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# *De novo* synthesis of pentoses via cyanohydrins as key intermediates

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ABSTRACT

A *de novo* synthesis of pentoses is described starting from (*Z*)-2-buten-1,4-diol (**1**). The key step is the enzyme catalysed enantioselective HCN-addition to *O*-protected 4-hydroxybut-2-enal using the hydroxynitrile lyase from *Hevea brasiliensis*, followed by an asymmetric dihydroxylation. For the cyanohydrin reaction the influence of the configuration of the double bond and of the protecting group was investigated. The dihydroxylation step was found to be influenced by the protecting group on position 4.


## 1. Introduction

Recently, L-sugars have found increasing application in pharmaceuticals and cosmetics.[1–3,37] As building blocks of nucleoside analogues they are promising candidates in antiviral and antitumoral therapy. L-nucleosides often exhibit comparable or even greater antiviral activity, in combination with lower cytotoxicity and greater metabolic stability as their D-counterparts.[2] As a result clinical trials are reported, for example, for 1-(β-L-2-fluoro-2-deoxyarabinofuranosyl)-5-methyluracil (L-FMAU) as anti-hepatitis B virus (HBV) agent.[2,4]

These nucleosides are easily synthesised from L-ribose, which does, however, not occur in nature and is very expensive. In recent years several syntheses of L-ribose have been reported from readily available sugars, such as D-ribose,[5–8] D-glucose,[9] D-galactose,[10] L-arabinose[11,12] etc. But only few *de novo* syntheses of L-carbohydrates have been published.[13,14] Herein, a *de novo* synthesis of pentoses is reported, where the key step is an enzymatic cyanohydrin reaction followed by an asymmetric dihydroxylation.

Cyanohydrins are valuable building blocks making, for example, α-hydroxy acids and β-amino alcohols easily accessible.[15,16] They can be synthesised enantioselectively through the hydroxynitrile lyase (HNL) catalysed HCN addition to aldehydes and ketones. Many HNLs from plants are known, which differ in structure, substrate acceptance and stereoselectivity.[15,17] Thus, it is possible to convert a broad range of aldehydes and ketones into enantiopure (*R*)- or (*S*)-cyanohydrins depending on the HNL used. For example, the (*S*)-selective HNL from *Hevea brasiliensis* (*Hb*HNL) is used in the large scale production of (*S*)-3-phenoxybenzaldehyde cyanohydrin, which is an intermediate in the synthesis of pyrethroids, a class of synthetic insecticides.[18,19] On the other hand, (*R*)-selective HNL from *Prunus amygdalus* (*Pa*HNL) finds industrial application in the synthesis of (*R*)-2-hydroxy-4-phenylbutyronitrile, an important building block for the production of nonsulfhydril angiotensin-converting enzyme (ACE) inhibitors.[19,20]

Herein the enzymatic cyanohydrin transformation of different 4-*O*-protected 4-hydroxybut-2-enals with the (*S*)-selective *Hb*HNL and the following synthetic route to pentoses is described.

## 2. Results and discussion

As mentioned above the key steps to introduce the chiral centres are the *Hb*HNL catalysed cyanohydrin reaction followed by a dihydroxylation. The stereocentre introduced by the HCN addition should direct the dihydroxylation to take place from the less hindered side, affording the desired pentose.

(*Z*)-But-2-en-1,4-diol was monoprotected prior to oxidation to (*E*)- and (*Z*)-aldehydes according to literature[21,22] (Scheme 1). Protecting groups of different size and polarity were inserted to investigate their influence on the enzymatic cyanohydrin reaction. After monoprotection the oxidation with pyridinium chlorochromate (PCC)[21] afforded (*E*)-aldehydes **3a–e**. Therefore, a more gentle oxidation with $MnO_2$[22] had to be applied to obtain the (*Z*)-aldehydes **3′a–e**, suitable for the synthesis of the pentoses of the desired configuration.

The cyanohydrin reaction was performed in a biphasic system of *tert*-butyl methyl ether (*t*BME)/$H_2O$ (1/1 v/v) at pH 5.0 and 4.5 at 0 °C. The (*E*)-aldehydes were converted with high yields and high enantiomeric excess (ee 88–99%), except for **3c** and **3e** (Table 1). The unfavoured interaction of an additional oxygen atom in case of the methoxymethyl group in **3c** and the bulkiness of the TBDPS-group in **3e** could be an explanation for the lower ee's. An increase of pH-value from 4.5 to 5.0 resulted in faster conversion, but also in lower selectivity.

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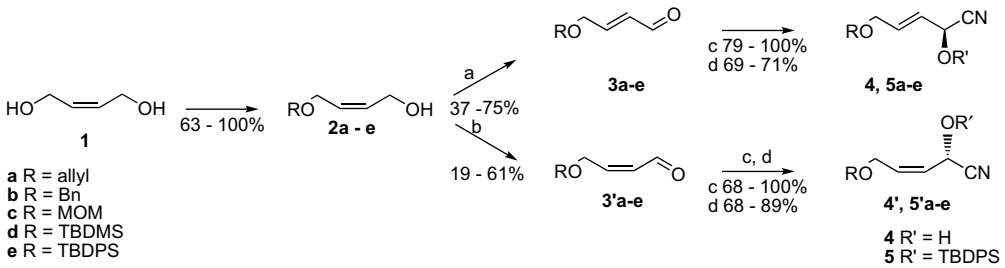



**Scheme 1.** Reagents and conditions: (a) PCC, sodium acetate, Celite 545, $CH_2Cl_2$. (b) $MnO_2$, $CH_2Cl_2$, 0 °C. (c) *Hb*HNL, HCN, *t*BME/buffer. (d) *t*BDPSiCl, imidazole, DMF.

**Table 1**
Yields and enantiomeric excess for the conversion of *E*-aldehydes **3a–e**

| Substrate | R | Enzyme amount, U/mmol | pH | yield,[a] % | ee, %[b] |
|---|---|---|---|---|---|
| **3a** | Allyl | 5680 | 5.0 | 104 | 88 |
| | | 6910 | 4.5 | 100 | 98 |
| **3b** | Bn | 4650 | 5.1 | 105 | 96 |
| | | 4670 | 4.6 | 113 | 98 |
| | | 19,800 | 4.5 | 94 | 97 |
| **3c** | MOM | 7200 | 5.0 | 84 | 32 |
| | | 6900 | 4.6 | 79 | 66 |
| **3d** | TBDMS | 19,600 | 5.0 | 95 | 99 |
| | | 19,200 | 4.5 | 87 | 99 |
| **3e** | TBDPS | 10,700 | 5.0 | 36[c] | 51[c] |
| | | 14,200 | 4.5 | 20[c] | 25[c] |

[a] Crude product.
[b] Measured by chiral HPLC after derivatisation.
[c] Measured by chiral HPLC without derivatisation.

Due to the low selectivity in case of the MOM-protected (*E*)-substrate the corresponding (*Z*)-aldehyde **3′c** was not used for the enzymatic HCN-addition. The reaction time for the conversion of (*Z*)-aldehydes **3′a–e** is much longer in comparison to (*E*)-aldehydes **3a–e**, but fortunately no isomerisation to the (*E*)-aldehydes is observed. Therefore, the reaction temperature was raised to room temperature (rt). In comparison with the corresponding (*E*)-aldehydes substrates **3′a, 3′b** and **3′d** were converted with lower yields and only low to moderate ee's (10–80%), whereas **3′e** was not converted at all (Table 2). Only for **3′a** *Hb*HNL gave reasonable selectivities, affording the (*S*)-cyanohydrin **4′a** in 89% yield and 81% ee at pH 4.5. Again, raising the pH resulted in a drop of selectivity.

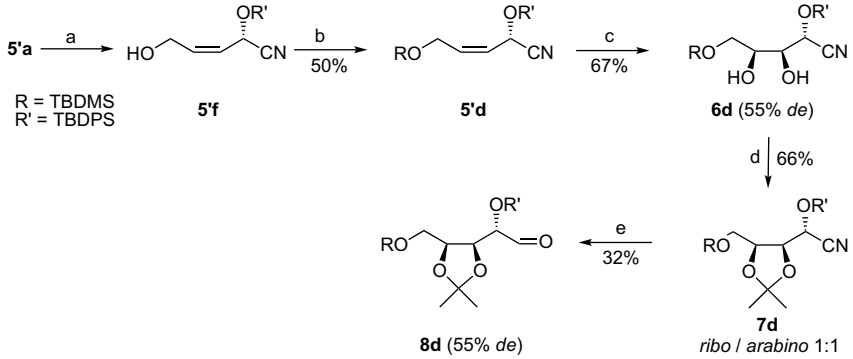
In order to obtain a product with high enantiomeric purity, suitable for the follow-up synthesis, the conversion of **3′a** was optimised. The pH-range was varied from 5.0 to 4.0 and the best selectivities were achieved between pH 4.1–4.3. Lower pH-values seem to affect the catalyst's stability, whereas at higher pH-values the chemical background reaction is more competitive. The organic solvent/aqueous phase ratio showed also to have great influence on the enantiomeric excess. The ee is strongly pH-dependent when performing the reaction in a 1/1 ratio, whereas using a 2/1 organic solvent/aqueous phase ratio the selectivities achieved are marginally higher (88% ee) and constant over a wider pH-range. In order to obtain ee's>90% also the enzyme amount was optimised. The conversion of **3′a** was investigated in *t*BME/$H_2O$ (2/1 v/v) at pH 4.2 varying the enzyme amount from 150 to 5000 U/mmol substrate. As a result, the ee could be enhanced to 92.4% applying 700 U/mmol substrate in a biphasic system of *t*BME/$H_2O$ (2/1 v/v) at pH 4.1–4.3. The achieved optically purity was satisfactory for the follow-up synthesis.

