Influence of Steric Crowding on the Diastereoselective Arabinofuranosylations

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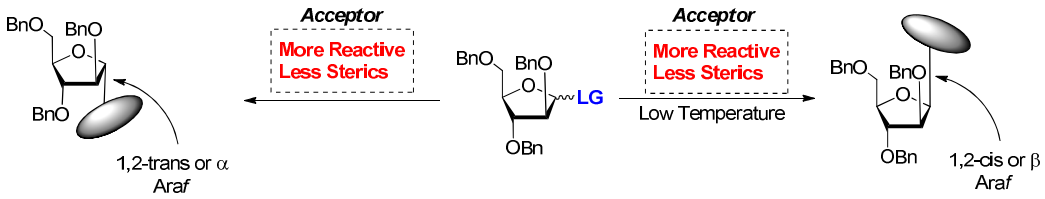


Abstract:

Occurrence of arabinofuranosides in the cell surface of *Mycobacterium tuberculosis* (Mtb) and their significance in controlling the disease spurred interest in developing strategies for their diastereoselective synthesis. Mtb uses enzymes to achieve the diastereoselectivity through non-covalent interactions. Of the two possible glycosidic linkages, chemically, 1,2-*trans* linkage is relatively easy to synthesize by taking advantage of the neighbouring group participation whereas synthesis of the 1,2-*cis* linkage is notoriously difficult. In this article, stereochemical effects on the diastereoselectivity of arabinofuranosidation are investigated with thiopyridyl, imidate and thiotolyl donors and differently crowded glycosyl acceptors; subtle differences in the stereochemical environment of the acceptors were observed to alter the diastereoselectivity of the furanoside formation. Results from this endeavour suggest 1,2-*cis* arabinofuranosides can be synthesized conveniently by conducting the reaction at lower temperature on sterically demanding and less reactive substrates.

INTRODUCTION

Tuberculosis has plagued mankind for a long time and it has been continuing to show its socioeconomic impact even now.[1] *Mycobacterium tuberculosis*, the causative agent of tuberculosis is established to have a thick cell wall which makes the small molecules difficult to enter for eventual killing.[2] Fine structural details of mycobacterial cell wall has been uncovered to find that arabinose and galactose in furanosyl form along with other sugars.[3] Arabinogalactan (AG) and Lipoarabinomannan (LAM) are the broad constituents of the mycobacterial cell wall and the terminal arabinofuranosyl residues of AG are esterified with mycolic acid.[3] The presence of 1,2-*cis* arabinofuranosyl residues at the terminal position of AG is yet another characteristic that distinguishes AG and LAM.

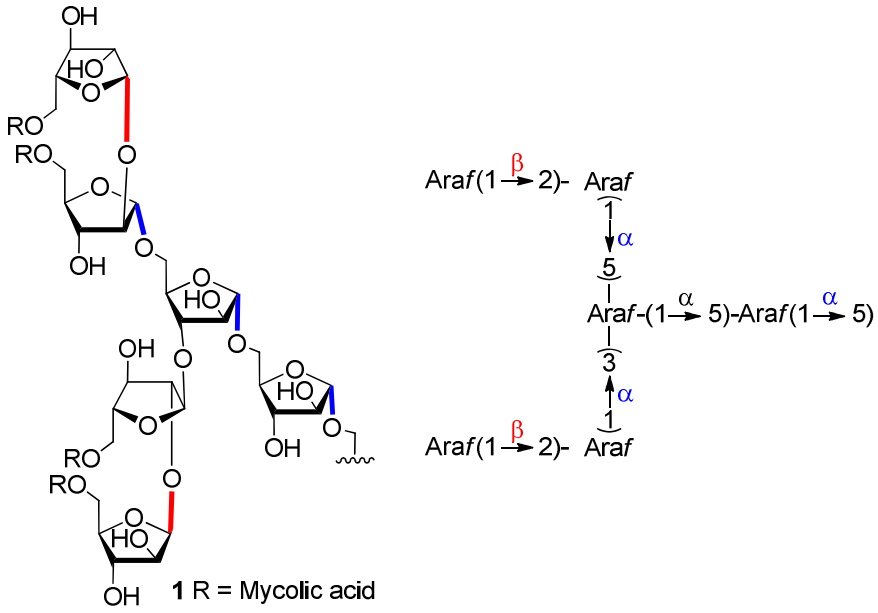
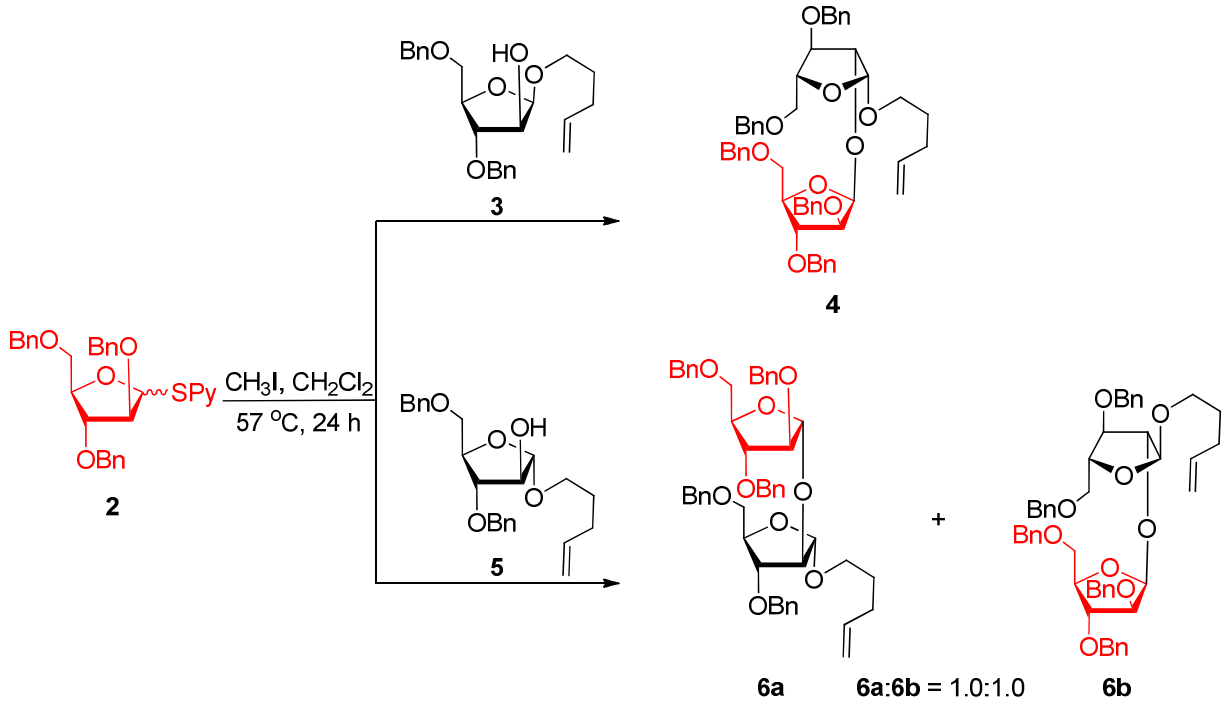


Figure 1. Motif A of *Mycobacterium tuberculosis* cell wall

Chemical synthesis of oligosaccharides is important for understanding disease processes and the development of various therapeutic agents.[4a] Chemical synthesis of 1,2-*cis* furanosides is more challenging compared to 1,2-*trans* furanosides.[4b] Several approaches have been developed for the synthesis of both 1,2-*trans* and 1,2-*cis* linkages of arabinofuranosides.[5] Various glycosyl donors such as thio glycosides,[5a-d] alkyl glycosides,[5a,6a] silyl glycosides,[6b] esters,[5g] halo-,[6c,d] imidate,[6e] 1,2-anhydro,[6f,g] orthoesters[6h-j] were investigated for the synthesis of mycobacterial arabinan fragments. One of the fragments of mycobacterial cell wall is the motif A (**1**) which is a hexaarabinofuranoside containing two 1,2-*cis* and four 1,2-*trans* linkages (Figure 1).[3]

RESULTS AND DISCUSSION

The synthesis of motif A has attracted the attention of many researchers and culminated into the investigation of variety of glycosyl donors.[7,6a,j,5a,g] Previous report[5a] on the synthesis of pentaarabinofuranosyl motif A of *Mycobacterium tuberculosis* showed stereoselective formation of 1,2-*cis* disaccharide **4** from the thiopyridyl donor **2** and *n*-pentenyl furanoside **3**. However, very little is mentioned about the origin of the selectivity; further investigation on the stereochemical influence on the stereoselectivity might pave way for a milder and general method for the synthesis of 1,2-*cis* arabinofuranosides. Hence, the initial aim of this research has therefore been to understand the factors that influence stereoselectivity of the thiopyridyl-based arabinofuranosidation.



