Organic & Biomolecular Chemistry

Accepted Manuscript

ROYAL SOCIETY OF CHEMISTRY

www.rsc.org/obc

Cite this: DOI: 10.1039/c0xx00000x

www.rsc.org/xxxxxx

ARTICLE TYPE

Synthesis and evaluation of 1,2-*trans* alkyl galactofuranoside mimetics as mycobacteriostatic agents.

Rémy Dureau,[a,c] Maxime Gicquel,[a,c] Isabelle Artur,[a,c] Jean-Paul Guégan,[a,c] Bertrand Carboni,[b,c] Vincent Ferrières,[a,c] Fabienne Berrée*[b,c] and Laurent Legentil*[a,c]

Received (in XXX, XXX) Xth XXXXXXXXX 20XX, Accepted Xth XXXXXXXXX 20XX
DOI: 10.1039/b000000x

The simple octyl β-D-galactofuranoside was previously described as good bacteriostatic agent against *Mycobacterium smegmatis*, a non-pathogenic model of *M. tuberculosis*. In order to decipher its mechanism of action, STD NMR on whole *M. smegmatis* cells was implemented. It outlined the crucial role of the alkyl chain and the possibility of modulation on the furanosyl entity. From there, 16 new alkyl furanosides were synthesized in order to optimize the mycobacteriostatic activity. They all present the pending alkyl chain in a 1,2-*trans* configuration relative to the sugar ring. Three families were studied, that differ by the substituent on the primary position of the galactofuranose ring, the series or the pending alkyl chain. Four of these neofuranosides showed growth inhibition inferior to the parent octyl β-D-galactofuranoside. Double alkyl chains at C-1 and polar substituent on the primary position of the furanoside significantly favored the activity. Finally, a mixed biantennary alkyl/aryl β-D-galactofuranoside exhibited the best growth inhibition concentration at 90 µM.

Introduction

Tuberculosis is a medical, social, and economic disaster of immense magnitude that occurs over the world, reaching a dramatic level of 9 million people infected and 1.5 million deaths each year.[1] This deadly infection is difficult to cure and doing so successfully requires long treatment periods with multiple antibiotics.[2] Recent first-line drugs against tuberculosis include ethambutol and isoniazid in association with rifampicin and pyrazinamid. Such Directly Observed Treatment, Short course therapies (DOTS) present multiple shortcomings, like resistance and side-effects.[3] Therefore novel therapeutic approaches, particularly those aimed at exploring new horizons for the development of efficient anti-tuberculosis molecules, are required. The use of poly- and monosaccharides with bactericidal or bacteriostatic activities is nowadays gaining momentum regarding to their natural distribution, in particular in crucial cellular architecture of pathogenic microorganisms.[4] For example, the cell wall of *Mycobacterium tuberculosis*, the bacteria responsible for tuberculosis, contains a complex mixture of polysaccharides named arabinogalactanes.[5, 6] This structure incorporates in particular D-galactofuranose (D-Gal*f*), thermodynamically less stable than its pyranose counterparts and exogenous in mammals. In the light of the crucial role played by such galactofuranosyl-containing conjugates, molecules that are able to act on their biosynthesis, catabolism or degradation will certainly interfere with the proliferation, virulence and even survival of the corresponding cell. Such molecules will thus have all the characteristic of a therapeutic agent directed towards Gal*f*-presenting cells with less toxicity toward other organisms.[7]

Different families of carbohydrate derivatives have been already screened against strains of mycobacteria. For example, uridine diphosphate galactofuranoses modified at the primary position (C-6) of Gal*f* were able to inhibit *M. tuberculosis* growth.[8] However their poor availability and low stability limited their therapeutic potential. Another family was based on alkyl D-arabinofuranosides. Such alkyl furanosides are able to inhibit the growth of different strains of mycobacteria (*M. smegmatis*, *M. bovis*, *M. tuberculosis*) and even to destroy it at concentrations around micromolar.[9-17] A model proposed by Sucheck *et al.* hypothesized a specific recognition of the alkyl arabinofuranoside motif by mycolyl transferases.[13] It is worth noting that such transferase inhibition is the key mechanism linked with the action of ethambutol. Finally, a last class of molecules was designed on the alkyl galactofuranoside model. The most promising results described so far concerned a biantennary thiogalactofuranose developed by von Iztein *et al.*[18] In our laboratory, we conceived a simpler version, the octyl β-D-galactofuranoside **1** (Fig. 1) that is able to inhibit the proliferation of *M. smegmatis*,

[a] *Ecole Nationale Supérieure de Chimie de Rennes, CNRS, UMR 6226, 11 Allée de Beaulieu, CS 50837, 35708 Rennes Cedex 7, France. E-mail : laurent.legentil@ensc-rennes.fr*
[b] *Institut des Sciences Chimiques de Rennes, UMR 6226 CNRS−Université de Rennes1, Avenue du Général Leclerc, CS 74205, 35042 Rennes Cedex, France. E-mail : fabienne.berree@univ-rennes1.fr*
[c] *Université européenne de Bretagne, France.*

† Electronic Supplementary Information (ESI) available: STD NMR parameter, STD spectrum of **1**, **18** and *n*-octanol with *M. smegmatis*, ^{1}H and ^{13}C NMR spectra. See DOI: 10.1039/b000000x/

Cite this: DOI: 10.1039/c0xx00000x

www.rsc.org/xxxxxx

ARTICLE TYPE

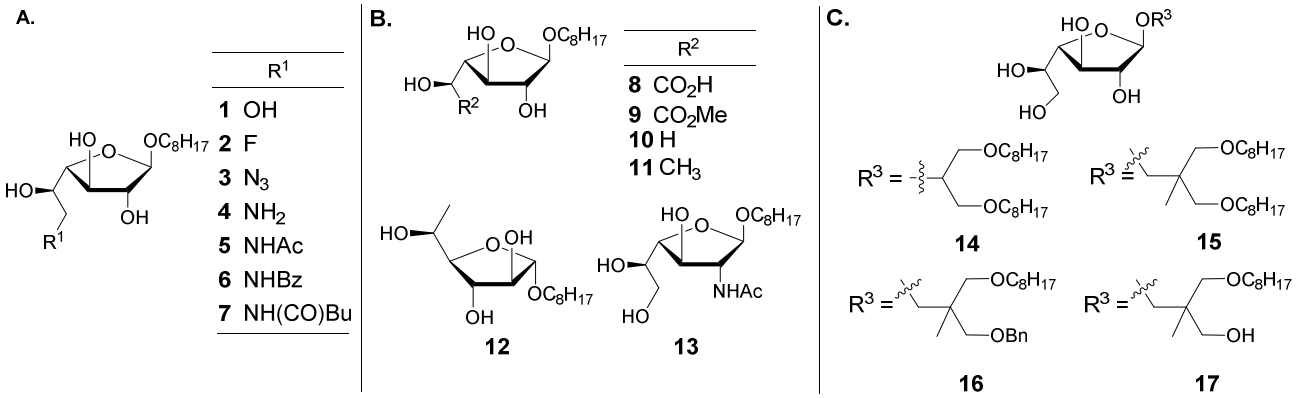


Fig. 1 Targeted alkyl furanosides **2**-**17**

the non pathogenic analogs of *M. tuberculosis* at a concentration of 0.86 mM. Furthermore a bactericidal effect was observed when it was embedded into a polymeric matrix based on PBAT/sodium caseinate.[19, 20]

The mechanism of action associated with such galactofuranolipids remains unclear and it is of importance to decipher structure-activity relationships. To do so, we first compared the affinity of both octyl β-D-galactofuranoside **1** and its octyl pyranoside counterpart with the microorganism's surface using Saturated Transfer Difference (STD) NMR technique on whole cell. This preliminary experiment confirmed the importance of the nature and length of the lipid chain but also pointed out the weak interaction of the sugar with the cell membrane and so the possibility for modulation.

In this context, a wider range of glycofuranosides bearing an alkyl chain at the anomeric position in a 1,2-*trans* configuration was synthesized. To tune the lipophilic nature of the alkyl furanoside scaffold, three modulations were introduced (Fig. 1): i) substitution of the hydroxyl group at primary position (A-family); ii) modification of the osidic series (B-family) and iii) doubling of the octyl chain at the anomeric position (C-family). The resulting compounds were eventually evaluated against their inhibition of *M. smegmatis* growth.

Results and discussion

STD NMR experiment

We first investigated the action mechanism of octyl β-D-galactofuranoside **1** as mycobacteriostastic. Compound **1** was described as a mycobacteriostatic agent at a concentration of 0.86 mM.[19] This value is far below its Critical Micellar Concentration (CMC) that reaches 6.1 mM.[21] Consequently, **1** is unable to form some micelles in the considered inhibitory concentration and we can rule out a possible surfactant effect as action mechanism. It is possible nowadays to map the part of the drug specifically involved in the interaction with the targeted receptor thanks to Saturated Transfer Difference (STD) NMR technique.[22, 23] However the exact biological target of our galactofuranolipid is yet unknown. Consequently the STD NMR was here performed on the whole cell of *M. smegmatis*. Using this technique, we compared the interaction profile of **1**, its octyl galactopyranoside counterparts **18** and *n*-octanol (Fig. 2 and supplementary information). All compounds were used at a concentration of 5 mM in D_2O. This concentration was higher than growth inhibition value of **18** but lower that the CMC of each molecules (6.1 mM for **1** and 16 mM for **18**) in order to avoid again any surfactant effect. When incubated with *M. smegmatis* cell, a strong STD effect was observed at the extremity of the octyl chain of **1**. The percentage of STD effect decreased when moving toward the furanose. There was also some detectable effect on the furanoside ring. The same profile was found for the octyl pyranoside **18** and octanol. For the latter one, the STD effect was identical along the alkyl chain.

From these results, it first appeared that the alkyl chain on the sugar played a crucial role on the activity, thus corroborating previous results on such galactofuranolipids. Mycobacteria present a unique cell surface made of mycolic acids that are grafted on the arabinogalactan. This highly hydrophobic cell wall

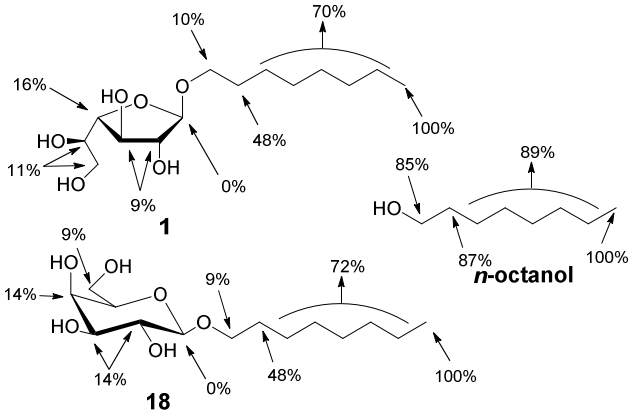


Fig. 2 Quantification of molecular interactions of **1**, **18** and octanol with *M. smegmatis* by STD NMR.

allows the bacteria to reduce its sensitivity against antibiotics and the recognition by the immune cells.[24] It can nevertheless interact with other lipids through weak van der Walls interactions. We can subsequently hypothesize that the alkyl chain strongly contributes to the interactions of the glycolipid with the cell membrane.

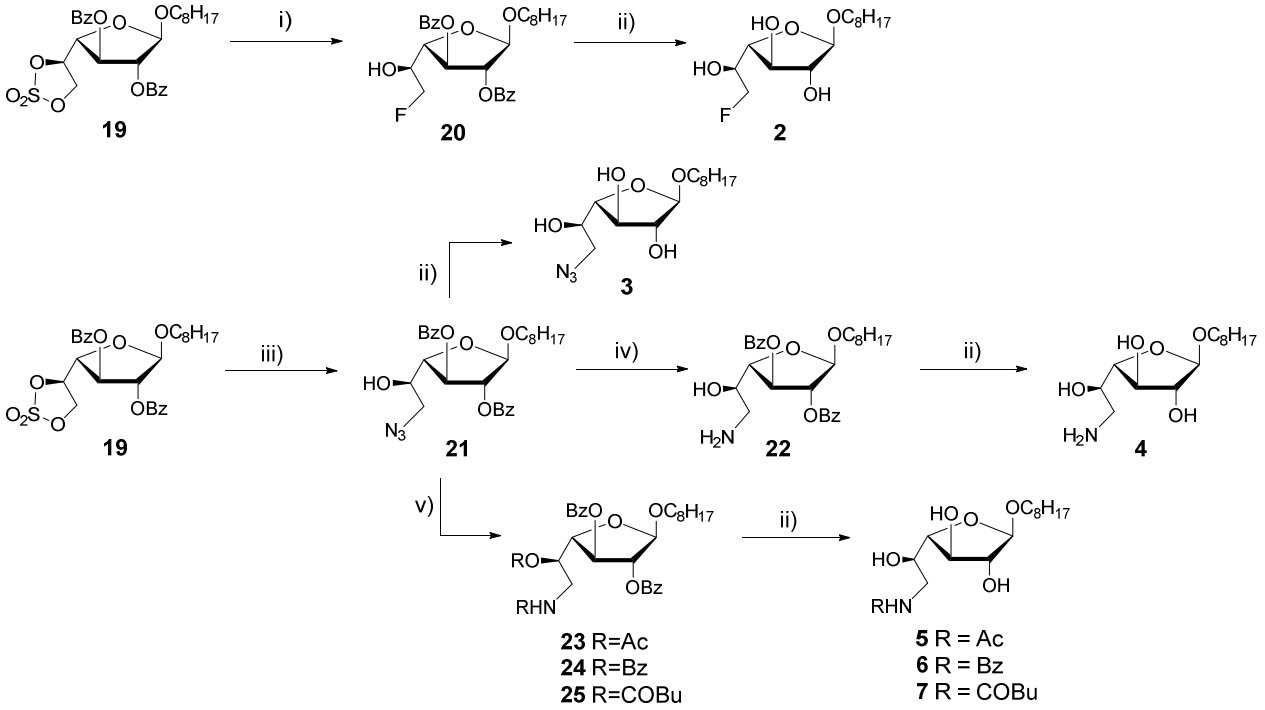
On the other hand, such experiment did not allow concluding on the importance of the furanoside ring as the STD values on the polar ring were low and no difference occurred between pyranoside and furanoside. If the nature of the sugar moiety did not reduce the measured affinity, we can therefore suggest that modification on the carbohydrate scaffold should not deter the interaction between the cell membrane and the glycolipids. Interestingly, previous screening on eukaryote parasites of the *Leishmania* genus concluded on the importance of the substituent on the galactofuranoside scaffold to measure some growth inhibition.[25] In this context, and in an attempt to improve the biological activity of the parent furanolipid, we decided to modulate the lipophilicity of the alkyl chain and the polarity of the sugar head.

