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Synthesis of Docosasaccharide Arabinan Motif of Mycobacterial Cell Wall

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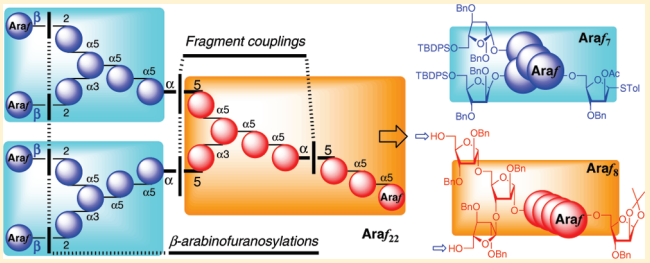
Supporting Information

ABSTRACT: Mycobacterial arabinan is a common constituent of both arabinogalactan (AG) and lipoarabinomannan (LAM). In this study, synthesis of β-Araf containing common arabinan docosasaccharide motif (22 Araf monomer units) of mycobacterial cell wall was achieved. Our synthetic strategy toward arabinan involves (1) the stereoselective β-arabinofuranosylation using both 3,5-*O*-TIPDS-protected and NAP-protected arabinofuranosyl donors for straightforward intermolecular glycosylation and intramolecular aglycon delivery (IAD), respectively, and (2) the convergent fragment coupling with branched fragments at the linear sequence using thioglycoside donor obtained from the corresponding acetonide at the reducing terminal of each fragment through a three-step procedure. Because the acetonide at the reducing terminal of all fragments would be converted to thioglycoside as the glycosyl donor, and mainly Bn ether protections were used, our strategy will be readily applicable to the synthesis of more complex arabinan, arabinogalactan, and arabinomycolate derived from mycobacterial CWS.



INTRODUCTION

Mycobacterial arabinan is a common constituent of both arabinogalactan (AG) and lipoarabinomannan (LAM). They are attracting exceptionally broad attention among furanoside-containing glycans[1] originated from bacteria,[2] fungi,[3] and parasites,[4] which play key roles in their infectivity and pathogenicity. Biosynthetic steps of these glycans catalyzed by mycobacterial arabinofuranosyl transferases (Araf Ts)[5] are promising therapeutic targets[6] against *Mycobacterium tuberculosis*, a causative agent of tuberculosis, which remains rampant and is a growing threat worldwide due to the emergence of strains that have multidrug resistance (MDR).[7] On the other hand, adjuvants derived from the cell wall skeleton (CWS) of mycobacteria, such as Bacillus Calmette-Guérin (BCG-CWS) from *M. bovis*, are known to be potent activators of innate immunity.[8,9] Although BCG-CWS-initiated immunity has been proposed to involve the activation of macrophages via Toll-like receptor (TLR) 2,[10] its structural basis has been elusive, due to the extreme complexity of BCG-CWS.

Structural architecture of mycobacterial CWS is unique, being composed of mycolic acid (MA), D-arabinan, D-galactan, linker disaccharide (α-Rha*p*-(1→3)-α-GlcNAc), and peptidoglycan (PG)[5,11] (Figure 1). Recent efforts[12] have been extended to draw the finer picture of mycobacterial cell wall, in which hentriacontaarabinan (31 araninofuranoside (Araf) monomer units),[12e] consisting of an [α-Araf-(1→5)-α-Araf]$_n$ repeat, is linked to the inner complex and is capped by a branched motif. The latter contains terminal β-Araf residues, each of which is linked to the 2-position of penultimate α-Araf. β-Araf residues are *O*-acylated at their *C*-5 positions by mycolic acid, a structurally heterogeneous, long chain functionalized fatty acid. Further complexity has been found, which is produced by substitutions at the 2-*O*-position of inner 3,5-branched-Araf by $GalNH_2$[12a] or succinate ester.[12e] On the other hand, galactan portions are composed of β-Galf-(1→5)-β-Galf repeating units, which are linked by β-(1→6)-linkages and contain three arabinans.[12b]

In this study, we achieved the stereoselective synthesis of β-Araf containing common arabinan docosasaccharide motif (22 monomer units, $Araf_{22}$) of mycobacterial arabinogaractan. Our synthesis features the extensive use of branched thioglycosides as key components for fragment coupling reactions. As the target contains problematic β-Arafs, several approaches developed in this group to stereoselectively construct this type of linkage were tested for their suitability to the current purpose.

RESULTS AND DISCUSSION

With the exception of homopolymerization, the synthesis of structurally defined oligosaccharide over 20 residues is a significant challenge in synthetic carbohydrate chemistry. In 1993, Ogawa et al.[13] achieved the synthesis of polylactosamine pentacosasaccharide using trisaccharyl fluoride donor with decasaccharide pentaol as the key reaction. More recently, Fraser-Reid et al.[14] reported the synthesis of mannose-capped arabinomannan fragment, in its protected form, using octacosasaccharide derived trichloroacetimidate, which in turn was synthesized from hexasaccharyl trichloroacetimidates and pentasaccharide, and dodecasaccharide acceptor. As for the

Received: November 5, 2010
Published: February 2, 2011

dx.doi.org/10.1021/ja109932t | J. Am. Chem. Soc. 2011, 133, 2275–2291

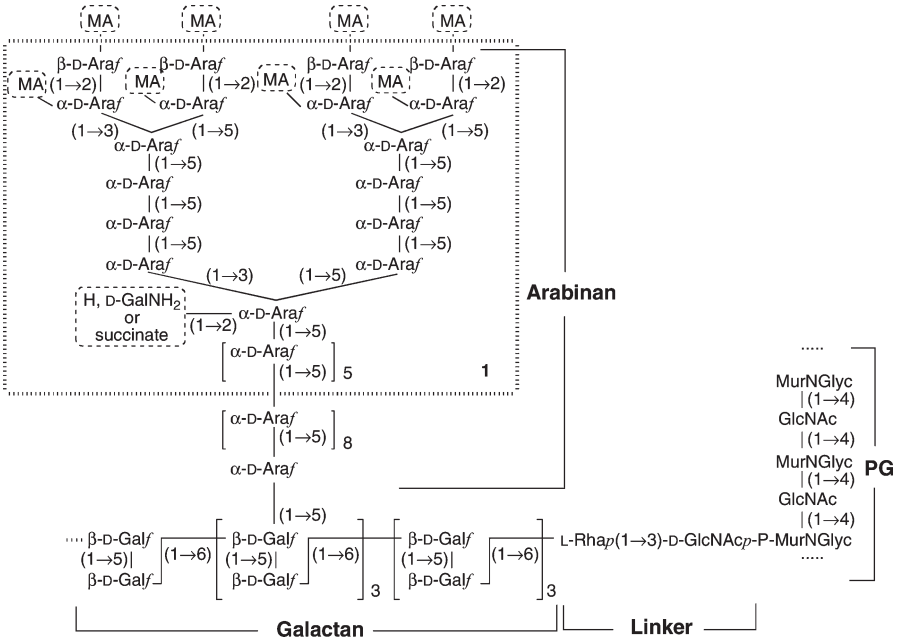


Figure 1. Structure of mycobacterial cell wall glycoconjugate.

synthesis of mycobacterial arabinans, Lowary et al.[15] reported the synthesis of docosasaccharide ($Araf_{22}$) using two pentasaccharyl trichloroacetimidates as donors and dodecasaccharide as an acceptor, which in turn was synthesized from heptasaccharyl trichloroacetimidate and pentasaccharide fragment. While all of these examples relied upon fragment couplings at branching sites, our approach was designed to conduct all fragment couplings at linear sequences so as to maximize the reactivity of reaction sites.[16] It also features the use of thioglycosides[17] as branched oligosaccharide donors. Although the synthesis of linear thioglycoside could be synthesized by orthogonal strategy,[18] preparation of thiglycosides of complex and branched glycans is less straightforward. We achieved this task in a unified manner by using 1,2-acetonide as the common precursors (vide infra).

Mycobacterial arabinan contains, in its nonreducing end, β-Arafs, which are further decorated by mycolic acid esters. Stereocontrolled formation of β-Araf is intrinsically problematic, because of its 1,2-*cis*, nonaxial nature. To solve this, several innovative methods have been developed. Of particular note were approaches based on S_N2-type displacement of α-triflates derived from 2,3-anhydro-modified and carboxybenzyl (CB)-substituted donors, which were developed by Lowary[19] and by Kim,[20] respectively. Alternatively, certain cyclic protections have given promising results by virtue of their abilities to bring conformational constrain to arabinofuranosyl donors. For instance, bicyclic donors,[21−25] 3,5-*O*-di-*t*-butylsilylene (DTBS)-protected donors in particular, reported by Boons[21] and others,[22−25] were shown to give substantial β-selectivity, while our study indicated that the introduction of 3,5-*O*-tetra-*i*-propyldisiloxanylidene (TIPDS)-protection was optimum for this purpose.[22]

To realize more complete selectivity in β-Araf formation, approaches based on intramolecular aglycon delivery (IAD) have been investigated. They employed 2-*O*-*p*-methoxybenzyl (PMB)[26] or 2-*O*-(2-naphthyl)methyl (NAP)[27] equipped donor.[28] Our study also addressed the possibility to deploy 5-*O*-NAP group as a tether.

Our synthetic plan toward target arabinan **1** was based on the canonical disconnection depicted in Figure 2. It employed two identical heptasaccharide ($Araf_7$) donors (**2**) and octasaccharide ($Araf_8$) diol acceptor (**4**) so that fragment couplings can be conducted to make linkage at nonbranched Ara residue. The synthesis of heptasaccharide ($Araf_7$) fragment (**3**) was to involve stereoselective introduction of two β-Araf residues by using our TIPDS- or NAP-protected donors ($Araf_1$, **5**−**7**)[22,27] to pentasaccharide ($Araf_5$) diol (**8**). On the other hand, as precursors of the octasaccharide ($Araf_8$) acceptor (**4**), pentasaccharide ($Araf_5$) donor (**9**) and trisaccharide ($Araf_3$) acceptor (**11**) were assumed. According to this scheme, all branches are created before fragment condensation, at the stage of the synthesis of pentasaccharides ($Araf_5$) fragments (**8**, **10**) from trisaccharide ($Araf_3$) diol acceptors (**12**, **13**). Reducing end terminus of acceptors (e.g., **3**, **4**, **8**, **10**, **11**−**13**) was masked with 1,2-*O*-acetonide, which has a dual benefit as follows. First, our general protocol enabled high-yield conversion of 1,2-*O*-acetonides (**3**, **10**) to thioglycosides (**2**, **9**) in a unified manner. Second, acetonide group (**4**, **8**, **11**−**13**) served as a marker, the presence of which was easily seen with ^{1}H NMR, thereby facilitating the isolation of successfully assembled product.

In our convergent strategy, fragment couplings that employed NIS−AgOTf[29] mediated activation of 4-methylphenyl thioglycoside instead of using glycosyl imidate[14,15] or fluoride[13] for fragment condensation. The use of benzyl ether for global protection will allow us to approach mycolated arabinans.[30] However, acyl protections were introduced to the 2-position of thioglycoside moieties to secure stereocontrolled formation of the α-Araf linkages. As typified in Scheme 1, protective groups of glycosylation product, such as silyl and acyl groups, were exchanged to benzyl ether (e.g., **19**), except reducing terminal acetonide and selected hydroxy groups that were going to be liberated for further glycosylation.

According to this plan, our study commenced with the synthesis of $Araf_3$ fragment **11** from common disaccharide ($Araf_2$) intermediate **19**,[31] which was prepared from monosaccharide ($Araf_1$) units **14**[32] and **15**[22] as depicted in Scheme 1. The disaccharide **19** was then glycosylated with **15** to give **20**, which was converted to **11** that will be used as the reducing end

dx.doi.org/10.1021/ja109932t |*J. Am. Chem. Soc.* 2011, 133, 2275–2291

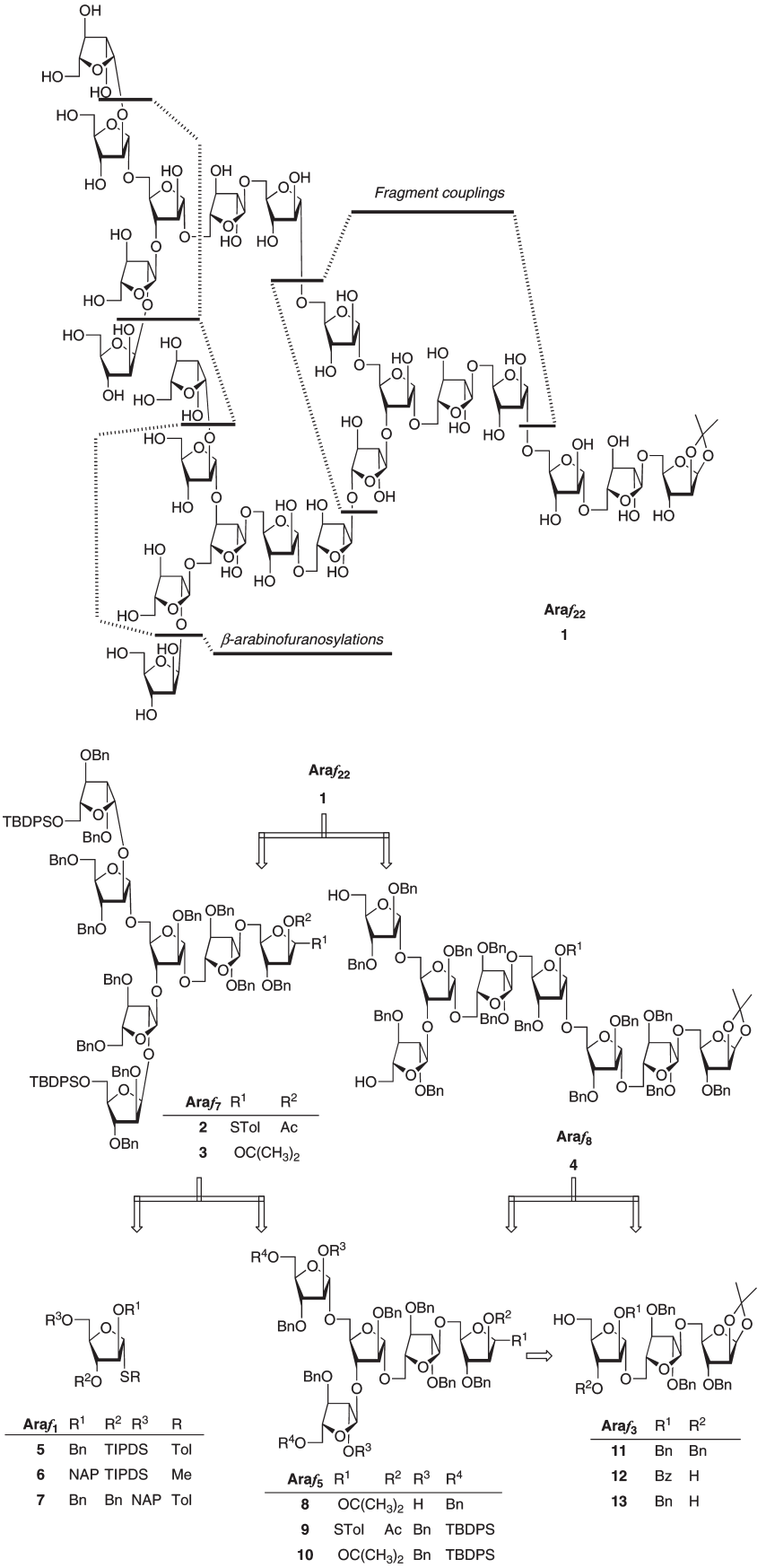
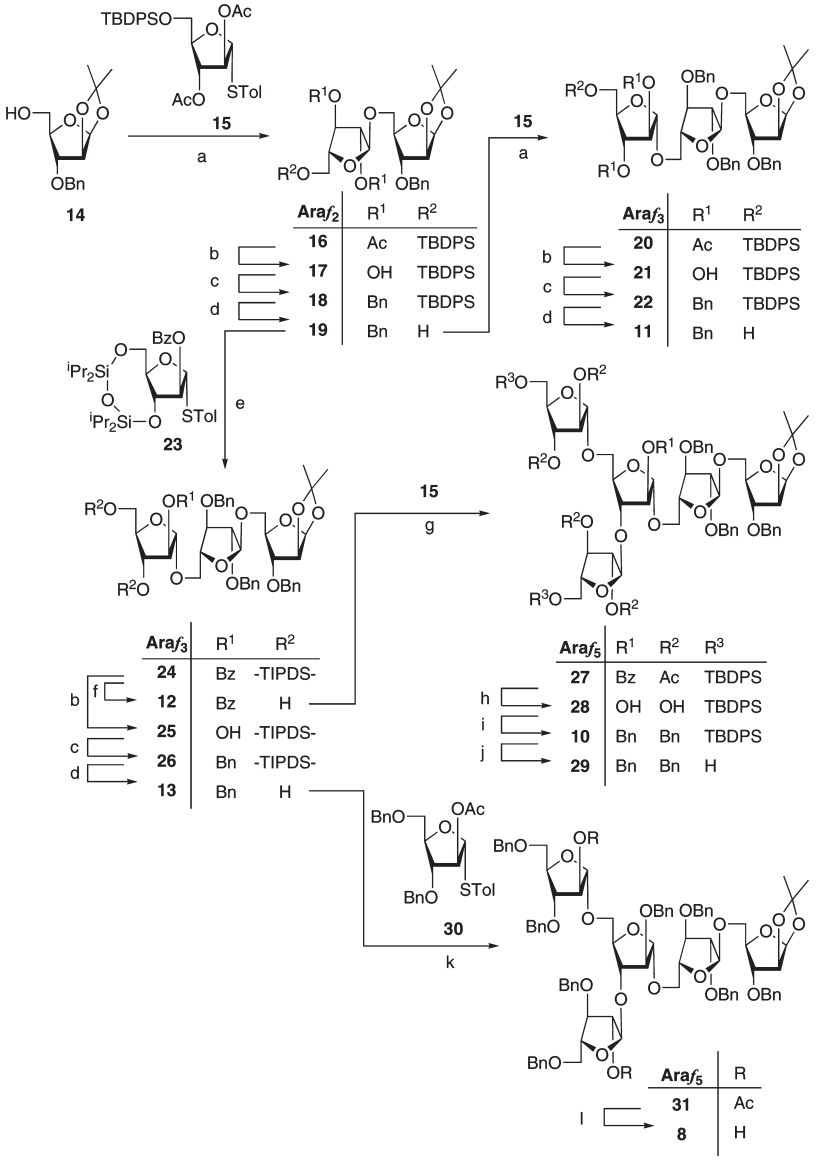


Figure 2. Retrosynthetic analysis of docosasaccharide arabinan motif.

dx.doi.org/10.1021/ja109932t |*J. Am. Chem. Soc.* 2011, 133, 2275–2291

Scheme 1. Synthesis of Pentasaccharide Fragments[a]



[a] Reagents and conditions: (a) **15**, *N*-iodosuccinimide, AgOTf, MS4 Å, CH_2Cl_2, 0 °C; (b) NaOMe, MeOH; (c) BnBr, NaH, DMF, 0 °C; (d) TBAF, THF, 91% in four steps from **14** (**19**), 94% in four steps from **19** (**11**), 84% in three steps from **24** (**13**); (e) **23**, *N*-iodosuccinimide, AgOTf, MS4 Å, CH_2Cl_2, 0 °C, 93%; (f) TBAF, THF, 91%; (g) **15**, *N*-iodosuccinimide, AgOTf, MS4 Å, CH_2Cl_2, 0 °C, 96%; (h) NaOMe, MeOH; (i) BnBr, NaH, DMF, 0 °C, 83% in two steps; (j) TBAF, THF, 93%; (k) **30**, MeOTf, DTBMP, MS4 Å, CH_2Cl_2, room temperature; (l) Et_3N, MeOH, H_2O, 93% in two steps.

