Synthesis, structure and comparative stability of β-hydrazono, oximino methyl ether and imino boronates

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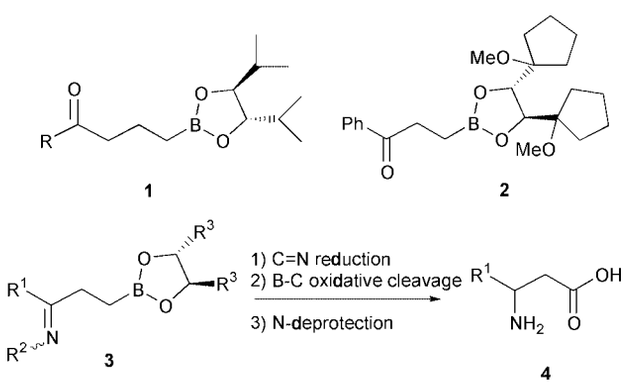
β-Hydrazono and oximino ether boronates have been prepared by the sequential lithiation of the corresponding methyl hydrazone or oxime methyl ether, followed by reaction with an iodomethylboronate ester, typically in the form of the pinacol ester. The resulting products have contrasting hydrolytic stabilities. β-Hydrazono boronates are highly sensitive to intramolecularly catalysed hydrolysis, providing the corresponding β-keto boronates in generally high yields; β-oximino ether boronates are stable to silica gel chromatography and show evidence of *E*–*Z*-isomerisation. Stable homochiral boronate ester derivatives of β-oximino ethers can be readily prepared by a double transesterification process, *via* a diethanolamine-mediated pinacol ester exchange, followed by diethanolamine ester hydrolysis–reesterification process with a homochiral diol. β-Imino boronates can be generated *in situ* by condensation of the corresponding β-keto boronate with a primary amine, however the resulting imine function is highly hydrolytically unstable and cannot be isolated in a pure form.

Introduction

Chiral boronate esters have been demonstrated to be useful for controlling the remote asymmetric reduction of carbonyl functions in γ-keto boronate substrates **1**[1] and β-keto boronate systems **2**,[2] to provide the corresponding chiral secondary alcohols with high asymmetric induction. In both cases, intramolecular boronate–ketone complexes are implicated in controlling the asymmetric reduction process.[3] By direct analogy with this method, we proposed that the 1,6-diastereoselective reduction of imine derivatives **3** (Scheme 1), could have potential application in the enantioselective synthesis of β-amino acids **4**.[4]



Scheme 1

Thus, an enantiomerically pure boronate system such as **3**, would be expected to react with hydride equivalents *via* an activated intramolecular B–N complex as shown in Fig. 1. Subsequent oxidative cleavage of the boronate directly to the carboxylic acid and removal of the nitrogen substituent (if not removed under the C=N reduction conditions) would provide an asymmetric route to β-amino acids **4**. Indeed, β-imino boronate ester compounds of general type **3** could reasonably be expected to be equal to, or more efficient than, their ketone counterparts **1** and **2** in directing remote asymmetric reduction

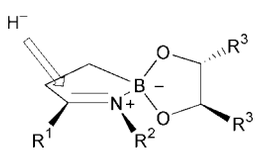


Fig. 1

due to enhanced boron–nitrogen chelation (Fig. 1), resulting from the increased lone pair basicity of nitrogen *versus* oxygen.

We therefore examined the suitability of different C=N equivalents for directed asymmetric reduction by means of a remote chiral boronate ester group and recently reported our preliminary results in this area.[5] In this paper, we report the full details about the synthesis and structure of different β-boronate C=N derivatives.

Results and discussion

β-Hydrazono boronates

In earlier work, we had prepared various β-boronate carbonyl systems *via* the alkylation of an enolate with an α-haloboronate ester[6] for application in stereocontrolled aldol reactions.[7] During this work, the application of hydrazone-stabilised anions was also developed in order to improve certain β-keto boronate syntheses.[6] However, such substrates are also potentially suitable for the reduction process proposed in Scheme 1, if the hydrazones were sufficiently stable. Thus we prepared a series of hydrazones **7** according to Scheme 2 and Table 1.

In all cases, the hydrazones **7** could not be isolated in a pure form direct from Scheme 2; complete or partial hydrolysis always occurred during the aqueous work-up of the reaction mixture, with further hydrolysis occurring upon silica gel chromatography. Presumably the hydrolysis is catalysed by the presence of the intramolecular boronate function assisting with the hydrolysis process, as shown in Fig. 2, involving chelation of the dimethylamino function (binding to the C=N function cannot be ruled out as an alternative mode of hydrazone

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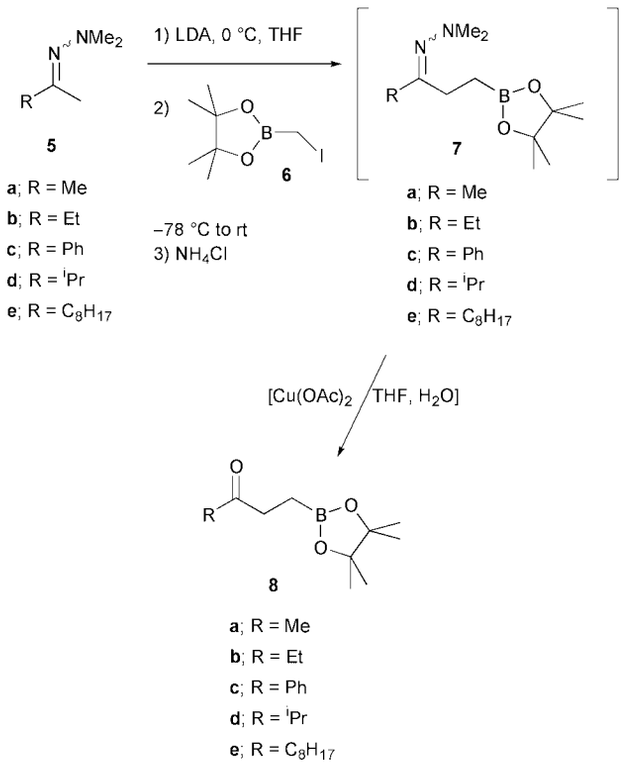
Table 1

Entry	R	Yield of **8** (%)[a]	$Cu(OAc)_2$ required
1	Me	59	No
2	Et	66	No
3	Ph	75	Yes
4	^{i}Pr	51	No
5	C_8H_{17}	35	Yes

[a] Isolated yield after silica gel chromatography.



Scheme 2

activation). The intramolecular intervention of the boronate moiety is reinforced by the ^{11}B NMR studies on crude system **7a** (after a non-aqueous work-up), which exhibited a resonance at δ 5; clearly indicative of a boronate "ate"-complex of the type suggested in Fig. 2.

The hydrolytic sensitivity of the hydrazone systems **7** meant that it was necessary to examine the preparation of alternative C=N derivatives, in which the C=N bond was stable in the presence of the boronate function. Such stability was essential, if we were to access chiral boronate analogues of type **3**. The use of oxime methyl ethers was therefore examined.

β-Oximino methyl ether boronates

The synthesis of various β-boronate oxime methyl ethers **11** was undertaken *via* alkylation of the corresponding methyl *O*-methyloximes[8] **10**, as shown in Scheme 3 and Table 2.

Comparison of the ^{1}H NMR spectrum of the oxime ether product **10a** with that reported,[8] confirmed the presence of a single stereoisomer, the thermodynamically favoured *anti*-oxime (*E*) (Table 2, entry 1). Subsequent deprotonation of oxime ether **10a** with LDA at −78 °C and subsequent treatment with iodomethylboronate **6**, successfully provided oxime ether **11a** as a single *E*-stereoisomer. The synthesis of a series of aliphatic β-boronate oxime ethers **11** was similarly achieved (Table 2). In the aliphatic cases, mixtures of *E*- and *Z*-stereoisomers were obtained for products **10**, except for oxime ethers **10b** and **f**. The ratio of *cis*- and *trans*-isomers (*Z* to *E*)

Table 2

Entry	R	*E*:*Z* ratio of **10**[a]	Yield of **10** (%)[b]	*E*:*Z* ratio of **11**[a]	Yield of **11** (%)[b]
1	Ph	1:0	96	1:0	82
2	Me	—	29	1:3	80
3	Et	3:1	79	0:1	79
4	^{n}Pr	3:1	62	1:0	64
5	^{i}Pr	7.8:1	44	1:0	48
6	^{t}Bu	1:0	67	1:0	79
7	$CH_3(CH_2)_3CHCH_3$	6:1	56	1:0	61
8	$^{n}C_8H_{17}$	2.7:1	54	1:0	48

[a] Determined by ^{1}H NMR. [b] Isolated yield after silica gel chromatography.

Table 3 Selected analytical data for oxime ethers **10a**–**h**

Entry	Oxime ether **10**	R	Isomer	δ_H (ppm)[a] $CH_3C{=}N$[c]	δ_H (ppm)[a] OCH_3[c]	δ_C (ppm)[b] C=N
1	**a**	Ph	*E*	2.2	3.9	149.7
2	**b**	Me	—	1.84 (*syn*) 1.87 (*anti*)	3.82	154.6
3	**c**	Et	*E*	1.82	3.83	158.6
4			*Z*	1.85	3.81	159.3
5	**d**	Pr	*E*	1.81	3.83	157.6
6			*Z*	1.84	3.80	158.0
7	**e**	^{i}Pr	*E*	1.76	3.82	161.5
8			*Z*	1.77	3.80	162.4
9	**f**	^{t}Bu	*E*	1.79	3.82	163.2
10	**g**	$CH_3(CH_2)_3CHCH_3$	*E*	1.73	3.82	161.2
11			*Z*	1.75	3.79	162.0
12	**h**	C_8H_{17}	*E*	1.81	3.84	157.8
13			*Z*	1.84	3.80	158.4

[a] 300 MHz, $CDCl_3$. [b] 75.5 MHz, $CDCl_3$. [c] Singlet.

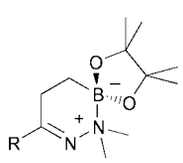
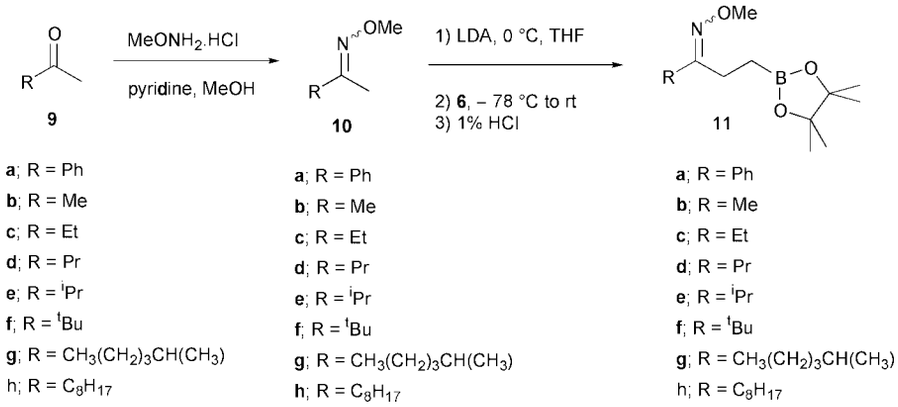


Fig. 2

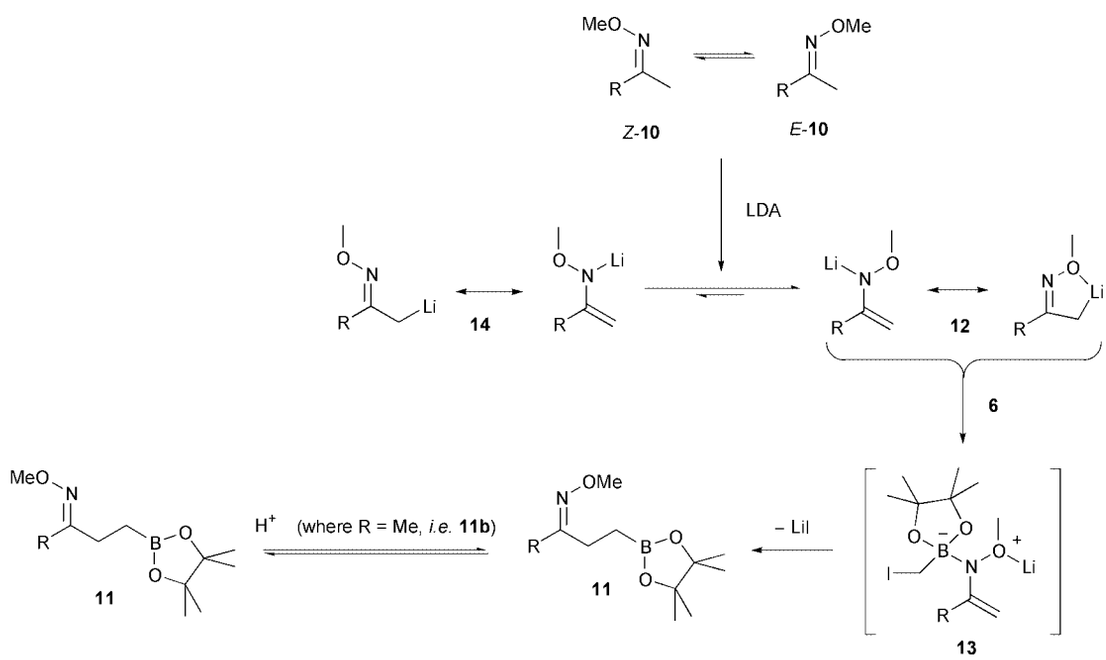
was determined by ^{1}H NMR and the assignment of C=N bond geometry was consistent with extensive structural studies reported by Karabatsos.[9] The α-methyl group chemical shifts for the *Z*-isomers were found to be consistently downfield compared to those for the corresponding *E*-oxime ether isomers (Table 3, entries 3–8 and 10–13). The thermodynamically favoured *E*-oxime isomer, in which the small α-methyl and oxime methoxy functions are *cis*, was observed predominantly in all cases (Table 3).

Regioselective alkylation of the lithiated anions derived from oxime ethers **10c**–**h** with iodomethylboronate ester **6**, yielded β-boronate oximes **11c**–**h** as single stereoisomers in modest to good yields after a swift acidic work-up (Scheme 2) (Table 2). Similar chemical shifts were observed for the oxime methoxy groups in the ^{1}H NMR of the boronates **11** compared to systems **10**. In addition, the ^{11}B NMR spectra of systems **11** in $CDCl_3$ at room temperature did not show any evidence for boron chelation, showing the presence of an uncoordinated boron atom in each of the cases **11a**–**h**.

