153. Asymmetric Synthesis of α-Amino Acids and α-*N*-Hydroxyamino Acids from *N*-Acylbornane-10,2-sultams: 1-Chloro-1-nitrosocyclohexane as a Practical [NH_2^+] Equivalent

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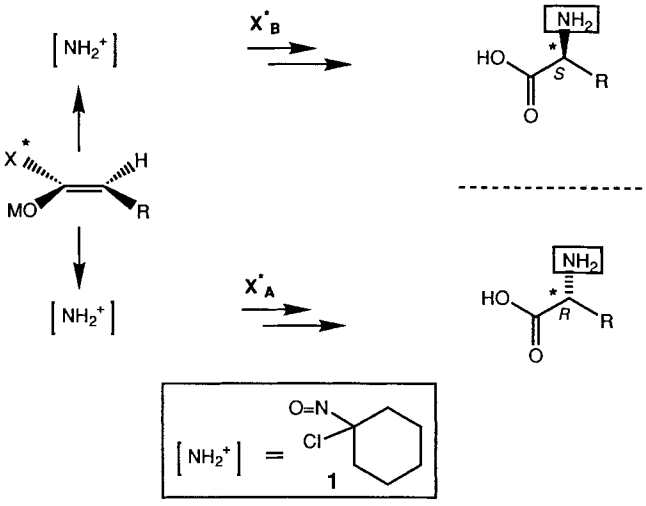
Successive treatment of *N*-acylsultams **3** with sodium hexamethyldisilazide, 1-chloro-1-nitrosocyclohexane (**1**), and aq. HCl gave diastereoisomerically pure, crystalline *N*-hydroxyamino-acid derivatives **5**. These were converted into various amino acids **7**, *N*-hydroxyamino acids **8**, and an *N*-Boc-amino acid **9**. (*S,S*)-Isoleucine (**17**) and (*S,S*)-2-acetamido-3-phenylbutyric acid (**23**) were obtained from *N*-crotonoylsultam **15** *via* 1,4-addition of an organomagnesium or organocopper reagent followed by enolate 'amination' with **1**.

Introduction. – Enantiomerically pure α-amino acids are of immense interest, particularly, as chiral building blocks for the synthesis of more complex molecules, chiral reagents, and catalysts [1]. Asymmetric preparation of amino acids *via* π-face selective, electrophilic 'aminations' of enolates (*Scheme 1*) has been described only recently [2].

Scheme 1



However, this approach suffered initially from the paucity of practical [NH_2^+] equivalents.

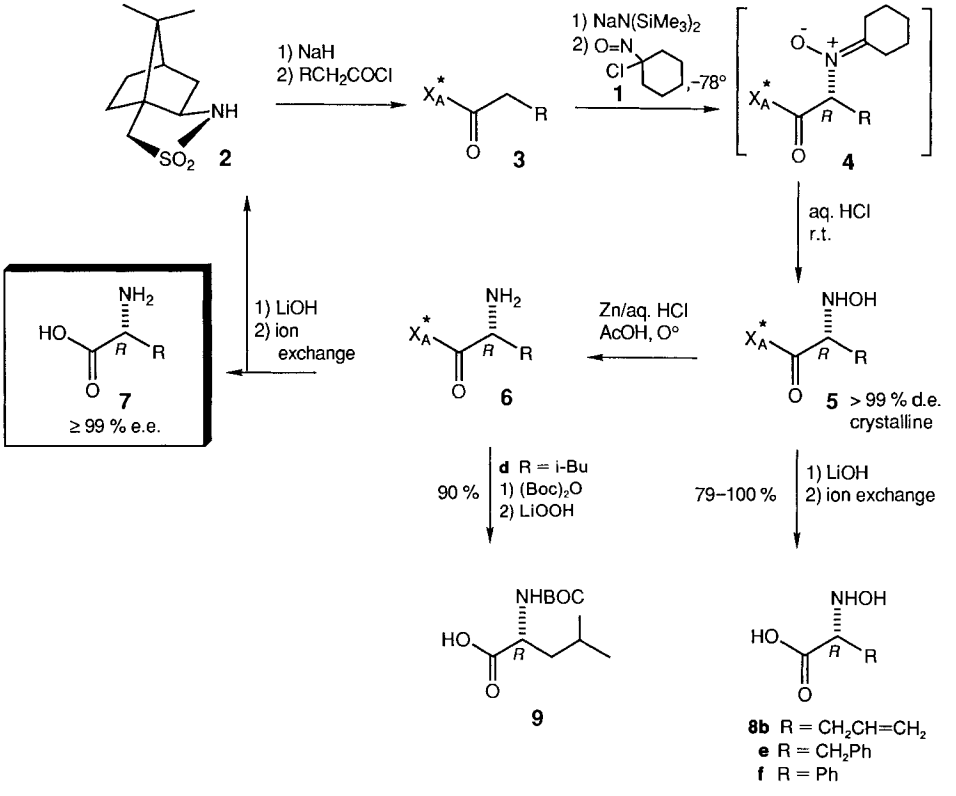
As a complement to a previous communication [3], we present here in full detail the more attractive use of 1-chloro-1-nitrosocyclohexane (**1**) as a convenient, electrophilic

nitrogen source. The bright-blue reagent **1**, readily accessible by chlorination of cyclohexanone oxime [4], can safely be stored for a least 1 year at −30° but is preferably distilled *in vacuo* before use. In contrast to infamous *N*-nitroso derivatives, *C*-nitroso compound **1** proved not to be mutagenic in the *Ames* test[1]). Nitroso compound **1** and its analogues are well known dieno- and enophiles [5] which also form nitrone products with methyl- and phenylmagnesium halides or Me_3Al [6]. Their reactivity towards enolates, however, remained totally unexplored.

Chiral 'enolates', derived from sultam **2**, react with a broad range of electrophiles in a highly stereoface-selective manner [7] and, thus, were expected to undergo asymmetric C–N-bond formation on exposure to **1**.

Preparation of (2*R*)- and (2*S*)-α-Amino Acids and *N*-Hydroxyamino Acids by Asymmetric, Electrophilic Amination. – Sultam **2** as well as its antipode *ent*-**2**, which are readily available on a kg scale [8][2]) were routinely transformed into their *N*-acyl derivatives [9a] [10] (*Scheme 2*). Deprotonation of acyl sultam **3a** with sodium hexamethyldisi-

Scheme 2



[1]) We thank Dr. *W. Suter*, WSP, Toxicology, *Sandoz Pharma Ltd.*, Basel, for kindly carrying out the *Ames* test.

[2]) *Newport Synthesis Ireland Ltd.*, Dublin/Ireland; *Oxford Asymmetry Ltd.*, Abingdon, Oxon, OX14 4RX, England.

lazide at −78°, followed by slow addition of the blue nitrosocompound **1** instantaneously gave a colorless solution of nitrone **4a**. Hydrolysis of non-isolated **4a** with aq. HCl furnished crude hydroxyamino compound **5a** (87% yield) as a single diastereoisomer (^{1}H-NMR) which was readily purified by crystallization (*Table, Entry 1*). Extent (> 99% d.e.) and sense (*R*) of the induced chirality in **5a** were assigned by conversion to (*R*)-alanine **7a**. *N/O*-Hydrogenolysis with Zn dust (excess, 0.7N HCl in aq. AcOH, 0°) provided *N*-(α-aminoacyl)sultam **6a** (83% after crystallization of the HCl salt). Mild saponification of **6a** with 0.3N LiOH (aq. THF, 0°) and extraction (CH_2Cl_2) gave recovered sultam auxiliary **2** (91%). Neutralization of the aq. phase, adsorption on *Amberlite IR 120* resin and desorption with aq. NH_3 afforded enantiomerically pure (*R*)-alanine **7a** (~ 100% yield). The absolute configuration and the enantiomeric excess (e.e.) of **7a** was readily determined by GC analysis of its *N*-(trifluoroacetyl)propyl ester (*Chirasil-Val*) [11].

Table. *Transformation of* N-*Acylbornanesultams into Enantiomerically Pure* α-*Amino Acids* **3** → **7** *and* **10** → **13**

Entry	R	Acyl-sultam	*N*-(Hydroxylamino)-acylsultam		*N*-Amino-acylsultam		Amino acid			
				Yield[a] [%]		Yield[a] [%]		Yield[b] [%]	e.e.[b] [%]	Configuration
1	CH_3	**3a**	**5a**	80 (87)	**6a**	83	**7a**	~ 100	> 99	*R*
2	CH_2=CH–CH_2	**3b**	**5b**	70 (88)	**6b**	74	**7b**	~ 100	> 99	*R*
3	Me_2CH	**3c**	**5c**	70 (86)	**6c**	85	**7c**	~ 100	> 99	*R*
4	Me_2CH–CH_2	**3d**	**5d**	87 (100)	**6d**	97	**7d**	~ 100	99	*R*
5	$PhCH_2$	**3e**	**5e**	78 (96)	**6e**	93	**7c**	94	> 99	*R*
6	Ph	**3f**	**5f**	77 (94)	**6f**	95	**7f**	97	> 99	*R*
7	*p*-MeOPh	**3g**	**5g**	71 (93)	**6g**	75	**7g**	~ 100	> 99	*R*
8	CH_3	**10a**	**11a**	82 (95)	**12a**	73	**13a**	93	> 99	*S*
9	*p*-MeOPh	**10b**	**11b**	73 (95)	**12b**	90	**13b**	~ 100	> 99	*S*

[a]) After crystallization (yield of crude product in parentheses).
[b]) Crude amino acid.

This general protocol applies to the efficient preparation of various pure (*R*)- and (*S*)-α-amino acids. Examination of the *Table* reveals several trends:

1) Without exception, 'animations' **3** → **5** were shown to be 100% stereoface-selective within the limits of ^{1}H-NMR analysis. Indeed, **3a** and **3b** gave enantiomerically pure amino acids **7a** and **7b**, respectively, without purification of intermediates **5** and **6**.

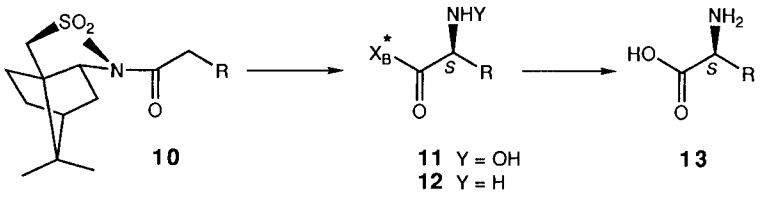
2) No epimerization occurred during hydrogenolysis/saponification, even *en route* to notoriously epimerizable phenylglycine and *p*-methoxyphenylglycine (*Entries 6, 7,* and *9*).

3) The *N,O*-hydrogenolysis conditions do not affect a C=C bond (*Entry 2*).

4) (*S*)-α-Amino acids **13** are equally accessible using the antipodal auxiliary *ent*-**2** (*Entries 8* and *9*, *Scheme 3*).

Furthermore, all acylsultams **3**, (hydroxylamino)acylsultams **5**, and (amino-acyl)sultams **6** were conveniently crystallized; after saponification, sultam auxiliary **2** or *ent*-**2** was routinely recovered (85–100%) by simple extraction.

