Studies on the preparation of camphorylidene derivatives of α-amino acids

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An improved method has been developed for the efficient synthesis of stable camphor imine salts. Camphor imine readily undergoes transimination with α-amino acid ester hydrochlorides to yield camphorylidene amino acid derivatives with *E* stereochemistry about the C=N double bond. Sodium cyanoborohydride reduction of the derived ketimines gives *exo*-bornylamines.

Introduction

The preparation of imines derived from camphor and α-amino acids was required as part of a project directed to the synthesis of peptides in aqueous phase. In contrast to aldimines that are readily prepared, ketimines are difficult to synthesise,[1] particularly from camphor derivatives.[2] The method which has been employed with varying degrees of success is the addition/elimination of camphor and a primary amine. Reagents such as $TiCl_4$,[3] $BF_3{\cdot}Et_2O$,[4,5] molecular sieves,[6] anhydrous $ZnCl_2$,[7] and tetraethyl orthosilicate with acid catalysis,[8] have been employed. Generally forcing conditions have been used, such as high temperatures, non-stoichiometric quantities of reagents, and stringently anhydrous conditions, including azeotropic distillation.[3] Additionally the enhanced 'carbonyl' addition of thiocamphor[9] and the addition–elimination of thiocamphor *S*-oxide[10] have been employed.

Of these methods, 3 Å molecular sieves in methanol have been used to prepare stable ketimines derived from *ortho*-hydroxyaryl ketones and a range of α-amino acid tetramethylammonium salts,[11] and thiocamphor has been refluxed in toluene with *tert*-butyl glycinate in the presence of 1,4-diazabicyclo[2.2.2]octane (DABCO) to give the desired imine.[12]

Results and discussion

Exploratory studies showed that all of the above mentioned methods lacked generality for the synthesis of camphorylidene α-amino acid ester derivatives. For example, when camphor and glycine ethyl ester were refluxed in benzene with water entrainment, unchanged camphor was recovered together with some polyglycinate. Moreover, the methods using titanium tetrachloride, anhydrous zinc chloride, or boron trifluoride–diethyl ether failed to effect conversion of the camphor. In each case some of the ethyl glycinate was converted into glycine polymer. Clearly, the Lewis acid is activating the amino acid to polycondensation in preference to activating the carbonyl group of camphor.

Further studies in which thiocamphor and glycine ethyl ester were refluxed together in both the absence and presence of boron trifluoride–diethyl ether failed to elicit reaction. However, a successful reaction was achieved using the procedure of McIntosh and Mishra[12] in which thiocamphor was refluxed in xylene containing a large excess of DABCO with glycine ethyl ester hydrochloride. However, this example appeared to be unique and utilisation of the procedure with, for example, diethyl (*S*)-glutamate hydrochloride, failed to reveal any evidence of reaction after a 48 h reflux. We therefore conclude that camphor shows such severe steric hindrance as to preclude conventional imine-forming reactions with α-amino acid esters, particularly those with side-chain substitution. Accordingly, a method needs to be found which is mechanistically distinct from the conventional methods and allows for the protic equilibrium to be altered so that use can be made of the steric expulsion of the leaving group. This is the subject of the present investigation.

Formation of camphor imine

O'Donnell and Polt[13] have reported that benzophenone imine readily undergoes transimination under very mild conditions, with a range of α-amino acid ester hydrochlorides, to yield a variety of benzophenone ketimines of α-amino esters. The present paper reports on the application of this method to the camphor system.

(*R*,*R*)-Camphor imine[14] was first prepared in 1896 as a stable nitrate salt **2a** by Mahla and Tiemann by nitrosation of (*R*,*R*)-camphor oxime **1**.[15]† Camphor oxime in diethyl ether was shaken in a separating funnel with aq. sodium nitrite to which a deficiency of sulfuric acid had been added. The separated ether phase turned deep red and fine, white, needle-like crystals of the product **2a** separated. A possible mechanism for this redox process, based on the observation that the presumptive reactive intermediate can be trapped as a nitramine by lithium aluminium hydride reduction,[16] and that nitrimine formation can be demonstrated in related systems,[17] is shown in Scheme 1.

In our hands the procedure gave a yield of only 15%, presumably due to the water present in the reaction mixture. The yield could be improved to 22–28% by extracting the generated nitrous acid into diethyl ether and briefly drying the ether phase by filtering it through cotton wool before adding it to an ethereal solution of the oxime (Scheme 2).

Later, in a related system, Guziec and Russo[17] showed that camphor imine could be prepared more efficiently in a two-step process, first by treatment of camphor oxime **1** with nitrosyl chloride to yield camphor nitrimine and secondly by ammonolysis of the nitrimine to yield the imine. However, the complexity of this procedure was a disadvantage and the single-step process, described below, was used on the grounds of simplicity.

† Free camphor imine is moderately unstable, undergoing hydrolysis to camphor, but the nitrate salt is surprisingly stable.

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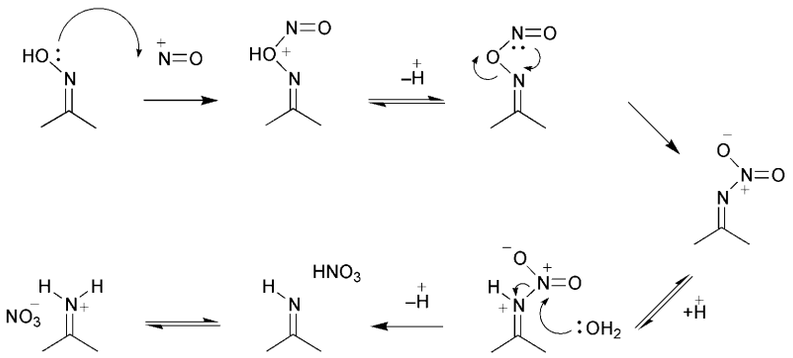
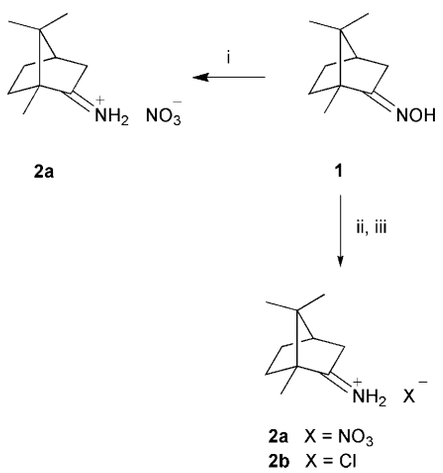


Scheme 1 Possible mechanism for the formation of camphor imine nitrate salt **2a** by nitrosation of the oxime.



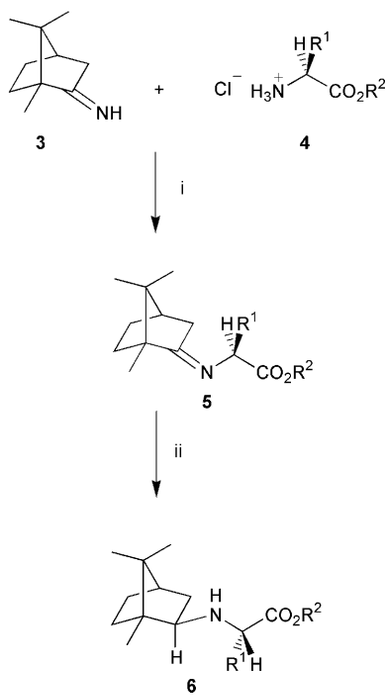
Scheme 2 Synthesis of camphor imine salt (**2a** and **2b**). *Reagents and conditions*: i, HNO_2 in Et_2O; ii, Bu^n_3P, PhSSPh in THF; iii, HNO_3 or HCl in Et_2O.

Barton, Motherwell, Simon and Zard[18] have shown that ketoximes (particularly steroidal ketoximes) can be smoothly reduced to imines using the mild reagent tri-*n*-butylphosphine–diphenyl disulfide under essentially neutral conditions. The free imines were not isolated but were trapped *in situ* as the diacetylenamine, the amine, or the amino nitrile. The reagent is self drying, thereby protecting the labile imine against premature hydrolysis. Accordingly, (*R*,*R*)-camphor oxime **1** and diphenyl disulfide in dry tetrahydrofuran (THF) were treated with tri-*n*-butylphosphine under an inert atmosphere at room temperature. After 2.5 h, anhydrous nitric acid in diethyl ether was added to afford long, white, needle-shaped crystals of the pure target (*R*,*R*)-camphor imine nitrate salt **2a** in excellent yield (Scheme 2). In later work the nitric acid in diethyl ether was replaced by dry hydrogen chloride in diethyl ether, since the latter reagent is less hazardous to prepare. Thus fine, white, needle-shaped crystals of (*R*,*R*)-camphor imine chloride salt **2b** was obtained in excellent yield.

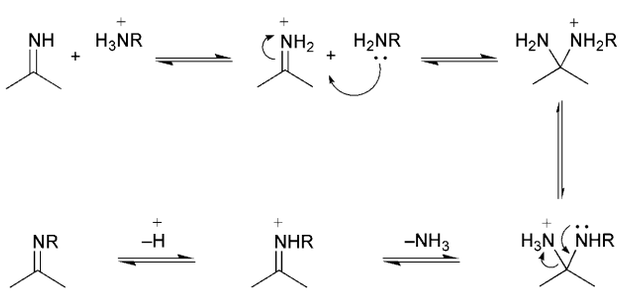
Regeneration of camphor imine **3** from the salt was easily accomplished, prior to reaction with the α-amino acid ester salt (see below), by rapidly extracting an aqueous solution just basified with ammonia with diethyl ether or dichloromethane (DCM) and rapidly drying the organic phase.

Transimination

The target (*S*)-α-amino acid ketimines **5** were readily prepared in very good yield by stirring a molar equivalent of the finely ground (*S*)-amino acid ester hydrochloride **4** with the dry organic solution of (*R*,*R*)-camphor imine **3** for 50–70 h‡ at room temperature under an inert atmosphere. A co-solvent such as methanol, ethanol or DCM can be used to improve the solubility of the amino acid ester hydrochloride. A wide range of α-amino acid derivatives **5** was prepared (Scheme 3): these are listed in Table 1. The mechanism of the reaction based on analogy is shown in Scheme 4.



Scheme 3 Synthesis of camphorylidene α-amino acid esters **5** and subsequent reduction to the corresponding secondary amines **6** [see Table 1 for the definition of R^1 and R^2]. *Reagents and conditions*: i, Et_2O plus co-solvent (MeOH, EtOH or DCM), 50–70 h, 23 °C; ii, $NaBH_3(CN)$ in MeOH, pH <4, 4 days, 23 °C.



Scheme 4 Presumptive mechanism for the transimination.

The target camphorylidene α-amino esters **5** can potentially exist as *E* or *Z* geometric isomers about the C=N bond. However, the ^1H and ^{13}C NMR spectra of the derivatives reveal that only one isomer is present. NOE difference studies with ethyl (*R*,*R*)-camphorylidene glycinate **5a** and methyl (*R*,*R*)-

‡ The long reaction time is purely a consequence of the poor solubility of the salt of the amino component.

Table 1 List of camphorylidene α-amino acid esters prepared

Compound	Camphor derivative	Amino ester hydrochloride	R^1	R^2	Yield (%)
5a	*R*,*R*	Glycine	H	Et	76
5b	*R*,*R*	*S*-Alanine	CH_3	Me	71
5c	*R*,*R*	*S*-Valine	$CH(CH_3)_2$	Me	62
5d	*R*,*R*	*S*-Leucine	$CH_2CH(CH_3)_2$	Me	45
5e	*R*,*R*	*S*-Isoleucine	$CH(CH_3)CH_2CH_3$	Me	65
5f	*R*,*R*	*S*-Serine	CH_2OH	Me	66
5g	*R*,*R*	*S*-Glutamic acid	$CH_2CH_2CO_2CH_2CH_3$	Et	76
5h	*R*,*R*	*S*-Methionine	$CH_2CH_2SCH_3$	Me	67
5i	*R*,*R*	*S*-Phenylalanine	$CH_2C_6H_5$	Me	68
5j	*R*,*R*	*S*-Phenylalanine	$CH_2C_6H_5$	Bzl	68
5k	*R*,*R*	*S*-Phenylalanine	$CH_2C_6H_5$	Bu′	70
5l	*R*,*R*	*R*-Phenylalanine	$CH_2C_6H_5$	Bu′	69
5m	*R*,*R*	*S*-Tyrosine	$CH_2C_6H_4OH$	Me	70
5o	(±)	Glycine	H	Et	63
5p	(±)	*S*-Leucine	$CH_2CH(CH_3)_2$	Me	18
5q	(±)	*S*-Glutamic acid	$CH_2CH_2CO_2CH_2CH_3$	Et	66
5r	(±)	*S*-Methionine	$CH_2CH_2SCH_3$	Me	46
5s	*R*,*R*	(±)-Phenylalanine	$CH_2C_6H_5$	Me	72

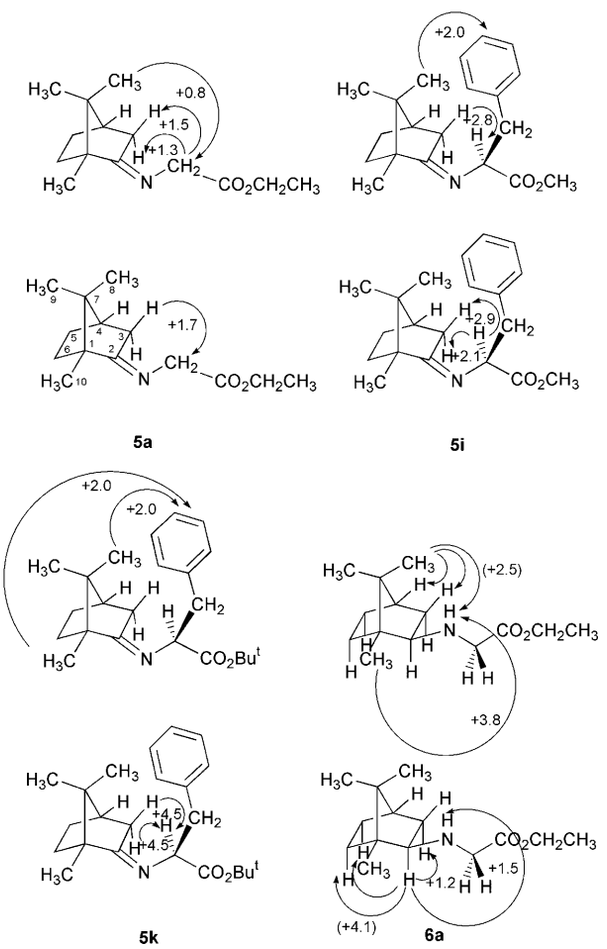


Fig. 1 Principal NOE difference data (% enhancement) for compounds **5a**, **5i**, **5k**, and **6a**.

camphorylidene-(*S*)-phenylalaninate **5i** show conclusively that the geometry is *E*. This is summarised in Fig. 1. These findings are consistent with the results of Bolton, Danks and Paul,[7] McIntosh and Mishra[12] and of Forni, Moretti and Torre.[19]

The mild conditions of the transimination reaction make it unlikely that the stereochemical integrity of the amino acid ester component is impaired. That this is the case was shown by the fact that the ^1H and ^{13}C NMR spectra of the camphor α-amino ester conjugates **5** show the absence of signals due to diastereomeric nuclei (methyl camphorylidene isoleucinate **5e** is particularly useful in this regard[20]), and by experiments in which the amino acid ester was recovered with unchanged specific optical rotation from hydrolysis reactions.[12,13]

Direct *in situ* capture of the camphor imine **3**, during its generation by oxime reduction, by an amino ester hydrochloride **4** in a 'one-pot' process could produce a further simplification to the procedure. Orientation experiments showed that no camphorylidene amino acid derivative **5a** was produced when glycine ethyl ester hydrochloride **4a** was added to the reaction mixture containing preformed (*R*,*R*)-camphor imine **3**.§ It appears that the amino ester is being captured by one or more components in the reaction mixture. Exploratory ^1H NMR experiments were conducted by treating glycine ethyl ester in $CDCl_3$ with various combinations of the reactants. It was established that there was a significant change in the spectrum of the ester only when both tributylphosphine and diphenyl disulfide were present.

Accordingly the 300 MHz ^1H NMR spectra of a mixture of glycine ethyl ester (1 equiv.), tributylphosphine (4 equiv.) and diphenyl disulfide (4 equiv.) was studied over a 14 h time course. The data showed that the intensity of the glycine α-CH_2 resonance at δ_H 3.20 decreased in parallel with the appearance and increase of a doublet at δ_H 3.65 (total combined integration remained at 2 throughout). Another new broad signal integrating for two protons was observed at δ_H 2.63 which progressively shifted with further broadening to δ_H 4.25. The protons responsible for this signal underwent D_2O-exchange and were identified as the SH protons of PhSH by comparison. In addition, the phenyl group proton signals broadened and progressively moved upfield by 0.25 ppm over the course of the experiment, and towards the end of the experiment the signals attributable to the ethyl ester doubled.

