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Asymmetric Tandem Michael-Aldol Reactions between 3-Cinnamoyloxazolidine-2-thiones and Aldehydes

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Abstract: Reactions between chiral 3-cinnamoyl-4-methyl-5-phenyl-1,3-oxazolidine-2-thiones and aromatic aldehydes in the presence of $BF_3{\cdot}Et_2O$ diastereoselectively produced tricyclic compounds incorporating a bridgehead carbon bound to four heteroatoms in high yields. Four stereocenters were induced during the reaction. The tricyclic products were transformed into propane-1,3-diols bearing three consecutive stereocenters by acid hydrolysis, *S*-methylation, and reductive removal of the chiral auxiliary.

Keywords: aldehydes · asymmetric synthesis · oxazolidinethiones · sulfanylpropanediols · tandem Michael-aldol reactions

Introduction

We have previously developed a chalcogenide/Lewis acid mediated tandem Michael-aldol reaction, which produced Morita–Baylis–Hillman adducts after treatment of the reaction mixture with a base.[1] This reaction proceeded quickly, so the main defect of the Morita–Baylis–Hillman reaction[2]—its very slow reaction rate—was alleviated, so our reaction can be utilized as an alternative to the Morita–Baylis–Hillman reaction. During the course of our study we found that a chalcogenide caused the intramolecular Michael addition in the presence of a Lewis acid[3] and that a thioketone[4] or a thioamide[5] group worked as a catalyst.

On the other hand, it is well known that *N*-unsubstituted thioamides undergo Michael additions with α,β-unsaturated carbonyl compounds.[6] Michael additions of *N*-substituted thiocarbamates, however, are scarcely known, though Palomo and co-workers reported the sulfur-transfer reaction of *N*-enoyl thiocarbamates with a Lewis acid followed by hydrolysis of the products.[7]

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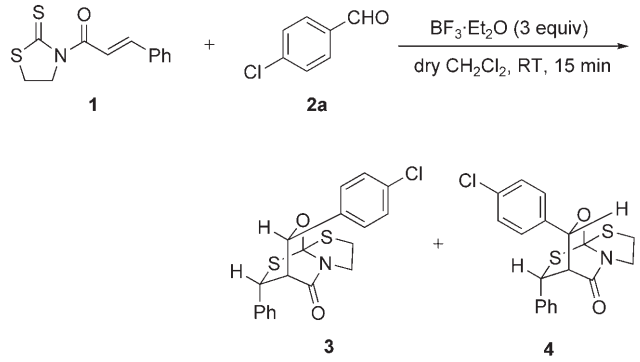
Results and Discussion

We combined the above findings, the intramolecular Michael cyclization of the chalcogenide group and the catalytic action of thioamides, and studied a new tandem Michael-aldol reaction between *N*-cinnamoyl cyclic thiocarbamates and aldehydes.[8] Herein we report the details of the reaction and the transformation of the products into propane-1,3-diols. Reactions between 3-cinnamoyl-1,3-thiazolidine-2-thione (**1**) and *p*-chlorobenzaldehyde (**2a**) in the presence of $BF_3{\cdot}Et_2O$ were examined first (Table 1). When two equivalents of **1**, one equivalent of **2a**, and three equivalents of $BF_3{\cdot}Et_2O$ were used, tricyclic compounds **3** and **4** were obtained in yields of 58% and 31%, respectively. The structures of **3** and **4** were determined by comparison of their ^1H and ^{13}C NMR spectral data with those for **6c** and **7c** shown below.

We next applied this approach to asymmetric reactions between (4*S*,5*R*)-4-methyl-5-phenyloxazolidine-2-thione **5** and aldehydes (Table 2). Treatment of **5** with **2a** at −40 °C for 24 h produced a mixture of diastereoisomers **6a**, **7a**, and **8a** in the ratio of 86:7:7 (Table 2,entry 1). The *p*- and *m*-nitrobenzaldehydes **2b–c** similarly produced the tricyclic compounds **6b–c**, **7b–c**, and **8b–c** in good yields and with high diastereoselectivity (Table 2, entries 2 and 3). The reactions with benzaldehyde (**2d**) and *p*-tolualdehyde (**2e**) were slow, so the reaction temperature was raised to 0 °C. The yields, however, were moderate and in the case of **2d** the diastereoselectivity had decreased (Table 2, entries 4 and 5).

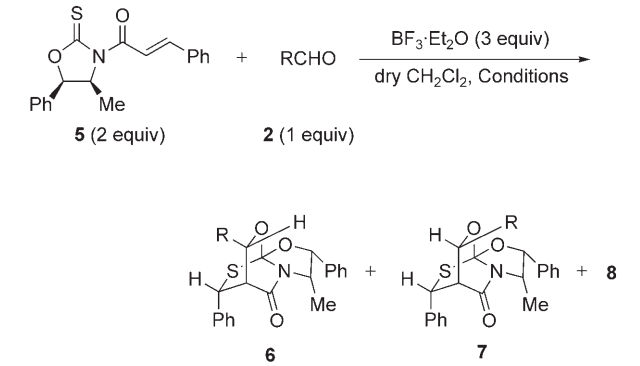
Table 1. Reactions between the *N*-enoylthiocarbamate **1** and the aldehyde **2a**.



Entry	Enone ([equiv])	Aldehyde ([equiv])	Products (yield [%])
1	**1** (2)	**2a** (1)	**3** (58), **4** (31)
2[a]	**1** (2)	**2a** (1)	**3** (50), **4** (33)
3	**1** (1)	**2a** (1)	**3** (48), **4** (30)

[a] Two equivalents of $BF_3{\cdot}Et_2O$ were used.

Table 2. Reactions between *N*-cinnamoylthiocarbamate **5** and aldehydes **2a–e**.



Entry	R	Conditions	Yield [%][a]	**6**:**7**:**8**
1	*p*-ClC_6H_4 (**2a**)	−40 °C, 24 h	71	86:7:7
2	*p*-$NO_2C_6H_4$ (**2b**)	−40 °C, 24 h	93	95:5:0
3	*m*-$NO_2C_6H_4$ (**2c**)	−40 °C, 24 h	85	95:5:0
4	C_6H_5 (**2d**)	0 °C, 1 h	69	71:0:29
5	*p*-MeC_6H_4 (**2e**)	0 °C, 1 h	59	92:0:8

[a] Mixture of diastereomers.

The diastereomer ratios were determined from the signal intensities in the ^{1}H NMR spectra, and the structure of the *m*-nitro derivative **6c** was determined by X-ray analysis (Figure 1), which showed that **6c** was not a Morita–Baylis–Hillman adduct, but an unexpected tricyclic compound incorporating a bridgehead carbon bound to four heteroatoms.

According to high-resolution mass-spectral data, product **8** had the same molecular formula as products **6** and **7**. Its ^{1}H and ^{13}C NMR spectra indicated that compound **8** had a tricyclic structure and was a diastereomer of **6** and **7**, but its stereostructure could not be determined because of its small amount.

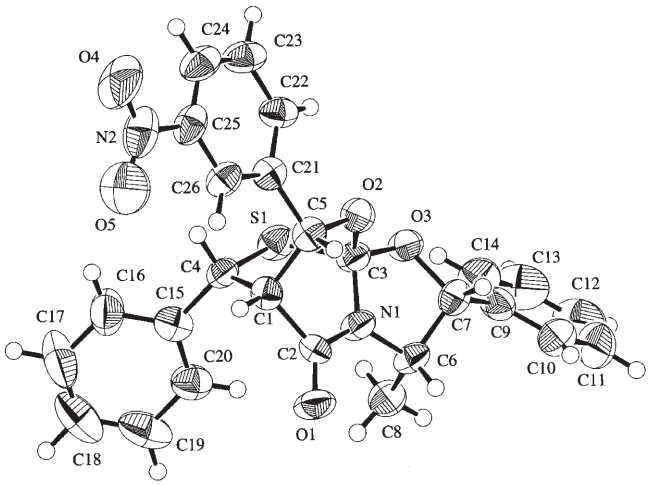
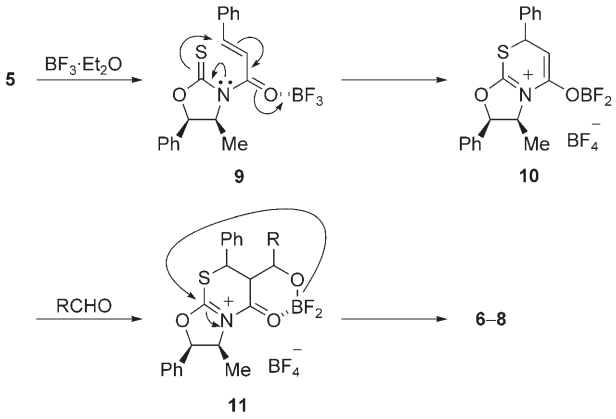


Figure 1. Structure of **6c** (ORTEP drawing).

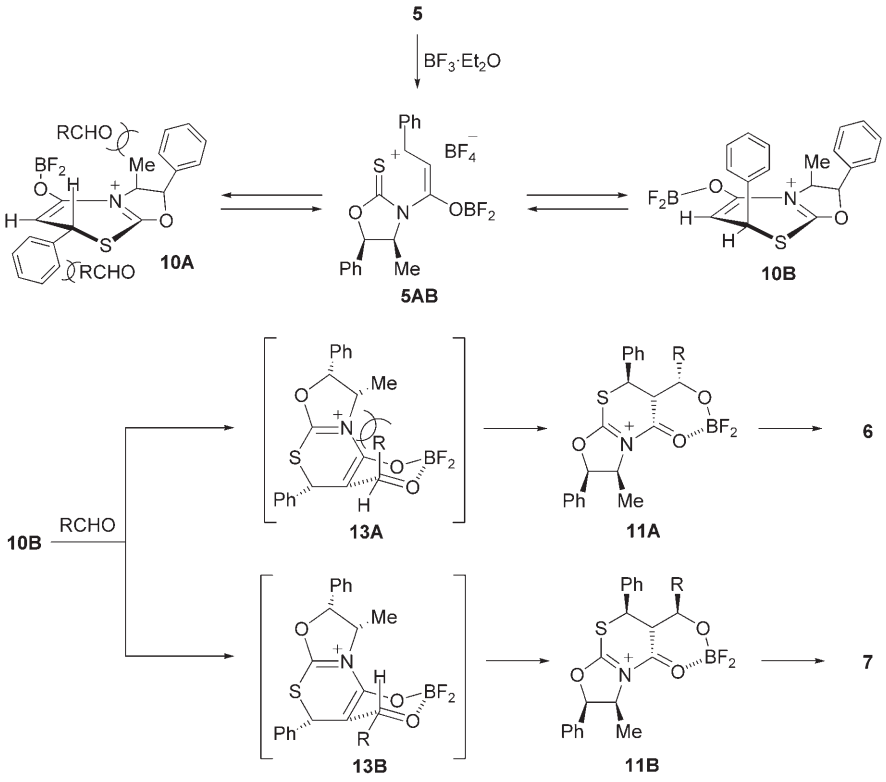
The structurally rare compounds **6–8** were presumably formed along the reaction pathways shown in Scheme 1. $BF_3{\cdot}Et_2O$ coordinates with the carbonyl oxygen of the *N*-cinnamoylthiocarbamate **5**, and the enone moiety is activated. The intramolecular Michael addition of the thione group to the enone moiety proceeds via **9**, and forms the boron enolate-iminium salt **10**. An aldol reaction between the boron enolate moiety and an aldehyde yields the aldol product **11**, which intramolecularly cyclizes (i.e., its alkoxide ion nucleophilically attacks the iminium carbon) to afford the tricyclic products **6–8**.