Scheme 3

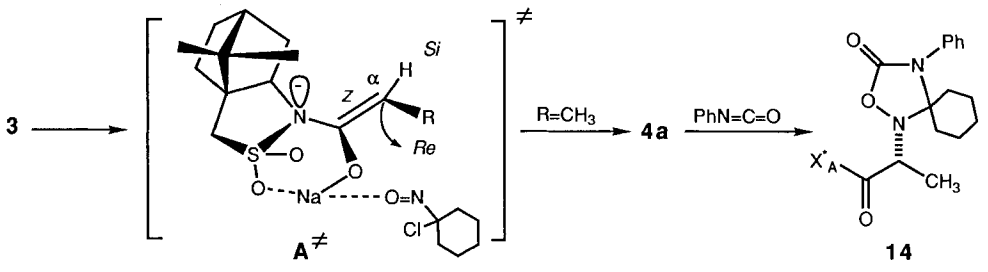


Successive treatment of **6d** with $(Boc)_2O$ and LiOOH gave *N*-Boc-leucine (**9**, 99% e.e., 76% overall from **3d**) which illustrates a convenient approach to *N*-protected amino acids.

Moreover, this 'amination' protocol lends itself to the direct preparation of enantiomerically pure α-*N*-hydroxyamino acids, some of which are components of naturally occurring metabolites [12]. α-*N*-Hydroxyamino acids have also attracted interest for the synthesis of biologically relevant *N*-hydroxypeptides [13]. Thus, mild saponification of (*N*-hydroxyamino)sultams **5b**, **5e**, and **5f**, extraction of sultam **2**, adsorption on *Dowex 50W* × *8* (H^+ form), and elution with aq. NH_3 furnished *N*-hydroxyamino acids **8b**, **8e**, and **8f** in good overall yield. We assume that **8b** and **8e** were obtained in high e.e., since the most critical conversion **5f** → **8f** inflicted only 8.7% racemization.

The observed reaction topicity for transformations **3** → **5** is consistent with the transition state $\mathbf{A}^{\neq}$ (*Scheme 4*).

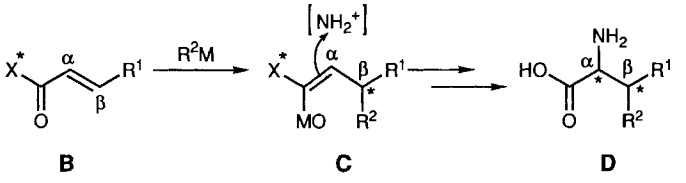
Scheme 4



Transition state $\mathbf{A}^{\neq}$ features a chelated (*Z*)-enolate which is attacked by the nitroso electrophile from the C(α)-*Re*-face, opposite to the lone electron pair on the N-atom. This parallels the topicity of bornanesultam-directed alkylations [9], aldolizations [10], acylations [14], brominations [7b], and *Mannich* reactions [15]. Consequently, non-isolated nitrones **4** possess the (*R*)-configuration at C(α). Evidence for the postulated nitrone intermediates was easily obtained *via* 1,3-dipolar trapping of nitrone **4a** with phenyl isocyanate which yielded the oxadiazolidinone **14**.

Preparation of (2*S*,3*S*)-α-Amino Acids from *N*-Enoylsultams by Asymmetric 1,4-Addition/Electrophilic Amination. – This 'amination' method also lends itself to the synthesis of diastereoisomerically and enantiomerically pure amino acids **D**, containing a second stereogenic center at C(β) (*Scheme 5*).

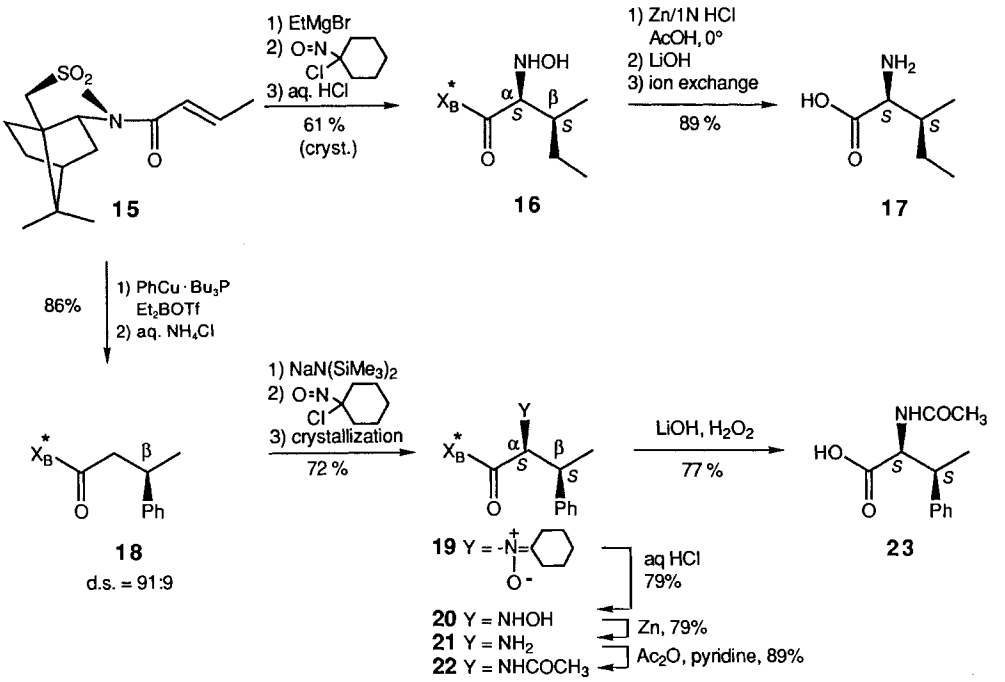
Scheme 5



Previously, we have found that (*E*)-α,β-unsaturated enoyl sultams **B** undergo conjugate additions of organomagnesium [16] or organocopper reagents [17], forming (*Z*)-enolates **C** with high induction at C(β). Trapping of those *in situ* formed enolates **C** with reagent **1** should, thus, provide two contiguous stereogenic centers in one synthetic operation.

This concept was readily exemplified by the following preparation of (2*S*,3*S*)-isoleucine (**17**) (*Scheme 6*).

Scheme 6



Consecutive treatment of sultam **15** with EtMgBr (1.4 mol-equiv.), nitrosocompound **1**, and 1N aq. HCl furnished hydroxyamino compound **16** (61% yield after crystallization). Subjecting **16** to the *N,O*-hydrogenolysis/saponification sequence (as above) gave crude (2*S*,3*S*)-isoleucine (**17**, > 99% e.e. at C(α), 90% e.e. at C(β) in 89% yield).

(−)-(2*S*,3*S*)-2-Amino-3-phenylbutyric acid is a component of the peptide antibiotic bottromycine [18]. Several laboratories have reported syntheses of this unusual amino

acid which was characterized as its *N*-acetyl derivative **23** [19]. Exploring a shorter route to **23**, *N*-crotonoylsultam **15** was initially reacted with PhMgCl. However, only products of 1,2-addition (cleavage of the N–C(=O) bond) were observed. PhMgCl/CuCl 9:1, $LiCuPh_2$, or Li_2CuPh_2SCN underwent 1,4-addition to 'crotonate' **15**, but trapping of the non-isolated enolates **C** with **1** and acidic workup failed to give isolable quantities of hydroxyamino compound **19**. It seemed, therefore, preferable to carry out the 1,4-addition and 'amination' steps separately.

Addition of *in situ* prepared PhCu·Bu_3P (5 mol-equiv.) to a mixture of enoylsultam **15** and Et_2BOTf (5 mol-equiv.) at −78° and quenching of the reaction with aq. NH_4Cl afforded a 95:5 to 91:9 mixture of **18** and its C(*β*)-epimer (86%)[3]). Successive treatment of this mixture with sodium hexamethyldisilazide and nitroso reagent **1** and convenient removal of the minor C(*β*)-epimer by crystallization afforded pure nitrone **19** (72%). Acidic hydrolysis/*N,O*-hydrogenolysis/*N*-acetylation/peroxide-assisted saponification (**19** → **20** → **21** → **22** → **23**) yielded pure (+)-(2*S*,3*S*)-2-acetamido-3-phenylbutyric acid (**23**, 83%) which was identified by comparison (m.p., ^{1}H-NMR, $[\alpha]_D$) with published data [19].

In summary, the 'amination' of chiral enolates with a nitroso electrophile offers an advantageous route to enantiomerically pure α-amino acids and α-*N*-hydroxyamino acids. 1,4-Additions, combined with enolate aminations, are directed by the same sultam auxiliary and, thus, provide a short and stereoselective approach to amino acids containing two contiguous stereogenic centers. Further applications and extensions of this method attest to its utility in organic synthesis [20].

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Experimental Part

General. All reactions are carried out under Ar with magnetic stirring, unless otherwise specified. Solvents are dried by distillation from drying agents as follows: Et_2O (Na), THF (Na), toluene (Na), CH_2Cl_2, and HMPA (CaH_2). 'Workup' denotes extraction with an org. solvent, drying ($MgSO_4$), and evaporation. Column flash chromatography (FC): SiO_2 (*Merck 60*). GC: *Hewlett-Packard 5790 A*, integrator *HP 3390*, chiral capillary column: *Chirasil-Val II* (*Altech Associates Inc.*), 10 psi H_2, 2 min 100°, 5°/min to 140°, unless otherwise specified, t_R in min (area-%). M.p.: *Kofler* hot stage; uncorrected. $[\alpha]_D$: *Perkin-Elmer-241* polarimeter; in $CHCl_3$ at 20°, unless otherwise specified. IR: *Polaris, Matteson Instruments*, in $CHCl_3$, unless otherwise specified. ^{1}H-NMR at 360 MHz in $CDCl_3$, unless otherwise specified; ^{13}C-NMR at 50 MHz in $CDCl_3$, unless otherwise specified; standard $CDCl_3$ ($\delta = 7.27$ ppm), *J* in Hz. MS: *m/z* (rel.-%).

Preparation of *N*-Acylsultams 3 and 12. – *(2R)-Bornane-10,2-sultam* (**2**) or *(2S)-bornane-10,2-sultam* (*ent*-**2**) was acylated by successive treatment with NaH and the corresponding acid chloride according to the general procedure in [10].

(2R)-N-*Propionylbornane-10,2-sultam* (**3a**). Prepared as described in [10].

(2R)-N-*(Pent-4-enoyl)bornane-10,2-sultam* (**3b**). Acylation [10] of **2** (3.96 g, 18.4 mmol) with pent-4-enoyl chloride followed by FC (hexane/AcOEt 8:1) and crystallization (hexane) furnished **3b** (4.93 g, 90%). M.p. 74–75°. $[\alpha]_D = -104.2$ ($c = 1.47$). IR: 2980, 1700, 1450, 1380, 1330, 1270, 1240, 1130. ^{1}H-NMR (200 MHz): 0.96 (*s*, 3 H); 1.14 (*s*, 3 H); 1.32–1.46 (2 H); 1.82–1.94 (3 H); 2.04–2.12 (2 H); 2.42 (*m*, 2 H); 2.82 (*m*, 2 H); 3.40 (*d*, $J = 14$, 1 H); 3.49 (*d*, $J = 14$, 1 H); 3.86 (*t*, $J = 6.5$, 1 H); 4.92–5.12 (2 H); 5.82 (*m*, 1 H). ^{13}C-NMR: 171.11 (*s*); 136.42 (*d*);

[3]) Et_2AlCl-promoted 1,4-addition of PhCu·BU_3P to **15** yielded a 90:10 mixture of **18** and its C(*β*)-epimer.