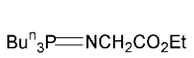
The spectroscopic data indicate that the amino group of the amino ester has undergone reaction with the equilibrating phosphorane to yield a compound which can be formulated as **7** or **8**. There is insufficient evidence to distinguish between these two possibilities. Therefore, in order to secure the synthesis of camphorylidene α-amino esters **5** it is necessary to isolate the preformed camphor imine prior to reaction with the α-amino ester.¶

§ Some polyglycinate was formed.

¶ Use of a scavenger to remove the phosphorane was not entertained owing to the complexity of the reaction mixture. However, in future work a solid-phase scavenger might well be explored.

Table 2 ^{1}H NMR shielding data for the aromatic camphorylidene adducts **5i–m**

Compound	Amino ester	3-*exo*	C-8 CH_3	3-*endo*	C-9 CH_3	C-10 CH_3
5a	Gly-OEt	2.25	0.72	1.74	0.86	0.93
5i	*S*-Phe-OMe	1.90	0.17	1.77	0.82	0.93
	Δ (ppm)	0.35	0.55	−0.03	0.04	0
5j	*S*-Phe-OBzl	1.92	0.19	1.76	0.82	0.95
	Δ (ppm)	0.33	0.53	−0.02	0.04	−0.02
5k	*S*-Phe-OBu^t	1.93	0.19	1.81	0.82	0.95
	Δ (ppm)	0.32	0.53	−0.07	0.04	−0.02
5l	*R*-Phe-OBu^t	2.19	0.71	1.07	0.83	0.95
	Δ (ppm)	0.06	0.01	0.67	0.03	−0.02
5m	*S*-Tyr-OMe	1.99	0.27	1.82	0.83	0.97
	Δ (ppm)	0.26	0.45	−0.08	0.03	−0.04



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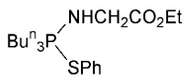

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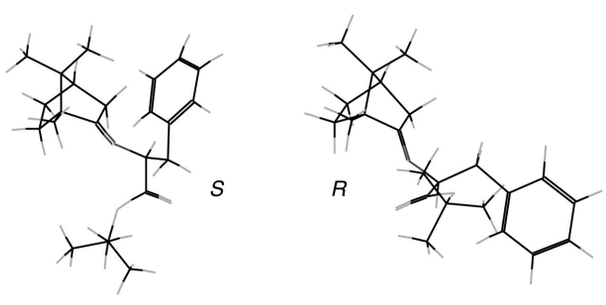
Camphor is differentially solvated by aromatic solvents. In the ^{1}H NMR spectrum this is manifest by the observation of a marked upfield shift of the methyl groups at positions 8 and 9.[21] It was therefore of interest to look for such an effect in the spectra of the camphorylidene derivatives of the aromatic α-amino esters **5i–5m**. Indeed, the (*R*,*R*)-camphor ketimines of the aromatic (*S*)-amino esters **5i–5k** and **5m** do show a marked shielding of the resonance due to the 8-methyl group and of the 3-*exo* hydrogen. The data are shown in Table 2 using ethyl camphorylideneglycinate **5a** for comparison.

The magnitude of the shielding effect on the C-8 methyl group (≈ 0.5 ppm) and on the 3-*exo* proton (≈ 0.3 ppm) indicates that in the (*S*)-amino ester series the side-chain aromatic ring is virtually locked in position, the predominant rotamer being that shown for **5k** in Fig. 2. This is confirmed by the observation of an NOE at the aromatic protons on irradiation of the C-8 methyl group (Fig. 1, compounds **5i** and **5k**) and by molecular mechanics using geometry optimisation, followed by molecular dynamics both using the MM2 program in CS Chem3D. It is noteworthy that the (*R*)-phenylalanine ester **5l** does not show the shielding effect on the C-8 methyl group experienced in the *S*-series, instead the 3-*endo* proton is strongly shielded (≈ 0.7 ppm). Thus the principal rotamer in this case is likely to be that shown in Fig. 2, and this was confirmed by molecular modelling.

These observations provide a simple tool for assigning the configuration to aromatic amino acids produced by asymmetric alkylation of *tert*-butyl camphorylideneglycinate **5n**. For instance, the compound produced by benzylation of the above mentioned glycinate[12] is undoubtedly the *R*-configurated material (**5l**) on the basis of the spectroscopic correlations discussed above (Scheme 5). Indeed, the method discussed in this paper will enable the provision of chiral standards for

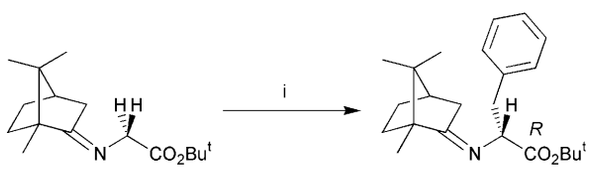


5k **5l**

Fig. 2 The results of MM2 molecular modelling on compounds **5k** and **5l** using geometry optimisation, followed by molecular dynamics.

Table 3 List of *N*-*exo*-bornan-2-yl α-amino acid esters **6** prepared

Compound	Starting camphorylidene amino ester hydrochloride	R^1	R^2	Yield (%)
6a	Glycine	H	Et	50
6b	*S*-Alanine	CH_3	Me	45
6e	*S*-Isoleucine	$CH(CH_3)CH_2CH_3$	Me	55
6i	*S*-Phenylalanine	$CH_2C_6H_5$	Me	48
6k	*S*-Phenylalanine	$CH_2C_6H_5$	Bu^t	45



5n **5l**

Scheme 5 Asymmetric alkylation of *tert*-butyl camphorylideneglycinate **5n**. *Reagents and conditions*: i, LDA in THF, 15 min, −78 °C; ii, HMPA, $C_6H_5CH_2Br$, several hours, −78 °C.

determining the absolute configuration of diastereomeric amino acid conjugates resulting from the asymmetrically induced alkylation,[12,22,23] allylation[12,22,23] or Michael reaction[23,24] of *tert*-butyl camphorylideneglycinate **5n** and similar substrates.

It is of interest to test whether the transimination reaction is capable of chiral descrimination. Accordingly, (*R*,*R*)-camphor imine was treated with various racemic amino acid esters and (±)-camphor imine was treated with various (*S*)-amino acid esters. The 'purified' mixture of diastereomeric products was subjected to ^{1}H NMR spectroscopy, which revealed (within the accuracy of integration) a composition of 50% for each diastereomer. Therefore no asymmetric induction was detected. This seems to be reasonable, since the transimination reaction involves equilibration (Scheme 4). It is clear that in future work the ammonia produced as co-product should be removed completely, so that the reaction becomes essentially irreversible; under these conditions such kinetic resolution might be achieved.

Further characterisation of the camphorylidene amino esters **5** was sought and this was accomplished by sodium cyanoborohydride reduction,[25] at an apparent pH of 4, to the corresponding secondary amines. A selection of α-amino acid derivatives **6** was prepared (Scheme 3): these are listed in Table 3. It is to be expected that axial hydride attack will occur largely from the *endo*-face to produce the *exo*-amine[2,26] and this has been confirmed by NOE studies on ethyl *N*-[(1*R*,4*R*)-bornan-2-yl]glycinate **6a** which are summarised in Fig. 1. However, the literature indicates that the stereochemistry of the reduction is complex:[7,27] the facial selectivity is dependent on the nature of the reductant and the configuration at the α-carbon atom of the amine.

Conclusions

An improved method has been developed for the efficient conversion of camphor oxime **1** into stable camphor imine salts **2**. (*R*,*R*)-Camphor imine **3** undergoes simple transimination with α-amino acid ester hydrochlorides **4** to yield camphorylidene amino acid derivatives **5** with *E* stereochemistry about the C=N double bond. Sodium cyanoborohydride reduction of the camphorylidene (*S*)-amino ester derivatives **5** gives *exo*-bornylamines **6**.

Experimental

General

Mps were determined with an Electrothermal capillary apparatus and are uncorrected. Optical rotations ($[a]_D$-values are given in units of 10^{-1} deg cm^{-2} g^{-1}) were measured on an Optical Activity AA-1000 polarimeter using a 1 dm path-length micro cell. Mass spectra were recorded on a Kratos Profile HV3 instrument (EI [or LSIMS, using *m*-nitrobenzyl alcohol as the matrix]) or a VG ZAB-E instrument. NMR spectra were recorded on an Brüker ACF 300 MHz machine, with tetramethylsilane as the reference: ^{1}H at 300 MHz, ^{13}C at 75 MHz with broad-band decoupling. *J*-Values are given in Hz. Homonuclear shift-correlated 2D spectra were used to identify three- and four-bond coupling using the standard Brüker microprogram COSY.AU. Heteronuclear shift-correlated 2D spectra were used to assign proton/carbon resonances using the standard Brüker microprogram XHCORR.AU.

TLC was carried out on Merck Kieselgel GF_{254} plates. Column chromatography was carried out using Merck silica gel 60H. All solvents were purified following standard literature methods. Light petroleum refers to the fraction boiling in the range 40–60 °C except where stated otherwise.

Preparation of anhydrous nitric acid in anhydrous diethyl ether

Colourless fuming nitric acid (95% w/v, specific gravity ≈ 1.5) was distilled over sulfuric acid *in vacuo* as described in the literature.[28] **CAUTION**: Anhydrous nitric acid was added very cautiously dropwise to stirred anhydrous diethyl ether at −4 °C. The addition was interrupted if the mixture began to decrepitate and further cooling was applied before continuing. In this way a 0.5–1.0 M solution was prepared.

Molecular modelling was performed using molecular mechanics using geometry optimisation, followed by molecular dynamics both using the MM2 program in Cambridge Soft Chem3D version 5.0. The parameters used in the molecular dynamics were: step interval 2.0 fs, frame interval 10.0 fs, heating/cooling rate 4.184 kJ atom^{-1} ps^{-1} and target temperature 300 K and trajectory 4.0 ps. The computation on **5k** terminated with a steric energy of 401.45 kJ mol^{-1} and that of **5l** with a steric energy of 392.16 kJ mol^{-1}.

Spectroscopic data for camphor

The spectroscopic correlations for (±)-camphor are listed below for use in the assignment of the camphor skeleton in the compounds reported. Asymmetric solvation of camphor by aromatic solvents gave rise to chemical-shift changes of diagnostic importance. These results and NOE-difference studies on camphor matched previously published results.[21,29]

(±)-Camphor. ν_{max}(KBr)/cm^{-1} 3476, 2962 and 2737, 1740 (C=O str), 1448, 1390, 1372; δ_H(300 MHz; $CDCl_3$) 0.67 (3H, s, C-8 Me), 0.73 (3H, s, C-10 Me), 0.80 (3H, s, C-9 Me), 1.12–1.28 (2H, m, 5-H_{endo} and 6-H_{endo}), 1.44–1.57 (1H, m, 6-H_{exo}), 1.66 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 18.1, 3-H_{endo}), 1.73–1.86 (1H, m, 5-H_{exo}), 1.92 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.8, 4-H), 2.17 (1H, overlapping ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 18.1, $^3J_{3\text{-}exo,4}$ 4.8, $^4J_{3\text{-}exo,5\text{-}exo}$ 4.0, 3-H_{exo}); δ_H(300 MHz; C_6D_6) 0.59 (3H, s, C-8 Me), 0.64 (3H, s, C-9 Me), 0.87 (3H, s, C-10 Me), 0.91–1.00 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.4, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.3, $^3J_{5\text{-}endo,6\text{-}exo}$ 4.2, 5-H_{endo}), 1.12–1.22 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 13.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.3, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.6, 6-H_{endo}), 1.28–1.39 (1H, overlapping dddd [appears as a complex dt], $^2J_{6\text{-}exo,6\text{-}endo}$ 13.5, $^3J_{6\text{-}exo,5\text{-}exo}$ 11.0, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.2, $^5J_{6\text{-}exo,3\text{-}exo}$ 0.9, 6-H_{exo}), 1.51–1.62 (2H, overlapping d and m, $^2J_{3\text{-}endo,3\text{-}exo}$ 18.0, 3-H_{endo}, and $^2J_{5\text{-}exo,5\text{-}endo}$ 12.4, $^3J_{5\text{-}exo,6\text{-}exo}$ 11.0, $^3J_{5\text{-}exo,4}$ 4.8, $^3J_{5\text{-}exo,6\text{-}endo}$ 4.6, 5-H_{exo}), 1.64 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.8, 4-H), 2.09 (1H, overlapping ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 18.0, $^3J_{3\text{-}exo,4}$ 4.8, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.8, $^5J_{3\text{-}exo,6\text{-}exo}$ 0.9, 3-H_{exo}); δ_C (75.5 MHz; $CDCl_3$) 9.1 (C-10), 19.0 (C-9), 19.6 (C-8), 26.9 (C-5), 29.8 (C-6), 42.9 (C-4), 43.1 (C-3), 46.6 (C-7), 57.4 (C-1), 218.8 (C=O); δ_C (75.5 MHz; C_6D_6) 9.6 (C-10), 19.1 (C-9), 19.7 (C-8), 27.3 (C-5), 30.1 (C-6), 43.2 (C-3), 43.3 (C-4), 46.5 (C-7), 57.3 (C-1), 216.3 (C=O).

NOE difference (C_6D_6) irradiation at δ 0.59 C-8 Me (enhances signal at δ 0.87 C-10 Me by +1.7%, δ 2.09 3-H_{exo} +1.85%), 0.87 C-10 Me (0.59 C-8 Me +1.4%, 0.64 C-9 Me +1.4%), 0.91–1.00 5-H_{endo} (1.51–1.64 3-H_{endo}, 4-H, 5-H_{exo} +4.9%), 1.12–1.22 6-H_{endo} (0.87 C-10 Me +0.8%, 0.91–1.00 5-H_{endo} +1.7%, 1.28–1.39 6-H_{exo} +6.2%), 1.28–1.39 6-H_{exo} (0.64 C-9 Me +1.65%, 0.87 C-10 Me +0.8%, 1.12–1.22 6-H_{endo} +4.5%), 1.51–1.62 3-H_{endo} and 5-H_{exo} (0.91–1.00 5-H_{endo} +7.6%, 1.28–1.39 6-H_{exo} +3.5%, 2.09 3-H_{exo} +7.0%), 1.64 4-H (0.59 C-8 Me +1.5%, 0.64 C-9 Me +1.85%), 2.09 3-H_{exo} (0.59 C-8 Me +2.0%, 1.51–1.62 3-H_{endo} and 5-H_{exo} +7.0%).

(±)-Thiocamphor. (±)-Camphor (1.52 g, 10 mmol) and Lawesson's reagent[30]‖ (2.43 g, 6 mmol) were refluxed in anhydrous benzene (15 cm^3) for 12 h. The resulting orange solution was filtered, the filtrate evaporated to dryness *in vacuo*, and the residue purified by flash chromatography (light petroleum–DCM [95 : 5]). Combination and concentration of the appropriate product fractions gave the desired (±)-thiocamphor (0.96 g, 57%) as bright orange crystals, mp 145–146 °C (lit.,[31] 145–146 °C); ν_{max}(KBr)/cm^{-1} 3409w, 2959s, 1445m, 1413m, 1388m, 1309m, 1277m, 1211m, 1191w, 1130m (C=S str); δ_H(300 MHz; $CDCl_3$) 0.78 (3H, s, C-8 Me), 1.02 (3H, s, C-9 Me), 1.08 (3H, s, C-10 Me), 1.22–1.41 (2H, m, 5-H_{endo} and 6-H_{endo}), 1.69–1.80 (1H, m, 6-H_{exo}), 1.93–2.05 (1H, m, 5-H_{exo}), 2.15 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.2, 4-H), 2.39 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 20.5, 3-H_{endo}), 2.71–2.82 (1H, dm, $^2J_{3\text{-}exo,3\text{-}endo}$ 20.5, 3-H_{exo}); δ_C(75.5 MHz; $CDCl_3$) 13.1 (C-10), 19.6 (C-9), 19.8 (C-8), 27.2 (C-5), 33.9 (C-6), 45.1 (C-4), 48.9 (C-7), 55.5 (C-3), 69.2 (C-1), 193.7 (C=S).

Camphor imine 3 and its precursors

Camphor oxime 1. A solution of hydroxylamine hydrochloride (2.09 g, 30 mmol) and sodium acetate (1.97 g, 24 mmol) in water (18 cm^3) was treated with a solution of (±)-camphor or (*R*,*R*)-camphor (3.04 g, 20 mmol) in ethanol (7 cm^3) and the mixture was heated at 60 °C for 15 h. The resulting clear solution was concentrated *in vacuo* until crystals of camphor oxime began to form. The suspension was set aside at 4 °C to complete the crystallisation and the product was collected by suction filtration and dried over $CaCl_2$ *in vacuo*. TLC ($CHCl_3$) confirmed that both products were pure.