Subsequently, the hydroxy group of cyanohydrin **(*S*)-4′a** was protected as silyl ether prior to the dihydroxylation. Today the method of choice for an asymmetric *cis*-dihydroxylation of an alkene clearly is the Sharpless methodology.[38,39] However, attempted transformation of (*Z*)-cyanohydrin **5′f**, the (*Z*)-stereochemistry is required for the intended *ribo*-configuration of the product and protection of the cyanohydrin is necessary for stability reasons, applying standard conditions[40] failed also after pH-adjustment.[41] Therefore, several variants of the $OsO_4$-procedure were investigated. The bulky TBDPS-group was introduced to maximise the directing effect of the chiral centre and drive the dihydroxylation to take place on the less hindered side.[23] *cis*-hydroxylation of **5′a** with $OsO_4$ and *N*-methyl morpholine-*N*-oxide (NMO)[24,25] should afford 2-*t*-

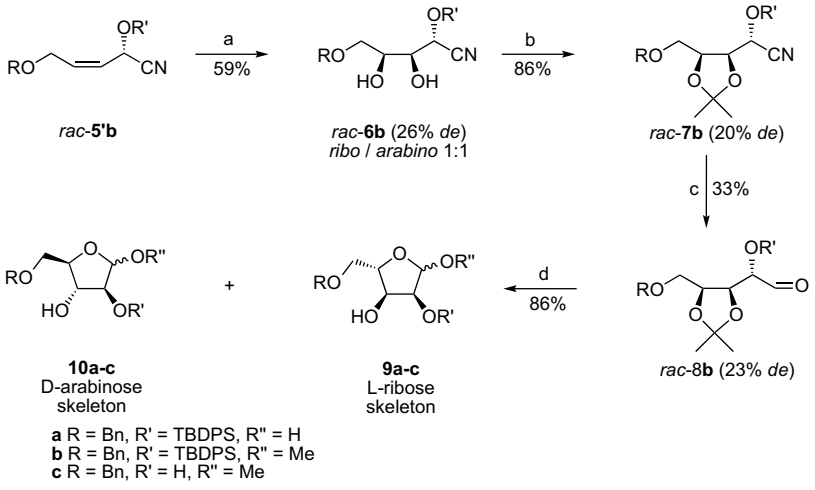
**Table 2**
Yields and enantiomeric excess for the conversion of *Z*-aldehydes **3′a,b,d,e**

| Substrate | R | enzyme amount, U/mmol | pH | Yield, % | ee, %[a] |
|---|---|---|---|---|---|
| **3′a** | Allyl | 7600 | 5.0 | 65[b] | 74 |
| | | 6700 | 4.5 | 89 | 81 |
| **3′b** | Bn | 6900 | 5.0 | >99 | 54 |
| | | 7200 | 4.5 | 89 | 59 |
| **3′d** | TBDMS | 7900 | 5.0 | 99 | 9 |
| | | 8490 | 4.5 | 78 | 10 |
| **3′e** | TBDPS | 10,000 | 4.5 | n.d.[c] | n.d.[c] |

[a] Measured by chiral HPLC after derivatisation.
[b] Crude substrate.
[c] Measured by chiral HPLC without derivatisation.




**Scheme 2.** Reagents and conditions: (a) $SeO_2$, acetic acid, dioxane, reflux. (b) *t*BuDMSiCl, imidazole, $CH_2Cl_2$. (c) $OsO_4$, $H_2O_2$, acetone/$H_2O$. (d) 2,2-dimethoxypropane, pyridinium-*p*-toluene sulfonate, $CH_2Cl_2$. (e) DIBAL-H, pentane, −78 °C.




**Scheme 3.** Reagents and conditions: (a) OsO4, H2O2, acetone/H2O. (b) 2,2-dimethoxypropane, pyridinium-*p*-toluene sulfonate, $CH_2Cl_2$. (c) DIBAL-H, pentane, −78 °C. (d) Dowex 50 W-X4, MeOH. All compounds are racemic, only one enantiomer is shown.

butyldiphenylsilyloxy-3, 4, 5-trihydroxypentanenitrile because of the simultaneous cleavage of the allyl ether under these conditions. However, NMR-spectra of the peracetylated product mixture indicated, that both double bonds were dihydroxylated. Therefore, cleavage of the protecting group to give compound **5′f** was performed according to literature with $SeO_2$ and acetic acid[26] prior to the hydroxylation step.

Attempts to convert **5′f** into 2-*t*-butyldiphenylsilyloxy-3, 4, 5-trihydroxypentanenitrile with $OsO_4$ and NMO were unsuccessful. Therefore, the protected cyanohydrins **5′b**, **5′d** and 5-acetyl-**5′f** were investigated under different hydroxylation conditions. The best results were achieved for asymmetric dihydroxylation of **5′b** and **5′d** with a catalytic amount of $OsO_4$ and $H_2O_2$ as reoxidant.[23,24] Unfortunately, it was not feasible to use the protected cyanohydrins from the enzymatic cyanohydrin reaction of **3′b** and **3′d**, since these compounds could only be obtained with low enantiomeric excess. Therefore, the allyl ether of intermediate **5′a** was cleaved and the obtained free hydroxy group was protected again to obtain the desired product **6d** without loss of enantiomeric purity (Scheme 2). Conversion with *tert*-butyldimetylsilyl chloride gave the desired product **5′d** in high yields, whereas it was not possible to introduce the benzyl group.

The following hydroxylation of **(*S*)-5′d** yielded **6d** as a mixture of two stereoisomers in a 3.5/1 ratio. After protection of the diol with 2,2-dimethoxypropane to give **7d** and reduction with DIBAL-H, **8d** was obtained in 32% yield in an isomeric ratio of 3.5/1 (Scheme 2). Therefore, besides the desired L-ribose also some D-arabinose was obtained.

For structure elucidation racemic **5′b** was converted to **8b** following the same synthetic route (Scheme 3). A mixture of protected arabinose and ribose is obtained in 17% overall yield and in a ratio of 1.7/1. Cleavage of the protecting groups with a strong acidic ion exchanger in methanol gave a mixture of 5-*O*-benzyl pentoses. Separation by flash chromatography, analysis by NMR and comparison with data from literature[27,28] showed that the major products are 5-*O*-benzyl arabinose derivatives (**10**).

Comparison of the NMR-spectra of the product mixtures **6d**, **7d** and **8d** with **6b**, **7b** and **8b** showed that for the conversion of **5′d** the major product is also the D-arabinose derivative. The dihydroxylation step is thereby influenced by the protecting group at C5. **6d** (R=TBDMS) is obtained in a ratio of arabinose/ribose of 2/1, whereas **6b** (R=Bn) is formed in a 1/1 ratio. The influence of the already existing stereocentre seems to have far less influence on directing the dihydroxylation step. Additionally, *ribo*-**6d** and *ribo*-**6b** are not converted at the same rate as compared to *arabino*-**6d** and *arabino*-**6b**, affording **8d** in a 3.5/1 ratio of arabinose/ribose and **8b** in a 1.7/1 ratio. Separation by flash chromatography allows to obtain both sugars in pure form.

## 3. Conclusion

A *de novo* synthesis of pentoses is described starting from (*Z*)-2-buten-1,4-diol (**1**). The enantioselective HCN addition to *O*-protected 4-hydroxybut-2-enal using the HNL from *H. brasiliensis* is the key step, which is followed by an asymmetric dihydroxylation. The configuration of the double bond and the protecting group strongly influence the conversion and selectivity of the reaction. In the series of *O*-protected (*Z*)-4-hydroxybut-2-enals, which are adequate for the purpose of synthesis of pentoses, only the allyl protected compound **3′a** was converted in sufficiently high selectivity. The dihydroxylation step is also influenced by the protecting group at position 4. Only compounds **5′b** and **5′d** were converted, affording product mixtures with different ratios of D-arabinose and L-ribose.

## 4. Experimental

### 4.1. General

All solvents and materials not described in this chapter are commercially available and were appropriately purified, if necessary. The hydroxynitrile lyases were kindly provided by DSM Fine Chemicals Austria. Reactions were monitored by TLC (Merck silica gel 60 $F_{254}$) and the compounds were visualised by UV (254 nm) and by spraying with Mo-reagent (10% $H_2SO_4$, 10% $(NH_4)Mo_7O_{24}\cdot 4H_2O$ and 0.8% $Ce(SO_4)_2\cdot 4H_2O$ in water) or vanillin/$H_2SO_4$ solution (1 g vanillin in1000 ml $H_2SO_4$ conc). Flash chromatography was performed on Silica gel 60 (230–400 mesh, Merck). $^1H$ and $^{13}C$ NMR-spectra were recorded on a VARIAN GEMINI 200 MHz ($^1H$ 200 MHz, $^{13}C$ 50 MHz) and VARIAN INOVA 500 MHz ($^1H$ 500 MHz, $^{13}C$ 125 MHz) spectrometer with TMS as an internal reference. HPLC enantiomeric separation was performed using a JASCO 880-PU pump and a JASCO 873 UV/VIS detector connected to a DAICEL OD-H column (25 cm×0.46 cm) or a DAICEL AD column (25 cm×0.46 cm). Mass spectra: GCT Premier (Waters). For analytical data vide infra.