Scheme 1. Reaction mechanism.

The newly induced stereocenters were assigned as 1*R*, 7*R*, 8*R*, and 11*R* on the basis of the 3*R* and 4*S* absolute configurations. The *m*-nitrophenyl group of **6c** is located on the same side of the −SCHPh− moiety. The phenyl groups at the 3- and 11-positions (3-Ph and 11-Ph) and 4-Me adopt the *endo* configuration. The stereostructure of the diastereomer **7c** was determined by its ^{1}H NMR spectrum and NOE enhancement data through comparison with those of **6c** and the isopropyl derivative **12**,[8] the structure of which

had been assigned by X-ray crystallography. The signals of **7c** due to 3-H, 4-H, and 4-Me appeared at $\delta = 5.98$, 4.70, and 1.09 ppm, respectively, close to those of **6c** at $\delta = 5.83$ (3-H), 4.72 (4-H), and 1.14 ppm (4-Me), indicating that the O−CH(Ph)−CH(Me) moiety in the oxazolidine ring has a configuration similar to that of **6c**. The 11-H signal of **7c** at $\delta = 5.21$ ppm was similar to that of **12** at $\delta = 5.15$ ppm, but different from that of **6c** at $\delta = 4.34$. This large downfield shift implies that 11-H of **7c** was not affected by the anisotropic effect of the *m*-nitrophenyl group and that the aryl ring was situated on the same side of the −N−CO− moiety. NOE enhancement in **7c** was observed between 7-H and 8-H (7%), 7-H and 11-H (9%), and 8-H and 11-H (15%) and was very similar to that of **12**, shown in Figure 2.



Scheme 2. Cyclic model.

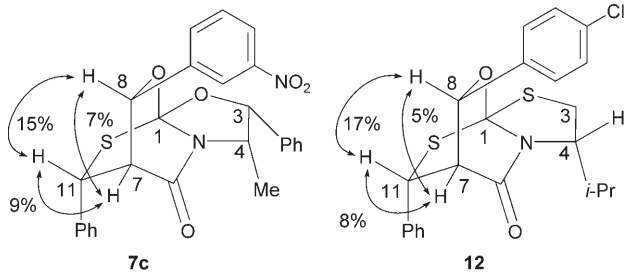
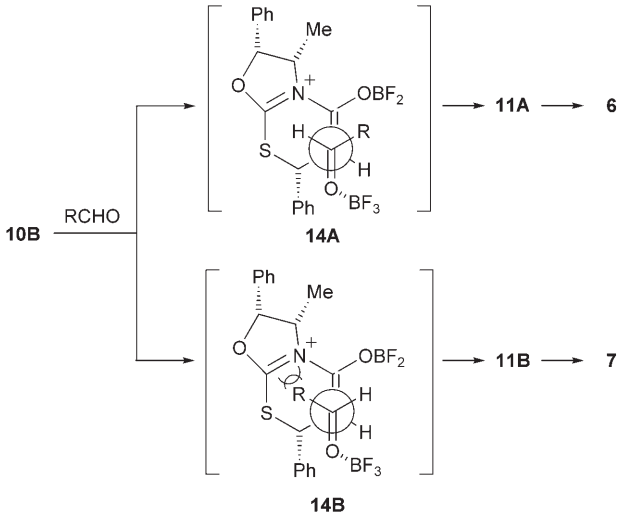


Figure 2. NOE data for tricyclic compounds **7c** and **12**.



Scheme 3. Acyclic model.

It became apparent that the tandem Michael-aldol reactions between the (4*S*,5*R*)-4-methyl-5-phenyloxazolidine-2-thione **5** and aldehydes simultaneously induced four chiral stereocenters and diastereoselectively afforded novel tricyclic compounds **6**, incorporating a bridgehead carbon bound to four heteroatoms, in high yields.

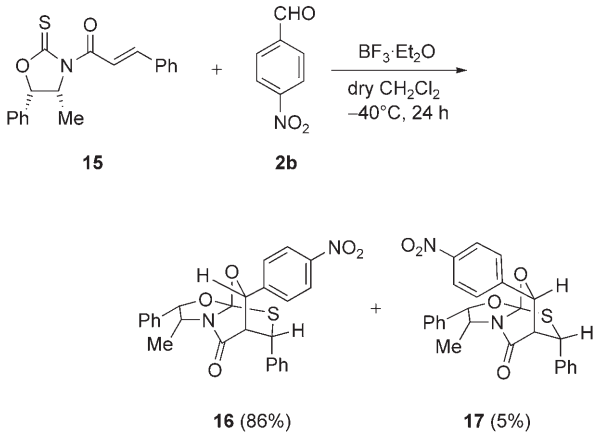
The reaction mechanism for the formation of tricyclic compounds **6** and **7** is discussed from the viewpoints of the cyclic transition state and the acyclic one, shown in Scheme 2 and Scheme 3, respectively. The boron enolate-iminium salt **10** formed through the cyclization of **5** with $BF_3{\cdot}Et_2O$ (Scheme 1) consists of two diastereomers, **10A** and **10B**; the former has the *anti* configuration between the phenyl group α to the sulfur atom and the methyl and the phenyl groups of the oxazolidine ring, whilst the latter has the *syn* configuration between them. The approach of an aldehyde from the *Si*- and the *Re*-faces to the boron enolate moiety is hindered by the methyl and phenyl groups of the oxazolidine ring and the phenyl group α to the sulfur in isomer **10A**. If the reaction were to proceed via **10A**, the chiral carbon α to the sulfur of the product should have an (*S*) configuration, but it actually had the (*R*) configuration. Therefore, this pathway via intermediate **10A** does not appear to be productive.

On the other hand, isomer **10B** has three substituents on the *Si*-face, and an aldehyde can easily attack the enolate carbon from the sterically relaxed *Re*-face. If the reaction between **10B** and an aldehyde were to proceed via the cyclic chelation mechanism, the two transition states shown in Scheme 2 should be considered for the aldol reaction step. The transition state **13B**, bearing an equatorial R group, should be more stable than the transition state **13A**, bearing an axial R group. The reaction via **13B** should form the aldol product **11B**, which should afford the tricyclic product **7**. This is inconsistent with the finding that compound **7** is not the major product but the minor one.

To solve this contradiction, we discuss other pathways going through the acyclic transition states shown in Scheme 3.

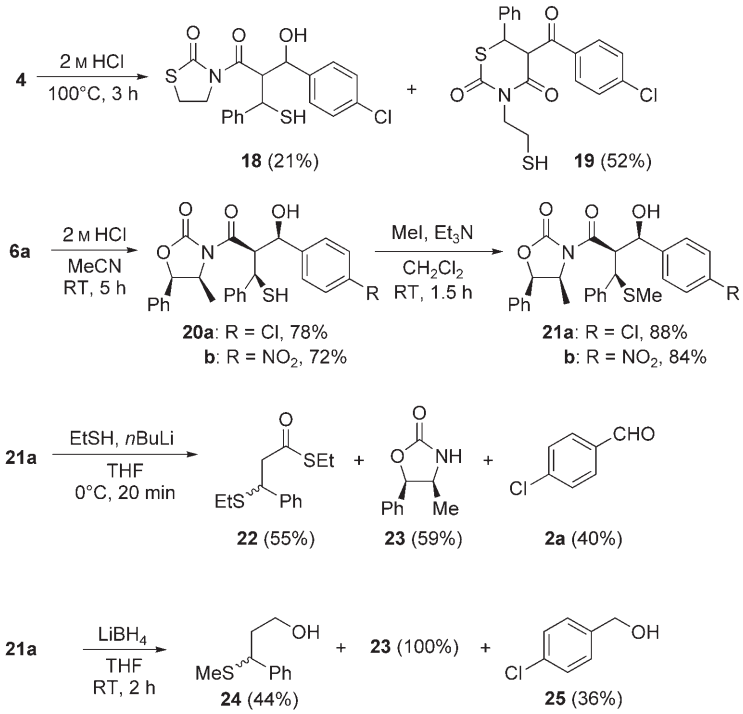
The two transition states **14A** and **14B** are important for controlling the stereoselection in the aldol reaction. The transition state **14A** should be more stable than **14B**, which should have steric repulsion between the iminium moiety and the R group. The pathway via **14A** should produce the aldol adduct **11A**, which should cyclize to product **6**. This mechanism is consistent with the finding that product **6** is the major product. From the above discussion, it is concluded that these tandem Michael-aldol reactions between **5** and aldehydes proceed via the boron–enolate–iminium salts **10B** and acyclic transition states **14A**.

The reaction between the *N*-enoylthiocarbamate **15**, the enantiomer of **5**, and *p*-nitrobenzaldehyde (**2b**) produced the tricyclic products **16** (86%) and **17** (5%), enantiomers of **6b** and **7b**, respectively (Scheme 4).



Scheme 4. Reaction between **15** (the enantiomer of **5**) and aldehyde **2b**.

