C–C Coupling with Sulfur-Stabilized Carbanions, 9[+] Reaction of the Carbanions of 2-(Alkylthio)thiolane 1-Oxides with Oxiranes

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Carbanions of the 2-(alkylthio)thiolane 1-oxides **1** and **2** are generated and subjected to reaction with the epoxides **3–5**. The resulting carbinols **6–11** are formed with high α diastereoselectivity, which is explained by a stabilization of the *trans* configuration of the carbanions in the activated complex. A minor γ stereoselectivity is also observed in case of the reactions with **4** and **5**. The pure enantiomers (1*S*,2*S*,2′*S*)-**9a** and (1*R*,2*R*,2′*S*)-**11b** were obtained from **2** and (*S*)-**4** or (*R*)-**5**, respectively, and their configurations were proved by X-ray structural analyses.

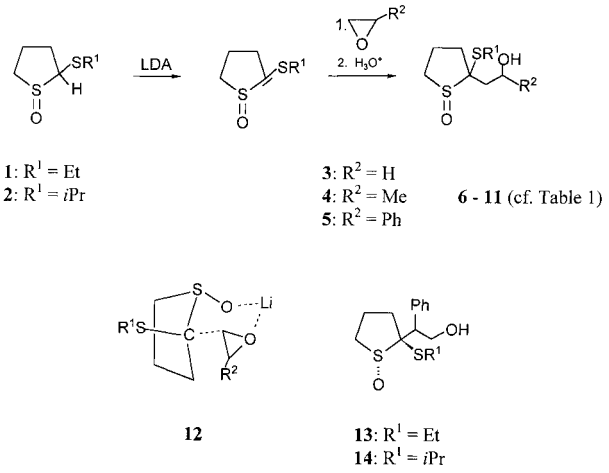
In continuation of our investigations on the reactions of the carbanions of 2-(alkylthio)thiolanes[2] and especially 2-(alkylthio)thiolane 1-oxides[3] with carbon electrophiles such as haloalkanes, carbonyl compounds, and nitriles we have studied the corresponding reactions with epoxides. We were interested in the regioselectivity of the ring-opening reaction to form carbinols and, in particular, the stereoselectivity during the course of the reaction with the sulfinyl carbanions.

We chose 2-(ethylthio)- (**1**) and 2-(isopropylthio)thiolane 1-oxide (**2**) as starting compounds, which can be conveniently prepared from 2-bromothiolane 1-oxide and the corresponding potassium alkanethiolate.[3] Both sulfoxides are readily obtained as the pure *trans* diastereoisomers and were used in this stereochemically well-defined form.

Deprotonation of **1** and **2** was achieved by use of lithium diisopropylamide in tetrahydrofuran and the carbinols **6**−**11** were formed after reaction with the epoxides **3**−**5** according to Scheme 1.

Whereas simple sulfinyl carbanions react smoothly with epoxides[4] the carbanions of **1** and **2** turned out to be considerably more persistent, i.e. less reactive. Only unsubstituted oxirane **3** was reactive enough to attack the carbanions below or at room temperature. In the case of methyl- (**4**) and phenyloxirane (**5**) heating to reflux was necessary to achieve satisfactory yields. Cyclohexene epoxide was totally unreactive even under these conditions. Attempts to enhance the reactivity of **4** and **5** by adding hexamethylphosphoric triamide as a cosolvent[5] or ceric ammonium nitrate, which has proved to be an effective catalyst for nucleophilic ring opening reactions of epoxides,[6] were unsuccessful.

The *trans* diastereoisomers **6a** and **7a** were formed almost exclusively during the reaction with **3**. Only 1−2% of the



Scheme 1

cis diastereoisomers, **6b** and **7b,** were detected by gas chromatography and could be separated from the mixtures by column chromatography. Pronounced diastereoselectivity was also observed for the reaction of carbonyl compounds, e.g. acetone, with the carbanions of **1** and **2**.[3] We explain the high α diastereoselectivity of the reaction by assuming a six-membered cyclic transition state **12** with a chair conformation including the complexed lithium cation,[3][7] in which the carbanion exhibits the thermodynamically most stable *trans* configuration. The attack of the epoxide occurs, therefore, under stereochemical control. As a result, the products **6a** and **7a** are obtained predominantly as the *trans* isomers. This structure is in agreement with the NMR spectra of **6a** and **7a**. The assignment is further corroborated by unequivocal evidence from the X-ray structural analyses of **9a** and **11b** (see below) and corresponds with results which we have obtained for the adduct of butane-2,3-dione[8] or the Michael adduct of butenone[9] with 2-lithio-2-(methylthio)thiolane 1-oxide.

The situation is more complicated in the case of the reactions with propene oxide (**4**) and styrene oxide (**5**) since two different regioisomers and four diastereoisomers (Scheme 2) may be expected as reaction products.

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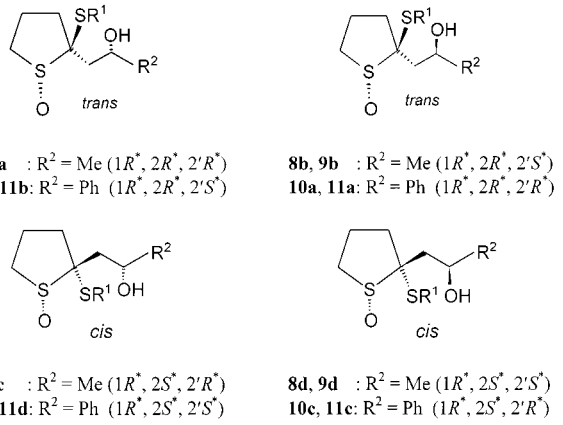

Scheme 2. Relative configuration of the four diastereoisomers of **8**−**11**

NMR signals of the *trans* stereoisomers **10a**, **10b**, **11a**, and **11b** relative to those of the *cis* isomers **10c**, **10d**, **11c**, and **11d**.

The diastereoisomeric ratios of **8**−**11** are smaller than for **6** and **7**. Due to the elevated temperatures applied during the reactions of **4** and **5**, the stability of the transition state **12** and hence the stereocontrol are decreased. The preponderance of the *trans* diastereoisomers is more significant for the isopropylthio derivatives **9** (16.2:1) and **11** (7.3:1) than for the ethylthio derivatives **8** (9.7:1) and **10** (3.9:1). This difference should be due to the bulkiness of the isopropylthio group. There are also small but significant differences in the yields of the two possible *trans* and *cis* isomers. This γ diastereoselectivity can be explained by slightly preferred orientations in the corresponding transition states.

In order to prove the geometrical structures of the carbinols unequivocally, we have performed reactions between

Table 1. Yields (%) of the isolated products, *trans*-(1*R**,2*R**)-**6a**, and -**7a** and *cis*-(1*R**,2*S**) diastereoisomers **6b** and **7b** and the four diastereoisomers (Scheme 2) of **8**−**11**

Compound	R^1	R^2	Relative configuration (1*R**,2*R**,2′*R**)	(1*R**,2*R**,2′*S**)	(1*R**,2*S**,2′*R**)	(1*R**,2*S**,2′*S**)
6	Et	H	82		1	
7	*i*Pr	H	78		2	
8	Et	Me	38	49	5	4
rac-**9**	*i*Pr	Me	35	46	3	2
(2′*S*)-**9**[a]	*i*Pr	Me	25[b]	29	3	2
10[c]	Et	Ph	37	21	9	6
rac-**11**[c]	*i*Pr	Ph	26	18	3	3
(2′*S*)-**11**[a]	*i*Pr	Ph	25	18[b]	3	2

[a] Mixture of the pure (2′*S*) enantiomers obtained from pure (*S*)-**4** and (*R*)-**5**, respectively (cf. text and Experimental Section). − [b] X-ray structural analyses were performed with the enantiomers (1*S*,2*S*,2′*S*)-**9a** and (1*R*,2*R*,2′*S*)-**11b**. − [c] Along with 9% of **13** or 5% of **14**, respectively.

In practice, however, propene oxide (**4**) was attacked exclusively at the unsubstituted carbon atom, which is the regular behaviour of monosubstituted epoxides on nucleophilic cleavage[4][10]. Table 1 shows the results.

The carbinols **8** and **9** were obtained as mixtures of the four diastereoisomers, which could be separated by column chromatography.[11] Their structures were established by ^{1}H-NMR spectroscopy. Due to the *cis* orientation of the sulfoxide and the side-chain CH_2 group in the *trans* isomers **8a**, **8b** and **9b** the CH_2 protons come under the influence of the anisotropy of the sulfoxide oxygen atom and exhibit, therefore, downfield shifts of 0.2−0.3 ppm relative to those of the corresponding *cis* isomers **8c**, **8d**, and **9d**. The two *trans* isomers were each formed as predominant products with a slight excess of one isomer in each pair. The two *cis* diastereomers were found as minor by-products.

