Stereochemistry Control in the Lewis Acid Mediated Lactonization Reaction of γ,δ-Epoxy-β-silyloxy Esters

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$ZnCl_2$-triggered lactonization reactions of γ,δ-epoxy-β-silyloxy esters with remote alkoxy groups $(CH_2)_nOR$ (n = 2, 3), producing five- and/or six-membered ring lactones, have been investigated. Under such conditions, the regiochemistry of the reaction is governed by the *cis* or *trans* nature of the starting epoxy ester and also by its C(3) stereochemistry. An X-ray crystallographic structure of a γ-lactone (compound **24′**) and a ^{13}C NMR correlation for the C(4) carbon chemical shifts of all γ-lactones were obtained and used to determine the regioselectivity of the epoxide ring-opening. A mechanistic hypothesis, involving an oxocarbenium ion as a common intermediate, is presented in interpretation of the results.

Introduction

The high interest attracted by lactones, evident in numerous publications and reviews,[1−5] is related (or attributed) to their involvement either in biological activity and response[6−7] or as key intermediates in the syntheses of natural products,[1−5,8−12] antibiotics,[8−12] carbohydrates and nucleosides.[13−15]

In connection with a program directed towards the total synthesis of ulosonic esters and deoxynucleosides,[13−15] chiral lactones obtained from chiral β-hydroxy-γ,δ-epoxy esters[16−18] were used as pivotal intermediates. These compounds have proved useful for syntheses of modified sugars and nucleosides.[13−15] We have previously described lactonizations of epoxy esters possessing CH_2OR[19] or methyl[20,21] groups at C(5). For these two types of epoxy esters, the outcome of the reaction was unambiguous, and ultimately gave one γ-lactone. In this paper, however, we present the findings of our ongoing investigations into the lactonization reaction, starting from epoxy esters with remote alkoxy groups at the C(5) positions [$(CH_2)_nOR$ (n = 2, 3)], which often produce mixtures of γ-lactones and δ-lactones. These compounds can also act as intermediates for syntheses of modified sugars, particularly fucose derivatives, and they may be helpful for understanding of the biochemical and biological roles of the L-fucose present in many oligosaccharidic structures and a potential biological indicator of abnormal processes.[22] Here we describe full accounts of these lactone syntheses and present a mechanistic interpretation of the results.

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Results and Discussion

Optically active lactones were synthesized by a $ZnCl_2$-triggered intramolecular cyclization of compounds **5−9** and **12−14** (Scheme 1). The starting materials were obtained in good to excellent yields by silylation of the secondary hydroxyl groups of the corresponding β-hydroxy-γ,δ-epoxy esters.[18]

The five-membered ring lactones produced in the lactonization were classified as *exo* or *endo*[23−25] lactones on the basis of the regioselectivity of the epoxide ring-opening at positions 4 or 5 respectively.

Cyclization Reactions Conducted on *trans* Epoxy Esters

The results of the Lewis acid mediated cyclizations of *trans* epoxy esters are presented in Table 1. When the reaction was performed using *trans* epoxy ester **6a**, three lactones (**18**, **19**, and **20**; Scheme 2) were isolated in almost quantitative overall yield. δ-Lactone **19** was quantitatively converted into γ-lactone **18** on basic treatment with diisopropylamine, according to a previously published procedure.[20] This conversion confirms that compounds **18** and **19** were both generated by the same *endo* cyclization process. The minor lactone **20** was generated through an *exo*-5 ring-closure process.

Lactonization of epoxy esters **5a**, **5′a**, and **6a** (n = 2 and R^1 = *t*BuPh$_2$Si) gave lactones from C(5) epoxide ring-opening as major products. The six-membered ring lactones **16**, **16′**, and **19** (*endo*-6) and γ-lactones **17**, **17′**, and **18** (*endo*-5), respectively, were isolated. The five-membered ring lactones **15**, **15′**, and **20**, generated by an *exo*-5 cyclization process, were obtained as minor products in each reaction (Table 1, entries 1−3). For n = 3 (compounds **8a**, **8a′**, and **9a/9s**), we still observed epoxide ring-opening at C(5) as the

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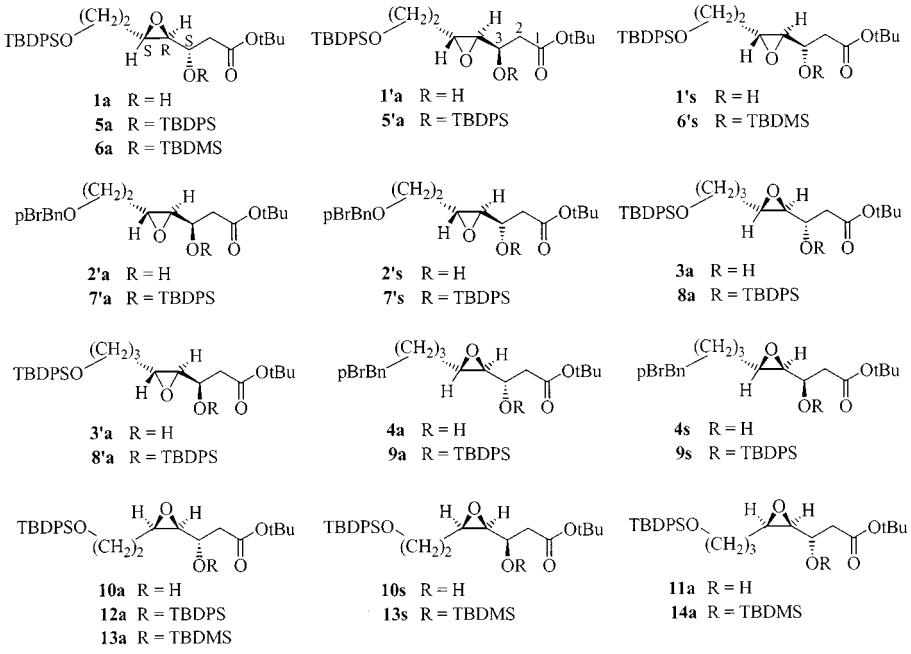
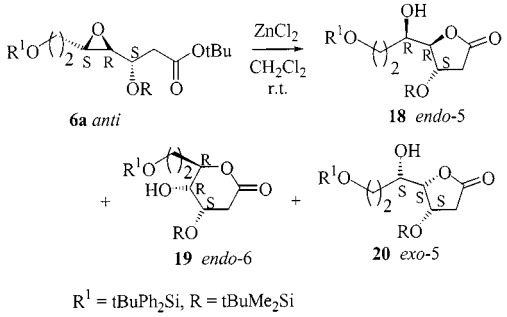


Scheme 1

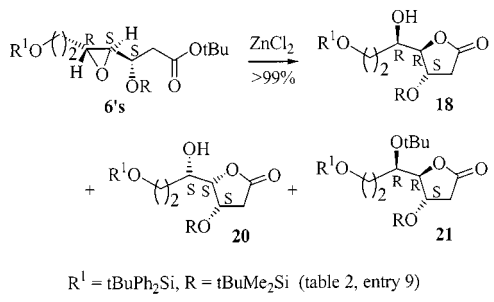
Table 1. Yields and ratios obtained on performing the $ZnCl_2$ lactonization reaction on *trans* epoxy esters (A = *t*BuPh$_2$Si, B = *t*BuMe$_2$Si, C = *p*BrBn. **a** = *anti*, **s** = *syn*, **8′a** = enantiomer of **8a**)

Entry	*n*	Epoxy ester No.	C(5) C(4) C(3)	R^1	R	yield (%)	*exo*-5 (%)	No.	*endo*-6 (%)	No.	*endo*-5 (%)	No.
1	2	**5a**	*S R S*	A	A	93	12	**15**	22	**16**	66	**17**
2	2	**5′a**	*R S R*	A	A	82	8	**15′**	4	**16′**	88	**17′**
3	2	**6a**	*S R S*	A	B	99	20	**20**	55	**19**	25	**18**
4	3	**8a**	*S R S*	A	A	78	0	–	0	–	100	**22**
5	3	**8′a**	*R S R*	A	A	73	0	–	0	–	100	**22′**
6	2	**7′a/7′s**	*R S R*/*R S S*	C	A	72	nd[a]	**24/23**	0	–	nd	**23′/24′**
7	3	**9a/9s**	*S R S*/*S R R*	C	A	80	nd	**26′/25′**	0	–	nd	**25/26**
8	2	**6′s**	*R S S*	A	B	>99	86	**21**[b]**/18**	0	–	14	**20**

[a] nd: not determined for the mixtures. – [b] *exo*-5 lactone bearing O*t*Bu at C(5) position.



Scheme 2

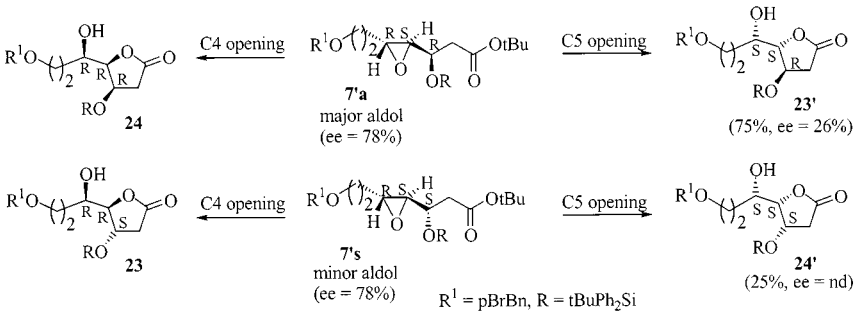


Scheme 3

major reaction, but no six-membered ring lactone was detected.

Compound **6′s**, on treatment with zinc chloride, gave different results (Scheme 3). The regioselectivity in the epoxide ring-opening switched from C(5) to C(4), mostly resulting in two *exo*-5 lactones **18** and **21** (*tert*-butylated on the secondary hydroxyl function) and an *endo*-5 lactone **20**, in an overall ratio of 87:13.

