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New 1,3-Oxathianes Derived from Myrtenal: Synthesis and Reactivity

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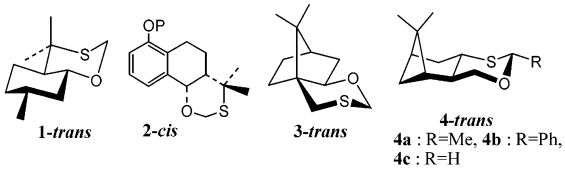
2-Methyl- and 2-phenyl-substituted oxathianes derived from Myrtenal have been synthesized in satisfying yields. Lithiation of 2-methyl-substituted oxathiane could not be done, but lithiation of 2-phenyl-substituted and non-substituted oxathianes could be performed with *s*-BuLi. Quenching with D_2O, TMSCl, and/or a carbonyl compound always provides the equatorial product in consistency with a prefered equatorial orientation of the lithium in the lithiated derivatives. A model is proposed to rationalize the diastereoselectivities observed at C5′ during reaction of aldehydes with lithiated non-substituted oxathiane. The model is based on the hypothesis that the lithium, being linked simultaneously to the carbon and the oxygen, is shifted toward the oxygen side, making the steric hindrance of this side more effective. Dimeric side products were observed during formation of these oxathianes (condensation of various aldehydes with the corresponding hydroxythiol), which had not been reported for other oxathianes (derived from pulegone and/or camphorsulfonic acid).

Chiral 1,3-oxathianes **1**−**4** have been used at the SCH_2O bridge[1−3] for diastereoselective synthesis of bioactive compounds[4] or at the sulfur atom[5,6] as a precursor of chiral ylides. Concerning the reactivity of the SCH_2O-bridge of oxathianes it appeared that lithiation was easily performed with *n*-BuLi in the case of **1**-*trans*[1c] and **2**-*cis*[3] while *s*-BuLi had to be used with **3**-*trans*.[1a]

We present here two new oxathianes **4a** and **4b**, derived from myrtenal, a study of the reactivity of these oxathianes, as well as the first successful lithiation of oxathiane **4c** which could not be lithiated yet. It is reported also that, unlike for oxathianes **1**−**3**, side products are observed during the synthesis of type **4** oxathianes and that these compounds (often *major*) have dimeric structures.



1-*trans* **2-*cis*** **3-*trans*** **4-*trans***
4a : R=Me, **4b** : R=Ph,
4c : R=H

Synthesis and Identification of Oxathianes 4a and 4b and of the Side Products. Oxathianes **4a** and **4b** have been synthesized from hydroxythiol **7** using *p*-toluenesulfonic acid (0.05 equiv) in benzene at room temperature, Scheme 1, or using BF_3:OEt_2 (0.5 equiv) in CH_2Cl_2 at 0 °C, Table 1. The hydroxythiol **7** was obtained from (−)-myrtenal **5** according to the usual procedure; however, DBU had to be used as base instead of pyridine to obtain 99% yield and 99% diastereoselectivity. Then $LiAlH_4$ reduction of **6** provided the desired hydroxythiol **7** in 90% isolated yield and as a single diastereomer, Scheme 1.

It is worth noting that this reaction is not as clean as it is usually for the synthesis of oxathianes **1**−**3**. A dimer **8a** (17%) has also been obtained (as a ∼1/1 mixture of the two possible diastereomers) together with traces of a new compound **9a** (5%) in the case of condensation of **7** with acetaldehyde, while in the case of condensation

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(1) (a) Eliel, E. L.; Frazee, W. J. *J. Org. Chem*. **1979**, *44*, 3598. (b) Eliel, E. L.; Lynch, J. E. *Tetrahedron Lett*. **1981**, *22*, 2855. (c) Lynch, J. E.; Eliel, E. L. *J. Am. Chem. Soc.* **1984**, *106*, 2943.

(2) Martinez-Ramos, F.; Vargas-Diaz, M. E.; Chacon-Garcia, L.; Tamariz, J.; Joseph-Nathan, P.; Zepeda, L. G. *Tetrahedron: Asymmetry* **2001**, *12*, 3095.

(3) (a) Solladié-Cavallo, A.; Balaz, M.; Salisova, M.; Suteu, C.; Nafie, L. A.; Cao, X.; Freedman T. B. *Tetrahedron: Asymmetry* **2001**, *12*, 2605. (b) Solladié-Cavallo, A.; Balaz, M.; Salisova, M. *Eur. J. Org. Chem*. **2003**, 337.

(4) For some examples of the use of oxathianes for the preparation of bioactive compounds, see: (a) Eliel, E. L.; Soai, K. *Tetrahedron Lett*. **1981**, *22*, 2859. (b) Frye, S. V.; Eliel, E. L. *J. Org. Chem*. **1985**, *50*, 3402. (c) Ohwa, M.; Kogure, T.; Eliel, E. L. *J. Org. Chem*. **1986**, *51*, 2599. (d) Cervantes-Cuevas, H.; Joseph-Nathan, P. *Tetrahedron Lett*. **1988**, *29*, 5535. (e) Kaulen, J. *Angew. Chem., Int. Ed. Engl*. **1989**, *28*, 462. (f) Nemoto, H.; Matsuhashi, N.; Imaizumi, M.; Nagai, M.; Fukumoto, K. *J. Org. Chem*. **1990**, *55*, 5626. (g) Bai, X.; Eliel, E. L. *J. Org. Chem*. **1991**, *56*, 2086.

(5) (a) Solladié-Cavallo, A.; Adib, A. *Tetrahedron* **1992**, *48*, 2453. (b) Solladié-Cavallo, A.; Diep-Vohuule, A. *J. Org. Chem*. **1995**, *60*, 3494. (c) Solladié-Cavallo, A.; Diep-Vohuule, A.; Sunjic, V.; Vinkovic, V. *Tetrahedron: Asymmetry* **1996**, *7*, 1783. (d) Solladié-Cavallo, A.; Diep-Vohuule, A.; Isarno, T. *Angew. Chem., Int. Ed. Engl.* **1998**, *37*, 1689.

(6) (a) Aggarwal, V. K.; Thompson, A., Jones, R. V. H.; Standen, M. *Tetrahedron: Asymmetry* **1995**, *6*, 2557. (b) Aggarwal, V. K.; Smith, H. W.; Hynd, G.; Jones, R. V. H.; Fieldhouse, R.; Spey, S. E. *J. Chem. Soc., Perkin Trans. 1* **2000**, 3267. (c) Aggarwal, V. K.; Ferrara, M.; O'Brien, C. J.; Thompson, A.; Jones, R. V. H.; Fieldhouse, R. *J. Chem. Soc., Perkin Trans. 1* **2001**, 1635.

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SCHEME 1

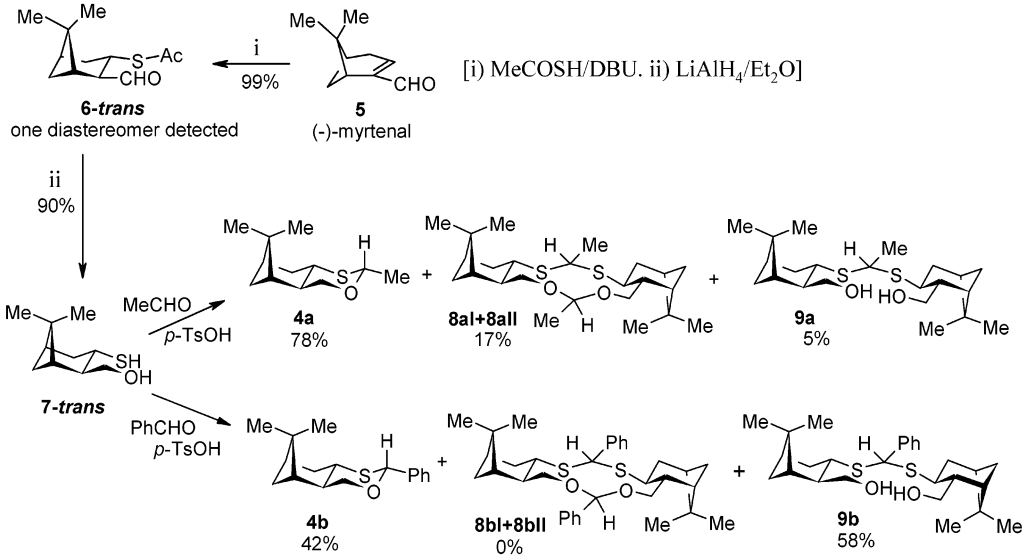


TABLE 1. Preparation of Oxathianes 4a and 4b from Hydroxythiol 7

aldehyde	catalyst	% in weight recovered[a]	**4**/**8**/**9**	unidentified product	**4** (% recovered)[b]
MeCHO	*p*-TsOH	75	78/17/5	no	60
	BF_3:OEt_2	60	72/13/15	yes	36
PhCHO	*p*-TsOH	95	42/0/58	no	23
	BF_3:OEt_2	90	19/0/81	no	10

[a] Percent in weight of material recovered compared to the mass used for the reaction (correspond to samples after filtration of solids and/or after extraction and containing no solvent). [b] Percent isolated of oxathiane **4** (in mol), after chromatography.