Trace amounts of the unusual regioisomers **13** and **14** were observed besides the major products **10** and **11** when styrene oxide (**5**) was the electrophile. Again, the four diastereoisomers of **10** and **11** (Scheme 2) were formed. The diastereoisomeric ratios are similar as for **8** and **9** but the predominance of the *trans* over the *cis* isomers of **10** and **11** is less pronounced (Table 1). As in the case of **8** and **9** the anisotropy effect of the sulfoxide oxygen atom causes significant downfield shifts for the side-chain CH_2-proton racemic **2** and enantiomerically pure (*S*)-**4** and (*R*)-**5**. The mixtures of diastereoisomers were separated by column chromatography and each one of the two *trans* isomers, **9a** and **11b** according to their NMR spectra, could be isolated in crystalline form. Suitable single crystals were grown and X-ray analyses were performed which confirmed their structure (Figure 1 and 2).[12] As expected, in both compounds the S−O bonds are quasi-axial with respect to the thiolane ring, which exhibits the usual semi-chair conformation with angles of 32.0° (**9a**) and 14.6° (**11b**) between the C2−S1−C5 and the C2−C3−C4−C5 planes.

Interestingly, the carbinols **9a** and **11b** do not exhibit intramolecular hydrogen bonds between the hydroxy group and the sulfur or sulfoxide oxygen acceptor atoms. Instead, nearly linear intermolecular O−H···O=S hydrogen bonds with OH−O distances of 217 pm (**9a**) and 276 pm (**11b**) and OH−O angles of 170° (**9a**) and 173° (**11b**) are observed in the crystal.[8] The bridging protons can be well localized in the structure, which is also evidence for their fixed position.

Conclusions

The carbanions formed by deprotonation of 2-(alkylthio)thiolane 1-oxides react with oxirane (**3**), methyloxirane

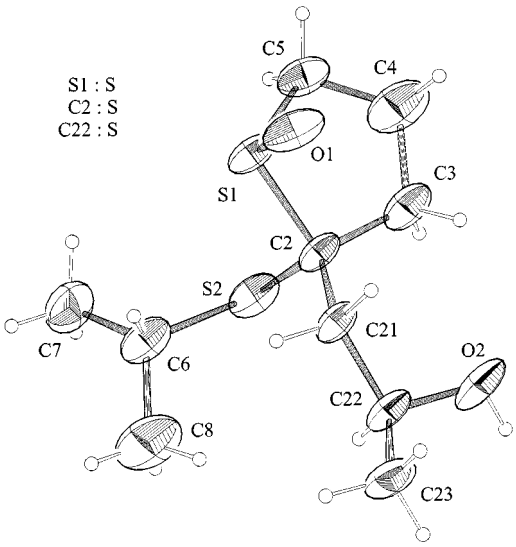

Figure 1. Structure of (1*S*,2*S*,2′*S*)-**9a** (ORTEP plot); selected bond lengths [pm], angles [°], and torsional angles [°]: S1−O1 149.9(5), S1−C2 185.8(6), S1−C5 179.8(8), S2−C2 181.0(6), S2−C6 183.6(7); C2−S1−C5 91.0(3), O1−S1−C2 106.3(3), O1−S1−C5 106.4(3), S1−C2−S2 106.1(3), S1−C2−C21 107.9(4), S2−C2−C3 107.0(4), C2−S2−C6 106.6(3); O1−S1−C5−C4 73.1(7), O1−S1−C2−S2 167.2(3), O1−S1−C2−C3 −79.8(5)

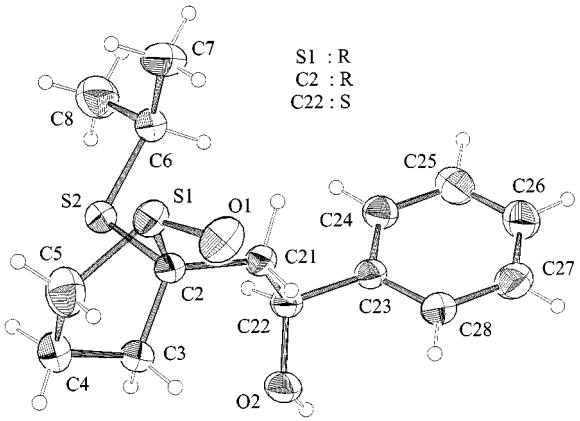

Figure 2. Structure of (1*R*,2*R*,2′*S*)-**11b** (ORTEP plot); selected bond lengths [pm], angles [°], and torsional angles [°]: S1−O1 148.7(2), S1−C2 187.5(3), S1−C5 182.3(5), S2−C2 182.1(3), S2−C6 182.1(3); C2−S1−C5 92.1(2), O1−S1−C2 108.9(1), O1−S1−C5 106.0(2), S1−C2−S2 105.0(1), S1−C2−C21 108.4(2), S2−C2−C3 107.0(2), C2−S2−C6 108.2(1); O1−S1−C5−C4 −110.0(4), O1−S1−C2−S2 −164.4(1), O1−S1−C2−C3 83.4(2)

(**4**), and phenyloxirane (**5**) to form carbinols with good yields. Regioselective ring opening of **4** and **5** occurs and the secondary carbinols **8**−**11** are obtained almost exclusively. The products are formed with pronounced α diastereoselectivity, i.e. the carbanions exhibit considerable configurational stability. Chiral induction (γ diastereoselectivity), is also observed although only to a small extent. X-ray structural analyses of the two pure enantiomers (1*S*,2*S*,2′*S*)-**9a** and (1*R*,2*R*,2′*S*)-**11b** obtained from (*S*)-**4** and (*R*)-**5** reveal the assignments of the stereoisomers.

Experimental Section

General: M.p. (corrected): Electrothermal melting point apparatus. − IR: Genesis ATI-Mattson. − NMR: Bruker WM 400 (400 MHz and 100.6 MHz, for ^{1}H and ^{13}C, respectively), Bruker AC 250 P (62.9 MHz, for ^{13}C); $CDCl_3$ and [D$_6$]DMSO as solvents, TMS as internal standard. The ^{13}C signals were assigned on the basis of DEPT spectra. − MS: Varian CH7 (70 eV). − HRMS: VG-Analytical 70−2050S. − GC: Carlo Erba CE4200 (SE54 column, 25m, FID, carrier gas: He). − Elemental analyses: Microanalytical laboratory, Institute of Organic Chemistry, Univ. Hamburg, Germany.

***trans*-2-(Ethylthio)thiolane 1-Oxide (1), *trans*-2-(Isopropylthio)thiolane 1-Oxide (2)**: Prepared as previously described.[3]

General Procedure for the Reactions of 1 and 2 with Epoxides: The reaction was carried out under nitrogen. A solution of 1.1 equivalents dry diisopropylamine in dry THF was cooled to −30°C and 1.1 equivalents of *n*-butyllithium (15% in hexane) were added. The mixture was stirred for 30 min and 1 equivalent of **1** or **2** was added. After stirring for 3 h at −30°C, 1.0 equivalent of the epoxide was added at −78°C. In the case of **3** the solution was slowly warmed to room temperature for about 12 h, otherwise it was refluxed for 1 h. Addition of methanol and concentration to dryness gave a residue which was dissolved in water and extracted with dichloromethane. The organic phase was dried with Na_2SO_4 and concentrated in vacuo. The crude products were purified and the diastereomers separated by column chromatography (silica gel, ethyl acetate, R_F values given for ethyl acetate).

2-(Ethylthio)-2-(2-hydroxyethyl)thiolane 1-Oxide (6): 300 mg (1.83 mmol) of **1**, 30 ml of THF, 192 mg (1.90 mmol) of diisopropylamine, 840 mg (1.92 mmol) of *n*-butyllithium (15% in hexane), 3 ml of liquified **3** gave 316 mg (1.52 mmol, 83%) of **6**. The *trans*/*cis* isomers **6a** and **6b** were obtained in a ratio of 62.0:1.0 (26.1:1.0 by GC).

6a: 311 mg, yellow-brown liquid, R_f = 0.05. − IR (Film): $\tilde{\nu}$ = 3353 cm^{-1} (OH), 2936, 2873, 2250, 2124, 1717, 1152, 1134, 1056, 1029 (S=O), 1010, 890, 822, 759, 687, 574. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.15 (t, ^3J = 7.35 Hz, 3 H, CH_3), 1.91−2.14 (m, 4 H, 3-H, 4-H, CH_2CH$_2$OH), 2.25−2.36 (m, 2 H, 3-H, 4-H), 2.29−2.56 (m, 1 H, 5-H), 2.58 (dq, ^2J_d = 11.75 Hz, ^3J_q = 7.56 Hz, 1 H, CH_2CH$_3$), 2.64 (dq, ^2J_d = 11.72 Hz, ^3J_q = 7.51 Hz, 1 H, CH_2CH$_3$), 3.52 (ddd, ^2J = 13.93 Hz, ^3J = 9.26 Hz, ^3J = 4.64 Hz, 1 H, 5-H), 3.62 (dt, ^2J_d = 10.72 Hz, ^3J_t = 7.50 Hz, 1 H, CH_2OH), 3.71−3.73 (m, 1 H, CH_2OH), 4.20−4.80 (bs, 1 H, OH). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 14.59 (+, CH_3), 22.99 (−, *C*H$_2$CH$_3$), 25.39 (−, C-4), 33.59 (−, *C*H$_2$CH$_2$OH), 36.62 (−, C-3), 53.10 (−, C-5), 57.54 (+, CH_2OH), 76.38 (0, C-2). − MS (70 eV); *m*/*z* (%): 208 (0.03) [M$^+$], 190 (14) [M$^+$ − H_2O], 147 (26), 129 (25), 117 (15) [$C_5H_9OS^+$], 87 (10) [$C_4H_7S^+$], 84 (77) [$C_4H_4S^+$], 67 (20), 66 (100), 59 (21), 46 (22). − HRMS [M$^+$ − H_2O] ($C_8H_{14}OS_2$): calcd. 190.0486; found 190.0477.