(*R*,*R*)-Camphor oxime 1. (*R*,*R*)-Camphor oxime (3.30 g, 99%) was obtained as white crystals, mp 118–119 °C (lit.,[32] 115 °C); $[a]_D^{25.5}$ −36.8 (*c* 10 in EtOH) {lit.,[32] $[a]_D$ −41.4 (*c* 12 in EtOH)}; ν_{max}(KBr)/cm^{-1} 3284s br (OH str), 2975s, 1687m (C=N str), 1447s, 1391s, 1376s, 1191m; δ_H(300 MHz; $CDCl_3$) 0.77 (3H, s, C-8 Me), 0.88 (3H, s, C-9 Me), 0.98 (3H, s, C-10 Me), 1.15–1.26 (1H, complex overlapping ddd, 5-H_{endo}), 1.36–1.48 (1H, overlapping ddd, 6-H_{endo}), 1.60–1.72 (1H, dt, $^2J_{6\text{-}exo,6\text{-}endo}$ 12.0, $^3J_{6\text{-}exo,5\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 4.2, 6-H_{exo}), 1.74–1.86 (1H, m, 5-H_{exo}), 1.88 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.2, 4-H), 2.02 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 17.5, 3-H_{endo}), 2.52 (1H, overlapping ddd, $^2J_{3\text{-}exo,3\text{-}endo}$

‖ 2,4-Bis(4-methoxyphenyl)-1,3,2,4-dithiadiphosphetane 2,4-disulfide.

17.5, $^3J_{3\text{-}exo,4}$ 4.2, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.5, 3-H_{exo}), 8.98 (1H, br, OH); δ_C(75.5 MHz; $CDCl_3$) 11.1 (C-10), 18.5 (C-9), 19.4 (C-8), 27.2 (C-5), 32.6 (C-6), 33.1 (C-3), 43.7 (C-4), 48.3 (C-7), 51.8 (C-1), 169.7 (C=N).[5]

(±)-Camphor oxime 1. (±)-Camphor oxime (3.14 g, 94%) was obtained as white crystals, mp 117–119 °C (lit.,[17,33] 118–119 °C); ν_{max}(KBr)/cm^{-1} 3283br s (OH str), 2961s, 1686m (C=N str), 1475s, 1445s, 1392s, 1376s, 1302s, 1201m, 1193m, 923s; δ_H(300 MHz; $CDCl_3$) 0.79 (3H, s, C-8 Me), 0.91 (3H, s, C-9 Me), 1.00 (3H, s, C-10 Me), 1.18–1.28 (1H, overlapping ddd, 5-H_{endo}), 1.41–1.50 (1H, overlapping ddd, 6-H_{endo}), 1.70 (1H, dt, $^2J_{6\text{-}exo,6\text{-}endo}$ 12.0, $^3J_{6\text{-}exo,5\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 4.0, 6-H_{exo}), 1.77–1.89 (1H, m, 5-H_{exo}), 1.91 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.3, 4-H), 2.05 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 17.8, 3-H_{endo}), 2.55 (1H, overlapping ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 17.8, $^3J_{3\text{-}exo,4}$ 4.3, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.5, 3-H_{exo}), 8.60 (1H, br, OH); δ_C(75.5 MHz; $CDCl_3$) 11.1 (C-10), 18.5 (C-9), 19.4 (C-8), 27.3 (C-5), 32.6 (C-6), 33.1 (C-3), 43.7 (C-4), 48.3 (C-7), 51.9 (C-1), 170.0 (C=N).

Camphor imine nitrate salt 2a. Camphor imine nitrate salt was prepared by an adaptation of the procedure of Barton, Motherwell, Simon and Zard (Procedure A)[18] and by a modification of the method of Mahla and Tiemann (Procedure B).[15]

Procedure A.—Tri-*n*-butylphosphine (93.4 cm^3, 379 mmol) was added to a solution of (*R*,*R*)-camphor oxime **1** (15.78 g, 94 mmol) and diphenyl disulfide (41.92 g, 192 mmol) in dry THF (450 cm^3) under an inert atmosphere and the solution stirred at ambient temperature for 2.5 h. Anhydrous nitric acid in dry diethyl ether** (approximately 0.5–1.0 M) was added dropwise to the reaction mixture, whereupon white crystals of the camphor imine nitrate salt began to separate. The addition of the nitric acid solution was continued until no more crystallisation occurred. The crystals were collected by suction filtration, washed well with dry diethyl ether, and dried *in vacuo* over $CaCl_2$.

(R,R)-Camphor imine nitrate salt ***2a***.—(*R*,*R*)-Camphor imine nitrate salt **2a** (20.24 g, 99%) was obtained as fine, white, needle-shaped crystals, mp 158–159 °C (lit.,[15] 158–159 °C); $[\alpha]_D^{27}$ −42.0 (*c* 0.84 in EtOH); ν_{max}(KBr)/cm^{-1} 3300–2700br s (N-H str), 2964s, 2875s, 1685s (C=N str), 1440–1350br s, 1307s, 1210m, 1197m; δ_H(300 MHz; $CDCl_3$) 0.89 (3H, s, C-8 Me), 1.03 (3H, s, C-9 Me), 1.26 (3H, s, C-10 Me), 1.37–1.45 (1H, m, 5-H_{endo}), 1.52–1.64 (1H, m, 6-H_{endo}), 1.90–2.01 (2H, m, 5-H_{exo}, 6-H_{exo}), 2.17 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.0, 4-H), 2.58 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 20.2, 3-H_{endo}), 3.0 (1H, ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 20.2, $^3J_{3\text{-}exo,4}$ 4.0 and $^4J_{3\text{-}exo,5\text{-}exo}$ 1.5, 3-H_{exo}), 11.9 (1H, br, NH) and 12.4 (1H, br, NH); δ_C(75.5 MHz; $CDCl_3$) 9.4 (C-10), 18.4 (C-9), 19.6 (C-8), 26.1 (C-5), 31.8 (C-6), 38.6 (C-3), 43.4 (C-4), 49.9 (C-7), 57.7 (C-1), 208.0 (C=N).

Procedure B.—(±)-Camphor oxime or (*R*,*R*)-camphor oxime **1** (30.05 g, 180 mmol) in dry diethyl ether (250 cm^3) was treated successively with three portions of cold nitrous acid in 'dried' diethyl ether prepared as described below. Sodium nitrite (25.02 g, 360 mmol) in water (50 cm^3), layered with diethyl ether (100 cm^3) and cooled to 0 °C in a separating funnel, was treated with 2 M aq. sulfuric acid (24.5 cm^3, 49 mmol) and the mixture was swirled gently. The lower aqueous layer was removed and the upper, pale yellow organic layer was filtered through a cotton wool plug into the ethereal oxime solution. The separated aqueous layer was re-treated with sulfuric acid (24.5 cm^3, 49 mmol), extracted with diethyl ether (100 cm^3), and the separated organic phase was filtered as before into the ethereal reaction mixture. This process was repeated once more.

The addition of nitrous acid to the oxime solution gave a deep red solution from which fine, white crystals of camphor imine nitrate salt **2a** separated. The mixture was kept at 0 °C for 20 min and the crystals were filtered off from the pale blue supernatant liquor, washed well with dry diethyl ether, and dried *in vacuo* over $CaCl_2$.

(R,R)-Camphor imine nitrate salt **2a**.—(*R*,*R*)-Camphor imine nitrate salt (8.88 g, 23%) was obtained as fine, white, needle-shaped crystals, mp 158–159 °C (lit.,[15] 158–159 °C); $[\alpha]_D^{27}$ −42.0 (*c* 0.84 in EtOH); ν_{max}(KBr)/cm^{-1} 3300–2700s (N-H str), 2960s, 2878s, 1702s (C=N str), 1432s, 1376s, 1311s, 1299s, 1212m, 1196m.

(±)-Camphor imine nitrate salt ***2a***.—(±)-Camphor imine nitrate salt (8.28 g, 21.5%) was obtained as fine, white, needle-shaped crystals, mp 158–159 °C (lit.,[34] 144.5–145 °C); ν_{max}(KBr)/cm^{-1} 3420–3100w (N-H str), 2966s, 2878s, 1713s (C=N str), 1436s, 1386s, 1311s, 1299s, 1212m, 1196w; δ_H(300 MHz; $CDCl_3$) 0.83 (3H, s, C-8 Me), 0.96 (3H, s, C-9 Me), 1.20 (3H, s, C-10 Me), 1.32–1.42 (1H, m, 5-H_{endo}), 1.48–1.60 (1H, m, 6-H_{endo}), 1.85–1.96 (2H, m, 5-H_{exo}, 6-H_{exo}), 2.12 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 3.5, 4-H), 2.53 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 20.0, 3-H_{endo}), 3.00 (1H, dd, $^2J_{3\text{-}exo,3\text{-}endo}$ 20.0, $^3J_{3\text{-}exo,4}$ 4.0, 3-H_{exo}), 11.9 (1H, br, NH), 12.3 (1H, br, NH); δ_C(75.5 MHz; $CDCl_3$) 9.3 (C-10), 18.4 (C-9), 19.5 (C-8), 26.1 (C-5), 31.8 (C-6), 38.6 (C-3), 43.4 (C-4), 49.9 (C-7), 57.7 (C-1), 208.0 (C=N).

(*R*,*R*)-Camphor imine hydrochloride salt 2b. (*R*,*R*)-Camphor imine hydrochloride salt was prepared either by a modification of Procedure A[18] used above for the preparation of (*R*,*R*)-camphor imine nitrate salt or directly from camphor imine itself (Procedure C).[15]

Procedure A.—Tri-*n*-butylphosphine was added slowly to a solution of (*R*,*R*)-camphor oxime **1** and diphenyl disulfide in dry THF under an inert atmosphere as described above for the nitrate salt. The solution was stirred at ambient temperature for 2.5 h. Anhydrous hydrogen chloride in dry diethyl ether (approximately 2 M) was added dropwise to the reaction mixture, whereupon white crystals of the camphor imine hydrochloride salt began to separate. The addition of the hydrogen chloride solution was continued until no more crystallisation occurred. The crystals were collected by suction filtration, washed well with dry diethyl ether, and dried *in vacuo* over anhydrous $CaCl_2$. (*R*,*R*)-Camphor imine hydrochloride salt **2b** (86%) was obtained as fine, white, needle-shaped crystals, mp 327–328 °C (lit.,[15] records sublimation without melting) [Found: *m*/*z* (EI): M$^+$, 151.13653, $C_{10}H_{17}N$ (free base) requires *M*, 151.13570, deviation 2.8 ppm]; ν_{max}(KBr)/cm^{-1} 3100–2550br s (N-H str), 2968s, 2774s, 1696s (C=N str), 1475m, 1448s, 1414s, 1394m, 1372w, 1214m, 1196w; δ_H(300 MHz; $CDCl_3$) 0.81 (3H, s, C-8 Me), 0.95 (3H, s, C-9 Me), 1.30 (3H, s, C-10 Me), 1.27–1.38 (1H, m, 5-H_{endo}), 1.42–1.56 (1H, m, 6-H_{endo}), 1.83–1.99 (2H, m, 5-H_{exo}, 6-H_{exo}), 2.12 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 3.5, 4-H), 2.56 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 20.2, 3-H_{endo}), 2.98 (1H, dd, $^2J_{3\text{-}exo,3\text{-}endo}$ 20.2, $^3J_{3\text{-}exo,4}$ 3.5, 3-H_{exo}), 12.6 (1H, br, NH), 13.3 (1H, br, NH); δ_C(75.5 MHz; $CDCl_3$) 10.4 (C-10), 18.3 (C-9), 19.6 (C-8), 26.1 (C-5), 31.9 (C-6), 38.4 (C-3), 43.4 (C-4), 49.8 (C-7), 57.8 (C-1), 206.4 (C=N); *m*/*z* (EI) 151 (52%, M$^+$ [free base]), 136 (46, M − CH_3), 123 (11), 108 (58, $C_8H_{12}^+$), 95 (100, $C_7H_{11}^+$), 84 (36, M − 67), 68 (98, $C_4H_6N^+$), 55 (39).[35]

Procedure C.—Anhydrous hydrogen chloride in dry diethyl ether (approximately 2 M) was added dropwise to a stirred, dry, concentrated ethereal solution of (*R*,*R*)-camphor imine **3** (prepared from camphor imine nitrate **2a** as described below), whereupon white crystals of the camphor imine hydrochloride salt began to separate. The addition of the hydrogen chloride solution was continued until no more crystallisation occurred. The crystals were collected by suction filtration, washed well with dry diethyl ether, and dried *in vacuo* over $CaCl_2$. (*R*,*R*)-Camphor imine hydrochloride salt **2b** was obtained as fine,

** For the preparation of anhydrous nitric acid in dry diethyl ether see the general experimental section. Particular attention should be paid to the safety precautions mentioned.

white, needle-shaped crystals, with properties similar to those already reported.

(*R*,*R*)-Camphor imine 3. (*R*,*R*)-Camphor imine nitrate **2a** or hydrochloride salt **2b** was dissolved in the minimum of water, layered with diethyl ether, and treated with aq. ammonia (2 M; 20% excess). The free imine was extracted into diethyl ether (× 3) and the organic phases were pooled, dried ($MgSO_4$), and concentrated cautiously on a rotatory evaporator to give a white solid, camphor imine **3**; ν_{max}(KBr)/cm^{-1} 3312br s (N-H str), 2963s, 2880s, 1683m (C=N str), 1438s, 1387m, 1370m; δ_H(60 MHz; $CDCl_3$) 0.90 (3H, s, C-8 Me), 1.02 (3H, s, C-9 Me), 1.10 (3H, s, C-10 Me), 1.40–2.60 (7H, complex m of overlapping signals, 3-H_2, 4-H, 5-H_2 and 6-H_2).††

General procedure for the preparation of camphorylidene α-amino acid ester derivatives

(*R*,*R*)-camphor imine nitrate salt **2a** (1.07 g, 5 mmol) or the corresponding hydrochloride salt **2b** (0.94 g, 5 mmol) was dissolved in water (10 cm^3), layered with diethyl ether (30 cm^3), and treated with aq. ammonia (2 M; 3 cm^3, 6 mmol, 20% excess). The layers were equilibrated, separated, and the aqueous phase was extracted with a further portion of diethyl ether. The combined organic phases were pooled, backwashed with cold water (2 × 10 cm^3), dried ($MgSO_4$), filtered and reduced in volume to ≈10 cm^3. The *S*- or *R*-amino ester hydrochloride **4** (5 mmol) was added together with a suitable co-solvent (dry MeOH, EtOH or DCM, 10 cm^3). The suspension was stirred at ambient temperature for 2–3 days with the exclusion of moisture ($CaCl_2$ guard tube). The precipitate of ammonium chloride which formed was filtered off, and the filtrate cautiously concentrated on a rotatory evaporator to give the crude product. The crude material was purified by flash chromatography (DCM–MeOH, 99 : 1). Combination and concentration of the appropriate product fractions and drying over $CaCl_2$ *in vacuo* gave the desired camphorylidene α-amino ester which was shown to be pure by TLC (DCM–MeOH, 99 : 1).