Synthesis

5-Membered ring hexofuranoses generally tend to isomerise into 6-membered one, the most thermodynamically stable form. It is thus critical to first lock the ring size and then modulate the functional groups on the scaffold. To access to the A-family, we started from the known octyl β-D-galactofuranoside **1**[26, 27] whose C-6 position could be tuned and whose anomeric configuration was already installed, thus avoiding complex purification process.

Four functional groups were envisioned at the primary position of the galactofuranose, the 6-fluoro, 6-azido, 6-amino and three 6-amido. They can be easily introduced thanks to selective nucleophilic attacks of the corresponding nucleophiles on position 6 of the cyclic sulfate **19** (Scheme 1). Compound **19** was synthesized from octyl β-D-galactofuranoside according to literature procedure.[28] Ring-opening by tetrabutylammonium fluoride (TBAF), followed by the hydrolysis of the resulting sulfate, led to the intermediate **20**. In a similar way, **21** was prepared from **19** using sodium azide in dimethylformamide. Its subsequent palladium-catalyzed hydrogenolysis gave the amine **22** in a moderate yield. It can be purified by column chromatography on silica gel or directly converted to *N*,*O*-diacyl derivatives **23**, **24**, and **25** by action of acetyl chloride, benzoyl chloride or valeroyl chloride, respectively, in presence of DMAP. Finally, all the ester groups on compounds **20**-**25** were cleaved under basic conditions to give desired products **2**-**7**. All resulting compounds were obtained as pure 1,2-*trans* anomers as confirmed by the value of the coupling constant between *H*-1 and *H*-2 ($J_{1,2} < 2$ Hz).

In order to investigate the importance of the D-galactofuranose scaffold, other series presenting a common skeleton with Gal*f* were also sought. The more hydrosoluble and pH-sensitive octyl-D-galactofuranoside uronic acid (Octyl D-Gal*f*A) **8** was obtained according to reported furanosylation strategy of octanol in presence of calcium chloride.[22] The same procedure was implemented to access to the octyl (methyl-β-D-galactofuranosid)uronate **9** using (methyl-β-D-galactopyranoside)uronate **26**[29] (Scheme 2). The resulting uronate **9** was obtained as a mixture of anomers with a slight excess towards the β-one. The targeted anomer was separated from the α-isomer by purification on C18-grafted silica column. As for the

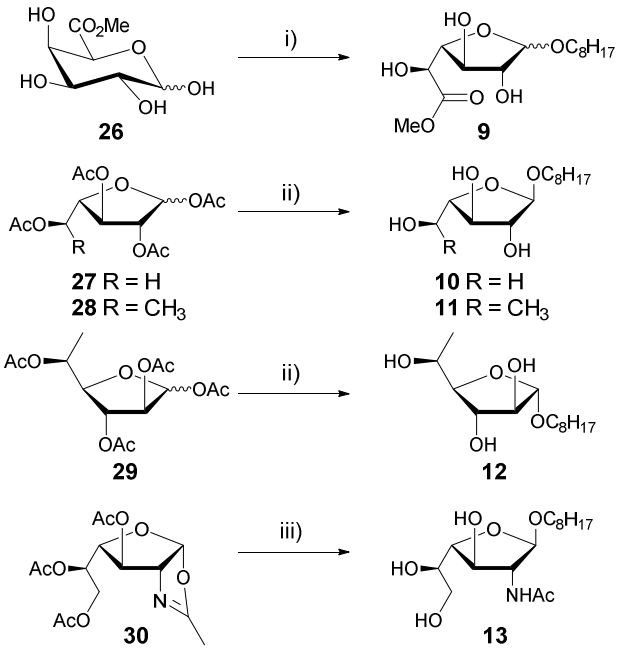


Scheme 1 Synthesis of octyl galactofuranosides of A-family **2**-**7**. Reaction conditions: i) a. TBAF, THF, r.t., 1 h, b. H_2SO_4, H_2O, THF, r.t., 30 min., 80% over 2 steps; ii) MeONa, MeOH, r.t., 12 h, 43% for **2**, 86% for **3**, 40% for **4**, 61% for **5**, 64% for **6**, 89% for **7**; iii) a. NaN_3, DMF, r.t., 24 h, b. H_2SO_4, H_2O, THF, r.t., 30 min., 87% over 2 steps; iv) $Pd(OAc)_2$, H_2, THF, 3 days, 38%; v) a. $Pd(OAc)_2$, H_2, THF, 2 days, b. RCOCl, DMAP, CH_2Cl_2, 2 h, 48% for **23**, 41% for **24**, 78% for **25** over 2 steps.

Cite this: DOI: 10.1039/c0xx00000x

www.rsc.org/xxxxxx

ARTICLE TYPE

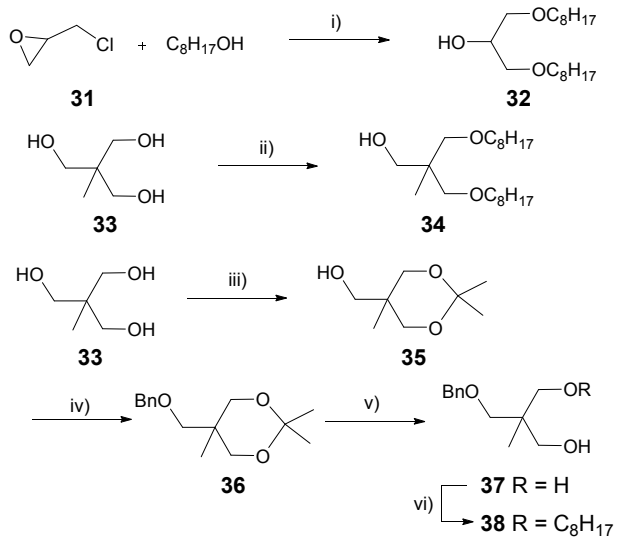


Scheme 2 Synthesis of furanolipids from B-family **9**-**13**. Reaction conditions: i) $C_8H_{17}OH$, $FeCl_3$, $CaCl_2$, r.t., 24 h, 32% (α/β 2:3); ii) a. $C_8H_{17}OH$, $BF_3.Et_2O$, CH_2Cl_2, RT, 8 h, b. MeONa, MeOH, r.t., 12 h, 12% for **10**, 35% for **11**, 44% for **12** over 2 steps; iii) a. $C_8H_{17}OH$, $CuCl_2$,$ClCH_2CH_2Cl$, r.t., 8 h, b. MeONa, MeOH, r.t., 12 h, 30% over 2 steps.

L-arabinose (L-Ara), and L- and D-fucose (L- and D-Fuc) series, a two-step strategy starting from the corresponding per-*O*-acetyl furanose **27**-**29**, respectively, was used. Such activated furanoses were easily obtained from the parent sugars as described previously.[29] Glycosylation of octanol by **27**, **28** or **29**, in presence of trifluoroboron etherate complex, generated again the 1,2-*trans* anomers as the major isomers. They were purified first to remove the 1,2-*cis* anomer before subsequent transesterification to give **10**, **11** or **12**, respectively.

We previously described the formation of the oxazoline derivative of 2-acetamido-2-deoxy-D-galactofuranose (D-Gal*f*NHAc) **30** thanks to the acetylation of per-*O*-silylated Gal*f*NHAc in presence of acetic anhydride and a large excess of *p*-toluenesulfonic acid (*p*TSA).[29] Such oxazoline could nevertheless undergo nucleophilic attack by methanol to give selectively the methyl β-D-Gal*f*NHAc in excellent yield. Unfortunately no reaction occurred when using octanol as nucleophile in presence of various Lewis acids like $BF_3.Et_2O$ or TMSOTf. Nevertheless, copper(II) chloride, a weak Lewis acid, allowed obtaining octyl Gal*f*NHAc as a mixture of anomers.[30] The 1,2-*trans* anomer was the major product of the reaction. Transesterification of the ester finally gave the targeted octyl β-D-Gal*f*NHAc **13** with 30% yield over two steps.

Four biantennary substituents were envisioned at the C-1 position of galactofuranose (C-family). For that, three acceptors



Scheme 3 Synthesis of the acceptors **32**, **34** and **38**. Reaction conditions: i) $C_8H_{17}OH$, Na, toluene, r.t., 24 h, 41%; ii) a. NaH, DMF, 50 °C, 15 min. b. TBAI, $C_8H_{17}Br$, DMF, 90 °C, 20 h, 52%; iii) acetone, *p*TSA, $MgSO_4$, r.t., 5 days, 74%; iv) NaH, benzylbromide, THF, 70 °C, 15 h, 95%; v) H_2SO_4, MeOH, 70 °C, 4 h, 81%; vi) NaH, TBAI, $C_8H_{17}Br$, DMF, 50 °C, 48 h, 70%.

32, **34** and **38** were synthesized (Scheme 3). Glycerol derivative **32** was first prepared by reaction of epichlorohydrin with sodium octanolate according to literature procedure.[31] Dialkylation of 2-(hydroxymethyl)-2-methyl-1,3-propanediol **33** with bromooctane in presence of sodium hydride and tetrabutylammonium iodide afforded the desired compound **34**. On the other hand, the protection of two alcohol functions of the triol **33** was easily achieved by treatment with acetone in presence of *p*TSA leading to the acetal **35**. After benzylation with benzylbromide in the presence of sodium hydride, the ketal moiety was hydrolyzed by treatment with sulfuric acid in methanol. Monoalkylation of diol **37** was then accomplished in good yield using conditions identical to those employed for the synthesis of **34**.[32]

Next, glycosylation of alcohols **32**, **34** and **38** with 2,3,5,6-tetra-*O*-acyl β-thiogalactofuranoside **39**[33] in presence of silver triflate and *N*-iodosuccinimide gave the corresponding intermediates **40**, **41** and **42**, respectively (Scheme 4).[34] If the biantennary galactofuranosides **41** and **42** were obtained as a mixture of anomers, respectively α/β = 1:4 and 1:19, **40** was only isolated as a pure β-anomer. Acyl groups were then removed under basic conditions to give final products **14**-**16**. Due to the presence of an asymmetric carbon on the alkyl chain, **16** was obtained as a complex mixture. Finally, debenzylation of **16** by hydrogenolysis gave **17** as a non-separable diasteromeric mixture but with 1,2-*trans* configuration at the anomeric carbon.

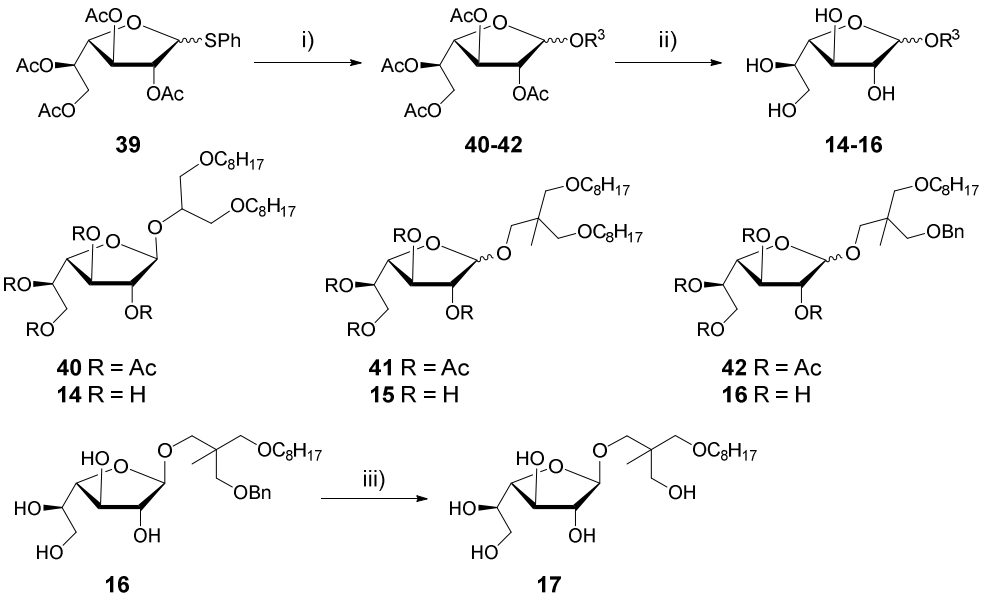
Biological evaluation

The resulting library of alkyl furanosides was then evaluated for their bacteriostatic properties against a mutated strain of *M.*

Cite this: DOI: 10.1039/c0xx00000x

www.rsc.org/xxxxxx

ARTICLE TYPE



Scheme 4 Access to biantennary galactofuranosides **14**-**17** (C-family). Reaction conditions: i) a. **32**, **34** or **38**, MS, AgOTf, NIS, CH_2Cl_2, r.t., 5-48 h, 71% for **40**, 91% for **41** (α/β 1:4), 32% for **42** (α/β 1:19); ii) MeONa, MeOH, r.t., 12 h, 96% for **14**, 99% for **15**, 87% for **16**; iii) H_2, Pd/C, EtOH, r.t., 2 days, 70%.

smegmatis (mc^2 155), one of the non-pathogenic model of mycobacteria. The Minimum Inhibition Concentration (MIC) responsible for 99% of bacteria growth inhibition was reported for each compound in Table 1. The determination of the MIC values was based on a resazurin modified assay in which the deep blue resazurin was oxidized into the fluorescent pink resorufine in the presence of living bacteria.[35] The aim of this study was to confirm: i) the influence of the alkyl chain at the anomeric position (chain length, linear *vs.* split); to complete the study, methyl and butyl galactofuranosides **43** and **44**[36] were also evaluated, ii) the impact of various functions at C-6 on the activity, iii) the impact of the cycle (furanoside *vs.* pyranoside); octyl galactopyranoside **18** was thus included in the evaluation and iv) the importance of the nature and configuration of the carbohydrate (Gal*f* *vs.* others, D *vs.* L). Ethambutol (Eth), a known antituberculosis molecule, was used as positive control.