We next examined the removal of the chiral auxiliary from the tricyclic compounds, as shown in Scheme 5. Alkaline hydrolysis of the thiazolidine compound **4** did not take place, and **4** was recovered. Acidic hydrolysis of **4** was then conducted with HCl (2M) at 100°C for 3 h and produced products **18** (21%) and **19** (52%). Since two C–S bonds were cleaved and the desired product **18** was a minor one, the oxazolidine derivatives **6a**,**b** were employed instead at room temperature for 5 h, affording the *N*-(3-sulfanylpropanoyl)oxazolidines **20a** (78%) and **20b** (72%) through the selective C–S bond cleavage of the six-membered ring. The methylation of a sulfanyl group with methyl iodide and triethylamine converted **20a**,**b** into **21a**,**b** in high yields. The transformation of the amide **21a** into a thioester was attempted by treatment with lithium ethanethiolate, producing the *S*-ethyl 3-methylsulfanyl-3-phenylpropanethioate **22** (55%), the oxazolidinone **23** (59%), and *p*-chlorobenzaldehyde (**2a**; 40%).



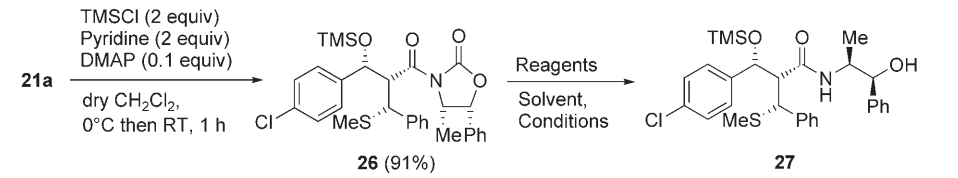
Scheme 5. Attempted transformations of the tricyclic compounds.

The thioester **22** was formed through the retro-tandem Michael-aldol reaction of **21a**, followed by transformation of the amide moiety into a thioester and the Michael addition of the ethanethiolate ion to the enone moiety.

The reductive removal of a chiral auxiliary **23** from **21a** was conducted with $LiBH_4$, affording the propanol **24** (44%), the oxazolidinone **23** (100%), and the benzyl alcohol **25** (36%), which were formed by the reduction of the retro-aldol products.

These results indicated that the presence of the free hydroxy group in **21a** was causing the retro-aldol reaction upon treatment with a basic reagent. We therefore protected the hydroxy group with a silyl group to prevent it from undergoing the retro-aldol reaction and to achieve smooth removal of the auxiliary **23**. Silylation of **21a** with trimethylsilyl chloride produced the silyl ether **26** in 91% yield, and the reduction of **26** with $LiBH_4$ brought about the oxazolidine ring opening to give the amide **27** in a quantitative yield (Table 3, entry 1). Treatment with sodium ethanethiolate (Table 3, entry 2) or sodium methoxide (Table 3, entry 3) gave the same product **27** in 35% or 83% yields, respectively. Protection of the hydroxy group prevented **21a** from undergoing the retro-aldol reaction, but the bulky trimethylsil-

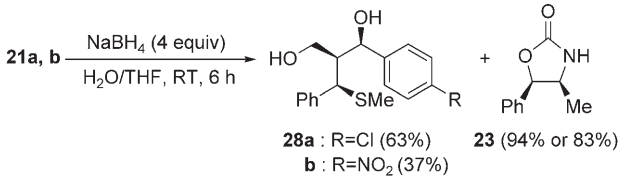
Table 3. Transformation of *O*-TMS aldol **26**.



Entry	Reagents (equiv)	Solvent	Conditions	Yield [%]
1	$LiBH_4$ (1.1)	dry THF	RT, 4 h	100
2	EtSH (1.1), NaH (0.25)	dry THF	0 °C add, RT, 50 min	35
3	MeONa (1.1)	dry CH_2Cl_2	−25 °C, 8 min	83

yl group interfered with the attack of a nucleophile on the *exo*-carbonyl group, the nucleophile exclusively attacking the *endo*-carbonyl group.

We therefore sought means to remove the chiral auxiliaries from **21a**,**b** without protecting the hydroxy group, and succeeded in the reductive removal of the oxazolidinone moiety by use of sodium borohydride in aqueous THF[9] to give propanediols **28a**,**b** and the oxazolidinone **23** (Scheme 6). The recovered oxazolidinone **23** can be converted into the oxazolidinethione by treatment with Lawesson's reagent and is reusable for the synthesis of the *N*-enoyloxazolidinethiones.[7]



Scheme 6. Synthesis of propanediols **28a** and **28b** and recovery of the chiral auxiliary **23**.

Conclusions

In conclusion, we have developed asymmetric tandem Michael-aldol reactions between *N*-enoylthiocarbamates and aldehydes, which simultaneously induced four stereocenters, giving tricyclic compounds incorporating a bridgehead carbon bound to four heteroatoms. The tricyclic compounds were converted into propanediols bearing three consecutive chiral centers **28**, accompanied in each case by the oxazolidinone chiral auxiliary, by a sequence of reactions involving hydrolysis, *S*-methylation, and reduction. Investigations into the transformation of **23** into other derivatives and the utilization of the chiral thiols **20** and propanediols **28** are now in progress.

Experimental Section

Melting points were obtained with a Yanagimoto micro-melting-point apparatus and are uncorrected. IR spectra of solids (KBr) and liquids (NaCl) were recorded on a JASCO IRA-100 spectrophotometer. ^{1}H NMR spectra were recorded on JEOL GX-270 (270 MHz) or JEOL EX-400 (400 MHz) spectrometers with tetramethylsilane as an internal standard. ^{13}C NMR spectra were obtained on a JEOL EX-400 spectrometer. Mass spectra were recorded on a JEOL JMS-SX102 A spectrometer with a direct-insertion probe at 70 eV. Elemental analyses of new compounds were performed with a Yanaco CHN Corder MT-5. All chromatographic isolations were carried out with BW-350 (Fuji Silysia) for column chromatography or with Kieselgel 60 PF_{254} containing gypsum (Merck) for preparative TLC. CH_2Cl_2 was washed with water, dried over $CaCl_2$, and freshly distilled. The recycling preparative HPLC was performed by LC-918 liquid chromatography (Japan Analytical Industry Co., Ltd.) on JAIGEL-1H and -2H columns (polystyrene gels).

Reaction between *N*-enoylthiocarbamate 1 and *p*-chlorobenzaldehyde (2a): $BF_3{\cdot}Et_2O$ (190 μL, 1.5 mmol) was added dropwise at 0 °C to a stirred solution of 3-((*E*)-cinnamoyl)-1,3-thiazolidine-2-thione[10] (**1**, 249 mg, 1.0 mmol) and **2a** (70 mg, 0.5 mmol) in dry CH_2Cl_2 (1.5 mL). The mixture was stirred at the same temperature for 15 min, poured into an aqueous $NaHCO_3$ solution, and extracted with CH_2Cl_2. The organic layers were dried ($MgSO_4$) and concentrated in vacuo. Purification of the residue by preparative TLC with elution with CH_2Cl_2/AcOEt 50:1 furnished **3** (113 mg, 58 %) and **4** (60 mg, 31 %).

(1*R,7*R**,8*R**,11*R**)-8-(4-Chlorophenyl)-11-phenyl-9-oxa-2,10-dithia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (3)**: Colorless prisms (from CH_2Cl_2/hexane); m.p. 220.5–221.0 °C (dec); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 3.23–3.29 (m, 1H; 3-H), 3.25 (t, J = 2.5 Hz, 1H; 7-H), 3.38–3.45 (m, 1H; 3-H), 4.00–4.06 (m, 1H; 4-H), 4.40–4.45 (m. 1H; 4-H), 4.43 (d, J = 3.4 Hz, 1H; 11-H), 5.39 (d, J = 2.5 Hz, 1H; 8-H), 7.15 (d, J = 8.3 Hz, 2H; ArH), 7.21–7.30 (m, 3H; ArH), 7.44 (d, J = 8.8 Hz, 2H; ArH), 7.52 ppm (d, J = 8.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 30.3 (t), 45.2 (d), 47.5 (t), 52.9 (d), 77.8 (d), 104.4 (s), 127.1 (d), 127.9 (d), 128.2 (d), 128.7 (d), 129.0 (d), 134.4 (s), 134.9 (s), 138.6 (s), 166.6 ppm (s), four aromatic carbons were overlapped; IR (KBr): $\tilde{\nu}$ = 1682 cm^{-1} (C=O); MS (EI): *m/z* (%): 389 (15) $[M]^+$, 165 (100); elemental analysis calcd (%) for $C_{19}H_{16}ClNO_2S_2$: C 58.53, H 4.14, N 3.59; found: C 58.35, H 4.07, N 3.61.

(1*R,7*R**,8*S**,11*R**)-8-(4-Chlorophenyl)-11-phenyl-9-oxa-2,10-dithia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (4)**: Colorless prisms (from CH_2Cl_2/hexane); m.p. 188.0–192.0 °C (decomp); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 3.28–3.36 (m, 1H; 3-H), 3.33 (d, J = 3.5 Hz, 1H; 7-H), 3.39–3.46 (m, 1H; 3-H), 4.03–4.07 (m, 1H; 4-H), 4.32–4.38 (m. 1H; 4-H), 5.09 (d, J = 3.5 Hz, 1H; 11-H), 5.45 (s, 1H; 8-H), 7.20 (d, J = 7.0 Hz, 2H; ArH), 7.22–7.38 ppm (m, 7H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 30.3 (t), 47.6 (t), 52.5 (d), 54.2 (d), 80.2 (d), 103.9 (s), 127.1 (d), 127.8 (d), 128.3 (d), 128.9 (d), 129.0 (d), 134.5 (s), 137.3 (s), 138.6 (s), 164.0 ppm (s), four aromatic carbons were overlapped; IR (KBr): $\tilde{\nu}$ = 1682 cm^{-1} (C=O); MS (EI): *m/z* (%): 389 (20) $[M]^+$, 165 (100); elemental analysis calcd (%) for $C_{19}H_{16}ClNO_2S_2$: C 58.53, H 4.14, N 3.59; found: C 58.36, H 4.22, N 3.59.