(*R*,*R*)-Camphorylidene α-amino ester derivatives

Ethyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]glycinate[12] 5a {ethyl ([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)acetate}. Ethyl glycinate hydrochloride **4a** (0.70 g, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *ethyl N-[(1R,2E,4R)-bornan-2-ylidene]glycinate* **5a**, as a pale yellow oil (902 mg, 76%), $[\alpha]_D^{25.5}$ −7.04 (*c* 0.5 in DCM) [Found: *m*/*z* (EI) M$^+$, 237.17417. Calc. for $C_{14}H_{23}NO_2$: *M*, 237.17288, deviation 5.45 ppm]; ν_{max}(film)/cm^{-1} 2962s, 2885s, 1745s (C=O str), 1689s (C=N str), 1475m, 1448m, 1392m, 1373s, 1338m, 1184s;[12] δ_H(300 MHz; $CDCl_3$) 0.72 (3H, s, C-8 Me), 0.86 (3H, s, C-9 Me), 0.93 (3H, s, C-10 Me), 1.09–1.18 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 16.0, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.0 and $^3J_{5\text{-}endo,6\text{-}exo}$ 4.0, 5-H_{endo}), 1.177 and 1.180 (3H, t, *J* 7.0, $CH_3CH_2O_2C$),‡‡ 1.29–1.39 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 14.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.0, 6-H_{endo}), 1.61 (1H, dt, $^2J_{6\text{-}exo,6\text{-}endo}$ 14.5, $^3J_{6\text{-}exo,5\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 4.0, 6-H_{exo}), 1.74 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 17.0, 3-H_{endo}), 1.73–1.84 (1H, m, 5-H_{exo}), 1.88 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.0, 4-H), 2.25 (1H, dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 17.0, $^3J_{3\text{-}exo,4}$ and $^4J_{3\text{-}exo,5\text{-}exo}$ 4.0, 3-H_{exo}), 3.99 and 4.00 (2H, 2 × s, NCH_2),§§ 4.087 and 4.093 (2H, q, *J* 7.0, $CH_3CH_2O_2C$);[12] δ_C(75.5 MHz; $CDCl_3$) 11.1 (C-10), 14.1 (Gly, OCH_2CH_3), 18.9 (C-9), 19.5 (C-8), 27.3 (C-5), 31.9 (C-6), 35.6 (C-3), 43.8 (C-4), 47.25 (C-7), 53.8 (Gly, α-CH_2), 54.2 (C-1), 60.6 (Gly, OCH_2CH_3), 170.2 (C=O), 187.5 (C=N);[12] *m*/*z* (EI) 237 (10%, M$^+$), 165 (16), 164 (100, M − CO_2Et), 129 (8), 108 (10, $C_8H_{12}^+$), 95 (17, $C_7H_{11}^+$), 83 (23), 69 (9), 55 (9).[35]

NOE difference ($CDCl_3$) irradiation at δ 0.72 C-8 Me (enhances signal at δ 1.88 4-H by +1.05%, δ 2.25 3-H_{exo} +2.6%, δ 3.99 NCH_2 +0.8%), 0.86 C-9 Me (1.61 6-H_{exo} +2.0%, 1.73–1.84 3-H_{endo} and 5-H_{exo} +2.1%, 1.88 4-H +1.4%), 0.93 C-10 Me (1.61 6-H_{exo} +1.5%), 1.09–1.18 5-H_{endo} and CH_3CH_2O (1.73–1.88 3-H_{endo}, 4-H and 5-H_{exo} +12.7%), 1.29–1.39 6-H_{endo} (1.61 6-H_{exo} +9.3%), 1.61 6-H_{exo} (1.29–1.39 6-H_{endo} +9.3%), 1.88 4-H (1.73–1.84 3-H_{endo} and 5-H_{exo} +1.3%, 2.25 3-H_{exo} +4.3%), 2.25 3-H_{exo} (1.73–1.84 3-H_{endo} and 5-H_{exo} +7.0%, 1.88 4-H +1.9%, 3.99 NCH_2 +1.7%), 3.99 NCH_2 (1.73–1.84 3-H_{endo} and 5-H_{exo} +1.3%, 2.25 3-H_{exo} +1.5%).

Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-alaninate 5b {methyl (*S*)-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]-heptan-2-ylideneamino)propanoate}. Methyl (*S*)-alaninate hydrochloride **4b** (0.70 g, 5 mmol) was used in the general procedure using MeOH (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-alaninate* **5b**, as a pale yellow oil (843 mg, 71%), $[\alpha]_D^{25.5}$ −114.7 (*c* 0.51 in DCM) [Found: C, 70.3; H, 9.7; N, 5.9. Calc. for $C_{14}H_{23}NO_2$: C, 70.8; H, 9.8; N, 5.9%. Found: *m*/*z* (EI) M$^+$, 237.17305. Calc. for $C_{14}H_{23}NO_2$: *M*, 237.17288, deviation 0.7 ppm]; ν_{max}(film)/cm^{-1} 2957s, 2875s, 1738s (C=O str), 1679s (C=N str), 1475sh m, 1447m, 1391w, 1371m, 1201s; δ_H(300 MHz; $CDCl_3$) 0.73 (3H, s, C-8 Me), 0.91 (3H, s, C-9 Me), 0.98 (3H, s, C-10 Me), 1.14–1.24 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.0, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.1 and $^3J_{5\text{-}endo,6\text{-}exo}$ 4.2, 5-H_{endo}), 1.37 (3H, d, $^3J_{Me,a\text{-}CH}$ 6.8, Ala β-CH_3), 1.36–1.46 (1H, partly obscured overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 13.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.1, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.2, 6-H_{endo}), 1.65 (1H, dt, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 13.5 and $^3J_{6\text{-}exo,5\text{-}endo}$ 4.2, 6-H_{exo}), 1.88 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.5, 3-H_{endo}), 1.76–1.89 (1H, m, 5-H_{exo}), 1.92 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.2, 4-H), 2.31 (1H, complex dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.5, $^3J_{3\text{-}exo,4}$ 4.2, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.4, 3-H_{exo}), 3.67 (3H, s, CH_3O_2C), 4.04 (1H, q, $^3J_{a\text{-}CH,Me}$ 6.8, Ala α-CH); δ_C(75.5 MHz; $CDCl_3$) 11.4 (C-10), 18.6 (C-9), 18.9 (Ala β-CH_3), 19.4 (C-8), 27.3 (C-5), 31.8 (C-6), 35.3 (C-3), 43.8 (C-4), 47.0 (C-7), 51.9 (OCH_3), 53.9 (C-1), 59.4 (Ala α-CH), 173.45 (C=O), 184.5 (C=N); *m*/*z* (EI) 237 (2%, M$^+$), 178 (100, M − CO_2Me), 122 (3.5), 108 (3, $C_8H_{12}^+$), 95 (12, $C_7H_{11}^+$), 83 (7), 70 (9), 55 (9).

Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-valinate 5c {methyl (*S*)-3′-methyl-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo-[2.2.1]heptan-2-ylideneamino)butanoate}. Methyl (*S*)-valinate hydrochloride **4c** (838 mg, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-valinate* **5c**, as a clear oil (823 mg, 62%), $[\alpha]_D^{20}$ −181.2 (*c* 0.52 in DCM) [Found: C, 72.1; H, 10.15; N, 5.2. Calc. for $C_{16}H_{27}NO_2$: C, 72.4; H, 10.3; N, 5.3%. Found: *m*/*z* (EI) M$^+$, 265.20485. Calc. for $C_{16}H_{27}NO_2$: *M*, 265.20418, deviation 2.5 ppm]; ν_{max}(film)/cm^{-1} 2958s, 2874s, 1743s (C=O str), 1683s (C=N str), 1470m, 1448m, 1386w, 1368w, 1252m, 1196m, 1175m, 1137m; δ_H(300 MHz; $CDCl_3$) 0.72 (3H, s, C-8 Me), 0.85 (3H, d, $^3J_{Me,\beta\text{-}CH}$ 6.5, Val γ-Me_a), 0.87 (3H, d, $^3J_{Me,\beta\text{-}CH}$ 6.5, Val γ-Me_b), 0.89 (3H, s, C-9 Me), 0.96 (3H, s, C-10 Me), 1.10–1.20 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.2, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.4 and $^3J_{5\text{-}endo,6\text{-}exo}$ 4.2, 5-H_{endo}), 1.28–1.38 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 13.0, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.4, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.3, 6-H_{endo}), 1.62 (1H, dt, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 10.2, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.2, 6-H_{exo}), 1.73–1.85 (1H, m, 5-H_{exo}), 1.83

†† The N–H proton could not be located as the resolution of this spectrum was poor.

‡‡ The ^{1}H NMR signals of the ethyl ester group are split, presumably due to a conformational effect. Note: the upfield quartet and triplet are of lower intensity than the downfield component; this is in contradistinction to the corresponding behaviour of ethyl (±)-camphorylideneglycinate **5o** (see below).

§§ The two signals for the NCH_2 group are presumably due to non-equivalence.

(1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.5, 3-H_{endo}), 1.90 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.5, 4-H), 2.26 (1H, complex octet, $^3J_{\beta\text{-}CH,Me}$ 6.5 and $^3J_{\beta\text{-}CH,\alpha\text{-}CH}$ 7.2, Val β-CH), 2.29 (1H, complex overlapping br dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.5, $^3J_{3\text{-}exo,4}$ 4.5, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.7, 3-H_{exo}), 3.59 (1H, d, $^3J_{\alpha\text{-}CH,\beta\text{-}CH}$ 7.2, Val α-CH), 3.65 (3H, s, CH_3O_2C); δ_C(75.5 MHz; $CDCl_3$) 11.3 (C-10), 18.5 (Val γ-Me_a), 18.8 (C-9), 19.5 (Val γ-Me_b), 19.53 (C-8), 27.3 (C-5), 31.5 (Val β-CH), 31.8 (C-6), 35.8 (C-3), 43.9 (C-4), 46.5 (C-7), 51.6 (OCH_3), 54.3 (C-1), 71.2 (Val α-CH), 172.5 (C=O), 184.8 (C=N); *m/z* (EI) 265 (7%, M^+), 237 (4, M − 28), 222 (57, M − C_3H_7), 206 (100, M − CO_2Me), 162 (4), 150 (4, M − $C_6H_{11}O_2^+$), 115 (7, $C_6H_{11}O_2^+$), 108 (3, $C_8H_{12}^+$), 95 (14, $C_7H_{11}^+$), 83 (13), 69 (12), 59 (17), 55 (18).

Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-leucinate 5d {methyl (*S*)-4′-methyl-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo-[2.2.1]heptan-2-ylideneamino)pentanoate}. Methyl (*S*)-leucinate hydrochloride **4d** (908 mg, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-leucinate* **5d**, as a pale yellow oil (631 mg, 45%), $[\alpha]_D^{20}$ −102.4 (*c* 0.50 in DCM) [Found: *m/z* (EI) M^+, 279.22014. Calc. for $C_{17}H_{29}NO_2$: *M*, 279.21983, deviation 1.1 ppm; (CI, NH_3) MH^+, 280.22770. Calc. for $C_{17}H_{30}NO_2$: *m/z*, 280.22763, deviation 0.3 ppm]; ν_{max}(film)/cm^{-1} 2960s, 2876s, 1747s (C=O str), 1685s (C=N str), 1468m, 1442m, 1389m, 1371m, 1272m, 1242m, 1197m, 1170m, 1142m; δ_H(300 MHz; $CDCl_3$) 0.73 (3H, s, C-8 Me), 0.82 (3H, d, $^3J_{Mea,\gamma\text{-}CH}$ 6.6, Leu δ-Me_a), 0.915 (3H, d, $^3J_{Meb,\gamma\text{-}CH}$ 6.6, Leu δ-Me_b), 0.92 (3H, s, C-9 Me), 0.98 (3H, s, C-10 Me), 1.13–1.23 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.6, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.1 and $^3J_{5\text{-}endo,6\text{-}exo}$ 4.1, 5-H_{endo}), 1.35–1.45 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 13.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.1, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.5, 6-H_{endo}), 1.49–1.89 (5H, series of overlapping multiplets, partially discernable as: 1.49–1.62, complex m, 6-H_{exo}; 1.63–1.71, complex m, Leu γ-CH; 1.68–1.82, m, ^3J 8.6 and 5.2, Leu β-CH_2; 1.78–1.89, complex m, 5-H_{exo}), 1.88 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.8, 3-H_{endo}), 1.92 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.5, 4-H), 2.33 (1H, overlapping ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.8, $^3J_{3\text{-}exo,4}$ 4.5, $^4J_{3\text{-}exo,5\text{-}exo}$ 2.8, 3-H_{exo}), 3.67 (3H, s, CH_3O_2C), 3.97 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 8.6, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 5.2, Leu α-CH); δ_C(75.5 MHz; $CDCl_3$) 11.3 (C-10), 18.9 (C-9), 19.5 (C-8), 21.6 (Leu δ-Me_a), 23.3 (Leu δ-Me_b), 24.7 (Leu γ-CH), 27.3 (C-5), 31.8 (C-6), 35.7 (C-3), 42.1 (Leu β-CH_2), 43.9 (C-4), 46.7 (C-7), 51.7 (OCH_3), 54.1 (C-1), 62.6 (Leu α-CH), 173.2 (C=O), 184.7 (C=N); *m/z* (EI) 279 (4.5%, M^+), 264 (9, M − CH_3), 251 (28, M − 28), 236 (17, M − C_3H_7), 223 (100, M − C_4H_8), 220 (90, M − CO_2Me), 208 (12), 194 (11), 178 (12), 163 (19.5), 150 (12, M − $C_7H_{13}O_2$), 136 (6), 129 (6, $C_7H_{13}O_2^+$), 108 (8, $C_8H_{12}^+$), 95 (26, $C_7H_{11}^+$), 83 (35), 69 (35), 55 (27); *m/z* (CI, NH_3), 280 (100%, MH^+), 264 (2, M − CH_3), 251 (8, M − 28), 236 (1, M − C_3H_7), 220 (21, M − CO_2Me), 208 (1), 152 (2), 95 (1, $C_7H_{11}^+$).

Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(2′*S*,3′*S*)-isoleucinate 5e {methyl (2′*S*,3′*S*)-3′-methyl-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)pentanoate}. Methyl (2*S*,3*S*)-isoleucinate hydrochloride **4e** (908 mg, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(2′S,3′S)-isoleucinate* **5e**, as a clear oil (908 mg, 65%), $[\alpha]_D^{27}$ −149.4 (*c* 0.32 in DCM) [Found: *m/z* (EI) M^+, 279.22039. Calc. for $C_{17}H_{29}NO_2$: *M*, 279.21983, deviation 1.9 ppm]; ν_{max}(film)/cm^{-1} 2960s, 2876m, 1743s, 1732sh (C=O str), 1679m (C=N str), 1453m, 1436m, 1388w, 1374w, 1261m, 1194m, 1171m, 1139m; δ_H(300 MHz; $CDCl_3$) 0.73 (3H, s, C-8 Me), 0.84 [3H, t, $^3J_{(Me,\gamma\text{-}CH_2)}$ 7.2, Ile δ-Me], 0.87 (3H, d, $^3J_{Me,\beta\text{-}CH}$ 6.4, Ile γ-Me), 0.915 (3H, s, C-9 Me), 0.98 (3H, s, C-10 Me), 1.01–1.12 (1H, complex m, Ile γ-CH_aH_b), 1.11–1.20 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.2, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.1 and $^3J_{5\text{-}endo,6\text{-}exo}$ 4.0, 5-H_{endo}), 1.29–1.40 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.6, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.1, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.2, 6-H_{endo}), 1.42–1.56 [1H, dqd, $^2J_{\gamma\text{-}CHa,CHb}$ 13.2, $^3J_{(\gamma\text{-}CH_2,Me)}$ 7.2, $^3J_{(\gamma\text{-}CH_2,\beta\text{-}CH)}$ 3.8, Ile γ-CH_aH_b], 1.58–1.69 (1H, td, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 12.6, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.0, 6-H_{exo}), 1.75–1.87 (1H, complex m, 5-H_{exo}), 1.85 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.9, 3-H_{endo}), 1.91 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.5, 4-H), 2.01–2.15 (1H, complex m, Ile β-CH), 2.31 (1H, overlapping ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.9, $^3J_{3\text{-}exo,4}$ 4.5, $^4J_{3\text{-}exo,5\text{-}exo}$ 2.8, 3-H_{exo}), 3.667 (1H, d, $^3J_{\alpha\text{-}CH,\beta\text{-}CH}$ 7.9, Ile α-CH), 3.67 (3H, s, CH_3O_2C); δ_C(75.5 MHz; $CDCl_3$) 11.1 (Ile δ-Me), 11.3 (C-10), 15.7 (Ile γ-Me), 18.9 (C-9), 19.5 (C-8), 24.9 (Ile γ-CH_2), 27.3 (C-5), 31.9 (C-6), 35.8 (C-3), 37.8 (Ile β-CH), 43.9 (C-4), 46.7 (C-7), 51.6 (OCH_3), 54.4 (C-1), 70.3 (Ile α-CH), 172.6 (C=O), 185.1 (C=N); *m/z* (EI) 279 (6%, M^+), 264 (4, M − CH_3), 251 (22, M − 28), 223 (68, M − C_4H_8), 222 (70, M − C_4H_9), 220 (100, M − CO_2-Me), 208 (9), 180 (6), 163 (18), 150 (10, M − $C_7H_{13}O_2$), 129 (11, $C_7H_{13}O_2^+$), 108 (8, $C_8H_{12}^+$), 95 (25, $C_7H_{11}^+$), 83 (16), 69 (53), 59 (33), 55 (39).

Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-serinate 5f {methyl (*S*)-3′-hydroxy-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo-[2.2.1]heptan-2-ylideneamino)propanoate}. Methyl (2*S*)-serinate hydrochloride **4f** (778 mg, 5 mmol) was used in the general procedure using MeOH (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-serinate* **5f**, as a clear oil (836 mg, 66%) [Found: *m/z* (EI) M, 253.16779. Calc. for $C_{14}H_{23}NO_3$: *M*, 253.16779, deviation 0 ppm]; ν_{max}(film)/cm^{-1} 3432vbr m (O-H str), 2957s, 2876m, 1741s (C=O str), 1679s (C=N str), 1437m, 1390m, 1371m, 1200s, 1171s, 1052s; δ_H(300 MHz; $CDCl_3$)¶¶ 0.70 and 0.77 (3H, s, C-8 Me), 0.88 (3H, s, C-9 Me), 0.93 and 0.94 (3H, s, C-10 Me), 1.12–1.21 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.8, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.0 and $^3J_{5\text{-}endo,6\text{-}exo}$ 4.1, 5-H_{endo}), 1.23–1.33 and 1.35–1.45 (1H, 2 × overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.7, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.5, 6-H_{endo}), 1.58–1.70 (1H, br ddd, $^2J_{6\text{-}exo,6\text{-}endo}$ 12.7, $^3J_{6\text{-}exo,5\text{-}exo}$ 12.0 and $^3J_{6\text{-}exo,5\text{-}endo}$ 4.1, 6-H_{exo}), 1.75–1.86 (1H, complex m, 5-H_{exo}), 1.78 and 1.84 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.8, 3-H_{endo}), 1.90 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.4, 4-H), 2.32 (1H, br ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.8, $^3J_{3\text{-}exo,4}$ 4.4, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.0, 3-H_{exo}), 3.11 (1H, br s, OH), 3.64 and 3.66 (3H, s, CH_3O_2C), 3.83 [1H, ddd, $^2J_{\beta\text{-}CHa,CHb}$ 11.0, $^3J_{\beta\text{-}CHa,\alpha\text{-}CH}$ 5.5, $^3J_{(\beta\text{-}CH_2\text{-}OH)}$ 1.5, Ser β-C$H_a$$CH_b$], 3.89 [1H, ddd, $^2J_{\beta\text{-}CHaCHb}$ 11.0, $^3J_{\beta\text{-}CHb,\alpha\text{-}CH}$ 5.0, $^3J_{(\beta\text{-}CH_2\text{-}OH)}$ 1.5, Ser β-CH_aCH_b], 4.22 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 5.5, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 5.0, Ser α-CH); δ_C(75.5 MHz; $CDCl_3$) 11.18 and 11.24 (C-10), 18.8 and 19.0 (C-9), 19.3 and 19.5 (C-8), 27.2 and 27.3 (C-5), 31.7 and 32.3 (C-6), 36.0 and 36.3 (C-3), 43.81 and 43.84 (C-4), 46.8 and 47.6 (C-7), 51.93 and 51.98 (OCH_3), 54.43 and 54.46 (C-1), 63.6 and 63.7 (Ser β-CH_2), 65.0 and 65.2 (Ser α-CH), 171.07 and 171.14 (C=O), 188.2 and 188.6 (C=N); *m/z* (EI) 253 (3%, M^+), 238 (3, M − CH_3), 223 (M − H_2CO), 222 (100, M − CH_2OH), 208 (4), 194 (57.5, M − CO_2Me), 164 (37), 136 (13.5, M − $C_4H_7NO_3$), 108 (25.2, $C_8H_{12}^+$), 95 (78.5, $C_7H_{11}^+$), 83 (57), 69 (37), 55 (39).

Diethyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-glutamate 5g {diethyl (*S*)-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]-heptan-2-ylideneamino)pentanedioate}. Diethyl (*S*)-glutamate hydrochloride **4g** (1.20 g, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *diethyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-glutamate* **5g**, as a clear oil (1.29 g, 76%), $[\alpha]_D^{26}$ −142.4 (*c* 0.50 in DCM) [Found: *m/z* (EI) M^+, 337.22574. Calc. for $C_{19}H_{31}NO_4$: *M*, 337.22531, deviation 1.3 ppm]; ν_{max}(film)/cm^{-1} 2962s, 2886m, 1739s (C=O str), 1685s (C=N str), 1448m, 1374m, 1254m, 1180s; δ_H(300 MHz; $CDCl_3$) 0.71 (3H, s, C-8 Me), 0.89 (3H, s, C-9 Me), 0.95 (3H, s, C-10 Me), 1.11–1.23 (1H,

¶¶ Spectroscopic evidence for this homogeneous compound indicates the existence of two conformers. This may be due to conformational isomerism involving the amino acid side-chain or the geometry of the CN double bond. Since NOE studies and temperature-dependence studies were not carried out, a distinction between these two possibilities cannot be made. The explanation is likely to reside in an equilibrium between hydrogen-bonded and non-hydrogen-bonded conformers.

submerged complex m, 5-H_{endo}), 1.19 [3H, t, $^3J_{(CH_2,Me)}$ 7.0, γ-$CO_2CH_2CH_3$], 1.20 [3H, t, $^3J_{(CH_2,Me)}$ 7.0, α-$CO_2CH_2CH_3$], 1.33–1.43 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.7, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.2, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.2, 6-H_{endo}), 1.58–1.69 (1H, td, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 12.7, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.0, 6-H_{exo}), 1.74–1.87 (1H, complex m, 5-H_{exo}), 1.86 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 17.0, 3-H_{endo}), 1.90 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.8, 4-H), 2.04–2.37 (5H, overlapping complex m, Glu β-CH_2, Glu γ-CH_2 and 3-H_{exo}), 3.95 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 9.0, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 4.2, Glu α-CH), 4.06 [2H, q, $^3J_{(CH_2,Me)}$ 7.0, γ-$CO_2CH_2CH_3$], 4.093 and 4.100 [2H, q, $^3J_{(CH_2,Me)}$ 7.0, α-$CO_2CH_2CH_3$];|||| δ_C(75.5 MHz; $CDCl_3$) 11.2 (C-10), 14.07 (Glu γ-$CO_2CH_2CH_3$), 14.15 (Glu α-$CO_2CH_2CH_3$), 18.8 (C-9), 19.5 (C-8), 27.3 (C-5), 27.8 (Glu β-CH_2), 30.4 (Glu γ-CH_2), 31.8 (C-6), 35.8 (C-3), 43.9 (C-4), 46.7 (C-7), 54.3 (C-1), 60.2 (Glu γ-$CO_2CH_2CH_3$), 60.7 (Glu α-$CO_2CH_2CH_3$), 62.5 (Glu α-CH), 171.6 (γ-C=O), 173.2 (α-C=O), 186.5 (C=N); *m/z* (EI) 337 (15%, M^+), 309 (2, M − C_2H_4), 308 (6, M − C_2H_5), 292 (11, M − OC_2H_5), 264 (95, M − CO_2Et), 263 (20, M − Et_2O), 250 (50), 237 (4, M − $C_5H_8O_2$), 236 (7), 208 (2), 190 (6), 150 (5), 121 (7), 108 (7, $C_8H_{12}^+$), 95 (15, $C_7H_{11}^+$), 85 (72.5), 83 (100), 69 (9), 55 (12).

Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-methioninate 5h {methyl (*S*)-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)-5′-thiahexanoate}. Methyl (*S*)-methioninate hydrochloride **4h** (998 mg, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-methioninate* **5h**, as a pale yellow oil (993 mg, 67%), $[\alpha]_D^{29}$ −14.8 (*c* 1.15 in DCM) [Found: *m/z* (EI) M^+, 297.17528. Calc. for $C_{16}H_{27}NO_2S$: *M*, 297.17625, deviation 3.2 ppm]; ν_{max}(film)/cm^{-1} 2961s, 2882m, 1744s (C=O str), 1683s (C=N str), 1436s, 1390m, 1371m, 1275m, 1201s, 1166s; δ_H(300 MHz; $CDCl_3$) 0.72 (3H, s, C-8 Me), 0.90 (3H, s, C-9 Me), 0.95 (3H, s, C-10 Me), 1.13–1.23 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.5, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.1, $^3J_{5\text{-}endo,6\text{-}exo}$ 4.0, 5-H_{endo}), 1.34–1.44 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.1, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.4, 6-H_{endo}), 1.59–1.69 (1H, td, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 12.5, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.0, 6-H_{exo}), 1.75–1.88, (1H, complex m, 5-H_{exo}), 1.86 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.9, 3-H_{endo}), 1.92 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.5, 4-H), 2.02 (3H, s, Met ε-Me), 2.11–2.19 (2H, complex m, Met γ-CH_2), 2.36 [1H, dt, $^2J_{\beta\text{-}CHa,CHb}$ 13.0, $^3J_{(\beta CHa,\gamma\text{-}CH_2)}$ 7.5, Met β-C*H*^{a}H^b)], 2.44 (1H, br ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.9, $^3J_{3\text{-}exo,4}$ 4.5, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.5, 3-H_{exo}), 2.53 [1H, dt, $^2J_{\beta\text{-}CHa,CHb}$ 13.0, $^3J_{(\beta\text{-}CHb,\gamma\text{-}CH_2)}$ 5.5, Met β-CH^a*H*^{b}], 3.66 (3H, s, CH_3O_2C), 4.12 (1H, t, $^3J_{\alpha\text{-}CH,\beta\text{-}CH?}$ 6.5, Met α-CH); δ_C(75.5 MHz; $CDCl_3$) 11.1 (C-10), 15.1 (Met ε-Me), 18.8 (C-9), 19.5 (C-8), 27.3 (C-5), 30.7 (Met γ-CH_2), 31.5 (Met β-CH_2), 31.7 (C-6), 36.0 (C-3), 43.8 (C-4), 46.8 (C-7), 51.9 (OCH_3), 54.3 (C-1), 61.9 (Met α-CH), 172.5 (C=O), 186.6 (C=N); *m/z* (EI) 299 (2%, M + 2), 297 (10, M^+), 282 (7.5, M − CH_3), 269 (4, M − 28), 250 (2.5, M − SCH_3), 238 (13, M − CO_2Me), 236 (27, M − CH_3SCH_2), 223 (100, M − C_3H_6S), 208 (11), 163 (20.5), 150 (11, M − $C_6H_{11}O_2S$), 108 (9, $C_8H_{12}^+$), 95 (17, $C_7H_{11}^+$), 83 (78), 69 (19.5), 61 (27, $CH_3SCH_2^+$), 55 (14).

Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-phenylalaninate 5i {methyl (*S*)-3′-phenyl-2′-([1*R*,2*E*,4*E*]-1,7,7-trimethylbicyclo-[2.2.1]heptan-2-ylideneamino)propanoate}. Methyl (*S*)-phenylalaninate hydrochloride **4i** (1.078 g, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-phenylalaninate* **5i**, as white, needle-shaped crystals (1.066 g, 68%), mp 38.0–38.5 °C; $[\alpha]_D^{27}$ −156.5 (*c* 0.50 in DCM) [Found: C, 76.5; H, 8.6; N, 4.5. Calc. for $C_{20}H_{27}NO_2$: C, 76.6; H, 8.7; N, 4.5%. Found: *m/z* (EI) M^+, 313.20396. Calc. for $C_{20}H_{27}NO_2$: *M*, 313.20418, deviation 0.7 ppm; (CI, NH_3): MH^+, 314.21200. Calc. for $C_{20}H_{28}NO_2$: *m/z*, 314.21198, deviation 0.1 ppm]; ν_{max}(film)/cm^{-1} 3068w, 3033m, 2961s, 2878m, 1744s (C=O str), 1687s (C=N str), 1607w, 1498m, 1456m, 1440m, 1391m, 1372m, 1279m, 1244m, 1201s, 1169s, 749m, 700s; δ_H(300 MHz; $CDCl_3$) 0.17 (3H, s, C-8 Me), 0.82 (3H, s, C-9 Me), 0.93 (3H, s, C-10 Me), 1.08–1.17 (1H, complex m, 5-H_{endo}), 1.335 (1H, complex ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.2, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.0, 6-H_{endo}), 1.55–1.67 (1H, complex dt, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 12.5, $^3J_{6\text{-}exo,5\text{-}endo}$ 5.0, 6-H_{exo}), 1.70–1.78, (2H, overlapping complex m, 4-H, 5-H_{exo}), 1.77 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.4, 3-H_{endo}), 1.90 (1H, dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.4, $^3J_{4,3\text{-}exo}$ and $^4J_{3\text{-}exo,5\text{-}exo}$ 3.5, 3-H_{exo}), 3.08 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.2, $^3J_{\beta\text{-}CHa,\alpha\text{-}CH}$ 9.8, Phe β-C*H*^{a}CH^b), 3.28 (1H, dd, $^2J_{\beta\text{-}CHb,CHa}$ 13.2, $^3J_{\beta\text{-}CHb,\alpha\text{-}CH}$ 4.2, Phe β-CH^{a}C*H*^{b}), 3.71 (3H, s, CH_3O_2C), 4.16 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 9.8, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 4.2, Phe α-CH), 7.18 (5H, apparent s, Phe aryl CH); δ_C(75.5 MHz; $CDCl_3$) 11.3 (C-10), 18.8 (C-9), 18.9 (C-8), 27.2 (C-5), 31.9 (C-6), 35.8 (C-3), 39.4 (Phe β-CH_2), 43.8 (C-4), 46.6 (C-7), 52.0 (OCH_3), 54.1 (C-1), 66.3 (Phe α-CH), 126.2 (Phe *p*-CH), 128.2 (Phe *m*-CH), 129.5 (Phe *o*-CH), 138.5 (Phe *i*-C), 172.4 (C=O), 185.2 (C=N); *m/z* (EI), 313 (3%, M^+), 254 (21, M − CO_2Me), 223 (13), 222 (100, M − C_7H_7), 221 (26.5), 162 (3.5, [{M − 90} − 59]), 121 (6), 95 (4, $C_7H_{11}^+$), 91 (5.5, $C_7H_7^+$), 83 (17), 77 ($C_6H_5^+$), 69 (11), 55 (2); *m/z* (CI, NH_3) 314 (100%, MH^+), 254 (6, M − CO_2Me), 222 (35, M − C_7H_7), 152 (19), 121 (2), 108 (2, $C_8H_{12}^+$), 91 (3, $C_7H_7^+$).

NOE difference ($CDCl_3$) irradiation at δ 0.17 C-8 Me (enhances signal at δ 0.82 C-9 Me by +0.1%, δ 0.93 C-10 Me +0.7%, δ 1.90 3-H_{exo} +2.9%, δ 7.18 Ph +2.0%), 0.82 C-9 Me (0.17 C-8 Me +3.0%, 1.55–1.67 6-H_{exo} +2.6%, 1.70–1.78 4-H and 5-H_{exo} +4.4%), 0.93 C-10 Me (1.55–1.67 6-H_{exo} +1.8%), 1.08–1.17 5-H_{endo} (1.70–1.78 3-H_{endo}, 4-H and 5-H_{exo} +12.1%), 1.335 6-H_{endo} (1.55–1.67 6-H_{exo} +8.5%), 1.55–1.67 6-H_{exo} (1.335 6-H_{endo} +8.0%), 1.90 3-H_{exo} (1.70–1.78 3-H_{endo}, 4-H and 5-H_{exo} +4.9%, 4.16 Phe α-CH +2.8%), 3.08 Phe β-CH_a (3.28 Phe β-CH_b +9.6%, 4.16 Phe α-CH +0.9%, 7.18 Ph +2.3%), 3.28 Phe β-CH_b (3.08 Phe β-CH_a +9.3%, 4.16 Phe α-CH +2.5%, 7.18 Ph +1.8%), 3.71 CH_3O_2C (no effect), 4.16 Phe α-CH (1.70–1.78 3-H_{endo}, 4-H and 5-H_{exo} +2.1%, 1.90 3-H_{exo} +2.9%, 3.28 Phe β-CH_b +2.1%).

Benzyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-phenylalaninate 5j {benzyl (*S*)-3′-phenyl-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)propanoate}. Benzyl (*S*)-phenylalaninate hydrochloride **4j** (1.458 g, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *benzyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-phenylalaninate* **5j**, as a clear oil (1.324 g, 68%), $[\alpha]_D^{27}$ −138.3 (*c* 0.57 in DCM) [Found: C, 79.5; H, 8.0; N, 3.6. Calc. for $C_{26}H_{31}NO_2$: C, 80.2; H, 8.0; N, 3.6%. Found: *m/z* (EI) M^+, 389.23692. Calc. for $C_{26}H_{31}NO_2$: *M*, 389.23548, deviation 3.7 ppm]; ν_{max}(film)/cm^{-1} 3065w, 3031w, 2957s, 2880m, 1740s (C=O str), 1680m (C=N str), 1604w, 1496m, 1453m, 1389w, 1373w, 1277m, 1209m, 1161s, 748m, 698s; δ_H(300 MHz; $CDCl_3$)*** 0.19 (3H, s, C-8 Me), 0.82 (3H, s, C-9 Me), 0.95 (3H, s, C-10 Me), 0.96–1.05 (1H, complex m, 5-H_{endo}), 1.25 (1H, complex ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 13.0, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.2, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.0, 6-H_{endo}), 1.52–1.63 (1H, complex dt, $^2J_{6\text{-}exo,6\text{-}endo}$ 13.0, $^3J_{6\text{-}exo,5\text{-}exo}$ 13.0, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.0, 6-H_{exo}), 1.66–1.77 (2H, overlapping complex m, 4-H, 5-H_{exo}), 1.76 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 17.0, 3-H_{endo}), 1.92 (1H, dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 17.0, $^3J_{4,3\text{-}exo}$ and $^4J_{3\text{-}exo,5\text{-}exo}$ 3.6, 3-H_{exo}), 3.15 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.2, $^3J_{\beta\text{-}CHa,\alpha\text{-}CH}$ 9.8, Phe β-C*H*^{a}CH^b), 3.33 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.2, $^3J_{\beta\text{-}CHb,\alpha\text{-}CH}$ 4.2, Phe β-CH^{a}C*H*^{b}), 4.20 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 9.8, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 4.2, Phe α-CH), 5.16 (2H, s,

|||| A conformational effect may be responsible for the splitting of the α-ester CH_2 signal.