Interestingly, the two compounds **20** and **18** were generated from the diastereoisomeric mixture of epoxy esters **6a** and **6′s**. These diastereoisomers [at C(4) and C(5)] preferentially gave the five-membered ring lactone **18**. Epoxy ester **6′s** afforded **18** as an *exo*-5 lactone, while **6a** gave the same



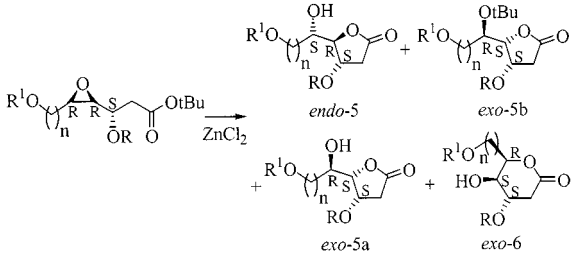
Scheme 4

γ-lactone through a two-step process: an *endo*-6 ring-closure gave a six-membered ring lactone to **19**, which was further converted into **18**. This example highlights the fact that two diastereoisomers can give identical products, depending on the regiochemical opening of the epoxide ring. A further observation also supports that point; the enantiomeric excesses (*ee*s) measured for the same lactone (or product) were different, depending on whether the reaction had been conducted with a mixture of *syn* and *anti* epoxy esters or from one of the isolated compounds (Scheme 4). In the former case, the *ee* was smaller. Compounds **7′a** and **7′s**, for example, are the silylated major and minor products, respectively, from the aldol condensation between *tert*-butyllithio ester and a single α,β-epoxyaldehyde (diastereoisomeric ratio *anti*/*syn* 72:18).[18] As they were not separable by liquid chromatography, the lactonization reaction was conducted on the diastereoisomeric mixture (Table 1, entry 6 and Scheme 4).

Combinations of **7′a** and **7′s** mostly yielded γ-lactones **23′** and **24′**, products of C(5)-opening of the epoxide ring of the two epoxy esters. Nevertheless, during the cyclization process on the minor *syn* adduct **7′s**, a competitive C(4)-opening of the epoxide also took place, affording γ-lactone **23**, the enantiomer of **23′**. The existence of **23** was confirmed by measuring the enantiomeric excesses (*ee*s) of lactones **23**/**23′** on an HPLC system equipped with a chiral column. The *ee* dropped from 78% for the starting epoxy ester to 26%, implying that the reaction **7′s** → *exo*-5 lactone **23** was the reaction competing with **7′a** → **23′**, obtained through an *endo* ring-closure. The same trends were observed when the lactonization reaction was conducted on the diastereoisomeric mixture **9a**/**9s** (Table 2, entry 8) to generate lactones **25**, **25′**, and **26**.

Lactonization Reaction on *cis* Epoxy Esters

cis Epoxy esters **12a**, **13a**, **13s**, and **14a**, under the same cyclization conditions as applied to *trans* epoxy esters, generally afforded four lactones (Scheme 5, Table 2) in excellent overall yields.



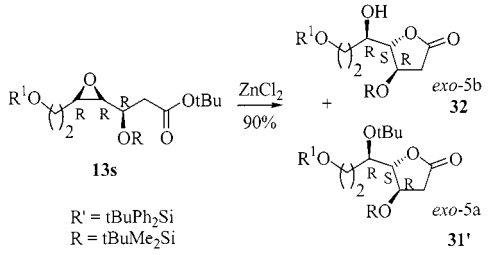
Scheme 5

With epoxy esters **12a** and **13a** as starting materials, for example, three types of *exo* lactones were isolated from a C(4)-opening of the epoxide ring. Two of these (**29** and **30** for **12a**; **35** and **34** for **13a**) were γ-lactones of the same absolute configuration, one of them *tert*-butylated on the secondary hydroxyl group. The third (**28** and **33**, respectively), were valerolactones (*exo*-6), which were transformed into the corresponding γ-lactones (**29**, **34**, respectively). Finally, γ-lactones resulting from a C(5)-opening of the epoxide ring (**27** and **31** from **12a** and **13a**, respectively) were identified. The observed regioselectivity ratio of 73:27 observed was in favour of the *exo* cyclization.

With the epoxy ester **14a** (n = 3) as starting material, no valerolactone was observed and the regioselectivity of the intramolecular cyclization, as evidenced by a 4:1 ratio, was again in favour of the *exo* process. Finally, the same regioselectivity was observed for the minor aldol adduct **13s**

Table 2. Yields and ratio obtained on performing the $ZnCl_2$ lactonization reaction on *cis* epoxy esters (A = *t*BuPh$_2$Si, B = *t*BuMe$_2$Si)

Entry	Epoxy ester n	No.	C(5) C(4) C(3)	R^1	R	Yield total %	*exo*-5b No.	%	*exo*-5a No.	%	*exo*-6 No.	%	*endo*-5 No.	%
1	2	**12a**	*R R S*	A	A	99	**29**	27	**30**	42	**28**	15	**27**	16
2	2	**13a**	*R R S*	A	B	90	**34**	27	**35**	51	**33**	11	**31**	11
3	3	**14a**	*R R S*	A	B	90	**37**	18	**38**	67	–	–	**36**	15
4	2	**13s**	*R R R*	A	B	90	**32**	14	**31′**	86	–	–	–	–



Scheme 6

(Scheme 6), with only two γ-lactones (**32** and **31′**) being obtained. So, regardless of the diastereoisomer (*syn* or *anti*) of the *cis* epoxysilyloxy esters and the secondary alcohol protecting group, *exo* cyclization is the major event.

In summary of these detailed results, the regioselectivity of the lactonization reaction in terms of *exo* to *endo* ratio, independently of the lactone size, is presented in Table 3. It appears that *endo* cyclization processes are predominant for *trans* epoxy esters, with the exception of compound **6′s**, while *exo* ring-closure prevails for *cis* isomers.

Table 3. *exo* versus *endo* epoxide ring-opening regioselectivity for lactonization reactions performed on *trans* and *cis* epoxy esters. The ratio are calculated on the basis of purified products

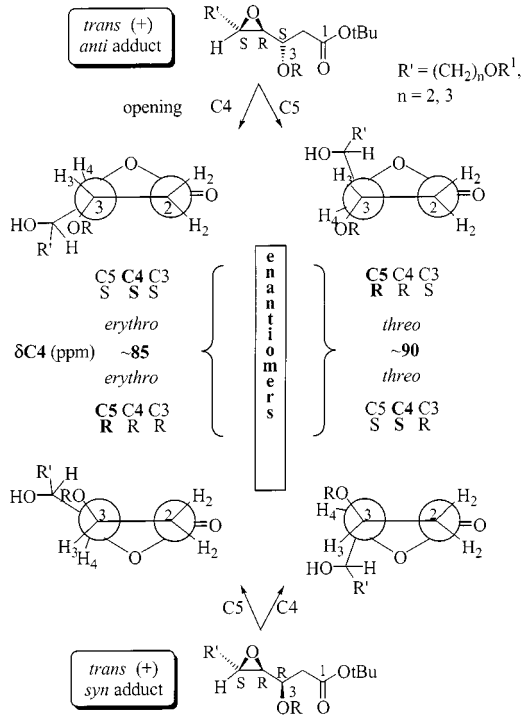
	No.	*exo* %	*endo* %
trans	**5a**	12	88
	5′a	8	92
	6a	20	80
	8a	–	>99
	6′s	86	14
cis	**12a**	84	16
	13a	89	11
	14a	85	15
	13s	>99	–

Identification of Lactones

The cyclization reaction in this study involves an intramolecular opening of the epoxide ring to give the lactones. The determination of the absolute configurations of all γ-lactones obtained, and hence the regioselectivity of the epoxide ring-opening, was based on the following points: i) the capability to obtain enantiomeric lactones; the enantiomers arising from the diastereoisomeric epoxy esters *syn* or *anti* [epimers at C(3)], and ii) the X-ray crystallographic structure of γ-lactone **24′**, together with the correlation of the ^{13}C NMR C(4) chemical shifts of all the γ-lactones studied and also observations from some of our previous results.

a) Lactonization and Enantiomerization

In the knowledge of the absolute configurations of the asymmetric centres of the reactant epoxy ester, we present in Scheme 7 a Newman projection of all the possible five-membered ring lactones that can hypothetically be obtained. Starting, for example, from an *anti* aldol adduct with the (3*S*,4*R*,5*S*) absolute configuration, the lactonization reaction may ultimately give rise to two diastereoisomeric γ-lactones originating from C(4)- and/or C(5)-opening of the epoxide ring, with (3*S*,4*S*,5*S*) and (3*S*,4*R*,5*R*) absolute configurations, corresponding to *erythro*, and *threo* C(3)/C(4) relative configurations, respectively.



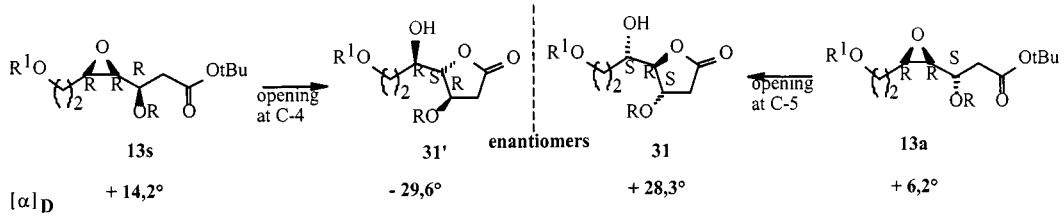
Scheme 7

Starting, on the other hand, from the epimeric at C(3) *syn* aldol adduct (3*S*,4*R*,5*S*), C(4) and/or C(5)-opening of the epoxide will produce γ-lactones with (3*R*,4*S*,5*S*) and (3*R*,4*R*,5*R*) absolute configurations, corresponding to *threo*/*erythro* C(3)/C(4) relative configurations, respectively. Thus, the *threo* and *erythro* lactones produced from epoxy esters epimeric at C(3) (*anti* and *syn*) are enantiomers. The same observation is also valid for the *cis* aldol series.