Scheme 1. Influence of anomeric configuration of the arabinofuranosyl acceptor on the furanoside formation

The furanosidation reaction between thiopyridyl donor **2**[5a] and β-pentenyl acceptor **3** afforded 1,2-*cis* disaccharide as observed earlier;[5a] surprisingly, the same reaction between α-pentenyl acceptor **5** and donor **2** resulted in the formation of disaccharides **6a** and **6b** in 1:1 ratio (Scheme 1).[8] A possible explanation for the difference in stereoselectivity may be the temperature and the steric environment around the C2-OH of acceptors **3** and **5**. Earlier reports[9a-b] on the reciprocal donor-acceptor selectivity (RDAS) put forward by Fraser-Reid have focused largely on the donor; however, the difference in outcome of the glycosidation due to acceptors′ steric environment in this reaction is unique.[9c]

Formation of the 1,2-*trans* disaccharide **6a** at 57 °C can be ascribed to the lesser steric crowding around

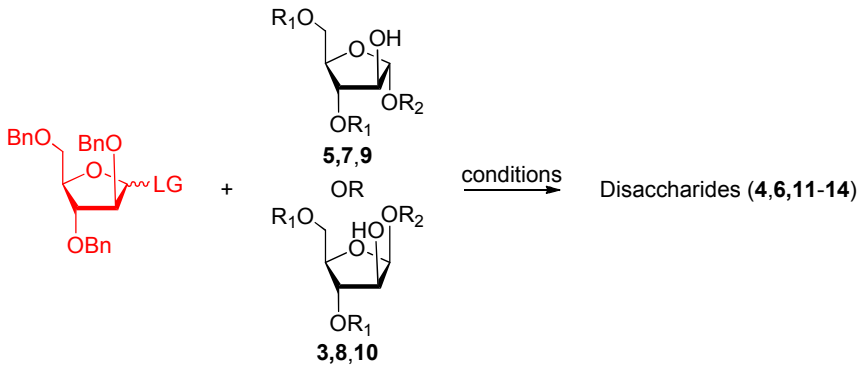
the glycosyl acceptor **5** compared to the acceptor **3**. In lieu of this, sterically less demanding methyl (**7**,**8**) and more demanding decanyl (**9**,**10**) arabinofuranosides were thought out to study the effect of C1-substituent of the glycosyl acceptor on the stereoselectivity (Table 1). The α-acceptors **7** and **9** afforded an α,β-mixture of disaccharides **11** and **13** with thiopyridyl donor **2**.[8] Gratifyingly, the β-selectivity increased from acceptor **7** to acceptor **9** which in turn was found to be equal to that of acceptor **5** which can be attributed to the gradual increase in the steric crowding around the –OH of the acceptor. Less hindered β-acceptor **8** showed α,β-mixture (0.4:1.0) of disaccharides **12** whereas the sterically demanding decanyl furanosyl acceptor **10** gave fully β-diastereoselective product **14** (Table 1).[8] Here again, the selectivity towards β-disaccharide formation was observed to be dependent on the overall steric crowding around the –OH of the acceptor. The very high β-selectivity was observed for the acceptors **3** and **10** compared to that of acceptor **8**.[8]

Quantum chemical calculations were performed on the reactants and products to unravel the preferred formation of products. Initially conformations were generated using the Macromodel module of Schrodinger[10] by employing MMFF94 force field with a convergence threshold of 0.005. Among the conformations generated for the complexes, reactants (acceptors) and products, those conformations within an energy cut-off of <5.0 kcal/mol compared to the most stable conformation were selected. The selected structures were optimized at M06-2X/STO-3G level of theory as M06-2X method is found to be reliable for modelling non-covalent interactions such as π-π. It was shown previously that non-covalent interactions, such as π-π and hydrogen bonding interactions, play a major role in deciding the stability of molecules.[11] Among these optimized structures the most stable structure in each case was considered and further optimized at M06-2X/6-31G(d) level to understand the relative stability of α and β isomers. All the optimizations were performed using Gaussian 09 programme package.[12]

The optimized structures of the most stable conformations show that β isomer is thermodynamically preferred to α isomer.[8] However, experimentally the α isomer is observed in minor quantities in the cases of **5**,**7**-**9** while **3** and **10** show no traces of α isomer. To account for this unexpected behaviour, atoms in molecules (AIM[13]) analysis is carried out by considering the various arabinofuranosyl acceptors **3**,**5**,**7**-**10**. Fewer bond critical points and cage critical points are observed around the OH group in **5**,**7**,**8**,**9** (Table 2). This also suggests a small number of non-covalent interactions around OH group. This in turn causes the

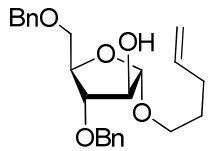
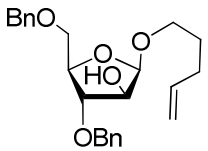
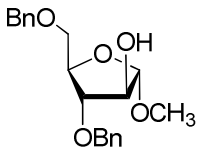
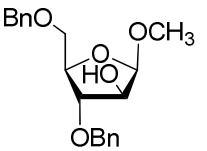
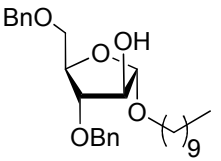
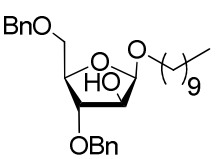
donor molecule to experience less steric hindrance from the bulky substituents of acceptor and, therefore is less accessible for the attack from both the sides resulting in the formation of α and β isomers, the later being formed in major quantities. In case of **3** and **10** the -OH group is surrounded by various non-covalent interactions and also crowded by the bulky substituent which makes the -OH group less accessible for the attack from one of the faces. Also these systems show a greater number of cage critical points in turn making the OH group less accessible for attack. Thus in these cases the donor group can attack only from the side where the steric hindrance from the bulky substituent is less thereby forming β-isomer alone. These results clearly suggest that the steric and electronic effects from the bulky substitutents and the nature of substituents have a major influence on the product formation.

Table 1. Effect of steric crowding around the alcohol of the glycosyl acceptor



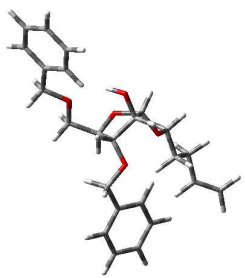
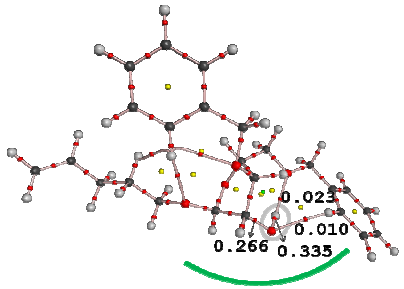
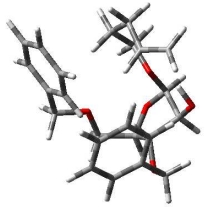
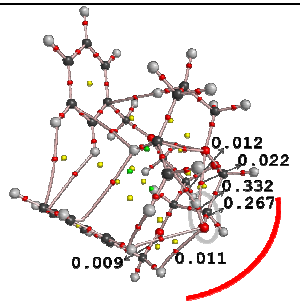
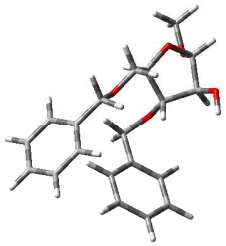
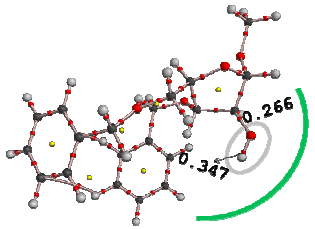
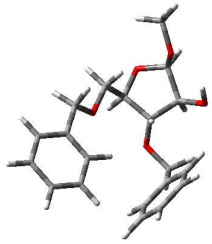
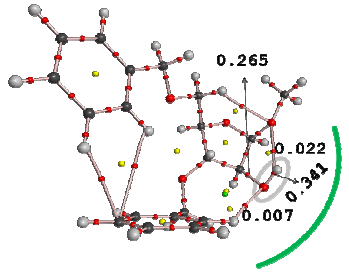
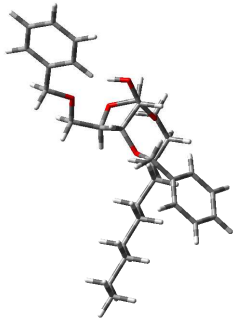
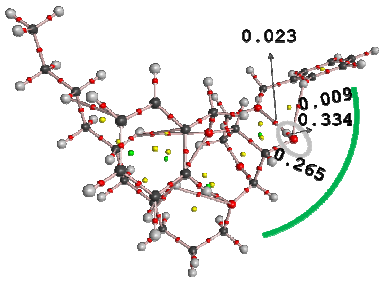
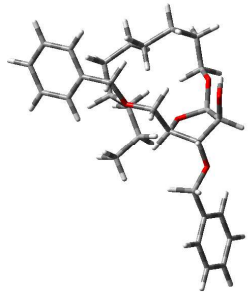
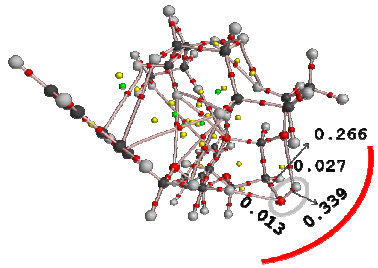
LG = -SPy (**2**); -OC(=NH)CCl_3 (**15**); -STol (**16**)

R_1 = -CH_2Ph; R_2 = -CH_3 (**7**,**8**), -$(CH_2)_3CH{=}CH$ (**3**,**5**), -$(CH_2)_9CH_3$ (**9**,**10**)

Donor	Acceptor																	
																		
	5			**3**			**7**			**8**			**9**			**10**		
	Product No.	% Yield	α:β Ratio	Product No.	% Yield	α:β Ratio	Product No.	% Yield	α:β Ratio	Product No.	% Yield	α:β Ratio	Product No.	% Yield	α:β Ratio	Product No.	% Yield	α:β Ratio
2[a]	**6**	71	1.0:1.0	**4**	73	0.0:1.0	**11**	69	1.0:0.3	**12**	75	0.4:1.0	**13**	64	1.0:1.0	**14**	67	0.0:1.0
15[b]	**6**	62	0.1:1.0	**4**	61	0.0:1.0	**11**	60	0.3:1.0	**12**	63	0.1:1.0	**13**	62	0.0:1.0	**14**	63	0.0:1.0
16[c]	ND	ND	ND	ND	ND	ND	**11**	83	1.0:1.0	**12**	88	0.4:1.0	**13**	86	0.3:1.0	**14**	85	0.0:1.0

[a]CH_3I, CH_2Cl_2, 57 ^{0}C, 4 Å MS powder, 15 h; [b]TMSOTf, CH_2Cl_2, -78 to -40 ^{0}C; 4 Å MS powder, 1 h; [c] NIS, AgOTf, CH_2Cl_2, 0 ^{0}C, 4 Å MS powder, 15 h; ND denotes not determined

Table 2. Optimized structures of the acceptors **5**,**3**,**7**-**10** along with bond critical points and electron density(ρ) values.