### 4.2. Synthesis of (*Z*)-4-allyloxybut-2-en-1-ol (2a) with KOH

To a solution of 6.5 ml (79.1 mmol, 1 equiv) of **1** in 150 ml of DMSO 1.2 equiv allylbromide and 1.8 equiv potassium hydroxide

are added. The mixture is stirred at rt until quantitative conversion. The solution is diluted with water and extracted three times with $CH_2Cl_2$. The aqueous layer is acidified with 1 M HCl and extracted again five times with $CH_2Cl_2$. The combined organic layers are dried over $Na_2SO_4$ and the solvent is removed under reduced pressure. Purification by flash chromatography (elution gradient cyclohexane/ethyl acetate 25/1 to pure ethyl acetate) gives 6.4 g (63%) of **2a** as light yellow oil. Spectroscopic data are comparable with those reported in literature.[21]

### 4.3. Synthesis of (*Z*)-4-Methoxymethoxybut-2-en-1-ol (2c)

To a solution of 1.0 g (11.4 mmol, 1 equiv) of **1** and 1.6 equiv. *N*-ethyldiisopropylamine in 25 ml $CH_2Cl_2$ 1.4 equiv methoxymethyl chloride are added dropwise under stirring. After quantitative conversion the solution is extracted with 1 M HCl and saturated aqueous $NaHCO_3$. The organic layer is dried over $Na_2SO_4$ and the solvent is removed under reduced pressure. After purification by flash chromatography (cyclohexane/ethyl acetate 10/1) **2b** is obtained in 33% yield (482 mg) as light yellow oil. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 2.40 (br d, 1H, OH); 3.36 (s, 3H, MOM-$CH_3$); 4.13 (d, 2H, H4, $J$=7.5); 4.17 (d, 2H, H1, $J$=7.0); 4.62 (s, 2H, MOM-$CH_2$); 5.60–5.89 (m, 2H, H2, H3). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 55.50, 58.47, 62.68, 95.57, 127.88, 132.91.

### 4.4. General procedure for the mono *O*-protection of (*Z*)-but-2-en-1,4-diol with NaH[29]

According to literature[29] diol **1** is converted using NaH and the corresponding protecting reagent. Purification by flash chromatography gives the pure 4-*O*-protected but-2-en-1,4-diols **2b, 2d** and **2e**.

#### *4.4.1. (Z)-4-Benzyloxybut-2-en-1-ol (**2b**)*

2.45 g (42%) as light yellow oil. Spectroscopic data are slightly different from those reported[30] $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 2.11 (br s, 1H, OH); 4.09 (d, 2H, H4, $J$=5.3); 4.16 (d, 2H, H1, $J$=5.7); 4.53 (s, 2H, Bn-$CH_2$); 5.67–5.88 (m, 2H, H2, H3); 7.29–7.36 (m, 5H, Bn-Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 58.89, 65.86, 72.71, 128.05, 128.11, 128.45, 128.71, 132.62, 138.05.

#### *4.4.2. (Z)-4-(tert-Butyldimethylsilyloxy)-but-2-en-1-ol (**2d**)*

12.4 g (100%) as light yellow oil (crude). Spectroscopic data correspond with those reported in literature.[31]

#### *4.4.3. (Z)-4-(tert-Butyldiphenylsilyloxy)-but-2-en-1-ol (**2e**)*

1.11 g (56%) as colourless oil. Spectroscopic data are comparable with those in literature.[32]

### 4.5. General procedure for the oxidation to (*E*)-aldehydes 3a–e[21]

To a solution of 4-*O*-protected but-2-en-1,4-diol in anhydrous $CH_2Cl_2$ 1.5 equiv pyridinium chlorochromate, 1.5 equiv sodium acetate and Celite 545 are added. The mixture is stirred at rt until quantitative conversion and subsequently poured into $Et_2O$ under vigorous stirring. The mixture is filtered over a Florisil bed. Evaporation of the solvent and purification by flash chromatography yields aldehydes **3a–e**.

#### *4.5.1. (E)-4-Allyloxybut-2-enal (**3a**)*

2.1 g (46%) as light yellow oil. Spectroscopic data are comparable with those reported.[21]

#### *4.5.2. (E)-4-Benzyloxybut-2-enal (**3b**)*

2.37 g (75%) as light yellow oil. Spectroscopic data are comparable with those in literature.[30]

#### *4.5.3. (E)-4-Methoxymethoxybut-2-enal (**3c**)*

696 mg (37%) as light yellow oil. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 3.37 (s, 3H, MOM-$CH_3$); 4.33 (dd, 2H, H4; $J$=4.0, 1.8); 4.67 (s, 2H, MOM-$CH_2$); 6.35 (ddd, 1H, H2, $J$=15.8, 7.9, 1.3); 6.84 (dtd, 1H, H3, $J$=15.8, 4.0, 1.3); 9.57 (dd, 1H, H1, $J$=7.9, 1.3). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 55.72, 66.04, 96.39, 131.85, 153.00, 193.47.

#### *4.5.4. (E)-4-t-Butyldimethylsilyloxybut-2-enal (**3d**)*

455 mg (56%) as colourless liquid. Spectroscopic data are comparable with those reported in literature.[31]

#### *4.5.5. (E)-4-t-Butyldiphenylsilyloxybut-2-enal (**3e**)*

685 mg (57%) as colourless oil. Spectroscopic data correspond with those reported previously.[33]

### 4.6. General procedure for the oxidation to (*Z*)-aldehydes 3′a–e[27]

The oxidation of 4-*O*-protected but-2-en-1,4-diol was performed according to literatute[27] in $CH_2Cl_2$. After purification by flash chromatography aldehydes **3′a–e** are obtained and the unconverted educts are recovered.

#### *4.6.1. (Z)-4-Allyloxybut-2-enal (**3′a**)*

1.57 g (19%) as light yellow oil. 63% of **2a** recovered. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 4.05 (d, 2H, $All_{aliph}$-$CH_2$, $J$=4.8); 4.49 (d, 2H, H4, $J$=5.3); 5.20–5.34 (m, 2H, $All_{olef}$-$CH_2$); 5.82–5.96 (m, 1H, All-CH); 5.99–6.10 (n.a., 1H, H2); 6.55–6.67 (m, 1H, H3); 10.07 (d, 1H, H1, $J$=7.0). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 67.14, 72.11, 118.07, 129.90, 134.18, 147.79, 191.69.

#### *4.6.2. (Z)-4-Benzyloxybut-2-enal (**3′b**)*

1.96 g (20%) as light yellow oil. 77% of **2c** recovered. Spectroscopic data are comparable with those reported.[34]

#### *4.6.3. (Z)-4-t-Butyldimethylsilyloxybut-2-enal (**3′d**)*

3.74 g (61%) as colourless liquid. Spectroscopic data are slightly different from those reported.[35] $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 0.10 (s, 6H, TBDMS-2$CH_3$); 0.90 (s, 9H, TBDMS-3$CH_3$); 4.67 (d, 2H, H4, $J$=4.8); 5.93–6.03 (n.a., 1H, H2); 6.51–6.62 (m, 1H, H3); 10.15 (d, 1H, H1, $J$=7.0). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: −5.10, 18.50, 26.06, 61.42, 128.78, 150.89, 192.11.

#### *4.6.4. (Z)-4-t-Butyldiphenylsilyloxybut-2-enal (**3′e**)*

207 mg (54%) as light yellow oil. $^1$H NMR data correspond with those in literature.[36] $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 19.36, 26.99, 61.72, 128.14, 129.05, 130.75, 133.00, 135.75, 150.19, 191.68.

### 4.7. Synthesis and safe-handling of anhydrous HCN–CAUTION

All reaction equipment, in which HCN or cyanides were involved, was placed in a well-ventilated hood. For continuous warning, an electrochemical sensor for HCN detection was used. The required amount of HCN was freshly prepared by adding dropwise a saturated NaCN solution to aqueous sulfuric acid (60%) at 80 °C. HCN was transferred in a nitrogen stream through a drying column and collected in a cooling trap at −12 °C. Waste solutions containing cyanides were treated with aqueous sodium hypochlorite (10%). Subsequently the pH was adjusted to 7.0 with aqueous sulfuric acid.

### 4.8. General procedure A (GPA): synthesis of racemic cyanohydrins

To a cooled (0 °C) solution of aldehyde in anhydrous *tert*-butyl methyl ether (*t*BME) basic ion exchanger (Amberlyst A-21) and 2.0–5.0 equiv. HCN are added. The resulting mixture is stirred at 0 °C until quantitative conversion and subsequently filtered over a $Na_2SO_4$ bed. Evaporation of the solvent under reduced pressure yields the crude cyanohydrins **4a**–**e** and **4′a**–**e** as light yellow liquids, which were further converted without purification. For spectroscopic data see below.

### 4.9. General procedure B (GPB): synthesis of (*S*)-cyanohydrins with *Hb*HNL

To a solution of aldehyde in *t*BME an aqueous enzyme solution (1/1 or 2/1 v/v) of *Hb*HNL is added and the resulting mixture is stirred at 0 °C until an emulsion is formed. The pH of the enzyme solution is previously adjusted with a diluted citric acid solution. After addition of freshly prepared prussic acid (2.0 to 5.0 equiv), the mixture is stirred at 0 °C or rt until quantitative conversion. The emulsion is diluted with *t*BME and broken with Celite 545, filtered and dried over $Na_2SO_4$. Evaporation of the solvent under reduced pressure yields the crude cyanohydrins **4a**–**e** and **4′a**–**e** as light yellow liquids. They are further converted without purification.