The compiled results showed no inhibition for octanol (entry 21), 6-acetamido-Gal*f* **5** (entry 5), L-Fuc*f* **12** (entry 12), Gal*f*NHAc **13** (entry 13) and Gal*f* pending with branched alcohol **17** (entry 17) or with short chains **43** and **44** (entries 19 and 20) as well as for octyl pyranoside **18** (entry 18). However, inhibitory values were measured when the microorganism was incubated with the other alkyl glycosides that derived from octyl D-galactofuranose **1** (A-Family, entries 2-4, 6 and 7), that shared common structural characteristics with **1** (B-Family, entries 8-11) or Gal*f* with biantennary alkyl chain at the anomeric position (C-Family, entries 14-16). Their MIC were found to be between 0.1 and 2 mM. Four neoglycolipids exhibited MIC values below the one found for the parent octyl β-D-Gal*f* **1**. First, octyl 6-amino-Gal*f* **4** and octyl β-D-Gal*f*A **8**, with polar and pH sensitive substituent on the pending C-4 arm of the skeleton, exhibited respectively MIC value of 0.3 and 0.16 mM (entries 4 and 8). Secondly, biantennary derivatives **15** and **16** showed inhibition of *M. smegmatis* growth at 0.5 and 0.09 mM, respectively (entries 15 and 16).

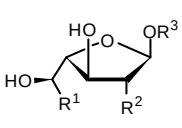
It therefore appeared that the furanose form was essential for the activity as the pyranoside analog **18** showed no bacteriostatic activity. In addition, no or low activity was measured with most compounds from B-family (**10**-**13**). There was so a strong impact of the considered series on the activity (Fuc*f*, Ara*f*, ester from Gal*f*A *vs.* Gal*f*). The lack of inhibitory activity of methyl and butyl Gal*f*, **43** and **44**, confirmed also that a minimum chain length was compulsory to measure any inhibition. The doubling of the alkyl chain had nevertheless a medium effect. Furanoside **14**, the *O*-glycoside analog of von Iztein's best inhibitor[18] surprisingly showed poor activity. It might be linked with lower stability of *O*-glycosides when compared with *S*-glycosides. However when the split chain was separated from the sugar by one methyl, the inhibition increased. The best activity was found for **16** with an aromatic group on one of the pendant arm instead of the chain. In addition, structural modulations at C-6 position greatly influenced the biological activity. Indeed compounds **5** (6-NHAc) showed no activity while decreasing MIC values were found for furanosides **6** (6-NHBz), **3** (6-N_3), **9** (methyl D-Gal*f*A),

Cite this: DOI: 10.1039/c0xx00000x

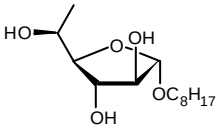
www.rsc.org/xxxxxx

ARTICLE TYPE

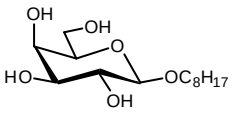
Table 1 Minimum Inhibition Concentration of tested alkyl furanosides



1-11; **13-17**; **43-44**



12



18

Entry	R^1	R^2	R^3	Pduct	MIC (mM)
1	CH_2OH	OH	C_8H_{17}	**1**	0.8
2	CH_2F	OH	C_8H_{17}	**2**	1.5
3	CH_2N_3	OH	C_8H_{17}	**3**	1.7
4	CH_2NH_2	OH	C_8H_{17}	**4**	0.3
5	CH_2NHAc	OH	C_8H_{17}	**5**	> 1.5[a]
6	CH_2NHBz	OH	C_8H_{17}	**6**	2.0
7	NH(CO)Bu	OH	C_8H_{17}	**7**	1.2
8	CO_2H	OH	C_8H_{17}	**8**	0.16
9	CO_2Me	OH	C_8H_{17}	**9**	1.6
10	H	OH	C_8H_{17}	**10**	1.7
12	-	-	-	**12**	> 1.8[a]
13	CH_2OH	NHAc	C_8H_{17}	**13**	> 1.5[a]
14	CH_2OH	OH	$CH(CH_2OC_8H_{17})_2$	**14**	1
15	CH_2OH	OH	$CH_2CCH_3(CH_2OC_8H_{17})_2$	**15**	0.5
16	CH_2OH	OH	$CH_2CCH_3(CH_2OC_8H_{17})(CH_2OBn)$	**16**	0.09
17	CH_2OH	OH	$CH_2CCH_3(CH_2OC_8H_{17})(CH_2OH)$	**17**	> 2[a]
18	-	-	-	**18**	> 2[a]
19	CH_2OH	OH	CH_3	**43**	> 2.6[a]
20	CH_2OH	OH	C_4H_9	**44**	> 2.1[a]
21	-	-	-	**Octanol**	> 3.8[a]
22	-	-	-	**Eth**	0.02

[a] No measured inhibition in the concentration range.

2 (6-F), **7** (6-NHCOBu), **4** (6-NH_2) and **8** (D-Gal*f*A). We can so hypothesize that increasing the hydrophobicity on the carbohydrate side arm was detrimental to the activity but that polar substituents like hydroxyl, acid or amine increased the potency of the molecule. The same trend was observed when A-family analogs were incubated in presence of *Leishmania donovani* promastigote.[25]

There is consequently a strong impact of both the nature of the lipid chain at the anomeric centre and the substituent on the furanose C-4 side arm on the development of the mycobacteria. The biantennary molecule **16** was found to be the best growth inhibitor found so far in this family of *O*-alkyl galactofuranosides. Previously, we showed that such family of galactofuranolipids was completely innocuous towards both soil microorganism and human macrophages.[19, 25] It confirmed their potential as alternative of DOTS.

Conclusion

Two strategies were implemented in order to obtain a library of 16 furanolipids bearing one or two alkyl chains, in a 1,2-*trans* configuration of the carbohydrate moiety. After incubation with *M. smegmatis*, four of them revealed good inhibitory values against the microorganism growth. The best molecules are all derived from galactofuranose and bear either a polar group on the galactofuranose moiety or a biantennary alkyl chain at the anomeric position. The non symmetrical biantennary compound **16** with octyl and benzyl group on the bis(hydroxymethyl) linker was found to inhibit the growth of *M. smegmatis* at 90 µM. Even if these values were at least four times higher than the one found with ethambutol, such family of molecules showed up to ten times better inhibition than the parent octyl Gal*f*, and was described as innocuous towards other microorganisms or even macrophages, thus increasing their associated therapeutic index.[25] First attempt to better understand their mechanism of action was achieved by STD NMR experiments that showed a strong affinity between the alkyl chain and the cell wall of mycobacteria. There should be first an anchorage of the alkyl chain to the cell wall followed by the recognition of the furanose by specific receptors. Studies to confirm this second step are under investigation.

Experimental section

All reactions were carried out in oven-dried glassware. Tetrahydrofuran and toluene were distilled from sodium/benzophenone, dimethylformamide from CaH_2, dried MeOH was purchased sealed on molecular sieves. Dichloromethane used was stabilized on amylene. Optical rotations were measured at 20 °C on a Perkin-Elmer 341 polarimeter. NMR spectra were recorded at 300 or 400 MHz for ^{1}H and 75 or 100 MHz for ^{13}C. Chemical shifts are given in δ units (ppm) and referenced to $CDCl_3$ (7.26 ppm) or CD_3OD (3,31 ppm). Coupling constants *J* were calculated in Hertz (Hz). High Resolution Masses were measured by electrospray with a MS/MS ZabSpec TOF Micromass using *m*-nitrobenzylic alcohol as a matrix and accelerated caesium ions for ionization (Centre Regional des Mesures Physiques de l'Ouest, Université de Rennes 1). Compounds **8**,[27] **19**,[28] **21**,[28] **26**,[29] **32**,[31] **37**[32] and **39**[33] were prepared according to reported procedures.

Synthesis of the A-family

***n*-Octyl 2,3-di-*O*-benzoyl-6-deoxy-6-fluoro-β-D-galactofuranoside 20**. To a solution of **19**[28] (0.15 g, 0.27 mmol) in acetone (6 mL) was added a 1M solution of TBAF in THF (0.6 mL, 0.55 mmol) and the mixture was stirred at room temperature for 1 h. After concentration, the crude oil was diluted with THF (6 mL) before adding a solution of conc. H_2SO_4 (50 µL, 0.8 mmol), and water (10 µL). The reaction mixture was stirred at room temperature for 15 min then neutralized with Et_3N, concentrated under reduced pressure and portioned between AcOEt (50 mL), and brine (25 mL). The organic layer was washed with a saturated aqueous $NaHCO_3$ solution (3×25 mL) and the aqueous layers extracted with AcOEt (2×5 mL). Finally, the combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification of the residue by flash chromatography on silica gel (cyclohexane/AcOEt, 4:1) afforded the desired product (0.104 g, 80%) as a colorless oil. $[\alpha]_D^{20}$= +23.5 (*c* 1.25 in $CHCl_3$). δ_H (400 MHz, $CDCl_3$) 8.09-8.03

(4H, m, Ar-H), 7.62-7.57 (2H, m, Ar-H), 7.49-7.44 (4H, m, Ar-H), 5.59 (1H, ddd, $J_{3,4}$ 4.4, $J_{3,2}$ 1.2, ^4J 0.8, 3-H), 5.50 (1H, d, $J_{3,2}$ 1.2, 2-H), 5.26 (1H, brs, 1-H), 4.72 (1H, ddd, $J_{6a,F}$ 47.2, $J_{6a,6b}$ 9.6, $J_{6a,5}$ 5.6 Hz, 6a-H), 4.55 (1H, ddd, $J_{6b,F}$ 46.8, $J_{6b,6a}$ 9.6, $J_{6b,5}$ 5.2, 6b-H), 4.39-4.29 (2H, m, 4-H, 5-H), 3.73 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.53 (1H, dt, ^2J 9.6, ^3J 6.4, OCH_2CH$_2$), 2.65 (1H, d, J 8.4, OH), 1.68-1.59 (2H, m, OCH$_2$CH_2), 1.42-1.24 [10H, m, (CH$_2$)$_5$], 0.86 (3H, t, ^3J 7.2, CH$_3$). δ_C (100 MHz, CDCl$_3$), 166.1, 165.3 (*C*OPh), 133.6, 129.9, 129.8, 129.1, 128.6, 128.5 (CAr), 105.7 (C-1), 83.6 (d, $J_{6,F}$ 170, C-6), 82.3 (d, $J_{4,F}$ 5, C-4), 81.3 (C-3), 77.9 (C-2), 69.2 (d, $J_{5,F}$ 20, C-5), 67.7 (O*C*H$_2$CH$_2$), 31.8, 29.5, 29.3, 29.2, 26.1, 22.6 [(CH$_2$)$_6$], 14.1 (CH$_3$). δ_F (376 MHz, CDCl$_3$) -229. HRMS (ESI): calcd for $C_{28}H_{35}FO_7Na$ [M+Na]$^+$ 525.2264, found 525.2263.

***n*-Octyl 6-deoxy-6-fluoro-β-D-galactofuranoside 2.** To a solution compound **20** (0.82 g, 1.63 mmol) in dry MeOH (10 mL) was added a 30% wt. solution of sodium methoxide in MeOH (30 µL, 0.16 mmol). The mixture was stirred at room temperature until no starting material was detected by TLC. Neutralization was then carefully performed by adding Amberlite IR-120 (H$^+$-form). The resin was filtered off and the solvent removed under reduced pressure. The resulting crude product was purified by column chromatography on silica gel (CH$_2$Cl$_2$/MeOH 9:1) to give the desired product (210 mg, 43%) as a yellow oil. $[\alpha]_D^{20}$= -77.7 (*c* 1.2 in MeOH). δ_H (400 MHz, CD$_3$OD) 4.85 (1H, d, 1-H), 4.47 (1H, ddd, $J_{6a,F}$ 46.8, $J_{6a,6b}$ 9.2, $J_{6a,5}$ 4.8, 6a-H), 4.42 (1H, ddd, $J_{6b,F}$ 48.0, $J_{6a,6b}$ 9.2, $J_{6b,5}$ 6.8, 6b-H), 4.01 (1H, dd, $J_{3,4}$ 6.8, 3-H), 3.94-3.90 (1H, m, 5-H), 3.93 (1H, dd, $J_{2,3}$ 4.0, $J_{2,1}$ 2.0, 2-H), 3.88 (1H, dd, $J_{4,3}$ 6.8, $J_{4,5}$ 3.2, 4-H), 3.68 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.41 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 1.59-1.54 (2H, m, OCH$_2$CH_2), 1.37-1.30 [10H, m, (CH$_2$)$_5$], 0.90 (3H, t, ^3J 6.8, CH$_3$). δ_C (100 MHz, CD$_3$OD) 109.5 (C-1), 85.2 (d, $J_{6,F}$ 168.5, C-6), 84.4 (C-2), 83.2 (d, $J_{4\text{-}F}$ 6.4, C-4), 78.4 (C-3), 70.2 (d, $J_{5,F}$ 19.7, C-5), 69.0 (O*C*H$_2$CH$_2$), 33.0, 30.7, 30.5, 30.4, 27.3, 23.7 [(CH$_2$)$_6$], 14.5 (CH$_3$). δ_F (376 MHz, CDCl$_3$) -230. HRMS (ESI): calcd for $C_{14}H_{27}FNaO_5$ [M+Na]$^+$ 317.1740, found 317.1739.