	Optimized structure	Bond critical points[a]		Optimized structure	Bond critical points[a]
5			**3**		
7			**8**		
9			**10**		

[a:]The side of attack by the donor is indicated by green (indicating feasibility of attack) and red (indicating non-feasibility of attack) curves. The OH group, which is the site of attack, in the acceptor is highlighted.

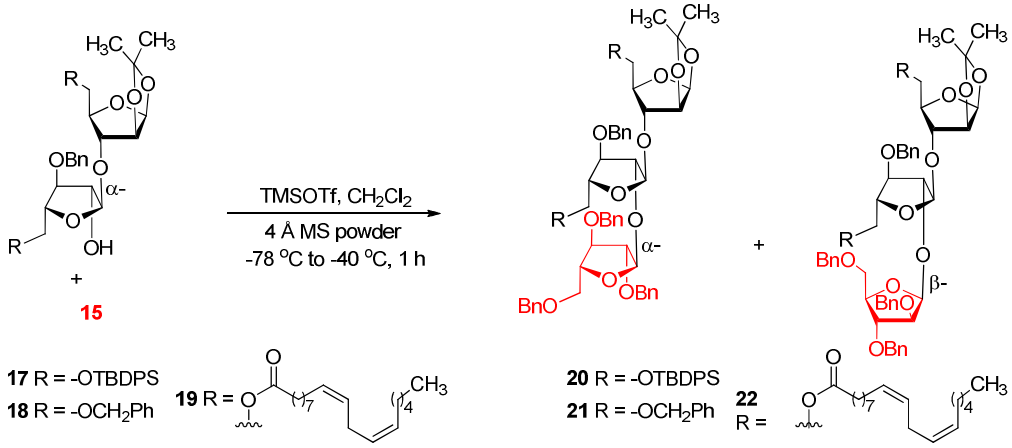
Temperature of the reaction is yet another major influencing factor for the diastereoselectivity. Accordingly, the arabinofuranosyl imidate **15**[6e,5h] and thiotolyl **16**[5d] donors were synthesized and reacted at -78 ^{0}C → -40 ^{0}C and 0 ^{0}C with glycosyl acceptors **3**, **5**, **7**-**10** respectively.[8] The furanosidation between imidate **15** and acceptors **5**, **7** and **9** showed increased ratio of β-disaccharide compared to the corresponding thiopyridyl donor **2**. β-Disaccharides are observed when the furanosidation was conducted between imidate donor **15** and acceptors **3**, **8** and **10**.

Activation of thiotolyl donor **16** could not be carried out on glycosyl acceptors **3** and **5** since conditions employed (NIS/AgOTf) for the activation of thiotolyl donor **16** can also activate *n*-pentenyl glycosides at 0 ^{0}C. Further α:β ratios were measured for the furanosidation between the thiotolyl donor **16** and the acceptors **7**-**10.** Mixture of disaccharides was observed with acceptors **7**, **8**, **9** whereas the sterically demanding acceptor **10** gave β-disaccharide only in good yield (Table 1).[8] Hence, the stereoselectivity of the arabinofuranosidation was observed to be influenced by the temperature and the steric crowding around the glycosyl acceptor also.

Further, C-5 position of terminal residues of motif A (**1**) is esterified with mycolic acid which can also impart steric crowding on the C-OH of the glycosyl acceptor. Aforementioned discussion encouraged to consider three model disaccharides **17**-**19** which are very similar to the motif A (**1**) in order to find out the steric influence of the C-5 substituent on the stereochemical outcome. Firstly, the silyl protected furanosyl acceptor **17** was subjected to the furanosidation with donor **15** at -78 ^{0}C → -40 ^{0}C to afford an α:β mixture (0.4:1.0) of trisaccharides **20** in 60% yield. Further, furanosidation was performed between the benzyl protected disaccharide **18** and donor **15** to observe an α:β mixture (0.1:1.0) of trisaccharides **21** in 64% yield with increased ratio of β-trisaccharides (Scheme 2). Subsequent furanosidation between the linoleate **19** as the glycosyl acceptor and the

imidate donor **15** resulted in the formation of β-trisaccharide **22** only suggesting that the overall stereoelectronic conditions around the furanosyl acceptor influence the stereochemical outcome (Scheme 2).[8]

Scheme 2. Effect of protecting groups at *C*-5 on the furanoside formation



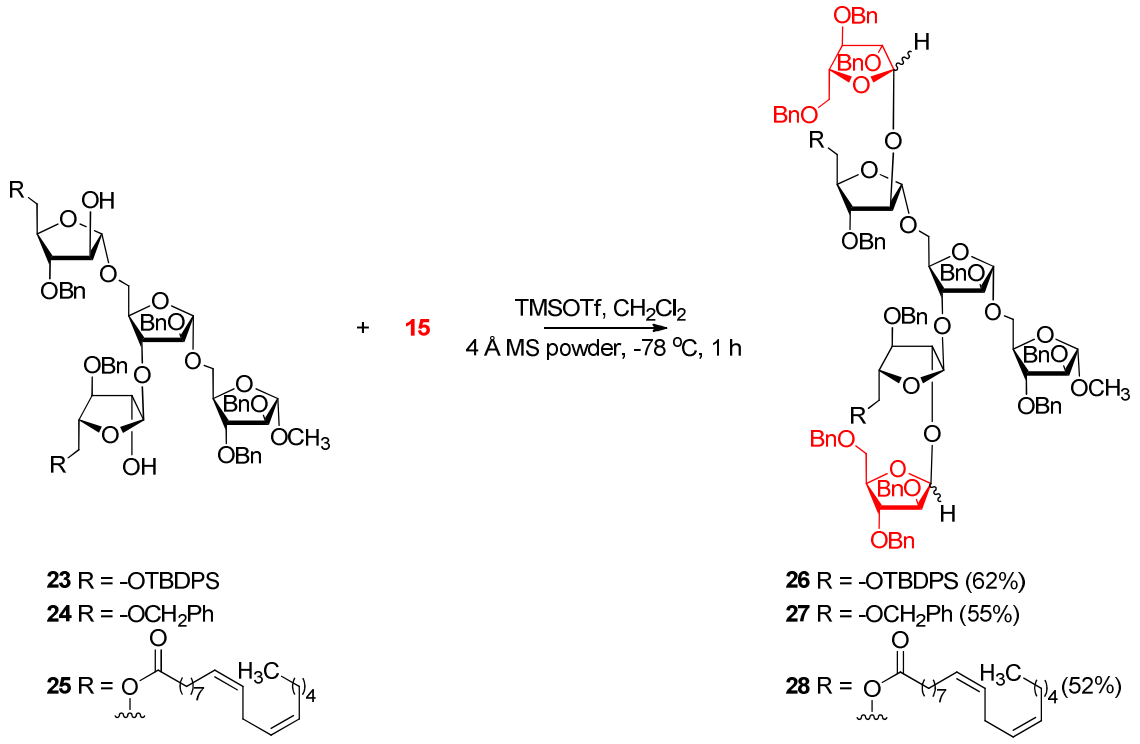
Donor	Acceptor	Product	% Yield	α:β Ratio
15	**17**	**20**	60	0.4:1.0
15	**18**	**21**	64	0.1:1.0
15	**19**	**22**	63	0.0:1.0

In continuation, tetrasaccharides **23-25** reacted with imidate donor **15** to afford an α:β mixture of hexaarabinofuranosides **26-28** (Scheme 3). The individual ratios could not be determined; however, the ratio shifted towards more β-hexaarabinofuranoside from **26→27→28** which further shows that the diastereoselectivity of the arabinofuranosidation depends on the stereochemical factors around the hydroxyl group of the glycosyl acceptor.[8,15]

CONCLUSIONS

In conclusion, β-arabinofuranosidation was found to be influenced by the stereochemical environment around the hydroxyl group of the acceptor and the temperature of the reaction. 1,2-*cis* Arabinofuranosides can be synthesized conveniently by conducting the reaction at

Scheme 3. Synthesis of hexaarabinofuranosyl motif A



lower temperature on sterically demanding and less reactive substrates. Trends noticed in mono-, di- saccharides were noticed to follow even for tetra- saccharide acceptor. These observations further support the hypothesis of reciprocal donor acceptor selectivity matching.[9c]

EXPERIMENTAL SECTION

General Methods. Unless otherwise noted, materials were obtained from commercial suppliers and were used without further purification. Unless otherwise reported all reactions were performed under argon atmosphere. Removal of solvent *in vacuo* refers to distillation using a rotary evaporator attached to an efficient vacuum pump. Products obtained as solids or syrups were dried under high vacuum. Analytical thin-layer chromatography was performed on pre-coated silica plates (F_{254}, 0.25 mm thickness); compounds were visualized by UV light or by staining with anisaldehyde spray. Optical rotations were measured on a digital polarimeter. IR spectra were recorded on a FT-IR spectrometer. NMR spectra were

recorded either on a 400 or a 500 MHz with $CDCl_3$ as the solvent and TMS as the internal standard. High resolution mass spectroscopy (HRMS) was performed using a ESI-TOF mass analyzer. Low resolution mass spectroscopy (LRMS) was performed on UPLC-MS with TLC interface.

