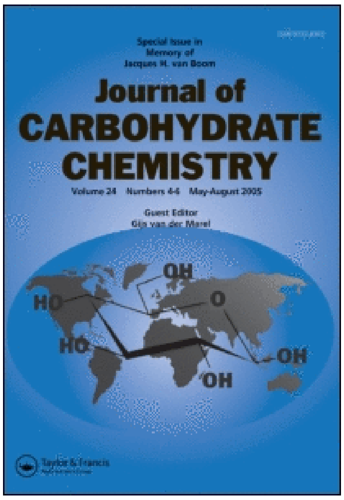

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PREPARATION OF 2,5-ANHYDROHEXITOLS (PART I). SILICON-DIRECTED STEREOCONTROLLED CYCLIZATION

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ABSTRACT

Stereoselective chain-extension of carbohydrate aldehydes with the hydroxymethylating reagent (dimethylphenylsilyl)methylmagnesium chloride (1) followed by acid-mediated cyclization gives access to 2,5-anhydro-hexitols. The stereoselectivity of the ring closure depends on the nature of the acid, *i.e.*, treatment with excess $BF_3{\cdot}Et_2O$ or catalytic H_2SO_4 leads to tetrahydrofurans with 2,3-*cis* or 2,3-*trans* configuration, respectively. Concomitant elimination is effectively suppressed in case of cyclisation of the more sterically hindered isopropyl substituted silanes.

INTRODUCTION

Tetrahydrofurans (THFs) are common structural elements of many natural products, *e.g.* polyether antibiotics, acetogenins and *C*-glycosides. Consequently, numerous strategies for the preparation of THFs have been devised.[1] For instance, Lewis-acid mediated addition of an allylsilane to an aldehyde may afford, *via* a silicon-stabilized carbocation, the tetrahydrofuran product.[2] In a related approach, allylation of pyruvate esters[3] or addition of (*E*)-crotylsilanes to aldehydes[4] may provide tetrahydrofurans *via* a stereospecific 1,2-silyl shift.

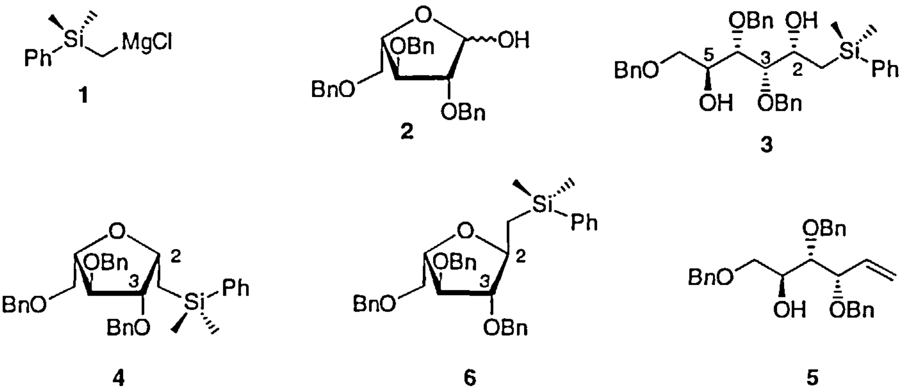


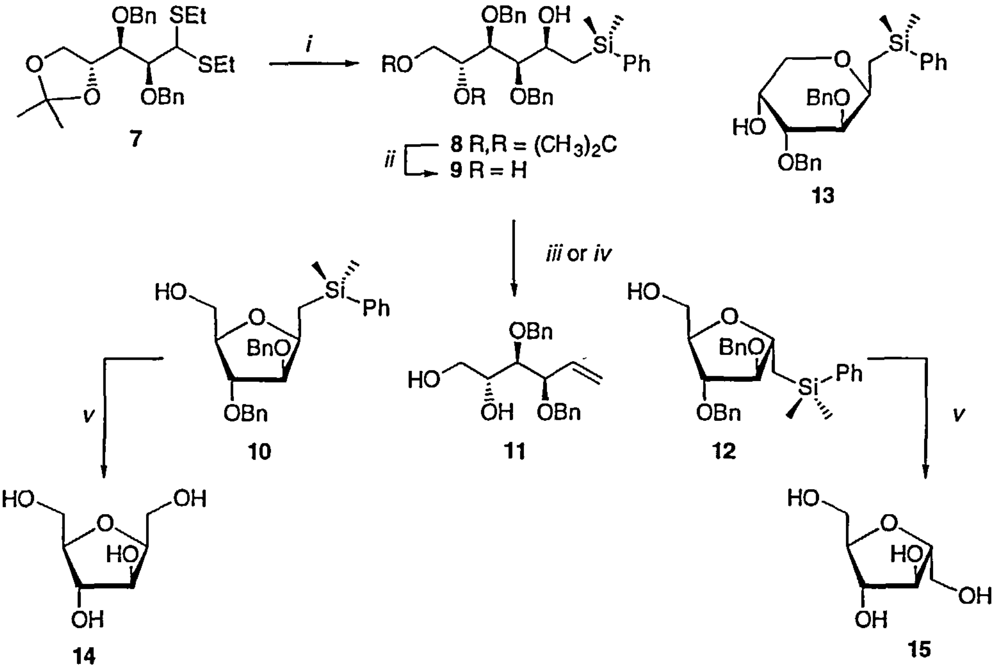
Figure 1

Preliminary studies from our laboratory have revealed[5] (see Fig. 1) that 3,4,6-tri-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-L-glucitol (**3**), obtained[6] by highly diastereoselective nucleophilic addition of (dimethylphenylsilyl)methylmagnesium chloride[7] (**1**) to 2,3,5-tri-*O*-benzyl-L-arabinose (**2**), can be stereoselectively transformed into 2,5-anhydrohexitols *via* acid-mediated cyclization. Thus, treatment of **3** with $BF_3{\cdot}Et_2O$ gave 2,3-*cis*-tetrahydrofuran **4**, whereas a catalytic amount of H_2SO_4 led to the predominant formation of 2,3-*trans*-isomer **6**. On the other hand, the efficacy of the process is diminished due to competing elimination[8] of the β-hydroxysilyl moiety in the 1,2-position leading to olefin **5**.

We here describe the synthesis of 2,5-anhydrohexitols (THFs) *via* stereocontrolled cyclization of 2,5,6-trihydroxysilanes, as well as the effective suppression of the undesired elimination reaction.

RESULTS AND DISCUSSION

At first instance, attention was focused[9] on the acid-mediated cyclization of 3,4-di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-D-glucitol (**9**, Scheme 1). To this end, the readily accessible D-arabinose derivative **7**[10] was transformed into triol **9** *via* hydrolysis of the dithioacetal moiety ($HgO/BF_3{\cdot}Et_2O$),[11] followed by hydroxymethylation of the resulting crude aldehyde with Grignard reagent **1**. The surprisingly[6] low



Reagents and conditions

(*i*) (a) HgO, $BF_3{\cdot}Et_2O$, THF, H_2O, 0.5 h. (b) **1**, Et_2O, 0 °C, 2 h (90%); (*ii*) 80% HOAc, 16 h (86%); (*iii*) $BF_3{\cdot}Et_2O$, CH_2Cl_2, 0 °C → rt, 1 h; (*iv*) H_2SO_4, THF, 50 °C; (*v*) (a) KBr, AcO_2H, AcOH, 2 h. (b) H_2, Pd-C, 5 h (**14**: 77%, **15**: 53%).

Scheme 1

diastereoselectivity of the Grignard addition in THF as the solvent (67% de) could be improved by performing the condensation in diethyl ether to give 2,3-*syn* configurated β-hydroxysilane **8** as the exclusive diastereoisomer. Finally, hydrolysis of the isopropylidene protective group in **8** led to the isolation of target triol **9** in good overall yield. Addition of $BF_3{\cdot}Et_2O$ (1.1 equiv) to a solution of **9** in CH_2Cl_2 resulted in the rapid transformation of starting material into two main products, *i.e.* tetrahydrofuran **10** and olefin **11** (Table 1, entry 1). The 2,3-*cis* configuration of the cyclic product **10**, formed with retention of configuration at C-2, was ascertained[12] by its conversion into 2,5-anhydro-D-glucitol (**14**). The isolation of a negligible amount of 6-membered cyclic product **13** (1.6%) from the mixture of products obtained after acid treatment, indicated the highly preferential formation of the 5-membered ring. In contrast, treatment of **9** with

Table 1. Acid-mediated cyclization of β-hydroxy silanes **9**, **18** and **28**.

Entry	Substrate	Conditions[a]	THF (%)	ratio[b]	olefin (%)
1	**9**	A	**10+12** (53)	1:0	**11** (28)
2	**9**	B	**10+12** (43)	1:4	**11** (50)
3	**18**	A	**19+21** (22)	1:0	**20** (58)
4	**18**	B	**19+21** (73)	1:20	**20** (15)
5	**28**	A	**29+31** (61)	1:0	**30** (35)
6	**28**	B	**29+31** (25)	1:2	**30** (61)

a. A: $BF_3 \cdot Et_2O$, CH_2Cl_2, 0 °C → rt; B: H_2SO_4, THF, 50 °C.

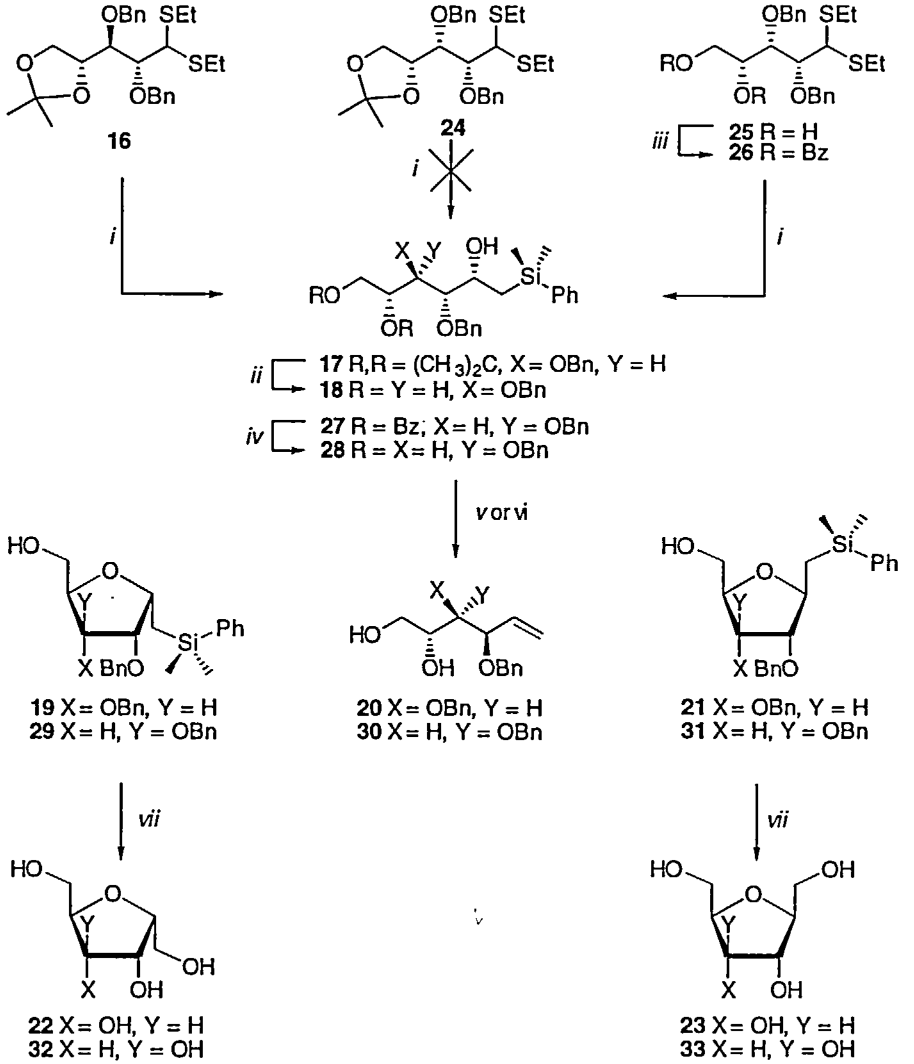
b. Judged by ^1H and ^{13}C NMR.

catalytic H_2SO_4 in THF (entry 2) led to a cyclization reaction with opposite stereoselectivity, to give THF derivatives **12** and **10** in a 4:1 ratio. Unfortunately, increased elimination to olefin **11** (50%) was also observed. The cyclic compound **12** was converted into the corresponding 2,5-anhydro-D-hexitols **14** and **15** by standard procedures involving oxidative unmasking followed by hydrogenolysis.

