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An enantioselective synthesis of carbafuranose sugars based on a linchpin carbacyclisation approach

Leo M. H. Leung [a], Mark E. Light [a], Vicky Gibson [b], Bruno Linclau [a,*]

[a] *School of Chemistry, University of Southampton, Highfield, Southampton SO17 1BJ, UK*
[b] *Carbosynth Ltd, 8&9 Old Station Business Park, Compton, Berkshire RG20 6NE, UK*

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Dedicated to Professor George Fleet on the occasion of his 65th birthday

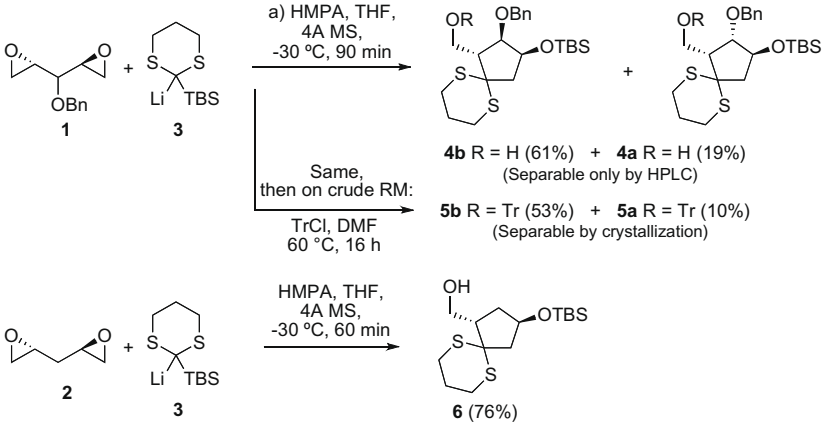
ABSTRACT

Enantiopure carbafuranose derivatives were synthesised via a linchpin carbacyclisation process starting from 1,4-bisepoxides. Both 2-deoxy and 2-deoxy-6-hydroxycarbafuranose derivatives were obtained, which were converted to suitably protected precursors for carbanucleoside synthesis.

1. Introduction

Carbasugars are an important subset of carbohydrate analogues in which the ring-oxygen is replaced by a methylene (–CH_2–) group. This modification transforms the anomeric centre from a (hemi-) acetal into an ether (alcohol) group, which has significant implications towards enzymatic and hydrolytic stability as well as towards conformational changes. Carbafuranoses are particularly relevant compounds as they are a subunit of the medicinally very important carbanucleosides. There are a few naturally occurring carbanucleosides, such as aristeromycin and Neplanocin A, but there are no known direct carbafuranose analogues of natural carbohydrates occurring in Nature. The synthesis and conformational aspects of carbafuranoses have been discussed in detail in a recent seminal review.[1a]

Hence, the synthesis of carbafuranose derivatives is of interest, especially the development of methodology that allows access to both enantiomeric forms. We have reported a linchpin carbacyclisation reaction starting from bis-epoxides **1** and **2** (Scheme 1), which leads to carbafuranose derivatives **4**–**6** in excellent yield, on a large scale.[2] Importantly, diastereomers **5a** and **5b** are easily separable via a crystallisation procedure. The bis-epoxides **1**[3] and **2**[4] are available in both enantiomeric forms.



Scheme 1. The linchpin cyclisation process leading to carbafuranose precursors.

* Corresponding author. Tel.: +44 23 8059 3816; fax +44 23 8058 6805.
E-mail address: bruno.linclau@soton.ac.uk (B. Linclau).

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The dithiane-based linchpin cyclisation with 1,3-bis-epoxides to give cyclopentane derivatives has been described,[5] and the usefulness of this process for the synthesis of cyclohexane and cycloheptane-based carbasugars from 1,5-bis-epoxides has been demonstrated.[5a,6]

In this report, we describe the conversion of **4**–**6** to 2-deoxy carbafuranose derivatives, including 6′-hydroxylated derivatives, and their conversion to suitable precursors for carbanucleoside synthesis.

2. Results and discussion

2.1. Hydrolysis of the 1,3-dithiane group

Conversion of **4**–**6** into carbafuranoses requires deprotection of the C3 keto group. The hydrolysis of 1,3-dithianes, and more general, of *S*,*S*-acetals, has been extensively investigated, not least because the reaction often is capricious and compound-specific. As a result, many conditions to effect this transformation have been developed.[7] A number of literature reports for 1,3-dithiane hydrolysis leading to various substituted cyclopentanones were available, which included the use of $HgCl_2/CaCO_3$,[8] $HgO/BF_3{\cdot}OEt_2$,[9] trichloroisocyanuric acid,[9] MeI/EtOH/H_2O,[10] BTI ($PhI(OCOCF_3)$,[10] DAIB ($PhI(OAc)_2$),[11] NBS[12] and NCS/$AgNO_3$.[13]

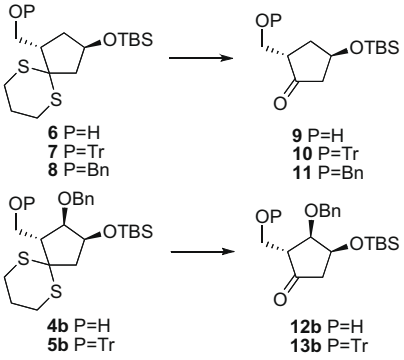
The dithiane hydrolysis was investigated with a number of carbacyclisation products featuring different protecting groups for the hydroxymethyl moiety. Hence, **6** was reacted with TrCl and BnBr to give **7** and **8** (Scheme 2).

Scheme 2. Protection of the hydroxymethyl group in **6**.

However, the use of most of the abovementioned reagents for the deprotection of **4**–**8** was unsuccessful: no reaction was observed with $HgCl_2/CaCO_3$,[14] and the use of trichloroisocyanuric acid[15] and MeI/EtOH/H_2O led to decomposition. The same result was obtained with $Hg(NO_3)_2{\cdot}3H_2O$.[16] Other methods such as the use of pyridinium hydrobromide perbromide,[17] benzene selenic anhydride,[18] cerium ammonium nitrate[19] or chlorinated silica gel[20] all led to decomposition. However, the use of hypervalent iodine species led to some success (Table 1). Treatment of **6** with BTI[21] led to the complete consumption of starting material within 5 min; however, only 32% of **9** was isolated (entry 1), which is much lower than yields obtained by Le Merrer for the deprotection of a six-membered ring carbasugar linchpin cyclisation adduct using this method.[6c] A similar yield was observed starting from the benzyl-protected **8** (entry 2), but hydrolysis of **4b** only took place in very low yield (entry 3).

The byproduct of BTI-mediated hydrolysis is trifluoroacetic acid, and hence diacetoxyiodobenzene (DAIB), which releases the milder acetic acid, was investigated next.[11] However, only low yields of **13b** were obtained (entries 4 and 5). When hydrolysis of **6** was investigated, 18% of **9** was isolated (entry 6), together with a byproduct which was identified (NMR and MS) as the corresponding oxidised dithiane (sulfoxide). Sulfoxides derived from dithioketals can be converted to the corresponding ketone by

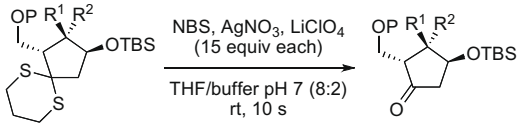
Table 1
Optimisation of the 1,3-dithiane hydrolysis



Entry	Substrate	Reagent (equiv)	Solvent	*T* (°C)	Time[a]	Additive (equiv)	Product yield[b] (%)
1	**6**	BTI (1.6)	MeOH/H_2O (9:1)	rt	5 m	—	**9** (32)
2	**8**	BTI (1.5)	MeOH/DCM/H_2O	0	15 m	—	**11** (28)
3	**4b**	BTI (1.6)	MeOH/H_2O (9:1)	0	5 m	—	**12b** (15)
4	**5b**	DAIB (2.5)	Acetone/buffer[c] (9:1)	rt	3 h	—	**13b** (13)
5	**5b**	DAIB (10)	MeCN/buffer[c] (8:2)	rt	25 m	—	**13b** (16)
6	**6**	DAIB (2.0)	2-Propanol/H_2O (9:1)	rt	2 h	—	**9** (18)
7	**6**	DAIB (2.0)	2-Propanol/H_2O (9:1)	rt	90 m	HBF_4 (1)	**9** (21)
8	**6**	DAIB (2.0)	2-Propanol/H_2O (9:1)	rt	2 h	AcOH (2)	**9** (20)
9	**5b**	NCS (4)	MeCN/H_2O (9:1)	rt	3 m	$AgNO_3$ (4.5)	**13b** (12)
10	**5b**	NCS (4)	Acetone/H_2O (9:1)	−30	5 m	$AgNO_3$ (4.5)	**13b** (0)
11	**5b**	NBS (15)	Acetone/H_2O (4:1)	rt	10 s	$AgNO_3$ (15)	**13b** (16)
12	**5b**	NBS (15)	THF/H_2O (4:1)	rt	10 s	$AgNO_3$ (15)	**13b** (14)
13	**5b**	NBS (15)	THF/buffer[c] (97:3)	rt	10 s	$AgNO_3$ (15) $LiClO_4$ (15)	**13b** (45)
14	**5b**	NBS (4)	THF/buffer[c] (97:3)	rt	10 s	$AgNO_3$ (4) $LiClO_4$ (4)	**13b** (31)

[a] Unless indicated otherwise.
[b] Isolated yield.
[c] pH 7.

Table 2
The 1,3-dithiane hydrolysis



Entry	Substrate	P	R^1	R^2	Product	Yield (%)
1	**5b**	Tr	OBn	H	**13b**	45
2	**5a**	Tr	H	OBn	**13a**	41[a]
3	**7**	Tr	H	H	**10**	49
4	**4b**	H	OBn	H	**12b**	44
5	**4a**	H	H	OBn	**12a**	43[b]
6	**6**	H	H	H	**9**	55

[a] Water was used instead of buffer.
[b] Reaction solvent was 2-propanol instead of THF.

HBF_4-mediated hydrolysis.[22] However, despite the observation that a dramatic acceleration in the reaction rate was seen when HBF_4 was added, the yield of **9** did not improve even though no sulfoxide was present after workup (entry 7). Replacing HBF_4 with HOAc led to similar results. Thioketal hydrolysis using other hypervalent iodine reagents such as iodoxybenzoic acid (IBX)[23] and Dess–Martin periodinane (DMP)[24] failed completely.

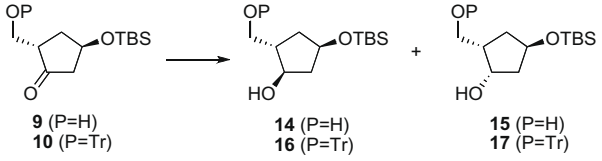
The best results were found using *N*-halosuccinimides. Le Merrer[6c,d] had successfully used NBS in acetone/water[12,14b] to hydrolyse the 1,3-dithiane moiety of a six-membered ring carbasugar linchpin cyclisation adduct, but these conditions led to decomposition in our case. The addition of $AgNO_3$[14] had a beneficial effect, and using NCS in combination with $AgNO_3$ gave a yield of 12% when conducted at room temperature (entry 9). Lowering the temperature resulted in no reaction (entry 10). With NBS/$AgNO_3$, a large excess had to be used, with very short reaction times required to arrive at the same yields (entries 11 and 12); however, inspired by the beneficial effect of $LiClO_4$ on NBS-mediated glycosylation reactions with thioglycosides,[25] when $LiClO_4$ was added, the yield increased to 45% (entry 13). A control experiment with a reduced excess of reagents led to a drop in yield (entry 14). A pH 7 buffer was used in these experiments, though it was later found that the use of water worked equally well.

Despite the fact that the best yield obtained was still a moderate 45%, we decided to apply the NBS/$AgNO_3$/$LiClO_4$ cocktail for the hydrolysis of all linchpin cyclisation products with and without primary alcohol protection (Table 2). Pleasingly, similar or even slightly higher yields were observed.

2.2. Selective reduction of the ketogroup

With the hydrolysis achieved, the ketone reduction was investigated (Table 3). From the outset, it was envisioned that the adjacent hydroxymethyl group could be used as a directing group for diastereoselective ketone reduction. Equally, the trityloxymethyl group would offer complementary selectivity by imposing steric hindrance. Surprisingly, we found virtually no examples of such 3-keto reductions in carbafuranose synthesis.[26] Nevertheless, hydroxyl-directed diastereoselective reduction of 2-(1-hydroxyalkyl)

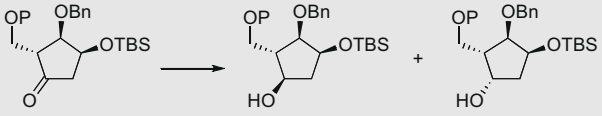
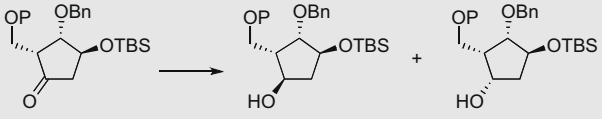
Table 3
The diastereoselective ketone reduction



9 (P=H)
10 (P=Tr)

14 (P=H)
16 (P=Tr)

15 (P=H)
17 (P=Tr)

Entry	Substrate	Reagent	Product (yield, %)[a]	
1	**9**	$Me_4NBH(OAc)_3$	**14** (76)	**15** (5)
2	**9**	$Et_2B(OMe)$; $NaBH_4$	**14** (51)	**15** (3)
3	**10**	BH_3·THF	**16** (16)	**17** (80)
				
		12b (P=H) **13b** (P=Tr)	**18b** (P=H) **20b** (P=Tr)	**19b** (P=H) **21b** (P=Tr)
4	**12b**	$Me_4NBH(OAc)_3$	**18b** (81)	**19b** (0)
5	**13b**	BH_3·THF	**20b** (29)	**21b** (56)
				
		12a (P=H) **13a** (P=Tr)	**18a** (P=H) **20a** (P=Tr)	**19a** (P=H) **21a** (P=Tr)
6	**12a**	$Me_4NBH(OAc)_3$	**18a** (77)	**19a** (0)
7	**13a**	BH_3·THF	**20a** (33)	**21a** (43)
8	**13a**	$NaBH_4$	**20a** (12)	**21a** (37)
9	**13a**	$NaBH_3CN$	**20a** (0)	**21a** (46)

[a] Isolated yield.