6b: 5 mg, yellow oil, R_f = 0.19. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.15 (t, ^3J = 7.46 Hz, 3 H, CH_3), 2.60 (dq, ^2J_d = 11.71 Hz, ^3J_q = 7.44 Hz, 1 H, CH_2CH$_3$), 2.69 (dq, ^2J_d = 11.69 Hz, ^3J_q = 7.41 Hz, 1 H, CH_2CH$_3$), 3.55 (ddd, ^2J = 13.85 Hz, ^3J = 4.86 Hz, ^3J = 9.26 Hz, 1 H, 5-H), 4.20 (ddd, ^2J = 11.08 Hz, ^3J = 6.78 Hz, ^3J = 7.61 Hz, 1 H, CH_2OH), 4.37 (ddd, ^2J = 11.10 Hz, ^3J = 5.82 Hz, ^3J = 7.76 Hz, 1 H, CH_2OH), only a few signals could be identified in the spectrum of a mixture of **6a** and **6b**. − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 14.08 (+, CH_3), 22.51 (−, *C*H$_2$CH$_3$), 24.88 (−, C-4), 29.25 (−, *C*H$_2$-CH$_2$OH), 36.06 (−, C-3), 52.86 (−, C-5), 60.24 (+, CH_2OH), 75.42 (0, C-2).

2-(2-Hydroxyethyl)-2-(isopropylthio)thiolane 1-Oxide (7): 300 mg (1.68 mmol) of **2**, 30 ml of THF, 187 mg (1.85 mmol) of diisopropylamine, 814 mg (1.86 mmol) of *n*-butyllithium (15% in hexane), 3 ml of liquified **3** gave 330 mg (1.50 mmol, 89%) of **7**. The *trans*/*cis* isomers **7a** and **7b** were obtained in a ratio of 54.0:1.0 (26.1:1.0 by GC).

7a: 324 mg, yellow liquid, R_f = 0.02. − IR (film): $\tilde{\nu}$ = 3372 cm^{-1} (OH), 2960, 2928, 2868, 1718, 1484, 1456, 1246, 1050, 1029 (S=O), 466. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.24 [d, ^3J = 7.31 Hz, 3 H, CH(CH_3)$_2$], 1.26 [d, ^3J = 7.44 Hz, 3 H, CH (CH_3)$_2$], 1.92−2.16 (m, 4 H, CH_2, 3-H, 4-H), 2.24−2.37 (m, 2 H, 3-H, 4-H), 2.49−2.59 (m, 1 H, 5-H), 3.12 [sept, ^3J = 6.77 Hz, 1 H, CH(CH$_3$)$_2$], 3.52 (ddd, ^2J = 13.61 Hz, ^3J = 4.34 Hz, ^3J = 9.45 Hz, 1 H, 5-H), 3.63 (dt, ^2J_d = 10.49 Hz, ^3J_t = 7.38 Hz, 1 H, CH_2OH), 3.72−3.80 (m, 1 H, CH_2OH), 4.10−4.70 (br. s, 1 H, OH). − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 24.43 [+, CH(*C*H$_3$)$_2$], 24.77 (−, C-4), 25.91 [+, CH(*C*H$_3$)$_2$], 33.36 (−, CH_2), 33.81 [+, *C*H(CH$_3$)$_2$], 36.39 (−, C-3), 52.32 (−, C-5), 57.25 (+, CH_2OH), 76.91 (0, C-2). − MS (70 eV); *m*/*z* (%): 222 (0.04) [M^+], 204 (14) [$M^+ - H_2O$], 147 (34), 129 (42), 117 (26) [$C_5H_9OS^+$], 99 (56), 87 (56) [$C_4H_7S^+$], 84 (73) [$C_4H_4S^+$], 76 (22), 67 (24), 66 (100), 59 (32), 46 (23), 45 (36). − HRMS [$M^+ - H_2O$] ($C_9H_{16}OS_2$): calcd. 204.0643; found 204.0631.

7b: 6 mg, yellow oil, R_f = 0.18. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 4.23 (dt, ^2J_d = 11.09 Hz, ^3J_t = 7.18 Hz, 1 H, CH_2OH), 4.36 (ddd, ^2J = 11.03 Hz, ^3J = 7.63 Hz, ^3J = 6.10 Hz, 1 H, CH_2OH), only the low-field signals of the diastereotopic CH_2OH group could be identified in the spectrum of a mixture of **7a** and **7b**. − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 24.40 [+, CH(*C*H$_3$)$_2$], 25.98 (−, C-4), 26.02 [+, CH(*C*H$_3$)$_2$], 29.54 (−, *C*H$_2$CH$_2$OH), 33.91 [+, *C*H(CH$_3$)$_2$], 36.30 (−, C-3), 52.57(−, C-5), 60.39 (−, CH_2OH), 76.34 (0, C-2).

2-(Ethylthio)-2-(2-hydroxypropyl)thiolane 1-Oxide (8): 350 mg (2.13 mmol) of **1**, 30 ml of THF, 223 mg (2.20 mmol) of diisopropylamine, 980 mg (2.24 mmol) of *n*-butyllithium (15% in hexane), 128 mg (2.20 mmol) of **4** gave 454 mg (2.04 mmol, 96%) of **8**. The four diastereoisomers were obtained in a ratio of 10.0:12.7:1.4:1.0 [25.3 (**8a** and **8b**):1.5:1.0 by GC].

8a: 180 mg, white waxy solid, m.p. 48°C (mixture with **8b**), R_f = 0.16. − IR (KBr), mixture with **8b**: $\tilde{\nu}$ = 3363 cm^{-1} (OH), 2973, 2965, 2936, 2891, 2877, 1455, 1430, 1412, 1377, 1326, 1309, 1261, 1128, 1072, 1023, 1011 (S=O), 939, 790. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.15 (t, ^3J = 7.50 Hz, 3 H, CH_3), 1.19 (d, ^3J = 6.29 Hz, 3 H, CH_3CHOH), 1.90−1.93 (m, 2 H, CH_2CHOH), 2.03−2.15 (m, 2 H, 4-H), 2.25−2.36 (m, 2 H, 3-H), 2.39−2.60 (m, 3 H, CH_2CH$_3$, 5-H), 3.50−3.59 (m, 1 H, 5-H), 4.03−4.11 (m, 1 H, CHOH), 4.46− 4.59 (br. s, 1 H, OH). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 14.12 (+, CH_3), 22.51 (−, CH_2), 25.16 (+, *C*H$_3$CHOH), 25.29 (−, C-4), 36.34 (−, C-3), 38.99 (−, *C*H$_2$CHOH), 52.70 (−, C-5), 62.26 (+, CHOH), 77.34 (0, C-2). − MS (70 eV), mixture with **8b**; *m*/*z* (%): 204 (4) [$M^+ - H_2O$], 178 (18), 160 (24), 143 (16), 118 (13), 117 (100) [$C_5H_9OS^+$], 115 (77), 101 (21), 99 (34), 97 (27), 87 (18) [$C_4H_9S^+$], 85 (34), 74 (26), 71 (20), 67 (18), 59 (46), 45 (32), 43 (30). − HRMS [$M^+ - H_2O$] ($C_9H_{16}OS_2$), mixture with **8b**: calcd. 204.0628, found 204.0628. − $C_9H_{18}O_2S_2$ (222.4), mixture with **8b**: calcd. C 48.61, H 8.16, S 28.84; found[12] C 47.32, H 8.16, S 26.79.