Attempts to elucidate the geometry of the oxime ether C=N bonds in compounds **11** by NOE experiments were universally unsuccessful. Therefore, the oxime ether stereochemistry was initially assigned by assuming kinetic deprotonation of the parent oxime ether **10** α-methyl group, followed by alkylation



Scheme 3



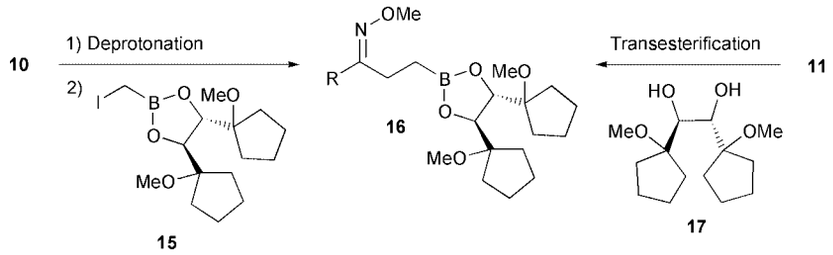
Scheme 4

of the preferred *syn*-oxime ether anion with iodide **6**. Retention of C=N geometry was presumed providing the corresponding β-boronate ester product **11**, in which the oxime methoxy and boron-containing substituent possess a *cis*-relationship. However, later studies revealed that treatment of acetone *O*-methyloxime **10b** with LDA and quenching with iodide **6**, yielded a 3:1 mixture of *Z*- to *E*-stereoisomers (Table 2). However, standing in $CDCl_3$ overnight caused a reversal in the *Z*:*E* ratio, to give a 1:3 mixture. Isomerisation of the substrate **11b** is presumably catalysed by the residual acid in the solvent. Such an effect was *not* observed for β-oxime boronate esters **11a** and **c**–**h**. This suggests that, under the reaction conditions described for the alkylation of **10** to give **11**, R groups larger than methyl produce a *syn*-relationship between the oxime methoxy function and boronate unit. It was also found that isomerisation of substrates **11b**–**d** could also occur on silica gel during chromatography. Attempted purification by flash column chromatography of α-ethyl- and α-propyl-substituted oxime ethers, **11c** and **11d**, furnished mixtures of stereoisomers, *i.e.* 1:1 and 2:1 respectively.

It has been reported[10] that acyclic ketone *N*,*N*-dimethylhydrazones show little preference for *syn*- or *anti*-deprotonation of otherwise equivalent methylene groups, however *syn*-anions are more thermodynamically stable and equilibration does occur.[10] In comparison, it has been reported that oxime ethers favour formation of a *syn*-oxime anion **12** upon deprotonation of *E*–*Z*-isomers **10**, with rapid isomerisation about the C–N bond, even at low temperatures, ensuring conversion to the *syn*-monoanion[11] **12** (Scheme 4), which is more stabilised than the corresponding anion **14**. Extensive theoretical studies on the structure of metalated oximes and oxime ethers, have confirmed the stability of the *syn*-anion isomer **12**.[12] Therefore, alkylation of **12** with iodomethylboronate ester **6** (Scheme 4), *via* complex **13**, would provide boronate **11** with the methoxy and R groups in the *trans*-configuration, as shown in Scheme 4. Lithiated acetone *O*-methyloxime anion **12** (R = Me) has been reported[13] to form a *Z*-bromomethyl-oxime ether, which readily isomerises to the thermodynamically favoured *E*-form in the presence of HBr. Thus, it is expected that *O*-methyloxime **11b** (where R = Me), will isomerise readily upon aqueous acidic work-up. The remaining β-boronate oxime ethers prepared, *i.e.* **11a** and **c**–**h**, are all conformationally stable under the reaction and work-up conditions described (Scheme 4).

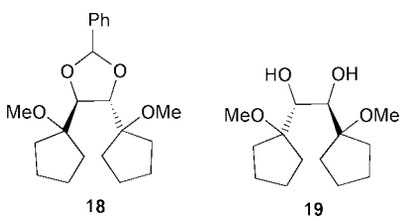
Having successfully prepared a range of stable, achiral pinacol-based β-boronate *O*-methyloximes **11**, routes for the preparation of the required chiral β-boronate oxime ether substrates **16** were investigated, as summarised in Scheme 5. Thus, using the deprotonation–alkylation sequence used for the preparation of boronates **11**, using iodide **15** in place of achiral iodide **6**, would furnish chiral ester **16**. Whereas transesterification of the pinacol ester of **11** with chiral diol **17** would also provide boronate **16**.

The C_2-symmetric chiral auxiliary (*S*,*S*)-**17** was achieved using a simple four-step procedure developed in our

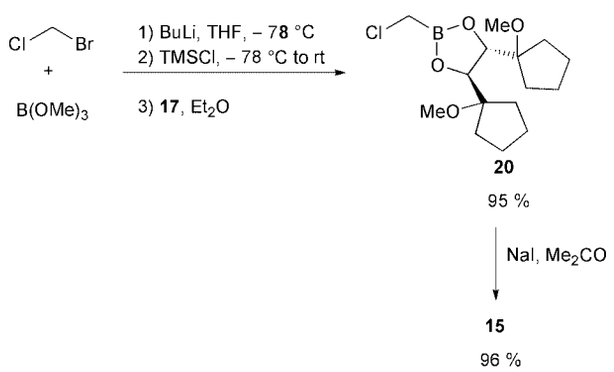


Scheme 5

laboratories[3a] starting from (−)-dimethyl D-tartrate. However, high-pressure (1000 psi) catalytic hydrogenation at room temperature using an autoclave was found to be more reliable for the deprotection of benzylidene derivative **18**. Similarly, the

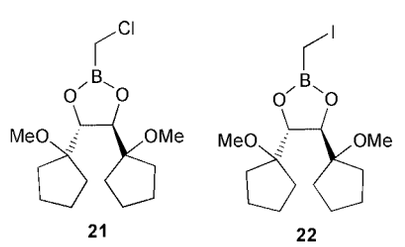


antipode of **17**, *i.e.* (*R*,*R*)-**19** was prepared from (+)-dimethyl L-tartrate.[3a] The preparation of iodomethylboronate **15** was subsequently investigated, as outlined in Scheme 6.



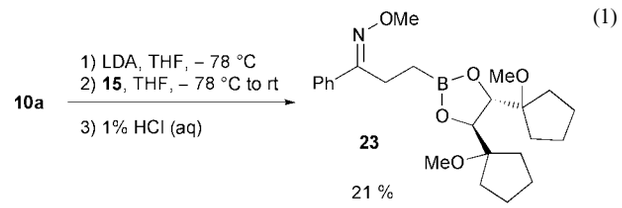
Scheme 6

The enantiomerically pure chloromethylboronate ester **20** was synthesised using an analogous method to that developed for the synthesis of chloromethylboronate pinacol ester[6] (Scheme 6). The corresponding iodomethylboronate **15** was subsequently accessed in quantitative yield by treatment of chloride **20** with sodium iodide in acetone. An identical strategy was used to prepare the corresponding enantiomers **21** and **22**.



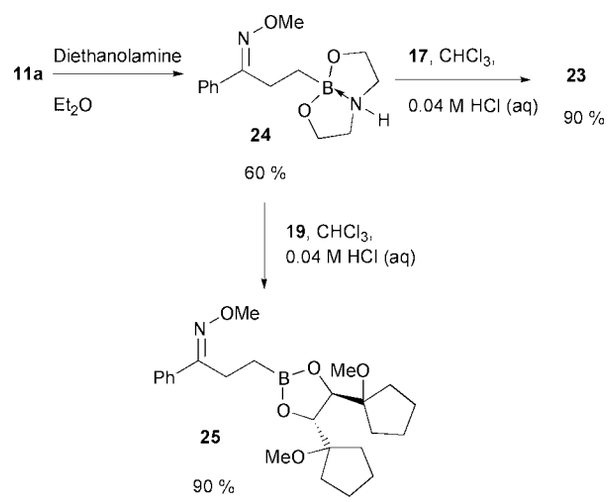
Deprotonation of acetophenone *O*-methyloxime **10a** with LDA at −78 °C, followed by alkylation with iodomethylboronate **15**, afforded chiral β-boronate *O*-methyloxime (*S*,*S*)-**23** as a single diastereoisomer, albeit in low yield (eqn. (1)).

In contrast, using a transesterification route (see Scheme 5) to the chiral boronate oxime systems proved much more efficient. Thus, both antipodes of the β-oxime boronate ester **23** and **25**



(1)

could be isolated in excellent yields (90%) by transesterification of the corresponding diethanolamine derivative **24** with the appropriate diols **17** or **19** (Scheme 7), *i.e.* using a method which

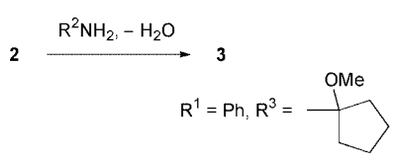


Scheme 7

is directly analogous to the chiral β-ketoboronate system **2** previously reported.[3a] It is again noteworthy that esters **23** and **25** showed no evidence of boron chelation (either by nitrogen or oxygen) by ^{11}B NMR in $CDCl_3$ at room temperature.

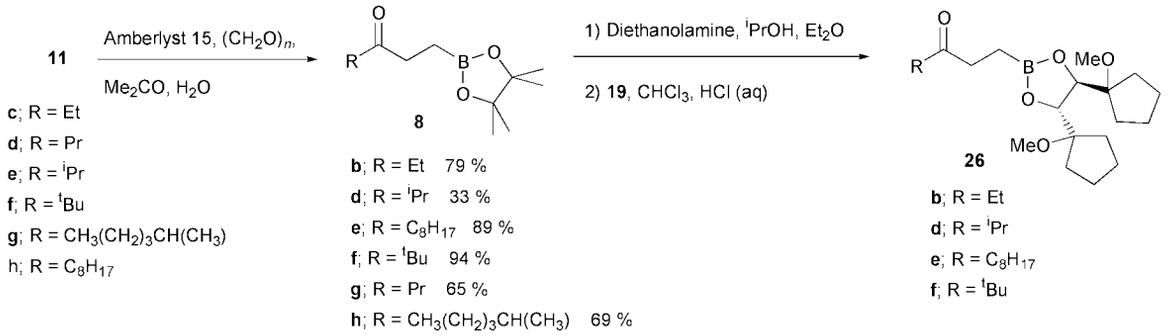
β-Imino boronates

Having discovered that β-hydrazone boronates **7** were hydrolytically unstable, efforts were directed towards the preparation of the β-imino boronate esters of type **3**, where R^2 = alkyl or aryl. It was envisaged that such species may be prepared *via* the condensation of the corresponding β-keto boronate ester, such as **2**, by condensation with a primary amine (eqn. (2)). The



(2)

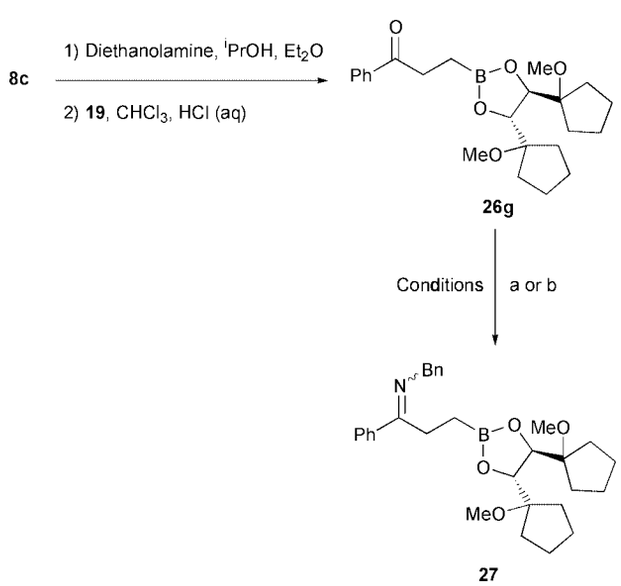
required β-keto boronates **8** were prepared either *via* the hydrazone route (Scheme 2) or by hydrolysis of the oxime ether derivatives **11**, as shown in Scheme 8.[14] Subsequent transesterification to provide the chiral boronates **26** was carried out by reaction with diethanolamine followed by diethanolamine ester displacement with the chiral diol **19**.



Scheme 8

Having accessed chiral ketones **26**, conversion to the corresponding imine derivatives **3** (R^2 = alkyl or aryl) was examined. Ketimines are frequently prepared by azeotropic distillation of a mixture of ketone and amine with benzene or toluene to remove the water formed in the reaction, or by directly distilling water as it is produced. The condensation reaction is acid catalysed, and catalysts such as $TiCl_4$,[15] $ZnCl_2$,[16] and toluene-*p*-sulfonic acid,[17] have been successfully used. Reaction of a ketone with an amine in the presence of a drying agent such as magnesium sulfate[18] or molecular sieves,[19] is also a convenient method for imine preparation. Indeed, Westheimer reported that molecular sieves serve as both a catalyst *and* a dehydrating agent in the preparation of imines.[20] It was therefore necessary to determine whether such methods could be used to derive β-imino boronates **3**.

As a preliminary study, imine derivatives of β-keto boronate ester (*R*,*R*)-**26g** were prepared from the corresponding pinacol-derived ketone **8c** by transesterification with diol (*R*,*R*)-**19** *via* the diethanolamine derivative (Scheme 9). Initial attempts to



Scheme 9 *Conditions*: a, $BnNH_2$, Δ or PhH, or PhMe, Δ; b, $BnNH_2$, 4 Å molecular sieves, $CDCl_3$; c, neat $BnNH_2$, Δ.

isolate enantiomerically pure β-imino boronate ester **27a** either by treatment of chiral β-boronate ketone **26g** by azeotropic distillation with benzene or toluene (Conditions a, Scheme 9) gave no evidence for imine formation (^{1}H NMR, IR, or MS), due to the extreme sensitivity towards hydrolysis of the imine product **27a** formed. However, when the condensation reaction of β-keto boronate ester **26g** with benzylamine, was directly monitored by ^{1}H NMR under strictly anhydrous conditions (Conditions b, Scheme 9), the formation of imine **27a** could be observed directly to be occuring. Examination of the ^{1}H NMR spectrum of the β-imino boronate ester **27a** revealed the presence of a 3:5 mixture of diastereoisomers in $CDCl_3$ solution at room temperature.

Presumably, the major diastereoisomer present in solution is the thermodynamically favoured *E*-isomer, in which the phenyl substituent and the *N*-benzyl substituent are *anti*, thus minimising unfavourable steric interactions. Accordingly, it was observed that chemical shift values for protons corresponding to the CH_2B and $CH_2C{=}N$ methylene groups, as well as the boronate ester methoxy and CHO methine units, were consistently upfield in the major diastereomer *E*-isomer, in which the *N*-benzyl and boron-containing substituents are *syn*, compared to those values for the minor *Z*-isomer.

It was also found that direct reaction of homochiral ketone **26g** with excess benzylamine, with removal of water by distillation of the excess benzylamine under reduced pressure, gave the desired β-imino boronate ester **27a** (Conditions c, Scheme 9), unfortunately however, this material was contaminated by the presence of traces of various contaminants, including starting materials and ketone **26g**, amongst others. It was not possible to obtain an analytically pure sample of imine **27a** by any of these methods.