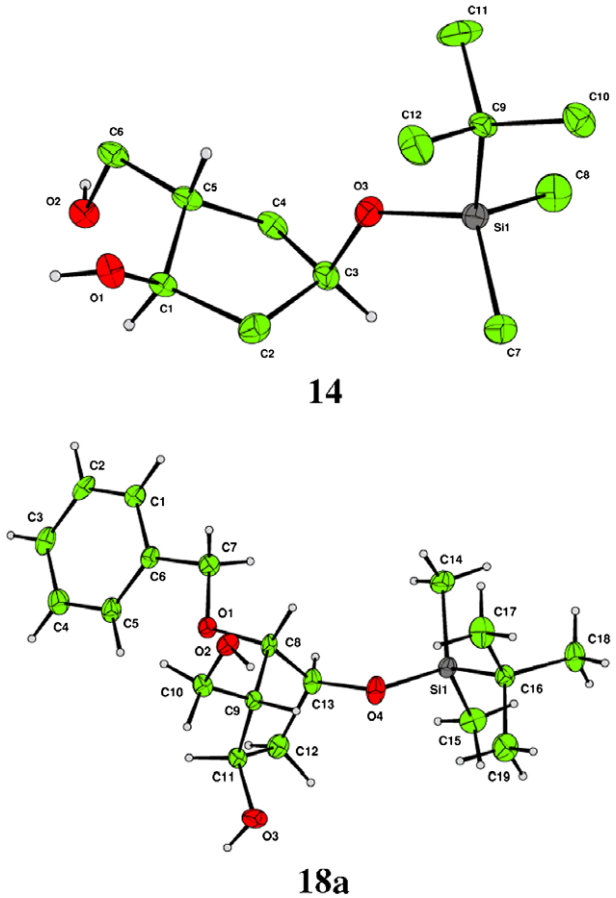
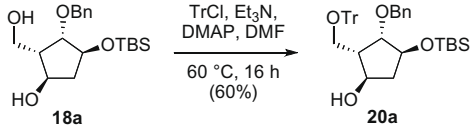


Figure 1. Single crystal structures of **14** and **18a**. Data were collected on a Bruker Nonius KappaCCD with a Mo rotating anode generator; standard procedures were followed. All hydrogen atoms were identified from the difference map and then positioned geometrically and refined using a riding model.

cyclopentanones has been described,[26,27] especially in the prostaglandin field.[28]

Hence, reduction of **9** using $Me_4NBH(OAc)_3$[27,29] in AcOH/THF at 0 °C afforded the crystalline diol **14**[30] as the major diastereomer in 76% yield, with the minor diastereoisomer **15** isolated in only 5% yield (entry 1). These diastereomers could easily be separated by column chromatography. The relative stereochemistry of the reduction products was determined by X-ray crystallographic analysis of **14** (Fig. 1),[31a,c] which confirmed that the reduction of **9** with $Me_4NBH(OAc)_3$ was directed by the hydroxymethyl group. Surprisingly,



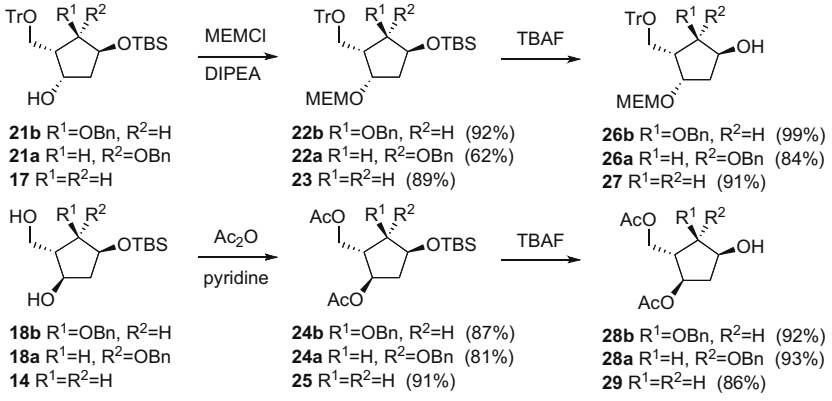
Scheme 3. Structural correlation of **20a** with **18a**.

reduction using $Et_2BOMe/NaBH_4$[32] also gave **14** as the major isomer with excellent diastereoselectivity (entry 2). The α-3OH diastereomer **17** was obtained as the major product by reduction of the trityl-protected substrate **10** in excellent yield (entry 3), in which hydride attack occurred via the least hindered carbonyl face. Compounds **16** and **17** were easily separable by column chromatography.

Starting from **12b** and **12a**, reduction with $Me_4NBH(OAc)_3$ led to **18b** and **18a** as the sole product in excellent yields (entries 4 and 6).[33] The relative stereochemistry of **18a** was determined by X-ray crystallographic analysis (Fig. 1b),[31b,c] which again proved the directing role of the free hydroxyl group. The relative stereochemistry of **18b** could not be confirmed by X-ray crystallography, but was assigned in analogy with **18a**. In contrast, borane reduction on the corresponding trityl ethers **13b** and **13a** only gave moderate diastereoselectivity, in favour of the α-3OH epimers **21b** and **21a** (entries 5 and 7). No reaction of **13a** was observed with 9-BBN. Reduction of **13a** with sodium borohydride was more selective (entry 8). The low overall yield was due to elimination of the OTBS group. This side reaction was not observed with borane or with sodium cyanoborohydride (entry 9). This last reagent displayed full diastereoselectivity, albeit in modest yield. The diastereoselection induced by the trityloxymethyl group was confirmed by structural correlation of **18a** with **20a**, by tritylation of the former (Scheme 3), and indeed showed that the major isomer arising from hydroxyl-directed reduction of **12a** corresponded to the minor isomer arising from trityloxymethyl-directed reduction, proving the different facial selectivities of the ketone reduction. On this basis, the relative configuration of **16**/**17** and **20b**/**21b** was assigned as shown.

2.3. Conversion to fully protected carbafuranoses

The carbafuranose derivatives thus obtained can easily be converted to suitable substrates for carbanucleoside synthesis by protection of the free alcohol groups followed by removal of the silyl moiety (Scheme 4). Hence, **17** and **21a/b** were protected with MEMCl, while **14** and **18a/b** were subjected to acetylation. Finally, the fully protected carbafuranose derivatives **22**–**25** were treated with TBAF in order to reveal the 1-OH group.



Scheme 4. Conversion of the reduction products to carbanucleoside precursors.

3. Conclusion

2-Deoxy- and 2-deoxy-6-hydroxycarbafuranose derivatives suitably protected for the synthesis of the corresponding carbanucleosides are accessible in only 5 or 6 steps from 1,4-bis-epoxides. The key step is a linchpin carbacyclisation process, and the C3 stereochemistry is introduced by a diastereoselective ketone reduction. Despite the modest yields for the 1,3-dithiane hydrolysis step, this represents a quick and convenient synthesis of carbapentafuranose derivatives. As the 1,3-bis-epoxides are easily accessible in both enantiomeric forms, both carbasugar enantiomers can be obtained via this methodology.

4. Experimental

4.1. General experimental

Chemical shifts are quoted in ppm relative to residual solvent peaks as appropriate. All assignments are supported by DEPT, COSY and HMQC experiments. Melting points are uncorrected. Column chromatography was performed on 230–400 mesh Matrex silica gel. Preparative HPLC was carried out using a Biorad Biosil D 90-10, 250 × 22 mm column eluting at 20 mL/min^{-1}, connected to a refractive index detector. Reactions were monitored by TLC (Merck) with detection by $KMnO_4$ or anisaldehyde stains. Reaction solvents were dried before use as follows: THF and Et_2O were distilled from the sodium/benzophenone ketyl; CH_2Cl_2 and Et_3N were distilled from CaH_2; toluene was distilled from sodium; pyridine was double distilled from CaH_2 and stored in a Schlenk flask; HMPA was distilled from CaH_2 and stored over 4 Å molecular sieves. All reaction vessels were flame dried under vacuum and cooled under nitrogen prior to use, and all experiments were carried out under a nitrogen atmosphere. All other reagents were purchased from commercial sources and used without further purification.

4.2. Dithiane hydrolysis

4.2.1. (2*S*,4*R*)-[4-(*tert*-Butyldimethylsilyloxy)-2-trityloxymethyl]cyclopentan-1-one-1,3-propanedithioketal 7

TrCl (0.875 g, 3.14 mmol) was added to a solution of **6** (0.525 g, 1.57 mmol) and Et_3N (0.46 mL) in DMF (7.8 mL). The mixture was stirred at 60 °C for 16 h and then cooled to rt. Satd NH_4Cl (5 mL) followed by H_2O (10 mL) and Et_2O (15 mL) was added. The aqueous phase was extracted with Et_2O (2 × 15 mL). The organic phases were dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was purified by column chromatography to afford **7** as a white solid (0.814 g, 90%). mp 43–47 °C. $[\alpha]_D = -16.6$ (*c* 0.67, $CHCl_3$, 26 °C). IR 3058 (w), 2952 (s), 2927 (s), 1490 (m), 1471 (s), 1448 (m), 1067 (s) cm^{-1}. ^{1}H NMR (400 MHz, $CDCl_3$) 7.50–7.21 (15H, m, ArH), 4.36 (1H, m, CHOSi), 3.52 (1H, dd, *J* = 9.0, 5.0 Hz, CH_aH$_b$OTr), 3.10 (1H, app t, *J* = 9.0 Hz, CH$_a$$H_b$OTr), 2.94 (1H, ddd, *J* = 14.0, 10.5, 3.0 Hz, SCH_aH$_b$), 2.87 (1H, dd, *J* = 14.0, 7.5 Hz, SSCCH_aH$_b$), 2.81–2.72 (2H, m, SCH$_a$$H_b$ + SCH_cH$_d$), 2.67 (1H, qd, *J* = 9.0, 4.5 Hz, C*H*CH$_2$OTr), 2.57 (1H, ddd, *J* = 14.0, 6.0, 3.0 Hz, SCH$_c$$H_d$), 2.08–2.01 (3H, m, CHC$H_2$CH + SSCCH$_a$$H_b$), 1.97 (1H, m, SCH$_2CH_aH_b$), 1.82 (1H, m, SCH$_2CH_a$$H_b$), 0.90 (9H, s, SiC(CH$_3$)$_3$), 0.06 (3H, s, SiCH$_3$), 0.05 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 144.4 (C_{Ar} × 3), 129.0 (CH_{Ar} × 6), 127.9 (CH_{Ar} × 6), 127.0 (CH_{Ar} × 3), 87.1 (CPh_3), 71.1 (CHOSi), 64.2 (CH_2OTr), 56.6 (SSC), 52.7 (SSCCH_2), 50.0 (*C*HCH$_2$OTr), 39.1 (*C*H$_2$CHOSi), 28.8 (SCH_2), 27.4 (SCH_2), 26.1 (SiC(*C*H$_3$)$_3$), 25.6 (SCH$_2$*C*H$_2$), 18.3 (SiC), −4.5 ($SiCH_3$ × 2). ES$^+$ *m/z* (%) 599 ((M+Na)$^+$, 100). HRMS (ES$^+$) for $C_{34}H_{44}O_2S_2SiNa$ (M+Na)$^+$: Calcd 599.2444; Measured 599.2438.