The preparation of tetrahydrofurans by the methodology outlined above was further evaluated using the isomeric triols **18** and **28** (Scheme 2). Starting from D-ribose dithioacetal **16**, the corresponding triol **18** was prepared following a similar synthetic route as described for the conversion of dithioacetal **7** into trihydroxysilane **9**. In contrast, hydrolysis of thioacetal moiety of D-xylose derivative **24** with $HgO/BF_3 \cdot Et_2O$ proceeded with concomitant deacetonation,[13] thus necessitating prior transformation of acetonide **24** into dibenzoylated product **26**. Hydrolysis of the thioacetal moiety in **26** followed by Grignard addition of **1** and debenzoylation of the resulting adduct **27** gave **28** in good yield, with no noticeable debenzylation.

Triols **18** and **28** were subjected to $BF_3 \cdot Et_2O$ or H_2SO_4, the results of which are summarized in Table 1 (entry 3-6). Further processing of the THF-products **19**, **21**, **29** and **31** was executed as described above to give the known[14,15] 2,5-anhydrohexitols **22**/**23** and **32**/**33**, respectively.

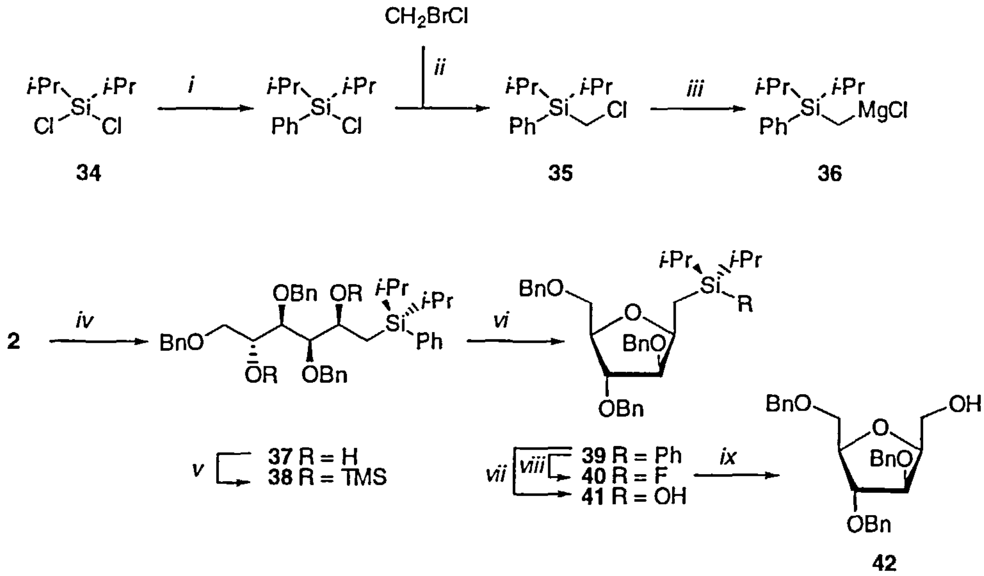
A significant drawback of the cyclization of β-hydroxysilanes for the synthesis of tetrahydrofurans entails the concurrent elimination to the olefin. It was reasoned that



Reagents and conditions

(*i*) (a) HgO, $BF_3{\cdot}Et_2O$, THF/H_2O, 0.5 h. (b) **1**, Et_2O, 0 °C, 2 h (**17**: 67%, **27**: 71%); (*ii*) 80% HOAc, 16 h (**18**: 92%, **25**: 87%); (*iii*) BzCl, pyridine, 20 h (93%); (*iv*) KO*t*-Bu, MeOH (87%); (*v*) $BF_3{\cdot}Et_2O$, CH_2Cl_2, 0 °C → rt, 1 h; (*vi*) H_2SO_4, THF, 50 °C; (*vii*) (a) KBr, AcO_2H, AcOH, 2 h. (b) H_2, Pd-C, 5 h (**22**: 64%, **32**: 68%, **23**: 53%, **33**: 43%).

Scheme 2



Reagents and conditions

(*i*) PhLi, Et_2O, -78 °C, 0.5 h; (*ii*) *n*-BuLi, THF, -65 °C (72%); (*iii*) Mg, THF, 50 °C; (*iv*) **36**, THF, 60 °C, 2 h (88%); (*v*) HMDS, TMSCl, CH_3CN; (*vi*) $BF_3{\cdot}Et_2O$, CH_2Cl_2, 0 °C → rt; (*vii*) KBr, AcO_2H, NaOAc, AcOH (53%). (*viii*) $BF_3{\cdot}Et_2O$, AcOH, CH_2Cl_2 (94%). (*ix*) *t*-BuOOH, CsOH, DMF, 70 °C, 4 h (71% from **39**).

Scheme 3

increased steric congestion around silicon[16] would effectively suppress elimination.[17] To assess this assumption, the diisopropyl substituted β-hydroxysilane **37** was prepared (Scheme 3) by treatment of **2** with the Grignard reagent derived from **35**, in turn prepared by sequential monophenylation and addition of chloromethyllithium[18] to dichloro(diisopropyl)silane (**34**). Upon acid treatment of **37**, it was indeed observed that the sterically hindered isopropyl groups on silicon completely prevented elimination to olefin **11**. However, it was found that $BF_3{\cdot}Et_2O$-assisted ring-closure of **37** led to concomitant fluorodesilylation, *e.g.*, to **40**, presumably due to *in situ* liberation of water. The latter side-reaction could be effectively suppressed by trimethylsilylation of hydroxyl functions (**37** → **38**) prior to cyclization, resulting in the isolation of compound **39** in 90% yield based on **37**.

Oxidation of the carbon-silicon bond in the diisopropylated silanes turned out to be more cumbersome.[19] Application of Fleming conditions[20] for unmasking of **39**, *i.e.*, treatment with KBr in peracetic acid, resulted in the formation of silanol **41** instead of the desired alcohol **42**. Likewise, Tamao oxidation[21] of the fluorosilane **40** with H_2O_2 and KF in THF/MeOH led to the exclusive formation of **41** (54%). Recently, Woerpel *et al.* reported[22] that oxidation of a carbon-silicon bond in sterically congested alkoxysilanes can be realized with *tert*-butyl hydroperoxide (*t*-BuOOH), cesium fluoride and tetrabutylammonium fluoride (TBAF) at elevated temperature. Analogously, fluorosilane **40**, readily accessible by protodesilylation[23] of **39**, was subjected to the slightly modified *t*-BuOOH unmasking conditions, *i.e.* without the addition of TBAF. After 4 h at 70 °C, **40** was completely converted into a single product (71% yield), which was in all aspects identical with previously prepared **42**.[5]

In conclusion, hydroxymethylation of sugar aldehydes, followed by acid-mediated cyclization, presents a valuable asset for the preparation of 2,5-disubstituted tetrahydrofurans.[1,24] The thus obtained THF derivatives are amenable for further functionalization at C-1 and C-6 and can be applied in the synthesis of biologically important *C*-glycosides.[25]

EXPERIMENTAL

General methods and materials. Toluene was distilled from P_2O_5 and stored over 4Å molecular sieves, tetrahydrofuran and diethyl ether were freshly distilled from $LiAlH_4$ and dried over 4Å molecular sieves for one hour. Methanol (HPLC-grade, Rathburn), 1,4-dioxane and acetic acid were used as received. All reactions were performed under strictly anhydrous conditions unless noted otherwise. Reactions were followed by TLC analysis on Schleicher and Schüll DC Fertigfolien F 1500 LS 254. Compounds were visualized by UV light (254 nm) and by spraying with 20% sulfuric acid in methanol followed by charring at 140 °C. Column chromatography was performed on silica gel 60, 230-400 mesh (Merck). ^{1}H NMR spectra and ^{13}C NMR spectra (50.1 MHz) were recorded in $CDCl_3$ using a Jeol JNM-FX 200 spectrometer, unless noted otherwise. ^{1}H NMR spectra (300 MHz) were recorded using a Bruker WM-300 spectrometer. Chemical shifts (δ) are given in ppm relative to tetramethylsilane as internal standard. Optical rotations were measured in $CHCl_3$ on a Propol automatic polarimeter. Mass spectra were recorded on a Finnigan MAT TSQ70 triple quadrupole mass spectrometer. (Chloromethyl)dimethylphenylsilane and dichloro(diisopropyl)silane (34) were obtained from Aldrich Chemical Co. and ABCR GmbH & Co., respectively, and used as received.

(Dimethylphenylsilyl)methylmagnesium Chloride (1),[7] 1M in THF or Et_2O. Under a N_2 atmosphere, magnesium powder (0.56 g, 23.1 mmol) in refluxing solvent (THF or Et_2O, 3 mL) was activated by the addition of 1,2-dibromoethane (0.1 mL). Next, (chloromethyl)dimethylphenylsilane (3.79 mL, 21.0 mmol) in the same solvent (15 mL) was slowly added at such a rate as to maintain a gentle reflux. After the addition was complete, the resulting dark-grey mixture was stirred an additional hour at 40 °C (THF) or 30 °C (Et_2O).

Preparation of dithioacetals 7, 16 and 24.[10] To a well-stirred suspension of the diethyl dithioacetals of D-arabinose,[27a] D-ribose[27b] or D-xylose[27c] (20 mmol) in acetone (100 mL), 2,2-dimethoxypropane (5 mL, 40 mmol) and pyridinium *p*-toluenesulfonate (0.5 g, 2.0 mmol) were added and the reaction was monitored by TLC (EtOAc/light petroleum, 1/1, v/v). After 1-1.5 h the reaction was complete and the mixture became homogeneous. The mixture was quenched with saturated $NaHCO_3$ solution (30 mL), concentrated and the residue taken up in EtOAc (80 mL). The organic layer was washed with $NaHCO_3$ solution (2x 20 mL), dried ($MgSO_4$), concentrated *in vacuo* and coevaporated with toluene to give the crude product which was crystallized from light petroleum. The crystals were dried *in vacuo*, dissolved in THF (100 mL) and benzyl bromide was added (2.3 equiv). The solution was cooled to 0 °C and NaH (2.2 equiv, 60% in oil) was added in portions. The mixture was stirred until TLC-analysis (Et_2O/light petroleum, 1/1, v/v) indicated the presence of a single highly lipophilic product. Et_2O (150 mL) and saturated NH_4Cl (20 mL) were added, and the layers were separated. The organic layer was washed with brine (20 mL), dried ($MgSO_4$), filtered and concentrated under reduced pressure. The oily residue was purified by column chromatography, elution was effected with Et_2O/light petroleum (1/4 1/3, v/v) to give **7**, **16** or **24**.