*** Spectroscopic evidence for this homogeneous compound indicates the existence of two conformers. This may be due to conformational isomerisation involving the amino acid side-chain or the geometry of the CN double bond. Since NOE studies and temperature dependence studies were not carried out, a distinction between these two possibilities cannot be made.

PhCH_2O_2C), 7.19 (5H, apparent s, Phe aryl CH), 7.32 (5H, apparent s, $C_6H_5CH_2O_2C$); δ_C(75.5 MHz; $CDCl_3$) 11.3 (C-10), 18.8 (C-9), 18.9 (C-8), 27.2 (C-5), 31.8 (C-6), 35.9 (C-3), 39.1 (Phe β-CH_2), 43.8 (C-4), 46.7 (C-7), 54.3 (C-1), 66.2 (Phe α-CH), 66.5 (OCH_2Ph), 126.2 (Phe *p*-CH), 128.1 (OCH_2Ph, *p*-CH), 128.2 (Phe *m*-CH), 128.3 (OCH_2Ph, *m*-CH), 128.5 (OCH_2Ph, *o*-CH), 129.6 (Phe *o*-CH), 135.9 (OCH_2Ph, *i*-C), 138.5 (Phe *i*-C), 171.4 (C=O), 185.7 (br C=N); *m/z* (EI) 389 (1%, M^+), 298 (17, M − C_7H_7), 254 (21, M − $CO_2C_7H_7$), 164 (4, [{M − 135} − 90]), 92 (9), 91 (100, $C_7H_7^+$), 77 (1, $C_6H_5^+$).

***tert*-Butyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-phenylalaninate 5k {*tert*-butyl (*S*)-3′-phenyl-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)propanoate}.** *tert*-Butyl (*S*)-phenylalaninate hydrochloride **4k** (1.289 g, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *tert-butyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-phenylalaninate* **5k**, as a clear oil (1.244 g, 70%), $[a]_D^{25}$ −181.1 (*c* 0.25 in DCM) [Found: *m/z* (EI) M^+, 355.25174. Calc. for $C_{23}H_{33}NO_2$: *M*, 355.25113, deviation 1.7 ppm]; ν_{max}(film)/cm^{-1} 3065w, 3029m, 2959s, 2874m, 1734s (C=O str), 1683s (C=N str), 1604w, 1494m, 1453s, 1390m, 1367s, 1284m, 1255m, 1218m, 1151s, 748m, 698s; δ_H(300 MHz; $CDCl_3$)††† 0.19 (3H, s, C-8 Me), 0.82 (3H, s, C-9 Me), 0.95 (3H, br s, C-10 Me), 1.07–1.17 (1H, complex m, 5-H_{endo}), 1.35 (1H, complex ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 3.5, 6-H_{endo}), 1.44 (9H, s, Bu^t), 1.57–1.68 (1H, complex overlapping dt, 6-H_{exo}), 1.72–1.80 (2H, overlapping complex m, 4-H, 5-H_{exo}), 1.81 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.6, 3-H_{endo}), 1.93 (1H, dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.6, $^3J_{4,3\text{-}exo}$ and $^4J_{3,5\text{-}exo}$ 3.5, 3-H_{exo}), 3.05–3.17 (1H, very br m, $^2J_{\beta\text{-}CHa,CHb}$ 13.5, $^3J_{\beta\text{-}CHa,\alpha\text{-}CH}$ 9.9, Phe β-CH^aCH^b), 3.25 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.5, $^3J_{\beta\text{-}CHb,\alpha\text{-}CH}$ 4.0, Phe β-CH^aCH^b), 4.02 (1H, dd, $^3J_{\alpha CH,\beta CHa}$ 9.9, $^3J_{\alpha CH,\beta CHb}$ 4.0, Phe α-CH), 7.17–7.18 (5H, 2 × apparent s, Phe aryl CH); δ_C(75.5 MHz; $CDCl_3$) 11.3 (C-10), 18.8 (C-9), 18.9 (C-8), 27.3 (C-5), 28.1 (Bu^t CMe_3), 31.9 (C-6), 36.0 (C-3), 38.8 (br, Phe β-CH_2), 43.8 (C-4), 46.6 (br, C-7), 54.1 (br, C-1), 66.7 (Phe α-CH), 80.9 (br, Bu^t *C*Me_3), 126.0 (Phe *p*-CH), 128.0 (Phe *m*-CH), 129.5 (Phe *o*-CH), 139.0 (Phe *i*-C), 170.6 (C=O), 184.8 (C=N); *m/z* (EI) 355 (1%, M^+), 298 (2, M − C_4H_9), 264 (5, M − C_7H_7), 255 (20, M − [CO_2 + C_4H_8]), 254 (100, M − CO_2Bu^t), 209 (11), 208 (82), 108 (3, $C_8H_{12}^+$), 95 (9, $C_7H_{11}^+$), 91 (17, $C_7H_7^+$), 83 (8), 77 (7, $C_6H_5^+$), 69 (10), 55 (17).

NOE difference ($CDCl_3$) irradiation at δ 0.19 C-8 Me (enhances signal at δ 0.82 C-9 Me by +4.3%, δ 0.95 C-10 Me +2.4%, δ 1.72–1.80 4-H and 5-H_{exo} +1.2%, δ 1.93 3-H_{exo} +2.8%, δ 7.17–7.18 Phe Ar C*H* +2.0%), 0.82 C-9 Me (0.19 C-8 Me +3.1%, 1.57–1.68 6-H_{exo} +2.6%, 1.72–1.80 4-H and 5-H_{exo} +4.8%), 0.95 C-10 Me (0.19 C-8 Me +3.3%, 0.82 C-9 Me +1.6%, 7.17–7.18 Phe ArC*H* +2.0%), 1.07–1.17 5-H_{endo} (1.72–1.86 3-H_{endo}, 4-H and 5-H_{exo} +19.3%), 1.30–1.40 6-H_{endo} (1.57–1.86 3-H_{endo}, 4-H, 5-H_{exo} and 6-H_{exo} +15.6%), 1.57–1.68 6-H_{exo} (0.82 C-9 Me +3.25%, 0.95 C-10 Me +1.9%, 1.30–1.40 6-H_{endo} +1.25%), 1.72–1.86 3-H_{endo}, 4-H, 5-H_{exo} (0.82 C-9 Me +4.5%, 1.07–1.17 5-H_{endo} +13.6%, 1.88–1.98 3-H_{exo} +8.7%, 4.02 Phe α-CH +4.5%), 1.88–1.98 3-H_{exo} (1.74–1.82 3-H_{endo}, 4-H and 5-H_{exo} +5.4%, 4.02 Phe α-CH +4.5%).

Temperature-dependence study (δ_H; $CDCl_3$).—As the temperature was lowered (only +60, 0 and −60 °C are recorded here), the following principal changes in chemical shift and multiplicity occurred; 0.19, s, C-8 Me (0.23 s, 0.11 s, −0.03 s), 0.82, s, C-9 Me (0.84 s, 0.79 s, 0.76 s), 0.95, s, C-10 Me (0.97 s, 0.92 s, 0.89 s), 1.44, s, Bu^t (no change), 3.05–3.17 very br m, Phe β-CH_a (3.06–3.17 very br m, 3.04–3.06 br m, 3.05 t, $^2J_{\beta\text{-}CHa,CHb}$ 12), 3.25, dd, Phe β-CH_b (3.25 dd, 3.26 dd, 3.27 br d), 4.02, dd, Phe α-CH (4.27 dd, 4.13 dd, 4.00 br d) (δ_C; $CDCl_3$). The broadened signals at δ_C 38.8, 46.6 and 54.1 in the ambient-temperature spectrum became sharp at 60 °C.

***tert*-Butyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*R*)-phenylalaninate 5l {*tert*-butyl (*R*)-3′-phenyl-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)propanoate}.** *tert*-Butyl (*R*)-phenylalaninate hydrochloride **4l** (1.289 g, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *tert-butyl N-[(1R,2E,4R)-bornan-2-ylidene]-(R)-phenylalaninate* **5l** as white crystals (1.227 g, 69%), mp 72–74 °C (lit.,[12] 69–72 °C); $[a]_D^{24}$ +100.6 (*c* 0.50 in 95% EtOH) [lit.,[12] $[a]_D^{26}$ +86.5 (*c* 10 in 95% EtOH)] [Found: C, 77.7; H, 9.3; N, 4.0. Calc. for $C_{23}H_{33}NO_2$: C, 77.7; H, 9.4; N, 3.9%. Found: *m/z* (EI) M^+, 355.25109. Calc. for $C_{23}H_{33}NO_2$: *M*, 355.25113, deviation 0.1 ppm]; ν_{max}(film)/cm^{-1} 3065w, 3032w, 2960s, 2877m, 1736s (C=O str), 1684s (C=N str), 1490w, 1452m, 1391w, 1369m, 1284m, 1252w, 1218w, 1152s, 746w, 699m; δ_H(300 MHz; $CDCl_3$) 0.62 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.0, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.0, $^3J_{5\text{-}endo,6\text{-}exo}$ 4.0, 5-H_{endo}), 0.71 (3H, s, C-8 Me), 0.83 (3H, s, C-9 Me), 0.95 (3H, s, C-10 Me), 0.98 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.0, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.0, 6-H_{endo}), 1.07 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.5, 3-H_{endo}), 1.41 (9H, s, Bu^t), 1.47 (1H, partially submerged dt, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 12.0, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.0, 6-H_{exo}), 1.55–1.66 (1H, complex m, 5-H_{exo}), 1.69 (1H, apparent t, $^3J_{4,3\text{-}exo}$ 4.0, $^3J_{4,5\text{-}exo}$ 4.2, 4-H), 2.19 (1H, overlapping ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 17.0, $^3J_{4,3\text{-}exo}$ 4.0, $^4J_{3,5\text{-}exo}$ 3.5, 3-H_{exo}), 3.015 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.2, $^3J_{\beta\text{-}CHa,\alpha\text{-}CH}$ 10.0, Phe β-CH^aCH^b), 3.235 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.2, $^3J_{\beta\text{-}CHb,\alpha\text{-}CH}$ 4.0, Phe β-CH^aCH^b), 3.99 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 10.0, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 4.0, Phe α-CH), 7.16–7.17 (5H, 2 × apparent s, Phe aryl CH); δ_C(75.5 MHz; $CDCl_3$) 11.5 (C-10), 18.8 (C-9), 19.4 (C-8), 27.1 (C-5), 28.0 (Bu^t CMe_3), 31.7 (C-6), 35.8 (C-3), 38.6 (Phe β-CH_2), 43.5 (C-4), 47.0 (C-7), 53.9 (C-1), 66.6 (Phe α-CH), 80.8 (Bu^t *C*Me_3), 126.1 (Phe *p*-CH), 128.0 (Phe *m*-CH), 129.8 (Phe *o*-CH), 138.9 (Phe *i*-C), 171.0 (C=O), 184.9 (C=N); *m/z* (EI) 356 (7%, MH^+), 298 (2, M − C_4H_9), 264 (47, M − C_7H_7), 255 (67, M − [CO_2 + C_4H_8]), 254 (99, M − CO_2Bu^t), 209 (55), 208 (100), 164 (9, M − [C_7H_7 + CO_2Bu^t]), 108 (7, $C_8H_{12}^+$), 95 (21, $C_7H_{11}^+$), 91 (33, $C_7H_7^+$), 77 (16, $C_6H_5^+$), 69 (17), 57 (46).

Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-tyrosinate 5m {methyl (*S*)-3′-(4-hydroxyphenyl)-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)propanoate}. Methyl (*S*)-tyrosinate hydrochloride **4m** (1.158 g, 5 mmol) was used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S)-tyrosinate* **5m**, as white, needle-shaped crystals (1.153 g, 70%), mp 48.0–49.0 °C; $[a]_D^{25.5}$ −131.7 (*c* 0.50 in DCM) [Found: C, 72.7; H, 8.3; N, 4.35. Calc. for $C_{20}H_{27}NO_3$: C, 72.9; H, 8.3; N, 4.25%. Found: *m/z* (EI) M^+, 329.19981. Calc. for $C_{20}H_{27}NO_3$: *M*, 329.19909, deviation 2.2 ppm]; ν_{max}(film)/cm^{-1} 3600–2800br (OH str), 3033m, 2958s, 1739s (C=O str), 1671s (C=N str), 1513m, 1446m, 1372m, 736m; δ_H(300 MHz; $CDCl_3$) 0.27 (3H, s, C-8 Me), 0.83 (3H, s, C-9 Me), 0.97 (3H, s, C-10 Me), 1.10–1.20 (1H, complex m, 5-H_{endo}), 1.365 (1H, complex ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 13.0, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.2, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.0, 6-H_{endo}), 1.57–1.68 (1H, complex dt, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 13.0, $^3J_{6\text{-}exo,5\text{-}endo}$ 3.8, 6-H_{exo}), 1.72–1.82 (2H, overlapping complex m, 4-H, 5-H_{exo}), 1.815 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 17.0, 3-H_{endo}), 1.99 (1H, dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 17.0, $^3J_{4,3\text{-}exo}$ and $^4J_{3\text{-}exo,5\text{-}exo}$ 3.5, 3-H_{exo}), 3.05 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.2, $^3J_{\beta\text{-}CHa,\alpha\text{-}CH}$ 10.0, Tyr β-CH^aCH^b), 3.21 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.2, $^3J_{\beta\text{-}CHb,\alpha\text{-}CH}$ 4.3, Tyr β-CH^aCH^b), 3.685 (3H, s, CH_3O_2C), 4.16 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 10.0, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 4.3, Tyr α-CH), 6.4–6.6 (1H, br, OH), 6.71 and 7.04 (2H, d, ^3J 8.0, Ar *m*-H] and 2H, d, ^3J 8.0, Ar *o*-H], AA′BB′, Tyr); δ_C(75.5 MHz; $CDCl_3$) 11.3 (C-10), 18.8 (C-9), 19.0 (C-8), 27.2 (C-5), 31.8 (C-6), 36.2 (C-3), 38.1 (Tyr β-CH_2), 43.7 (C-4), 47.0 (C-7), 52.1 (OCH_3), 54.6 (C-1), 66.4 (Tyr α-CH), 115.3 (Tyr 3′-CH), 129.6 (Tyr 1′-C), 130.5 (Tyr

††† Spectroscopic evidence for this homogeneous compound indicates some conformational restriction.

2′-CH), 154.9 (Tyr 4′-C), 172.1 (C=O), 186.1 (C=N); *m/z* (EI) 329 (4%, M^+), 301 (3), 270 (20, $M - CO_2Me$), 222 (100, $M - C_7H_7O$), 194 (16), 162 (4), 137 (7), 107 (6, $C_7H_7O^+$), 83 (11), 69 (7), 55 (3).

Racemic camphorylidene α-amino ester derivative

Racemic ethyl *N*-[(1*R*,2*E*,4*R* and 1*S*,2*E*,4*S*)-bornan-2-ylidene]glycinate 5o {racemic ethyl ([1*R*,2*E*,4*R* and 1*S*,2*E*,4*S*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)acetate}. (±)-Camphor imine nitrate salt **2a** (1.07 g, 5 mmol) and ethyl glycinate hydrochloride **4a** (0.70 g, 5 mmol) were used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, racemic *ethyl N-[(1R,2E,4R and 1S,2E,4S)-bornan-2-ylidene]glycinate* **5o**, as a pale yellow oil (753 mg, 63%), ν_{max}(film)/cm^{-1} 2962s, 2880s, 1747s (C=O str), 1689s (C=N str), 1473m, 1448s, 1392m, 1372s, 1339m, 1184s; δ_H(300 MHz; $CDCl_3$) 0.70 (3H, s, C-8 Me), 0.84 (3H, s, C-9 Me), 0.91 (3H, s, C-10 Me), 1.07–1.16 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.5, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.0, $^3J_{5\text{-}endo,6\text{-}exo}$ 4.0, 5-H_{endo}), 1.160 and 1.163 (3H, t, *J* 7.0, $CH_3CH_2O_2C$),‡‡‡ 1.25–1.37 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 14.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.0, 6-H_{endo}), 1.58 (1H, dt, $^2J_{6\text{-}exo,6\text{-}endo}$ 14.5, $^3J_{6\text{-}exo,5\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 4.0, 6-H_{exo}), 1.72 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 17.0, 3-H_{endo}), 1.71–1.83 (1H, m, 5-H_{exo}), 1.86 (1H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.0, 4-H), 2.23 (1H, dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 17.0, $^3J_{3\text{-}exo,4}$ and $^4J_{3\text{-}exo,5\text{-}exo}$ 4.0, 3-H_{exo}), 3.70 and 3.77 (2H, 2 × s, NCH_2),§§ 4.065 and 4.071 (2H, q, *J* 7.0, $CH_3CH_2O_2C$);‡‡‡ δ_C(75.5 MHz; $CDCl_3$) 11.1 (C-10), 14.1 (Gly, OCH_2CH_3), 18.9 (C-9), 19.4 (C-8), 27.3 (C-5), 31.9 (C-6), 35.6 (C-3), 43.8 (C-4), 47.2 (C-7), 53.8 (Gly, α-CH_2), 54.1 (C-1), 60.6 (Gly, OCH_2CH_3), 170.2 (C=O), 187.4 (C=N).