4.2.2. (2*S*,4*R*)-[4-(*tert*-Butyldimethylsilyloxy)-2-benzyloxymethyl]cyclopentan-1-one-1,3-propanedithioketal 8

NaH (60% dispersion in mineral oil; 0.0490 g, 1.23 mmol) was added to a solution of **6** (0.270 g, 0.807 mmol) in THF (5.4 mL) at 0 °C, and the mixture was stirred at 0 °C for 1 h. BnBr (0.144 mL, 1.21 mmol) was added, and the reaction mixture was stirred at rt for 16 h. H_2O (5 mL) and Et_2O (10 mL) were then added, and the aqueous layer was extracted with Et_2O (2 × 10 mL). The organic layer was dried over $MgSO_4$, filtered and concentrated in vacuo. Purification by column chromatography gave **8** as a colourless oil (0.179 g, 52%). $[\alpha]_D = -10.8$ (*c* 0.6, $CHCl_3$, 24 °C). IR 2952 (m), 2928 (m), 2859 (m), 1471 (m), 1362 (m), 1253 (m), 1087 (s) cm^{-1}. ^{1}H NMR (400 MHz, $CDCl_3$) 7.35–7.26 (5H, m, ArH), 4.58 (1H, d, *J* = 12.0 Hz, CH_aH$_b$Ph), 4.53 (1H, d, *J* = 12.0 Hz, CH$_a$$H_b$Ph), 4.44–4.38 (1H, m, CHOSi), 3.81 (1H, dd, *J* = 9.0, 5.0 Hz, CH_aH$_b$OBn), 3.52 (1H, t, *J* = 9.0 Hz, CH$_a$$H_b$OBn), 3.04–2.87 (3H, m, SCH_aH$_b$ + SCH_cH$_d$ + SCCH_aH$_b$), 2.84–2.65 (3H, m, SCH$_a$$H_b$ + SCH$_c$$H_d$ + C*H*CH$_2$OBn), 2.14–2.00 (4H, m, SCH$_2$CH_aH$_b$ + SCCH$_a$$H_b$ + CHCH_2CH), 1.94–1.83 (1H, m, SCH$_2$CH$_a$$H_b$), 0.88 (9H, s, SiC(CH$_3$)$_3$), 0.04 (6H, s, SiCH$_3$ × 2). ^{13}C NMR (100 MHz, $CDCl_3$) 138.7 (C_{Ar}), 128.5 (CH_{Ar} × 2), 127.7 (CH_{Ar} × 2), 127.6 (CH_{Ar}), 73.3 (CH_2Ph), 71.3 (*C*H$_2$OBn), 71.2 (*C*HOSi), 56.7 (SCS), 52.7 (SCCH$_2$), 49.5 (*C*HCH$_2$OBn), 39.2 (CHCH_2CH), 28.8 (SCH_2), 27.4 (SCH_2), 26.0 (SiC(*C*H$_3$)$_3$), 25.8 (SCH$_2$*C*H$_2$), 18.2 (SiC), −4.57 ($SiCH_3$), −4.61 ($SiCH_3$). ES$^+$ *m/z* (%) 447 ((M+Na)$^+$, 100). HRMS (ES$^+$) for $C_{22}H_{36}O_2S_2$SiNa (M+Na)$^+$: Calcd 447.1818; Measured 447.1809.

4.2.3. (2*S*,4*R*)-[4-(*tert*-Butyldimethylsilyloxy)-2-hydroxymethyl]cyclopentanone 9

A solution of thioketal **6** (57.0 mg, 0.170 mmol) in THF (1.0 mL) was added to a solution of NBS (430 mg, 2.42 mmol), $LiClO_4$ (257 mg, 2.42 mmol) and $AgNO_3$ (412 mg, 2.43 mmol) in THF/pH 7.0 buffer (8:2; 4.4 mL). The mixture was stirred at rt for 10 s, and was then poured into a mixture of satd $NaHCO_3$ (20 mL) and Et_2O (20 mL). The aqueous layer was extracted with Et_2O (3 × 20 mL). The organic layer was dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was purified by column chromatography (EtOAc/petroleum ether 35:65) to afford **9** as a clear oil that crystallised upon storage in the fridge (23.0 mg, 55 %). mp 47–49 °C. $[\alpha]_D$ = +99.0 (*c* 0.26, $CHCl_3$, 22 °C) (*Note*: the specific rotation was taken from the (2*R*,4*S*)-enantiomer). IR 3448 (br s), 2954 (m), 2929 (m), 2856 (m), 1736 (m), 1256 (m) cm^{-1}. ^{1}H NMR (300 MHz, $CDCl_3$) 4.56–4.54 (1H, m, CHOSi), 3.89 (1H, dd, *J* = 11.0, 4.5 Hz, CH_aH$_b$OH), 3.68 (1H, dd, *J* = 11.0, 6.0 Hz, CH$_a$$H_b$OH), 2.70 (1H, m, C*H*CH$_2$OH), 2.32–2.30 (2H, m, C$H_2$CO), 2.13 (1H, m, CHC$H_aH_b$CH), 1.94 (1H, ddd, *J* = 13.0, 11.5, 4.0 Hz, CHCH$_a$$H_b$CH), 0.86 (9H, s, C(CH$_3$)$_3$), 0.07 (3H, s, SiCH$_3$), 0.06 (3H, s, SiCH$_3$). The OH was not observed. ^{13}C NMR (75 MHz, $CDCl_3$) 217.1 (C=O), 68.4 (CHOSi), 61.8 (CH_2OH), 48.9 (CH_2CO), 47.7 (*C*HCH$_2$OH), 35.8 (CHCH$_2$OH), 25.8 (SiC(*C*H$_3$)$_3$), 18.1 (SiC), −4.7 ($SiCH_3$), −4.8 ($SiCH_3$). CIMS *m/z* (%) 262 ((M+NH$_4$)$^+$, 7), 75 (100). Anal. Calcd for $C_{12}H_{24}O_3Si$: C, 58.97; H, 9.90. Found: C, 58.93; H, 10.24.

4.2.4. (2*S*,4*R*)-[4-(*tert*-Butyldimethylsilyloxy)-2-trityloxymethyl]cyclopentanone 10

A solution of thioketal **7** (365 mg, 0.632 mmol) in THF (5.0 mL) was added to a solution of NBS (1.69 g, 9.49 mmol), $LiClO_4$ (1.01 g, 9.49 mmol) and $AgNO_3$ (1.61 g, 9.49 mmol) in THF/H_2O (8:2, 16 mL). The mixture was stirred at rt for 10 s, and was poured into a mixture of $NaHCO_3$ (20 mL) and Et_2O (20 mL). The aqueous layer was extracted with Et_2O (3 × 20 mL). The organic phases were washed with satd $NaHCO_3$ (20 mL) and brine (20 mL), dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was purified by column chromatography (EtOAc/petroleum ether 1:9) to afford **10** as a clear oil that solidified upon storage in the fridge (148 mg, 48%). $[\alpha]_D = -48.7$ (*c* 1.1, $CHCl_3$, 26 °C). IR 3059 (w), 2954 (m), 2928

(m), 1747 (s), 1490 (m), 1448 (m), 1051 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.43–7.21 (15H, m, ArH), 4.64 (1H, tt, J = 4.5, 2.5 Hz, CHOSi), 3.52 (1H, dd, J = 9.0, 5.0 Hz, CH_aH$_b$OTr), 3.17 (1H, dd, J = 9.0, 3.5 Hz, CH$_a$$H_b$OTr), 2.63 (1H, m, C$HCH_2$OTr), 2.48 (1H, dd, J = 18.0, 5.0 Hz, COCH_aH$_b$), 2.30 (1H, dtd, J = 18.0, 2.5, 1.0 Hz, COCH$_a$$H_b$), 2.23–2.13 (2H, m, C$H_2$CHOSi), 0.88 (9H, s, SiC(CH$_3$)$_3$), 0.09 (3H, s, SiCH$_3$), 0.08 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 218.0 (C=O), 144.1 (C$_{Ar}$ × 3), 128.8 (CH$_{Ar}$ × 6), 127.9 (CH$_{Ar}$ × 6), 127.1 (CH$_{Ar}$ × 3), 86.7 (CPh$_3$), 68.9 (CHOSi), 62.3 (CH$_2$OTr), 49.2 (COCH$_2$), 46.6 (CHCH$_2$OTr), 36.9 (CH$_2$CHOSi), 25.9 (SiC(CH$_3$)$_3$), 18.2 (SiC), −4.6 (SiCH$_3$), −4.7 (SiCH$_3$). ES$^+$ m/z (%) 509 ((M+Na)$^+$, 100). HRMS (ES$^+$) for $C_{31}H_{38}O_3SiNa$ (M+Na)$^+$: Calcd 509.2482; Measured 509.2470.

4.2.5. (2*S*,4*R*)-[4-(*tert*-Butyldimethylsilyloxy)-2-benzyloxymethyl]cyclopentanone 11

Bis-(trifluoroacetoxy)iodobenzene (0.148 g, 0.344 mmol) was added to a solution of **8** (0.100 g, 0.236 mmol) in MeOH/CH_2Cl_2/H_2O (9:1:1, 1 ml), and the solution was stirred at 0 °C in the dark for 15 min. The reaction mixture was then poured into satd $NaHCO_3$ (2 mL), extracted with Et_2O (3 × 5 mL), dried over Na_2SO_4, concentrated in vacuo and purified by column chromatography (EtOAc/petroleum ether 1:9) to yield **11** as a colourless oil (22.0 mg, 28%). $[\alpha]_D$ = −72.6 (*c* 0.9, $CHCl_3$, 23 °C). IR 2953 (m), 2929 (m), 2856 (m), 1746 (s), 1471 (m), 1360 (m), 1253 (m), 1047 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.30–7.21 (5H, m, ArH), 4.51 (1H, m, CHOSi), 4.47 (1H, d, J = 12.5 Hz, CH_aH$_b$Ph), 4.43 (1H, d, J = 12.5 Hz, CH$_a$$H_b$Ph), 3.70 (1H, dd, J = 9.5, 5.0 Hz, CH_aH$_b$OBn), 3.56 (1H, dd, J = 9.5, 4.0 Hz, CH$_a$$H_b$OBn), 2.63 (1H, tt, J = 9.5, 4.0 Hz, CHCH$_2$OBn), 2.29 (1H, dd, J = 18.0, 4.5 Hz, CH_aH$_b$CO), 2.21 (1H, m, CH$_a$$H_b$CO), 2.15–2.10 (2H, m, CHCH_2CH), 0.82 (9H, s, SiC(CH$_3$)$_3$) 0.02 (3H, s, SiCH$_3$), 0.01 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 218.1 (C=O), 138.4 (C$_{Ar}$), 128.5 (CH$_{Ar}$ × 2), 127.69 (CH$_{Ar}$), 127.62 (CH$_{Ar}$ × 2), 73.4 (CH$_2$Ph), 69.0 (CH$_2$OBn), 68.7 (CHOSi), 49.0 (COCH$_2$), 46.6 (CHCH$_2$OBn), 36.7 (CHCH$_2$CH), 25.9 (SiC(CH$_3$)$_3$), 18.1 (SiC), −4.66 (SiCH$_3$), −4.72 (SiCH$_3$). ES$^+$ m/z (%) 357 ((M+Na)$^+$, 100). HRMS (ES$^+$) for $C_{19}H_{30}O_3SiNa$ (M+Na)$^+$: Calcd 357.1856; Measured 357.1850.

4.2.6. (2*R*,3*R*,4*S*)-[3-Benzyloxy-4-(*tert*-butyldimethylsilyloxy)-2-hydroxymethyl]cyclopentanone 12b

A solution of thioketal **4b** (72.0 mg, 0.163 mmol) in THF (1.0 mL) was added to a solution of NBS (436 mg, 2.45 mmol), $LiClO_4$ (261 mg, 2.45 mmol) and $AgNO_3$ (416 mg, 2.45 mmol) in THF/pH 7.0 buffer (8:2, 4.5 mL). The mixture was stirred at rt for 10 s followed by the addition of satd $NaHCO_3$ (5 mL) and H_2O (5 mL). The aqueous layer was extracted with Et_2O (3 × 5 mL). The organic layer was dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was purified by column chromatography (EtOAc/petroleum ether 35:65) to afford **12b** as a white solid (25.0 mg, 44%). mp 54–58 °C. $[\alpha]_D$ = +3.8 (*c* 0.55, $CHCl_3$, 23 °C). IR 3460 (w,br), 2952 (m), 2928 (m), 2856 (m), 1746 (s), 1462 (m), 1360 (m), 1087 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.34–7.26 (5H, m, ArH), 4.80 (1H, d, J = 11.5 Hz, CH_aH$_b$Ph), 4.61 (1H, m, CHOSi), 4.51 (1H, d, J = 11.5 Hz, CH$_a$$H_b$Ph), 4.01 (1H, dd, J = 11.5, 4.0 Hz, CH_aH$_b$OH), 3.97 (1H, dd, J = 10.5, 3.5 Hz, CHOBn), 3.73 (1H, dd, J = 11.5, 4.5 Hz, CH$_a$$H_b$OH), 2.76 (1H, dtd, J = 10.0, 4.3, 1.8 Hz, CHCH$_2$OH), 2.43 (1H, dt, J = 18.5, 1.5 Hz, CH_aH$_b$CO), 2.25 (1H, dd, J = 18.5, 4.0 Hz, CH$_a$$H_b$CO), 1.72 (1H, s, OH), 0.89 (9H, s, SiC(CH$_3$)$_3$), 0.12 (3H, s, SiCH$_3$), 0.10 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 215.0 (C=O), 138.1 (C$_{Ar}$), 128.6 (CH$_{Ar}$ × 2), 128.0 (CH$_{Ar}$), 127.9 (CH$_{Ar}$ × 2), 79.4 (CHOBn), 71.5 (CH$_2$Ph), 67.8 (CHOSi), 59.3 (CH$_2$OH), 53.1 (CHCH$_2$OH), 47.8 (CH$_2$CO), 25.8 (SiC(CH$_3$)$_3$), 18.2 (SiC), −4.5 (SiCH$_3$ × 2). ES$^+$ m/z (%) 373 ((M+Na)$^+$, 100). HRMS (ES$^+$) for $C_{19}H_{30}O_4SiNa$ (M+Na)$^+$: Cald 373.1805; Measured 373.1801.