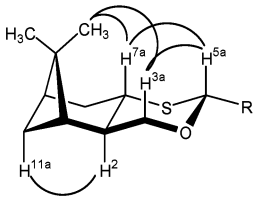
of **7** with benzaldehyde (under identical conditions) **9b** was *major* (58%) and **8b** was not observed.

Moreover, the use of BF_3:OEt_2 in CH_2Cl_2, which worked perfectly for the preparation of 2-substituted oxathianes of type **2** (Me: 90%; Ph: 80%)[3] and **3** (Me: 99%; Ph: 84%),[7] provided lower yields in the preparation of oxathiane **4a** and **4b**, Table 1.

After chromatography on silica gel, 60% of **4a** and 23% of **4b** were isolated.

Assignment of all the proton signals of oxathianes **4a** and **4b** has been done using COSY experiments. The large value (10 Hz) of the coupling constant observed between protons H2 and H7 in both cases is consistent with a trans structure. This trans structure was then corroborated by the presence of positive nuclear Overhauser effects between one of the methyl protons (singlet at 1.14 ppm for **4a** and 1.22 ppm for **4b**) and protons H7 and $H3_{axial}$ or between proton $H11_{axial}$ and H2, Figure 1.

It is worth noting that, in both cases, proton H7 appears as a quadruplet with three coupling constants of similar value (~10 Hz) due to the dihedral angles[8] (see X-ray of **8c**).



4a: R= Me, **4b**: R= Ph, **4c**: R= H

FIGURE 1. NOE in compounds **4a**, **4b,** and **4c**.

Moreover, NOE experiments, with positive effects between proton H5 and protons H7 and $H3_{axial}$, Figure 1, showed that the R-groups have *equatorial* orientation in both oxathianes **4a** and **4b,** as we already observed in the case of type **2** oxathianes.[3]

Compounds **8a**, **9a,** and **9b** have been identified by comparison with compound **8c,** for which an X-ray structure could be performed (cf. bellow), and using ^{1}H NMR, ^{13}C NMR, and MS.

Oxathiane 4c and Identification of Dimer 8c. The synthesis of **4c** (already prepared by Zepeda et al.[2]) was done using the same route but when the hydroxythiol **7** was treated with paraformaldehyde in the presence of a catalytic amount of *p*-toluenesulfonic acid in refluxing benzene, dimer **8c** was the *major* product (56% in mole) and only a trace amount of compound **10** was obtained (2 mol %) as determined by ^{1}H NMR on CH_2 signals (2H). No starting **7** was detected, indicating a full conversion, Scheme 2. After chromatography on NEt_3 pretreated silica gel 30% of **4c**, 63% of dimer **8c** and traces of **10** (~1%) were isolated.

The ^{1}H and ^{13}C NMR spectra of *trans*-oxathiane **4c** are identical to the literature and consistent with those of *trans*-oxathianes **4a** and **4b**. It is worth noting that proton H7 appears also as a quadruplet with three coupling constants of similar values (~10 Hz) due to the dihedral angles[8] (see X-ray of **8c**).

The ^{1}H NMR spectrum of compound **8c**, Figure 2, exhibits two singlets (at 3.70 and 4.48 ppm) corresponding to two protons each (CH_2) together with all the signals of the starting hydroxythiol skeleton **7** (but multiplied

(7) Aggarwal, V. K.; Ford, J. G.; Fonquerna, S.; Adams, H.; Jones, R. V. H.; Fieldhouse, R. *J. Am. Chem. Soc.* **1998**, *120*, 8328.

(8) From the Karplus−Conroy curve it appears immediately that the values of ^3J coupling constants corresponding to dihedral angles of about 20° (^3JH7−H8$_{eq}$ = $^3J \approx 20$) and 140° (^3JH7−H2 and ^3JH7−H8$_{ax}$ = $^3J \approx 140$) can be predicted to be similar and in the range 8−11 Hz which is the case. See: Günter, H. *NMR Spectroscopy* (translated by Gleason, R. W.); John Wiley & Sons: Chichester, 1980; p 107.

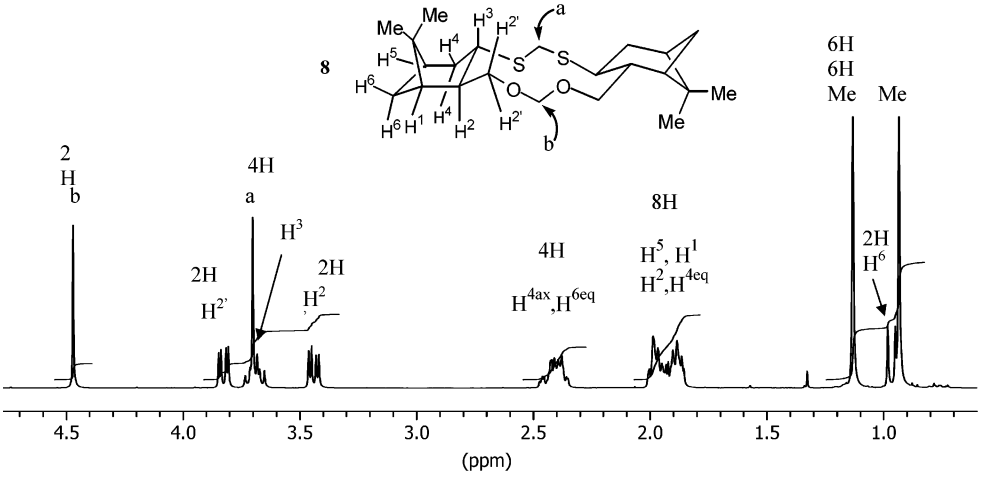


FIGURE 2. ^{1}H NMR of compound **8c**.

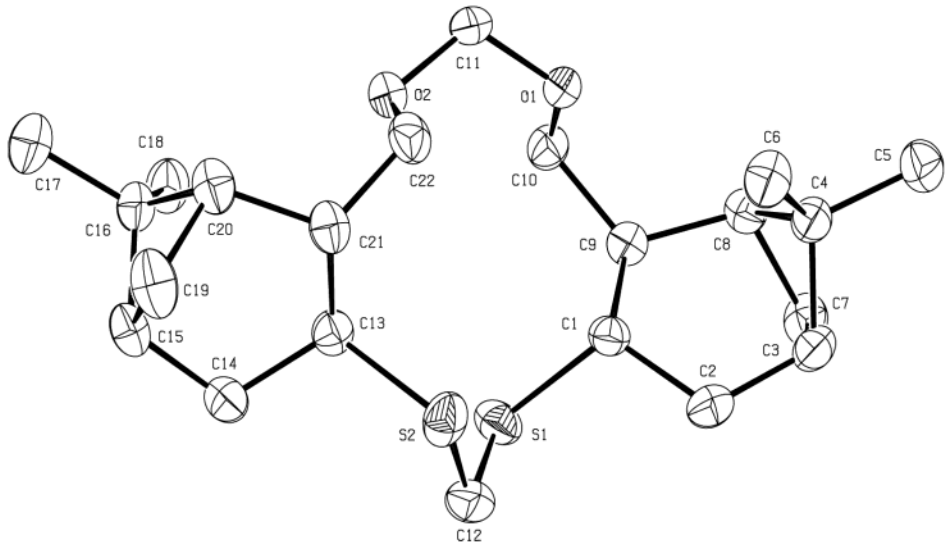
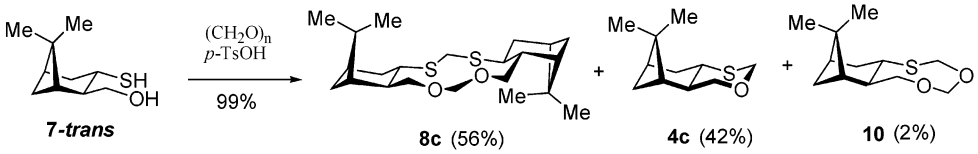


FIGURE 3. Molecular structure of compound **8c**; ORTEP with atom numbering. Thermal ellipsoids are drawn at 50% probability level. Hydrogen atoms are omitted for clarity.