8b: 230 mg, white waxy solid, m.p. 48°C (mixture with **8a**), R_f = 0.16. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.13 (t, ^3J = 7.50 Hz, 3 H, CH_3), 1.16 (d, ^3J = 6.17 Hz, 3 H, CH_3CHOH), 1.86 (ddd, ^2J = 14.75 Hz, ^3J = 4.89 Hz, 1 H, CH_2CHOH), 2.07 (dd, ^2J = 14.89 Hz, ^3J = 6.75 Hz, 1 H, CH_2CHOH), 1.95−2.13 (m, 2 H, 3-H, 4-H), 2.24−2.35 (m, 2 H, 3-H, 4-H), 2.49−2.60 (m, 1 H, 5-H), 2.67 (dq, ^2J_d = 11.57 Hz, ^3J_q = 7.48 Hz, 1 H, CH_2CH$_3$), 2.75 (dq, ^2J_d = 11.59 Hz, ^3J_q = 7.46 Hz, 1 H, CH_2CH$_3$), 3.54 (ddd, ^2J = 13.86 Hz, ^3J = 4.50 Hz, ^3J = 9.36 Hz, 1 H, 5-H), 4.02 (sext, ^3J = 5.89 Hz, 1 H, CHOH), 4.49−4.59 (br. s, 1 H, OH). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 14.05 (+, CH_3), 22.68 (−, CH_2), 24.70 (−, C-4), 24.81 (+, *C*H$_3$CHOH), 36.28 (−, C-3), 39.91 (−, *C*H$_2$CHOH), 52.82 (−, C-5), 63.56 (+, CHOH), 76.12 (0, C-2).

8c: 26 mg, yellow oil, R_f = 0.09. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.15 (t, ^3J = 7.50 Hz, 3 H, CH_3), 1.16 (d, ^3J = 5.97 Hz, 3 H, *C*H$_3$CHOH), 1.51 (dd, ^2J = 14.75 Hz, ^3J = 8.33 Hz, 1 H, CH_2CHOH), 1.69 (dd, ^2J = 14.91 Hz, ^3J = 4.17 Hz, 1 H, CH_2CHOH), 1.94−2.31 (m, 2 H, 4-H), 2.43−2.48 (m, 2 H, 3-H), 2.52−2.80 (m, 3 H, 5-H, CH_2CH$_3$), 3.35 (ddd, ^2J = 13.98 Hz, ^3J = 5.14 Hz, ^3J = 8.83 Hz, 1 H, 5-H), 4.06−4.14 (m, 1 H, CHOH), 4.57− 4.60 (br. s, 1 H, OH). − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 14.10 (+, CH_3), 22.62 (−, C-4), 23.22 (−, CH_2), 25.32 (+, *C*H$_3$CHOH), 33.52 (−, C-3), 39.72 (−, *C*H$_2$CHOH), 51.78 (−, C-5), 63.36 (+, CHOH), 78.56 (0, C-2). − MS (70 eV); *m*/*z* (%): 204 (0,4) [$M^+ - H_2O$], 178 (20), 160 (12), 143 (14), 118 (16), 117 (100) [$C_5H_9OS^+$], 115 (80), 101 (25), 99 (33), 97 (20), 87 (15) [$C_4H_9S^+$], 85 (34), 74 (27), 71 (22), 67 (22), 59 (54), 45 (56), 43 (32).

8d: 18 mg, yellow oil, R_f = 0.06. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.12 (d, ^3J = 6.23 Hz, 3 H, CH_3CHOH), 1.13 (t, ^3J = 7.44 Hz, 3 H, CH_3), 1.69 (dd, ^2J = 14.91 Hz, ^3J = 4.17 Hz, 1 H, CH_2CHOH), 1.87 (dd, ^2J = 14.91 Hz, ^3J = 6.96 Hz, 1 H, CH_2CHOH), 1.94−2.31 (m, 4 H, 3-H, 4-H), 2.61−2.72 (m, 1 H, 5-H), 2.71 (dq, ^2J_d = 11.34 Hz, ^3J_q = 7.58 Hz, 1 H, CH_2CH$_3$), 2.80 (dq, ^2J_d = 11.41 Hz, ^3J_q = 7.53 Hz, 1 H, CH_2CH$_3$), 3.27 (ddd, ^2J = 13.80 Hz, ^3J = 5.94 Hz, ^3J = 9.03 Hz, 1 H, 5-H), 3.93− 4.02 (m, 1 H, CHOH), 4.57− 4.60 (br. s, 1 H, OH). − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 14.10 (+, CH_3), 22.60 (−, C-4), 22.96 (−, CH_2), 24.90 (+, *C*H$_3$CHOH), 35.13 (−, C-3), 42.83 (−, *C*H$_2$CHOH), 51.13 (−, C-5), 63.29 (+, CHOH), 77.60 (0, C-2). − MS (70 eV); *m*/*z* (%): 204 (2) [$M^+ - H_2O$], 178 (20), 160 (12), 143 (11), 118 (11), 117 (100) [$C_5H_9OS^+$], 115 (83), 101 (24), 99 (31), 97 (20), 87 (16) [$C_4H_9S^+$], 85 (35), 74 (30), 71 (19), 67 (22), 59 (58), 45 (59), 43 (30).

2-(2-Hydroxypropyl)-2-(isopropythio)thiolane 1-Oxide (9): 300 mg (1.68 mmol) of **2**, 30 ml of THF, 187 mg (1.85 mmol) of diisopropylamine, 814 mg (1.86 mmol) of *n*-butyllithium (15% in hexane), 102 mg (1.76 mmol) of *rac*-**4** gave 341 mg (1.44 mmol, 86%) of **9**. The four diastereoisomers were obtained in a ratio of 17.4:23.0:1.3:1.0 [33.0 (**9a** + **9b**):1.3:1.0 by GC].

9a: 139 mg, pale yellow solid, m.p. 85°C, R_f = 0.13. − IR (KBr): $\tilde{\nu}$ = 3322 cm^{-1} (OH), 2964, 2927, 2867, 1459, 1407, 1381, 1245, 1131, 1069, 1049, 1021 (S=O), 994, 969, 626. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.20 [d, ^3J = 6.42 Hz, 3 H, CH(CH_3)$_2$], 1.21 [d, ^3J = 7.24 Hz, 3 H, CH(CH_3)$_2$], 1.25 (d, ^3J = 6.74 Hz, 3 H, CH_3CHOH), 1.83−2.09 (m, 3 H, 4-H, CH_2CHOH), 2.18 (ddd, ^2J = 14.42 Hz, ^3J = 2.02 Hz, ^3J = 6.85 Hz, 1 H, 3-H), 2.24−2.33 (m, 1 H, 4-H), 2.41−2.53 (m, 2 H, 5-H, 3-H), 3.06 [sept, ^3J = 6.79 Hz, 1 H, CH(CH$_3$)$_2$], 3.52 (ddd, ^2J = 14.02 Hz, ^3J = 4.52 Hz, ^3J = 9.63 Hz, 1 H, 5-H), 4.08 (sext, ^3J = 5.74, 1 H, CHOH), 4.40−4.60 (br. s, 1 H, OH). − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 24.61 [+, CH(*C*H$_3$)$_2$], 25.04 (+, *C*H$_3$CHOH), 25.09 (−, C-4), 26.07 [+, CH(*C*H$_3$)$_2$], 33.60 [+, *C*H(CH$_3$)$_2$], 36.50 (−, C-3), 40.12 (−, CH_2), 52.22 (−, C-5), 62.32 (+, CHOH), 78.43 (0, C-2). − MS (70 eV), mixture with **9b**; *m*/*z* (%): 218 (0.4) [$M^+ - H_2O$], 174 (12), 143 (14), 132 (18), 129 (25), 118 (14), 117 (72) [$C_5H_9OS^+$], 111 (11), 101 (29), 99 (35), 97 (32), 76 (15), 75 (21), 71

(13), 67 (12), 59 (21), 45 (59), 43 (100) [$C_3H_7^+$]. − HMRS [$M^+ - H_2O$] ($C_{10}H_{18}OS_2$), mixture with **9b**: calcd. 218.0799; found 218.0802. − $C_{10}H_{20}O_2S_2$ (236.4), mixture with **9b**: calcd. C 50.81, H 8.53, S 27.12; found[12] C 48.99, H 8.47, S 27.06.

9b: 184 mg, yellow oil, R_f = 0.10. − IR (KBr), mixture with **9a**: $\tilde{\nu}$ = 3576 cm^{-1} (OH), 2964, 2928, 2867, 1457, 1409, 1354, 1244, 1131, 1066, 1026 (S=O), 1004, 460. − ^1H NMR (400 MHz, [D$_6$]DMSO): δ = 1.16 (d, ^3J = 6.16 Hz, 3 H, CH_3CHOH), 1.23 [d, ^3J = 6.93 Hz, 3 H, CH(CH_3)$_2$], 1.26 [d, ^3J = 6.67 Hz, 3 H, CH(CH_3)$_2$], 1.92 (dd, ^2J = 14.78 Hz, ^3J = 4.80 Hz, 1 H, CH_2CHOH), 1.92−2.05 (m, 1 H, 4-H), 2.06−2.14 (m, 1 H, 3-H), 2.10 (dd, ^2J = 14.88 Hz, ^3J = 6.74 Hz, 1 H, CH_2CHOH), 2.23−2.36 (m, 2 H, 3-H, 4-H), 2.51−2.57 (m, 1 H, 5-H), 3.27 [sept, ^3J = 6.80 Hz, 1 H, CH(CH$_3$)$_2$], 3.53 (ddd, ^2J = 13.95 Hz, ^3J = 4.15 Hz, ^3J = 9.81 Hz, 1 H, 5-H), 4.01−4.10 (m, 1 H, CHOH), 4.52 (d, ^3J = 5.08 Hz, 1 H, OH). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 24.06 [+, CH(CH_3)$_2$], 24.52 (−, C-4), 24.84 (+, CH_3CHOH), 26.20 [+, CH(CH_3)$_2$], 33.66 [+, CH(CH$_3$)$_2$], 36.46 (−, C-3), 40.30 (−, CH$_2$), 52.48 (−, C-5), 63.47 (+, CHOH), 77.05 (0, C-2).