Conclusions

Having accessed various C=N boronate systems **3**, it is possible clearly to compare the relative stability of each of the three systems derived. β-Hydrazono boronate systems **7** are not sufficiently stable to allow isolation, due to the internal activation of the boronate function. In contrast, β-oximino ether boronates **11** behave quite differently. In parallel with their carbonyl counterparts, there is no evidence of internal boronate–nitrogen or oxygen chelation as shown by ^{11}B NMR. In addition, these systems are readily manipulated to access the desired chiral boronate esters, typified by structures **23** and **25**. The β-imino boronates, such as **27**, appear to have similar instability to the hydrazone systems and these findings strongly suggested that any attempts to derive β-amino acids **4** *via* imine derivatives **3** (R = alkyl) would require *in situ* generation of the imine, such as **27**, due to their high sensitivity to hydrolysis, which can largely be attributed to presence of the boronate function.

Experimental

Hydroxyacetone was purchased from Fluka. All other reagents were obtained from Acros, Aldrich or Lancaster. Dimethyl sulfoxide and ethanolamine were stored under argon, over activated 3 Å molecular sieves. Dry tetrahydrofuran was freshly distilled from sodium and benzophenone immediately prior to use. Dry dichloromethane was distilled from calcium hydride. Bromochloromethane and diisopropylamine were distilled from calcium hydride before use under an argon atmosphere. Flash column chromatography was achieved using Acros silica gel, pore size 60 Å, or Lancaster silica gel 60, 0.060–0.2 mm (70–230 mesh). Thin layer chromatography was performed on

Merck plastic or aluminium sheets coated with silica gel 60 F_{254} (Art. 5735). Chromatograms were initially examined under UV light and then developed by spraying with either phosphomolybdic acid (6 g in 125 ml of ethanol) or aqueous potassium permanganate, followed by heating. All anhydrous reactions were carried out in oven-dried (120 °C) glassware which was cooled under a stream of argon. Organic extracts were dried over $MgSO_4$ before evaporation. Evaporations were achieved using a Büchi rotary evaporator followed by drying at *ca.* 5 mmHg using a vacuum pump. Bulb-to-bulb distillations were carried out using a Büchi GKR-51 Kugelrohr apparatus. Melting points were determined using an Electrothermal melting point apparatus and are uncorrected. NMR spectra were recorded using Bruker NMR spectrometers. ^{1}H NMR and ^{13}C NMR spectra were recorded using $CHCl_3$ and $CDCl_3$ respectively, as internal standards. Resonances for ^{11}B NMR spectra are quoted relative to $BF_3{\cdot}Et_2O$ (δ ^{11}B = 0.00 ppm) as external standard. Chemical shift values (δ) are given in ppm, coupling constants (J) are given in Hz, and NMR peaks are described as singlet (s), doublet (d), triplet (t), quartet (q) and multiplet (m). Infrared (IR) spectra were recorded on a Perkin-Elmer 298 spectrophotometer or a Matson Unicam FTIR spectrometer. Electron impact (EI) (70 eV) and chemical ionisation (CI) were recorded with a Kratos MS50 or a Finnigan MAT 95S spectrometer. Fast atom bombardment (FAB) spectra were recorded on a Kratos MS50 using a *m*-nitrobenzyl alcohol matrix. Accurate mass determinations were carried out on a Kratos Concept IS spectrometer. Microanalyses were performed using a Carlo-Erba 1106 elemental analyser. Optical rotations were determined using a Perkin-Elmer Model 241 or an Optical Activity AA-1000 polarimeter and are given in units of 10^{-1} deg cm^2 g^{-1}.

Acetone *N*,*N*-dimethylhydrazone 5a

This compound was prepared according to the procedure of Eliel[21] on a 0.395 mol scale, and furnished hydrazone **5a** (21.40 g, 0.214 mol, 54%) as a colourless liquid after distillation. IR and NMR spectra were as reported. Additional data: δ (^{13}C, $CDCl_3$) 17.39 and 24.5 [*E*- and *Z*-((CH_3)$_2$C=N)], 46.4 ((CH_3)$_2$N), 163.9 (C=N). Anal. Calculated for $C_5H_{12}N_2$: C, 60.0; H, 12.0; N, 28.0. Found: C, 59.7; H, 12.3; N, 28.3%.

4-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)butan-2-one 8a

To a vigorously stirred solution of diisopropylamine (0.30 ml, 4.1 mmol) in tetrahydrofuran (10 ml) at 0 °C was added butyllithium (1.65 ml, 2.5 M in hexanes, 4.1 mmol). After 20 minutes, hydrazone **5a** (0.37 g, 3.7 mmol) was added dropwise and the temperature maintained at 0 °C for a further 20 minutes, the formation of a fine, cloudy precipitate occurring after 5–10 minutes. Cooling the solution to −78 °C, followed by addition of iodomethylboronate ester **6** (1.00 g, 3.7 mmol) resulted in a homogeneous solution which was allowed to warm to room temperature after 10 minutes. The reaction was quenched after 4 hours at room temperature with saturated ammonium chloride. Partitioning between ethyl acetate and saturated ammonium chloride was followed by drying of the organic phase ($MgSO_4$). Removing the solvent by rotary evaporation and high vacuum furnished a pale yellow oil, which after Kugelrohr distillation (75 °C, 0.5 mmHg) yielded the boronate ester **8a** (0.44 g, 2.2 mmol, 59%) as a pale yellow oil; ν_{max} *inter alia* 1716 (C=O) cm^{-1}; δ (^{11}B, $CDCl_3$) +33.8; δ_H ($CDCl_3$) 0.90 (2 H, t, J = 7.4 Hz, CH_2B), 1.23 (12 H, s, 2 × (CH_3)$_2$CO), 2.13 (3 H, s, CH_3C=O), 2.59 (2 H, t, J = 7.1 Hz, CH_2C=O); δ_C ($CDCl_3$) ~5 (br, CH_2B), 24.8 ((CH_3)$_2$CO), 28.9 (CH_3C=O), 38.4 (CH_2C=O), 83.0 ((CH_3)$_2$CO), 209.2 (C=O); *m*/*z* (FAB), CsI additive, $(M + Cs)^+$.

Butan-2-one *N*,*N*-dimethylhydrazone 5b

N,*N*-Dimethylhydrazine (10 ml, 0.132 mol) was introduced dropwise to neat butan-2-one (10 ml, 0.112 mol) at room temperature and the solution stirred for 12 hours. After refluxing for an hour, the resulting water layer was removed and refluxing continued for a further hour. The reaction mixture was dried with calcium hydride after removal of any residual water by pipette. Fractional distillation from calcium hydride through a Vigreux column, furnished the hydrazone **5b** (12.07 g, 0.106 mol, 95%) as a colourless liquid; ν_{max} (film) *inter alia* 1635 (C=N) cm^{-1}; δ_C ($CDCl_3$) (*E*)-isomer, 11.2 (CH_3CH_2), 15.7 (CH_3C=N), 31.9 (CH_2C=N), 46.7 ((CH_3)$_2$N), 168.3 (C=N); (*Z*)-isomer, 10.8 (CH_3CH_2), 21.8 (CH_3C=N), 24.2 (CH_2C=N), 47.3 ((CH_3)$_2$N), 170.0 (C=N). Anal. Calculated for $C_6H_{14}N_2$: C, 63.1; H, 12.4; N, 24.5. Found: C, 62.8; H, 12.7; N, 24.8%.

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)pentan-3-one 8b

To a vigorously stirred solution of diisopropylamine (1.43 ml, 10.2 mmol) in THF (30 ml) at 0 °C was added butyllithium (4.1 ml, 2.5 M in hexanes, 10.2 mmol) under argon. After 20 minutes butanone *N*,*N*-dimethylhydrazone **5b** (1.07 g, 9.3 mmol) was introduced and the temperature maintained at 0 °C for a further 30 minutes, resulting in a white suspended precipitate. Cooling the solution to −78 °C, followed by addition of iodomethylboronate ester **6** (2.50 g, 9.3 mmol) and warming to room temperature after 10 minutes gave a clear, pale yellow solution which was quenched with saturated ammonium chloride after 12 hours. Partitioning between ethyl acetate and saturated ammonium chloride (two extractions), and an additional extraction of the combined aqueous phase with ethyl acetate, was followed by drying of the combined organic phase ($MgSO_4$). Removal of the solvent by rotary evaporation and high vacuum, and subsequent Kugelrohr distillation (90–100 °C, 0.1 mmHg), furnished the boronate ester **8b** (1.28 g, 6.1 mmol, 66%) as a pale yellow oil; ν_{max} (film) *inter alia* 1718 (C=O) cm^{-1}; δ_B ($CDCl_3$) +33.1; δ_H ($CDCl_3$) 0.90 (2 H, t, J = 7.2 Hz, CH_2B), 1.04 (3 H, t, J = 7.4 Hz, CH_3CH_2), 1.22 (12 H, s, 2 × (CH_3)$_2$CO), 2.40 (2 H, q, J = 7.2 Hz, CH_3CH_2), 2.55 (2 H, t, J = 7.1 Hz, C=OCH_2CH_2); δ_C ($CDCl_3$) ~5 (br, CH_2B), 8.1 (CH_3CH_2), 24.7 ((CH_3)$_2$CO), 35.2 (C=OCH_2CH_2B), 36.7 (CH_3CH_2), 83.0 ((CH_3)$_2$CO), 212.6 (C=O); *m*/*z* (FAB) 213 $(M + H)^+$, 154 $(M - C_3H_6O)^+$; high resolution mass spectrum, calculated for $C_{11}H_{22}BO_3$ $(M + H)^+$ 213.1662, found 213.1662.

3-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)propiophenone 8c

To a vigorously stirred solution of diisopropylamine (4.76 ml, 40.0 mmol) in tetrahydrofuran (160 ml) at 0 °C under argon was added butyllithium (16.56 ml, 2.5 M in hexanes, 41.4 mmol). After 20 minutes hydrazone **5c**[22] (5.00 g, 30.9 mmol) was introduced and the temperature maintained at 0 °C for a further 2 hours, resulting in a thick yellow suspension. Cooling the solution to −78 °C, followed by addition of iodomethylboronate ester **6** (8.26 g, 30.7 mmol) and warming to room temperature after 5 minutes, gave a clear pale orange solution which was stirred for a further 12 hours. The reaction was quenched with saturated ammonium chloride followed by partitioning between ethyl acetate (400 ml) and saturated ammonium chloride (2 × 100 ml). Drying the combined organic phases ($MgSO_4$) and removal of solvent by rotary evaporation and high vacuum gave a viscous, pale yellow oil, of which the hydrazone **7c** was found to be the major component by ^{1}H NMR. Dissolving the oil in tetrahydrofuran (300 ml) at room temperature was followed by addition of aqueous copper(II) acetate (300 ml of a 0.2 M solution, 62 mmol) and the solution stirred for 12 hours. The tetrahydrofuran was removed by rotary evaporation and saturated ammonium chloride added to the aqueous solution. Partitioning the solution between ethyl acetate and saturated ammonium chloride, and washing the organic phase with a saturated sodium bicarbonate solution, gave a dark brown oil after drying the organic phase ($MgSO_4$) and rotary evaporation.

Kugelrohr distillation (120 °C, 0.5 mmHg) of this residue furnished the boronate ester **8c** (6.05 g, 23.2 mmol, 75%) as a pale yellow oil, which was identical to that previously reported.[6]

3-Methylbutan-2-one *N*,*N*-dimethylhydrazone 5d

N,*N*-Dimethylhydrazine (39 ml, 0.513 mol) was slowly introduced to neat 3-methylbutan-2-one (50 ml, 0.467 mol), and the stirred solution refluxed for 6 hours. After cooling, the reaction mixture was partitioned between diethyl ether and water, and the organic phase dried ($MgSO_4$). Rotary evaporation and fractional distillation at water aspirator vacuum (74 °C) through a Vigreux column, furnished the hydrazone **5d** (43.71 g, 0.341 mol, 73%) as a colourless liquid; ν_{max} (film) *inter alia* 1630 (C=N) cm^{-1}; δ_H ($CDCl_3$), *E*:*Z* ratio 92:8, (*E*)-isomer 1.04 (6 H, d, *J* = 6.9 Hz, $(CH_3)_2CH$), 1.86 (3 H, s, CH_3C=N), 2.40 (6 H, s, $(CH_3)_2N$), 2.49 (1 H, septet, *J* = 6.9 Hz, $(CH_3)_2CH$); (*Z*)-isomer 1.03 (6 H, d, *J* = 7.2 Hz, $(CH_3)_2CH$), 1.82 (3 H, s, CH_3C=N), 2.39 (6 H, s, $(CH_3)_2N$), $(CH_3)_2CH$ coincident with (*E*)-isomer signal; δ_C ($CDCl_3$) (*E*)-isomer, 12.5 (CH_3C=N), 19.7 ($(CH_3)_2CH$), 36.6 ($(CH_3)_2CH$), 46.6 ($(CH_3)_2N$), 171.4 (C=N); (*Z*)-isomer, 17.5 (CH_3C=N), 19.4 ($(CH_3)_2CH$), 28.1 ($(CH_3)_2CH$), 47.5 ($(CH_3)_2N$), 174.1 (C=N); *m*/*z* (EI) 128 (M^+), 84 $(M - C_2H_6N)^+$, 44 (C_2H_6N) base peak. Anal. Calculated for $C_7H_{16}N_2$: C, 65.6; H, 12.6; N, 21.8. Found: C, 65.5; H, 12.9; N, 22.0%.

4-Methyl-1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-pentan-3-one 8d

To a vigorously stirred solution of diisopropylamine (2.38 ml, 17.0 mmol) in tetrahydrofuran (50 ml) at 0 °C under argon was added butyllithium (6.78 ml, 2.5 M in hexanes, 17.0 mmol). After 20 minutes, hydrazone **5d** (1.98 g, 15.4 mmol) was added dropwise and the temperature maintained at 0 °C for a further hour, the formation of a yellow–cream precipitate occurred over 20 to 30 minutes. Cooling the solution to −78 °C, was followed by addition of iodomethylboronate ester **6** (4.13 g, 15.4 mmol), warming to room temperature after 5 minutes gave a pale yellow precipitous solution. Quenching the reaction after 4 hours at room temperature with saturated ammonium chloride was followed by partition between ethyl acetate and consecutively, saturated ammonium chloride and aqueous hydrochloric acid (30 ml of a 0.5 M solution, 15 mmol). The organic phase was dried ($MgSO_4$), and the solvent removed by rotary evaporation to effect a pale yellow oil; Kugelrohr distillation of this residue (0.5 mmHg, 90 °C) furnished the boronate ester **8d** (1.78 g, 7.9 mmol, 51%) as a colourless oil; ν_{max} (film) *inter alia* 1718 (C=O) cm^{-1}; δ_B ($CDCl_3$) +33.7; δ_H ($CDCl_3$) 0.90 (2 H, t, *J* = 7.1 Hz, CH_2B), 1.08 (6 H, d, *J* = 6.9 Hz, $(CH_3)_2CH$), 1.23 (12 H, s, 2 × $(CH_3)_2CO$), 2.60 (3 H, septet/triplet *exactly* superimposed, *J* = 7.0 Hz, $CH(CH_3)_2$ and CH_2C=O); δ_C ($CDCl_3$) ~5 (br, CH_2B), 18.4 ($(CH_3)_2CH$), 24.7 ($(CH_3)_2CO$), 35.1 (CH_2C=O), 40.3 ($(CH_3)_2CHC$=O), 83.0 ($(CH_3)_2CO$), 215.2 (C=O); *m*/*z* (CI) 244 $(M + NH_4)^+$, 227 $(M + H)^+$; high resolution mass spectrum, calculated for $C_{12}H_{23}BO_3$ $(M + H)^+$ 227.1819, found 227.1822.