2,3-Di-*O*-benzyl-4,5-*O*-isopropylidene-D-arabinose Diethyl Dithioacetal (7). ^{1}H NMR: δ 7.40-7.25 (m, 10H, H-arom), 4.83 (AB, 2H, CH_2, Bn, J -10.9 Hz), 4.77 (s, 2H, CH_2, Bn), 4.22 (m, 1H, H-4), 4.18-4.11 (m, 1H, H-3), 4.14 (d, 1H, H-1, $J_{1,2}$ 6.4 Hz), 4.02 (dd, 1H, H-5a, $J_{4,5a}$ 6.1 Hz, $J_{5a,5b}$ -8.2 Hz), 3.87 (dd, 1H, H-5b, $J_{4,5b}$ 6.5 Hz), 3.79 (dd, 1H, H-2, $J_{2,3}$ 4.3 Hz), 2.75-2.60 (m, 4H, CH_2, SEt), 1.41, 1.33 (2x s, 6H, CH_3, isoprop), 1.28-1.19 (m, 6H, CH_3, SEt). $^{13}C\{^1H\}$ NMR: δ 138.4, 138.3 (Cq, arom), 128.2-127.5 (CH, arom), 108.7 (Cq, isoprop), 83.2, 80.0, 76.6 (C-2, C-3, C-4), 75.2, 74.8 (CH_2, Bn), 66.8 (C-6), 53.0 (C-1), 26.6, 25.2 (CH_3, isoprop), 25.8, 24.8 (CH_2, SEt), 14.4 (CH_3, Et).

Anal. Calcd for $C_{26}H_{36}O_4S_2$ (476.69): C, 65.51; H, 7.61. Found: C, 65.01; H, 7.66.

2,3-Di-*O*-benzyl-4,5-*O*-isopropylidene-D-ribose Diethyl Dithioacetal (16). ^1H NMR: δ 7.52-7.15 (m, 10H, H-arom), 4.92-4.63 (m, 4H, CH_2, Bn), 4.44 (d, 1H, H-1, $J_{1,2}$ 5.7 Hz), 4.41 (dt, 1H, H-4, $J_{3,4}$ 3.8 Hz, $J_{4,5a}$ $J_{4,5b}$ 6.9 Hz), 4.11 (dd, 1H, H-3, $J_{2,3}$ 4.8 Hz), 3.96 (dd, 1H, H-5a, $J_{5a,5b}$ -8.0 Hz), 3.80 (dd, 1H, H-5b), 3.67 (dd, 1H, H-2), 2.90-2.66 (m, 4H, CH_2, SEt), 1.45, 1.31 (2x s, 6H, CH_3, isoprop), 1.26-1.12 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 138.3, 137.6 (Cq, arom), 128.1-127.4 (CH, arom), 108.2 (Cq, isoprop), 82.5, 78.8, 75.9 (C-2, C-3, C-4), 75.7, 73.9 (CH_2, Bn), 64.9 (C-6), 53.0 (C-1), 26.2, 25.0 (CH_3, isoprop), 25.4, 25.1 (CH_2, SEt), 14.2 (CH_3, Et).

Anal. Calcd for $C_{26}H_{36}O_4S_2$ (476.69): C, 65.51; H, 7.61. Found: C, 65.46; H, 7.55.

2,3-Di-*O*-benzyl-4,5-*O*-isopropylidene-D-xylose Diethyl Dithioacetal (24). ^1H NMR: δ 7.36-7.24 (m, 10H, H-arom), 4.82 (AB, 2H, CH_2, Bn, J -11.3 Hz), 4.74 (s, 2H, CH_2, Bn), 4.37 (ddd, 1H, H-4, $J_{3,4}$ 5.6 Hz, $J_{4,5a}$ 6.4 Hz, $J_{4,5b}$ 7.5 Hz), 4.14 (d, 1H, H-1, $J_{1,2}$ 3.9 Hz), 3.96-3.88 (m, 2H, H-2, H-5a), 3.82 (t, 1H, H-3, $J_{2,3}$ 5.6 Hz), 3.77 (dd, 1H, H-5b, $J_{5a,5b}$ -8.1 Hz), 2.74 (dq, 2H, CH_2, SEt, J -3.0, 7.3 Hz), 2.62 (q, 2H, CH_2, SEt, J 7.3 Hz), 1.43, 1.34 (2x s, 6H, CH_3, isoprop), 1.25 (t, 3H, CH_3, SEt), 1.24 (t, 3H, CH_3, SEt). $^{13}C\{^1H\}$ NMR: δ 138.3, 138.1 (Cq, arom), 128.0-127.3 (CH, arom), 108.7 (Cq, isoprop), 82.6, 79.7, 76.3 (C-2, C-3, C-4), 74.4 (CH_2, Bn), 65.6 (C-6), 52.4 (C-1), 26.3, 25.5 (CH_3, isoprop), 25.4, 25.0 (CH_2, SEt), 14.2 (CH_3, Et).

Anal. Calcd for $C_{26}H_{36}O_4S_2$ (476.69): C, 65.51; H, 7.61. Found: C, 65.14; H, 7.23.

General procedure for hydrolysis of thioacetals 7, 16 and 26 with HgO and $BF_3 \cdot Et_2O$.[11] Red mercury(II) oxide (0.87 g, 4.0 mmol), $BF_3 \cdot Et_2O$ (0.49 mL, 4.0 mmol) and 85% aqueous THF (5 mL) were stirred vigorously, while a solution of a dithioacetal

(2 mmol) in THF (1 mL) was added dropwise under N_2. The mixture was stirred until TLC analysis (Et_2O/light petroleum, 1/1, v/v) indicated the conversion was complete (1-1.5 h). Et_2O (20 mL) was added and the reaction mixture was neutralized with anhydrous Na_2CO_3 (1.5 g). The salts were removed by filtration and the filtrate was concentrated to give the corresponding aldehyde, which was used immediately in the next step.

General procedure for the nucleophilic addition of 1 to the open-chain aldehydes. The aldehyde obtained by hydrolysis of thioacetals **7**, **16** or **26** (1 mmol) was coevaporated with toluene (2x 2 mL) and dissolved in THF or Et_2O (5 mL). The solution was cooled (0 °C), a 1M solution of **1** in the same solvent was added slowly, and stirring continued until TLC-analysis (Et_2O/light petroleum, 1/1, v/v) indicated the reaction to be complete (1-2 h). The mixture was cooled to 0 °C, quenched by the addition of aqueous NH_4Cl (5 mL, 20%) and extracted with Et_2O (20 mL). The organic layer was washed with H_2O (5 mL), dried ($MgSO_4$), filtered and concentrated under reduced pressure.

3,4-Di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-5,6-*O*-isopropylidene-D-glucitol (8). The aldehyde obtained from hydrolysis of **7** (7.10 g, 14.92 mmol) in Et_2O was treated with **1** according to the general procedure for open-chain aldehydes. The oil obtained after extraction was applied onto a column of silica gel and elution was effected with Et_2O/light petroleum (1/4 1/3, v/v) to afford **8** as an oil, yield 7.0 g (90%). R_f 0.8 (Et_2O/light petroleum, 1/1, v/v). $[\alpha]_D^{20}$ +9.7° (*c* 1). ^1H NMR: δ 7.53-7.24 (m, 15H, H-arom), 4.63 (d, 2H, CH_2, Bn, *J* -1.3 Hz), 4.62 (AB, 2H, CH_2, Bn, *J* -11.1), 4.23 (q, 1H, H-5, $J_{4,5}$ $J_{5,6a}$ $J_{5,6b}$ 6.4 Hz), 4.00 (dd, 1H, H-6a, $J_{6a,6b}$ -8.4 Hz), 3.89 (dd, 1H, H-6b, $J_{5,6b}$ 6.8 Hz), 3.87 (m, 1H, H-2), 3.78 (t, 1H, H-4, $J_{3,4}$ $J_{4,5}$ 5.2 Hz), 3.33 (t, 1H, H-3, $J_{2,3}$ 4.5 Hz), 2.35 (d, 1H, OH, *J* 6.8 Hz), 1.40, 1.31 (2x s, 6H, CH_3, isoprop), 1.11 (dd, 1H, H-1a, $J_{1a,1b}$ -14.1 Hz, $J_{1a,2}$ 9.6 Hz), 0.98 (dd, 1H, H-1b, $J_{1b,2}$ 4.7 Hz), 0.33, 0.32 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 139.0, 137.9 (Cq, arom), 133.3, 128.5-127.4 (CH, arom), 108.3 (Cq, isoprop), 84.5, 78.9, 76.2 (C-3, C-4, C-5), 74.5, 74.1 (CH_2, Bn), 68.2 (C-2), 66.2 (C-6), 26.3, 24.8 (CH_3, isoprop), 21.5 (C-1), -2.0, -2.7 ($SiCH_3$).

Anal. Calcd for $C_{31}H_{40}O_5Si$ (520.74): C, 71.50; H, 7.74. Found: C, 71.01; H, 7.75.

General procedure for deacetonation. An isopropylidene compound (1 mmol) was dissolved in 80% aqueous AcOH/H_2O (5 mL) and stirring continued until TLC analysis (Et_2O/light petroleum, 3/1, v/v) showed the reaction to be complete (10-16 h).

Solvents were evaporated, the residue coevaporated with toluene (4x 2 mL) and purified by silica gel column chromatography.

3,4-Di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-D-glucitol (9). Compound **8** (1.57 g, 3.08 mmol) was deacetonated as described in the general procedure to give triol **9** as an oil, yield 1.25 g (86%). R_f 0.3 (Et_2O/light petroleum, 3/1, v/v). $[\alpha]_D^{20}$ +6.9° (*c* 2). ^1H NMR: δ 7.52-7.22 (m, 15H, H-arom), 4.55 (AB, 2H, CH_2, Bn, *J* -11.1 Hz), 4.53 (s, 2H, CH_2, Bn), 4.08 (m, 1H, H-5), 3.84 (m, 1H, H-2), 3.74-3.62 (m, 3H, H-4, H-6), 3.38 (dd, 1H, H-3, $J_{2,3}$ 3.2 Hz, $J_{3,4}$ 4.3 Hz), 2.30 (bs, 1H, OH), 2.20 (bs, 1H, OH), 1.62 (s, 1H, OH), 1.17 (dd, 1H, H-1a, $J_{1a,1b}$ -14.7 Hz, $J_{1a,2}$ 9.2 Hz), 1.05 (dd, 1H, H-1b, $J_{1b,2}$ 5.2 Hz), 0.33, 0.32 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 138.9, 137.7, 137.6 (Cq, arom), 133.3, 128.6-127.5 (CH, arom) 83.4, 77.6 (C-3, C-4), 73.2 (C-5), 73.9, 73.2 (CH_2, Bn), 67.9 (C-2), 63.2 (C-6), 21.7 (C-1), -2.0, -2.9 ($SiCH_3$).

