The Configurational Stability of an Enantioenriched α-Thiobenzyllithium Derivative and the Stereochemical Course of Its Electrophilic Substitution Reactions; Synthesis of Enantiomerically Pure, Tertiary Benzylic Thiols[1, 2]

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Dedicated to Professor Richard Neidlein on the occasion of his 70th birthday

Abstract: The lithium compound (*S*)-**7**, formed by deprotonation of the (*S*)-*S*-1-phenylethyl thiocarbamate (*S*)-**10**, is configurationally stable at $-70\,^{\circ}C$. Even at elevated temperatures it racemizes only very slowly. It represents the first essentially enantiopure α-thiocarbanion derivative and can be utilized in asymmetric synthesis. Most electrophiles (except proton acids) add to (*S*)-**7** with complete stereoinversion. Cleavage of the substitution products leads to practically enantiopure, tertiary 1-phenylalkanethiols.

Keywords: asymmetric synthesis · chirality · carbanions · electrophilic substitution · thiocarbanions

Introduction

Chiral, non-racemic, α-heterosubstituted organolithium compounds have become important tools in enantioselective synthesis.[3] If the metal-bearing carbon atom is the sole source of chiral information and if no chiral additive, such as (−)-sparteine,[4] is present in a preceding step, the configurational stability of the carbanionic intermediates is the essential precondition for their utilization in asymmetric synthesis. Configurationally stable 1-(alkoxymethoxy)alkyllithium derivatives **1a** (Scheme 1) have been known since 1980,[5] and in 1986 it was recognized that *N*,*N*-dialkylcarbamoyloxy groups enhance the configurational stability of chiral 1-oxyallyllithium[6] (**1b**), -benzyllithium[7] (**1c**), and, generally, -alkyllithium[8] (**1d**) derivatives by chelation. The carbamoyloxy group also causes high kinetic acidities by binding the lithium base in a preceding step of the deprotonation reaction.[6] A few *N*-Boc-α-aminoalkyllithium derivatives, such as the pyrrolidine **2a** and allylamines **3**, behave similarly.[9] *N*-Alkyl derivatives, as for example **2b**, generally exhibit high configurational stability, but these cannot be generated by direct deprotonation (Scheme 1).[10]

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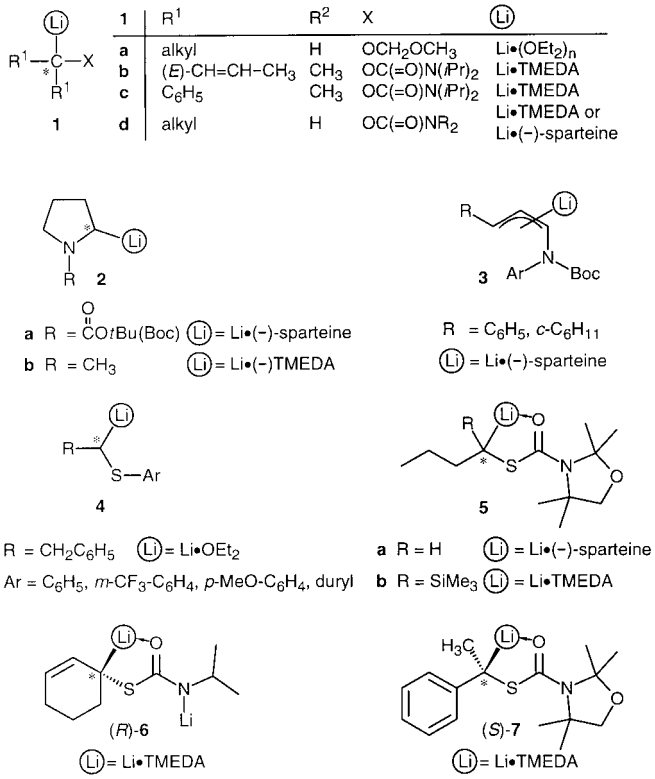
X-ray crystal structure analysis



Scheme 1. Structures of chiral lithium compounds **1**–**7**.

There is a striking contrast between the reported configurational lability of α-thioalkyllithium derivatives such as type **4** (Scheme 1) and the related oxygen and nitrogen compounds.

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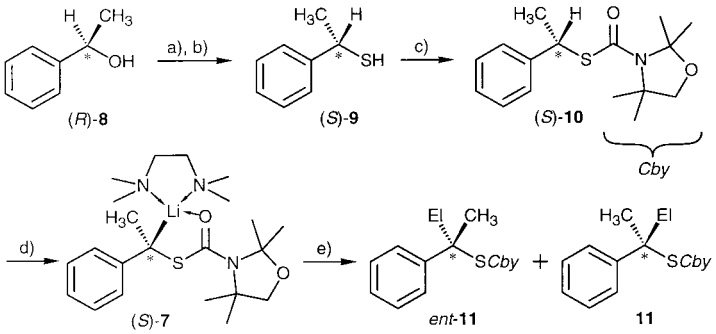
From reactivity and NMR studies with samples of racemic compounds of type **4**, it seems that a rapid interconversion of the enantiomers (the enantiomerization) takes place even at $-78\,^{\circ}C$ or below.[11, 12] Even the (−)-sparteine complex **5a**, which is stabilized by a chelating carbamoyl residue, epimerizes rapidly under these conditions.[13] However, the partially enantioenriched α-trimethylsilyl derivatives **5b** did not suffer racemization; they constitute the first example of an optically active α-thioalkyllithium derivative.[14] Evidence has been accumulated from the work of R. W. Hoffmann et al. and H. J. Reich et al. that the mechanism of racemization here is different from that of other chiral organolithium compounds.[12, 15] The rate-determining step is not the separation of the ion pair, but the torsion of the hyperconjugated S–C bond in the thio substituent. The rate of this torsion is decreased by increasing bulk in the vicinity of the sulfur atom. On the basis of this assumption we prepared the benzyllithium compound **7**, which had a remarkable configurational stability.[1] This concept, very recently, also led to the first example of an enantioenriched α-thioallyllithium compound **6**.[16]

Information on the stereochemical course of substitution reactions in chiral α-thio-substituted lithium compounds is very scarce; therefore we investigated compound **7** in that respect.

Results and Discussion

Deprotonation and configurational stability: (*R*)-1-Phenylethanol [(*R*)-**8**] of more than 99% enantiomeric purity[17], prepared by enzymatic kinetic resolution of the racemic acetate,[18, 7b] was converted into the corresponding thiol (*S*)-**9** (>99% *ee*) by a Mitsunobu reaction[19] with thioacetic acid, followed by hydride reduction of the intermediate (*S*)-*S*-alkyl thioacetate (Scheme 2). It is important to carry out all



Scheme 2. a) Diisopropyl azodicarboxylate (DIAD), PPh_3, MeCOSH (THF), 70%; b) $LiAlH_4$ (Et_2O), 98%; c) NaH, *Cby*Cl (THF), 95%; d) *s*BuLi, TMEDA (Et_2O); e) ElX (For El see Table 1).

reactions with strict exclusion of air under argon in order to avoid the formation of the corresponding disulfide, which it is essential to remove (see below). Acylation of (*S*)-**9** with 2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonyl chloride by the sodium hydride method[20] provided the thiocarbamate (*S*)-**10**.

The deprotonation of (*S*)-**10** in diethyl ether with *sec*-butyllithium (1.25 equiv) in the presence of *N*,*N*,*N*′,*N*′-tetramethylethylenediamine (TMEDA, 1.5 equiv) was complete within 1 h at $-78\,^{\circ}C$. The reaction mixture was usually stirred for 2 h below $-70\,^{\circ}C$ and the corresponding electrophile was added in excess to form the products *ent*-**11**/**11** in good yields (standard conditions). Practically complete deprotonation was confirmed by trapping the carbanionic intermediate with $DOCH_3$ to produce **11a** in 94% yield and with 90% D content (Table 1, entry 1). After the solution of (*S*)-**7** had been stored for 2 h at $-78\,^{\circ}C$ and quenched with methanol, 95% of the starting material (*S*)-**10** was isolated without any decrease in enantiomeric purity.[21] Complete retention is also observed for experiments performed with a 3 M solution of acetic acid in diethyl ether as reprotonating reagent. However, in a few experiments, lower *ee* values (down to 57% retention) were measured. Though the reasons are not transparent, we assume that TMEDA · HOAc is the active proton source to a certain extent. This assumption is based on a control experiment with a solution of the preformed adduct TMEDA · HOAc in diethyl ether, which yielded 98% (*S*)-**10** with partial retention (77% *ee*).

Even when the reaction mixture had been stirred for 12 min at $1\,^{\circ}C$ before quenching below $-70\,^{\circ}C$, we obtained (*S*)-**10** with ≥99% *ee* (yield 92%; Table 2, entry 1). The methoxycarbonylation (to form *ent*-**11b**, Table 2, entries 2 and 3), or acetylation (*ent*-**11c**, Table 2, entry 5) of the previously warmed carbanionic intermediate (*S*)-**7** led to similar results. These experiments are evidence of the unprecedentedly high configurational stability of the lithium compound (*S*)-**7**.[22] Even at $0\,^{\circ}C$ the half-time of enantiomerization has a magnitude of several hours. We were not able to determine the exact rate of racemization since the decomposition proceeds faster than racemization (Table 2, entries 3 and 6). Further, the decomposition products seem to catalyse the process (Table 2, entry 4).

However, at the beginning of our work, we were unable to confirm these results in control experiments. When using new batches of the thiocarbamate (*S*)-**10** or of *sec*-butyllithium solutions, we often obtained products with decreased enantiomeric excesses and yields until we noticed the following preconditions for optimal results: (*S*)-**10** has to be completely free of disulfide; furthermore, only clear solutions of *sec*-butyllithium (in cyclohexane or cyclohexane/hexane 92:8) qualify. Otherwise the *sec*-butyllithium solutions have to be filtered through Celite under argon before use. We assume that ether-soluble lithium salts (e.g. lithium alcoholates or thiolates) cause a partial racemization by a lithium–lithium substitution step with inversion of the configuration.

Acylations: The reaction of (*S*)-**7** with methyl chloroformate under standard conditions furnished the methyl ester *ent*-**11b** with ≥99% *ee* (Table 1, entry 2). Use of carbon dioxide as electrophile, followed by esterification with diazomethane, furnished the same product (entry 3). The absolute configuration of *ent*-**11b** was proved to be *R* by means of X-ray crystal structure analysis[23] (Figure 1). Similarly several acid chlorides reacted with complete stereoinversion to yield the (*R*)-ketones *ent*-**11c–g** (entries 4, 6, 8, 9, and 11). Evidence for the correct stereochemical assignment of *ent*-**11d** (Figure 2), *ent*-**11e** (Figure 3), and *ent*-**11g** (Figure 4) is drawn from the same X-ray technique.[23]

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Table 1. Substitution of (*S*)-**7** by various electrophiles (Scheme 1).

Entry	Product[a] *ent*-**11**/**11**	El	Electrophile	Yield [%]	e.r.[b] *ent*-**11**:**11**	% *ee*[b]	$[\alpha]_D$[c]	m.p. [°C]
1	**a**	D[d]	MeOD	99	< 1:99	> 99 (*S*)	− 129.1	94
2	**b**	CO_2Me	$ClCO_2Me$	98	> 99:1	> 99 (*R*)	− 26.0	113
3	**b**	CO_2Me	CO_2[e]	99	> 99:1	> 99 (*R*)	− 25.8	114
4	**c**	C(=O)Me	MeC(=O)Cl	95	> 99:1	> 99 (*R*)	− 22.5	65
5	**c**	C(=O)Me	$[MeC(=O)]_2O$	88	20:80	60 (*S*)	+ 13.7	–
6	**d**	C(=O)Et	EtC(=O)Cl	97	> 99:1	> 99 (*R*)	− 17.9	73
7	**d**	C(=O)Et	$[EtC(=O)]_2O$	99	22:78	55 (*S*)	+ 9.4	–
8	**e**	C(=O)*i*Pr	*i*PrCOCl	92	> 99:1	> 99 (*R*)	− 42.4	84
9	**f**	C(=O)*t*Bu	*t*BuCOCl	83	> 99:1	> 99 (*R*)	− 68.5	64
10	**f**	C(=O)*t*Bu	$[tBuC(=O)]_2O$	46	> 99:1	> 99 (*R*)	− 68.4	–
11	**g**	C(=O)Ph	PhCOCl	92	≥ 99:1	> 98 (*R*)	+ 116.6	124
12	**h**	CH(OH)Me	MeCHO	69	> 99:1[f]	> 99 (*R*)	− 68.3	oil
13	**i**	CH(OH)Et	EtCHO	89	≥ 99:1[f]	≥ 98 (*R*)	− 61.9	oil
14	**j**	CH(OH)*i*Pr	*i*PrCHO	99	98:2[f]	96 (*R*)	− 82.6	oil
15	**k**	CH(OH)*t*Bu	*t*BuCHO	59	> 99:1[f]	> 99 (*R*)	− 120.3	80
16	**l**	CH(OH)Ph	PhCHO	89	> 99:1[f]	> 99 (*R*)	− 48.2	84
17	**m**	$C(OH)Me_2$	$Me_2C{=}O$	58	81:19	62 (*R*)	− 52.1	oil
18	**n**	$C(OH)Ph_2$	$Ph_2C{=}O$	51	84:16[g]	68 (*R*)	− 35.0	110
19	**o**	CH_2CH_3	CH_3CH_2I	90	> 98:2	97 (*S*)	− 30.3	90
20	**p**	$CH_2CH_2CH_3$	$CH_3CH_2CH_2I$	89	[h]	[h] (*S*)	− 48.1	–
21	**q**	$CH_2(CH_2)_4CH_3$	$CH_3(CH_2)_4CH_2I$	69	> 99:1	> 99 (*S*)	− 38.4	oil
22	**r**	$CH_2CH{=}CH_2$	$CH_2{=}CHCH_2Br$	90	[h]	[h] (*S*)	− 25.2	91
23	**s**	CH_2Ph	$PhCH_2Br$	95	[h]	[h] (*S*)	− 29.4	76
24	**t**	$SiMe_3$	Me_3SiCl	90	≥ 99:1	> 98 (*R*)	− 90.7	76

[a] All products were obtained analytically pure (C ± 0.4 %, H ± 0.3 %, N ± 0.3 %). [b] For the method of determination see ref. [21]. [c] Measured with $c =$ 0.88 to 1.76 g (100 mL)$^{-1}$ in CH_2Cl_2 at room temperature (18 to 27 °C); for details see Experimental Section. [d] Protonation of (*S*)-**7** with MeOH leads to (*S*)-**10** (98 % yield, > 99 % *ee*). Though protonation with HOAc also results in the formation of (*S*)-**10** with 98 % yield and > 99 % *ee*, in a few control experiments lower *ee* values were observed. Because of the supposed participation of TMEDA · HOAc in the protonation reaction we performed an experiment using a premixed solution of TMEDA and HOAc in diethyl ether that gave (*S*)-**10** in 99 % yield and with 77 % *ee*. [e] Work-up without neutralizing, followed by esterification of the carboxylic acid with diazomethane. [f] Determined at the stage of the corresponding ketone *ent*-**11c**–**g** after Swern oxidation. [g] The absolute configuration was not proved independently; (partial) inversion was deduced, analogous to all other carbonyl additions. [h] The enantiomeric ratio was not determined.

Table 2. Warming experiments with the anionic intermediate (*S*)-**7**.

Entry	Product	El	Electrophile	Warming conditions	Yield [%]	e.r.	% *ee*[b]	$[\alpha]_D$[a]
1	**10**	H	MeOH	12 min (0 °C)	92	> 99: 1	≥ 99 (*R*)	− 128.6
2	*ent*-**11b**	CO_2Me	$ClCO_2Me$	3 min (0 °C)	98	> 99: 1	> 99 (*R*)	− 25.5
3	*ent*-**11b**	CO_2Me	$ClCO_2Me$	63 min (0 °C)	58	86:14	73 (*R*)	− 18.5
4	*ent*-**11b**	CO_2Me	$ClCO_2Me$	125 min (0 °C)	32	57:43	13 (*R*)	− 2.6
5	*ent*-**11c**	C(=O)Me	MeC(=O)Cl	6 min (0 °C)	89	> 99: 1	> 99 (*R*)	− 21.8
6	*ent*-**11c**	C(=O)Me	MeC(=O)Cl	4 min (17 °C)	44	≥ 98: 2	≥ 96 (*R*)	− 21.6

[a] Measured with $c = 0.88$ to 1.34 g (100 mL)$^{-1}$ in CH_2Cl_2 at room temperature (21 to 25 °C). [b] For the method of determination see ref. [21].

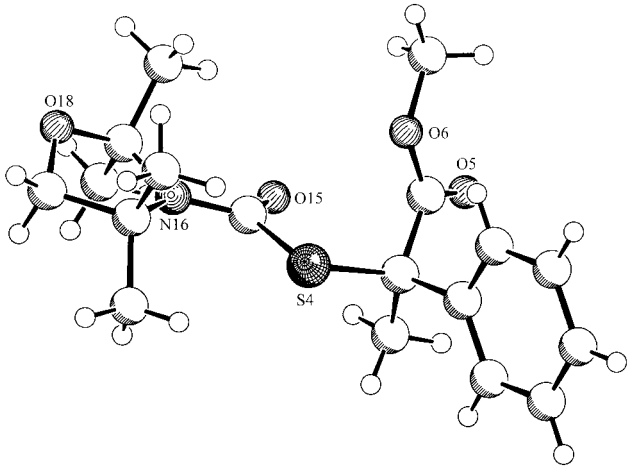


Figure 1. X-ray crystal structure of *ent*-**11b**.