#### *4.9.1. (E)-5-Allyloxy-2-hydroxypent-3-enenitrile (**4a**)*

540 mg (89%) of ***rac*-4a** are given according to GPA and 357 mg (99%) of crude **(2*S*)-4a** are obtained using GPB. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 3.79 (br s, 1H, OH); 4.02 (n.a., 4H, $All_{aliph}$-$CH_2$, H4); 4.99 (br s, 1H, H2); 5.19–5.34 (m, 2H, $All_{olef}$-$CH_2$); 5.91 (n.a., 2H, H3, All-CH); 6.14 (dt, 1H, H4, $J$=15.4, 4.0). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 61.37, 68.96, 71.90, 118.07, 118.83, 125.93, 132.53, 134.19.

#### *4.9.2. (Z)-5-Allyloxy-2-hydroxypent-3-enenitrile (**4′a**)*

GPA gives 100 mg (68%) of ***rac*-4′a**, whereas GPB affords 2.74 g (76%) of crude **(2*S*)-4′a**. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 3.97 (br d, 1H, OH); 4.06 (d, 2H, $All_{aliph}$-$CH_2$, $J$=5.3); 4.17 (d, 2H, H5, $J$=4.4); 5.17–5.36 (n.a., 3H, H2, $All_{olef}$-$CH_2$); 5.88 (m, 3H, H3, H4, All-CH). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 57.64, 66.69, 72.28, 117.63, 118.81, 127.11, 132.49, 133.63.

#### *4.9.3. (E)-5-Benzyloxy-2-hydroxypent-3-enenitrile (**4b**)*

Following GPA 111 mg (80%) ***rac*-4c** are obtained. GPB gives 650 mg (113%) of crude **(2*S*)-4c**. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 3.20 (br s, 1H, OH); 4.09 (dd, 2H, H5; $J$=4.8, 1.3); 4.55 (s, 2H, Bn-$CH_2$); 4.95 (d, 1H, H2, $J$=5.3); 5.88 (ddd, 1H, H3, $J$=15.4, 5.3, 1.3); 6.16 (dtd, 1H, H4, $J$=15.4, 4.8, 1.3); 7.35–7.50 (m, 5H, Bn-Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 61.44, 69.04, 73.07, 118.39, 125.84, 128.10, 128.19, 128.77, 132.81, 137.79.

#### *4.9.4. (Z)-5-Benzyloxy-2-hydroxypent-3-enenitrile (**4′b**)*

GPA yields 169 mg (93%) of crude ***rac*-4′c** as colourless liquid. GPB affords 266 mg (89%) of crude **(2*S*)-4′c**. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 4.03 (br s, 1H, OH); 4.20 (d, 2H, H5, $J$=4.4); 4.59 (s, 2H, Bn-$CH_2$); 5.15 (d, 1H, H2, $J$=7.0); 5.75–5.97 (m, 2H, H3, H4); 7.32–7.43 (m, 5H, Bn-Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 57.58, 66.66, 73.47, 118.98, 127.15, 128.39, 128.50, 128.84, 132.54, 136.91.

#### *4.9.5. (E)-2-Hydroxy-5-methoxymethoxypent-3-enenitrile (4c)*

109 mg (82%) of crude ***rac*-4b** are given by GPA and 236 mg (79%) of crude **(2*S*)-4b** are obtained following GPB. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 3.37 (s, 3H, MOM-$CH_3$); 4.13 (d, 2H, H5, $J$=4.8); 4.65 (s, 2H, MOM-$CH_2$); 4.98 (d, 1H, H2, $J$=4.4); 5.86 (ddd, 1H, H3, $J$=15.4, 5.3, 1.3); 6.14 (dtd, H4, $J$=15.4, 4.8, 1.3). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 55.66, 61.35, 66.41, 96.15, 118.46, 125.86, 132.44.

#### *4.9.6. (E)-5-t-Butyldimethylsilyloxy-2-hydroxypent-3-enenitrile (**4d**)*

GPA affords 96 mg (56%) of ***rac*-4d** and GPB 504 mg (87%) of **(2*S*)-4d**. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 0.08 (s, 6H, TBDMS-$2CH_3$); 0.91 (s, 9H, TBDMS-$3CH_3$); 3.05 (br s, 1H, OH); 4.24 (d, 2H, H5, $J$=1.8); 5.01 (d, 1H, H2, $J$=4.0); 5.87 (ddd, 1H, H3, $J$=15.4, 5.3, 1.3); 6.16 (dt, 1H, H4, $J$=15.4, 3.5). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: −5.16, 18.59, 26.10, 61.62, 62.26, 118.58, 123.23, 135.98.

#### *4.9.7. (Z)-5-t-Butyldimethylsilyloxy-2-hydroxypent-3-enenitrile (**4′d**)*

155 mg (88%) of crude ***rac*-4′d** are obtained as colourless oil following GPA. 222 mg (78%) of crude **(2*S*)-4′d** are given by GPB. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 0.08 (s, 6H, TBDMS-$2CH_3$); 0.91 (s, 9H, TBDMS-$3CH_3$); 4.37 (d, 2H, H5, $J$=3.1); 4.59 (br s, 1H, OH); 5.24 (d, 1H, H2, $J$=5.3); 5.68–5.89 (n.a., 2H, H3, H4). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: −5.16, 18.57, 26.09, 57.81, 61.05, 118.68, 125.78, 134.43.

#### *4.9.8. (E)-5-t-Butyldiphenylsilyloxy-2-hydroxypent-3-enenitrile (**4e**)*

GPA gives 111 mg (103%) of crude ***rac*-4e** and GPB yields 655 mg (102%) of crude **(2*S*)-4e**. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 1.09 (s, 9H, TBDPS-$3CH_3$); 2.63 (br s, 1H, OH); 4.28 (dd, 2H, H5, $J$=3.2, 1.3); 5.00 (br s, 1H, H2); 5.96 (ddd, 1H, H3, $J$=15.4, 5.3); 6.15 (dt, 1H, H4, $J$=15.4, 3.1); 7.41–7.69 (m, 10H, TBDPS-2Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 19.46, 27.03, 61.66, 62.99, 118.48, 123.21, 128.05, 130.13, 133.36, 135.74. **(2*S*)-4e**: 51% *ee* (n-heptane/*i*-propanol=99.75/0.25, Diacel OD-H, 254 nm, flow=0.6 mL/min, $T$=25 °C, $t_{R,S}$=8.7, $t_{R,R}$=8.0).

#### *4.9.9. (Z)-5-t-Butyldiphenylsilyloxy-2-hydroxypent-3-enenitrile (**4′e**)*

105 mg (103%) of crude ***rac*-4′e** are given following GPA. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 1.08 (TBDPS-$3CH_3$); 3.22 (s, 1H, OH); 4.31 (d, 2H, H5, $J$=4.8); 5.22 (d, 1H, H2, $J$=7.0); 5.65–5.91 (n.a., 2H, H3, H4); 7.42–7.71 (m, 10H, TBDPS-2Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 19.28, 26.95, 57.85, 61.25, 118.96, 125.73, 128.20, 130.71, 132.60, 134.58, 135.78.

### 4.10. General procedure for the acetylation of cyanohydrins 4b and 4′b

Cyanohydrins **4b** and **4′b** are acetylated according to standard procedures with 2.0 equiv acetic anhydride in a pyridine/$CH_2Cl_2$ mixture (1/1 v/v).

#### *4.10.1. (E)-Acetic acid-4-benzyloxy-1-cyanobut-2-enyl ester (**Ac-4b**)*

61%. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 2.17 (s, 3H, Ac-$CH_3$); 4.12 (d, 2H, H5, $J$=4.4); 4.58 (s, 2H, Bn-$CH_2$); 5.90 (n.a., 2H, H2, H3); 6.26 (n.a., 1H, H4); 7.28–7.43 (Bn-Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 20.62, 61.08, 68.76, 73.08, 115.59, 121.27, 127.98, 128.14, 128.76, 135.84, 137.84, 169.06. HRMS (EI) $m/z$ calcd for $C_{14}H_{15}NO_2$ ($M^+$) 245, 1052, found 245.1055. **(2*S*)-Ac-4b**: 99% *ee* (n-heptane/*i*-propanol=99/1, Diacel AD, 210 nm, flow=0.7 mL/min, $T$=25 °C, $t_{R,S}$=39.3 min, $t_{R,R}$=45.6 min).

#### *4.10.2. (Z)-Acetic acid-4-benzyloxy-1-cyanobut-2-enyl ester (**Ac-4′b**)*

92%. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 2.12 (s, 3H, Ac-$CH_3$); 4.19 (dd, 2H, H5, $J$=3.5, 1.8); 4.55 (s, 2H, Bn-$CH_2$); 5.66 (n.a., 1H, H3); 5.97 (m, 1H, H4); 6.28 (d, 1H, H2, $J$=8.4); 7.30–7.36 (m, 5H, Bn-Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 20.61, 57.82, 66.53, 73.25, 116.16, 122.44, 128.07, 128.18, 128.75, 134.89, 137.53, 168.94. **(2*S*)-Ac-4′b**: 59% *ee* (*n*-heptane/*i*-propanol=99.75/0.25, Diacel AD, 210 nm, flow=1.2 mL/min, $T$=25 °C, $t_{R,S}$=36.8 min, $t_{R,R}$=42.3 min).

### 4.11. General procedure for the protection of cyanohydrins 4 a–d and 4′a–d with TBDPS

To a solution of cyanohydrin in *N*,*N*-dimethylformamide 1.1 equiv *t*-butyldiphenylsilyl chloride and 1.4 equiv imidazole are added and the reaction mixture is stirred at rt until quantitative conversion. The DMF is removed under reduced pressure and the residue is transferred with $CH_2Cl_2$ in a separatory funnel. The solution is extracted with 1 M HCl and water and the organic layer is dried over $Na_2SO_4$. Evaporation of the solvent under reduced pressure and purification by flash chromatography yields the protected cyanoyhydrins **5a**–**e** and **5′a**–**e**.