This is observed experimentally when the lactonization reaction is conducted on *cis* epoxy ester **13s** (*syn*) to yield lactones **31′** and **32** and on *cis* epoxy ester **13a** (*anti*) to provide **31** (enantiomer of **31′**). The decrease in the enantiomeric excess observed when the lactonization reaction is conducted on a mixture of epoxy esters (*anti* and *syn*) is additional evidence, Scheme 8.

b) X-ray Structures and ^{13}C NMR Correlation

γ-Lactone **24′** was crystallized and its X-ray structure established (Figure 1). It displayed an *erythro* relative configuration about the C(3)/C(4) carbon atoms. ^{13}C NMR spectra revealed that the C(4) chemical shift was δ = 85.19. On examination of the C(4) chemical shifts (^{13}C NMR) of all the γ-lactones synthesized, we observed (Table 4) that all compounds have their C(4) chemical shift values either at δ = approximately 85 or at δ = approximately 90. A correlation[26–28] could therefore be made between the C(4)



Scheme 8

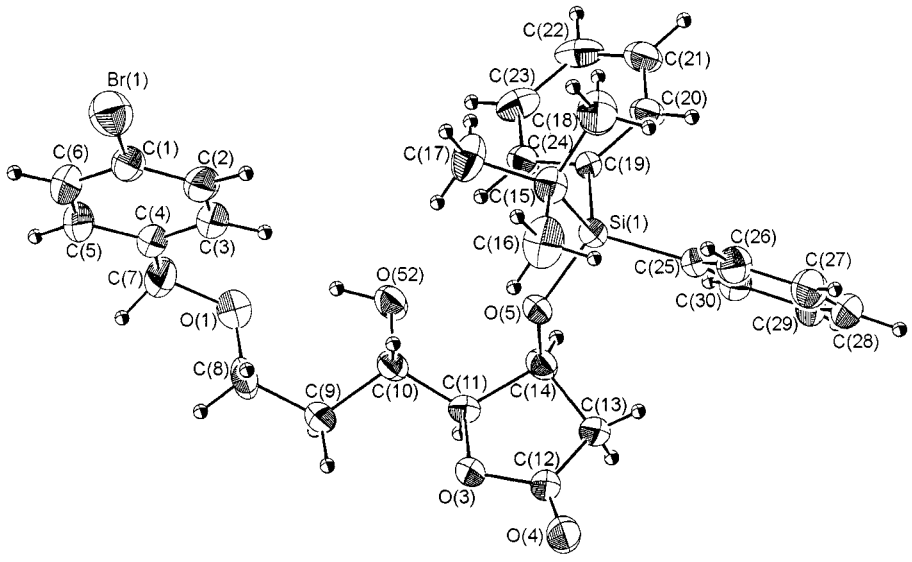


Figure 1. ORTEP drawing of the X-ray structure of compound **24′**, δ(C4) = 85.19

Table 4. C(4) Chemical shifts of all γ-lactones (^{13}C NMR spectra in $CDCl_3$)

Nature epoxy ester	γ-Lactones *n* N°	Absolute configuration	δ C(4) [ppm]	Nature epoxy ester	γ-Lactones *n* N°	Absolute configuration	δ C(4) [ppm]
	2 **17**	*S R R*	90.7		2 **35**	*S S R*	85.1
	2 **18**	*S R R*	90.4		3 **38**	*S S R*	85.5
	2 **21**	*S R R*	89.9		3 **37**	*S S R*	85.7
T	2 **20**	*S S S*	85.6	*C*	3 **36**	*S R S*	90.4
R	2 **19′**	*R S S*	90.5	*I*	2 **31**	*S R S*	90.5
A	2 **24′**	*S S S*	85.2	*S*	2 **34**	*S S R*	86.2
N	2 **23′**	*R S S*	90.3		2 **29**	*S S R*	86.2
S	3 **22**	*S R R*	91.1		2 **27**	*S R S*	90.6
	3 **25**	*S R R*	90.8		2 **30**	*S S R*	84.3
	3 **26**	*R R R*	85.3		2 **32**	*R S R*	89.5

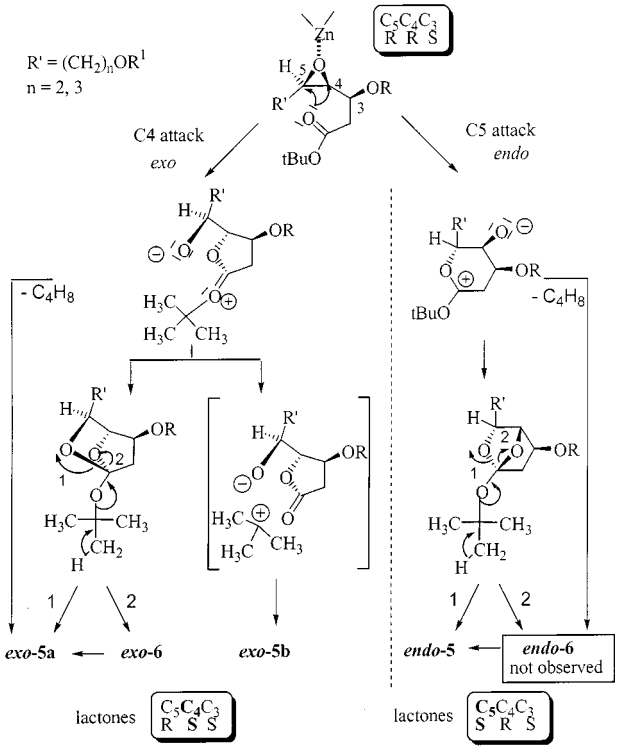
chemical shifts and the γ-lactone C(3)/C(4) relative configurations (*erythro* or *threo*), and hence with the regioselectivity of the lactonization reaction. To be precise, for a γ-lactone with *erythro* or *threo* C(3)/C(4) relative configuration, the C(4) chemical shift will be observed at δ ≈ 85 or at ≈ 90, respectively. Thus, as the epoxy ester isomer used as the starting material is known, the C(4) chemical shift of its five-membered ring lactone derivative in this system will permit a determination to be made as to which carbon of the epoxide ring was involved in the initial ring-closure and thus the C(4) and C(5) absolute configurations to be assigned.

These results are in agreement with our previous observations. In fact, an X-ray crystal structure of a γ-lactone originating from a *cis* epoxy ester (*anti*), reported in our first communication,[29] possessed an *erythro* configuration [C(4)-opening of the epoxide ring] and δC(4) = 86.2. A second X-ray crystal structure of a functionalized γ-lactone originating from an epoxy ester (*anti*) generated from nerol had a *threo* configuration (C(5)-opening of the epoxide ring) and δC(4) = 92.1.[20]

Lactonization Regioselectivity

Considering the results obtained, opening either at C(4) or at C(5) of the epoxide ring[30−32] need not in either case exclusively generate a five-membered ring lactone; a six-membered ring lactone is also possible. While it can readily be imagined that a direct attack at C(5) may afford a six-

membered ring lactone, a C(4)-opening to afford a δ-lactone was rather unanticipated. This fact prompted us to infer the existence of an intermediate that could be generated either by C(5)-opening or by C(4)-opening of the epoxy ester epoxide function, and which could then collapse to afford a five and/or a six-membered ring lactone. The cyclization process at the C(4) and C(5) carbon atoms of the epoxy ester may be triggered by intramolecular attack of the carbonyl oxygen atom on the epoxide function. Such a cyclization process would result in the formation of an oxocarbenium ion (Scheme 9), which may react in situ with the just formed alkoxide in two different ways. One way would be by formation of an orthoester intermediate, Lewis acid catalysed elimination of the *tert*-butyl group of which would result in a γ-and/or a δ-lactone. The alternative would be alkoxide attack on the activated tertiary carbon of the *tert*-butyl group, producing a γ-lactone bearing a *tert*-butoxy group at the C(5) position. Both the *exo* and *endo* cyclization process could follow the oxocarbenium and the corresponding orthoester formation pathways, and so the orthoester fragmentation according to route 2 would afford δ-lactones (*exo*-6, *endo*-6).



Scheme 9

The proposed mechanism involving oxocarbenium ion intermediates in this reaction type is in agreement with results previously reported by Chamberlin et al.,[33−35] studying Lewis acid mediated cyclization of a number of γ,δ-epoxy ketones and esters.

In an attempt to account for of the regioselectivity of the lactonization reaction, we can consider stereoelectronic and conformational effects that may steer the reaction into the *endo* or the *exo* mode of attack. An electron-deficient orbital might be developed either on the C(4) or on the C(5) carbon atom of the corresponding epoxy ester, depending on possible stabilisation through adjacent substituents.[36] This is the case with epoxy esters originating from nerol and/or geraniol, in which the opening of the epoxide ring occurs exclusively at the C(5) carbon atom (quaternary carbon atom) to afford δ-lactones.[20−21] The two alkyl substituents in this (C(5)) position efficiently stabilise the developing positive charge, resulting in a completely regioselective reaction. We may also mention the results of the lactonization reaction concerning γ,δ-epoxy-β-hydroxy esters (*cis* or *trans*) possessing only one methylenic group at the C(5) position ($ROCH_2-$; $n = 1$). These compounds are almost symmetrically substituted around the epoxy function, and so there is no preferential position for the development of positive charge. The regioselectivity of this reaction, as expected, always results in the smaller ring [γ-lactones, C(4) attack] because of the better antiparallel alignment of the incipient and rupturing bonds.[19]

In the case of epoxy esters possessing remote alkoxy groups at their C(5) positions ($n = 2, 3$), as analysed in this study, we can predict a small preference for the C(5) position for the development of positive charge during the acid-catalysed cyclisation reaction, due to the better positive inductive effect from the two (or three) methylenic groups. Stereoelectronic and conformational effects may act competitively or synergistically. For *cis* epoxy esters, conformational and steric effects should predominate, resulting in all cases in C(4)-opening of the epoxide ring as the major event. For *anti* aldol adducts of *trans* epoxy esters, steric effects are not preponderant, so the acid-catalysed cyclisation reaction produces δ-lactones through predominant C(5)-opening of the epoxide ring. A synergistic effect is observed for the cyclisation of compound **8a** ($n = 3$), in which an exclusively *endo* attack is observed. Finally, for the minor aldol adduct **6′s**, the regioselectivity of the reaction is reversed, due to conformational effects that become predominant in this case.

To explain the conformational or steric effects on the regioselectivity of the lactonization reaction, we still have two possible conformations, E and F, for the lactonization reaction of the *anti* aldol adducts, together with conformation G for the minor *syn* aldol adducts. Here we present the Newman projections (Figure 2) in which the carbonyl group

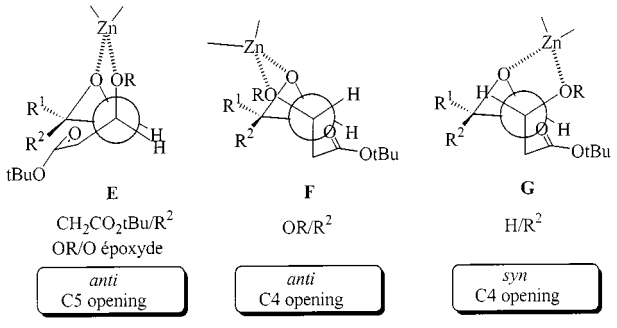


Figure 2. Selected conformers of epoxy esters undergoing intramolecular cyclization

is in a suitable position for antiperiplanar opening of the epoxide ring either at C(4) or at C(5). Zinc may participate through intermolecular chelation of the oxygen atom of the epoxide ring, and possibly of the C(3) silyloxy group.