SCHEME 2



by two). Moreover, the equivalence of the protons in both of the CH_2 groups suggested the presence in the molecule of a C_2 axis. Mass spectroscopy of **8c** indicated a dimeric-type structure with a parent ion $M^+ = 396$ corresponding to $C_{22}H_{36}O_2S_2$.

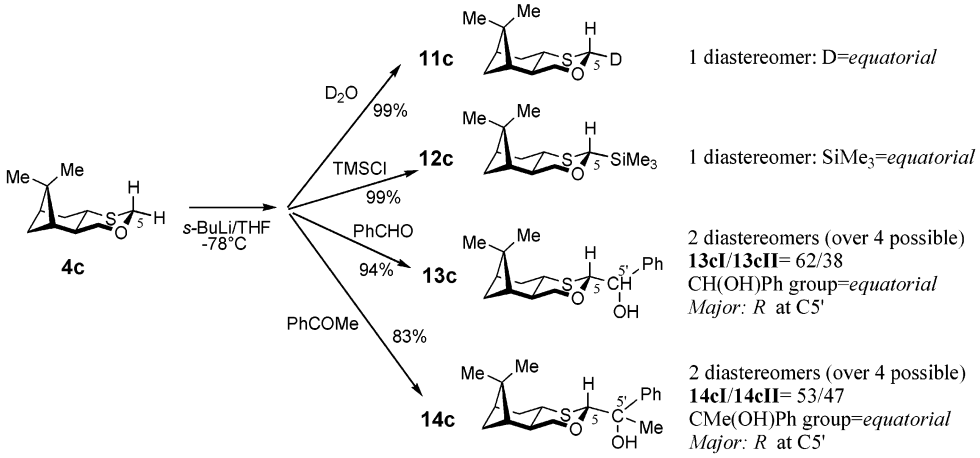
After crystallization from hexane a selected single crystal of compound **8c** was submitted to X-ray diffraction analysis. The structure obtained, Figure 3, is the expected dimer **8c** with a C_2 axis. It appears also that the substituents at C13 (or C1) and C21 (or C9), using the ORTEP numbering, are in a trans relationship. Moreover, flattering of the ring appears clearly and the dihedral angles C15−C14−C13−C21 (or C3−C2−C1−C9) and C14−C13−C21−C20 (or C2−C1−C9−C8) values are 19.0(2)° and 23.0(2)°, respectively, which explains the similar values for the ^3JH7−H8$_{eq}$, ^3JH7−H8$_{ax}$, and ^3JH7−H2 coupling constants.[8]

Lithiation and Quenching of Oxathianes 4a−c. Although lithiation of **4c** with BuLi had failed,[2] we succeeded to obtain the lithium derivative of **4c** using *s*-BuLi in THF at −78 °C as seen from the quantitative yield in monodeuterated oxathiane **11c** obtained, Scheme 3.

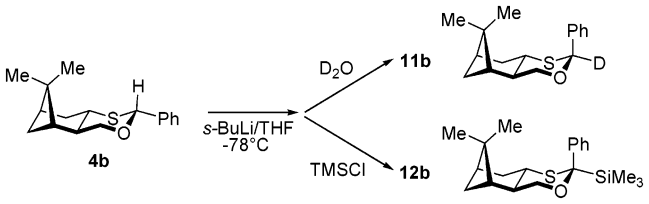
Quenching with TMSCl also provided compound **12c** in quantitative yield.

Quenching of the lithiated oxathiane **4c** with PhCHO and PhCOMe, Scheme 3, provided the desired alcohols **13c** and **14c** in 94% and 83% yield, respectively,

SCHEME 3



SCHEME 4



and as a mixture of two diastereomers (over the four possible).

NOE experiments exhibit in all cases positive effects between proton H5 and protons H7 and $H3_{axial}$, indicating that the remaining proton at C5 has an *axial* orientation. Therefore, the deuterium in **11c** and the $SiMe_3$ group in **12c** have an *equatorial* position. Likewise, in both diastereomers of **13c** and **14c** the CH(OH)Ph and CMe(OH)-Ph groups are also *equatorial*.

From the synthesis of diastereomer **13cII** having the *S*-configuration at C5′ (cf. below), the *R*-configuration has been assigned to the *major* diastereomer **13cI** obtained during the condensation of benzaldehyde on lithiated **4c**, Scheme 3.

However, no deuterium exchange was observed when oxathiane **4a** was treated with *s*-BuLi in THF (at −78 °C and/or at −30 °C) followed by quenching with D_2O. Only the starting oxathiane was recovered and in quantitative yield. Although some decomposition was observed when the reaction time for formation of the lithiated derivative was too long (40 min instead of 15 min).

Oxathiane **4b**, treated with *s*-BuLi in THF at −78 °C, afforded, after quenching with D_2O, the monodeuterated oxathiane **11b** in quantitative yield, Scheme 4.

Quenching with TMSCl also provided compound **12b** in 43% yield.

Positive nuclear Overhouser effects were observed between the *ortho* protons of the phenyl group and protons H7 and $H3_{axial}$, indicating that the phenyl ring, in **11b** and **12b**, has an *axial* orientation. Therefore, the deuterium atom and the $SiMe_3$ group were introduced in the *equatorial* position.

Assignment of Absolute Configuration at C5′ of Compounds 13cI from 13cII. Assignment of the configuration at C5′ has been done by preparation of compound **13cII** using $LiAlH_4$ reduction of the desired keto-derivative **15**, reaction which is known to proceed through a Cram's approach[9] with entrance of the hydride from the oxygen side, thus providing the *S*-configuration at C5′, Scheme 5.

The keto-derivative **15** was synthesized through condensation of benzonitrile onto lithiated oxathiane **4c** followed by HCl hydrolysis.[10]

Isomer 13cII having the *S*-configuration at C5′ is characterized by a triplet ($^3J_{5-5'} = {}^3J_{5'-OH} = 3.5$ Hz) at 5.01 ppm for H5′ and a doublet ($^3J_{5-5'} = 3.5$ Hz) at 5.17 ppm for H5; while, in **13cI**, H5′ is a double-doublet ($^3J_{5-5'} = 7.5$ Hz, $^3J_{5'-OH} = 2$ Hz) at 4.73 ppm and H5 a doublet ($^3J_{5-5'} = 7.5$ Hz) at 4.98 ppm.

TABLE 2. Diastereoselectivity at C5′ for Oxathiane 4c and/or at C2′ for Oxathianes 1 and 2 (during condensation of carbonyl reagent onto lithiated oxathianes)

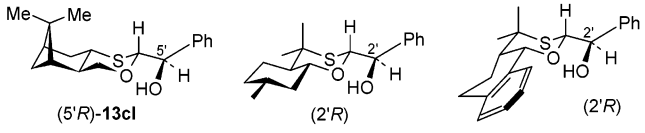
	4c 5′*R*/5′*S*	**1**[a] 2′*R*/2′*S*	**2**[a] 2′*R*/2′*S*
PhCHO	62/38	67/33	70/30
PhCOMe	53/47	70/30	80/20

[a] For **1**, see ref 11; for **2**, see ref 3b.