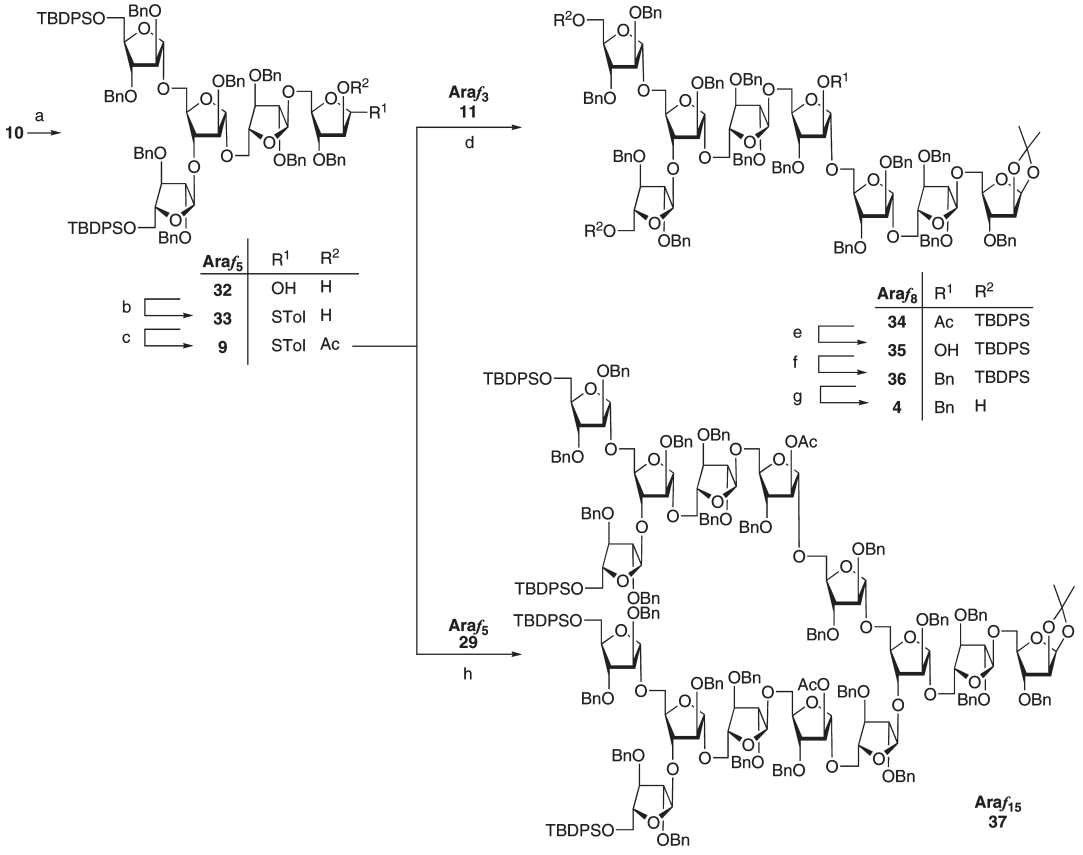
trisaccharide component. On the other hand, reaction with 3,5-*O*-TIDPS-protected donor **23**[33] gave **24**, which in turn was converted to Ara*f*$_3$ diols **12**[31] and **13**.[31] Thus, double glycosylation of **12** with 2 equiv of **15** produced branching to give **27**, which was followed by protective group manipulation to provide **10** and **29**. Another branched Ara*f*$_5$ fragment **8** was prepared from the diol **13** and a glycosyl donor **30**,[22] completing the synthesis of all small fragments, including reducing-end trisaccharide and branched pentasaccharide frameworks.

Synthesis of Octasaccharide Fragment: Conversion of 1,2-Acetonide to Thioglycoside and Model Fragment Couplings. Our synthetic plan required a general access to thioglycosides form 1,2-*O*-acetonides (e.g., **9** from **10**; Scheme 2). Initial attempts for direct conversion of acetonide **10** to thioglycoside by using $CH_3C_6H_4SH-BF_3\cdot OEt_2$ conditions[34] turned out to be fruitless. We next explored the utility of 1,2-diol **32**, obtained by acidic hydrolysis[35] of acetonide **10**, as a precursor of thioglycoside. However, treatment of diacetate derived from **32** with $CH_3C_6H_4SH-BF_3\cdot OEt_2$ met with limited success, giving very low yield of the desired product **9**. On the other hand, to our delight, treatment of **32** with $(CH_3C_6H_4S)_2-n\text{-}Bu_3P$[36] afforded the desired Ara*f*$_5$ thioglycoside **33**, which was immediately acetylated to give **9**. Subsequently, the latter was used as the Ara*f*$_5$ donor **9** and coupled with the Ara*f*$_3$ acceptor **11** to give Ara*f*$_8$ product **34**, which was converted to Ara*f*$_8$ acceptor **4** through three steps.

To confirm the adequacy of our approach to construct the tetra-branched structure of the target arabinan, an attempt was made to simultaneously introduce two Ara*f*$_5$ fragments to **29**.

dx.doi.org/10.1021/ja109932t |*J. Am. Chem. Soc.* 2011, 133, 2275–2291

Scheme 2. Synthesis of Octasaccharide Fragment and Heptadecasaccharide[a]



[a] Reagents and conditions: (a) dioxane−70% AcOH aqueous−10% HCl aqueous (10:10:1), 50 °C; (b) $(TolS)_2$, *n*-Bu_3P, CH_2Cl_2; (c) Ac_2O, pyridine, DMAP, 71% in three steps; (d) **11**, *N*-iodosuccinimide, AgOTf, MS4 Å, CH_2Cl_2, −30 to −10 °C, 73%; (e) NaOMe, MeOH, 0 °C; (f) BnBr, NaH, DMF, 0 °C; (g) TBAF, THF, 83% in three steps; (h) **29**, *N*-iodosuccinimide, AgOTf, MS4 Å, CH_2Cl_2, 0 °C, 73%.

In fact, the use of **9** as the Ara*f*$_5$ donor gave the pentadecasaccharide (Ara*f*$_{15}$) **37** in good yield.[16] The presence of two acetates, two TBDPS groups, and an acetonide, all of which were evident from 1D ^{1}H NMR, provided strong support of the structure, which was rigorously confirmed by ^{13}C and HMQC NMR measurements.

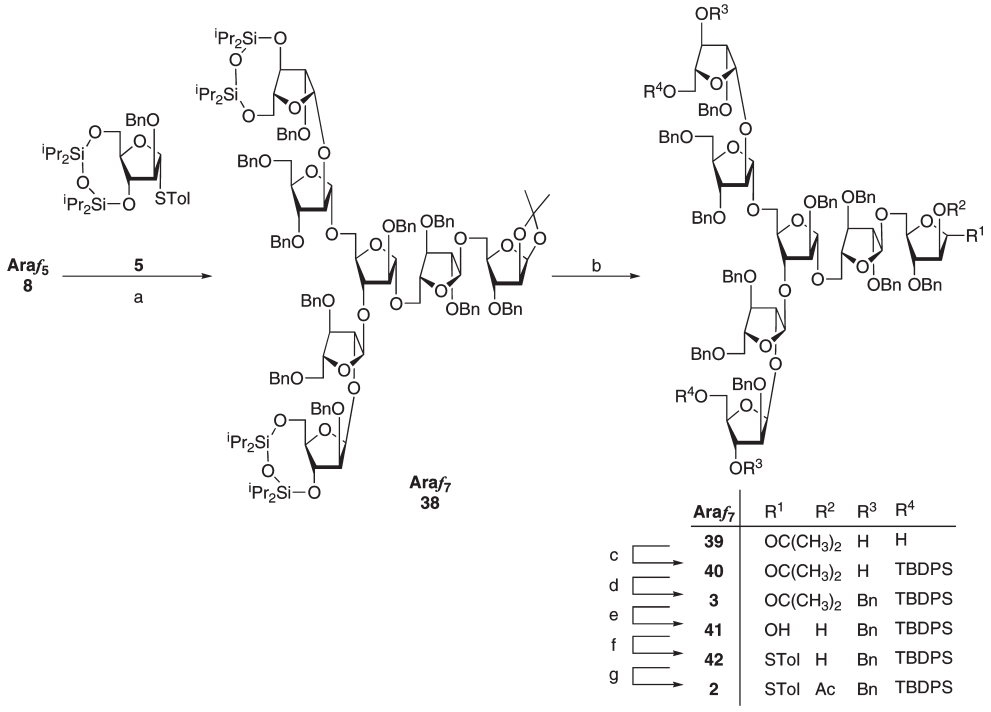
Synthesis of Heptasaccharide Fragment Having 1,2-*cis*-*β* Linkages. Synthesis of the Ara*f*$_7$ fragment entailed the introduction of two *β*-Ara*f* residues. As the most straightforward approach, double glycosylation of Ara*f*$_5$ acceptor **8** was first conducted by using arabinofuranosyl donors specialized for *β*-Ara*f* formation (Scheme 3). Because our previous study revealed the suitability of the 3,5-*O*-TIDPS-protected thioglyoside **5**[22] for *β*-Ara*f* linkage formation, this donor was a priori selected for this purpose. As expected, the desired *β*,*β*-isomer **38** was obtained as the major isomer (*β*,*β*-isomer:other isomers = 10.8:1). Stereochemistry of newly formed linkages was confirmed by their ^{13}C NMR signals, which appeared at 98.8 and 98.9 ppm.[22] Although isomer separation at this stage was not practical, removal of TIPDS groups from **38** enabled facile separation of the isomers, and stereochemically homogeneous diol **39** was isolated in 87% yield from **8**. Subsequent introduction of a TBDPS group to primary alcohols and benzylation of secondary alcohols gave Ara*f*$_7$ fragment **3**. Further conversion to thioglycoside **2** was conducted with the aforementioned three-step protocol that includes acidic hydrolysis, thioglycoside formation using $(CH_3C_6H_4S)_2$−*n*-Bu_3P, and acetylation.

Although the use of **5** as a donor realized the introduction of *β*-Ara*f* residues in a practically useful selectivity, to achieve *β*-Ara*f* formation in a completely selective manner, approaches based on intramolecular aglycon delivery were examined.[28] In fact, we previously reported that the NAP-mediated IAD was effective for exclusive formation of the *β*-Ara*f* glycosides. For instance, the two-step reaction ((1) DDQ, (2) MeOTf, DTBMP) between the thioglycoside **6**[27] and acceptor **44**[27,37] gave the *β*-glycoside **47** in 77% yield through mixed acetal **46a** (Table 1, entry 1).[27] When this reaction was applied to the double glycosylation of **8** using **6** as the donor, the desired *β*,*β*-heptasaccharide hexaacetate **53** was obtained as a single isomer in 60% yield from **8**, after acidic workup and reprotection (Scheme 4). This result clearly indicated the advantage of using NAP ether as a tether, because a similar transformation with PMB ether-mediated IAD gave only low yield (23%) of doubly glycosylated product.[26]

Our effort was then extended to 5-*O*-NAP ether-protected Ara*f* donors such as **43**[31,38] and **7**.[31] Although similar "long-distance" intramolecular aglycon delivery has been reported for the formation of simple glucopyranoside and ribofuranoside,[39] its application to complex glycan synthesis has not been explored. This option seemed particularly attractive, because C-5 OH will be liberated as the IAD from **7**/**43** proceeds, thereby enabling site-selective introduction of mycolic acid without additional protective group manipulation. Accordingly, as a model, we conducted the reaction between **43** and **44** under our standard

dx.doi.org/10.1021/ja109932t |*J. Am. Chem. Soc.* 2011, 133, 2275–2291

Scheme 3. Stereoselective Synthesis of Heptasaccharide Fragment Using 3,5-*O*-TIDPS-Protected Thioglyoside 5[a]



[a] Reagents and conditions: (a) **5**, *N*-iodosuccinimide, AgOTf, MS4 Å, CH_2Cl_2, −40 °C, ($\beta\beta$:other isomers = 8.46:1); (b) TBAF, THF, 87%, $\beta\beta$: other isomers; (c) TBDPSCl, imidazole, DMF, 0 °C to room temperature; (d) BnBr, NaH, DMF, 0 °C, 84% in two steps; (e) dioxane−70% AcOH aqueous−10% HCl aqueous (10:10:1), 50 °C; (f) $(TolS)_2$, *n*-Bu_3P, CH_2Cl_2; (g) Ac_2O, pyridine, DMAP, 76% in three steps.

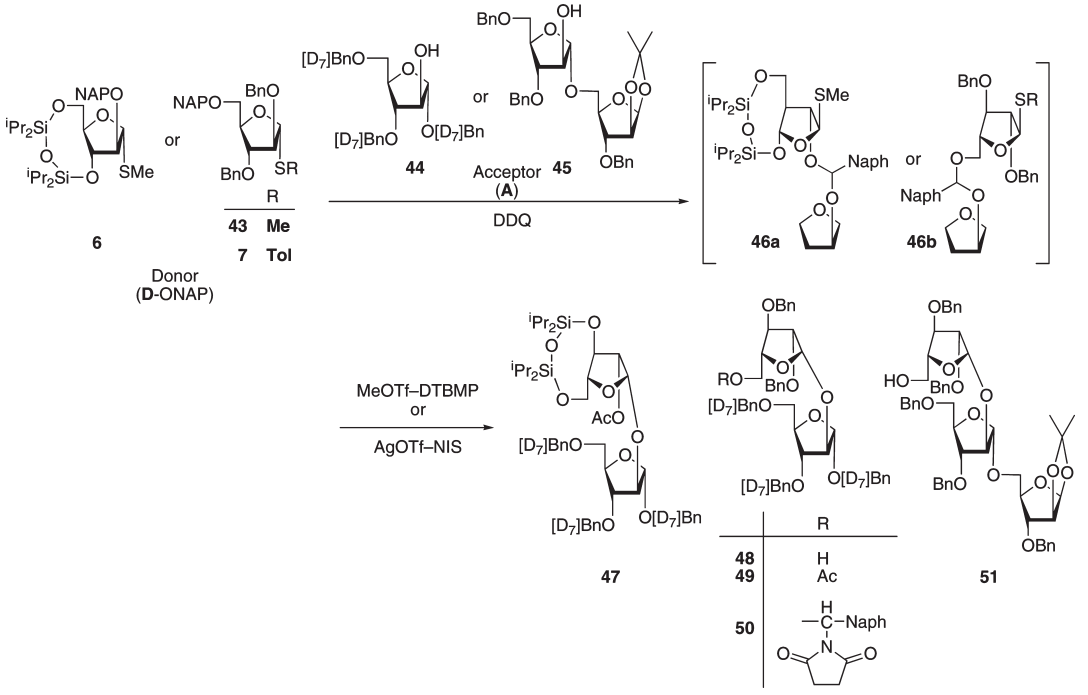
IAD conditions. Formation of the mixed acetal proceeded quite smoothly, giving 82% yield of **46b**. It was followed by thioglycoside activation by MeOTf−DTBMP in CH_2Cl_2 to give the IAD product **48**, which was isolated as **49** after acidic workup followed by acetylation (Table 1, entry 2). However, somewhat to our disappointment, the yield was only modest (34%), and the product was a mixture of isomers, in which the desired β-isomer predominated in a ratio of 6.67:1 (entry 2). Corresponding *p*-methylphenyl (Tol) thioglycoside **7** required slightly higher temperature (40 °C) for activation, giving the same product in 46% yield in somewhat lower selectivity (β:α = 4.24:1) (entry 3). Further screening clarified that the selectivity was enhanced when the IAD was conducted under dilute conditions, suggesting that the intramolecular pathway was competing with IAD. At 1 mM concentration, nearly exclusive formation of the β-isomer was observed, although the yield was still modest (entry 4). As an activator, a combination of NIS−AgOTf turned out to be more effective. The IAD product was obtained as **50**, which had a *O*-(2-naphthyl)-(succinimido)methyl group at 5-position of the β-Araf moiety. Formation of this unexpected product, which was caused presumably by quenching the immediate cationic species by succinimide, was not consequential. Treatment of **50** with $(CH_2NH_2)_2$ in MeOH[40] liberated the 5-OH to provide **48** in 58% overall yield from **44** (entry 5). A similar reaction with *p*-methylphenyl thioglycoside **7** was significantly more effective, giving 72% yield of **48** (entry 6). The disaccharide acceptor **45**[31] also afforded the β-glycoside **51**, which corresponds to the nonreducing end trisaccharide of arabinan, with high selectivity (entry 7).