Anal. Calcd for $C_{28}H_{36}O_5Si$ (480.68): C, 69.97; H, 7.55. Found: C, 69.46; H, 7.36.

General procedure for $BF_3{\cdot}Et_2O$-mediated cyclization. To an ice-cooled solution of a β,ε-dihydroxysilane (1.0 mmol) in CH_2Cl_2 (10 mL) was quickly added $BF_3{\cdot}Et_2O$ (0.14 mL, 1.1 mmol) and the mixture was allowed to reach rt. After TLC analysis indicated the disappearance of starting material, Et_3N (0.21 mL, 1.5 mmol) was added. The mixture was diluted with CH_2Cl_2 (30 mL), washed with H_2O (10 mL), dried ($MgSO_4$), filtered and concentrated *in vacuo*. The residue was purified by flash chromatography on silica gel.

$BF_3{\cdot}Et_2O$-mediated cyclization of 9. Cyclization of triol **9** (0.38 g, 0.79 mmol) with $BF_3{\cdot}Et_2O$ was executed as described in the general procedure to give two products (R_f 0.3 and R_f 0.7) as indicated by TLC analysis (toluene/acetone, 85/15, v/v). The oil obtained after work-up was applied onto a column of silica gel, which was eluted with Et_2O/light petroleum (1/1 2/1, v/v) to give 2,5-anhydro-3,4-di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-D-glucitol (**10**), yield 0.19 g (53%). R_f 0.7 (toluene/acetone, 85/15, v/v). $[\alpha]_D^{20}$ +36.2° (*c* 2). MS (*m/z*): 463 $[M+H]^+$, 485 $[M+Na]^+$. ^1H NMR: δ 7.55-7.25 (m, 15H, H-arom), 4.47 (s, 2H, CH_2, Bn), 4.30 (AB, 2H, CH_2, Bn, *J* -12.1 Hz), 4.12 (m, 1H, H-2), 3.92 (m, 2H, H-5, H-6a), 3.74 (dd, 1H, H-6b, $J_{5,6b}$ 1.8 Hz, $J_{6a,6b}$ -9.8 Hz), 3.63 (d, 1H, H-4, $J_{4,5}$ 3.7 Hz), 3.56 (d, 1H, H-3, $J_{2,3}$ 3.2 Hz), 1.38 (dd, 1H, H-1a, $J_{1a,1b}$ -14.2 Hz, $J_{1a,2}$ 7.3 Hz), 1.20 (dd, 1H, H-1b, $J_{1b,2}$ 7.5 Hz), 0.31 (s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ

138.8, 137.6 (Cq, arom), 133.4, 128.6-127.9 (CH, arom), 83.6, 83.2, 79.0 (C-2, C-3, C-4, C-5), 71.7, 70.8 (CH_2, Bn), 63.0 (C-6), 15.2 (C-1), -2.3, -2.7 ($SiCH_3$). Further elution with Et_2O/light petroleum (2/1, v/v) gave **13**, yield 5.8 mg (1.6%). R_f 0.7 (Et_2O/light petroleum, 3/1, v/v). ^{1}H NMR: δ 7.54-7.20 (m, 15H, H-arom), 4.43 (AB, 2H, CH_2, Bn, J -11.8 Hz), 4.31 (AB, 2H, CH_2, Bn, J -11.6 Hz), 4.22 (ddd, 1H, H-2, $J_{1a,2}$ 7.6 Hz, $J_{1b,2}$ 7.3 Hz, $J_{2,3}$ 3.5 Hz), 4.13 (q, 1H, H-5), 4.04 (dd, 1H, H-4, $J_{3,4}$ 1.5 Hz, $J_{4,5}$ 5.3 Hz), 3.77 (dd, 1H, H-6a, $J_{5,6a}$ 5.5 Hz, $J_{6a,6b}$ -11.6 Hz), 3.67 (dd, 1H, H-6b, $J_{5,6b}$ 4.9 Hz), 3.60 (dd, 1H, H-3), 1.32 (dd, 1H, H-1a, $J_{1a,1b}$ -14.3 Hz), 1.19 (dd, 1H, H-1b), 0.33, 0.31 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 138.9, 137.8, 137.4 (Cq, arom), 133.5, 128.7-127.3 (CH, arom), 82.9, 82.7 (C-3, C-4), 78.5, 77.5 (C-2, C-5), 72.2, 71.5 (CH_2, Bn), 61.6 (C-6), 15.7 (C-1), -2.2, -2.7 ($SiCH_3$).

Anal. Calcd for $C_{28}H_{34}O_4Si$ (462.66): C, 72.69; H, 7.41. Found: C, 72.49; H, 7.49.

Further elution with Et_2O/light petroleum (3/1, v/v) gave 3,4-di-*O*-benzyl-1,2-dideoxy-D-*arabino*-hex-1-enitol (**11**), yield 73 mg (28%). R_f 0.3 (toluene/acetone, 85/15, v/v). $[\alpha]_D^{20}$ -0.4° (*c* 2). ^{1}H NMR: δ 7.38-7.25 (m, 10H, H-arom), 5.96 (ddd, 1H, H-2, $J_{1a,2}$ 10.9 Hz, $J_{1b,2}$ 16.7 Hz, $J_{2,3}$ 8.3 Hz), 5.44-5.33 (m, 2H, H-1), 4.63 (AB, 2H, CH_2, Bn, J -11.3 Hz), 4.53 (AB, 2H, CH_2, Bn, J -12.0 Hz), 4.10 (ddd, 1H, H-5, $J_{4,5}$ 1.0 Hz, $J_{5,6a}$ 3.5 Hz, $J_{5,6b}$ 7.2 Hz), 3.80 (m, 1H, H-3), 3.69-3.64 (m, 3H, H-4, H-6. $^{13}C\{^1H\}$ NMR: δ 137.8, 137.5 (Cq, arom), 134.2 (C-2), 128.4-127.8 (CH, arom), 119.3 (C-1), 80.3, 80.0 (C-3, C-4), 74.0, 70.7 (CH_2, Bn), 71.1 (C-5), 63.2 (C-6).

Anal. Calcd for $C_{20}H_{24}O_4$ (328.41): C, 73.15; H, 7.37. Found: C, 73.17; H, 7.25.

General procedure for oxidative unmasking of phenylsilanes with KBr and AcO_2H. NaOAc (1.07 g, 13.0 mmol) was dissolved in AcOH (10 mL) and the solution was added to a phenylsilane (1.0 mmol). KBr (0.14 g, 1.20 mmol) was added, the mixture was cooled to 10 °C, and AcOOH (5.0 mL, 30% in AcOH) was added dropwise under exclusion of light. During the addition gas was liberated. The reaction mixture was stirred until TLC analysis indicated complete conversion of the starting material into a more hydrophilic product. The mixture was diluted with EtOAc (50 mL) and poured into a cooled (0 °C) solution of $Na_2S_2O_3$ (10 mL, 15%). The layers were separated and to the organic phase was added a saturated solution of $NaHCO_3$ (15 mL), followed by solid

$NaHCO_3$ until no more gas evolved. The organic phase was washed with H_2O (15 mL), dried ($MgSO_4$), filtered and concentrated. The residue was coevaporated with toluene (2x 5 mL) and purified by silica gel column chromatography.

*Oxidative unmasking of compound **10**.* Compound **10** (0.39 g, 0.84 mmol) was oxidatively unmasked as described in the general procedure to give 2,5-anhydro-3,4-di-*O*-benzyl-D-glucitol as an oil, yield 0.23 g (81%). R_f 0.3 (Et_2O). $[\alpha]_D^{20}$ -32.8° (*c* 1). ^1H NMR: δ 7.52-7.25 (m, 10H, H-arom), 4.56 (s, 2H, CH_2, Bn), 4.53 (AB, 2H, CH_2, Bn, J -11.8 Hz), 4.18-3.83 (m, 6H, H-1a, H-2, H-4, H-5, H-6), 3.80 (d, 1H, H-3, $J_{2,3}$ 2.8 Hz), 3.66 (dd, 1H, H-1b, $J_{1a,1b}$ -12.0 Hz, $J_{1b,2}$ 4.3 Hz). $^{13}C\{^1H\}$ NMR: δ 137.4, 137.0 (Cq, arom), 128.2-127.3 (CH, arom), 83.5, 83.2, 82.6, 80.4 (C-2, C-3, C-4, C-5), 71.7, 71.5 (CH_2, Bn), 62,4, 61.5 (C-1, C-6). Hydrogenation of 2,5-anhydro-3,4-di-*O*-benzyl-D-glucitol using Pd-C (10%) and H_2 in methanol gave 2,5-anhydro-D-glucitol (**14**) as an amorphous material, which crystallized when scratched, yield 0.10 g (95%). R_f 0.2 (EtOAc/MeOH, 85/15, v/v). Mp 54-56 C (Lit.[14c] 56-57 °C). ^1H NMR: Table 2. $^{13}C\{^1H\}$ NMR (H_2O): δ 85.0 (C-5), 81.4 (C-2), 78.4 (C-4), 77.3 (C-3), 62.1 (C-6), 60.6 (C-1).

General procedure for H_2SO_4-mediated cyclization. To a solution of a silane (4 mmol) in THF (20 mL) was added 1 drop of concentrated H_2SO_4. The solution was heated to 50 °C and stirred until TLC analysis indicated complete disappearance of starting material. The mixture was cooled to rt and partitioned between Et_2O (80 mL) and $NaHCO_3$ (20 mL, 15%). The layers were separated and the organic layer was dried ($MgSO_4$), filtered and concentrated, followed by purification by flash chromatography.

*H_2SO_4-mediated cyclization of **9**.* Cyclization of **9** (0.23 g, 0.48 mmol) in the presence of H_2SO_4 was performed as described above to afford, after work-up and silica gel chromatography, 2,5-anhydro-3,4-di-*O*-benzyl-1-deoxy-1-dimethyl-phenylsilyl-D-mannitol (**12**) and **10** as a 4:1 mixture, yield 95 mg (43%). R_f 0.3 (toluene/acetone, 85/15, v/v). Compound **12**: $^{13}C\{^1H\}$ NMR: δ 138.8, 137.3 (Cq, arom), 133.5, 128.3-127.4 (CH, arom), 89.0, 85.6 (C-2, C-3), 80.7, 80.0 (C-4, C-5), 72.7, 71.5 (CH_2, Bn), 63.1 (C-6), 20.8 (C-1), -1.5, -2.0 ($SiCH_3$). Further elution gave olefin **11**, yield 75 mg (48%).