Decan-2-one *N*,*N*-dimethylhydrazone 5e

Glacial acetic acid (~0.1 ml) was introduced to a stirred solution of *N*,*N*-dimethylhydrazine (30 ml, 0.395 mol) and decan-2-one (17.00 g, 0.109 mol), and refluxed for an hour. After removing the aqueous layer, the solution was refluxed for a further 11 hours, whereupon the cooled solution was partitioned between diethyl ether and water. Drying the organic phase ($MgSO_4$) gave a pale yellow oil after rotary evaporation. Distillation under vacuum (114 °C at 0.5 mmHg) through a Vigreux column furnished the pure hydrazone **5e** (18.25 g, 0.092 mol, 84%) as colourless oil; ν_{max} (film) *inter alia* 1640 (C=N) cm^{-1}; δ_H ($CDCl_3$), *E*:*Z* 81:19, (*E*)-isomer, 0.86 (3 H, t, CH_3CH_2), 1.25 (10 H, m, $(CH_2)_5$), 1.45 (2 H, m, CH_2), 1.92 (3 H, s, CH_3C=N), 2.17 (2 H, t, *J* = 7.6 Hz, CH_2C=N), 2.41 (6 H, s, $(CH_3)_2N$); (*Z*)-isomer, all signals coincident with (*E*)-isomer except 1.89 (3 H, s, CH_3C=N), 2.38 (6 H, s, $(CH_3)_2N$); δ_C ($CDCl_3$) (*E*)-isomer, 14.1 and 16.4 (CH_3C=N and CH_3CH_2), 22.7, 27.1, 29.1, 29.2, 29.3, 31.9 and 39.1 ($(CH_2)_7$), 47.0 ($(CH_3)_2N$), 168.1 (C=N); (*Z*)-isomer, only signals at 16.4 (CH_3C=N), 26.5, 29.8 and 31.5 (CH_2), 47.5 ($(CH_3)_2N$), 169.7 (C=N) identifiable as (*Z*)-isomer; *m*/*z* (FAB) 199 $(M + H)^+$. Anal. Calculated for $C_{12}H_{26}N_2$: C, 72.7; H, 13.2: N, 14.1. Found: C, 72.4; H, 13.5; N, 14.4%.

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)undecan-3-one 8e

The alkylation of hydrazone **5e** by iodomethylboronate ester **6**, was carried out by the procedure described for the preparation of boronate ester **8d** on a 28 mmol scale with respect to the hydrazone component. Dissolving the crude hydrazone **7e** in tetrahydrofuran (150 ml) at room temperature was followed by addition of aqueous copper(II) acetate (10 ml of 5.0 M solution, 50 mmol) and the solution was stirred for 12 hours. The tetrahydrofuran was removed by rotary evaporation and saturated ammonium chloride was added to the aqueous solution. Partitioning the solution between chloroform and saturated ammonium chloride, and washing the organic phase with a saturated sodium bicarbonate solution, gave a dark brown oil after drying the organic phase ($MgSO_4$) and rotary evaporation. Kugelrohr distillation (120 °C, 0.5 mmHg) of this residue removed unreacted iodomethylboronate ester **6** and decan-2-one. The residue was further purified by flash chromatography (neat chloroform as eluant) to furnish the boronate ester **8e** (2.56 g, 8.6 mmol, 35%) as an orange oil that solidified to a waxy solid on standing; mp 35 °C; ν_{max} (film) *inter alia* 1715 (C=O) cm^{-1}; δ_H ($CDCl_3$) 0.87 (3 H, t, *J* = 7.0 Hz, CH_2CH_3), 0.90 (2 H, t, *J* = 7.1, CH_2B), 1.23 (12 H, s, 2 × $(CH_3)_2CO$), 1.26 (12 H, br s, $(CH_2)_6$), 2.37 (2H, t, *J* = 7.4 Hz, *n*-heptCH_2C=O), 2.55 (2 H, t, *J* = 7.1 Hz, CH_2BCH_2C=O); δ_C ($CDCl_3$) ~5 (br, CH_2B), 14.0 (CH_3CH_2), 24.7 ($(CH_3)_2CO$), 22.6, 24.1, 29.1, 29.2, 29.3, 31.8, 37.4 and 42.2 (CH_2), 82.96 ($(CH_3)_2CO$), 211.6 (C=O); *m*/*z* (FAB) 297 $(M + H)^+$, 197 $(M - C_6H_{11}O)^+$ base peak; high resolution mass spectrum, calculated for $C_{17}H_{34}BO_3$ $(M + H)^+$ 297.2601, found 297.2595. Anal. Calculated for $C_{17}H_{33}BO_3$: C, 68.9; H, 11.2: B, 3.6. Found: C, 69.2; H, 11.5; B, 4.0%.

Acetophenone *O*-methyloxime 10a

The procedure of Beak *et al.*[8] was followed on a 0.080 mol scale, affording acetophenone *O*-methyloxime **10a** (11.40 g, 0.076 mol, 96%) as a colourless liquid upon distillation from calcium hydride; bp 118 °C, 20 mmHg (lit.,[23] 73–73 °C, 2.2 mmHg); ^1H NMR and IR spectral data were as reported in the literature;[8] δ_C (75.5 MHz; $CDCl_3$) 12.5 (CH_3C=N), 61.8 (OCH_3), 125.9, 128.5, 128.9, 135.8 (C aromatic), 149.7 (C=N); *m*/*z* (FAB) 149 M^+.

3-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)propiophenone *O*-methyloxime 11a

To a vigorously stirred solution of diisopropylamine (3.34 ml, 23.70 mmol) in dry THF (50 ml) at 0 °C under argon, butyllithium (9.60 ml of a 2.5 M solution in hexanes, 24.00 mmol) was slowly added. The solution was stirred at 0 °C for 45 minutes, then cooled to −78 °C. Acetophenone *O*-methyloxime **10a** (2.88 ml, 19.70 mmol) was added dropwise and the solution stirred at −78 °C for 3 hours. 2-(Iodomethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **6** (5.36 g, 20.00 mmol) was then slowly added to the resulting bright yellow solution. The reaction was allowed to warm to room temperature after 2 hours and stirred overnight. A clear, pale yellow solution was formed to which 1% HCl (aq) (50 ml) was added. The solution was quickly extracted with ethyl acetate (3 × 25 ml). The combined

organic phases were washed with water (50 ml), dried and evaporated, yielding boronate ester **11a** (4.67 g, 16.00 mmol, 82%) as a very pale yellow oil, after distillation using a Kugelrohr apparatus (100 °C, 0.5 mmHg) (Found: C, 66.4; H, 8.4; B, 3.7; N, 4.9. $C_{16}H_{24}BNO_3$ requires C, 66.5; H, 8.4; B, 3.7; N, 4.8%); ν_{max} (film)/cm^{-1} 3000, 2800, 1370, 1320, 1140, 1040; δ_H (300 MHz; $CDCl_3$) 0.99–1.05 (2 H, m, CH_2B), 1.22 [12 H, s, 2 × $(CH_3)_2C$], 2.77–2.82 (2 H, m, $CH_2C{=}N$), 3.96 (3 H, s, OCH_3), 7.30–7.39 (3 H, m, H *meta*, H *para*), 7.59–7.64 (2 H, m, H *ortho*); δ_C (75.5 MHz; $CDCl_3$) 8.0–8.6 (br, CH_2B), 20.8 ($CH_2C{=}N$), 24.6 [$(CH_3)_2C$], 61.6 (OCH_3), 82.5 [$(CH_3)_2C$], 126.3, 128.1, 128.6, 135.4 (C aromatic), 160.0 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.6; *m*/*z* (FAB) 290 (M + H)$^+$ [Found (HRMS): *m*/*z* 289.1851. $C_{16}H_{24}BNO_3$ requires M$^+$ 289.1849].

Acetone *O*-methyloxime 10b

Acetone (4.19 ml, 0.057 mol) was added to methoxylamine hydrochloride (4.00 g, 0.048 mol) in pyridine (5 ml) and dichloromethane (20 ml). The solution was heated at reflux overnight, then partitioned between dichloromethane and saturated NaCl (aq). The combined organic extracts were washed with 10% HCl (aq) (50 ml), saturated $NaHCO_3$ (aq) (50 ml), then brine (50 ml), and dried. Careful evaporation of the solvent and fractional distillation, under argon, from calcium hydride of the residue, furnished acetone *O*-methyloxime **10b** (1.20 g, 0.014 mol, 29%) as a colourless liquid; bp 64–66 °C, 760 mmHg (lit.,[24] 60–65 °C, 760 mmHg); ν_{max} (film)/cm^{-1} 2925, 2880, 1610 (w), 1410, 1360, 1040, 1020; ^{1}H NMR was identical to that reported in the literature;[24] δ_C (75.5 MHz; $CDCl_3$) 15.3 (*syn* CH_3), 21.8 (*anti* CH_3), 61.0 (OCH_3), 154.6 (C=N); *m*/*z* (CI, NH_3) 88 (M + H)$^+$.

4-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)butan-2-one *O*-methyloxime 11b

To a stirred solution of diisopropylamine (0.18 ml, 1.27 mmol) in dry THF (15 ml) at 0 °C under argon, butyllithium (0.51 ml of a 2.5 M solution in hexanes, 1.275 mmol) was added slowly. After 30 minutes the solution was cooled to −40 °C and treated with acetone *O*-methyloxime **10b** (0.10 g, 1.15 mmol). The reaction was cooled to −78 °C after 90 minutes and 2-(iodomethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **6** (0.46 g, 1.73 mmol) was added dropwise. The reaction was allowed to warm to room temperature after 1 hour and stirred overnight. A pale yellow solution was formed to which 1% HCl (aq) (10 ml) was added. The mixture was then quickly extracted with ethyl acetate (3 × 10 ml). The combined organic extracts were washed with water (50 ml), dried and evaporated to yield the crude title compound **11b** (0.21 g, 0.92 mmol, 80%) as a yellow oil; ν_{max} (film)/cm^{-1} 2970, 1370, 1310, 1140, 1050; δ_H (300 MHz; $CDCl_3$) 1:3, mixture of stereoisomers, major stereoisomer: 0.92–0.98 (2 H, m, CH_2B), 1.25 [12 H, s, 2 × $(CH_3)_2C$], 1.85 (3 H, s, $CH_3C{=}N$), 2.35–2.41 (2 H, m, $CH_2C{=}N$), 3.79 (3 H, s, OCH_3); minor stereoisomer: 0.92–0.98 (2 H, m, CH_2B), 1.24 [12 H, s, 2 × $(CH_3)_2C$], 1.81 (3 H, s, $CH_3C{=}N$), 2.25–2.31 (2 H, m, $CH_2C{=}N$), 3.81 (3 H, s, OCH_3); δ_C (100.6 MHz; $CDCl_3$) 7.4 (br, CH_2B), 19.3 ($CH_3C{=}N$), 23.2 ($CH_2C{=}N$), 24.7 [$(CH_3)_2C$], 60.8 (OCH_3), 82.9 [$(CH_3)_2C$], 159.6 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.7; *m*/*z* (CI, NH_3) 228 (M + H)$^+$ [Found (HRMS): *m*/*z* 228.1775. $C_{11}H_{22}BNO_3$ requires (M + H)$^+$ 228.1771].

Butan-2-one *O*-methyloxime 10c

Butan-2-one (3.94 ml, 0.044 mol) was added to methoxylamine hydrochloride (4.00 g, 0.048 mol) in pyridine (5 ml) and dichloromethane (20 ml), and the solution heated at reflux for 16 hours. A biphasic mixture was formed which was diluted with saturated NaCl (aq) (50 ml), and extracted with dichloromethane (3 × 20 ml). The combined organic extracts were washed with 10% HCl (aq) (50 ml), saturated $NaHCO_3$ (aq) (50 ml), then brine (50 ml), and dried. The solvent was carefully removed by rotary evaporation under atmospheric pressure. The colourless liquid residue was fractionally distilled from calcium hydride. Butan-2-one *O*-methyloxime **10c** (3.53 g, 0.035 mol, 79%) was collected as a colourless liquid; bp 90–94 °C, 760 mmHg (lit.,[23] 66.2 °C, 301 mmHg); ν_{max} (film)/cm^{-1} 2900, 2800, 1640 (m), 1450, 1350, 1050; δ_H (300 MHz; $CDCl_3$) *E*:*Z*, 3:1, *E*-isomer: 1.08 (3 H, t, *J* 7.6, CH_3CH_2), 1.82 (3 H, s, $CH_3C{=}N$), 2.19 (2 H, q, *J* 7.5, $CH_2C{=}N$), 3.83 (3 H, s, OCH_3); *Z*-isomer: 1.04 (3 H, t, *J* 7.7, CH_3CH_2), 1.85 (3 H, s, $CH_3C{=}N$), 2.32 (2 H, q, *J* 7.6, $CH_2C{=}N$), 3.81 (3 H, s, OCH_3); δ_C (75.5 MHz; $CDCl_3$), *E*-isomer: 11.0 (CH_3CH_2), 13.3 ($CH_3C{=}N$), 29.0 ($CH_2C{=}N$), 60.9 (OCH_3), 158.6 (C=N); *Z*-isomer: 10.0 (CH_3CH_2), 19.1 ($CH_3C{=}N$), 22.2 ($CH_2C{=}N$), 60.9 (OCH_3), 159.3 (C=N); *m*/*z* (EI) 101 M$^+$ [Found (HRMS): *m*/*z* 101.0838. $C_5H_{11}NO$ requires M$^+$ 101.0840].