4.2.7. (2*R*,3*S*,4*S*)-[3-Benzyloxy-4-(*tert*-butyldimethylsilyloxy)-2-hydroxymethyl]cyclopentanone 12a

A solution of thioketal **4a** (480 mg, 1.09 mmol) in propan-2-ol (6.3 mL) was added to a solution of NBS (2.91 g, 16.3 mmol), $LiClO_4$ (1.74 g, 16.3 mmol) and $AgNO_3$ (2.78 g, 16.3 mmol) in propan-2-ol/pH 7.0 buffer (8:2; 30 mL). The mixture was stirred at rt for 10 s followed by the addition of satd $NaHCO_3$ (50 mL) and H_2O (50 mL). The aqueous layer was extracted with Et_2O (3 × 80 mL). The organic layer was dried over Na_2SO_4, filtered and concentrated in vacuo. The crude was purified by column chromatography (EtOAc/petroleum ether 3:7) to afford **12a** as a white solid (166 mg, 43%). $[\alpha]_D$ = −88.3 (*c* 0.35, $CHCl_3$, 26 °C). IR 3460 (m,br), 2953 (s), 2929 (s), 2857 (m), 1743 (vs), 1471 (m) 1254 (s), 1082 (vs) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.40–7.30 (5H, m, ArH), 4.63 (1H, d, J = 12.0 Hz, CH_aH$_b$Ph), 4.51 (1H, d, J = 12.0 Hz, CH$_a$$H_b$Ph), 4.38 (1H, dt, J = 5.5, 1.5 Hz, CHOSi), 4.05 (1H, dt, J = 5.5, 2.0 Hz, CHOBn), 3.93 (1H, ddd, J = 11.5, 6.0, 3.5 Hz, CH_aH$_b$OH), 3.82 (1H, ddd, J = 11.5, 9.0, 6.0 Hz, CH$_a$$H_b$OH), 2.72 (1H, qd, J = 6.0, 1.5 Hz, CHCH$_2$OH), 2.53 (1H, dd, J = 18.5, 5.5 Hz, CH_aH$_b$CHOSi), 2.39 (1H, dd, J = 9.0, 3.5 Hz, OH), 2.14 (1H, dq, J = 18.5, 1.5 Hz, CH$_a$$H_b$CHOSi), 0.87 (9H, s, SiC(CH$_3$)$_3$), 0.09 (3H, s, SiCH$_3$), 0.08 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 216.9 (C=O), 137.7 (C$_{Ar}$), 128.8 (CH$_{Ar}$ × 2), 128.3 (CH$_{Ar}$), 127.8 (CH$_{Ar}$ × 2), 83.9 (CHOBn), 72.4 (CH$_2$Ph), 70.1 (CHOSi), 59.2 (CH$_2$OH), 52.3 (CHCH$_2$OH), 45.6 (CH$_2$CHOSi), 25.8 (SiC(CH$_3$)$_3$), 18.1 (SiC), −4.68 (SiCH$_3$), −4.69 (SiCH$_3$). ES$^+$ m/z (%) 373 ((M+Na)$^+$, 100), 723 ((2M+Na)$^+$, 90). HRMS (ES$^+$) for $C_{19}H_{30}O_4SiNa$ (M+Na)$^+$: Calcd 373.1805; Measured 373.1805.

4.2.8. (2*R*,3*R*,4*S*)-[3-Benzyloxy-4-(*tert*-butyldimethylsilyloxy)-2-trityloxymethyl]cyclopentanone 13b

A solution of thioketal **5b** (49.2 mg, 0.0720 mmol) in THF (1.0 mL) was added to a solution of NBS (190 mg, 1.07 mmol), $LiClO_4$ (115 mg, 1.08 mmol) and $AgNO_3$ (180 mg, 1.06 mmol) in THF/pH 7.0 buffer (8:2; 2.5 mL). The mixture was stirred at rt for 10 s followed by the addition of satd $NaHCO_3$ (3 mL) and Et_2O (5 mL). The aqueous layer was extracted with Et_2O (2 × 5 mL). The organic layer was dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was purified by column chromatography (EtOAc/petroleum ether 5:95) to afford **13b** as a white foam (19.0 mg, 45%). $[\alpha]_D$ = −6.3 (*c* 1.1, $CHCl_3$, 24 °C). IR 3058 (w), 2926 (w), 2854 (w), 1748 (m), 1448 (m), 1253 (m), 1072 (m) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.45–7.26 (20H, m, ArH), 4.73 (1H, m, CHOSi), 4.67 (1H, d, J = 11.5 Hz, CH_aH$_b$Ph), 4.44 (1H, d, J = 11.5 Hz, CH$_a$$H_b$Ph), 4.31 (1H, dd, J = 9.0, 3.5 Hz, CHOBn), 3.82 (1H, dd, J = 9.0, 3.0 Hz, CH_aH$_b$OTr), 3.28 (1H, dd, J = 9.0, 3.0 Hz, CH$_a$$H_b$OTr), 2.69 (1H, m, C$HCH_2$OTr), 2.59 (1H, m, COC$H_aH_b$), 2.51 (1H, dd, J = 17.5, 4.0 Hz, COCH$_a$$H_b$), 0.93 (9H, s, SiC(CH$_3$)$_3$), 0.14 (6H, s, SiCH$_3$ × 2). ^{13}C NMR (100 MHz, $CDCl_3$) 213.7 (C=O), 143.9 (C$_{Ar}$ × 3), 138.2 (C$_{Ar}$), 128.8 (CH$_{Ar}$ × 6), 128.4 (CH$_{Ar}$ × 2), 128.0 (CH$_{Ar}$ × 6), 127.8 (CH$_{Ar}$ × 2), 127.7 (CH$_{Ar}$), 127.2 (CH$_{Ar}$ × 3), 86.8 (CPh$_3$), 80.2 (CHOBn), 71.9 (CH$_2$Ph), 68.9 (CHOSi), 59.2 (CH$_2$OTr), 52.4 (CHCH$_2$OTr), 47.9 (COCH$_2$), 25.9 (SiC(CH$_3$)$_3$), 18.2 (SiC), −4.51 (SiCH$_3$), −4.54 (SiCH$_3$). ES$^+$ m/z (%) 615 ((M+Na)$^+$, 100). HRMS (ES$^+$) for $C_{38}H_{44}O_4SiNa$ (M+Na)$^+$: Calcd 615.2901; Measured 615.2891.

4.2.9. (2*R*,3*S*,4*S*)-[3-Benzyloxy-4-(*tert*-butyldimethylsilyloxy)-2-trityloxymethyl]cyclopentanone 13a

A solution of thioketal **5a** (835 mg, 1.22 mmol) in THF (6.0 mL) was added to a solution of NBS (2.61 g, 14.7 mmol), $LiClO_4$ (1.56 g, 14.7 mmol) and $AgNO_3$ (2.49 g, 14.7 mmol) in THF/H_2O (8:2, 35 mL). The mixture was stirred at rt for 10 s before it was poured

into a mixture of satd $NaHCO_3$ (80 mL). The aqueous layer was extracted with Et_2O (3 × 80 mL). The organic layer was washed with satd $NaHCO_3$ (80 mL) and brine (80 mL), dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was purified by column chromatography and HPLC (EtOAc/petroleum ether 6:4) to afford **13a** as a colourless oil (299 mg, 41%). $[\alpha]_D = -23.7$ (*c* 0.45, $CHCl_3$, 28 °C). IR 3060 (w), 2928 (m), 1747 (s), 1491 (m), 1449 (m), 1090 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.36–7.09 (20H, m, ArH), 4.50 (1H, d, *J* = 12.0 Hz, CH_aH$_b$Ph), 4.46 (1H, d, *J* = 12.0 Hz, CH$_a$$H_b$Ph), 4.41 (1H, dt, *J* = 5.5, 2.0 Hz, CHOSi), 4.11 (1H, m, CHOBn), 3.57 (1H, dd, *J* = 9.5, 4.0 Hz, CH_aH$_b$OTr), 3.28 (1H, t, *J* = 9.5 Hz, CH$_a$$H_b$OTr), 2.85 (1H, m, C*H*CH$_2$OTr), 2.46 (1H, dd, *J* = 18.5, 6.0 Hz, CH_aH$_b$CHOSi), 2.07 (1H, dq, *J* = 18.5, 1.5 Hz, CH$_a$$H_b$CHOSi), 0.85 (9H, s, SiC(CH$_3$)$_3$), 0.03 (3H, s, SiCH$_3$), 0.00 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 215.0 (C=O), 144.2 (C_{Ar} × 3), 138.3 (C_{Ar}), 128.9 (CH_{Ar} × 6), 128.5 (CH_{Ar} × 2), 127.9 (CH_{Ar} × 6), 127.8 (CH_{Ar}), 127.7 (CH_{Ar} × 2), 127.1 (CH_{Ar} × 3), 87.1 (CPh$_3$), 82.7 (CHOBn), 72.5 (CH$_2$Ph), 70.9 (CHOSi), 58.6 (CH$_2$OTr), 52.2 (*C*HCH$_2$OTr), 45.5 (*C*H$_2$CHOSi), 25.9 (SiC(*C*H$_3$)$_3$), 18.2 (SiC), −4.6 (SiCH$_3$), −4.7 (SiCH$_3$). ES^+ *m/z* (%) 615 ((M+Na)$^+$, 100). HRMS (ES^+) for $C_{38}H_{44}O_4SiNa$ (M+Na)$^+$: Calcd 615.2901; Measured 615.2886.

4.3. General procedure for the $Me_4NBH(OAc)_3$-mediated reduction

A solution of ketone (1 equiv) in THF (≈4–7 mL/mmol) was added to a solution of $Me_4NBH(OAc)_3$ (4 equiv) in THF/acetic acid (1:1, 7 mL/mmol ketone) at 0 °C, and the mixture was stirred for 4 h. 1 M NaOH was added, and the aqueous layer was extracted with Et_2O. The organic layer was dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was filtered through silica gel and purified by HPLC to give the products.

4.3.1. (1*R*,2*S*,4*R*)-[4-(*tert*-Butyldimethylsilyloxy)-2-hydroxymethyl]cyclopentanol 14

Starting from **9** (39.0 mg), yield of **14**: 76% (30.0 mg, crystalline solid), yield of **15**: 5% (1.9 mg); HPLC (acetone/hexane 1:3). Data for **14**: mp 56–59 °C (CH_2Cl_2/hexane). $[\alpha]_D = -7.9$ (*c* 0.98, $CHCl_3$, 26 °C). IR 3350 (m,br), 2928 (m), 2856 (m), 1472 (w), 1463 (m), 1255 (s), 1026 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 4.36 (1H, m, CHOSi), 4.03 (1H, br s, C*H*OH), 3.65 (1H, dd, *J* = 10.5, 5.5 Hz, CH_aH$_b$OH), 3.50 (1H, dd, *J* = 10.5, 8.0 Hz, CH$_a$$H_b$OH), 3.05 (1H, d, *J* = 7.5 Hz, CHO*H*), 2.40 (1H, qdd, *J* = 8.5, 6.0, 3.5 Hz, C*H*CH$_2$OH), 1.97–1.87 (3H, m, CH_aH$_b$CHOSi + HOCHCH$_a$$H_b$ + CH$_2$O*H*), 1.80 (1H, m, HOCHCH$_a$$H_b$), 1.41 (1H, ddd, *J* = 14.0, 8.5, 5.0 Hz, CH$_a$$H_b$CHOSi), 0.89 (9H, s, SiC(CH$_3$)$_3$), 0.08 (6H, s, SiCH$_3$ × 2). ^{13}C NMR (100 MHz, $CDCl_3$) 76.7 (CHOSi), 74.1 (CHOH), 65.7 (CH$_2$OH), 49.8 (*C*HCH$_2$OH), 43.9 (HOCH*C*H$_2$), 37.8 (*C*H$_2$CHOSi), 26.0 (SiC(*C*H$_3$)$_3$), 18.1 (SiC), −4.7 (SiCH$_3$), −4.8 (SiCH$_3$). ES^+ *m/z* (%) 269 ((M+Na)$^+$, 100). HRMS (ES^+) for $C_{12}H_{26}O_3SiNa$ (M+Na)$^+$: Calcd 269.1543; Measured 269.1546.

(The amount of compound **15** isolated was insufficient for full characterisation).

4.3.2. (1*R*,2*S*,3*R*,4*S*)-[3-Benzyloxy-4-(*tert*-butyldimethylsilyloxy)-2-hydroxymethyl]cyclopentanol 18b

Starting from **12b** (36.3 mg), yield of **18b**: 81% (30.0 mg, crystalline solid); HPLC (acetone/hexane 3:7). Data for **18b**: $[\alpha]_D = +82.0$ (*c* 1.5, $CHCl_3$, 27 °C). IR 3395 (m,br), 2928 (s), 2856 (s), 1471 (m), 1360 (m), 1253 (m), 1066 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.35–7.27 (5H, m, ArH), 4.72 (1H, d, *J* = 12.0 Hz, CH_aH$_b$Ph), 4.44 (1H, d, *J* = 12.0 Hz, CH$_a$$H_b$Ph), 4.31 (1H, m, C*H*OSi), 3.92 (1H, m, C*H*OH), 3.80 (1H, dd, *J* = 10.5, 5.5 Hz, CH_aH$_b$OH), 3.65 (1H, m, CH$_a$$H_b$OH), 3.45 (1H, dd, *J* = 8.5, 3.5 Hz, CHOBn), 2.73 (1H, d, *J* = 10.0 Hz, CHO*H*), 2.32 (1H, m, C*H*CH$_2$OH), 1.95–1.89 (2H, m, CH$_2$O*H* + CH_aH$_b$CHOSi) 1.80 (1H, dtd, *J* = 14.5, 2.5, 1.0 Hz, CH$_a$$H_b$CHOSi), 0.93 (9H, s, SiC(CH$_3$)$_3$), 0.132 (3H, s, SiCH$_3$), 0.126 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 138.4 (C_{Ar}), 128.5 (CH_{Ar} × 2), 127.8 (CH_{Ar} × 3), 82.7 (CHOBn), 73.4 (CHOH), 72.2 (CHOSi), 72.0 (CH$_2$Ph), 63.3 (CH$_2$OH), 54.4 (*C*HCH$_2$OH), 41.1 (*C*H$_2$CHOSi), 26.0 (SiC(*C*H$_3$)$_3$), 18.2 (SiC), −4.5 (SiCH$_3$), −4.6 (SiCH$_3$). ES^+ *m/z* (%) 375 ((M+Na)$^+$, 100), 727 ((2 M+Na)$^+$, 18). HRMS (ES^+) for $C_{19}H_{32}O_4SiNa$ (M+Na)$^+$: Calcd 375.1962; Measured 375.1952.