For the *syn* epoxy ester, conformer G would be the more representative conformation, since steric interactions would be minimised and intermolecular chelation with zinc would be favoured. The *cis* or *trans* isomeric nature of the epoxy ester would have little influence on its stability. This conformer offers a good explanation of why the C(4)-opening of the epoxide ring is the major event taking place for all minor *syn* aldol adducts.

Lactonization of the major *anti* aldol adducts produced from a *cis* epoxyaldehyde [R^1 = H, R^2 = $RO(CH_2)_n$] may occur through a favoured conformer F. This conformation might be preferred over the more stable one found in the absence of Lewis acid,[18] due to favourable complexation on both oxygen atoms. The major event is therefore the C(4)-opening of the epoxide ring, as observed experimentally. For *anti* aldol adducts originating from *trans* epoxyaldehydes, and for the same reasons as before (Lewis acid and complexation), conformer E is favoured. It becomes very competitive in comparison with conformer F because there is a very weak interaction between R^2 = H and the ester group while conformer F has not noticeably changed in stability. In this case we therefore observe experimentally an inversion of regioselectivity in the epoxide opening, which takes place at the C(5) carbon atom of the epoxy ester.

Conclusion

Although lactonization reactions of *trans* or *cis* silylated epoxy esters can potentially give five types of lactones (*exo*-5b, *exo*-5a, *exo*-6, *endo*-5, and *endo*-6), the results demonstrated good (to excellent in some cases) regioselectivity in the opening of the epoxide function. This is governed by:

- the *cis* or *trans* structure of the starting epoxy ester
- the C(3) stereochemistry in the epoxy ester;
- stereoelectronic and conformational effects.

In all cases, an oxocarbenium ion is the most probable common intermediate. The C(4) chemical shifts of the γ-lactones synthesized, along with their X-ray crystallographic structures, were essential for determination of the regioselectivity of the epoxide ring-opening. For *cis* epoxy ester *anti* or *syn* adducts, opening is at C(4). In contrast, for *trans* epoxy esters, when the starting material is an *anti* adduct, C(5)-opening is the major event. The situation is reversed for the *syn* adduct, resulting in C(4)-opening of the epoxide.

Experimental Section

General: Reactions were performed in oven-dried glassware, which was sealed with a rubber septum, and stirred with a magnetic stirring bar, under argon or nitrogen if required. Materials were obtained from commercial suppliers and were used without purification, unless otherwise stated. The solvents used were from Aldrich, anhydrous grade if required, unless otherwise noted. Tetrahydrofuran (THF) was freshly distilled from sodium wire; diethyl ether (Et_2O) was distilled from sodium and kept over sodium wire. Dichloromethane (CH_2Cl_2) was distilled from calcium hydride and kept in the dark over 4 Å molecular sieves. − Reactions were monitored by thin layer chromatography carried out on Riedel−de Haën 60 f_{254} special (0.2 mm) thin layer plates, using UV light as visualizing agent and a phosphomolybdic acid solution in ethanol and heating as developing agents. − NMR spectra were recorded on Bruker AC 200 or AC 250 instruments and calibrated using deuterated solvent as internal reference. − IR spectra were recorded on a Perkin−Elmer model 883 Series FTIR spectrometer. − Optical rotations were recorded on a Perkin−Elmer model 141 polarimeter. − Mass spectra were recorded on a Nermag R10-10 mass spectrometer under electronic impact or chemical ionization conditions. − Liquid chromatography purifications were performed under the following conditions, classified according to increasing difficulty in purification:

− **A** Gravity chromatography using silica particle size of 70−200 μm, supplied by Amicon.

− **B** Flash chromatography using silica particle size of 35−70 μm, supplied by Amicon.

− **C** Medium pressure chromatography with a Jobin-Yvon axial compression apparatus, using silica particle size of 6−35 μm (Amicon) or 15 μm (Merck).

Enantiomeric excesses were measured by high performance liquid chromatography on the following set-up: Kratos Spectroflow 400 pump, abI 759A UV detector and Chiracel OD l = 25 cm, Ø = 0.46 cm chiral column. − The same apparatus with a Waters Nova-Pak normal phase silica column (l = 15 cm, Ø = 0.39 cm) was used for diastereoisomeric ratio measurements, performed on the crude products of aldolisation reactions, and also for product purity monitoring.

Melting points were measured with a Kofler apparatus and are uncorrected. − Molecular sieves (4 Å) were heated to dryness at 150 °C for four hours under 0.1 Torr vacuum. Zinc chloride was dried under the same conditions.

Note: Reagents quantities in mL/mmol or % are expressed relative to the starting material.

The syntheses of compounds **1a**, **1′a**, **1′s**, **2′a**, **2′s**, **3a**, **3′a**, **4a**, **4s**, **10a**, **10s**, and **11a** have already been reported.[18]

Lactonization Reactions

Synthesis of Compounds 15, 16, and 17: A solution of epoxy esters **5a** (0.31 g, 0.43 mmol) in anhydrous CH_2Cl_2 (8 mL, 18 mL/mmol) at room temp. was treated with dry zinc chloride (0.13 g, 0.96 mmol, 2.2 equiv.) (3 h at 150 °C, under a vacuum of 0.1 Torr). After this had been stirred for 4 h at room temp., a saturated aqueous solution of sodium bicarbonate (3 mL) was added, and the aqueous layer was extracted with Et_2O (3 × 10 mL). The organic phases were combined, dried with $MgSO_4$, filtered, and concentrated to afford a residue, which was purified according to method C (100 g of silica 6−35 μm), eluent PE/EA, 8:2 (TLC, R_{f17} = 0.34, R_{f15} = 0.25, R_{f16} = 0.17). We isolated 0.172 g (0.26 mmol, 66%) of γ-lactone **17**, 0.057 g (0.087 mmol, 22%) of valerolactone **16**, and 0.042 g of a mixture containing 76% of γ-lactone **15** (0.032 g, 0.05 mmol, 12%). The overall reaction yield was 93%.

(3*S*,4*S*,1′*S*)-3-(*tert*-Butyldiphenylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (15): IR ($CHCl_3$): $\tilde{\nu}$ cm^{-1}:

3497 (O−H). 3075−2935: (C−H), 1782 (C=O), 1110 (C−O). − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.71 and 7.66 (m, 20 H), 4.76 (m, 1 H), 4.56 (m, 1 H), 4.10 (dd, *J* = 2.5; 7.5 Hz, 1 H), 3.98 (m, 2 H), 3.86 (d, *J* = 2.75 Hz, 1 H), 2.28 (m, 2 H), 2.10 and 1.90 (m, 2 H), 1.12 and 1.08 (2s, 18 H). − ^{13}C NMR ($CDCl_3$, 63 MHz): δ = 175.2, 136.0, 135.7, 135.6, 133.4, 132.9, 130.5, 130.0, 129.8, 128.2, 127.9, 85.6, 70.0, 68.3, 63.4, 39.1, 35.1, 26.9, 19.4, 19.0. − $C_{39}H_{48}O_5Si_2$: calcd. C 71.74, H 7.41; found C 73.03, H 7.60.

(3*S*,4*R*,1′*R*)-3-(*tert*-Butyldiphenylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (17): $[\alpha]_D$ = +0.78 (*c* = 2.30, $CHCl_3$). − IR ($CHCl_3$): $\tilde{\nu}$ cm^{-1}: 3625−3493 (O−H), 3005−2936: (C−H), 1776 (C=O), 1110 (C−O). − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.64 and 7.43 (m, 20 H), 4.58 (m, 1 H), 4.28 (d, *J* = 4.1 Hz, 1 H), 3.85 (m, 1 H), 3.67 (m, 2 H), 3.14 (d, *J* = 3.0 Hz, 1 H), 2.72 (A part of ABX, *J* = 18.0, *J* = 6.2, 1 H), 2.42 (B part of ABX, *J* = 18.0; 1.5 Hz, 1 H), 1.20 (m, 2 H), 1.06 and 1.02 (2s, 18 H). − ^{13}C NMR ($CDCl_3$, 63 MHz): δ = 176.2, 135.9, 135.8, 135.5, 132.9, 132.8, 132.6, 130.1 130.0, 128.0 127.9, 90.7, 70.8, 69.6, 62.6, 38.8, 33.3, 26.8, 19.1, 19.0. − $C_{39}H_{48}O_5Si_2$ (653.0): calcd. C 71.74, H 7.41; found C 71.49, H 7.12.

(3*S*,4*R*,5*R*)-3-(*tert*-Butyldiphenylsilyloxy)-5-[2′-(*tert*-butyldiphenylsilyloxy)-1′-ethyl]-4-hydroxy-δ-lactone (16): NMR, IR, identical to those of compound **16′**. − $C_{39}H_{48}O_5Si_2$ (653.0): calcd. C 71.74, H 7.41; found C 71.34, H 7.53.

Synthesis of Compounds 15′, 16′, and 17′: A solution of epoxy ester **5′a** (1.27 g, 1.79 mmol) in anhydrous CH_2Cl_2 (27 mL, 15 mL/mmol) was treated with dry $ZnCl_2$ (0.486 g, 3.59 mmol, 2 equiv.) and stirred for 4 h 30 min. A saturated aqueous solution of $NaHCO_3$ (8 mL) was added. The aqueous layer was extracted with Et_2O (3 × 20 mL). The combined organic phases were dried with $MgSO_4$, filtered, and concentrated. The residue was purified according to method C (150 g of silica 15 μm), eluent PE/AE, 8:2 (TLC, $R_{f17'}$ = 0.31, $R_{f15'}$ = 0.25, $R_{f16'}$ = 0.17). We obtained 0.862 g (1.32 mmol, 90%) of γ-lactone **95′**, 0.036 g (0.050 mmol, 4%) of valerolactone **16′** as a white solid and 0.081 g of a mixture containing 75% of **15′** (0.061 g, 0.09 mmol, 6%). The overall reaction yield was 82%.

(3*R*,4*R*,1′*R*)-3-(*tert*-Butyldiphenylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (15′): NMR, IR: identical to those of compound **15**.