***n*-Octyl 6-azido-6-deoxy-β-D-galactofuranoside 3.** Deprotection proceeded according to the general procedure used for compound **2** starting from compound **21** (0.15 g, 0.28 mmol) in dry MeOH (10 mL) with a 30% wt. solution of sodium methoxide in MeOH (5 µL, 0.03 mmol). Purification of the residue by column chromatography on silica gel (CH$_2$Cl$_2$/MeOH, 9:1) afforded the desired product (76.6 mg, 86%) as a colorless oil. $[\alpha]_D^{20}$= -48.7 (*c* 0.8 in MeOH). δ_H (400 MHz, CD$_3$OD) 4.84 (1H, d, $J_{1,2}$ 2.0, 1-H), 3.97 (1H, dd, $J_{3,4}$ 6.4, $J_{3,2}$ 4.0, 3-H), 3.93 (1H, dd, $J_{2,3}$ 4.0, $J_{2,1}$ 2.0, 2-H), 3.83 (1H, dd, $J_{4,5}$ 3.2, 4-H), 3.88 (1H, ddd, $J_{5,6a}$ 7.6, $J_{5,6b}$ 4.8, $J_{5,4}$ 3.2, 5-H), 3.68 (1H, dt, ^2J 9.6, ^3J 6.4, OCH_2CH$_2$), 3.41 (1H, dd, $J_{6a,6b}$ 13.2, $J_{6a,5}$ 7.6, 6a-H), 3.40 (1H, dt, ^2J 9.6, ^3J 6.4, OCH_2CH$_2$), 3.31 (1H, dd, $J_{6b,6a}$ 13.2, $J_{6b,5}$ 4.8, H-6b), 1.61-1.54 (2H, m, OCH$_2$CH_2), 1.39-1.29 [10H, m, (CH$_2$)$_5$], 0.89 (3H, t, ^3J 6.8, CH$_3$). δ_C (100 MHz, CD$_3$OD) 109.4 (C-1), 84.3 (C-4), 83.6 (C-2), 78.6 (C-3), 70.9 (C-5), 69.0 (O*C*H$_2$CH$_2$), 55.0 (C-6), 33.0, 30.8, 30.5, 27.3, 23.8 [(CH$_2$)$_6$], 14.5 (CH$_3$). HRMS (ESI): calcd for $C_{14}H_{27}N_3NaO_5$ [M+Na]$^+$ 340.1843, found 340.1843.

***n*-Octyl 6-amino-2,3-di-*O*-benzoyl-6-deoxy-β-D-galactofuranoside 22.** To a solution of **21** (1.0 g, 1.90 mmol) in dry THF (20 mL) was added Pd(OAc)$_2$ (43 mg, 0.19 mmol). The mixture was stirred at room temperature under a positive pressure of H$_2$ for 3 days then concentrated under reduced pressure. The residue was redissolved with AcOEt (100 mL), then washed with saturated aq NaHCO$_3$ solution (3 × 50 mL) and brine (50 mL). The combined organic layers were dried over MgSO$_4$, filtered and concentrated under reduced pressure. Purification of the residue by flash chromatography on silica gel (CH$_2$Cl$_2$/MeOH, 4:1) afforded the desired product (0.36 g, 38%) as a colorless oil. $[\alpha]_D^{20}$= -32 (*c* 1 in MeOH). δ_H (400 MHz, CDCl$_3$) 8.07-8.03 (4H, m, Ar-H), 7.59-7.53 (2H, m, Ar-H), 7.45-7.41 (4H, m, Ar-H), 5.57 (1H, dd, $J_{3,4}$ 4.8, $J_{3,2}$ 1.2, 3-H), 5.46 (1H, d, $J_{2,3}$ 1.2, 2-H), 5.21 (1H, s, 1-H), 4.22 (1H, dd, $J_{4,3}$ 4.8, $J_{4,5}$ 3.2, 4-H), 4.11-4.08 (1H, m, 5-H), 3.71 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.49 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.01 (2H, d, $J_{5,6}$ 6.0, 6-H), 1.65-1.57 (2H, m, OCH$_2$CH_2), 1.39-1.19 [10H, m, (CH$_2$)$_5$], 0.86 (3H, t, ^3J 6.8, CH$_3$). δ_C (100 MHz, CDCl$_3$) 166.0, 165.4 (CO), 133.5, 129.9, 129.2, 128.5, 128.4, (CAr), 105.7 (C-1), 84.2 (C-4), 81.6 (C-2), 78.0 (C-3), 70.6 (C-5), 67.6 (O*C*H$_2$CH$_2$), 45.0 (C-6), 31.8, 29.5, 29.4, 29.2, 26.1, 22.6 [(CH$_2$)$_6$], 14.1 (CH$_3$). HRMS (ESI): calcd for $C_{28}H_{37}NNaO_7$ [M+Na]$^+$ 522.2468, found 522.2470.

***n*-Octyl 6-amino-6-deoxy-β-D-galactofuranoside 4.** Deprotection proceeded according to the general procedure used for compound **2** starting from compound **22** (0.34 g, 0.68 mmol) in dry MeOH (10 mL) with a 30% wt. solution of sodium methoxide in MeOH (12.7 µL, 0.07 mmol). Purification of the residue by column chromatography on silica gel (CH$_2$Cl$_2$/MeOH, 9:1) afforded **4** (78.9 mg, 40%) as a white foam. $[\alpha]_D^{20}$= -0.5 (*c* 1.3 in MeOH). δ_H (400 MHz, CD$_3$OD) 4.82 (1H, dd, ^4J 0.8, $J_{1,2}$ 0.8, 1-H), 3.93-3.90 (2H, m, 2-H, 3-H), 3.80-3.76 (1H, m, H-4), 3.67 (1H, dt, ^2J 9.2, ^3J 6.4, OCH_2CH$_2$), 3.63 (1H, ddd, $J_{5,6a}$ 6.8, $J_{5,6b}$ 5.2, $J_{5,4}$ 4.0, 5-H), 3.40 (1H, dt, ^2J 9.6, ^3J 6.4, OCH_2CH$_2$), 2.78 (1H, dd, $J_{6a,6b}$ 13.2, $J_{6a,5}$ 6.8, 6a-H), 2.74 (1H, dd, $J_{6b,6a}$ 13.2, $J_{6b,5}$ 5.2, 6b-H), 1.60-1.53 (2H, m, OCH$_2$CH_2), 1.39-1.29 [10H, m, (CH$_2$)$_5$], 0.88 (3H, t, ^3J 6.8, CH$_3$). δ_C (100 MHz, CD$_3$OD) 109.4 (C-1), 85.4 (C-4), 83.7 (C-2), 79.0 (C-3), 72.9 (C-5), 69.0 (O*C*H$_2$CH$_2$), 45.7 (C-6), 33.0, 30.8, 30.6, 30.5, 27.3, 23.8 [(CH$_2$)$_6$], 14.5 (CH$_3$). HRMS (ESI): calcd for $C_{14}H_{29}NNaO_5$ [M+Na]$^+$ 314.1943, found 314.1943.

***n*-Octyl 6-acetamido-5-*O*-acetyl-2,3-di-*O*-benzoyl-6-deoxy-β-D-galactofuranoside 23.** To a solution of **21** (0.6 g, 1.14 mmol) in dry THF (6 mL) was added Pd(OAc)$_2$ (25 mg, 0.11 mmol). The mixture was stirred at room temperature for 2 days under a positive pressure of H$_2$, then concentrated under reduced pressure. The residue was redissolved in pyridine (10 mL), then DMAP (14 mg, 0.11 mmol) and acetyl chloride (0.24 mL, 3.42 mmol) were added. The mixture was stirred at room temperature for 2h and concentrated under reduced pressure. The residue was redissolved with AcOEt (50 mL), washed with saturated aqueous NaHCO$_3$ solution (3×25 mL) and brine (25 mL). The combined organic layers were dried over MgSO$_4$, filtered and concentrated under reduced pressure. Purification of the residue by flash chromatography on silica gel (cyclohexane/AcOEt, 7:3) afforded the desired product (0.32 g, 48%) as a slightly yellow oil. $[\alpha]_D^{20}$= -2.4 (*c* 1 in CHCl$_3$). δ_H (400 MHz, CDCl$_3$) 8.07-8.03 (4 H, m, Ar-H), 7.60-7.56 (2 H, m, Ar-H), 7.47-7.42 (4 H, m, Ar-H), 6.09 (1H, t, $J_{NH,6}$ 5.6, NH), 5.44 (1H, d, $J_{2,3}$ 1.2, 2-H), 5.39 (1H, dt, $J_{5,6b}$ 7.2, $J_{4,5}$ 3.6, $J_{5,6a}$ 3.6, 5-H), 5.37 (1H, dd, $J_{3,4}$ 5.2, $J_{3,2}$ 1.2, 3-H), 5.25 (1H, s, 1-H), 4.38 (1H, dd, $J_{4,3}$ 5.2, $J_{4,5}$ 3.6, 4-H), 3.79

(1H, dd, $J_{6a,6b}$ 14.8, $J_{6a,5}$ 3.6, 6a-H), 3.74 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.56 (1H, dd, $J_{6b,6a}$ 14.8, $J_{6b,5}$ 7.2, 6b-H), 3.51 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 2.04 (3H, s, COCH$_3$), 1.95 (3H, s, COCH$_3$), 1.67-1.59 (2H, m, OCH$_2$CH_2), 1.38-1.25 [10H, m, (CH$_2$)$_5$], 0.86 (3H, t, ^3J 7.2, CH$_3$). δ_C (100 MHz, CDCl$_3$) 170.9, 170.1, 165.7, 165.3 (CO), 133.5, 129.9, 129.8, 129.1, 128.9, 128.5, 128.4 (CAr), 105.5 (C-1), 82.2 (C-4), 81.6 (C-2), 77.3 (C-3), 70.9 (C-5) 67.7 (OCH$_2$CH$_2$), 41.1 (C-6), 31.7, 29.4, 29.3, 29.2 [(CH$_2$)$_6$], 20.8 (COCH$_3$), 14.0 (CH$_3$). HRMS (ESI): calcd for $C_{32}H_{41}NNaO_9$ [M+Na]$^+$ 606.2673, found 606.2675.

***n*-Octyl 6-acetamido-6-deoxy-β-D-galactofuranoside 5.** Deprotection proceeded according to the general procedure used for compound **2** starting from compound **23** (0.32 g, 0.55 mmol) in dry MeOH (10 mL) with a 30% wt. solution of sodium methoxide in MeOH (10.3 µL, 0.05 mmol). Purification of the residue by column chromatography on silica gel (CH_2Cl_2/MeOH, 9:1) afforded the desired product (0.11 g, 61%) as a white foam. $[\alpha]_D^{20}$= -59 (*c* 1 in MeOH). δ_H (400 MHz, CD$_3$OD) 4.83 (1H, d, $J_{1,2}$ 2.4, 1-H), 3.96 (1H, dd, $J_{3,4}$ 6.4, $J_{3,2}$ 4.0, 3-H), 3.91 (1H, dd, $J_{2,3}$ 4.0, $J_{2,1}$ 2.4, 2-H), 3.80 (1H, dd, $J_{4,3}$ 6.4, $J_{4,5}$ 4.0, 4-H), 3.75 (1H, ddd, $J_{5,6b}$ 7.6, $J_{5,6a}$ 4.8, $J_{5,4}$ 4.0, 5-H), 3.69 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.40 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.40 (1H, dd, $J_{6a,6b}$ 14.0, $J_{6a,5}$ 4.8, 6a-H), 3.23 (1H, dd, $J_{6b,6a}$ 14.0, $J_{6b,5}$ 7.6, 6b-H), 1.94 (3H, s, COCH$_3$), 1.60-1.53 (2H, m, OCH$_2$CH_2), 1.37-1.29 [10H, m, (CH$_2$)$_5$], 0.88 (3H, t, ^3J 6.8, CH$_3$). δ_C (100 MHz, CD$_3$OD) 173.7 (CO), 109.4 (C-1), 84.9 (C-4), 83.5 (C-2), 78.8 (C-3), 70.2 (C-5), 69.0 (OCH$_2$CH$_2$), 44.1 (C-6), 33.1, 30.8, 30.6, 30.5, 27.3, 23.8 [(CH$_2$)$_6$], 14.5 (CH$_3$). HRMS (ESI): calcd for $C_{16}H_{31}NNaO_6$ [M+Na]$^+$ 356.2049, found 356.2048.