*Oxidative unmasking of compounds **10** and **12**.* Treatment of the 4:1 mixture of **12** and **10** (95 mg, 0.20 mmol) with KBr and AcOOH was executed as described in the general procedure to give 2,5-anhydro-3,4-di-*O*-benzyl-D-mannitol and 2,5-anhydro-3,4-

Table 2. Optical rotation and measured ^1H NMR data (300 MHz) of 2,5-anhydrohexitols[a]

Compound (2,5-anhydro-)	[α] (H_2O)	H-1a ($J_{1a,1b}$,$J_{1a,2}$)	H-1b ($J_{1b,2}$)	H-2 ($J_{2,3}$)	H-3 ($J_{3,4}$)	H-4 ($J_{4,5}$)	H-5 ($J_{5,6a}$)	H-6a ($J_{6a,6b}$)	H-6b ($J_{5,6b}$)	ref.
14 (D-glucitol)[b]	+23.1	3.82 (-12.0,4.4)	3.71 (6.9)	4.10 (4.5)	4.16 (2.5)	4.00 (4.3)	3.81 (3.8)	3.76 (-12.0)	3.67 (6.0)	14c
22 (D-altritol)[c]	+44.5	3.84 (-11.7,4.8)	3.75 (7.0)	4.14 (3.6)	4.27 (4.5)	4.20 (8.0)	3.92 (2.8)	3.81 (-12.4)	3.66 (5.0)	14f
32 (D-iditol)	-6.5	3.58 (-11.8,4.6)	3.51 (6.8)	4.04[d] (3.3)	4.01[d] -	4.01 (3.3)	4.04 (4.6)	3.58 (-11.8)	3.51 (6.8)	14e,g
15 (D-mannitol)	+57.0	3.58 (-12.4,3.2)	3.49 (5.4)	3.70 (7.3)	3.86 -	3.86 (7.3)	3.70 (3.2)	3.58 (-12.4)	3.49 (5.4)	14d,e
23 (allitol)	0	3.77 (-12.4,3.4)	3.63 (5.3)	3.93 (5.4)	4.04 (5.7)	4.04 (5.4)	3.93	3.77 (-12.4)	3.63 (5.3)	-
33 (D-gulitol)[b]	-23.1	3.76 (-12.0,3.8)	3.67 (6.0)	3.81 (4.3)	4.00 (2.5)	4.16 (4.5)	4.10 (4.4)	3.82 (-12.0)	3.71 (6.9)	14c
- (galactitol)[e]	0	3.81 (-12.0,4.1)	3.72 (6.1)	4.06 (5.8)	4.40 (5.3)	4.40 (5.8)	4.06 (4.1)	3.81 (-12.0)	3.72 (6.1)	-

a. For ^{13}C NMR data, see reference 14a,b
b. **14** and **33** are enantiomers
c. Also 2,5-anhydro-D-talitol
d. Interchangeable
e. Following paper

di-*O*-benzyl-D-glucitol as a mixture after silica gel column chromatography, yield 49 mg (69%). R_f 0.3 (Et_2O). $^{13}C\{^1H\}$ NMR, *manno* isomer: δ 137.8 (Cq, arom), 128.3, 128.0, 127.3 (CH, arom), 84.2 (C-2, C-3), 81.0 (C-4, C-5), 71.7 (CH_2, Bn), 62.3 (C-1, C-6). Hydrogenation of 2,5-anhydro-3,4-di-*O*-benzyl-D-mannitol with H_2/Pd-C gave 2,5-anhydro-D-mannitol (**15**) after selective crystallization from EtOH, yield 18 mg (77%). R_f 0.70 (MeOH). Mp 97-99 °C (Lit.[14d] 101-101.5 °C). ^1H NMR: Table 2. $^{13}C\{^1H\}$ NMR (H_2O): δ 84.7 (C-3, C-4), 78.8 (C-2, C-5), 63.6 (C-1, C-6).

3,4-Di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-5,6-*O*-isopropylidene-D-altritol (17). The aldehyde obtained from hydrolysis of **16** (5.50 g, 11.55 mmol) in Et_2O was treated with **1** according to the general procedure for open-chain aldehydes. The oil obtained after extraction was applied onto a column of silica gel and elution was effected with Et_2O/light petroleum (1/4 1/3, v/v) to afford **17** as an oil, yield 4.02 g (67%). R_f 0.7 (Et_2O/light petroleum, 1/1, v/v). ^1H NMR: δ 7.54-7.23 (m, 15H, H-arom), 4.68 (s, CH_2, Bn), 4.60 (AB, 2H, CH_2, Bn, J -11.4 Hz), 4.25 (m, 1H, H-5), 4.00-3.90 (m, 3H, H-2, H-6), 3.80 (dd, 1H, H-4, $J_{3,4}$ 3.4 Hz, $J_{4,5}$ 5.2 Hz), 3.39 (dd, 1H, H-3, $J_{2,3}$ 4.9 Hz), 2.82 (d, 1H, OH, J 4.1 Hz), 1.39, 1.31 (2x s, 6H, CH_3, isoprop), 1.02 (m, 1H, H-1a), 0.85 (dd, 1H, H-1b, $J_{1a,1b}$ -11.1 Hz, $J_{1b,2}$ 5.4 Hz), 0.33, 0.32 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 139.0, 137.7, 137.6 (Cq, arom), 133.4, 128.3-127.5 (CH, arom), 108.3 (Cq, isoprop), 83.5, 79.6 (C-3, C-4), 75.2 (C-5), 73.9, 73.6 (CH_2, Bn), 68.4 (C-2), 65.8 (C-6), 26.2, 24.9 (CH_3, isoprop), 20.7 (C-1), -1.9, -2.8 ($SiCH_3$).

Anal. Calcd for $C_{31}H_{40}O_5Si$ (520.74): C, 71.50; H, 7.74. Found: C, 71.39; H, 7.71.

3,4-Di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-D-altritol (18). Compound **17** (1.43 g, 2.75 mmol) was deacetonated as described in the general procedure to give triol **18** as an oil, yield 1.21 g (92%). R_f 0.4 (Et_2O/light petroleum, 3/1, v/v). $[\alpha]_D^{20}$ +9.1° (*c* 2). ^1H NMR: δ 7.54-7.24 (m, 15H, H-arom), 4.63 (AB, CH_2, Bn, J -11.1 Hz), 4.54 (s, 2H, CH_2, Bn), 3.92-3.63 (m, 4H, H-2, H-5, H-6), 3.58-3.53 (m, 2H, H-3, H-4), 1.17-1.07 (m, 2H, H-1), 0.34, 0.32 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 138.8, 137.6, 137.4 (Cq, arom), 133.3, 128.4-127.5 (CH, arom), 82.2, 81.1 (C-3, C-4), 73.6, 73.2 (CH_2, Bn), 70.6, 69.0 (C-2, C-5), 63.3 (C-6), 21.4 (C-1), -2.0, -3.0 ($SiCH_3$).

Anal. Calcd for $C_{28}H_{36}O_5Si$ (480.68): C, 69.97; H, 7.55. Found: C, 69.96; H, 7.49.

*BF_3·Et_2O-mediated cyclization of **18**.* Cyclization of triol **18** (0.34 g, 0.70 mmol) was executed as described in the general procedure to give two products (R_f 0.5 and R_f 0.8) as indicated by TLC analysis (Et_2O). The oil obtained after work-up was applied onto a column of silica gel, which was eluted with Et_2O/light petroleum (1/1 2/1, v/v) to 2,5-anhydro-3,4-di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-D-altritol (**19**), yield 71 mg (22%). R_f 0.8 (Et_2O). $[\alpha]_D^{20}$ +38.3° (*c* 1). ^{1}H NMR: δ 7.54-7.26 (m, 15H, H-arom), 4.63 (AB, 2H, CH_2, Bn, *J* -11.8 Hz), 4.55 (AB, 2H, CH_2, Bn, *J* -11.8 Hz), 4.10-3.96 (m, 3H, H-2, H-5, H-6a), 3.76-3.72 (m, 2H, H-4, H-6b), 3.47 (m, 1H, H-3), 1.44 (dd, 1H, H-1a, $J_{1a,1b}$ -14.5 Hz, $J_{1a,2}$ 9.2 Hz), 1.14 (dd, 1H, H-1b, $J_{1b,2}$ 5.8 Hz), 0.33, 0.30 (2x s, 6H, CH_3Si). $^{13}C\{^1H\}$ NMR: δ 139.1, 138.5, 137.8 (Cq, arom), 133.6, 128.4-127.5 (CH, arom), 79.8, 79.7, 78.8, 78.4 (C-2, C-3, C-4, C-5), 72.9, 72.7 (CH_2, Bn), 62.5 (C-6), 16.9 (C-1), -2.0, -2.3 ($SiCH_3$).

Anal. Calcd for $C_{28}H_{34}O_4Si$ (462.66): C, 72.69; H, 7.41. Found: C, 72.66; H, 7.46.

Further elution with Et_2O/light petroleum (3/1, v/v) afforded 3,4-di-*O*-benzyl-1,2-dideoxy-D-*ribo*-hex-1-enitol (**20**), yield 0.12 g (52%). R_f 0.5 (Et_2O). $[\alpha]_D^{20}$ +63.3° (c 2). NMR: δ 7.40-7.25 (m, 10H, H-arom), 5.91 (ddd, 1H, H-2, $J_{1a,2}$ 16.7 Hz, $J_{1b,2}$ 11.0 Hz, $J_{2,3}$ 7.7 Hz), 5.46-5.36 (m, 2H, H-1), 4.62 (AB, 2H, CH_2, Bn, *J* -11.0 Hz), 4.52 (AB, 2H, CH_2, Bn, *J* -11.8 Hz), 4.08 (dd, 1H, H-3, $J_{3,4}$ 6.0 Hz), 3.78-3.71 (m, 3H, H-5, H-6), 3.61 (t, 1H, H-4, $J_{4,5}$ 6.2 Hz), 3.10 (d, 1H, OH, *J* 3.2 Hz). $^{13}C\{^1H\}$ NMR: δ 137.9, 137.7 (Cq, arom), 135.1 (C-2), 128.3-127.6 (CH, arom), 119.8 (C-1), 81.8, 81.1 (C-3, C-4), 73.9, 70.3 (CH_2, Bn), 72.0 (C-5), 63.3 (C-6). ^{1}H NMR: δ 7.40-7.25 (m, 10H, H-arom), 5.91 (ddd, 1H, H-2, $J_{1a,2}$ 16.7 Hz, $J_{1b,2}$ 11.0 Hz, $J_{2,3}$ 7.7 Hz), 5.46-5.36 (m, 2H, H-1), 4.62 (AB, 2H, CH_2, Bn, *J* -11.0 Hz), 4.52 (AB, 2H, CH_2, Bn, *J* -11.8 Hz), 4.08 (dd, 1H, H-3, $J_{3,4}$ 6.0 Hz), 3.78-3.71 (m, 3H, H-5, H-6), 3.61 (t, 1H, H-4, $J_{4,5}$ 6.2 Hz), 3.10 (d, 1H, OH, *J* 3.2 Hz). $^{13}C\{^1H\}$ NMR: δ 137.9, 137.7 (Cq, arom), 135.1 (C-2), 128.3-127.6 (CH, arom), 119.8 (C-1), 81.8, 81.1 (C-3, C-4), 73.9, 70.3 (CH_2, Bn), 72.0 (C-5), 63.3 (C-6).

Anal. Calcd for $C_{20}H_{24}O_4$ (328.41): C, 73.15; H, 7.37. Found: C, 72.99; H, 7.29.