115.60 (*t*); 65.15 (*d*); 52.87 (*s*); 48.37 (*s*); 47.68 (*s*); 44.59 (*d*); 38.42 (*t*); 34.50 (*t*); 32.76 (*t*); 28.26 (*t*); 26.40 (*t*); 20.78 (*q*); 19.82 (*q*). MS: 297 (3, $C_{15}H_{23}NO_3S^+$), 135(12), 108 (6), 107 (5), 93 (8), 83 (34), 55 (100). HR-MS: 297.1393 ($C_{15}H_{23}NO_3S^+$, calc. 297.1399).

(2R)-N-(3-Methylbutanoyl)bornane-10,2-sultam (**3c**). Acylation [10] of **2** (2.0 g, 9.3 mmol) with 3-methylbutanoyl chloride and crystallization (MeOH) gave **3c** (2.31 g, 83%). M.p. 129–130°. $[\alpha]_D = -89.16$ ($c = 1.14$). IR: 2980, 1700, 1330, 1130. ^{1}H-NMR: 0.98 (*d*, $J = 7$, 3 H); 0.99 (*s*, 3 H); 1.00 (*d*, $J = 7$, 3 H); 1.29 (*s*, 3 H); 1.3–1.45 (2 H); 1.85–1.97 (3 H); 2.07–2.15 (2 H); 2.26 (*sext.*, $J = 13$, 1 H); 2.52 (*dd*, $J = 16$, 7, 1 H); 2.70 (*dd*, $J = 16$, 7, 1 H); 3.44 (*d*, $J = 14$, 1 H); 3,50 (*d*, $J = 14$, 1 H); 3.90 (*t*, $J = 7$, 1 H). ^{13}C-NMR: 171.45 (*s*); 65.13 (*d*); 52.96 (*t*); 48.20 (*s*); 47.70 (*s*); 44.57 (*d*); 44.14 (*t*); 38.55 (*t*); 32.75 (*t*); 26.39 (*t*); 25.48 (*d*); 22.30 (*q*); 22.25 (*q*); 20.75 (*q*); 19.82 (*q*). MS: 257 (4, $[C_{15}H_{25}NO_3-C_3H_6]^{+\cdot}$), 193 (3), 151 (6), 135 (15), 108 (9), 85 (88), 57 (100).

(2R)-N-(4-Methylpentanoyl)bornane-10,2-sultam (**3d**). Acylation [10] of **2** (2.0 g, 9.3 mmol) with 4-methylpentanoyl chloride gave **3d** (2.31 g, 80%). M.p. 45–46°. $[\alpha]_D = -94.0$ ($c = 1.22$). IR: 2980, 1700, 1340, 1140. ^{1}H-NMR: 0.90 (*d*, $J = 7$, 6 H); 0.98 (*s*, 3 H); 1.16 (*s*, 3 H); 1.3–1.7 (5 H); 1.8–2.0 (3 H); 2.05–2.2 (2 H); 2.6–2.8 (2 H); 3.43 (*d*, $J = 14$, 1 H); 3.50 (*d*, $J = 14$, 1 H); 3.87 (*dd*, $J = 7.5$, 5.5, 1 H). MS: 298 (1, $[C_{16}H_{27}NO_3S-CH_3]^+$), 270 (1), 257 (20), 234 (12), 216 (2), 206 (6), 193 (9), 151 (10), 135 (59), 108 (20), 99 (88), 81 (100).

(2R)-N-(3-Phenylpropanoyl)bornane-2,10-sultam (**3e**). Acylation [10] of **2** (4.0 g, 18.6 mmol) with 3-phenylpropanoyl chloride and crystallization (MeOH) gave **3e** (5.48 g, 85%). M.p. 153–154°. $[\alpha]_D = -78.9$ ($c = 1.14$). IR: 3010, 2980, 1700, 1350, 1280, 1240, 1130. ^{1}H-NMR (200 MHz): 0.95 (*s*, 3 H); 1.09 (*s*, 3 H); 1.22–1.45 (2 H); 1.77–1.98 (3 H); 2.0–2.1 (2 H); 2.90–3.12 (4 H); 3.40 (*d*, $J = 14$, 1 H); 3.48 (*d*, $J = 14$, 1 H); 3.85 (*t*, $J = 6$, 1 H); 7.12–7.32 (5 H). ^{13}C-NMR: 171.0 (*s*); 140.0 (*s*); 128.44 (*d*); 128.38 (*d*); 126.17 (*d*); 65.15 (*d*); 52.90 (*d*); 48.37 (*s*); 47.68 (*s*); 44.60 (*d*); 38.40 (*t*); 36.87 (*t*); 32.77 (*t*); 30.41 (*t*); 26.39 (*t*); 20.76 (*q*); 19.82 (*q*). MS: 347 (27, $C_{19}H_{25}NO_3S^{+\cdot}$), 133 (37), 105 (100), 91 (98), 79 (16). HR-MS: 347.1589 ($C_{19}H_{25}NO_3S^{+\cdot}$, calc. 347.1623).

(2R)-N-(Phenylacetyl)bornane-10,2-sultam (**3f**). Acylation [10] of **2** (1.505 g, 7 mmol) with phenylacetyl chloride and crystallization (MeOH) gave **3f** (2.015 g, 86%). M.p. 95–96°. $[\alpha]_D = -116.8$ ($c = 1.11$). IR: 3030, 2970, 1700, 1340, 1140. ^{1}H-NMR: 0.99 (*s*, 3 H); 1.16 (*s*, 3 H); 1.24–1.51 (2 H); 1.85–2.16 (5 H); 3.49 (*d*, $J = 14$, 1 H); 3.56 (*d*, $J = 14$, 1 H); 3.92 (*dd*, $J = 8$, 6.5, 1 H); 4.01 (*d*, $J = 16$, 1 H); 4.11 (*d*, $J = 16$, 1 H); 7.2–7.36 (5 H). MS: 333 (5, $C_{18}H_{23}NO_3S^{+\cdot}$), 152 (3), 135 (27), 118 (18), 107 (7), 91 (100).

(2R)-N-[(4-Methoxyphenyl)acetyl]bornane-10,2-sultam (**3g**). Acylation [10] of **2** (1.72 g, 8 mmol) with (4-methoxyphenyl)acetyl chloride (2.23 g) gave **3g** (2.347 g, 81%) as a colorless oil. $[\alpha]_D = -109.2$ ($c = 9.87$). IR: 2980. 1700, 1520, 1340, 1250, 1130. ^{1}H-NMR (200 MHz): 0.96 (*s*, 3 H); 1.13 (*s*, 3 H); 1.2–1.4 (2 H); 1.8–2.1 (5 H); 3.45 (*d*, $J = 14$, 1 H); 3.53 (d, $J = 14$, 1 H); 3.77 (*s*, 3 H); 3.88 (*t*, $J = 6$, 1 H); 3.91 (*d*, $J = 16$, 1 H); 4.02 (*d*, $J = 16$, 1 H); 6.84 (*d*, $J = 8$, 2 H); 7.21 (*d*, $J = 8$, 2 H). ^{13}C-NMR: 170.23 (*s*); 158.63 (*s*); 130.74 (*d*); 125.3 (*s*); 113.9 (*d*); 65.35 (*d*); 55.20 (*q*); 53.00 (*t*); 48.40 (*s*); 47.70 (*s*); 44.60 (*d*); 41.03 (*t*); 38.31 (*t*); 32.75 (*t*); 26.40 (*t*); 20.75 (*q*); 19.85 (*q*). MS: 363 (8, $C_{19}H_{25}NO_4S^{+\cdot}$), 148 (45), 121 (100). HR-MS: 363.1484 ($C_{19}H_{25}NO_4S^{+\cdot}$, calc. 363.1504).

(2S)-N-Propanoylbornane-10,2-sultam (**10a**). Acylation [10] of *ent*-**2** (2.0 g, 9.3 mmol) with propanoyl chloride and crystallization (MeOH) gave **10a** (2.12 g, 84%). M.p. 150–152°. $[\alpha]_D = +117$ ($c = 1.22$). ^{1}H- and ^{13}C-NMR: identical to those of the enantiomer [10].

(2S)-N-[(4-Methoxyphenyl)acetyl]bornane-10,2-sultam (**10b**). Acylation [10] of *ent*-**2** (1.72 g, 8 mmol) with (4-methoxyphenyl)acetyl chloride and crystallization (MeOH) gave **10b** (2.38 g, 82%). $[\alpha]_D = +110.4$ ($c = 3.91$). ^{1}H- and ^{13}C-NMR: identical to those of **3g**.

Reaction of Deprotonated *N*-Acylsultams with 1-Chloro-1-nitrosocyclohexane (1) and Subsequent Acidic Hydrolysis. – *General Procedure.* A 1M soln. of $NaN(TMS)_2$ in THF (1.1 mol-equiv.) was added to a stirred soln. of acylsultam **3** or **12** at −78°. After 1 h, a 1M soln. of 1-chloro-1-nitrosocyclohexane (**1**, 1.1 mol-equiv.) in THF was added to the mixture. Stirring of the mixture for 30 min, addition of 1 N aq. HCl (7 ml) at −78°, stirring at r.t. for 30 min, evaporation *in vacuo*, shaking of the residue with Et_2O/hexane 1:1 and 1N aq. HCl, washing of the org. phase with 1N aq. HCl, basification of the combined aq. phases with solid $NaHCO_3$ to pH 9–10, extraction with CH_2Cl_2, drying of the extracts ($MgSO_4$), and evaporation gave the crude *N*-[2-(hydroxyamino)acyl]bornane-2,10-sultam **4** or **13**, respectively, which was purified by FC and crystallization (hexane/AcOEt).

(2R,2′R)-N-[2′-(Hydroxyamino)propanoyl]bornane-10,2-sultam (**5a**). Using the *General Procedure*, **3a** (1.032 g, 3.8 mmol) was converted to crude **5a** (1.097 g). 1.061 g of this material gave after FC and crystallization pure **5a** (880 mg, 80%). M.p. 125–139° (dec.). $[\alpha]_D = -67.0$ ($c = 0.57$). IR: 3600, 3200, 2960, 1695, 1340. ^{1}H-NMR: 0.93 (*s*, 3 H); 1.16 (*s*, 3 H); 1.26 (*d*, $J = 6.5$, 3 H); 1.25–2.3 (7 H); 3.43 (*d*, $J = 14$, 1 H); 3.52 (*d*, $J = 14$, 1 H); 3.91 (*dd*, $J = 8$, 5, 1 H); 4.32 (*q*, $J = 6.5$, 1 H); 4.88 (br. *s*, 1 H); 5.80 (br., 1 H). ^{13}C-NMR: 173.92 (*s*); 65.30 (*d*); 59.92 (*d*); 52.98 (*t*); 48.82 (*s*); 47.80 (*s*); 44.57 (*d*); 38.20 (*t*); 32.74 (*t*); 26.40 (*t*); 20.68 (*q*); 19.86 (*q*); 13.85 (*q*). MS: 284 (7,

$[C_{13}H_{22}N_2O_4S-H_2O]^+$), 271 (11), 242 (21), 214 (31), 207 (30), 179 (26), 151 (47), 135 (68), 119 (62), 108 (78), 93 (92), 60 (100). HR-MS: 271.1230 ($[C_{13}H_{22}N_2O_4S-NOH]^+$, calc. 271.1228).

