2 (C-1_B), 84.6 (C-3_E), 82.5 (C-2_E), 81.0 (C-4_B), 77.8 (C-4_E), 75.5 (CH_2Ph), 75.4 (C-3_B), 75.2 (C-5_E), 75.0, 74.9, 74.8, 73.5 (4C, CH_2Ph), 72.8 (C-2_B), 68.6 (C-6_E), 67.5 (C-5_B), 54.7 (OCH_3), 17.9 (C-6_B); ES: *m/z* 833.4 ($[M+H]^+$), 855.5 ($[M+Na]^+$).

Anal. Calcd for $C_{50}H_{56}O_{11}$: C, 72.01; H, 6.78. Found: C, 72.16; H, 6.80.

The slower moving product, isolated as a colourless oil, was the α anomer **16**, $[\alpha]_D$ +50° (*c* 1.0); lit.[17] $[\alpha]_D$ +54.4° (*c* 1.0); NMR: ^{1}H, δ 7.38-7.04 (m, 25H, Ph), 5.36 (dd, 1H, $J_{1,2}$ = 1.9 Hz, H-2_B), 5.16 (d, 1H, $J_{1,2}$ = 3.4 Hz, H-1_E), 5.04-4.33 (m, 10H, CH_2Ph), 4.63 (bs, overlapped, 1H, H-1_B), 4.21 (dd, 1H, $J_{2,3}$ = 3.3, $J_{3,4}$ = 9.6 Hz, H-3_B), 4.10 (dd, 1H, $J_{3,4}$ = 9.3 Hz, H-3_E), 4.02 (m, 1H, H-5_E), 3.74 (dq, partially overlapped, 1H, $J_{4,5}$ = 9.2 Hz, H-5_B), 3.73 (dd, partially overlapped, 1H, $J_{4,5}$ = 9.9 Hz, H-4_E), 3.64-3.58 (m, 3H, H-2_E, $6a_E$, $6b_E$), 3.55 (dd, 1H, H-4_B), 3.34 (s, 3H, OCH_3), 1.96 (s, 3H, C(=O)CH_3), 1.40 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_B). The ^{13}C NMR data were identical to those reported previously.[17] ES: *m/z* 833.4 ($[M+H]^+$), 855.5 ($[M+Na]^+$).

Anal. Calcd for $C_{50}H_{56}O_{11}$: C, 72.10; H, 6.78. Found: C, 72.12; H, 6.79.

Methyl [2,3,4,6-Tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (18) and Methyl [2,3,4,6-Tetra-*O*-benzyl-β-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (19). (a) A solution of **14** and **15** (670 mg, 75 μmol) in a mixture of dry CH_2Cl_2 and methanol (15

mL, 1:1) was treated with 1 M MeONa in MeOH until strongly alkaline to litmus and stirred for 16 h at rt. After neutralisation with Amberlite IR-120 (H^+) and evaporation of the volatiles, the crude product was chromatographed from a column of silica gel (solvent *F*, 9.8:0.2) to give **19** (136 mg, 23 %) and as the first eluting product **18** (468 mg, 74 %), both as amorphous compounds. Compound **19** had $[\alpha]_D$ -17° (*c* 1.0); lit.[18] $[\alpha]_D$ -7° (*c* 2.0), lit.[17] $[\alpha]_D$ -11.1° (*c* 1.1), lit.[39] $[\alpha]_D$ -15° (*c* 2.4); NMR: ^1H, δ 7.62-7.07 (m, 25H, Ph), 5.31-4.51 (m, 10H, CH_2Ph), 4.53 (d, overlapped, 1H, $J_{1,2}$ = 7.2 Hz, H-1_E), 4.75 (s, 1H, H-1_B), 4.07 (m, 2H, H-2_B, 3_E), 3.75-3.11 (m, 8H, H-3_B, 4_B, 5_B, 2_E, 4_E, 5_E, $6a_E$, $6b_E$), 3.35 (s, 3H, CH_3), 1.34 (d, 3H, $J_{5,6}$ = 6.0 Hz, H-6_B); ^{13}C, δ 138.5-127.5 (Ph), 102.7 (C-1_E), 100.4 (C-1_B), 84.8 (C-3_E), 82.1 (C-2_E), 80.9 (C-3_B), 80.0 (C-4_B), 77.8 (C-4_E), 75.7, 75.1, 75.0, 74.8 (CH_2Ph), 74.6 (C-5_E), 73.6 (CH_2Ph), 70.0 (C-2_B), 68.9 (C-6_E), 67.3 (C-5_B), 54.8 (CH_3), 18.0 (C-6_B).

(b) A solution of **16** and **17** (12.5 g) in a mixture of dry CH_2Cl_2 and methanol (80 mL, 4:1) was treated with 1 M MeONa in MeOH until strongly alkaline to litmus. After 16 h at rt and conventional processing as described above, the crude product was chromatographed from a column of silica gel (solvent *F*, 9.8:0.2) to give **19** (1.43 g, 16 %) and as the first eluting product **18** (5.14 g, 59 % from **11**).

(c) A solution of diol[30] **11** (268 mg, 1.0 mmol) and dibutyltin oxide (360 mg, 1.5 mmol) in toluene (20 mL) was refluxed in a soxhlet apparatus for 3 h, then cooled to rt and concentrated to dryness. A mixture of the residue, glycosyl bromide **4**, prepared[24] from the corresponding nitrobenzoate (980 mg, 1.45 mmol), and molecular sieves 4Å in CH_2Cl_2 (10 mL) was stirred at 0 °C for 30 min. Tetraethylammonium iodide (1.10 g, 2.8 mmol) was added, and stirring was continued in the dark for 4 d, at which time TLC showed that no diol remained. The reaction mixture was filtered and the filtrate was washed several times with water, satd aq NaCl, dried and concentrated. Chromatography of the residue (solvent *F*, 9.6:0.4) gave **18** (280 mg, 36%) as a colourless oil, $[\alpha]_D$ +35° (*c* 1.0); lit.[18] $[\alpha]_D$ +33° (*c* 2.0); NMR: ^1H, δ 7.61-7.07 (m, 25H, Ph), 4.80-4.42 (m, 10H, CH_2Ph), 4.89 (d, overlapped, 1H, H-1_E), 4.75 (d, 1H, $J_{1,2}$ = 1.0 Hz, H-1_B), 4.05 (dd, 1H, $J_{3,4}$ = 9.3 Hz, H-3_E), 3.98 (dd, 1H, $J_{2,3}$ = 3.4, $J_{3,4}$ = 9.0 Hz, H-3_B), 3.94 (m, 1H, H-5_E), 3.91 (bs, 1H, H-2_B), 3.73 (m, 1H, H-5_B), 3.72 (dd, 1H, $J_{4,5}$ = 9.3 Hz, H-4_E), 3.59 (dd, 1H, $J_{2,3}$ = 9.6 Hz, H-2_E), 3.47 (dd, 1H, $J_{4,5}$ = 9.3 Hz, H-4_B), 3.44 (dd, 1H, $J_{5,6a}$ = 2.6, $J_{6a,6b}$ = 10.9 Hz, H-$6a_E$), 3.39 (dd, 1H, H-$6b_E$), 3.35 (s, 3H, CH_3), 1.36 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_B); ^{13}C, δ 138.6-127.6 (Ph), 100.0 (C-1_B), 94.0 (C-1_E), 82.5 (C-3_E), 79.3 (C-4_B), 78.9 (C-2_E), 77.7 (C-4_E), 76.6 (C-3_B), 75.6, 75.5, 74.9, 74.3, 73.4 (CH_2Ph), 70.6 (C-2_B), 67.9 (C-6_E), 67.3 (C-5_E), 67.1 (C-5_B), 54.7 (CH_3), 17.9 (C-6_B).

Methyl (2,3,4-Tri-*O*-acetyl-α-L-rhamnopyranosyl)-(1→2)-[2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (20). A solution of disaccharide **18** (530 mg, 671 μmol) and trichloroacetimidate[27]

8 (380 mg, 883 μmol) in anhydrous CH_2Cl_2 (10 mL) was stirred at -78 °C for 30 min. TMSOTf (13 μL, 67 μmol) was added, and the mixture was stirred for 15 h while slowly warming up to rt. Et_3N (1 drop) was added and the solvent was evaporated. Chromatography of the crude mixture (solvent *C*, 90:10) afforded **20** (420 mg, 59 %) as a colourless foam, $[\alpha]_D$ -6° (*c* 1.0); NMR: ^1H, δ 7.37-7.07 (m, 25H, Ph), 5.60 (bs, 1H, H-1_A), 5.57 (dd, 1H, $J_{1,2}$ = 1.6 Hz, H-2_A), 5.39 (dd, 1H, $J_{2,3}$ = 3.3, $J_{3,4}$ = 10.1 Hz, H-3_A), 5.09 (dd, 1H, $J_{4,5}$ = 9.9 Hz, H-4_A), 4.92 (d, 1H, J = 11.1 Hz, CH_2Ph), 4.90 (d, 1H, H-1_E), 4.86 (d, 1H, J = 11.2 Hz, CH_2Ph), 4.84 (d, 1H, J = 10.7 Hz, CH_2Ph), 4.79 (d, 1H, J = 10.9 Hz, CH_2Ph), 4.77 (d, 1H, J = 12.1 Hz, CH_2Ph), 4.66 (d, 1H, J = 10.2 Hz, CH_2Ph), 4.65 (d, 1H, $J_{1,2}$ = 1.6 Hz, H-1_B), 4.64 (d, 1H, J = 12.1 Hz, CH_2Ph), 4.50 (d, 1H, J = 12.1 Hz, CH_2Ph), 4.38 (d, 1H, J = 11.0 Hz, CH_2Ph), 4.22 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.09 (dd, 1H, H-2_B), 4.04 (dd, 1H, $J_{2,3}$ = 2.7, $J_{3,4}$ = 9.6 Hz, H-3_B), 4.01-3.95 (m, 3H, H-5_A, 3_E, 5_E), 3.71 (dq, partially overlapped, 1H, H-5_B), 3.66 (dd, 1H, $J_{3,4}$ = 9.6 Hz, H-4_E), 3.62 (dd, 1H, $J_{4,5}$ = 9.4 Hz, H-4_B), 3.53 (dd, 1H, $J_{1,2}$ = 3.3, $J_{2,3}$ = 9.8 Hz, H-2_E), 3.36 (dd, 1H, $J_{5,6}$ = 2.6 Hz, H-$6a_E$), 3.35 (s, 3H, CH_3), 3.28 (dd, 1H, $J_{6a,6b}$ = 10.8 Hz, H-$6b_E$), 2.08, 1.99. 1.88 (3 s, 9H, C(=O)CH_3), 1.41 (d, 3H, $J_{5,6}$ = 5.9 Hz, H-6_B), 1.28 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 170.0, 169.9, 169.6 (C=O), 138.8-127.2 (Ph), 99.7 (C-1_B), 98.2 (C-1_A), 95.8 (C-1_E), 82.0 (C-3_B), 79.6 (C-4_B), 78.9 (C-2_E), 77.8 (C-4_E), 76.7 (C-3_E), 75.7, 75.3, 74.8 (CH_2Ph), 73.6 (C-2_B), 73.5, 73.2 (CH_2Ph), 71.3 (C-4_A), 70.3 (C-5_E), 69.3 (2C, C-2_A, 3_A), 68.7 (C-5_B), 67.9 (C-6_E), 66.7 (C-5_A), 54.5 (CH_3), 20.8, 20.7, 20.6 (3C, C(=O)CH_3), 17.9 (C-6_B), 17.6 (C-6_A); CIMS: *m/z* 1080 ($[M+NH_4]^+$).