*a) Synthesis of glycosyl acceptors (**3,5,7-10**)*: 3,5-di-*O*-benzyl arabinofuranosyl acetonide[5a,14] (4.00 g, 10.8 mmol), PTSA (0.23 g, 1.35 mmol) and alcohol (ROH, 13.5 mmol) were dissolved in anhydrous CH_2Cl_2 and was stirred at 60 ^oC for 2 h. The reaction mixture was cooled to room temperature, neutralized with Et_3N and purified by silica gel flash column chromatography (*n*-hexane/EtOAc) to afford glycosyl acceptors **3**, **5**, **7**-**10** in 72-81% yield.

*b) General procedure[5a] for the glycosylation using thiopyridyl donor **2***: To a solution of furanosyl acceptor (**3**,**5**,**7**-**10**) (250 μmol) and donor **2** (326 μmol) in anhydrous CH_2Cl_2 (10 mL) was added freshly activated 4Å molecular sieves powdered (0.40 g) and 5% CH_3I in CH_2Cl_2 at 25 ^0C. The reaction mixture was heated to 57 ^0C for 15 h, the reaction mixture was filtered through a pad of Celite®. The filtrate was concentrated *in vacuo* to afford an yellow coloured oil which was purified by silica gel flash column chromatography (*n*-hexane/EtOAc, 9:1, v/v) to obtain furanosides in 64-75% yield.

*b) General procedure[5g,6e] for the glycosylation using imidate donor **15***: To the solution of acceptor (**3**,**5**,**7**-**10**) (250 μmol) and donor **15** (326 μmol) in anhydrous CH_2Cl_2 (10 mL) was added freshly activated 4Å MS powder (0.400 g) at 25 ^0C. After cooling to -78 °C, TMSOTf (37.6 μmol) was added to the reaction mixture and gradually increased the temperature to -40 °C over 5 min. After 1.0 h, the reaction was neutralized by Et_3N and filtered through a bed of Celite®. The filtrate was concentrated in vacuo to obtain brown coloured oil that was purified by silica gel flash column chromatography (n-hexane/EtOAc, 9:1, v/v) to afford furanosides in 61-63% yield.

c) General procedure[5d] for the glycosylation using p-thiotolyl donor **16**: To a solution of

acceptor (**7**-**10**) (250 μmol) and donor **16** (326 μmol) in anhydrous CH_2Cl_2 (10 mL) was added freshly activated 4Å MS powder (0.400 g) at 25 ^{0}C. After cooling to 0 °C, NIS (502 μmol) and AgOTf (50 μmol) were added to the reaction mixture and stirred for 1.5h at 0 °C, the reaction was neutralized by Et_3N and filtered through a bed of Celite®. The filtrate was concentrated *in vacuo* to obtain reddish coloured oil that was purified by silica gel flash column chromatography (*n*-hexane/EtOAc, 9:1, v/v) to afford furanosides in 83-88% yield.

General procedure[2,3] for the preparation of trisaccharides (**20**,**21**,**22**) *and hexasaccharides* (**26**,**27**,**28**) *using imidate donor (***15***):* To the solution of acceptor (**17**-**19** or **23**-**25**) (106 μmol) and donor **15** (320 μmol) in anhydrous CH_2Cl_2 (10 mL) was added freshly activated 4Å MS powder (0.400 g) at 25 ^{0}C and stirred at 25 ^{0}C for 10 minutes. After cooling to -78 °C, TMSOTf (37.6 μmol) was added to the reaction mixture and gradually increased the temperature to -40 °C over 5 min. After 1.0h, the reaction was neutralized by Et_3N and filtered through a bed of Celite®. The filtrate was concentrated *in vacuo* to obtain brown coloured oil that was purified by silica gel flash column chromatography (n-hexane/EtOAc) to afford furanosides in 46-50% yield.

4-Pentenyl 3,5-di-*O*-benzyl-β-D-arabinofuranoside (**3**): Yield: (3.49g, 81%); $[\alpha]_D^{25}$ = -39.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 1.64 (td, *J* = 15.4, 14.7, 7.6 Hz, 2H), 1.96 – 2.17 (m, 2H), 2.59 (d, *J* = 9.6 Hz, 1H), 3.44 (dt, *J* = 9.6, 6.6 Hz, 1H), 3.52 (d, *J* = 5.9 Hz, 2H), 3.77 (dt, *J* = 9.6, 6.5 Hz, 1H), 3.83 (t, *J* = 5.7 Hz, 1H), 4.14 (q, *J* = 5.6 Hz, 1H), 4.19 – 4.30 (m, 1H), 4.56 (s, 2H), 4.62 (d, *J* = 11.9 Hz, 1H), 4.76 (d, *J* = 11.9 Hz, 1H), 4.93 – 5.04 (m, 3H), 5.78 (ddt, *J* = 16.9, 10.2, 6.7 Hz, 1H), 7.27 – 7.35 (m, 10H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 28.3, 29.9, 67.5, 71.5, 71.8, 72.9, 77.6, 80.4, 84.5, 101.3, 114.6, 127.3(2C), 127.4(4C), 128.0(4C), 137.6(2C), 137.7; IR ($CHCl_3$); 3619, 3030, 2921, 1546, 1455, 1212, 1104, 699 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{24}H_{30}NaO_5$ 421.1991, found 421.1989.

4-Pentenyl 2-*O*-[2,3,5-tri-*O*-benzyl β-D-arabinofuranosyl]-3,5-di-*O*-benzyl β-D-arabinofuranoside (**4**): Yield: (0.122g, 61%); $[\alpha]_D^{25}$ = -43.8 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 1.59 (q, *J* = 7.1 Hz, 2H), 2.01 (q, *J* = 7.3 Hz, 2H), 3.38 (dt, *J* = 9.6, 6.6 Hz, 1H), 3.46 – 3.56 (m, 3H), 3.57 – 3.62 (m, 1H), 3.71 (dt, *J* = 9.6, 6.9 Hz, 1H), 4.13 (td, *J* = 9.9, 8.7, 5.7 Hz, 5H), 4.29 (d, *J* = 12.0 Hz, 1H), 4.37 – 4.45 (m, 2H), 4.49 (d, *J* = 11.3 Hz, 1H), 4.52 (s, 2H), 4.57 (s, 2H), 4.60 (d, *J* = 11.8 Hz, 1H), 4.68 (d, *J* = 11.8 Hz, 1H), 4.80 (d, *J* = 11.3 Hz, 1H), 4.90 (t, *J* = 1.2 Hz, 1H), 4.92 – 4.96 (m, 1H), 5.09 (d, *J* = 4.2 Hz, 1H), 5.16 (d, *J* = 2.5 Hz, 1H), 5.70 (ddt, *J* = 17.1, 10.4, 6.6 Hz, 1H), 7.18 – 7.41 (m, 25H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 28.8, 30.2, 67.1, 71.6, 72.2(2C), 72.4, 72.5, 73.0, 73.2, 79.0, 80.2, 80.7, 82.6, 82.9, 83.9, 98.4, 100.0, 114.9, 127.5, 127.5, 127.6(2C), 127.6(2C), 127.7(2C), 127.7(2C), 127.8, 128.0(2C), 128.3(3C), 128.3(3C), 128.3(3C), 128.3(3C), 137.7(2C), 137.8, 137.9, 138.0, 138.0; IR ($CHCl_3$): 3035, 2920, 1550, 1455, 1212, 1104, 699 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd. for $C_{50}H_{56}NaO_9$ 823.3822, found 823.3832.

4-Pentenyl 3,5-di-*O*-benzyl-α-D-arabinofuranoside (**5**): Yield: (3.49g, 81%); $[\alpha]_D^{25}$ = +97.8 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78MHz, $CDCl_3$): δ 1.70 (dt, *J* = 14.2, 6.9 Hz, 2H), 2.05 – 2.19 (m, 2H), 3.31 (d, *J* = 10.2 Hz, 1H), 3.40 – 3.54 (m, 2H), 3.57 – 3.78 (m, 2H), 3.87 (s, 1H), 4.14 (d, *J* = 9.6 Hz, 1H), 4.26 (s, 1H), 4.50 (t, *J* = 10.8 Hz, 2H), 4.65 (dd, *J* = 22.6, 11.9 Hz, 2H), 4.98 (dt, *J* = 20.9, 10.4 Hz, 3H), 5.82 (td, *J* = 16.7, 16.2, 6.6 Hz, 1H), 7.24 – 7.35 (m, 10H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 28.7, 30.2, 66.9, 69.8, 71.9, 73.7, 77.8, 83.3, 85.2, 109.1, 114.7, 127.7(3C), 127.8(2C), 128.0, 128.4(2C), 128.5(2C), 137.0, 137.9, 138.3; IR ($CHCl_3$): 3615, 3040, 2925, 1546, 1455, 1212, 1104, 712 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{24}H_{30}NaO_5$ 421.1991,found 421.1989.