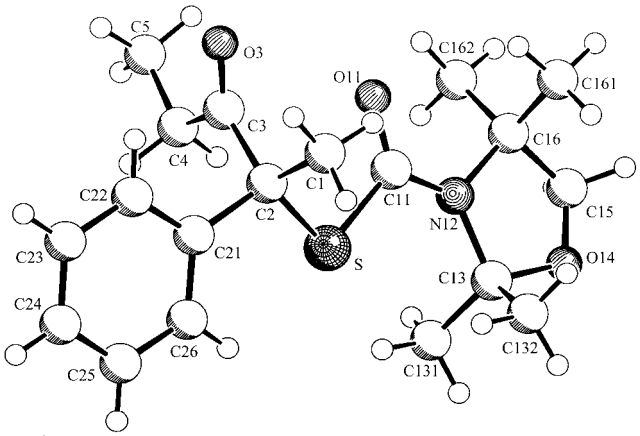


Figure 2. X-ray crystal structure of *ent*-**11d**.

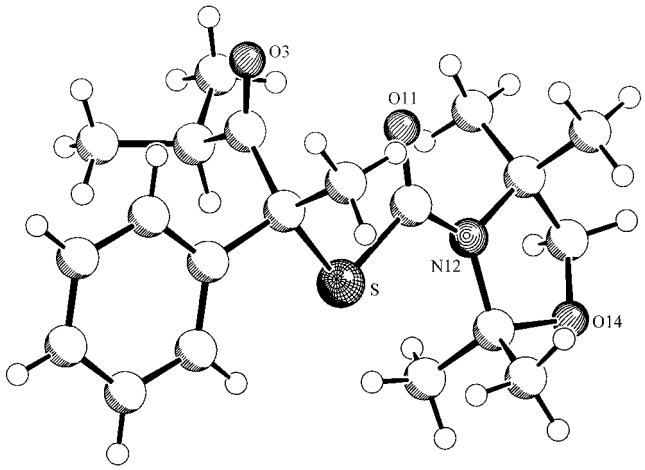


Figure 3. X-ray crystal structure of *ent*-**11e**.

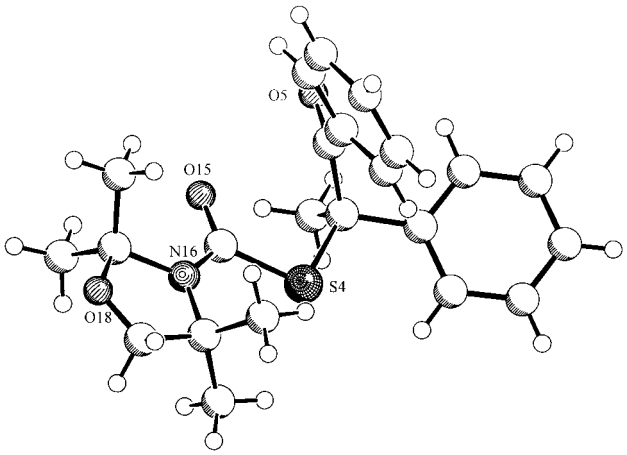
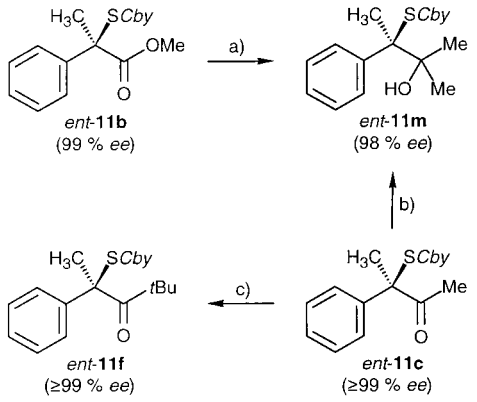


Figure 4. X-ray crystal structure of *ent*-**11g**.

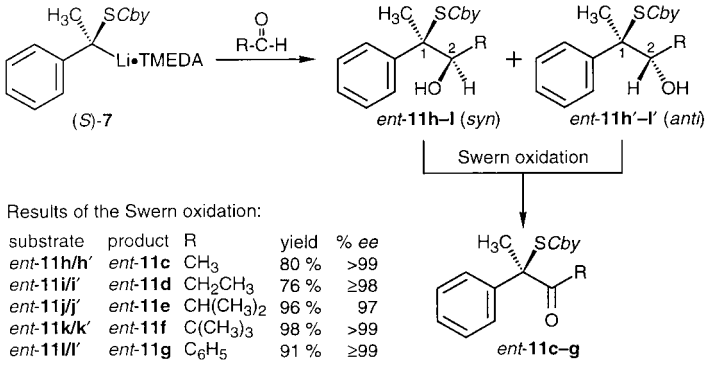
The exhaustive Grignard reactions of the ester *ent*-**11b**, with known *R* configuration, and the ketone *ent*-**11c** both result in the formation of the alcohol *ent*-**11m**. The enolate of the acetylation product *ent*-**11c** (≥99% *ee*) was completely alkylated with methyl iodide and furnished the *tert*-butyl ketone *ent*-**11f** (≥99% *ee*). With these additional correlation experiments the absolute configuration is proved to be *R* for *ent*-**11c**, *ent*-**11m**, and *ent*-**11f** (Scheme 3).



Scheme 3. a) MeMgI (Et_2O), 47%; b) MeMgI (Et_2O), 65%; c) 1. LDA, 2. MeI (THF), 21% isolated.

For acylations with acid anhydrides, surprisingly, only the reaction of pivalic acid anhydride resulted in complete stereoinversion to yield *ent*-**11f** (Table 1, entry 10), whereas acetic and propionic acid anhydride gave rise to the products **11c** (entry 5, 60% *ee*) and **11d** (entry 7, 55% *ee*) with partial retention. No plausible explanation for these two exceptions is obvious. In the view of stereoinverting addition reactions of the appropriate aldehydes and acid chlorides we do not see convincing reasons for the attack of the electrophile on the front face of the carbanionic center owing to a lithium–electrophile interaction. The reactions of (*S*)-**7** with ethyl acetate and propionate were too slow for a meaningful stereochemical study.

Aldehyde additions: The reaction of aldehydes with the lithium compound (*S*)-**7**, generated under standard conditions, proceeds smoothly, giving rise to mixtures of the epimeric *syn*/*anti* alcohols *ent*-**11h/h′**–*ent*-**11l/l′** with high stereospecificity (96–>99% *ee*) and complete inversion, but without significant diastereoselection concerning the carbonyl group (Scheme 4; Table 1, entries 12–16, Table 3). The epimers



Results of the Swern oxidation:

substrate	product	R	yield	% *ee*
ent-**11h/h′**	*ent*-**11c**	CH_3	80%	>99
ent-**11i/i′**	*ent*-**11d**	CH_2CH_3	76%	≥98
ent-**11j/j′**	*ent*-**11e**	$CH(CH_3)_2$	96%	97
ent-**11k/k′**	*ent*-**11f**	$C(CH_3)_3$	98%	>99
ent-**11l/l′**	*ent*-**11g**	C_6H_5	91%	≥99

Scheme 4. Swern oxidation to give *ent*-**11c**–**g**.

Table 3. Ratios of *syn*/*anti* alcohols *ent*-**11** and characteristic NMR data (Scheme 4).

Product *ent*-**11**/**11**	*syn*:*anti*		^{1}H NMR [δ] OH	1-CH_3	2-H	^{13}C NMR [δ] 1-CH_3	C-2
h	52:48	*syn*	5.66	1.81	4.60	21.7	74.5
		anti	3.69	2.00	4.27	23.0	74.2
i	41:59	*syn*	5.31	1.85	4.27	22.4	77.0
		anti	3.47	2.00	3.94	25.2	76.8
j	41:59	*syn*	5.59	1.95	4.37	21.6–26.0	82.3
		anti	3.74	2.05	3.92	21.1–25.5	82.0
k	43:57	*syn*	5.52	2.06	4.33	21.8	84.4
		anti	4.11	2.12	4.05	27.9	83.6
l	42:58	*syn*	6.52	1.45–1.64	5.49	23.0–26.0	81.1
		anti	4.31	2.05	5.24	23.0–26.0	80.9

could not be separated, and were converted to the known corresponding ketones *ent*-**11c**–*ent*-**11g** by Swern oxidation[24] (Scheme 4).

The relative configurations of the aldehyde adducts were deduced from ^{1}H NMR and ^{13}C NMR spectroscopic data. Apart from accepted empirical rules concerning the chemical shifts of the OH group (^{1}H NMR[25]) and the benzylic methyl

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group (1-CH_3, ^{13}C NMR[26]) some additional proof was collected as shown in Table 3. Whereas the ^1H NMR criteria for 1-CH_3[27, 28] and 2-H[28] coincide with results from investigations of the appropriate *O*-benzylcarbamates, the ^{13}C NMR regularity concerning C-2 was firstly found for the series of thiocarbamates *ent*-**11h/h′** – *ent*-**11l/l′**.

Ketone additions: The addition of acetone to the solution of (*S*)-**7** and stirring of the resulting reaction mixture for 16 h at $-78\,^{\circ}C$ afforded the tertiary alcohol *ent*-**11m** in 58% yield with 62% *ee* (inversion). The *R* configuration of *ent*-**11m** was established by converting the ester *ent*-**11b** into alcohol *ent*-**11m** by exhaustive methyl Grignard addition (Scheme 3). Similarly, benzophenone yielded the diphenylcarbinol *ent*-**11n** (yield 51%, 68% *ee*). Several attempts to phenylate the ester *ent*-**11b** only afforded the ketone *ent*-**11g**, whereas *ent*-**11g** added to neither phenylmagnesium bromide nor phenyllithium.

During the reaction with benzophenone, the color of the reaction mixture first changed to blue and then through green to yellow. This leads to the conclusion that the addition proceeds via a radical pair formed by single-electron transfer (SET)[29] which results in a partially racemized product. Although the ketyl radical formed from acetone is less stabilized, a SET might also be involved in this case.

Alkylation and silylation: The alkylation of (*S*)-**7** with ethyl, propyl, and hexyl iodide smoothly yielded the corresponding tertiary thiocarbamates *ent*-**11o**, *ent*-**11p**, and *ent*-**11q**, respectively (Table 1; entries 19–21). Allyl and benzyl bromide gave products *ent*-**11r** and *ent*-**11s** (Table 1, entries 22 and 23). Complete stereospecificity was proved strictly for the hexylation (>99% *ee*) and ethylation (97% *op* compared with a previously prepared sample[30]). Since *ent*-**11o**, *ent*-**11r**, and *ent*-**11s** furnished enantiomerically pure crystalline samples with excellent enantiopol parameters (max. 0.03 ± 0.03), a very high enantiomeric purity can be concluded directly from the X-ray crystal structure analysis (Figure 5, Figure 6, and

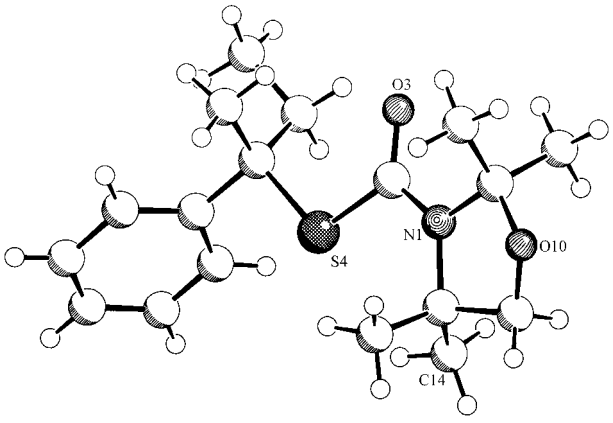


Figure 5. X-ray crystal structure of *ent*-**11o**.

Figure 7).[23] Hydrogenation of a sample of the allylation product *ent*-**11r** afforded the propyl derivative *ent*-**11p** with the same optical purity as the original sample of *ent*-**11p** (Scheme 5, Table 1, entry 20) within an experimental error of

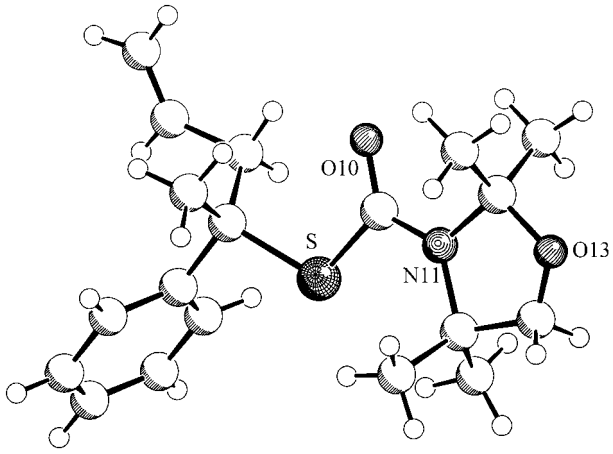


Figure 6. X-ray crystal structure of *ent*-**11r**.

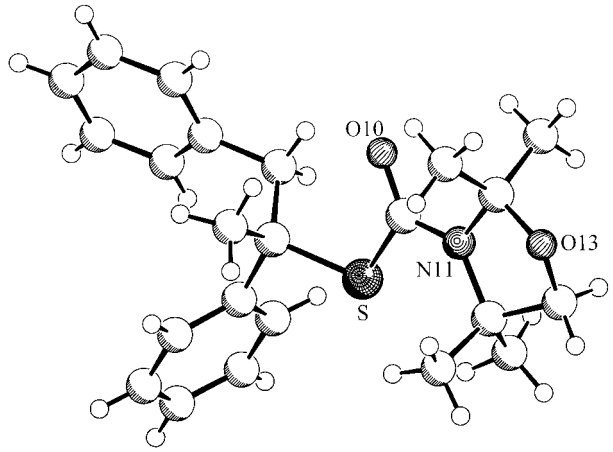
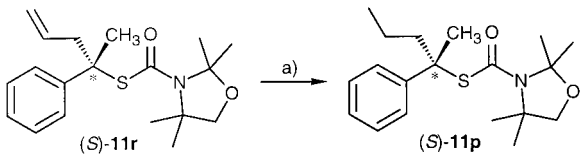


Figure 7. X-ray crystal structure of *ent*-**11s**.



Scheme 5. a) H_2, Pd/C (MeOH), 84%.

approx. 3%. Thus all alkylation reactions proceed with strict stereoinversion.

Trimethylsilylation led to the enantiomerically pure silane *ent*-**11t** in 90% yield and with complete inversion (>98% *ee*; Table 1, entry 24). The absolute configuration of *ent*-**11t** was confirmed by X-ray crystal structure analysis (Figure 8).[23]

Stereochemical course: Compared with that of the known α-thioalkyllithium compounds, the configurational stability of the lithium complex (*S*)-**7** is surprisingly high. Nevertheless this fact qualitatively fits the mechanistic model outlined by R. W. Hoffmann and H. J. Reich.[15] Whereas the oxygen analogue (*R*)-**1c** adds to aliphatic aldehydes with total stereoretention[27], (*S*)-**7** reacts with alkanals with complete stereoinversion. Only for protonation by methanol or acetic acid do both lithium compounds join in stereoretention. We suggest that in benzyllithium compounds two features support the electrophilic attack at the face occupied by the lithium

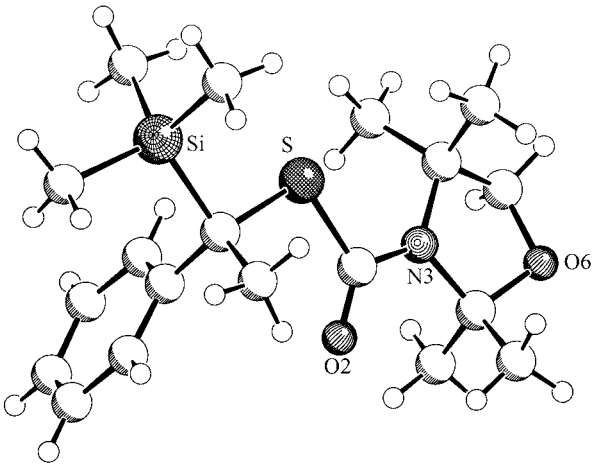
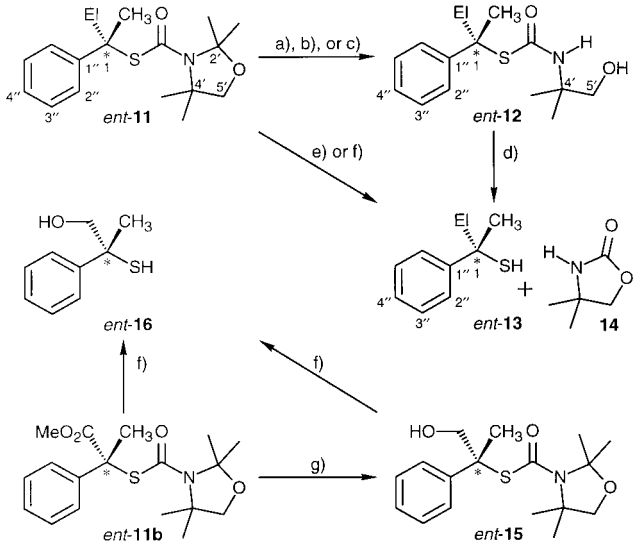


Figure 8. X-ray crystal structure of *ent*-**11t**.

cation: strong interaction of the lithium cation with the incoming electrophile,[7b] which is expected to occur with methanol or acetic acid, and increasing pyramidalization of the carbanionic center.[7d, 7e] Further theoretical investigations might uncover the reasons for the increased tendency of the α-thio-substituted benzyllithium derivatives to undergo stereoinverting electrophilic substitution.