*Oxidative unmasking of **19**.* Treatment of **19** (0.14 g, 0.30 mmol) with KBr and AcOOH was executed as described in the general procedure to give 2,5-anhydro-3,4-di-*O*-benzyl-D-altritol, which was purified by silica gel column chromatography (elution:

EtOAc/light petroleum, 3/1 1/0, v/v), yield 74 mg (71%). R_f 0.2 (Et_2O). $[\alpha]_D^{20}$ +20.6° (*c* 0.5). ^{1}H NMR: δ 7.34-7.25 (m, 10H, H-arom), 5.33 (AB, 2H, CH_2, Bn, *J* -11.8 Hz), 5.30 (d, 2H, CH_2, Bn, *J* -0.4 Hz), 4.77-3.80 (m, 6H, H-1, H-2, H-3, H-4, H-5), 3.57 (m, 1H, H-3), 2.51 (m, 1H, OH), 1.88 (m, 1H, OH). $^{13}C\{^1H\}$ NMR: δ 137.7, 137.4 (Cq, arom), 128.5-127.7 (CH, arom), 81.2, 80.2, 78.5, 77.9 (C-2, C-3, C-4, C-5), 73.3, 72.8 (CH_2, Bn), 62.2 (C-1, C-6).Hydrogenation of 2,5-anhydro-3,4-di-*O*-benzyl-D-altritol (49 mg, 0.14 mmol) in MeOH using Pd-C/H_2 with gave 2,5-anhydro-D-altritol (**22**), yield 32 mg (90%). R_f 0.4 (MeOH). ^{1}H NMR: Table 2. $^{13}C\{^1H\}$ NMR (CD_3OD): δ 83.4, 82.3 (C-3, C-4), 73.5, 73.3 (C-2, C-5), 63.2 (C-6), 62.2 (C-1).

Anal. Calcd for $C_6H_{12}O_5$ (164.16): C, 43.90; H, 7.37. Found: C, 43.64; H, 7.12.

H_2SO_4-mediated cyclization of 18. Cyclization of **18** (0.33 g, 0.68 mmol) in the presence of H_2SO_4 was performed as described above, to give **19** and **21** as an intractable mixture (ratio 1:20) after purification, yield 0.23 g (73%). R_f 0.5 (Et_2O). $[\alpha]_D^{20}$ -7.1° (*c* 2). Compound **21**: ^{1}H NMR: δ 7.53-7.25 (m, 15H, H-arom), 4.52 (d, 2H, CH_2, Bn, *J* -1.1 Hz), 4.48 (AB, 2H, CH_2, Bn, *J* -11.8 Hz), 4.18 (dt, 1H, H-2, $J_{1a,2}$ $J_{2,3}$ 5.2 Hz, $J_{1b,2}$ 9.6 Hz), 3.95 (dt, 1H, H-5, $J_{4,5}$ $J_{5,6a}$ 5.5 Hz, $J_{5,6b}$ 4.4 Hz), 3.85 (t, 1H, H-4, $J_{3,4}$ 5.5 Hz), 3.62 (ddd, 1H, H-6a, $J_{6a,6b}$ -10.3 Hz), 3.45 (t, 1H, H-3, $J_{3,4}$ 5.1 Hz), 3.39 (m, 1H, H-6b), 1.35 (dd, 1H, OH, *J* 4.7, 8.4 Hz), 1.12 (dd, 1H, H-1a, $J_{1a,1b}$ -14.4 Hz), 0.97 (dd, 1H, H-1b), 0.33, 0.30 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 139.1, 137.6 (Cq, arom), 133.3, 128.6-127.5 (CH, arom), 83.4, 81.6, 79.3, 76.6 (C-2, C-3, C-4, C-5), 71.9, 71.8 (CH_2, Bn), 62.2 (C-6), 22.0 (C-1), -2.5 ($SiCH_3$). Further elution gave olefin **20**, yield 34 mg (15%).

Oxidative demasking of 21 and 19. Treatment of the mixture of **21** and **19** (0.23 g, 0.73 mmol, ratio 20:1) with KBr and AcOOH was executed as described in the general procedure to give 2,5-anhydro-3,4-di-*O*-benzyl-D-allitol and 2,5-anhydro-3,4-di-*O*-benzyl-D-altritol after silica gel column chromatography, yield 49 mg (69%). R_f 0.3 (Et_2O). ^{1}H NMR, *allo*-isomer: δ 7.34-7.26 (m, 10H, H-arom), 4.60 (AB, 4H, CH_2, Bn, *J* -12.0 Hz), 4.13 (m, 2H, H-2, H-5), 4.01 (dd, 2H, H-3, H-4, $J_{3,4}$ 3.7 Hz, $J_{2,3}$ $J_{4,5}$ 1.1 Hz), 3.83 (dd, 2H, H-1a, $J_{1a,1b}$ $J_{6a,6b}$ -12.0 Hz, $J_{1a,2}$ $J_{5,6a}$ 2.8 Hz), 3.57 (dd, 2H, H-1b, H-6b, $J_{1b,2}$ $J_{5,6b}$ 3.0 Hz), 2.40 (m, 1H, OH). $^{13}C\{^1H\}$ NMR, *allo*-isomer: δ 137.7 (Cq, arom), 128.3, 127.8, 127.7 (CH, arom), 82.3, 77.3 (C-2, C-3, C-4, C-5), 72.1 (CH_2, Bn), 62.1 (C-1). Hydrogenation of 2,5-anhydro-3,4-di-*O*-benzyl-D-allitol (49 mg, 0.14 mmol) with H_2/Pd-

C gave 2,5-anhydroallitol (**23**), yield 18 mg (77%). R_f 0.2 (MeOH). ^{1}H NMR: Table 2. ^{13}C{^{1}H} NMR (CD_3OD): δ 85.3 (C-3, C-4), 72.7 (C-2, C-5), 63.2 (C-6).

Anal. Calcd for $C_6H_{12}O_5$ (164.16): C, 43.90; H, 7.37. Found: C, 43.72; H, 7.12.

2,3-Di-*O*-benzyl-D-xylose Diethyl Dithioacetal (25).[28] Compound **24** (14.8 g, 31.1 mmol) was deacetonated as decribed in the general procedure to give crude **25** after purification, yield 11.8 g (87%).

4,5-Di-*O*-benzoyl-2,3-di-*O*-benzyl-D-xylose Diethyl Dithioacetal (26). To a cooled (0 °C) solution of crude diol **25** (7.46 g, 17.1 mmol) in pyridine (150 mL) was added benzoyl chloride (4.57 mL, 39.3 mmol). Stirring was continued at rt for 3 h, the mixture was concentrated and the residue partitioned between Et_2O (300 mL) and H_2O (50 mL). The organic layer was washed with H_2O (30 mL), separated and dried ($MgSO_4$). After filtration, solvents were evaporated and the residue purified by silica gel column chromatography (elution: Et_2O/light petroleum, 1/3 1/2, v/v) to give **26**, yield 10.21 g (93%). R_f 0.4 (Et_2O/light petroleum, 1/1, v/v). $[\alpha]_D^{20}$ +40.5° (*c* 2). ^{1}H NMR: δ 8.04-7.90 (m, 4H, H-arom), 7.52-7.24 (m, 16H, H-arom), 5.76 (dt, 1H, H-4, $J_{3,4}$ $J_{4,5a}$ 4.0 Hz, $J_{4,5b}$ 6.8 Hz), 4.73 (AB, 2H, CH_2, Bn, J -11.2 Hz), 4.65 (AB, 2H, CH_2, Bn, J -12.1 Hz), 4.60 (dd, 1H, H-5a, $J_{5a,5b}$ -11.7 Hz), 4.57 (dd, 1H, H-5b), 4.16 (dd, 1H, H-3, $J_{3,4}$ 3.7 Hz), 4.01 (d, 1H, H-1, $J_{1,2}$ 3.6 Hz), 3.91 (dd, 1H, H-2, $J_{2,3}$ 7.0 Hz). ^{13}C{^{1}H} NMR: δ 165.8, 165.6 (C=O), 139.6, 137.8, 137.6 (Cq, arom), 133.6-127.6 (CH, arom), 83.0, 77.2, 71.5 (C-2, C-3, C-4), 74.0, 73.5 (CH_2, Bn), 63.2 (C-5), 52.7 (C-1), 25.6, 25.0 (CH_2, SEt), 14.2 (CH_3, SEt).

Anal. Calcd for $C_{37}H_{40}O_6S_2$ (664.84): C, 68.92; H, 6.25. Found: C, 68.75; H, 6.20.

5,6-Di-*O*-benzoyl-3,4-di-*O*-benzoyl-1-deoxy-1-dimethylphenylsilyl-D-iditol (27). The aldehyde obtained from hydrolysis of **26** (3.64 g, 5.65 mmol) in THF was treated with **1** according to the general procedure for open-chain aldehydes. The oil obtained after extraction was applied onto a column of silica gel and elution was effected with Et_2O/light petroleum (1/3 1/2, v/v) to afford **27** as an oil, yield 2.76 g (71%). R_f 0.8 (Et_2O/light petroleum, 3/1, v/v). $[\alpha]_D^{20}$ +26.7° (*c* 2). ^{1}H NMR: δ 8.08-7.90 (m, 4H, H-arom), 7.57-7.24 (m, 21H, H-arom), 5.78 (dt, 1H, H-5, $J_{4,5}$ $J_{5,6a}$ 5.4 Hz, $J_{5,6b}$ 6.0 Hz), 4.72 (AB, 2H, CH_2, Bn, J -11.3 Hz), 4.65 (AB, 2H, CH_2, Bn, J -12.2 Hz), 4.59-4.44 (m, 2H, H-6), 4.03 (dd, 1H, H-4, $J_{3,4}$ 6.1 Hz), 3.98 (m, 1H, H-2), 3.39 (dd, 1H, H-3, $J_{2,3}$ 2.4 Hz), 2.01 (d, 1H, OH, J 6.7 Hz), 1.14 (dd, 1H, H-1a, $J_{1a,1b}$ -14.4 Hz, $J_{1a,2}$ 9.6 Hz), 0.93 (dd, 1H, H-1b, $J_{1b,2}$ 4.5 Hz), 0.34, 0.29 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 165.6 (C=O), 140.0, 137.8, 137.6 (Cq, arom), 133.6-127.6 (CH, arom), 83.0, 77.2 (C-3, C-4), 74.7, 74.4 (CH_2, Bn), 71.3, 68.5 (C-2, C-5), 63.5 (C-6), 22.2 (C-1), -2.1, -2.9 ($SiCH_3$).

Anal. Calcd for $C_{42}H_{44}O_7Si$ (688.89): C, 73.23; H, 6.44. Found: C, 72.96; H, 6.35.