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)pentan-3-one *O*-methyloxime 11c

To a vigorously stirred solution of diisopropylamine (2.10 ml, 14.90 mmol) in dry THF (20 ml) at 0 °C under an argon atmosphere, butyllithium (6.00 ml of a 2.5 M solution in hexanes, 15.00 mmol) was slowly introduced. The solution was stirred for 45 minutes and then cooled to −40 °C. Addition of butan-2-one *O*-methyloxime **10c** (1.48 ml, 12.30 mmol) and stirring for a further 90 minutes afforded a yellow solution. The reaction was then cooled to −78 °C and 2-(iodomethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **6** (4.96 g, 18.50 mmol) added dropwise. After 1 hour the reaction was allowed to warm to room temperature and stirred overnight. Addition of 1% HCl (aq) (20 ml) to the pale yellow solution formed was rapidly followed by extraction with ethyl acetate (3 × 20 ml). The combined organic phases were washed with water (50 ml) and dried. Evaporation of the solvent afforded a dark orange oil which was purified by distillation using a Kugelrohr apparatus (100 °C, 0.5 mmHg), furnishing 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pentan-3-one *O*-methyloxime **11c** (2.35 g, 9.75 mmol, 79%) as a colourless oil; ν_{max} (film)/cm^{-1} 2900, 2800, 1380, 1330, 1160, 1060; δ_H (300 MHz; $CDCl_3$) 0.94–0.99 (2 H, m, CH_2B), 1.07 (3 H, t, *J* 7.4, CH_3CH_2), 1.25 [12 H, s, 2 × $(CH_3)_2C$], 2.20 (2 H, q, *J* 7.5, CH_3CH_2), 2.32–2.37 (2 H, m, CH_2CH_2B), 3.79 (3 H, s, OCH_3); δ_C (75.5 MHz; $CDCl_3$) 6.8–8.0 (br, CH_2B), 11.2 (CH_3CH_2), 21.9 (CH_2CH_2B), 24.8 [$(CH_3)_2C$], 26.9 (CH_3CH_2), 60.9 (OCH_3), 83.1 [$(CH_3)_2C$], 163.6 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.0; *m*/*z* (FAB) 242 (M + H)$^+$ [Found (HRMS): *m*/*z* 241.1846. $C_{12}H_{24}BNO_3$ requires M$^+$ 241.1849].

Pentan-2-one *O*-methyloxime 10d

Pentan-2-one (4.68 ml, 0.044 mol) was added to methoxylamine hydrochloride (4.00 g, 0.048 mol) in pyridine (5 ml) and dichloromethane (20 ml). The mixture was refluxed overnight, then partitioned between dichloromethane and saturated NaCl (aq). The combined organic extracts were washed with 10% HCl (aq) (50 ml), saturated $NaHCO_3$ (aq) (50 ml), then brine (50 ml), and dried. Careful evaporation of the solvent and distillation, under Ar, over calcium hydride, of the residue, furnished pentan-2-one *O*-methyloxime **10d** (3.13 g, 0.027 mmol, 62%) as a colourless liquid; bp 118 °C, 760 mmHg (lit.,[25] 118–120 °C, 760 mmHg); ν_{max} (film)/cm^{-1} 2900, 2800, 1630 (m), 1460, 1360, 1050; δ_H (300 MHz; $CDCl_3$) *E*:*Z*, 3:1, *E*-isomer: 0.92 (3 H, t, *J* 7.4, CH_3CH_2), 1.53 (2 H, sextet, *J* 7.6, CH_3CH_2), 1.81 (3 H, s, $CH_3C{=}N$), 2.10–2.16 (2 H, m, $CH_2C{=}N$), 3.83 (3 H, s, OCH_3); *Z*-isomer: 0.93 (3 H, t, *J* 7.4, CH_3CH_2), 1.53 (2 H, sextet, *J* 7.6, CH_3CH_2), 1.84 (3 H, s, $CH_3C{=}N$), 2.26–2.31 (2 H, m, $CH_2C{=}N$), 3.80 (3 H, s, OCH_3); δ_C (75.5 MHz, $CDCl_3$) *E*-isomer: 13.5 ($CH_3C{=}N$), 19.8 (CH_3CH_2), 31.0 ($CH_2C{=}N$), 37.6 (CH_3CH_2), 60.9 (OCH_3), 157.6 (C=N); *Z*-isomer: 14.0 ($CH_3C{=}N$), 19.0 (CH_3CH_2), 31.0 ($CH_2C{=}N$), 37.6 (CH_3CH_2), 60.9 (OCH_3), 158.0 (C=N); *m*/*z* (CI, NH_3) 116 (M + H)$^+$.

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)hexan-3-one *O*-methyloxime 11d

Butyllithium (0.60 ml of a 2.5 M solution in hexanes, 1.50 mmol) was added to a vigorously stirred solution of diisopropylamine (0.21 ml, 1.49 mmol) in THF (20 ml) at 0 °C under an argon atmosphere. After 45 minutes the reaction was cooled to −40 °C, and pentan-2-one *O*-methyloxime **10d** (0.14 g, 1.22 mmol) was slowly introduced. The solution was stirred for a further 2.5 hours yielding a pale yellow solution. The reaction was then cooled to −78 °C and 2-(iodomethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **6** (0.50 g, 1.87 mmol) was slowly added. After 2 hours the reaction was left to warm to room temperature overnight. 1% HCl (aq) (20 ml) was added to the yellow solution formed, and the mixture extracted with ethyl acetate (3 × 20 ml). The combined organic phases were washed with water (50 ml) and dried. Evaporation of the solvent yielded an orange oil. Distillation using a Kugelrohr apparatus (100 °C, 0.5 mmHg) furnished the β-boronate oxime ether derivative **11d** (0.20 g, 0.78 mmol, 64%) as a colourless oil; ν_{max} (film)/cm^{-1} 2900, 2800, 1625 (w), 1360, 1320, 1140, 1040; δ_H (300 MHz; $CDCl_3$) 0.91 (3 H, t, *J* 7.4, C*H*$_3$CH$_2$), 0.93–0.98 (2 H, m, CH$_2$B), 1.24 [12 H, s, 2 × (CH$_3$)$_2$C], 1.52 (2 H, sextet, *J* 7.5, CH$_3$C*H*$_2$), 2.11–2.16 (2 H, m, CH$_3$CH$_2$C*H*$_2$), 2.30–2.36 (2 H, m, C*H*$_2$CH$_2$B), 3.80 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) 7.5–7.7 (br, CH$_2$B), 13.6 (*C*H$_3$CH$_2$), 19.8 (CH$_3$*C*H$_2$), 21.8 (*C*H$_2$CH$_2$B), 24.4 [(*C*H$_3$)$_2$C], 35.4 (*C*H$_2$C=N), 60.7 (OCH$_3$), 82.9 [(CH$_3$)$_2$*C*], 162.4 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.9; *m*/*z* (FAB) 256 (M + H)$^+$ [Found (HRMS): *m*/*z* 256.2084. $C_{13}H_{26}BNO_3$ requires (M + H)$^+$ 256.2073].

3-Methylbutan-2-one *O*-methyloxime 10e

3-Methylbutan-2-one (4.60 ml, 0.043 mol) was added to a solution of methoxylamine hydrochloride (4.00 g, 0.048 mol) in pyridine (5 ml) and dichloromethane (20 ml). Refluxing the solution overnight yielded a biphasic solution. This solution was partitioned between saturated NaCl (aq) and dichloromethane. The combined organic extracts were washed with 10% HCl (aq) (50 ml), saturated $NaHCO_3$ (aq) (50 ml) and brine (50 ml), then dried. The solvent was carefully removed by rotary evaporation, and the residue fractionally distilled under atmospheric pressure from calcium hydride, furnishing 3-methylbutan-2-one *O*-methyloxime **10e** (2.17 g, 0.019 mol, 44%) as a colourless liquid; bp 112 °C, 760 mmHg; ν_{max} (film)/cm^{-1} 2900, 2800, 1635 (m), 1440, 1340, 1060, 1030; δ_H (300 MHz; $CDCl_3$) *E*:*Z*, 7.8:1, *E*-isomer: 1.07 [6 H, d, *J* 6.9, (C*H*$_3$)$_2$CH], 1.76 (3 H, s, CH$_3$C=N), 2.50 [1 H, septet, *J* 6.9, (CH$_3$)$_2$C*H*], 3.82 (3 H, s, OCH$_3$); *Z*-isomer: 1.01 [6 H, d, *J* 7.0, (C*H*$_3$)$_2$CH], 1.77 (3 H, s, CH$_3$C=N), 3.35 [1 H, septet, *J* 7.0, (CH$_3$)$_2$C*H*], 3.80 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) *E*-isomer: 10.5 (*C*H$_3$C=N), 19.5 [(*C*H$_3$)$_2$CH], 33.9 [(CH$_3$)$_2$*C*H], 60.7 (OCH$_3$), 161.5 (C=N); *Z*-isomer: 15.0 (*C*H$_3$C=N), 18.7 [(*C*H$_3$)$_2$CH], 26.1 [(CH$_3$)$_2$*C*H], 60.7 (OCH$_3$), 162.4 (C=N); *m*/*z* (EI) 115 M$^+$ [Found (HRMS): *m*/*z* 115.0988. $C_6H_{13}NO$ requires M$^+$ 115.0997].

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-4-methylpentan-3-one *O*-methyloxime 11e

To a stirred solution of diisopropylamine (2.10 ml, 14.90 mmol) in THF (20 ml) at 0 °C under argon, butyllithium (6.00 ml of a 2.5 M solution in hexanes, 15.00 mmol) was slowly added. After 30 minutes the reaction was cooled to −40 °C and 3-methylbutan-2-one *O*-methyloxime **10e** (1.40 g, 12.16 mmol) was added. The reaction was stirred for 3.5 hours, then cooled to −78 °C before adding 2-(iodomethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **6** (4.20 g, 15.68 mmol) to the orange solution formed. After 2 hours, the reaction was allowed to warm to room temperature, and stirred overnight. A clear yellow solution was formed to which 1% HCl (aq) (20 ml) was added. The solution was quickly extracted with ethyl acetate (3 × 20 ml) and the combined organic extracts washed with water (50 ml), then dried. Evaporation of the solvent and distillation of the residue using a Kugelrohr apparatus (100 °C, 0.5 mmHg), yielded the title compound **11e** (1.50 g, 5.88 mmol, 48%) as a colourless oil; ν_{max} (film)/cm^{-1} 3050, 2980, 1370, 1265, 1145, 1050; δ_H (300 MHz; $CDCl_3$) 0.97–1.02 (2 H, m, CH$_2$B), 1.08 [6 H, d, *J* 6.9, (C*H*$_3$)$_2$CH], 1.25 [12 H, s, 2 × (CH$_3$)$_2$CO], 2.24–2.30 (2 H, m, C*H*$_2$C=N), 2.49 [1 H, septet, *J* 6.9, (CH$_3$)$_2$C*H*], 3.79 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) 8.3 (br, CH$_2$B), 20.1 [(*C*H$_3$)$_2$CH], 20.8 (*C*H$_2$C=N), 24.8 [(*C*H$_3$)$_2$CO], 33.3 [(CH$_3$)$_2$-*C*H], 60.9 (OCH$_3$), 83.1 [(CH$_3$)$_2$*C*O], 166.5 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.9; *m*/*z* (FAB) 256 (M + H)$^+$ [Found (HRMS): *m*/*z* 255.2005. $C_{13}H_{26}BNO_3$ requires M$^+$ 255.2006].

3,3-Dimethylbutan-2-one *O*-methyloxime 10f

To a stirred solution of methoxylamine hydrochloride (8.00 g, 0.096 mol) in pyridine (10 ml) and dichloromethane (40 ml), 3,3-dimethylbutan-2-one (13.18 ml, 0.11 mol) was added. The mixture was refluxed for 16 hours. Saturated NaCl (aq) (50 ml) was then added and the solution extracted with dichloromethane (3 × 25 ml). The combined organic extracts were washed with 10% HCl (aq) (50 ml), saturated $NaHCO_3$ (aq) (50 ml), then brine (50 ml), and dried. Evaporation of the solvent and distillation, under Ar, over calcium hydride, of the residue, yielded the title compound **10f** (8.26 g, 0.064 mol, 67%) as a colourless liquid; bp 122–124 °C, 760 mmHg (lit.,[23] 52.5 °C, 56 mmHg); ν_{max} (film)/cm^{-1} 2900, 2800, 1625 (m), 1460, 1370, 1050; δ_H (300 MHz; $CDCl_3$) 1.11 [9 H, s, (CH$_3$)$_3$C], 1.79 (3 H, s, CH$_3$C=N), 3.82 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) 10.3 (*C*H$_3$C=N), 27.6 [(*C*H$_3$)$_3$C], 36.9 [(CH$_3$)$_3$*C*], 61.0 (OCH$_3$), 163.2 (C=N); *m*/*z* (EI) 129 M$^+$ [Found (HRMS): *m*/*z* 129.1147. $C_7H_{15}NO$ requires M$^+$ 129.1153].

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-4,4-dimethylpentan-3-one *O*-methyloxime 11f

To a vigorously stirred solution of diisopropylamine (3.31 ml, 23.49 mmol) in THF (40 ml) at 0 °C under Ar, butyllithium (9.60 ml of a 2.5 M solution in hexanes, 24.00 mmol) was slowly added. Stirring for 30 minutes yielded a pale yellow solution. The reaction was then cooled to −40 °C and 3,3-dimethylbutan-2-one *O*-methyloxime **10f** (2.54 g, 19.66 mmol) was introduced. After 3 hours the reaction temperature was lowered to −78 °C and 2-(iodomethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **6** (6.32 g, 23.59 mmol) was added dropwise. The mixture was allowed to warm to room temperature after 1 hour, then stirred overnight, yielding a pale yellow solution. 1% HCl (aq) (50 ml) was added and the solution extracted with ethyl acetate (3 × 20 ml). Drying the combined organic extracts and evaporation of the solvent afforded a yellow oil. Distillation of this oil using a Kugelrohr apparatus (100 °C, 0.5 mmHg) furnished 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-4,4-dimethylpentan-3-one *O*-methyloxime **11f** (4.20 g, 15.60 mmol, 79%) as a colourless oil; ν_{max} (film)/cm^{-1} 2900, 2800, 1360, 1310, 1140, 1040; δ_H (300 MHz; $CDCl_3$) 0.98–1.04 (2 H, m, CH$_2$B), 1.10 [9 H, s, (CH$_3$)$_3$CC=N], 1.25 [12 H, s, 2 × (CH$_3$)$_2$CO], 2.24–2.30 (2 H, m, CH$_2$C=N), 3.79 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) 9.2 (br, CH$_2$B), 20.1 (*C*H$_2$C=N), 24.8 [(*C*H$_3$)$_2$CO], 27.7 [(*C*H$_3$)$_3$C], 37.2 [(CH$_3$)$_3$*C*C=N], 59.9 (OCH$_3$), 83.0 [(CH$_3$)$_2$*C*O], 168.1 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.5; *m*/*z* (FAB) 270 (M + H)$^+$ [Found (HRMS): *m*/*z* 269.2169. $C_{14}H_{28}BNO_3$ requires M$^+$ 269.2162].