Cleavage of the substituted thiocarbamates *ent*-11: The oxazolidine moiety *Cby* was selected in order to provide rigorous protection of the carbonyl group against nucleophilic attack while being sensitive to acidic conditions.[8, 3a] Under acid catalysis acetone is removed from the cyclic aminoacetal group in *ent*-**11** to yield the β-hydroxyalkyl thiourethanes *ent*-**12** (Scheme 6, Methods a–c). Refluxing these intermediates in a suspension of potassium carbonate in methanol liberates the thiols *ent*-**13** (Scheme 6, Method d). By forming the oxazolidinone **14**, the β-hydroxy group plays an active role in this cleavage reaction. In contrast to the conversion of appropriate benzyl carbamates to tertiary alcohols (O for S in *ent*-**11**),[27] partial racemization does not occur. As long as the starting material does not carry reducible functionalities, a one-step deprotection procedure can be applied by stirring *ent*-**11** with a large excess of diisobutylaluminum hydride (DIBALH)[31] at low temperature (Scheme 6, Method f). Refluxing the thiocarbamates *ent*-**11** in 6 M HCl leads directly to the thiols *ent*-**13**, too (Scheme 6, Method e).



Scheme 6. For El and yields see Table 4; a) Method a: $MeSO_3H$ (MeOH), reflux; b) Method b: Amberlyst 15 (MeOH), reflux; c) Method c: 1,3-propanedithiol, Amberlyst 15 (CH_2Cl_2), r.t.; d) Method d: K_2CO_3 (MeOH), reflux; e) Method e: 6 M HCl, reflux; f) Method f: DIBALH (hexane/toluene), -78 to 0 °C; g) Method g: $LiAlH_4$ (THF), reflux.

Even when the methyl ester *ent*-**11a** is refluxed with a large excess of $LiAlH_4$ in THF (Scheme 6, Method g), the oxazolidine carbonyl group remains unchanged and the primary alcohol *ent*-**15** is isolated with high yield. However, DIBALH (10 mol equiv) reduces both carbonyl groups to yield thiol alcohol *ent*-**16** when *ent*-**11a** is subjected to the conditions of Method f (Scheme 6, Table 4).

Altogether, the reaction sequence provides an easy route to highly enantioenriched tertiary benzyl thiols. These compounds cannot be prepared by S_N2 substitution reactions starting from optically active tertiary benzyl alcohols.

Conclusion

We have demonstrated that the lithium compound (*S*)-**7**, derived from the optically active secondary *S*-benzyl monothiocarbamate (*S*)-**10**, exhibits surprisingly high configurational stability. The substitution by most electrophiles proceeds with strict stereoinversion. On the basis of the facile deblocking of the protected thio group, a predictable route to highly enantiomerically enriched tertiary thiols was developed, which will most likely be applicable to further benzylic and related substrates.

Experimental Section

General methods: ^1H and ^{13}C NMR spectra were recorded on a Bruker ARX 300, AM 360, or AMX 400 instrument at 300, 360, or 400 MHz and 75.5, 90, and 100 MHz, respectively. Chemical shifts are reported in relation to Me_4Si as internal standard. IR spectra were registered on a Perkin–Elmer 298 spectrometer; only the strongest bands are given. Optical rotations were obtained with a Perkin–Elmer 241 polarimeter and are specified in units of $^\circ mL\,dm^{-1}\,g^{-1}$. Melting points were measured on a Mettler FP61 apparatus and are uncorrected. The Mikroanalytische Abteilung des Organisch-Chemischen Institutes der Universität Münster performed the elementary analyses on a Heraeus CHN-O-Rapid. All yields are given with reference to neat products purified by flash column chromatography[32] on silica gel (Merck, 60–200 mesh). Solvents and reagents were distilled and, if necessary, dried prior to use. Diethyl ether was freshly distilled from Na/benzophenone, THF from K/benzophenone, and CH_2Cl_2 from CaH_2. Commercial samples of *N*,*N*,*N*′,*N*′-tetramethylethylenediamine (TMEDA), triethylamine (NEt_3), dimethyl sulfoxide (DMSO), and trimethylsilyl chloride (Me_3SiCl) were dried by distillation from CaH_2. Solutions of *sec*-butyllithium were received as a 1.4 M solution in cyclohexane/hexane (92:8) or in cyclohexane and usually had to be filtered through Celite before use to separate from solid impurities. MeMgI was prepared from MeI and Mg in diethyl ether. The concentration of all solutions of organolithium and -magnesium compounds was measured by titration.[33] The *ee* values of the carbamates **10** and **11** were determined by ^1H NMR spectroscopy.[21] Isomer ratios of diastereomeric mixtures were derived from suitable ^1H NMR or GC integrals (Hewlett Packard HP 5890 II chromatograph with a 25 m HP1 column or Hewlett Packard HP 6890 II

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Table 4. Cleavage experiments with the thiocarbamates **10** and *ent*-**11**.

Entry	Product	Substrate	Method, conditions	El	Yield [%]	% *ee*[a]	$[\alpha]_D$[b]	M.p. [°C]
1	(*S*)-**12u**	(*S*)-**10**	a, reflux, 3.0 h	H	93	≥ 99	− 173.0	oil
2	*ent*-**12b**	*ent*-**11b**	a, r.t., 8 d	CO_2Me	95	> 99	− 23.8	128
3	*rac*-**12o**	*rac*-**11o**	a, reflux, 3.0 h	CH_2CH_3	67	–	–	oil
4	*rac*-**12p**	*rac*-**11p**	a, r.t., 13 d	$CH_2CH_2CH_3$	58	–	–	oil
5	(*S*)-**12u**	(*S*)-**10**	b, CH_2Cl_2, reflux, 1.5 h	H	87	≥ 98	− 169.6	oil
6	*ent*-**12b**	*ent*-**11b**	b, Et_2O, reflux, 2.0 h	CO_2Me	90	> 99	− 23.4	oil
7	*ent*-**12f**	*ent*-**11f**	b, MeOH, r.t., 40 h	C(=O)*t*Bu	92	> 99	− 98.9	oil
8	*rac*-**12m**	*rac*-**11m**	b, Et_2O, r.t., 10 d	$C(OH)Me_2$	86	–	–	oil
9	*rac*-**12q**	*rac*-**11q**	b, Et_2O/MeOH, r.t., 7 d	$CH_2(CH_2)_4CH_3$	92	–	–	oil
10	*ent*-**12o**	*ent*-**11o**	b, Et_2O/MeOH, r.t., 6 d	CH_2CH_3	86	97[c]	− 48.1	oil
11	*ent*-**12t**	*ent*-**11t**	b, MeOH, r.t., 3 d	$SiMe_3$	94	≥ 98[c]	− 103.8	oil
12	*rac*-**12u**	*rac*-**10**	c, CH_2Cl_2, r.t., 18 h	H	88	–	–	oil
13	*ent*-**12d**	*ent*-**11d**	c, r.t., 14 h	C(=O)Et	95	> 99[c]	− 49.4	83
14	*ent*-**12e**	*ent*-**11e**	c, r.t., 38 h	C(=O)*i*Pr	98	> 99[c]	− 97.1	109
15	*ent*-**12g**	*ent*-**11g**	c, r.t., 14 h	C(=O)Ph	79	≥ 98[c]	+ 73.2	oil
22	(*S*)-**9**	(*S*)-**12u**	d, reflux, 13 h	H	82	97[d]	− 86.4 (EtOH)	oil
23	*ent*-**13e**	*ent*-**12e**	d, r.t., 2 d	C(=O)*i*Pr	97	> 99[c]	− 78.8	oil
21	*ent*-**13s**	*ent*-**11s**	e, reflux, 21.0 h	CH_2Ph[e]	96	–	− 31.1	oil
16	(*S*)-**9**	(*S*)-**10**	f,[f] − 78 °C, 14.0 h	H	70	> 99[d]	− 89.6 (EtOH)	oil
17	*ent*-**13s**	*ent*-**11s**	f,[f] − 78 → 20 °C, 17.0 h	CH_2Ph[e]	83	–	− 29.5	oil
18	*ent*-**13t**	*ent*-**11t**	f,[g] − 78 °C, 16.0 h	$SiMe_3$	80	≥ 98[c]	− 247.2	oil
19	*ent*-**16**	*ent*-**11b**	f,[f] − 78 °C, 18.0 h	CH_2OH,[h] CO_2Me[i]	84	> 99[c]	− 31.8	106[j]
20	*ent*-**16**	*ent*-**15**	f,[g] − 78 → 20 °C, 20.0 h	CH_2OH	88	> 99[c]	− 31.2	–
24	*ent*-**15**	*ent*-**11b**	g, THF, reflux, 6.0 h	CH_2OH,[h] CO_2Me[i]	83	> 99	− 22.1	101

[a] For the method of determination see ref. [21]. [b] Measured with $c = 0.36$ to 1.60 g (100 mL)$^{-1}$ in CH_2Cl_2 at room temperature (18 to 25 °C). [c] Not determined; deduced from the *ee* value of the starting material. [d] Deduced from the optical purity of the thiol (*S*)-**9** compared to samples of the starting material (*S*)-**9** (Scheme 2). [e] The measured spectroscopic data correspond to those given for *rac*-**13s**.[35] [f] Work-up with 2 M aqueous HCl and subsequent ethereal extraction. [g] Work-up analogous to the procedure of Fieser.[34] [h] El in product. [i] El in substrate. [j] Melting includes partial decomposition.

chromatograph with a 25 m HP 1701 column). All numbers in the spectroscopic data follow Scheme 6 (beginning with C-2 in the group El).

(−)-(*S*)-1-Phenylethanethiol [(*S*)-9]: A pale yellow precipitate was formed by dropwise addition of diisopropyl azodicarboxylate (9.70 mL, 10.1 g, 50.0 mmol) to an ice-cooled solution of triphenylphosphine (13.2 g, 50.0 mmol) in anhydrous THF (80 mL) under argon. The solidifying mixture was stirred continuously while it was warmed to room temperature. A solution of (*R*)-1-phenylethanol[18] (4.64 g, 40.0 mmol, 99 % *ee*) and thioacetic acid (5.70 mL, 6.09 g, 80.0 mmol) in THF (30 mL) was injected. The reaction mixture was stirred for 3 h at room temperature and changed from yellow to green and finally orange before the solvent was evaporated in vacuo. The yellow slurry was suspended and stirred in 100 mL of hexanes until a yellow solid formed. The complete separation from the solid by-products required two filtrations through 20 g silica gel and elution with hexanes. The concentrated crude thioacetate was purified by flash chromatography on silica gel (Et_2O/hexanes, 1:40).

An ice-cooled solution of the purified thioacetate {$[\alpha]_D^{20} = -291.3$, $c = 1.72$ in CH_2Cl_2, > 99 % *ee*} in anhydrous diethyl ether (8 mL) was added dropwise to a suspension of $LiAlH_4$ (774 mg, 20.4 mmol) in diethyl ether (90 mL) under argon. After 2 h of refluxing the reaction mixture was carefully treated with 2 M aqueous HCl (30 mL) at 0 °C. The organic layer was separated and the aqueous solution extracted with diethyl ether (4 × 20 mL). The combined organic layers were stirred over solid $NaHCO_3$/Na_2SO_4. Evaporation of the solvent and flash chromatography of the crude product on silica gel (hexanes) afforded thiol (*S*)-**9** (3.75 g, 27.1 mmol, 68 %) as a pale yellow oil.

Intermediate (−)-(*S*)-*S*-(1-phenylethyl) thioacetate: $[\alpha]_D^{25} = -291.3$ (c = 1.72 in CH_2Cl_2); > 99 % *ee* [see (*S*)-**10**]; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.65 (d, 3H, 1-CH_3), 2.29 (s, 3H, 2′-H_3), 4.74 (q, 1H, 1-H), 7.20 – 7.37 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{1\text{-H},1\text{-CH}_3} = 7.2$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 24.4 (q, 1-CH_3), 30.0 (q, C-2′), 43.4 (d, C-1), 127.2 (d, C-4″), 128.6, 129.4 (d, C-2″, C-3″), 144.9 (s, C-1″), 194.9 (s, C-1′); IR (film): $\tilde{\nu}$ (cm^{-1}) = 1680 (C=O); $C_{10}H_{12}OS$ (180.27): calcd C 66.63, H 6.71, found C 66.40, H 6.95.

Data for (−)-(*S*)-1-phenylethanethiol [(*S*)-9]: $[\alpha]_D^{25} = -88.7$ (c = 0.63 in abs. EtOH); > 99 % *ee* [see (*S*)-**10**]; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.67 (dd, 3H, 1-CH_3), 1.98 (dq, 1H, SH), 4.23 (qd, 1H, 1-H), 7.18 – 7.44 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{1\text{-H},1\text{-CH}_3} = 6.9$ Hz, $^3J_{1\text{-H,SH}} = 5.3$ Hz, $^4J_{\text{SH},1\text{-CH}_3} = 0.5$ Hz; IR (film): no strong bands.

(−)-(*S*)-*S*-Phenylethyl 2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate [(*S*)-10]: A solution of thiol (*S*)-**9** (2.19 g, 15.8 mmol) in anhydrous THF (8.0 mL) was added dropwise to an ice-cooled suspension of sodium hydride (760 mg, 19.0 mmol, 60 % in mineral oil) in THF (30 mL). The reaction mixture was stirred for 30 min at room temperature. 2,2,4,4-Tetramethyl-1,3-oxazolidine-3-carbonyl chloride[20] (3.32 g, 17.4 mmol) in THF (6 mL) was added and the solution was refluxed for 3 h. The reaction mixture was allowed to cool to room temperature and poured into a mixture of Et_2O and 2 M aqueous HCl (30 mL each). The organic layer was separated and the aqueous solution was extracted with Et_2O (3 × 30 mL). The combined extracts were stirred over solid Na_2SO_4/$NaHCO_3$. The crude product was recrystallized several times from diethyl ether and the remaining mother liquor was purified by flash chromatography on silica gel (Et_2O/hexanes, 1:4). The combined yield was 4.50 g (15.3 mmol, 97 %). $[\alpha]_D^{24} = -129.3$ (c = 1.44 in CH_2Cl_2); > 99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 40 mol % (+)-Eu(hfc)$_3$: 5′-H_2, $\Delta\delta$ = 0.03 ppm at δ = 4.1, (*R*):(*S*) < 1:466); m.p.: 96 °C; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.45 – 1.64 (m, 12H, 2′-CH_3, 4′-CH_3), 1.70 (d, 3H, 1-CH_3), 3.72 (s, 2H, 5′-H_2), 4.79 (q, 1H, 1-H), 7.20 – 7.40 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{1\text{-H},1\text{-CH}_3} = 6.9$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 23.0 (1-CH_3), 24.8, 25.8 (2′-CH_3, 4′-CH_3), 44.0 (C-1), 60.9 (C-4′), 76.7 (C-5′), 97.3 (C-2′), 127.0 (C-4″), 127.4, 129.0 (C-2″, C-3″), 143.0 (C-1″), 163.2 (S–C–N); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1610 (C=O); GC-MS (EI, 70 eV): *m*/*z* (%) = 293 (6) [M^+], 278 (2) [$M - CH_3^+$], 238 (1) [$M - C_4H_7^+$], 189 (2) [HS*Cby*$^+$], 174 (3) [HS*Cby* − CH_3^+], 156 (48) [*Cby*$^+$], 105 (46) [$C_8H_9^+$], 98 (34) [$C_5H_8NO^+ = Cby - C_3H_6O^+$], 91 (34) [$C_7H_7^+$], 77 (10) [$C_6H_5^+$], 59 (100) [$C_3H_7O^+$], 55 (32) [$C_4H_7^+$], 42 (12) [$C_3H_6^+$]; GC-MS (CI, NH_3): *m*/*z* (%) = 311 (4) [M+NH_4^+], 294 (100) [M+H^+], 293 (5) [M^+], 236 (6) [M+H − $C_3H_6O^+$], 188 (6) [S*Cby*$^+$], 156 (13) [*Cby*$^+$]; $C_{16}H_{23}NO_2S$ (293.43): calcd C 65.49, H 7.90, N 4.77, found C 65.58, H 8.18, N 4.91.

Deprotonation reactions

Standard conditions: Under argon, thiocarbamate (*S*)-**10** (293 mg, 1.00 mmol) and TMEDA (174 mg, 1.50 mmol) were dissolved in anhydrous diethyl ether (10.0 mL) and cooled to − 78 °C (dry ice/acetone). At this temperature salt-free *sec*-butyllithium solution (1.25 mmol, ca. 1.3 M in cyclohexane or in cyclohexane/hexane, 92:8) was added. After 2 h of

stirring, the electrophile (1.1–3.0 mmol) was injected and the reaction mixture was stirred for another 2 to 16 hours. The cold solution was poured into a mixture of diethyl ether and 2 M aqueous HCl (10 mL each). The aqueous layer was extracted three times with diethyl ether. After drying and neutralizing the combined ethereal layers with solid Na_2SO_4/$NaHCO_3$, the crude product *ent*-**11**/**11** was purified by flash chromatography on silica gel with Et_2O/hexanes (1:1–1:4) as eluent.