(3*R*,4*S*,5*S*)-3-(*tert*-Butyldiphenylsilyloxy)-5-[2′-(*tert*-butyldiphenylsilyloxy)-1′-ethyl]-4-hydroxy-δ-lactone (16′): M.p. 125.5 °C. $[\alpha]_D$ = −32.5 (*c* = 1.1, $CHCl_3$). − IR ($CHCl_3$): $\tilde{\nu}$ = 3572 (O−H), 3007−2935 (C−H), 1735 (C=O), 1111 (C−O) cm^{-1}. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.67 and 7.41 (m, 20 H), 4.80 (ddd, *J* = 7.0; 6.8; 4.5 Hz, 1 H), 4.17 (X part of ABX, *J* = 5.4; 4.7; 2.7 Hz, 1 H), 3.80 (m, 2 H), 3.61 (ddd, *J* = 6.8; 6.0; 2.7 Hz, 1 H), 2.73 (d, *J* = 6.0 Hz, 1 H), 2.64 (A part of ABX, *J* = 17.7; 5.4 Hz, 1 H), 2.46 (B part of ABX, *J* = 17.7; 4.7 Hz, 1 H), 1.86 (m, 2 H), 1.11 and 1.04 (2s, 18 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 168.8, 135.8, 135.7, 135.4, 133.2, 132.7, 132.4, 130.4, 130.3, 129.8, 128.1, 127.8, 133.3, 76.7, 70.0, 67.5, 59.6, 36.9, 36.0, 27.0, 26.8, 19.3, 19.2.

(3*R*,4*S*,1′*S*)-3-(*tert*-Butyldiphenylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (17′): NMR, IR: identical to those of compound **17**.

$[\alpha]_D$ = −1.40 (*c* = 1.42, $CHCl_3$) 94% *ee*.

Synthesis of 18, 19, and 20: A solution of epoxy ester **6a** (1.30 g, 2.23 mmol) in anhydrous CH_2Cl_2 (34 mL, 15 mL/mmol) at room temp. was treated with dry $ZnCl_2$ (0.753 g, 5.56 mmol, 2.5 equiv.) and stirred for 1 h at room temp. until complete conversion of the starting material. A saturated aqueous solution of $NaHCO_3$ (10 mL) was added and the aqueous layer was extracted three times with Et_2O. The combined organic phases were dried with $MgSO_4$, filtered, and concentrated. The residue was purified according to method C (180 g of silica 6−35 μm), eluting with PE/EA, 8:2 (TLC, R_{f18} = 0.32, R_{f20} = 0.22, R_{f19} = 0.15). We obtained 0.324 g (0.61 mmol) of **18**, 0.248 g (0.47 mmol) of **20** and 0.708 g (1.34 mmol) of **19** as white crystals. The yield was quantitative.

(3*S*,4*R*,1′*R*)-3-(*tert*-Butyldimethylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (18): $[\alpha]_D$ = +2.7° (*c* = 0.7, $CHCl_3$) *ee* = 95%. − IR (film): $\tilde{\nu}$ = 3435 (O−H); 3073−2934 (C−H); 1784 (C=O); 1110 (C−O) cm^{-1}. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.61 and 7.40 (m, 10 H), 4.64 (X part of ABX, *J* = 6.7; 2.4; 1.8 Hz, 1 H), 4.22 (dd, *J* = 5.3; 1.8 Hz, 1 H), 3.92 (m, 3 H), 2.85 (A part of ABX, *J* = 18.0; 6.7 Hz, 1 H), 2.39 (B part of ABX, *J* = 18.0; 2.4 Hz, 1 H), 1.77 (m, 2 H), 1.05 (s, 9 H), 0.89 (s, 9 H), 0.09 (s, 6 H). − ^{1}H NMR (250 MHz, C_6D_6): δ = 7.70 and 7.23 (m, 10 H), 4.47 (ddd, X part of ABX, *J* = 6.7; 5.5; 2.44 Hz, 1 H), 4.10 (dd, *J* = 5.5; 1.8 Hz, 1 H), 3.74 and 3.54 (m, 2 H), 3.28 (m, 1 H), 2.52 (A part of ABX, *J* = 17.7; 6.7 Hz, 1 H), 2.20 (B part of ABX, *J* = 17.7; 2.4 Hz, 1 H), 1.55 (m, 2 H), 1.10 (s, 9 H), 0.94 (d, *J* = 3.8 Hz, 1 H), 0.87 (s, 9 H), −0.024 and −0.088 (2s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 175.8, 135.5, 132.7, 132.6, 130.1, 127.9, 90.4, 70.6, 68.3, 62.6, 38.6, 34.0, 26.8, 25.8, 19.0, 17.9, 4.6, 4.8. − $C_{29}H_{44}O_5Si_2$ (528.8): calcd. C 65.87, H 8.39; found C 65.60, H 8.40

(3*S*,4*R*,5*R*)-3-(*tert*-Butyldimethylsilyloxy)-5-[2′-(*tert*-butyldiphenylsilyloxy)-1′-ethyl]-4-hydroxy-δ-lactone (19): M.p. 88.0 °C. $[\alpha]_D$ = +46.4 (*c* = 0.8, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3571 (O−H), 3075−2959 (C−H), 1734 (C=O), 1111 (C−O) cm^{-1}. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.67 and 7.41 (m, 10 H), 4.67 (t d, *J* = 8.0; 4.2 Hz, 1 H), 4.19 (t d, *J* = 4.5; 3.0 Hz, 1 H), 3.86 (m, *J* = 10.0; 5.0; 4.0 Hz, 2 H), 3.67 (dd, *J* = 8.0; 3.0 Hz, 1 H), 2.70 (d, *J* = 4.5 Hz, 2 H), 2.13 (m, 1 H), 1.83 (m, 1 H), 1.50 and 0.91 (2s, 18 H), 0.14 (s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 168.9, 135.6, 133.3, 133.2, 129.8, 127.8, 76.4, 69.8, 66.9, 59.7, 37.8, 35.8, 26.8, 25.7, 19.2, 18.0, 4.6, 4.8. − $C_{29}H_{44}O_5Si_2$ (528.8): calcd. C 65.87, H 8.39; found C 65.75, H 8.45.

(3*S*,4*S*,1′*S*)-3-(*tert*-Butyldimethylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (20): $[\alpha]_D$ = −9.5 (*c* = 0.8, $CHCl_3$) *ee* = 95%. − IR (neat): $\tilde{\nu}$ = 3503 (O−H), 3019−2933 (C−H), 1787 (C=O), 1111 (C−O) cm^{-1}. − ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.69 and 7.40 (m, 10 H), 4.60 (ddd, *J* = 4.9; 3.4; 1.0 Hz, 1 H), 4.30 (dd, *J* = 8.8; 2.9 Hz, 1 H), 4.12 (dd, *J* = 8.8; 3.4 Hz, 1 H), 3.93 (m, 2 H), 3.76 (d, *J* = 2.9 Hz, 1 H), 2.71 (dd, *J* = 17.2; 4.9 Hz, 1 H), 2.47 (dd, *J* = 17.2; 1 Hz, 1 H), 2.04 (m, 1 H), 1.81 (m, 1 H), 1.06 (s, 9 H), 0.94 (s, 9 H), 0.14 and 0.10 (2s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 175.4, 135.5, 132.61, 130.0, 127.9, 85.6, 68.8, 68.4, 63.6, 39.9, 35.0, 26.78, 25.7, 19.0, 18.1, −4.8, −5.2. − $C_{29}H_{44}O_5Si_2$ (528.8): calcd. C 65.87, H 8.39; found C 65.81, H 8.39

Synthesis of Compounds 18, 20, and 21 from the Minor *syn* Adduct of Type 6: A solution of epoxy ester **6′s** (1.10 g, 1.88 mmol) in anhydrous CH_2Cl_2 (34 mL) at room temp. was treated with dry $ZnCl_2$ (0.638 g, 4.70 mmol, 2.5 equiv.) and stirred for 10 h at room temp. Saturated aqueous $NaHCO_3$ (8 mL) was then added and the aqueous layer was extracted with Et_2O (3 × 16 mL). The combined organic phases were dried with $MgSO_4$, filtered, and concentrated. The residue was purified according to method C (120 g of silica 15−40 μm), eluting with PE/EA, 8:2 (TLC, R_{f21} = 0.54, R_{f18} =

0.33, R_{f20} = 0.18). We isolated 0.134 g (0.23 mmol, 12%) of **22**, 0.730 g (1.38 mmol, 74%) of **18** and 0.130 g (0.25 mmol, 13%) of **20**. The overall yield was 99%.

(3*S*,4*R*,1′*R*)-4-[1′-(*tert*-Butoxy)-3-(*tert*-butyldimethylsilyloxy)-3′-(*tert*-butyldiphenylsilyloxy)propyl]-γ-lactone (21): IR (film): $\tilde{\nu}$ = 3052−2934 (C−H), 1786 (C=O), 1097 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.67 and 7.40 (m, 10 H), 4.50 (X part of ABX, *J* = 7.5; 1.8; 1.5 Hz, 1 H), 4.35 (m, *J* = 1.8 Hz, 1 H), 4.02 (ddd, *J* = 9.0; 3.5; 2.2 Hz, 1 H), 3.73 (m, 2 H), 2.83 (dd, A part of ABX, *J* = 17.5; 7.5 Hz, 1 H), 2.28 (B part of ABX, *J* = 17.5; 1.5 Hz, 1 H), 1.77 and 1.61 (m, 2 H), 1.14, 1.07 and 0.84 (3s, 27 H), 0.05 and 0.02 (2s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 176.8, 135.6, 133.4, 133.2, 129.8, 127.8, 89.9, 74.9, 66.7, 66.2, 60.6, 39.9, 36.1, 28.5, 26.7, 25.6, 19.2, 17.8, −4.5, −4.8. − $C_{33}H_{52}O_5Si_2$ (584.9): calcd. C 67.79, H 11.23; found C 67.43, H 10.95.