***n*-Octyl 6-benzamido-2,3,5-tri-*O*-benzoyl-6-deoxy-β-D-galactofuranoside 24.** To a solution of **21** (0.96 g, 1.83 mmol) in dry THF (10 mL) was added Pd(OAc)$_2$ (40.4 mg, 0.18 mmol). The mixture was stirred at room temperature for 2 days under a positive pressure of H_2, then concentrated under reduced pressure. The residue was redissolved in pyridine (10 mL), then DMAP (22.3 mg, 0.18 mmol) and benzoyl chloride (0.53 mL, 4.57 mmol) were added. The mixture was stirred at room temperature for 2 h and further concentrated under reduced pressure. The residue was redissolved with AcOEt (100 mL), washed with saturated aqueous $NaHCO_3$ solution (3×50 mL) and brine (50 mL). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification of the residue by flash chromatography on silica gel (cyclohexane/AcOEt, 4:1) afforded the desired product (0.52 g, 41%) as a colorless oil. $[\alpha]_D^{20}$= -3.0 (*c* 1.2 in CHCl$_3$). δ_H (400 MHz, CDCl$_3$) 8.07-8.05 (4H, m, Ar-H), 7.96-7.94 (2H, m, Ar-H), 7.76-7.74 (2H, m, Ar-H), 7.60-7.35 (10H, m, Ar-H), 7.27-7.23 (2H, m, Ar-H), 7.05 (1H, t, $J_{NH,6}$ 5.2, NH), 5.86 (1H,dt, $J_{5,6b}$ 7.2, $J_{5,6a}$ 3.6, $J_{5,4}$ 3.6, 5-H), 5.55 (1H, dd, $J_{3,4}$ 5.2, $J_{3,2}$ 0.8, 3-H), 5.48 (1H, d, $J_{2,3}$ 0.8, 2-H), 5.36 (1H, s, 1-H), 4.58 (1H, dd, $J_{4,3}$ 5.2, $J_{4,5}$ 3.6, 4-H), 4.14 (1H, dd, $J_{6a,6b}$ 14.8, $J_{6a,5}$ 3.6, 6a-H), 3.95 (1H, dd, $J_{6b,6a}$ 14.8, $J_{6b,5}$ 7.2, 6b-H), 3.79 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.56 (1H, dt, ^2J 9.6, ^3J 6.0, OCH_2CH$_2$), 1.70-1.62 (2H, m, OCH$_2$CH_2), 1.42-1.25 [10H, m, (CH$_2$)$_5$], 0.87 (3H, t, ^3J 6.4, CH$_3$). δ_C (100 MHz, CDCl$_3$) 167.4, 166.8, 165.9, 165.5 (CO), 134.2, 133.5, 133.4, 133.3, 131.4, 130.0, 129.9, 129.8, 129.2, 129.0, 128.9, 128.5, 128.4, 128.3, 126.9 (CAr), 105.6 (C-1), 82.8 (C-4), 82.1 (C-2), 77.8 (C-3), 71.6 (C-5) 67.7 (OCH$_2$CH$_2$), 42.2 (C-6), 31.8, 29.4, 29.2, 26.1, 22.6 [(CH$_2$)$_6$], 14.1 (CH$_3$). HRMS (ESI): calcd for $C_{42}H_{45}NNaO_9$ [M+Na]$^+$ 730.2992, found 730.2990.

***n*-Octyl 6-benzamido-6-deoxy-β-D-galactofuranoside 6.** Deprotection proceeded according to the general procedure used for compound **2** starting from compound **24** (0.8 g, 1.13 mmol) in dry MeOH (10 mL) with a 30% wt. solution of sodium methoxide in MeOH (21.2 µL, 0.11 mmol). Purification of the residue by column chromatography on silica gel (CH_2Cl_2/MeOH, 9:1) afforded the desired product (0.29 g, 64%) as a white foam. $[\alpha]_D^{20}$= -41 (*c* 0.8 in MeOH). δ_H (400 MHz, CD$_3$OD) 7.84-7.81 (2H, m, Ar-H), 7.52-7.48 (1H, m, Ar-H), 7.44-7.40 (2H, m, Ar-H), 4.83 (1H, d, $J_{1,2}$ 2.0, 1-H), 4.05 (1H, dd, $J_{3,4}$ 6.4, $J_{3,2}$ 4.0, 3-H), 3.97-3.94 (2H, m, 2-H, 5-H), 3.91 (1H, dd, $J_{3,4}$ 6.4, $J_{4,5}$ 3.2, 4-H), 3.67 (1H, dt, ^2J 9.2, ^3J 6.4, OCH_2CH$_2$), 3.65 (1H, dd, $J_{6a,6b}$ 13.6, $J_{6a,5}$ 4.8, 6a-H), 3.65 (1H, dd, $J_{6b,6a}$ 13.6, $J_{6b,5}$ 7.2, 6b-H), 3.39 (1H, dt, ^2J 9.2, ^3J 6.4, OCH_2CH$_2$), 1.58-1.51 (2H, m, OCH$_2$CH_2), 1.33-1.26 [10H, m, (CH$_2$)$_5$], 0.87 (3H, t, ^3J 6.8, CH$_3$). δ_C (100 MHz, CD$_3$OD) 170.4 (CO), 135.5, 132.7, 129.5, 128.3 (C$_6$H$_5$), 109.4 (C-1), 85.0 (C-4), 83.4 (C-2), 78.7 (C-3), 70.0 (C-5), 68.9 (OCH$_2$CH$_2$), 44.7 (C-6), 33.0, 30.7, 30.5, 30.4, 27.2, 23.7 [(CH$_2$)$_6$], 14.5 (CH$_3$). HRMS (ESI): calcd for $C_{21}H_{33}NNaO_6$ [M+Na]$^+$ 418.2206, found 418.2206.

***n*-Octyl 2,3-di-*O*-benzoyl-6-deoxy-6-valeramido-5-*O*-valeroyl-β-D-galactofuranoside 25.** To a solution of **21** (2.0 g, 3.80 mmol) in dry THF (20 mL) was added Pd(OAc)$_2$ (85 mg, 0.38 mmol). The mixture was stirred at room temperature for 2 days under a positive pressure of H_2, then concentrated under reduced pressure. The residue was redissolved in pyridine (20 mL), then DMAP (46 mg, 0.38 mmol) and valeroyl chloride (1.38 mL, 11.4 mmol) were added. The mixture was stirred at room temperature for 2 h and concentrated under reduced pressure. The residue was redissolved with AcOEt (100 mL), washed with saturated aqueous $NaHCO_3$ solution (3×50 mL) and brine (50 mL). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification of the residue by flash chromatography on silica gel (cyclohexane/AcOEt, 7:3) afforded the desired product (1.99 g, 78%) as a slightly yellow oil. $[\alpha]_D^{20}$= -6.0 (*c* 1 in CHCl$_3$). δ_H (400 MHz, CDCl$_3$) 8.08-8.04 (4H, m, Ar-H), 7.61-7.57 (2H, m, H-Ar), 7.48-7.43 (4H, m, Ar-H), 6.02 (1H, t, $J_{NH,6}$ 5.2, NH), 5.44 (1H, d, $J_{2,3}$ 1.2, 2-H), 5.25 (1H, s, 1-H), 5.41-5.38 (2H, m, 3-H, 5-H), 4.38 (1H, dd, $J_{4,3}$ 5.2, $J_{4,5}$ 3.6, 4-H), 3.80 (1H, ddd, $J_{6a,6b}$ 14.0, $J_{6a,5}$ 3.6, 6a-H), 3.74 (1H, dt, ^2J 9.6, ^3J 6.8, OCH$_2$ *octyl*), 3.57 (1H, ddd, $J_{6b,6a}$ 14.0, $J_{6b,5}$ 7.2, 6b-H), 3.51 (1H, dt, ^2J 9.6, ^3J 6.4, OCH$_2$ *octyl*), 2.29 (2H, dt, ^2J 7.6, ^3J 3.6, CH$_2$ *valeroyl*), 2.15 (2H, t, ^3J 7.6, CH$_2$ *amide*), 1.66-1.51 (8H, m, OCH$_2$CH_2 *octyl*, CH$_2$ *valeroyl*, CH$_2$ *valeroyl*, CH$_2$ *amide*), 1.34-1.20 [12H, m, CH$_2$ *amide*, (CH$_2$)$_5$ *octyl*], 0.88 (3H, t, ^3J 7.2, CH$_3$), 0.86 (3H, t, ^3J 6.8, CH$_3$), 0.82 (3H, t, ^3J 7.2, CH$_3$). δ_C (100 MHz, CDCl$_3$) 173.8, 173.2, 165.7, 165.4 (CO), 133.5, 129.9, 129.8, 129.1, 129.0, 128.5, 128.4 (CAr), 105.5 (C-1), 82.3 (C-4), 81.7 (C-2), 77.3 (C-3), 70.6 (C-5), 67.7 (OCH$_2$ *octyl*), 41.1 (C-6), 36.5 (CH$_2$ *valeroyl*), 33.9 (CH$_2$ *amide*), 31.8, 29.5, 29.4, 29.3, 27.7, 26.9, 26.1, 22.6, 22.3, 22.1 [(CH$_2$)$_6$ *octyl*, (CH$_2$)$_2$ *valeroyl*, (CH$_2$)$_2$ *amide*], 14.1, 13.7, 13.6 (CH$_3$). HRMS (ESI): calcd for $C_{38}H_{53}NNaO_9$ [M+Na]$^+$ 690.3618, found 690.3613.

***n*-Octyl 6-deoxy-6-pentanamido-β-D-galactofuranoside 7.** Deprotection proceeded according to the general procedure used

for compound **2** starting from compound **25** (0.4 g, 0.60 mmol) in dry MeOH (10 mL) with a 30% wt. solution of sodium methoxide in MeOH (11.2 µL, 0.06 mmol). Purification of the residue by column chromatography on silica gel (CH_2Cl_2/MeOH, 9:1) afforded the desired product (0.19 g, 89%) as a white foam. $[\alpha]_D^{20}$= -59 (*c* 0.9 in MeOH). δ_H (400 MHz, CD_3OD) 4.82 (1H, d, $J_{1,2}$ 2.0, 1-H), 3.96 (1H, dd, $J_{3,4}$ 6.4, $J_{3,2}$ 4.0, 3-H), 3.91 (1H, dd, $J_{2,3}$ 4.0, $J_{1,2}$ 2.0, 2-H), 3.79 (1H, dd, $J_{4,3}$ 6.4, $J_{4,5}$ 3.2, 4-H), 3.76 (1H, ddd, $J_{5,6b}$ 7.6, $J_{5,6a}$ 4.4, $J_{5,4}$ 3.2, 5-H), 3.69 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.41 (1H, dd, $J_{6a,6b}$ 14.0, $J_{6a,5}$ 4.4, 6a-H), 3.40 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.24 (1H, dd, $J_{6b,6a}$ 14.0, $J_{6b,5}$ 7.6, 6b-H), 2.19 (2H, m, CH_2 *amide*), 1.61-1.53 (4H, m, CH_2 *amide*, OCH_2CH_2), 1.39-1.29 [12H, m, $(CH_2)_5$, CH_2 *amide*], 0.92 (3H, t, ^3J 7.2, CH_3), 0.88 (3H, t, ^3J 7.2, CH_3). δ_C (100 MHz, CD_3OD) 176.7 (CO), 109.4 (C-1), 84.9 (C-4), 83.6 (C-2), 78.8 (C-3), 70.3 (C-5), 69.0 (OCH_2CH$_2$), 43.9 (C-6), 36.9 (CH_2 *amide*), 33.1, 30.8, 30.6, 30.5, 29.2, 27.3, 23.8, 23.4 [$(CH_2)_6$, $(CH_2)_2$ *amide*], 14.5, 14.1 (CH_3). HRMS (ESI): calcd for $C_{19}H_{37}NNaO_6$ $[M+Na]^+$ 398.2519, found 398.2518.

Synthesis of the B-family

***n*-Octyl β-D-(methyl-galactofuranosid) uronate 9.** Compound **9** was obtained starting from **26** according to known procedure.[27] To a suspension of uronate **26** (15 g, 72 mmol) in anhydrous THF (150 mL) was added successively, at 0 °C and under vigorous stirring, $CaCl_2$ (9,24 g, 83,2 mmol), 1-octanol (19,7 ml,125 mmol) and, by portion, $FeCl_3$ (40,5 g, 249,7 mmol). The resulting mixture was allowed to stir at r.t. for 24 h. The solvent was evaporated under reduced pressure and the resulting residue was partitioned between ethyl acetate and 5% aqueous solution of HCl. The resulting organic phase was washed with 5% aqueous solution of HCl (10 times). The combined aqueous phases were further extracted with ethyl acetate (3 times). The resulting combined organic phase were finally washed with water and brine, dried over $MgSO_4$, and concentrated. The resulting mixture was purified by column chromatography with CH_2Cl_2/MeOH (99 :1) as eluent to give **9** as a mixture of anomers (7.44 g, 32%, α/β 2:3). The separation was achieved by column chromatography on C-18 grafted silica using H_2O/CH_3CN (7:3 to 1:1) as eluent to give **9β** (4g, 17%). $[\alpha]_D^{20}$= -68 (*c* 0.3 in MeOH). δ_H (400 MHz, CD_3OD) 4.83 (1H, d, $J_{1,2}$ 2.3, 1-H), 4.30 (1H, d, $J_{5,4}$ 2.4, 5-H), 4.18 (1H, dd, $J_{4,3}$ 7.1, $J_{4,5}$ 2.4, 4-H), 4.10 (1H, dd, $J_{3,4}$ 7.1, $J_{3,2}$ 4.5, 3-H), 3.93 (1H, dd, $J_{2,1}$ 2.3, $J_{2,3}$ 4.5, 2-H), 3.77 (3H, s, $COCH_3$), 3.63 (1H, td, ^2J 9.7, ^3J 6.7, OCH_2), 3.41 (1H, td, ^2J 9.7, ^3J 6.5, OCH_2), 1.61-1.52 (2H, m, OCH_2CH_2), 1.40-1.25 [10H, m, $(CH_2)_5$], 0.90 (3H, t, ^3J 6.8, CH_2CH_3). δ_C (100 MHz, CD_3OD) 174.2 (CO), 109.4 (C-1), 84.7 (C-4), 83.4 (C-2), 77.7 (C-3), 70.7 (C-5), 69.2 (OCH_2), 52.7 ($COCH_3$), 33.0, 30.8, 30.5, 30.4, 27.3, 23.7 [$(CH_2)_6$], 14.4 (CH_2CH_3). HRMS (ESI): calcd for $C_{15}H_{28}NaO_7$ $[M+Na]^+$ 343.1733, found 343.1736.