4.3.3. (1*R*,2*S*,3*S*,4*S*)-[3-Benzyloxy-4-(*tert*-butyldimethylsilyloxy)-2-hydroxymethyl]cyclopentanol 18a

Starting from **12a** (63.0 mg), yield of **18a**: 77% (49.0 mg, crystalline solid); HPLC (acetone/hexane 25:75). Data for **18a**: $[\alpha]_D = -29.8$ (*c* 1.2, $CHCl_3$, 28 °C). IR 3371 (m,br), 2953 (s), 2928 (s), 1471 (m), 1255 (s), 1070 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.38–7.27 (5H, m, ArH), 4.65 (1H, d, *J* = 12.0 Hz, CH_aH$_b$Ph), 4.49 (1H, d, *J* = 12.0 Hz, CH$_a$$H_b$Ph), 4.29 (1H, m, C*H*OH), 4.25 (1H, m, CHOSi), 3.99 (1H, m, CHOBn), 3.93 (1H, dt, *J* = 11.5, 4.0 Hz, CH_aH$_b$OH), 3.85 (1H, ddd, *J* = 11.5, 8.5, 5.5 Hz, CH$_a$$H_b$OH), 2.47 (1H, dd, *J* = 8.5, 4.0 Hz, CH$_2$O*H*), 2.41 (1H, d, *J* = 8.0 Hz, CHO*H*), 2.32 (1H, m, C*H*CH$_2$OH), 2.29 (1H, ddd, *J* = 13.5, 7.0, 5.5 Hz, CH_aH$_b$CHOSi), 1.67 (1H, dt, *J* = 13.5, 4.0 Hz, CH$_a$$H_b$CHOSi), 0.90 (9H, s, SiC(CH$_3$)$_3$), 0.10 (6H, s, SiCH$_3$ × 2). ^{13}C NMR (100 MHz, $CDCl_3$) 138.0 (C_{Ar}), 128.7 (CH_{Ar} × 2), 128.1 (CH_{Ar}), 127.7 (CH_{Ar} × 2), 87.9 (CHOBn), 76.2 (CHOSi), 73.8 (CHOH), 72.5 (CH$_2$Ph), 61.4 (CH$_2$OH), 52.8 (*C*HCH$_2$OH), 42.2 (*C*H$_2$CHOSi), 25.9 (SiC(*C*H$_3$)$_3$), 18.0 (SiC), −4.5 (SiCH$_3$), −4.7 (SiCH$_3$). ES^+ *m/z* (%) 375 ((M+Na)$^+$, 100). HRMS (ES^+) for $C_{19}H_{32}O_4SiNa$ (M+Na)$^+$: Calcd 375.1962; Measured 375.1970.

4.4. General procedure for the borane reduction

BH_3 (1.0 M solution in THF; 1.5–2.0 equiv) was added to a solution of ketone (1 equiv) in THF (10 mL/mmol ketone) at 0 °C, and the mixture was stirred at rt for 0.5–1 h. Then 1–2 M NaOH was added, and the aqueous layer was extracted with Et_2O. The organic layer was dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was purified by column chromatography or by filtration over a plug of silica gel followed by HPLC, to afford the corresponding alcohols.

4.4.1. (1*S*,2*S*,4*R*)- and (1*R*,2*S*,4*R*)-[4-(*tert*-Butyldimethylsilyloxy)-2-trityloxymethyl]cyclopentanol 17 and 16

Starting from **10** (37.4 mg), yield of **17**: 80% (30.1 mg, foam), yield of **16**: 16% (6.0 mg, foam); HPLC (EtOAc/hexane 1:9). *Data for* **17**: $[\alpha]_D = +1.7$ (*c* 1.1, $CHCl_3$, 26 °C). IR 3452 (w,br), 3058 (w), 2954 (s), 2928 (s), 2856 (m), 1490 (m), 1448 (m), 1063 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.45–7.22 (15H, m, ArH), 4.35 (1H, m, CHOSi), 4.01 (1H, ddt, *J* = 8.5, 6.5, 3.5 Hz, C*H*OH), 3.17 (1H, dd, *J* = 9.0, 6.0 Hz, CH_aH$_b$OTr), 3.06 (1H, d, *J* = 8.5 Hz, OH), 2.99 (1H, dd, *J* = 9.0, 7.0 Hz, CH$_a$$H_b$OTr), 2.53 (1H, m, C*H*CH$_2$OTr), 1.96–1.86 (2H, m, CH_aH$_b$CHOSi + OCHCH_aH$_b$CHO), 1.79 (1H, m, OCHCH$_a$$H_b$CHO), 1.47 (1H, ddd, *J* = 14.0, 8.5, 5.5 Hz, CH$_a$$H_b$CHOSi), 0.90 (9H, s, SiC(CH$_3$)$_3$), 0.08 (6H, s, SiCH$_3$ × 2). ^{13}C NMR (100 MHz, $CDCl_3$) 144.3 (C_{Ar} × 3), 128.8 (CH_{Ar} × 6), 127.9 (CH_{Ar} × 6), 127.1 (CH_{Ar} × 3), 86.7 (CPh$_3$), 77.1 (CHOSi), 74.3 (CHOH), 66.1 (CH$_2$OTr), 47.7 (CHCH$_2$OTr), 43.8 (HOCH*C*H$_2$), 38.2 (TrOCH$_2$CHCH$_2$), 26.0 (SiC(*C*H$_3$)$_3$), 18.1 (SiC), −4.7 (SiCH$_3$), −4.8 (SiCH$_3$). ES^+ *m/z* (%) 511 ((M+Na)$^+$, 100). HRMS (ES^+) for $C_{31}H_{40}O_3SiNa$ (M+Na)$^+$: Calcd 511.2639; Measured 511.2628.

Data for **16**: $[\alpha]_D = +30.5$ (*c* 0.32, $CHCl_3$, 26 °C). IR 3448 (w,br), 3059 (w), 2928 (m), 1490 (m), 1448 (m), 1061 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.45–7.23 (15H, m, ArH), 4.53 (1H, tt, *J* = 5.0, 2.5 Hz, C*H*OH), 4.43 (1H, tdd, *J* = 6.5, 4.5, 2.5 Hz, CHOSi), 3.41 (1H, dd, *J* = 9.0, 5.0 Hz, CH_aH$_b$OTr), 3.06 (1H, t, *J* = 9.0 Hz, CH$_a$$H_b$OTr), 2.55 (1H, m, C*H*CH$_2$OTr), 2.05 (1H, dd, *J* = 2.5, 1.0 Hz, OH), 1.97 (1H, ddd, *J* = 14.5, 6.5, 2.5 Hz, CH(OH)CH_aH$_b$CHOSi), 1.86 (1H, m, CH(OH)CH$_a$$H_b$CHOSi), 1.68 (1H, ddd, *J* = 13.0, 11.0, 6.5 Hz,

CHCH_aH$_b$CHOSi), 1.56 (1H, ddd, J = 13.0, 8.0, 2.5 Hz, CHCH$_a$$H_b$CHOSi), 0.88 (9H, s, SiC(CH$_3$)$_3$), 0.031 (3H, s, SiCH$_3$), 0.030 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, CDCl$_3$) 144.1 (C$_{Ar}$ × 3), 128.6 (CH$_{Ar}$ × 6), 128.1 (CH$_{Ar}$ × 6), 127.3 (CH$_{Ar}$ × 3), 87.0 (CPh$_3$), 73.7 (CHOH), 72.5 (CHOSi), 63.3 (CH$_2$OTr), 45.4 (OCHCH$_2$CHO), 42.8 (*C*HCH$_2$OTr), 36.7 (*C*H$_2$CHOSi), 26.1 (SiC(*C*H$_3$)$_3$), 18.3 (SiC), −4.6 (SiCH$_3$ × 2). ES$^+$ *m/z* (%) 511 ((M+Na)$^+$, 10). HRMS (ES$^+$) for C$_{31}$H$_{40}$O$_3$SiNa (M+Na)$^+$: Calcd 511.2639; Measured 511.2632.

4.4.2. (1*S*,2*S*,3*R*,4*S*)- and (1*R*,2*S*,3*R*,4*S*)-[3-Benzyloxy-4-(*tert*-butyldimethylsilyloxy)-2-trityloxymethyl]cyclopentanol 21b and 20b

Starting from **13b** (63.4 mg), yield of **21b**: 56% (35.8 mg, white foam), yield of **20b**: 29% (18.2 mg, white foam); column chromatography (EtOAc/petroleum ether 10:90). *Data for* **21b**: [α]$_D$ = +42.6 (*c* 0.95, CHCl$_3$, 27 °C). IR 3446 (w,br), 3059 (w), 2927 (m), 1449 (m), 1073 (s) cm^{-1}. ^{1}H NMR (400 MHz, CDCl$_3$) 7.42–7.21 (20H, m, ArH), 4.58 (1H, d, J = 11.5 Hz, CH_aH$_b$Ph), 4.35 (1H, d, J = 11.5 Hz, CH$_a$$H_b$Ph), 4.32 (1H, q, J = 3.5 Hz, CHOSi), 4.02 (1H, m, C*H*OH), 3.62 (1H, dd, J = 8.0, 4.0 Hz, CHOBn), 3.40 (1H, dd, J = 9.0, 4.0 Hz, CH_aH$_b$OTr), 3.19 (1H, dd, J = 9.0, 5.5 Hz, CH$_a$$H_b$OTr), 2.76 (1H, d, J = 10.0 Hz, OH), 2.35 (1H, m, C*H*CH$_2$OTr), 1.99 (1H, ddd, J = 14.0, 6.5, 4.0 Hz, CH_aH$_b$CHOSi), 1.86 (1H, m, CH$_a$$H_b$CHOSi), 0.92 (9H, s, SiC(CH$_3$)$_3$), 0.12 (3H, s, SiCH$_3$), 0.10 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, CDCl$_3$) 144.2 (C$_{Ar}$ × 3), 138.6 (C$_{Ar}$), 128.9 (CH$_{Ar}$ × 6), 128.3 (CH$_{Ar}$ × 2), 127.9 (CH$_{Ar}$ × 6), 127.7 (CH$_{Ar}$ × 2), 127.5 (CH$_{Ar}$), 127.1 (CH$_{Ar}$ × 3), 86.7 (CPh$_3$), 82.8 (CHOBn), 74.2 (CHOH), 73.0 (CHOSi), 72.1 (CH$_2$Ph), 63.0 (CH$_2$OTr), 53.3 (*C*HCH$_2$OTr), 41.0 (*C*H$_2$CHOSi), 26.0 (SiC(*C*H$_3$)$_3$), 18.3 (SiC), −4.5 (SiCH$_3$), −4.6 (SiCH$_3$). ES$^+$ *m/z* (%) 617 ((M+Na)$^+$, 100). HRMS (ES$^+$) for C$_{38}$H$_{46}$O$_4$SiNa (M+Na)$^+$: Calcd 617.3058; Measured 617.3063.

Data for minor isomer 20b: [α]$_D$ = +66.1 (*c* 0.80, CHCl$_3$, 27 °C). IR 3490 (w,br), 3060 (w), 2928 (m), 1471 (m), 1448 (m), 1066 (s) cm^{-1}. ^{1}H NMR (400 MHz, CDCl$_3$) 7.43–7.23 (20H, m, ArH), 4.66 (1H, d, J = 12.0 Hz, CH_aH$_b$Ph), 4.50 (1H, tt, J = 7.0, 4.0 Hz, C*H*OH), 4.39 (1H, m, CHOSi), 4.36 (1H, d, J = 12.0 Hz, CH$_a$$H_b$Ph), 3.69 (1H, dd, J = 9.0, 4.5 Hz, CHOBn), 3.51 (1H, dd, J = 9.5, 4.5 Hz, CH_aH$_b$OTr), 3.24 (1H, dd, J = 9.5, 8.0 Hz, CH$_a$$H_b$OTr), 2.57 (1H, d, J = 3.5 Hz, OH), 2.54 (1H, m, C*H*CH$_2$OTr), 2.11 (1H, ddd, J = 14.0, 7.0, 3.5 Hz , CH_aH$_b$CHOSi), 1.80 (1H, dt, J = 14.0, 4.5 Hz, CH$_a$$H_b$CHOSi), 0.91 (9H, s, SiC(CH$_3$)$_3$), 0.09 (3H, s, SiCH$_3$), 0.08 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, CDCl$_3$) 143.8 (C$_{Ar}$ × 3), 138.8 (C$_{Ar}$), 128.6 (CH$_{Ar}$ × 6), 128.3 (CH$_{Ar}$ × 2), 128.1 (CH$_{Ar}$ × 6), 127.6 (CH$_{Ar}$ × 2), 127.5 (CH$_{Ar}$), 127.3 (CH$_{Ar}$ × 3), 87.3 (CPh$_3$), 81.2 (CHOBn), 71.7 (CH$_2$Ph), 70.7 (CHOSi), 70.4 (CHOH), 62.0 (CH$_2$OTr), 46.8 (*C*HCH$_2$OTr), 42.5 (*C*H$_2$CHOSi), 26.0 (SiC(*C*H$_3$)$_3$), 18.3 (SiC), −4.4 (SiCH$_3$), −4.5 (SiCH$_3$). ES$^+$ *m/z* (%) 617 ((M+Na)$^+$, 20). HRMS (ES$^+$) for C$_{38}$H$_{46}$O$_4$SiNa (M+Na)$^+$: Calcd 617.3058; Measured 617.3064.