#### *4.11.1. (E)-5-Allyloxy-2-t-butyldiphenylsilyloxypent-3-enenitrile (**5a**)*

69%.$^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 1.11 (s, 9H, TBDPS-3$CH_3$); 3.68 (d, 2H, $All_{aliph}$-$CH_2$, $J$=3.1); 3.98 (d, 2H, H5, $J$=3.1); 4.85 (d, 1H, H2, $J$=5.3); 5.18–5.32 (m, 2H, $All_{olef}$-$CH_2$); 5.61–6.00 (n.a., 3H, H3, H4, All-CH); 7.40–7.74 (m, 10H, TBDPS-2Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 19.51, 26.89, 63.10, 69.01, 71.57, 117.45, 118.30, 126.33, 128.17, 128.25, 130.59, 130.62, 130.71, 131.59, 132.07, 134.04, 135.95, 136.01. **(2*S*)-5a**: 98% *ee* (n-heptane/*i*-propanol=99.75/0.25, Diacel OD-H, 254 nm, flow=0.7 mL/min, $T$=25 °C, $t_{R,S}$=17.5 min, $t_{R,R}$=15.8 min).

#### *4.11.2. (Z)-5-Allyloxy-2-t-butyldiphenylsilyloxypent-3-enenitrile (**5′a**)*

84%. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 1.09 (s, 9H, TBDPS-3$CH_3$); 3.67–3.74 (n.a., 4H, H5, $All_{aliph}$-$CH_2$); 5.06–5.24 (n.a., 3H, H2, $All_{olef}$-$CH_2$); 5.79 (m, 3H, H3, H4, All-CH); 7.36–7.74 (m, 10H, TBDPS-2Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 19.45, 26.82, 59.52, 66.15, 71.65, 117.60, 118.72, 127.48, 128.16, 128.62, 130.52, 130.64, 131.58, 131.81, 132.12, 134.23, 135.94, 136.01. **(2*S*)-5′a**: 93% ee (*n*-heptane/*i*-propanol=99.75/0.25, Diacel OD-H, 254 nm, flow=0.7 mL/min, $T$=25 °C, $t_{R,S}$=17.8 min, $t_{R,R}$=14.9 min). HRMS (El) $m/z$ calcd for $C_{24}H_{29}NO_2Si$ ($M^+$) 391.1967, found 391.1961.

#### *4.11.3. (Z)-5-Benzyloxy-2-t-butyldiphenylsilyloxypent-3-enenitrile (**5′b**)*

75%.$^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 1.10 (s, 9H, TBDPS-3$CH_3$); 3.67–3.74 (m, 2H, $CH_2$-Bn); 4.24 (d, 1H, H5, $J$=11.77); 4.31 (d, 1H, H5′, $J$=11.76); 5.24 (m, 1H, H2); 5.75 (m, 2H, H3, H4); 7.16–7.19 (m, 2H, Ph); 7.26–7.32 (m, 3H, Ph); 7.37–7.51 (m, 6H, Ph); 7.62–7.65 (m, 2H, Ph); 7.69–7.73 (m, 2H, Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 19.41, 26.78, 59.46, 66.18, 72.79, 118.68, 127.51, 127.84, 127.93, 128.08, 128.21, 128.60, 130.46, 130.59, 131.50, 131.71, 132.07, 135.88, 135.93, 137.63.

#### *4.11.4. (E)-2-t-Butyldiphenylsilyloxy-5-methoxymethoxypent-3-enenitrile (**5c**)*

71%.$^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 1.10 (s, 9H, TBDPS-3$CH_3$); 3.36 (s, 3H, MOM-$CH_3$); 4.05 (d, 2H, H5, $J$=3.5); 4.61 (s, 2H, MOM-$CH_2$); 4.85 (d, 1H, H2, $J$=4.8); 5.72–5.97 (n.a., 2H, H3, H4); 7.39–7.73 (m, 10H, TBDPS-2Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: 19.52, 26.90, 55.59, 63.10, 66.23, 96.07, 126.34, 128.17, 128.25, 130.60, 130.71, 131.67, 131.78, 132.10, 135.97, 136.06. **(2*S*)-5b**: 66% *ee* (n-heptane/*i*-propanol=99.75/0.25, Diacel OD-H, 254 nm, flow=0.7 mL/min, $T$=25 °C, $t_{R,S}$=27.4 min, $t_{R,R}$=23.5 min). HRMS (El) $m/z$ calcd for $C_{23}H_{29}NO_3Si$ ($M^+$) 395.1917, found 395.1921.

#### *4.11.5. (E)-5-t-Butyldimethylsilyloxy-2-t-butyldiphenylsilyloxypent-3-enenitrile (**5d**)*

71%. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 0.06 (s, 6H, TBDMS-2$CH_3$); 0.91 (s, 9H, TBDMS-3$CH_3$); 1.10 (s, 9H, TBDPS-3$CH_3$); 4.16 (dd, 2H, H5, $J$=3.1; $J_3$=1.3); 4.85 (d, 1H, H2, $J$=4.8); 5.75 (ddd, 1H, H3, $J$=15.4, 5.3, 1.3); 5.91 (dt, 1H, H4, $J$=15.4, 3.1); 7.35–7.73 (m, 10H, TBDPS-2Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: −5.12, 18.58, 19.52, 26.11, 26.90, 62.29, 63.20, 122.58, 123.91, 128.16, 128.32, 130.66, 134.89, 136.07. **(2*S*)-5d**: 99% ee (n-heptane/*i*-propanol=99/1, Diacel OD-H, 254 nm, flow=0.5 mL/min, $T$=10 °C, $t_{R,S}$=9.8 min, $t_{R,R}$=9.3 min). HRMS (El) $m/z$ calcd for $C_{27}H_{39}NO_2Si_2$ ($M^+$) 465.2519, found 465.2517.

#### *4.11.6. (Z)-5-(t-Butyldimethylsilyloxy)-2-(t-butyldiphenylsilyloxy)-pent-3-enenitrile (**5′d**)*

50%. $^1$H NMR (200 MHz, $CDCl_3$) $\delta$: 0.07 (s, 6H, TBDMS-2$CH_3$); 0.77 (s, 9H, TBDMS-3$CH_3$); 1.09 (s, 9H, TBDPS-3$CH_3$); 3.93 (n.a., 2H, H5); 5.35 (d, 1H, H2, $J$=5.3); 5.56–5.71 (n.a., 2H, H3, H4); 7.35–7.74 (m, 10H, TBDPS-2Ph). $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$: −5.39, 18.38, 19.46, 26.00, 26.82, 59.57, 60.43, 118.95, 125.93, 128.14, 128.25, 130.48, 130.61, 131.93, 132.24, 134.04, 135.92, 135.99. **(2*S*)-5′d**: 10% ee (n-heptane/*i*-propanol=99.75/0.25, Diacel OD-H, 254 nm, flow=0.6 mL/min, $T$=25 °C, $t_{R,S}$=10.1 min, $t_{R,R}$=8.1 min).

### 4.12. (*Z*)-(*S*)-2-(*t*-Butyldiphenylsilyloxy)-5-hydroxypent-3-enenitrile (5′f)[26]

To a solution of 630 mg of **5′a** (1.62 mmol, 1 equiv) in 800 μL of dioxane 180 mg of $SeO_2$ (1.78 mmol, 1.1 equiv) and 140 μL of glacial acetic acid (2.43 mmol, 1.5 equiv) are added and the mixture is stirred under reflux for 1 h. After cooling to rt the orange solution is filtered through a pad of Celite and washed with $CH_2Cl_2$. Evaporation of the solvent under reduced pressure and purification by flash chromatography (cyclohexane/ethyl acetate 10/1) affords **5′f** (0.387 g, 68%) as a yellow oil. $^1$H NMR ($CDCl_3$) $\delta$: 1.09 (s, 9H, TBDPS-3$CH_3$); 3.82 (d, 2H, H5); 5.21 (m, 1H, H2); 5.69 (m, 2H, H3, H4); 7.44–7.75 (m, 10H TBDPS-2Ph). $^{13}$C NMR ($CDCl_3$) $\delta$: 19.45, 26.80, 59.08, 62.7, 118.80, 126.71, 128.15, 128.32, 130.75, 131.69, 132.18, 133.74, 135.98, 136.03.

### 4.13. (*Z*)-(*S*)-5-(*t*-Butyldimethylsilyloxy)-2-(*t*-butyldiphenylsilyloxy)-pent-3-enenitrile (5′d), alternative procedure

To a solution 390 mg of **5′f** (1.11 mmol, 1 equiv) in 3 mL of $CH_2Cl_2$ are added 185 mg of *tert*-butyldimethylsilyl chloride (1.1 equiv) and 105 mg of imidazole (1.4 equiv) and the mixture is stirred overnight. The solution is washed with 1 M HCl and saturated aqueous $NaHCO_3$ and the organic layer is dried over $Na_2SO_4$. Evaporation of the solvent under reduced pressure yields 462 mg (89%) of **5′d** as colourless oil, which is used without further purification. For spectroscopic data see above.