(4*S*,5*R*)-3-[(*E*)-Cinnamoyl]-4-methyl-5-phenyl-1,3-oxazolidine-2-thione (5): Pyridine (1.98 g, 25 mmol) was gradually added at room temperature to a solution of (4*S*,5*R*)-4-methyl-5-phenyl-1,3-oxazolidine-2-thione (3.9 g, 20 mmol) and cinnamoyl chloride (3.67 g, 22 mmol) in benzene (25 mL). The reaction mixture was stirred at room temperature for 23 h and then poured into water. The organic layer was separated and the aqueous layer was extracted with AcOEt. The organic layer and the extracts were combined, washed successively with 2 % hydrochloric acid, water, and saturated aqueous $NaHCO_3$, dried ($MgSO_4$), and concentrated in vacuo. The residue was purified by column chromatography on silica gel (hexane/AcOEt 3:1) to give **5** (6.3 g, 97 %). Yellow crystals (from AcOEt/hexane); m.p. 82.0–82.5 °C; $[\alpha]_D^{24}$ = −247.7 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.03 (d, J = 6.8 Hz, 3H; Me), 5.04 (quintet, J = 6.8 Hz, 1H; 4′-H), 5.83 (d, J = 6.8 Hz, 1H; 5′-H), 7.26–7.46

(m, 8H; ArH), 7.57–7.63 (m, 2H; ArH), 7.78 (d, J = 15.6 Hz, 1H; 3-H), 8.41 ppm (d, J = 15.6 Hz, 1H; 2-H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.2 (q), 59.2 (d), 83.6 (d), 118.8 (d), 125.8 (d), 128.5 (d), 128.6 (d), 128.8 (d), 128.9 (d), 130.5 (d), 132.4 (s), 134.6 (s), 145.1 (d), 166.2 (s), 185.4 ppm (s), four aromatic carbons were overlapped; IR (KBr): $\tilde{\nu}$ = 1676 cm^{-1} (C=O); MS (EI): m/z (%): 323 (8) $[M]^+$, 157 (100); elemental analysis calcd (%) for $C_{19}H_{17}NO_2S$: C 70.56, H 5.30, N 4.33; found: C 70.66, H 5.28, N 4.28.

A typical reaction between *N*-enoylthiocarbamate 5 and an aldehyde 2: $BF_3{\cdot}Et_2O$ (190 μL, 1.5 mmol) was added dropwise at −40 °C to a stirred solution of **5** (323 mg, 1.0 mmol) and *p*-nitrobenzaldehyde (**2b**, 76 mg, 0.5 mmol) in dry CH_2Cl_2 (1.6 mL). The mixture was stirred at the same temperature for 24 h, poured into a saturated aqueous $NaHCO_3$ solution, and extracted with CH_2Cl_2. The organic layers were dried ($MgSO_4$) and concentrated in vacuo. Purification of the residue by the recycling preparative HPLC with elution with chloroform furnished **6b** (209 mg, 88%) and **7b** (13 mg, 5%).

(1*R*,3*R*,4*S*,7*R*,8*R*,11*R*)-8-(4-Chlorophenyl)-4-methyl-3,11-diphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (6a): Colorless prisms (from AcOEt/hexane); m.p. 85.0–87.0 °C; $[\alpha]_D^{24}$ = −24.8 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.13 (d, J = 6.5 Hz, 3H; Me), 3.24 (t, J = 2.5 Hz, 1H; 7-H), 4.45 (d, J = 2.5 Hz, 1H; 11-H), 4.70 (quintet, J = 6.5 Hz, 1H; 4-H), 5.40 (d, J = 2.5 Hz, 1H; 8-H), 5.80 (d, J = 6.5 Hz, 1H; 3-H), 7.20–7.29 (m, 4H; ArH), 7.36–7.47 (m, 8H; ArH), 7.58 ppm (d, J = 8.3 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.4 (q), 43.3 (d), 53.7 (d), 54.3 (d), 76.4 (d), 84.6 (d), 113.8 (s), 126.0 (d), 126.9 (d), 127.8 (d), 128.1 (d), 128.46 (d), 128.54 (d), 128.6 (d), 129.0 (d), 133.7 (s), 134.2 (s), 135.2 (s), 138.5 (s), 164.9 ppm (s), six aromatic carbons were overlapped; IR (KBr): $\tilde{\nu}$ = 1702 cm^{-1} (C=O); MS (EI): m/z (%): 463 (32) $[M]^+$, 191 (100); elemental analysis calcd (%) for $C_{26}H_{22}ClNO_3S$: C 67.30, H 4.78, N 3.02; found: C 67.04, H 4.62, N 3.00.

(1*R*,3*R*,4*S*,7*R*,8*S*,11*R*)-8-(4-Chlorophenyl)-4-methyl-3,11-diphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (7a): White powder; m.p. 55.0–55.5 °C; $[\alpha]_D^{23}$ = −20.0 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.07 (d, J = 6.5 Hz, 3H; Me), 3.35 (d, J = 3.4 Hz, 1H; 7-H), 4.66 (quintet, J = 6.5 Hz, 1H; 4-H), 5.15 (d, J = 3.4 Hz, 1H; 11-H), 5.44 (s, 1H; 8-H), 5.88 (d, J = 6.5 Hz, 1H; 3-H), 7.23–7.45 ppm (m, 14H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.8 (q), 50.3 (d), 54.1 (d), 54.7 (d), 77.4 (d), 84.9 (d), 113.6 (s), 126.2 (d), 127.0 (d), 127.7 (d), 128.3 (d), 128.57 (d), 128.65 (d), 128.8 (d), 129.0 (d), 133.8 (s), 134.4 (s), 137.3 (s), 138.5 (s), 162.7 ppm (s), six aromatic carbons were overlapped; IR (KBr): $\tilde{\nu}$ = 1695 cm^{-1} (C=O); MS (EI): m/z (%): 463 (53) $[M]^+$, 191 (100); elemental analysis calcd (%) for $C_{26}H_{22}ClNO_3S$: C 67.30, H 4.78, N 3.02; found: C 67.07, H 4.66, N 3.13.

Product of undetermined structure (8a): White powder; m.p. 158.0–159.0 °C; $[\alpha]_D^{20}$ = −252.1 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.70 (d, J = 6.6 Hz, 3H; Me), 3.89 (quintet, J = 6.6 Hz, 1H; 4-H), 4.54 (d, J = 6.6 Hz, 1H; 3-H), 5.09 (d, J = 10.3 Hz, 1H; 11-H), 5.20 (dd, J = 8.3 and 10.3 Hz, 1H; 7-H), 5.75 (d, J = 8.3 Hz, 1H; 8-H), 7.09 (d, J = 7.3 Hz, 2H; ArH), 7.31–7.42 (m, 8H; ArH), 7.61 (d, J = 7.8 Hz, 2H; ArH), 7.66 ppm (d, J = 7.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.4 (q), 40.0 (d), 41.0 (d), 55.1 (d), 57.6 (d), 79.5 (d), 125.4 (d), 128.3 (d), 128.6 (d), 128.8 (d), 128.9 (d), 129.2 (d), 132.6 (s), 133.5 (s), 140.3 (s), 140.7 (s), 152.1 (s), 168.9 ppm (s), eight aromatic carbons are overlapped; IR (KBr): $\tilde{\nu}$ = 1698 cm^{-1} (C=O); MS (EI): m/z (%): 463 (73) $[M]^+$, 191 (100); elemental analysis calcd (%) for $C_{26}H_{22}ClNO_3S$: C 67.30, H 4.78, N 3.02; found: C 67.30, H 4.85, N 3.14.

(1*R*,3*R*,4*S*,7*R*,8*R*,11*R*)-4-Methyl-8-(4-nitrophenyl)-3,11-diphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (6b): Colorless prisms (from acetone/hexane); m.p. 208.0–208.5 °C; $[\alpha]_D^{20}$ = −46.5 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.15 (d, J = 6.3 Hz, 3H; Me), 3.34 (t, J = 2.7 Hz, 1H; 7-H), 4.35 (d, J = 2.7 Hz, 1H; 11-H), 4.72 (quintet, J = 6.3 Hz, 1H; 4-H), 5.51 (d, J = 2.7 Hz, 1H; 8-H), 5.83 (d, J = 6.3 Hz, 1H; 3-H), 7.20–7.25 (m, 2H; ArH), 7.27–7.31 (m, 2H; ArH), 7.38–7.47 (m, 6H; ArH), 7.86 (d, J = 8.8 Hz, 2H; ArH), 8.36 ppm (d, J = 8.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.5 (q), 43.6 (d), 53.4 (d), 54.5 (d), 76.3 (d), 84.9 (d), 113.9 (s), 124.1 (d), 126.1 (d), 126.7 (d), 127.8 (d), 128.4 (d), 128.6 (d), 128.7 (d), 128.8 (d), 133.6 (s), 138.2 (s), 144.2 (s), 148.1 (s), 164.5 ppm (s), six aromatic carbons were overlapped; IR (KBr): $\tilde{\nu}$ = 1701 (C=O), 1522 (NO_2), 1347 cm^{-1} (NO_2); MS (EI): m/z (%): 474 (45) $[M]^+$, 122 (100); elemental analysis calcd (%) for $C_{26}H_{22}N_2O_5S$: C 65.81, H 4.67, N 5.90; found: C 65.58, H 4.58, N 5.86.

(1*R*,3*R*,4*S*,7*R*,8*S*,11*R*)-4-Methyl-8-(4-nitrophenyl)-3,11-diphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (7b): Colorless plates (from CH_2Cl_2/hexane); m.p. 203.5–205.0 °C; $[\alpha]_D^{24}$ = +11.1 (c = 0.25 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.09 (d, J = 6.3 Hz, 3H; Me), 3.41 (d, J = 3.7 Hz, 1H; 7-H), 4.68 (quintet, J = 6.3 Hz, 1H; 4-H), 5.20 (d, J = 3.7 Hz, 1H; 11-H), 5.59 (s, 1H; 8-H), 5.92 (d, J = 6.3 Hz, 1H; 3-H), 7.26–7.48 (m, 10H; ArH), 7.52 (d, J = 8.8 Hz, 2H; ArH), 8.25 ppm (d, J = 8.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.8 (q), 50.3 (d), 54.3 (d), 54.6 (d), 77.0 (d), 85.1 (d), 113.8 (s), 124.1 (d), 126.2 (d), 126.6 (d), 127.8 (d), 128.6 (d), 128.7 (d), 128.8 (d), 128.9 (d), 133.6 (s), 138.2 (s), 145.7 (s), 148.0 (s), 162.2 ppm (s), six aromatic carbons overlapped; IR (KBr): $\tilde{\nu}$ = 1692 (C=O), 1524 (NO_2), 1344 cm^{-1} (NO_2); MS (EI): m/z (%): 474 (43) $[M]^+$, 122 (100); elemental analysis calcd (%) for $C_{26}H_{22}N_2O_5S$: C 65.81, H 4.67, N 5.90; found: C 65.65, H 4.60, N 5.79.