9c: 10 mg, yellow oil, R_f = 0.08. − ^1H NMR (400 MHz, [D$_6$]DMSO): δ = 1.15 (d, ^3J = 7.06 Hz, 3 H, CH$_3$), 1.21 (d, ^3J = 6.93 Hz, 3 H, CH$_3$), 1.28 (d, ^3J = 6.49 Hz, 3 H, CH$_3$), 4.10−4.17 (m, 1 H, CHOH), 4.61 (d, ^3J = 5.53 Hz, 1 H, OH), only a few characteristic signals could be identified in the spectrum of the mixture of **9c** and **9d**. −^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 22.80 (−, C-4), 24.79 [+, CH(CH_3)$_2$], 25.33 (+, CH_3CHOH), 25.38 [+, CH(CH_3)$_2$], 33.20 [+, CH(CH$_3$)$_2$], 33.91 (−, C-3), 38.84 (−, CH$_2$), 52.21 (−, C-5), 63.26 (+, CHOH), 80.00 (0, C-2). − MS (70 eV), mixture with **9d**; *m/z* (%): 192 (2), 129 (24), 117 (76) [$C_5H_9OS^+$], 101 (36), 99 (40), 87 (38) [$C_4H_7S^+$], 85 (47), 79 (6), 75 (20), 59 (26), 45 (80), 43 (100) [$C_3H_7^+$].

9d: 8 mg, yellow oil, R_f = 0.08. − ^1H NMR (400 MHz, [D$_6$]DMSO): δ = 1.12 (d, ^3J = 6.04 Hz, 3 H, CH$_3$), 1.23 (d, ^3J = 6.87 Hz, 3 H), 1.27 (d, ^3J = 6.67 Hz, 3 H, CH$_3$), 1.65 (dd, ^2J = 15.10 Hz, ^3J = 4.04 Hz, 1 H, CH_2CHOH), 1.83 (dd, ^2J = 15.10 Hz, ^3J = 6.90 Hz, 1 H, CH_2CHOH), 3.95− 4.03 (m, 1 H, CHOH), 4.55 (d, ^3J = 4.83 Hz, 1 H, OH), only a few characteristic signals could be identified in the spectrum of the mixture of **9c** and **9d**. − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 22.60 (−, C-4), 24.26 [+, CH(CH_3)$_2$], 24.98 (+, CH_3CHOH), 25.57 [+, CH(CH_3)$_2$], 33.17 [+, CH(CH$_3$)$_2$], 35.10 (−, C-3), 42.19 (−, CH$_2$), 51.32 (−, C-5), 63.13 (+, CHOH), 78.43 (0, C-2).

(1*S*,2*S*)-2-[(2*S*)-2-Hydroxypropyl]-2-(isopropylthio)thiolane 1-Oxide (9a): 300 mg (1.68 mmol) of **2**, 30 ml of THF, 187 mg (1.85 mmol) of diisopropylamine, 814 mg (1.86 mmol) of *n*-butyllithium (15% in hexane), 102 mg (1.76 mmol) of (*S*)-(−)-**4** (Merck, Darmstadt, Germany) gave 234 mg (0.99 mmol, 59%) of **9**. The four diastereoisomers were obtained in a ratio of 14.3:16.6:1.0:1.6 [40.5 (**9a** + **9b**):1.4:1.0 by GC]. Enantiomerically pure **9a** (NMR spectra identical with the spectra of *rac*-**9a**) was separated from the mixture by column chromatography (SiO_2, ethyl acetate) and a single crystal, m.p. 85°C, suitable for the X-ray analysis was grown from chloroform.

2-(Ethylthio)-2-(2-hydroxy-2-phenylethyl)thiolane 1-Oxide (10): 300 mg (1.83 mmol) of **1**, 30 ml of THF, 184 mg (1.82 mmol) of diisopropylamine, 840 mg (1.92 mmol) of *n*-butyllithium (15% in hexane), 228 mg (1.90 mmol) of *rac*-**5** gave 379 mg (1.33 mmol, 73%) of **10** and 42 mg (9%) of **13**. The four diastereoisomers and the regioisomer **13** were obtained in a ratio of 5.8:3.4:1.4:1:1.4 [3.4 (**10a** + **10b**):1.0 (**10c** + **10d**) by GC].

10a: 169 mg, white-yellow needles, m.p. 102°C, R_f = 0.21. − IR (KBr): $\tilde{\nu}$ = 3337 cm^{-1} (OH), 2975, 2936, 2878, 1492, 1450, 1426, 1413, 1362, 1323, 1307, 1086, 1059, 1036, 1002 (S=O), 751, 705, 651, 558. − ^1H NMR (400 MHz, [D$_6$]DMSO): δ = 1.19 (t, ^3J = 7.47 Hz, 3 H, CH$_3$), 1.69−1.76 (m, 1 H, 3-H), 1.84−2.00 (m, 2 H, 3-H, 4-H), 2.16 (dd, ^2J = 14.72 Hz, ^3J = 5.89 Hz, 1 H, CH$_2$), 2.14−2.22 (m, 1 H, 4-H), 2.35 (dd, ^2J = 14.77 Hz, ^3J = 6.73 Hz, 1 H, CH$_2$), 2.48 (ddd, ^2J = 14.21 Hz, ^3J = 5.80 Hz, ^3J = 8.12 Hz, 1 H, 5-H), 2.68 (dq, ^2J_d = 11.60 Hz, ^3J_q = 7.49 Hz, 1 H, CH_2CH$_3$), 2.82 (dq, ^2J_d = 11.62 Hz, ^3J_q = 7.45 Hz, 1 H, CH_2CH$_3$), 3.51 (ddd, ^2J = 13.90 Hz, ^3J = 4.79 Hz, ^3J = 9.03 Hz, 1 H, 5-H), 4.95 (t, ^3J = 6.24 Hz, 1 H, CHOH), 5.29−5.36 (br. s, 1 H, OH), 7.23−7.28 (m, 1 H, Ar-H), 7.31−7.40 (m, 4 H, Ar-H). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 14.08 (+, CH$_3$), 22.61 (−, CH$_2$), 24.65 (−, C-4), 35.86 (−, C-3), 39.70 (−, CH_2COH), 52.70 (−, C-5), 70.01 (+, CHOH), 75.84 (0, C-2), 125.28 (+, C$_{ar}$), 127.09 (+, C$_{ar}$), 128.03 (+, C$_{ar}$), 146.74 (0, C-1′$_{ar}$). − MS (70 eV); *m/z* (%): 266 (2) [$M^+ - H_2O$], 178 (45) [$C_7H_{14}OS_2^+$], 160 (45), 141 (32), 133 (30), 117 (100) [$C_5H_9OS^+$], 115 (67), 107 (65), 105 (62), 101 (25), 99 (26), 87 (29) [$C_4H_7S^+$], 85 (21), 79 (58), 77 (75) [$C_6H_5^+$], 59 (29), 51 (20). − MS (CI with NH$_3$); *m/z* (%): 285 (54) [M^+ + 1], 267 (100) [$M^+ + 1 - H_2O$], 249 (22), 205 (24), 189 (50), 179 (20), 161 (30), 101 (30). − $C_{14}H_{20}O_2S_2$ (284.4): calcd. C 59.12, H 7.09, S 22.54; found[12] C 58.17, H 7.13, S 22.45.