Warming experiments: After lithiation and 1 h of stirring at −78 °C (see above) the reaction mixture was warmed to 0 °C (internal thermometer) in an ice/water bath over 2 to 5 min, kept at this temperature for 10 min, and cooled to −78 °C with a dry ice/acetone bath over a period of about 10 min. The electrophile was added and the reaction mixture was worked up as described above.

(−)-(*S*)-*S*-1-Deutero-1-phenylethyl 2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate (11a): $[\alpha]_D^{22} = -129.1$ ($c = 1.24$ in CH_2Cl_2); 90 % D (GC-MS, CI, NH_3); ≥99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 53 mol % (+)-Eu(hfc)$_3$: 5′-H_2, $\Delta\delta = 0.01$ ppm at $\delta = 4.2$, (*R*):(*S*) < 1:218]; m.p.: 94 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.45$, 1.50, 1.62, 1.62 (s, 12 H, 2′-CH_3, 4′-CH_3), 1.69 (s, 3 H, 1-CH_3), 3.73 (s, 2 H, 5′-H_2), 7.25–7.40 (m, 5 H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 23.0$, 24.8 (q, 2′-CH_3, 4′-CH_3), 25.8 (q, 1-CH_3), 44.2 (s, C-1), 61.1 (s, C-4′), 76.7 (t, C-5′), 96.7 (s, C-2′), 127.1, 128.5 (d, C-2″C-3″), 127.4 (d, C-4″), 142.9 (s, C-1″), 163.2 (s, C=O); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1615 (C=O); $C_{16}H_{22}DNO_2S$ (294.44): calcd C 65.27, (H+D) 8.22, N 4.76; found C 65.55, (H + D) 7.97, N 4.85.

Methyl (−)-(*R*)-2-phenyl-2-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)propionate (*ent*-11b): $[\alpha]_D^{21} = -26.0$ ($c = 1.05$ in CH_2Cl_2 with ElX = ClCOOMe), $[\alpha]_D^{21} = -25.8$ ($c = 1.05$ in CH_2Cl_2 with ElX = CO_2); >99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 22 mol % (+)-Eu(hfc)$_3$: OCH_3, $\Delta\delta = 0.04$ ppm at $\delta = 4.2$, (*S*):(*R*) < 1:175]; m.p.: 113 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.48$, 1.64 (s, 12 H, 2′-CH_3, 4′-CH_3), 2.18 (s, 3 H, 1-CH_3), 3.75 (s, 2 H, 5′-H_2), 3.76 (s, 3 H, O-CH_3), 7.26–7.55 (m, 5 H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.8$, 25.6 (q, 2′-CH_3, 4′-CH_3), 28.9 (q, 1-CH_3), 52.9 (q, O-CH_3), 58.4 (s, C-1), 60.9 (s, C-4′), 76.8 (t, C-5′), 97.8 (s, C-2′), 127.0, 128.6 (d, C-2″, C-3″), 128.1 (d, C-4″), 138.8 (s, C-1″), 162.2 (s, SC=O), 173.1 (s, OC=O); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1710 (OC=O), 1615 (SC=O); $C_{18}H_{25}NO_4S$ (351.47): calcd C 61.51, H 7.17, N 3.99; found C 61.79, H 7.31, N 4.27.

(−)-(*R*)-3-Phenyl-3-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-2-butanone (*ent*-11c): $[\alpha]_D^{22} = -22.5$ ($c = 1.17$ in CH_2Cl_2); >99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 17 mol % (+)-Pr(hfc)$_3$: 3-H_3, $\Delta\delta = 0.02$ ppm at $\delta = 1.7$, (*R*):(*S*) > 191:1 and 1-CH_3, $\Delta\delta = 0.03$ ppm at $\delta = 1.5$, (*S*):(*R*) < 1:205] or [^{1}H NMR, 300 MHz, $CDCl_3$, 15 mol % (+)-Eu(hfc)$_3$: 3-H_3, $\Delta\delta = 0.02$ ppm at $\delta = 2.6$, (*S*):(*R*) < 1:182 and 1-CH_3, $\Delta\delta = 0.01$ ppm at $\delta = 2.3$, (*R*):(*S*) > 194:1]; m.p.: 65 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.53$ (s, 6 H, 4′-CH_3), 1.64 (s, 6 H, 2′-CH_3), 2.07 (s, 3 H, 1-CH_3), 2.28 (s, 3 H, 3-H_3), 3.71 (s, 2 H, 5′-H_2), 7.24–7.60 (m, 5 H, 2″-H, 3″-H, 4″-H), ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 22.8$, 23.2 (q, C-3, 1-CH_3), 23.7, 24.8 (q, 2′-CH_3, 4′-CH_3), 57.0 (s, C-1), 62.8 (s, C-4′), 74.8 (t, C-5′), 96.0 (s, C-2′), 125.0, 126.9 (d, C-2″, C-3″), 126.0 (d, C-4″), 136.8 (s, C-1″), 160.0 (s, SC=O), 203.1 (s, C-2); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1695 (CC=O), 1620 (SC=O); GC-MS (EI, 70 eV): *m*/*z* (%) = 335 (6) [M^+], 293 (66) [$M - CH_3CO^+$], 278 (6) [$M - CH_3CO - CH_3^+$], 189 (8) [S*Cby*$^+$], 156 (100) [*Cby*$^+$], 147 (18) [$C_{10}H_{11}O^+ = M - S$*Cby*$^+$], 98 (44) [$C_5H_8NO^+ = Cby - C_3H_6O^+$], 59 (90) [$C_3H_7O^+$]; GC-MS (CI, NH_3): *m*/*z* (%) = 336 (100) [M+H^+], 293 (3) [$M - CH_3CO^+$], 156 (5) [*Cby*$^+$]; $C_{18}H_{25}NO_3S$ (335.47): calcd C 64.45, H 7.52, N 4.18; found C 64.10, H 7.55, N 4.39.

(−)-(*R*)-2-Phenyl-2-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-3-pentanone (*ent*-11d): $[\alpha]_D^{21} = -17.9$ ($c = 1.20$ in CH_2Cl_2); >99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 28 mol % (+)-Eu(hfc)$_3$: 1-CH_3, $\Delta\delta = 0.03$ ppm at $\delta = 2.4$, (*R*):(*S*) > 426:1]; m.p.: 73 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.01$ (dd, 3 H, 4-H_3), 1.52, 1.54 (s, 6 H, 4′-CH_3), 1.63 (s, 6 H, 2′-CH_3), 2.08 (s, 3 H, 1-CH_3), 2.55 (dq, 1 H, 3-H_a), 2.73 (dq, 1 H, 3-H_b), 3.76 (s, 2 H, 5′-H_2), 7.26–7.33 (m, 5 H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-}H_a,4\text{-}H_3} = 7.3$ Hz, $^3J_{3\text{-}H_b,4\text{-}H_3} = 7.3$ Hz, $^2J_{3\text{-}H_a,3\text{-}H_b} = 17.5$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 9.4$ (q, C-4), 25.3, 26.3, 27.1, 27.3 (q, 2′-CH_3, 4′-CH_3), 30.9 (t, C-3), 31.0 (q, 1-CH_3), 61.6 (s, C-4′), 65.2 (s, C-1), 77.1 (t, C-5′), 98.3 (s, C-2′), 127.4, 129.2 (d, C-2″, C-3″), 128.3 (d, C-4″), 139.6 (s, C-1″), 162.5 (s, SC=O), 208.5 (s, C-2); IR (film): $\tilde{\nu}$ (cm^{-1}) = 1710 (CC=O), 1620 (SC=O); $C_{19}H_{27}NO_3S$ (349.49): calcd C 65.30, H 7.79, N 4.01; found C 65.55, H 7.88, N 4.10.

(−)-(*R*)-4-Methyl-2-phenyl-2-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-3-pentanone (*ent*-11e): $[\alpha]_D^{20} = -42.4$ ($c = 1.56$ in CH_2Cl_2); >99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 28 mol % (+)-Eu(hfc)$_3$: 5′-H_2, $\Delta\delta = 0.08$ ppm at $\delta = 3.3$, (*S*):(*R*) < 1:167]; m.p.: 84 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.76$ (d, 3 H, 4a-H_3), 0.97 (d, 3 H, 4b-H_3), 1.52, 1.55, 1.59, 1.62 (s, 12 H, 2′-CH_3, 4′-CH_3), 2.15 (s, 3 H, 1-CH_3), 3.20 (sept, 1 H, 3-H), 3.75 (s, 2 H, 5′-H_2), 7.24–7.50 (m, 5 H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-}H,4a\text{-}H_3} = 6.7$ Hz, $^3J_{3\text{-}H,4b\text{-}H_3} = 6.7$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 21.0$, 22.0, 25.2, 25.5, 26.1, 26.3, 26.4 (q, 1-CH_3, C-4a, C-4b, 2′-CH_3, 4′-CH_3), 36.9 (d, C-3), 62.1 (s, C-4′), 65.5 (s, C-1), 77.4 (t, C-5′), 97.2 (s, C-2′), 127.7, 128.9 (d, C-2″, C-3″), 128.2 (d, C-4″), 138.9 (s, C-1″), 162.1 (s, SC=O), 211.4 (s, C-2); IR (film): $\tilde{\nu}$ (cm^{-1}) = 1710 (CC=O), 1630 (SC=O); GC-MS (EI, 70 eV): *m*/*z* (%) = 363 (5) [M^+], 293 (10) [$M - C_3H_7CO^+$], 278 (2) [$M - C_3H_7CO - CH_3^+$], 156 (100) [*Cby*$^+$], 105 (10) [$C_8H_9^+$], 98 (30) [*Cby* − $C_3H_6O^+$], 59 (86) [$C_3H_7O^+$]; $C_{20}H_{29}NO_3S$ (363.52): calcd C 66.08, H 8.04, N 3.85; found C 65.90, H 8.10, N 3.93.

(−)-(*R*)-4,4-Dimethyl-2-phenyl-2-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-3-pentanone (*ent*-11f): $[\alpha]_D^{22} = -68.5$ ($c = 0.92$ in CH_2Cl_2); >99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 61 mol % (+)-Pr(hfc)$_3$: 5′-H_2, $\Delta\delta = 0.08$ ppm at $\delta = 3.3$, (*S*):(*R*) < 1:215]; m.p.: 64 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.07$ (s, 9 H, 3-CH_3), 1.52, 1.54, 1.61, 1.63 (s, 12 H, 2′-CH_3, 4′-CH_3), 2.16 (s, 3 H, 1-CH_3), 3.75 (s, 2 H, 5′-H_2), 7.26–7.34 (m, 5 H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.9$, 25.1, 25.8, 29.0, 29.0 (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 29.7 (q, 3-CH_3), 46.0 (s, C-3), 61.0 (s, C-4′), 65.4 (s, C-1), 76.6 (t, C-5′), 97.7 (s, C-2′), 126.7, 128.6 (d, C-2″, C-3″), 127.5 (d, C-4″), 139.5 (s, C-1″), 161.6 (s, SC=O), 209.7 (s, C-2); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1695 (CC=O), 1625 (SC=O); $C_{21}H_{31}NO_3S$ (377.55): calcd C 66.81, H 8.28, N 3.71; found C 66.68, H 8.21, N 3.96.

(+)-(*R*)-*S*-(1-Benzoyl-1-phenylethyl)-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthiocarboxylate) (*ent*-11g): $[\alpha]_D^{24} = +116.6$ ($c = 1.68$ in CH_2Cl_2); >98 % *ee* [^{1}H NMR, 360 MHz, $CDCl_3$, 20 mol % (+)-Eu(hfc)$_3$: 1-CH_3, $\Delta\delta = 0.04$ ppm at $\delta = 2.2$, (*R*):(*S*) > 126:1]; m.p.: 124 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.23–1.44$ (4s, 12 H, 2′-CH_3, 4′-CH_3), 2.16 (s, 3 H, 1-CH_3), 3.58 (d, 1 H, 5′-H_a), 3.62 (d, 1 H, 5′-H_b), 7.16–7.61 (m, 10 H, 4-H, 5-H, 6-H, 2″-H, 3″-H, 4″-H), $^2J_{5'\text{-}H_a,5'\text{-}H_b} = 8.7$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.3–25.7$ (q, 2′-CH_3, 4′-CH_3), 31.2 (q, 1-CH_3), 60.8 (s, C-4′), 63.6 (s, C-1), 76.6 (t, C-5′), 97.6 (s, C-2′), 126.6, 127.0 (d, C-2″, C-3″), 127.8 (d, C-4″), 129.0, 129.8 (d, C-4, C-5), 130.9 (d, C-6), 136.4 (s, C-1″), 140.0 (s, C-3), 161.1 (s, SC=O), 199.4 (s, PhC=O); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1670 (CC=O), 1620 (SC=O); $C_{23}H_{27}NO_3S$ (397.54): calcd C 69.49, H 6.74, N 3.52; found C 69.32, H 6.81, N 3.67.

(2*R*,3*R*)- and (2*S*,3*R*)-3-Phenyl-3-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-2-butanol (*ent*-11h/h′): $[\alpha]_D^{21} = -68.3$ ($c = 1.26$ in CH_2Cl_2, *syn*-**11h**:*anti*-**11h** = 52:48, 99 % *ee* after Swern oxidation); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3300 (O–H), 1625, 1595 (C=O); $C_{18}H_{27}NO_3S$ (337.48): calcd C 64.06, H 8.06, N 4.15, found C 64.21, H 8.31, N 4.17; *syn*-**11h** (major diastereomer): ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.00$ (d, 3 H, 3-H_3), 1.47, 1.48, 1.57, 1.57 (s, 12 H, 2′-CH_3, 4′-CH_3), 1.81 (s, 3 H, 1-CH_3), 3.73 (s, 2 H, 5′-H_2), 4.60 (dq, 1 H, 2-H), 5.66 (d, 1 H, OH), 7.21–7.62 (m, 5 H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-}H_3,2\text{-}H} = 6.2$ Hz, $^3J_{2\text{-}H,OH} = 2.2$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 19.0$ (q, C-3), 21.7 (q, 1-CH_3), 25.0, 26.0 (q, 2′-CH_3, 4′-CH_3), 61.8 (s, C-4′), 64.4 (s, C-1), 74.5 (d, C-2), 76.6 (t, C-5′), 98.4 (s, C-2′), 127.0, 128.7 (d, C-2″, C-3″), 127.8 (d, C-4″), 143.1 (s, C-1″), 165.1 (s, C=O); *anti*-**11h** (minor diastereomer): ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.15$ (d, 3 H, 3-H_3), 1.45, 1.51, 1.55, 1.62 (s, 12 H, 2′-CH_3, 4′-CH_3), 2.00 (s, 3 H, 1-CH_3), 3.69 (s, 1 H, OH), 3.72 (s, 2 H, 5′-H_2), 4.27 (q, 1 H, 2-H), 7.21–7.62 (m, 5 H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-}H_3,2\text{-}H} = 6.4$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 19.6$ (q, C-3), 23.0 (q, 1-CH_3), 24.3, 25.7 (q, 2′-CH_3, 4′-CH_3), 62.1 (s, C-4′), 63.7 (s, C-1), 74.2 (d, C-2), 76.9 (t, C-5′), 97.2 (s, C-2′), 127.5, 128.5 (d, C-2″, C-3″), 127.6 (d, C-4″), 142.6 (s, C-1″), 163.9 (s, C=O).