Discussion and Conclusion

Postulating that condensations of PhCHO and PhCOMe undergo the same stereochemical approach, one can conclude that the *major* diastereomer **I** of **13c** and **14c** has the *R*-configuration at C5′.

The diastereoselectivities observed at C5′ with oxathiane **4c** (62/38 and 53/47) are much smaller compared to those obtained under similar conditions with oxathianes **2**[3] and/or **1**,[11] but the configuration at the carbon undergoing addition for all the *major* isomers is *R* at carbon C5′ or C2′, Table 2.



(9) Ko, K. Y.; Frazee, W. J.; Eliel, E. L. *Tetrahedron* **1984**, *40*, 1333.
(10) Eliel, E. L.; Bai, X.; Abdel-Magid, A. F.; Hutchins, R. O. *J. Org. Chem.* **1990**, *55*, 4951.

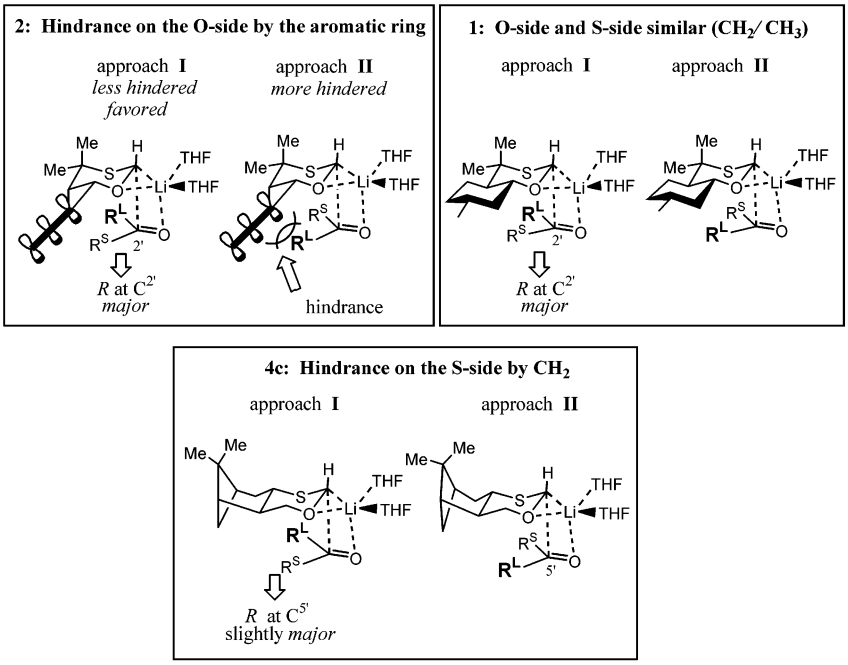
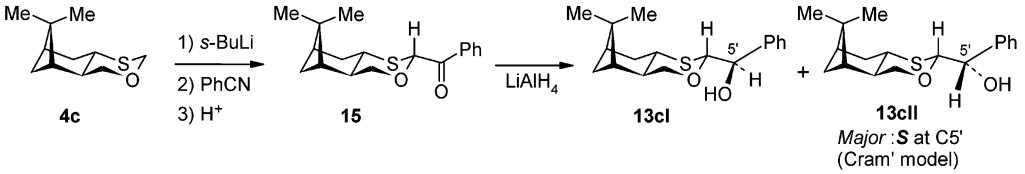


FIGURE 4.

SCHEME 5



Close examination of the models that we proposed recently[3] shows that, in lithiated oxathiane **2**, the oxygen side is significantly more hindered than the sulfur side (because of the aromatic ring and of the folding of the molecule), causing approach **I** (with the large group R^L away from the concave part of the molecule) to be favored over approach **II** , Figure 4.

In lithiated oxathiane **1,** the O-side and S-side are similarly hindered (with an *equatorial* Me on the S-side versus an *equatorial* CH_2 on the O-side) and should provide low enantioselectivities, which is not the case. With the propensity of lithium (in carbanions) to interact more with an oxygen present in the molecule than with the carbanion-carbon being well-known, at least in the solid state,[12] and its propensity to link to a sulfur atom being weaker,[13] one can reasonably postulate that the lithium atom in lithiated oxathianes interacts both with the carbon and the oxygen, Figure 5, and is shifted toward the O-side, making the hindrance at this side

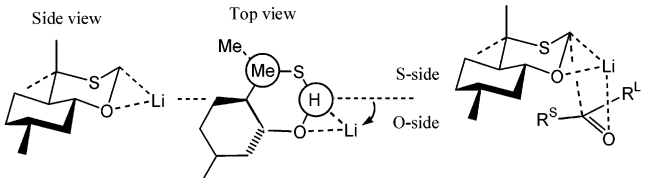


FIGURE 5.

closer and therefore more effective, leading in oxathiane **1** to an increase of the contribution of approach **I** compared to approach **II** and a larger diastereoselectivity as observed.

In oxathiane **4c** the S-side is more hindered than the O-side (with a CH_2 *equatorial* on the S-side versus a H *equatorial* on the O-side), and approach **II** should be favored. The *R* preference, but with a low diastereoselectivity, is consistent with the hypothesis of a shift of the lithium toward the O-side and a smaller than expected influence of the hindrance located on the S-side on the diastereoselectivity.

In conclusion, 2-methyl- and 2-phenyl-substituted oxathianes **4a** and **4b** have been synthesized in satisfying yields. Lithiation of 2-methyl-substituted **4a** could not be done (*n*-BuLi or *s*-BuLi), although lithiation of 2-phenyl-substituted **4b** and nonsubstituted **4c** have been successfully performed with *s*-BuLi. Quenching with D_2O, TMSCl, and/or a carbonyl compound always provides the

(11) Eliel, E. L.; Morris-Natschke, S. *J. Am. Chem. Soc.* **1984**, *106*, 2937.

(12) In the crystal of lithiosulfones and lithiosulfoxides the lithium was found to be linked to the oxygen atom, see: Gais, H. J.; Lindner, H. J.; Vollhardt, J. *Angew. Chem., Int. Ed. Engl.* **1985**, *24*, 859 and Boche, G.; Marsch, M.; Harms, K.; Sheldrick, G. M. *Angew. Chem., Int. Ed. Engl.* **1985**, *24*, 573.

(13) In lithiated thioethers, dimerization may occur through a (Li−C−Li−C) four-membered ring or through a (Li−C−S−Li−C) six-membered ring, see: Amstutz, R.; Laube, T.; Schweizer, W. B.; Seebach, D.; Dunitz, J. D. *Helv. Chim. Acta* **1984**, *67*, 224.

C5 *equatorial* products (deuterium, $SiMe_3$, $CR^1(OH)R^2$ are introduced in the *equatorial* orientation), consistent with a preferred *equatorial* orientation of the lithium in the lithiated derivatives.[14,15]

A model is proposed to rationalize the diastereoselectivities observed at C5′ during reaction of aldehydes with lithiated oxathianes. The model is based on the hypothesis that the lithium, being linked simultaneously to the carbon and the oxygen, is shifted toward the oxygen side, making the steric hindrance of this side more effective.

Moreover, dimeric side products were observed in all cases (oxathianes **4a**−**c**) during condensation of various aldehydes (CH_2O, RCHO) with the starting hydroxythiol, which was not observed in the case of other oxathianes such as **1**, **2,** and **3**.

Experimental Section

Commercially available reagents were used without further purification; all solvents were dried and distilled before use. 1D proton and ^{13}C NMR, recorded at 300 MHz for ^1H and 75 MHz for ^{13}C, were referenced to solvent (7.26/77.0 for $CDCl_3$); 2D experiments (COSY and NOESY) were recorded at 400 MHz. Mass spectra were run by EI ionization (70 eV). Rotation were determined at room temperature. All characteristics of the starting hydroxythiol **7** were identical to the literature values.[2]

Cyclization of 7 with Aldehydes. A solution of hydroxythiol **7**-*trans (*3.2 mmol, 1 equiv), the desired aldehyde (3.5 mmol, 1.1 equiv), and *p*-TsOH (0.16 mmol, 0.05 equiv) in benzene (30 mL) was stirred at the desired temperature under an argon atmosphere (reflux for 30 min for paraformaldehyde; at room temperature for 4.5 h for acetaldehyde; at room temperature for 2 h for benzaldehyde). The solution was stirred with anhydrous K_2CO_3 overnight, filtered, and concentrated. The crude product was purified by flash chromatography over silica gel pretreated with 5% Et_3N and using a hexane:ether mixture (40:1) as the eluent.