(3*S*,4*R*,1′*R*)-3-(*tert*-Butyldiphenylsilyloxy)-4-[4′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxybutyl]-γ-lactone (22): A solution of epoxy ester **8a** (2.0 g, 2.77 mmol) in anhydrous CH_2Cl_2 (42 mL) at room temp. was treated with dry $ZnCl_2$ (0.75 g, 5.54 mmol, 2 equiv.) and stirred for 4 h 50 min at room temp. A saturated aqueous solution of $NaHCO_3$ (10 mL) was then added and the aqueous layer was extracted with Et_2O (3 × 30 mL). The combined organic phases were dried with $MgSO_4$, filtered, and concentrated. The residue was purified according to method C (150 g of silica 15 μm), eluting with PE/EA, 8:2 (TLC, R_f = 0.27). We isolated 1.47 g (2.22 mmol) of lactone **22**. Yield 80%. $[\alpha]_D$ = +1.44 (*c* = 1.9, $CHCl_3$). $[\alpha]_D$ = +1.22 (*c* = 0.91, $CHCl_3$), *ee* = 88%. − IR ($CHCl_3$): $\tilde{\nu}$ = 3626−3390 (O−H), 3075−2863 (C−H), 1775 (C=O), 1110 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.65 and 7.41 (m, 20 H), 4.56 (X part of ABX, *J* = 6.3; 4.1; 1.5 Hz, 1 H), 4.29 (m, *J* = 4.1; 3.8 Hz, 1 H), 3.50 (m, 3 H), 2.95 (d, *J* = 4.5 Hz, 1 H), 2.71 (A part of ABX, *J* = 18.0; 6.3 Hz, 1 H), 2.41 (B part of ABX, *J* = 18.0; 1.5 Hz, 1 H), 1.63 (m, 2 H), 1.22 (m, 2 H), 1.10 and 1.04 (2s, 18 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 176.4, 135.9, 135.8, 135.5, 133.2, 132.9, 132.8, 130.1, 129.8, 128.0, 127.9, 127.8, 91.1, 71.1, 69.6, 64.0, 39.0, 29.4, 28.7, 26.8, 19.1. − $C_{40}H_{52}O_5Si_2$ (669.0): calcd. C 72.03, H 7.56; found C 71.90, H 7.62.

(3*R*,4*S*,1′*S*)-3-(*tert*-Butyldiphenylsilyloxy)-4-[4′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxybutyl]-γ-lactone (22′): A solution of epoxy ester **8′a** (2.82 g. 3.91 mmol) in anhydrous CH_2Cl_2 (59 mL) at room temp. was treated with dry $ZnCl_2$ (2.12 g, 15.66 mmol, 4 equiv.) and stirred for 14 h at room temp. A saturated aqueous solution of $NaHCO_3$ (20 mL) was then added and the aqueous layer was extracted with Et_2O (3 × 40 mL). The combined organic phases were dried with $MgSO_4$, filtered, and concentrated. The residue was purified according to method C (100 g of silica 6−35 μm), eluting with PE/EA, 8:2 (TLC, R_f = 0.24). We isolated 1.90 g (2.86 mmol) of lactone **22′** and 0.33 g of the starting material. The yield was 85%, based on recovered starting material. $[\alpha]_D$ = −1.96 (*c* = 1.12, $CHCl_3$). IR and NMR: identical to those of the above compound (**22**).

Synthesis of Compounds 23′ and 24′: A solution of epoxy ester **7′a** (5.33 g, 8.56 mmol) and **7′s** (mixture) in anhydrous CH_2Cl_2 (132 mL) at room temp. was treated with dry $ZnCl_2$ (4.8 g, 4 equiv.). A saturated aqueous solution of $NaHCO_3$ (25 mL) was added, and the aqueous layer was extracted three times with Et_2O. The combined organic phases were dried with $MgSO_4$, filtered, and concentrated. The residue was purified according to method C (200 g of silica 6−35 μm), eluting with pentane/THF/CH_2Cl_2: 3.5:0.5:6, (TLC, $R_{f23'}$ = 0.21, $R_{f24'}$ = 0.28). We isolated 2.46 g (4.22 mmol) of lactone **23′**, 0.75 g (1.29 mmol) of **24′** and 0.36 g (0.62 mmol) of **23′** and **24′** mixture. The overall yield was 72%.

(3*R*,4*S*,1′*S*)-4-[3′-(*p*-Bromobenzyloxy)-1′-hydroxypropyl]-3-(*tert*-butyldiphenylsilyloxy)-γ-lactone (23′): $[\alpha]_D$ = +2.6 (*c* = 1.1, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3449 (O−H), 3073−2936 (C−H), 1786 (C=O), 1110 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.64, 7.44 and 7.13 (m, 14 H), 4.58 (X part of ABX, *J* = 6.1; 1.4; 1.0 Hz, 1 H), 4.37 (s, 2 H), 4.28 (bd, *J* = 4.6; 1.0 Hz, 1 H), 3.75 (m, *J* = 3.1 Hz, 1 H), 3.50 (m, 2 H), 2.94 (d, *J* = 3.1 Hz, 1 H), 2.69 (A part of ABX, *J* = 18.0; 6.1 Hz, 1 H); 2.41 (B part of ABX, *J* = 18.0; 1.4 Hz, 1 H), 1.33 (m, 2 H), 1.06 (s, *t*Bu, 9 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 176.12, 144.0, 135.9, 135.8, 134.8, 132.9, 131.7, 130.2, 129.3, 127.9, 121.9, 90.5, 72.6, 70.6, 69.6, 68.6, 38.7, 31.5, 28.8, 19.1. − $C_{30}H_{35}BrO_5Si$ (583.6): calcd. C 61.74, H 6.04; found C 61.76, H 6.11.

(3*S*,4*S*,1′*S*)-4-[3′-(*p*-Bromobenzyloxy)-1′-hydroxypropyl]-3-(*tert*-butyldiphenylsilyloxy)-γ-lactone (24′): $[\alpha]_D$ = +0.5 (*c* = 0.9, $CHCl_3$). − IR (neat): $\tilde{\nu}$ = 3503 (OH), 2934−2861 (C−H), 1789 (C=O), 1111 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.74, 7.46, and 7.19 (m, 14 H), 4.71 (dd, *J* = 3.5; 3.3 Hz, 1 H), 4.50 (s, 2 H), 4.38 (tt, *J* = 8.5; 2.1; 3.7 Hz, 1 H), 4.07 (dd, *J* = 8.5; 3.5 Hz, 1 H), 3.77 (m, 2 H), 2.30 (d, 2 H), 2.15 (m, 1 H), 1.92 (m, 1 H), 1.09 (s, 9 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 174.97, 136.9, 135.9, 135.8, 133.1, 132.1, 131.9, 130.3, 129.3, 128.0, 121.7, 85.2, 72.6, 70.1, 68.8, 67.8, 38.9, 33.2, 28.9, 19.3. − $C_{30}H_{35}BrO_5Si$ (583.6): calcd. C 61.74, H 6.04; found C 61.59, H 6.13.

Synthesis of Compounds 25 and 26: A solution of epoxy esters **9a** and **9s** (mixture, 1.44 g, 2.21 mmol) in anhydrous CH_2Cl_2 (33 mL) at room temp. was treated with dry $ZnCl_2$ (0.597 g, 4.41 mmol, 2 equiv.). A saturated aqueous solution of $NaHCO_3$ (4 mL) was added and the aqueous layer was extracted with Et_2O (2 × 10 mL). The combined organic phases were dried with $MgSO_4$, filtered, and concentrated. The residue was purified according to method C (80 g of silica 15 μm), eluting with PE/EA/CH_2Cl_2, 4:2/4 (CCM, R_{f26} = 0.37, R_{f25} = 0.29). We isolated 0.931 g (1.56 mmol) of lactone **25** and 0.12 g (0.20 mmol) of **25**. The overall yield was 80%.

(3*S*,4*R*,1′*R*)-4-[4′-(*p*-Bromobenzyloxy)-1′-hydroxybutyl]-3-(*tert*-butyldiphenylsilyloxy)-γ-lactone (25): $[\alpha]_D$ = −1.1 (*c* = 1.9, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3438 (O−H), 3073−2861 (C−H), 1781 (C=O), 1110 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.64, 7.43, and 7.14 (m, 14 H), 4.55 (X part of ABX, *J* = 6.3; 1.7; 1.5 Hz, 1 H), 4.41 (s, 2 H), 4.28 (dd, *J* = 3.2; 1.5 Hz, 1 H), 3.56 (m, 1 H), 3.37 (m, 2 H), 3.10 (d, *J* = 4.8 Hz, 1 H), 2.67 (A part of ABX, *J* = 18.0; 6.3 Hz, 1 H), 2.40 (B part of ABX, *J* = 18.0; 1.7 Hz, 1 H), 1.60 (m, 2 H), 1.25 (m, 2 H), 1.06 (s, 9 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 176.2, 136.7, 135.9, 135.8, 132.9, 131.6, 130.1, 129.4, 128.0, 127.9, 121.7, 90.8, 72.4, 71.1, 70.2, 69.6, 38.9, 29.9, 26.8, 26.2, 19.1. − $C_{31}H_{34}BrO_5Si$ (594.6): calcd. C 62.30, H 6.24; found C 62.44, H 6.41.

(3*R*,4*R*,1′*R*)-4-[4′-(*p*-Bromobenzyloxy)-1′-hydroxybutyl]-3-(*tert*-butyldiphenylsilyloxy)-γ-lactone (26): $[\alpha]_D$ = −5.4 (*c* = 1.3, $CHCl_3$). − IR (neat): $\tilde{\nu}$ = 3438 (O−H), 3072−2861 (C−H), 1782 (C=O), 1111 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.67, 7.43, and 7.19 (m, 14 H), 4.69 (d, *J* = 3.7 Hz, 1 H), 4.47 (s, 2 H), 4.11 (td, *J* = 8.6; 8.5; 2.5 Hz, 1 H), 4.06 (td, *J* = 8.5; 8.5; 3.7 Hz, 1 H), 3.55 (td, *J* = 6.5; 1.5 Hz, 2 H), 2.32 (m, 2 H), 2.04 (m, 1 H), 1.84 (quint, *J* = 6.6; 6.5 Hz, 2 H), 1.58 (m, 1 H), 1.05 (s, 9 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 174.9, 137.0, 135.8, 132.9, 132.0, 131.6, 130.4, 129.4, 128.1, 121.2, 85.3, 72.4, 70.8, 70.3, 68.2, 38.7, 31.6, 27.0, 26.8, 19.3. − $C_{31}H_{34}BrO_5Si$ (594.6): calcd. C 62.30, H 6.24; found C 62.12, H 6.17.

Synthesis of Compounds 27, 28, 29, and 30: A solution of epoxy ester **12a** (1.0 g, 1.41 mmol) in CH_2Cl_2 (21 mL) at room temp. was

treated with $ZnCl_2$ (0.765 g, 4 equiv.) and stirred for 17 h. After dilution with Et_2O (60 mL), a saturated aqueous solution of $NaHCO_3$ (8 mL) was then added. The aqueous phase was extracted with Et_2O (2 × 20 mL). The combined organic layers were dried with $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was purified according to purification method C (180 g of silica 6−35 μm), eluting with PE/EA, 8:2 (TLC, R_{f29} = 0.42, R_{f27} = 0.26, R_{f30} = 0.21, R_{f28} = 0.10) to afford 0.281 g (0.40 mmol) of **29**, 0.154 g (0.24 mmol) of **27**, 0.398 g (0.61 mmol) of **30** and 0.142 g (0.22 mmol) of **28**. The overall yield was quantitative.