(2*R*,3*R*)- and (2*R*,3*S*)-2-Phenyl-2-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-3-pentanol (*ent*-11i/i′): $[\alpha]_D^{22} = -61.9$ ($c = 1.62$ in CH_2Cl_2, *syn*-**11i**:*anti*-**11i** = 41:59, ≥98 % *ee* after Swern oxidation); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3450, 3320 (O–H), 1610, 1595 (C=O); $C_{19}H_{29}NO_3S$ (351.51): calcd C 64.92, H 8.32, N 3.98, found C 64.91, H 8.34, N 3.80; *anti*-**11i** (major diastereomer): ^{1}H NMR (360 MHz, $CDCl_3$): $\delta = 0.90–1.03$ (m, 3 H, 4-H_3), 1.12–1.26 (m, 1 H, 3-H_a), 1.44, 1.51, 1.56, 1.56 (s, 12 H, 2′-CH_3, 4′-CH_3), superimposed: 1.48–1.57 (m, 1 H, 3-H_b), 2.00 (s, 3 H, 1-CH_3), 3.47 (d, 1 H, OH), 3.73 (s, 2 H, 5′-H_2), 3.94 (ddd, 1 H, 2-H), 7.21–7.60 (m, 5 H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-}H,OH} = 6.0$ Hz, $^3J_{2\text{-}H,3\text{-}H_a} = 10.2$ Hz, $^3J_{2\text{-}H,3\text{-}H_b} = 1.9$ Hz, the correct assignment of ^{1}H NMR signals was aided by H,H-COSY; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 11.1$ (q, C-4), 25.2 (q, 1-CH_3), 26.0, 26.4, 28.2, 29.2 (q,

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2′-CH_3, 4′-CH_3), 26.0 (t, C-3), 62.6 (s, C-4′), 65.6 (s, C-1), 76.8 (t, C-5′), 81.2 (d, C-2), 94.4 (s, C-2′), 128.9, 129.3 (d, C-2″, C-3″), 129.2 (d, C-4″), 144.5 (s, C-1″), 165.0 (s, C=O); *syn*-**11i** (minor diastereomer): ^{1}H NMR 360 MHz, $CDCl_3$): $\delta = 0.90-1.03$ (m, 3H, 4-H_3), 1.07–1.18 (m, 1H, 3-H_a), 1.21–1.34 (m, 1H, 3-H_b), 1.45, 1.47, 1.55, 1.62 (s, 12H, 2′-CH_3, 4′-CH_3), 1.85 (s, 3H, 1-CH_3), 3.71 (s, 2H, 5′-H_2), 4.27 (ddd, 1H, 2-H), 5.31 (d, 1H, OH), 7.21–7.60 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-H,OH}} = 2.4$ Hz, $^3J_{2\text{-H,3-H}_a} = 9.9$ Hz, $^3J_{2\text{-H,3-H}_b} = 2.2$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 11.7$ (q, C-4), 22.4 (q, 1-CH_3), 25.6, 26.4, 26.7, 27.3 (q, 2′-CH_3, 4′-CH_3), 25.8 (t, C-3), 62.6 (s, C-4′), 65.4 (s, C-1), 77.0 (t, C-5′), 81.1 (d, C-2), 94.2 (s, C-2′), 127.5, 128.3 (d, C-2″, C-3″), 128.0 (d, C-4″), 143.9 (s, C-1″), 165.1 (s, C=O).

(2*R*,3*S*)- and (2*R*,3*R*)-4-Methyl-2-phenyl-2-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-3-pentanol (*ent*-11j/j′): $[\alpha]_D^{21} = -82.6$ ($c = 1.76$ in CH_2Cl_2, *syn*-**11j**:*anti*-**11j** = 41:59, 96% *ee* after Swern oxidation); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3300 (O–H), 1625, 1595 (C=O); $C_{20}H_{31}NO_3S$ (365.54): calcd C 65.72, H 8.55, N 3.83, found C 65.70, H 8.48, N 3.61; *anti*-**11j** (major diastereomer): ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.74$ (d, 3H, 4a-H_3), 0.86 (d, 3H, 4b-H_3), 1.48, 1.51, 1.60, 1.60 (s, 12H, 2′-CH_3, 4′-CH_3), 1.84 (dqq, 1H, 3-H), 2.05 (s, 3H, 1-CH_3), 3.73 (s, 2H, 5′-H_2), 3.74 (d, 1H, OH), 3.92 (dd, 1H, 2-H), 7.22–7.62 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-H,OH}} = 3.3$ Hz, $^3J_{2\text{-H,3-H}} = 6.4$ Hz, $^3J_{3\text{-H,4a-H}_3} = 6.9$ Hz, $^3J_{3\text{-H,4b-H}_3} = 6.7$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 14.1$, 17.2 (q, C-4a, C-4b), 21.1, 23.0, 23.2, 25.4, 25.5 (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 30.1 (d, C-3), 60.8 (s, C-4′), 63.8 (s, C-1), 76.6 (t, C-5′), 82.0 (d, C-2), 97.7 (s, C-2′), 127.1, 128.4 (d, C-2″, C-3″), 127.5 (d, C-4″), 142.7 (s, C-1″), 164.8 (s, C=O); *syn*-**11j** (minor diastereomer): ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.82$ (d, 3H, 4a-H_3), 0.85 (d, 3H, 4b-H_3), 1.27 (m, 1H, 3-H), 1.42, 1.44, 1.55, 1.63 (s, 12H, 2′-CH_3, 4′-CH_3), 1.95 (s, 3H, 1-CH_3), 3.70 (s, 2H, 5′-H_2), 4.37 (dd, 1H, 2-H), 5.59 (d, 1H, OH), 7.22–7.62 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-H,OH}} = 3.0$ Hz, $^3J_{2\text{-H,3-H}} = 3.0$ Hz, $^3J_{3\text{-H,4a-H}_3} = 6.9$ Hz, $^3J_{3\text{-H,4b-H}_3} = 6.9$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 16.8$, 17.2 (q, C-4a, C-4b), 21.6, 22.7, 23.8, 25.7, 26.0 (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 30.7 (d, C-3), 60.8 (s, C-4′), 65.0 (s, C-1), 76.6 (t, C-5′), 82.3 (d, C-2), 97.7 (s, C-2′), 126.6, 128.0 (d, C-2″, C-3″), 127.3 (d, C-4″), 143.0 (s, C-1″), 165.4 (s, C=O).

(2*R*,3*S*)- and (2*R*,3*R*)-4,4-Dimethyl-2-phenyl-2-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-3-pentanol (*ent*-11k/k′): $[\alpha]_D^{20} = -120.3$ ($c = 0.88$ in CH_2Cl_2, *syn*-**11k**:*anti*-**11k** = 43:57, >99% *ee* after Swern oxidation); m.p.: 80 °C; IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3450 (O–H), 1600 (C=O); $C_{21}H_{33}NO_3S$ (379.56): calcd C 66.45, H 8.76, N 3.69, found C 66.42, H 8.87, N 3.85; *anti*-**11k** (major diastereomer): ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.80$ (s, 9H, 3-CH_3), 1.50, 1.52, 1.60, 1.65 (s, 12H, 2′-CH_3, 4′-CH_3), 2.12 (s, 3H, 1-CH_3), 3.74 (s, 2H, 5′-H_2), 4.05 (s, 1H, 2-H), 4.11 (s, 1H, OH), 7.21–7.33, 7.60–7.63 (m, 5H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.6$, 25.5, 25.8, 26.1 (q, 2′-CH_3, 4′-CH_3), 27.9 (q, 1-CH_3), 28.5 (q, 3-CH_3), 37.5 (s, C-3), 62.3 (s, C-4′), 64.9 (s, C-1), 76.7 (t, C-5′), 83.6 (d, C-2), 97.8 (s, C-2′), 127.1 (d, C-4″), 127.7, 127.9 (d, C-2″, C-3″), 143.3 (s, C-1″), 164.0 (s, C=O); *syn*-**11k** (minor diastereomer): ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.76$ (s, 9H, 3-CH_3), 1.36, 1.42, 1.51, 1.58 (s, 12H, 2′-CH_3, 4′-CH_3), 2.06 (s, 3H, 1-CH_3), 3.68 (s, 2H, 5′-H_2), 4.33 (s, 1H, 2-H), 5.52 (s, 1H, OH), 7.21–7.33, 7.60–7.63 (m, 5H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 21.8$ (q, 1-CH_3), 25.0, 26.4, 28.2, 28.3 (q, 2′-CH_3, 4′-CH_3), 29.0 (q, 3-CH_3), 38.3 (s, C-3), 62.3 (s, C-4′), 67.2 (s, C-1), 76.9 (t, C-5′), 84.4 (d, C-2), 97.9 (s, C-2′), 126.7 (d, C-4″), 127.3, 128.2 (d, C-2″, C-3″), 144.0 (s, C-1″), 165.8 (s, C=O).

(1*R*,2*R*)- and (1*S*,2*R*)-1,2-Diphenyl-2-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-1-propanol (*ent*-11l/l′): $[\alpha]_D^{22} = -48.2$ ($c = 1.15$ in CH_2Cl_2, *syn*-**11l**:*anti*-**11l** = 42:58, ≥99% *ee* after Swern oxidation); m.p.: 84 °C; IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3450 (O–H), 1610 (C=O); $C_{23}H_{29}NO_3S$ (399.55): calcd C 69.14, H 7.32, N 3.51, found C 69.23, H 7.48, N 3.71; *anti*-**11l** (major diastereomer): ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.46$, 1.50, 1.59, 1.65 (s, 12H, 2′-CH_3, 4′-CH_3), 2.05 (s, 3H, 1-CH_3), 3.73 (s, 2H, 5′-H_2), 4.31 (d, 1H, OH), 5.24 (d, 1H, 2-H), 6.91–7.51 (m, 10H, 4-H, 5-H, 6-H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-H,OH}} = 2.6$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 23.0-26.4$ (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 62.3 (s, C-4′), 64.6 (s, C-1), 77.0 (t, C-5′), 80.9 (d, C-2), 98.2 (s, C-2′), 127.5–128.8 (d, C-4, C-5, C-6, C-2″, C-3″, C-4″), 140.2, 141.6 (s, C-3, C-1″), 164.1 (s, C=O); *syn*-**11l** (minor diastereomer): ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.45$, 1.50, 1.56, 1.61, 1.64 (s, 15H, 1-CH_3, 2′-CH_3, 4′-CH_3), 3.73 (s, 2H, 5′-H_2), 5.49 (d, 1H, 2-H), 6.52 (d, 1H, OH), 6.91–7.51 (m, 10H, 4-H, 5-H, 6-H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-H,OH}} = 2.6$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 23.0-26.4$ (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 62.1 (s, C-4′), 63.5 (s, C-1), 77.8 (t, C-5′), 81.1 (d, C-2), 98.2 (s, C-2′), 127.5–128.8 (d, C-4, C-5, C-6, C-2″, C-3″, C-4″), 141.1, 143.4 (s, C-3, C-1″), 166.4 (s, C=O).

(−)-(*R*)-2-Methyl-3-phenyl-3-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-2-butanol (*ent*-11m): $[\alpha]_D^{22} = -52.1$ ($c = 1.12$ in CH_2Cl_2); 62% *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 35 mol% (+)-Pr(hfc)$_3$: 5′-H_2, $\Delta\delta = 0.03$ ppm at $\delta = 4.1$, (*R*):(*S*) = 4.2:1.0]; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.02$, 1.42 (s, 6H, 2-CH_3), 1.49, 1.51, 1.57, 1.62 (s, 12H, 2′-CH_3, 4′-CH_3), 2.10 (s, 3H, 1-CH_3), 3.74 (s, 2H, 5′-H_2), 4.67 (s, 1H, OH), 7.21–7.62 (m, 5H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 23.8$, 25.0, 25.6, 26.0, 26.2, 27.2, 27.8 (q, 1-CH_3, 2-CH_3, 2′-CH_3, 4′-CH_3), 65.2, 65.6, 67.2 (s, C-1, C-2, C-4′), 75.1 (t, C-5′), 99.7 (s, C-2′), 126.6 (d, C-4″), 127.8, 127.9 (d, C-2″, C-3″), 142.8 (s, C-1″), 163.8 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3300 (O–H), 1625, 1585 (C=O); $C_{19}H_{29}NO_3S$ (351.51): calcd C 64.92, H 8.32, N 3.98; found C 64.89, H 8.60, N 3.90.

(−)-(*R*)-1,1,2-Triphenyl-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-carbonylthio)-1-propanol (*ent*-11n): $[\alpha]_D^{21} = -35.0$ ($c = 1.20$ in CH_2Cl_2); 68% *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 63 mol% (+)-Pr(hfc)$_3$: C_{arom}-H, $\Delta\delta =$ 0.07 ppm at $\delta = 5.9$, (*R*):(*S*) = 5.2:1.0]; m.p.: 110 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.40$, 1.40, 1.51, 1.55 (s, 12H, 2′-CH_3, 4′-CH_3), 2.11 (s, 3H, 1-CH_3), 3.69 (s, 2H, 5′-H_2), 6.96 (s, 1H, OH), 7.06–7.81 (m, 15H, 4-H, 5-H, 6-H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 25.0$, 25.5, 25.9, 26.0, 26.1 (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 62.4 (s, C-4′), 69.6 (s, C-1), 77.1 (t, C-5′), 83.4 (s, C-2), 98.7 (s, C-2′), 127.1, 127.2, 128.7, 129.3, 130.0, 130.1 (d, C-4a, C-4b, C-5a, C-5b, C-2″, C-3″), 127.6, 130.4, 132.8 (d, C-6a, C-6b, C-4″), 142.3, 144.9, 145.3 (s, C-3a, C-3b, C-1″), 165.3 (s, C=O); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3450 (O–H), 1595 (C=O); $C_{29}H_{33}NO_3S$ (475.65): calcd C 73.23, H 6.99, N 2.94; found C 72.86, H 7.10, N 2.71.

(−)-(*S*)-*S*-1-Methyl-1-phenylpropyl 2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate (*ent*-11o): $[\alpha]_D^{23} = -30.3$ ($c = 1.12$ in CH_2Cl_2, 97% *op*); *ee* not determined; m.p.: 90 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.79$ (dd, 3H, 3-H_3), 1.44, 1.57 (s, 12H, 2′-CH_3, 4′-CH_3), 1.97 (s, 3H, 1-CH_3), 2.14 (dq, 1H, 2-H_a), 2.29 (dq, 1H, 2-H_b), 3.68 (s, 2H, 5′-H_2), 7.10–7.54 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-H}_3,2\text{-H}_a} = 7.4$ Hz, $^3J_{3\text{-H}_3,2\text{-H}_b} = 7.4$ Hz, $^2J_{2\text{-H}_a,2\text{-H}_a} = 13.8$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 9.6$ (q, C-3), 24.6, 25.4, 25.8, 26.1, 26.3 (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 35.5 (t, C-2), 56.9 (s, C-1), 69.4 (s, C-4′), 77.2 (t, C-5′), 97.0 (s, C-2′), 126.7 (d, C-4″), 127.3, 128.2 (d, C-2″, C-3″), 144.1 (s, C-1″), 162.0 (s, C=O); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1605 (C=O); $C_{18}H_{27}NO_2S$ (321.48): calcd C 67.25, H 8.47, N 4.36; found C 67.24, H 8.41, N 4.56.

(−)-(*S*)-*S*-1-Methyl-1-phenylbutyl 2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate (*ent*-11p): $[\alpha]_D^{20} = -48.1$ ($c = 1.26$ in CH_2Cl_2); *ee* not determined; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.85$ (dd, 3H, 4-H_3), 1.00–1.40 (m, 2H, 3-H_2), 1.43, 1.47, 1.51, 1.57 (s, 12H, 2′-CH_3, 4′-CH_3), 2.00 (s, 3H, 1-CH_3), superimposed: 2.00–2.10 (ddd, 1H, 2-H_a), 2.15–2.26 (ddd, 1H, 2-H_b), 3.68 (s, 2H, 5′-H_2), 7.15–7.54 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-H}_a,3\text{-H}_a} = 4.5$ Hz, $^3J_{2\text{-H}_a,3\text{-H}_b} = 7.4$ Hz, $^3J_{2\text{-H}_b,3\text{-H}_a} = 7.1$ Hz, $^3J_{2\text{-H}_b,3\text{-H}_b} = 4.8$ Hz, $^3J_{3\text{-H}_a,4\text{-H}_3} = 7.2$ Hz, $^3J_{3\text{-H}_b,4\text{-H}_3} = 7.2$ Hz, $^2J_{2\text{-H}_a,2\text{-H}_b} = 13.6$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 14.7$ (q, C-4), 18.4 (t, C-3), 24.3, 25.2, 25.4, 26.1, 26.4 (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 45.3 (t, C-2), 57.3 (s, C-1), 61.3 (s, C-4′), 72.2 (t, C-5′), 97.7 (s, C-2′), 126.2 (d, C-4″), 126.7, 127.8 (d, C-2″, C-3″), 145.3 (s, C-1″), 162.9 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 1625 (C=O); $C_{19}H_{29}NO_2S$ (335.51): calcd C 68.02, H 8.71, N 4.17; found C 67.78, H 8.48, N 4.28.

(−)-(*S*)-*S*-1-Methyl-1-phenylheptyl 2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate (*ent*-11q): $[\alpha]_D^{20} = -38.4$ ($c = 1.60$ in CH_2Cl_2); >99% *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 90 mol% (+)-Pr(hfc)$_3$: 5′-H_2, $\Delta\delta = 0.008$ ppm at $\delta = 3.5$, (*S*):(*R*) > 590:1]; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.84$ (dd, 3H, 7-H_3), 1.07–1.31 (m, 10H, 2-H_2, 3-H_2, 4-H_2, 5-H_2, 6-H_2), 1.44, 1.47, 1.51, 1.57 (s, 12H, 2′-CH_3, 4′-CH_3), 1.99 (s, 3H, 1-CH_3), 3.69 (s, 2H, 5′-H_2), 7.15–7.54 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{7\text{-H}_3,6\text{-H}_a} = 6.9$ Hz, $^3J_{7\text{-H}_3,6\text{-H}_b} = 6.9$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 14.0$ (q, C-7), 22.6, 24.6 (t, C-3, C-6), 24.8, 25.0, 25.7, 25.9, 26.0 (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 29.6, 31.6 (t, C-4, C-5), 42.5 (t, C-2), 56.9 (s, C-1), 60.9 (s, C-4′), 76.6 (t, C-5′), 97.3 (s, C-2′), 126.2 (d, C-4″), 126.8, 127.8 (d, C-2″, C-3″), 145.4 (s, C-1″), 163.0 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 1630 (C=O); $C_{22}H_{35}NO_2S$ (377.59): calcd C 70.00, H 9.34, N 3.71; found C 70.01, H 9.48, N 3.90.