3-Methylheptan-2-one *O*-methyloxime 10g

3-Methylheptan-2-one (6.82 ml, 0.044 mol) was added to a solution of methoxylamine hydrochloride (4.00 g, 0.048 mol) in pyridine (5 ml) and dichloromethane. The solution was refluxed overnight. A yellow solution was formed which was diluted with saturated NaCl (aq) (50 ml) and extracted with dichloro-

methane (3 × 20 ml). The combined organic phases were washed with 10% HCl (aq) (50 ml), saturated $NaHCO_3$ (aq) (50 ml), then brine (50 ml), and dried. The solvent was evaporated and the residue distilled under water aspirator vacuum, from calcium hydride, furnishing the *O*-methyloxime **10g** (3.87 g, 0.025 mol, 56%) as a colourless liquid; bp 28 °C, 20 mmHg; ν_{max} (film)/cm^{-1} 2900, 2800, 1630 (m), 1440, 1360, 1340, 1070, 1040; δ_H (300 MHz; $CDCl_3$) *E*:*Z*, 6:1, *E*-isomer: 0.88 (3 H, t, *J* 7.1, C*H*$_3$CH$_2$), 1.05 (3 H, d, *J* 6.9, C*H*$_3$CH), 1.14–1.51 [6 H, m, (C*H*$_2$)$_3$CH$_3$], 1.73 (3 H, s, CH$_3$C=N), 2.35 (1 H, sextet, *J* 6.9, CH$_3$C*H*), 3.82 (3 H, s, OCH$_3$); *Z*-isomer: 0.91 (3 H, t, *J* 7.2, C*H*$_3$CH$_2$), 0.99 (3 H, d, *J* 7.0, C*H*$_3$CH), 1.14–1.51 [6 H, m, (C*H*$_2$)$_3$CH$_3$], 1.75 (3 H, s, CH$_3$C=N), 3.28 (1 H, sextet, *J* 7.2, CH$_3$C*H*), 3.79 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) *E*-isomer: 10.2 (*C*H$_3$C=N), 13.9 (*C*H$_3$CH$_2$), 18.0 (*C*H$_3$CH), 22.5 (CH$_3$*C*H$_2$), 29.5 (CH$_3$CH$_2$CH$_2$*C*H$_2$), 33.6 (CH$_3$CH$_2$-*C*H$_2$), 39.2 (CH$_3$*C*H), 60.9 (OCH$_3$), 161.2 (C=N); *Z*-isomer: 15.2 (*C*H$_3$C=N), 17.1 (*C*H$_3$CH$_2$), 18.0 (*C*H$_3$CH), 25.5 (CH$_3$-*C*H$_2$), 26.3 (CH$_3$CH$_2$CH$_2$*C*H$_2$), 31.5 (CH$_3$*C*H), 33.3 (CH$_3$CH$_2$-*C*H$_2$), 60.9 (OCH$_3$), 162.0 (C=N); *m*/*z* (CI, NH_3) 158 (M + H)$^+$ [Found (HRMS): *m*/*z* 157.1472. $C_9H_{19}NO$ requires M$^+$ 157.1467].

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-4-methyloctan-3-one *O*-methyloxime 11g

To a vigorously stirred solution of diisopropylamine (1.24 ml, 8.80 mmol) in dry THF (20 ml) at 0 °C under argon, butyllithium (3.60 ml of a 2.5 M solution in hexanes, 9.00 mmol) was slowly added. After 30 minutes stirring, the reaction was cooled to −40 °C and 3-methylheptan-2-one *O*-methyloxime **10g** (1.16 g, 7.38 mmol) was introduced dropwise. The reaction was cooled to −78 °C after 3.5 hours, and 2-(iodomethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **6** (2.40 g, 8.96 mmol) was added. The yellow solution was allowed to warm to room temperature after 2 hours. A clear, yellow solution was formed to which 1% HCl (aq) (20 ml) was added. The solution was quickly extracted with ethyl acetate (3 × 20 ml) and the combined organic phases washed with water (50 ml), then dried. Evaporation of the solvent afforded a dark orange oil which was purified by flash chromatography [1:20, ethyl acetate–petroleum ether (40–60 °C) as eluent], furnishing 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-4-methyloctan-3-one *O*-methyloxime **11g** (1.35 g, 4.53 mmol, 61%) as a pale yellow oil; ν_{max} (film)/cm^{-1} 2900, 2800, 1625 (w), 1430, 1350, 1300, 1120, 1030; δ_H (300 MHz; $CDCl_3$) 0.85–0.89 (2 H, m, CH$_2$B), 1.06 (3 H, d, *J* 7.0, C*H*$_3$CH), 1.15–1.36 [18 H, m, 2 × (C*H*$_3$)$_2$-CO, CH$_3$(C*H*$_2$)$_3$], 2.14–2.35 (3 H, m, CH$_3$C*H*, C*H*$_2$CH$_2$B), 3.79 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) 7.8–9.3 (br, CH$_2$B), 14.1 (*C*H$_3$CH$_2$), 18.2 (*C*H$_3$CH), 20.6 (*C*H$_2$CH$_2$B), 22.7 (CH$_3$*C*H$_2$), 24.8 [(*C*H$_3$)$_2$CO], 29.6 (CH$_3$CH$_2$*C*H$_2$), 33.8 (*C*H$_2$CH), 38.9 (CH$_3$*C*H), 61.0 (OCH$_3$), 83.1 [(CH$_3$)$_2$*C*O], 166.1 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.5; *m*/*z* (FAB) 298 (M + H)$^+$ [Found (HRMS): *m*/*z* 298.2552. $C_{16}H_{33}BNO_3$ requires (M + H)$^+$ 298.2553].

Decan-2-one *O*-methyloxime 10h

A solution of decan-2-one (7.58 ml, 0.040 mol) and methoxylamine hydrochloride (4.00 g, 0.048 mol) in pyridine (15 ml) and methanol (100 ml) was heated at reflux for 24 hours. The solvent was removed by rotary evaporation and the residue partitioned between water and diethyl ether. The combined organic phases were dried and evaporated. Distillation yielded decan-2-one *O*-methyloxime **10h** (4.01 g, 0.022 mol, 54%) as a colourless liquid; bp 138–140 °C, 20 mmHg; ν_{max} (film)/cm^{-1} 2995, 2927, 2856, 2815, 1466, 1440, 1115, 1057; δ_H (300 MHz; $CDCl_3$) *E*:*Z*, 2.7:1, *E*-isomer: 0.87 (3 H, t, *J* 6.7, C*H*$_3$CH$_2$), 1.27–1.50 (12 H, m, (C*H*$_2$)$_6$CH$_3$), 1.81 (3 H, s, CH$_3$C=N), 2.12–2.17 (2 H, m, CH$_2$C=N), 3.84 (3 H, s, OCH$_3$); *Z*-isomer: 0.87 (3 H, t, *J* 6.7, C*H*$_3$CH$_2$), 1.27–1.50 [12 H, m, (C*H*$_2$)$_6$CH$_3$], 1.84 (3 H, s, CH$_3$C=N), 2.26–2.31 (2 H, m, CH$_2$C=N), 3.80 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) *E*-isomer: 13.6 (*C*H$_3$C=N), 14.1 (*C*H$_3$CH$_2$), 22.6, 26.6, 29.2, 31.8, 35.8 (CH$_2$), 61.0 (OCH$_3$), 157.8 (C=N); *Z*-isomer: 14.1 (*C*H$_3$CH$_2$), 19.9 (*C*H$_2$C=N), 22.6, 25.7, 29.2, 29.6, 31.8 (CH$_2$), 59.9 (OCH$_3$), 158.4 (C=N); *m*/*z* (EI) 185 M$^+$ [Found (HRMS): *m*/*z* 185.1783. $C_{11}H_{23}NO$ requires M$^+$ 185.1780].

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)undecan-3-one *O*-methyloxime 11h

To a stirred solution of diisopropylamine (1.24 ml, 8.80 mmol) in dry THF (40 ml) at 0 °C under Ar, butyllithium (3.60 ml of a 2.5 M solution in hexanes, 9.00 mmol) was added dropwise. After 30 minutes the solution was cooled to −40 °C and decan-2-one *O*-methyloxime **10h** (1.34 g, 7.23 mmol) was slowly added. After 2 hours, the bright yellow solution was cooled to −78 °C, before dropwise addition of 2-(iodomethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **6** (2.40 g, 8.96 mmol). The reaction was allowed to warm to room temperature overnight. A clear pale yellow solution was formed to which 1% HCl (aq) (50 ml) was added. The solution was quickly extracted with ethyl acetate (3 × 30 ml), and the combined organic phases were washed with water (50 ml), and dried. Evaporation afforded a pale orange liquid which was purified by flash chromatography [1:20, ethyl acetate–petroleum ether (40–60 °C) as eluent], furnishing title compound **11h** (1.12 g, 3.44 mmol, 48%) as a pale yellow oil; ν_{max} (film)/cm^{-1} 2990–2860, 1470, 1380, 1320, 1150, 1050; δ_H (300 MHz; $CDCl_3$) 0.87 (3 H, t, *J* 6.7, C*H*$_3$CH$_2$), 0.93–0.99 (2 H, m, CH$_2$B), 1.25 [12 H, s, 2 × (CH$_3$)$_2$C], 1.23–1.50 [12 H, m, CH$_3$(C*H*$_2$)$_6$], 2.12–2.17 [2 H, m, (CH$_2$)$_6$-C*H*$_2$C=N], 2.30–2.36 (2 H, m, C*H*$_2$CH$_2$B), 3.79 (3 H, s, OCH$_3$); δ_C (75.5 MHz; $CDCl_3$) 7.4 (br, CH$_2$B), 14.1 (*C*H$_3$CH$_2$), 22.0 (*C*H$_2$CH$_2$B), 22.6 (CH$_3$*C*H$_2$), 24.7 [(*C*H$_3$)$_2$CO], 26.7, 29.2, 29.3, 29.4, 31.8, 33.7 [(*C*H$_2$)$_6$C=N], 60.9 (OCH$_3$), 83.1 [(CH$_3$)$_2$*C*O], 162.8 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.9; *m*/*z* (FAB) 326 (M + H)$^+$ [Found (HRMS): *m*/*z* 325.2785. $C_{18}H_{36}BNO_3$ requires M$^+$ 325.2788].

(1*S*,2*S*)-1,2-Bis(1-methoxycyclopentyl)ethane-1,2-diol (*S*,*S*)-17

10% Palladium-on-charcoal (0.64 g, 0.61 mmol) was added to a solution of (4*S*,5*S*)-4,5-bis(1-methoxycyclopentyl)-2-phenyl-1,3-dioxolane (*S*,*S*)-**18**[3a] (4.00 g, 0.012 mol) in methanol (250 ml). The mixture was stirred in an autoclave at room temperature under an atmosphere of H_2 (1000 psi) for 24 hours. The solution was then evaporated, the residue redissolved in ethyl acetate (200 ml), and filtered through a pad of magnesium sulfate. Evaporation afforded the title compound (*S*,*S*)-**17** (2.93 g, 0.011 mol, 95%) as a white solid, which was identical to that previously reported.[3a]

(1*R*,2*R*)-1,2-Bis(1-methoxycyclopentyl)ethane-1,2-diol (*R*,*R*)-19

The procedure described above was followed on a 0.012 mol scale using (4*R*,5*R*)-4,5-bis(1-methoxycyclopentyl)-2-phenyl-1,3-dioxolane[3a] to yield the title compound (*R*,*R*)-**19** (2.82 g, 0.011 mol, 91%) as a white solid, which was identical to that previously reported.[3a]

(4*S*,5*S*)-2-Chloromethyl-4,5-bis(1-methoxycyclopentyl)-1,3,2-dioxaborolane (*S*,*S*)-20

To a stirred solution of bromochloromethane (0.19 ml, 2.84 mmol) and trimethyl borate (0.27 ml, 2.38 mmol) in THF (10 ml) at −78 °C under argon, butyllithium (0.96 ml of a 2.5 M solution in hexanes, 2.40 mmol) was added dropwise. After two hours the reaction was quenched with chlorotrimethylsilane (0.34 ml, 2.68 mmol) and allowed to warm to room temperature overnight. A colourless solution and white precipitate were formed, to which diol (*S*,*S*)-**17** (0.31 g, 1.20 mmol) dissolved in diethyl ether (5 ml) was added. After stirring the solution for 90

minutes, the mixture was partitioned between water and diethyl ether. The organic phases were dried, filtered and evaporated to yield a pale yellow oil. Impurities were removed by distillation using a Kugelrohr apparatus (100 °C, 0.5 mmHg,), yielding the title compound (*S*,*S*)-**20** (0.36 g, 1.14 mmol, 95%) as a pale yellow oil; $[\alpha]_D^{26}$ +56 (*c* 1.075, $CHCl_3$); ν_{max} (film)/cm^{-1} 3000–2820, 1390, 1355, 1090–1070, 901; δ_H (300 MHz; $CDCl_3$) 1.57–1.80 (16 H, m, CH_2 cyclopentyl), 3.01 (2 H, s, CH_2Cl), 3.25 (6 H, s, 2 × OCH_3), 4.40 (2 H, s, 2 × CHO); δ_C (75.5 MHz; $CDCl_3$) 24.5, 30.6, 31.3 (CH_2 cyclopentyl), 50.4 (OCH_3), 82.0 (CHO), 87.6 (*C*OCH_3); δ_B (64.2 MHz; $CDCl_3$) +32.1; *m*/*z* (FAB) 317 $(M + H)^+$ [Found (HRMS): *m*/*z* 317.1691. $C_{15}H_{26}BClO_4$ requires $(M + H)^+$ 317.1690].

(4*S*,5*S*)-2-Iodomethyl-4,5-bis(1-methoxycyclopentyl)-1,3,2-dioxaborolane (*S*,*S*)-15

To a stirred solution of chloromethylboronate ester (*S*,*S*)-**20** (0.13 g, 0.41 mmol) in acetone (2 ml), sodium iodide (0.070 g, 0.47 mmol) in acetone (3 ml) was added. A creamy yellow solution was formed which was stirred at ambient temperature for 24 hours. The solution was filtered through a glass sinter, and the solvent evaporated. Petroleum ether (40–60 °C) (10 ml) was added to the orange residue. Additional filtration yielded the title compound (*S*,*S*)-**15** (0.16 g, 0.39 mmol, 96%) as an orange oil after evaporation; $[\alpha]_D^{26}$ +41 (*c* 1.91, $CHCl_3$); ν_{max} (film)/cm^{-1} 3000–2820, 1410, 1385, 1340, 1090–1070, 920; δ_H (300 MHz; $CDCl_3$) 1.64–1.82 (16 H, m, CH_2 cyclopentyl), 2.22 (2 H, s, CH_2I), 3.24 (6 H, s, 2 × OCH_3), 4.39 (2 H, s, 2 × CHO); δ_C (75.5 MHz; $CDCl_3$) 8.9–9.3 (br, CH_2B), 24.6, 30.7, 31.2 (CH_2 cyclopentyl), 50.3 (OCH_3), 81.4 (CHO), 87.9 (*C*OCH_3); δ_B (64.2 MHz; $CDCl_3$) +31.9; *m*/*z* (FAB) 409 $(M + H)^+$ [Found (HRMS): *m*/*z* 409.1048. $C_{15}H_{26}BIO_4$ requires $(M + H)^+$ 409.1049].