3,4-Di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-D-iditol (28). Compound **27** (6.32 g, 9.19 mmol) was dissolved in MeOH (80 mL) and KO*t*-Bu (0.21 g, 1.84 mmol) was added. The mixture was stirred for 16 h, neutralized with Dowex-H^+, filtered and concentrated *in vacuo*. The residual oil was applied onto a column of silica gel and elution was effected with Et_2O/light petroleum (1/1 2/1, v/v) to give **28** as an oil, yield 3.84 g (87%). R_f 0.1 (Et_2O/light petroleum, 3/1, v/v). $[\alpha]_D^{20}$ -13.6° (*c* 1). ^1H NMR: δ 7.53-7.18 (m, 15H, H-arom), 4.55 (AB, 2H, CH_2, Bn, J -10.5 Hz), 4.51 (AB, 2H, CH_2, Bn, J -11.5 Hz), 4.07 (ddd, 1H, H-2, $J_{1a,2}$ 9.4 Hz, $J_{1b,2}$ 5.1 Hz, $J_{2,3}$ 0.8 Hz), 3.84 (ddd, 1H, H-5, $J_{4,5}$ 0.9 Hz, $J_{5,6a}$ 6.8 Hz, $J_{5,6b}$ 4.9 Hz), 3.58 (dd, 1H, H-6a, $J_{6a,6b}$ -10.9 Hz), 3.48-3.38 (m, 3H, H-3, H-4, H-5), 1.24 (dd, 1H, H-1a, $J_{1a,1b}$ -14.7 Hz), 0.98 (dd, 1H, H-1b), 0.33, 0.32 (2x s, 6H, $SiCH_3$). $^{13}C\{^1H\}$ NMR: δ 139.3, 137.7, 137.6 (Cq, arom), 133.3, 128.6-127.6 (CH, arom), 81.6, 77.4 (C-3, C-4), 74.0, 73.8 (CH_2, Bn), 69.8, 67.2 (C-2, C-5), 63.7 (C-6), 21.9 (C-1), -2.1, -3.0 ($SiCH_3$).

Anal. Calcd for $C_{42}H_{44}O_7Si$ (688.89): C, 73.23; H, 6.44. Found: C, 73.01; H, 6.21.

BF_3·Et_2O-mediated cyclization of ***28***. Cyclization of **28** (0.33 g, 0.69 mmol) was executed as described above to afford 2,5-anhydro-3,4-di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-D-iditol (**29**) as an oil after purification on silica gel (elution: Et_2O/light petroleum, 1/1, v/v), yield 0.34 g (61%). R_f 0.6 (Et_2O/light petroleum, 3/1, v/v). $[\alpha]_D^{20}$ -12.8° (*c* 1). ^1H NMR: δ 7.54-7.20 (m, 15H, H-arom), 4.43 (AB, 2H, CH_2, Bn, J -11.8 Hz), 4.31 (AB, 2H, CH_2, Bn, J -11.6 Hz), 4.22 (ddd, 1H, H-2, $J_{1a,2}$ 7.6 Hz, $J_{1b,2}$ 7.3 Hz, $J_{2,3}$ 3.5 Hz), 4.13 (q, 1H, H-5), 4.04 (dd, 1H, H-4, $J_{3,4}$ 1.5 Hz, $J_{4,5}$ 5.3 Hz), 3.77 (dd, 1H, H-6a, $J_{5,6a}$ 5.5 Hz, $J_{6a,6b}$ -11.6 Hz), 3.67 (dd, 1H, H-6b, $J_{5,6b}$ 4.9 Hz), 3.60 (dd, 1H, H-3), 1.32 (dd, 1H, H-1a, $J_{1a,1b}$ -14.3 Hz), 1.19 (dd, 1H, H-1b), 0.33, 0.31 (2x s, 6H,

SiCH$_3$). ^{13}C{^{1}H} NMR: δ 138.9, 137.8, 137.4 (Cq, arom), 133.5, 128.7-127.3 (CH, arom), 82.9, 82.7 (C-3, C-4), 78.5, 77.5 (C-2, C-5), 72.2, 71.5 (CH_2, Bn), 61.6 (C-6), 15.7 (C-1), -2.2, -2.7 (SiCH$_3$).

Anal. Calcd for $C_{28}H_{34}O_4Si$ (462.66): C, 72.69; H, 7.41. Found: C, 72.67; H, 7.40.

Further elution with Et_2O/light petroleum (2/1, v/v) afforded 3,4-di-*O*-benzyl-1,2-dideoxy-D-*xylo*-hex-1-enitol (**30**), yield 0.14 g (35%). R_f 0.2 (Et_2O/light petroleum, 3/1, v/v). $[\alpha]_D^{20}$ -2.0° (*c* 1). ^{1}H NMR: δ 7.36-7.21 (m, 10H, H-arom), 6.00 (ddd, 1H, H-2, $J_{1a,2}$ 10.9 Hz, $J_{1b,2}$ 16.7 Hz, $J_{2,3}$ 8.5 Hz), 5.46-5.32 (m, 2H, H-1), 4.58 (AB, 2H, CH_2, Bn, J -10.8 Hz), 4.52 (AB, 2H, CH_2, Bn, J -12.0 Hz), 3.85 (ddd, 1H, H-5, $J_{4,5}$ 1.1 Hz, $J_{5,6a}$ 6.8 Hz, $J_{5,6b}$ 4.8 Hz), 3.56 (dd, 1H, H-6a, $J_{6a,6b}$ -10.5 Hz), 3.50-3.40 (m, 3H, H-3, H-4, H-6b). ^{13}C{^{1}H} NMR: δ 137.4 (Cq, arom), 134.8 (C-2), 128.4-127.6 (CH, arom), 119.4 (C-1), 81.3, 81.0 (C-3, C-4), 74.7, 70.8 (CH_2, Bn), 71.1 (C-5), 64.0 (C-6).

Anal. Calcd for $C_{20}H_{24}O_4$ (328.41): C, 73.15; H, 7.37. Found: C, 72.95; H, 7.36.

Oxidative unmasking of 29. Treatment of **29** (0.21 g, 0.45 mmol) with KBr and AcOOH was executed as described in the general procedure to give 2,5-anhydro-3,4-di-*O*-benzyl-D-iditol as an oil after work-up and purification by silica gel column chromatography (elution: Et_2O/light petroleum, 1/2, v/v), yield 0.11 g (73%). R_f 0.2 (Et_2O). $[\alpha]_D^{20}$ -48.2° (*c* 1). ^{1}H NMR: δ 7.37-7.25 (m, 10H, H-arom), 4.56 (s, 2H, CH_2, Bn), 4.50 (AB, 2H, CH_2, Bn, J -12.2 Hz), 4.05-3.95 (m, 1H, H-2), 3.91-3.36 (m, 7H, H-1, H-3, H-4, H-5, H-6), 2.10 (bs, 1H, OH), 1.73 (bs, 1H, OH). ^{13}C{^{1}H} NMR: δ 137.4, 137.2 (Cq, arom), 128.6-127.8 (CH, arom), 74.7, 73.4 (C-3, C-4, C-5), 72.9, 72.6 (CH_2, Bn), 66.7 (C-1), 64.6 (C-2), 62.3 (C-6). Hydrogenation of 2,5-anhydro-3,4-di-*O*-benzyl-D-iditol (0.11 g, 0.32 mmol) in methanol, using H_2 and Pd-C gave 2,5-anhydro-D-iditol (**32**), yield 49 mg (93%). R_f 0.1 (MeOH). Crystallization from EtOH afforded white crystals (20 mg). Mp 113-115 °C (Lit.[14e,g] 119 °C). ^{1}H NMR: Table 2. ^{13}C{^{1}H} NMR (CD_3OD): δ 81.9 (C-2, C-5), 78.5 (C-3, C-4), 61.8 (C-1, C-6).

H_2SO_4-mediated cyclization of 28. Cyclization of **28** (0.43 g, 0.90 mmol) in the presence of H_2SO_4 was performed as described above, to give **29** and 2,5-anhydro-3,4-di-*O*-benzyl-1-deoxy-1-dimethylphenylsilyl-D-gulitol (**31**) as an intractable mixture (ratio 2:3) after purification, yield 0.10 g (25%). Compound **31**: ^{13}C{^{1}H} NMR: δ 138.5, 138.1

(Cq, arom), 133.5, 128.4-127.3 (CH, arom), 83.8, 81.0 (C-3, C-4), 77.5, 77.3 (C-2, C-5), 73.3, 72.1 (CH_2, Bn), 61.6 (C-6), 18.9 (C-1), -2.0, -2.6 ($SiCH_3$). Olefin **30** was isolated as the major product, yield 0.18 g (61%).

Oxidative unmasking of 29 and 31. Treatment of the mixture of **29** and **31** (0.10 g, 0.22 mmol, ratio 1:2) with KBr and AcOOH was executed as described in the general procedure to give 2,5-anhydro-3,4-di-*O*-benzyl-D-iditol as an oil after work-up and silica gel column chromatography (elution: Et_2O/light petroleum, 1/3, v/v), yield 22 mg (29%). Further elution with Et_2O afforded the 2,5-anhydro-3,4-di-*O*-benzyl-D-gulitol, yield 33 mg (44%). R_f 0.1 (Et_2O). $[\alpha]_D^{20}$ -35.5° (*c* 1). ^1H NMR: δ 7.35-7.25 (m, 15H, H-arom), 4.57 (AB, 2H, CH_2, Bn, *J* -12.0 Hz), 4.53 (AB, 2H, CH_2, Bn, *J* -11.8 Hz), 4.48 (AB, 2H, CH_2, Bn, *J* -12.0 Hz), 4.35, 4.33 (2x dd, H-2, H-5), 4.05, 3.98 (2x d, 2H, H-3, H-4), 3.75-3.68 (m, 4H, H-1, H-6), 2.27 (bs, 1H, OH). $^{13}C\{^1H\}$ NMR: δ 138.0, 137.7, 137.3 (Cq, arom), 128.5-127.5 (CH, arom), 84.5, 82.8, 82.3, 80.0 (C-2, C-3, C-4, C-5), 73.5, 71.9, 71.6 (CH_2, Bn), 68.2 (C-6), 63.0 (C-1). Hydrogenation of 2,5-anhydro-3,4-di-*O*-benzyl-D-gulitol (33 mg, 0.10 mmol) gave 2,5-anhydro-D-gulitol (**33**), the enantiomer of **14**, yield 15 mg (97%).

(Chloromethyl)(diisopropyl)phenylsilane (35). To a cooled (0 °C) solution of bromobenzene (2.32 mL, 22.0 mmol) in Et_2O (60 mL) under an atmosphere of nitrogen was added dropwise with stirring a solution of *n*-BuLi in hexanes (13.8 mL, 1.6 M) and stirring continued for 1 h. The solution was cooled (-60 °C) and there was added all at once dichloro(diisopropyl)silane (3.70 g, 20 mmol) *via* syringe. After stirring the resulting mixture for 0.5 h, the reaction mixture was allowed to warm to rt and deposited salts, under a stream of argon, were filtered off (Celite), before concentration of the filtrate *in vacuo*. The residue was dissolved in THF (65 mL), bromochloromethane (1.56 mL, 24.0 mmol) was added and the mixture was cooled to –70 °C before the slow addition, *via* the cold wall of the flask, of a solution of *n*-BuLi in hexanes (15.0 mL, 1.6 M). Stirring was continued at -65 to –70 °C for 1 h, allowed to warm to rt and neutralized by the addition of aqueous NH_4Cl (40 mL, 15%). The mixture was transferred to a separatory funnel, light petroleum (100 mL) was added and the layers were separated. The organic phase washed with brine (30 mL), dried ($MgSO_4$), filtered and concentrated. Purification on silica gel (eluent: light petroleum) afforded **35** as a liquid, yield 3.49 g

(72%). R_f 0.6 (light petroleum). ^{1}H NMR: δ 7.52-7.25 (m, 5H, H-arom), 3.20 (s, 2H, $SiCH_2Cl$), 1.52-1.36 (m, 2H, CH, *i*-Pr), 1.14-0.92 (m, 6H, CH_3, *i*-Pr). $^{13}C\{^1H\}$ NMR: δ 134.7 (CH, arom), 133.8 (Cq, arom), 129.3, 127.8 (CH, arom), 25.5 ($SiCH_2Cl$), 17.8 (CH_3, *i*-Pr), 10.3 (CH, *i*-Pr).