With these results in hand, double IAD of **8** using the 5-*O*-NAP-protected thioglycoside **7** as a donor was conducted in a manner similar to that described for **48**, giving the β,β-isomer **55** as the sole stereoisomer, after treatment of initially formed 5-*O*-(2-naphthyl)-(succinimido)methyl group of the product with $(CH_2NH_2)_2$ in MeOH. Subsequent silylation gave **3**, which was identical to the same compound obtained by intermolecular glycosylation (Scheme 3). However, the overall yield of **55** from **8** was rather low (25% overall), indicating that the approach based on 5-*O*-NAP needs further improvement to be competitive with other approaches using **5** or **6**.

Assembly of Docosasaccharide Arabinan Motif. To complete the total framework of the target $Araf_{22}$, double glycosylation of $Araf_8$ acceptor **4** with $Araf_7$ donor **2** was carried out through activation by NIS−AgOTf at −40 °C (Scheme 5). Progress of the reaction was monitored by MALDI-TOF mass, which indicated the first accumulation of the $Araf_{15}$ product and subsequent formation of $Araf_{22}$ that was complete after 3 days. Purification by gel filtration chromatography afforded **56**. Although the calculated yield (96%) may not be accurate due to the minuteness of the reaction scale (theoretical yield, 7.9 mg), nearly quantitative formation of $Araf_{22}$ **56** was evident from MALDI-TOF-MS. After isolation, Nano ESI FT-ICR mass spectrum (R = 90 000, fwhm, at m/z 2500) was acquired, which was in full agreement with the structure.[31] While the presence of 38 Bn ethers obscured NMR peaks of anomric protons, the structure of **56** was supported by the presence of two acetates, four TBDPS groups, and an acetonide group. Furthermore, extensive assignment of peaks was made at this stage using various techniques (600 MHz, ^1H, ^{13}C, DQF-COSY, TOCSY, HSQC, HSQC-TOCSY, HMBC) giving nearly complete assignment of peaks. The anomeric peak of reducing arabinofuranose residue protected by 1,2-acetonide was clearly distinct from other anomeric peaks, appearing at 5.88 ppm. Signals of anomeric

dx.doi.org/10.1021/ja109932t |*J. Am. Chem. Soc.* 2011, 133, 2275–2291

Table 1. NAP Ether-Mediated IAD Approaches for Stereoselective Synthesis of β-Arabinofuranosides



entry	D	A	activator	conc./mM	temp	product (%)	α; β
1	**6**	**44**	MeOTf−DTBMP	10	room temperature	**47**[b] (77[c])	β
2	**43**[a]	**44**	MeOTf−DTBMP	10	room temperature	**49** (34)	1:6.67
3	**7**[a]	**44**	MeOTf−DTBMP	10	40 °C	**49** (46)	1:4.24
4	**43**	**44**	MeOTf−DTBMP	1	room temperature	**49** (34)	1:>20
5	**43**	**44**	AgOTf−NIS[d]	1	−30 °C	**48**[e] (58)	1:>20
6	**7**	**44**	AgOTf−NIS[d]	1	−30 °C	**48**[e] (72)	1:>20
7	**7**	**45**	AgOTf−NIS	2	−30 °C	**51**[e] (65[c])	1:>20

[a] Yields of MA formation: 82% (**43** + **44**), 82% (**6** + **44**). [b] Acidic workup and acetylation were carried out after IAD. [c] Multistep yield from acceptor. [d] In the presence of 1.7 equiv of DTBMP. [e] Removal of (2-naphthyl)-succinimidomethyl group was carried out by the treatment of a crude mixture of IAD reaction with $(CH_2NH_2)_2$ in n-butanol.

peaks derived from nonreducing terminal β-linked Ara*f* residues appeared at ca. 100 ppm in ^{13}C NMR spectra. The anomeric peaks of three branches were also found as broad singlets in ^{1}H NMR spectra. Detailed assignment of connectivity of each residue was made by using HMBC spectra, although several simple α(1→5) linkages were obscured by extensive overlapping. Subsequently, deprotection was conducted in a standard fashion to afford free Araf_{22} **1** ($[M + Na]^+$ calcd for **1**: $C_{113}H_{182}O_{89}Na$, 2985.96, found 2985.63). Extensive assignment of ^{1}H (800 MHz) and ^{13}C (125 MHz) NMR peaks was made as in the case for protected Araf_{22} **56**, which clearly indicated the presence of 22 Ara*f* residues with correct stereochemistry.[41]

CONCLUSION

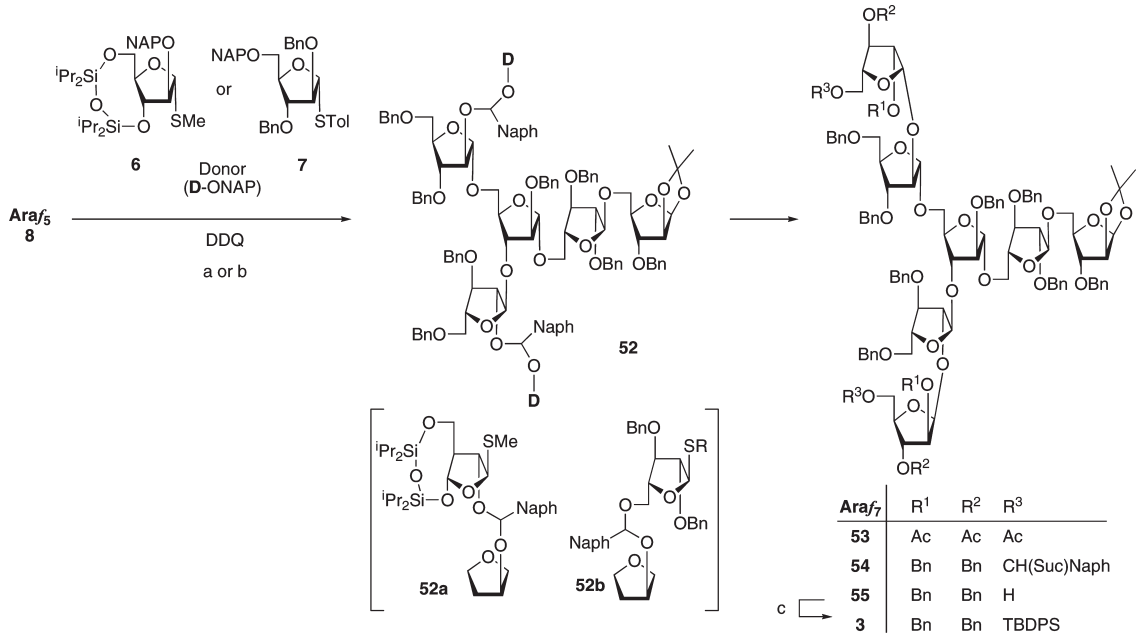
Our study achieved the synthesis of arabinan docosasaccharide motif of mycobacterial CWS, which features (1) the stereoselective β-arabinofuranosylation using both 3,5-*O*-TIPDS-protected or NAP-equipped arabinofuranosyl donor for intermolecular glycosylation and intramolecular aglycon delivery (IAD), respectively, and (2) the convergent fragment coupling with branched fragments at the linear sequence using thioglycoside donor obtained from the corresponding acetonide at the reducing terminal of each fragment through a three-step procedure. Our synthetic scheme involves eight glycosylations from monosaccharide acceptor **14** including two fragment couplings with acceptors (**4** and **11**) and four double glycosylations with diol acceptors (**4**, **8**, **12**, and **13**), as well as one β-arabinofuranosylation with **8**.

Although the use of **5** as a donor realized the introduction of β-Ara*f* residues in a practically useful selectivity, β-Ara*f* formation using 2-*O*- and 5-*O*-NAP ether protected donors (**6**, **7**) through intramolecular aglycon delivery was achieved with complete stereoselectivity. We also observed that double glycosylation of **5** or **6** with diol acceptor **8** afforded the desired β,β-isomer stereoselectively in good yield through inter- and intramolecular glycosylation pathway, respectively.

Conversion of acetonide at the reducing terminal of each fragment to corresponding thioglycoside is one of the key steps of our strategy for fragment couplings, which was achieved by a three-step procedure including acetonide hydrolysis, chemoselective thioglycosylation using $(CH_3C_6H_4S)_2$−*n*-Bu_3P, and acetylation of the resulting hydroxyl group. Subsequent fragment couplings between fragments (**2** + **4** and **9** + **11**) at the linear sequence were achieved successfully to afford larger motifs

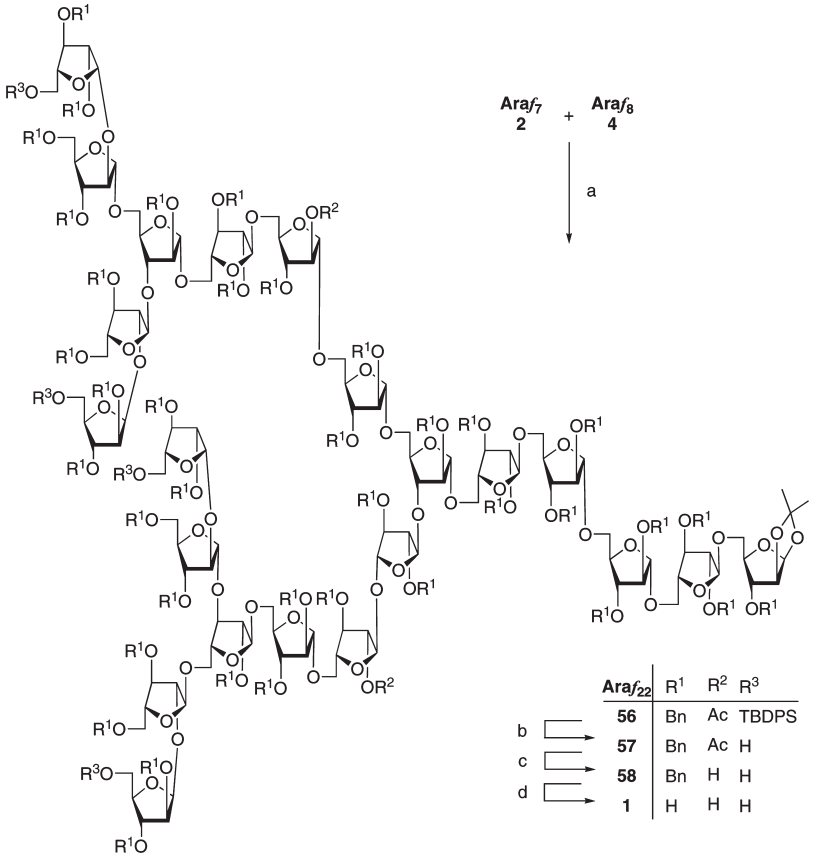
dx.doi.org/10.1021/ja109932t |*J. Am. Chem. Soc.* 2011, 133, 2275–2291

Scheme 4. Double IAD Approaches for Stereoselective Synthesis of Heptasaccharide Fragment[a]



[a] Reagents and conditions: (a) (i) **6**, DDQ, MS4 Å, $(CH_2Cl)_2$, 82%; (ii) MeOTf, DTBMP, MS4 Å, $(CH_2Cl)_2$; (iii) AcOH, H_2O, 80 °C; (iv) TBAF, THF; (v) Ac_2O, pyridine, DMAP, 73% from mixed acetal **52a**; (b) (i) **7**, DDQ, MS4 Å, $(CH_2Cl)_2$, 74%; (ii) *N*-iodosuccinimide, AgOTf, −40−0 °C; (iii) $(CH_2NH_2)_2$, *n*-BuOH, 34% from mixed acetal **52b**; (c) TBDPSCl, imidazole, DMF, 89%.

Scheme 5. Synthesis of Docosasaccharide Arabinan Motif[a]



[a] Reagents and conditions: (a) *N*-iodosuccinimide, AgOTf, −40 to 0 °C, 97%; (b) TBAF, THF; (c) $Et_3N-MeOH-H_2O$; (d) H_2, $Pd(OH)_2$, $EtOAc-MeOH-H_2O$, 48% in three steps.

dx.doi.org/10.1021/ja109932t |*J. Am. Chem. Soc.* 2011, 133, 2275–2291

(**56**, **34**) in good yield. Because the acetonide at the reducing terminal of all fragments would be converted to thioglycoside as the glycosyl donor, and mainly Bn ether protections were used, our strategy will be directly applicable to the synthesis of arabinogalactans and arabinomycolates of further complexity.

EXPERIMENTAL SECTION

General Procedure. All reactions sensitive to air and/or moisture were carried out under argon atmosphere with anhydrous solvents. Substrates of glycosylations were dried by azeotoropic removal with toluene. Column chromatography was performed on silica gel 60N, 100−210 mesh (Kanto Kagaku Co., Ltd.). Preparative TLC was performed on silica gel 60 F_{254}, 0.5 mm (E. Merck). Gel filtration was performed on Bio beads SX-3 or Sephadex LH-20 (Pharmacia). Optical rotations (deg; deg·mL/g·dm) were measured with a JASCO DIP 370 polarimeter. ^{1}H NMR spectra were recorded at 400 MHz on a JEOL ECX 400, at 600 MHz on ECA 600 (RIKEN Advanced Science Institute), and at 800 MHz on ECA 800 (NMR facility at RIKEN Yokohama Institute) spectrometers, and chemical shifts are referred to internal residual solvent signals, 7.24 ppm ($CDCl_3$) or 2.23 ppm for internal acetone (D_2O). ^{13}C NMR spectra were recorded on the same instruments, and chemical shifts are referred to internal $CDCl_3$ (77.0 ppm) or 31.1 ppm for internal acetone (D_2O). MALDI-TOF mass spectra were recorded on a SHIMADZU Kompact MALDI AXIMA-CFR spectrometer with 2,5-dihydroxybenzoic acid as the matrix. ESI-TOF mass spectra were recorded on a JEOL AccuTOF JMS-T700LCK with CF_3CO_2Na as the internal standard. Fourier transform ion cyclotron resonance (FT-ICR) mass spectra was recorded on a Bruker Daltonics Bio APEX II 70e FT Mass Spectrometer (RIKEN Advanced Science Institute). All other reagents were purchased from Wako Pure Chemical Industries Ltd., Kanto Chemicals Co. Inc., Tokyo Chemical Industry Co., Ltd., and Aldrich Chemical Co.

2,3-Di-O-acetyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-(2,3-di-O-acetyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(d/e)}$)-(1→3)-2-O-benzoyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (***27***). To a mixture of **12**[31] (2.02 g, 2.44 mmol) and **15**[22] (2.97 mg, 5.13 mmol) in dry CH_2Cl_2 (100 mL) was added MS4 Å (15 g, freshly dried) at room temperature. After the mixture was cooled to 0 °C, NIS (1.92 g, 8.27 mmol) and AgOTf (125 mg, 486 μmol) were added to the mixture. After being stirred for 3 h at the same temperature, the reaction was quenched by triethylamine, followed by filtration through Celite pad and washing of pad with $CHCl_3$. The combined solutions were washed with 20% aqueous $Na_2S_2O_3$, saturated aqueous $NaHCO_3$, and brine, dried over Na_2SO_4, and concentrated in vacuo. The residue was purified by flash column chromatography using gradient solvent system (hexane/ethyl acetate = 20/1 to 10/1 to 5/1 to 2/1) to give the title compound **27** (4.08 g, 96%). **27**: $[\alpha]^{26}_D$ 65.2 (*c* 1.00, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.00 (s, TBDPS, 9H), 1.02 (s, TBDPS, 9H), 1.32 (s, acetonide, 3H), 1.49 (s, acetonide, 3H), 1.76 (s, Ac, 3H), 1.91 (s, Ac, 3H), 1.93 (s, Ac, 3H), 1.95 (s, Ac, 3H), 3.57 (dd, *J* = 10.0, 6.8 Hz, C5−H^a, 1H), 3.63−3.83 (m, C5−H^b, C5−H^c, C5−H$_2^d$, C5−H$_2^e$, 6H), 3.84−3.93 (m, C5−H^a, C5−H^b, C5−H^c, 3H), 3.99−4.10 (m, C3−H^a, C2−H^b, C3−H^b, C4−H^d, C4−H^e, 5H), 4.12−4.18 (m, C4−H^b, 1H), 4.19−4.26 (m, C4−H^a, C4−H^c, 1H), 4.29−4.35 (m, C3−H^c, Bn, 2H), 4.42−4.59 (m, Bn, 6H), 4.64 (d, *J* = 4.0 Hz, C2−H^a, 1H), 5.03 (s, C1−H^b, 1H), 5.09 (d, *J* = 1.6 Hz, C2−H^e, 1H), 5.11 (s, C1−H^e, 1H), 5.16 (d, *J* = 2.0 Hz, C2−H^d, 1H), 5.20−5.25 (m, C3−H^d, C3−H^e, 2H), 5.25 (s, C1−H^c, 1H), 5.39 (d, *J* = 1.6 Hz, C2−H^c, 1H), 5.40 (s, C1−H^d, 1H), 5.88 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.10−8.08 (m, Ar, 40H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 19.2, 19.3, 20.4, 20.6, 20.7 (×2), 20.8, 26.4, 26.7, 27.2, 62.8 (×2), 65.4, 65.8, 66.9, 71.6, 71.9, 72.3, 76.8 (×2), 80.0, 80.4, 81.7 (×2), 81.8, 81.9, 82.2, 82.8, 82.9, 83.19, 83.22, 83.3, 85.3, 88.2, 104.9, 105.6, 105.6, 106.0, 106.3, 112.8, 127.61, 127.63, 127.7, 127.78, 127.84, 128.3, 128.36, 128.44, 128.5, 129.65, 129.72, 129.8, 133.13, 133.18, 133.37, 135.58, 135.60, 165.3, 169.6 (×2), 169.95, 170.04. ESI-TOF MS: $[M + Na]^+$ calcd for $C_{96}H_{112}O_{26}Si_2Na$, 1759.69, found 1759.33. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{96}H_{112}O_{26}Si_2Na$, 1759.6870, found 1759.6831.