4.4.3. (1*S*,2*S*,3*S*,4*S*) and (1*R*,2*S*,3*S*,4*S*)-[3-Benzyloxy-4-(*tert*-butyldimethylsilyloxy)-2-trityloxymethyl]cyclopentanol 21a and 20a

Starting from **13a** (98.0 mg), yield of **21a**: 43% (37.0 mg, colourless oil), yield of **20a**: 33% (28.0 mg, colourless oil); column chromatography (EtOAc/petroleum ether 15:85). *Data for* **21a**: [α]$_D$ = +13.3 (*c* 0.45, CHCl$_3$, 28 °C). IR 3544 (w,br), 3059 (w), 2928 (m), 2856 (m), 1491 (m), 1449 (m), 1255 (m), 1072 (s) cm^{-1}. ^{1}H NMR (400 MHz, CDCl$_3$) 7.45–7.09 (20H, m, ArH), 4.54 (1H, d, J = 12.0 Hz, CH_aH$_b$Ph), 4.39 (1H, d, J = 12.0 Hz, CH$_a$$H_b$Ph), 4.38 (1H, m, CHOSi), 4.32 (1H, m, C*H*OH), 3.85 (1H, d, J = 4.5 Hz, CHOBn), 3.53 (1H, dd, J = 9.5, 7.0 Hz, CH_aH$_b$OTr), 3.41 (1H, dd, J = 9.5, 7.5 Hz, CH$_a$$H_b$OTr), 2.45 (1H, tt, J = 7.5, 5.0 Hz, C*H*CH$_2$OTr), 2.35 (1H, d, J = 10.0 Hz, OH), 2.17 (1H, ddd, J = 15.0, 6.5, 2.0 Hz , CH_aH$_b$CHOSi), 1.96 (1H, ddd, J = 15.0, 6.5, 3.0 Hz, CH$_a$$H_b$CHOSi), 0.90 (9H, s, SiC(CH$_3$)$_3$), 0.08 (3H, s, SiCH$_3$), 0.06 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, CDCl$_3$) 144.4 (C$_{Ar}$ × 3), 138.2 (C$_{Ar}$), 128.9 (CH$_{Ar}$ × 6), 128.5 (CH$_{Ar}$ × 2), 127.9 (CH$_{Ar}$ × 6), 127.8 (CH$_{Ar}$), 127.5 (CH$_{Ar}$ × 2), 127.1 (CH$_{Ar}$ × 3), 87.5 (CHOBn), 86.8 (CPh$_3$), 75.0 (CHOSi), 73.5 (CHOH), 72.2 (CH$_2$Ph), 59.4 (CH$_2$OTr), 46.9 (*C*HCH$_2$OTr), 45.6 (*C*H$_2$CHOSi), 26.0 (SiC(*C*H$_3$)$_3$), 18.2 (SiC), −4.5 (SiCH$_3$), −4.6 (SiCH$_3$). ES$^+$ *m/z* (%) 617 ((M+Na)$^+$, 100). HRMS (ES$^+$) for C$_{38}$H$_{46}$O$_4$SiNa (M+Na)$^+$: Calcd 617.3058; Measured 617.3054.

Data for minor isomer **20a**: [α]$_D$ = +23.6 (*c* 0.35, CHCl$_3$, 28 °C). IR 3450 (w,br), 3060 (w), 2928 (s), 2856 (m), 1491 (m), 1449 (m), 1255 (m), 1067 (s) cm^{-1}. ^{1}H NMR (400 MHz, CDCl$_3$) 7.44–7.05 (20H, m, ArH), 4.46 (1H, d, J = 12.0 Hz, CH_aH$_b$Ph), 4.32 (1H, d, J = 12.0 Hz, CH$_a$$H_b$Ph), 4.14 (1H, ddd, J = 5.5, 3.0, 2.0 Hz, CHOSi), 4.05 (1H, tt, J = 7.5, 5.5 Hz, C*H*OH), 3.80 (1H, m, CHOBn), 3.41 (1H, dd, J = 9.0, 7.0 Hz, CH_aH$_b$OTr), 3.38 (1H, dd, J = 9.0, 8.0 Hz, CH$_a$$H_b$OTr), 2.47 (1H, m, C*H*CH$_2$OTr), 2.39 (1H, d, J = 5.5 Hz, OH), 2.36 (1H, ddd, J = 14.0, 8.0, 5.5 Hz, CH_aH$_b$CHOSi), 1.56 (1H, dddd, J = 14.0, 5.0, 3.5, 1.0 Hz, CH$_a$$H_b$CHOSi), 0.90 (9H, s, SiC(CH$_3$)$_3$), 0.06 (6H, s, SiCH$_3$ × 2). ^{13}C NMR (100 MHz, CDCl$_3$) 144.3 (C$_{Ar}$ × 3), 138.6 (C$_{Ar}$), 128.9 (CH$_{Ar}$ × 6), 128.4 (CH$_{Ar}$ × 2), 128.0 (CH$_{Ar}$ × 6), 127.5 (CH$_{Ar}$), 127.4 (CH$_{Ar}$ × 2), 127.1 (CH$_{Ar}$ × 3), 87.2 (CPh$_3$), 86.4 (CHOBn), 75.8 (CHOSi), 75.5 (CHOH), 72.1 (CH$_2$Ph), 63.0 (CH$_2$OTr), 51.0 (CHCH$_2$OTr), 42.2 (*C*H$_2$CHOSi), 26.0 (SiC(*C*H$_3$)$_3$), 18.2 (SiC), −4.5 (SiCH$_3$), −4.6 (SiCH$_3$). ES$^+$ *m/z* (%) 617 ((M+Na)$^+$, 100). HRMS (ES$^+$) for C$_{38}$H$_{46}$O$_4$SiNa (M+Na)$^+$: Calcd 617.3058; Measured 617.3050.

4.5. General procedure for the MEM-ether formation

MEMCl (4–5 equiv) was added to a solution of alcohol (1 equiv) and DIPEA (4–5 equiv) in CH$_2$Cl$_2$ (10 mL/mmol). The mixture was stirred at reflux for 2–4 h, and the solvent was evaporated in vacuo. The crude was either purified by column chromatography (acetone/petroleum ether), or by filtration over a plug of silica gel followed by HPLC, to afford the corresponding MEM-ether, in all cases as a colourless oil.

4.5.1. (1*S*,2*R*,3*S*,4*S*)-[(2-Benzyloxy-4-(2-(methoxy)ethoxymethoxy)-3-trityloxymethyl)cyclopentyloxy]*tert*-butyldimethylsilane 22b

Starting from **21b** (18.0 mg), yield: 92% (19.0 mg, colourless oil); column chromatography (acetone/petroleum ether 20:80). Data: [α]$_D$ = +23.7 (*c* 0.35, CHCl$_3$, 27 °C). IR 2927 (m), 1490 (w), 1449 (m), 1251 (m), 1095 (s), 1047 (s) cm^{-1}. ^{1}H NMR (400 MHz, CDCl$_3$) 7.46–7.25 (20H, m, ArH), 4.75 (1H, d, J = 12.5 Hz, CH_aH$_b$Ph), 4.71 (1H, d, J = 7.0 Hz, OCH_aH$_b$O), 4.65 (1H, d, J = 7.0 Hz, OCH$_a$$H_b$O), 4.59 (1H, d, J = 12.5 Hz, CH$_a$$H_b$Ph), 4.19 (1H, m, CHOSi), 4.01 (1H, q, J = 7.0 Hz, CHOMEM), 3.75–3.68 (2H, m, CHOBn + OCH_aH$_b$CH$_2$O), 3.60 (1H, dt, J = 11.0, 4.5 Hz, OCH$_a$$H_bCH_2$O), 3.52 (2H, app t, J = 4.5 Hz, OCH$_2$CH_2OMe), 3.41 (3H, s, OMe), 3.34 (1H, dd, J = 9.5, 4.0 Hz, CH_aH$_b$OTr), 3.23 (1H, dd, J = 9.0, 4.5 Hz, CH$_a$$H_b$OTr), 2.41 (1H, m, C*H*CH$_2$OTr), 2.28 (1H, ddd, J = 13.0, 7.5, 5.5 Hz , CH_aH$_b$CHOSi), 1.99 (1H, dt, J = 13.0, 7.0 Hz, CH$_a$$H_b$CHOSi), 0.97 (9H, s, SiC(CH$_3$)$_3$), 0.13 (3H, s, SiCH$_3$), 0.12 (3H, s, SiCH$_3$). ^{13}C NMR (100 MHz, CDCl$_3$) 144.2 (C$_{Ar}$ × 3), 139.1 (C$_{Ar}$), 128.9 (CH$_{Ar}$ × 6), 128.3 (CH$_{Ar}$ × 2), 127.9 (CH$_{Ar}$ × 6), 127.7 (CH$_{Ar}$ × 2), 127.4 (CH$_{Ar}$), 127.1 (CH$_{Ar}$ × 3), 95.1 (OCH$_2$O), 86.6 (CPh$_3$), 81.0 (CHOBn), 75.8 (CHOMEM), 71.8 and 71.7 (OCH$_2$CH$_2$O + CH$_2$Ph), 71.6 (CHOSi), 66.8 (OCH$_2$CH$_2$O), 61.8 (CH$_2$OTr), 59.1 (OCH$_3$), 50.7 (CHCH$_2$OTr), 39.0 (*C*H$_2$CHOSi), 26.0 (SiC(*C*H$_3$)$_3$), 18.4 (SiC), −4.5 (SiCH$_3$), −4.6 (SiCH$_3$). ES$^+$ *m/z* (%) 705 ((M+Na)$^+$, 100). HRMS (ES$^+$) for C$_{42}$H$_{54}$O$_6$SiNa (M+Na)$^+$: Calcd 705.3581; Measured 705.3588.

4.5.2. (1*S*,2*S*,3*S*,4*S*)-[(2-Benzyloxy-4-(2-(methoxy)ethoxymethoxy)-3-trityloxymethyl)cyclopentyloxy]*tert*-butyldimethylsilane 22a

Starting from **21a** (51.1 mg), yield: 62% (36.5 mg, colourless oil); column chromatography (acetone/petroleum ether 15:85). Data: [α]$_D$ = +28.1 (*c* 0.26, CHCl$_3$, 26 °C). IR 3060 (w), 2928 (m),

1490 (w), 1449 (m), 1254 (m), 1089 (s), 1044 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.50–7.20 (20H, m, ArH), 4.67 (1H, d, J = 7.0 Hz, OCH_aH_bO), 4.60 (1H, d, J = 12.5 Hz, CH_aH_bPh), 4.59 (1H, d, J = 7.0 Hz, OCH_aH_bO), 4.50 (1H, d, J = 12.5 Hz, CH_aH_bPh), 4.40 (1H, td, J = 6.5, 4.0 Hz, CHOMEM), 4.33 (1H, ddd, J = 6.5, 4.0, 2.5 Hz, CHOSi), 3.82 (1H, dd, J = 6.0, 2.5 Hz, CHOBn), 3.62 (1H, m, OCH_aH_b-CH_2O), 3.55–3.43 (3H, m, $OCH_aH_bCH_2O + OCH_2CH_2O$), 3.39 (3H, s, OCH_3), 3.41–3.36 (2H, m, CH_2OTr), 2.59 (1H, quintet, J = 6.5 Hz, $CHCH_2OTr$), 2.17 (1H, ddd, J = 14.0, 6.5, 4.0 Hz, CH_aH_bCHOSi), 1.91 (1H, ddd, J = 14.0, 6.5, 4.0 Hz, CH_aH_bCHOSi), 0.93 (9H, s, $SiC(CH_3)_3$), 0.083 (3H, s, $SiCH_3$), 0.076 (3H, s, $SiCH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 144.6 ($C_{Ar} \times 3$), 139.0 (C_{Ar}), 128.9 ($CH_{Ar} \times 6$), 128.3 ($CH_{Ar} \times 2$), 128.0 ($CH_{Ar} \times 6$), 127.6 ($CH_{Ar} \times 2$), 127.4 (CH_{Ar}), 127.0 ($CH_{Ar} \times 3$), 95.0 (OCH_2O), 87.0 (CPh_3), 86.2 (CHOBn), 77.2 (CHOMEM), 77.0 (CHOSi), 72.1 (CH_2Ph), 71.9 (OCH_2CH_2O), 66.8 (OCH_2CH_2O), 59.5 (CH_2OTr), 59.1 (OCH_3), 45.8 ($CHCH_2OTr$), 41.5 (CH_2CHOSi), 26.0 ($SiC(CH_3)_3$), 18.1 (SiC), −4.5 ($SiCH_3$), −4.7 ($SiCH_3$). ES^+ m/z (%) 705 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{42}H_{54}O_6SiNa$ $(M+Na)^+$: Calcd 705.3581; Measured 705.3565.