(1*R*,3*R*,4*S*,7*R*,8*R*,11*R*)-4-Methyl-8-(3-nitrophenyl)-3,11-diphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (6c): Colorless prisms (from CH_2Cl_2/hexane); m.p. 195.0–195.5 °C; $[\alpha]_D^{20}$ = −35.7 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.14 (d, J = 6.3 Hz, 3H; Me), 3.36 (t, J = 2.8 Hz, 1H; 7-H), 4.34 (d, J = 2.8 Hz, 1H; 11-H), 4.72 (quintet, J = 6.3 Hz, 1H; 4-H), 5.51 (d, J = 2.8 Hz, 1H; 8-H), 5.83 (d, J = 6.3 Hz, 1H; 3-H), 7.21–7.30 (m, 5H; ArH), 7.40–7.47 (m, 5H; ArH), 7.70 (t, J = 8.1 Hz, 1H; ArH), 8.00 (d, J = 8.1 Hz, 1H; ArH), 8.30 (d, J = 8.1 Hz, 1H; ArH), 8.56 ppm (s, 1H, ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.5 (q), 43.6 (d), 53.4 (d), 54.5 (d), 76.1 (d), 84.9 (d), 114.0 (s), 120.9 (d), 123.6 (d), 126.1 (d), 127.8 (d), 128.4 (d), 128.6 (d), 128.7 (d), 128.8 (d), 130.0 (d), 131.6 (s), 133.6 (s), 138.2 (s), 139.3 (s), 148.7 (s), 164.5 ppm (s), four aromatic carbons were overlapped; IR (KBr) $\tilde{\nu}$ = 1705 (C=O), 1532 (NO_2), 1349 cm^{-1} (NO_2); MS (EI): m/z (%): 474 (12) $[M]^+$, 122 (100); elemental analysis calcd (%) for $C_{26}H_{22}N_2O_5S$: C 65.81, H 4.67, N 5.90; found: C 65.66, H 4.60, N 5.90.

(1*R*,3*R*,4*S*,7*R*,8*S*,11*R*)-4-Methyl-8-(3-nitrophenyl)-3,11-diphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (7c): Colorless prisms (from CH_2Cl_2/hexane); m.p. 201.5–202.0 °C; $[\alpha]_D^{20}$ = −11.1 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.09 (d, J = 6.5 Hz, 3H; Me), 3.41 (d, J = 3.4 Hz, 1H; 7-H), 4.70 (quintet, J = 6.5 Hz, 1H; 4-H), 5.21 (d, J = 3.4 Hz, 1H; 11-H), 5.61 (s, 1H; 8-H), 5.98 (d, J = 6.5 Hz, 1H; 3-H), 7.26–7.47 (m, 10H; ArH), 7.58 (t, J = 8.1 Hz, 1H; ArH), 7.66 (d, J = 8.1 Hz, 1H; ArH), 8.20 (d, J = 8.1 Hz, 1H; ArH), 8.24 ppm (s, 1 Hz, 1H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.8 (q), 50.0 (d), 54.3 (d), 54.9 (d), 76.8 (d), 85.2 (d), 113.8 (s), 120.8 (d), 123.5 (d), 126.2 (d), 127.8 (d), 128.5 (d), 128.6 (d), 128.8 (d), 128.9 (d), 130.0 (d), 131.4 (d), 133.6 (s), 138.3 (s), 141.1 (s), 148.5 (s), 162.2 ppm (s), four aromatic carbons were overlapped; IR (KBr): $\tilde{\nu}$ = 1646 (C=O), 1530 (NO_2), 1344 cm^{-1} (NO_2); MS (EI): m/z (%): 474 (10) $[M]^+$, 456 (100); elemental analysis calcd (%) for $C_{26}H_{22}N_2O_5S$: C 65.81, H 4.67, N 5.90; found: C 65.63, H 4.68, N 5.94.

(1*R*,3*R*,4*S*,7*R*,8*R*,11*R*)-4-Methyl-3,8,11-triphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (6d): White powder; m.p. 92.0–93.0 °C; $[\alpha]_D^{24}$ = −21.0 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.14 (d, J = 6.3 Hz, 3H; Me), 3.28 (t, J = 2.4 Hz, 1H; 7-H), 4.50 (d, J = 2.4 Hz, 1H; 11-H), 4.71 (quintet, J = 6.3 Hz, 1H; 4-H), 5.45 (d, J = 2.4 Hz, 1H; 8-H), 5.81 (d, J = 6.3 Hz, 1H; 3-H), 7.20–7.29 (m, 6H; ArH), 7.36–7.50 (m, 7H; ArH), 7.64 ppm (d, J = 7.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.5 (q), 43.4 (d), 54.0 (d), 54.4 (d), 77.1 (d), 84.6 (d), 114.0 (s), 125.6 (d), 126.2 (d), 127.9 (d), 128.1 (d), 128.4 (d), 128.55 (d), 128.59 (d), 128.7 (d), 128.8 (d), 133.9 (s), 136.7 (s), 138.9 (s), 165.4 ppm (s), six aromatic carbons were overlapped; IR (KBr): $\tilde{\nu}$ = 1702 cm^{-1} (C=O); MS (EI): m/z (%): 429 (55) $[M]^+$, 157 (100); elemental analysis calcd (%) for $C_{26}H_{23}NO_3S$: C 72.70, H 5.40, N 3.26; found: C 72.85, H 5.48, N 3.14.

Product of undetermined structure (8d): White solid (from AcOEt/hexane); m.p. 147.0–150.0 °C; $[\alpha]_D^{24}$ = −209.2 (c = 1.0 in $CHCl_3$);

^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.69 (d, J = 6.8 Hz, 3H; Me), 3.90 (quintet, J = 6.8 Hz, 1H; 4-H), 4.53 (d, J = 6.8 Hz, 1H; 3-H), 5.11 (d, J = 10.3 Hz, 1H; 11-H), 5.28 (dd, J = 8.0 and 10.3 Hz, 1H; 7-H), 5.79 (d, J = 8.0 Hz, 1H; 8-H), 7.10 (d, J = 7.3 Hz, 2H; ArH), 7.28–7.42 (m, 9H; ArH), 7.67 (d, J = 7.3 Hz, 2H; ArH), 7.68 ppm (d, J = 7.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.4 (q), 40.6 (d), 41.0 (d), 55.1 (d), 57.5 (d), 79.4 (d), 125.4 (d), 127.7 (d), 127.8 (d), 128.2 (d), 128.4 (d), 128.54 (d), 128.59 (d), 128.63 (d), 128.7 (d), 132.7 (s), 140.5 (s), 142.2 (s), 152.1 (s), 169.0 ppm (s), six aromatic carbons are overlapped; IR (KBr): $\tilde{\nu}$ = 1695 cm^{-1} (C=O); MS (EI): m/z (%): 429 (13) $[M]^+$, 131 (100); elemental analysis calcd (%) for $C_{26}H_{23}NO_3S$: C 72.70, H 5.40, N 3.26; found: C 72.50, H 5.35, N 3.11.

(1*R*,3*R*,4*S*,7*R*,8*R*,11*R*)-4-Methyl-3,11-diphenyl-8-*p*-tolyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (6e): Yellow powder; m.p. 105.0–105.5 °C; $[\alpha]_D^{20}$ = −18.9 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.13 (d, J = 6.3 Hz, 3H; Me), 2.41 (s, 3H; Me), 3.25 (t, J = 2.5 Hz, 1H; 7-H), 4.52 (d, J = 2.5 Hz, 1H; 11-H), 4.70 (quintet, J = 6.3 Hz, 1H; 4-H), 5.42 (d, J = 2.5 Hz, 1H; 8-H), 5.81 (d, J = 6.3 Hz, 1H; 3-H), 7.20–7.46 (m, 12H; ArH), 7.52 ppm (d, J = 7.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.4 (q), 21.2 (q), 43.3 (d), 53.4 (d), 54.3 (d), 77.1 (d), 84.6 (d), 114.0 (s), 125.4 (d), 125.7 (d), 126.2 (d), 126.38 (d), 126.43 (d), 127.9 (d), 128.0 (d), 128.2 (d), 128.5 (d), 128.54 (d), 128.65 (d), 128.5 (d), 128.8 (d), 129.8 (d), 133.6 (s), 133.9 (s), 138.2 (s), 139.0 (s), 165.5 ppm (s); IR (KBr): $\tilde{\nu}$ = 1701 cm^{-1} (C=O); MS (EI): m/z (%): 443 (23) $[M]^+$, 171 (100); HRMS (EI): calcd for $C_{27}H_{25}NO_3S$ $[M]^+$: 443.1555; found 443.1550.

Product of undetermined structure (8e): White needles (from CH_2Cl_2/hexane); m.p. 107.0–107.5 °C; $[\alpha]_D^{20}$ = −224.3 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.68 (d, J = 6.7 Hz, 3H; Me), 2.36 (s, 3H; Me), 3.89 (quintet, J = 6.7 Hz, 1H; 4-H), 4.54 (d, J = 6.7 Hz, 1H; 3-H), 5.10 (d, J = 10.5 Hz, 1H; 11-H), 5.26 (dd, J = 8.1 and 10.5 Hz, 1H; 7-H), 5.75 (d, J = 8.1 Hz, 1H; 8-H), 7.10 (d, J = 6.7 Hz, 2H; ArH), 7.20 (d, J = 8.3 Hz, 2H; ArH), 7.31–7.42 (m, 6H; ArH), 7.57 (d, J = 8.3 Hz, 2H; ArH), 7.67 ppm (d, J = 7.3 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.3 (q), 21.0 (q), 40.5 (d), 40.8 (d), 54.9 (d), 57.6 (d), 79.3 (d), 125.3 (d), 125.5 (d), 127.7 (d), 128.0 (d), 128.3 (d), 128.4 (d), 128.5 (d), 128.6 (d), 128.8 (d), 129.2 (d), 132.6 (s), 137.4 (s), 139.1 (s), 140.5 (s), 151.9 (s), 168.9 ppm (s), four aromatic carbons are overlapped; IR (KBr) $\tilde{\nu}$ = 1694 cm^{-1} (C=O); MS (EI): m/z (%): 443 (11) $[M]^+$, 171 (100); elemental analysis calcd (%) for $C_{27}H_{25}NO_3S$: C 73.11, H 5.68, N 3.16; found: C 72.87, H 5.59, N 3.37.