4a: Colorless oil; $[\alpha]^{20}_D = -63.0$ ($CHCl_3$, $c = 1$). ^1H NMR ($CDCl_3$) δ: 1.01 (1H, d, $J = 9.5$ Hz, H^{11ax}), 1.14 (3H, s, Me), 1.26 (3H, s, Me), 1.50 (3H, d, $J = 6$ Hz, Me), 1.72 (1H, dd, $J = 12.5$ Hz, $J = 10$ Hz, H^{8ax}), 1.81 (1H, t, $J = 6$ Hz, H^1), 2.10 (1H, q, $J = 6$ Hz, H^9), 2.34 (1H, dddd, $J = 12.5$ Hz, $J = 10$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.41 (1H, dt, $J = J = 10$ Hz, $J = 3$ Hz, H^2), 2.60 (1H, dtd, $J = 9.5$ Hz, $J = J = 6$ Hz, $J = 2$ Hz, H^{11eq}), 3.60 (1H, t, $J = 10$ Hz, H^{3ax}), 3.75 (1H, q, $J = 10$ Hz, H^7), 3.97 (1H, dd, $J = 10$ Hz, $J = 3$ Hz, H^{3eq}), 4.99 (1H, q, $J = 6$ Hz, H^5). ^{13}C NMR ($CDCl_3$) δ: 21.8 (Me), 24.5 (Me), 29.7 (Me), 33.5 (CH_2), 39.0 (C), 39.6 (CH_2), 41.4 (CH), 43.3 (CH), 45.8 (CH), 51.4 (CH), 76.2 (CH_2O), 82.4 (OCHS). Anal. Calcd for $C_{12}H_{20}OS$: C, 67.87; H, 9.49. Found: C, 68.00; H, 9.25.

8a: White solid; mp 113−115 °C. $[\alpha]^{20}_D = +219$ ($CHCl_3$, $c = 1$). 1/1 mixture of **8aI** and **8aII**: ^1H NMR ($CDCl_3$) δ 1.00 (3H, s, Me), 1.01 (3H, s, Me), 1.02 (3H, s, Me), 1.03 (1H, d, $J = 9.5$ Hz), 1.07 (3H, s, Me), 1.10 (1H, d, $J = 9.5$ Hz), 1.16 (2H, d, $J = 9.5$ Hz), 1.22 (12H, s, 4·Me), 1.28 (6H, d, $J = 5.5$ Hz), 1.29 (6H, d, $J = 5.5$ Hz), 1.64 (6H, d, $J = 7$ Hz, 2·Me), 1.66 (6H, d, $J = 7$ Hz, 2·Me), 1.90−2.20 (15H, m), 2.32 (1H, ddt, $J = 7$ Hz, $J = J = 5$ Hz, $J = 2$ Hz), 2.38−2.59 (8H, m), 3.41 (1H, ddd, $J = 10$ Hz, $J = 7$ Hz, $J = 5.5$ Hz), 3.46−3.57 (4H, m), 3.60−3.75 (5H, m), 3.87 (1H, t, $J = 5$ Hz), 3.89 (1H, dd, $J = 5.5$ Hz, $J = 4.5$ Hz), 4.17 (1H, q, $J = 5.5$ Hz, SCHS), 4.26 (1H, q, $J = 5.5$ Hz, SCHS), 4.64 (1H, q, $J = 5.5$ Hz, OCHO), 4.66 (1H, q, $J = 5.5$ Hz, OCHO). ^{13}C NMR ($CDCl_3$) δ: 19.5 (Me), 19.6 (Me), 24.3 (Me), 24.5 (Me), 24.9 (Me), 25.1 (Me), 25.3 (Me), 27.9 (Me), 28.1 (Me), 28.2 (Me), 28.3 (Me), 33.5 (CH_2), 33.6 (CH), 34.2 (CH_2), 34.8 (CH_2), 35.0 (CH), 35.8 (CH_2), 37.4 (CH), 37.9 (CH), 38.0 (CH_2), 38.1 (CH_2), 40.0 (CH_2), 41.6 (CH_2), 42.3 (CH), 42.5 (CH), 43.0 (CH), 46.3 (CH), 46.48 (CH), 46.52 (SCHS), 46.8 (SCHS), 47.2 (CH), 47.4 (CH), 49.4 (CH), 51.0 (CH), 51.4 (CH), 52.2 (CH), 67.6 (CH_2O), 68.5 (CH_2O), 68.8 (CH_2O), 69.6 (CH_2O), 99.0 ($O-CH_2-O$), 99.1 ($O-CH_2-O$). MS: $M^+ = 424$.

9a: Colorless oil; $[\alpha]^{20} = +224$ ($CHCl_3$, $c = 1$). ^1H NMR ($CDCl_3$) δ: 0.97 (3H, s, Me), 0.98 (3H, s, Me), 1.13 (2H, d, $J = 10$ Hz), 1.21 (6H, s, 2·Me), 1.66 (3H, d, $J = 7$ Hz, Me), 2.00 (2H, m), 2.06−2.22 (6H, m), 2.43 (4H, m), 2.55 (2H, dddd, $J = 13$ Hz, $J = 9.5$ Hz, $J = 3$ Hz, $J = 2$ Hz), 3.30 (2H, ddd, $J = 9.5$ Hz, $J = 7.5$ Hz, $J = 5.5$ Hz), 3.63 (2H, m), 3.79 (2H, dt, $J = 10.5$ Hz, $J = J = 8$ Hz), 4.16 (1H, q, $J = 7$ Hz). ^{13}C NMR ($CDCl_3$) δ: 24.0 (Me), 24.1 (Me), 24.6 (Me), 27.83 (Me), 27.86 (Me), 33.27 (CH_2), 33.29 (CH_2), 36.1 (CH), 37.0 (CH), 38.6 (CH_2), 38.8 (C), 40.0 (CH_2), 42.45 (CH), 42.46 (CH), 44.1 (CH), 44.2 (CH), 45.7 (SCHS), 52.2 (CH), 53.0 (CH), 67.30 (CH_2), 67.35 (CH_2). MS: $M^+ = 398$

4b: White solid, mp 74−76 °C. $[\alpha]^{20}_D = -36$ ($CHCl_3$, $c = 1$). ^1H NMR ($CDCl_3$) δ: 1.08 (1H, d, $J = 9.5$ Hz, H^{11ax}), 1.22 (3H, s, Me), 1.31 (3H, s, Me), 1.78 (1H, dd, $J = 13$ Hz, $J = 10$ Hz, H^{8ax}), 1.89 (1H, t, $J = 6$ Hz, H^1), 2.10 (1H, q, $J = J = J = 6$ Hz, H^9), 2.40 (1H, dddd, $J = 13$ Hz, $J = 10$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.64 (2H, m), 3.80 (1H, t, $J = 11$ Hz, H^{3ax}), 3.96 (1H, q, $J = 10$ Hz, H^7), 4.17 (1H, dd, $J = 11$ Hz, $J = 3$ Hz, H^{3eq}), 5.95 (1H, s, H^5), 7.29−7.39 (3H, m), 7.49 (2H, dd, $J = 8$ Hz, $J = 2$ Hz). ^{13}C NMR ($CDCl_3$) δ: 24.6 (Me), 29.7 (Me), 33.4 (CH_2), 39.0 (C), 39.6 (CH_2), 42.4 (CH), 43.5 (CH), 45.9 (CH), 51.5 (CH), 76.7 (CH_2O), 87.7 (OCHS), 126.2 (CH), 128.4 (CH), 128.4 (CH), 139.2 (C). Anal. Calcd for $C_{17}H_{22}OS$: C, 74.41; H, 8.08. Found: C, 74.24; H, 8.00.