Anal. Calcd for $C_{60}H_{70}O_{17}$: C, 67.78; H, 6.64. Found: C, 67.82; H, 6.70.

Methyl (2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-[2,3,4,6-tetra-*O*- benzyl-α-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (21). A solution of disaccharide **18** (567 mg, 717 μmol) trichloroacetimidate[28] **9** (667 mg, 1.07 mmol) in anhydrous Et_2O (10 mL) was stirred at -78 °C for 30 min. TMSOTf (15 μL, 77 μmol) was added and the mixture was stirred for 15 h while slowly warming up to rt. Et_3N (1 drop) was added and the solvent was evaporated. Chromatography of the crude mixture (solvent *F*, 99.5:0.5) afforded **21** (824 mg, 92 %) as a colourless foam, $[\alpha]_D$ +65° (*c* 1.0); lit.[18] $[\alpha]_D$ +130.5° (*c* 2.0); NMR: ^1H, δ 7.45-6.91 (m, 40H, Ph), 6.06 (dd, 1H, $J_{1,2}$ = 1.7, $J_{2,3}$ = 3.2 Hz, H-2_A), 5.93 (bs, 1H, H-1_A), 5.92 (dd, 1H, $J_{3,4}$ = 10.2 Hz, H-3_A), 5.66 (dd, 1H, H-4_A), 4.80-4.42 (m, 8H, CH_2Ph), 4.82 (d, 1H, $J_{1,2}$ = 3.3 Hz, H-1_E), 4.77 (d, 1H, $J_{1,2}$ = 1.7 Hz, H-1_B), 4.31 (m, 2H, J = 11.2, $J_{4,5}$ = 9.7 Hz, CH_2Ph, H-5_A), 4.18 (d, 1H, J = 11.7 Hz, CH_2Ph), 4.16 (bs, 1H, H-2_B), 4.04 (m, 1H, H-3_B), 3.96 (m, 2H, H-3_E, 5_E), 3.76 (m, 2H, H-4_B, 5_B), 3.60 (dd, 1H, $J_{3,4}$ = 9.7 Hz, H-4_E), 3.46 (dd, 1H, $J_{2,3}$ = 9.8 Hz, H-2_E), 3.39 (s, 3H, CH_3), 3.30 (dd,

1H, $J_{5,6a}$ = 2.2 Hz, H-6a$_E$), 3.23 (dd, 1H, $J_{6a,6b}$ = 10.6 Hz, H-6b$_E$), 1.49 (d, 3H, $J_{5,6}$ = 5.1 Hz, H-6$_B$), 1.42 (d, 3H, $J_{5,6}$ = 6.3 Hz, H-6$_A$); ^{13}C, δ 165.8, 165.5, 165.0 (C=O), 138.8-127.3 (Ph), 99.9 (C-1$_B$, $J_{C,H}$ = 172 Hz), 98.4 (C-1$_A$, $J_{C,H}$ = 170 Hz), 96.3 (C-1$_E$, $J_{C,H}$ = 167 Hz), 82.1 (C-3$_E$), 79.5 (C-4$_B$), 78.5 (C-2$_E$), 77.8 (C-4$_E$), 77.0 (C-3$_B$), 75.8, 75.4, 74.8 (CH_2Ph), 73.9 (C-2$_B$), 73.5, 73.3 (CH_2Ph), 72.1 (C-4$_A$), 70.3 (C-5$_E$), 70.2 (2C, C-2$_A$, 3$_A$), 68.9 (C-5$_B$), 67.9 (C-6$_E$), 67.0 (C-5$_A$), 54.6 (OCH_3), 18.0 (C-6$_B$), 17.9 (C-6$_A$); CIMS: *m/z* 1266 ([M+NH_4]$^+$).

Anal. Calcd for $C_{75}H_{76}O_{17}$: C, 72.10; H, 6.13. Found: C, 71.97; H, 6.15.

Methyl α-L-Rhamnopyranosyl-(1→2)-[2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (22). (a) A solution of trisaccharide **20** (200 mg, 160 μmol) in a mixture of CH_2Cl_2 was treated with 1 M MeONa until strongly alkaline to litmus. After 16 h at rt, the mixture was processed as described for **18**. Chromatography of the crude residue (solvent *A*, 9.5:0.5) afforded **22** (137 mg, 94%) as a colourless amorphous solid, $[\alpha]_D$ +30° (*c* 1.0); NMR: ^{1}H, δ 7.43-7.08 (m, 25H, Ph), 5.19 (bs, 1H, H-1$_A$), 5.04 (d, 1H, H-1$_E$), 4.99 (d, 1H, J = 11.0 Hz, CH_2Ph), 4.92 (d, 1H, J = 11.0 Hz, CH_2Ph), 4.87-4.75 (m, 4H, CH_2Ph), 4.66 (d, 1H, $J_{1,2}$ = 1.4 Hz, H-1$_B$), 4.58 (d, 1H, J = 10.4 Hz, CH_2Ph), 4.56 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.45 (d, 1H, J = 10.9 Hz, CH_2Ph), 4.29 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.10-4.03 (m, 5H, H-2$_A$, 2$_B$, 3$_B$, 3$_E$, 5$_E$), 3.88 (dd, 1H, $J_{2,3}$ = 3.4, $J_{3,4}$ = 9.4 Hz, H-3$_A$), 3.75-3.65 (m, 3H, H-5$_A$, 5$_B$, 4$_E$), 3.68 (dd, 1H, $J_{1,2}$ = 3.4, $J_{2,3}$ = 9.8 Hz, H-2$_E$), 3.50 (dd, 1H, $J_{3,4}$ = 9.1, $J_{4,5}$ 9.6 Hz, H-4$_B$), 3.48 (dd, partially overlapped, 1H, H-6a$_E$), 3.38 (dd, 1H, $J_{4,5}$ = 9.5 Hz, H-4$_A$), 3.37 (dd, partially overlapped, 1H, H-6b$_E$), 3.31 (s, 3H, CH_3), 1.42 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6$_B$), 1.31 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6$_A$); ^{13}C, δ 138.6-127.5 (Ph), 101.3 (C-1$_A$), 99.9 (C-1$_B$), 94.6 (C-1$_E$), 82.2 (C-3$_B$), 79.9 (C-4$_B$), 79.3 (C-2$_E$), 78.1 (C-4$_E$), 75.8 (CH_2Ph), 75.6 (C-3$_E$), 75.5, 75.0 (2C, CH_2Ph), 74.1 (C-5$_E$*), 73.9 (CH_2Ph), 73.4 (C-4$_A$), 73.3 (CH_2Ph), 71.5 (C-3$_A$), 70.7 (C-2$_A$), 70.2 (C-2$_B$*), 68.4 (C-5$_A$), 68.2 (C-5$_B$), 68.1 (C-6$_E$), 54.7 (CH_3), 18.1 (C-6$_B$), 17.7 (C-6$_A$); CIMS: *m/z* 954 ([M+NH_4]$^+$).

Anal. Calcd for $C_{54}H_{64}O_{14}$: C, 69.21; H, 6.88. Found: C, 69.14; H, 6.97.

Methyl (2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-[α-D-glucopyranosyl-(1→3)]-α-L-rhamnopyranoside (23). (a) A solution of the fully protected **21** (320 mg, 0.25 mmol) in a mixture of EtOH and acetic acid (5 mL, 4:1) was stirred for 48 h at rt in a hydrogen atmosphere, at atmospheric pressure in the presence of 10% palladium-on-charcoal (250 mg). The mixture was filtered, and the filtrate was coevaporated several times with cyclohexane. The crude product was eluted from a column of silica gel (solvent *A*, 9.5:0.5) to give **23** as a colourless, hygroscopic solid (186 mg, 91%), $[\alpha]_D$ +122° (*c* 1.0); NMR: ^{1}H, δ 8.09-7.17 (m, 15H, Ph), 5.83 (bs, 1H, H-2$_A$),

5.65 (dd, 1H, $J_{2,3}$ = 3.0, $J_{3,4}$ = 10.1 Hz, H-3_A), 5.65 (dd, 1H, $J_{4,5}$ = 9.7 Hz, H-4_A), 5.29 (bs, 1H, H-1_A), 4.98 (m, 3H, 2 OH, H-1_E), 4.76 (s, 1H, H-1_B), 4.31 (dq, 1H, H-5_A), 4.09 (bs, 1H, H-2_B), 4.00 (m, 1H, H-4_E), 3.94-3.63 (m, 8H, 2 OH, H-3_B, 4_B, 5_B, 3_E, $6a_E$, $6b_E$), 3.47 (m, 3H, OH, H-2_E, 5_E), 3.35 (s, 3H, CH_3), 1.39 (d, 3H, $J_{5,6}$ = 5.8 Hz, H-6_B), 1.33 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 166.3-165.8 (3C, C=O), 133.6-128.3 (Ph), 99.9 (C-1_B), 99.6 (C-1_A), 96.4 (C-1_E), 77.0 (2C, C-2_B, 3_B), 73.5 (C-4_B), 72.4 (C-4_E), 71.8 (C-2_E), 71.5 (C-4_A), 71.0 (C-3_E), 70.7 (C-2_A), 70.4 (C-5_E), 70.3 (C-3_A), 68.4 (C-5_B), 67.1 (C-5_A), 61.9 (C-6_E), 54.8 (CH_3), 17.8 (C-6_B), 17.6 (C-6_A); ES: *m/z* 799.4 ($[M+H]^+$).

Anal. Calcd for $C_{40}H_{46}O_{17}$: C, 60.14; H, 5.80. Found: C, 59.99; H, 5.98.

Methyl α-L-Rhamnopyranosyl-(1→2)-[α-D-glucopyranosyl-(1→3)]-α-L-rhamnopyranoside (1). To a solution of **23** (237 mg, 0.25 mmol) in a 4:1 mixture of EtOH and acetic acid, was added 10% palladium-on-charcoal (100 mg) and the mixture was stirred under a hydrogen atmosphere for 24 h. The solution was filtered and coevaporated several times with cyclohexane and toluene. Reverse phase chromatography (solvent *G*, gradient) of the crude product, followed by lyophilization, gave compound **1** (112 mg, 91%) as a colourless powder; $[\alpha]_D$ +44° (*c* 1.0, water), lit.[18] $[\alpha]_D$ +57° (*c* 1.6, water), lit.[17] $[\alpha]_D$ +21.8° (*c* 1.6, water); CIMS: *m/z* 504 ($[M+NH_4]^+$). The ^{13}C and ^{1}H NMR spectra of **1** are identical to those described in ref. 14.

Anal. Calcd for $C_{19}H_{34}O_{14}\cdot H_2O$: C, 45.23; H, 7.19. Found: C, 45.31; H, 7.18.