(−)-(*S*)-*S*-1-Methyl-1-phenylbut-3-enyl 2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate (*ent*-11r): $[\alpha]_D^{21} = -25.2$ ($c = 1.08$ in CH_2Cl_2); *ee* not determined; m.p.: 91 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.44$, 1.46, 1.54, 1.56 (s, 12H, 2′-CH_3, 4′-CH_3), 1.93 (s, 3H, 1-CH_3), 2.90 (dddd, 1H, 2-H_a), 3.08 (dddd, 1H, 2-H_b), 3.69 (s, 5′-H_2), 4.98–5.10 (m, 2H, 4-H_2), 5.62 (m, 1H, 3-H), 6.88–7.63 (m, 5H, 2″-H, 3″-H, 4″-H), $^4J_{2\text{-H}_a,4\text{-H}} = 1.2$ Hz, $^4J_{2\text{-H}_b,4\text{-H}} = 1.0$ Hz, $^3J_{2\text{-H}_a,3\text{-H}} = 7.6$ Hz, $^3J_{2\text{-H}_b,3\text{-H}} = 6.7$ Hz, $^3J_{3\text{-H},4\text{-H}_b} = 16.9$ Hz, $^3J_{3\text{-H},4\text{-H}_a} = 9.3$ Hz, $^2J_{2\text{-H}_a,2\text{-H}_b} = 14.1$ Hz, $^2J_{4\text{-H}_a,4\text{-H}_b} = 2.1$ Hz; ^{13}C NMR (90 MHz,

$CDCl_3$): $\delta = 24.2$, 24.4, 25.0, 25.7, 26.2 (q, 1-CH_3, 2′-CH_3, 4′-CH_3), 44.0 (t, C-2), 55.9 (s, C-1), 65.8 (s, C-4′), 77.2 (t, C-5′), 95.2 (s, C-2′), 118.1 (t, C-4), 126.5, 127.9 (d, C-2″, C-3″), 126.8 (d, C-4″), 133.9 (d, C-3), 145.1 (s, C-1″), 162.8 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 1620 (C=O); $C_{19}H_{27}NO_2S$ (333.49): calcd C 68.43, H 8.17, N 4.20; found C 68.32, H 7.94, N 3.97.

(−)-(*S*)-*S*-1-Methyl-1,2-diphenylethyl 2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate (*ent*-11s): $[\alpha]_D^{20} = -29.4$ ($c = 1.04$ in CH_2Cl_2); *ee* not determined; m.p.: 76 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.46 - 1.58$ (4s, 12H, 2′-CH_3, 4′-CH_3), 1.90 (s, 3H, 1-CH_3), 3.38 (d, 1H, 1-CH_a), 3.60 (d, 1H, 1-CH_b), 3.70 (s, 2H, 5′-H_2), 6.82 – 7.49 (m, 10H, 2″-H, 3″-H, 4″-H, 4-H, 5-H, 6-H), $^2J_{1\text{-}H_a,1\text{-}H_b} = 8.7$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.8$, 25.0 (q, 2′-CH_3, 4′-CH_3), 25.7 (q, 1-CH_3), 48.0 (t, 1-CH_2), 57.2 (s, C-1), 61.3 (s, C-4′), 76.8 (t, C-5′), 97.1 (s, C-2′), 125.0 – 131.0 (d, C-4, C-5, C-6, C-2″, C-3″, C-4″), 137.0, 144.9 (s, C-3, C-1″), 162.8 (s, C=O), IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1610 (C=O); GC-MS (CI, NH_3): *m*/*z* (%) = 410 (2) [*M*+NH_3^+], 384 (66) [*M*+H^+], 293 (4) [*M*+H − $C_7H_7^+$], 212 (44) [*M* − *Cby*$^+$], 195 (100) [*M* − S*Cby*$^+$], 190 (32) [HS*Cby*+H^+], 156 (35) [*Cby*$^+$], $C_{23}H_{29}NO_2S$ (383.55): calcd C 72.02, H 7.62, N 3.65; found C 72.11, H 7.58, N 3.67.

(−)-(*R*)-*S*-1-Phenyl-1-trimethylsilylethyl 1-(2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate) (*ent*-11t): $[\alpha]_D^{25} = -90.7$ ($c = 1.12$ in CH_2Cl_2); > 98 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 56 mol % (+)-Pr(hfc)$_3$: 1-CH_3, $\Delta\delta = 0.005$ ppm at $\delta = 2.0$, (*S*):(*R*) ≤ 1:123]; m.p.: 76 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.01$ (s, 9H, Si-CH_3), 1.46, 1.48, 1.55, 1.60 (s, 12H, 2′-CH_3, 4′-CH_3), 2.07 (s, 3H, 1-CH_3), 3.71 (s, 2H, 5′-H_2), 7.08 – 7.44 (m, 5H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = -1.0$ (q, Si-CH_3), 25.2 (q, 1-CH_3), 27.3, 27.5, 28.1, 28.3 (q, 2′-CH_3, 4′-CH_3), 45.9 (s, C-1), 63.3 (s, C-4′), 79.3 (t, C-5′), 99.9 (s, C-2′), 126.9 (d, C-4″), 128.8, 130.1 (d, C-2″, C-3″), 147.2 (s, C-1″), 165.0 (s, C=O); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 1640 (C=O); $C_{19}H_{31}NO_2SSi$ (365.61): calcd C 62.43, H 8.56, N 3.83; found C 62.70, H 8.30, N 4.07.

Stereochemical correlations

Swern oxidation of the alcohols *ent*-11h/h′ – *ent*-11l/l′ (for detailed results see Scheme 4): Oxalyl chloride (0.050 mL, 0.55 mmol) and then dimethyl sulfoxide (0.090 mL, 1.1 mmol) were added to dry CH_2Cl_2 (2.5 mL) at −78 °C and mixed for 15 min. The solution of the secondary alcohol (0.5 mmol) in CH_2Cl_2 (1.5 mL) was added dropwise. The reaction mixture was stirred at −78 °C for another 40 min. Then triethylamine (0.35 mL, 0.25 g, 2.5 mmol) was added and after a few minutes the reaction mixture was allowed to warm to room temperature. The addition of water (5 mL) was followed by extraction of the aqueous phase with CH_2Cl_2 (3 × 5 mL). The combined organic layers were dried over $MgSO_4$ and purified by flash chromatography on silica gel (Et_2O/hexanes, 1:2 or 1:4).

***Ent*-11f by methylation of the enolate of *ent*-11c**: At −78 °C and in the presence of triphenylmethane (ca. 1 mg), diisopropylamine (143 mg, 1.41 mmol) in anhydrous THF (4.0 mL) was treated with *n*-butyllithium solution (1.00 mL, 1.44 mmol, 1.44 M in hexanes). While the solution was allowed to warm to 0 °C over a period of 2 h its color turned to deep red. At −20 °C a solution of ketone *ent*-**11c** (122 mg, 0.36 mmol, ≥ 99 % *ee*) in THF (3.0 mL) was added. Over 3 h the reaction mixture was warmed to 22 °C and methyl iodide (0.60 mL, 1.0 g, 10 mmol) was added. After the reaction mixture had been heated to 50 °C for an additional 2 h, it was poured into a mixture of diethyl ether and 2 M aqueous HCl (10 mL each). The aqueous layer was extracted three times with diethyl ether. The combined organic layers were treated with solid Na_2SO_4/$NaHCO_3$ and the crude product was purified by flash chromatography on silica gel with Et_2O/hexanes (1:4). The completely methylated ketone *ent*-**11f** (26 mg, 0.07 mmol, 21 %) was isolated with ≥ 99 % *ee* {$[\alpha]_D^{23} = -66.2$, $c = 0.50$ in CH_2Cl_2, ≥ 99 % *ee*, 97 % *op*}.

***Ent*-11m by reductive methylation of the carbonyl compounds *ent*-11b and *ent*-11c**: A solution of the ester *ent*-**11b** (53 mg, 0.15 mmol) in dry diethyl ether (2 mL) was added dropwise to a suspension of MeMgI (0.24 mL, 1.67 M, 0.40 mmol) in dry diethyl ether (3 mL). After the reaction mixture had been refluxed for 2 h, aqueous HCl (2 M, 5 mL) was added. The aqueous phase was extracted with diethyl ether and the combined organic layers were dried with solid Na_2SO_4/$NaHCO_3$. Flash chromatography on silica gel with Et_2O/hexanes (1:2) yielded the alcohol *ent*-**11m** {24 mg, 0.07 mmol, 47 %, $[\alpha]_D^{26} = -82.9$, $c = 0.55$ in CH_2Cl_2, 98 % *ee*}. In the same way the ketone *ent*-**11c** (135 mg, 0.40 mmol) was transformed to the alcohol *ent*-**11m** {90 mg, 0.26 mmol, 65 %, $[\alpha]_D^{26} = -81.4$, $c = 1.02$ in CH_2Cl_2, 98 % *ee*} by means of MeMgI (0.30 mL, 1.67 M, 0.50 mmol).

***Ent*-11p by catalytic hydrogenation of *ent*-11r**: Pd/C (308 mg, 10 % Pd) was suspended in a solution of the thiocarbamate *ent*-**11r** (90 mg, 0.27 mmol) in MeOH (5 mL) and stirred under hydrogen for two weeks at room temperature. The hydrogenation catalyst was separated by filtration through $MgSO_4$. Flash chromatography of the crude product on silica gel with Et_2O/hexanes (1:2) yielded *ent*-**11p** {76 mg, 0.23 mmol, 84 %, $[\alpha]_D^{23} = -49.7$, $c = 1.41$ in CH_2Cl_2, ≈ 100 % *op*}.

Acidic cleavage of the thiocarbamates *ent*-11 to form β-hydroxythiourethanes *ent*-12 (Methods a, b, and c):

Method a: Methanesulfonic acid (3 drops) and MeOH (0.5 mL) were added to a solution of thiocarbamate *ent*-**11** (0.5 mmol) in diethyl ether (5.0 mL). The reaction mixture was refluxed for a few hours or stirred at room temperature for several days (see Table 4) before conversion was complete. The solvent was evaporated in vacuo and the residue was purified by flash chromatography on silica gel with Et_2O/hexanes (1:1 – 1:2) to yield the product *ent*-**12**.

Method b: The solution of thiocarbamate *ent*-**11** (0.5 mmol) in MeOH (5 mL) was slowly stirred with Amberlyst 15 (approx. 40 mg). After approx 4 d at room temperature or 2 h refluxing the suspension was filtered and the solvent was evaporated in vacuo. The residue was transferred onto a flash chromatography column (silica gel) and the product *ent*-**12** was eluted with Et_2O/hexanes (1:1 – 1:2). The same transformation succeeded when pure diethyl ether, diethyl ether/methanol (approx. 4:1), or dichloromethane were used as solvents.

Method c: The thiocarbamate *ent*-**11** (0.5 mmol) and 1,3-propanedithiol (0.10 mL, 0.11 g, 1.0 mmol) were added to the suspension of Amberlyst 15 (approx. 40 mg) in CH_2Cl_2 (2 mL) at room temperature. The reaction mixture was slowly stirred overnight and used for the flash chromatography of the product *ent*-**12** on silica gel (Et_2O/hexanes, 1:1 – 1:2) without further work-up. The use of 1,2-ethanedithiol instead of 1,3-propanedithiol resulted in slightly lowered yields. The same sample of cationic ion exchanger could be used for several batches without perceptible decrease of activity in methods b and c.

Methyl (−)-(*R*)-*S*-2-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-2-phenylpropanoate (*ent*-12b): **Method a**: $[\alpha]_D^{20} = -23.8$ ($c = 1.60$ in CH_2Cl_2); > 99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 28 mol % (+)-Eu(hfc)$_3$: 1-CH_3, $\Delta\delta = 0.08$ ppm at $\delta = 2.5$, (*S*):(*R*) < 1:204]; m.p.: 128 °C; **Method b**: $[\alpha]_D^{20} = -23.4$ ($c = 1.35$ in CH_2Cl_2, > 99 % *ee*); m.p.: 128 °C. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.19$, 1.22 (s, 6H, 4′-CH_3), 2.08 (s, 3H, 1-CH_3), 3.04 (s, 1H, NH), 3.49 (d, 1H, 5′-H_a), 3.55 (d, 1H, 5′-H_b), 3.81 (s, 3H, O-CH_3), 5.81 (s, 1H, OH), 7.26 – 7.50 (m, 5H, 2″-H, 3″-H, 4″-H), $^2J_{5'\text{-}H_a,5'\text{-}H_b} = 11.8$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.0$, 24.3 (q, 4′-CH_3), 27.0 (q, 1-CH_3), 53.3 (q, O−CH_3), 57.6, 59.1 (s, C-1, C-4′), 69.7 (t, C-5′), 126.8, 128.7 (d, C-2″, C-3″), 128.2 (d, C-4″), 139.1 (s, C-1″), 165.7 (s, S−C=O), 173.5 (s, C-2); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3500, 3300 (O−H, N−H), 1720 (CC=O), 1650 (SC=O); $C_{15}H_{21}NO_4S$ (311.40): calcd C 57.86, H 6.80, N 4.50; found C 58.10, H 6.94, N 4.38.

(−)-(*R*)-*S*-2-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-2-phenyl-3-pentanone (*ent*-12d): $[\alpha]_D^{19} = -49.4$ ($c = 1.07$ in CH_2Cl_2); > 99 % *ee* (concluded from the substrate *ent*-**11d**); m.p.: 84 °C; ^{1}H NMR (300 MHz and 360 MHz, $CDCl_3$): $\delta = 1.00$ (dd, 3H, 4-H_3), 1.25, 1.26 (s, 6H, 4′-CH_3), 2.07 (s, 3H, 1-CH_3), 2.53 (dq, 1H, 3-H_a), superimposed: 2.61 (dq, 1H, 3-H_b), 2.98 (s, 1H, NH), 3.52 (d, 1H, 5′-H_a), 3.57 (d, 1H, 5′-H_b), 5.67 (s, 1H, OH), 7.25 – 7.40 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-}H_a,4\text{-}H_3} = 7.1$ Hz, $^3J_{3\text{-}H_b,4\text{-}H_3} = 7.2$ Hz, $^2J_{3\text{-}H_a,3\text{-}H_b} = 17.7$ Hz, $^2J_{5'\text{-}H_a,5'\text{-}H_b} = 11.4$ Hz; ^{13}C NMR (90 MHz, $CDCl_3$): $\delta = 9.3$ (q, C-4), 24.7, 24.7 (q, 4′-CH_3), 26.7 (q, 1-CH_3), 31.3 (t, C-3), 58.0 (s, C-1), 65.3 (s, C-4′), 70.1 (t, C-5′), 127.3, 129.3 (d, C-2″, C-3″), 128.5 (d, C-4″), 139.3 (s, C-1″), 165.9 (s, S−C=O), 208.6 (s, C-2); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3480, 3310 (O−H, N−H), 1690 (CC=O), 1640 (SC=O); $C_{16}H_{23}NO_3S$ (309.43): calcd C 62.11, H 7.49, N 4.53; found C 62.05, H 7.39, N 4.38.

(−)-(*R*)-*S*-2-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-4-methyl-2-phenyl-3-pentanone (*ent*-12e): $[\alpha]_D^{19} = -97.1$ ($c = 1.22$ in CH_2Cl_2, > 99 % *ee* (concluded from the substrate *ent*-**11e**); m.p.: 106 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.89$ (d, 3H, 4a-H_3), 0.95 (d, 3H, 4b-H_3), 1.23, 1.25 (s, 6H, 4′-CH_3), 2.15 (s, 3H, 1-CH_3), 2.35 (s, 1H, NH), 3.03 (sept, 1H, 3-H), 3.50 (d, 1H, 5′-H_a), 3.55 (d, 1H, 5′-H_b), 5.71 (s, 1H, OH), 7.15 – 7.44 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-}H,4a\text{-}H_3} = 6.7$ Hz, $^3J_{3\text{-}H,4b\text{-}H_3} = 6.7$ Hz, $^2J_{5'\text{-}H_a,5'\text{-}H_b} = 11.4$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 20.8$, 21.3 (q, C-4a, C-4b), 24.1, 24.2 (q, 4′-CH_3), 25.2 (q, 1-CH_3), 35.7 (d, C-3), 57.5 (s, C-1), 65.8 (s, C-4′), 69.6 (t, C-5′), 127.4, 128.7 (d, C-2″, C-3″), 128.2 (d, C-4″), 138.2 (s, C-1″),

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165.2 (s, S–C=O), 211.1 (s, C-2); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3440, 3310 (O–H, N–H), 1700 (CC=O), 1650 (SC=O); $C_{17}H_{25}NO_3S$ (323.46): calcd C 63.13, H 7.79, N 4.33; found C 63.12, H 7.79, N 4.06.