9b: Colorless oil. $[\alpha]^{20}_D = +102$ ($CHCl_3$, $c = 1$). ^1H NMR ($CDCl_3$) δ: 0.81 (3H, s, Me), 0.95 (3H, s, Me), 1.09 (1H, d, $J = 10$ Hz), 1.14 (1H, d, $J = 10$ Hz), 1.18 (3H, s, Me), 1.20 (3H, s, Me), 1.91−2.19 (8H, m), 2.40 (4H, m), 2.65 (2H, bs, OH), 2.81 (1H, ddd, $J = 9.5$ Hz, $J = 7$ Hz, $J = 5.5$ Hz), 3.22 (1H, ddd, $J = 9.5$ Hz, $J = 7.5$ Hz, $J = 5.5$ Hz), 3.43 (1H, dd, $J = 10.5$ Hz, $J = 7.5$ Hz), 3.59 (2H, dd, $^3J = 10$ Hz, $^3J = 7$ Hz), 3.72 (1H, dd, $J = 10.5$ Hz, $J = 7$ Hz), 5.18 (1H, s), 7.22−7.35 (3H, m, H^{Ph}), 7.47 (2H, d, $J = 8$ Hz, H^{Ph}). ^{13}C NMR ($CDCl_3$) δ: 23.4 (Me), 23.5 (Me), 27.45 (Me), 27.49 (Me), 32.4 (CH_2), 32.7 (CH_2), 37.1 (CH), 37.4 (CH_2), 37.7 (CH), 37.9 (CH_2), 38.2 (C), 38.3 (C), 41.7 (CH), 41.9 (CH), 43.3 (CH), 43.4 (CH), 51.9 (SCHS), 52.8 (CH), 53.0 (CH), 66.3 (CH_2), 66.5 (CH_2), 127.6 (CH), 127.9 (CH), 128.5 (CH), 140.4 (C). MS: $M^+ = 460$.

4c: Colorless oil; $[\alpha]^{20}_D = -26.4$ ($c = 1.4$, $CHCl_3$). ^1H NMR ($CDCl_3$) δ: 1.03 (1H, d, $J = 10$ Hz, H^{11ax}), 1.17 (3H, s, Me), 1.27 (3H, s, Me), 1.73 (1H, ddd, $J = 13$ Hz, $J = 10$ Hz, $J = 1.5$ Hz, H^{8ax}), 1.78 (1H, t, $J = 6$ Hz, H^1), 2.11 (1H, dq, $J = 6$ Hz, $J = 1.5$ Hz, H^9), 2.36 (1H, dddd, $J = 13$ Hz, $J = 10$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.51 (1H, ddd, $J = 11$ Hz, $J = 10$ Hz, $J = 3$ Hz, H^2), 2.59 (1H, dtd, $J = 10$ Hz, $J = J = 6$ Hz, $J = 2$ Hz, H^{11eq}), 3.60 (1H, t, $J = 11$ Hz, H^{3ax}), 3.73 (1H, q, $J = 10$ Hz, H^7), 3.96 (1H, dd, $J = 11$ Hz, $J = 3$ Hz, H^{3eq}), 4.95 (2H, AB system, $J_{AB} = 12$ Hz, $\Delta\nu_{AB} = 7$ Hz, H^5). ^{13}C NMR ($CDCl_3$) δ: 24.5 (C^{12}), 29.6 (C^{13}), 33.6 (C^8), 39.1 (C^{10}), 39.6 (C^{11}), 42.1 (C^7), 43.5 (C^1), 46.2 (C^9), 52.5 (C^2), 74.0 (C^5), 76.6 (C^3).

8c: White solid, mp 130−132 °C, $[\alpha]^{20}_D = +427.6$ ($CHCl_3$, $c = 1$). ^1H NMR ($CDCl_3$) δ: 1.01 (6H, s, 2×Me), 1.05 (2H, d, $J = 9.5$ Hz, 2·H^{6ax}), 1.21 (6H, s, 2·Me), 1.96 (4H, m), 2.05 (4H, m), 2.48 (4H, m), 3.52 (2H, dd, $J = 9.5$ Hz, $J = 3.5$ Hz, 2·$H^{2'eq}$), 3.77 (2H, dt, $J = J = 9.5$ Hz, $J = 6$ Hz, 2·H^3), 3.78 (2H, s, SCH_2S), 3.90 (2H, dd, $J = 9.5$ Hz, $J = 3.5$ Hz, 2×$H^{2'ax}$), 4.55 (2H, s, OCH_2O). ^{13}C NMR ($CDCl_3$) δ: 24.5 (Me), 28.1 (Me), 32.9 (CH), 33.4 (SCH_2S), 35.5 (CH_2), 37.2 (CH_2), 38.7 (C), 42.3 (CH), 47.3 (CH), 49.3 (CH), 70.1 (CH_2O), 93.8 (OCH_2O). MS: $M^+ = 396$.

10: Colorless oil. ^1H NMR and ^{13}C NMR ($CDCl_3$) identical to literature.[2]

Typical Procedure for the Lithiation of 1,3-Oxathianes. To a solution of the desired 1,3-oxathiane (0.227 mmol, 1 equiv) in 1 mL of anhydrous THF was added a 0.8 M cyclohexane

(14) Eliel, E. L.; Koskimies, J. K.; Lohri, B. *J. Am. Chem. Soc.* **1978**, *100*, 1614.

(15) Lehn, J. M.; Wipff, G. *J. Am. Chem. Soc.* **1976**, *98*, 7489.

solution of *s*-BuLi (0.295 mmol, 1.3 equiv) at −78 °C under an argon atmosphere. After being stirred for 40 min at −78 °C, the quenching is done.

Quenching of 4b-Li and 4c-Li with D2O. D_2O (1 mL) was added dropwise, and the bath was removed. The resulting mixture was extracted with ether to give **11b** (100%, colorless oil) and/or **11c** (100%, colorless oil). ^{1}H NMR analysis of both compounds indicated quantitative incorporation of deuterium at C-5.

11b: Colorless oil. $[\alpha]^{20}_D = -127$ ($CHCl_3$, $c = 1$). ^{1}H NMR ($CDCl_3$) δ: 1.05 (3H, s, Me), 1.10 (1H, d, $J = 9.5$ Hz, H^{11ax}), 1.25 (3H, s, Me), 1.81 (1H, ddd, $J = 13.5$ Hz, $J = 10$ Hz, $J = 1.5$ Hz, H^{8ax}), 1.85 (1H, t, $J = 6$ Hz, H^1), 2.10 (1H, dq, $J = J = J = 6$ Hz, $J = 1.5$ Hz, H^9), 2.34 (1H, dddd, $J = 13.5$ Hz, $J = 9$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.61 (1H, dtd, $J = 9.5$ Hz, $J = J = 6$ Hz, $J = 2$ Hz, H^{11eq}), 2.87 (1H, ddd, $J = 12$ Hz, $J = 11$ Hz, $J = 6$ Hz, H^2), 3.78 (1H, dd, $J = 12$ Hz, $J = 11$ Hz, H^{3ax}), 3.95 (2H, m, $H^7 + H^{3eq}$), 5.95 (1H, s, H^5), 7.28−7.40 (3H, m), 7.56 (2H, m). ^{13}C NMR ($CDCl_3$) δ: 23.7 (Me), 29.4 (Me), 32.9 (CH_2), 34.4 (CH), 38.6 (CH_2), 39.0 (C), 43.3 (CH), 44.1 (CH), 48.4 (CH), 70.2 (CH_2O), 79.5 (t, CD), 126.8 (CH), 128.1 (CH), 128.4 (CH), 139.6 (CH).