(3*S*,4*R*,1′*S*)-3-(*tert*-Butyldiphenylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (27): $[\alpha]_D$ = +24.4 (*c* = 0.1, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3464 (O−H), 3074−2935 (C−H), 1780 (C=O), 1110 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.64 and 7.40 (m, 20 H), 4.58 (X part of ABX, *J* = 6.5; 1.7; 1.7 Hz, 1 H), 4.14 (br. s, 1 H), 3.77 and 3.67 (m, 2 H), 3.42 (m, *J* = 1.7; 9.5 Hz, 1 H), 3.22 (d, *J* = 1.95 Hz, 1 H), 2.82 (A part of ABX, *J* = 18.0; 6.5 Hz, 1 H), 2.44 (B part of ABX, *J* = 18.0; 1.7 Hz, 1 H), 1.85 and 1.38 (m, 2 H), 1.08 and 1.01 (2s, *t*Bu, 18 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 176.6, 135.8, 135.7, 135.5, 135.5, 133.4, 132.2, 130.2, 130.0, 129.9, 128.0, 127.9, 127.9, 90.6, 71.5, 63.2, 38.7, 34.4, 26.9, 26.8, 19.0, 18.9.

(3*S*,4*S*,5*R*)-3-(*tert*-Butyldiphenylsilyloxy)-5-[2′-(*tert*-butyldiphenylsilyloxy)-1′-ethyl]-4-hydroxy-δ-lactone (28): $[\alpha]_D$ = +1.3 (*c* = 2.0, $CHCl_3$). − IR (neat): $\tilde{\nu}$ = 3419 (O−H), 3074−2935 (C−H), 1712 (C=O), 1110 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.64 and 7.44 (m, 20 H), 5.00 (m, 1 H), 4.28 (X part of ABX, *J* = 4.3; 3.84; 1.9 Hz, 1 H), 3.95 (d, *J* = 2.5 Hz, OH, 1 H), 3.91 and 3.69 (m, 2 H), 3.80 (d, *J* = 3.8 Hz, 1 H), 2.79 (A part of ABX, *J* = 17.5; 4.3 Hz, 1 H), 2.46 (B part of ABX, *J* = 17.5; 1.9 Hz, 1 H), 2.08 (m, 2 H), 1.09 and 1.03 (2s, 18 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 170.0, 135.7, 135.6, 135.6, 135.4, 133.0, 132.8, 132.4, 132.2, 130.2, 130.2, 130.1, 128.0, 76.4, 68.4, 67.9, 59.3, 34.7, 33.9, 26.9, 26.7, 19.1, 19.0. − MS (DCI/NH_3): *m*/*z*: 670 [M + 18] (100%), 653 [M + 1] (1.17%).

(3*S*,4*S*,1′*R*)-4-[1′-*tert*-Butoxy-3′-(*tert*-butyldiphenylsilyloxy)propyl]-3-(*tert*-butyldiphenylsilyloxy)-γ-lactone (29): IR (film): $\tilde{\nu}$ = 3074−2965 (C−H), 1783 (C=O), 1110 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.65 and 7.42 (m, 20 H), 4.53 (m, 2 H), 4.37 (m, 1 H), 4.00 (m, 1 H), 3.64 (m, 1 H), 2.43 (A part of ABX, *J* = 17.0; ≈1 Hz, 1 H), 2.21 (B part of ABX, *J* = 17.0; 4.7 Hz, 1 H), 1.79 (m, 2 H), 1.24, 1.09 and 0.93 (3s, 27 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 175.4, 135.8, 135.8, 135.5, 133.5, 133.4, 133.3, 130.3, 130.2, 129.7, 129.7, 128.2, 127.9, 127.7, 86.2, 74.4, 71.2, 67.5, 59.3, 39.6, 34.6, 28.8, 28.6, 26.9, 19.3, 19.0. − MS (DCI/NH_3): *m*/*z*: 726 [M + 18] (100%).

(3*S*,4*S*,1′*R*)-3-(*tert*-Butyldiphenylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (30): $[\alpha]_D$ = −5.1 (*c* = 1.0, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3510 (O−H), 3074−2935 (C−H), 1787 (C=O), 1110 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.66 and 7.46 (m, 20 H), 4.68 (X part of ABX, *J* = 7.5; 6.5; 6.3 Hz, 1 H), 4.56 (m, 1 H), 4.21 (dd, *J* = 6.5; 2.5 Hz, 1 H), 3.87 (m, 2 H), 3.12 (m, 1 H), 2.64 (dd, A part of ABX, *J* = 17.3; 6.0 Hz, 1 H), 2.30 (B part of ABX, *J* = 17.3; 7.5 Hz, 1 H), 1.93 and 1.77 (m, 2 H), 1.15 and 1.06 (2s, 18 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 174.5, 135.7, 135.6, 133.4, 133.2, 132.5, 132.0, 128.2, 128.9, 127.8, 84.3, 70.4, 68.1, 61.2, 37.8, 34.9, 26.9, 19.2, 19.1. − MS (DCI/NH_3): *m*/*z*: 670 [M + 18] (100%), 653 [M + 1] (14%).

Synthesis of Compounds 31, 33, 34, and 35: A solution of epoxy ester **13a** (1.0 g, 1.68 mmol) in CH_2Cl_2 (25 mL) at room temp. was treated with dry $ZnCl_2$ (1.4 g, 5 equiv.) and stirred for 11 h 30 min. A saturated aqueous solution of $NaHCO_3$ (10 mL) was then added. The aqueous layer was extracted with Et_2O (3 × 20 mL). The combined organic phases were dried over $MgSO_4$, filtered and concentrated under vacuum. The residue was purified according to method C (80 g of silica 15−40 μm), eluent PE/EA, 8:2 (TLC, R_{f34} = 0.32, R_{f31} = 0.19, R_{f35} = 0.10, R_{f33} = 0.07) to afford 0.242 g (0.41 mmol) of **34**, 0.07 g (0.13 mmol) of **31**, 0.414 g (0.78 mmol) of **35** and 0.105 g (0.20 mmol) of **33**. The overall yield was 90%.

(3*S*,4*R*,1′*S*)-3-(*tert*-Butyldimethylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (31): $[\alpha]_D$ = +28.3 (*c* = 2.6, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3450 (O−H), 3073−2934 (C−H), 1782 (C=O), 1109 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.68 and 7.42 (m, 10 H), 4.59 (X part of ABX, *J* = 6.8; 3.0; 3.0 Hz, 1 H), 4.19 (m, 1 H), 4.10 (m, *J* = 8.0; 2.9; 2.0 Hz, 1 H), 3.99 (m, 2 H), 3.35 (d, *J* = 2.92 Hz, 1 H), 2.95 (A part of ABX, *J* = 17.5; 6.8 Hz, 1 H), 2.39 (dd, B part of ABX, *J* = 17.5; 3.0 Hz, 1 H), 2.00 (m,1 H), 1.69 (m, 1 H), 1.04 (s, 9 H), 0.90 (s,9 H), 0.10 (s, 6 H). − ^1H NMR (250 MHz, C_6D_6): δ = 7.73 and 7.24 (m, 10 H), 4.46 (X part of ABX, *J* = 7.0; 4.0; 3.0 Hz, 1 H), 4.04 (dd, *J* = 3.0; 2.0 Hz, 1 H), 3.94 (ddd, *J* = 9.0; 2.5; 2.0 Hz, 1 H), 3.72 (m, 1 H), 3.58 (m, 1 H), 2.73 (A part of ABX, *J* = 17.5; 7.0 Hz, 1 H), 2.21 (B part of ABX, *J* = 17.5; 4.0 Hz, 1 H), 1.81 (m, 1 H), 1.43 (m, 1 H), 1.11 (s, 9 H), 0.86 (s, 9 H), −0.04 and −0.10 (2s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 176.2, 135.6, 135.5, 132.8, 132.6, 130.1, 130.0, 128.0, 127.9, 90.5, 71.1, 70.1, 63.0, 39.0, 34.8, 26.8, 25.7, 19.0, 17.9, −4.7, −4.8. − MS (DCI/NH_3): *m*/*z*: 546 [M + 18] (100%).

(3*S*,4*S*,5*R*)-3-(*tert*-Butyldimethylsilyloxy)-5-[2′-(*tert*-butyldiphenylsilyloxy)-1′-ethyl]-4-hydroxy-δ-lactone (33): $[\alpha]_D$ = +9.6 (*c* = 3.2, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3519 (O−H), 3072−2933 (C−H), 1709 (C=O), 1099 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.66 and 7.45 (m, 10 H), 4.85 (ddd, *J* = 7.0; 5.0; 1.5 Hz, 1 H), 4.25 (X part of ABX, *J* = 4.0; 4.0; 2.3 Hz, 1 H), 4.18 (d, *J* = 3.0 Hz, 1 H), 3.93 (ddd, *J* = 11.0; 6.5; 2.6 Hz, 1 H), 3.82 (m, 1 H), 3.69 (ddd, *J* = 11.0; 8.0; 6.5 Hz, 1 H), 2.97 (A part of ABX, *J* = 18.0; 4.0 Hz, 1 H), 2.48 (B part of ABX, *J* = 18.0; 2.3 Hz, 1 H), 2.03 (m, 2 H), 1.06 (s, 9 H), 0.89 (s, 9 H), 0.12 and 0.11 (2s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 170.1, 135.5, 132.4, 132.2, 130.1, 128.0, 76.2, 68.5, 67.7, 59.3, 35.1, 33.8, 26.7, 25.7, 19.0, 17.9, −4.8, −4.9. − MS (DCI/NH_3): *m*/*z*: 546 [M + 18], 529 [M + 1] (0.35).