### 4.14. (2*R*)-5-(*t*-Butyldimethylsilyloxy)-2-(*t*-butyldiphenylsilyloxy)-3,4-dihydroxypentanenitrile (6d)

To 1 mL of a solvent mixture of acetone/$H_2O$ (4:1) in a 2-necked round bottom flask with septum 15.7 μL of an aqueous $OsO_4$ solution (4%, 0.002 mmol, 0.05 equiv) and 14.3 μL of a 30% aqueous $H_2O_2$ solution (0.14 mmol, 1.3 equiv) are added and stirred for 4–5 min. Afterwards 1 mL of a solution of 50 mg of **5′d** (0.107 mmol, 1 equiv) in acetone/$H_2O$ (4:1) is added. Additional 28.6 μL of aqueous $H_2O_2$ solution (30%) are added slowly over a period of 4–5 h. The reaction mixture is stirred for 14 h until quantitative conversion. A few crystals of $Na_2SO_3$ are added and after stirring for another 30 min, the mixture is filtered over a bed of silica gel and $Na_2SO_4$ and the silica/$Na_2SO_4$ bed is washed with ethyl acetate. Evaporation of the solvent under reduced pressure and purification by flash chromatography (cyclohexane/ethyl acetate 20:1 v/v) affords 36 mg (67%) of **6d** as colourless oil. Isomeric ratio 1/2. $^1$H NMR ($CDCl_3$) $\delta$: *arabino* (500 MHz): 0.12 (s, 6H, 2$CH_3$-Si); 0.92 (s, 9H, TBDMS-3$CH_3$); 1.17 (s, 9H, TBDPS-3$CH_3$); 2.52 (d, 1H, OH(C4), $J$=6.05); 2.91 (d, 1H, OH(C3), $J$=7.65); 3.69–3.77 (m, 2H, H3, H5, $J$=10.25, 2.84); 3.85–3.91 (dq, 2H, H4, H5′, $J$=10.30, 6.05); 4.77 (d, 1H, H2, $J$=2.78); 7.44–7.55 (m, 6H, TBDPS-Ph); 7.72–7.77 (m, 4H, TBDPS-Ph). *ribo* (200 MHz): 0.08 (s, 6H, $CH_3$-Si); 0.85 (s, 9H TBDMS-3$CH_3$); 1.10 (s, 9H TBDPS-3$CH_3$); 3.62–3.80 (m, 2H, H3, H5); 3.82–3.91 (m, 2H, H4, H5′); 4.76 (m, 1H, H2);

7.37–7.55 (m, 6H, TBDPS-Ph); 7.60–7.80 (m, 4H, TBDPS-Ph). $^{13}$C NMR $\delta$: *arabino* (125 MHz): −5.30, −5.25, 18.45, 19.68, 26.03, 27.04, 64.0, 70.09, 74.01, 77.45, 118.38, 128.17, 128.29, 130.80, 130.82, 131.12, 131.32, 136.09, 136.20. *ribo* (50 MHz): −5.30, −5.25, 18.44, 19.52, 25.85, 26.89, 63.35, 70.75, 73.57, 77.72, 117.94, 128.34, 128.44, 130.81, 130.86, 131.15, 131.37, 135.82, 136.02.

### 4.15. (2*R*)-[5-(*t*-Butyldimethylsilyloxymethyl)-2,2-dimethyl-[1,3]dioxolan-4-yl]-(*t*-butyldiphenylsilyloxy)-acetonitrile (7d)

To a solution of 90 mg of **6d** (0.18 mmol, 1 equiv) in 5 mL of $CH_2Cl_2$ 2,2-dimethoxypropane (445 μL, 3.6 mmol, 20 equiv) and a catalytic amount of pyridinium *para*-toluene sulfonate are added. The mixture is stirred at rt until quantitative conversion. After evaporation of the solvent under reduced pressure and purification by flash chromatography (cyclohexane/ethyl acetate 10:1 v/v) 64 mg (66%) of **7d** are obtained as colourless oil. Isomeric ratio 1/1. $^1$H NMR ($CDCl_3$) $\delta$: *arabino*+*ribo*: −0.06 (s, 3H, $CH_3$-Si); −0.05 (s, 3H, $CH_3$-Si); 0.01 (s, 3H, $CH_3$-Si); 0.03 (s, 6H, $CH_3$-Si); 0.76 (s, 9H, TBDMS-3$CH_3$); 0.83 (s, 9H, TBDMS-3$CH_3$); 1.12 (s, 18H, TBDPS-3$CH_3$); 1.35 (s, 3H, $CH_{3,isoprop}$); 1.37 (s, 3H, $CH_{3,isoprop}$); 1.45 (s, 3H, $CH_{3,isoprop}$); 1.55 (s, 3H, $CH_{3,isoprop}$); 3.63–3.68 (dd, 1H, H5 *ribo*, *J*=10.71, 5.34); 3.80–3.86 (dd, 1H, H5′ *ribo*, *J*=10.72, 7.59), 3.92–3.98 (dd, 1H, H5 *arabino*, *J*=4.25, 11.17); 3.98–4.04 (dd, 1H, H5′ *arabino*, *J*=11.32, 5.27); 4.09–4.15 (dt, 1H, H4 *ribo*, *J*=7.11, 5.58); 4.23–4.27 (dd, 1H, H3 *ribo*, *J*=6.82, 2.99); 4.28–4.35 (m, 2H, H3, H4 *arabino*, *J*=6.18); 4.52 (d, 1H, H2 *arabino*, *J*=6.04); 4.79 (d, 1H, H2 *ribo*, *J*=3.06); 7.38–7.50 (m, 12H, 6H, TBDPS-Ph *ribo*, 6H, TBDPS-Ph *arabino*); 7.68–7.74 (m, 8H, 4H, TBDPS-Ph *ribo*, 4H, TBDPS-Ph *arabino*). $^{13}$C NMR $\delta$: *arabino*+*ribo*: −5.35, −5.18, −5.15, 18.39, 18.62, 19.54, 19.61, 25.26, 25.27, 26.02, 26.11, 26.97, 26.99, 27.26, 27.33, 61.35, 61.59, 63.17, 63.27, 76.66, 77.93, 78.09, 79.27, 109.66, 109.95, 117.93, 118.45, 128.07, 128.15, 128.20, 130.53, 130.58, 130.64, 130.66, 131.54, 131.56, 131.88, 132.22, 135.97, 136.11, 136.15, 136.20.

#### *4.15.1. (2R)-[5-(t-Butyldimethylsilanyloxymethyl)-2,2-dimethyl-[1,3]dioxolan-4-yl]-(t-butyldiphenylsilanyloxy)-acetaldehyde (**8d**)*

50 mg of cyanohydrin **7d** (0.093 mmol, 1 equiv) are dissolved in 6 mL of dry pentane and cooled to −78 °C. A 1.5 M DIBAL-H (1.5 equiv) solution in toluene is added under argon atmosphere. After stirring for 3 h at −78 °C 2.5 mL of MeOH are added via a syringe and the mixture is allowed to warm to 0 °C. After stirring for additionally 2.5 h, 1 mL of 0.5 M $H_2SO_4$ is added and the resulting mixture is stirred further for 1 h at 0 °C. The mixture is diluted with 2 mL $H_2O$ and extracted three times with 10 mL of $Et_2O$ each. The combined organic layers are dried over $Na_2SO_4$ and concentrated under reduced pressure. Purification by flash chromatography (cyclohexane/ethyl acetate 20:1 v/v) affords **8d** (16 mg, 32%) as colourless oil. Isomeric ratio 3.5/1. $^1$H NMR ($CDCl_3$) $\delta$: *arabino*: −0.08 (s, 3H, $CH_3$-Si); −0.05 (s, 3H, $CH_3$-Si); 0.77 (s, 9H TBDMS-3$CH_3$); 1.09 (s, 9H TBDPS-3$CH_3$); 1.29 (s, 3H, $CH_{3,isoprop}$); 1.37 (s, 3H, $CH_{3,isoprop}$); 3.53–3.57 (dd, 1H, H5, *J*=10.77, 5.41); 3.63–3.67 (dd, 1H, H5′, *J*=10.69, 6.86); 4.22 (dt, 1H, H4, *J*=6.86, 5.58); 4.31 (d, 1H, H2, *J*=6.88); 4.39 (dd, 1H, H3, *J*=6.87, 5.86); 7.31–7.44 (m, 6H, TBDPS-Ph); 7.67–7.71 (m, 4H, TBDPS-Ph); 9.51 (s, 1H, CHO). *ribo*: −0.02 (s, 6H 2$CH_3$-Si); 0.81 (s, 9H TBDMS-3$CH_3$); 1.11 (s, 9H TBDPS-3$CH_3$); 1.30 (s, 3H, $CH_{3,isoprop}$); 1.43 (s, 3H, $CH_{3,isoprop}$); 3.66–3.70 (dd, 1H, H5, *J*=10.37, 5.67); 3.91–3.94 (dd, 1H, H5′, *J*=10.60, 6.85); 4.11 (dt, 1H, H4, *J*=6.76, 5.79); 4.39 (dd, 1H, H3, *J*=6.87, 3.36), 4.48 (dd, 1H, H2, *J*=3.33, 1.07); 7.31–7.44 (m, 6H, TBDPS-Ph); 7.62–7.65 (m, 4H, TBDPS-Ph); 9.44 (d, 1H, CHO, *J*=1.08).