Methyl (2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-4-*O*-benzyl-3-*O*-*para*-methoxybenzyl-α-L-rhamnopyranoside (26). A solution of compound[34] **24** (388 mg, 1.0 mmol), donor[29] **7** (808 mg, 1.5 mmol) and *sym*-collidine (165 μL, 1.25 mmol) in CH_2Cl_2 (5 mL) was added dropwise to a suspension of AgOTf (462 mg, 1.8 mmol) in CH_2Cl_2 (5 mL). Stirring was continued for 5 h, at which time the temperature of the bath had reached 20 °C. TLC (solvent *D*, 9:1) showed the complete disappearance of **25**. The mixture was filtered through a bed of Celite. The filtrate was washed with a 1:1 mixture of 5% aq $NaHCO_3$ and 5% aq $Na_2S_2O_3$, then water and satd aq NaCl. The organic phase was dried and concentrated. The crude product was chromatographed (solvent *D*, 97:3) to give pure disaccharide **26** (564 mg, 66 %) as a colourless foam, $[\alpha]_D$ +96° (*c* 1.0); RMN: ^{1}H, δ 8.11-6.69 (m, 24H, Ph), 5.90 (dd, 2H, H-2_A, 3_A), 5.68 (dd, 1H, $J_{3,4}$ = 9.6 Hz, H-4_A), 5.23 (d, 1H, H-1_A), 4.97 (d, 1H, J = 11.0 Hz, CH_2Ph), 4.75 (d, 1H, H-1_B), 4.73 (d, 1H, CH_2Ph), 4.67 (d, 1H, J = 11.4 Hz, CH_2PhCH_3), 4.60 (d, 1H, CH_2PhCH_3), 4.30 (dq, 1H, $J_{4,5}$ = 9.7 Hz, H-5_A), 4.05 (dd, 1H, H-2_B), 3.89 (dd, 1H, $J_{2,3}$ = 2.9, $J_{3,4}$ = 8.9 Hz, H-3_B), 3.72 (dq, 1H, H-5_B), 3.67 (dd, 1H, $J_{4,5}$ = 9.0, $J_{4,3}$ 9.0 Hz, H-4_B), 3.62 (s, 3H, CH_3OPh), 3.37 (s, 3H, CH_3), 1.41 (d, 3H, $J_{5,6}$ = 5.9 Hz, H-6_B), 1.36 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 165.9, 165.5,

165.2 (C=O), 159.0 (Ph), 138.7-125.3 (Ph), 113.8 (Ph), 99.9 (C-1_B), 99.5 (C-1_A), 80.0 (C-4_B), 79.6 (C-3_B), 75.9 (C-2_B), 75.5 (CH_2Ph), 72.2 (CH_2PhCH_3), 71.9 (C-4_A), 70.6 (C-3_A), 70.0 (C-2_A), 68.0 (C-5_B), 67.1 (C-5_A), 55.0 (CH_3OPh), 54.7 (CH_3), 18.0 (C-6_B), 17.8 (C-6_A); CIMS: *m/z* 864 ($[M+NH_4]^+$).

Anal. Calcd for $C_{49}H_{50}O_{13}$: C, 69.49; H, 5.95. Found: C, 69.57; H, 5.98.

Methyl (2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-3-*O*-allyl-4-*O*-benzyl-α-L-rhamnopyranoside (27). A solution of the glycosyl bromide[29] **7** (2.50 g, 4.6 mmol), the nucleophile[19,35] **25** (928 mg, 3.0 mmol) and *sym*-collidine (490 μL, 3.8 mmol) in CH_2Cl_2 (10 mL) was added dropwise, at -20 °C, to a stirred suspension of AgOTf (1.41 g, 5.5 mmol) in CH_2Cl_2 (10 mL) and the mixture was processed as described for the preparation of compound **26**. Chromatography of the residue (solvent *D*, 96.5:3.5) gave disaccharide **27** (1.76 g, 76%) as a colourless foam, $[\alpha]_D$ +90° (*c* 1.0); RMN: ^1H, δ 8.18-7.08 (m, 20H, Ph), 5.90 (m, 3H, H-2_A, 3_A, C*H*=CH_2), 5.68 (dd, 1H, $J_{3,4}$ = 10.0 Hz, H-4_A), 5.31 (d, 1H, $J_{1,2}$ = 1.6 Hz, H-1_A), 5.30 (dd, 1H, J = 12.3 Hz, C*H*$_2$=CH), 5.09 (bd, 1H, J = 10.4 Hz, C*H*$_2$=CH), 4.98 (d, 1H, J = 11.0 Hz, CH_2Ph), 4.75 (d, 1H, H-1_B), 4.73 (d, 1H, CH_2Ph), 4.30 (dq, 1H, $J_{4,5}$ = 9.7 Hz, H-5_A), 4.21 (d, 2H, J = 5.3 Hz, C*H*$_2$-CH), 4.11 (bs, 1H, H-2_B), 3.80 (dd, 1H, $J_{2,3}$ = 2.8, $J_{3,4}$ = 9.1 Hz, H-3_B), 3.71 (dq, 1H, $J_{4,5}$ = 9.3 Hz, H-5_B), 3.62 (dd, 1H, H-4_B), 3.39 (s, 3H, CH_3), 1.41 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_B), 1.37 (d, 3H, $J_{5,6}$ = 6.3 Hz, H-6_A); ^{13}C, δ 165.9, 165.6, 165.4 (C=O), 138.7-125.4 (*C*H=CH_2, Ph), 116.8 (*C*H_2=CH), 99.9 (C-1_B), 99.3 (C-1_A), 80.0 (C-4_B), 79.2 (C-3_B), 75.7 (C-2_B), 75.5 (CH_2Ph), 71.9 (C-4_A), 71.2 (*C*H_2CH), 70.7 (C-3_A), 70.0 (C-2_A), 68.0 (C-5_B), 67.1 (C-5_A), 54.6 (CH_3), 17.9 (C-6_B), 17.7 (C-6_A); CIMS: *m/z* 784 ($[M+NH_4]^+$).

Anal. Calcd for $C_{44}H_{46}O_{12}$: C, 68.92; H, 6.05. Found: C, 68.92; H, 6.07.

Methyl (2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-4-*O*-benzyl-α-L-rhamnopyranoside (28). Compound **27** (1.27 g, 1.62 mmol) 1,5-cyclooctadiene-bis(methyldiphenylphosphine)iridium hexafluorophosphate (45 mg, 53 μmol) were dissolved in anhydrous THF (20 mL). The solution was degassed and placed under Ar. The catalyst was activated by passing over a stream of hydrogen until the solution had turned yellow (~3 min). The reaction mixture was degassed and stirred under an Ar atmosphere until no starting material could be detected by TLC (solvent *D*, 97:3) (~3 h), then concentrated to dryness. The residue was dissolved in acetone (200 mL), then water (20 mL), mercuric oxide (846 mg, 3.94 mmol), and mercuric chloride (845 mg, 3.11 mmol) were added successively. The mixture, protected from light, was stirred at rt for 5 h and acetone was evaporated. The resulting suspension was taken up in CH_2Cl_2, washed twice with 50% aq KI, water and satd aq NaCl, dried and concentrated. Purification of the crude material was effected by silica gel column chromatography (solvent *D*, 97:3) to

furnish monohydroxylated **28** (1.03 g, 85%) as a colourless foam, $[\alpha]_D$ +103° (*c* 1.0); RMN: ^1H, δ 8.11-7.19 (m, 20H, Ph), 5.83 (dd, 2H, $J_{2,3}$ = 3.3 Hz, H-2_A, 3_A), 5.69 (dd, 1H, $J_{3,4}$ = 9.7 Hz, H-4_A), 5.28 (d, 1H, H-1_A), 4.90 (d, 1H, J = 11.4 Hz, CH_2Ph), 4.81 (d, 1H, CH_2Ph), 4.80 (d, 1H, H-1_B), 4.33 (dq, 1H, $J_{4,5}$ = 9.7 Hz, H-5_A), 4.03 (m, 2H, H-2_B, 3_B), 3.75 (dq, 1H, $J_{4,5}$ = 9.4 Hz, H-5_B), 3.67 (t, 1H, $J_{4,3}$ 9.1 Hz, H-4_B), 3.39 (s, 3H, CH_3), 2.27 (d, 1H, $J_{OH,3}$ 5.4 Hz, OH-3), 1.45 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_B), 1.37 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 165.8, 165.7, 165.5 (C=O), 138.3-128.0 (Ph), 99.8 (C-1_A), 99.7 (C-1_B), 81.8 (C-4_B), 79.4 (C-2_B), 75.3 (CH_2Ph), 71.7 (C-4_A), 71.4 (C-3_B), 70.6 (C-2_A), 70.1 (C-3_A), 67.6 (C-5_B), 67.3 (C-5_A), 54.9 (OCH_3), 18.2 (C-6_B), 17.7 (C-6_A); CIMS: *m/z* 744 ($[M+NH_4]^+$).

Anal. Calcd for $C_{41}H_{42}O_{12}$: C, 67.76; H, 5.82. Found: C, 67.68; H, 5.95.

Methyl (2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-[2,3,4,6-tetra-*O*- benzyl-β-D-glucopyranosyl-(1 → 3)]-4-*O*-benzyl-α-L-rhamnopyranoside (29). TMSCl (115 μL, 900 μmol) was added dropwise at 0°C to a solution of the alcohol **28** (218 mg, 300 μmol) and pyridine (110 μL, 900 μmol) in CH_2Cl_2 (5 mL). After 15 min, the cooling bath was removed and the mixture was stirred for 3 h at rt. CH_2Cl_2 was added and the solution was successively washed with cold water, 5% aq $NaHCO_3$, water, and satd aq NaCl, dried, and concentrated to dryness. A mixture of activated powered 4Å molecular sieves (1.0 g) and compound[21] **3** (290 mg, 534 μmol) in anhydrous Et_2O (12 mL) was stirred at rt for 45 min, then cooled to 0°C. Triflic anhydride (140 μL, 840 μmol) was added, and stirring was continued at 0 °C for 1 h. Next, the crude silylated material (225 mg, 280 μmol), taken up in anhydrous Et_2O (5 mL), was added dropwise, and the resulting mixture was stirred at 4 °C for 40 h. At this time, no starting material could be detected (solvent *F*, 95:5). Et_3N was added at rt, and the mixture was diluted with CH_2Cl_2, filtered and concentrated. The residue was taken up in CH_2Cl_2, washed successively with 5% aq HCl, water and, satd aq NaCl, dried and concentrated. The oily residue was eluted from a column of silica gel (solvent *F*, 99:1) to give the condensation product as a 2:3 mixture of **21** and **29** (285 mg, 81%). A new chromatography of the mixture allowed the isolation of an analytical sample of each anomer. The faster moving product was the α-anomer **21**, identical to that described above. The slower moving product corresponding to the β-anomer **29** was isolated as a colourless amorphous solid, $[\alpha]_D$ +50° (*c* 1.0); NMR: ^1H, δ 8.13-6.99 (m, 40H, Ph), 5.98 (dd, 1H, $J_{1,2}$ = 1.3 Hz, H-2_A), 5.94 (dd, 1H, $J_{2,3}$ = 3.3 Hz, H-3_A), 5.73 (dd, 1H, $J_{3,4}$ = 9.8 Hz, H-4_A), 5.52 (bs, 1H, H-1_A), 5.18 (d, 1H, J = 11.6 Hz, CH_2Ph), 4.91 (d, 1H, J = 10.5 Hz, CH_2Ph), 4.90 (s, 1H, H-1_B), 4.88 (d, 1H, J = 10.3 Hz, CH_2Ph), 4.83-4.78 (m, 3H, CH_2Ph), 4.77 (d, 1H, $J_{1,2}$ = 8.1 Hz, H-1_E), 4.52-4.43 (m, 4H, CH_2Ph), 4.36 (dq, 1H, $J_{4,5}$ = 9.7 Hz, H-5_A), 4.33 (dd, 1H, H-2_B), 4.20 (dd, 1H, $J_{2,3}$ = 3.2, $J_{3,4}$ = 9.0 Hz, H-3_B), 3.73 (m,