(4*R*,5*R*)-2-Chloromethyl-4,5-bis(1-methoxycyclopentyl)-1,3,2-dioxaborolane (*R*,*R*)-21

The procedure described for **20** was followed on a 1.20 mmol scale using diol (*R*,*R*)-**19**, affording chloromethylboronate ester (*R*,*R*)-**21** (0.344 g, 1.09 mmol, 91%); $[\alpha]_D^{26}$ −50 (*c* 0.82, $CHCl_3$); all other spectrometric data were identical to those reported for compound (*S*,*S*)-**20**.

(4*R*,5*R*)-2-Iodomethyl-4,5-bis(1-methoxycyclopentyl)-1,3,2-dioxaborolane (*R*,*R*)-22

The procedure used was identical to that used for **15**, on a 0.80 mmol scale using chloromethylboronate ester (*R*,*R*)-**21**, yielding iodide (*R*,*R*)-**22** (0.32 g, 0.78 mmol, 98%); $[\alpha]_D^{26}$ −37 (*c* 0.96, $CHCl_3$); all other spectrometric data were identical to those reported for compound (*S*,*S*)-**15**.

3-[(4*S*,5*S*)-4,5-Bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]propiophenone *O*-methyloxime (*S*,*S*)-23

To a stirred solution of diisopropylamine (0.070 ml, 0.50 mmol) at 0 °C in dry THF (5 ml), butyllithium (0.24 ml of a 2.5 M solution in hexanes, 0.60 mmol) was slowly added. After 30 minutes the pale yellow solution was cooled to −78 °C and acetophenone *O*-methyloxime **10a** (0.066 ml, 0.45 mmol) was added dropwise. A bright yellow solution was formed which was stirred for a further 2.5 hours, after which time, a solution of (4*S*,5*S*)-2-iodomethyl-4,5-bis(1-methoxycyclopentyl)-1,3,2-dioxaborolane (*S*,*S*)-**15** (0.20 g, 0.49 mmol) in THF (0.50 ml) was slowly added. The reaction was maintained at −78 °C for a further 1 hour. The solution was then allowed to warm to room temperature overnight. A clear yellow solution was formed to which 1% HCl (aq) (5 ml) was added. The solution was quickly extracted with ethyl acetate (3 × 10 ml). The combined organic phases were washed with water (20 ml), dried and evaporated to furnish a pale orange oil. Flash column chromatography [1 : 25, ethyl acetate–petroleum ether (40–60 °C) as eluent] yielded the title compound (*S*,*S*)-**23** (0.040 g, 0.093 mmol, 21%) as a colourless oil; $[\alpha]_D^{24}$ +33.0 (*c* 0.0485, MeOH); ν_{max} (film)/cm^{-1} 3050, 2990–2920, 1420, 1360, 1050; δ_H (300 MHz; $CDCl_3$) 1.06–1.11 (2 H, m, CH_2B), 1.53–1.82 (16 H, m, CH_2 cyclopentyl), 2.77–2.83 (2 H, m, C$H_2$$CH_2B$), 3.24 (6 H, s, 2 × $COCH_3$), 3.96 (3 H, s, $NOCH_3$), 4.31 (2 H, s, 2 × CHO), 7.32–7.37 (3 H, m, H *meta*, H *para*) and 7.58–7.62 (2 H, m, H *ortho*); δ_C (75.5 MHz; $CDCl_3$) 7.6 (br, CH_2B), 20.7 (*C*$H_2$$CH_2B$), 24.4, 24.6, 30.6, 31.2 (CH_2 cyclopentyl), 50.3 (CO*C*H_3), 61.7 ($NOCH_3$), 80.7 (CHO), 87.7 (*C*OCH_3), 126.2, 128.2, 128.7, 135.4 (C aromatic), 159.9 (C=N); δ_B (64.2 MHz; $CDCl_3$) +33.1; *m*/*z* (FAB) 430 $(M + H)^+$ [Found (HRMS): *m*/*z* 430.2775. $C_{24}H_{36}BNO_5$ requires $(M + H)^+$ 430.2765].

3-(1,3,6,2-Dioxazaborocan-2-yl)propiophenone *O*-methyloxime 24

To a solution of boronate ester **11a** (4.67 g, 0.016 mol) in diethyl ether (30 ml), diethanolamine (8.00 ml of a 2.0 M solution in propan-2-ol, 0.016 mol) was added dropwise. Refrigeration of the resulting milky solution yielded the title compound **24** (2.67 g, 9.67 mmol, 60%) as a white amorphous solid, after filtration and drying under vacuum over P_2O_5; mp 175–176 °C; ν_{max} (KBr)/cm^{-1} 3050, 2980, 1420, 1365; δ_H (300 MHz; $CDCl_3$) 0.76 (2 H, t, *J* 7.8, CH_2B), 2.65 (2 H, t, *J* 7.8, C$H_2$$CH_2B$), 2.79–2.82 (2 H, m, C$H_2$NH), 3.21–3.30 (2 H, m, CH_2NH), 3.87–3.91 (2 H, m, CH_2O), 4.00 (3 H, s, OCH_3), 3.98–4.06 (2 H, m, CH_2O), 4.89 (1 H, br s, NH), 7.32–7.37 (3 H, m, H *meta*, H *para*), 7.66–7.70 (2 H, m, H *ortho*) [After treatment with D_2O, 1.4 : 1 mixture of stereoisomers, major diastereomer: 0.65–0.70 (2 H, m, CH_2B), 2.60–2.65 (2 H, m, C$H_2$$CH_2B$), 2.69–2.76 (2 H, m, CH_2ND), 3.14–3.23 (2 H, m, CH_2ND), 3.78–3.85 (2 H, m, CH_2O), 3.90–3.98 (2 H, m, CH_2O), 3.95 (3 H, s, OCH_3), 7.31–7.37 (3 H, m, H *meta*, H *para*), 7.60–7.68 (2 H, m, H *ortho*); minor diastereomer: 1.05 (2 H, t, *J* 7.6, CH_2B), 2.69–2.76 (2 H, m, CH_2ND), 2.82 (2 H, t, *J* 7.6, C$H_2$$CH_2B$), 3.14–3.23 (2 H, m, CH_2ND), 3.78–3.85 (2 H, m, CH_2O), 3.90–3.98 (2 H, m, CH_2O), 4.00 (3 H, s, OCH_3), 7.31–7.37 (3 H, m, H *meta*, H *para*), 7.60–7.68 (2 H, m, H *ortho*)]; δ_C (75.5 MHz; $CDCl_3$) 15.0 (br, CH_2B), 22.3 (*C*$H_2$$CH_2B$), 51.4 ($CH_2NH$), 61.5 ($OCH_3$), 62.6 ($CH_2O$), 126.5, 128.2, 128.7, 135.7 (C aromatic), 162.8 (C=N); δ_B (64.2 MHz; $CDCl_3$) +12.5; *m*/*z* (FAB) 277 $(M + H)^+$ [Found (HRMS): *m*/*z* 276.1637. $C_{14}H_{21}BN_2O_3$ requires M^+ 276.1645].

3-[(4*R*,5*R*)-4,5-Bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]propiophenone *O*-methyloxime (*R*,*R*)-25

To a solution of diethanolamine derivative **24** (0.96 g, 3.48 mmol) and diol (*R*,*R*)-**19** (0.90 g, 3.48 mmol) in chloroform (50 ml), HCl (aq) (87.00 ml of a 0.040 M solution, 3.48 mmol) was added. The biphasic solution was stirred vigorously for 1 hour at room temperature. The organic layer was separated, washed with water (50 ml) and dried. Filtration and evaporation yielded the title compound (*R*,*R*)-**25** (1.35 g, 3.14 mmol, 90%) as a colourless oil; $[\alpha]_D^{24}$ −33.4 (*c* 0.8615, MeOH); all other spectroscopic and analytical properties were identical to those obtained for compound (*S*,*S*)-**23**.

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-4,4-dimethylpentan-3-one 8f

To a solution of 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-4,4-dimethylpentan-3-one *O*-methyloxime **11f** (0.086 g, 0.32 mmol) in acetone (3 ml) and water (0.3 ml), paraformaldehyde (0.15 g) and Amberlyst 15 (0.10 g) were added. The mixture was stirred at room temperature for 24 hours, then the insoluble materials were removed by filtration. The solvent was removed and the resulting cloudy residue was dissolved in diethyl ether (10 ml), washed with saturated NaCl (aq) (20 ml), dried and evaporated to yield the title compound **8f** (0.072 g, 0.30 mmol,

94%) as a very pale yellow oil; ν_{max} (film)/cm^{-1} 3000–2850, 1695, 1380–1360, 1140, 1070; δ_H (300 MHz; $CDCl_3$) 0.88 (2 H, t, *J* 6.9, CH_2B), 1.13 [9 H, s, $(CH_3)_3C$], 1.23 [12 H, s, 2 × $(CH_3)_2CO$], 2.65 (2 H, t, *J* 7.0, $CH_2C{=}O$); δ_C (75.5 MHz; $CDCl_3$) 24.7 [$(CH_3)_2CO$], 26.6 [$(CH_3)_3C$], 31.7 ($CH_2C{=}O$), 43.6 [$(CH_3)_3C$], 82.9 [$(CH_3)_2CO$], 216.6 (C=O); δ_B (64.2 MHz; $CDCl_3$) +33.5; *m*/*z* (FAB) 241 $(M + H)^+$ [Found (HRMS): *m*/*z* 241.1971. $C_{13}H_{25}BO_3$ requires $(M + H)^+$ 241.1975].

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)pentan-3-one 8b

The procedure outlined for the conversion of **11f** to **8f** was followed on a 1.20 mmol scale using 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pentan-3-one *O*-methyloxime **11c** to yield ketone **8b** (0.20 g, 0.94 mmol, 79%) as a colourless oil; all spectroscopic and analytical properties were identical to those reported above.

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)hexan-3-one 8g

The procedure outlined for the conversion of **11f** to **8f** was followed on a 0.32 mmol scale using 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)hexan-3-one *O*-methyloxime **11d**, to afford the title compound **8g** (0.047 g, 0.21 mmol, 65%) as a colourless oil; ν_{max} (film)/cm^{-1} 3000–2880, 1710–1695, 1140, 1010; δ_H (300 MHz; $CDCl_3$) 0.90 (3 H, t, *J* 7.3, CH_3CH_2), 0.89–0.96 (2 H, m, CH_2B), 1.23 [12 H, s, 2 × $(CH_3)_2C$], 1.58 (2 H, sextet, *J* 7.3, CH_3CH_2), 2.37 (2 H, t, *J* 7.3, $CH_3CH_2CH_2$), 2.56 (2 H, t, *J* 7.2, CH_2CH_2B); δ_C (75.5 MHz; $CDCl_3$) 13.7 (CH_3-CH_2), 17.5 (CH_3CH_2), 24.7 [$(CH_3)_2C$], 37.5 (CH_2CH_2B), 44.1 ($CH_3CH_2CH_2$), 83.0 [$(CH_3)_2C$], 211.6 (C=O); δ_B (64.2 MHz; $CDCl_3$) +33.9; *m*/*z* (CI, NH_3) 227 $(M + H)^+$, 244 $(M + NH_4)^+$ [Found (HRMS): *m*/*z* 227.1812. $C_{12}H_{23}BO_3$ requires $(M + H)^+$ 227.1818].

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-4-methylpentan-3-one 8d

The procedure outlined for the conversion of **11f** to **8f** was followed on a 4.39 mmol scale using 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-4-methylpentan-3-one *O*-methyloxime **11e**, to yield the title compound **8d** (0.33 g, 1.46 mmol, 33%) as a colourless oil, which was identical to that reported above.

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)-4-methyloctan-3-one 8h

The procedure outlined for the conversion of **11f** to **8f** was followed on a 1.14 mmol scale using 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-4-methyloctan-3-one *O*-methyloxime **11g**, to afford the title compound **8h** (0.21 g, 0.78 mmol, 69%) as a colourless oil; ν_{max} (film)/cm^{-1} 3000–2850, 1705, 1380, 1320, 1140; δ_H (300 MHz; $CDCl_3$) 0.88 (3 H, t, *J* 7.0, CH_3CH_2), 0.89 (2 H, t, *J* 6.8, CH_2B), 1.05 (3 H, d, *J* 6.9, CH_3CH), 1.23 [12 H, s, 2 × $(CH_3)_2C$], 1.17–1.32 [6 H, m, $CH_3(CH_2)_3$], 2.48–2.54 (1 H, m, CH_3CH), 2.57–2.62 (2 H, m, $CH_2C{=}O$); δ_C (75.5 MHz; $CDCl_3$) 5.1 (br, CH_2B), 13.9 (CH_3CH_2), 16.6 (CH_3CH), 22.7 (CH_3CH_2), 24.7 [$(CH_3)_2C$], 29.4 ($CH_3CH_2CH_2$), 33.0 (CH_2CH), 36.2 ($CH_2C{=}O$), 45.7 (CH_3CH), 83.0 [$(CH_3)_2C$], 215.3 (C=O); δ_B (64.2 MHz; $CDCl_3$) +33.6; *m*/*z* (FAB) 269 $(M + H)^+$ [Found (HRMS): *m*/*z* 269.2290. $C_{15}H_{29}BO_3$ requires $(M + H)^+$ 269.2288].

1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)undecan-3-one 8e

The procedure outlined for the conversion of **11f** to **8f** was followed on a 1.14 mmol scale using 1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)undecan-3-one *O*-methyloxime **11h**, to furnish the title compound **8e** (0.30 g, 1.01 mmol, 89%) as a colourless oil, which was identical to that reported above.