(3*S*,4*S*,1′*R*)-4-[1′-*tert*-Butoxy-3′-(*tert*-butyldiphenylsilyloxy)propyl]-3-(*tert*-butyldimethylsilyloxy)-γ-lactone (34): $[\alpha]_D$ = −29.4 (*c* = 1.5, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3073−2959 (C−H), 1785 (C=O), 1090 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.69 and 7.44 (m, 10 H), 4.33 (dd, *J* = 8.3; 3.3 Hz, 1 H), 4.24 (m, 1 H), 4.13 (X part of ABX, *J* = 4.8, *J* = 1.3, 1 H), 4.11 (m, 1 H), 3.87 (m, 1 H), 2.28 (A part of ABX, *J* = 16.9; 1.3 Hz, 1 H), 2.09 (B part of ABX, *J* = 16.9;4.9 Hz, 1 H), 1.84 (m, 2 H), 1.17, 1.13 and 0.87 (3s, 27 H), −0.03 et −0.11 (2s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 175.4, 135.6, 135.6, 133.5, 133.4, 129.7, 127.7, 86.2, 74.4, 69.5, 67.4, 65.9, 59.5, 40.1, 34.4, 28.7, 26.9, 25.7, 19.1, 17.9, −3.9, −5.0.

(3*S*,4*S*,1′*R*)-3-(*tert*-Butyldimethylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (35): $[\alpha]_D$ = −3.9 (*c* = 1.2, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3517 (O−H), 3073−2934 (C−H), 1785 (C=O), 1108 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.68 and 7.42 (m, 10 H), 4.68 (X part of ABX, *J* = 6.5; 4.3; 4.3 Hz, 1 H), 4.36 (m, 2 H), 3.88 (m, 2 H), 3.00 (d, *J* = 1.92 Hz, 1 H), 2.72 (A part of ABX, *J* = 17.5; 6.5 Hz, 1 H), 2.61 (B part of ABX, *J* = 17.0; 4.5 Hz, 1 H), 1.86 (m, 2 H), 1.05 (s, 9 H), 0.91 (s, 9 H), 0.13 (s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 174.5, 135.5, 133.5, 133.3, 129.8, 127.8, 85.1, 69.7, 67.7, 60.7, 38.9, 34.7, 26.9, 25.7,

19.2, 17.9, −4.5, −5.1. − $C_{29}H_{44}O_5Si_2$ (528.8): calcd. C 70.55, H 10.66; found C 70.25, H 11.06.

Synthesis of Compounds 31′ and 32: A solution of epoxy ester **13s** (1.13 g, 1.93 mmol) in anhydrous CH_2Cl_2 (35 mL) was treated with dry $ZnCl_2$ (1.3 g, 9.60 mmol, 5 equiv.) and stirred for 5 h at room temp. A saturated aqueous solution of $NaHCO_3$ (10 mL) was then added and the aqueous phase was extracted with Et_2O (3 × 10 mL). The combined organic phases were dried with $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was purified according to purification method C (100 g of silica 15−40 μm), eluting with PE/EA, 8:2 (TLC R_{f32} = 0.47, $R_{f31'}$ = 0.26) to afford 0.148 g (0.25 mmol, 14%) of **32** and 0.779 g (1.48 mmol, 86%) of **31′**. The overall yield was 90%.

(3*R*,4*R*,1′*S*)-3-(*tert*-Butyldimethylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxypropyl]-γ-lactone (31′): $[\alpha]_D$ = −29.6 (*c* = 1.1, $CHCl_3$). NMR, IR spectra are identical to those of compound **31**.

(3*R*,4*S*,1′*R*)-4-[1′-*tert*-Butoxy-3′-(*tert*-butyldiphenylsilyloxy)propyl]-3-(*tert*-butyldimethylsilyloxy)-γ-lactone (32): $[\alpha]_D$ = −10.3 (*c* = 0.74, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 2934−2860 (C−H), 1788 (C=O), 1083 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.66 and 7.41 (m, 10 H), 4.53 (dd, *J* = 2.8, *J* = 1.5, 1 H), 4.43 (X part of ABX, *J* = 6.5; 1.5; 1.5 Hz, 1 H), 4.03 (ddd, *J* = 8.0; 5.0; 2.8 Hz, 1 H), 3.74 (dd, *J* = 7.0; 5.0 Hz, 2 H), 2.83 (dd, A part of ABX, *J* = 17.7; 6.5 Hz, 1 H), 2.33 (B part of ABX, *J* = 17.7; 1.5 Hz, 1 H), 1.77 (m, 2 H), 1.20, 1.05 and 0.88 (3s, 27 H), 0.09 (s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 176.2, 135.5, 133.6, 133.4, 129.8, 129.7, 127.8, 127.7, 89.5, 74.3, 70.3, 68.2, 60.5, 39.3, 34.8, 28.8, 26.9, 25.7, 19.2, 17.9, −4.6, −4.7.

Synthesis of Compounds 36, 37, and 38: A solution of epoxy ester **14a** (1.0 g, 1.64 mmol) in CH_2Cl_2 (25 mL) at room temp. was treated with $ZnCl_2$ (1.12 g, 4.5 equiv.) and stirred for 11 h. After dilution with Et_2O (60 mL), a saturated aqueous solution of $NaHCO_3$ (10 mL) was added. The aqueous phase was extracted with Et_2O (2 × 40 mL). The combined organic phases were dried with $MgSO_4$, filtered, and concentrated under reduced pressure. Purification: Method C, 100 g of silica 6−35 μm, eluent EP/AE: 8:2 (CCM, R_{f37} = 0.21, R_{f36} = 0.13, R_{f38} = 0.06). We isolated 0.162 g (0.27 mmol), of **37**, 0.119 g (0.22 mmol) of **36**, and 0.534 g (0.99 mmol) of **38**. The yield was 90%.

(3*S*,4*R*,1′*S*)-3-(*tert*-Butyldimethylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxybutyl]-γ-lactone (36): $[\alpha]_D$ = +18.9 (*c* = 0.9, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3444 (O−H), 3073−2934 (C−H), 1783 (C=O), 1110 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.65 and 7.39 (m, 10 H), 4.54 (X part of ABX, *J* = 6.8; 3.0; 3.0 Hz, 1 H), 4.20 (dd, *J* = 3.0; 2.0 Hz, 1 H), 3.80 (m, 1 H), 3.70 (m, 2 H), 3.10 (m, 1 H), 2.92 (A part of ABX, *J* = 17.5; 6.8 Hz, 1 H), 2.59 (B part of ABX, *J* = 17.5; 3.0 Hz, 1 H), 1.76 (m, 4 H), 1.05 (s, 9 H), 0.89 (s, 9 H), 0.09 (s, 6 H). − ^{13}C NMR (63 MHz, $CDCl_3$): δ = 176.0, 135.6, 133.2, 133.0, 129.9, 127.8, 90.4, 71.1, 70.2, 64.2, 38.9, 31.1, 28.7, 26.8, 25.7, 19.1, 17.9, −4.7, −4.8.

(3*S*,4*S*,1′*R*)-3-(*tert*-Butyldimethylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxybutyl]-γ-lactone (37): $[\alpha]_D$ = −10.3 (*c* = 1.1, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3073−2961 (C−H), 1792 (C=O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.67 and 7.42 (m, 10 H), 4.36 (X part of ABX, *J* = 4.5; 3.3; 1.5 Hz, 1 H), 4.16 (dd, *J* = 8.3; 3.3 Hz, 1 H), 4.10 (m, 1 H), 3.68 (m, 2 H), 2.64 (A part of ABX, *J* = 17.0; 4.5 Hz, 1 H), 2.49 (B part of ABX, *J* = 17.0; 1.5 Hz, 1 H), 1.72 and 1.58 (m, 4 H), 1.20 (s, 9 H), 1.05 (s, 9 H), 0.88 (s, 9 H), 0.09 and 0.04 (2s, 6 H). − ^{13}C NMR: (63 MHz, $CDCl_3$): δ = 175.2, 135.6, 133.9, 133.8, 129.6, 127.6, 85.7, 74.5, 69.3, 68.2, 64.4, 40.1, 28.9, 28.5, 27.2, 26.9, 25.6, 19.2, 17.9, −4.0, −5.1.

(3*S*,4*S*,1′*R*)-3-(*tert*-Butyldimethylsilyloxy)-4-[3′-(*tert*-butyldiphenylsilyloxy)-1′-hydroxybutyl]-γ-lactone (38): $[\alpha]_D$ = +0.3 (*c* = 1.0, $CHCl_3$). − IR (film): $\tilde{\nu}$ = 3463 (O−H), 3073−2934 (C−H), 1785 (C=O), 1109 (C−O) cm^{-1}. − ^1H NMR (250 MHz, $CDCl_3$): δ = 7.66 and 7.40 (m, 10 H), 4.61 (X part of ABX, *J* = 6.5; 5.0; 3.5 Hz, 1 H), 4.20 (dd, *J* = 5.1;5.0 Hz, 1 H), 4.00 (m, 1 H), 3.70 (m, *J* = 5.5; 5.0 Hz, 2 H), 2.74 (A part of ABX, *J* = 17.5; 6.5 Hz, 1 H), 2.57 (B part of ABX, *J* = 17.5; 3.5 Hz, 1 H), 1.80 and 1.66 (m, 4 H), 1.05 (s, 9 H), 0.90 (s, 9 H), 0.10 and 0.09 (2s, 6 H). − ^{13}C NMR: (63 MHz, $CDCl_3$): δ = 174.5, 135.6, 133.7, 129.6, 127.7, 85.5, 69.8, 69.6, 63.9, 39.2, 29.0, 28.6, 26.9, 25.6, 19.2, 17.8, −4.5, −5.10.

Crystal Data for **24′:** Crystal data $C_{30}H_{35}BrO_6Si$, *M* = 583.59, white crystal centric monoclinic, space group *C*2/*c*, lattice type mc, *a* = 19.924, *b* = 13.0854, *c* = 23.736 Å, *V* = 5705.9 $Å^3$, *Z* = 9, *F*(000) = 2432.0. Data collected on a CAD4 Enraf−Nonius diffractometer at room temperature, using graphite monochromated Mo-K_α radiation. 3439 unique reflections were collected in the range of $0 \le \theta \le 24.36$. The data were corrected for Lorentz polarization but absorption effects were ignored. The structure was solved by direct methods and refined (difference Fourier synthesis; full-matrix, least-squares), using 3439 reflections with $I > 3\sigma(I)$. The final residuals were $R = 0.085$ and $R_w = 0.093$.

Supporting Information Available (see also footnote on page 1): Synthesis and characterization details for compounds **5a**, **6a**, **5′a**, **6′s**, **7′a**, **7′s**, **8a**, **8′a**, **9a**, **9s**, **12a**, **13a**, **13s**, **14a** (5 pages). Spectroscopic data for selected compounds **16′**, **22′**, and **25−38**. Crystal data and ORTEP drawing for **24′** and compound "**3a**" of reference 6[29] have been deposited at the Cambridge Crystallographic Data Centre.

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