partially overlapped, 1H, H-5_B), 3.70 (m, 2H, H-4_B, $6a_E$), 3.64-3.58 (m, 3H, H-2_E, 5_E, $6b_E$), 3.47 (m, 2H, H-3_E, 4_E), 3.34 (s, 3H, CH_3), 1.41 (d, 3H, $J_{5,6}$ = 5.9 Hz, H-6_B), 1.36 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 165.9, 165.5, 165.2 (C=O), 138.8-127.0 (Ph), 104.1 (C-1_B), 100.1 (C-1_E), 99.7 (C-1_A), 84.8, 82.7, 78.3 (C-2_E, 3_E, 4_E), 80.5 (C-4_B), 79.3 (C-2_B), 78.3 (C-3_B), 75.4, 75.2, 75.0 (CH_2Ph), 74.8 (C-5_E), 73.5 (CH_2Ph), 72.0 (C-4_A), 70.7 (C-2_A), 70.1 (C-3_A), 69.0 (C-6_E), 67.7 (C-5_B), 67.0 (C-5_A), 54.6 (CH_3), 18.0 (C- 6_B), 17.7 (C-6_A); CIMS: *m/z* 1266 ($[M+NH_4]^+$).

Anal. Calcd for $C_{75}H_{76}O_{17}$: C, 72.10; H, 6.13. Found: C, 72.11; H, 6.27.

Methyl α-L-Rhamnopyranosyl-(1→2)-[β-D-glucopyranosyl-(1→3)]-α-L-rhamnopyranoside (30). A mixture of **21** and **29** (1.30 g, 1.05 mmol), prepared according to the protocol described above, 10% palladium-on-charcoal (400 mg) in a 4:1 mixture of EtOH and acetic acid (25 mL) was hydrogenolyzed as described for the preparation of **23**. Sodium methoxide was added to a solution of the crude material in MeOH (10 mL) at 25 °C. After 18 h, the solution was neutralised with Amberlite IR-120 (H^+), filtered and concentrated. After extraction with CH_2Cl_2, reverse phase column chromatography (solvent *G*, gradient) of the crude product, followed by lyophilization, gave in order of elution, compound **1** (161 mg, 26%) and compound **30** (183 mg, 39%) as colourless amorphous powders. Compound **30** had $[\alpha]_D$ -39° (*c* 1.0, water); lit.[18] $[\alpha]_D$ -41° (*c* 1.8, water); CIMS: *m/z* 504 ($[M+NH_4]^+$). The ^{13}C and ^1H NMR spectra of **30** are identical to those described in ref. 18.

Anal. Calcd for $C_{19}H_{34}O_{14}\cdot H_2O$: C, 45.23; H, 7.19. Found: C, 44.89; H, 7.10.

3,4-Di-*O*-allyl-1,2-*O*-methoxyethylidene-α-L-rhamnopyranose (32). A solution of crude orthoester[44] **31** (17.4 g, 57.2 mmol) in dry MeOH (220 mL) was cooled to 0 °C and saturated with gaseous ammonia. The mixture was stirred at rt for 20 h. When TLC (solvent *A*, 19:1) showed the complete disappearance of the starting material, volatiles were evaporated, and the residue was dried under vacuum over phosphorous pentoxide. Sodium hydride (60% suspension in oil, 9.2 g, 230 mmol) was added portionwise to a solution of the crude diol in dry DMF (250 mL), while the temperature was maintained below 5 °C. Stirring was continued for 45 min at rt, then allyl bromide (14.8 mL, 172.0 mmol) was added dropwise to the reaction mixture kept under strong stirring, below 10°C. The solution was then left stirring at rt for 18 h. Then MeOH (20 mL) was added. After 2 h, the reaction mixture was concentrated under vacuum. The residue, taken up in CH_2Cl_2, was washed successively with water, 5% aqueous HCl, water and satd aqueous NaCl, dried, and concentrated to dryness. Chromatography of the residue (solvent *B*, 8.5:1.5) afforded orthoester **32** (16.2 g, 94%) as a colourless oil, $[\alpha]_D$ +22° (*c* 1.0); NMR: ^1H, δ 6.01-5.88 (m, 2H, C*H*=CH_2), 5.33 (d, 1H, H-1), 5.35-5.14 (m, 4H, CH=CH_2), 4.49 (dd, 1H, $J_{1,2}$ = 2.5, $J_{2,3}$ = 4.1 Hz, H-2), 4.41-4.11 (m, 4H, CH_2CH=CH_2), 3.57 (m,

1H, H-3), 3.29 (m, 5H, CH_3, H-4, 5), 1.70 (s, 3H, CH_3), 1.31 (d, 3H, $J_{5,6}$ = 5.7 Hz, H-6); ^{13}C, δ 134.8, 134.7 (*C*H=CH_2), 117.8, 117.1 (CH=*C*H_2), 97.3 (C-1), 79.0 (C-4), 78.9 (C-3), 77.4 (C-2), 74.2, 71.5 (*C*H_2CH=CH_2), 70.3 (C-5), 49.8 (CH_3), 24.4 (CH_3), 17.9 (C-6); CIMS: *m/z* 318 ($[M+NH_4]^+$).

Anal. Calcd for $C_{15}H_{24}O_6$: C, 59.98; H, 8.05. Found: C, 59.98; H, 7.96.

2-*O*-Acetyl-3,4-di-*O*-allyl-α/β-L-rhamnopyranose (33). To a solution of orthoester **32** (1.87 g, 6.2 mmol) in $CHCl_3$ (30 mL), was added 50% aq CF_3CO_2H (3 mL) at 0 °C. The mixture was stirred vigorously at 0 °C for 20 min, at which time TLC (solvent *C*, 4:1) showed the complete disappearance of **32**. The reaction mixture was concentrated under vacuum and coevaporated 3 times with toluene. The residue was eluted from a column of silica gel (solvent *B*, 4:1) to give **33** (1.27 g, 72%) as a colourless oil in a 4/1 α/β ratio, $[\alpha]_D$ -11° (*c* 1.0); NMR: ^1H, δ 5.97-5.84 (m, 2H, 2 C*H*=CH_2α, 2 C*H*=CH_2β), 5.39 (bd, 0.2H, $J_{1,2}$ = 1.0 Hz, H-2β), 5.31-5.14 (m, 3.8H, H-1β, 2α, CH=C*H*$_2$), 5.10 (dd, 0.8H, $J_{1,2}$ = 1.7, $J_{1,OH}$ 3.7 Hz, H-1α), 4.88 (dd, 0.2H, J 1.1, J 9.0 Hz, CH=C*H*$_2$β), 4.35, 4.16-3.98 (m, 4H, CH_2CH=CH_2), 3.93 (dq, 0.8H, $J_{4,5}$ = 9.5 Hz, H-5α), 3.81 (dd, 0.8H, $J_{2,3}$ = 3.4, $J_{3,4}$ = 9.4 Hz, H-3α), 3.46 (dd, 0.2H, $J_{2,3}$ = 3.4, $J_{3,4}$ = 9.2 Hz, H-3β), 3.38 (dq, 0.2H, $J_{4,5}$ = 9.4 Hz, H-5β), 3.27 (d, 0.8H, OHα), 3.26 (dd, 0.8H, H-4α), 3.19 (dd, 0.2H, H-4β), 2.18 (s, 0.6H, C(=O)CH_3β), 2.13 (s, 2.4H, C(=O)CH_3α), 1.35 (d, 0.6H, $J_{5,6}$ = 6.1 Hz, H-6β), 1.30 (d, 2.4H, $J_{5,6}$ = 6.2 Hz, H-6α); ^{13}C, δ 170.9 (C=Oβ), 170.5 (C=Oα), 134.9, 134.6 (*C*H=CH_2α), 134.8, 134.3 (2C, *C*H=CH_2β), 117.3, 117.0 (2C, CH=*C*H_2β), 117.0, 116.9 (2C, CH=*C*H_2α), 92.9 (C-1β), 92.3 (C-1α), 79.9 (C-4α), 79.5 (C-3β), 79.1 (C-4β), 76.7 (C-3α), 74.2 (*C*H_2CH=CH_2α, *C*H_2CH=CH_2β), 71.7 (C-5β), 70.6 (*C*H_2CH=CH_2β), 70.4 (*C*H_2CH=CH_2α), 69.9 (C-2β), 69.7 (C-2α), 67.7 (C-5α), 21.0 (C(=O)*C*H_3α), 20.9 (C(=O)*C*H_3β), 17.9 (C-6α), 17.8 (C-6α); ES: *m/z* 287.2 ($[M+H]^+$), 309.2 ($[M+Na]^+$).

Anal. Calcd for $C_{14}H_{22}O_6$: C, 58.73; H, 7.74. Found: C, 58.74; H, 7.67.

2-*O*-Acetyl-3,4-di-*O*-allyl-α-L-rhamnopyranosyl Trichloroacetimidate (35). The crude reaction mixture obtained by opening of the orthoester **32** (5.68 g, 17.9 mmol) was dissolved in dry CH_2Cl_2 (30 mL). Trichloroacetonitrile (8 mL, 79.7 mmol) and DBU (370 μL, 2.45 mmol) were added, and the solution was stirred for 30 min. The volatiles were evaporated, and the residue was coevaporated twice with toluene. The residue was chromatographed (solvent *B*, 8.7:1.3, containing Et_3N 0.1%) to give the pure α anomer **35** (5.63 g, 73%) as a colourless oil, $[\alpha]_D$ -46° (*c* 1.0); NMR: ^1H, δ 8.66 (s, 1H, NH), 6.15 (bd, 1H, $J_{1,2}$ = 1.8 Hz, H-1), 6.00-5.83 (m, 2H, C*H*=CH_2), 5.40 (dd, 1H, $J_{2,3}$ = 3.4 Hz, H-2), 5.32-5.16 (m, 4H, CH=C*H*$_2$), 4.41-4.02 (m, 4H, C*H*$_2$CH=CH_2), 3.90 (dq, 1H, $J_{4,5}$ = 9.6 Hz, H-5), 3.84 (dd, 1H, $J_{3,4}$ = 9.9 Hz, H-3), 3.36 (dd, 1H, H-4), 2.16 (s, 3H, C(=O)CH_3), 1.35 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6); ^{13}C, δ

170.0 (O(C=O)), 160.1 (N(C=O)), 134.8, 134.4 (*C*H=CH_2), 117.6, 117.3 (CH=*C*H_2), 95.2 (C-1), 79.2 (C-4), 76.8 (C-3), 74.5, 71.1 (*C*H_2CH=CH_2), 70.7 (C-5), 67.8 (C-2), 21.0 (C(=O)*C*H_3), 18.0 (C-6); ES: *m/z* 287.2 ([M+H]$^+$).