10b: 98 mg, white needles, m.p. 132−134°C, R_f = 0.25. − IR (KBr): $\tilde{\nu}$ = 3343 cm^{-1} (OH), 2977, 2953, 2936, 2926, 2880, 1451, 1433, 1416, 1350, 1319, 1091, 1064, 1044, 1018 (S=O), 757, 704, 533. − ^1H NMR (400 MHz, [D$_6$]DMSO): δ = 1.15 (t, ^3J = 7.36 Hz, 3 H, CH$_3$), 1.96−2.08 (m, 2 H, 4-H, CH$_2$), 2.15 (dd, ^2J = 14.91 Hz, ^3J = 9.66 Hz, 1 H, CH$_2$), 2.31 (ddd, ^2J = 14.34 Hz, ^3J = 2.82 Hz, ^3J = 6.67 Hz, 1 H, 3-H), 2.31−2.40 (m, 1 H, 4-H), 2.59 (q, ^3J = 7.19 Hz, 2 H, CH_2CH$_3$), 2.51−2.65 (m, 2 H, 3-H, 5-H), 3.55 (ddd, ^2J = 13.93 Hz, ^3J = 4.71 Hz, ^3J = 9.22 Hz, 1 H, 5-H), 4.99 (ddd, ^3J(CH$_2$) = 2.23 Hz, ^3J(OH) = 5.07 Hz, ^3J(CH$_2$) = 9.60 Hz, 1 H, CHOH), 5.37 (d, ^3J = 5.05 Hz, 1 H, OH), 7.22−7.27 (m, 1 H, Ar-H), 7.32−7.40 (m, 4 H, Ar-H). − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 14.08 (+, CH$_3$), 22.60 (−, CH$_2$), 25.43 (−, C-4), 36.67 (−, C-3), 40.27 (−, CH_2COH), 52.69 (−, C-5), 68.61 (+, CHOH), 77.30 (0, C-2), 125.53 (+, C$_{ar}$), 126.83 (+, C$_{ar}$), 128.08 (+, C$_{ar}$), 146.50 (0, C-1′$_{ar}$). − MS (70 eV); *m/z* (%): 266 (3) [$M^+ - H_2O$], 178 (37) [$C_7H_{14}OS_2^+$], 117 (100) [$C_5H_9OS^+$], 115 (70), 107 (37), 85 (25), 79 (56), 77 (50) [$C_6H_5^+$], 59 (20). − MS (CI with NH$_3$); *m/z* (%): 285 (38) [M^+ + 1], 267 (100) [$M^+ + 1 - H_2O$], 249 (26), 205 (32), 189 (78), 179 (24), 161 (42), 101 (42). − $C_{14}H_{20}O_2S_2$ (284.4): calcd. C 59.12, H 7.09, S 22.54; found C 58.90, H 7.11, S 22,59.

10c: 41 mg, pale yellow oil, R_f = 0.16. − IR (film): $\tilde{\nu}$ = 3426 cm^{-1} (OH), 2940, 2927, 2252, 2132, 1657, 1052, 1027 (S=O), 1008, 824, 761. − ^1H NMR (400 MHz, [D$_6$]DMSO): δ = 1.17 (t, ^3J = 7.47 Hz, 3 H, CH$_3$), 1.78 (dd, ^2J = 14.92 Hz, ^3J = 2.91 Hz, 1 H, CH$_2$), 1.84 (dd, ^2J = 14.89 Hz, ^3J = 8.30 Hz, 1 H, CH$_2$), 2.06−2.31 (m, 3 H, 3-H, 4-H), 2.58−2.72 (m, 2 H, 3-H, 5-H), 2.70 (q, ^3J = 7.49 Hz, 2 H, CH_2CH$_3$), 3.37 (ddd, ^2J = 14.14 Hz, ^3J = 5.30 Hz, ^3J = 8.92 Hz, 1 H, 5-H), 5.05 (dd, ^3J = 8.09 Hz, ^3J = 2.85 Hz, 1 H, CHOH), 5.41 (br. s, 1 H, OH), 7.21−7.28 (m, 1 H, Ar-H), 7.29−7.42 (m, 4 H, Ar-H). − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 14.05 (+, CH$_3$), 22.79 (−, CH$_2$), 23.56 (−, C-4), 34.05 (−, C-3), 40.58 (−, CH_2COH), 51.71 (−, C-5), 69.74 (+, CHOH), 79.46 (0, C-2), 125.47 (+, C$_{ar}$), 126.84 (+, C$_{ar}$), 128.10 (+, C$_{ar}$), 146.37 (0, C-1′$_{ar}$). − MS (70 eV); *m/z* (%): 266 (2) [$M^+ - H_2O$], 205 (10), 178 (24) [$C_7H_{14}OS_2^+$], 160 (19), 141 (24), 117 (94) [$C_5H_9OS^+$], 115 (80), 105 (56), 99 (22), 87 (18) [$C_4H_7S^+$], 85 (32), 79 (90), 77 (100) [$C_6H_5^+$], 59 (32), 51 (34).

10d: 29 mg, colorless oil, R_f = 0.16. − IR (film): $\tilde{\nu}$ = 3419 cm^{-1} (OH), 2965, 2910, 2875, 2254, 2126, 1658, 1453, 1056, 1028 (S=O), 1009, 822, 759, 709. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.18 (t, ^3J = 7.47 Hz, 3 H, CH_3), 1.70 (ddd, ^2J = 12.91 Hz, ^3J = 4.61 Hz, ^3J = 6.81 Hz, 1 H, 3-H), 1.74−1.82 (m, 1 H, 4-H), 1.91−2.00 (m, 1 H, 3-H), 1.95 (dd, ^2J = 14.91 Hz, ^3J = 5.18 Hz, 1 H, CH_2), 2.00−2.15 (m, 1 H, 4-H), 2.14 (dd, ^2J = 14.78 Hz, ^3J = 6.90 Hz, 1 H, CH_2), 2.62 (ddd, ^2J = 13.94 Hz, ^3J = 5.17 Hz, ^3J = 8.73 Hz, 1 H, 5-H), 2.75 (dq, ^2J_d = 11.47 Hz, ^3J_q = 7.39 Hz, 1 H, CH_2CH$_3$), 2.84 (dq, ^2J_d = 11.45 Hz, ^3J_q = 7.53 Hz, 1 H, CH_2CH$_3$), 3.29 (ddd, ^2J = 13.86 Hz, ^3J = 5.94 Hz, ^3J = 9.10 Hz, 1 H, 5-H), 4.91 [dt, ^3J_t(CH$_2$,OH) = 4.71 Hz, ^3J_d(CH$_2$) = 6.63 Hz, 1 H, C*H*OH], 5.36 (d, ^3J = 4.26 Hz, 1 H, OH), 7.22−7.27 (m, 1 H, Ar-H), 7.30−7.39 (m, 4 H, Ar-H). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 14.37 (+, CH_3), 22.95 (−, C-4), 23.06 (−, CH_2), 34.76 (−, C-3), 42.75 (−, *C*H$_2$COH), 51.36 (−, C-5), 70.04 (+, CHOH), 77.94 (0, C-2), 125.45 (+, C_{ar}), 127.42 (+, C_{ar}), 128.34 (+, C_{ar}), 145.85 (0, C-1′$_{ar}$). − MS (70 eV); *m*/*z* (%): 266 (0.56) [M^+ − H_2O], 160 (36), 141 (39), 131 (23), 117 (48) [$C_5H_9OS^+$], 115 (56), 107 (49), 106 (41), 99 (33), 97 (32), 87 (21) [$C_4H_7S^+$], 79 (46), 77 (100) [$C_6H_5^+$], 71 (20), 62 (20), 59 (28), 51 (20), 45 (38), 40 (94).

2-(Ethylthio)-2-(2-hydroxy-1-phenylethyl)thiolan 1-Oxide (13): 42 mg, white solid, m.p. 122°C, R_f = 0.15. − IR (KBr): $\tilde{\nu}$ = 3341 cm^{-1} (OH), 2971, 2953, 2891, 2860, 1454, 1437, 1304, 1255, 1084, 1068, 1034, 1006, 995 (S=O), 713, 694, 638, 514. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.05 (t, ^3J = 7.47 Hz, 3 H, CH_3), 1.47 (dd, ^2J = 14.02 Hz, ^3J = 6.46 Hz, 1 H, 3-H), 1.79−1.92 (m, 1 H, 4-H), 2.15−2.24 (m, 1 H, 4-H), 2.24−2.37 (m, 1 H, 3-H), 2.31 (dq, ^2J_d = 11.09 Hz, ^3J_d = 7.53 Hz, 1 H, CH_2CH$_3$), 2.48 (dq, ^2J_d = 11.10 Hz, ^3J_q = 7.37 Hz, 1 H, CH_2CH$_3$), 2.60−2.83 (m, 1 H, 5-H), 3.32 (t, ^3J = 7.25 Hz, 1 H, C*H*Ph), 3.61 (ddd, ^2J = 14.29 Hz, ^3J = 4.24 Hz, ^3J = *1*0.16 Hz, 1 H, 5-H), 3.96 [dd, ^3J(OH) = 5.21 Hz, ^3J(CH) = 7.25 Hz, 2 H, CH_2OH], 4.75 (t, ^3J = 5.19 Hz, 1 H, OH), 7.24−7.35 (m, 1 H, Ar-H), 7.43−7.48 (m, 4 H, Ar-H). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 14.15 (+, CH_3), 23.24 (−, CH_2), 23.62 (−, C-4), 36.58 (−, C-3), 50.12 (+, *C*HPh), 53.24 (−, C-5), 62.49 (−, CH_2OH), 79.73 (0, C-2), 127.06 (+, C_{ar}), 128.00 (+, C_{ar}), 129.41 (+, C_{ar}), 139.01 (0, C-1′$_{ar}$). − MS (70 eV); *m*/*z* (%): 284 (4) [M^+], 266 (10) [M^+ − H_2O], 223 (34) [$C_{12}H_{15}O_2S^+$], 205 (60) [$C_{12}H_{13}OS^+$], 193 (84), 173 (51), 147 (52), 141 (67), 129 (75), 117 (32) [$C_5H_9OS^+$], 115 (83), 107 (49), 103 (100) [$C_4H_7OS^+$], 91 (76), 87 (48) [$C_4H_7S^+$], 77 (49), [$C_6H_5^+$], 45 (60).