*(2*R*,2'*R*)-*N*-[2'-(Hydroxyamino)pent-4-enoyl]bornane-10,2-sultam* (**5b**). Using the *General Procedure*, **3b** (1.026 g, 3.4 mmol) was converted to crude **5b** (1.063 g); 1.036 g of this material gave after FC and crystallization pure **5b** (769 mg, 70%). M.p. 169–178° (dec.). $[\alpha]_D = -74.8$ ($c = 0.935$). IR: 3590, 3280, 2970, 1694, 1340. ^{1}H-NMR: 1.00 (*s*, 3 H); 1.22 (*s*, 3 H); 1.46 (2 H); 1.85–2.25 (5 H); 2.35 (*m*, 1 H); 2.55 (*m*, 1 H); 3.46 (*d*, $J = 14$, 1 H); 3.56 (*d*, $J = 14$, 1 H); 3.93 (*dd*, $J = 8$, 5, 1 H); 4.27 (br. *dd*, $J = 8$, 5, 1 H); 4.65 (br. *s*, 1 H); 5.06–5.17 (2 H); 5.83 (*m*, 1 H); 5.88 (br. *s*, 1 H, disappears upon exchange with D_2O). ^{13}C-NMR: 19.87 (*q*); 20.66 (*q*); 26.37 (*t*); 32.74 (*t*); 32.87 (*t*); 32.20 (*t*); 44.50 (*d*); 47.79 (*s*); 48.82 (*s*); 53.02 (*t*); 63.83 (*d*); 65.31 (*d*); 118.00 (*t*); 133.43 (*d*); 172.47 (*s*). MS: 310 (12), 297 (18), 287 (8), 271 (24), 216 (13), 179 (42), 151 (20), 135 (49), 119 (39), 108 (32), 93 (43), 86 (50), 79 (21), 70 (100), 55 (25). HR-MS: 287.1066 ($[C_{15}H_{24}N_2O_4S-C_3H_5]^+$, calc. 287.1067).

*(2*R*,2'*R*)-*N*-[2'-(Hydroxyamino)-4'-methylbutanoyl]bornane-10,2-sultam* (**5c**). Using the *General Procedure*, **3c** (1.046 g, 3.5 mmol) was converted to crude **5c** (988 mg); 962 mg of this material gave after FC and crystallization pure **5c** (790 mg, 70%). M.p. 165–177° (dec.). $[\alpha]_D = -93.3$ ($c = 0.89$). IR: 3590, 3290, 2960, 1688, 1330, 1140. ^{1}H-NMR: 1.00 (*s*, 3 H); 1.01 (*d*, $J = 7$, 3 H); 1.02 (*d*, $J = 7$, 3 H); 1.21 (*s*, 3 H); 1.42 (*m*, 2 H); 1.85–2.38 (6 H); 3.46 (*d*, $J = 13.5$, 1 H); 3.56 (*d*, $J = 13.5$, 1 H); 3.92 (*d*, $J = 7.5$, 1 H); 3.94 (*dd*, $J = 8$, 5, 1 H); 4.68 (br. *s*, 1 H); 5.80 (br. *s*, 1 H, disappears upon exchange with D_2O). ^{13}C-NMR: 18.16 (*q*); 19.88 (*q*); 20.20 (*q*); 20.58 (*q*); 26.38 (*t*); 27.90 (*d*); 32.75 (*t*); 38.24 (*t*); 44.53 (*d*); 47.75 (*s*); 48.58 (*s*); 53.09 (*t*); 65.38 (*d*); 69.92 (*d*); 173.22 (*s*). MS: 313 (5, $[C_{15}H_{26}N_2O_4S-17]^+$), 312 (10), 271 (13), 257 (17), 233 (12), 216 (56), 180 (10), 151 (11), 135 (20), 107 (15), 88 (100), 72 (60), 55 (17). HR-MS: 313.1594 ($[C_{15}H_{26}N_2O_4S-OH]^+$, calc. 313,1603).

*(2*R*,2'*R*)-*N*-[2'-(Hydroxyamino)-4'-methylpentanoyl]bornane-10,2-sultam* (**5d**). Using the *General Procedure*, **3d** (1.097 g, 3.5 mmol) was converted to crude **5d** (1.227 g); 1.195 g of this material gave after FC and crystallization pure **5d** (1.025 g, 87%). M.p. 161–173° (dec.). $[\alpha]_D = -67.5$ ($c = 1.22$). IR: 3590, 3280, 2960, 1690, 1330, 1140. ^{1}H-NMR: 0.93 (*d*, $J = 7$, 3 H); 0.96 (*d*, $J = 7$, 3 H); 1.00 (*s*, 3 H); 1.20 (*s*, 3 H); 1.3–2.3 (10 H); 3.45 (*d*, $J = 13.5$, 1 H); 3.56 (*d*, $J = 13.5$, 1 H); 3.94 (*dd*, $J = 8.5$, 5, 1 H); 4.28 (br. *dd*, $J = 8.5$, 5, 1 H); 4.82 (br. *s*, 1 H); 5.83 (br. *s*, 1 H, disappears upon exchange with D_2O). ^{13}C-NMR: 19.86 (*q*); 20.59 (*q*); 21.85 (*q*); 23.26 (*q*); 24.80 (*d*); 26.39 (*t*); 32.71 (*t*); 37.44 (*t*); 38.20 (*t*); 44.53 (*d*); 47.80 (*s*); 48.80 (*s*); 53.02 (*t*); 62.92 (*d*); 65.31 (*d*); 173.55 (*s*). MS: 326 (11, $[C_{16}H_{28}N_2O_4S-H_2O]^+$), 311 (19), 283 (7), 271 (18), 257 (47), 216 (78), 207 (18), 180 (19), 151 (8), 135 (19), 102 (100), 86 (72). HR-MS: 326.1623 ($[C_{16}H_{28}N_2O_4S-H_2O]^+$, calc. 326.1582).

*(2*R*,2'*R*)-*N*-[2'-(Hydroxyamino)-3'-phenylpropanoyl]bornane-10,2-sultam* (**5e**). Using the *General Procedure*, **3e** (1.212 g, 3.5 mmol) was converted to crude **5e** (1.268 g); 1.224 g of this material gave after FC and crystallization pure **5e** (990 mg, 78%). M.p. 118–128° (dec.). $[\alpha]_D = -86.5$ ($c = 0.49$). IR: 3580, 3300, 2980, 1690, 1330, 1135. ^{1}H-NMR: 1.01 (*s*, 3 H); 1.22 (*s*, 3 H); 1.32–1.50 (2 H); 1.84–2.0 (3 H); 2.13 (*dd*, $J = 14$, 8, 1 H); 2.2–2.31 (1 H); 2.74 (*dd*, $J = 14$, 9, 1 H); 3.21 (*dd*, $J = 14$, 4.5, 1 H); 3.49 (*d*, $J = 13.5$, 1 H); 3.57 (*d*, $J = 13.5$, 1 H); 3.96 (*dd*, $J = 8$, 4.5, 1 H); 4.49 (*dd*, $J = 9$, 4.5, 1 H); 4.75 (br. *s*, 1 H); 5.76 (br., 1 H); 7.2–7.36 (5 H). ^{13}C-NMR: 19.93 (*q*); 20.76 (*q*); 26.42 (*t*); 32.80 (*t*); 34.75 (*t*); 38.31 (*t*); 44.63 (*d*); 47.85 (*s*); 48.91 (*s*); 53.03 (*t*); 65.39 (*d*); 65.77 (*d*); 126.68 (*d*); 128.42 (*d*); 129.33 (*d*); 137.27 (*s*); 172.73 (*s*). MS: 360 (30, $[C_{19}H_{26}N_2O_4S-H_2O]^+$), 347 (15), 287 (22), 271 (48), 216 (14), 180 (12), 136 (35), 120 (100), 91 (48). HR-MS: 360.1506 ($[C_{19}H_{26}N_2O_4S-H_2O]^+$, calc. 360.1505).

*(2*R*,2'*R*)-*N*-[2'-(Hydroxyamino)phenylacetyl]bornane-10,2-sultam* (**5f**). Using the *General Procedure*, **3f** (1.008 g, 3.03 mmol) was converted to crude **5f** (1.037 g); 996 mg of this material gave after FC and crystallization pure **5f** (813 mg, 77%). M.p. 182–194° (dec.). $[\alpha]_D = -146$ ($c = 0.295$). IR: 3580, 3280, 3020, 2970, 1692, 1340, 1130. ^{1}H-NMR: 1.00 (*s*, 3 H); 1.23 (*s*, 3 H); 1.30–1.43 (2 H); 1.84–1.98 (3 H); 2.16 (*dd*, $J = 14$, 8, 1 H); 2.35 (*m*, 1 H); 3.49 (*d*, $J = 14$, 1 H); 3.54 (*d*, $J = 14$, 1 H); 3.95 (*dd*, $J = 8$, 5, 1 H); 5.44 (br. *s*, 1 H); 5.60 (br. *s*, 1 H); 5.95 (br., 1 H); 7.32–7.57 (5 H). ^{13}C-NMR: 19.87 (*q*); 20.78 (*q*); 26.34 (*t*); 32.75 (*t*); 38.29 (*t*); 44.59 (*d*); 47.83 (*d*); 48.88 (*s*); 52.87 (*t*); 65.47 (*d*); 68.54 (*d*); 128.55 (*d*); 128.85 (*d*); 129.02 (*d*); 132.38 (*s*); 171.18 (*s*). MS: 346 (3, $[C_{18}H_{24}N_2O_4S-H_2O]^+$), 333 (4), 179 (7), 122 (100), 91 (12), 77 (23). HR-MS: 333.1374 ($[C_{18}H_{24}N_2O_4S-NOH]^+$, calc. 333.1349).

*(2*R*,2'*R*)-*N*-[2'-(Hydroxyamino)-2'-(4''-methoxyphenyl)acetyl]bornane-10,2-sultam* (**5g**). Using the *General Procedure*, **3g** (1.205 g, 3.32 mmol) was converted to crude **5g** (1.216 g); 1.171 g of this material gave after FC and crystallization (AcOEt) pure **5g** (910 mg, 72%). M.p. 175–185° (dec.). $[\alpha]_D = -136.6$ ($c = 1.055$). IR: 3590, 3270, 2980, 1690, 1515, 1340, 1130. ^{1}H-NMR: 1.00 (*s*, 3 H); 1.24 (*s*, 3 H); 1.32–1.45 (2 H); 1.84–2.00 (3 H); 2.15 (*dd*, $J = 14$, 8, 1 H); 2.28–2.40 (1 H); 3.39 (*d*, $J = 14$, 1 H); 3.53 (*d*, $J = 14$, 1 H); 3.80 (*s*, 3 H); 3.94 (*dd*, $J = 8$, 5, 1 H); 5.40 (*s*, 1 H); 5.54 (br. *s*, 1 H); 5.7–6.1 (br., 1 H); 6.88 (*d*, $J = 9$, 2 H); 7.42 (*d*, $J = 9$, 2 H). ^{13}C-NMR: 19.88 (*q*); 20.78 (*q*); 26.35 (*t*); 32.75 (*t*); 38.30 (*t*); 44.60 (*d*); 47.79 (*s*); 48.85 (*s*); 52.87 (*t*); 55.17 (*q*); 65.46 (*d*); 67.93 (*d*); 113.97 (*d*); 124.38 (*s*); 130.32 (*d*); 159.92 (*s*); 171.44 (*s*). MS: 376 (2, $[C_{19}H_{26}N_2O_5S-H_2O]^+$), 363 (1), 180 (5), 163 (4), 152 (88), 134 (100), 121 (17), 107 (12), 77 (20). HR-MS: 376.1457 ($[C_{19}H_{26}N_2O_5S-H_2O]^+$, calc. 376.1458).