Diastereomeric camphorylidene α-amino ester derivatives

Diastereomeric methyl *N*-[(1*R*,2*E*,4*R* and 1*S*,2*E*,4*S*)-bornan-2-ylidene]-(*S*)-leucinate 5p {diastereomeric methyl (*S*)-4′-methyl-2′-([1*R*,2*E*,4*R* and 1*S*,2*E*,4*S*]-1,7,7-trimethylbicyclo-[2.2.1]heptan-2-ylideneamino)pentanoate}. (±)-Camphor imine nitrate salt **2a** (1.07 g, 5 mmol) and methyl (*S*)-leucinate hydrochloride **4d** (908 mg, 5 mmol) were used in the general procedure using MeOH (20 cm^3) as co-solvent and gave the product, *methyl N-[(1R,2E,4R and 1S,2E,4S)-bornan-2-ylidene]-(S)-leucinate* **5p**, as a clear oil (251 mg, 18%), ν_{max}(film)/cm^{-1} 2962s, 2876s, 1745s (C=O str), 1687s (C=N str), 1475m, 1450m, 1419w, 1391m, 1373m, 1314m, 1278m, 1199m, 1168m; δ_H(300 MHz; $CDCl_3$) 0.74/0.78 (6H, s, C-8 Me), 0.82/0.85 [6H, d, $^3J_{(Mea,\gamma\text{-}CH)}$ 6.7, Leu δ-Me_a], 0.92/0.93 [6H, d, $^3J_{(Meb,\gamma\text{-}CH)}$ 3.6, Leu δ-Me_b], 0.92/0.94 (6H, s, C-9 Me), 0.99 (6H, s, C-10 Me), 1.15–1.24 (2H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.5, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.0, $^3J_{5\text{-}endo,6\text{-}exo}$ 4.0, 5-H_{endo}), 1.27–1.37 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.6, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.0, 6-H_{endo}), 1.36–1.46 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 13.2, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.2, 6-H_{endo}), 1.51–1.93 (12H, series of continuously overlapping complex multiplets, 6-H_{exo}, Leu γ-CH, Leu β-CH_2, 5-H_{exo} and 3-H_{endo}), 1.94 (2H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.2, 4-H), 2.35 (1H, overlapping complex ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.5, $^3J_{3\text{-}exo,4}$ 4.2, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.2, 3-H_{exo}), 2.42 (1H, overlapping complex ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.5, $^3J_{3\text{-}exo,4}$ 4.2, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.2, 3-H_{exo}), 3.66/3.68 (6H, s, CH_3O_2C), 3.96–4.40 (2H, complex m, Leu α-CH); δ_C(75.5 MHz; $CDCl_3$) 11.3/11.4 (C-10), 18.9/19.0 (C-9), 19.4/19.5 (C-8), 21.6/21.8 (Leu δ-Me_a), 23.2/23.3 (Leu δ-Me_b), 24.70/24.74 (Leu γ-CH), 27.3/27.5 (C-5), 31.8/32.3 (C-6), 35.8/36.1 (C-3), 41.8/42.0 (Leu β-CH_2), 43.86/43.90 (C-4), 46.8/47.3 (C-7), 51.77/51.84 (OCH_3), 54.2 (C-1), 62.54/62.58 (Leu α-CH), 173.1 (C=O), 185.3 (C=N).

‡‡‡ The ^{1}H NMR signals of the ethyl ester group are split, presumably due to a conformational effect. Note: the downfield quartet and triplet are of lower intensity than the upfield component; this is in contradistinction to the corresponding behaviour of ethyl (*R*,*R*)-camphorylideneglycinate (see above).

Diastereomeric diethyl *N*-[(1*R*,2*E*,4*R* and 1*S*,2*E*,4*S*)-bornan-2-ylidene]-(*S*)-glutamate 5q {diasteromeric diethyl (*S*)-2′-([1*R*,2*E*,4*R* and 1*S*,2*E*,4*S*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)pentanedioate}. (±)-Camphor imine nitrate salt **2a** (1.07 g, 5 mmol) and diethyl (*S*)-glutamate hydrochloride **4g** (1.20 g, 5 mmol) were used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, diastereomeric *diethyl N-[(1R,2E,4S and 1S,2E,4S)-bornan-2-ylidene]-(S)-glutamate* **5r**, as a pale yellow oil (1.12 g, 66%), ν_{max}(film)/cm^{-1} 2962s, 2878m, 1741s (C=O str), 1685s (C=N str), 1448m, 1391m, 1374s, 1301m, 1257s, 1180s; δ_H(300 MHz; $CDCl_3$) 0.70/0.75 (6H, s, C-8 Me), 0.87/0.88 (6H, s, C-9 Me), 0.93 (6H, s, C-10 Me), 1.09–1.22 (2H, submerged complex m, 5-H_{endo}), 1.164/1.177 [6H, 2 × t, $^3J_{(CH_2,Me)}$ 7.0, γ-$CO_2CH_2CH_3$], 1.188/1.193 [6H, 2 × t, $^3J_{(CH_2,Me)}$ 7.0, α-$CO_2CH_2CH_3$], 1.29/1.36 (2H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.5, 6-H_{endo}), 1.57–1.69 (2H, 2 × overlapping ddd [resembles tt], $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 12.5, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.5, 6-H_{exo}), 1.74–1.87 (2H, complex m, 5-H_{exo}), 1.80/1.84 (2H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.7, 3-H_{endo}), 1.88/1.89 (2H, t, $^3J_{4,3\text{-}exo}$ and $^3J_{4,5\text{-}exo}$ 4.6, 4-H), 2.01–2.39 (10H, overlapping complex m, Glu β-CH_2, Glu γ-CH_2 and 3-H_{exo}), 3.93/3.95 (2H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 9.0, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 4.6 and 4.0, Glu α-CH), 4.025/4.064 [4H, q, $^3J_{(CH_2,Me)}$ 7.0, γ-$CO_2CH_2CH_3$], 4.073/4.083 and 4.075/4.088 [4H, q, $^3J_{(CH_2,Me)}$ 7.0, α-$CO_2CH_2CH_3$].‖‖ Spectra recorded at 30, 80 and 140 °C showed no change in chemical shift or multiplicity apart from a sharpening of some of the multiplets; δ_C(75.5 MHz; $CDCl_3$) 11.2/11.3 (C-10), 14.07 (Glu γ-$CO_2CH_2CH_3$), 14.14/14.18 (Glu α-$CO_2CH_2CH_3$), 18.8/18.9 (C-9), 19.37/19.44 (C-8), 27.3/27.4 (C-5), 27.7/27.9 (Glu β-CH_2), 30.3/30.4 (Glu γ-CH_2), 31.8/32.3 (C-6), 35.8/36.0 (C-3), 43.8/43.9 (C-4), 46.6/47.3 (C-7), 54.1/54.3 (C-1), 60.16/60.21 (Glu γ-CO_2-CH_2CH_3), 60.7 (Glu α-$CO_2CH_2CH_3$), 62.5/62.8 (Glu α-CH), 171.58/171.62 (γ-C=O), 173.15/173.18 (α-C=O), 186.27/186.28 (C=N).

Diastereomeric methyl *N*-[(1*R*,2*E*,4*R* and 1*S*,2*E*,4*S*)-bornan-2-ylidene]-(*S*)-methioninate 5r {diastereomeric methyl (*S*)-2′-([1*R*,2*E*,4*R* and 1*S*,2*E*,4*S*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylideneamino)-5′-thiahexanoate}. (±)-Camphor imine nitrate salt **2a** (1.07 g, 5 mmol) and methyl (*S*)-methioninate hydrochloride **4h** (998 mg, 5 mmol) were used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, diastereomeric *methyl N-[(1R,2E,4R and 1S,2E,4S)-bornan-2-ylidene]-(S)-methioninate* **5r**, as a pale straw-coloured oil (684 mg, 46%); ν_{max}(film)/cm^{-1} 2959s, 2877m, 1744s (C=O str), 1686s (C=N str), 1439m, 1391m, 1376w, 1276m, 1226m, 1201s, 1162m; δ_H(300 MHz; $CDCl_3$) 0.71/0.76 (6H, s, C-8 Me), 0.89 (6H, s, C-9 Me), 0.94 /0.95 (6H, s, C-10 Me), 1.12–1.31 (2H, complex overlapping m, 5-H_{endo}), 1.33–1.43 (2H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 13.2, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.0, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.5, 6-H_{endo}), 1.58–1.71 (2H, complex td, 6-H_{exo}), 1.75–1.87, (2H, complex m, 5-H_{exo}), 1.85 (2H, br d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.8, 3-H_{endo}), 1.87–1.93 (2H, complex br m, 4-H), 2.02/2.04 (6H, s, Met ε-Me), 2.08–2.19 (4H, complex m, Met γ-CH_2), 2.30–2.58 (6H, overlapping complex m, Met β-C$H^a$$H^b$, 3-$H_{exo}$, Met β-C$H^a$$H^b$), 3.63/3.65 (6H, s, CH_3O_2C), 4.08–4.15 (2H, complex m, Met α-CH); δ_C(75.5 MHz; $CDCl_3$) 11.3/11.4 (C-10), 15.1/15.2 (Met ε-Me), 18.8/19.0 (C-9), 19.4/19.5 (C-8), 27.3/27.4 (C-5), 30.6/30.7 (Met γ-CH_2), 31.5/31.6 (Met β-CH_2), 32.5 (C-6), 36.0/36.2 (C-3), 43.9 (C-4), 46.7/47.3 (C-7), 51.8/51.9 (OCH_3), 54.2 (C-1), 62.0/62.1 (Met α-CH), 172.46/172.50 (C=O), 186.5/186.6 (C=N).

Epimeric methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S* and *R*)-phenylalaninate 5s {diastereomeric methyl (*S* and *R*)-3′-phenyl-2′-([1*R*,2*E*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-ylidene-amino)propanoate}. (*R*,*R*)-Camphor imine nitrate salt **2a** (1.07 g, 5 mmol) (after conversion into the free base) and racemic methyl phenylalaninate hydrochloride **4i** (1.078 g, 5 mmol) were

used in the general procedure using DCM (20 cm^3) as co-solvent and gave the product, diastereomeric *methyl N-[(1R,2E,4R)-bornan-2-ylidene]-(S and R)-phenylalaninate* **5s**, as a clear oil (1.128 g, 72%) [Found: *m/z* (EI) M^+, 313.20459. Calc. for $C_{20}H_{27}NO_2$: *M*, 313.20418, deviation 1.3 ppm]; ν_{max}(film)/cm^{-1} 3068w, 3029w, 2958s, 2880m, 1745s (C=O str), 1681m (C=N str), 1604w, 1495w, 1454m, 1440m, 1389m, 1371w, 1277m, 1244m, 1200m, 1169m, 748m, 699m; δ_H(300 MHz; $CDCl_3$)§§§ for (*R*,*R*)-Camphor–(*S*)-phenylalanine adduct, 0.16 (3H, s, C-8 Me), 0.83 (3H, s, C-9 Me), 0.93 (3H, s, C-10 Me), 1.07–1.17 (1H, complex m, 5-H_{endo}), 1.33 (1H, overlapping ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.5, $^3J_{6\text{-}endo,5\text{-}exo}$ 4.0, 6-H_{endo}), 1.54–1.67 (1H, overlapping complex m, 6-H_{exo}), 1.73–1.77 (2H, overlapping complex m, 4-H, 5-H_{exo}), 1.765 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 16.8, 3-H_{endo}), 1.895 (1H, dt, $^2J_{3\text{-}exo,3\text{-}endo}$ 16.8, $^3J_{3\text{-}exo,4}$ and $^4J_{3\text{-}exo,5\text{-}exo}$ 4.0, 3-H_{exo}), 3.09 (1H, dd, $^2J_{\beta\text{-}CHa,CHb}$ 13.5, $^3J_{\beta\text{-}CHa,\alpha\text{-}CH}$ 9.5, Phe β-C*H*^{a}H^b), 3.29 (1H, dd, $^2J_{\beta\text{-}CHa,Hb}$ 13.5, $^3J_{\beta\text{-}CHb,\alpha\text{-}CH}$ 4.0, Phe β-CH^a*H*^{b}), 3.70 (3H, s, CH_3O_2C), 4.155 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 9.5, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 4.0, Phe α-CH), 7.08–7.26 (5H, complex m, Phe aryl CH); (*R*,*R*)-Camphor–(*R*)-phenylalanine adduct, 0.60 (1H, overlapping ddd, $^2J_{5\text{-}endo,5\text{-}exo}$ 12.0, $^3J_{5\text{-}endo,6\text{-}endo}$ 9.4, $^3J_{5\text{-}endo,6\text{-}exo}$ 4.0, 5-H_{endo}), 0.69 (3H, s, C-8 Me), 0.80 (3H, s, C-9 Me), 0.96 (3H, s, C-10 Me), 0.99 (1H, ddd, $^2J_{6\text{-}endo,6\text{-}exo}$ 12.5, $^3J_{6\text{-}endo,5\text{-}endo}$ 9.4, $^3J_{6\text{-}endo,5\text{-}exo}$ 5.0, 6-H_{endo}), 1.07 (1H, d, $^2J_{3\text{-}endo,3\text{-}exo}$ 17.0, 3-H_{endo}), 1.48 (1H, dt, $^2J_{6\text{-}exo,6\text{-}endo}$ and $^3J_{6\text{-}exo,5\text{-}exo}$ 12.0, $^3J_{6\text{-}exo,5\text{-}endo}$ 4.0, 6-H_{exo}), 1.54–1.67 (1H, overlapping complex m, 5-H_{exo}), 1.70 (1H, apparent t, $^3J_{4,3\text{-}exo}$ 4.5, $^3J_{4,5\text{-}exo}$ 4.6, 4-H), 2.185 (1H, overlapping ddd, $^2J_{3\text{-}exo,3\text{-}endo}$ 17.0, $^3J_{3\text{-}exo,4}$ 4.5, $^4J_{3\text{-}exo,5\text{-}exo}$ 3.1, 3-H_{exo}), 3.055 (1H, dd, $^2J_{\beta\text{-}CHa,Hb}$ 13.3, $^3J_{\beta\text{-}CHa,\alpha\text{-}CH}$ 9.8, Phe β-C*H*^{a}H^b), 3.275 (1H, dd, $^2J_{\beta\text{-}CHa,Hb}$ 13.3, $^3J_{\beta\text{-}CHb,\alpha\text{-}CH}$ 3.9, Phe β-CH^a*H*^{b}), 3.69 (3H, s, CH_3O_2C), 4.12 (1H, dd, $^3J_{\alpha\text{-}CH,\beta\text{-}CHa}$ 9.8, $^3J_{\alpha\text{-}CH,\beta\text{-}CHb}$ 3.9, Phe α-CH), 7.08–7.26 (5H, complex m, Phe aryl CH); δ_C(75.5 MHz; $CDCl_3$) (*R*,*R*)-Camphor–(*S*)-phenylalanine adduct, 11.3 (C-10), 18.8 (C-9), 18.9 (C-8), 27.2 (C-5), 31.8 (C-6), 35.9 (C-3), 39.3 (Phe β-CH_2), 43.7 (C-4), 46.6 (C-7), 52.0 (OCH_3), 54.2 (C-1), 66.0 (Phe α-CH), 126.3 (Phe *p*-CH), 128.2 (Phe *m*-CH), 129.5 (Phe *o*-CH), 138.4 (Phe *i*-C), 172.4 (C=O), 185.8 (C=N); (*R*,*R*)-Camphor–(*R*)-phenylalanine adduct, 11.4 (C-10), 18.8 (C-9), 19.3 (C-8), 27.1 (C-5), 31.8 (C-6), 35.7 (C-3), 39.0 (Phe β-CH_2), 43.5 (C-4), 47.0 (C-7), 52.0 (OCH_3), 54.1 (C-1), 66.3 (Phe α-CH), 126.2 (Phe *p*-CH), 128.1 (Phe *m*-CH), 129.8 (Phe *o*-CH), 138.5 (Phe *i*-C), 172.2 (C=O), 185.6 (C=N); *m/z* (EI) 313 (2%, M^+), 254 (15, M − CO_2Me), 223 (15), 222 (100, M − C_7H_7), 162 (3, [{M − 90} − 59]), 121 (7), 95 (4, $C_7H_{11}^+$), 91 (7, $C_7H_7^+$), 77 (3, $C_6H_5^+$), 55 (3).