2-(2-Hydroxy-2-phenylethyl)-2-(isopropylthio)thiolane 1-Oxide (11): 300 mg (1.68 mmol) of **2**, 30 ml of THF, 187 mg (1.85 mmol) of diisopropylamine, 814 mg (1.86 mmol) of *n*-butyllithium (15% in hexane), 210 mg (1.75 mmol) of *rac*-**5** gave 245 mg (0.82 mmol, 49%) of **11** and 21 mg (5%) **14**. The four diastereoisomers and the regioisomer **14** were obtained in a ratio of 9.8:6.8:1.0:1.1:1.8 [7.1 (**11a** + **11b**):1.0 (**11c** + **11d**) by GC].

11a: 118 mg, white needles, m.p. 117−118°C, R_f = 0.31. IR (KBr): $\tilde{\nu}$ = 3349 cm^{-1} (OH), 2982, 2961, 2940, 2921, 1451, 1425, 1058, 1036, 1005 (S=O), 979, 752, 703, 645, 559. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.31 [d, ^3J = 6.86 Hz, 6 H, CH(CH_3)$_2$], 1.78 (ddd, ^2J = 13.06 Hz, ^3J = 2.12 Hz, ^3J = 6.21 Hz, 1 H 3-H), 1.83−2.04 (m, 2 H, 3-H, 4-H), 2.12−2.21 (m, 1 H, 4-H), 2.22 (dd, ^2J = 14.85 Hz, ^3J = 5.62 Hz, 1 H, CH_2), 2.37 (dd, ^2J = 14.80 Hz, ^3J = 6.95 Hz, 1 H, CH_2), 2.48 (ddd, ^2J = 13.96 Hz, ^3J = 5.81 Hz, ^3J = 8.14 Hz, 1 H, 5-H), 3.32 [sept, ^3J = 6.81 Hz, 1 H, C*H*(CH$_3$)$_2$], 3.50 (ddd, ^2J = 14.00 Hz, ^3J = 4.57 Hz, ^3J = 9.45 Hz, 1 H, 5-H), 4.99 (q, ^3J = 5.69 Hz, 1 H, C*H*OH), 5.32 (d, ^3J = 4.46 Hz, 1 H, OH), 7.23−7.28 (m, 1 H, Ar-H), 7.31−7.39 (m, 4 H, Ar-H). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 24.16 [+, CH(*C*H$_3$)$_2$], 24.45 (−, C-4), 26.14 [+, CH(*C*H$_3$)$_2$], 33.76 [+, *C*H(CH$_3$)$_2$], 36.09 (−, C-3), 40.43 (−, CH_2), 52.40 (−, C-5), 70.06 (+, CHOH), 78.34 (0, C-2), 126.26 (+, C_{ar}), 127.07 (+, C_{ar}), 128.06 (+, C_{ar}), 145.80 (0, C-1′$_{ar}$). − MS (70 eV); *m*/*z* (%): 280 (3) [M^+ − H_2O], 192 (28) [$C_8H_{16}OS_2^+$], 142 (24), 129 (40), 118 (30), 117 (100), [$C_5H_9OS^+$], 107 (54), 105 (40), 101 (26), 99 (23), 87 (26) [$C_4H_9S^+$], 85 (35), 79 (47), 77 (44) [$C_6H_5^+$]. − MS (CI with NH_3); *m*/*z* (%): 299 (40) [M^+ + 1], 281 (100) [M^+ + 1 − H_2O], 263 (25), 205 (26), 189 (45), 175 (41). − $C_{15}H_{22}O_2S_2$ (298.5): calcd. C 60.37, H 7.43, S 21.48; found C 60.25, H 7.47, S 21.58.

11b: 82 mg, white rhombic crystals, m.p. 109−111°C, R_f = 0.38. − IR (KBr): $\tilde{\nu}$ = 3305 cm^{-1} (OH), 2975, 2943, 2908, 2898, 2863, 1451, 1081, 1067 1037, 1014 (S=O), 994, 764, 700, 556. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.248 [d, ^3J = 6.90 Hz, 3 H, CH(CH_3)$_2$], 1.253 [d, ^3J = 6.68 Hz, 3 H, CH(CH_3)$_2$], 1.96−2.07 (m, 1 H, 4-H) 2.10 (d, ^2J = 14.06 Hz, 1 H, CH_2), 2.26 (dd, ^2J = 14.85 Hz, ^3J = 10.01 Hz, 1 H, CH_2), 2.27−2.39 (m, 2 H, 3-H, 4-H), 2.55 (ddd, ^2J = 14.28 Hz, ^3J = 6.05 Hz, ^3J = 8.32 Hz, 1 H, 5-H), 2.57−2.64 (m, 1 H, 3-H), 3.10 [sept, ^3J = 6.84 Hz, 1 H, C*H*(CH$_3$)$_2$], 3.54 (ddd, ^2J = 14.10 Hz, ^3J = 4.69 Hz, ^3J = 9.49 Hz, 1 H, 5-H), 5.00 [ddd, J(CH$_2$) = 1.86 Hz, ^3J(OH) = 5.12 Hz, ^3J(CH$_2$) = 9.80 Hz, 1 H, C*H*OH], 5.36 (d, ^3J = 5.12 Hz, 1 H, OH), 7.23−7.28 (m, 1 H, Ar-H), 7.32−7.39 (m, 4 H, Ar-H). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 24.60 [+, CH(*C*H$_3$)$_2$], 25.25 (−, C-4), 26.29 [+, CH(*C*H$_3$)$_2$], 33.72 [+, *C*H(CH$_3$)$_2$], 36.88 (−, C-3), 40.10 (−, CH_2), 52.10 (−, C-5), 68.74 (+, CHOH), 78.44 (0, C-2), 125.64 (+, C_{ar}), 126.92 (+, C_{ar}), 128.16 (+, C_{ar}), 146.38 (0, C-1′$_{ar}$). − MS (70 eV); *m*/*z* (%): 299 (0,02) [M^+ + 1], 280 (3) [M^+ − H_2O], 192 (22) [$C_8H_{16}OS_2^+$], 129 (43), 117 (100), [$C_5H_9OS^+$], 107 (60), 105 (31), 101 (20), 87 (26) [$C_4H_9S^+$], 79 (59), 77 (45) [$C_6H_5^+$]. − MS (CI with NH_3); *m*/*z* (%): 299 (38) [M^+ + 1], 281 (90) [M^+ + 1 − H_2O], 263 (38), 205 (50), 189 (100), 175 (78), 101 (46). − $C_{15}H_{22}O_2S_2$ (298.5): calcd. C 60.37, H 7.43, S 21.48; found C 60.12, H 7.36, S 21.47.

11c: 12 mg, pale yellow solid, m.p. 115−118°C, R_f = 0.23. − IR (KBr): $\tilde{\nu}$ = 3287 cm^{-1} (OH), 2962, 2923, 2886, 2868, 1452, 1429, 1365, 1225, 1081, 1066, 1037, 1010 (S=O), 763, 700, 549. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.24 [d, ^3J = 6.89 Hz, 3 H, CH(CH_3)$_2$], 1.29 [d, ^3J = 6.68 Hz, 3 H, CH(CH_3)$_2$], 1.71 (d, ^2J = 15.00 Hz, 1 H, CH_2), 1.83 (dd, ^2J = 14.91 Hz, ^3J = 8.97 Hz, 1 H, CH_2), 2.06 (dt, ^2J_d = 12.43 Hz, ^3J_t = 9.13 Hz, 1 H, 3-H), 2.13−2.27 (m, 2 H, 4-H), 2.65 ddd, ^2J = 14.70 Hz, ^3J = 5.93 Hz, ^3J = 7.84 Hz, 1 H, 5-H), 2.71 (ddd, ^2J = 12.60 Hz, ^3J = 3.06 Hz, ^3J = 5.89 Hz, 1 H, 3-H), 3.19 [sept, ^3J = 6.84 Hz, 1 H, C*H*(CH$_3$)$_2$], 3.44 (ddd, ^2J = 14.32 Hz, ^3J = 5.07 Hz, ^3J = 9.30 Hz, 1 H, 5-H), 5.06 [ddd, ^3J(CH$_2$) = 1.85 Hz, ^3J(OH) = 4.75 Hz, ^3J(CH$_2$) = 8.94 Hz, 1 H, C*H*OH], 5.41 (d, ^3J = 4.70 Hz, 1 H, OH), 7.21−7.28 (m, 1 H, Ar-H), 7.31−7.38 (m, 4 H, Ar-H). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 22.97 (−, C-4), 23.96 [+, CH(*C*H$_3$)$_2$], 25.41 [+, CH(*C*H$_3$)$_2$], 33.43 [+, *C*H(CH$_3$)$_2$], 34.14 (−, C-3), 39.48 (−, CH_2), 52.20 (−, C-5), 69.69 (+, CHOH), 80.37 (0, C-2), 125.55 (+, C_{ar}), 126.93 (+, C_{ar}), 128.16 (+, C_{ar}), 146.30 (0, C-1′$_{ar}$). − MS (70 eV); *m*/*z* (%): 280 (0.4) [M^+ − H_2O], 192 (25) [$C_8H_{16}OS_2^+$], 129 (34), 118 (28), 117 (100), [$C_5H_9OS^+$], 107 (56), 105 (45), 101 (23), 87 (27) [$C_4H_9S^+$], 85 (39), 79 (46), 77 (52) [$C_6H_7^+$]. − MS (CI with NH_3); *m*/*z* (%): 299 (44) [M^+ + 1], 281 (100) [M^+ + 1 − H_2O], 193 (43), 175 (22), 101 (40).