(−)-(*R*)-4,4-Dimethyl-2-[*N*-(2-hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-2-phenyl-3-pentanone (*ent*-12 f): $[\alpha]_D^{22} = -98.9$ ($c = 0.77$ in CH_2Cl_2); > 99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 31 mol % (+)-Eu(hfc)$_3$: 1-CH$_3$, $\Delta\delta = 0.02$ ppm at $\delta = 2.6$, (*S*):(*R*) < 1:185]; m.p.: 133 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.06$ (s, 9H, 3-CH$_3$), 1.23, 1.26 (s, 6H, 4′-CH$_3$), 2.23 (s, 3H, 1-CH$_3$), 3.12 (s, 1H, NH), 3.50 (d, 1H, 5′-H$_a$), 3.55 (d, 1H, 5′-H$_b$), 5.66 (s, 1H, OH), 7.24–7.37 (m, 5H, 2″-H, 3″-H, 4″-H), $^2J_{5'\text{-}H_a,5'\text{-}H_b}$ = 11.4 Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.5$ (q, 4′-CH$_3$), 27.3 (q, 1-CH$_3$), 29.8 (q, 3-CH$_3$), 46.3 (s, C-3), 57.7 (s, C-1), 67.2 (s, C-4′), 70.0 (t, C-5′), 127.2, 129.0 (d, C-2″, C-3″), 128.2 (d, C-4″), 139.5 (s, C-1″), 165.7 (s, S–C=O), 210.6 (s, C-2); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3500, 3320 (O–H, N–H), 1670 (CC=O), 1630 (SC=O); $C_{18}H_{27}NO_3S$ (337.48): calcd C 64.06, H 8.06, N 4.15; found C 64.41, H 8.11, N 4.01.

(−)-(*R*)-*S*-1-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-1,2-diphenyl-1-propanone (*ent*-12 g): $[\alpha]_D^{19} = +73.2$ ($c = 0.53$ in CH_2Cl_2, > 98 % *ee* (concluded from the substrate *ent*-**11 g**); ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.13, 1.16 (s, 6H, 4′-CH$_3$), 2.18 (s, 3H, 1-CH$_3$), 2.66 (s, 1H, NH), 3.37 (d, 1H, 5′-H$_a$), 3.49 (d, 1H, 5′-H$_b$), 5.34 (s, 1H, OH), 7.12–7.41, 7.54–7.56 (m, 10H, 4-H, 5-H, 6-H, 2″-H, 3″-H, 4″-H), $^2J_{5'\text{-}H_a,5'\text{-}H_b}$ = 11.5 Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.0$, 24.3 (q, 4′-CH$_3$), 29.7 (q, 1-CH$_3$), 57.5 (s, C-1), 64.2 (s, C-4′), 69.3 (t, C-5′), 126.7, 127.6, 129.1, 129.8 (d, C-4, C-5, C-2″, C-3″), 128.1, 131.5 (d, C-6, C-4″), 136.5, 140.2 (s, C-3, C-1″), 164.9 (s, S–C=O), 198.8 (s, C-2); IR (film):$\tilde{\nu}$ (cm^{-1}) = 3460, 3320 (O–H, N–H), 1715 (CC=O), 1670 (SC=O); MS (EI, 70 eV): *m*/*z* (%) = 357 (0.1) [M^+], 339 (1) [$M - H_2O^+$], 242 (5) [$M - \mathbf{14}^+$], 210 (3) [$M - \mathbf{14} - S^+$]; $C_{20}H_{23}NO_3S$ (357.47): calcd C 67.20, H 6.49, N 3.92; found C 67.47, H 6.49, N 3.56.

***rac*-*S*-3-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-2-methyl-3-phenyl-2-pentanol (*rac*-12 m)**: ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.15$, 1.17, 1.20, 1.31 (s, 12H, 2-CH$_3$, 4′-CH$_3$), 2.10 (s, 3H, 1-CH$_3$), 3.09 (s, 2H, OH, NH), 3.42 (d, 1H, 5′-H$_a$), 3.46 (d, 1H, 5′-H$_b$), 5.56 (s, 1H, OH), 7.24–7.36, 7.61–7.64 (m, 5H, 2″-H, 3″-H, 4″-H), $^2J_{5'\text{-}H_a,5'\text{-}H_b}$ = 11.7 Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 23.8$, 24.0, 24.2, 26.6, 26.8 (q, 1-CH$_3$, 2-CH$_3$, 4′-CH$_3$), 57.4 (s, C-1), 66.2, 69.6 (s, C-2, C-4′), 75.6 (t, C-5′), 127.3 (d, C-4″), 128.0, 128.5 (d, C-2″, C-3″), 142.0 (s, C-1″), 166.9 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3360, 3200 (O–H, N–H), 1635 (C=O); $C_{16}H_{25}NO_3S$ (311.45): calcd C 61.70, H 8.09, N 4.49; found C 61.79, H 7.88, N 4.09.

(−)-(*S*)-*S*-2-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-2-phenylbutane (*ent*-12 o): $[\alpha]_D^{19} = -48.1$ ($c = 0.56$ in CH_2Cl_2); 97 % *ee* (concluded from the substrate *ent*-**11 o**); ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.80$ (dd, 3H, 3-H$_3$), 1.10, 1.12 (s, 6H, 4′-CH$_3$), 1.93 (s, 3H, 1-CH$_3$), 2.09 (dq, 1H, 2-H$_a$), superimposed: 2.15 (dq, 1H, 2-H$_b$), 2.71 (s, 1H, NH), 3.40 (d, 1H, 5′-H$_a$), 3.45 (d, 1H, 5′-H$_b$), 5.18 (s, 1H, OH), 7.18–7.37, 7.52–7.56 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-}H_a,3\text{-}H_3}$ = 7.4 Hz, $^3J_{2\text{-}H_b,3\text{-}H_3}$ = 7.4 Hz, $^2J_{2\text{-}H_a,2\text{-}H_b}$ = 13.8 Hz, $^2J_{5'\text{-}H_a,5'\text{-}H_b}$ = 11.4 Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 9.0$ (q, C-3), 24.2, 24.4 (q, 4′-CH$_3$), 25.4 (t, C-2), 35.5 (q, 1-CH$_3$), 56.7, 57.3 (s, C-1, C-4′), 69.8 (t, C-5′), 127.0 (d, C-4″), 127.1, 128.3 (d, C-2″, C-3″), 144.2 (s, C-1″), 166.7 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3360, 3290 (O–H, N–H), 1640 (C=O); MS (EI, 70 eV): *m*/*z* (%) = 281 (3) [M^+], 250 (2) [$M - CH_2OH^+$], 166 (10) [$M - \mathbf{14}^+$], 133 (100) [$M - \mathbf{14} - SH^+$], 105 (11) [$C_8H_9^+$], 91 (91) [$C_7H_7^+$], 77 (8) [$C_6H_5^+$], 57 (15) [$C_4H_9^+$], 55 (28) [$C_4H_7^+$]; HR-MS (EI, 70 eV): calcd for $C_{15}H_{23}NO_2S$ [M^+] 281.1450; found 281.1463.

***rac*-*S*-2-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-2-phenylpentane (*rac*-12 p)**: ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.85$ (dd, 3H, 4-H$_3$), 0.95–1.50 (m, 2H, 3-H$_2$), superimposed: 1.10, 1.11 (s, 6H, 4′-CH$_3$), 1.96 (s, 3H, 1-CH$_3$), 1.98–2.14 (m, 2H, 2-H$_2$), 3.16 (s, 1H, NH), 3.40 (d, 1H, 5′-H$_a$), 3.45 (d, 1H, 5′-H$_b$), 5.18 (s, 1H, OH), 7.20–7.55 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-}H_a,4\text{-}H_3}$ = 7.4 Hz, $^3J_{3\text{-}H_b,4\text{-}H_3}$ = 7.4 Hz, $^2J_{5'\text{-}H_a,5'\text{-}H_b}$ = 11.4 Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 14.3$ (q, C-4), 17.9 (t, C-3), 24.2, 24.4 (q, 4′-CH$_3$), 26.0 (q, 1-CH$_3$), 45.2 (t, C-2), 56.3, 57.3 (s, C-1, C-4′), 69.8 (t, C-5′), 126.9 (d, C-4″), 127.0, 128.3 (d, C-2″, C-3″), 144.5 (s, C-1″), 166.7 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3390, 3260 (O–H, N–H), 1655 (C=O); GC-MS (EI, 70 eV): *m*/*z* (%) = 295 (5) [M^+], 264 (4) [$M - CH_2OH^+$]; GC-MS (CI, NH_3): *m*/*z* (%) = 296 (4) [M+H$^+$], 164 (7) [$C_{10}H_{12}S^+$], 147 (24) [$C_{11}H_{15}^+$], 133 (100) [M+NH$_4$ − $C_{11}H_{15}S^+$], 116 (76) [$M - C_{11}H_{15}S^+$]; $C_{16}H_{25}NO_2S$ (295.44): calcd C 65.05, H 8.53, N 4.74; found C 65.07, H 8.78, N 4.95.

***rac*-*S*-2-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-2-phenyloctane (*rac*-12 q)**: ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.84$ (t, 3H, 7-H$_3$), 1.10, 1.11 (s, 6H, 4′-CH$_3$), 1.22–1.34 (m, 10H, 2-H$_2$, 3-H$_2$, 4-H$_2$, 5-H$_2$, 6-H$_2$), 1.95 (s, 3H, 1-CH$_3$), 2.87 (s, 1H, NH), 3.39 (d, 1H, 5′-H$_a$), 3.44 (d, 1H, 5′-H$_b$), 5.19 (s, 1H, OH), 7.17–7.35, 7.52–7.55 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{7\text{-}H_3,6\text{-}H_2}$ = 6.7 Hz, $^2J_{5'\text{-}H_a,5'\text{-}H_b}$ = 11.5 Hz; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 14.0 (q, C-7), 22.6, 24.4, 26.0 (q, 1-CH$_3$, 4′-CH$_3$), 27.5, 28.9, 29.5, 31.6, 37.0 (t, C-2, C-3, C-4, C-5, C-6), 56.3, 57.3 (s, C-1, C-4′), 69.8 (t, C-5′), 127.0, 128.3 (d, C-2″, C-3″), 127.6 (d, C-4″), 144.5 (s, C-1″), 166.7 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3360, 3280 (O–H, N–H), 1640 (C=O); GC-MS (EI, 70 eV): *m*/*z* (%) = 337 (2) [M^+], 253 (2) [$M - C_6H_{12}^+$], 222 (4) [$M - \mathbf{14}^+$], 189 (48) [$M - C_5H_{10}NO_2S^+$], 105 (100) [$C_8H_9^+$], 91 (69) [$C_7H_7^+$]; HR-MS (EI, 70 eV): calcd for $C_{19}H_{31}NO_2S$ [M^+] 337.2076, found 337.2073; $C_{19}H_{31}NO_2S$ (337.53): calcd C 67.61, H 9.26, N 4.15; found C 67.28, H 9.17, N 4.25.

(−)-(*R*)-*S*-1-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-1-phenyl-1-trimethylsilylethane (*ent*-12 t): $[\alpha]_D^{20} = -103.8$ ($c = 1.89$ in CH_2Cl_2); ≥ 98 % *ee* (concluded from the substrate *ent*-**11 t**); ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.02$ (s, 9H, Si–CH$_3$), 0.96, 1.03 (s, 6H, 4′-CH$_3$), 2.02 (s, 3H, 1-CH$_3$), 2.51 (s, 1H, NH), 3.36 (d, 1H, 5′-H$_a$), 3.41 (d, 1H, 5′-H$_b$), 5.04 (s, 1H, OH), 7.14–7.36, 7.46–7.52 (m, 5H, 2″-H, 3″-H, 4″-H), $^2J_{5'\text{-}H_a,5'\text{-}H_b}$ = 11.4 Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = -3.7$ (q, Si–CH$_3$), 23.2, 24.2, 24.4 (q, 1-CH$_3$, 4′-CH$_3$), 57.4 (s, C-1), 65.8 (s, C-4′), 69.8 (t, C-5′), 127.2, 128.6 (d, C-2″, C-3″), 128.4 (d, C-4″), 143.0 (s, C-1″), 167.0 (s, C=O); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3360, 3290 (O–H, N–H), 1640 (C=O); $C_{16}H_{27}NO_2SSi$ (325.54): calcd C 59.03 H 8.36 N 4.30; found C 58.87 H 8.39 N 4.31.

(−)-(*S*)-*S*-1-[*N*-(2-Hydroxy-1,1-dimethylethyl)-aminocarbonylthio]-1-phenylethane (*ent*-12 u):

Method a: $[\alpha]_D^{20} = -173.0$ ($c = 1.41$ in CH_2Cl_2); ≥ 99 % *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 4 mol % (+)-Pr(hfc)$_3$: 1-CH$_3$, $\Delta\delta = 0.006$ ppm at $\delta = 1.5$, (*R*):(*S*) < 1:154]; m.p.: 89 °C;

Method b: $[\alpha]_D^{20} = -169.6$ ($c = 1.10$ in CH_2Cl_2, ≥ 98 % *ee*); ^{1}H NMR (300 MHz and 360 MHz, $CDCl_3$): $\delta = 1.26$, 1.27 (s, 6H, 4′-CH$_3$), 1.67 (d, 3H, 1-CH$_3$), 3.50 (s, 1H, NH), 3.53 (s, 2H, 5′-H$_2$), 4.65 (q, 1H, 1-H), 5.58 (s, 1H, OH), 7.20–7.37 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{1\text{-}H,1\text{-}CH_3}$ = 7.2 Hz; ^{13}C NMR (90 MHz, $CDCl_3$): $\delta = 22.9$ (q, 1-CH$_3$), 24.1, 24.2 (q, 4′-CH$_3$), 44.1 (d, C-1), 57.2 (s, C-4′), 69.8 (t, C-5′), 127.1, 128.5 (d, C-2″, C-3″), 127.2 (d, C-4″), 142.9 (s, C-1″), 166.9 (s, C=O); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3250 (O–H, N–H), 1635 (C=O); $C_{13}H_{19}NO_2S$ (253.37): calcd C 61.63, H 7.56, N 5.55; found C 61.89, H 7.57, N 5.70.

Deblocking of β-hydroxythiourethanes *ent*-12 to thiols *ent*-13:

Method d: Under argon, K_2CO_3 (124 mg, 0.9 mmol) was added to a solution of the hydroxythiourethane *ent*-**12** (0.3 mmol) in MeOH (3 mL). The reaction mixture was refluxed for approx. 4 h (or alternatively stirred at room temperature for 2 d) and transferred directly onto the silica gel column for flash chromatography without intermediate work-up. Elution with Et_2O/hexanes (1:1) yielded the thiol *ent*-**13**.

(−)-(*R*)-2-Thio-4-methyl-2-phenylpentan-3-one (*ent*-13 e):

Method d: $[\alpha]_D^{21} = -78.8$ ($c = 0.42$ in CH_2Cl_2; > 99 % *ee* (concluded from the substrate *ent*-**11 e**); ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.84$ (d, 3H, 4a-H$_3$), 1.12 (d, 3H, 4b-H$_3$), 1.88 (s, 3H, 1-CH$_3$), 2.20 (s, 1H, SH), 2.83 (sept, 1H, 3-H), 7.19–7.44 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{3\text{-}H,4a\text{-}H_3}$ = 6.7 Hz, $^3J_{3\text{-}H,4b\text{-}H_3}$ = 6.7 Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 21.3$, 22.3 (q, C-4a, C-4b), 29.3 (q, 1-CH$_3$), 36.1 (d, C-3), 59.9 (s, C-1), 126.8, 128.6 (d, C-2″, C-3″), 127.9 (d, C-4″), 140.4 (s, C-1″), 211.5 (s, C-2); IR (film): $\tilde{\nu}$ (cm^{-1}) = 1690 (C=O), 690 (C–S); MS (EI, 70 eV): *m*/*z* (%) = 208 (4) [M^+], 207 (10) [$M - H^+$], 175 (81) [$M - SH^+$], 105 (100) [$C_8H_9^+$], 91 (72) [$C_7H_7^+$], 77 (31) [$C_6H_5^+$], 71 (53) [$C_3H_7CO^+$]; HR-MS (EI, 70 eV): calcd for $C_{12}H_{15}OS$ [$M - H^+$] 207.0840, found 207.0838.

Thiols 9, *ent*-13, and *ent*-16 (methods e and f):

Method e: Under argon atmosphere the thiocarbamate *ent*-**11** (0.5 mmol) was refluxed in 6 M aqueous HCl (5.0 mL) for 7 h. The reaction mixture was cooled to room temperature and poured into diethyl ether (20 mL). The aqueous phase was quickly extracted with diethyl ether. The combined organic layers were dried with solid Na_2SO_4/$NaHCO_3$ under argon and carefully liberated from the solvent at reduced pressure. The crude product was purified by flash chromatography on silica gel with Et_2O/hexanes (1:1) to yield the thiol *ent*-**13**.

Method f: DIBALH (1.0 M, 5.0 mL, 5.0 mmol) in hexanes was added to a solution of the thiocarbamate *ent*-**11** (0.5 mmol) in toluene (5.0 mL) at −78 °C and the reaction mixture was stirred overnight. By watching the decreasing intensity of the carbonyl band due to the thiocarbamoyl moiety

near 1620 cm^{-1}, one can easily follow the reaction progress by IR spectroscopy. If required the solution might be warmed to room temperature. Following a procedure of Fieser,[34] the reaction mixture was treated with i) water (0.8 mL), ii) NaOH (15%, 0.8 mL), and iii) water (2.4 mL) with several minutes of stirring in between. The coarse-grained aluminum salts were filtered off and the solvent was carefully evaporated at reduced pressure. Subsequent flash chromatography on silica gel (Et_2O/hexanes, 1:1 – 1:4) yielded the thiol *ent*-**13**. Alternatively, an acidic work-up with 2 M aqueous HCl can be chosen. In this case the aluminum salts were dissolved by addition of approx. 20 – 30 mL HCl. The ethereal extraction was followed by drying and neutralization with solid Na_2SO_4/$NaHCO_3$ and flash chromatography as noted above.