2,3-Di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-(2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(d/e)}$)-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (***10***). To a solution of **27** (3.28 g, 1.89 mmol) in MeOH (100 mL) was added 1 M solution of NaOMe in MeOH (0.40 mL) at 0 °C. After being stirred for 2 h at the same temperature, and for 1 h at room temperature at the same temperature, the reaction was quenched by Amberlyst H^+ resin, filtered, and concentrated in vacuo to give a crude deacylated compound **28**. To a solution of crude **28** in dry DMF (20 mL) were added NaH (528 mg, 13.2 mmol) and BnBr (1.23 mL, 7.19 mmol) at 0 °C, and the mixture was stirred for 2 h, during which time temperature was going up to room temperature. The reaction was quenched by triethylamine and brine, extracted with $CHCl_3$, dried over Na_2SO_4, and evaporated in vacuo. The residue was purified by flash column chromatography using gradient solvent system (hexane/ethyl acetate = 20/1 to 10/1 to 5/1 to 3/1 to 1/1) to give the title compound **10** (2.99 g, 83% in two steps). **10**: $[\alpha]^{26}_D$ 59.0 (*c* 1.00, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.15 (s, TBDPS, 9H), 1.16 (s, TBDPS, 9H), 1.45 (s, acetonide, 3H), 1.64 (s, acetonide, 3H), 3.70 (dd, *J* = 10.8, 7.2 Hz, C5−H^a, 1H), 3.84 (dd, *J* = 12.0, 2.8 Hz, C5−H^b, 1H), 3.87−3.98 (m, C5−H^c, C5−H$_2^d$, C5−H$_2^e$, 1H), 4.00−4.05 (m, C5−H^a, C5−H^b, 2H), 4.08 (dd, *J* = 12.0, 4.8 Hz, C5−H^c, 1H), 4.16−4.34 (m, C3−H^a, C2−H^b, C3−H^b, C4−H^b, C2−H^c, C4−H^c, C2−H^d, C3−H^d, C4−H^d, C2−H^e, C3−H^e, C4−H^e, 12H), 4.33−4.39 (m, C4−H^a, 1H), 4.46 (dd, *J* = 6.8, 3.2 Hz, C3−H^c, 1H), 4.49−4.74 (m, Bn, 16H), 4.77 (d, *J* = 3.6 Hz, C2−H^a, 1H), 5.15 (s, C1−H^b, 1H), 5.28 (s, C1−H^c, 1H), 5.320 (s, C1−H^d, 1H), 5.324 (s, C1−H^e, 1H), 6.01 (d, *J* = 3.6 Hz, C1−H^a, 1H), 7.00−7.64 (m, Ar, 60H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 19.1, 19.2, 26.3, 26.67, 26.72, 27.1, 63.1, 63.3, 65.4, 65.9, 66.7, 71.47, 71.53, 71.57, 71.69, 71.74, 71.9, 72.0, 72.3, 80.0, 80.2, 81.1, 81.7, 82.2, 82.7 (×2), 82.8, 82.9, 83.1, 85.2, 87.8, 88.3, 88.5 (×2), 105.2, 105.5, 106.1, 106.3, 106.5, 112.7, 127.3, 127.47, 127.51, 127.56, 127.62, 127.8, 128.11, 128.14, 128.19, 128.23, 128.27, 128.35, 129.44, 129.5, 133.1, 133.3, 133.4, 135.45, 135.49, 135.53, 135.55, 137.2, 137.36, 137.42, 137.6, 137.8, 137.9, 137.1. ESI-TOF MS: $[M + Na]^+$ calcd for $C_{116}H_{130}O_{21}Si_2Na$, 1937.85, found 1937.44. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{116}H_{130}O_{21}Si_2Na$, 1937.8541, found 1937.8533.

2,3-Di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-(2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$)-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (***29***). To a solution of **10** (243.0 mg, 127 mmol) in dry THF (3 mL) was added 1 M solution of TBAF in THF (3.75 mL, 3.75 mmol) at room temperature. After being stirred for 4 h at the same temperature, the mixture was concentrated in vacuo. The residue was purified by flash column chromatography using gradient solvent system (hexane/ethyl acetate = 20/1 to 10/1 to 5/1 to 1/1 to 1/2 to 1/5) to give the title compound **29** (170.6 mg, 93%). **29**: $[\alpha]^{27}_D$ 67.6 (*c* 1.00, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.32 (s, acetonide, 3H), 1.50 (s, acetonide, 3H), 3.52−3.59 (m, C5−H^a, C5−H^e, 2H), 3.60−3.81 (m, C5−H^c, C5−H^b, C5−H$_2^d$, C3−H^e, C5−H^e, 6H), 3.84−3.94 (m, C5−H^a, C5−H^b, C5−H^c, C3−H^d, 4H), 3.99−4.11 (m, C3−H^a, C2−H^b, C3−H^b, C2−H^c, C4−H^c, C2−H^d, C2−H^e, C4−H^e, 8H), 4.12−4.18 (m, C4−H^b, 1H), 4.19−4.26 (m, C4−H^a, C4−H^d, 1H), 4.29−4.35 (m, C3−H^c, Bn, 2H), 4.40−4.60 (m, Bn, 15H), 4.65 (d, *J* = 4.0 Hz, C2−H^a, 1H), 5.01 (s, C1−H^b, 1H), 5.10 (s, C1−H^e, 1H), 5.13 (s, C1−H^c, C1−H^d, 2H), 5.88 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.10−7.40

(m, Ar, 40H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 26.4, 27.2, 62.7 (×2), 64.7, 66.0, 66.9, 71.7, 71.8, 71.9, 72.0, 72.1 (×2), 72.2, 72.3, 79.6, 80.3, 80.6, 81.8, 82.3, 82.8, 82.9 (×2), 83.0, 83.3, 85.2, 87.4, 88.4, 88.5, 88.6, 105.6, 105.9, 106.1 (×2), 106.2, 112.8, 127.69, 127.72, 127.78, 127.89, 128.16, 128.23, 128.35, 128.41, 137.23, 137.30, 137.35, 137.39, 137.44, 137.61, 137.65, 137.82. ESI-TOF MS: $[M + Na]^+$ calcd for $C_{84}H_{94}O_{21}Na$, 1461.62, found 1461.30. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{84}H_{94}O_{21}Na$, 1461.6185, found 1461.6152.

*3,5-Di-O-benzyl-α-D-arabinofuranosyl$^{(d)}$-(1→5)-(3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(e)}$)-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**8**).* To a mixture of **13**[31] (408 mg, 0.500 mmol, acceptor), **30**[22] (527 mg, 1.10 mmol, acceptor), and DTBMP (513 mg, 2.50 mmol) in dry CH_2Cl_2 (10 mL) was added MS4 Å (1.5 g, freshly dried) at room temperature. Next, MeOTf (283 mL, 2.50 mmol) was added to the mixture. After being stirred for 24 h at the same temperature, the reaction was quenched by triethylamine, followed by filtration through Celite pad and washing of pad with $CHCl_3$. The combined solutions were washed with saturated aqueous $NaHCO_3$ and brine, dried over Na_2SO_4, and concentrated in vacuo. To the crude mixture (**31**) in MeOH (10 mL) were added TEA (2 mL) and H_2O (1 mL) at room temperature. After being stirred for 2 d at the same temperature and concentrated in vacuo, the residue was purified by flash column chromatography using gradient solvent system (hexane/ethyl acetate = 20/1 to 10/1 to 5/1 to 2/1 to 1/1 to 1/2) to give deacylated compound **8** (670 mg, 93% in two steps). **8**: $[\alpha]^{25}_D$ 103.88 (*c* 1.03, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.33 (s, acetonide, 3H), 1.50 (s, acetonide, 3H), 3.26 (d, *J* = 9.2 Hz, C2−OH^e, 1H), 3.30 (d, *J* = 9.2 Hz, C2−OH^d, 1H), 3.41−3.46 (m, C5−H^d, C5−H^e, 2H), 3.53−3.60 (m, C5−H^a, C5−H^d, C5−H^e, 3H), 3.63 (dd, *J* = 11.2, 3.2 Hz, C5−H^b, 1H), 3.69 (dd, *J* = 12.0, 3.2 Hz, C5−H^c, 1H), 3.80−3.90 (m, C5−H^a, C5−H^b, C3−H^d, C3−H^e, 4H), 3.93 (dd, *J* = 12.0, 3.6 Hz, C5−H^c, 1H), 4.00−4.07 (m, C3−H^a, C2−H^c, C2−H^b, C3−H^b, 4H), 4.08−4.18 (m, C4−H^b, C4−H^c, C2−H^d, C2−H^e, 4H), 4.20−4.25 (m, C4−H^a, C4−H^e, 2H), 4.25−4.29 (m, C4−H^d, 1H), 4.33 (dd, *J* = 6.8, 4.0 Hz, C3−H^c, 1H), 4.20−4.25 (m, Bn, 16H), 4.65 (d, *J* = 4.0 Hz, C2−H^a, 1H), 5.00 (s, C1−H^b, 1H), 5.05 (s, C1−H^d, 1H), 5.06 (s, C1−H^e, 1H), 5.11 (s, C1−H^c, 1H), 5.89 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.20−7.40 (m, Ar, 50H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 26.4 (acetonide), 27.2 (acetonide), 65.4 (C5^b), 65.9 (C5^c), 66.9 (C5^a), 69.6 (C5$^{d/e}$), 69.7 (C5$^{d/e}$), 71.66 (Bn), 71.73 (Bn), 71.8 (×2, Bn), 72.1 (Bn), 72.3 (Bn), 73.6 (×2, Bn), 78.36 (C2$^{d/e}$), 78.42 (C2$^{d/e}$), 79.0 (C3^c), 80.2 (C4^b), 80.9 (C4^c), 82.3 (C4^d), 82.8 (C3^a), 82.9 (C4^a), 83.0 (C4^e), 83.2 (C3^b), 84.5 (C3^d), 84.8 (C3^e), 85.2 (C2^a), 87.5 (C2^c), 88.6 (C2^b), 105.6 (C1^a), 106.1 (C1^c), 106.2 (C1^b), 107.5 (C1^e), 109.2 (C1^d), 112.9 (acetonide), 127.6, 127.7, 127.8, 127.86, 127.90, 127.93, 128.0, 128.3, 128.42, 128.45, 128.53, 137.25, 137.31, 137.4, 137.5, 137.85, 137.89. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{84}H_{94}O_{21}Na$, 1461.62, found 1461.93. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{84}H_{94}O_{21}Na$, 1461.6185, found 1461.6187.

*4-Methylphenyl 2,3-Di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-(2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(d/e)}$)-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-2-O-acetyl-3-O-benzyl-1-thio-D-arabinofuranoside$^{(a)}$ (**9**).* A solution of **10** (162 mg, 845 μmol) in dioxane (2.0 mL), 10% aqueous HCl (0.2 mL), and 70% aqueous AcOH (2.0 mL) was stirred at 50 °C for 2 h. After being cooled to room temperature, the reaction was quenched with saturated aqueous $NaHCO_3$, extracted with $CHCl_3$, washed with brine, dried over Na_2SO_4, and concentrated in vacuo with azeotropic removal of H_2O with toluene. The residue was used without further purification. To a solution of the crude hemiacetal **32** and ditolyldisulfide (312 mg, 1.27 mmol) in dry THF (2.0 mL) was added *n*-Bu_3P (317 μL, 1.23 mmol) at 0 °C under Ar atmosphere. After being stirred for 2 h at the same temperature, the mixture was concentrated in vacuo. To the mixture (**33**) in pyridine (3.0 mL) were added Ac_2O (1.0 mL) and DMAP (5.0 mg) at room temperature, and the mixture was stirred for 1 h, during which time the temperature was going up to room temperature. After being concentrated in vacuo, the residue was purified by flash column chromatography using gradient solvent system (hexane/ethyl acetate = 50/1 to 30/1 to 10/1 to 5/1 to 3/1 to 2/1) to give the title compound **9** (120.9 mg, 71% in three steps) as a mixture of anomers. **9** (α-isomer), ^{1}H NMR ($CDCl_3$, 400 MHz): δ 0.99 (s, TBDPS, 9H), 1.00 (s, TBDPS, 9H), 1.45 (s, acetonide, 3H), 1.92 (s, Ac, 3H), 2.28 (s, Me, 3H), 3.60−3.98 (m, C5−H$_2^a$, C5−H$_2^b$, C5−H$_2^c$, C5−H$_2^d$, C5−H$_2^e$, 10H), 3.98−4.18 (m, C3−H^a, C2−H^b, C3−H^b, C4−H^b, C2−H^c, C4−H^c, C2−H^d, C3−H^d, C4−H^d, C2−H^e, C3−H^e, C4−H^e, 12H), 4.30 (dd, *J* = 7.6, 3.2 Hz, C3−H^c, 1H), 4.33−4.75 (m, C4−H^a, Bn, 17H), 5.03 (s, C1−H^b, 1H), 5.11 (s, C1−H^c, 1H), 5.147 (s, C1−H$^{d/e}$, 1H), 5.154 (s, C1−H$^{d/e}$, 1H), 5.28 (t, *J* = 2.0 Hz, C2−H^a, 1H), 5.45 (s, C1α−H^a, 1H), 7.00−7.64 (m, Ar, 64H). β-isomer: 5.41 (dd, *J* = 4.8, 2.8 Hz, C2β−H^a, 0.93H), 5.52 (d, *J* = 4.8 Hz, C1β−H^a, 0.93H). Selected ^{13}C NMR ($CDCl_3$, 100 MHz): δ 91.3 (C1^a), 105.3, 106.4, 106.5, 106.6. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{122}H_{134}O_{21}SSi_2Na$, 2045.86, found 2045.39. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{122}H_{134}O_{21}SSi_2Na$, 2045.8575, found 2045.8600.

*2,3-Di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(f1/2)}$-(1→5)-(2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(f1/2)}$)-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(e)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(d)}$-(1→5)-2-O-acetyl-3-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b1/2)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b1/2)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**34**).* To a mixture of Ara*f*$_3$ acceptor **11**[31] (14.4 mg, 15.9 μmol) and Ara*f*$_5$ donor **9** (35.3 mg, 17.4 μmol) in dry CH_2Cl_2 (2 mL) was added MS4 Å (250 mg, freshly dried) at room temperature. After the mixture was cooled to −30 °C, NIS (6.1 mg, 27.1 μmol) and AgOTf (1.0 mg, 3.9 μmol) were added to the mixture. After being stirred for 24 h at the same temperature and 3 h at −10 °C, the reaction was quenched by triethylamine and followed by filtration through Celite pad and washing of pad with $CHCl_3$. The combined solutions were washed with 20% aqueous $Na_2S_2O_3$, saturated aqueous $NaHCO_3$, and brine, dried over Na_2SO_4, and concentrated in vacuo. The residue was purified by gel filtration (Bio beads SX-3, toluene/ethyl acetate = 1/1) to give the title compound Ara*f*$_8$ **34** (33.1 mg, 73%). **34**: $[\alpha]^{23}_D$ 64.4 (*c* 1.0, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 0.98 (s, TBDPS, 9H), 0.99 (s, TBDPS, 9H), 1.31 (s, acetonide, 3H), 1.49 (s, acetonide, 3H), 1.86 (s, Ac, 3H), 3.50−3.93 (m, C5−H$_2^a$, C5−H$_2^{b1}$, C5−H$_2^{b2}$, C3−H^c, C5−H$_2^c$, C5−H$_2^d$, C5−H$_2^e$, C5−H$_2^{f1}$, C5−H$_2^{f2}$, 17H), 3.99−4.07 (m, C3−H^a, C2−H^{b1}, C3−H^{b1}, C4−H^{b1}, C2−H^{b2}, C3−H^{b2}, C4−H^{b2}, C4−H^c, C2−H^d, C3−H^d, C4−H^d, C2−H^e, C4−H^e, C2−H^{f1}, C3−H^{f1}, C4−H^{f1}, C2−H^{f2}, C3−H^{f2}, C4−H^{f2}, 19H), 4.19 (ddd, *J* = 6.8, 4.8, 3.6 Hz, C4−H^a), 4.26 (dd, *J* = 7.6, 4.0 Hz, C3−H^e), 4.26−4.58 (m, Bn, 25H), 4.63 (d, *J* = 4.0 Hz, C2−H^a), 4.70 (d, *J* = 12.4 Hz, Bn), 5.00 (s, C1−H$^{b/d}$, 2H), 5.08 (s, C1−H^c, 1H), 5.10 (s, C1−H$^{b/d}$, C1−H^e, 2H), 5.13 (d, *J* = 0.8 Hz, C1−H^f, 1H), 5.14 (s, C1−H^f, 1H), 5.15 (d, *J* = 1.2 Hz, C2−H^c, 1H), 5.87 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.15−7.70 (m, Ar, 85H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 19.2 (s), 19.3 (s), 20.8 (q), 26.4 (q), 26.75 (x3, q), 26.8075 (×3, q), 27.2 (q), 63.2 (t), 63.4 (t), 65.4 (t), 65.6 (t), 65.8 (t), 65.9 (t), 66.0 (t), 66.8 (t), 71.58 (t), 71.67 (×2, t), 71.77 (×2, t), 71.86 (t), 71.93 (t), 71.99 (t, ×2), 72.15 (t), 72.21 (t), 72.32 (t, ×2), 80.1 (d), 80.3 (d, ×2), 80.4 (d), 80.6 (d), 81.2 (d), 81.4 (d), 81.8 (d), 82.1 (d), 82.3 (d), 82.80 (×2, d), 82.88 (d, ×2), 82.97 (d), 83.1 (d), 83.2 (d), 83.3 (d), 85.4 (d), 87.9 (d), 88.0 (d), 88.36 (d), 88.46 (d), 88.54 (d), 88.59 (d), 88.63 (d), 105.3, (d), 105.6 (d), 106.1 (d), 106.2 (d), 106.4 (d, ×2), 106.5 (d), 106.6 (d), 112.9 (s), 127.41, 127.55, 127.60, 127,67, 127.70, 127.9, 128.0, 128.21, 128.24, 128.28, 128.32, 128.37, 128.46, 129.52, 129.6, 133.2, 133.40, 133.43, 133.5, 135.56, 135.60, 135.63, 135.7, 137.3, 137.46, 137.50, 137.54, 137.65, 137.67, 137.8, 137.90, 137.92, 138.0, 138.1, 138.2, 169.7. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{168}H_{186}O_{34}Si_2Na$, 2826.23, found 2826.00. HRMS ESI-TOF:

$[M + Na]^+$ calcd for $C_{168}H_{186}O_{34}Si_2Na$, 2826.2262, found 2826.2299.