***n*-Octyl α-L-arabinofuranoside 10.** To a solution of **27**[29] (0.3 g, 0.94 mmol) in dry CH_2Cl_2 (15 mL) was added octan-1-ol (0.22 mL, 1.41 mmol) and $BF_3.Et_2O$ (0.3 mL, 2.35 mmol) dropwise. The mixture was stirred for 5 h at room temperature, then diluted with CH_2Cl_2 (100 mL), washed with saturated aqueous $NaHCO_3$ solution (3×50 mL) and brine (50 mL). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Subsequent deprotection proceeded according to the general procedure used for compound **2**, in dry MeOH (10 mL) with a 30% wt. solution of sodium methoxide in MeOH (16.9 µL, 0.09 mmol). Purification of the residue by flash chromatography on silica gel (AcOEt/cyclohexane, 1:1) afforded the desired product (30.1 mg, 12%) as a colorless oil. $[\alpha]_D^{20}$= -9 (*c* 1.1,in MeOH). δ_H (400 MHz, CD_3OD) 4.80 (1H, d, $J_{1,2}$ 1.6, 1-H), 3.90 (1H, dd, $J_{2,3}$ 3.6, $J_{2,1}$ 1.6, 2-H), 3.87 (1H, ddd, $J_{4,3}$ 6.4, $J_{4,5b}$ 5.2, $J_{4,5a}$ 3.2, 4-H), 3.78 (1H, dd, $J_{3,4}$ 6.4, $J_{3,2}$ 3.6, 3-H), 3.70 (1H, dd, $J_{5a,5b}$ 12.0, $J_{5a,4}$ 3.2, 5a-H), 3.66 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.58 (1H, dd, $J_{5b,5a}$ 12.0, $J_{5b,4}$ 5.2, 5b-H), 3.36 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 1.58-1.51 (2H, m, OCH_2CH_2), 1.34-1.26 [10H, m, $(CH_2)_5$], 0.86 (3H, t, ^3J 6.8, CH_3). δ_C (100 MHz, CD_3OD) 109.4 (C-1), 85.2 (C-4), 83.7 (C-2), 78.7 (C-3), 68.9 (OCH_2CH$_2$), 63.0 (C-5), 33.1, 30.8, 30.6, 30.5, 27.3, 23.8 [$(CH_2)_6$], 14.5 (CH_3). HRMS (ESI): calcd for $C_{13}H_{26}NaO_5$ $[M+Na]^+$ 285.1678, found 285.1677.

***n*-Octyl β-D-fucofuranoside 11.** To a solution of **28**[29] (0.2 g, 0.66 mmol) in dry CH_2Cl_2 (10 mL) was added octan-1-ol (0.16 mL, 0.99 mmol) and $BF_3.Et_2O$ (0.21 mL, 1.65 mmol) dropwise. The mixture was stirred for 8 h at room temperature, then diluted with CH_2Cl_2 (100 mL), washed with saturated aqueous $NaHCO_3$ solution (3×50 mL) and brine (50 mL). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Subsequent deprotection proceeded according to the general procedure used for compound **2** in dry MeOH (10 mL) with a 30% wt. solution of sodium methoxide in MeOH (12.4 µL, 0.07 mmol). Purification of the residue by flash chromatography on silica gel (AcOEt/cyclohexane, 1:1) afforded the desired product (64 mg, 35%) as a colorless oil. Spectroscopic data of the resulting compound were in accordance with the literature.[37]

***n*-Octyl L-fucofuranoside 12.** To a solution of **29**[29] (0.15 g, 0.45 mmol) in dry CH_2Cl_2 (10 mL) was added octan-1-ol (0.11 mL, 0.67 mmol) and $BF_3.Et_2O$ (0.14 mL, 1.12 mmol) dropwise. The mixture was stirred for 8 h at room temperature, then diluted with CH_2Cl_2 (100 mL), washed with saturated aqueous $NaHCO_3$ solution (3×50 mL) and brine (50 mL). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Subsequent deprotection proceeded according to the general procedure used for compound **2** in dry MeOH (10 mL) with a 30% wt. solution of sodium methoxide in MeOH (8.4 µL, 0.04 mmol). Purification of the residue by flash chromatography on silica gel (AcOEt/cyclohexane, 2:3) afforded the desired product (54 mg, 44%) in anomeric mixture (α/β 8:1) as a colorless oil. *n*-Octyl α-L-fucofuranoside (**12α**): δ_H (400 MHz, CD_3OD) 4.79 (1H, d, $J_{1,2}$ 1.6, 1-H), 3.88 (1H, dd, $J_{2,3}$ 3.6, $J_{2,1}$ 1.6, 2-H), 3.79 (1H, dd, $J_{3,4}$ 6.4, 3-H), 3.76 (1H, td, $J_{5,6}$ 6.4, $J_{5,4}$ 4.8, 5-H), 3.66 (1H, dt, ^2J 9.6, ^3J 6.8, OCH_2CH$_2$), 3.63 (1H, dd, $J_{4,3}$ 6.4, $J_{4,5}$ 4.8, 4-H), 3.37 (1H, dt, ^2J 9.6, ^3J 6.4, OCH_2CH$_2$), 1.57-1.50 (2H, m, OCH_2CH_2), 1.34-1.26 [10H, m, $(CH_2)_5$], 1.19 (3H, d, $J_{6,5}$ 6.4, H-6), 0.85 (3H, t, ^3J 6.8, CH_2CH_3). δ_C (100 MHz, CD_3OD) 109.2 (C-1), 88.1 (C-4), 83.9 (C-2), 79.4 (C-3), 68.8 (OCH_2CH$_2$), 68.4 (C-5), 33.1, 30.8, 30.6, 30.5, 27.3, 23.8 [$(CH_2)_6$], 19.8 (C-6), 14.5 (CH_2CH_3). *n*-Octyl β-L-fucofuranoside (**12β**): δ_H (400 MHz, CD_3OD) 4.77 (1H, d, $J_{1,2}$ 4.0, 1-H), 3.89-3.87 (1H, m, 2-H), 3.85-3.83 (1H, m, 3-H), 3.81-3.73 (1H, m, OCH_2CH$_2$), 3.67-3.61 (1H, m, 5-H), 3.43-3.35 (2H, m, 4-H, OCH_2CH$_2$), 1.57-1.50 (2H, m, OCH_2CH_2), 1.34-1.26 [10H, m, $(CH_2)_5$], 1.12 (3H, d, $J_{6,5}$ 6.4, 6-H), 0.85 (3H, t, ^3J 6.8, CH_2CH_3).

δ_C (100 MHz, CD_3OD) δ 102.7 (C-1), 87.5 (C-4), 79.4 (C-2), 77.2 (C-3), 71.4 (C-5), 69.2 (OCH_2CH_2), 33.1, 30.8, 30.6, 30.5, 27.3, 23.8 [$(CH_2)_6$], 18.9 (C-6), 14.5 (CH_2CH_3). HRMS (ESI): calcd for $C_{14}H_{28}O_5Na$ $[M+Na]^+$ 299.1834, found 299.1832.

***n*-Octyl 2-acetamido-2-deoxy-β-D-galactofuranoside 13.** To a solution of **30**[29] (135 mg, 0.35 mmol) in dry 1,2-dichloroethane (1 mL) was added octan-1-ol (0.22 mL, 1.39 mmol) and $CuCl_2$ (279 mg, 2.08 mmol). The mixture was refluxed for 8 h. The solution was then allowed to cool to room temperature then vigorously stirred with saturated aqueous $NaHCO_3$ solution (1 mL). The resulting biphasic solution was filtered on a pad of Celite and the resulting cake extensively washed with ethyl acetate. The subsequent filtrate was washed with water and brine. The organic phase was dried over $MgSO_4$, filtered and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel (AcOEt/cyclohexane, from 9:1 to 3:2) to afford first *n*-octyl 2-acetamido-2-deoxy-3,5,6-tri-*O*-acetyl-β-D-galactofuranoside (48 mg, 30%) then the corresponding α-anomer (44 mg, 28%) both as colorless oils. β anomer: δ_H (400 MHz, $CDCl_3$) 5.99 (1H, d, $J_{NH,\,2}$ 7.5, NH), 5.36 (1H, dt, $J_{5,6b}$ 7.1, $J_{5,4}$ 4.4, $J_{5,6a}$ 4.4, 5-H), 4.92 (1H, d, $J_{1,2}$ 1.2, 1-H), 4.73 (1H, dd, $J_{3,4}$ 4.9, $J_{3,2}$ 2.3, 3-H), 4.37 (1H, ddd, $J_{2,NH}$ 7.5, $J_{2,1}$ 1.2, $J_{2,3}$ 2.3, 2-H), 4.35 (1H, dd, $J_{6a,6b}$ 11.8, $J_{6a,5}$ 4.4, 6a-H), 4.23 (1H, dd, $J_{6b,6a}$ 11.8, $J_{5,6b}$ 7.1, 6b-H), 4.17 (1H, dd, $J_{4,3}$ 4.9, $J_{4,5}$ 4.4, 4-H), 3.61 (1H, dt, ^2J 9.5, ^3J 6.8, OCH_2), 3.42 (1H, dt, ^2J 9.5, ^3J 6.4, OCH_2), 2.14 (3H, s, $COCH_3$), 2.08 (3H, s, $COCH_3$), 2.06 (3H, s, $COCH_3$), 2.00 (3H, s, $COCH_3$), 1.61-1.52 (2H, m, OCH_2CH_2), 1.38-1.20 [10H, m, $(CH_2)_5$], 0.87 (3H, t, ^3J 6.9, CH_2CH_3). δ_C (101 MHz, $CDCl_3$) 170.8 , 170.7, 170.2, 169.6 (CO), 106.8 (C-1), 80.0 (C-4), 78.2 (C-3), 70.2 (C-5), 68.0 (OCH_2), 62.8 (C-6), 60.3 (C-2), 32.0, 29.6, 29.5, 29.4, 26.2 [$(CH_2)_5$], 23.4 ($COCH_3$), 22.8 (OCH_2CH_2), 21.1, 20.9 ($COCH_3$), 14.2 (CH_2CH_3).

Deprotection of the β-anomer (19 mg, 0.04 mmol) proceeded according to the general procedure used for compound **2** in dry MeOH (1 mL) with a 30% wt. solution of sodium methoxide in MeOH (1 µL, 4 µmol). Evaporation of the solvent gave the desired product **13** (14 mg, 100%) as a light brown solid. $[\alpha]_D^{20}$= +78 (*c* 0.85 in MeOH). δ_H (400 MHz, CD_3OD+$CDCl_3$) 4.86 (1H, d, $J_{1,2}$ 1.5, 1-H), 4.12 (1H, dd, $J_{2,3}$ 3.1, $J_{2,1}$ 1.5, 2-H), 4.00 (1H, dd, $J_{3,4}$ 5.5, $J_{3,2}$ 3.1, 3-H), 3.96 (1H, dd, $J_{4,3}$ 5.5, $J_{4,5}$ 2.6, 4-H), 3.76 (1H, td, $J_{5,6}$ 6.1, $J_{5,4}$ 2.6, 5-H), 3.68-3.61 (3H, m, 6-H, OCH_2), 3.39 (1H, td, ^2J 9.6, ^3J 6.7, OCH_2), 1.94 (3H, s, $COCH_3$), 1.55 (2H, p, ^3J 6.7, OCH_2CH_2), 1.33-1.21 [10H, m, $(CH_2)_5$], 0.85 (3H, t, ^3J 6.9, CH_2CH_3). δ_C (101 MHz, CD_3OD+$CDCl_3$) 172.2 (CO), 107.2 (C-1), 84.6 (C-4), 77.6 (C-3), 71.6 (C-5), 68.4 (OCH_2), 64.3 (C-6), 63.3 (C-2), 32.4, 30.0, 29.9, 29.8, 26.6, 23.1 [$(CH_2)_6$], 22.7 ($COCH_3$), 14.3 (CH_2CH_3). HRMS (ESI): calcd for $C_{16}H_{31}NNaO_6$ $[M+Na]^+$ 356.2049, found 356.2045.

Synthesis of the C-family

2-Methyl-3-(octyloxy)-2-[(octyloxy)methyl]propan-1-ol 34. To a solution of **33** (1 g, 4.8 mmol) in dry DMF (50 mL) was added NaH 60% in oil (0.76 g, 19 mmol). The mixture was stirred at 50 °C for 15 minutes. A solution of TBAI (0.18 g, 0.48 mmol) and 1-bromo-octane (4.6 g, 24 mmol) in dry DMF (5 mL) was then added slowly. The reaction mixture was stirred at 90 °C for 20 h. The solvent was evaporated and the residue was dissolved in AcOEt (50 mL). The organic layer was washed with water (3x20 mL), dried over $MgSO_4$ and concentrated under vacuo. The residue was purified by chromatography (cyclohexane/AcOEt 9:1) to give the title compound as a colorless oil (800 mg, 52%). δ_H (300 MHz, $CDCl_3$) 3.57 (2H, d, ^3J 5.8, CH_2OH), 3.44-3.36 (8H, m, CCH_2, OCH_2), 3.18 (1H, t, ^3J 5.8, OH), 1.55 (4H, p, ^3J 6.8, OCH_2CH_2), 1.44-1.24 [20H, m, $(CH_2)_5$], 0.90-0.86 (9H, m, CCH_3, CH_2CH_3). δ_C (75 MHz, $CDCl_3$) 75.4, 71.7, 69.6 (CCH_2,OCH_2), 40.4 (CCH_2), 31.8 (OCH_2CH_2), 29.5, 29.35, 29.2, 26.1, 22.6 [$(CH_2)_5$], 17.5 (CCH_3), 14.0 (CH_2CH_3). HRMS (ESI): calcd for $C_{21}H_{44}O_3Na$ $[M+Na]^+$ 367.3188, found 367.3187.