#### *4.15.2. 5-Benzyloxy-2-(t-butyldiphenylsilyloxy)-3,4-dihydroxypentanenitrile (**6b**)*

To 5 mL of an acetone/$H_2O$ (5:1) mixture in a 2-necked round bottom flask with septum 350 μL of an aqueous $OsO_4$ (4%) solution and 310 μL of an aqueous $H_2O_2$ (30%, 3.04 mmol, 1.3 equiv) solution are added and the resulting mixture is stirred for 4–5 min. A solution of 1.033 g of ***rac*-5′b** (2.34 mmol, 1 equiv) in 19 mL of an acetone/$H_2O$ (5:1) mixture is added. Additional 620 μL of the aqueous $H_2O_2$ (30%, 3.08 mmol, 2.6 equiv) solution are added slowly over a period of 4–5 h and the reaction mixture is stirred for 14 h until quantitative conversion. A few crystals of $Na_2SO_3$ are added and after stirring for 30 min the mixture is filtered over a bed of silica gel and $Na_2SO_4$. The silica/$Na_2SO_4$ bed was washed with ethyl acetate and the combined organic layers are concentrated under reduced pressure. After purification by flash chromatography (cyclohexane/ethyl acetate 20:1 v/v) 655 mg (59%) of **6b** are obtained as colourless oil. Isomeric ratio 1/1. $^1$H NMR ($CDCl_3$) $\delta$: *arabino*+*ribo*: 1.13 (s, 18H, TBDMS-3$CH_3$, *arabino, ribo*); 3.58–3.63 (dd, 1H, H5, *J*=5.01, 9.7); 3.66–3.70 (dd, 1H, H5′, *J*=3.1, 9.72); 3.72–3.87 (m, 8H, H3, H4 *arabino*, H3, H4 *ribo*, H5, H5′); 4.52 (s, 2H, $CH_2$-Bn) 4.55, 4.56 (2s, 2H, $CH_2$-Bn); 4.72 (d, 1H, H2, *J*=3.30); 4.74 (d, 1H, H2, *J*=3.17); 7.27–7.52 (m, 22H, 6H TBDPS-Ph, 5H Bn *arabino*, 6H TBDPS-Ph, 5H Bn *ribo*); 7.64–7.75 (m, 8H, 4H TBDPS-Ph *arabino*+*ribo*). $^{13}$C NMR $\delta$ *arabino*: 19.68, 27.03, 63.92, 69.35, 71.18, 73.85, 74.06, 118.31, 127.99, 128.11, 128.21, 128.33, 128.87, 130.85, 130.86, 131.09, 131.33, 136.08, 136.21, 137.55. *ribo*: 19.51, 27.01, 65.96, 70.05, 70.76, 73.74, 73.80, 117.20, 127.99, 128.27, 128.29, 128.35, 128.74, 130.81, 130.85, 131.17, 131.72, 135.88, 136.08, 137.72.

### 4.16. (5-Benzyloxymethyl-2,2-dimethyl-[1,3]dioxolan-4-yl)-(*tert*-butyldiphenylsilyloxy)-acetonitrile (7b)

To a solution of **6b** (2 g, 4.205 mmol, 1 equiv) in 120 mL of $CH_2Cl_2$ 2,2-dimethoxypropane (10.3 mL, 84.1 mmol, 20 equiv) and a catalytic amount of pyridinium *para*-toluene sulfonate are added. The mixture is stirred at rt until quantitative conversion. Evaporation of the solvent under reduced pressure and purification by flash chromatography (cyclohexane/ethyl acetate 10:1 v/v) yields **7b** (1.87 g, 86%) as colourless oil. Isomeric ratio 1.5/1 $^1$H NMR ($CDCl_3$) $\delta$: *arabino*: 1.05 (s, 9H TBDPS-3$CH_3$); 1.36 (s, 3H, $CH_{3,isoprop}$); 1.50 (s, 3H, $CH_{3,isoprop}$); 3.93–4.01 (m, 2H, H5, H5′ *J*=4.02); 4.20 (t, 1H, H3, *J*=6.18); 4.42 (d, 1H, H2, *J*=5.64); 4.49 (d, 1H, $CH_2$-Bn, *J*=12.19); 4.52–4.57 (dt, 1H, H4, *J*=6.63, 4.03); 4.69 (d, 1H, $CH_2$-Bn, *J*=12.19); 7.26–7.51 (m, 6H, TBDPS-Ph); 7.60–7.69 (m, 4H, TBDPS-Ph). *ribo*: 1.08 (s, 9H TBDPS-3$CH_3$); 1.38 (s, 3H, $CH_{3,isoprop}$); 1.53 (s, 3H, $CH_{3,isoprop}$); 3.47–3.52 (dd, 1H, H5, *J*=10.04, 5.81); 3.61–3.66 (dd, 1H, H5′, *J*=10.05, 5.95); 4.24–4.28 (dd, 1H, H3, *J*=6.57, 4.18); 4.32–4.35 (m, 1H, H4, *J*=6.20); 4.36 (s, 1H, $CH_2$-Bn); 4.37 (s, 1H, $CH_2$-Bn), 4.64 (d, 1H, H2, *J*=4.18), 7.26–7.51 (m, 6H, TBDPS-Ph); 7.60–7.69 (m, 4H, TBDPS-Ph). $^{13}$C NMR $\delta$: *arabino*: 19.44, 25.23, 26.92, 27.06, 63.19, 67.68, 73.81, 76.70, 77.22, 110.24, 118.38, 127.95, 128.14, 128.22, 128.68, 130.68, 130.77, 131.15, 131.64, 135.99, 136.14, 137.89. *ribo*: 19.50, 25.28, 26.97, 27.36, 63.23, 68.04, 73.81, 75.42, 78.72, 110.17, 117.87, 127.95, 128.17, 128.18, 128.63, 130.62, 130.70, 131.30, 131.90, 136.02, 136.17, 137.66.

### 4.17. (5-Benzyloxymethyl-2,2-dimethyl-[1,3]dioxolan-4-yl)-(*tert*-butyldiphenylsilyloxy)-acetaldehyde (8b)

To a solution of 1.0 g of **7b** (1.94 mmol, 1.0 equiv) in 100 mL of dry pentane at −78 °C a 1.5 M DIBAL-H (2.61 mL, 2 equiv) solution in toluene is added under argon atmosphere. After stirring for 2 h at −78 °C 50 mL of MeOH are added via a syringe and the mixture is allowed to warm to 0 °C. After stirring for additionally 2 h, 20 ml of 0.5 M $H_2SO_4$ are added and the resulting mixture is stirred for 1 h at 0 °C. Afterwards the mixture is diluted with 20 mL $H_2O$ and extracted three times with 100 mL of $Et_2O$ each. The combined organic layers are dried over $Na_2SO_4$ and concentrated under reduced pressure. Purification by flash chromatography (cyclohexane/ethyl acetate 10:1 v/v) affords 330 mg (33%) of **8b** as colourless oil. Isomeric ratio 1.6/1. $^1$H NMR ($CDCl_3$) $\delta$ *arabino*+*ribo*: 1.06 (s, 9H, TBDPS-3$CH_3$, *arabino*); 1.07 (s, 9H, TBDPS-3$CH_3$, *ribo*); 1.30 (s, 3H, $CH_{3,isoprop}$,

*arabino*); 1.31 (s, 3H, $CH_{3,isoprop}$, *ribo*); 1.42 (s, 3H, $CH_{3,isoprop}$, *arabino*); 1.43 (s, 3H, $CH_{3,isoprop}$, *ribo*); 3.45–3.49 (dd, 1H, H5 *arabino*, $J$=10.18, 6.56); 3.50–3.54 (dd, 1H, H5 *ribo*, $J$=9.87, 6.76); 3.56–3.61 (dd, 1H, H5′ *arabino*, $J$=10.19, 4.90); 3.61–3.65 (dd, 1H, H5′ *ribo*, $J$=9.89, 5.39); 4.18 (d, 1H, H2 *arabino*, $J$=6.14); 4.29 (d, 1H, $CH_2$-Bn *arabino*, $J$=12.06); 4.30–4.35 (m, 3H, H3 *arabino*, H2, H3 *ribo*); 4.37–4.45 (m, 4H, H4 *arabino*, H4, $CH_2$-Bn *ribo*); 4.45 (d, 1H, CH2-Bn, *arabino*, $J$=12.08); 7.18–7.44 (m, 12H, 6H TBDPS-Ph, 5H Bn *arabino*, 6H TBDPS-Ph, 5H Bn *ribo*); 7.57–7.67 (m, 8H, 4H TBDPS-Ph *arabino*, 6H TBDPS-Ph *ribo*); 9.40 (d, 1H, CHO *ribo*, $J$=1.45); 9.53 (s, 1H, CHO *arabino*). $^{13}$C NMR $\delta$: *arabino*: 19.64, 25.19, 27.14, 27.17, 68.55, 73.45, 76.29, 77.17, 77.36, 109.18, 127.87, 127.88, 127.92, 128.00, 128.58, 130.20, 130.24, 132.98, 136.19, 136.21, 137.84, 200.12. *ribo*: 19.56, 24.92, 27.09, 27.13, 69.30, 73.45, 75.76, 77.20, 78.37, 109.05, 127.84, 127.90, 127.94, 128.03, 128.56, 130.24, 130.32, 132.93, 136.07, 136.21, 137.96, 201.13.

### 4.18. Deprotection of 8b to 5-*O*-benzylfuranoses

To a solution of **8b** (100 mg, 0.193 mol) in 2.5 mL of MeOH Dowex 50 W-X4 (washed with MeOH) is added at rt and the suspension is stirred for 9 h. Filtration and evaporation of the solvent under reduced pressure affords a mixture of four products. Separation is done by flash chromatography (cyclohexane/ethyl acetate 10:1 v/v).