*2,3-Di-O-benzyl-α-D-arabinofuranosyl$^{(d1/2)}$-(1→5)-(2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(d1/2)}$)-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**4**).* To a solution of **34** (52.7 mg, 18.8 μmol) in MeOH (2 mL)−THF (1 mL) was added 1 M NaOMe in MeOH (0.1 mL, 0.1 mmol) at 0 °C. After being stirred for 30 min at the same temperature, the reaction was quenched by Amberlyst H^+ resin, filtered, and concentrated in vacuo to give deacylated compound **35**. After azeotoropic removal of MeOH with toluene, to a solution of **35** in dry DMF (1 mL) were added NaH (1.1 mg, 27.5 μmol) and BnBr (2.5 μL, 21.0 μmol) at 0 °C, and the mixture was stirred for 2 h, during which time the temperature was going up to room temperature. The reaction was quenched by triethylamine and brine, extracted with $CHCl_3$, washed with brine, dried over Na_2SO_4, and evaporated in vacuo to give a crude mixture, which was used without further purification. To a solution of crude **36** in dry THF (1 mL) was added 1 M solution of TBAF in THF (50 μL, 50 mmol) at room temperature. After being stirred overnight at the same temperature, the mixture was concentrated in vacuo. The residue was purified by PTLC (toluene/ethyl acetate = 3/1) to give the title compound **4** (37.0 mg, 83% in three steps). **4**: $[\alpha]^{23}_D$ 18.1 (*c* 0.31, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.32 (s, acetonide, 3H), 1.49 (s, acetonide, 3H), 3.50−3.92 (m, C5−H_2^a, C5−H_2^{b1}, C5−H_2^{b2}, C5−H_2^{b3}, C5−H_2^{b4}, C5−H_2^c, C3−H^{d1}, C5−H_2^{d1}, C3−H^{d2}, C5−H_2^{d2}, 18H), 3.99−4.17 (m, C3−H^a, C2−H^{b1}, C3−H^{b1}, C4−H^{b1}, C2−H^{b2}, C3−H^{b2}, C4−H^{b2}, C2−H^{b3}, C3−H^{b3}, C4−H^{b3}, C2−H^{b4}, C3−H^{b4}, C4−H^{b4}, C2−H^c, C4−H^c, C2−H^{d1}, C4−H^{d1}, C2−H^{d2}, 18H), 4.18−4.25 (m, C4−H^a, C4−H^{d2}, 2H), 4.31 (dd, *J* = 6.0, 4.0 Hz, C3−H^c, 1H), 4.30−4.59 (m, Bn, 28H), 4.66 (d, *J* = 4.0 Hz, C2−H^a, 1H), 5.01 (s, C1−H^c, 1H), 5.10 (s, C1−H^{b1}, C1−H^{b2}, C1−H^{d1}, 3H), 5.12 (s, C1−H^{b3}, 1H), 5.13 (s, C1−H^{b4}, 1H), 5.11 (s, C1−H^{d2}, C1−H^e, 2H), 5.89 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.16−7.33 (m, Ar, 70H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 26.4 (q), 27.2 (q), 62.7 (t), 62.8 (t), 64.7 (t), 65.84 (t), 65.88 (t), 65.95 (t), 65.99 (t), 66.8 (t), 71.7 (t), 71.9 (t, ×4), 72.0 (t, ×3), 72.2 (t), 72.25 (t, ×4), 72.34 (t), 79.6 (d), 80.1 (d), 80.38 (d), 80.42 (d), 80.5 (d), 80.6 (d), 81.8 (d), 82.3 (d), 82.8 (d), 82.9 (d, ×3), 83.0 (d), 83.18 (d, ×2), 83.24 (d), 85.3 (d), 87.4 (d), 88.3 (d, ×3), 88.4 (d), 88.54 (d), 88.56 (d), 105.6 (d), 106.0 (d), 106.1 (d, ×2), 106.3 (d), 106.5 (d, ×3), 112.9 (s), 127.6, 127.7, 127.8, 127.86, 127.92, 128.0, 128.35, 128.39, 128.5, 137.25, 137.34, 137.48, 137.51, 137.61, 137.63, 137.7, 137.9, 138.0. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{141}H_{154}O_{33}Na$, 2398.03, found 2398.88. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{141}H_{154}O_{33}Na$, 2398.0270, found 2398.0271.

*2,3-Di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(f)}$-(1→5)-(2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(f)}$)-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-2-O-acetyl-3-O-benzyl-α-D-arabinofuranosyl$^{(e)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(d)}$-(1→5)-[2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(f)}$-(1→5)-(2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-α-D-arabinofuranosyl$^{(f)}$)-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-2-O-acetyl-3-O-benzyl-α-D-arabinofuranosyl$^{(e)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(d)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**37**).* To a mixture of Araf$_5$ acceptor **29** (7.6 mg, 5.28 μmol) and Araf$_5$ donor **9** (23.8 mg, 11.8 μmol) in dry CH_2Cl_2 (2 mL) was added MS4 Å (250 mg, freshly dried) at room temperature. After the mixture was cooled to −30 °C, NIS (4.2 mg, 18.1 μmol) and AgOTf (1.0 mg, 3.9 μmol) were added to the mixture. After being stirred for 6 h at the same temperature and 24 h at −10 °C, the reaction was quenched by triethylamine and followed by filtration through Celite pad and washing of pad with $CHCl_3$. The combined solutions were washed with 20% aqueous $Na_2S_2O_3$, saturated aqueous $NaHCO_3$, and brine, dried over Na_2SO_4, and concentrated in vacuo. The residue was purified by gel filtration (Bio beads SX-3, toluene/ethyl acetate = 1/1) and PTLC (hexane/EtOAc = 2:1) to give the title compound Araf$_{15}$ **37** (20.9 mg, 73%). **37**: $[\alpha]^{25}_D$ 60.0 (*c* 0.43, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 0.99 (s, TBDPS ×2, 18H), 1.00 (s, TBDPS ×2, 18H), 1.32 (s, acetonide, 3H), 1.49 (s, acetonide, 3H), 1.83 (s, Ac, 3H), 1.85 (s, Ac, 3H), 3.49−3.94 (m, C5−H_2^a, C5−H_2^{b1}, C5−H_2^{b2}, C5−H_2^{b3}, C5−H_2^{c1}, C5−H_2^{c2}, C5−H_2^{c3}, C5−H_2^{d1}, C5−H_2^{d2}, C3−H^{e1}, C5−H_2^{e1}, C3−H^{e2}, C5−H_2^{e2}, C5−H_2^{f1}, C5−H_2^{f2}, C5−H_2^{f3}, C5−H_2^{f4}, 32H), 3.95−4.17 (m, C3−H^a, C2−H^{b1}, C3−H^{b1}, C4−H^{b1}, C2−H^{b2}, C3−H^{b2}, C4−H^{b2}, C2−H^{b3}, C3−H^{b3}, C4−H^{b3}, C2−H^{c1}, C4−H^{c1}, C2−H^{c2}, C4−H^{c2}, C2−H_2^{c3}, C4−H_2^{c3}, C2−H^{d1}, C3−H^{d1}, C4−H^{d1}, C2−H^{d2}, C3−H^{d2}, C4−H^{d2}, C4−H^{e1}, C4−H^{e2}, C2−H^{f1}, C4−H^{f1}, C2−H^{f2}, C4−H^{f2}, C2−H^{f3}, C4−H^{f3}, C2−H^{f4}, C4−H^{f4}, C3−$H^{f1/2/3/4}$, C3−$H^{f1/2/3/4}$, C3−$H^{f1/2/3/4}$, 35H), 4.16−4.23 (m, C4−H^a, C3−$H^{f1/2/3/4}$, 2H), 4.24 (dd, *J* = 7.2, 3.2 Hz, C3−H^{c1}, 1H), 4.28 (dd, *J* = 6.8, 3.6 Hz, C3−H^{c2}, C3−H^{c3}, 2H), 4.31−4.60 (m, Bn, 30H), 4.64 (d, *J* = 4.0 Hz, C2−H^a, 1H), 4.69 (d, *J* = 12.4 Hz, Bn, 1H), 4.70 (d, *J* = 12.4 Hz, Bn, 1H), 4.97 (s, C1−$H^{b1/2/3}$, 1H), 4.99 (s, C1−$H^{b1/2/3}$, 1H), 5.00 (s, C1−$H^{b1/2/3}$, 1H), 5.08 (s, C1−H^{c1}, C1−$H^{e1/2}$, 2H), 5.10 (s, C1−H^{c2}, C1−H^{c3}, C1−$H^{e1/2}$, 3H), 5.15−5.18 (s ×8, C1−H^{d1}, C1−H^{d2}, C2−H^{e1}, C2−H^{e2}, C1−H^{f1}, C1−H^{f2}, C1−H^{f3}, C1−H^{f4}, 3H), 5.88 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.13−7.80 (m, Ar, 200H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 19.2, 19.3, 20.77, 20.78, 26.4, 26.7, 26.8, 27.2, 63.2 (×2), 63.4 (×2), 65.1, 65.2, 65.3 (×2), 65.5, 65.9 (×2), 66.0 (×2), 66.1, 66.9, 71.56 (×2), 71.66 (×4), 71.77 (×4), 71.86 (×2), 71.90 (×2), 71.98 (×2), 72.06 (×2), 72.11, 72.17, 72.23, 72.3 (×2), 72.4, 79.8, 79.9, 80.1 (×2), 80.22, 80.28, 80.32, 80.39, 81.18 (×2), 81.20 (×2), 82.15, 82.21, 82.3 (×2), 82.7, 82.8 (×4), 82.9, 83.0 (×3), 83.1 (×2), 83.2 (×2), 83.3, 85.3, 87.8, 87.9 (×2), 88.0, 88.5 (×3), 88.58 (×3), 88.64 (×3), 105.0, 105.3 (×2), 105.6, 105.00, 106.1, 106.2, 106.4 (×5), 106.6 (×3), (acetonide), 127.4, 127.55, 127.59, 127.65, 127.70, 127.86, 127.90, 127.94, 128.21, 128.23, 128.27, 128.32, 128.5, 129.5, 129.6, 133.2, 133.39, 133.42, 133.50, 135.55, 135.60, 135.63, 135.7, 137.3, 137.4, 137.5, 137.6, 137.90, 137.93, 138.06, 138.14, 138.2, 169.62, 169.64. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{314}H_{346}O_{63}NaSi_4$, 5259.28, found 5259.36. ESI-TOF: $[M + 2Na]^{2+}$ calcd for $[C_{314}H_{346}O_{63}Na_2Si_4]/2$, 2641.14, found 2641.62.

*2-O-Benzyl-3,5-O-(tetraisopropylsiloxane-1,3-diyl)-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-[2-O-benzyl-3,5-O-(tetraisopropylsiloxane-1,3-diyl)-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**38**).* To a mixture of Araf$_5$ acceptor **8** (230 mg, 160 μmol) and TIPDS-protected Araf donor **5**[21] (235 mg, 400 μmol) in dry CH_2Cl_2 (4 mL) was added MS4 Å (500 mg, freshly dried) at room temperature. After being cooled to −40 °C, NIS (126 mg, 560 μmol) and AgOTf (20.5 mg, 7.98 μmol) were added to the mixture. After being stirred for 4 h at the same temperature, the reaction was quenched by triethylamine, followed by filtration through Celite pad and washing of pad with $CHCl_3$. The combined solutions were washed with 20% aqueous $Na_2S_2O_3$, saturated aqueous $NaHCO_3$, and brine, dried over Na_2SO_4, and concentrated in vacuo. The residue was purified by gel filtration (Bio beads SX-3, toluene/ethyl acetate = 1/1) to give the title compound Araf$_7$ **38** (α:β = 8.46:1). **38** (major β,β-isomer), ^{1}H NMR ($CDCl_3$, 400 MHz): δ 0.80−1.05 (s, TIPDS, 28H), 1.25 (s, acetonide, 3H), 1.41 (s, acetonide, 3H), 3.40−3.53 (m, C5−H^a, C5−H^b, C5−H_2^d, C5−H_2^e, 6H), 3.70−3.90 (m, C5−H^a, C5−H^b, C5−H^c, C2−H^f, C4−H^f, C5−H_2^f, C2−H^g, C4−H^g, C5−H_2^g, 11H), 3.93−4.00 (m, C3−H^d, C3−H^e, C5−H^c, C2−H^b, C3−H^b, 5H), 4.00−4.40 (m, C3−H^a, C2−H^c, 2H), 4.06−4.20 (m, C4−H^a, C4−H^b, C4−H^c, C4−H^e, 4H), 4.24−4.31 (m, C3−H^c, C2−H^d,

C4−H^{d}, C2−H^{e}, 4H), 4.38−4.51 (m, C3−H^{f}, C3−H^{g}, Bn, 20H), 4.53−4.56 (m, C2−H^{a}, Bn, 3H), 4.94 (d, J = 4.8 Hz, C1b−H$^{f/g}$, 1H), 5.08 (d, J = 4.4 Hz, C1β−H$^{f/g}$, 1H), 4.88 (s, C1−H^{b}, 1H), 4.96 (s, C1−H^{c}, 1H), 5.00 (s, C1−H^{d}, C1−H^{e}, 2H), 5.80 (d, J = 4.0 Hz, C1−H^{a}, 1H), 7.00−7.64 (m, Ar, 50H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 12.4 (TIPDS), 12.7 (TIPDS), 13.2 (TIPDS), 13.3 (TIPDS), 16.97 (TIPDS), 17.03 (TIPDS), 17.30 (TIPDS), 17.36 (TIPDS), 17.45 (TIPDS), 26.4 (acetonide), 27.2 (acetonide), 65.2 (C5^{c}), 65.5 (C5^{d}), 66.2 (C5$^{f/g}$), 66.3 (C5$^{f/g}$), 66.7 (C5^{a}), 69.6 (C5$^{d/e}$), 69.8 (C5$^{d/e}$), 71.6 (×2, Bn), 71.7 (Bn), 71.9 (Bn), 72.0 (Bn), 72.23 (×2, Bn), 72.3 (Bn), 73.1 (×2, Bn), 79.98 (C3^{c}), 80.28 (C4$^{d/e}$), 80.44 (C4$^{d/e}$), 80.8 (×2, C4^{b}, C4^{c}), 81.37 (C4$^{g/f}$), 81.51 (C4$^{g/f}$), 81.61 (×2, C3^{f}, C3^{g}), 82.68 (C3^{a}), 82.78 (C4^{a}), 83.07 (C3^{b}), 83.89 (×2, C3^{d}, C3^{e}), 84.13 (C2$^{f/g}$), 84.23 (C2$^{f/g}$), 85.23 (C2^{a}), 85.82 (C2$^{d/e}$), 85.74 (C2$^{d/e}$), 88.32 (C2$^{b/c}$), 88.46 (C5$^{b/c}$), 98.77 (C1^{g}), 98.88 (C1^{f}), 105.32 (C1^{b}), 105.47 (C1^{a}), 106.04 (C1^{e}), 106.17 (C1^{d}), 106.55 (C1^{c}), 112.78 (acetonide), 127.37, 127.49, 127.53, 127.57, 127.60, 127.66, 127.78, 127.86, 128.1, 128.19, 128.23, 128.3, 128.4, 137.25, 137.39, 137.42, 137.5, 137.62, 137.67, 137.78, 137.84, 137.9, 138.0, 138.1. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{132}H_{174}O_{31}NaSi_4$, 2390.10, found 2390.02.