3-(Benzyloxy)-2-methyl-2-[(octyloxy)methyl]propan-1-ol 38. To a solution of **37** (1 g, 4.8 mmol) in dry DMF (50 mL) was added NaH 60% in oil (0.58 g, 14.4 mmol). The mixture was stirred at 50 °C for 15 minutes. A solution of TBAI (0.18 g, 0.48 mmol) and 1-bromooctane (2.76 g, 14.4 mmol.) in dry DMF (5 mL) was then slowly added. The reaction mixture was stirred at 50 °C for 2 days. The solvent was evaporated and the residue was dissolved in AcOEt (50 mL). The organic layer was washed with water (3x20 mL), dried over $MgSO_4$ and concentrated under vacuo. The residue was purified by chromatography (cyclohexane/AcOEt 8:2) to give compound **37** (800 mg, 70%) as a colorless oil. δ_H (300 MHz, $CDCl_3$) 7.41-7.28 (5H, m, Ar-H), 4.53 (2H, d, ^3J 1.9, OCH_2Ph), 3.59 (2H, d, ^3J 5.8, CH_2OH), 3.49-3.37 (6H, m, CCH_2O, OCH_2), 3.05 (1H, t, ^3J 5.9, OH), 1.54 (2H, p, ^3J 6.7, OCH_2CH_2), 1.33-1.24 [10H, m, $(CH_2)_5$], 0.91-0.86 (6H, m, CH_3). δ_C (75 MHz, $CDCl_3$) 138.4, 128.1, 127.3, 127.2 (CAr), 75.4, 74.2, 73.3, 71.6, 68.9 (OCH_2), 40.5 (CCH_3), 31.7 (OCH_2CH_2), 29.4, 29.2, 29.1, 26.0, 22.5 [$(CH_2)_5$], 17.4 (CCH_3), 13.9 (CH_2CH_3). HRMS (ESI): calcd for $C_{20}H_{34}O_3Na$ $[M+Na]^+$ 345.2406, found 345.2409.

General Procedure for the synthesis of per-*O*-acetylated galactofuranosides 40-42

To a solution of **39**[33] (100 mg, 0.23 mmol) in dry DCM (10 mL) were added successively alcohol **32**, **34** or **38** (0.31 mmol) and molecular sieves (500 mg). The solution, placed in the dark, was stirred at room temperature for 1 h and then cooled to -40 °C. *N*-iodosuccinimide (61 mg, 0.27 mmol) and AgOTf (18 mg, 0.07 mmol) were successively added to the solution and the reaction mixture was then stirred at -40 °C. After 1.5 h the mixture was warmed to room temperature and was kept under stirring between 5 h and 48 h. The reaction was then quenched by addition of Et_3N (2 mL), filtered through celite and concentrated under vacuo. The residue was purified by chromatography (cyclohexane/AcOEt 8:2) to give the corresponding compounds.

1,3-Bis(octyloxy)propanyl-2,3,5,6-tetra-*O*-acetyl-β-D-galactofuranoside 40. After 5 h at room temperature and work-up, the title compound was obtained as a colorless oil (104 mg, 71%) (β only). δ_H (400 MHz, $CDCl_3$) 5.40 (1H, td, $J_{5,6b}$ 7.5, $J_{5,6a}$ 3.9, 5-H), 5.30 (1H, s, 1-H), 5.09 (1H, d, $J_{2,3}$ 2.0, 2-H), 4.97 (1H, dd, $J_{3,4}$ 6.2, $J_{3,2}$ 2.0, 3-H), 4.37-4.32 (2H, m, 4-H, 6a-H), 4.21 (1H, dd, $J_{6b,6a}$ 11.9, $J_{6b,5}$ 7.5, 6b-H), 3.96 [1H, tt, ^3J 9.9, ^3J 5.5, $CH(CH_2OC_8H_{17})_2$], 3.56-3.39 (8H, m, $CHCH_2$, OCH_2), 2.13 (3H, s, $COCH_3$), 2.09 (3H, s, $COCH_3$), 2.07 (3H, s, $COCH_3$), 2.05 (3H, s, $COCH_3$), 1.55-1.51 (4H, m, OCH_2CH_2), 1.31-1.27 [20H, m, $(CH_2)_5$], 0.88 (6H, t, ^3J 7.2, CH_3). δ_C (100 MHz, $CDCl_3$) 170.5, 170.1, 170.0, 169.5 (CO), 104.8 (C-1), 81.5 (C-2), 79.6 (C-4), 76.6 (C-3), 74.6 ($CHCH_2$), 71.7, 71.7, 70.8, 70.7 ($CHCH_2$,

OCH_2), 69.2 (C-5), 62.9 (C-6), 31.8 (OCH_2CH_2), 29.7, 29.6, 29.4, 29.3, 26.1, 22.6 [$(CH_2)_5$], 20.8, 20.7, 20.6 ($COCH_3$), 14.1 (CH_2CH_3). HRMS (ESI) calcd for $C_{33}H_{58}NaO_{12}$ $[M+Na]^+$: 669.3826, found 669.3831.

1,3-Bis(octyloxy)propanyl β-D-galactofuranoside 14. Deprotection of compound **40** (104 mg, 0.16 mmol) proceeded according to the general procedure used for compound **2** in dry MeOH (3 mL) with a 30% wt. solution of sodium methoxide in MeOH (30 µL, 0.016 mmol). The desired product was obtained as a colorless oil (92 mg, 96%) (β only). $[\alpha]_D^{20}$ = -51.85 (*c* 0.54 in MeOH). δ_H (400 MHz, $CDCl_3$) 5.27 (1H, s, 1-H), 4.16 (1H, brs, 4-H), 4.10 (1H, tt, ^3J 9.9, ^3J 5.5, $CH(CH_2OC_8H_{17})_2$), 4.12-4.02 (2H, m, 3-H, 2-H), 3.96 (1H, ddd, $J_{5,6b}$ 6.1, $J_{5,6a}$ 4.1, $J_{5,4}$ 1.8, 5-H), 3.84 (1H, dd, $J_{6a,6b}$ 11.4, $J_{6a,5}$ 4.1, 6a-H), 3.75 (dd, 1H, $J_{6b,6a}$ 11.4, $J_{6b,5}$ 6.1, 6b-H), 3.46-3.38 (8H, m, CH_2O), 3.18 (4H, brs, OH), 1.59-1.52 (4H, m, OCH_2CH_2), 1.31-1.23 [20H, m, $(CH_2)_5$], 0.88 (6H, t, ^3J 6.9, CH_3). δ_C NMR (100 MHz, $CDCl_3$) δ 106.0 (C-1), 87.2 (C-4), 79.0 (C-2), 78.6 (C-3), 72.0 (CH), 71.8, 71.6 (OCH_2), 71.1 (C-5), 70.7, 69.8 (OCH_2), 64.2 (C-6), 31.8 (OCH_2CH_2), 29.5, 29.4, 29.3, 26.0, 22.6 [$(CH_2)_5$], 14.1 (CH_3). HRMS (ESI) calcd for $C_{25}H_{50}O_8Na$ $[M+Na]^+$: 501.3403, found: 501.3402.

2-Methyl-3-(octyloxy)-2-[(octyloxy)methyl]propanyl-2,3,5,6-tetra-*O*-acetyl-D-galactofuranoside 41. After 5 h at room temperature and work-up, the title compound was obtained as a colorless oil (140 mg, 91%) (α/β 1:4). Selected data for the α anomer: δ_H (400 MHz, $CDCl_3$) 5.12 (1H, d, $J_{1,2}$ 4.6, 1-H). β anomer: δ_H (400 MHz, $CDCl_3$) 5.39 (1H, td, $J_{5,6b}$ 7.2, $J_{5,4}$ 4.0, $J_{5,6a}$ 4.0, 5-H), 5.05 (1H, d, $J_{2,3}$ 2.2**,** 2-H), 4.97 (1H, brs, 1-H), 4.96 (1H, dd, $J_{3,4}$ 5.4, $J_{3,2}$ 2.2**,** 3-H), 4.33 (1H, dd, $J_{6a,6b}$ 11.8, $J_{6a,5}$ 4.0, 6a-H), 4.24-4.19 (2H, m, 6b-H, 4-H), 3.54 (1H, d, ^2J 9.2, OCH_2), 3.37-3.22 (9H, m, OCH_2), 2.13 (3H, s, $COCH_3$), 2.10 (3H, s, $COCH_3$), 2.07 (3H, s, $COCH_3$), 2.05 (3H, s, $COCH_3$), 1.54-1.49 (4H, m, OCH_2CH_2), 1.32-1.25 [20H, m, $(CH_2)_5$], 0.92 (3H, s, CH_3), 0.88 (6H, t, ^3J 7.0, CH_3). δ_C (100 MHz, $CDCl_3$) 170.5, 170.1, 169.9, 169.6 (CO), 105.5 (C-1), 81.0 (C-2), 79.8 (C-4), 76.6 (C-3), 73.2, 73.1, 71.6, 69.9 (OCH_2), 69.3 (C-5), 62.8 (C-6), 40.5 (CCH_3), 31.85 (OCH_2CH_2), 29.6, 29.4, 29.3, 26.2, 22.7 [$(CH_2)_5$], 20.8, 20.7, 20.6 ($COCH_3$), 17.4 (CCH_3), 14.1 (CH_2CH_3). HRMS (ESI) calcd for $C_{35}H_{62}O_{12}Na$ $[M+Na]^+$: 697.4139, found 697.4143.

2-Methyl-3-(octyloxy)-2-[(octyloxy)methyl]propanyl-D-galactofuranoside 15 . Deprotection of compound **41** (140 mg, 0.2 mmol) proceeded according to the general procedure used for compound **2** in dry MeOH (4 mL) with a 30% wt. solution of sodium methoxide in MeOH (40 µL, 0.02 mmol). The desired product was obtained as a yellow oil (100 mg, 99%) (α/β 1:4). Selected data for the α anomer: δ_H (400 MHz, $CDCl_3$) 5.90 (1H, d, $J_{1,2}$ 4.2, 1-H). β anomer: δ_H (400 MHz, $CDCl_3$) δ 4.93 (1H, s, 1-H), 4.05-3.97 (3H, m, 4-H, 3-H, 2-H), 3.92 (1H, m, 5-H), 3.81-3.60 (4H, m, OCH_2, 6-H), 3.37-3.21 (8H, m, OCH_2), 2.29 (4H, brs, OH), 1.56-1.49 (4H, m, OCH_2CH_2), 1.30-1.25 [20H, m, $(CH_2)_5$], 0.88 (3H, s, CCH_3), 0.87 (6H, t, ^3J 7, CH_2CH_3). δ_C (100 MHz, $CDCl_3$) δ 107.9 (C-1), 88.1 (C-4), 78.7 (C-2, C-3), 73.5, 71.9, 71.8, 71.6 (OCH_2), 71.0 (C-5), 70.8 (OCH_2), 64.4 (C-6), 40.2 (CCH_3), 31.8 (OCH_2CH_2), 29.6, 29.5, 29.4, 29.3, 26.1, 22.7 [$(CH_2)_5$], 17.8 (CCH_3), 14.1 (CH_2CH_3). HRMS (ESI) calcd for $C_{27}H_{54}O_8Na$ $[M+Na]^+$: 529.3716, found: 529.3712.

3-(Benzyloxy)-2-methyl-2-[(octyloxy)methyl]propanyl-2,3,5,6-tetra-*O*-acetyl-D-galactofuranoside 42. After 48 h at room temperature and work-up, the title compound was obtained as a colorless oil (71 mg, 32%) (α/β 5:95). Selected data for the α anomer: δ_H (400 MHz, $CDCl_3$) 5.85 (1H, d, $J_{1,2}$ 3.7, 1-H). β anomer: δ_H (400 MHz, $CDCl_3$) 7.35-7.27 (5H, m, Ar-H), 5.38 (1H, td, $J_{5,6b}$ 7.2, $J_{5,4}$ 4.1, $J_{5,6a}$ 4.1, 5-H), 5.04 (1H, d, $J_{2,3}$ 1.8, 2-H), 4.98 (1H, brs, 1-H), 4.96 (1H, dd, $J_{3,4}$ 5.8, $J_{3,2}$ 1.8, 3-H), 4.48 (2H, brs, CH_2Ph), 4.29 (1H, dd, $J_{6b,6a}$ 11.8, $J_{6a,5}$ 4.1, 6a-H), 4.22-4.17 (2H, m, 6b-H, 4-H), 3.59 (1H, dd, ^2J 9.2, ^4J 3.9, OCH_2), 3.37-3.27 (7H, m, OCH_2), 2.12 (3H, s, $COCH_3$), 2.09 (3H, s, $COCH_3$), 2.06 (3H, s, $COCH_3$), 2.02 (3H, d, ^4J 2, $COCH_3$), 1.53-1.50 (2H, m, OCH_2CH_2), 1.31-1.25 [10H, m, $(CH_2)_5$], 0.97 (3H, d, ^4J 1.4, CCH_3), 0.87 (3H, t, ^3J 7.0, CH_2CH_3). δ_C (100 MHz, $CDCl_3$) 170.5, 170.1, 169.9, 169.6 (CO), 138.9, 128.3, 127.4, 127.2 (CAr), 105.5 (C-1), 81.0 (C-2), 79.9 (C-4), 76.6 (C-3), 73.3, 73.1, 72.8, 71.6, 69.85 (OCH_2), 69.3 (C-5), 62.8 (C-6), 40.6 (CCH_3), 31.9 (OCH_2CH_2), 29.6, 29.5, 29.3, 26.2, 22.6 [$(CH_2)_5$], 20.8, 20.7 ($COCH_3$), 17.5 (CCH_3), 14.1 (CH_2CH_3). HRMS (ESI) calcd for $C_{34}H_{52}O_{12}Na$ $[M+Na]^+$: 675.3356, found 675.3358.