X-ray determination of compound 6c: CCDC-289047 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

(4*R*,5*S*)-3-[(*E*)-Cinnamoyl]-4-methyl-5-phenyl-1,3-oxazolidine-2-thione (15): This compound was prepared from (4*R*,5*S*)-4-methyl-5-phenyl-1,3-oxazolidine-2-thione[11] in a similar way as for isomer **5** above. Yellow prism (from AcOEt/hexane); m.p. 87.0–87.5 °C (decomp); $[\alpha]_D^{20}$ = +224.4 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.04 (d, J = 6.8 Hz, 3H; CH_3), 5.05 (quintet, J = 6.8 Hz, 1H; 4′-H), 5.83 (d, J = 6.8 Hz, 1H; 5′-H), 7.35–7.46 (m, 8H; ArH), 7.62 (q, J = 3.4 Hz, 2H; ArH), 7.78 (d, J = 15.6 Hz, 1H; 2-H), 8.41 ppm (d, J = 15.6 Hz, 1H; 3-H); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.3 (q), 59.3 (d), 83.7 (d), 118.8 (d), 125.9 (d), 128.6 (d), 128.7 (d), 128.9 (d), 130.6 (d), 132.5 (s), 134.7 (s), 145.3 (d), 166.3 (s), 185.5 ppm (s), five aromatic carbons overlapped; IR (KBr): $\tilde{\nu}$ = 1677 cm^{-1} (C=O); MS (EI): m/z (%): 323 (15) $[M]^+$, 157 (100); elemental analysis calcd (%) for $C_{19}H_{17}NO_2S$: C 70.56, H 5.30, N 4.33; found: C 70.63, H 5.29, N 4.19.

(1*S*,3*S*,4*R*,7*S*,8*S*,11*S*)-4-Methyl-8-(4-nitrophenyl)-3,11-diphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (16): White powder; m.p. 203.5–205 °C (decomp); $[\alpha]_D^{24}$ = +51.4 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.14 (d, J = 6.8 Hz, 3H; CH_3), 3.34 (t, J = 2.9 Hz, 1H; 7-H), 4.35 (d, J = 3.4 Hz, 1H; 11-H), 4.71 (quintet, J = 6.8 Hz, 1H; 11-H), 5.51 (d, J = 2.9 Hz, 1H; 8-H), 5.82 (d, J = 5.9 Hz, 1H; 3-H), 7.19–7.47 (m, 10H; ArH), 7.86 (d, J = 8.3 Hz, 2H; ArH), 8.36 ppm (d, J = 8.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.5 (q), 43.6 (d), 53.4 (d), 54.5 (d), 76.3 (d), 84.9 (d), 113.9 (s), 124.1 (d), 126.1 (d), 126.7 (d), 127.8 (d), 128.4 (d), 128.6 (d), 128.7 (d), 128.8 (d), 133.6 (s), 138.2 (s), 144.2 (s), 148.1 (s), 164.5 ppm (d), six aromatic carbons overlapped; IR (KBr): $\tilde{\nu}$ = 1704 (C=O), 1522 (NO_2), 1347 cm^{-1} (NO_2); MS (EI): m/z (%): 474 (30) $[M]^+$, 122 (100); elemental analysis calcd (%) for $C_{26}H_{22}N_2O_5S$: C 65.80, H 4.67, N 5.90; found: C 65.56, H 4.71, N 5.79.

(1*S*,3*S*,4*R*,7*S*,8*R*,11*S*)-4-Methyl-8-(4-nitrophenyl)-3,11-diphenyl-2,9-dioxa-10-thia-5-azatricyclo[5.2.2.0^{1,5}]undecan-6-one (17): Colorless plates (from acetone/hexane); m.p. 208.5–209 °C (decomp); $[\alpha]_D^{24}$ = −9.88 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.09 (d, J = 6.8 Hz, 3H; CH_3), 3.41 (d, J = 3.4 Hz, 1H; 7-H), 4.68 (quintet, J = 6.4 Hz, 1H; 4-H), 5.20 (d, J = 3.9 Hz, 1H; 11-H), 5.59 (s, 1H; 8-H), 5.92 (d, J = 6.4 Hz, 1H; 3-H), 7.26–7.55 (m, 12H; ArH), 8.25 ppm (d, J = 8.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.8 (q), 50.2 (d), 54.2 (d), 54.5 (d), 85.1 (d), 113.7 (s), 124.1 (d), 126.1 (d), 126.2 (d), 126.8 (d), 127.8 (d), 128.5 (d), 128.6 (d), 128.8 (d), 128.9 (d), 133.6 (s), 138.2 (s), 145.7 (s), 147.9 (s), 162.2 ppm (s), six aromatic carbons overlapped; IR (KBr): $\tilde{\nu}$ = 1692 (C=O), 1524 (NO_2), 1344 cm^{-1} (NO_2); MS (EI): m/z (%): 474 (87) $[M]^+$, 122 (100); elemental analysis calcd (%) for $C_{26}H_{22}N_2O_5S$: C 65.80, H 4.67, N 5.90; found: C 65.40, H 4.87, N 5.75.

Hydrolysis of tricyclic compound 4: HCl (2 M, 7.5 mL) was added to a mixture of **4** (97 mg, 0.25 mmol) in CH_3CN (7.5 mL). The mixture was stirred at 100 °C for 3 h, the reaction mixture was then extracted with CH_2Cl_2, and the organic phase was dried ($MgSO_4$) and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/AcOEt 2:1) furnished **18** (21 mg, 21%) and **19** (53 mg, 52%).

(2′*R,3′*R**,1″*S**)-3-[3′-(4-Chlorophenyl)-3′-hydroxy-2′-(1″-sulfanyl-1″-phenylmethyl)propionyl]thiazolidin-2-one (18)**: Yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.27 (d, J = 10.3 Hz, 1H; SH), 2.87 (ddd, J = 2.4, 7.8, 11.2 Hz, 1H; 5-H), 3.08 (ddd, J = 4.9, 7.8, 11.2 Hz, 1H; 5-H), 3.79 (d, J = 10.3 Hz, 1H; OH), 3.87–3.98 (m, 1H; 4-H), 4.00–4.05 (m, 1H; 4-H), 4.41–4.47 (m, 2H; 2′-H and 1″-H), 5.08 (dd, J = 3.9, 11.2 Hz, 1H; 3′-H), 7.12 (d, J = 8.5 Hz, 2H; ArH), 7.25–7.31 (m, 3H; ArH), 7.37–7.41 (m, 2H, ArH), 7.49 ppm (d, J = 8.5 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 24.8 (t), 43.0 (d), 46.8 (t), 57.1 (d), 72.1 (d), 126.3 (d), 127.3 (d), 127.9 (d), 128.4 (d), 129.1 (d), 133.1 (s), 140.4 (s), 141.7 (s), 173.3 (s), 173.9 ppm (s), four aromatic carbons overlapped; IR (NaCl): $\tilde{\nu}$ = 1690 cm^{-1} (C=O); MS (FAB, NBA) m/z (%): 408 (1) $[M+H]^+$, 154 (100); HRMS (FAB, NBA): calcd for $C_{19}H_{18}ClNO_3S_2$ $[M+H]^+$: 408.0495; found 408.0501.

(5*R,6*R**,1′*S**)-5-(4-Chlorobenzoyl)-3-(2-sulfanylethyl)-6-phenyl-[1,3]thiazinane-2,4-dione (19)**: Yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.33 (t, J = 8.5 Hz, 1H; SH), 2.40 (d, J = 7.5 Hz, 1H; OH), 2.64–2.71 (m, 2H; CH_2SH), 3.50 (dd, J = 5.0, 7.5 Hz, 1H; 5-H), 3.86–4.00 (m, 2H; NCH_2), 4.25 (t, J = 7.5 Hz, 1H; 1′-H), 5.36 (d, J = 5.0 Hz, 1H; 6-H) 7.23–7.33 (m, 3H, ArH), 7.36–7.42 ppm (m, 6H, ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 22.1 (t), 41.8 (d), 44.5 (t), 53.8 (d), 76.5 (d), 127.3 (d), 127.5 (d), 128.4 (d), 129.1 (d), 129.5 (d), 133.9 (s), 135.6 (s), 139.7 (s), 150.1 (s), 167.4 ppm (s), four aromatic carbons overlapped; IR (NaCl): $\tilde{\nu}$ = 1759, 1705 cm^{-1} (C=O); MS (EI): m/z (%): 407 (5) $[M]^+$, 131 (100); HRMS (EI): calcd for $C_{19}H_{18}ClNO_3S_2$ $[M+]$: 407.0417; found 407.0405.

Hydrolysis of tricyclic compound 6a: HCl (2 N, 7.5 mL) was added to a mixture of **6a** (116 mg, 0.25 mmol) in CH_3CN (7.5 mL). The mixture was stirred at room temperature for 5 h and was then extracted with CH_2Cl_2. The organic phase was washed with a saturated aqueous NH_4Cl solution, dried ($MgSO_4$), and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/AcOEt 3:1) furnished **20** (94 mg, 78%).

(4*S*,5*R*,2′*R*,3′*R*,1″*R*)-3-[3′-(4-Chlorophenyl)-3′-hydroxy-2′-(1″-sulfanyl-1″-phenylmethyl)propionyl]-4-methyl-5-phenyloxazolidin-2-one (20a): White powder; m.p. 70.5–71.0 °C; $[\alpha]_D^{20}$ = +82.2 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.57 (d, J = 6.8 Hz, 3H; Me), 2.36 (d, J = 8.6 Hz, 1H; SH), 2.71 (d, J = 3.4 Hz, 1H; OH), 4.48 (t, J = 8.6 Hz, 1H; 1″-H), 4.59 (quintet, J = 6.8 Hz, 1H; 4-H), 5.13 (dd, J = 3.4, 7.3 Hz, 1H; 3′-H), 5.25 (dd, J = 7.3, 8.6 Hz, 1H; 2′-H), 5.31 (d. J = 6.8 Hz, 1H; 5-H), 7.18–7.48 ppm (m, 14H; ArH); ^{13}C NMR (100 MHz,

$CDCl_3$): δ = 13.9 (q), 43.6 (d), 54.7 (d), 55.7 (d), 74.0 (d), 78.8 (d), 125.5 (d), 127.5 (d), 127.7 (d), 128.1 (d), 128.5 (d), 128.6 (d), 128.7 (d), 128.8 (d), 132.7 (s), 133.6 (s), 138.6 (s), 141.3 (s), 152.6 (s), 171.6 ppm (s), six aromatic carbons overlapped; IR (KBr): $\tilde{\nu}$ = 3498 (OH), 2569 (SH), 1766 (C=O), 1685 cm^{-1} (C=O); MS (FAB, Gly) *m/z* (%): 482 (10) $[M+H]^+$, 308 (100); HRMS (FAB, Gly): calcd for $C_{26}H_{24}ClNO_4S$ $[M+H]^+$: 482.1115; found 482.1187.