*2-O-Benzyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-[2-O-benzyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**39**).* To a solution of **38** in dry THF (5 mL) was added 1 M solution of TBAF in THF (1.0 mL, 1.0 mmol) at room temperature. After being stirred for 18 h at the same temperature, the mixture was concentrated in vacuo. The residue was purified by flash column chromatography using gradient solvent system (hexane/ethyl acetate = 20/1 to 5/1 to 2/1 to 1/1 to 1/2 to 1/5) to give the pure β,β-compound **39** (262.5 mg, 87% in two steps from **8** and **5**). **39**: $[\alpha]^{27}_{D}$ 21.8 (c 1.00, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.34 (s, acetonide, 3H), 1.50 (s, acetonide, 3H), 2.50−2.80 (br m, OH, 4H), 3.47−3.64 (m, C5−H^{a}, C5−H^{b}, C5−H$_2^{d}$, C5−H$_2^{e}$, C5−H$_2^{f}$, C5−H$_2^{g}$, 10H), 3.72−3.90 (m, C5−H^{a}, C5−H^{b}, C5−H^{c}, C2−H^{f}, C4−H^{f}, C2−H^{g}, C4−H^{g}, 10H), 3.96 (dd, J = 12.4, 4.0 Hz, C5−H^{c}), 4.00−4.06 (m, C3−H^{a}, C2−H^{b}, C3−H^{b}, C2−H^{c}, C3−H^{c}, 5H), 4.09 (dd, J = 6.8, 4.0 Hz, C3−H^{e}, 1H), 4.10−4.19 (m, C3−H^{d}, C4−H^{d}, C4−H^{b}, C4−H^{c}, 4H), 4.20−4.15 (m, C4−H^{a}, C4−H^{e}, 2H), 4.28−4.36 (m, C2−H^{d}, C2−H^{e}, C3−H^{f}, C3−H^{g}, 4H), 4.41−4.63 (m, Bn×10, 20H), 4.66 (d, J = 4.0 Hz, C2−H^{a}, 1H), 4.977 (d, J = 4.4 Hz, C1−H$^{f/g}$, 1H), 4.983 (s, C1−H^{b}, 1H), 5.03 (d, J = 4.4 Hz, C1−H$^{f/g}$, 1H), 5.07 (s, C1−H^{c}, 1H), 5.12 (s, C1−H^{e}, 1H), 5.14 (s, C1−H^{d}, 1H), 5.90 (d, J = 4.0 Hz, C1−H^{a}, 1H), 7.16−7.40 (m, Ar, 50H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 26.3 (acetonide), 27.1 (acetonide), 62.6 (C5$^{f/g}$), 62.7 (C5$^{f/g}$), 65.5 (C5^{c}), 65.7 (C5^{b}), 66.8 (C5^{a}), 69.2 (C5$^{d/e}$), 69.3 (C5$^{d/e}$), 71.57 (Bn), 71.61 (Bn), 71.93 (Bn), 71.99 (Bn), 72.06 (Bn), 72.31 (Bn), 72.38 (Bn), 73.20 (×2, Bn), 73.25 (Bn), 79.9 (C3^{c}), 80.2 (C4^{b}), 80.5 (C4^{e}), 80.77 (C4^{c}), 81.1 (C4^{d}), 81.86 (C5$^{f/g}$), 81.88 (C5$^{f/g}$), 82.7 (C3^{a}), 82.87 (C3$^{b/d/e}$), 82.90 (C3$^{b/d/e}$), 82.94 (C3$^{b/d/e}$), 83.3 (C4^{a}), 84.1 (×2, C2^{f}, C2^{g}), 85.1 (C2^{a}), 85.6 (×2, C2$^{d/e}$, C2$^{f/g}$), 85.7 (×2, C2$^{d/e}$, C2$^{f/g}$), 88.3 (C2^{b}), 88.4 (C2^{c}), 99.3 (×2, C1^{f}, C1^{g}), 105.2 (C1^{d}), 105.5 (C1^{a}), 106.07 (C1^{e}), 106.16 (C1^{c}), 106.24 (C1^{b}), 112.81 (acetonide), 127.55, 127.60, 127.63, 127.66, 127.71, 127.77, 127.99, 128.15, 128.23, 128.29, 128.38, 128.42, 128.46, 128.96, 137.24, 137.34, 137.52, 137.54, 137.77, 137.80, 137.85, 137.90. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{108}H_{122}O_{29}Na$, 1905.80, found 1905.51. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{108}H_{122}O_{29}Na$, 1905.7970, found 1905.7954.

*2,3-Di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-[2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**3**).* To a solution of tetraol **39** (242 mg, 0.128 mmol) and imidazole (43.5 mg, 0.639 mmol) in dry DMF (2 mL) was added TBDPSCl (74.9 mL, 0.282 mmol) at 0 °C. After the mixture was stirred for 18 h at room temperature, further imidazole (22.0 mg, 0.323 mmol) and TBDPSCl (37.5 μL, 0.141 mmol) were added to the reaction mixture. After being stirred for 6 h at room temperature, the reaction was quenched by saturated aqueous $NaHCO_3$ and extracted with $CHCl_3$. The combined organic phase was washed with brine, dried over Na_2SO_4, and concentrated in vacuo. The residue was purified by flash column chromatography using gradient solvent system (hexane/ethyl acetate = 100/1 to 50/1 to 25/1 to 10/1 to 5/1 to 2/1 to 1/1) to give diol **40**. To a solution of diol **40** in dry DMF (2 mL) were added NaH (18.6 mg) and BnBr (40.5 mL, 43.3 mmol) at 0 °C. After being stirred for 2 h at room temperature, the reaction was quenched by triethylamine and brine, and extracted with $CHCl_3$. The combined organic phase was washed with brine, dried over Na_2SO_4, and concentrated in vacuo. The residue was purified by flash column chromatography using gradient solvent system (hexane/ethyl acetate = 100/1 to 50/1 to 25/1 to 10/1 to 5/1 to 1/1) to give the title compound **3** (0.273 g, 84% in two steps). **3**: $[\alpha]^{23}_{D}$ 10.2 (c 1.00, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 1.03 (s, TBDPS, 9H), 1.34 (s, acetonide, 3H), 1.51 (s, acetonide, 3H), 3.43−3.52 (m, C5−H$_2^{d}$, C5−H$_2^{e}$, 4H), 3.54 (dd, J = 10.4, 6.8 Hz, C5−H^{a}, 1H), 3.61 (dd, J = 12.0, 3.2 Hz, C5−H^{b}, 1H), 3.72 (dd, J = 12.0, 2.8 Hz, C5−H^{c}, 1H), 3.77−3.90 (m, C5−H^{a}, C5−H^{b}, C3−H^{d}, C3−H^{e}, C5−H$_2^{f}$, C5−H$_2^{g}$, 8H), 3.93−4.17 (m, C3−H^{a}, C2−H^{b}, C3−H^{b}, C4−H^{b}, C2−H^{c}, C4−H^{c}, C5−H^{c}, C4−H^{d}, C2−H^{f}, C3−H^{f}, C4−H^{f}, C2−H^{g}, C3−H^{g}, C4−H^{g}, Bn, 16H), 4.17−4.23 (m, C4−H^{a}, 1H), 4.23−4.26 (m, C2−H^{d}, C4−H^{e}, 2H), 4.27−4.32 (m, C3−H^{c}, C2−H^{e}, 2H), 4.34−4.62 (m, Bn, 22H), 4.66 (d, J = 4.0 Hz, C2−H^{a}, 1H), 4.94 (d, J = 4.4 Hz, C1β−H^{f}, 1H), 4.97 (s, C1−H^{b}, 1H), 5.06 (s, C1−H^{c}, 1H), 5.08 (d, J = 4.4 Hz, C1β−H^{g}, 1H), 5.11 (s, C1−H^{d}, C1−H^{e}, 2H), 5.89 (d, J = 4.0 Hz, C1−H^{a}, 1H), 7.00−7.64 (m, Ar, 80H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 19.1 (×2, tBu), 26.4 (acetonide), 26.8 (×2, tBu), 27.2 (acetonide), 65.3 (C5^{c}), 65.7 (C5^{b}), 66.1 (C5^{f}/C5^{g}), 66.2 (C5^{f}/C5^{g}), 66.8 (C5^{a}), 69.9 (C5^{d}), 70.1 (C5^{e}), 71.6 (Bn), 71.7 (Bn), 72.0 (×3, Bn), 72.16 (×3, Bn), 72.25 (Bn), 72.32 (Bn), 73.07 (Bn), 73.11 (Bn), 79.9 (C3^{c}), 80.41 (C4^{b}/C4^{c}), 80.44 (C4^{b}/C4^{c}), 81.4 (C4^{e}), 81.8 (×3, C4^{d}, C4^{f}, C4^{g}), 81.9 (C3^{e}), 82.8 (C2^{c}), 82.9 (C3^{a}), 83.2 (C4^{a}), 84.0 (C2^{f}/C4^{f}/C2^{g}/C4^{g}), 84.1 (C2^{f}/C4^{f}/C2^{g}/C4^{g}), 84.2 (×2, C2^{f}/C4^{f}/C2^{g}/C4^{g}), 84.52 (C2^{f}/C4^{f}/C2^{g}/C4^{g}), 84.5 (C3^{e}), 84.7 (C3^{d}), 85.3 (C2^{a}), 85.4 (C2^{e}), 85.7 (C2^{d}), 88.4 (C2^{b}), 100.2 (C1^{f}), 100.6 (C1^{g}), 105.2 (C1^{d}), 105.5 (C1^{a}), 106.2 (C1^{c}), 106.2 (C1^{b}), 106.4 (C1^{e}), 112.9 (acetonide), 127.26, 127.30, 127.34, 127.37, 127.49, 127.53, 127.62, 127.73, 127.83, 127.90, 127.97, 128.04, 128.21, 128.24, 128.26, 128.28, 128.36, 128.44, 129.71, 133.06, 133.15, 133.19, 135.5, 137.3, 137.5, 137.64, 137.70, 137.73, 137.89, 137.93, 138.0, 138.2, 138.3. HMBC δ_H 4.94 (C1−H^{f}) → δ_C 85.4 (C2^{d}), 4.98 (C1−H^{b}) → δ_C 66.8 (C5^{a}), δ_H 5.06 (C1−H^{c}) → δ_C 65.7 (C5^{b}), δ_H 5.08 (C1−H^{g}) → δ_C 85.7 (C2^{e}), δ_H 5.11 (C1−H^{d}) → δ_C 65.3 (C5^{c}), δ_H 5.11 (C1−H^{e}) → δ_C 79.9 (C3^{c}). MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{154}H_{170}O_{29}NaSi_2$, 2562.13, found 2561.99. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{154}H_{170}O_{29}NaSi_2$, 2562.1264, found 2562.1268.

*4-Methylphenyl 2,3-Di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-[2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-2-O-acetyl-3-O-benzyl-1-thio-D-arabinofuranoside$^{(a)}$ (**2**).* A solution of acetonide **3** (10.5 mg, 4.13 μmol) in dioxane (2 mL), 10% aqueous HCl (0.2 mL), and 70% aqueous AcOH (2.0 mL) was stirred at 50 °C for 3 h. After the mixture was cooled to room temperature and quenched with saturated aqueous $NaHCO_3$, the residue was extracted with AcOEt, and the combined organic phase was washed with brine and dried over Na_2SO_4. After concentration in vacuo and azeotropic removal of H_2O with toluene, the residue was used without further purification. To a solution of the crude hemiacetal **41** and ditolyldisulfide (16.0 mg,

64.9 μmol) in CH_2Cl_2 (1.0 mL) was added *n*-Bu_3P (16.0 μL, 64.1 μmol) at 0 °C under Ar atmosphere. After being stirred for 24 h at room temperature, the mixture was concentrated in vacuo to give crude **42** (MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{158}H_{172}O_{28}SSi_2Na$, 2628.12, found 2628.59. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{158}H_{172}O_{28}SSi_2Na$, 2628.1192, found 2628.1163). To the mixture in pyridine (2.0 mL) were added Ac_2O (0.5 mL) and DMAP (10 mg) at room temperature. After the mixture was stirred for 24 h at the same temperature, to the mixture was added ice water. The residue was extracted with AcOEt, and the combined organic phase was washed with H_2O, aqueous saturated $KHSO_4$, H_2O, aqueous saturated $NaHCO_3$, and brine, and dried over Na_2SO_4, then concentrated in vacuo. The residue was purified by PTLC (hexane/ethyl acetate = 4/1) to give the title compound **2** (8.3 mg, 76% in three steps). **2** (α-isomer), ^1H NMR ($CDCl_3$, 400 MHz): δ 0.97 (s, TBDPS ×2, 18H), 1.89 (s, Ac, 3H), 2.26 (s, Me, 3H), 3.39−3.46 (m, C5−H_2^d, C5−H_2^e, 4H), 3.52−3.58 (m, C5−H^a, C5−H^b, 2H), 3.63−3.81 (m, C5−H^a, C5−H^b, C5−H^c, C3−H^d, C3−H^e, C5−H_2^f, C5−H_2^g, 9H), 3.88−4.13 (m, C2−H^b, C3−H^b, C4−H^b, C2−H^c, C4−H^c, C5−H^c, C4−H^e, C2−H^f, C3−H^f, C4−H^f, C2−H^g, C3−H^g, C4−H^g, Bn, 15H), 4.16−4.22 (m, C4−H^d, C2−H^e, 2H), 4.22−4.27 (m, C3−H^c, C2−H^d, 5H), 4.28−4.66 (m, C4−H^a, Bn, 23H), 5.06 (d, *J* = 4.4 Hz, C1−$H^{f/g}$, 1H), 5.06 (s, C1−H^c, 1H), 5.06 (m, C1−H^b, C1−$H^{f/g}$, 2H), 5.06 (s, C1−H^d, C1−H^e, 2H), 5.25 (t, *J* = 1.2 Hz, C1α−H^a, 1H), 5.42 (s, C1α-H^a, 1H), 6.96−7.60 (m, Ar, 84H); β-isomer, 5.38 (dd, *J* = 4.8, 2.0 Hz, C2β−H^a, 0.43H), 5.49 (d, *J* = 4.8 Hz, C1β−H^a, 0.43H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 91.3 ($C1^a$), 100.2, (×2, $C1^f$, $C1^g$), 105.2 ($C1^{d/e}$), 106.2 ($C1^c$), 106.4 ($C1^b$), 106.5 ($C1^{d/e}$). MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{160}H_{174}O_{29}SSi_2Na$, 2670.13, found 2670.05. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{160}H_{174}O_{29}SSi_2Na$, 2670.1298, found 2670.1314.

5-O-Acetyl-2,3-di-O-benzyl-β-D-arabinofuranosyl$^{(b)}$-(1→2)-3,5-di-O-[D_7]benzyl-α-D-arabinofuranoside$^{(a)}$ (**49**). To a mixture of acceptor **44**[31] (21.0 mg, 47.6 μmol), 5-*O*-NAP-protected donor **43**[31] (26.2 mg, 52.3 μmol), and dried powdered MS4 Å (250 mg) in dry $(CH_2Cl)_2$ (2.0 mL) was added DDQ (10.3 mg, 49.8 μmol) at room temperature under Ar atmosphere. The mixture was stirred for 18 h at the same temperature, quenched with aqueous ascorbate buffer,[24] and filtered through Celite. The filtrate was extracted with $CHCl_3$, and washed with saturated aqueous $NaHCO_3$ and brine. A combined organic layer was dried over Na_2SO_4 and evaporated in vacuo. The crude product was purified by gel filtration chromatography (SX-3, EtOAc−toluene = 1:1) to give mixed acetal **46a** (36.9 mg, 82%) as the mixture of diastereomers. To the mixed acetal (20.0 mg, 21.3 μmol), DTBMP (17.5 mg, 85.2 μmol), and MS4 Å (1.5 g) in dry $(CH_2Cl)_2$ (21.3 mL) was added MeOTf (8.2 μL, 72.6 mmol) at room temperature under Ar atmosphere. The mixture was stirred for 3 d at the same temperature. The reaction mixture was quenched with triethylamine, diluted with EtOAc, and filtered through Celite. The filtrate was washed with saturated aqueous $NaHCO_3$ and brine. The washed organic layer was dried over Na_2SO_4 and evaporated in vacuo to give the crude product. To the crude mixture in CH_2Cl_2 (2.0 mL) was added TFA (0.2 mL) at 0 °C, and the mixture was stirred for 30 min at the same temperature. After evapolation, the resultant mixture was treated with Ac_2O (0.5 mL) in pyridine (1.0 mL) for 12 h at room temperature, and then evaporated in vacuo. The crude product was purified by gel filtration chromatography (SX-3, EtOAc−toluene = 1:1) to give the product **49** (6.0 mg, 34% from mixed acetal, β). **49**: $[\alpha]^{27}_D$ 1.77 (*c* 0.68, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz): δ 1.92 (s, Ac, 3H), 3.56 (dd, *J* = 11.2, 6.4 Hz, C5−H^a, 1H), 3.60 (dd, *J* = 11.2, 4.0 Hz, C5−H^a, 1H), 3.96−4.13 (m, C2−H^b, C3−H^a, C3−H^b, C4−H^b, C5−H^b, 5H), 4.15−4.22 (m, C5−H^b 1H), 4.24−4.28 (m, C4−H^a, 1H), 4.34 (d, *J* = 2.4, Hz, C2−H^a), 4.00−4.06 (m, C3−H^a, C2−H^b, C3−H^b, C2−H^c, 4H), 4.32−4.57 (m, Bn ×11, 22H), 4.61 (d, *J* = 4.0 Hz, C2−H^a, 1H), 4.39 (d, *J* = 12.0 Hz, Bn, 1H), 4.45 (d, *J* = 12.0 Hz, Bn, 1H), 4.56 (d, *J* = 12.0 Hz, Bn, 1H), 4.67 (d, *J* = 12.0 Hz, Bn, 1H), 4.96 (d, *J* = 4.4 Hz, C1−H^b, 1H), 5.05 (s, C1−H^a, 1H), 7.22−7.35 (m, Ar, 10H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 20.7 (Ac), 66.0 ($C5^b$), 69.8 ($C5^a$), 72.4 (Bn), 72.5 (Bn), 78.7 ($C4^b$), 81.4 ($C4^a$), 82.2 ($C3^b$), 83.6 ($C3^a$), 84.1 ($C2^b$), 86.5 ($C2^a$), 100.5 ($C1^b$), 104.7 ($C1^a$), 127.7, 127.8, 128.0, 128.4, 128.5, 137.3, 137.7, 170.6. ESI-TOF MS: $[M + Na]^+$ calcd for $C_{47}H_{29}D_{21}O_{10}Na$, 818.46, found 818.39. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{47}H_{29}D_{21}O_{10}Na$, 818.4620, found 818.4585.