11d: 13 mg, pale yellow oil, R_f = 0.19. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.29 [d, ^3J = 6.93 Hz, 3 H, CH(CH_3)$_2$], 1.31 [d, ^3J = 6.74 Hz, 3 H, CH(CH_3)$_2$], 1.67−1.78 (m, 2 H, 3-H, 4-H), 1.93 (dd, ^2J = 14.85 Hz, ^3J = 5.38 Hz, 1 H, CH_2), 1.94−2.12 (m, 2 H, 3-H, 4-H), 2.11 (dd, ^2J = 14.91 Hz, ^3J = 6.64 Hz, 1 H, CH_2), 2.62

Table 2. Crystal data, data collection and structural analyses and refinements for (1*S*,2*S*,2′*S*)-**9a** and (1*R*,2*R*,2′*S*)-**11b**

	9a	**11b**
Chemical formula	$C_{10}H_{20}O_2S_2$	$C_{15}H_{22}O_2S_2$
Molecular mass	236.38	248.45
System	hexagonal	orthorhombic
Space group	$P6_5$	$P2_12_12_1$
Z	6	4
$F(000)$	768	644
Lattice parameters [pm, °]	a = 898.5 (1) b = 898.5 (1) c = 2817.3 (1) α = β = 90 γ = 120	a = 865.6 (1) b = 903.0 (1) c = 2003.43 (1) α = β = γ = 90
Volume of cell [pm^3]	1969.7(3) × 10^6	1565.9(3) × 10^6
Temperature [K]	293(2)	298(2)
Density [gcm^{-3}]	1.196	1.270
Diffractometer	CAD-4 (Nonius), graphite monochromator	CAD-4 (Nonius), graphite monochromator
Radiation	Cu-K_α	Cu-K_α
Wavelength [Å]	1.54184	1.54184
Absorption coefficient μ [mm^{-1}]	4.491	3.043
Crystal dimensions [mm] (transparent colourless blocks)	0.61 × 0.38 × 0.29	0.54 × 0.28 × 0.23
Scan technique	ϑ-2ϑ mode	ϑ-2ϑ mode
Index range	$0 \le h \le 9$ $0 \le k \le 9$ $-32 \le l \le 35$	$0 \le h \le 10$ $0 \le k \le 11$ $-24 \le l \le 25$
ϑ range (lattice parameters)	23−41°	20−33°
ϑ range (intensities)	2−75°	2−75°
Standard reflections	2	2
Total no. of reflections	2512	3242
No. of independent reflections	2460	3218
No. of significant reflections (N)	2286	3048
Criterion for observed reflections	$I > 3\sigma(I)$	$I > 3\sigma(I)$
Parameter (P)	136	243
N/P ratio	16.81	12.54
R factor	0.0624	0.0408
R_w factor (F^2)	0.2044	0.1243

(ddd, ^2J = 14.05 Hz, ^3J = 4.97 Hz, ^3J = 9.06 Hz, 1 H, 5-H), 3.34 (ddd, ^2J = 14.22 Hz, ^3J = 4.81 Hz, ^3J = 9.22 Hz, 1 H, 5-H), 3.39 [sept, ^3J = 6.80 Hz, 1 H, C*H*(CH$_3$)$_2$], 4.93 (q, ^3J = 5.41 Hz, 1 H, C*H*OH), 5.35 (d, ^3J = 4.19 Hz, 1 H, OH), 7.23−7.28 (m, 1 H, Ar-H), 7.32−7.42 (m, 4 H, Ar-H). − ^{13}C NMR (62.9 MHz, [D$_6$]DMSO): δ = 22.41 (−, C-4), 24.26 [+, CH(*C*H$_3$)$_2$], 25.54 [+, CH(*C*H$_3$)$_2$], 33.30 [+, *C*H(CH$_3$)$_2$], 34.34 (−, C-3), 42.74 (−, CH$_2$), 51.26 (−, C-5), 69.71 (+, CHOH), 78.47 (0, C-2), 126.21 (+, C$_{ar}$), 127.18 (+, C$_{ar}$), 128.12 (+, C$_{ar}$), 145.52 (0, C-1′$_{ar}$).

2-(2-Hydroxy-1-phenylethyl)-2-(isopropylthio)thiolane 1-Oxide (14): 21 mg, pale yellow oil, R_f = 0.10. − ^{1}H NMR (400 MHz, [D$_6$]DMSO): δ = 1.25 [d, ^3J = 6.73 Hz, 3 H, CH(C*H*$_3$)$_2$], 1.32 [d, ^3J = 6.61 Hz, 3 H, CH(C*H*$_3$)$_2$], 1.40 (ddd, ^2J = 13.99 Hz, ^3J = 1.59 Hz, ^3J = 7.25 Hz, 1 H, 3-H), 1.92−2.09 (m, 1 H, 4-H), 2.17−2.26 (m, 1 H, 4-H), 2.26−2.37 (m, 1 H, 3-H), 2.65−2.76 (m, 1 H, 5-H), 3.19 [sept, ^3J = 6.79 Hz, 1 H, C*H*(CH$_3$)$_2$], 3.53 (ddd, ^2J = 14.16 Hz, ^3J = 5.71 Hz, ^3J = 10.28 Hz, 1 H, 5-H), 3.85 [ddd, ^2J = 10.73 Hz, ^3J(CH) = 5.36 Hz, ^3J = 7.84 Hz, 1 H, C*H*$_2$OH], 3.97 [ddd, ^2J = 10.77 Hz, ^3J(CH) = 5.15 Hz, ^3J = 6.90 Hz, 1 H, C*H*$_2$OH], 4.86 (t, ^3J = 5.25 Hz, 1 H, C*H*Ph), 7.24−7.34 (m, 1 H, Ar-H), 7.43−7.46 (m, 4 H, Ar-H). − ^{13}C NMR (100.6 MHz, [D$_6$]DMSO): δ = 23.51 (−, C-4), 24.87 [+, CH(*C*H$_3$)$_2$], 27.37 [+, CH(*C*H$_3$)$_2$], 34.45 [+, *C*H(CH$_3$)$_2$], 37.03 (−, C-3), 50.04 (*C*HPh), 52.10 (−, C-5), 62.51 (−, CH$_2$OH), 81.15 (0, C-2), 126.92 (+, C$_{ar}$), 127.74 (+, C$_{ar}$), 129.52 (+, C$_{ar}$), 138.83 (0, C-1′$_{ar}$).

(1*R*,2*R*)-2-[(2*S*)-2-Hydroxy-2-phenylethyl]-2-(isopropylthio)thiolane 1-Oxide (11b): 300 mg (1.68 mmol) of **2**, 30 ml of THF, 187 mg (1.85 mmol) of diisopropylamine, 814 mg (1.86 mmol) of *n*-butyllithium (15% in hexane), 210 mg (1.75 mmol) of (*R*)-(+)-**5** (Merck, Darmstadt, Germany) gave 241 mg (0.81 mmol, 48%) of **11** and 18 mg (4%) of **13**. The four diastereomers and the regioisomer **13** were obtained in a ratio of 8.3:11.3:1.0:1.4:4.7 [17.6 (**11a** + **11b**):1.0:1.2 by GC]. Enantiomerically pure **11b** (NMR spectra identical with the spectra of *rac*-**11b**) was separated from the mixture by column chromatography (SiO$_2$, ethyl acetate) and a single crystal, m.p. 109−111 °C, suitable for the X-ray analysis was grown from chloroform.

X-ray Structural Analyses of (1*S*,2*S*,2′*S*)-9a and (1*R*,2*R*,2′*S*)-11b:[14] The structures were solved with the direct method SIR92[15] and differential Fourier synthesis. Refinement was performed by least-squares methods[16]. Details of the measurements are given in Table 2 and selected geometric parameters of the molecules in Figure 1 (**9a**) and Figure 2 (**11b**).

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[11] The yields given in Table 1 are isolated yields. The isomeric ratios are in good agreement with GC analytical results (cf. Experimental Section) obtained from the crude product mixtures.
[12] The deviation of the elemental analysis is due to colloidal silica gel.
[13] Crystallographic data (excluding structure factors) for the structures reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. CCDC-102735 (**9a**) and -102734 (**11b**). Copies of the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, UK [Fax: (internat.) + 44-1223/336-033, E-mail: deposit@ccdc.cam.ac.uk].
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