3-(Benzyloxy)-2-methyl-2-[(octyloxy)methyl]propanyl-D-galactofuranoside 16. Deprotection of compound **42** (71 mg, 0.11 mmol) proceeded according to the general procedure used for compound **2** in dry MeOH (2 mL) with a 30% wt. solution of sodium methoxide in MeOH (20 µL, 0.011 mmol). The desired product was obtained as a yellow oil (84 mg, 87%) (α/β = 5:95). Selected data for the α anomer: δ_H (400 MHz, $CDCl_3$) 5.94 (1H, d, $J_{1,2}$ 3.9**,** 1-H). β anomer: δ_H (400 MHz, $CDCl_3$) 7.36-7.27 (5H, m, Ar-H), 4.93 (1H, s, 1-H), 4.47 (2H, brs, CH_2Ph), 4.02 (1H, brs, 4-H), 3.99-3.95 (2H, m, 3-H, 2-H), 3.89 (1H, brs, 5-H), 3.78-3.63 (3H, m, OCH_2, 6a-H), 3.36-3.24 (7H, m, OCH_2, 6b-H), 1.54-1.47 (2H, m, OCH_2CH_2), 1.32-1.28 [10H, m, $(CH_2)_5$], 0.91 (3H, d, ^4J 3.4, CCH_3), 0.88 (3H, t, ^3J 7, CH_2CH_3). δ_C (100 MHz, $CDCl_3$) 138.4, 128.3, 127.5, 127.45 (CAr), 108.0 (C-1), 87.2 (C-4), 78.8, 78.6 (C-2, C-3), 73.4, 73.3, 71.9, 71.8 (OCH_2), 70.9 (C-5), 70.6 (OCH_2), 64.3 (C-6), 40.2 (CCH_3), 31.8 (OCH_2CH_2), 29.5, 29.4, 29.3, 26.1, 22.7 [$(CH_2)_5$], 17.9 (CCH_3), 14.1 (CH_2CH_3). HRMS (ESI) calcd for $C_{26}H_{44}O_8Na$ $[M+Na]^+$: 507.2934, found: 507.2931.

3-Hydroxy-2-methyl-2-[(octyloxy)methyl]propanyl-β-D-galactofuranoside 17. To a solution of **16** (19 mg, 0.04 mmol) in ethanol (1 mL) was added palladium on activated charcoal (10% Pd contents, 5 mg). The mixture was stirred for 2 days under 1atm of H_2. Then, the solution was filtered on a pad of Celite and the resulting cake extensively washed with ethanol. The subsequent filtrate was concentrated under reduced pressure. The residue was purified by flash chromatography on C-18 grafted silica gel (H_2O/CH_3CN, 4:6) to afford **17** as a mixture of diastereomers (10 mg, 70%) as a colorless oil (β only). δ_H (400 MHz, CD_3OD) 4.83-4.81 (1H, m, 1-H), 4.00 (1H, dd, $J_{3,4}$ 6.0, $J_{3,2}$ 3.4, 3-H), 3.98-3.89 (2H, m, 3-H, 2-H), 3.77-3.68 (1H, m, 5-H), 3.67-3.57 (3H, m, 6-H, $CHOCH_2$), 3.48-3.44 (2H, m, CH_2OH), 3.46-3.36 [2H, m, $CH_2(CH_2)_6CH_3$], 3.35-3.25 (3H, m, CH_2OOct, $CHOCH_2$), 1.59-1.50 [2H, m, $CH_2(CH_2)_5CH_3$], 1.38-1.27 [10H, m, $(CH_2)_5CH_3$], 0.93-0.88 [6H, m, $(CH_2)_5CH_3$, CCH_3]. δ_C (100 MHz, CD_3OD) 109.6 (C-1), 84.7, 84.5 (C-4), 83.1, 83.0 (C-2), 78.9 (C-3), 75.0, 74.7 (CH_2OOct), 72.7 ($CH_2(CH_2)_6CH_3$), 72.5

(C-5), 71.4 ($CHOCH_2$), 66.7, 66.4 (CH_2OH), 64.5 (C-6), 41.9, 41.8 (CCH_3), 33.0, 30.7, 30.6, 30.4, 27.4, 23.7 [$(CH_2)_6$], 17.6 (CCH_3), 14.4 (CH_2CH_3). HRMS (ESI) calcd for $C_{19}H_{38}O_8Na$ $[M+Na]^+$: 417.2464, found 417.2469.

Microtiter test based evaluation of Minimum Inhibitory Concentration (MIC) against *Mycobacterium smegmatis*

Preparation of *M. smegmatis* cultures. A single colony of strain mc^2155 of *M. smegmatis* was grown in 25 mL Luria Bertani (LB) broth containing kanamycin (50 µg/mL) for 24 h at 37 °C (180 rpm). A 1% inoculum from this culture was transferred into fresh 5 mL LB medium containing kanamycin (50 µg/mL) and incubated overnight (37 °C, 180 rpm), giving. the desired *M. smegmatis* suspension.

Preparation of different concentrations of octyl glycofuranosides. Different amounts of octyl glycofuranosides were dissolved in LB broth containing kanamycine (50 µg/mL) in order to obtain a total volume of 1.1 mL with the following concentrations in furanosides: 0, 0.05, 0.1, 0.2, 0.3 and 0.4 mg/mL. Each tube was then supplemented with 10 µL of the *M. smegmatis* culture. In parallel, an equal number of tubes without inoculums was prepared to serve as blanks. All samples were finally incubated for 3 days at 37 °C and 180 rpm.

Determination of MIC. A 30 µL aliquot from a 0.1% (w/v) solution of resazurine prepared in sterile water was added to each sample. After developing for 1 h at 37 °C and 180 rpm, each sample (1 mL) was centrifuged (10000 rpm, 4 °C, 10 min). The supernatant (200 µL) was then pipetted and added to identified wells of a 96-well microplate, containing sterile water (0.2 mL). The plate had a set of controls: a column with a broad-spectrum antibiotic as positive control (ethambutol in serial dilution), a column with all solutions with the exception of the test compound, and a column with all solutions with the exception of *M. smegmatis*. The absorbance of each well at 600 nm was then measured in 96-wells-microtiter plate reader. The MIC of sample without bacterial inoculum was then calculated as the concentration where 99% of the bacteria growth is inhibited.

Acknowledgements

We are grateful to Dr. K. Mikušová from Comenius University, Bratislava for the gift of mc^2155 strain of *M. smegmatis*. We thank also UMR CNRS 6226 for financial supports.

Notes and references

1. Global Tuberculosis report 2014, World Health Organization, http://www.who.int/tb/publications/global_report/en/ (accessed January 2015).
2. J. B. Bass, Jr., L. S. Farer, P. C. Hopewell, R. O'Brien, R. F. Jacobs, F. Ruben, D. E. Snider, Jr. and G. Thornton, *Am. J. Respir. Crit. Care Med.*, 1994, **149**, 1359-1374.
3. A. Scorpio and Y. Zhang, *Nat. Med.*, 1996, **2**, 662-667.
4. P. Stallforth, B. Lepenies, A. Adibekian and P. H. Seeberger, *J. Med. Chem.*, 2009, **52**, 5561-5577.
5. P. J. Brennan, *Tuberculosis*, 2003, **83**, 91-97.
6. T. L. Lowary, in *Glycoscience: Chemistry and Chemical Biology*, eds. B. Fraser-Ried, K. Tatsuka and J. Thiem, Springer Verlag, Berlin Heilderberg New York, 2001, vol. III, pp. 2005-2080.
7. F. Pan, M. Jackson, Y. Ma and M. McNeil, *J. Bacteriol.*, 2001, **183**, 3991-3998.
8. P. Peltier, M. Beláňová, P. Dianišková, R. Zhou, R. B. Zheng, J. A. Pearcey, M. Joe, P. J. Brennan, C. Nugier-Chauvin, V. Ferrières, T. L. Lowary, R. Daniellou and K. Mikušová, *Chem. Biol.*, 2010, **17**, 1356-1366.
9. C. A. Centrone and T. L. Lowary, *Bioorg. Med. Chem.*, 2004, **12**, 5495-5503.
10. N. K. Khare, F. J. Duarte, R. C. Reynolds and J. A. Maddry, *ARKIVOC*, 2013, 290-315.
11. A. K. Pathak, V. Pathak, M. Kulshrestha, D. Kinnaird, W. J. Suling, S. S. Gurcha, G. S. Besra and R. C. Reynolds, *Tetrahedron*, 2003, **59**, 10239-10248.
12. J. A. Maddry, N. Bansal, L. E. Bermudez, R. N. Comber, I. M. Orme, W. J. Suling, L. N. Wilson and R. C. Reynolds, *Bioorg. Med. Chem. Lett.*, 1998, **8**, 237-242.
13. A. K. Sanki, J. Boucau, P. Srivastava, S. S. Adams, D. R. Ronning and S. J. Sucheck, *Bioorg. Med. Chem.*, 2008, **16**, 5672-5682.
14. B. K. Singh, A. K. Yadav, B. Kumar, A. Gaikwad, S. K. Sinha, V. Chaturvedi and R. P. Tripathi, *Carbohydr. Res.*, 2008, **343**, 1153-1162.
15. B. L. Wilkinson, H. Long, E. Sim and A. J. Fairbanks, *Bioorg. Med. Chem. Lett.*, 2008, **18**, 6265-6267.
16. B. Ayers, H. Long, E. Sim, I. A. Smellie, B. L. Wilkinson and A. J. Fairbanks, *Carbohydr. Res.*, 2009, **344**, 739-746.
17. K. Naresh, B. K. Bharati, P. G. Avaji, N. Jayaraman and D. Chatterji, *Org. Biomol. Chem.*, 2010, **8**, 592-599.
18. C. B. Davis, R. D. Hartnell, P. D. Madge, D. J. Owen, R. J. Thomson, A. K. J. Chong, R. L. Coppel and M. von Itzstein, *Carbohydr. Res.*, 2007, **342**, 1773-1780.
19. L. Legentil, J.-L. Audic, R. Daniellou, C. Nugier-Chauvin and V. Ferrières, *Carbohydr. Res.*, 2011, **346**, 1541-1545.
20. J.-L. Audic, L. Legentil, C. Nugier-Chauvin, V. Ferrières, M. Potel and T. Roisnel, *J. Mater. Chem.*, 2012, **47**, 5806-5814.
21. J. W. Goodby, J. A. Haley, G. Mackenzie, M. J. Watson, D. Plusquellec and V. Ferrières, *J. Mater. Chem.*, 1995, **5**, 2209-2220.
22. M. Mayer and B. Meyer, *Angew. Chem. Int. Ed.*, 1999, **38**, 1784-1788.
23. B. Claasen, M. Axmann, R. Meinecke and B. Meyer, *J. Am. Chem. Soc.*, 2004, **127**, 916-919.
24. J. A. Verschoor, M. S. Baird and J. Grooten, *Prog. Lipid Res.*, 2012, **51**, 325-339.
25. M. Suleman, J.-P. Gangneux, L. Legentil, S. Belaz, Y. Cabezas, C. Manuel, R. Dureau, O. Sergent, A. Burel, F. Daligault, V. Ferrières and F. Robert-Gangneux, *Antimicrob. Agents Chemother.*, 2014, **58**, 2156-2166.
26. V. Ferrières, J.-N. Bertho and D. Plusquellec, *Tetrahedron Lett.*, 1995, **36**, 2749-2752.
27. V. Ferrières, J.-N. Bertho and D. Plusquellec, *Carbohydr. Res.*, 1998, **311**, 25-35.
28. R. Dureau, F. Robert-Gangneux, J.-P. Gangneux, C. Nugier-Chauvin, L. Legentil, R. Daniellou and V. Ferrières, *Carbohydr. Res.*, 2010, **345**, 1299-1305.
29. R. Dureau, L. Legentil, R. Daniellou and V. Ferrières, *J. Org. Chem.*, 2012, **77**, 1301-1307.

30. V. Subramanian, M. Moumé-Pymbock, T. Hu and D. Crich, *J. Org. Chem.*, 2011, **76**, 3691-3709.
31. G. R. Bebernitz, J. G. Dain, R. O. Deems, D. A. Otero, W. R. Simpson and R. J. Strohschein, *J. Med. Chem.*, 2000, **44**, 512-523.
32. M. Ouchi, Y. Inoue, K. Wada, S. Iketani, T. Hakushi and E. Weber, *J. Org. Chem.*, 1987, **52**, 2420-2427.
33. M. Gelin, V. Ferrières and D. Plusquellec, *Eur. J. Org. Chem.*, 2000, 1423-1431.
34. Y. Bai and T. L. Lowary, *J. Org. Chem.*, 2006, **71**, 9658-9671.
35. S. D. Sarker, L. Nahar and Y. Kumarasamy, *Methods*, 2007, **42**, 321-324.
36. L. Baldoni and C. Marino, *J. Org. Chem.*, 2009, **74**, 1994-2003.
37. R. Euzen, V. Ferrières and D. Plusquellec, *J. Org. Chem.*, 2005, **70**, 847-855.