General Procedure for IAD Using NIS−AgOTf as the Activator. *2,3-Di-O-benzyl-β-D-arabinofuranosyl$^{(c)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$* (**51**). To a mixture of acceptor **45**[31] (25.2 mg, 41.0 μmol), 5-*O*-NAP-protected donor **7**[31] (26.0 mg, 45.1 μmol), and dried powdered MS4 Å (250 mg) in dry $(CH_2Cl)_2$ (2.0 mL) was added DDQ (6.5 mg, 49.8 μmol) at room temperature under Ar atmosphere. The mixture was stirred for 18 h at the same temperature, quenched with aqueous ascorbate buffer, and filtered through Celite. The filtrate was extracted with $CHCl_3$, and washed with saturated aqueous $NaHCO_3$ and brine. A combined organic layer was dried over Na_2SO_4 and evaporated in vacuo. The crude product was purified by gel filtration (SX-3, EtOAc−toluene = 1:1) to give a crude mixed acetal. To the crude mixed acetal and MS4 Å (1.5 g) in dry CH_2Cl_2 (20.0 mL) were added NIS (16.2 mg, 71.9 μmol) and AgOTf (1.1 mg, 4.3 μmol) at −30 °C under Ar atmosphere. The mixture was stirred for 12 h at the same temperature. The reaction mixture was quenched with triethylamine, diluted with EtOAc, and filtered through Celite. The filtrate was washed with 20% aqueous $Na_2S_2O_3$, saturated aqueous $NaHCO_3$, and brine. The washed organic layer was dried over Na_2SO_4 and evaporated in vacuo to give the crude product including the diastereomeric mixture of (2-naphthyl)-(succinimido)methyl ether (HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{68}H_{71}O_{15}NNa$, 1164.4721, found 1164.4672). The crude mixture in $(CH_2NH_2)_2$ (0.25 mL) and *n*-BuOH (3.0 mL) was stirred at 80 °C for 3 d, then evaporated in vacuo. The crude product was purified by gel filtration chromatography (SX-3, EtOAc−toluene = 1:1) to give the product **51** (24.2 mg, 65% from **45**, ββ). **51**: $[\alpha]^{25}_D$ −2.80 (*c* 0.50, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz): δ 1.31(s, acetonide, 3H), 1.49 (s, acetonide, 3H), 2.25−2.37 (br m, OH, 1H), 3.47−3.60 (m, C5−H^a, C5−H_2^b, C5−H_2^c, 5H), 3.87 (dd, *J* = 10.8, 5.6 Hz, C5−H^a, 1H), 3.93−3.98 (m, C4−H^c, 1H), 4.02−4.06 (m, C3−H^a, C2−H^c, 2H), 4.09−4.17 (m, C3−H^b, C4−H^b, 2H), 4.18−4.27 (m, C4−H^a, C2−H^b, C3−H^c, 3H), 4.42−4.58 (m, Bn, 8H), 4.60 (d, *J* = 12.0 Hz, Bn, 1H), 4.63 (d, *J* = 4.0 Hz, C2−H^a, 1H), 4.70 (d, *J* = 12.0 Hz, Bn, 1H), 4.66 (d, *J* = 12.0 Hz, Bn, 1H), 5.00 (s, C1−H^b, 1H), 5.01 (d, *J* = 4.0 Hz, C1−H^c, 1H), 5.87 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.23−7.345 (m, Ar, 25H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 26.4 (acetonide), 27.2 (acetonide), 63.4 ($C5^c$), 66.9 ($C5^a$), 69.3 ($C5^b$), 71.7 (Bn), 72.2 (Bn), 72.5 (Bn), 72.7 (Bn), 73.4 (Bn), 80.4 ($C4^a$), 80.9 ($C4^b$), 82.8 ($C4^c$), 82.81 ($C3^a$), 82.83 ($C3^c$), 83.1 ($C3^b$), 84.0 ($C2^c$), 85.3 ($C2^a$), 86.3 ($C2^b$), 100.2 ($C1^c$), 105.6 ($C1^a$), 106.0 ($C1^b$), 112.9 (acetonide), 127.66, 127.71, 127.80, 127.84, 128.0, 128.32, 128.37, 128.43, 128.45, 128.51, 137.3, 137.5, 137.8, 137.9, 138.0. ESI-TOF MS: $[M + Na]^+$ calcd for $C_{53}H_{60}O_{13}Na$, 927.39, found 927.32. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{53}H_{60}O_{13}Na$, 927.3932, found 927.3911.

[D_7]Benzyl 2,3-Di-O-benzyl-β-D-arabinofuranosyl$^{(b)}$-(1→2)-3,5-di-O-[D_7]benzyl-α-D-arabinofuranoside$^{(a)}$ (**48**). This compound **48** was synthesized from **44**[31] according to the general procedure for IAD using NIS−AgOTf as the activator synthesis (82% for mixed acetal formation with **6** and 72% from mixed acetal **46b**, α:β = 1:>20) (58% from mixed acetal **46a**, α:β = 1:>20). **48**: $[\alpha]^{27}_D$ 1.18 (*c* 0.38, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz): δ 2.22−2.37 (br m, OH, 1H), 3.45−3.67 (m, C5−H_2^a, C5−H_2^b, 4H), 3.95 (ddd, *J* = 6.8, 4.8, 3.2 Hz, C4−H^b, 1H), 4.01 (dd, *J* = 7.6, 4.4 Hz, C2−H^b, 1H), 4.10 (dd, *J* = 7.6, 4.4 Hz, C3−H^a, 1H), 4.16−4.28 (m, C3−H^b, C4−H^a, 2H), 4.31 (dd, *J* = 4.0, 1.6 Hz, C2−H^a, 1H), 4.40 (d, *J* = 12.0 Hz, Bn, 1H), 4.45 (d, *J* = 12.0 Hz, Bn, 1H), 4.55 (d, *J* = 12.0 Hz, Bn, 1H), 4.68 (d, *J* = 12.0 Hz, Bn, 1H), 4.96 (d, *J* = 4.4 Hz, C1−H^b, 1H), 5.05 (d, *J* = 1.6 Hz, C1−H^a, 1H), 7.21−7.35 (m, Ar, 10H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 63.3 ($C5^b$), 69.4 ($C5^a$),

72.4 (Bn), 72.6 (Bn), 80.5 ($C3^b$), 80.9 ($C4^a$), 82.0 ($C4^b$), 83.1 ($C3^a$), 83.9 ($C2^b$), 86.5 ($C2^a$), 100.2 ($C1^b$), 104.7 ($C1^a$), 127.7, 128.0, 128.4, 128.5, 137.4, 138.0. ESI-TOF MS: $[M + Na]^+$ calcd for $C_{45}H_{27}D_{21}O_9Na$, 776.45, found 776.39. HRMS ESI-TOF: $[M + Na]^+$ calcd for $C_{47}H_{29}D_{21}O_{10}Na$, 776.4478, found 776.4514.

2,3,5-Tri-O-acetyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-[2,3,5-tri-O-acetyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**53**). To a mixture of acceptor **8** (81.2 mg, 56.4 μmol), 2-*O*-NAP-protected donor **6**[27] (29.5 mg, 124 μmol), and dried powdered MS4 Å (250 mg) in dry CH_2Cl_2 (2.0 mL) was added DDQ (45.2 mg, 199 μmol) at room temperature under Ar atmosphere. The mixture was stirred for 20 h, quenched with aqueous ascorbate buffer, and filtered through Celite. The filtrate was extracted with $CHCl_3$, and washed with saturated aqueous $NaHCO_3$ and brine. A combined organic layer was dried over Na_2SO_4 and evaporated in vacuo. The crude product was purified by gel filtration chromatography (SX-3, EtOAc−toluene = 1:1) to give mixed acetal (119 mg, 82%) as the mixture of diastereomers (MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{142}H_{182}O_{31}Si_4Na$, 2582.10, found 2582.47). To the mixed acetals were added DTBMP (76.4 mg, 372 μmol) and MS4 Å in dry $(CH_2Cl)_2$ (5.0 mL) at room temperature under Ar atmosphere. Next, MeOTf (35.8 μL, 316 μmol) was added to the mixture, and the mixture was stirred for 18 h at the same temperature. The reaction mixture was quenched with triethylamine, diluted with EtOAc, and filtered through Celite. The filtrate was washed with saturated aqueous $NaHCO_3$ and brine. The washed organic layer was dried over Na_2SO_4 and evaporated in vacuo to give the diastereomeric mixture of 5,5′-naphylidene acetal (MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{129}H_{168}O_{31}Si_4Na$, 2348.05, found 2348.93) and product (MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{118}H_{162}O_{31}Si_4Na$, 2210.01, found 2210.06). The mixture in THF (3.0 mL) and 70% AcOH (3.0 mL) was stirred at 80 °C for 2 d, then evaporated in vacuo. At this stage, the hydrolysis of TIPDS group was observed. After azeotropic removal of acetic acid with toluene, the mixture was treated with TBAF in THF for 18 h at room temperature. After evaporation, to the mixture were added pyridine (2.0 mL), Ac_2O (0.5 mL), and DMAP (5.0 mg). The mixture was stirred for 12 h at room temperature. After addition of ice water, the residue was diluted with EtOAc, and washed with H_2O, saturated aqueous $NaHCO_3$ $KHSO_4$, H_2O, saturated aqueous $NaHCO_3$ and brine. The washed organic layer was dried over Na_2SO_4 and evaporated in vacuo. The crude product was purified by PTLC (toluene−EtOAc = 3:1) to give the product **53** (65.2 mg, 73% from mixed acetal, ββ) as the hexaacetate. **53**: $[\alpha]^{23}_D$ 35.4 (*c* 1.27, $CHCl_3$). ^1H NMR ($CDCl_3$, 400 MHz): δ 1.25 (s, acetonide, 3H), 1.42 (s, acetonide, 3H), 1.80 (s, Ac, 3H), 1.84 (s, Ac, 3H), 1.85 (s, Ac, 3H), 1.88 (s, Ac, 3H), 2.00 (s, Ac, 3H), 2.01 (s, Ac, 3H), 3.40−3.52 (m, C5−H^c, C5−$H_2{}^d$, C5−$H_2{}^e$, 5H), 3.58 (dd, *J* = 12.0, 3.6 Hz, C5−H^b), 3.64 (dd, *J* = 12.0, 2.0 Hz, C5−H^a), 3.76 (dd, *J* = 12.0, 4.4 Hz, C5−H^b), 3.78−3.83 (m, C5−H^a, C5−H^c, 2H), 3.85 (dd, *J* = 6.4, 2.4 Hz, C3−H^d), 3.64 (dd, *J* = 6.4, 2.0 Hz, C3−H^e), 3.93−4.03 (m, C3−H^a, C2−H^b, C3−H^b, C2−H^c, C3−H^c, C4−H^f, C5−H^f, C4−H^g, C5−H^g, 9H), 4.03−4.08 (m, C4−H^b, C4−H^e, 2H), 4.11−4.18 (m, C4−H^c, C4−H^d, 2H), 4.19−4.23 (m, C4−H^a, C2−H^e, 2H), 4.19−4.23 (m, C2−H^d, C5−H^f, C5−H^g, 3H), 4.32−4.58 (m, C2−H^a, Bn ×8, 17H), 4.83−4.88 (m, C2−H^f, C2−H^g, 2H), 4.91 (s, C1−H^d, 1H), 4.93 (s, C1−H^c, 1H), 4.95 (s, C1−H^e, 1H), 5.06 (s, C1−H^b, 1H), 5.20−5.22 (m, C3−H^f, C3−H^g, 2H), 5.23 (d, *J* = 4.8 Hz, C1−$H^{f/g}$, 1H), 5.27 (d, *J* = 4.8 Hz, C1−$H^{f/g}$, 1H), 5.80 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.10−7.30 (m, Ar, 40H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 20.2 (Ac), 20.4 (Ac), 20.6 (Ac ×2), 20.7 (Ac ×2), 26.4 (acetonide), 27.2 (acetonide), 65.20 ($C5^a$), 65.3 ($C5^{f/g}$), 65.4 ($C5^{f/g}$), 65.8 ($C5^b$), 66.8 ($C5^c$), 69.2 ($C5^e$), 69.6 ($C5^d$), 71.7 (Bn ×2), 71.9 (Bn), 71.95 (Bn), 72.04 (Bn), 72.3 (Bn), 73.20 (Bn), 73.23 (Bn), 75.7 ($C3^f$, $C3^g$), 76.4 ($C2^{f/g}$), 76.6 ($C2^{f/g}$), 78.3 ($C4^{f/g}$), 78.5 ($C4^{f/g}$), 79.7 ($C4^a$), 80.4 ($C4^b$), 80.6 ($C3^a$), 81.0 ($C4^d$), 81.4 ($C4^e$), 82.8 ($C4^c$), 82.9 ($C3^c$), 83.2 ($C3^b$), 83.8 ($C3^e$), 83.9 ($C3^d$), 85.3 ($C2^a$), 85.9 ($C2^d$), 86.2 ($C2^e$), 88.4 ($C2^c$), 88.5 ($C2^b$), 99.8 ($C1^{f/g}$), 99.8 ($C1^{f/g}$), 104.7 ($C1^e$), 105.5 ($C1^a$), 106.1 ($C1^d$), 106.2 ($C1^{b/c}$, $C1^{b/c}$), 112.8 (acetonide), 127.4, 127.5, 127.6, 127.67, 127.73, 127.75, 127.83, 127.9, 128.2, 128.3, 128.36, 128.42, 137.3, 137.5, 137.9, 137.97, 138.02, 138.06, 138.11, 170.01, 170.03 (×2), 170.07, 170.45, 170.48. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{106}H_{122}O_{35}Na$, 1977.77, found 1977.70.

2,3-Di-O-benzyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$-(1→5)-[2,3-di-O-benzyl-β-D-arabinofuranosyl$^{(f/g)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(d/e)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(c)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**55**). To a mixture of diol acceptor **8** (35.5 mg, 24.7 μmol), 5-*O*-NAP-protected donor **7**[28] (31.7 mg, 54.3 μmol), and dried powdered MS4 Å (250 mg) in dry $(CH_2Cl)_2$ (2.0 mL) was added DDQ (19.1 mg, 84.1 μmol) at room temperature under Ar atmosphere. The mixture was stirred for 24 h at the same temperature, quenched with aqueous ascorbate buffer, and filtered through Celite. The filtrate was extracted with $CHCl_3$, and washed with saturated aqueous $NaHCO_3$ and brine. A combined organic layer was dried over Na_2SO_4 and evaporated in vacuo. The crude product was purified by gel filtration chromatography (SX-3, EtOAc−toluene = 1:1) to give mixed acetal (47.4 mg, 74%) as the mixture of diastereomers (MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{158}H_{162}O_{29}S_2Na$, 2610.05, found 2609.98). To the mixed acetal and MS4 Å (1.5 g) in dry $(CH_2Cl)_2$ (8 mL) and dry CH_2Cl_2 (8.0 mL) were added NIS (14.4 mg, 62.1 μmol) and AgOTf (2.0 mg, 7.8 μmol) at −30 °C under Ar atmosphere. The mixture was stirred for 1 h at −20 °C, and further NIS (14.4 mg, 62.1 μmol) and AgOTf (2.0 mg, 7.8 μmol) were added to the mixture. The mixture was stirred for 3 h at −10 °C and for 18 h at 0 °C. The reaction mixture was quenched with triethylamine, diluted with EtOAc, and filtered through Celite. The filtrate was washed with 20% aqueous $Na_2S_2O_3$, saturated aqueous $NaHCO_3$, and brine. The washed organic layer was dried over Na_2SO_4 and evaporated in vacuo to give the crude product including the diastereomeric mixture of naphthyl(succinimido)methyl ether (MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{152}H_{156}O_{33}N_2Na$, 2560.05, found 2560.26). The crude mixture in $(CH_2NH_2)_2$ (0.25 mL) and *n*-BuOH (3.0 mL) was stirred at 80 °C for 2 d, then evaporated in vacuo. The residue in THF (2 mL) and 70% AcOH aqueous (2 mL) was stirred at 80 °C for 24 h, then evaporated in vacuo. The crude product was purified by PTLC (toluene−EtOAc = 5:1) to give the product **55** (12.7 mg, 34% from **52**, ββ). **55**, ^1H NMR ($CDCl_3$, 400 MHz): δ 1.29 (s, acetonide, 3H), 1.54 (s, acetonide, 3H), 2.25−2.37 (br m, OH, 2H), 3.41−3.59 (m, C5−H^a, C5−H^b, C5−$H_2{}^d$, C5−$H_2{}^e$, C5−$H_2{}^f$, C5−$H_2{}^g$, 10H), 3.70 (dd, *J* = 12.0, 4.4 Hz, C5−H^c, 1H), 3.78 (dd, *J* = 12.0, 4.0 Hz, C5−H^b, 1H), 3.81 (dd, *J* = 10.8, 5.6 Hz, C5−H^a, 1H), 3.86−4.02 (m, C3−H^a, C2−H^b, C3−H^b, C2−H^c, C5−H^c, C2−H^f, C3−H^f, C2−H^g, C3−H^g, 9H), 4.03−4.12 (m, C4−H^b, C4−H^c, C3−H^d, C4−H^d, C3−H^e, 5H), 4.14−4.20 (m, C4−H^a, C4−H^e, C4−H^f, C4−H^g, 4H), 4.25−4.31 (m, C3−H^c, C2−H^d, C2−H^e, 3H), 4.32−4.57 (m, Bn ×11, 22H), 4.61 (d, *J* = 4.0 Hz, C2−H^a, 1H), 4.64 (d, *J* = 12.0 Hz, Bn, 1H), 4.66 (d, *J* = 12.0 Hz, Bn, 1H), 4.93 (s, C1−H^b, 1H), 4.96 (d, *J* = 4.8 Hz, C1−$H^{f/g}$, 1H), 5.02 (s, C1−H^c, 1H), 5.05 (d, *J* = 4.0 Hz, C1−$H^{f/g}$, 1H), 5.08 (d, *J* = 1.6 Hz, C1−H^e, 1H), 5.09 (d, *J* = 2.0 Hz, C1−H^d, 1H), 5.85 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.16−7.35 (m, Ar, 60H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 26.4 (q), 27.2 (q), 63.4 (t, ×2), 65.56 (t), 65.60 (t), 66.8 (t), 69.3 (t), 69.5 (t), 71.6 (t), 71.8 (t), 72.0 (t), 72.1 (t, ×2), 72.28 (t, ×2), 72.33 (t), 72.5 (t, ×2), 73.3 (t, ×2), 80.0 (d), 80.2 (d), 80.57 (d), 80.64 (d), 80.8 (d), 81.2 (d), 81.8 (d), 81.9 (d, ×2), 82.8 (d), 82.9 (d), 83.0 (d), 83.1 (d), 83.2 (d), 84.00 (d), 84.02 (d), 85.3 (d), 85.9 (d), 86.1 (d), 88.41 (d), 88.43 (d), 99.86 (d), 99.91 (d), 105.2 (d), 105.6 (d), 106.1 (d), 106.2 (d), 106.3 (d), 112.8 (s), 127.60, 127.63, 127.69, 127.74, 127.83,

127.87, 127.92, 127.93, 128.0, 128.3, 128.4, 128.5, 137.3, 137.4, 137.5, 137.8, 137.9, 137.97, 138.04, 138.09, 138.11. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{122}H_{134}O_{29}Na$, 2085.89, found 2085.77.