General procedure for the reduction of camphorylidene α-amino acid ester derivatives to the corresponding *N*-bornanyl amino acid ester derivatives[25]

A few crystals of Bromocresol Green indicator were added to a solution of the (*R*,*R*)-camphorylidene α-amino acid ester **5** (1 mmol) and sodium cyanoborohydride (4 mmol) in dry methanol (12 cm^3) under argon. The reaction mixture was stirred at ambient temperature and titrated dropwise with conc. hydrochloric acid so as to maintain the pH below 4 (indicator blue–green to yellow) for 4 days. A small amount of amorphous material was removed by filtration, and the filtrate was diluted with water (25 cm^3), basified with 2 M aq. potassium hydroxide, and extracted thoroughly with DCM (5 × 10 cm^3). The organic phases were pooled, dried (K_2CO_3), and filtered, and the filtrate was evaporated *in vacuo* to give a syrup, which was purified by flash chromatography (light petroleum [60–80 °C]–ethyl acetate 90:10). Combination and concentration of the appropriate fractions gave the desired product pure by TLC.

Ethyl *N*-[(1*R*,4*R*)-*exo*-bornan-2-yl]glycinate 6a {ethyl *N*-([1*R*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-*exo*-ylamino)-acetate}. Ethyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]glycinate **5a** and sodium cyanoborohydride gave the product, *ethyl N-[(1R,4R)-exo-bornan-2-yl]glycinate* **6a**, as a pale yellow oil (120 mg, 50%) [Found: *m/z* (EI) M^+, 239.18803. Calc. for $C_{14}H_{25}NO_2$: *M*, 239.18853, deviation 2.1 ppm]; ν_{max}(film)/cm^{-1} 3360w (N-H str), 2975s, 2880s, 1750s (C=O str), 1453m, 1377m, 1200s; δ_H(300 MHz; $CDCl_3$) 0.76 (3H, s, C-9 Me), 0.87 (3H, s, C-10 Me), 0.99 (3H, s, C-8 Me), 0.95–1.05 (2H, m, 5-H_{endo} and 6-H_{endo}), 1.22 (3H, t, *J* 7.0, C*H*$_3$CH$_2$O$_2$C), 1.39–1.55 (4H, complex m, 3-H_{endo}, 4-H, 5-H_{exo} and 6-H_{exo}), 1.60–1.65 (2H, br m, 3-H_{exo} and NH), 2.44 (1H, t, $^3J_{2\text{-}endo,3\text{-}endo}$ and $^3J_{2\text{-}endo,3\text{-}exo}$ 6.8, 2-H_{endo}), 3.23 and 3.29 (2H, 2 × complex d, $^2J_{\alpha\text{-}CHa,CHb}$ 17.0, AB system NCH^{a}H^b), 4.13 (2H, q, *J* 7.0, CH_3C*H*$_2$O$_2$C); δ_H(300 MHz; C_6D_6)¶¶¶ 0.77 (3H, s, C-9 Me), 0.89 (3H, s, C-10 Me), 0.94 (3H, t, *J* 7.0, C*H*$_3$CH$_2$O$_2$C), 0.94–1.02 (2H, m, 5-H_{endo} and 6-H_{endo}), 1.15 (3H, s, C-8 Me), 1.38–1.62 (6H, c overlapping m, 3-H_{endo}, 3-H_{exo}, 4-H, 5-H_{exo}, 6-H_{exo} and NH), 2.45 (1H, dd, $^3J_{2\text{-}endo,3\text{-}endo}$ 8.0, $^3J_{2\text{-}endo,3\text{-}exo}$ 4.8, 2-H_{endo}), 3.16 and 3.23 (2H, 2 × complex d, $^2J_{\alpha\text{-}CHa,CHb}$ 17.0, AB system NCH^{a}H^b), 3.93 (2H, q, *J* 7.0, CH_3C*H*$_2$O$_2$C);‖‖‖‖‖‖ δ_C(75.5 MHz; $CDCl_3$) 11.9 (C-10), 14.2 (Gly, OCH_2CH_3), 20.3 (C-9), 20.5 (C-8), 27.3 (C-5), 36.7 (C-6), 38.3 (C-3), 45.2 (C-4), 46.7 (C-7), 48.4 (C-1), 49.9 (Gly, α-CH_2), 60.4 (Gly, O*C*H$_2$CH$_3$), 66.5 (C-2), 173.0 (C=O); δ_C(75.5 MHz; C_6D_6) 12.2 (C-10), 14.3 (Gly, OCH_2CH_3), 20.7 (C-9), 20.9 (C-8), 27.8 (C-5), 37.0 (C-6), 38.7 (C-3), 45.8 (C-4), 47.0 (C-7), 48.7 (C-1), 50.2 (Gly, α-CH_2), 60.4 (Gly, O*C*H$_2$CH$_3$), 66.9 (C-2), 172.7 (C=O); *m/z* (EI), 239 (5%, M^+), 168 (25), 166 (25, M − CO_2Et), 137 (8), 116 (9, $C_8H_{12}^+$), 95 (63, $C_7H_{11}^+$), 81 (37), 67 (65), 56 (100).[36]

NOE difference (C_6D_6) irradiation at δ 0.77 C-9 Me (enhances signal at δ 1.15 C-8 Me by +3.3%, δ 1.41–1.48 +2.2% and δ 1.56–1.65 +3.6%, probably due to 4-H, 5-H_{exo} and 6-H_{exo}), 0.89 C-10 Me (0.77 C-9 Me +1.5%, 1.15 C-8 Me +0.9%, 1.57–1.61 +3.8%, probably NH and 6-H_{exo}), 1.15 C-8 Me (0.77 C-9 Me +3.1%, 0.89 C-10 Me +1.0%, 1.57–1.61 +2.5%, probably 3-H_{exo}, 4-H and NH), 2.45 2-H_{endo} (0.93–1.01 +4.1%, 5-H_{endo} and 6-H_{endo}, 1.39–1.45 +1.2% and 1.56–1.59 +1.5%, probably 3-H_{endo} and NH).

Methyl *N*-[(1*R*,4*R*)-*exo*-bornan-2-yl]-(*S*)-alaninate 6b {methyl (*S*)-2′-([1*R*,4*R*]-1,7,7-trimethylbicyclo[2.2.1]heptan-2-*exo*-ylamino)propanoate}. Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-alaninate **5b** and sodium cyanoborohydride gave the product, *methyl N-[(1R,4R)-exo-bornan-2-yl]alaninate* **6b**, as a yellow oil (108 mg, 45%) [Found: *m/z* (EI) M^+, 239.18769. Calc. for $C_{14}H_{25}NO_2$: *M*, 239.18853, deviation 3.5 ppm]; ν_{max}(film)/cm^{-1} 3325w (N-H str), 2952s, 2875m, 1736s (C=O str), 1448m, 1387w, 1369w, 1198s; δ_H(300 MHz; $CDCl_3$) 0.79 (3H, s, C-9 Me), 0.87 (3H, s, C-10 Me), 1.05 (3H, s, C-8 Me), 0.98–1.08 (2H, m, 5-H_{endo} and 6-H_{endo}), 1.22 [3H, d, $^3J_{(Me,\alpha\text{-}CH)}$ 6.8, Ala β-CH_3], 1.40–1.52 and 1.54–1.72 (5H, complex m, 3-H_{endo}, 3-H_{exo}, 4-H, 5-H_{exo} and 6-H_{exo}), 1.68–1.93 (1H, very br, NH), 2.42 (1H, dd, $^3J_{2\text{-}endo,3\text{-}endo}$ 7.8, $^3J_{2\text{-}endo,3\text{-}exo}$ 4.8, 2-H_{endo}), 3.30 [1H, q, $^3J_{(\alpha\text{-}CH,Me)}$ 6.8, Ala α-CH], 3.69 (3H, s, CH_3O_2C); δ_C(75.5 MHz; $CDCl_3$) 11.8 (C-10), 19.8 (Ala β-CH_3), 20.5 (C-9), 20.5 (C-8), 27.3 (C-5), 36.8 (C-6), 38.0 (C-3), 45.4 (C-4), 46.7 (C-7), 48.2 (C-1), 51.5 (OCH_3), 54.2 (Ala α-CH), 64.3 (C-2) and 176.9 (C=O); *m/z* (EI) 239 (4%, M^+), 208 (10, M − OMe), 180 (26, M − CO_2Me), 137 (12, 180–C_2H_5N), 95 (34, $C_7H_{11}^+$), 83 (29), 57 (100).

Methyl *N*-[(1*R*,4*R*)-*exo*-bornan-2-yl]-(*S*)-isoleucinate 6e {methyl (2′*S*,3′*S*)-3′-methyl-2′-([1*R*,4*R*]-1,7,7-trimethylbicyclo-[2.2.1]heptan-2-*exo*-ylamino)pentanoate}. Methyl *N*-[(1*R*,2*E*,

§§§ For simplicity, the spectral characterisation of this epimeric material has been recorded as the individual diastereomers and not as a composite.

¶¶¶ The effect of asymmetric solvation on the bornylamines is very much less marked than with the camphorylidene derivatives.

‖‖‖‖‖‖ The ester CH_2 signal is split by 0.6 Hz; a conformational effect may be responsible.

4*R*)-bornan-2-ylidene]-(2′*S*,3′*S*)-isoleucinate **5e** and sodium cyanoborohydride gave the product, *methyl N-[(1R,4R)-exo-bornan-2-yl]-(S)-isoleucinate* **6e**, as a clear oil (155 mg, 55%) [Found: *m/z* (EI) M^+, 281.23585. Calc. for $C_{17}H_{31}NO_2$: *M*, 281.23548, deviation 1.3 ppm]; ν_{max}(film)/cm^{-1} 3339w (N-H str), 2953s, 2877s, 1734s (C=O str), 1453m, 1433m, 1388w, 1195s; δ_H(300 MHz; $CDCl_3$) 0.80 (3H, s, C-9 Me), 0.85 (3H, s, C-10 Me), 0.855 [3H, t, $^3J_{(Me,\gamma\text{-}CH_2)}$ 6.4, Ile δ-Me], 1.02 [3H, d, $^3J_{(Me,\beta\text{-}CH)}$ 8.2, Ile γ-Me], 1.08 (3H, s, C-8 Me), 1.00–1.21 (3H, complex overlapping m, 5-H_{endo}, 6-H_{endo} and Ile γ-CH^aH^b), 1.37–1.61 and 1.62–1.72 (8H, complex overlapping m, 3-H_{endo}, 3-H_{exo}, 4-H, 5-H_{exo}, 6-H_{exo}, NH, Ile γ-CH^aH^b and Ile β-CH), 2.37 (1H, br dd, 2-H_{endo}), 2.95 (1H, br d, Ile α-CH), 3.70 (3H, s, CH_3O_2C); δ_C(75.5 MHz; $CDCl_3$) 11.1 (Ile δ-CH_3), 11.7 (C-10), 16.0 (Ile γ-CH_3), 20.5 (C-9), 20.5 (C-8), 25.2 (Ile γ-CH_2), 27.3 (C-5), 36.8 (C-6), 37.4 (C-3), 38.1 (Ile β-CH), 45.5 (C-4), 46.6 (C-7), 48.2 (C-1), 51.2 (OCH_3), 63.8 (Ile α-CH), 64.3 (C-2), 176.6 (C=O); *m/z* (EI) 281 (11%, M^+), 225 (9, M − C_4H_8), 222 (100, M − CO_2Me), 210 (29, M − $C_7H_{13}O_2$), 137 (35, 222 − $C_5H_{11}N$), 95 (54, $C_7H_{11}^+$), 81 (39), 69 (19), 57 (13).

Methyl *N*-[(1*R*,4*R*)-*exo*-bornan-2-yl]-(*S*)-phenylalaninate 6i {methyl (*S*)-3′-phenyl-2′-([1*R*,4*R*]-1,7,7-trimethylbicyclo-[2.2.1]hept-2-*exo*-ylamino)propanoate}. Methyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-phenylalaninate **5i** and sodium cyanoborohydride gave the product, *methyl N-[(1R,4R)-exo-bornan-2-yl]-(S)-phenylalaninate* **6i**, as a pale yellow oil (151 mg, 48%); ν_{max}(film)/cm^{-1} 3364w (N-H str), 2971s, 2875m, 1745s (C=O str), 1448m, 1382w, 1180s; δ_H(300 MHz; $CDCl_3$) 0.79 (3H, s, C-9 Me), 0.88 (3H, s, C-10 Me), 0.92 (3H, s, C-8 Me), 0.96–1.09 (2H, complex m, 5-H_{endo} and 6-H_{endo}), 1.36–1.53 (3H, complex overlapping m, 4-H, 5-H_{exo} and 6-H_{exo}), 1.59–1.68 (3H, complex m, 3-H_{endo}, 3-H_{exo} and NH), 2.43 (1H, t, *J* 6.2, 2-H_{endo}), 2.81 and 2.90 (2H, complex dd, second order AB part of ABX pattern, $^2J_{\beta\text{-}CH_a,CH_b}$ 13.3, Phe β-CH^aCH^b),**** 3.44 (1H, dd, X part of ABX system, $^3J_{\alpha CH,\beta CH_a}$ 7.5, $^3J_{\alpha CH,\beta CH_b}$ 6.5, Phe α-CH),[37] 3.66 (3H, s, CH_3O_2C), 7.15–7.32 (5H, complex m, Phe aryl CH); δ_C(75.5 MHz; $CDCl_3$) 11.8 (C-10), 20.3 (C-9), 20.6 (C-8), 27.3 (C-5), 36.8 (C-6), 37.6 (C-3), 40.5 (C-4), 45.4 (Phe β-CH_2), 46.6 (C-7), 48.2 (C-1), 51.4 (OCH_3), 60.6 (Phe α-CH), 64.1 (C-2), 126.4 (Phe *p*-CH), 128.1 (Phe *m*-CH), 129.3 (Phe *o*-CH), 138.0 (Phe *i*-C), 175.8 (C=O).

***tert*-Butyl *N*-[(1*R*,4*R*)-*exo*-bornan-2-yl]-(*S*)-phenylalaninate 6k {*tert*-Butyl (*S*)-3′-phenyl-2′-([1*R*,4*R*]-1,7,7-trimethylbicyclo-[2.2.1]hept-2-*exo*-ylamino)propanoate}.** *tert*-Butyl *N*-[(1*R*,2*E*,4*R*)-bornan-2-ylidene]-(*S*)-phenylalaninate **5k** and sodium cyanoborohydride gave the product, *tert-butyl N-[(1R,4R)-exo-bornan-2-yl]-(S)-phenylalaninate* **6k**, as a clear oil (161 mg, 45%) [Found: *m/z* (EI) M^+, 357.26710. Calc. for $C_{23}H_{35}NO_2$: *M*, 357.26678, deviation 0.8 ppm]; ν_{max}(film)/cm^{-1} 3325w (N-H str), 3065w, 3030w, 2951s, 2875s, 1723s (C=O str), 1476m, 1452m, 1367m, 1151s; δ_H(300 MHz; $CDCl_3$) 0.78 (3H, s, C-9 Me), 0.87 (3H, s, C-10 Me), 0.93 (3H, s, C-8 Me), 0.98 and 1.03 (2H, dd, $^3J_{5\text{-}endo,\ 6\text{-}endo}$ 10.0, 5-H_{endo} and 6-H_{endo}), 1.39 (9H, s, Bu^t), 1.38–1.55 (3H, complex overlapping m, 4-H, 5-H_{exo} and 6-H_{exo}), 1.58–1.71 (3H, br overlapping m, 3-H_{endo}, 3-H_{exo} and NH), 2.48 (1H, br t, $^3J_{2\text{-}endo,3\text{-}endo}$ and $^3J_{2\text{-}endo,3\text{-}exo}$ 6.0, 2-H_{endo}), 2.84 [2H, br d, $^3J_{(\beta\text{-}CH_2,\alpha\text{-}CH)}$ 6.0, Phe β-CH_2], 3.31 [1H, br t, $^3J_{(\alpha\text{-}CH,\beta\text{-}CH_2)}$ 6.0, Phe α-CH], 7.15–7.25 (5H, complex m, Phe aryl CH); δ_C(75.5 MHz; $CDCl_3$) 11.8 (C-10), 20.4 (C-9), 20.5 (C-8), 27.3 (C-5), 28.1 (Bu^t CMe_3), 36.9 (C-6), 37.6 (C-3), 40.3 (br Phe β-CH_2), 45.4 (C-4), 46.5 (C-7), 48.2 (C-1), 61.2 (Phe α-CH), 64.2 (br, C-2), 80.8 (Bu^t CMe_3), 126.3 (Phe *p*-CH), 128.0 (Phe *m*-CH), 129.5 (Phe *o*-CH), 138.2 (Phe *i*-C), 175.0 (br, C=O); *m/z* (EI) 358 (0.2%, M^+), 266 (20), 257 (20, M − CO_2Bu^t), 256 (100), 210 (78), 137 (64, 257 − $C_8H_{10}N$), 120 (52, $C_8H_{10}N^+$), 95 (36, $C_7H_{11}^+$), 91 (18, $C_7H_7^+$), 81 (54), 57 (16).

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