Anal. Calcd for $C_{16}H_{22}Cl_3NO_6$: C, 44.62; H, 5.15; N, 3.25. Found: C, 44.61; H, 5.23; N, 3.17.

Methyl (3,4,6-Tri-*O*-acetyl-2-deoxy-2-(2,2,2-trichloroethoxycarbonylamino)-β-D-glucopyranosyl)-(1 → 2)-3,4-di-*O*-benzyl-α-L-rhamnopyranoside (41). A solution of alcohol[34] **40** (680 mg, 1.90 mmol) and donor[48] **38** (1.54 g, 2.46 mmol) in anhydrous Et_2O (15 mL) was stirred at -78 °C for 30 min. TMSOTf (24 μL, 124 μmol) was added, and the mixture was stirred for 15 h while slowly warming up to rt. As no starting material could be detected (solvent *D*, 8.5:1.5), Et_3N (1 drop) was added and the solvent was evaporated. Chromatography of the crude mixture (solvent *C*, 4:1) afforded **41** (1.14 g, 95%) as a colourless foam, $[\alpha]_D$ +7° (*c* 1.0); NMR: ^{1}H, δ 7.43-7.27 (m, 10H, Ph), 5.55 (bd, 1H, $J_{NH,2}$ = 6.8 Hz, NH), 5.02 (dd, 1H, $J_{3,4}$ = 9.4, $J_{4,5}$ = 9.6 Hz, H-4_D), 4.97 (dd, 1H, H-3_D), 4.95 (d, 1H, J = 10.8 Hz, CH_2Ph), 4.84 (d, 1H, J = 11.3 Hz, CH_2Ph), 4.82 (bd, 1H, J = 12.0 Hz, CH_2CCl_3), 4.70 (d, 1H, $J_{1,2}$ = 1.2 Hz, H-1_A), 4.63 (d, 1H, J = 10.8 Hz, CH_2Ph), 4.61 (d, 1H, J = 11.3 Hz, CH_2Ph), 4.59 (d, 1H, $J_{1,2}$ = 8.5 Hz, H-1_D), 4.40 (d, 1H, CH_2CCl_3), 4.22 (dd, 1H, $J_{5,6a}$ = 4.5, $J_{6a,6b}$ = 12.2 Hz, H-$6a_D$), 4.11 (dd, 1H, $J_{5,6b}$ = 2.4 Hz, H-$6b_D$), 3.92 (dd, 1H, H-2_A), 3.84 (dd, 1H, $J_{2,3}$ = 3.0, $J_{3,4}$ = 9.3 Hz, H-3_A), 3.74 (m, 1H, H-2_D), 3.67 (dq, 1H, $J_{4,5}$ = 9.5 Hz, H-5_A), 3.51 (m, 1H, H-5_D), 3.42 (dd, 1H, H-4_A), 3.33 (s, 3H, CH_3), 2.09, 2.02, 1.98 (3 s, 9H, C(=O)CH_3), 1.32 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_A); ^{13}C, δ 170.7, 170.4, 169.4 (3C, OC(=O)), 154.2 (NC(=O)), 138.3-127.8 (Ph), 102.0 (C-1_D), 99.8 (C-1_A), 95.5 (CCl_3), 80.7 (C-4_A), 80.5 (C-3_A), 77.4 (C-2_A), 75.5, 74.4, 73.6 (3C, CH_2Ph, CH_2CCl_3), 73.1 (C-3_D), 72.0 (C-5_D), 68.4 (C-4_D), 67.7 (C-5_A), 62.0 (C-6_D), 56.1 (C-2_D), 54.6 (CH_3), 20.8, 20.7, 20.6 (3C, C(=O)CH_3), 17.8 (C-6_A); CIMS: *m/z* 837 ([M+NH_4]$^+$).

Anal. Calcd for $C_{36}H_{44}Cl_3NO_{14}$: C, 52.66; H, 5.40; N, 1.71. Found: C, 53.30; H, 5.58; N, 1.66.

Methyl (3,4,6-Tri-*O*-acetyl-2-trichloroacetamido-2-deoxy-β-D-glucopyranosyl)-(1→2)-3,4-di-*O*-benzyl-α-L-rhamnopyranoside (42). A solution of compound[34] **40** (985 mg, 2.75 mmol) and donor[49] **39** (2.12 g, 3.56 mmol) in anhydrous CH_2Cl_2 (20 mL) was stirred at -78 °C for 30 min. TMSOTf (53 μL, 27 μmol) was added, and the mixture was stirred for 15 h, while slowly warming up to rt. As no starting material could be detected (solvent *D*, 9.5:0.5), Et_3N (1 drop) was added and the solvent was evaporated. Chromatography of the crude mixture (solvent *D*, 94:6) afforded **42** (1.93 g, 97 %) as a colourless solid; mp 170-171 °C (from ethyl acetate-isopropyl ether), $[\alpha]_D$ -5° (*c* 1.0); NMR: ^{1}H, δ 7.43-7.28 (m, 10H, Ph), 6.78 (d, 1H, $J_{NH,2}$ = 8.4 Hz, NH), 5.11 (dd,

partially overlapped, 1H, H-4_D), 5.08 (dd, partially overlapped, 1H, H-3_D), 4.86 (d, 1H, J = 10.9 Hz, CH_2Ph), 4.76 (d, 1H, J = 11.3 Hz, CH_2Ph), 4.68 (d, 1H, $J_{1,2}$ = 1.6 Hz, H-1_A), 4.65 (d, 1H, $J_{1,2}$ = 8.5 Hz, H-1_D), 4.60 (d, 1H, J = 11.3 Hz, CH_2Ph), 4.59 (d, 1H, J = 10.9 Hz, CH_2Ph), 4.25 (dd, 1H, $J_{5,6a}$ = 4.6, $J_{6a,6b}$ = 12.3 Hz, H-$6a_D$), 4.15 (dd, 1H, $J_{5,6b}$ = 2.5 Hz, H-$6b_D$), 4.05 (ddd, 1H, H-2_D), 3.91 (dd, 1H, H-2_A), 3.84 (dd, 1H, $J_{2,3}$ = 3.2, $J_{3,4}$ = 9.3 Hz, H-3_A), 3.65 (dq, 1H, $J_{4,5}$ = 9.4 Hz, H-5_A), 3.56 (m, 1H, H-5_D), 3.38 (dd, 1H, H-4_A), 3.35 (s, 3H, OCH_3), 2.11, 2.05, 2.02 (3 s, 9H, $C(=O)CH_3$), 1.32 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 170.7, 170.6, 169.2 ($OC(=O)$), 161.7 ($NC(=O)$), 138.5-127.5 (Ph), 101.4 (C-1_D), 99.8 (C-1_A), 92.2 (CCl_3), 80.9 (C-4_A), 80.0 (C-3_A), 76.4 (C-2_A), 75.5, 73.7 (2C, CH_2Ph), 72.4 (C-4_D), 72.1 (C-5_D*), 68.2 (C-3_D*), 67.6 (C-5_A), 61.9 (C-6_D), 55.7 (C-2_D), 54.5 (CH_3), 20.7, 20.6, 20.5 ($OC(=O)CH_3$), 17.9 (C-6_A); ES: *m/z* 790.4 ($[M+H]^+$), 812.2 ($[M+Na]^+$).

Anal. Calcd for $C_{35}H_{42}Cl_3NO_{13}$: C, 53.14; H, 5.35; N, 1.77. Found: C, 53.00; H, 5.32; N, 1.73.

Methyl (2-*O*-Acetyl-3,4-di-*O*-allyl-α-L-rhamnopyranosyl)-(1→2)-[2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (43). A solution of disaccharide **16** (7.61 g, 9.63 mmol) and donor **35** (5.40 g, 12.5 mmol) in anhydrous Et_2O (100 mL) was stirred at -78 °C for 30 min. TMSOTf (70 μL, 360 μmol) was added, and the mixture was stirred for 15 h while slowly warming up to rt. As no starting material could be detected (solvent *E*, 9:1), Et_3N (500 μL, 360 mmol) was added and the solvent was evaporated. Chromatography of the crude mixture (solvent *B*, 85:15, then solvent *C*, 92:8) afforded the fully protected trisaccharide **43** (9.78 g, 96 %) as a sticky oil, $[\alpha]_D$ -2° (*c* 1.0); NMR: ^1H, δ 7.42-7.07 (m, 25H, Ph), 6.02-5.85 (m, 2H, $CH=CH_2$), 5.58 (bs, 1H, H-1_A), 5.49 (dd, 1H, $J_{1,2}$ = 1.6 Hz, H-2_A), 5.32-5.16 (m, 4H, $CH=CH_2$), 4.97 (d, 1H, H-1_E), 4.96-4.77 (m, 5H, CH_2Ph), 4.70-4.61 (m, 3H, CH_2Ph, H-1_B), 4.52 (d, 1H, CH_2Ph), 4.39 (m, 2H, CH_2Ph, $CH_2CH=CH_2$), 4.25 (d, 1H, CH_2Ph), 4.22-4.08 (m, 3H, $CH_2CH=CH_2$), 4.11 (dd, 1H, $J_{1,2}$ = 1.8, $J_{2,3}$ = 4.3 Hz, H-2_B), 4.07-3.97 (m, 3H, H-3_B, 3_E, 5_E), 3.83 (dd, 1H, $J_{2,3}$ = 3.4, $J_{3,4}$ = 9.4 Hz, H-3_A), 3.76 (dq, 1H, $J_{4,5}$ = 9.5, $J_{5,6}$ = 6.1 Hz, H-5_A), 3.68 (m, overlapped, 1H, H-5_B), 3.66 (dd, 1H, $J_{3,4}$ = 9.6, $J_{4,5}$ = 9.6 Hz, H-4_E), 3.55 (dd, 1H, $J_{4,5}$ = 9.4, $J_{3,4}$ = 9.2 Hz, H-4_B), 3.54 (dd, 1H, $J_{1,2}$ = 3.4, $J_{2,3}$ = 9.8 Hz, H-2_E), 3.41 (dd, 1H, $J_{5,6a}$ = 2.7, $J_{6a,6b}$ = 11.0 Hz, H-$6a_E$), 3.34 (dd, partially overlapped, 1H; H-$6b_E$), 3.32 (s, 3H, CH_3), 3.27 (dd, 1H, $J_{3,4}$ = 9.4 Hz, H-4_A), 1.88 (s, 3H, $OC(=O)CH_3$), 1.36 (d, 3H, H-6_A), 1.35 (d, 3H, $J_{5,6}$ = 6.0 Hz, H-6_B); ^{13}C, δ 169.8 (C=O), 139.0-127.4 ($CH=CH_2$, Ph), 116.9, 116.8 ($CH=CH_2$), 99.9 (C-1_B, $^1J_{C,H}$ = 168 Hz), 98.0 (C-1_A, $^1J_{C,H}$ = 172 Hz), 95.4 (C-1_E, $^1J_{C,H}$ = 167 Hz), 82.2 (C-3_E), 80.1 (C-4_A), 79.7 (C-4_B*), 79.0 (C-2_E*), 77.8 (C-4_E), 77.3 (C-3_A), 76.5 (C-3_B), 75.7, 75.5,

74.9, 74.3, 73.4, 73.3 (6C, 4 CH_2Ph, 2 $CH_2CH{=}CH_2$), 72.0 (C-2_B), 70.8 (CH_2Ph), 70.4 (C-5_E), 69.1 (C-2_A), 68.5 (C-5_B), 68.2 (C-5_A), 68.1 (C-6_E), 54.7 (CH_3), 20.9 (OC(=O)CH_3), 18.2, 18.1 (C-6_A, 6_B); CIMS: *m/z* 1076 ([M+NH_4]$^+$).