*2,3-Di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl-(1→5)-[2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose (**4**).* To the solution of diol **55** (4.1 mg, 1.99 μmol) in dry DMF (0.5 mL) were added imidazole (2.1 mg, 25.7 mmol) and *t*-butyldiphenylsilyl chloride (4.0 μL, 11.4 mmol) at room temperature, and the mixture was stirred for 24 h at the same temperature. After being quenched by saturated aqueous $NaHCO_3$, the product was extracted with $CHCl_3$. Combined solution was washed with brine and dried over Na_2SO_4. After filtration followed by concentration, the residue was purified by PTLC (hexane−EtOAc = 5:1) to give the product **4** (4.5 mg, 89%).

*2,3-Di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl$^{(i1)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(j1)}$-(1→5)-[2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl$^{(m1)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(k1)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(l1)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(h1)}$-(1→5)-2-O-acetyl-3-O-benzyl-α-D-arabinofuranosyl$^{(g1)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(e)}$-(1→5)-{2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl$^{(i2)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(j2)}$-(1→5)-[2,3-di-O-benzyl-5-O-t-butyldiphenylsilyl-β-D-arabinofuranosyl$^{(m2)}$-(1→2)-3,5-di-O-benzyl-α-D-arabinofuranosyl$^{(k2)}$]-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(l2)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(h2)}$-(1→5)-2-O-acetyl-3-O-benzyl-α-D-arabinofuranosyl$^{(g1)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(f)}$}-(1→3)-2-O-benzyl-α-D-arabinofuranosyl$^{(d)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(c3)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(c2)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(c1)}$-(1→5)-2,3-di-O-benzyl-α-D-arabinofuranosyl$^{(b)}$-(1→5)-3-O-benzyl-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**56**).* To a mixture of Araf_8 acceptor **4** (2.5 mg, 1.1 μmol) and Araf_7 donor **2** (6.2 mg, 2.3 μmol) in dry CH_2Cl_2 (2 mL) was added MS4 Å (250 mg, freshly dried) at room temperature. After being cooled to −40 °C, NIS (1.0 mg, 4.4 μmol) and AgOTf (1.0 mg, 3.9 μmol) were added to the mixture. After being stirred for 3 d at the same temperature and 2 h at 0 °C, the reaction was quenched by triethylamine and followed by filtration through Celite pad and washing of pad with $CHCl_3$. The combined solutions were washed with 20% aqueous $Na_2S_2O_3$, saturated aqueous $NaHCO_3$, and brine, dried over Na_2SO_4, and concentrated in vacuo. The residue was purified by gel filtration (Bio beads SX-1, toluene/ethyl acetate = 1/1) to give the title compound Araf_{22} **56** (7.6 mg, 96%). **56**: $[\alpha]^{25}{}_D$ 50.0 (*c* 0.44, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 600 MHz): δ 0.99 (s, *t*Bu ×4, 36H), 1.32 (s, acetonide, 3H), 1.49 (s, acetonide, 3H), 1.81 (s, Ac, 3H), 1.82 (s, Ac, 3H), 3.40−4.59 (m, 181H), 4.64 (d, *J* = 4.0 Hz, C2−H^a, 1H), 4.65 (d, *J* = 12.1 Hz, Bn, 1H), 4.67 (d, *J* = 12.1 Hz, Bn, 1H), 4.90 (d, *J* = 4.5 Hz, C1−H^{m2}, C1−H^{m2}, 2H), 4.94 (s, C1−H$^{l1/l2}$, 1H), 4.95 (s, C1−H$^{l1/l2}$, 1H), 5.01 (s, C1−H^{b2}, 1H), 5.02 (s, C1−H^{i1}, C1−H^{i2}, 2H), 5.04 (d, *J* = 4.5 Hz, C1−H^{l2}, C1−H^{l2}, 2H), 5.06 (s, C1−H^{c3}, 1H), 5.07 (s, C1−H^{g2}, C1−H^{k1}, C1−H^{k2}, 3H), 5.08 (s, C1−H^d, C1−H^{g1}, C1−H^{j1}, C1−H^{j2}, 4H), 5.09 (s, C1−H^{c2}, 1H), 5.10 (s, C1−H^{c1}, 1H), 5.13 (s, C1−H^f, 1H), 5.14 (s, C1−H^e, C2−H^{g1}, 2H), 5.15 (s, C2−H^{g2}, 1H), 5.88 (d, *J* = 4.0 Hz, C1−H^a, 1H), 7.69−7.60 (m, Ar, 230H); see also Table SI-1. ^{13}C NMR ($CDCl_3$, 125 MHz): δ 19.2 (s, *t*Bu), 20.7 (q, Ac), 20.8 (q, Ac), 26.4 (q, acetonide), 26.8 (q, *t*Bu), 27.2 (q, acetonide), 65.1 (t), 65.3 (t, ×2), 65.5 (t), 65.6 (t, ×2), 65.8 (t), 65.86 (t, ×2), 65.88 (t, ×2), 66.0 (t), 66.1 (t, ×2), 66.2 (t, ×3), 66.8 (t), 66.9 (t, ×2), 70.1 (t, ×2), 71.6 (t, Bn), 71.7 (t, ×2, Bn), 71.76 (t, ×2, Bn), 71.78 (t, Bn), 71.80 (t, ×2, Bn), 71.84 (t, Bn), 71.9 (t, ×2, Bn), 71.98 (t, ×3, Bn), 72.03 (t, ×2, Bn), 72.04 (t, ×3, Bn), 72.1 (t, ×2, Bn), 72.17 (t, ×3, Bn), 72.20 (t, ×3, Bn), 72.21 (t, ×2, Bn), 72.24 (t, ×2, Bn), 72.26 (t, ×3, Bn), 72.33 (t, Bn), 72.35 (t, Bn), 73.09 (t, ×2, Bn), 73.14 (t, ×2, Bn), 79.85 (d), 79.96 (d, ×2), 80.08 (d), 80.41 (d), 80.42 (d, ×2), 80.45 (d), 80.46 (d), 80.50 (d, ×2), 80.57 (d), 80.98 (d), 81.21 (d, ×2), 81.43 (d, ×2), 81.83 (d, ×2), 81.86 (d, ×2), 81.96 (d, ×2), 81.18 (d), 81.24 (d), 82.71 (d), 82.81 (d), 82.84 (d), 82.88 (d, ×2), 82.89 (d, ×2), 82.92 (d), 82.99 (d), 83.15 (d), 83.16 (d), 83.26 (d), 84.02 (d, ×2), 84.09 (d, ×2), 84.11 (d, ×2), 84.19 (d, ×2), 84.56 (d, ×2), 84.69 (d, ×2), 85.33 (d), 85.41 (d, ×2), 85.73 (d, ×2), 87.72 (d), 88.31 (d), 88.34 (d, ×2), 88.40 (d), 88.42 (d), 88.50 (d), 88.53 (d), 88.54 (d, ×2), 88.60 (d), 100.23 (d, ×2), 100.60 (d, ×2), 105.01 (d), 105.23 (d, ×2), 105.57 (d), 106.23 (d), 106.09 (d), 106.19 (d, ×2), 106.28 (d, ×2), 106.35 (d), 106.40 (d, ×3), 106.52 (d), 106.54 (d), 106.57 (d), 106.65 (d), 112.89 (s, acetonide), 127.28 (d, Ar), 127.32 (d, Ar), 127.35 (d, Ar), 127.38 (d, Ar), 127.45 (d, Ar), 127.47 (d, Ar), 127.50 (d, Ar), 127.53 (d, Ar), 127.57 (d, Ar), 127.63 (d, Ar), 127.69 (d, Ar), 127.71 (d, Ar), 127.73 (d, Ar), 127.74 (d, Ar), 127.78 (d, Ar), 127.81 (d, Ar), 127.83 (d, Ar), 127.84 (d, Ar), 127.87 (d, Ar), 127.91 (d, Ar), 127.92 (d, Ar), 127.94 (d, Ar), 127.96 (d, Ar), 127.97 (d, Ar), 128.00 (d, Ar), 128.06 (d, Ar), 128.21 (d, Ar), 128.22 (d, Ar), 128.25 (d, Ar), 128.27 (d, Ar), 128.29 (d, Ar), 128.31 (d, Ar), 128.33 (d, Ar), 128.35 (d, Ar), 128.36 (d, Ar), 128.40 (d, Ar), 128.46 (d, Ar), 129.69 (d, Ar), 129.71 (d, Ar), 129.73 (d, Ar), 129.74 (d, Ar), 133.08 (s, Ar), 133.09 (s, Ar), 133.17 (s, Ar), 133.22 (s, Ar), 135.49 (s, Ar), 135.50 (s, Ar), 135.52 (s, Ar), 135.53 (s, Ar), 137.35 (s, Ar), 137.46 (s, Ar), 137.47 (s, Ar), 137.49 (s, Ar), 137.54 (s, Ar), 137.56 (s, Ar), 137.63 (s, Ar), 137.65 (s, Ar), 137.67 (s, Ar), 137.72 (s, Ar), 137.75 (s, Ar), 137.88 (s, Ar), 137.90 (s, Ar), 137.94 (s, Ar), 137.96 (s, Ar), 138.06 (s, Ar), 138.07 (s, Ar), 138.20 (s, Ar), 138.22 (s, Ar), 138.22 (s, Ar), 138.28 (s, Ar), 169.61 (s, C═O), 169.64 (s, C═O); see also Table SI-1. MALDI-TOF MS: $[M + Na]^+$ calcd for $C_{447}H_{486}O_{91}Si_4Na$, 7444.24, found 7444.78. Nano ESI FT-ICR mass: see Figure SI-1.

*β-D-Arabinofuranosyl$^{(i1/2)}$-(1→2)-α-D-arabinofuranosyl$^{(g1/2)}$-(1→5)-[β-D-arabinofuranosyl$^{(j1/2)}$-(1→2)-α-D-arabinofuranosyl$^{(h1/2)}$]-(1→3)-α-D-arabinofuranosyl$^{(f1/2)}$-(1→5)-α-D-arabinofuranosyl$^{(c)}$-(1→5)-α-D-arabinofuranosyl$^{(c)}$-(1→5)-α-D-arabinofuranosyl$^{(c)}$-(1→5)-{β-D-arabinofuranosyl$^{(i1/2)}$-(1→2)-α-D-arabinofuranosyl$^{(g1/2)}$-(1→5)-[β-D-arabinofuranosyl$^{(j1/2)}$-(1→2)-α-D-arabinofuranosyl$^{(h1/2)}$]-(1→3)-α-D-arabinofuranosyl$^{(f1/2)}$-(1→5)-α-D-arabinofuranosyl$^{(c)}$-(1→5)-α-D-arabinofuranosyl$^{(c)}$-(1→5)-α-D-arabinofuranosyl$^{(e)}$}-(1→3)-α-D-arabinofuranosyl$^{(d)}$-(1→5)-α-D-arabinofuranosyl$^{(c)}$-(1→5)-α-D-arabinofuranosyl$^{(c)}$-(1→5)-α-D-arabinofuranosyl$^{(c)}$-(1→5)-α-D-arabinofuranosyl$^{(b)}$-(1→5)-1,2-O-isopropylidene-α-D-arabinofuranose$^{(a)}$ (**1**).* To a solution of protected Araf_{22} **56** (12.0 mg, 1.62 μmol) in dry THF (2 mL) was added TBAF (16.2 μL, 16.2 μmol) at room temperature. After being stirred for 18 h at the same temperature, the solvent was evaporated in vacuo. The crude mixture in MeOH (2.0 mL), triethylamine (1.0 mL), and H_2O (0.2 mL) was stirred for 24 h at room temperature. After evaporation, the residue was purified by PTLC (toluene/EtOAc = 3:1) to give hexaol **58** (5.3 mg, 51% in two stps). Hydrogenolysis of resulting residue **58** was carried out in the presence of $Pd(OH)_2$ (6.0 mg) in EtOAc−MeOH−H_2O (4:4:1, 9.0 mL) for 6 h at room temperature. After further addition of $Pd(OH)_2$ (6.0 mg) to the mixture under Ar atmosphere, hydrogenolysis was continued for 24 h. The mixture was filtered through Celite, and filtrate was concentrated in vacuo. The residue was purified by gel filtration (Sephadex LH-20, MeOH−H_2O = 1/1) to give the title compound Araf_{22} **1** (1.3 mg, 93%). **1**, ^{1}H NMR (D_2O, 800 MHz): δ 1.27 (s, acetonide, 3H), 1.48 (s, acetonide, 3H), 3.68−4.31 (m, C2−S-H, 109H), 4.63 (d, *J* = 4.0 Hz, C2−H^a, 1H), 4.96 (s, C1−H^b, 1H), 4.97−5.00 (br s, C1−H^c, 8H), 5.02 (s, C1−H^d, C1−H^f, 3H), 5.15 (d, *J* = 4.0 Hz, C1β-H^j, 2H), 5.16 (d, *J* = 4.0 Hz, C1 β-H^i, 2H), 5.178 (s, C1−H^e, 1H), 5.1875 (s, C1−H^g, 1H), 5.1858 (s, C1−H^g, 1H), 5.256 (s, C1−H^h, 1H), 5.258 (s, C1−H^h, 1H), 6.06 (d, *J* = 4.0 Hz, C1−H^a, 1H); see also Table SI-2. ^{13}C NMR (D_2O, 125 MHz): δ 25.1 (q, acetonide), 25.8 (q, acetonide), 60.6 (t), 62.99 (t), 63.04 (t), 66.3 (t), 66.5 (t), 66.7 (t), 66.8 (t), 66.9 (t), 67.2 (t), 74.17 (d), 74.23 (d), 74.76 (d), 74.81 (d),

74.9 (d), 76.3 (d), 76.6 (d), 76.79 (d), 76.83 (d), 77.0 (d), 79.1 (d), 79.2 (d), 80.88 (d), 80.92 (d), 80.94 (d), 81.1 (d), 81.2 (d), 82.1 (d), 82.23 (d), 82.26 (d), 82.36 (d), 82.40 (d), 82.42 (d), 82.46 (d), 82.56 (d), 82.9 (d), 83.0 (d), 86.0 (d), 86.1 (d), 86.9 (d), 100.7 (d, $C1^{j}$ ×2), 100.8 (d, $C1^{i}$ ×2), 105.5 (d, $C1^{a}$), 105.6 (d, $C1^{j}$ ×2), 105.7 (d, $C1^{g}$ ×2), 107.2 (d, $C1^{e}$), 107.48 (d, $C1^{d}$, $C1^{f}$ ×2), 107.54 (d, $C1^{b}$), 107.6 (d, $C1^{c}$ ×8), 113.53 (s, acetonide); see also Table SI-2. MALDI-TOF MS: $[M + Na]^{+}$ calcd for $C_{113}H_{182}O_{89}Na$, 2985.96, found 2985.63.

■ ASSOCIATED CONTENT

Supporting Information. Complete ref 36a, lists of ^{1}H and ^{13}C NMR data of **56** and **1**, experimental procedures and characterization data for the preparation of trisaccharides **11**−**13** in Scheme 1, and of substrates **7**, **43**−**45** in Table 1, and ^{1}H and ^{13}C NMR spectra of all new key compounds. This material is available free of charge via the Internet at http://pubs.acs.org.

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■ ACKNOWLEDGMENT

We thank Dr. Hiroyuki Koshino for 600 MHz NMR, Dr. Mayumi Yoshida and Dr. Chihiro Kurosaki for 800 MHz NMR, and Dr. Takemichi Nakamura for nano ESI FT-ICR mass measurements, and Ms. Akemi Takahashi and Ms. Satoko Shirahata for technical assistance. This work was partly supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Culture, Sports, Science, and Technology (no. 22510243), and by an Incentive Research Grant (2009) and Fund for Collaborative Research (2010) in RIKEN.

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