4.5.3. (1*R*,3*S*,4*S*)-[(4-(2-(Methoxy)ethoxymethoxy)-3-tityl-oxymethyl)cyclopentyloxy]*tert*-butyldimethylsilane 23

Starting from **17** (18.8 mg), yield: 89% (19.7 mg, colourless oil); HPLC (acetone/hexane 15:85). Data: $[\alpha]_D = -6.7$ (c 0.90, $CHCl_3$, 26 °C). IR 3059 (w), 2928 (m), 1490 (w), 1449 (m), 1252 (m), 1046 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.47–7.24 (15H, m, ArH), 4.69 (1H, d, J = 7.0 Hz, OCH_aH_bO), 4.65 (1H, d, J = 7.0 Hz, OCH_aH_bO), 4.25 (1H, m, CHOSi), 3.91 (1H, q, J = 7.0 Hz, CHOMEM), 3.66 (1H, m, $OCH_aH_bCH_2O$), 3.57 (1H, m, $OCH_aH_bCH_2O$), 3.49–3.48 (2H, app t, J = 4.5 Hz, OCH_2CH_2O), 3.39 (3H, s, OCH_3), 3.18 (1H, dd, J = 9.0, 5.0 Hz, CH_aH_bOTr), 3.09 (1H, dd, J = 9.0, 6.0 Hz, CH_aH_bOTr), 2.44 (1H, m, $CHCH_2OTr$), 2.33 (1H, dt, J = 13.5, 7.0 Hz, MEMOCHCH_aH_b), 1.88 (1H, ddd, J = 13.5, 9.0, 5.0 Hz, $TrOCH_2CHCH_aH_b$), 1.76 (1H, ddd, J = 13.5, 7.0, 6.5 Hz, $TrOCH_2CHCH_aH_b$), 1.66 (1H, dtd, J = 13.5, 6.0, 1.0 Hz, $MEMOCHCH_aH_b$), 0.93 (9H, s, $SiC(CH_3)_3$), 0.091 (3H, s, $SiCH_3$), 0.084 (3H, s, $SiCH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 144.4 ($C_{Ar} \times 3$), 128.9 ($CH_{Ar} \times 6$), 127.8 ($CH_{Ar} \times 6$), 127.0 ($CH_{Ar} \times 3$), 95.0 (OCH_2O), 86.4 (CPh_3), 79.1 (CHOMEM), 71.9 (OCH_2CH_2O), 71.3 (CHOSi), 66.8 (OCH_2CH_2O), 64.5 (CH_2OTr), 59.1 (OCH_3), 44.4 ($CHCH_2OTr$), 42.7 ($MEMOCHCH_2$), 37.6 ($TrOCH_2CHCH_2$), 26.1 ($SiC(CH_3)_3$), 18.3 (SiC), –4.6 ($SiCH_3 \times 2$). ES^+ m/z (%) 599 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{35}H_{48}O_5SiNa$ $(M+Na)^+$: Calcd 599.3163; Measured 599.3174.

4.5.4. (1*R*,2*S*,3*R*,4*S*)-[2-Acetoxymethyl-3-benzyloxy-4-(*tert*-butyldimethylsilyloxy)]cyclopent-1-yl acetate 24b

Acetic anhydride (39.0 μL, 0.413 mmol) was added to a solution of **18b** (24 mg, 0.068 mmol) in pyridine (0.7 mL). The mixture was stirred at rt for 2 days. 1 M HCl (4.3 mL) was then added. The aqueous layer was extracted with Et_2O (3×8 mL). The organic layer was dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was purified by column chromatography (acetone/petroleum ether 2:8) to afford **24b** as a colourless oil (26 mg, 87%). $[\alpha]_D$ = +61.6 (c 0.45, $CHCl_3$, 27 °C). IR 2953 (m), 2929 (m), 1739 (s), 1472 (w), 1362 (m), 1248 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.34–7.27 (5H, m, ArH), 4.87 (1H, ddd, J = 8.5, 6.0, 3.5 Hz, CHOAc), 4.73 (1H, d, J = 12.0 Hz, CH_aH_bPh), 4.43 (1H, d, J = 12.0 Hz, CH_aH_bPh), 4.22 (1H, q, J = 4.0 Hz, CHOSi), 4.22–4.16 (2H, m, CH_2OAc), 3.46 (1H, dd, J = 9.0, 4.0 Hz, CHOBn), 2.63 (1H, m, $CHCH_2OAc$), 2.14 (1H, ddd, J = 15.0, 8.0, 4.5 Hz, CH_aH_bCHOSi), 2.03 (3H, s, $COCH_3$), 1.94 (3H, s, $COCH_3$), 1.78 (1H, dt, J = 15.0, 3.5 Hz, CH_aH_bCHOSi), 0.93 (9H, s, $SiC(CH_3)_3$), 0.11 (3H, s, $SiCH_3$), 0.09 (3H, s, $SiCH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 171.1 (C=O), 171.0 (C=O), 138.4 (C_{Ar}), 128.5 ($CH_{Ar} \times 2$), 127.84 ($CH_{Ar} \times 2$), 127.77 (CH_{Ar}), 80.3 (CHOBn), 72.9 (CHOAc), 71.8 (CH_2Ph), 70.2 (CHOSi), 62.8 (CH_2OAc), 47.4 ($CHCH_2OAc$), 38.8 (CH_2CHOSi), 25.9 ($SiC(CH_3)_3$), 21.2 ($COCH_3$), 20.9 ($COCH_3$), 18.2 (SiC), –4.46 ($SiCH_3$), –4.53 ($SiCH_3$). ES^+ m/z (%) 459 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{23}H_{37}O_6Si$ $(M+H)^+$: Calcd 437.2354; Measured 437.2360.

4.5.5. (1*R*,2*S*,3*S*,4*S*)-[2-Acetoxymethyl-3-benzyloxy-4-(*tert*-butyldimethylsilyloxy)]cyclopent-1-yl acetate 24a

Acetic anhydride (23.0 μL, 0.243 mmol) was added to a solution of diol **18a** (21.0 mg, 0.0596 mmol) in pyridine (0.6 mL). The mixture was stirred at rt for 2 days. 1 M HCl (10 mL) was then added. The aqueous layer was extracted with Et_2O (3×5 mL). The organic layer was washed with H_2O (5 mL) and brine (5 mL), dried over $MgSO_4$, filtered and concentrated in vacuo. The crude was filtered through silica gel and purified by HPLC (acetone/hexane 17:83) to afford **24a** as a colourless oil (21.0 mg, 81%). $[\alpha]_D = -41.3$ (c 0.6, $CHCl_3$, 27 °C). IR 2954 (m), 2929 (m), 1740 (vs), 1472 (w), 1364 (m), 1241 (vs) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.36–7.27 (5H, m, ArH), 5.02 (1H, ddd, J = 8.5, 7.5, 4.5 Hz, CHOAc), 4.58 (1H, d, J = 12.0 Hz, CH_aH_bPh), 4.48 (1H, d, J = 12.0 Hz, CH_aH_bPh), 4.30 (1H, dd, J = 11.0, 8.0 Hz, CH_aH_bOAc), 4.24 (1H, dd, J = 11.0, 6.5 Hz, CH_aH_bOAc), 4.18 (1H, dt, J = 6.0, 2.5 Hz, CHOSi), 3.78 (1H, m, CHOBn), 2.66 (1H, m, $CHCH_2OAc$), 2.59 (1H, ddd, J = 14.5, 8.5, 6.0 Hz, CH_aH_bCHOSi), 2.03 (3H, s, $COCH_3$), 2.00 (3H, s, $COCH_3$), 1.54 (1H, dddd, J = 14.5, 4.0, 2.5, 1.5 Hz, CH_aH_bCHOSi), 0.89 (9H, s, $SiC(CH_3)_3$), 0.060 (3H, s, $SiCH_3$), 0.057 (3H, s, $SiCH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 171.01 (C=O), 170.98 (C=O), 138.2 (C_{Ar}), 128.5 ($CH_{Ar} \times 2$), 127.8 (CH_{Ar}), 127.7 ($CH_{Ar} \times 2$), 84.8 (CHOBn), 75.8 (CHOAc), 74.2 (CHOSi), 72.1 (CH_2Ph), 62.0 (CH_2OAc), 46.2 ($CHCH_2OAc$), 40.2 (CH_2CHOSi), 25.9 ($SiC(CH_3)_3$), 21.3 ($COCH_3$), 21.1 ($COCH_3$), 18.1 (SiC), −4.57 ($SiCH_3$), −4.64 ($SiCH_3$). ES^+ m/z (%) 459 ($(M+Na)^+$, 28), 895 ($(2\,M+Na)^+$, 100). HRMS (ES^+) for $C_{23}H_{37}O_6Si$ $(M+H)^+$: Calcd 437.2354; Measured 437.2348.

4.5.6. (1*R*,2*S*,4*R*)-[2-Acetoxymethyl-4-(*tert*-butyldimethylsilyloxy)]cyclopent-1-yl acetate 25

Acetic anhydride (30.7 μL, 0.391 mmol) was added to a solution of diol **14** (20.0 mg, 0.0812 mmol) in pyridine (0.81 mL). The mixture was stirred at rt for 24 h. The solvent was evaporated in vacuo. The crude was filtered through silica gel and purified by HPLC (acetone/hexane 22:78) to afford **25** as a colourless oil (24.4 mg, 91%). $[\alpha]_D = -42.6$ (c 0.46, $CHCl_3$, 26 °C). IR 2954 (m), 2930 (m), 1738 (s), 1472 (w), 1364 (m), 1237 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 4.88 (1H, ddd, J = 8.0, 6.0, 5.0 Hz, CHOAc), 4.27 (1H, tt, J = 5.5, 3.5 Hz, CHOSi), 4.11 (1H, dd, J = 11.0, 6.0 Hz, CH_aH_bOAc), 4.07 (1H, dd, J = 11.0, 6.0 Hz, CH_aH_bOAc), 2.62 (1H, ddq, J = 9.5, 8.0, 6.0 Hz, $CHCH_2OAc$), 2.32 (1H, ddd, J = 14.0, 8.0, 5.5 Hz, $AcOCHCH_aH_b$), 2.05 (3H, s, $COCH_3$), 2.04 (3H, s, $COCH_3$), 1.87 (1H, dddd, J = 13.5, 8.0, 5.0, 2.0 Hz, $AcOCH_2CHCH_aH_b$), 1.66 (1H, dddd, J = 14.0, 5.0, 3.5, 2.0 Hz, $AcOCHCH_aH_b$), 1.54 (1H, ddd, J = 13.5, 9.5, 5.5 Hz, $AcOCH_2CHCH_aH_b$), 0.89 (9H, s, $SiC(CH_3)_3$), 0.05 (3H, s, $SiCH_3$), 0.04 (3H, s, $SiCH_3$). ^{13}C NMR (100 MHz, $CDCl_3$) 171.2 (C=O), 171.1 (C=O), 76.3 (CHOAc), 71.4 (CHOSi), 65.4 (CH_2OAc), 42.7 ($CHCH_2OAc$), 42.5 ($AcOCHCH_2$), 37.8 ($AcOCH_2CHCH_2$), 25.9 ($SiC(CH_3)_3$), 21.3 ($COCH_3$), 21.0 ($COCH_3$), 18.1 (SiC), –4.7 ($SiCH_3 \times 2$). ES^+ m/z (%) 353 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{16}H_{30}O_5SiNa$ $(M+Na)^+$: Calcd 353.1755; Measured 353.1749.

4.6. General procedure for the TBDMS-removal

TBAF (1.0 M solution in THF; 2 equiv) was added to a solution of silyl ether (1 equiv) in THF (10 mL/mmol). The mixture was stirred at rt for 2 h, and the solvent was evaporated in vacuo. The crude was filtered through silica gel and purified by HPLC to afford the corresponding alcohol.

4.6.1. (1*S*,2*R*,3*S*,4*S*)-[2-Benzyloxy-4-(2-(methoxy)ethoxymethoxy)-3-trityloxymethyl]cyclopentanol 26b)

Starting from **22b** (28.0 mg), yield: 99% (23.0 mg, clear oil); HPLC (acetone/hexane 35:65). Data: $[\alpha]_D$ +16.5 (*c* 0.65, $CHCl_3$, 27 °C). IR 3467 (w,br), 3058 (w), 2878 (m), 1490 (m), 1449 (m), 1090 (s), 1045 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.45–7.24 (15H, m, ArH), 4.70 (1H, d, *J* = 11.0 Hz, OCH_aH_bO), 4.69 (1H, d, *J* = 11.0 Hz, OCH_aH_bO), 4.56 (1H, d, *J* = 12.0 Hz, CH_aH_bPh), 4.55 (1H, d, *J* = 12.0 Hz, CH_aH_bPh), 4.13 (1H, quintet, *J* = 5.0 Hz, CHOH), 4.07 (1H, ddd, *J* = 7.5, 5.5, 5.0 Hz, CHOMEM), 3.80 (1H, dd, *J* = 7.5, 5.0 Hz, CHOBn), 3.68 (1H, ddd, *J* = 11.0, 5.5, 4.5 Hz, $OCH_aH_bCH_2O$), 3.59 (1H, ddd, *J* = 11.0, 5.0, 4.5 Hz, $OCH_aH_bCH_2O$), 3.50–3.47 (2H, m, OCH_2CH_2O), 3.38 (3H, s, OMe), 3.31 (1H, dd, *J* = 9.5, 4.5 Hz, CH_aH_bOTr), 3.28 (1H, dd, *J* = 9.5, 4.5 Hz, CH_aH_bOTr), 2.58 (1H, d, *J* = 5.0 Hz, OH), 2.40 (1H, m, $CHCH_2OTr$), 2.20 (1H, ddd, *J* = 14.0, 7.5, 5.0 Hz , CH_aH_bCHOH), 1.94 (1H, dt, *J* = 14.0, 4.5 Hz, CH_aH_b-CHOH). ^{13}C NMR (100 MHz, $CDCl_3$) 144.1 ($C_{Ar}\times 3$), 138.1 (C_{Ar}), 128.9 ($CH_{Ar}\times 6$), 128.6 ($CH_{Ar}\times 2$), 127.93 ($CH_{Ar}\times 6$), 127.88 ($CH_{Ar}\times 3$) 127.2 ($CH_{Ar}\times 3$), 94.9 (OCH_2O), 86.7 (CPh_3), 81.6 (CHOBn), 76.5 (CHOMEM), 72.0 and 71.8 ($CH_2Ph + OCH_2CH_2O$), 70.3 (CHOH), 67.0 (OCH_2CH_2O), 61.8 (CH_2OTr), 59.1 (OCH_3), 50.3 ($CHCH_2OTr$), 38.3 (CH_2CHOH). ES^+ *m/z* (%) 591 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{36}H_{40}O_6Na$ $(M+Na)^+$: Calcd 591.2717; Measured 591.2707.