11c: Colorless oil. $[\alpha]^{20}_D = -9.8$ ($CHCl_3$, $c = 1$). ^{1}H NMR ($CDCl_3$) δ: 1.04 (1H, d, $J = 10$ Hz, H^{11ax}), 1.17 (3H, s, Me), 1.27 (3H, s, Me), 1.77 (2H, m, $H^{8ax} + H^1$), 2.12 (1H, dq, $J = 6$ Hz, $J = 1.5$ Hz, H^9), 2.37 (1H, dddd, $J = 13$ Hz, $J = 9$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.51 (1H, dt, $J = J = 10$ Hz, $J = 3$ Hz, H^2), 2.60 (1H, dtd, $J = 10$ Hz, $J = J = 6$ Hz, $J = 2$ Hz, H^{11eq}), 3.60 (1H, t, $J = 10$ Hz, H^{3ax}), 3.73 (1H, dt, $J = J = 10$ Hz, $J = 9$ Hz, H^7), 3.97 (1H, dd, $J = 10$ Hz, $J = 3$ Hz, H^{3eq}), 4.96 (1H, s, H^5). ^{13}C NMR ($CDCl_3$) δ: 24.4 (Me), 29.6 (Me), 33.6 (CH_2), 39.0 (C), 39.5 (CH_2), 42.0 (CH), 43.4 (CH), 46.1 (CH), 52.4 (CH), 73.7 (t, $J_{CD} = 24$ Hz, CHD), 76.5 (CH_2O).

Quenching of 4b-Li and 4c-Li with TMSCl. Trimethylsilyl chloride (0.413 mmol, 1.3 equiv) was added dropwise. After 80 min, aqueous Na_2CO_3 was added and the resulting mixture was extracted with ether to give **12b** (43%), which was separated from starting **4b** (52%) by flash chromatography using a hexane:ether (19:1) mixture as eluent and/or **12c** (99%, pure by ^{1}H NMR, colorless oil, no purification).

12b: Colorless oil. $[\alpha]^{20}_D = -134$ ($CHCl_3$, $c = 1$). ^{1}H NMR ($CDCl_3$) δ: 0.01 (9H, s, CH_3Si), 0.70 (3H, s, Me), 1.04 (1H, d, $J = 10$ Hz, H^{11ax}), 1.15 (3H, s, Me), 1.66 (2H, m, $H^{8ax} + H^1$), 2.10 (1H, dq, $J = J = J = 6$ Hz, $J = 1$ Hz, H^9), 2.14 (1H, dddd, $J = 13$ Hz, $J = 8.5$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.53 (1H, dtd, $J = 10$ Hz, $J = J = 6$ Hz, $J = 2$ Hz, H^{11eq}), 2.58 (1H, td, $J = J = 10$ Hz, $J = 3$ Hz, H^2), 3.42 (1H, td, $J = 10$ Hz, $J = 8.5$ Hz, H^7), 3.65 (1H, dd, $J = 11$ Hz, $J = 3.5$ Hz, H^{3eq}), 3.84 (1H, dd, $J = 11$ Hz, $J = 10$ Hz, H^{3ax}), 7.19 (1H, tt, $J = 7.5$ Hz, $J = 1.5$ Hz), 7.35 (2H, t, $J = 7.5$ Hz), 7.55 (2H, d, $J = 7.5$ Hz). ^{13}C NMR ($CDCl_3$) δ: −3.6 (Me_3Si), 24.4 (Me), 30.0 (Me), 34.1 (CH_2), 36.6 (CH), 39.8 (CH_2), 38.9 (C), 44.0 (CH), 46.6 (CH), 52.8 (CH), 70.2 (CH_2O), 87.8 (O−C−S), 126.3 (CH), 128.2 (CH), 128.6 (CH), 141.6 (CH).

12c: Colorless oil. $[\alpha]^{20}_D = -42$ ($CHCl_3$, $c = 1$). ^{1}H NMR ($CDCl_3$) δ: 0.11 (9H, s, Me_3Si), 1.04 (1H, d, $J = 9.5$ Hz, H^{11ax}), 1.16 (3H, s, Me), 1.25 (3H, s, Me), 1.73 (2H, m, $H^{8ax} + H^1$), 2.10 (1H, qd, $J = J = J = 6$ Hz, $J = 1$ Hz, H^9), 2.35 (1H, dddd, $J = 13$ Hz, $J = 8.5$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.48 (1H, dt, $J = J = 10$ Hz, $J = 3$ Hz, H^2), 2.58 (1H, dtd, $J = 9.5$ Hz, $J = J = 6$ Hz, $J = 2$ Hz, H^{11eq}), 3.55 (1H, t, $J = 10$ Hz, H^{3ax}), 3.76 (1H, dt, $J = J = 10$ Hz, $J = 8.5$ Hz, H^7), 3.98 (1H, dd, $J = 10$ Hz, $J = 3$ Hz, H^{3eq}), 4.78 (1H, s, H^5). ^{13}C NMR ($CDCl_3$) δ: −3.6 (Me_3Si), 24.4 (Me), 29.7 (Me), 33.9 (CH_2), 39.0 (C), 39.6 (CH_2), 43.6 (CH), 43.8 (CH), 46.4 (CH), 51.7 (CH), 78.7 (CH_2O), 81.5 (CH).

Quenching of 4c-Li with Carbonyl Compounds. The desired carbonyl compound (1.5 equiv) was added dropwise to **4c**-Li prepared as described above. After 2 h of stirring, the reaction mixture was quenched with aqueous NH_4Cl and extracted with ether. The joined organic phases were dried over Na_2SO_4 and concentrated under vacuum. The crude product (94% conversion) was purified by flash chromatography and provided the following: **13c** (86%, colorless oil, mixture of two diastereoisomers 62:38) using a gradient hexane:ether mixture (9:1→3:1) as eluent and/or **14c** (76%, colorless oil, mixture of two diastereoisomers. 53:47) using an hexane:ether (9:1) mixture as eluent.

13c: Colorless oil. **13cI** (62%): ^{1}H NMR ($CDCl_3$) δ: 1.00 (1H, d, $J = 9.5$ Hz, H^{11ax}), 1.11 (3H, s, Me), 1.26 (3H, s, Me), 1.69 (1H, ddd, $J = 13$ Hz, $J = 11$ Hz, $J = 1$ Hz, H^{8ax}), 1.83 (1H, t, $J = 6$ Hz, H^1), 2.08 (1H, dq, $J = J = J = 6$ Hz, $J = 1$ Hz, H^9), 2.26 (1H, dddd, $J = 13$ Hz, $J = 8.5$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.44 (1H, dt, $J = J = 10.5$ Hz, $J = 3$ Hz, H^2), 2.59 (1H, dtd, $J = 10$ Hz, $J = J = 6$ Hz, $J = 2$ Hz, H^{11eq}), 3.13 (1H, d, $J = 2.5$ Hz, OH), 3.65 (1H, dt, $J = J = 10.5$ Hz, $J = 8.5$ Hz, H^7), 3.68 (1H, t, $J = 10.5$ Hz, H^{3ax}), 4.10 (1H, dd, $J = 10.5$ Hz, $J = 3$ Hz, H^{3eq}), 4.73 (1H, dd, $J = 7.5$ Hz, $J = 2.5$ Hz, $H^{5'}$), 4.98 (1H, d, $J = 7.5$ Hz, H^5), 7.30−7.45 (5H, m). ^{13}C NMR ($CDCl_3$) δ: 24.5 (Me), 29.6 (Me), 33.5 (CH_2), 39.5 (CH_2), 39.0 (C), 41.2 (CH), 43.4 (CH), 45.7 (CH), 51.5 (CH), 76.4 (CH), 76.2 (CH_2), 89.9 (CH), 127.1 (CH), 128.4 (CH), 128.6 (CH), 138.9 (C). IR (neat): 3390 (OH) cm^{-1}.