(2S,2'S)-N-[2'-(Hydroxyamino)propanoyl]bornane-10,2-sultam (**11a**). Using the *General Procedure*, **10a** (1.018 g, 3.75 mmol) was converted to crude **11a** (1.069 g); 1.029 g of this material gave after FC and crystallization pure **11a** (893 mg, 82%). M.p. 123–140° (dec.). $[\alpha]_D = +67.1$ ($c = 1.04$). ^{1}H- and ^{13}C-NMR: identical to those of **5a**.

(2S,2'S)-N-[2'-(Hydroxyamino)-2'-(4''-methoxyphenyl)acetyl]bornane-10,2-sultam (**11b**). Using the *General Procedure*, **10b** (1.184 g, 3.26 mmol) was converted to crude **11b** (1.452 g); 1.401 g of this material gave after FC and crystallization (AcOEt) pure **11b** (910 mg, 73%). M.p. 179–187° (dec.). $[\alpha]_D = +136.4$ ($c = 0.51$). ^{1}H- and ^{13}C-NMR: identical to those of **5g**.

***N,O*-Hydrogenolysis of *N*-[2-(Hydroxyamino)acyl]sultams.** – *General Procedure.* A mixture of hydroxyamino compound **5** or **11**, Zn powder (*ca.* 2.6 g/mmol of hydroxylamino compound) in aq. 1N HCl/AcOH (2:1, 8 ml/mmol of hydroxylamino compound) was stirred at 0° for 2 d. Filtration of the mixture through glass wool, evaporation of the filtrate, shaking of the residue with aq. $NaHCO_3/CH_2Cl_2$, evaporation of the org. phase, and crystallization of the residue from hexane/AcOEt gave the free amino compound **6** or **12**, respectively. To isolate **6** or **12** as their HCl salts, the CH_2Cl_2 phase was extracted with aq. 1N HCl. Evaporation of the aq. phase, addition of THF/toluene to the solid residue, evaporation and crystallization of the dry residue from EtOH/toluene (hexane) gave the pure HCl salt of **6** or **12**, respectively.

(2R,2'R)-N-(2'-Aminopropanoyl)bornane-10,2-sultam Hydrochloride (**6a**·HCl). Using the *General Procedure*, **5a** (453 mg, 1.5 mmol) was converted to the crude hydrochloride of amine **6a** (467 mg); 294 mg of this material was recrystallized to give pure **6a**·HCl (253 mg, 83%). M.p. 191–215° (dec.). $[\alpha]_D = -84.2$ ($c = 0.285$, MeOH). IR (KBr): 3250, 3000–2500, 1705, 1340. ^{1}H-NMR (CD_3OD): 1.02 (*s*, 3 H); 1.18 (*s*, 3 H); 1.3–1.55 (2 H); 1.58 (*d*, $J = 6.5$, 3 H); 1.8–2.04 (3 H); 2.08 (*dd*, $J = 13.5$, 8, 1 H); 2.25–2.35 (1 H); 3.68 (*d*, $J = 14$, 1 H); 3.70 (*d*, $J = 14$, 1 H); 3.97 (*dd*, $J = 8$, 5, 1 H); 4.46 (*q*, $J = 6.5$, 1 H). ^{13}C-NMR: 169.25 (*s*); 66.64 (*d*); 53.18 (*t*); 49.90 (*d*); 48.80 (*s*); 47.60 (*s*); 45.90 (*d*); 38.90 (*t*); 33.40 (*t*); 27.09 (*t*); 21.13 (*q*); 20.01 (*q*); 16.90 (*q*). Anal. calc. for $C_{13}H_{23}ClN_2O_3S$: C 48.36, H 7.18, N 8.68, S 9.93; found: C 48.20, H 7.18, N 8.56, S 10.10.

(2R,2'R)-N-(2'-Aminopent-4'-enoyl)bornane-10,2-sultam Hydrochloride (**6b**·HCl). Using the *General Procedure*, **5b** (124 mg, 0.377 mmol) was converted to the recrystallized **6b**·HCl (98 mg, 74%). M.p. 219–228° (dec.). $[\alpha]_D = -83.8$ ($c = 1.09$, MeOH). IR (KBr): 3250, 3000–2500, 1690, 1250. ^{1}H-NMR (CD_3OD): 1.02 (*s*, 3 H); 1.28 (*s*, 3 H); 1.30–1.55 (2 H); 1.83–2.03 (2 H); 2.08 (*dd*, $J = 13.5$, 8, 1 H); 2.31 (*m*, 1 H); 2.57 (*m*, 1 H); 2.93 (*m*, 1 H); 3.70 (*d*, $J = 14$, 1 H); 3.82 (*d*, $J = 14$, 1 H); 3.97 (*dd*, $J = 8$, 5, 1 H); 4.43 (*dd*, $J = 9$, 3.5, 1 H); 5.26–5.37 (2 H); 5.79 (*m*, 1 H). ^{13}C-NMR: 167.87 (*s*); 131.46 (*d*); 121.87 (*t*); 66.68 (*d*); 53.37 (*d*); 53.20 (*t*); 48.81 (*s*); 47.60 (*s*); 45.92 (*d*); 38.87 (*t*); 35.78 (*t*); 33.40 (*t*), 27.07 (*t*); 21.14 (*q*); 20.02 (*q*). Anal. calc. for $C_{15}H_{25}ClN_2O_3S$: C 51.64, H 7.22, N 8.03, S 9.19; found: C 51.80, H 7.13, N 7.89, S 9.36.

(2R,2'R)-N-(2'-Amino-3'-methylbutanoyl)bornane-10,2-sultam Hydrochloride (**6c**·HCl). Using the *General Procedure*, **5c** (427 mg, 1.292 mmol) was converted to the recrystallized **6c**·HCl (385 mg, 85%). M.p. 204–212° (dec.). $[\alpha]_D = -112.5$ ($c = 1.055$, MeOH). IR (KBr): 3210, 2980–2580, 1700, 1510, 1340, 1240, 1140. ^{1}H-NMR (CD_3OD): 1.01 (*d*, $J = 7$, 3 H); 1.02 (*s*, 3 H); 1.11 (*d*, $J = 7$, 3 H); 1.28 (*s*, 3 H); 1.32–1.55 (2 H); 1.82–2.03 (3 H); 2.09 (*dd*, $J = 13.5$, 8, 1 H); 2.35 (*m*, 1 H); 2.60 (*sept.*, $J = 7$, 4, 1 H); 3.67 (*d*, $J = 14$, 1 H); 3.79 (*d*, $J = 14$, 1 H); 3.96 (*dd*, $J = 8$, 5, 1 H); 4.28 (*d*, $J = 4$, 1 H). ^{13}C-NMR: 167.91 (*s*); 66.74 (*d*); 58.60 (*d*); 53.20 (*t*); 48.82 (*s*); 47.61 (*s*); 45.81 (*d*); 38.91 (*t*); 33.42 (*t*); 29.84 (*d*); 27.06 (*t*); 21.10 (*q*); 20.02 (*q*); 19.85 (*q*); 15.78 (*q*). Anal. calc. for $C_{15}H_{27}ClN_2O_3S$: C 51.34, H 7.76, N 7.98, S 9.14; found: C 51.06, H 7.64, N 8.19, S 8.94.

(2R,2'R)-N-(2'-Amino-4'-methylpentanoyl)bornane-10,2-sultam (**6d**). Using the *General Procedure*, **5d** (447 mg, 1.3 mmol) was converted to the recrystallized **6d** (411 mg, 97%). M.p. 93–108° (dec.). $[\alpha]_D = -98.0$ ($c = 0.945$). IR: 3370, 2970, 1694, 1330, 1140. ^{1}H-NMR: 0.93 (*d*, $J = 7$, 3 H); 0.96 (*d*, $J = 7$, 3 H); 1.00 (*s*, 3 H); 1.19 (*s*, 3 H); 1.3–2.0 (10 H); 2.08 (*dd*, $J = 13.5$, 8, 1 H); 2.1–2.2 (1 H); 3.46 (*d*, $J = 13$, 1 H); 3.56 (*d*, $J = 13$, 1 H); 3.91 (*dd*, $J = 7.5$, 5, 1 H); 3.99 (*dd*, $J = 7.5$, 6, 1 H). ^{13}C-NMR: 19.79 (*q*); 20.88 (*q*); 22.20 (*q*); 22.89 (*q*); 24,66 (*d*); 26.34 (*t*); 32.78 (*t*); 38.17 (*t*); 41.83 (*t*); 44.50 (*d*), 47.74 (*s*); 48.69 (*s*); 52.53 (*d*); 52.97 (*t*); 65.09 (*d*); 174.91 (*s*). MS: 329 (0.1, $[C_{16}H_{28}N_2O_3S + H]^{+\cdot}$), 271 (0.4), 207 (0.7), 152 (0.4), 151 (0.5), 135 (0.67), 107 (0.98), 86 (100).

(2R,2'R)-N-(2'-Amino-3'-phenylpropanoyl)bornane-10,2-sultam (**6e**). Using the *General Procedure*, **5e** (450 mg, 1.19 mmol) was converted to the recrystallized **6e** (401 mg, 93%). M.p. 155–158° (dec.). $[\alpha]_D = -113.5$ ($c = 0.97$). IR: 3370, 3010, 2950, 1694,1330, 1130, 1060. ^{1}H-NMR: 1.00 (*s*, 3 H); 1.19 (*s*, 3 H); 1.31–1.48 (2 H); 1.58 (br. *s*, 2 H); 1.84–2.00 (3 H); 2.10 (*dd*, $J = 13.5$, 8, 1 H); 2.13–2.23 (1 H); 2.73 (*dd*, $J = 14$, 9, 1 H); 3,23 (*dd*, $J = 14$, 5, 1 H); 3.47 (*d*, $J = 13.5$, 1 H); 3.54 (*d*, $J = 13.5$, 1 H); 3.91 (*dd*, $J = 8$, 5, 1 H);4.22 (*dd*, $J = 9$, 5, 1 H); 7.2–7.36 (5 H). ^{13}C-NMR: 19.80 (*q*); 20.91 (*q*); 26.34 (*t*); 32.77 (*t*); 38.19 (*t*); 39.59 (*t*); 44.54 (*d*); 47.74 (*s*); 48.74 (*s*); 52.91 (*t*); 55.69 (*d*); 65.11 (*d*); 126.52 (*d*); 128.39 (*d*); 129.53 (*d*); 137.67 (*s*); 173.85 (*s*). MS: 363 (0.7 $[C_{19}H_{26}N_2O_3S + 1]^{+\cdot}$), 271 (6), 135 (3), 120 (100), 77 (7). HR-MS: 271.1110 ($[C_{19}H_{26}N_2O_3S - CH_2Ph]^{+\cdot}$, calc. 271.1104).

(2R,2'R)-N-(2'-Amino-2'-phenylacetyl)bornane-10,2-sultam Hydrochloride (**6f**·HCl). Using the *General Procedure*, **5f** (264 mg, 0.725 mmol) was converted to the recrystallized **6f**·HCl (265 mg, 95%). M.p. 199–209° (dec.). $[\alpha]_D = -164.9$ ($c = 0.65$, MeOH). IR (KBr): 3500–2500, 1690, 1340, 1140. ^{1}H-NMR (CD_3OD): 1.00 (*s*, 3 H); 1.16 (*s*, 3 H); 1.28–1.50 (2 H); 1.80–1.98 (3 H); 2.11 (*dd*, $J = 13.5, 8, 1$ H); 2.25–2.37 (1 H); 3.52 (*d*, $J = 14$, 1 H); 3.70 (*d*, $J = 14$, 1 H); 3.94 (*dd*, $J = 8, 5, 1$ H); 5.50 (*s*, 1 H); 7.4–7.57 (5 H). Anal. calc. for $C_{18}H_{25}ClN_2O_3S$: C 56.17, H 6.55, N 7.28, S 8.33; found: C 56.08, H 6.73, N 8.00, S 8.52.