4-Pentenyl 3,5-di-*O*-benzyl-2-*O*-(2,3,5-tri-*O*-benzyl α-arabinofuranosyl) α-D-arabinofuranoside (**6a**) [as obtained from the 1:1 mixture of disaccharides **6a**,**6b**]: ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 1.68 (q, *J* = 7.0 Hz, 2H), 2.10 (p, *J* = 6.9 Hz, 2H), 3.36 – 3.42 (m,

2H), 3.44 (d, *J* = 3.0 Hz, 2H), 3.54 (m, 3H), 3.61 (d, *J* = 3.8 Hz, 2H), 3.73 (dt, *J* = 9.6, 6.6 Hz, 1H), 3.99 (dd, *J* = 6.4, 2.9 Hz, 1H), 4.11 (d, *J* = 2.0 Hz, 1H), 4.20 – 4.23 (m, 2H), 4.28 – 4.49 (m, 10H), 5.09 (s, 1H), 5.13 (s, 1H), 5.72 – 5.81 (m, 1H), 7.24 – 7.33 (m, 25H). ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 28.7, 28.7, 66.9, 69.8, 71.9, 72.0, 72.5, 73.0, 73.3, 77.2, 80.5, 80.8, 83.5, 84.0(2C), 86.3, 88.4, 105.6, 106.9, 114.8, 127.5(2C), 127.6(3C), 127.9(4C), 128.0, 128.1(4C), 128.2(4C), 128.4(4C), 137.4, 137.6, 137.8, 138.2, 138.3.

4-Pentenyl 3,5-di-*O*-benzyl-2-*O*-(2,3,5-tri-*O*-benzyl α-D-arabinofuranosyl) β-D-arabinofuranoside (**6b**) [as obtained from the 1:1 mixture of disaccharides **6a**,**6b**]: ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 1.68 (q, *J* = 7.0 Hz, 2H), 2.10 (p, *J* = 6.9 Hz, 2H), 3.36 – 3.42 (m, 2H), 3.44 (d, *J* = 3.0 Hz, 2H), 3.54 (dd, *J* = 8.6, 4.7 Hz, 3H), 3.61 (d, *J* = 3.8 Hz, 2H), 3.73 (dt, *J* = 9.6, 6.6 Hz, 1H), 3.99 (dd, *J* = 6.4, 2.9 Hz, 1H), 4.11 (d, *J* = 2.0 Hz, 1H), 4.20 – 4.23 (m, 2H), 4.28 – 4.49 (m, 10H), 4.98 (s, 1H), 5.07 (d, *J* = 4.2 Hz, 1H), 5.75 – 5.84 (m, 1H), 7.24 – 7.33 (m, 25H). ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 28.7, 30.2, 66.8, 70.0, 72.1, 72.3, 72.4, 73.0, 73.2, 77.2, 79.9, 80.9, 82.8, 83.9(2C), 86.0, 92.2, 100.2, 105.8, 114.6, 127.5(2C), 127.6(3C), 127.9(4C), 128.0, 128.1(4C), 128.2(4C), 128.4(4C), 136.9, 137.1, 137.5, 138.0, 138.1.

Methyl 3,5-di-*O*-benzyl-α-D-arabinofuranoside (**7**): Yield: (2.90g, 78%); $[\alpha]_D^{25}$ = +122.8 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78MHz, $CDCl_3$): δ 3.39 (s, 3H), 3.43 (m, 2H), 3.63 (dd, *J* = 10.4, 2.5 Hz, 1H), 3.82 (d, *J* = 3.3 Hz, 1H), 4.12 (d, *J* = 6.9 Hz, 1H), 4.21 – 4.29 (m, 1H), 4.48 (dd, *J* = 19.6, 12.1 Hz, 2H), 4.58 (d, *J* = 11.9 Hz, 1H), 4.67 (d, *J* = 12.3 Hz, 1H), 4.89 (s, 1H), 7.22 – 7.35 (m, 10H); ^{13}C NMR (101 MHz, $CDCl_3$): δ 55.1, 69.6, 71.9, 73.5, 78.0, 83.2, 84.8, 110.2, 127.7(3C), 127.8(2C), 127.9, 128.3(2C), 128.4(2C), 136.9, 137.6; IR ($CHCl_3$): 3618, 3042, 2925, 1550, 1455, 1215, 1100, 688 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{20}H_{24}NaO_5$ 367.1521, found 367.1521.

Methyl 3,5-di-*O*-benzyl-β-D-arabinofuranoside (**8**): Yield: (2.90g, 78%); $[\alpha]_D^{25}$ = -39.8 (*c* =

1.0, $CHCl_3$); ^1H NMR (399.78 MHz, $CDCl_3$): δ 2.67 (bs, 1 H), 3.38 (s, 3H), 3.52 (d, *J* = 5.7 Hz, 2H), 3.84 (t, *J* = 5.8 Hz, 1H), 4.14 (q, *J* = 5.6 Hz, 1H), 4.24 (t, *J* = 5.3 Hz, 1H), 4.55 (d, *J* = 2.2 Hz, 2H), 4.61 (d, *J* = 11.9 Hz, 1H), 4.74 (d, *J* = 11.9 Hz, 1H), 4.83 (d, *J* = 4.7 Hz, 1H), 7.23 – 7.38 (m, 10H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 55.3, 71.8, 72.0, 73.2, 77.9, 80.7, 84.5, 102.6, 127.6(4C), 127.7(2C), 128.3(4C), 137.9, 137.9; IR ($CHCl_3$): 3612, 3032, 2922, 1555, 1455, 1218, 1104, 685 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{20}H_{24}NaO_5$ 367.1521, found 367.1519 .

Decanyl 3,5-di-*O*-benzyl-α-D-arabinofuranoside (**9**): Yield: (3.81g, 75%); $[\alpha]_D^{25}$ = +91.6 (*c* = 1.0, $CHCl_3$); ^1H NMR (399.78MHz, $CDCl_3$): δ 0.81 – 0.93 (m, 3H), 1.16 – 1.38 (m, 14H), 1.59 (q, *J* = 6.7 Hz, 2H), 3.34 – 3.53 (m, 3H), 3.61 – 3.75 (m, 2H), 3.86 (d, *J* = 3.1 Hz, 1H), 4.14 (s, 1H), 4.21 – 4.27 (m, 1H), 4.45 – 4.53 (m, 2H), 4.64 (dd, *J* = 27.6, 12.1 Hz, 2H), 5.00 (s, 1H), 7.21 – 7.39 (m, 10H); ^{13}C NMR (10.53 MHz, $CDCl_3$): δ 14.1, 22.6, 26.0, 29.3, 29.4, 29.5, 29.5, 29.6, 31.8, 67.6, 69.7, 71.8, 73.6, 78.0, 83.0, 85.2, 108.9, 127.6, 127.7(2C), 127.8(2C), 127.9, 128.3(2C), 128.5(2C), 137.0, 137.9; IR ($CHCl_3$): 3622, 3030, 2925, 1552, 1455, 1219, 1104, 683 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{29}H_{42}NaO_5$ 493.2930, found 493.2929.

Decanyl 3,5-di-*O*-benzyl-β-D-arabinofuranoside (**10**): Yield: (3.66g, 72%); $[\alpha]_D^{25}$ = +39.6 (*c* = 1.0, $CHCl_3$); ^1H NMR (399.78MHz, $CDCl_3$): δ 0.88 (t, *J* = 6.8 Hz, 3H), 1.26 (s, 14H), 1.43 – 1.62 (m, 2H), 2.64 (d, *J* = 9.0 Hz, 1H), 3.41 (dt, *J* = 9.5, 6.7 Hz, 1H), 3.53 (d, *J* = 5.9 Hz, 2H), 3.74 (dt, *J* = 9.5, 6.8 Hz, 1H), 3.83 (t, *J* = 5.7 Hz, 1H), 4.14 (q, *J* = 5.7 Hz, 1H), 4.24 (dt, *J* = 9.9, 5.5 Hz, 1H), 4.55 (s, 2H), 4.62 (d, *J* = 11.9 Hz, 1H), 4.76 (d, *J* = 11.9 Hz, 1H), 4.95 (dd, *J* = 4.7, 2.8 Hz, 1H), 7.24 – 7.35 (m, 10H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 14.1, 22.6, 26.0, 29.3, 29.4, 29.4, 29.5(2C), 31.8, 68.4, 71.7, 72.1, 73.2, 77.9, 80.6, 84.9, 101.5, 127.6(2C), 127.6(4C), 128.3(4C), 138.0(2C); IR ($CHCl_3$): 3625, 3025, 2921, 1548, 1458, 1212, 1113, 698 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{29}H_{42}NaO_5$ 493.2930, found

493.2929.

Methyl 2-*O*-[2,3,5-tri-*O*-benzyl β-D-arabinofuranosyl]-3,5-di-*O*-benzyl α-D-arabinofuranoside (**11**): An analytical sample for characterization purposes was obtained by purification of the residue resulting from the aforementioned general reaction procedure using the imidate donor (**15**) as the glycosyl donor. Yield: (0.13g, 60%); $[\alpha]_D^{25}$ = -49.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 3.37 (s, 3H), 3.48 – 3.63 (m, 3H), 3.94 – 4. 01 (m, 1H), 4.09 (dd, *J* = 5.8, 2.5 Hz, 2H), 4.18 – 4.23 (m, 1H), 4.26 (s, 1H), 4.36 (td, *J* = 12.3, 1.7 Hz, 2H), 4.43 – 4.69 (m, 10H), 4.89 (s, 1H), 5.06 (d, *J* = 3.9 Hz, 1H), 7.16 – 7.38 (m, 25H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 54.9, 70.1, 72.0, 72.2, 72.3, 72.5, 73.0, 73.3, 80.0, 81.3, 82.9, 83.9, 84.0, 85.9, 100.2, 106.9, 127.5(3C), 127.5(3C), 127.6, 127.7(5C), 127.9, 128.0(2C), 128.2(2C), 128.3(5C), 128.4(3C), 137.6, 138.0(2C), 138.1(2C); IR ($CHCl_3$): 3033, 2923, 1552, 1459, 1213, 1101, 695 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{46}H_{50}NaO_9$ 769.3353, found 769.3358.