Methyl (3,4-Di-*O*-allyl-α-L-rhamnopyranosyl)-(1→2)-[2,3,4,6-tetra-*O*-benzyl-α-D- glucopyranosyl-(1→3)]- 4-*O*- benzyl-α-L- rhamnopyranoside (44). A solution of **43** (1.67 g, 1.58 mmol) in a mixture of CH_2Cl_2 (5 mL) and MeOH (10 mL) was treated with a catalytic amount of 1 M methanolic sodium methoxide (300 μL), and the solution was stirred for 48 h at rt. When the starting material was no longer detected (solvent *B*, 4:1), the solution was neutralised with Amberlite IR-120 (H^+) resin, filtered, and concentrated. The residue was chromatographed (solvent *B*, 4:1) to give acceptor **44** (1.57 g, 98%) as a sticky oil, $[\alpha]_D$ +20° (*c* 1.0); NMR: ^{1}H, δ 7.42-7.07 (m, 25H, Ph), 6.02-5.89 (m, 2H, C*H*=CH_2), 5.36-5.16 (m, 4H, CH=C*H*$_2$), 5.25 (bs, overlapped, 1H, H-1_B), 5.00 (d, 1H, $J_{1,2}$ = 3.4 Hz, H-1_E), 4.99 (d, 1H, J = 10.9 Hz, CH_2Ph), 4.90-4.79 (m, 5H, CH_2Ph), 4.65 (bs, 1H, H-1_A), 4.56 (d, 1H, J = 10.4 Hz, CH_2Ph), 4.55 (d, 1H, J = 12.1 Hz, CH_2Ph), 4.43 (d, 1H, J = 10.9 Hz, CH_2Ph), 4.33 (m, 1H, $CH_2CH{=}CH_2$), 4.28 (d, 1H, J = 12.1 Hz, CH_2Ph), 4.18-4.10 (m, 4H, 3 $CH_2CH{=}CH_2$, H-2_B), 4.08 (dd, 1H, H-3_E), 4.04 (m, 2H, H-2_A, 3_A), 4.02 (m, 1H, H-5_E), 3.78 (dq, 1H, $J_{4,5}$ = 9.5 Hz, H-5_B), 3.71 (dd, 1H, $J_{3,4}$ = 9.5, $J_{4,5}$ = 9.2 Hz, H-4_E), 3.70 (dd, 1H, $J_{2,3}$ = 3.3, $J_{3,4}$ = 9.2 Hz, H-3_B), 3.66 (dq, 1H, $J_{4,5}$ = 9.5 Hz, H-5_A), 3.60 (dd, 1H, $J_{2,3}$ = 3.4, $J_{3,4}$ = 9.8 Hz, H-2_E), 3.50 (dd, 1H, $J_{5,6a}$ = 2.9, $J_{6a,6b}$ = 10.8 Hz, H-$6a_E$), 3.46 (dd, 1H, $J_{4,5}$ = 9.3 Hz, H-4_A), 3.39 (dd, 1H, $J_{5,6b}$ = 1.6 Hz, H-$6b_E$), 3.31 (s, 3H, CH_3), 3.30 (dd, 1H, $J_{3,4}$ = 9.0, $J_{4,5}$ = 9.0 Hz, H-4_B), 2.14 (bs, 1H, OH), 1.35 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A), 1.31 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_B); ^{13}C, δ 138.8-127.5 (*C*H=CH_2, Ph), 116.9 (2 C, CH=*C*H$_2$), 101.0 (C-1_A), 100.0 (C-1_B), 94.9 (C-1_E), 82.4 (C-3_E), 79.9 (2C, C-4_A, 4_B), 79.1 (C-3_B), 78.8 (C-2_E), 78.0 (C-4_E), 75.7 (2C, C-2_A, CH_2Ph), 75.6, 75.0 (CH_2Ph), 74.3 (C-3_A), 74.2 ($CH_2CH{=}CH_2$), 73.5 (CH_2Ph), 71.0 ($CH_2CH{=}CH_2$), 70.3 (C-5_E), 68.9 (C-2_A), 68.1 (C-6_E), 68.0 (C-5_A), 67.9 (C-5_B), 54.7 (CH_3), 18.1 (C-6A), 17.9 (C-6_B); ES: *m/z* 1017.5 ([M+H]$^+$), 1039.5 ([M+H]$^+$).

Anal. Calcd for $C_{60}H_{72}O_{14}$: C, 70.85; H, 7.13. Found: C, 70.82; H, 7.24.

Methyl (3,4,6-Tri-*O*-acetyl-2-trichloroacetamido-2-deoxy-β-D-glucopyranosyl)-(1→2)-(3,4-di-*O*-allyl-α-L-rhamnopyranosyl)-(1→2)-[2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (45). A solution of acceptor **44** (1.75 g, 1.72 mmol), 3,4,6-tri-*O*-acetyl-2-deoxy-2-*N*-trichloroacetyl-α-D-glucopyranosyl trichloroacetimidate[49] (**39**, 1.32 g, 2.24 mmol), in dry CH_3CN (15 mL) was stirred at 0 °C for 30 min under dry Ar. TMSOTf (33 μL, 170 μmol) was added and the mixture was stirred at this temperature for 5 h, then at rt for 15 h. TLC (solvent *D*, 9:1) showed almost complete conversion of the starting materials

into a major product. Et_3N (240 µL, 170 µmol) was added, and the mixture was concentrated. The residue was eluted from a column of silica gel (solvent *B*, 77:23) to give **45** (2.21 g, 89 %) as a colourless foam, $[\alpha]_D$ +4° (*c* 1.0); NMR: ^1H, δ 7.43-7.06 (m, 25H, Ph), 6.69 (d, 1H, $J_{NH,2}$ = 10.1 Hz, NH), 6.00-5.86 (m, 2H, C*H*=CH_2), 5.35-5.14 (m, 4H, CH=CH_2), 5.27 (bs, 1H, H-1_A), 5.12 (dd, 1H, $J_{3,4}$ = 9.4 Hz, H-3_D), 5.07 (d, 1H, H-1_E), 4.94 (dd, 1H, $J_{4,5}$ = 9.6 Hz, H-4_D), 4.88 (d, 1H, $J_{1,2}$ = 7.6 Hz, H-1_D), 4.93-4.71 (m, 6H, CH_2Ph), 4.75 (bs, 1H, H-1_B), 4.56 (d, 1H, J = 10.3 Hz, CH_2Ph), 4.54 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.44 (d, 1H, J = 11.0 Hz, CH_2Ph), 4.30 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.26 (m, 1H, CH_2CH=CH_2), 4.21 (m, 1H, H-2_A), 4.20 (dd, 1H, $J_{5,6}$ = 2.0 Hz, H-$6a_D$), 4.18-3.98 (m, 8H, 3 CH_2CH=CH_2, H-2_B, 3_B, 3_E, 5_E, $6b_D$), 3.83 (m, 1H, $J_{2,3}$ = 10.3 Hz, H-2_D), 3.80-3.63 (m, 4H, H-3_A, 5_A, 5_B, 4_E), 3.61 (dd, 1H, $J_{1,2}$ = 3.4, $J_{2,3}$ 9.8 Hz, H-2_E), 3.59-3.43 (m, 4H, H-4_B, 5_D, $6a_E$, $6b_E$), 3.27 (dd, 1H, $J_{3,4}$ = 9.3, $J_{4,5}$ = 9.6 Hz, H-4_A), 3.25 (s, 3H, CH_3), 2.00 (s, 9H, OC(=O)CH_3), 1.91 (s, 3H, NHC(=O)C*H*$_3$), 1.34 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_B), 1.26 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_A); ^{13}C, δ 170.7-169.2 (3C, O*C*(=O)CH_3), 161.5 (N*C*(=O)CH_3), 138.6-127.4 (*C*H=CH_2, Ph), 117.3, 116.6 (CH=C*H*$_2$), 100.3 (C-1_D, $^1J_{C,H}$ = 162 Hz), 99.6 (C-1_B, $^1J_{C,H}$ = 169 Hz), 99.5 (C-1_A, $^1J_{C,H}$ = 170 Hz), 93.7 (C-1_E, $^1J_{C,H}$ = 170 Hz), 92.2 (CCl_3), 82.3 (C-3_E), 80.8 (C-4_A), 79.9 (C-4_B), 79.3 (C-3_A), 78.6 (C-2_E), 77.8 (C-4_E), 75.8 (CH_2Ph), 75.5 (C-2_A), 75.3, 74.9 (2C, CH_2Ph), 74.6 (C-3_B), 74.2 (All), 73.3 (CH_2Ph), 73.1 (C-2_B), 72.5 (CH_2Ph), 72.1 (All), 72.0 (C-5_D), 71.9 (C-3_D), 70.5 (C-5_E), 68.7 (C-5_A), 68.2 (C-4_D), 68.1 (C-6_E), 68.0 (C-5_B), 61.8 (C-6_D), 56.0 (C-2_D), 54.7 (CH_3), 20.5 (4C, NC(=O)C*H*$_3$, OC(=O)C*H*$_3$), 18.0 (C-6_B), 17.8 (C-6_A); CIMS: *m/z* 1465 ($[M+NH_4]^+$).

Anal. Calcd for $C_{74}H_{88}Cl_3NO_{22}$: C, 61.30; H, 6.12; N, 0.97. Found: C, 61.35; H, 6.06; N, 0.97.