(2R,2'R)-N-[2'-Amino-2'-(4''-methoxyphenyl)acetyl]bornane-10,2-sultam Hydrochloride (**6g**·HCl). Using the *General Procedure*, **5g** (512 mg, 1.3 mmol) was converted to the recrystallized **6g**·HCl (403 mg, 75%). M.p. 189–194° (dec.). $[\alpha]_D = -158.1$ ($c = 0.665$, MeOH). IR (KBr): 3400, 3200–2600, 1690, 1515, 1250, 1140. ^{1}H-NMR (200 MHz, CD_3OD): 1.00 (*s*, 3 H); 1.16 (*s*, 3 H); 1.26–1.56 (2 H); 1.80–2.0 (3 H); 2.07 (*dd*, $J = 14, 8, 1$ H); 2.30 (*m*, 1 H); 3.51 (*d*, $J = 14$, 1 H); 3.70 (*d*, $J = 14$, 1 H); 3.81 (*s*, 3 H); 3.92 (*dd*, $J = 8, 5, 1$ H); 5.46 (*s*, 1 H); 6.98 (*d*, $J = 9$, 2 H); 7.41 (*d*, $J = 9$, 2 H). Anal. calc. for $C_{19}H_{27}ClN_2O_4S$: C 55.00, H 6.56, N 6.75, S 7.73; found: C 54.94, H 6.69, N 6.91, S 7.95.

(2S,2'S)-N-(2'-Aminopropanoyl)bornane-10,2-sultam Hydrochloride (**12a**·HCl). Using the *General Procedure*, **11a** (453 mg, 1.5 mmol) was converted to the recrystallized **12a**·HCl (353 mg, 73%). $[\alpha]_D = +84.3$ ($c = 0.625$, MeOH). IR and ^{1}H-NMR: identical to those of **6a**.

(2S,2'S)-N-[2'-Amino-2'-(4''-methoxyphenyl)acetyl]bornane-2,10-sultam Hydrochloride (**12b**·HCl). Using the *General Procedure*, **11b** (512 mg, 1.3 mmol) was converted to the recrystallized **12b**·HCl (479 mg, 90%). M.p. 188–192° (dec.). $[\alpha]_D = +159.4°$ ($c = 0.725$, MeOH). IR and ^{1}H-NMR: identical to those of **6g**.

Saponification of (2-Aminoacyl)sultams and Determination of the Enantiomeric Purity of Resulting α-Amino Acids. – *General Procedure*. A soln. of (2-aminoacyl)sultam **6** or **12** in 1N aq. LiOH/THF (1:4; 10 ml/mmol of free (2-aminoacyl)sultam, 20 ml/mmol of (2-aminoacyl)sultam·HCl) was stirred at r.t. for 0.25–3 h. Evaporation of the THF, partition of the residue between CH_2Cl_2/H_2O, drying ($MgSO_4$), and evaporation of the org. phase furnished the corresponding bornane-10,2-sultam. Acidification of the aq. phase to pH 4–5, addition of *Amberlite IR-120* ion exchange resin (5 g/mmol), stirring of the mixture at r.t. for 15 h, filtration, washing of the resin with dist. H_2O (until the eluate remains clear upon addition of $AgNO_3$), stirring of the resin with 6N aq. NH_3 soln. at r.t. for 4 h, filtration, evaporation of the filtrate, trituration of the residue with THF/toluene, evaporation, and drying of the residue *in vacuo* afforded the amino acid **7** or **13**. To determine its enantiomeric excess, the amino acid (4 mg) was treated successively with a soln. of HCl in PrOH (prepared from AcCl (0.3 ml) and PrOH (1 ml)) and $(CF_3CO)_2O$ (0.2 ml) in CH_2Cl_2 (1 ml). The resulting *N*-(trifluoroacetyl)propyl ester was compared by chiral GC with a racemic sample.

(R)-Alanine (**7a**). Saponification of **6a** (165 mg, 0.51 mmol), using the *General Procedure*, furnished the sultam auxiliary **2** (99 mg, 91%) and **7a** (46 mg, 100%). ^{1}H-NMR (D_2O): 1.22 (*d*, $J = 7$, 3 H); 3.50 (*q*, $J = 7$, 1 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **7a** (100°): 4.62 (100); racemic sample: 4.67 (50.2), 5.00 (49.8). A sample of crude **5a** (20 mg) was converted to the *N*-(trifluoroacetyl)propyl ester of **7a** (15 mg) without purification of intermediates. Chiral GC: 4.74 (100); racemic sample: 4.79 (50.2), 5.12 (49.8).

(R)-Allylglycine (**7b**). Saponification of **6b** (174 mg, 0.5 mmol), using the *General Procedure*, furnished **2** (102 mg, 96%) and **7b** (59 mg, ~ 100%). ^{1}H-NMR (D_2O): 2.40 (2 H); 3.52 (*m*, 1 H); 5.08 (*m*, 2 H); 5.59 (*m*, 1 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **7b**: 5.94 (100); racemic sample: 5.96 (50), 6.34 (50). A sample of crude **5b** (20 mg) was converted to the *N*-(trifluoroacetyl)propyl ester of **7b** (5 mg) without purification of intermediates. Chiral GC: 6.10 (100); racemic sample: 6.17 (50), 6.56 (50).

(R)-Valine (**7c**). Saponification of **6c** (105.7 mg, 0.301 mmol), using the *General Procedure*, furnished **2** (64.4 mg, 99%) and **7c** (35.7 mg, ~ 100%). ^{1}H-NMR (D_2O): 0.76 (*d*, $J = 7$, 3 H); 0.82 (*d*, $J = 7$, 3 H); 1.97 (*m*, 1 H); 3.22 (*d*, $J = 4.5$, 1 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **7c**: 5.17 (100); racemic sample: 5.19 (49.4), 5.49 (50.6).

(R)-Leucine (**7d**). Saponification of **6d** (163 mg, 0.497 mmol), using the *General Procedure*, furnished **2** (108 mg, 100%) and **7d** (66 mg, ~ 100%). ^{1}H-NMR (D_2O): 0.73 (*d*, $J = 6.5$, 3 H); 0.76 (*d*, $J = 6.5$, 3 H); 1.33–1.58 (3 H); 3.40 (*m*, 1 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **7d** (100°): 7.59 (99.5), 8.19 (0.5); racemic sample: 7.70 (49.8), 8.34 (49.8).

(R)-Phenylalanine (**7e**). Saponification of **6e** (183 mg, 0.506 mmol), using the *General Procedure*, furnished **2** (101 mg, 96%) and **7e** (78.8 mg, 94%). ^{1}H-NMR (D_2O): 2.87 (*dd*, $J = 14, 8, 1$ H); 3.03 (*dd*, $J = 14, 5, 1$ H); 3.70 (*dd*, $J = 8, 5, 1$ H); 7.1–7.25 (5 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **7e**: 19.60 (100); racemic sample: 19.55 (48.3), 20.66 (48.0).

(R)-Phenylglycine (**7f**). Saponification of **6f** (33 mg, 0.0858 mmol), using the *General Procedure*, furnished **2** (15.4 mg, 85%) and **7f** (12 mg, 93%). ^{1}H-NMR (200 MHz, D_2O): 4.60 (*m*, 1 H); 7.15–7.35 (br. *s*, 5 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **7f**: 14.62 (100); racemic sample: 14.65 (49.9), 15.17 (50.1).

(R)-(4-Methoxyphenyl)glycine (**7g**). Saponification of **6g** (95 mg, 0.229 mmol), using the *General Procedure*, furnished **2** (48 mg, 98%) and **7g** (40.2 mg, ~ 100%). ^{1}H-NMR (200 MHz, D_2O): 3.64 (*s*, 3 H); 4.55 (*m*, 1 H); 6.84 (*d*, *J* = 9, 2 H); 7.18 (*d*, *J* = 9, 2 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **7g**: 26.47 (100); racemic sample: 26.81 (59.9), 27.75 (38.7).

(S)-Alanine (**13a**). Saponification of **12a** (101.4 mg, 0.314 mmol), using the *General Procedure*, furnished *ent*-**2** (63 mg, 93%) and **13a** (26.5 mg, 93%). ^{1}H-NMR (200 MHz, D_2O): 1.22 (*d*, *J* = 7, 3 H); 3.50 (br. *q*, *J* = 7, 1 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **13a** (100°): 3.37 (100); racemic sample: 3.06 (50.0), 3.49 (50.0).

(S)-(4-Methoxyphenyl)glycine (**13b**). Saponification of **12b** (103.7 mg, 0.25 mmol), using the *General Procedure*, furnished *ent*-**2** (49 mg, 92%) and **13b** (45 mg, ~ 100%). ^{1}H-NMR (200 MHz, D_2O): 3.64 (*s*, 3 H); 4.55 (*m*, 1 H); 6.84 (*d*, *J* = 9, 2 H); 7.18 (*d*, *J* = 9, 2 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester of **13b**: 27.31 (100); racemic sample: 26.37 (50.2), 27.30 (49.8).

Preparation of *N*-Hydroxy- and *N*-[(*tert*-Butoxy)carbonyl]amino Acids. – *(2R)-(N-Hydroxy)allylglycine* (**8b**). A 1M aq. soln. of LiOH (0.5 ml) was added at 0° to a stirred soln. of **5b** (82 mg, 0.25 mmol) in THF (1 ml), and the mixture was stirred for 15 min. Addition of 1N aq. HCl, evaporation, partition of the residue between CH_2Cl_2/H_2O, drying, and evaporation of the org. phase gave **2** (49 mg, 92%). The aq. phase was transferred onto a column (0.8 × 7 cm) of *Dowex 50W* × *8* (H^+ form, 200–400 mesh). The column was washed with distilled H_2O, until no precipitate was observed on addition of a $AgNO_3$ soln., then eluted with 3N aq. NH_3. The fractions, which were sensitive to ninhydrin, $KMnO_4$, and *Ehrlich*'s reagent, were collected and evaporated below 40°. The residue was evaporated with THF/toluene several times to afford **8b** as a colorless solid (33 mg, 100%). ^{1}H-NMR of **8b**·HCl (D_2O): 2.55 (*t*, *J* = 6, 2 H); 4.03 (*t*, *J* = 6, 1 H); 5.07–5.18 (2 H); 5.60 (*m*, 1 H).

(2R)-(N-Hydroxy)phenylalanine (**8e**). Following the protocol described above for the preparation of **8b**, **5e** (47.1 mg, 0.124 mmol) was saponified to afford **2** (24 mg, 90%) and **8e** (16.8 mg, 75%) M.p. 154–155° (dec.) (lit. m.p. 161–163° (dec.)). ^{1}H-NMR (400 MHz, D_2O): 2.86 (*d*, *J* = 7, 2 H); 3.67 (*t*, *J* = 7, 1 H); 7.1–7.25 (5 H).