#### *4.18.1. 5-O-Benzyl-2-O-(t-butyldiphenylsilyl)-α-L-ribofuranose (α-**9a**)*

5 mg (5.4%) as colourless oil $^1$H NMR ($CDCl_3$) $\delta$ 1.15 (s, 9H, TBDPS-3$CH_3$), 3.6 (dd, 1H, H5), 3.61 (m, 1H, C1-OH), 3.69 (dd, 1H, H5′, $J$=10.25); 3.94 (d, 1H, H3); 4.2 (m, 1H, H4); 4.23 (m, 1H, H2, $J$=5.4); 4.45 (dd, 2H, H6, H6′, $J$=11.7); 4.94 (dd, 1H, H1, $J$=4.4); 7.1–7.7 (m, 15H, Bn-Ph, TBDPS-2Ph). $^{13}$C NMR $\delta$ 70.40, 72.08, 73.61, 73.92, 84.41, 97.30, 127.68–137.29 (Ph-C). HRMS (El) *m/z* calcd for $C_{28}H_{34}O_5Si_4$ ($M^+$) 478.2176, found 478.2170.

#### *4.18.2. 5-O-Benzyl-2-O-(t-butyldiphenylsilyl)-β-L-ribofuranose (β-**9a**)*

5 mg (5.4%) as colourless oil. $^1$H NMR ($CDCl_3$) $\delta$ 1.15 (s, 9H, TBDPS-3$CH_3$); 2.76 (d, 1H, C3-OH); 3.22 (d, 1H, C1-OH); 3.46 (dd, 2H, H5, H5′); 4.13 (dd, 1H, H2); 4.2 (m, 1H, H3); 4.3 (m, 1H, H4); 4.41 (dd, 2H, H6, H6′ $J$=12.2); 5.03 (d, 1H, H1), 7.1–7.7 (m, 15H, Bn-Ph, TBDPS-2Ph). $^{13}$C NMR $\delta$ 70.27, 72.64, 73.42, 78.96, 82.76, 102.35, 127.82–138.06 (Ph-C). HRMS (El) *m/z* calcd for $C_{28}H_{34}O_5Si$ ($M^+$) 478.2176, found 478.2168.

#### *4.18.3. 5-O-Benzyl-2-O-(t-butyldiphenylsilyl)-α-L-arabinofuranose (α-**10a**)*

15 mg (16.3%) as colourless oil. $^1$H NMR ($CDCl_3$) $\delta$ 1.09 (s, 9H, TBDPS-3$CH_3$); 2.35 (br s, 1H, C3-OH); 3.15 (br s, 1H, C1-OH); 3.66 (dd, 1H, H5, $J$=10.25); 3.69 (dd, 1H, H5′); 3.95 (d, 1H, H3); 4.06 (d, 1H, H2); 4.34 (m, 1H, H4, $J$=6.8); 4.6 (dd, 2H, H6, H6′, $J$=12.2); 5.26 (d, 1H, H1), 7.3–7.8 (m, 15H, Bn-Ph, TBDPS-2Ph). $^{13}$C NMR $\delta$ 71.16, 73.72, 79.03, 82.29, 85.75, 103.35, 128.07–138.14 (Ph-C).

#### *4.18.4. 5-O-Benzyl-2-O-(t-butyldiphenylsilyl)-β-L-arabinofuranose (β-**10a**)*

8 mg (8.7%) as colourless oil. $^1$H NMR ($CDCl_3$) $\delta$ 1.13 (s, 9H, TBDPS-3$CH_3$); 3.60 (dd, 1H, H5, $J$=10.0); 3.63 (dd, 1H, H5′); 3.78 (dd, 1H, H4, $J$=5.4); 3.87 (br s, 1H, C1-OH); 4.07 (m, 1H, H3), 4.1 (dd, 1H, H2); 4.6 (dd, 2H, H6, H6′, $J$=11.7); 5.12 (d, 1H, H1, $J$=4.4); 7.3–7.8 (m, 15H, Bn-Ph, TBDPS-2Ph). $^{13}$C NMR $\delta$ 70.98, 73.85, 78.12, 79.89, 80.58, 96.98, 128.01–138.04 (Ph-C).

### 4.19. Deprotection of 8b to methyl-5-*O*-benzylfuranosides

To a solution of **8b** (200 mg, 0.39 mmol) in 5 mL MeOH Dowex 50 W-X4 (washed with MeOH) is added at rt and the suspension stirred for 5 d. Filtration and evaporation of the solvent under reduced pressure affords a mixture of six products. Products can be separated by flash chromatography (cyclohexane/ethyl acetate 10:1 v/v).

#### *4.19.1. Methyl 5-O-benzyl-2-O-(t-butyldiphenylsilyl)-α-L-ribofuranoside (α-**9b**)*

5.6 mg (2.9%) as colourless oil. $^1$H NMR ($CDCl_3$) $\delta$ 1.1 (s, 9H, TBDPS-3$CH_3$); 3.22 (d, 1H, OH); 3.33 (s, 3H, OMe), 3.48 (dd, 2H, H5, H5′, $J$=3.9); 3.9 (t, 1H, H3, $J$=4.8); 4.13 (m, 1H, H2); 4.22 (m, 1H, H4, $J$=3.9); 4.37 (d, 1H, H1, $J$=4.4); 4.44 (dd, 2H, H6, H6′, $J$=12.2); 7.15–7.74 (m, 15H, Bn-Ph, TBDPS-2Ph). $^{13}$C NMR $\delta$ 55.52, 70.55, 71.60, 73.26, 73.59, 84.81, 103.42, 127.80–138.42 (Ph-C). HRMS (El) *m/z* calcd for $C_{29}H_{36}O_5Si$ ($M^+$) 492.2332, found 492.2335.

#### *4.19.2. Methyl 5-O-benzyl-2-O-(t-butyldiphenylsilyl)-β-L-ribofuranoside (β-**9b**)*

20 mg (10.5%) as colourless oil. $^1$H NMR ($CDCl_3$) $\delta$ 1.12 (s, 9H, TBDPS-3$CH_3$); 2.58 (d, 1H, OH); 3.04 (s, 3H, OMe); 3.52 (dd, 1H, H5, $J$=10.5); 3.68 (dd, 1H, H5′); 4.04 (m, 1H, H3); 4.13 (d, 1H, H2); 4.18 (m, 1H, H4, $J$=6.8); 4.52 (s, 1H, H1); 4.59 (s, 2H, H6, H6′); 7.25–7.75 (m, 15H, Bn-Ph, TBDPS-2Ph). $^{13}$C NMR $\delta$ 19.57, 27.22, 55.24, 72.19, 72.75, 73.62, 76.92, 83.36, 108.06, 127.79, 127.91, 128.13, 128.20, 128.57, 130.42, 132.50, 133.11, 135.95, 136.06, 138.44. HRMS (El) *m/z* calcd for $C_{26}H_{36}O_5Si$ ($M^+$), 492.2332, found 492.2328.

#### *4.19.3. Methyl 5-O-benzyl-2-O-(t-butyldiphenylsilyl)-α-L-arabinofuranoside (α-**10b**)*

10 mg (5.3%) as colourless oil. $^1$H NMR ($CDCl_3$) $\delta$ 1.05 (s, 9H, TBDPS-3$CH_3$); 2.25 (d, 1H, OH); 3.22 (s, 3H, OMe); 3.65 (dd, 1H, H5, $J$=9.7); 3.72 (dd, 1H, H5′); 3.87 (d, 1H, H3, $J$=5.3); 4.09 (s, 1H, H2); 4.2 (m, 1H, H4); 4.58–4.68 (dd, 2H, H6, H6′, $J$=12.2); 4.76 (s, 1H, H1); 7.25–7.65 (m, 15H, Bn-Ph, TBDPS-2Ph). $^{13}$C NMR $\delta$55.04, 71.18, 73.68, 79.26, 81.95, 85.62, 109.27, 127.93, 128.03, 128.07, 128.14, 128.65, 130.26, 130.32, 133.11, 133.34, 135.96, 138.28.

#### *4.19.4. Methyl 5-O-benzyl-2-O-(t-butyldiphenylsilyl)-β-L-arabinofuranoside (β-**10b**)*

11.3 mg (6%) as colourless oil. $^1$H NMR ($CDCl_3$) $\delta$ 1.10 (s, 9H, TBDPS-3$CH_3$); 1.85 (br s, 1H, OH); 3.25 (s, 3H, OMe); 3.56 (dd, 1H, H5, $J$=9.3); 3.60 (dd, 1H, H5′); 3.86 (q, 1H, H4, $J$=6.3); 4.1 (m, 1H, H2); 4.2 (d, 1H, H1, $J$=4.4 Hz); 4.27 (t, 1H, H3); 4.58 (dd, 2H, H6, H6′, $J$=12.2); 7.15–7.75 (m, 15H, Bn-Ph, TBDPS-2Ph). $^{13}$C NMR $\delta$ 55.19, 73.08, 73.64, 78.10, 79.15, 79.89, 102.72, 127.74–138.31 (Ph-C).

#### *4.19.5. Methyl 5-O-benzyl-α-L-arabinofuranoside (α-**10c**)*

21 mg (21.4%) as colourless oil. Spectroscopic data correspond with those in literature.[27]

#### *4.19.6. Methyl 5-O-benzyl-β-L-arabinofuranoside (β-**10c**)*

5 mg (5.09%) as colourless oil. Spectroscopic data correspond with those reported earlier.[27]

### 4.20. Methyl 5-*O*-benzyl-β-ribofuranoside (β-9c)

To a solution β-**9c** in 2 mL of MeOH Amberlite IR-120 is added and the mixture is stirred for 7d at rt. Filtration and evaporation of the solvent affords β-**9b** as colourless oil in 7.8% yield. The unreacted starting material can be recovered. Spectroscopic data correspond with those in literature.[28]

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