4.6.2. (1*S*,2*S*,3*S*,4*S*)-[2-Benzyloxy-4-(2-(methoxy)ethoxymethoxy)-3-trityloxymethyl]cyclopentanol 26a

Starting from **22a** (23.6 mg), yield: 84% (16.5 mg, clear oil); HPLC (acetone/hexane 36:64). Data: $[\alpha]_D$ = +16.9 (*c* 0.54, $CHCl_3$, 26 °C). IR 3440 (m,br), 3059 (w), 2931 (m), 2885 (m), 1490 (m), 1449 (m), 1041 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.42–7.19 (20H, m, ArH), 4.63 (1H, d, *J* = 7.0 Hz, OCH_aH_bO), 4.56 (1H, d, *J* = 7.0 Hz, OCH_aH_bO), 4.55 (1H, d, *J* = 12.5 Hz, CH_aH_bPh), 4.51 (1H, d, *J* = 12.5 Hz, CH_aH_bPh), 4.38–4.32 (2H, m, CHOH + CHOMEM), 3.82 (1H, dd, *J* = 6.5, 3.0 Hz, CHOBn), 3.57 (1H, dt, *J* = 11.0, 5.0 Hz, $OCH_aH_bCH_2O$), 3.50-3.35 (5H, m, $OCH_aH_bCH_2O + OCH_2CH_2O + CH_2OTr$), 3.34 (3H, s, OCH_3), 2.60 (1H, quintet, *J* = 6.5 Hz, $CHCH_2OTr$), 2.23 (1H, ddd, *J* = 14.5, 7.0, 3.5 Hz , CH_aH_bCHOH), 1.82 (1H, ddd, *J* = 14.5, 6.0, 5.0 Hz, CH_aH_bCHOH), 1.42 (1H, d, *J* = 3.5 Hz, OH). ^{13}C NMR (100 MHz, $CDCl_3$) 144.5 ($C_{Ar}\times 3$), 138.8 (C_{Ar}), 128.9 ($CH_{Ar}\times 6$), 128.4 ($CH_{Ar}\times 2$), 127.83 ($CH_{Ar}\times 6$), 127.76 ($CH_{Ar}\times 2$), 127.6 (CH_{Ar}), 127.0 ($CH_{Ar}\times 3$), 94.9 (OCH_2O), 87.0 (CPh_3), 85.9 (CHOBn), 77.1 and 76.9 (CHOMEM + CHOH), 72.3 (CH_2Ph), 71.8 (OCH_2CH_2O), 66.8 (OCH_2CH_2O), 59.3 (CH_2OTr), 59.1 (OCH_3), 46.3 ($CHCH_2OTr$), 40.5 (CH_2CHOH). ES^+ *m/z* (%) 591 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{36}H_{40}O_6Na$ $(M+Na)^+$: Calcd 591.2717; Measured 591.2727.

4.6.3. (1*R*,3*S*,4*S*)-[4-(2-(Methoxy)ethoxymethoxy)-3-trityloxymethyl]cyclopentanol 27

Starting from **23** (18.7 mg), yield: 91% (13.7 mg, clear oil); HPLC (acetone/hexane 4:6). Data: $[\alpha]_D$ = +2.9 (*c* 0.60, $CHCl_3$, 26 °C). IR 3441 (m,br), 3057 (w), 2928 (m), 1490 (m), 1449 (m), 1045 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.44–7.21 (15H, m, ArH), 4.75 (1H, d, *J* = 7.0 Hz, OCH_aH_bO), 4.73 (1H, d, *J* = 7.0 Hz, OCH_aH_bO), 4.26 (1H, m, CHOH), 4.15 (1H, dt, *J* = 5.5, 3.5 Hz, CHOMEM), 3.70 (1H, m, $OCH_aH_bCH_2O$), 3.63 (1H, dt, *J* = 11.0, 4.5 Hz, $OCH_aH_bCH_2O$), 3.50 (2H, app t, *J* = 4.5 Hz, OCH_2CH_2O), 3.37 (3H, s, OCH_3), 3.08 (1H, dd, *J* = 9.0, 6.0 Hz, CH_aH_bOTr), 2.97 (1H, dd, *J* = 9.0, 7.0 Hz, CH_aH_bOTr), 2.57 (1H, m, $CHCH_2OTr$), 2.28 (1H, d, *J* = 7.0 Hz, OH), 2.00 (1H, ddt, *J* = 14.0, 8.5, 2.0 Hz, $TrOCH_2CHCH_aH_b$), 1.94–1.84 (2H, m, $MEMOCHCH_2$), 1.56 (1H, ddd, *J* = 14.0, 8.0, 5.5 Hz, $TrOCH_2CH$-CH_aH_b). ^{13}C NMR (100 MHz, $CDCl_3$) 144.3 ($C_{Ar}\times 3$), 128.9 ($CH_{Ar}\times 6$), 127.9 ($CH_{Ar}\times 6$), 127.1 ($CH_{Ar}\times 3$), 94.4 (OCH_2O), 86.6 (CPh_3), 80.8 (CHOMEM), 73.4 (CHOH), 71.9 (OCH_2CH_2O), 67.1 (OCH_2CH_2O), 65.1 (CH_2OTr), 59.1 (OCH_3), 45.1 ($CHCH_2OTr$), 41.1 ($MEMOCHCH_2$), 38.2 ($TrOCH_2CHCH_2$). ES^+ *m/z* (%) 485 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{29}H_{34}O_5Na$ $(M+Na)^+$: Calcd 485.2298; Measured 485.2291.

4.6.4. (1*R*,2*S*,3*R*,4*S*)-[2-Acetoxymethyl-3-benzyloxy-4-hydroxy]-cyclopent-1-yl acetate 28b

Starting from **24b** (25.0 mg), yield: 92% (17.0 mg, clear oil); HPLC (acetone/hexane 35:65). Data: $[\alpha]_D$ = +23.6 (*c* 0.55, $CHCl_3$, 27 °C). IR 3501 (m,br), 2944 (w), 1735 (s), 1455 (w), 1364 (m), 1243 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.39–7.30 (5H, m, ArH), 4.90 (1H, ddd, *J* = 8.5, 6.5, 4.0 Hz, CHOAc), 4.64 (1H, d, *J* = 12.0 Hz, CH_aH_bPh), 4.56 (1H, d, *J* = 12.0 Hz, CH_aH_bPh), 4.20–4.19 (2H, m, CH_2OAc), 4.13 (1H, m, CHOH), 3.61 (1H, dd, *J* = 9.0, 4.5 Hz, CHOBn), 2.55 (1H, ddt, *J* = 9.0, 6.5, 4.5 Hz, $CHCH_2OAc$), 2.46 (1H, dd, *J* = 3.0, 1.0 Hz, OH), 2.26 (1H, dddd, *J* = 15.5, 8.5, 5.0, 1.0 Hz, CH_aH_bCHOH), 2.05 (3H, s, $COCH_3$), 1.98 (3H, s, $COCH_3$), 1.85 (1H, s, CH_aH_bCHOH). ^{13}C NMR (100 MHz, $CDCl_3$) 171.0 (C=O), 170.9 (C=O), 137.6 (C_{Ar}), 128.8 ($CH_{Ar}\times 2$), 128.4 (CH_{Ar}), 128.1 ($CH_{Ar}\times 2$), 80.5 (CHOBn), 72.7 (CHOAc), 72.4 (CH_2Ph), 69.4 (CHOH), 62.4 (CH_2OAc), 47.3 ($CHCH_2OAc$), 37.7 (CH_2CHOH), 21.2 ($COCH_3$), 20.9 ($COCH_3$). ES^+ *m/z* (%) 345 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{17}H_{22}O_6Na$ $(M+Na)^+$: Calcd 345.1309; Measured 345.1316.

4.6.5. (1*R*,2*S*,3*S*,4*S*)-[2-Acetoxymethyl-3-benzyloxy-4-hydroxy]-cyclopent-1-yl acetate 28a

Starting from **24a** (19.0 mg), yield: 93% (13.0 mg, clear oil). Data: $[\alpha]_D$ = −55.7 (*c* 0.45, $CHCl_3$, 28 °C). IR 3464 (m,br), 2940 (m,br), 1736 (s), 1367 (m), 1241 (s) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 7.37–7.27 (5H, m, ArH), 5.06 (1H, ddd, *J* = 8.5, 7.0, 4.0 Hz, CHOAc), 4.60 (1H, d, *J* = 12.0 Hz, CH_aH_bPh), 4.52 (1H, d, *J* = 12.0 Hz, CH_aH_bPh), 4.31 (1H, dd, *J* = 11.0, 8.0 Hz, CH_aH_bOAc), 4.27 (1H, m, CHOH), 4.23 (1H, dd, *J* = 11.0, 6.5 Hz, CH_aH_bOAc), 3.90 (1H, m, CHOBn), 2.74–2.64 (2H, m, $CHCH_2OAc + CH_aH_bCHOH$), 2.05 (3H, s, $COCH_3$), 2.00 (3H, s, $COCH_3$), 1.82 (1H, d, *J* = 4.5 Hz, OH), 1.61 (1H, m, CH_aH_bCHOH). ^{13}C NMR (100 MHz, $CDCl_3$) 171.0 (C=O), 170.8 (C=O), 138.1 (C_{Ar}), 128.6 ($CH_{Ar}\times 2$), 128.0 (CH_{Ar}), 127.8 ($CH_{Ar}\times 2$), 84.4 (CHOBn), 75.6 (CHOAc), 74.2 (CHOH), 72.3 (CH_2Ph), 61.7 (CH_2OAc), 46.3 ($CHCH_2OAc$), 39.2 (CH_2CHOH), 21.3 ($COCH_3$), 21.0 ($COCH_3$). ES^+ *m/z* (%) 345 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{17}H_{22}O_6Na$ $(M+Na)^+$: Calcd 345.1309; Measured 345.1316.

4.6.6. (1*R*,2*S*,4*R*)-[2-Acetoxymethyl-4-hydroxy]cyclopent-1-yl acetate 29

Starting from **25** (13.7 mg), yield: 86% (7.7 mg, clear oil); HPLC (acetone/hexane 36:64). Data: $[\alpha]_D$ = −40.0 (*c* 0.34, $CHCl_3$, 26 °C). IR 3450 (m,br), 2943 (m,br), 1732 (vs), 1367 (m), 1238 (vs), 1046 (m) cm^{-1}. ^1H NMR (400 MHz, $CDCl_3$) 5.00 (1H, ddd, *J* = 8.0, 5.5, 4.0 Hz, CHOAc), 4.38 (1H, qt, *J* = 5.5, 2.5 Hz, CHOH), 4.11–4.09 (2H, m, CH_2OAc), 2.66 (1H, ddq, *J* = 9.5, 8.0, 5.5 Hz, $CHCH_2OAc$), 2.34 (1H, ddd, *J* = 15.0, 7.5, 5.5 Hz, $AcOCHCH_aH_b$), 2.07 (3H, s, $COCH_3$), 2.06 (3H, s, $COCH_3$), 1.99 (1H, ddt, *J* = 14.0, 8.0, 2.5 Hz, $AcOCH_2CHCH_aH_b$), 1.77 (1H, ddt, *J* = 15.0, 4.0, 2.5 Hz, $AcOCHCH_aH_b$), 1.68 (1H, d, *J* = 5.5 Hz, OH), 1.63 (1H, ddd, *J* = 14.0, 9.5, 5.5 Hz, $AcOCH_2CHCH_aH_b$). ^{13}C NMR (100 MHz, $CDCl_3$) 171.1 (C=O), 170.8 (C=O), 77.0 (CHOAc), 72.1 (CHOH), 65.2 (CH_2OAc), 43.2 ($CHCH_2OAc$), 41.8 ($AcOCHCH_2$), 37.7 ($AcOCH_2CHCH_2$), 21.4 ($COCH_3$), 21.0 ($COCH_3$). ES^+ *m/z* (%) 239 ($(M+Na)^+$, 100). HRMS (ES^+) for $C_{10}H_{16}O_5Na$ $(M+Na)^+$: Calcd 239.0889; Measured 239.0888.

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