(−)-(*R*)-1,2-Diphenyl-2-propanethiol (*ent*-13s):

Method e: $[\alpha]_D^{25} = -31.1$ ($c = 0.80$ in CH_2Cl_2). **Method f**: $[\alpha]_D^{25} = -29.5$ ($c = 0.98$ in CH_2Cl_2); *ee* value not determined; spectroscopic data correspond to ref. [35].

(−)-(*R*)-1-Phenyl-1-trimethylsilyl-ethanethiol (*ent*-13t): **Method f**: $[\alpha]_D^{21} = -247.2$ ($c = 0.80$ in CH_2Cl_2); ≥98% *ee* (concluded from the substrate *ent*-**11t**); ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.02$ (s, 9H, Si−CH_3), 1.83 (s, 3H, 1-CH_3), 2.60 (s, 1H, SH), 7.10 – 7.44 (m, 5H, 2″-H, 3″-H, 4″-H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = -3.6$ (q, Si-CH_3), 27.8 (q, 1-CH_3), 50.4 (s, C-1), 125.2 (d, C-4″), 126.8, 127.7 (d, C-2″, C-3″), 146.4 (s, C-1″); IR (film): $\tilde{\nu}$ (cm^{-1}) = 690 (C−S); MS (EI, 70 eV): *m*/*z* (%) = 209 (42) [*M* − H$^+$], 105 (100) [$C_8H_9^+$], 91 (9) [$C_7H_7^+$], 77 (19) [$C_6H_5^+$], 73 (48) [$Si(CH_3)_3^+$]; HR-MS (EI, 70 eV): calcd for $C_{11}H_{17}SSi$ [*M* − H$^+$] 209.0820, found *m*/*z* = 209.0827; $C_{11}H_{18}SSi$ (210.41): calcd C 62.79, H 8.62, found C 63.07, H 8.41.

(−)-(*R*)-2-Thio-2-phenyl-1-propanol (*ent*-16):

Method f (substrate *ent*-**11a**): $[\alpha]_D^{20} = -31.8$ ($c = 0.36$ in CH_2Cl_2); >99% *ee* (concluded from the substrate *ent*-**11a**); m.p.: 106 °C. **Method f** (substrate *ent*-**15**): $[\alpha]_D^{20} = -31.2$ ($c = 0.48$ in CH_2Cl_2); >99% *ee* (concluded from the substrate *ent*-**15**); ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.77$ (s, 3H, 1-CH_3), 2.05 (s, 2H, OH, SH), 3.80 (d, 1H, 2-H_a), 3.86 (d, 1H, 2-H_b), 7.23 – 7.55 (m, 5H, 2″-H, 3″-H, 4″-H), $^2J_{2\text{-}H_a,2\text{-}H_b} = 11.2$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 28.4$ (q, 1-CH_3), 52.2 (s, C-1), 73.3 (t, C-2), 126.8, 128.9 (d, C-2″, C-3″), 127.7 (d, C-4″), 144.2 (s, C-1″); IR (film): $\tilde{\nu}$ (cm^{-1}) = 3330 (O−H), 690 (C−S); GC-MS (CI, NH_3): *m*/*z* (%) = 186 (100) [*M*+NH_4^+], 168 (5) [*M*$^+$], 137 (42) [*M* − CH_2OH^+]; $C_9H_{12}OS$ (168.26): calcd C 64.25, H 7.19, found C 64.31, H 7.48.

Reduction of the ester *ent*-11b to the alcohol *ent*-15 with $LiAlH_4$ (Method g):

Method g; (−)-(*R*)-*S*-2-hydroxy-1-methyl-1-phenylethyl 2,2,4,4-tetramethyl-1,3-oxazolidine-3-thiocarboxylate (*ent*-15): A solution of the methyl ester *ent*-**11b** (204 mg, 0.58 mmol, ≥99% *ee*) in dry Et_2O (8 mL) was added to a suspension of $LiAlH_4$ (104 mg, 2.7 mmol) in Et_2O (20 mL) and refluxed for 10 h. The reaction mixture was cooled to 0 °C and poured into 2 M aqueous HCl (20 mL). The aqueous layer was extracted with diethyl ether (3 × 20 mL). The ethereal layers were dried and neutralized by means of solid Na_2SO_4/$NaHCO_3$. Flash chromatography on silica gel (Et_2O/hexanes, 1:1) provided the alcohol *ent*-**15** as a colorless solid with 93% yield and ≥99% *ee*. $[\alpha]_D^{21} = -22.1$ ($c = 1.09$ in CH_2Cl_2); >99% *ee* [^{1}H NMR, 300 MHz, $CDCl_3$, 15 mol% (+)-Eu(hfc)$_3$: 1-CH_3, $\Delta\delta = 0.06$ ppm at $\delta = 2.7$, (*S*):(*R*) < 1:608]; m.p.: 101 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.45$, 1.49, 1.54, 1.59 (s, 12H, 2′-CH_3, 4′-CH_3), 1.82 (s, 3H, 1-CH_3), 3.72 (s, 2H, 5′-H_2), 3.97 (dd, 1H, 2-H_a), 4.41 (dd, 1H, 2-H_b), 4.71 (m, 1H, OH), 7.22 – 7.59 (m, 5H, 2″-H, 3″-H, 4″-H), $^3J_{2\text{-}H_a,OH} \approx 3.5$ Hz, $^3J_{2\text{-}H_b,OH} \approx 3.0$ Hz, $^2J_{2\text{-}H_a,2\text{-}H_b} = 11.4$ Hz; ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 24.9$, 25.0 (q, 2′-CH_3, 4′-CH_3), 25.6 (q, 1-CH_3), 59.4 (s, C-1), 61.6 (s, C-4′), 71.5 (t, C-2), 76.6 (t, C-5′), 98.0 (s, C-2′), 126.6, 128.4 (d, C-2″, C-3″), 127.3 (d, C-4″), 142.7 (s, C-1″), 164.2 (s, C=O); IR (KBr): $\tilde{\nu}$ (cm^{-1}) = 3500 (O−H), 1610 (C=O); GC-MS (CI, NH_3): *m*/*z* (%) = 324 (100) [*M*+H$^+$], 293 (6) [*M*+H − CH_2OH^+], 190 (6) [HS*Cby*+H$^+$], 156 (4) [*Cby*$^+$]; $C_{17}H_{25}NO_3S$ (323.45): calcd C 63.13, H 7.79, N 4.33, found C 63.35, H 7.65, N 4.32.

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[21] Enantiomeric excesses were determined by ^{1}H NMR spectroscopy in the presence of optically active shift reagents (+)- or (−)- Eu(hfc)$_3$, Pr(hfc)$_3$, or Yb(hfc)$_3$. Small known amounts of the racemic samples were added for use in the estimation of the limits of detection (approx. ±1% error).
[22] In contrast to results obtained by H. J. Reich[12b] and our group[16], here the configurational stability of the ion pair (*S*)-**7** is obviously decreased by the use THF instead of diethyl ether. In THF solution the protonation with MeOH and the acylation with acetyl chloride surprisingly proceeded with only 88% *ee* and 91% *ee*, respectively.

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[23] X-ray crystal structure analysis of *ent*-**11b**: formula $C_{18}H_{25}NO_4S$, M_r = 351.45, colorless crystal $0.50 \times 0.35 \times 0.25$ mm, a = 6.225(1), b = 12.754(1), c = 23.029(1) Å, V = 1828.4(3) Å^3, ρ_{calcd} = 1.277 g cm^{-3}, μ = 17.49 cm^{-1}, no absorption correction, Z = 4, orthorhombic, space group $P2_12_12_1$ (No. 19), λ = 1.54178 Å, T = 223 K, $\omega/2\theta$ scans, 2220 reflections collected ($+h$, $-k$, $-l$), [$(\sin\theta)/\lambda$] = 0.62 Å^{-1}, 2220 independent and 2172 observed reflections [$I \geq 2\sigma(I)$], 224 refined parameters, R = 0.043, wR^2 = 0.121, max. residual electron density 0.57 (−0.27) e Å^{-3}, Flack parameter −0.03(3), hydrogens calculated and riding.

X-ray crystal structure analysis of *ent*-**11d**: formula $C_{19}H_{27}NO_3S$, M_r = 349.48, colorless crystal $0.20 \times 0.10 \times 0.10$ mm, a = 8.272(2), b = 9.920(2), c = 23.760(5) Å, V = 1949.7(7) Å^3, ρ_{calcd} = 1.191 g cm^{-3}, μ = 15.96 cm^{-1}, empirical absorption correction by ψ scan data ($0.952 \leq C \leq 0.999$), Z = 4, orthorhombic, space group $P2_12_12_1$ (No. 19), λ = 1.54178 Å, T = 223 K, $\omega/2\theta$ scans, 4341 reflections collected ($-h$, $\pm k$, $+l$), [$(\sin\theta)/\lambda$] = 0.62 Å^{-1}, 3975 independent (R_{int} = 0.063) and 3033 observed reflections [$I \geq 2\sigma(I)$], 223 refined parameters, R = 0.053, wR^2 = 0.146, max. residual electron density 0.26 (−0.30) e Å^{-3}, Flack parameter 0.00(3), hydrogens calculated and riding.

X-ray crystal structure analysis of *ent*-**11e**: formula $C_{20}H_{29}NO_3S$, M_r = 363.50, colorless crystal $1.60 \times 0.80 \times 0.70$ mm, a = 8.206(1), b = 9.970(1), c = 24.748(2) Å, V = 2024.7(3) Å^3, ρ_{calcd} = 1.192 g cm^{-3}, μ = 1.77 cm^{-1}, empirical absorption correction by SORTAV ($0.765 \leq T \leq 0.886$), Z = 4, orthorhombic, space group $P2_12_12_1$ (No. 19), λ = 0.71073 Å, T = 198 K, ω and φ scans, 18078 reflections collected ($\pm h$, $\pm k$, $\pm l$), [$(\sin\theta)/\lambda$] = 0.67 Å^{-1}, 4958 independent (R_{int} = 0.030) and 4879 observed reflections [$I \geq 2\sigma(I)$], 233 refined parameters, R = 0.039, wR^2 = 0.103, max. residual electron density 0.61 (−0.31) e Å^{-3}, Flack parameter −0.01(6), hydrogens calculated and riding.

X-ray crystal structure analysis of *ent*-**11g**: formula $C_{23}H_{27}NO_3S$, M_r = 397.52, colorless crystal $0.60 \times 0.30 \times 0.20$ mm, a = 9.931(1), c = 18.842(3) Å, γ = 120°, V = 1609.3(3) Å^3, ρ_{calcd} = 1.231 g cm^{-3}, μ = 15.17 cm^{-1}, empirical absorption correction by ψ scan data ($0.895 \leq C \leq 0.991$), Z = 3, trigonal, space group $P3_1$ (No. 144), λ = 1.54178 Å, T = 223 K, $\omega/2\theta$ scans, 6770 reflections collected ($\pm h$, $\pm k$, $-l$), [$(\sin\theta)/\lambda$] = 0.62 Å^{-1}, 2263 independent (R_{int} = 0.062) and 2188 observed reflections [$I \geq 2\sigma(I)$], 259 refined parameters, R = 0.041, wR^2 = 0.107, max. residual electron density 0.34 (−0.25) e Å^{-3}, Flack parameter 0.02(2), hydrogens calculated and riding.

X-ray crystal structure analysis of *ent*-**11o**: formula $C_{18}H_{27}NO_2S$, M_r = 321.47, colorless crystal $0.25 \times 0.20 \times 0.10$ mm, a = 7.357(1), b = 6.132(1), c = 20.222(7) Å, β = 93.93(2)°, V = 910.1(4) Å^3, ρ_{calcd} = 1.173 g cm^{-3}, μ = 16.23 cm^{-1}, empirical absorption correction by ψ scan data ($0.687 \leq T \leq 0.855$), Z = 2, monoclinic, space group $P2_1$ (No. 4), λ = 1.54178 Å, T = 223 K, $\omega/2\theta$ scans, 2083 reflections collected ($\pm h$, $-k$, $-l$), [$(\sin\theta)/\lambda$] = 0.62 Å^{-1}, 2028 independent (R_{int} = 0.051) and 1790 observed reflections [$I \geq 2\sigma(I)$], 205 refined parameters, R = 0.068, wR^2 = 0.173, max. residual electron density 0.56 (−0.49) e Å^{-3}, Flack parameter 0.00(7), hydrogens calculated and riding.

X-ray crystal structure analysis of *ent*-**11r**: formula $C_{19}H_{27}NO_2S$, M = 333.48, colorless crystal $0.40 \times 0.25 \times 0.05$ mm, a = 7.780(2), b = 10.516(3), c = 23.148(4) Å, V = 1893.8(8) Å^3, ρ_{calcd} = 1.170 g cm^{-3}, μ = 15.79 cm^{-1}, empirical absorption correction by ψ scan data ($0.902 \leq C \leq 0.998$), Z = 4, orthorhombic, space group $P2_12_12_1$ (No. 19), λ = 1.54178 Å, T = 223 K, $\omega/2\theta$ scans, 2220 reflections collected ($-h$, $-k$, $-l$), [$(\sin\theta)/\lambda$] = 0.62 Å^{-1}, 2220 independent and 1858 observed reflections [$I \geq 2\sigma(I)$], 214 refined parameters, R = 0.043, wR^2 = 0.119, max. residual electron density 0.35 (−0.28) e Å^{-3}, Flack parameter 0.03(3), hydrogens calculated and riding.

X-ray crystal structure analysis of *ent*-**11s**: formula $C_{23}H_{29}NO_2S$, M_r = 383.53, colorless crystal $0.30 \times 0.25 \times 0.15$ mm, a = 6.774(1), b = 12.791(2), c = 12.738(4) Å, β = 104.69(2)°, V = 1067.6(4) Å^3, ρ_{calcd} = 1.193 g cm^{-3}, μ = 14.68 cm^{-1}, empirical absorption correction by ψ scan data ($0.957 \leq C \leq 0.999$), Z = 2, monoclinic, space group $P2_1$ (No. 4), λ = 1.54178 Å, T = 223 K, $\omega/2\theta$ scans, 2372 reflections collected ($\pm h$, $-k$, $-l$), [$(\sin\theta)/\lambda$] = 0.62 Å^{-1}, 2274 independent (R_{int} = 0.021) and 2223 observed reflections [$I \geq 2\sigma(I)$], 250 refined parameters, R = 0.027, wR^2 = 0.077, max. residual electron density 0.31 (−0.14) e Å^{-3}, Flack parameter 0.01(2), hydrogens calculated and riding.

X-ray crystal structure analysis of *ent*-**11t**: formula $C_{19}H_{31}NO_2SSi$, M = 365.60, colorless crystal $0.70 \times 0.50 \times 0.20$ mm, a = 11.501(2), b = 7.914(2), c = 11.559(2) Å, β = 96.21(2)°, V = 1045.9(4) Å^3, ρ_{calcd} = 1.161 g cm^{-3}, μ = 19.98 cm^{-1}, empirical absorption correction by ψ scan data ($0.831 \leq C \leq 0.999$), Z = 2, monoclinic, space group $P2_1$ (No. 4), λ = 1.54178 Å, T = 223 K, $\omega/2\theta$ scans, 4574 reflections collected ($\pm h$, $-k$, $\pm l$), [$(\sin\theta)/\lambda$] = 0.62 Å^{-1}, 2294 independent (R_{int} = 0.153) and 1964 observed reflections [$I \geq 2\sigma(I)$], 225 refined parameters, R = 0.065, wR^2 = 0.147, max. residual electron density 0.60 (−0.44) e Å^{-3}, Flack parameter −0.01(3), hydrogens calculated and riding.

Data sets were collected with Nonius CAD4 and KappaCCD diffractometers, the latter equipped with a rotating anode generator Nonius FR591. Programs used: data collection EXPRESS (Nonius B.V., **1994**) and COLLECT (Nonius B.V., **1998**), data reduction MolEN (K. Fair, Enraf-Nonius B.V., **1990**) and Denzo-SMN (Z. Otwinowski, W. Minor, *Methods in Enzymology*, **1997**, *276*, 307–326), absorption correction for CCD data SORTAV (R. H. Blessing, *Acta Crystallogr.* **1995**, *A51*, 33–37; R. H. Blessing, *J. Appl. Crystallogr.* **1997**, *30*, 421–426), structure solution SHELXS-86 and SHELXS-97 (G. M. Sheldrick, *Acta Crystallogr.* **1990**, *A46*, 467–473), structure refinement SHELXL-93 and SHELXL-97 (G. M. Sheldrick, University of Göttingen, **1997**), graphics SCHAKAL (E. Keller, University of Freiburg, **1997**).

Crystallographic data (excluding structure factors) for the structures reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publications no. CCDC-142159 (*ent*-**11d**), CCDC-142160 (*ent*-**11e**), CCDC-142161 (*ent*-**11o**), CCDC-142162 (*ent*-**11s**), and CCDC-142163 (*ent*-**11r**); for further structures see ref. [1]. Copies of the data can be obtained free of charge on application to CCDC, 12 Union Road, Cambridge CB2 1EZ, UK (Fax: (+44) 1223-336-033, e-mail: deposit@ccdc.cam.ac.uk).

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