Methyl (3,4,6-Tri-*O*-acetyl-2-trichloroacetamido-2-deoxy-β-D-glucopyranosyl)-(1→2)-α-L-rhamnopyranosyl-(1→2)-[2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (46). Compound **45** (2.37 g, 1.63 mmol) was dissolved in anhydrous THF (30 mL). The solution was degassed and placed under Ar. 1,5-Cyclooctadiene-bis(methyldiphenylphosphine)-iridium hexafluorophosphate (200 mg, 237 µmol) was added, and the solution was degassed again. The catalyst was activated by passing over a stream of hydrogen until the solution had turned yellow (~5 min). The reaction mixture was degassed and stirred under an Ar atmosphere for 17 h, then concentrated to dryness. The residue was dissolved in acetone (200 mL), then water (20 mL), mercuric oxide (1.33 g, 6.2 mmol), mercuric chloride (1.42 g, 5.2 mmol) were added successively. The mixture, protected from light, was stirred at rt for 5 h and acetone was evaporated. The resulting suspension was taken up in CH_2Cl_2, washed twice with 50% aq KI, water and satd aq NaCl, dried and

concentrated. Purification of the crude material was effected by silica gel column chromatography (solvent *C*, 75:25) to furnish diol **46** (1.58 g, 71%) as a colourless solid; $[\alpha]_D$ +9° (*c* 1.0); NMR: ^{1}H, δ 7.62-7.06 (m, 25H, Ph), 6.85 (d, 1H, $J_{NH,2}$ = 8.5 Hz, NH), 5.14 (d, 1H, $J_{1,2}$ = 1.4 Hz, H-1_A), 5.12 (bs, 1H, $J_{1,2}$ 3.4 Hz, H-1_E), 4.96-4.93 (m, 2H, H-3_D, 4_D), 4.92-4.81 (m, 6H, CH_2Ph), 4.83 (bs, overlapped, 1H, H-1_B), 4.58 (d, 1H, J = 10.3 Hz, CH_2Ph), 4.56 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.46 (d, 1H, J = 10.9 Hz, CH_2Ph), 4.32 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.22 (d, 1H, $J_{1,2}$ = 8.3 Hz, H-1_D), 4.16-4.09 (m, 3H, H-3_B, $6a_D$, 3_E), 4.04 (m, 1H, $J_{4,5}$ = 10.2 Hz, H-5_E), 4.00-3.88 (m, 5H, H-2_A, 3_A, 2_B, 2_D, $6b_D$), 3.82 (dq, 1H, $J_{4,5}$ = 9.4 Hz, H-5_A), 3.72 (dd, 1H, $J_{3,4}$ = 9.5, $J_{4,5}$ = 9.6 Hz, H-4_E), 3.69-3.63 (m, 2H, H-5_B, 2_E), 3.58 (dd, 1H, $J_{5,6a}$ = 3.3, $J_{6a,6b}$ = 12.2 Hz, H-$6a_E$), 3.51 (dd, partially overlapped, 1H, $J_{3,4}$ = 9.4, $J_{4,5}$ = 9.3 Hz, H-4_A), 3.50 (dd, partially overlapped, 1H, H-$6b_E$), 3.43 (ddd, 1H, $J_{3,4}$ = 9.4 Hz, H-4_A), 3.36 (m, 1H, H-5_D), 3.30 (s, 3H, CH_3), 2.29 (d, 1H, $J_{OH,3}$ = 6.7 Hz, OH-3), 2.13 (d, 1H, $J_{OH,4}$ 3= .7 Hz, OH-4), 2.02, 2.01, 1.96 (3 s, 9H, OC(=O)CH_3), 1.35 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_B), 1.26 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_A); ^{13}C, δ 170.9, 170.5, 169.2, 169.3 (OC(=O)), 162.0 (NC(=O)), 138.7-127.5 (Ph), 101.5 (C-1_D), 100.0 (C-1_A), 99.3 (C-1_B), 93.3 (C-1_E), 92.4 (CCl_3), 81.9 (C-3_E), 79.9 (C-4_B), 79.0 (C-2_E), 78.9 (C-2_A), 77.9 (C-4_E), 75.9, 75.4, 74.9 (3C, CH_2Ph), 74.8 (C-2_B), 73.8 (C-3_B), 73.3 (CH_2Ph), 73.2 (C-4_A), 72.2 (CH_2Ph), 72.1 (C-3_D), 72.0 (C-5_D), 71.7 (C-3_A), 70.2 (C-5_E), 68.6 (C-5_A), 68.2 (C-6_E), 67.9 (2C, C-5_B, 4_D), 61.9 (C-6_D), 55.8 (C-2_D), 54.9 (CH_3), 20.6 (3C, OC(=O)CH_3), 18.2 (C-6_B), 17.4 (C-6_A); ES: *m/z* 1368.5 ($[M+H]^+$).

Anal. Calcd for $C_{68}H_{80}Cl_3NO_{22}$: C, 59.63; H, 5.89; N, 0.96. Found: C, 59.53; H, 5.97; N, 0.92.

Methyl (3,4,6-Tri-*O*-acetyl-2-trichloroacetamido-2-deoxy-β-D-glucopyranosyl)-(1→2)-(3,4-di-*O*-acetyl-α-L-rhamnopyranosyl)-(1→2)-[2,3,4,6-tetra-*O*-benzyl-α-D- glucopyranosyl- (1→3)]-4-*O*- benzyl-α-L-rhamnopyranoside (47). (a) To a solution of compound **46** (529 mg, 387 μmol) in pyridine (5 mL) was added acetic anhydride (800 μL, 850 μmol). After stirring for 48 h, the reaction was quenched with MeOH (3 mL). The solvents were evaporated, the residue was taken up in CH_2Cl_2, and the resulting solution was washed with water, 5% aq $NaHCO_3$, water, satd aq. NaCl, dried and concentrated. The residue was eluted from a column of silica gel (solvent *B*, 68:32) to yield the fully protected **47** (550 mg, 98%); $[\alpha]_D$ +3° (*c* 1.0); NMR: ^{1}H, δ 7.41-7.10 (m, 25H, Ph), 6.65 (d, 1H, $J_{NH,2}$ = 7.9 Hz, NH), 5.39 (bd, overlapped, 1H, H-3_A), 5.37 (dd, partially overlapped, 1H, $J_{3,4}$ = 10.1 Hz, H-3_D), 5.30 (bs, 1H, H-1_A), 5.14 (bs, 1H, H-1_E), 4.99 (dd, 1H, $J_{3,4}$ = 9.9 Hz, H-4_A), 4.95-4.79 (m, 6H, CH_2Ph), 4.89 (dd, overlapped, 1H, H-4_D), 4.78 (s, 1H, H-1_B), 4.72 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1_D), 4.59 (d, 1H, CH_2Ph), 4.56 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.45 (d, 1H, J =

11.0 Hz, CH_2Ph), 4.32 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.15-4.09 (m, 6H, H-2_A, 2_B, 3_B, $6a_D$, $6b_D$, 3_E), 4.03 (m, 1H, $J_{4,5}$ = 9.8 Hz, H-5_E), 3.97 (dq, 1H, $J_{4,5}$ = 9.7 Hz, H-5_A), 3.70 (dd, 1H, $J_{3,4}$ = 9.7 Hz, H-4_E), 3.67-3.58 (m, 4H, H-4_B, 5_B, 2_E, $6a_E$), 3.47 (bd, 1H, H-$6b_E$), 3.45 (ddd, 1H, H-2_D), 3.35 (m, 1H, H-5_D), 3.30 (s, 3H, CH_3), 2.10, 2.02, 2.00, 1.95 (4 s, 15H, OC(=O)CH_3), 1.35 (d, 3H, $J_{5,6}$ = 5.9 Hz, H-6_B), 1.18 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 170.3, 170.2, 170.1, 169.8, 169.3 (5C, O*C*(=O)CH_3), 161.6 (N*C*(=O)CCl_3), 138.8-127.4 (Ph), 99.6 (bs, C-1_A), 99.5 (C-1_B), 99.1 (C-1_D), 93.9 (C-1_E), 92.2 (CCl_3), 81.9 (C-3_E), 79.7 (bs, C-4_B), 79.3 (C-2_E), 77.7 (C-4_E), 75.3 (CH_2Ph), 75.2 (C-2_A), 74.9 (CH_2Ph), 74.4 (bs, C-3_B), 74.0 (C-2_B), 73.2, 72.5 (3C, CH_2Ph), 71.9 (C-5_D), 71.6 (C-4_A), 70.7 (C-3_A), 70.4 (C-3_D), 70.2 (C-5_E), 68.5 (C-4_D), 68.3 (C-6_E), 68.2 (C-5_B), 66.9 (C-5_A), 61.8 (C-6_D), 56.6 (C-2_D), 54.8 (CH_3), 21.1, 20.8, 20.7, 20.6, 20.5 (5C, OC(=O)*C*H_3), 18.1 (C-6_B), 17.5 (C-6_A); CIMS: *m/z* 1469 ([M+NH_4]$^+$).

Anal. Calcd for $C_{72}H_{84}Cl_3NO_{24}$: C, 59.48; H, 5.82; N, 0.96. Found: C, 59.44; H, 5.75; N, 0.97.

(b) Compound **45** (1.57 g, 1.08 mmol) in anhydrous THF was treated as described for the preparation of the diol **46**. The crude material, used without further purification, was acetylated as described in (a) to give, after work-up and chromatography (solvent *B*, 68:32), pure **47** (1.02 g, 65 %).

Methyl (2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1 → 2)-(3,4-di-*O*-acetyl-α-L-rhamnopyranosyl)-(1 → 2)-[2,3,4,6-tetra-*O*-benzyl-α-D-glucopyranosyl-(1→3)]-4-*O*-benzyl-α-L-rhamnopyranoside (48) A mixture of **47** (623 mg, 430 μmol) and tributyltin hydride (800 μL, 2.97 mmol) in dry toluene (30 mL) and dry *N,N*-dimethylacetamide (10 mL) was stirred for 20 min under a flow of dry Ar. α,α'-Azobisisobutyronitrile (6 mg, 36 μmol) was added, and the mixture was stirred at rt for 15 min, then heated at 90 °C for 1 h, cooled, and concentrated. The oily residue was triturated with petroleum ether (3 times 5 mL) to give a colourless solid which was eluted from a column of silica gel (solvent *C*, 75:25 → 70:30) to afford **48** (509 mg, 88 %) as a colourless foam; $[\alpha]_D$ +2° (*c* 1.0); NMR: ^1H, δ 7.45-7.08 (m, 25H, Ph), 5.50 (d, 1H, $J_{NH,2}$ = 7.9 Hz, NH), 5.41 (dd, 1H, $J_{2,3}$ = 9.6 Hz, H-3_D), 5.37 (dd, 1H, $J_{2,3}$ = 2.7, $J_{3,4}$ = 10.1 Hz, H-3_A), 5.24 (bs, 1H, H-1_A), 5.10 (bd, 1H, H-1_E), 5.03 (dd, 1H, $J_{3,4}$ = 10.0, $J_{4,5}$ = 10.0 Hz, H-4_A), 4.90 (d, 1H, J 11.1 Hz, CH_2Ph), 4.89 (dd, 1H, $J_{4,5}$ = 9.4, $J_{3,4}$ = 9.8 Hz, H-4_D), 4.79 (bd, 3H, CH_2Ph), 4.77 (m, overlapped, 2H, H-1_B, 1_D), 4.71 (d, 1H, J = 12.3 Hz, CH_2Ph), 4.59 (d, 1H, J = 11.4 Hz, CH_2Ph), 4.55 (d, 1H, J = 12.1 Hz, CH_2Ph), 4.43 (d, 1H, J = 11.0 Hz, CH_2Ph), 4.31 (d, 1H, J = 12.0 Hz, CH_2Ph), 4.15-3.98 (m, 8H, H-2_A, 5_A, 2_B, 3_B, $6a_D$, $6b_D$, 3_E, 5_E), 3.71-3.46 (m, 7H, H-4_B, 5_B, 2_D, 2_E, 4_E, $6a_E$, $6b_E$), 3.36 (m, 1H, H-5_D), 3.30 (s, 3H, CH_3), 2.10, 2.05, 2.01, 1.98 (4 s, 15H, OC(=O)CH_3), 1.67 (s, 3H, NHC(=O)C*H*$_3$), 1.35 (d, 3H, $J_{5,6}$ = 5.9 Hz,

H-6_B), 1.19 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 170.4-169.4 (6C, C=O), 138.6-126.7 (Ph), 100.0 (C-1_D*), 99.8 (C-1_A), 99.4 (C-1_B*), 93.9 (C-1_E), 81.9 (C-3_E), 79.7 (C-4_B), 78.7 (C-2_E), 77.7 (C-4_E), 78.6 (C-2_E), 75.5 (C-2_A), 75.3, 74.8 (2C, CH_2Ph), 74.5 (C-2_B), 74.3 (C-3_B), 73.2, 72.2 (2C, CH_2Ph), 71.7 (2C, C-4_A, 5_D), 71.3 (C-3_A), 70.2 (C-5_E), 68.6 (C-4_D), 68.2 (C-6_E), 68.1 (C-5_B), 66.8 (C-5_A), 61.7 (C-6_D), 55.6 (C-2_D), 54.9 (CH_3), 23.1 (NC(=O)*C*H_3), 20.9, 20.7, 20.6, 20.5, 20.4 (5C, OC(=O)*C*H_3), 18.1 (C-6_B), 17.3 (C-6_A); CIMS: *m/z* 1367 ($[M+NH_4]^+$).