(4*S*,5*R*,2′*R*,3′*R*,1″*R*)-3-[3′-Hydroxy-3′-(4-nitrophenyl)-2′-(1″-phenylmethyl)-1″-sulfanylpropionyl]-4-methyl-5-phenyloxazolidin-2-one (20b): Colorless plates (from AcOEt/hexane); m.p. 146.5–149.0 °C; $[\alpha]_D^{20}$ = +51.5 (*c* = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.72 (d, *J* = 6.4 Hz, 3H; Me), 2.30 (d, *J* = 8.8 Hz, 1H; SH), 3.17 (br s, 1H; OH), 4.48 (t, *J* = 8.8 Hz, 1H; 1″-H), 4.68 (quintet, *J* = 6.9 Hz, 1H; 4-H), 5.24 (d, *J* = 5.6 Hz, 1H; 3′-H), 5.29 (dd, *J* = 5.6, 8.8 Hz, 1H; 2′-H), 5.44 (d, *J* = 6.9 Hz, 1H; 5-H), 7.16–7.43 (m, 12H; ArH), 8.00 ppm (d, *J* = 8.3 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.8 (q), 42.9 (d), 55.1 (d), 55.7 (d), 73.2 (d), 79.2 (d), 123.0 (d), 125.5 (d), 127.5 (d), 127.6 (d), 127.9 (d), 128.8 (d), 128.9 (d), 129.0 (d), 132.5 (s), 140.9 (s), 147.15 (s), 147.23 (s), 153.0 (s), 172.3 ppm (s); IR (KBr) $\tilde{\nu}$ = 3483 (OH), 2570 (SH), 1778 (C=O), 1689 (C=O), 1520 (NO_2), 1345 cm^{-1} (NO_2); MS (FAB, NBA) *m/z* (%): 493 (7) $[M+H]^+$, 154 (100); elemental analysis calcd (%) for $C_{26}H_{24}N_2O_6S$: C 63.40, H 4.91, N 5.69; found: C 63.65, H 5.03, N 5.53.

Synthesis of 21: A solution of **20** (78 mg, 0.17 mmol), MeI (60.3 mg, 0.43 mmol), and triethylamine (43 mg, 0.43 mmol) in dry CH_2Cl_2 (2 mL) was stirred at 0 °C. After the addition was complete, the reaction was allowed to continue at room temperature for 1.5 h. The reaction mixture was extracted with AcOEt. The extract was washed successively with HCl (10%), water, and brine and then dried ($MgSO_4$). After removal of the solvent, purification of the residue by the recycling preparative HPLC with elution with chloroform furnished **21** (72 mg, 85%).

(4*S*,5*R*,2′*R*,3′*R*,1″*R*)-3-[3′-(4-Chlorophenyl)-3′-hydroxy-2′-(1″-methylsulfanyl-1″-phenylmethyl)propionyl]-4-methyl-5-phenyloxazolidin-2-one (21a): Colorless prisms (from $CHCl_3$/hexane); m.p. 170.0–170.5 °C; $[\alpha]_D^{20}$ = +96.1 (*c* = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.57 (d, *J* = 6.8 Hz, 3H; Me), 1.90 (s, 3H; SMe), 2.81 (d, *J* = 2.4 Hz, 1H; OH) 4.20 (d, *J* = 8.3 Hz, 1H; 1″-H), 4.63 (quintet, *J* = 6.8 H, 1H; 4-H), 5.12–5.57 (m, 2H; 2′-H and 3′-H), 5.39 (d, *J* = 6.8 Hz, 1H; 5-H), 7.16–7.41 ppm (m, 14H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.9 (q), 15.0 (q), 51.7 (d), 54.1 (d), 54.7 (d), 73.8 (d), 78.8 (d), 125.5 (d), 127.7 (d), 128.0 (d), 128.3 (d), 128.4 (d), 128.5 (d), 128.6 (d), 128.7 (d), 132.8 (s), 133.4 (s), 138.8 (s), 138.9 (s), 152.6 (s), 171.3 ppm (s), six aromatic carbons overlapped; IR (KBr): $\tilde{\nu}$ = 3579 (OH), 1779 (C=O), 1696 cm^{-1} (C=O); MS (FAB, NBA) *m/z* (%): 496 (5) $[M+H]^+$, 154 (100); elemental analysis calcd (%) for $C_{27}H_{26}ClNO_4S$: C 65.38, H 5.28, N 2.82; found: C 65.25, H 5.22, N 2.84.

(4*S*,5*R*,2′*R*,3′*R*,1″*R*)-3-[3′-Hydroxy-2′-(1″-methylsulfanyl-1″-phenylmethyl)-3′-(4-nitrophenyl)propionyl]-4-methyl-5-phenyloxazolidin-2-one (21b): Pale yellow plates (from AcOEt/hexane); m.p. 216.5–217.0 °C; $[\alpha]_D^{20}$ = +66.0 (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.74 (d, *J* = 6.7 Hz, 3H; Me), 1.89 (s, 3H; SMe), 3.27 (s, 1H; OH), 4.20 (d, *J* = 9.8 Hz, 1H; 1″-H), 4.71 (quintet, *J* = 6.7 H, 1H; 4-H), 5.17–5.20 (m, 1H; 3′-H), 5.23–5.25 (m, 1H; 2′-H), 5.52 (d, *J* = 6.7 Hz, 1H; 5-H), 7.16–7.44 (m, 12H; ArH), 8.00 ppm (d, *J* = 8.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.3 (q), 14.9 (q), 50.8 (d), 53.6 (d), 55.2 (d), 73.1 (d), 79.2 (d), 122.9 (d), 125.5 (d), 127.5 (d), 127.8 (d), 128.5 (d), 128.7 (d), 128.8 (d), 128.9 (d), 132.6 (s), 138.4 (s), 147.0 (s), 147.4 (s), 153.0 (s), 172.2 ppm (s); IR (KBr): $\tilde{\nu}$ = 3588 (OH), 1772 (C=O), 1697 (C=O), 1515 (NO_2), 1345 cm^{-1} (NO_2); MS (FAB, NBA) *m/z* (%): 507 (9) $[M+H]^+$, 154 (100); elemental analysis calcd (%) for $C_{27}H_{26}N_2O_6S$: C 64.02, H 5.17, N 5.53; found: C 63.78, H 5.09, N 5.49.

Reaction of 21 with lithium ethanethiolate: *n*-Butyllithium (150 μL, 0.3 mmol) was added at −78 °C to a solution of ethanethiol (30 μL, 0.4 mmol) in dry THF (2 mL). The solution was transferred to an ice/water bath and stirred for 10 min until it became milky. A solution of **21** (96.2 mg, 0.2 mmol) in dry THF (2 mL) was transferred into the thiolate solution by cannula, and the reaction mixture was stirred at 0 °C for 20 min. The reaction mixture was poured into a separating funnel containing a saturated aqueous NH_4Cl solution and extracted with Et_2O. The organic phase was separated, washed with brine, dried ($MgSO_4$), and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/EtOAc 5:1) furnished **22** (33 mg, 55%), oxazolidinone **23** (21 mg, 59%), and *p*-chlorobenzaldehyde (**2a**) (11 mg, 40%).

***S*-Ethyl 3-ethylsulfanyl-3-phenylpropanethioate (22)**:[12] Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.14–1.19 (m, 6H; CH_3), 2.29–2.38 (m, 2H; CH_2), 2.83 (q, *J* = 7.5 Hz, 2H; $COSCH_2$), 3.05–3.08 (m, 2H; 2-H), 4.36 (t, *J* = 7.6 Hz, 1H; 3-H), 7.21–7.34 ppm (m, 5H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.3 (q), 14.5 (d), 23.4 (t), 25.3 (t), 45.1 (d), 50.3 (t), 127.4 (d), 127.7 (d), 128.5 (t), 141.0 (s), 196.5 ppm (s), two aromatic carbons overlapped; IR (NaCl): $\tilde{\nu}$ = 1686 cm^{-1} (C=O); MS (FAB, NBA) *m/z* (%): 255 (35) $[M+H]^+$, 154 (100); HRMS (FAB, NBA): calcd for $C_{13}H_{18}OS_2$ $[M+H]^+$: 255.0799; found 255.0884.

Reaction of 21 with lithium borohydride: Lithium borohydride (6 mg, 0.28 mmol) was added to a mixture of **21** (49.6 mg, 0.1 mmol) in dry THF (1 mL). The mixture was stirred at room temperature for 2 h, and a saturated aqueous NH_4Cl solution (5 mL) was then added dropwise at room temperature. The reaction mixture was then extracted with CH_2Cl_2. The organic phase was washed with a saturated aqueous NaCl solution, dried ($MgSO_4$), and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/AcOEt 5:1) furnished **24** (8 mg, 44%), **23** (100%), and *p*-chlorobenzyl alcohol (**25**) (56%).

3-Methylsulfanyl-3-phenylpropan-1-ol (24):[13] Colorless oil; ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.15 (br s, 1H; OH), 1.88 (s, 3H; Me), 2.04–2.17 (m, 2H; CH_2), 3.60–3.65 (m, 1H; CH_2), 3.72–3.78 (m, 1H; CH_2), 3.88 (t, *J* = 7.8 Hz, 1H; 3-H), 7.23–7.26 (m, 1H; ArH), 7.32–7.33 ppm (m, 4H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.1 (q), 38.4 (t), 47.9 (d), 60.5 (t), 127.1 (d), 127.7 (d), 128.4 (d), 141.9 ppm (s), two aromatic carbons overlapped; IR (NaCl): $\tilde{\nu}$ = 3357 cm^{-1} (OH); MS (FAB, NBA): *m/z* (%): 183 (28) $[M+H]^+$, 154 (100); HRMS (FAB, NBA): calcd for $C_{10}H_{14}OS$ $[M+H]^+$: 183.0765; found 183.0852.