3,4,6-Tri-*O*-benzyl-1-deoxy-1-phenyl(diisopropyl)silyl-D-glucitol (37). Treatment of compound **2** (0.21 g, 0.5 mmol) with **36**, prepared by metallation of **35** (0.27 g, 1.5 mmol) with magnesium (0.04 g, 1.65 mmol) in THF (2 mL), and work-up were executed as described in the general procedure, yield 0.27 g (88%). R_f 0.8 (toluene/EtOAc, 3/2, v/v). ^{1}H NMR: δ 7.48-7.21 (m, 20H, H-arom), 4.66 (AB, 2H, CH_2, Bn, *J* -11.3 Hz), 4.56 (AB, 2H, CH_2, Bn, *J* -11.7 Hz), 4.50 (s, 2H, CH_2, Bn), 4.17-3.97 (m, 2H, H-2, H-5), 3.76-3.46 (m, 3H, H-4, H-6), 3.45 (t, 1H, H-3), 1.38-1.20 (m, 3H, H-1a, CH, *i*-Pr), 1.14-0.96 (m, 7H, H-1b, CH_3, *i*-Pr). $^{13}C\{^1H\}$ NMR: δ 138.0, 137.7, 135.6 (Cq, arom), 134.7, 128.5-127.4 (CH, arom), 84.4, 78.3 (C-3, C-4), 74.5, 73.5, 73.2 (CH_2, Bn), 71.0 (C-6), 70.7, 68.0 (C-2, C-5), 18.0 (CH_3, *i*-Pr), 15.9 (C-1), 11.3, 11.0 (CH, *i*-Pr).

Anal. Calcd for $C_{39}H_{50}O_5Si$ (626.91): C, 74.72; H, 8.04. Found: C, 74.51; H, 7.95.

BF_3·Et_2O-mediated cyclization of 37. Cyclization of compound **37** (0.16 g, 0.25 mmol) was executed as described in the general procedure. The oil obtained after work-up was applied onto a column of silica gel, which was eluted with Et_2O/light petroleum (1/4 1/3, v/v) to give 2,5-anhydro-3,4,6-tri-*O*-benzyl-1-deoxy-1-phenyl(diisopropyl)silyl-D-glucitol (**39**) and 2,5-anhydro-3,4,6-tri-*O*-benzyl-1-deoxy-1-fluoro(diisopropyl)silyl-D-glucitol (**40**) as an intractable mixture (ratio 1:1), yield 0.10 g (67%). R_f 0.8 (Et_2O/light petroleum, 1/1, v/v). Compound **39**: ^{1}H NMR: δ 7.52-7.23 (m, 20H, H-arom), 4.51 (AB, 2H, CH_2, Bn, *J* -12.0 Hz), 4.45 (AB, 2H, CH_2, Bn, *J* -12.1 Hz), 4.33 (AB, 2H, CH_2, Bn, *J* -11.5 Hz), 4.24 (m, 1H, H-2), 3.99 (ddd, 1H, H-5, $J_{5,6a}$ 5.6 Hz, $J_{5,6b}$ 7.5 Hz, $J_{4,5}$ 3.2 Hz), 3.85 (d, 1H, H-4, $J_{4,5}$ 2.8 Hz), 3.58 (dd, 1H, H-6a, $J_{6a,6b}$ -8.6 Hz), 3.54 (d, 1H, H-3, $J_{2,3}$ 3.2 Hz), 3.49 (dd, 1H, H-6b), 1.50-1.22 (m, 4H, H-1, CH, *i*-Pr), 1.06-0.97 (m, 6H, CH_3, *i*-Pr). $^{13}C\{^1H\}$ NMR: δ 138.2, 138.0, 137.8, 135.3 (Cq, arom), 134.8, 128.5-127.9 (CH, arom), 83.9, 83.7, 82.0, 78.6 (C-2, C-3, C-4, C-5), 73.1, 71.2, 70.8, 70.7 (CH_2, Bn, C-6), 18.1 (CH_3, *i*-Pr), 11.4, 11.0 (CH, *i*-Pr), 9.2 (C-1). Compound **40**: $^{13}C\{^1H\}$ NMR: δ 138.1,

137.9, 137.7 (Cq, arom), 128.5-127.6 (CH, arom), 84.2, 83.8, 82.2, 77.9 (C-2, C-3, C-4, C-5), 73.2, 71.3, 70.8 (CH_2, Bn, C-6), 16.8, 16.7 (CH_3, *i*-Pr), 12.8 (d, CH, *i*-Pr, $J_{F,C}$ 4.4 Hz), 12.6 (CH, *i*-Pr), 10.5 (d, C-1, $J_{F,C}$ 13.2 Hz). Further elution with Et_2O/light petroleum (1/2, v/v) gave 3,4,6-tri-*O*-benzyl-1-deoxy-1-fluoro(diisopropyl)silyl-D-glucitol, yield 20 mg (14%). MS (*m/z*): 551 $[M+H-H_2O]^+$, 569 $[M+H]^+$. $^{13}C\{^1H\}$ NMR: δ 137.9, 137.8 (Cq, arom), 128.4-127.7 (CH, arom), 83.8, 78.1 (C-3, C-4), 74.8, 73.7, 73.4 (CH_2, Bn), 71.1 (C-6), 70.9, 67.4 (C-2, C-5), 17.2 (C-1), 16.8 (CH_3, *i*-Pr), 12.8, 12.5 (CH, *i*-Pr).

$BF_3 \cdot Et_2O$-mediated cyclization of 38. To a solution of compound **37** (0.11 g, 0.18 mmol) in acetonitrile (2 mL) was added hexamethyldisilazane (0.19 mL, 0.90 mmol) and TMSCl (0.1 mL). After stirring for 1 h, salts were filtered off (Celite) and the filtrated concentrated *in vacuo* to give crude **38**, which was treated with $BF_3 \cdot Et_2O$ as described in the general procedure. Purification on silica gel afforded pure **39**, yield 0.10 g (90%).

2,5-Anhydro-3,4,6-tri-*O*-benzyl-1-deoxy-1-hydroxy(diisopropyl)silyl-D-glucitol (41). Oxidative unmasking of silane **39** (0.28 g, 0.45 mmol) was executed as described in the general procedure to give silanol **41** after silica gel chromatography, yield 0.13 g (53%). R_f 0.5 (Et_2O/light petroleum, 1/1, v/v). ^1H NMR: δ 7.33-7.18 (m, 15H, H-arom), 4.48 (AB, 2H, CH_2, Bn, *J* -10.8 Hz), 4.45 (s, 2H, CH_2, Bn), 4.30 (AB, 2H, CH_2, Bn, *J* -11.5 Hz), 4.28 (m, 1H, H-2), 3.97 (ddd, 1H, H-5, $J_{5,6a}$ 5.7 Hz, $J_{5,6b}$ 7.6 Hz, $J_{4,5}$ 3.0 Hz), 3.89 (dd, 1H, H-4, $J_{3,4}$ 1.2 Hz, $J_{4,5}$ 3.2 Hz), 3.76 (dd, 1H, H-3, $J_{2,3}$ 3.8 Hz), 3.56 (dd, 1H, H-6a, $J_{6a,6b}$ -8.6 Hz), 3.47 (dd, 1H, H-6b), 2.52 (bs, 1H, OH), 1.27 (dd, 1H, H-1a, $J_{1a,1b}$ -14.5 Hz, $J_{1a,2}$ 9.6 Hz), 1.02-0.90 (m, 6H, CH, CH_3, *i*-Pr), 0.85 (dd, 1H, H-1b, $J_{1b,2}$ 5.8 Hz). $^{13}C\{^1H\}$ NMR: δ 138.2, 138.0, 137.8 (Cq, arom), 128.3-127.3 (CH, arom), 83.8, 83.5, 81.7, 78.9 (C-2, C-3, C-4, C-5), 73.0, 71.2, 71.1, 70.3 (CH_2, Bn, C-6), 17.1 (CH_3, *i*-Pr), 13.2, 12.9 (CH, *i*-Pr), 10.4 (C-1).

Anal. Calcd for $C_{33}H_{43}O_5Si$ (548.79): C, 72.22; H, 8.08. Found: C, 72.03; H, 8.01.

2,5-Anhydro-3,4,6-tri-*O*-benzyl-1-deoxy-1-fluoro(diisopropyl)silyl-D-glucitol (40). To a solution of phenylsilane **39** (0.19 g, 0.32 mmol) in CH_2Cl_2 (3 mL) was added AcOH (21 mg, 0.35 mmol) and $BF_3 \cdot Et_2O$ (43 mg, 0.35 mmol) and stirring continued for 2 h. The mixture was neutralized by the addition of Et_3N and partitioned between Et_2O

(20 mL) and H_2O (5 mL). The organic phase was dried ($MgSO_4$), filtered and concentrated under reduced pressure. The residual oil was purified by flash chromatography (elution: Et_2O/light petroleum, 1/1, v/v) to give **40**, yield 0.17 g (98%).

Anal. Calcd for $C_{33}H_{43}FO_4Si$ (550.78): C, 71.96; H, 7.87. Found: C, 71.59; H, 7.59.

2,5-Anhydro-3,4,6-tri-*O*-benzyl-D-glucitol (42). To a cooled (0 °C) solution of *tert*-butyl hydroperoxide (0.50 mL, 90%) in DMF (2.5 mL) was added CsOH.H_2O (0.63 g, 3.84 mmol). After warming to rt, a solution of **40** (0.17 g, 0.31 mmol) in DMF (1.5 mL) was added dropwise *via* syringe. The reaction mixture was heated to 70 °C for 5 h. After cooling to rt, $Na_2S_2O_3$ (0.80 g, 5.06 mmol) was added and the solvent removed *in vacuo*. The resultant oil was partitioned between H_2O (10 mL) and Et_2O (40 mL). The layers were separated and the aqueous layer was extracted with Et_2O (20 mL). The combined organic layers were washed with brine (10 mL), dried ($MgSO_4$), filtered and concentrated under reduced pressure. The residue was applied onto a column of silica gel and elution effected with Et_2O/light petroleum (1/3 1/2, v/v) to give alcohol **42**, yield 0.12 g (71%). R_f 0.2 (Et_2O/light petroleum, 1/1, v/v). $[\alpha]_D^{20}$ -26.4° (*c* 1). ^{1}H NMR: δ 7.35-7.22 (m, 15H, H-arom), 4.55 (2x s, 2H, CH_2, Bn), 4.48 (AB, 2H, CH_2, Bn, *J* -11.8 Hz), 4.11-3.83 (m, 6H, H-1, H-2, H-3, H-4, H-5), 3.60 (d, 2H, H-6, $J_{5,6}$ 5.1 Hz), 2.35 (s, 1H, OH). $^{13}C\{^1H\}$ NMR: δ 137.7, 137.6, 137.4 (Cq, arom), 128.4-127.5 (CH, arom), 83.6, 83.0, 81.7, 80.2 (C-2, C-3, C-4, C-5), 73.2, 71.7, 70.0 (CH_2, Bn, C-6), 61.5 (C-1).

Anal. Calcd for $C_{27}H_{30}O_5$ (434.53): C, 74.63; H, 6.96. Found: C, 74.43; H, 6.85.

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