(2R)-(N-Hydroxy)phenylglycine (**8f**). Following the protocol described above for the preparation of **8b**, **5f** (70 mg, 0.192 mmol) was saponified to give **2** (38 mg, 92%) and **8f** (25.4 mg, 79%) which was characterized as its propyl ester. Treatment of **8f** (5.5 mg, 0.033 mmol) with a soln. of HCl in PrOH (prepared from AcCl (0.3 ml) and PrOH (1 ml)) and FC hexane/AcOEt 2:1 afforded the propyl ester of **8f** (3.5 mg, 51%). ^{1}H-NMR: 0.88 (*t*, *J* = 7, 3 H); 1.66 (*sext.*, *J* = 7, 2 H); 4.18 (*m*, 2 H); 4.81 (*s*, 1 H); 5.38 (br., 1 H); 5.75 (br., 1 H); 7.35–7.42 (5 H). To determine its enantiomeric purity, **8f** was converted to *N*-trifluoroacetylphenylglycine propyl ester. Zn powder (140 mg) was added at 0° to a stirred soln. of **8f** (6.5 mg, 0.39 mmol) in 1N HCl (0.65 ml). Stirring of the mixture for 3 h, addition of AcOH (0.1 ml), stirring for another 20 h, filtration through glass wool, and evaporation of the filtrate gave a residue. Stirring of the residue with *Amberlite IR-120* (500 mg, H^+ form) in dist. H_2O (2 ml) for 16 h, filtration, washing of the resin with dist. H_2O, until the eluate gave no precipitation on addition of an aq. $AgNO_3$ soln., stirring of the resin with 6N aq. NH_3 (10 ml) for 4 h, filtration, and evaporation of the filtrate gave **7f** (4.1 mg, 69%) as a white solid. Chiral GC of its *N*-(trifluoroacetyl)propyl ester: 11.79 (95.66), 12.16 (4.34); racemic sample 11.77 (50.0), 12.17 (50.0).

(R)-N-[(tert-Butoxy)carbonyl]leucine (**9**). A soln. of di(*tert*-butyl) dicarbonate (180 mg, 0.82 mmol) in MeCN (1 ml) was added at 0° to a stirred soln. of **6d** (124 mg, 0.378 mmol) in MeCN (0.5 ml). Stirring of the mixture at r.t. for 2 h, evaporation, chromatography of the residue (Et_2O/hexane 1:2), and crystallization (hexane) gave *(2R,2'R)-N-{2'-[(tert-butoxy)carbonyl]amino}-4'-methylbutanoyl}bornane-10,2-sultam* (151 mg, 94%). $[\alpha]_D = -27.6$ (*c* = 0.54, CH_2Cl_2). IR: 3470, 2920, 1712, 1692, 1500, 1340, 1170, 1140. ^{1}H-NMR: 0.95 (*d*, *J* = 7, 3 H); 0.98 (*d*, *J* = 7, 3 H); 0.99 (*s*, 3 H); 1.21 (*s*, 3 H); 1.43 (*s*, 9 H); 1.3–2.0 (8 H); 2.08 (*dd*, *J* = 13.5, 7.5, 1 H); 2.1–2.22 (1 H); 3.42 (*d*, *J* = 13, 1 H); 3.52 (*d*, *J* = 13, 1 H); 3.90 (*dd*, *J* = 8, 6, 1 H); 4.72 (br., 1 H); 4.92 (br., 1 H). A 1M soln. of aq. H_2O_2 (0.68 ml) and a 1M soln. of aq. LiOH (0.34 ml) were added at 0° to a stirred soln. of *(2R,2'R)-N-{2'-[(tert-butoxy)carbonyl]amino}-4'-methylbutanoyl}bornane-10,2-sultam* (72.3 mg, 0.169 mmol) in THF (2 ml), and the mixture was stirred for 1 h. Addition of a 1.5M soln. of Na_2SO_3 (0.6 ml), evaporation of the mixture, partition of the residue between H_2O/CH_2Cl_2, drying, and evaporation of the org. phase gave **2** (35 mg, 96%). Acidification of the aq. phase to pH 4 with a 10% aq. citric-acid soln., extraction with CH_2Cl_2, drying of the extracts, and evaporation afforded **9** (35.1 mg, 90%). $[\alpha]_D = +19.7$ (*c* = 1.545, CH_2Cl_2). Authentic **9**: $[\alpha]_D = +20.2$ (*c* = 1.145, CH_2Cl_2). IR and ^{1}H-NMR: identical to those of an authentic sample.

Trapping of a Nitrone Intermediate by 1,3-Dipolar Cycloaddition. – A 1M soln. of $NaN(TMS)_2$ in THF (0.33 ml) was added to a stirred soln. of **3a** (82 mg, 0.302 mmol) in THF (1 ml) at −78°. Stirring of the mixture for 1 h, addition at −78° for 15 min, addition of an aq. buffer soln. (pH 7), extraction with $CHCl_3$, drying, and evaporation of the extracts afforded a 1:1 mixture of nitrone **4a** and **5a** (136 mg). This mixture shows the following spectra: IR:

3700, 3200, 1710, 1585, 1330, 1265, 1235, 1165, 1135. ^{1}H-NMR (200 MHz): 0.91 (*s*, 3 H); 0.95 (*s*, 3 H); 1.14 (*s*, 3 H); 1.17 (*s*, 3 H); 1.21 (*d*, *J* = 6.5, 3 H); 1.56 (*d*, *J* = 6.5, 3 H); 1.1–2.8 (24 H); 3.35–3.6 (4 H); 3.8–4.0 (2 H); 4.24 (*q*, *J* = 6.5, 1 H); 5.42 (*q*, *J* = 6.5, 1 H); 5.65 (br., 1 H). PhNCO (12 µl) was added at r.t. to a soln. of the mixture **4a**/**5a** (38 mg) in toluene (1 ml). Stirring of the mixture for 1 h, evaporation, and chromatography of the residue (CH_2Cl_2/Et_2O 20:1 and hexane/AcOEt 3:2) afforded N-*[2′-(3″-oxo-4″-phenyl-2″-oxa-1″,4″-diazaspiro[4.5]dec-1-yl)propanoyl]bornane-10,2-sultam* (**14**; amorphous solid, 18.9 mg, 45% from **3a**). $[\alpha]_D = -70.5$ (*c* = 0.19). IR: 2900, 1780, 1335, 1130. ^{1}H-NMR (200 MHz): 0.97 (*s*, 3 H); 1.18 (*s*, 3 H); 1.64 (*d*, *J* = 7, 3 H); 1.1–2.3 (17 H); 3.45 (*d*, *J* = 13, 1 H); 3.53 (*d*, *J* = 13, 1 H); 3.95 (*t*, *J* = 6, 1 H); 4.55 (*q*, *J* = 7, 1 H); 7.1–7.6 (5 H). MS: 382 (68 $[C_{26}H_{35}N_3O_5S-PhNCO]^{+\cdot}$), 364 (32), 301 (31), 259 (19), 247 (32), 167 (15), 140 (91), 124 (100), 91 (39). HR-MS: 382.1894 ($[C_{26}H_{35}N_3O_5S-PhNCO]^{+\cdot}$, calc. 382.1862).

Preparation of (2*S*,3*S*)-α-Amino Acids from *N*-Enoylsultams by Asymmetric 1,4-Addition/Electrophilic Amination. – *(2S,2′S,3′S)*-N-*[2′-(Hydroxyamino)-3′-methylpentanoyl]bornane-10,2-sultam* (**16**). A 2.3M soln. of EtMgBr in Et_2O (2.4 ml, 5.52 mmol) was added dropwise at −78° to a stirred soln. of N-*crotonoylbornane-10,2-sultam* (**15**; 1.25 g, 4.41 mmol) in THF (60 ml), and the mixture was stirred at −78° for 14 h. Addition of a 1M soln. of **1** in THF (5.5 ml), stirring of the mixture at −78° for 1 h, addition of 1N aq. HCl (20 ml) at −78°, stirring at r.t. for 30 min, evaporation, partition of the residue between hexane/1N aq. HCl, washing of the org. phase with 1N aq. HCl, basification of the combined aq. phases with solid $NaHCO_3$ to pH 9, extraction with CH_2Cl_2, drying, and evaporation of the extracts gave crude **16** (1.148 g); 1.117 g of this material gave after FC (hexane/AcOEt 2:1, then CH_2Cl_2/Et_2O 10:1) and crystallization (hexane/AcOEt) purified **16** (808 mg, 55%). M.p. 160–173° (dec.). $[\alpha]_D = +85.7$ (*c* = 0.825). IR: 3670, 3600, 2920, 1680, 1332, 1270, 1135. ^{1}H-NMR: 0.85 (*t*, *J* = 7, 3 H); 0.95 (*s*, 3 H); 0.95 (*d*, *J* = 7, 3 H); 1.17 (*s*, 3 H); 1.1–2.0 (8 H); 2.04 (*dd*, *J* = 13.5, 8, 1 H); 2.2–2.36 (1 H); 3.42 (*d*, *J* = 13, 1 H); 3.52 (*d*, *J* = 13, 1 H); 3.93 (*dd*, *J* = 8, 5, 1 H); 4.02 (*d*, *J* = 8, 1 H); 5.49 (br. *s*, 1 H); 5.73 (br., 1 H). ^{13}C-NMR: 10.98 (*q*); 16.13 (*q*); 19.91 (*q*); 20.60 (*q*); 24.58 (*t*); 26.38 (*t*); 32.76 (*t*); 34.16 (*d*); 38.28 (*t*); 44.54 (*d*); 47.77 (*s*); 48.55 (*s*); 53.08 (*t*); 65.37 (*d*); 69.08 (*d*); 178.32 (*s*). MS: 345 (0.5, $[C_{16}H_{28}N_2O_4S + H]^{+\cdot}$), 216 (3), 180 (7), 135 (5), 109 (4), 102 (100), 93 (6), 79 (6), 69 (13), 55 (11), 46 (40).

(S,S)-Isoleucine (**17**). *N,O*-Hydrogenolysis of **16** (396 mg, 1.150 mmol), using the *General Procedure*, furnished *(2S,2′S,3′S)*-N-*(2′-amino-3′-methylpentanoyl)bornane-10,2-sultam hydrochloride* (colorless solid, 416 mg, 99%). This compound (129 mg, 0.356 mmol) was saponified without further purification by using the *General Procedure* to give the *ent*-**2** (65 mg, 85%) and **17** (42 mg, 91% from **16**). ^{1}H-NMR (400 MHz, D_2O): 0.72 (*t*, *J* = 7, 3 H); 0.77 (*d*, *J* = 7, 3 H); 1.02 (*m*, 1 H); 1.24 (*m*, 1 H); 1.64 (*m*, 1 H); 3.19 (*d*, *J* = 4.5, 1 H). Chiral GC of *N*-(trifluoroacetyl)propyl ester (85°):14.68 (5.1), 16.28 (94.9); authentic samples: (2*R*,3*S*)-isomer: 12.71; (2*R*,3*R*)-isomer: 14.19; (2*S*,3*R*)-isomer: 14.82; (2*S*,3*S*)-isomer: 16.18.