Synthesis of trimethylsilyl ether 26: Pyridine (18.2 μL, 0.2 mmol) was added to a solution of **21** (49.6 mg, 0.1 mmol) in dry CH_2Cl_2 (3 mL), followed by a catalytic amount of 4-(*N*,*N*-dimethylamino)pyridine. To this, a solution of trimethylsilyl chloride (25 μL, 0.2 mmol) was added dropwise with stirring at 0 °C. After the addition was complete, the reaction was continued at room temperature for 1 h. The excess solvent and pyridine were removed under reduced pressure to afford a residue, which was taken up in AcOEt and water. The organic phase was separated, washed with brine, dried ($MgSO_4$), and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/EtOAc 5:1) furnished **26** (50 mg, 91%).

(4*S*,5*R*,2′*R*,3′*R*,1″*R*)-3-[3′-(4-Chlorophenyl)-2′-(1″-methylsulfanyl-1″-phenylmethyl)-3′-trimethylsilanyloxypropionyl]-4-methyl-5-phenyloxazolidin-2-one (26): White powder; m.p. 159.5–160.0 °C; $[\alpha]_D^{20}$ = +104.3 (*c* = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.01 (s, 9H; Me_3Si), 0.44 (d, *J* = 6.8 Hz, 3H; Me), 1.93 (s, 3H; SMe), 4.28 (d, *J* = 5.9 Hz, 1H; 1″-H), 4.57 (q, *J* = 3.4 Hz, 1-H; 4-H), 5.16–5.23 (m, 3H; 5-H, 2′-H, and 3′-H), 7.16–7.50 ppm (m, 14H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 0.0 (q), 13.7 (q), 14.9 (q), 52.1 (d), 54.4 (d), 54.9 (d), 74.4 (d), 78.3 (d), 125.4 (d), 127.4 (d), 127.5 (d), 127.8 (d), 127.9 (d), 128.2 (d), 128.3 (d), 128.4 (d), 128.5 (d), 129.1 (d), 133.1 (s), 133.3 (s), 139.8 (s), 140.1 (s), 151.7 (s), 170.8 ppm (s), two TMS carbons and four aromatic carbons overlapped; IR (KBr): $\tilde{\nu}$ = 1782 (C=O), 1693 cm^{-1} (C=O); MS (FAB, NBA) *m/z* (%): 568 (7) $[M+H]^+$, 137 (100); elemental analysis calcd (%) for $C_{30}H_{34}ClNO_4SSi$: C 63.41, H 6.03, N 2.47; found: C 63.40, H 6.09, N 2.46.

Treatment of 26 with lithium borohydride (Table 3, entry 1): Lithium borohydride (6 mg, 0.28 mmol) was added to a mixture of **26** (56.8 mg, 0.1 mmol) in dry THF (1 mL). The mixture was stirred at room temperature for 4 h, and a saturated aqueous NH_4Cl solution (5 mL) was then added dropwise at room temperature. The reaction mixture was then extracted with CH_2Cl_2, and the organic phase was washed with a saturated aqueous NaCl solution, dried ($MgSO_4$), and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/AcOEt 5:1) furnished **27** (54 mg, 100%).

Treatment of 26 with sodium ethanethiolate (Table 3, entry 2): Sodium hydride (3 mg, 0.025 mmol) was added to a solution of ethanethiol

(7.5 μL, 0.1 mmol) in dry THF (1 mL). After 30 min, the mixture was cooled to 0 °C, and a solution of **26** (56.8 mg, 0.1 mmol) in dry THF (1 mL) was added by cannula over 5 min. An additional quantity of dry THF (1 mL) was added to rinse the flask. After 50 min at room temperature, the reaction mixture was poured into a separating funnel containing a saturated aqueous NH_4Cl solution and extracted with Et_2O. The organic phase was separated, washed with a saturated aqueous NaCl solution, dried ($MgSO_4$), and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/EtOAc 5:1) furnished **27** (19 mg, 35 %).

Treatment of 26 with sodium methoxide (Table 3, entry 3): Sodium methoxide in methanol (20 μL, 0.11 mmol, 28 %) was added at −25 °C to a mixture of **26** (56.8 mg, 0.1 mmol) in dry CH_2Cl_2 (0.83 mL). After 8 min at −25 °C, the reaction mixture was poured into a separating funnel containing a saturated aqueous NH_4Cl solution and extracted with CH_2Cl_2. The organic phase was separated, washed with a saturated aqueous NaCl solution, dried ($MgSO_4$), and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/EtOAc 5:1) furnished **27** (45 mg, 83 %).

(2*R*,3*R*,1′*S*,2′*R*,1″*R*)-2-[2-[(4-Chlorophenyl)(trimethylsilanyloxy)methyl]]-*N*-(2′-hydroxy-1′-methyl-2′-phenylethyl)-3-methylsulfanyl-3-phenylpropionamide (27): White powder; m.p. 62.5–63.0 °C; $[\alpha]_D^{23} = +55.7$ (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.01 (s, 9H; Me_3Si), 0.43 (d, J = 6.8 Hz, 3H; Me), 1.91 (s, 3H; SMe), 2.67 (dd, J = 5.8 and 8.1 Hz, 1H; 2-H), 2.74 (d, J = 4.4 Hz, 1H; OH), 3.88–3.91 (m, 1H; 1′-H), 4.22 (d, J = 5.8 Hz, 1H; 3-H), 4.59 (m, 1H; 2′-H), 4.95 (d, J = 8.1 Hz, 1H; 1″-H), 5.13 (d, J = 8.1 Hz, 1H; NH), 7.12 (d, J = 7.3 Hz, 2H; ArH), 7.20–7.39 (m, 10H; ArH), 7.52 ppm (d, J = 7.3 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 0.0 (q), 13.4 (q), 15.9 (q), 50.6 (d), 51.7 (d), 63.6 (d), 73.8 (d), 75.3 (d), 126.2 (d), 127.2 (d), 127.3 (d), 128.0 (d), 128.1 (d), 128.2 (d), 128.5 (d), 128.6 (d), 133.4 (s), 140.3 (s), 141.0 (s), 141.2 (s), 169.8 ppm (s), two TMS and six aromatic carbons overlapped; IR (KBr): $\tilde{\nu}$ = 3420 (NH), 1647 cm^{-1} (C=O); MS (FAB, NBA) *m/z* (%): 542 (5) $[M+H]^+$, 154 (100); HRMS (FAB, NBA): calcd for $C_{29}H_{36}ClNO_3SSi$ $[M+H]^+$: 542.1874; found 542.1943.

Synthesis of propanediols 28a,b: A solution of sodium borohydride (37.5 mg, 1 mmol) in water (0.25 mL) was added to a mixture of **21a** (124 mg, 0.25 mmol) in THF (0.75 mL). The mixture was stirred at room temperature for 6 h, HCl (2 M, 1.5 mL) was added, and the mixture was then extracted with AcOEt. The organic phase was washed with a saturated aqueous NaCl solution, dried ($MgSO_4$), and concentrated in vacuo. Purification of the residue by column chromatography over silica gel (hexane/AcOEt/*i*PrOH 30:10:1) furnished **28a** (51 mg, 63 %). Compound **28b** was prepared similarly.

(1*R*,2*S*,1′*R*)-1-(4-Chlorophenyl)-2-(1′-methylsulfanyl-1′-phenylmethyl)-propane-1,3-diol (28a): Colorless oil; $[\alpha]_D^{23} = +64.8$ (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.84 (s, 3H; Me), 2.21 (brt, 1H; 3-OH), 2.41–2.47 (m, 1H; 2-H), 3.49 (d, J = 5.6 Hz, 1H; 1-OH), 3.72–3.84 (m, 2H; 3-H), 3.90 (d, J = 6.4 Hz, 1H; 1′-H), 5.02 (t, J = 5.6 Hz, 1H; 1-H), 7.21–7.33 ppm (m, 9H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.8 (q), 50.0 (d), 51.5 (d), 60.9 (t), 73.6 (d), 127.1 (d), 127.6 (d), 128.2 (d), 128.4 (d), 132.9 (s), 140.0 (s), 140.3 ppm (s), five aromatic carbons overlapped; IR (NaCl): $\tilde{\nu}$ = 3742 cm^{-1} (OH); MS (FAB, Gly) *m/z* (%): 323 (3) $[M+H]^+$, 185 (100); HRMS (FAB, Gly): calcd for $C_{17}H_{19}ClO_2S$ $[M+H]^+$: 323.0794; found 323.0879.

(1*R*,2*S*,1′*R*)-2-(1′-Methylsulfanyl-1′-phenylmethyl)-1-(4-nitrophenyl)propane-1,3-diol (28b): Colorless oil; $[\alpha]_D^{23} = +57.1$ (c = 1.0 in $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.81 (s, 3H; Me), 2.43 (brt, 1H; 3-OH), 2.48–2.53 (m, 1H; 2-H), 3.82–3.87 (m, 1H; 3-H), 3.90 (d, J = 5.4 Hz, 1H; 1-OH), 3.93 (d, J = 7.3 Hz, 1H; 1′-H), 3.98–4.04 (m, 1H; 3-H), 5.02 (t, J = 4.8 Hz, 1H; 1-H), 7.15–7.23 (m, 5H; ArH), 7.41 (d, J = 8.8 Hz, 2H; ArH), 8.08 ppm (d, J = 8.8 Hz, 2H; ArH); ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.7 (q), 49.5 (d), 51.6 (d), 61.8 (t), 73.9 (d), 123.1 (d), 126.8 (d), 127.2 (d), 128.3 (d), 128.4 (d), 139.7 (s), 146.7 (s), 149.9 ppm (s); four aromatic carbons overlapped; IR (NaCl): $\tilde{\nu}$ = 3582 cm^{-1} (OH); MS (FAB, Gly) *m/z* (%): 334 (4) $[M+H]^+$, 185 (100); HRMS (FAB, Gly): calcd for $C_{17}H_{19}NO_4S$ $[M+H]^+$: 333.1035; found 333.1122.

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