Methyl 2-*O*-[2,3,5-tri-*O*-benzyl β-D-arabinofuranosyl]-3,5-di-*O*-benzyl β-D-arabinofuranoside (**12**): An analytical sample for characterization purposes was obtained by purification of the residue resulting from the aforementioned general reaction procedure using the imidate donor (**15**) as the glycosyl donor. Yield: (0.14g, 63%); $[\alpha]_D^{25}$ = -7.6 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 3.23 (s, 3H), 3.50 (qd, *J* = 9.8, 6.2 Hz, 2H), 3.56 – 3.66 (m, 2H), 4.05 – 4.17 (m, 6H), 4.49 – 4.55 (m, 6H), 4.57 (s, 1H), 4.58 – 4.71 (m, 3H), 4.76 (d, *J* = 4.1 Hz, 1H), 5.17 (d, *J* = 4.3 Hz, 1H), 7.08 – 7.37 (m, 25H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 54.2, 71.9, 72.2, 72.3, 72.5, 72.6, 73.1, 73.3, 79.7, 80.1, 82.9, 83.1, 83.5, 84.2, 102.0(2C), 127.5(2C), 127.6(3C), 127.7(4C), 127.7(5C), 128.3(5C), 128.3(4C), 128.4(2C), 137.4, 137.9(2C), 137.9, 138.1; IR ($CHCl_3$): 3030, 2921, 1546, 1455, 1212, 1104, 699 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{46}H_{50}NaO_9$ 769.3353, found 769.3358.

Decanyl 3,5-di-*O*-benzyl-2-*O*-(2,3,5-tri-*O*-benzyl α-D-arabinofuranosyl) β-D-

arabinofuranoside (**13**): An analytical sample for characterization purposes was obtained by purification of the residue resulting from the aforementioned general reaction procedure using the imidate donor (**15**) as the glycosyl donor. Yield: (0.11g, 62%); $[\alpha]_D^{25}$ = -31.4 (*c* = 1.0, $CHCl_3$). ^{1}H NMR (399.78 MHz, CDCl3): δ 0.87 (t, *J* = 6.8 Hz, 3H), 1.24 (s, 14H), 1.52 – 1.59 (m, 2H), 3.42 (d, *J* = 3.0 Hz, 1H), 3.45 (d, *J* = 2.9 Hz, 1H), 3.83 (dd, *J* = 6.4, 2.8 Hz, 1H), 4.06 (d, *J* = 4.2 Hz, 1H), 4.11 (dt, *J* = 7.5, 4.3 Hz, 3H), 4.14 – 4.27 (m, 5H), 4.45 – 4.61 (m, 10H), 5.02 (d, *J* = 4.3 Hz, 1H), 5.19 (s, 1H), 7.27 – 7.34 (m, 25H). 13C NMR (100.53 MHz, CDCl3): δ 14.1 , 22.7 , 26.1 , 29.3 , 29.4 , 29.6(2C) , 31.9 , 67.8 , 69.1 , 70.0 71.8 , 72.2 , 73.8 , 73.6 , 80.8 , 80.6 , 81.1 , 81.4 , 82.9 , 83.2 , 83.9 , 87.4 , 100.4 , 106.2 , 127.6(3C) , 127.7(4C) , 127.8(2C) , 128.0(2C) , 128.2 , 128.3(3C) , 128.4(4C) , 128.5(2C), 136.9(4C) , 136.9 , 137.1 , 137.6 , 138.1(2C). IR ($CHCl_3$): 3014, 2928, 1555, 1453, 1219, 1117, 696 cm^{-1}. HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{55}H_{68}NaO_9$ 895.4761, found 895.4752.

Decanyl 2-*O*-[2,3,5-tri-*O*-benzyl β-D-arabinofuranosyl]-3,5-di-*O*-benzyl β-D-arabinofuranoside (**14**): An analytical sample for characterization purposes was obtained by purification of the residue resulting from the aforementioned general reaction procedure using the imidate donor (**15**) as the glycosyl donor. Yield: (0.12g, 63%); $[\alpha]_D^{25}$ = +5.4 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 0.88 (t, *J* = 6.8 Hz, 3H), 1.25 (s, 14H), 1.52 (s, 2H), 3.21 – 3.32 (m, 1H), 3.56 (dddd, *J* = 39.9, 18.2, 9.6, 6.4 Hz, 5H), 4.06 – 4.16 (m, 6H), 4.47 – 4.63 (m, 8H), 4.67 (d, *J* = 11.9 Hz, 2H), 4.86 (d, *J* = 4.1 Hz, 1H), 5.18 (d, *J* = 3.9 Hz, 1H), 7.16 – 7.38 (m, 25H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 14.1, 22.7, 26.3, 29.4, 29.6, 29.6, 29.7, 29.8, 31.9, 67.6, 71.9, 72.4, 72.5, 72.6, 72.9, 73.0, 73.3, 79.5, 80.0, 83.2(2C), 83.5, 84.5, 101.0, 102.2, 127.5, 127.5(5C), 127.6, 127.7(5C), 127.7, 128.3(5C), 128.3(5C), 128.4(2C), 137.7, 137.8, 138.0, 138.1, 138.1; IR ($CHCl_3$): 3012, 2928, 1552, 1455, 1218, 1114, 697 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{55}H_{68}NaO_9$ 895.4761, found 895.4752.

1,2-*O*-Isopropylidene 3-*O*-[3-*O*-benzyl-5-*O*-*tert*-butyldiphenylsilyl-α-D-arabinofuranosyl]-5-*O*-*tert*-butyldiphenylsilyl-β-D-arabinofuranose (**17**): $[\alpha]_D^{25}$ = +58.2 (*c* = 1.0, $CHCl_3$); ^1H NMR (399.78MHz, $CDCl_3$): δ 1.07 (s, 9H), 1.10 (s, 9H), 1.37 (s, 3H), 1.42 (s, 3H), 3.52 – 3.62 (m, 2H), 3.79 – 3.88 (m, 2H), 3.89 – 3.97 (m, 1H), 4.10 (s, 1H), 4.20 (s, 1H), 4.30 (dd, *J* = 10.6, 2.7 Hz, 2H), 4.57 (dd, *J* = 12.1, 1.7 Hz, 1H), 4.67 (s, 1H), 4.69 – 4.75 (m, 2H), 5.28 – 5.39 (m, 1H), 5.96 (d, *J* = 3.6 Hz, 1H), 7.30 – 7.40 (m, 11H), 7.41 – 7.55 (m, 6H), 7.65 – 7.69 (m, 2H), 7.73 (td, *J* = 7.5, 3.9 Hz, 6H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 19.0, 19.1, 26.0, 26.7(3C), 26.7(3C), 26.9, 63.2, 63.8, 71.8, 77.4, 78.8, 84.6, 84.6, 84.9, 85.9, 105.8, 107.2, 112.4, 127.6(5C), 127.7, 127.9(4C), 128.3(2C), 129.6, 129.6, 130.0, 130.0, 132.0, 132.2, 133.1, 133.2, 135.5(4C), 135.5(5C), 137.8; IR ($CHCl_3$): 3618, 3031, 2921, 1547, 1456, 1212, 1104, 691 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{52}H_{64}NaO_9Si_2$ 911.3987, found 911.3979.

1,2-*O*-Isopropylidene 3-*O*-[3,5-di-*O*-benzyl-α-D-arabinofuranosyl]-5-*O*-benzyl-β-D-arabinofuranose (**18**): $[\alpha]_D^{25}$ = +42.2 (*c* = 1.0, $CHCl_3$); ^1H NMR (399.78MHz, $CDCl_3$): δ 1.32 (s, 3H), 1.52 (s, 3H), 2.34 (s, 1H), 3.60 (td, *J* = 11.8, 11.3, 3.9 Hz, 2H), 3.70 – 3.80 (m, 2H), 3.92 – 3.96 (m, 1H), 3.99 – 4.02 (m, 1H), 4.15 (dd, *J* = 8.7, 3.5 Hz, 2H), 4.17 – 4.20 (m, 1H), 4.41 – 4.60 (m, 7H), 5.16 (s, 1H), 5.85 (d, *J* = 3.9 Hz, 1H), 7.23 – 7.38 (m, 15H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 26.3, 27.1, 62.5, 69.4, 72.1, 72.2, 73.3, 80.4, 80.7, 83.4, 85.5, 86.2, 88.3, 105.2, 105.8, 112.9, 127.6, 127.7(4C), 127.9(4C), 128.3(4C), 128.4(2C), 137.3, 137.6, 137.8; IR ($CHCl_3$): 3617, 3036, 2918, 1549, 1445, 1222, 1114, 689 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{34}H_{40}NaO_9$ 615.2570, found 615.2561.