13cII (38%): ^{1}H NMR ($CDCl_3$) δ: 1.08 (1H, d, $J = 9.5$ Hz, H^{11ax}), 1.11 (3H, s, Me), 1.25 (3H, s, Me), 1.70 (1H, ddd, $J = 13$ Hz, $J = 11$ Hz, $J = 1$ Hz, H^{8ax}), 1.81 (1H, t, $J = 6$ Hz, H^1), 2.08 (1H, dq, $J = J = J = 6$ Hz, $J = 1$ Hz, H^9), 2.27 (1H, dddd, $J = 13$ Hz, $J = 8.5$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.44 (1H, dt, $J = J = 11$ Hz, $J = 3$ Hz, H^2), 2.58 (1H, dtd, $J = 9.5$ Hz, $J = J = 6$ Hz, $J = 2$ Hz, H^{11eq}), 2.78 (1H, d, $J = 3.5$ Hz, OH), 3.64 (1H, dt, $J = J = 11$ Hz, $J = 8.5$ Hz, H^7), 3.69 (1H, t, $J = 11$ Hz, H^{3ax}), 4.06 (1H, dd, $J = 11$ Hz, $J = 3$ Hz, H^{3eq}), 5.01 (1H, t, $J = 3.5$ Hz, $H^{5'}$), 5.17 (1H, d, $J = 3.5$ Hz, H^5), 7.30−7.45 (5H, m, H^{Ph}). ^{13}C NMR ($CDCl_3$) δ: 24.5 (Me), 29.6 (Me), 33.6 (CH_2), 39.0 (CH_2), 39.4 (C), 40.8 (CH), 43.4 (CH), 45.7 (CH), 51.5 (CH), 75.3 (CH), 76.4 (CH_2), 90.8 (CH), 126.3 (CH), 128.0 (CH), 128.2 (CH), 139.0 (C). IR (neat): 3390 (OH) cm^{-1}. Anal. Calcd for $C_{18}H_{24}O_2S$: C, 71.01; H, 7.95. Found: C, 71.26; H, 8.06.

14c: Colorless oil. **14cI** (53%): ^{1}H NMR ($CDCl_3$) δ: 0.98 (1H, d, $J = 9.5$ Hz, H^{11ax}), 1.10 (3H, s, Me), 1.25 (3H, s, Me), 1.65 (3H, s, Me), 1.61 (1H, m, H^{8ax}), 1.81 (1H, t, $J = 6$ Hz, H^1), 2.07 (1H, dq, $J = J = J = 6$ Hz, $J = 1$ Hz, H^9), 2.27 (1H, m, H^{8eq}), 2.42 (1H, dt, $J = J = 11$ Hz, $J = 3$ Hz, H^2), 2.58 (1H, m, H^{11eq}), 2.92 (1H, s, OH), 3.65 (2H, m, $H^{3ax} + H^7$), 4.09 (1H, dd, $J = 11$ Hz, $J = 3$ Hz, H^{3eq}), 5.11 (1H, s, H^5), 7.27−7.39 (3H, m), 7.48−7.53 (2H, m). ^{13}C NMR ($CDCl_3$) δ: 24.7 (Me), 27.3 (Me), 29.6 (Me), 33.54 (CH_2), 39.1 (C), 39.4 (CH_2), 40.9 (CH), 43.36 (CH), 45.6 (CH), 51.3 (CH), 75.8 (CH_2O), 76.5 (C−OH), 93.4 (OCHS), 125.3 (CH), 127.3 (CH), 128.00 (CH), 143.8 (C); IR: (neat) 3500 (OH) cm^{-1}.

14cII (47%): ^{1}H NMR ($CDCl_3$) δ: 1.01 (1H, d, $J = 9.5$ Hz, H^{11ax}), 1.11 (3H, s, Me), 1.25 (3H, s, Me), 1.66 (3H, s, Me), 1.65 (1H, m, H^{8ax}), 1.80 (1H, t, $J = 6$ Hz, H^1), 2.09 (1H, dq, $J = J = J = 6$ Hz, $J = 1$ Hz, H^9), 2.27 (1H, m, H^{8eq}), 2.39 (1H, dt, $J = J = 11$ Hz, $J = 3$ Hz, H^2), 2.58 (1H, m, H^{11eq}), 3.07 (1H, s, OH), 3.65 (2H, m, $H^{3ax} + H^7$), 4.03 (1H, dd, $J = 11$ Hz, $J = 3$ Hz, H^{3eq}), 5.05 (1H, s, H^5), 7.27−7.39 (3H, m), 7.48−7.53 (2H, m). ^{13}C NMR ($CDCl_3$) δ: 24.4 (Me), 27.3 (Me), 29.6 (Me), 33.50 (CH_2), 39.1 (C), 39.5 (CH_2), 41.1 (CH), 43.39 (CH), 45.7 (CH), 51.5 (CH), 75.9 (CH_2O), 77.2 (C−OH), 93.7 (OCHS), 125.7 (CH), 127.4 (CH), 128.02 (CH), 144.2 (C). IR (neat): 3500 (OH) cm^{-1}.

Preparation of 15. To oxathiane **4c** (0.43 mmol, 1 equiv) in dry THF (1.7 mL) under argon at −78 °C was added dropwise (through a syringe) a solution of *s*-BuLi 0.5 M in cyclohexane (0.56 mmol, 1.3 equiv). After stirring for 40 min, PhCN (0.56 mmol, 1.3 equiv) was added dropwise, and stirring was maintained for 45 min at −78 °C. Then a 2 M HCl solution (1 mL) was added, and the mixture was stirred briefly at room temperature until two clear phases appeared. The organic layer was separated, and the aqueous layer was extracted with diethyl ether. The combined organic solutions were washed with water, dried over Na_2SO_4, and concentrated under

vacuum. Purification by column chromatography using a hexane:ether mixture (5:1) as the eluent gave the desired ketone **15** (30%).

15: Colorless oil. $[\alpha]^{20}_D = -44.8$ ($CHCl_3$, $c = 1$). ^1H NMR ($CDCl_3$) δ: 1.07 (1H, d, $J = 10$ Hz, H^{11ax}), 1.22 (3H, s, Me), 1.30 (3H, s, Me), 1.80 (1H, ddd, $J = 13$ Hz, $J = 10.5$ Hz, $J = 1$ Hz, H^{8ax}), 1.88 (1H, t, $J = 6$ Hz, H^1), 2.16 (1H, qd, $J = 6$ Hz, $J = 1$ Hz, H^9), 2.41 (1H, dddd, $J = 13$ Hz, $J = 9$ Hz, $J = 6$ Hz, $J = 2$ Hz, H^{8eq}), 2.64 (2H, m, $H^2 + H^{11eq}$), 3.80 (1H, t, $J = 11$ Hz, H^{3ax}), 3.99 (1H, td, $J = J = 10.5$ Hz, $J = 9$ Hz, H^7), 4.22 (1H, dd, $J = 11$ Hz, $J = 3$ Hz, H^{3eq}), 6.21 (1H, s, H^5), 7.46 (2H, t, $J = 8$ Hz), 7.60 (1H, tt, $J = 7.5$ Hz, $J = 1$ Hz), 8.11 (2H, dd, $J = 8$ Hz, $J = 1$ Hz). ^{13}C NMR ($CDCl_3$) δ: 24.6 (Me), 29.5 (Me), 33.4 (CH_2), 39.0 (C), 39.5 (CH_2), 42.6 (CH), 43.4 (CH), 45.7 (CH), 51.2 (CH), 76.4 (CH_2O), 87.0 (O−C−S), 128.4 (CH), 129.5 (CH), 133.7 (CH), 133.8 (C). IR (neat): 1694 (CO) cm^{-1}. Anal. Calcd for $C_{18}H_{22}O_2S$: C, 71.49; H, 7.33. Found: C, 71.31; H, 7.49.

Reduction of 15. A well-stirred solution of **15** (0.07 mmol, 1 equiv) in 1 mL of dry THF under argon was treated with $LiAlH_4$ (0.14 mmol, 2 equiv) at −78 °C. After stirring for 2 h at the same temperature, the excess reducing agent was quenched at −78 °C with saturated aqueous NH_4Cl solution. The mixture was extracted with diethyl ether; the joined organic phases were dried over Na_2SO_4 and concentrated under vacuum to afford **13c** (99%, colorless oil) as a mixture of **13cII** (95%) and **13cI** (5%).

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Supporting Information Available: 1D and 2D (COSY and NOESY) ^1H and ^{13}C spectra of all new compounds; X-ray crystallographic data. This material is available free of charge via the Internet at http://pubs.acs.org.

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