Anal. Calcd for $C_{72}H_{87}NO_{24}$: C, 64.04; H, 6.49; N, 1.04. Found: C, 64.03; H, 6.51; N, 0.93.

Methyl (2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→2)-(3,4-di-*O*-acetyl-α-L- rhamnopyranosyl)-(1→2)-[α-D-glucopyranosyl-(1→3)]-α-L-rhamnopyranoside (49). A suspension of 10% Pd-C catalyst (800 mg) in a 3:12 mixture of acetic acid:ethanol (15 mL) containing the fully protected **48** (587 mg, 435 μmol) was stirred at rt for 48 h under a hydrogen atmosphere. The suspension was filtered on a bed of Celite, and the filtrate was concentrated. To eliminate any residual traces of the catalyst, the residue was chromatographed on a short column of silica gel (solvent *A*, 9:1) to give **53** (360 mg, 92%) as an amorphous solid. Compound **49** had $[\alpha]_D$ +31° (*c* 1.0, methanol); NMR: ^1H, δ 6.11 (d, 1H, $J_{NH,2}$ = 8.4 Hz, NH), 5.42 (dd, 1H, $J_{2,3}$ = 9.9, $J_{3,4}$ = 10.0 Hz, H-3_D), 5.12 (dd, 1H, $J_{2,3}$ = 3.0, $J_{3,4}$ = 9.6 Hz, H-3_A), 5.10-5.03 (m, 3H, H-1_A, 4_D, 1_E), 5.01 (dd, 1H, $J_{4,5}$ = 9.8 Hz, H-4_A), 4.96 (d, 1H, $J_{1,2}$ = 8.3 Hz, H-1_D), 4.69 (s, 1H, H-1_B), 4.34 (bd, 1H, $J_{6a,6b}$ = 11.0 Hz, H-$6a_D$), 4.24 (bs, 1H, H-2_A), 4.14 (dd, 1H, $J_{5,6b}$ = 2.9 Hz, H-$6b_D$), 3.99 (bs, 1H, H-2_B), 3.96-3.74 (m, 8H, H-5_A, 3_B, 2_D, 5_D, 3_E, 5_E, $6a_E$, $6b_E$), 3.65-3.54 (m, 4H, H-4_B, 5_B, 2_E, 4_E), 3.35 (s, 3H, CH_3), 2.10, 2.09, 2.05, 2.04, 2.03, 1.99 (6 s, 18H, OC(=O)CH_3), NC(=O)CH_3), 1.35 (d, 3H, $J_{5,6}$ = 5.6 Hz, H-6_B), 1.19 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_A); ^{13}C, δ 171.5-169.6 (6C, C=O), 101.1 (bs, C-1_A), 100.5 (bs, C-1_D), 99.9 (C-1_B), 96.3 (bs, C-1_E), 77.2 (bs, C-3_E), 76.7 (bs, C-2_B), 76.2 (C-2_A), 74.1 (C-3_E), 72.5 (C-2_E), 72.2 (C-5_E), 72.1 (C-3_D), 71.7 (C-5_D), 71.4 (C-4_E), 71.2 (C-3_A), 71.1 (bs, C-4_A), 70.5 (C-4_B), 68.8 (C-4_D), 68.1 (C-5_B), 66.9 (C-5_A), 62.1 (C-6_E), 61.8 (C-6_D), 55.1 (C-2_D), 54.9 (CH_3), 23.3 (NC(=O)*C*H_3), 21.1, 21.0, 20.9, 20.8, 20.7 (OC(=O)*C*H_3), 17.9 (C-6_B), 17.5 (C-6_A); NMR (DMSO-d_6): ^1H, δ 7.89 (d, 1H, $J_{NH,2}$ = 9.1 Hz, NH), 5.14 (dd, 1H, $J_{2,3}$ = 9.5 Hz, H-3_D), 5.04 (dd, 1H, $J_{2,3}$ = 3.2, $J_{3,4}$ = 10.1 Hz, H-3_A), 5.03 (bs, 1H, H-1_A), 4.91 (d, 1H, $J_{OH,4B}$ 6.1 Hz, OH-4_B), 4.86 (dd, 2H, $J_{4,5}$ = 9.6 Hz, H-4_D, 1_E), 4.79 (dd, 1H, $J_{4,5}$ = 10.1 Hz, H-4_A), 4.67 (d, 1H, $J_{1,2}$ = 8.5 Hz, H-1_D), 4.56 (bs, 1H, H-1_B), 4.48 (dd, 1H, J = 5.3 Hz, OH), 4.35 (bt, 1H, $J_{OH,6}$ = 5.8 Hz, OH-6_E), 4.20 (bs, 2H, H-$6a_D$, $6b_D$), 4.04 (bs, 1H, H-2_A), 3.95 (bs, 1H, H-2_B), 3.93 (m, 1H, H-5_D), 3.82-3.66

(m, 4H, H-5_A, 3_B, 2_D, 4_E), 3.59-3.49 (m, 3H, H-3_E, $6a_E$, $6b_E$), 3.43 (dq, 1H, $J_{4,5}$ = 9.2 Hz, H-5_B), 3.30 (m, 1H, H-4_B), 3.27 (s, 3H, CH_3), 3.18 (m, 2H, H-2_E, 5_E), 2.03, 2.02, 2.00, 1.97, 1.93, 1.78 (6 s, 18H, OC(=O)CH_3, NC(=O)CH_3), 1.20 (d, 3H, $J_{5,6}$ = 6.0 Hz, H-6_B), 1.06 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 170.1-169.9, 169.6, 169.3, 169.2, 169.1 (6C, C=O), 101.9 (C-1_D), 101.0 (C-1_A), 99.4 (C-1_B), 94.3 (C-1_E), 78.0 (C-2_A), 76.1 (C-2_B), 73.2 (C-3_B), 73.1 (C-3_E), 72.3 (C-3_D), 72.0 (C-4_E), 71.8 (C-2_E), 70.5 (C-4_A), 70.4 (C-5_D), 70.2 (C-4_B), 69.9 (C-5_E), 69.0 (C-3_A), 68.3 (C-4_D), 68.1 (C-5_B), 65.9 (C-5_A), 61.2 (C-6_D), 60.4 (C-6_E), 54.3 (OCH_3), 53.1 (C-2_D), 22.5 (NC(=O)*C*H_3), 20.6, 20.5, 20.4, 20.3 (5C, OC(=O)*C*H_3), 18.0 (C-6_B), 17.0 (C-6_A); CIMS: *m/z* 917 ([M+NH_4]$^+$).

Anal. Calcd for $C_{37}H_{57}NO_{24}$: C, 49.39; H, 6.38; N, 1.56. Found: C, 49.24; H, 6.47; N, 1.46.

Methyl 2-Acetamido-2-deoxy-β-D-glucopyranosyl-(1→2)-α-L-rhamnopyranosyl-(1 → 2)-[α-D-glucopyranosyl)-(1 → 3)]-α-L-rhamnopyranoside (2). A solution of **49** (250 mg, 278 μmol) in MeOH (5 mL) was treated with 1 M methanolic sodium methoxide (200 μL), and the solution was stirred at rt overnight. After neutralisation with Amberlite IR-120 (H^+), filtration, and evaporation of the solvent, purification of the crude product was achieved by reverse phase chromatography. The column was eluted with solvent *G* (gradient, 100:0 → 96:4) to give, after lyophilization, the target tetrasaccharide **2** (171 mg, 89%) as a colourless powder; $[\alpha]_D$ +35° (*c* 1.0, water), lit.[20] $[\alpha]_D$ +20.2° (*c* 0.3, methanol), lit.[21] $[\alpha]_D$ +33° (*c* 0.7, water), lit.[21] $[\alpha]_D$ +31° (*c* 1.0, methanol); NMR (D_2O): ^{1}H, δ 5.11 (d, 1H, $J_{1,2}$ = 1.3 Hz, H-1_A), 5.05 (d, 1H, $J_{1,2}$ = 3.8 Hz, H-1_E), 4.82 (bs, 1H, H-1_B), 4.71 (d, 1H, $J_{1,2}$ = 8.3 Hz, H-1_D), 4.14 (bs, 2H, H-2_A, 2_B), 3.93 (d, partially overlapped, 1H, H-$6a_D$), 3.91-3.86 (m, 3H, H-3_A, 3_B, 5_E), 3.80 (d, partially overlapped, 2H, H-$6a_E$, $6b_E$), 3.78 (dd, partially overlapped, 1H, H-4_E), 3.75-3.67 (m, 4H, H-5_A, 5_B, 2_D, $6b_D$), 3.62-3.53 (m, 3H, H-4_B, 3_D, 2_E), 3.48-3.41 (m, 2H, H-5_D, 3_E), 3.40 (m, 4H, CH_3, H-4_D), 3.34 (d, 1H, $J_{3,4}$ = 9.7, $J_{4,5}$ = 9.7 Hz, H-4_A), 2.05 (s, 3H, NC(=O)CH_3), 1.33 (d, 3H, $J_{5,6}$ = 6.1 Hz, H-6_B), 1.19 (d, 3H, $J_{5,6}$ = 6.2 Hz, H-6_A); ^{13}C, δ 175.5 (C=O), 103.3 (C-1_D, $J_{C,H}$ = 164 Hz), 101.8 (C-1_A, $J_{C,H}$ = 173 Hz), 100.3 (C-1_B, $J_{C,H}$ = 172 Hz), 95.1 (C-1_E, $J_{C,H}$ = 172 Hz), 79.3 (C-2_A), 76.7 (C-5_D), 75.5 (C-2_B), 74.3 (C-3_D), 74.1 (C-3_B), 73.8 (C-3_E), 73.1 (C-4_A), 72.4 (C-5_E), 71.8 (C-2_E), 71.1 (C-4_B), 70.7 (C-4_D), 70.6 (C-3_A), 70.2 (C-4_E), 70.0 (C-5_B), 69.3 (C-5_A), 61.7 (C-6_D), 61.1 (C-6_E), 56.6 (C-2_D), 55.8 (CH_3), 23.5 (NC(=O)*C*H_3), 17.8 (C-6_B), 17.4 (C-6_A); CIMS: *m/z* 707 ([M+NH_4]$^+$).

Anal. Calcd for $C_{27}H_{47}NO_{19}\cdot H_2O$: C, 45.82; H, 6.97; N, 1.97. Found: C, 45.95; H, 7.17; N, 1.86.

ACKNOWLEDGMENT

We are grateful to Dr. A. Namane (Chimie Structurale des Macromolécules, Institut Pasteur) for recording the Electrospray mass spectra.

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