1,2-*O*-Isopropylidene 3-*O*-[3-*O*-benzyl-5-*O*-(((9*Z*,12*Z*)-octadeca-9,12-dienoyl))-α-D-arabinofuranosyl]-5-*O*-[(((9*Z*,12*Z*)-octadeca-9,12-dienoyl))]-β-D-arabinofuranose (**19**): $[\alpha]_D^{25}$ = +49.6 (*c* = 1.0, $CHCl_3$); ^1H NMR (399.78MHz, $CDCl_3$): δ 0.87 – 0.89 (m, 6H), 1.20 – 1.37 (m, 35H), 1.53 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 2H), 2.04 (dt, *J* = 14.9, 7.2 Hz, 8H), 2.30 (dt, *J* =

11.4, 7.4 Hz, 4H), 2.77 (t, *J* = 6.4 Hz, 2H), 3.76 (d, *J* = 5.8 Hz, 3H), 4.10 – 4.19 (m, 3H), 4.20 – 4.26 (m, 3H), 4.52 (d, *J* = 12.0 Hz, 1H), 4.64 – 4.72 (m, 2H), 5.10 (d, *J* = 1.7 Hz, 1H), 5.13 (s, 1H), 5.35 (tq, *J* = 7.3, 4.7, 3.6 Hz, 8H), 5.90 (d, *J* = 4.1 Hz, 1H), 7.28 – 7.37 (m, 5H);^{13}C NMR (100.53 MHz, $CDCl_3$): δ 14.1, 14.1, 22.5, 22.6, 24.8, 24.8, 25.6, 26.4, 27.2(4C), 29.1(4C), 29.2, 29.3(3C), 29.5, 29.6, 29.7, 29.7, 31.5, 31.9, 34.0, 34.0, 63.3, 63.5, 72.3, 80.1, 80.2, 80.6, 82.6, 85.0, 85.1, 105.4, 107.5, 113.3, 127.7(2C), 127.8, 128.0, 128.0, 128.5(2C), 129.7, 129.7, 130.0, 130.0, 130.0, 130.2, 137.4, 173.2, 173.4; IR ($CHCl_3$): 3627, 3031, 2921, 1753, 1551, 1448, 1218, 1104, 698 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{56}H_{88}NaO_{11}$ 959.6224, found 959.6216.

1,2-*O*-Isopropylidene 3-*O*-[(3-*O*-benzyl-5-*O*-*tert*-butyldiphenylsilyl-α-D-arabinofuranosyl)-2-*O*-(2,3,5-tri-*O*-benzyl β-D-arabnofuranosyl)]-5-*O*-*tert*-butyldiphenylsilyl-β-D-arabinofuranose (**20**) [resonances for the major β-isomer as obtained from the 0.4:1.0 α,β mixture of trisaccharides]: ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 0.89 (s, 9H), 0.95 (s, 9H), 1.20 (s, 3H), 1.25 (s, 3H), 3.48 (d, *J* = 5.2 Hz, 2H), 3.67 – 3.73 (m, 4H), 3.98 – 4.02 (m, 1H), 4.02 – 4.06 (m, 2H), 4.12 (dd, *J* = 6.0, 3.2 Hz, 3H), 4.27 (d, *J* = 3.5 Hz, 2H), 4.31 – 4.36 (m, 1H), 4.37 – 4.61 (m, 8H), 4.95 (d, *J* = 4.1 Hz, 1H), 5.05 (s, 1H), 5.74 (d, *J* = 4.0 Hz, 1H), 7.16 – 7.28 (m, 32H), 7.53 – 7.59 (m, 8H). ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 19.1 , 19.3 , 26.7(3C) , 26.9(3C) , 63.3 , 72.2 , 72.2 , 72.3 , 72.5 , 73.1 , 79.4 , 80.0 , 80.8 , 82.8 , 83.1 , 83.8 , 84.0 , 84.8 , 85.7 , 88.5 , 99.9 , 104.2 , 105.6 , 112.5 , 127.4(2C) , 127.5(5C) , 127.6(13C) , 127.9(3C) , 128.2(2C) , 128.3(2C) , 128.3(2C) , 128.4(2C) , 129.5 , 129.69 , 133.1 , 133.2 , 133.3 , 133.4 , 135.6(9C) , 137.7 , 137.9 , 138.1(2C) .

1,2-*O*-Isopropylidene 3-*O*-[(3,5-di-*O*-benzyl-α-D-arabinofuranosyl)-2-*O*-(2,3,5-tri-*O*-benzyl β-D-arabnofuranosyl)]-5-*O*-benzyl-β-D-arabinofuranose (**21**) [resonances for the major β-isomer as obtained from the 0.1:1.0 α,β mixture of trisaccharides]: ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 1.32 (s, 3H), 1.51 (s, 3H), 3.49 – 3.63 (m, 4H), 3.65 – 3.83 (m, 2H), 3.93 – 4.23

(m, 9H), 4.50 (ddd, *J* = 15.4, 10.0, 2.7 Hz, 12H), 5.12 (d, *J* =3.8Hz,1H), 5.18 (s, 1H), 5.86 (d, *J* = 4.1 Hz, 1H), 7.24 – 7.34 (m, 30H). ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 26.4 , 27.1 , 66.5 , 69.3 , 71.8 , 72.1(3C) , 72.7 , 73.1 , 73.3 , 80.1 , 80.2 , 81.0 , 83.4 , 84.1 , 84.4 , 85.2 , 88.3 , 88.5 , 100.9 , 105.3 , 105.5 , 112.9 , 127.6(6C) , 127.8(4C) , 127.8(4C) , 128.2(5C) , 128.2(5C) , 128.4(6C) , 137.4 , 137.7 , 137.9(2C) , 138.1(2C) .

1,2-*O*-Isopropylidene 3-*O*-[3-*O*-benzyl-5-*O*-(((9*Z*,12*Z*)-octadeca-9,12-dienoyl))-2-*O*-(2,3,5-tri-*O*-benzyl-β-D-arabinofuranosyl)-α-D-arabinofuranosyl]-5-*O*-[(((9*Z*,12*Z*)-octadeca-9,12-dienoyl))]-β-D-arabinofuranose (**22**): Yield: (90 mg, 63%); $[\alpha]_D^{25}$ = +20.4 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78 MHz, $CDCl_3$): δ 0.64-1.04(m, 6H), 1.23 – 1.34 (m, 35H), 1.51 (s, 3H), 1.56 (d, *J* = 7.2 Hz, 2H), 1.97 – 2.08 (m, 8H), 2.19 – 2.26 (m, 2H), 2.30 (t, *J* = 7.5 Hz, 2H), 2.77 (t, *J* = 6.1 Hz, 2H), 3.52 – 3.58 (m, 2H), 3.65 – 3.73 (m, 1H), 3.77 (dd, *J* = 11.2, 4.3 Hz, 2H), 4.07 (dd, *J* = 4.5, 2.3 Hz, 2H), 4.09 – 4.14 (m, 2H), 4.19 (d, *J* = 3.6 Hz, 2H), 4.23 (dd, *J* = 7.0, 3.6 Hz, 2H), 4.47 – 4.55 (m, 4H), 4.55 – 4.60 (m, 2H), 4.65 (dd, *J* = 13.6, 3.9 Hz, 2H), 4.68 – 4.75 (m, 2H), 5.09 (d, *J* = 3.2 Hz, 1H), 5.18 (d, *J* = 3.4 Hz, 1H), 5.28 – 5.42 (m, 8H), 5.90 (d, *J* = 4.1 Hz, 1H), 7.29 (m, 20H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 14.1, 14.1, 24.8, 25.6, 26.4, 27.0, 27.2(2C), 29.1(3C), 29.2, 29.2, 29.3(3C), 29.5, 29.6, 29.7(2C), 29.7(2C), 31.5(2C), 31.9, 33.9, 34.0, 66.6, 71.9, 72.1(2C), 72.2, 72.6, 73.2(2C), 80.2, 80.4, 80.7, 81.3, 83.1, 83.2, 84.0, 84.2, 85.0, 100.8, 105.4, 105.6, 112.9, 127.5(2C), 127.7(3C), 127.7(3C), 127.8(3C), 127.8, 127.9, 128.1(3C), 128.3(3C), 128.3(3C), 128.4(2C), 129.9, 130.0, 130.0, 130.2, 137.2, 137.8, 138.2(2C), 172.7, 173.3; IR ($CHCl_3$): 3032, 2917, 1749, 1546, 1455, 1212, 1117, 693 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{82}H_{114}NaO_{15}$ 1361.8055 found 1361.8049.