(2S)-N-*(3′-Phenylbutanoyl)bornane-10,2-sultam* (**18**). A 1.31M soln. of PhLi in Et_2O (6.74 ml, 8.82 mmol) was added over 35 min (syringe pump) to a stirred soln. of $Bu_3P \cdot CuI$ (3.47 g, 8.82 mmol) in Et_2O (35 ml) at −78°. The mixture was stirred at −78° for 1.5 h. Triflic acid (775 µl, 8.82 mmol) was added dropwise to a 1M soln. of BEt_3 in hexane (8.82 ml) at r.t., and the mixture was warmed for 5 min in a 40° bath. The resulting soln. of Et_2BOTf was diluted with Et_2O (8 ml) and a soln. of **15** (500 mg, 1.76 mmol) was added at −78°. Stirring of the mixture at −78° for 10 min, addition of the above described cold (−78°) suspension of $PhCu \cdot Bu_3P$ *via* a cannula within 1–2 min at −78°, further stirring at −78° for 2 h, addition of a sat. aq. soln. of NH_4Cl, washing of the mixture with aq. NH_3, extraction of the aq. phase with CH_2Cl_2 drying, and evaporation of the combined org. phases and FC (hexane/Et_2O 2:1) of the residue afforded a 91:9 mixture of **18** and its C(β)-epimer (550 mg, 86%). GC (*HP-1* column, 12 m × 0.2 mm, 10 psi H_2, 150° 5 min, 10°/min to 270°): 15.37 (91.3), 15.65 (8.7%). ^{1}H-NMR of **18** (400 MHz): 0.87 (*s*, 3 H); 0.92 (*s*, 3 H); 1.32 (*d*, *J* = 7, 3 H); 1.2–2.1 (7 H); 2.81 (*dd*, *J* = 15, 7, 1 H); 3.17 (*dd*, *J* = 15, 8, 1 H); 3.39 (*d*, *J* = 13, 1 H); 3.45 (*d*, *J* = 13, 1 H); 3.35–3.51 (1 H); 3.81 (*m*, 1 H); 7.1–7.4 (5 H). The stereoisomer ratio could not be improved by crystallization from hexane/Et_2O 4:1. Accordingly the 91:9 mixture was subjected to the following amination procedure without further purification.

(2S,2′S,3′S)-N-*[2′-(Cyclohexylideneamino)-3′-phenylbutanoyl]bornane-10,2-sultam* N-*Oxide* (**19**). A 1M soln. of $NaN(TMS)_2$ in THF (0.76 ml) was added dropwise at −78° to a stirred soln. of **18** (250 mg, 0.69 mmol; containing 9% of its C(β)-epimer). After 1 h at −78°, **1** (88 µl, 0.69 mmol) was added. Stirring of the mixture at −78° for 30 min, addition of phosphate buffer (pH 7), partition of the mixture between CH_2Cl_2/H_2O, extraction of the aq. phase with CH_2Cl_2, drying, and evaporation of the org. phases and FC (AcOEt) gave a solid residue (313 mg) which was crystallized (hexane/Et_2O 2:1) to furnish pure **19** (235 mg, 72%). M.p. 183–185°. $[\alpha]_D = -24.7$ (*c* = 0.45, MeCN). IR (KBr): 2939, 1712, 1336, 1273, 1204, 1134, 1059, 704. ^{1}H-NMR (400 MHz): 0.62 (*m*, 1 H); 0.93 (*s*, 3 H);1.08 (*s*, 3 H); 1.1–1.2 (2 H); 1.23–1.44 (6 H); 1.45 (*d*, *J* = 7, 3 H); 1.8–1.96 (3 H); 2.01 (*dd*, *J* = 7.5, 14, 1 H); 2.16 (*ddd*, *J* = 4, 7.5, 12.5, 1 H); 2.22–2.4 (2 H); 2.49 (*ddd*, *J* = 6, 14, 16, 1 H); 3.43 (*s*, 2 H); 3.97–4.08 (2 H);

5.20 (*d*, *J* = 10.5, 1 H); 7.2–7.4 (5 H). ^{13}C-NMR (100 MHz): 164.56 (*s*); 152.72 (*s*); 140.89 (*s*); 128.49 (*d*, 2 C); 128.22 (*d*, 2 C); 127.30 (*d*); 73.83 (*d*); 65.56 (*d*); 53.35 (*t*); 48.77 (*s*); 47.91 (*s*); 44.65 (*d*); 37.77 (*d*); 37.04 (*t*); 32.60 (*t*); 30.05 (*t*); 26.67 (*t*); 26.31 (*t*); 24.15 (*t*); 24.09 (*t*); 23.95 (*t*); 20.21 (*q*); 19.95 (*q*); 16.45 (*q*).

*(2S,2'S,3'S)-*N*-[2'-(Hydroxyamino)-3'-phenylbutanoyl]bornane-10,2-sultam* (**20**). A 1N aq. HCl soln. (3 ml) was added to a soln. of **19** (200 mg, 0.42 mmol) in THF (5 ml). Stirring of the mixture at r.t. for 1 h, partition between aq. sat. $NaHCO_3$ soln./CH_2Cl_2, drying, and evaporation of the org. phase and crystallization (EtOH) afforded **20** (132 mg, 79%). M.p. 193–203° (dec.). $[\alpha]_D$ = +93.3 (*c* = 0.3, CH_2Cl_2). IR: 3660, 2960, 1690, 1335, 1270, 1135. ^{1}H-NMR (400 Mz): 0.98 (*s*, 3 H); 1.18 (*s*, 3 H); 1.31 (*d*, *J* = 7, 3 H); 1.3–1.5 (2 H); 1.8–2.0 (3 H); 2.14 (*dd*, *J* = 14, 8, 1 H); 2.25 (*m*, 1 H); 3,19 (*dq*, *J* = 9, 7, 1 H); 3.50 (*d*, *J* = 14, 1 H); 3.57 (*d*, *J* = 14, 1 H); 4.01 (*dd*, *J* = 7, 5, 1 H); 4.36 (*d*, *J* = 9, 1 H); 4.58 (br. *s*, 1 H); 5.51 (br., 1 H); 7.2–7.44 (5 H). ^{13}C-NMR (100 MHz): 172.73 (*s*); 142.79 (*s*); 128.57 (*d*, 2 C); 127.71 (*d*, 2 C); 126.92 (*d*); 69.81 (*d*); 65.62 (*d*); 53.30 (*t*); 48.66 (*s*); 47.85 (*s*); 44.63 (*d*); 39.46 (*d*); 38.37 (*t*); 32.87 (*t*); 26.43 (*t*); 20.65 (*q*); 19.94 (*q*); 19.56 (*q*). MS: 374 (8, $[C_{20}H_{28}N_2O_4S-H_2O]^{+\cdot}$), 361 (25), 287 (82), 271 (31), 216 (33), 180 (15), 150 (100), 134 (85), 105 (84). HR-MS: 374.1682 ($[C_{20}H_{28}N_2O_4S-H_2O]^{+\cdot}$, calc. 374.1701).

*(3S,2'S,3'S)-*N*-(2'-Amino-3'-phenylbutanoyl)bornane-2,10-sultam* (**21**). *N,O*-Hydrogenolysis of **20** (110 mg, 0.28 mmol), using the *General Procedure* (20 h, 25°), furnished crude **21** (99 mg). HPLC (*Merck Hibar, LiChrosorb Si 60*, 250 × 4 mm, hexane/i-PrOH/Et_2NH 97.2; 2.5; 0.3; 2 ml/min): t_R 3.6 min (97.9%). Crystallization (hexane/Et_2O 3:1) furnished pure **21** (83 mg, 79% from **20**). M.p. 164–166°. $[\alpha]_D$ = +106.0 (*c* = 0.5, MeCN). ^{1}H-NMR (400 MHz): 0.98 (*s*, 3 H); 1.17 (*s*, 3 H); 1.27 (*d*, *J* = 7, 3 H); 1.3–1.6 (4 H); 1.8–2.0 (3 H); 2.10 (*dd*, *J* = 14, 8, 1 H); 2.15–2.3 (1H); 3.16 (*dq*, *J* = 9, 7, 1 H); 3.50 (*d*, *J* = 14, 1 H); 3.56 (*d*, *J* = 14, 1 H); 3.97 (*dd*, *J* = 8, 5, 1 H); 4.08 (*d*, *J* = 9, 1 H); 7.2–7.37 (5 H). ^{13}C-NMR (100 MHz): 173.48 (*s*); 143.09 (*s*); 128.59 (*d*, 2 C); 128.13 (*d*, 2 C); 126.81 (*d*); 65.15 (*d*); 59.80 (*d*); 53.15 (*t*); 48.67 (*s*); 47.80 (*s*); 44.61 (*d*); 43.10 (*d*); 38.18 (*t*); 32.84 (*t*); 26.41 (*t*); 20.91 (*q*); 19.85 (*q*); 19.49 (*q*).

*(2S,3S)-*N*-Acetamido-3-phenylbutyric Acid* (= *(2S,3S)-*N*-Acetyl-β-methylphenylalanine*; **23**). A soln. of **21** (140 mg, 0.372 mmol) in pyridine/Ac_2O 2:1 (15 ml) was stirred at r.t. for 6 h. Addition of a sat. aq. soln. of $NaHCO_3$ (10 ml), stirring until the gas evolution has ceased, evaporation, partition of the residue between sat. aq. $NaHCO_3$/CH_2Cl_2, washing of the org. phase with 1N aq. HCl and H_2O, drying ($MgSO_4$), evaporation, and FC yielded *N*-acetyl derivative **22** as an amorphous solid (154 mg, 99%). ^{1}H-NMR (400 MHz); 0.97 (*s*, 3 H); 1.17 (*s*, 3 H); 1.31–1.53 (2 H); 1.37 (*d*, *J* = 7, 3 H); 1.47 (*m*, 1 H); 1.80 (*s*, 3 H); 1.83–2.0 (3 H); 2.07–2.24 (2 H); 3.46 (*d*, *J* = 13, 1 H); 3.52 (*d*, *J* = 13, 1 H); 3.58 (*quint.*, *J* = 5, 1 H); 4.0 (*dd*, *J* = 3.5, 5.5, 1 H); 4.92 (*t*, *J* = 5.5, 1 H); 5.64 (br. *d*, *J* = 5.5, 1 H); 7.2–7.4 (5 H). A 1M soln. of aq. H_2O_2 (770 µl) and a 1M soln. of aq. LiOH (385 µl) were added at 0° to a stirred soln. of **22** (80 mg, 0.191 mmol) in THF (4 ml), and the mixture was stirred at 0° for 1.5 h. Addition of a 1.5M soln. of Na_2SO_3 (0.8 ml), evaporation of the mixture, addition of a 10% aq. soln. of citric acid (pH 6), extraction with CH_2Cl_2, drying, and evaporation of the extracts furnished *ent*-**2** (35.6 mg, 87%). Acidification of the aq. phase to pH 3 with 10% aq. citric-acid soln., extraction with CH_2Cl_2, drying, and evaporation of the extracts gave crude **23** (35.3 mg, 83% from **22**, showing no stereoisomer signals in the ^{1}H-NMR) which was crystallized from aq. EtOH. M.p. 189–191° ([19b]: 188–190°; [19c]: 190–192°). $[\alpha]_D$ = +35.0 (*c* = 0.2, 96% EtOH; [19b]: +36.5° (96% EtOH); [19c]: +37.4° (*c* = 1, 96% EtOH)). IR (KBr): 3330, 3065, 3030, 2985, 2920, 2775, 2580, 1475, 1705, 1615, 1550, 1265, 1230, 1135, 990, 760, 700. ^{1}H-NMR (400 MHz, (D_6)DMSO): 1,18 (*d*, *J* = 7, 3 H); 1.69 (*s*, 3 H); 3.07 (br. *quint.*, *J* = 7.5, 1 H); 4.41 (br. *t*, *J* = 8.5, 1 H); 7.14–7.28 (5 H); 7.92 (br. *d*, *J* = 9.5, 1 H). ^{13}C-NMR (100 MHz, (D_6)DMSO): 172.87 (*s*); 168.92 (*s*); 142.83 (*s*); 128.00 (*d*, 2 C); 127.60 (*d*, 2 C); 126.32 (*d*); 57.50 (*d*); 49.90 (*d*); 22.20 (*q*); 18.50 (*q*). IR and ^{1}H-NMR match the data in [19].

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