Methyl 2,3-di-*O*-benzyl-5-*O*-[2-*O*-benzyl-3,5-di-*O*-(3-*O*-benzyl-5-*O*-*tert*-butyldiphenylsilyl-α-D-arabinofuranosyl)-α-D-arabinofuranosyl]-α-D-arabinofuranoside (**23**): $[\alpha]_D^{25}$ = +81.8 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78MHz, $CDCl_3$): δ 1.05 (d, *J* = 2.9 Hz, 18H), 3.37 (d, *J* = 9.3 Hz,

1H), 3.42 (s, 3H), 3.44 (d, *J* = 8.7 Hz, 1H), 3.55 (ddd, *J* = 10.9, 7.5, 2.2 Hz, 2H), 3.72 (t, *J* = 3.2 Hz, 1H), 3.74 (d, *J* = 3.8 Hz, 2H), 3.79 (dd, *J* = 13.2, 2.2 Hz, 1H), 3.93 (dd, *J* = 11.4, 4.3 Hz, 1H), 4.00 – 4.07 (m, 4H), 4.09 (dd, *J* = 6.7, 3.2 Hz, 1H), 4.16 (dd, *J* = 3.1, 1.1 Hz, 1H), 4.17 – 4.27 (m, 6H), 4.42 – 4.48 (m, 2H), 4.48 – 4.54 (m, 2H), 4.56 – 4.63 (m, 5H), 4.65 (dd, *J* = 12. 1, 3.8 Hz, 2H), 4.97 (s, 1H), 5.18 (s, 1H), 5.22 (s, 1H), 5.22 (s, 1H), 7.27 – 7.41 (m, 35H), 7.42 – 7.48 (m, 2H), 7.62 (ddd, *J* = 5.4, 4.0, 1.9 Hz, 4H), 7.66 – 7.70 (m, 4H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 19.0, 19.0, 26.6(3C), 26.6(3C), 54.9, 63.7, 63.7(2C), 65.7, 71.7(3C), 71.9, 72.2, 77.8, 78.1, 79.0, 80.3, 81.0, 83.0, 83.3, 83.7, 84.1, 84.3, 87.6, 88.3, 106.1, 107.1, 107.4, 108.9, 127.5, 127.6(2C), 127.7(5C), 127.7(3C), 127.7(3C), 127.8(5C),127.8, 127.9(2C), 127.9(3C), 128.3(4C), 128.3(3C), 128.3(3C), 128.4(2C), 129.7, 129.8 (2C), 129.8, 132.4, 132.4, 132.4, 132.5 , 135.5(3C), 135.5, 137.3, 137.4, 137.8(2C), 137.9; IR ($CHCl_3$): 3619, 3035, 2920, 1546, 1455, 1210, 1100, 693 cm^{-1}; HRMS (TOF) *m/z* $[M + Na]^+$ calcd for $C_{88}H_{102}NaO_{17}Si_2$ 1509.6553, found 1509.6548.

Methyl 2,3-di-*O*-benzyl-5-*O*-[2-*O*-benzyl-3,5-di-*O*-(3,5-di-*O*-benzyl-α-D-arabinofuranosyl)-α-D-arabinofuranosyl]-α-D-arabinofuranoside (**24**): $[\alpha]_D^{25}$ = -31.8 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78MHz, $CDCl_3$): δ 3.39 (s, 3H), 3.49 (qd, *J* = 7.1, 6.5, 4.2 Hz, 4H), 3.61 (dd, *J* = 10.5, 2.5 Hz, 1H), 3.65 (d, *J* = 2.4 Hz, 1H), 3.69 (dd, *J* = 11.7, 4.2 Hz, 1H), 3.75 (dd, *J* = 10.8, 5.7 Hz, 1H), 3.85 (dd, *J* = 4.4, 1.8 Hz, 1H), 3.87 – 3.98 (m, 3H), 4.00 – 4.06 (m, 2H), 4.16 (dq, *J* = 10.2, 3.5 Hz, 3H), 4.22 (t, *J* = 5.6 Hz, 2H), 4.26 (d, *J* = 4.0 Hz, 1H), 4.32 (dd, *J* = 6.9, 4.8 Hz, 2H), 4.42 – 4.52 (m, 4H), 4.52 – 4.61 (m, 6H), 4.62 – 4.72 (m, 4H), 4.94 (s, 1H), 5.11 (s, 1H), 5.15 (s, 1H), 5.18 (s, 1H), 7.31 (ddt, *J* = 15.3, 7.3, 4.4 Hz, 35H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 54.9, 66.3, 68.0, 69.6, 69.6, 71.7, 71.8, 71.8, 71.9, 72.2, 73.4, 73.5, 78.3, 78.7, 80.1, 80.4, 82.6, 82.7, 82.8, 83.2, 84.6, 84.8, 88.1, 88.5, 106.4, 107.0, 108.7, 109.1, 127.4, 127.5, 127.6(3C), 127.7(3C), 127.7(6C), 127.8, 127.8(3C), 127.9(3C), 128.1(2C), 128.2(2C), 128.3(6C), 128.4(2C), 128.4(2C), 137.1, 137.2, 137.4, 137.6, 137.8(2C), 137.9;

IR ($CHCl_3$): 3621, 3028, 2921, 1556, 1455, 1218, 1111, 699 cm^{-1}; HRMS (TOF) *m/z* [M + Na]$^+$ calcd for $C_{70}H_{78}NaO_{17}$ 1213.5137, found 1213.5134.

Methyl 2,3-di-*O*-benzyl-5-*O*-[2-*O*-benzyl-3,5-di-*O*-(3-*O*-benzyl-5-*O*-(((9*Z*,12*Z*)-octadeca-9,12-dienoyl))-α-D-arabinofuranosyl)-α-D-arabinofuranosyl]-α-D-arabinofuranoside (**25**): $[\alpha]_D^{25}$ = +80.0 (*c* = 1.0, $CHCl_3$); ^{1}H NMR (399.78MHz, $CDCl_3$): δ 0.88 (t, *J* = 3.5 Hz, 6H), 1.30 (m, 32H), 1.56 (d, *J* = 6.7 Hz, 2H), 1.91 – 2.11 (m, 8H), 2.27 (td, *J* = 7.8, 4.2 Hz, 4H), 2.77 (t, *J* = 6.4 Hz, 2H), 3.35 (s, 3H), 3.63 (dd, *J* = 11.3, 3.1 Hz, 1H), 3.71 (dt, *J* = 9.1, 2.8 Hz, 3H), 3.85 (dd, *J* = 11.3, 3.8 Hz, 1H), 3.92 (dd, *J* = 12.1, 3.5 Hz, 1H), 4.00 (dd, *J* = 3.2, 1.0 Hz, 1H), 4.02 – 4.08 (m, 3H), 4.14 (ddq, *J* = 14.0, 7.0, 2.3 Hz, 6H), 4.18 – 4.19 (m, 1H), 4.21 (dd, *J* = 6.1, 2.4 Hz, 2H), 4.23 – 4.25 (m, 1H), 4.28 (dd, *J* = 5.5, 1.9 Hz, 1H), 4.40 – 4.66 (m, 11H), 4.89 (s, 1H), 4.94 (d, *J* = 1.7 Hz, 1H), 5.01 (d, *J* = 2.5 Hz, 1H), 5.13 (s, 1H), 5.27 – 5.44 (m, 8H), 7.23 – 7.34 (m, 25H); ^{13}C NMR (100.53 MHz, $CDCl_3$): δ 14.1, 14.1, 22.5, 22.7, 24.8, 25.6, 27.2(3C), 29.1(2C), 29.1(2C), 29.2, 29.3(2C), 29.3(2C), 29.5, 29.6(2C), 29.7, 29.7, 31.5, 31.9, 34.0, 54.9, 63.4, 63.5, 64.8, 66.6, 71.9, 72.0, 72.2, 72.2, 72.3, 79.0, 79.4, 79.6, 80.0, 80.6, 80.7, 82.3, 82.9, 83.2, 84.3, 86.5, 88.4, 105.7, 106.8, 107.1, 109.1, 127.7(2C), 127.8(2C), 127.8(3C), 127.9(2C), 128.0(2C), 128.1, 128.1, 128.2(3C), 128.2(3C), 128.4(2C), 128.4(2C), 128.42(2C), 128.5(4C), 129.7, 130.0, 130.0, 130.2, 136.9, 137.1, 137.5, 137.7, 137.7, 173.4(2C); IR ($CHCl_3$): 3622, 3031, 2917, 1761, 1546, 1455, 1217, 1104, 699 cm^{-1}; HRMS (TOF) *m/z* [M + Na]$^+$ calcd for $C_{92}H_{126}NaO_{19}$ 1557.8791, found 1557.8787.

Hexasaccharides **26**: Individual resonances could not be determined due to overlapping signals in the anomeric region. However, the ratio of isomers was obtained by taking both the ^{13}C and ^{1}H NMR signals. The integration ratio of -OCH_3 (δ 3.18-3.22 ppm) present at the reducing end showed that the ratio is 0.4:1.0. The anomeric proton resonances were noticed from δ 4.73-5.38 ppm with overlapping signals. The ^{13}C NMR spectrum showed that the

resonances diagnostic for β-isomer are noticed from δ 99.4-100.1ppm and those of α-isomer were noticed from δ 104.7-107.2 ppm.

Hexasaccharides **27**: Individual resonances could not be determined due to overlapping signals in the anomeric region. However, the ratio of isomers was obtained by taking both the ^{13}C and ^{1}H NMR signals. The anomeric proton resonances were noticed from δ 4.83-5.45 ppm with overlapping signals. The ^{13}C NMR spectrum showed that the resonances diagnostic for β-isomer are noticed from δ 100.3-101.0 ppm and those of α-isomer were noticed from δ 105.7-107.0 ppm.

Hexasaccharides **28**: Individual resonances could not be determined due to overlapping signals in the anomeric region. However, the ratio of isomers was obtained by taking both the ^{13}C and ^{1}H NMR signals. The integration ratio of -OCH_3 (δ 3.28-3.31 ppm) present at the reducing end showed that the ratio is 0.2:1.0. The anomeric proton resonances were noticed from δ 4.85-5.42 ppm with overlapping signals. The ^{13}C NMR spectrum showed that the resonances diagnostic for β-isomer are noticed from δ 99.7-100.2ppm and those of α-isomer were noticed from δ 105.0-107.2 ppm.

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SUPPORTING INFORMATION

Computational data and copies of ^{1}H, ^{13}C and DEPT NMR spectra for all compounds. This material is available free of charge via the Internet at http://pubs.acs.org

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