3-[(4*S*,5*S*)-4,5-Bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]propiophenone 2

The procedure outlined for the conversion of **11f** to **8f** was followed on a 2.20 mmol scale using 3-[(4*S*,5*S*)-4,5-bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]propiophenone *O*-methyloxime (*S*,*S*)-**23** to afford the title compound ketone (*S*,*S*)-**2** (0.331 g, 0.83 mmol, 37%) as a colourless oil after column chromatography [1 : 20, ethyl acetate–petroleum ether (40–60 °C) as eluent], which was identical to that reported previously.[3a]

1-(1,3,6,2-Dioxazaborocan-2-yl)pentan-3-one

To a solution of boronate ester **8b** (1.02 g, 4.81 mmol) in diethyl ether (10 ml), diethanolamine (2.40 ml of a 2.0 M solution in isopropanol, 4.80 mmol) was added dropwise. Refrigeration of the resulting milky solution, yielded the title compound 1-(1,3,6,2-dioxazaborocan-2-yl)pentan-3-one (0.266 g, 1.34 mmol, 28%) as a white, hygroscopic, amorphous solid, after filtration and drying under vacuum, over P_2O_5; δ_H (400 MHz; $CDCl_3$) 0.62–0.65 (2 H, m, CH_2B), 1.03 (3 H, t, *J* 7.5, CH_3), 2.46 (2 H, q, *J* 7.5, CH_3CH_2), 2.64–2.67 (2 H, m, CH_2CH_2B), 2.75–2.81 (2 H, m, CH_2N), 3.12–3.21 (2 H, m, CH_2N), 3.81–3.86 (2 H, m, CH_2O), 3.95–4.01 (2 H, m, CH_2O), 6.39 (1 H, br s, NH) (addition of D_2O caused peak at δ 6.39 to disappear); δ_C (100.6 MHz; $CDCl_3$) 8.0 (CH_3), 10.9 (br, CH_2B), 36.0 (CH_2CH_2B), 38.6 (CH_3CH_2), 51.1 (CH_2N), 63.2 (CH_2O), 219.5 (C=O); δ_B (64.2 MHz; $CDCl_3$) +12.0; *m*/*z* (FAB) 200 $(M + H)^+$ [Found (HRMS): *m*/*z* 200.1465. $C_9H_{18}BNO_3$ requires $(M + H)^+$ 200.1458].

1-[(4*R*,5*R*)-4,5-Bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]pentan-3-one 26b

To a solution of diethanolamine derivative 1-(1,3,6,2-dioxazaborocan-2-yl)pentan-3-one (0.016 g, 0.080 mmol) and diol (*R*,*R*)-**19** (0.015 g, 0.058 mmol) in chloroform (1 ml), 10% HCl (aq) (1 ml) was added. The biphasic solution was stirred at room temperature for 1 hour then separated. The combined organic layers were dried and evaporated to yield product **26b** (0.016 g, 0.045 mmol, 78%) as a colourless oil; $[\alpha]_D^{27}$ −32.5 (*c* 0.75, $CHCl_3$); δ_H (400 MHz; $CDCl_3$) 0.95–1.09 (2 H, m, CH_2B), 1.04 (3 H, t, *J* 7.5, CH_3CH_2), 1.56–1.82 (16 H, m, CH_2 cyclopentyl), 2.41 (2 H, q, *J* 7.5, CH_3CH_2), 2.49–2.56 (2 H, m, CH_2CH_2B), 3.23 (6 H, s, 2 × OCH_3), 4.29 (2 H, s, 2 × CH); δ_C (100.6 MHz; $CDCl_3$) 8.0 (CH_3CH_2), 24.5, 24.6, 30.7, 31.3 (CH_2 cyclopentyl), 35.4 (CH_2CH_2B), 36.7 (CH_3CH_2), 50.3 (OCH_3), 80.8 (CHO), 87.9 ($COCH_3$), 211.6 (C=O); δ_B (62.4 MHz; $CDCl_3$) +35.2; *m*/*z* (FAB) 370 $(M + NH_4)^+$ [Found (HRMS): *m*/*z* 370.2766. $C_{19}H_{33}BO_5$ requires $(M + NH_4)^+$ 370.2765].

1-(1,3,6,2-Dioxazaborocan-2-yl)-4-methylpentan-3-one

To a solution of boronate ester **8d** (0.24 g, 1.06 mmol) in diethyl ether (5 ml), diethanolamine (0.53 ml of a 2.0 M solution in propan-2-ol, 1.06 mmol) was added dropwise. Refrigeration of the resulting milky solution yielded the title compound 1-(1,3,6,2-dioxazaborocan-2-yl)-4-methylpentan-3-one (0.10 g, 0.47 mmol, 44%) as a white hygroscopic amorphous solid, after filtration and drying under vacuum over P_2O_5; ν_{max} (KBr)/cm^{-1} 3050, 2980, 1690, 1420, 1265, 1070; δ_H (300 MHz; $CDCl_3$) 0.62–0.66 (2 H, m, CH_2B), 1.07 [6 H, d, *J* 7.0, $(CH_3)_2CH$], 2.61–2.78 [5 H, m, $CH_2C{=}O$, CH_2N, $(CH_3)_2CH$], 3.09–3.21 (2 H, m, CH_2N), 3.80–3.86 (2 H, m, CH_2O), 3.93–4.02 (2 H, m, CH_2O), 6.41 (1 H, br s, NH) (addition of D_2O causes peak at δ 6.41 to disappear); δ_C (75.5 MHz; $CDCl_3$) 10.7–11.8 (br, CH_2B), 18.5 [$(CH_3)_2C$], 37.0 ($CH_2C{=}O$), 40.9 [$(CH_3)_2C$], 51.1 (CH_2N), 60.6 (CH_2O), 218.0 (C=O); δ_B (64.2 MHz; $CDCl_3$) +12.2; *m*/*z* (FAB) 214 $(M + H)^+$ [Found (HRMS): *m*/*z* 213.1541. $C_{10}H_{20}BNO_3$ requires M^+ 213.1536].

1-[(4*R*,5*R*)-4,5-Bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]-4-methylpentan-3-one 26d

To a solution of diethanolamine derivative 1-(1,3,6,2-dioxazaborocan-2-yl)-4-methylpentan-3-one (0.031 g, 0.145 mmol) and diol (*R*,*R*)-**19** (0.031 g, 0.12 mmol) in chloroform (1 ml), 10% HCl (aq) (1 ml) was added. The biphasic solution was stirred at room temperature for 1 hour then separated. The combined organic layers were dried and evaporated to yield product **26d** (0.026 g, 0.071 mmol, 59%) after column chromatography [1 : 10, ethyl acetate–petroleum ether (40–60 °C) as eluent]; $[\alpha]_D^{27}$ −45 (*c* 1.0, $CHCl_3$); δ_H (300 MHz; $CDCl_3$) 0.96–1.03 (2 H, m, CH_2B), 1.08 [6 H, d, *J* 7.1, $(CH_3)_2C$], 1.59–1.78 (16 H, m, CH_2 cyclopentyl), 2.59 (2 H, t, *J* 7.2, $CH_2C{=}O$), 2.59 [1 H, septet, *J* 7.0, $(CH_3)_2CH$], 3.22 (6 H, s, 2 × OCH_3), 4.29 (2 H, s, 2 × CHO); *m*/*z* (CI, NH_3) 384 $(M + NH_4)^+$ [Found (HRMS): *m*/*z* 384.2923. $C_{20}H_{35}BO_5$ requires $(M + NH_4)^+$ 384.2921].

1-(1,3,6,2-Dioxazaborocan-2-yl)-4,4-dimethylpentan-3-one

To a solution of boronate ester **8f** (2.00 g, 8.33 mmol) in diethyl ether (10 ml), diethanolamine (4.15 ml of a 2.0 M solution in isopropanol, 8.30 mmol) was added dropwise. Refrigeration of the resulting milky solution yielded the title compound 1-(1,3,6,2-dioxazaborocan-2-yl)-4,4-dimethylpentan-3-one (0.80 g, 3.52 mmol, 43%) as a white amorphous solid, after filtration and drying under vacuum over P_2O_5; mp 148 °C (Found: C, 58.1; H, 10.0; N, 6.1; B, 4.8. $C_{11}H_{22}NO_3$ requires C, 58.2; H, 9.8; N, 6.2; B, 4.8%); ν_{max} (KBr)/cm^{-1} 3050, 2980–2860, 1680, 1420, 1265, 1070; δ_H (300 MHz; $CDCl_3$) 0.61–0.65 (2 H, m, CH_2B), 1.13 [9 H, s, $(CH_3)_3C$], 2.70–2.74 (2 H, m, $CH_2C{=}O$), 2.75–2.81 (2 H, m, CH_2N), 3.09–3.20 (2 H, m, CH_2N), 3.80–3.86 (2 H, m, CH_2O), 3.93–4.02 (2 H, m, CH_2O), 6.42 (1 H, br s, NH) (addition of D_2O caused peak at δ 6.42 to disappear); δ_C (75.5 MHz; $CDCl_3$) 26.8 [$(CH_3)_3C$], 33.2 ($CH_2C{=}O$), 44.4 [$(CH_3)_3C$], 51.1 (CH_2N), 63.2 (CH_2O), 216.4 (C=O); δ_B (128.3 MHz; $CDCl_3$) +12.0; *m*/z (FAB) 228 $(M + H)^+$ [Found (HRMS): *m*/*z* 227.1692. $C_{11}H_{22}BNO_3$ requires M^+ 227.1693].

1-[(4*R*,5*R*)-4,5-Bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]-4,4-dimethylpentan-3-one 26f

A solution of diethanolamine derivative 1-(1,3,6,2-dioxazaborocan-2-yl)-4,4-dimethylpentan-3-one (0.227 g, 1.00 mmol) and diol (*R*,*R*)-**19** (0.30 g, 1.16 mmol) in chloroform (30 ml) and HCl (aq) (30 ml of a 0.04 M solution, 1.20 mmol) was stirred at room temperature for 2 hours, then separated. The organic phases were washed with water. Evaporation yielded a colourless oil which was purified by flash chromatography [1 : 10, ethyl acetate–petroleum ether (40–60 °C) as eluent] affording the title compound **26f** (0.34 g, 0.89 mmol, 89%); $[\alpha]_D^{22}$ −46.5 (*c* 0.946, MeOH); ν_{max} (film)/cm^{-1} 2800–2828, 1707, 1392, 1366, 1240, 1076; δ_H (250 MHz; $CDCl_3$) 0.92–0.98 (2 H, m, CH_2B), 1.12 [9 H, s, $(CH_3)_3C$], 1.58–1.78 (16 H, m, CH_2 cyclopentyl), 2.60–2.66 (2 H, m, $CH_2C{=}O$), 3.21 (6 H, s, 2 × OCH_3), 4.28 (2 H, s, 2 × CHO); δ_C (62.9 MHz; $CDCl_3$) 24.5, 24.6 (CH_2 cyclopentyl), 26.7 [$(CH_3)_3C$], 30.8, 31.2 (CH_2 cyclopentyl), 31.3 ($CH_2C{=}O$), 43.7 [$(CH_3)_3C$], 50.3 (OCH_3), 80.7 (CHO), 88.0 ($COCH_3$), 215.9 (C=O); δ_B (128.3 MHz; $CDCl_3$) +33.9; *m*/*z* (FAB) 381 $(M + H)^+$ [Found (HRMS): *m*/*z* 381.2800. $C_{21}H_{37}BO_5$ requires $(M + H)^+$ 381.2812].

1-(1,3,6,2-Dioxazaborocan-2-yl)undecan-3-one

To a solution of boronate ester **8e** (0.162 g, 0.55 mmol) in diethyl ether (5 ml), diethanolamine (0.28 ml of a 2.0 M solution in propan-2-ol, 0.56 mmol) was added dropwise. Refrigeration of the resulting milky solution yielded the title compound 1-(1,3,6,2-dioxazaborocan-2-yl)undecan-3-one (0.048 g, 0.17 mmol, 31%) as a white hygroscopic amorphous solid, after filtration and drying under vacuum over P_2O_5; δ_H (400 MHz; $CDCl_3$) 0.62–0.64 (2 H, m, CH_2B), 0.88 (3 H, t, *J* 7.0, CH_3CH_2), 1.26–1.53 [12 H, m, $CH_3(CH_2)_6$], 2.42 [2 H, t, *J* 7.3, $(CH_2)_6CH_2C{=}O$], 2.63–2.67 (2 H, m, CH_2CH_2B), 2.75–2.80 (2 H, m, CH_2N), 3.12–3.20 (2 H, m, CH_2N), 3.81–3.86 (2 H, m, CH_2O), 3.91–4.01 (2 H, m, CH_2O), 6.39 (1 H, br s, NH) (addition of D_2O caused peak at δ 6.39 to disappear); δ_C (100.6 MHz; $CDCl_3$) 14.1 (CH_3CH_2), 22.6, 24.2, 29.1, 29.2, 29.3, 31.8 [$CH_3(CH_2)_6$], 39.2 (CH_2CH_2B), 43.1 [$(CH_2)_6CH_2C{=}O$], 51.1 (CH_2N), 63.2 (CH_2O), 219.6 (C=O); δ_B (62.4 MHz; $CDCl_3$) +12.1; *m*/*z* (FAB) 284 $(M + H)^+$ [Found (HRMS): *m*/*z* 284.2402. $C_{15}H_{30}BNO_3$ requires $(M + H)^+$ 284.2397].

1-[(4*R*,5*R*)-4,5-Bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]undecan-3-one 26e

To a solution of diethanolamine derivative 1-(1,3,6,2-dioxazaborocan-2-yl)undecan-3-one (0.025 g, 0.088 mmol) and diol (*R*,*R*)-**19** (0.023 g, 0.089 mmol) in chloroform (1 ml), 10% HCl (aq) (1 ml) was added. The biphasic solution was stirred at room temperature for 1 hour then separated. The combined organic layers were dried and evaporated to yield product **26e** (0.029 g, 0.066 mmol, 76%) after column chromatography [1 : 10, ethyl acetate–petroleum ether (40–60 °C) as eluent]; $[\alpha]_D^{22}$ −21.5 (*c* 0.95, $CHCl_3$); ν_{max} (film)/cm^{-1} 2980–2810, 1710, 1460–1450, 1390–1360, 1240, 1140, 1075; ^1H NMR was as reported;[25] δ_C (75.5 MHz; $CDCl_3$) 4.4 (br, CH_2B), 14.1 (CH_3CH_2), 22.6, 24.2, 24.6, 24.8, 29.1, 29.3, 29.4, 31.3, 31.8 [$CH_3(CH_2)_6$, CH_2 cyclopentyl)], 37.2 (CH_2CH_2B), 42.3 [$(CH_2)_6CH_2C{=}O$], 50.3 (OCH_3), 80.8 (CHO), 87.9 ($COCH_3$), 211.3 (C=O); δ_B (64.2 MHz; $CDCl_3$) +33.6; *m*/*z* (CI, NH_3) 437 $(M + H)^+$, 454 $(M + NH_4)^+$ [Found (HRMS): *m*/*z* 454.3708. $C_{25}H_{45}BO_5$ requires $(M + NH_4)^+$ 454.3703].

Monitoring of benzyl{3-[(4*R*,5*R*)-4,5-bis(1-methoxycyclopentyl)-1,3,2-dioxaborolan-2-yl]-1-phenylpropylidene}amine 27 formation by ^1H NMR

Method A. Activated granular molecular sieves (4 Å) were added to a stirred solution of β-keto boronate ester **26g** (0.10 g, 0.25 mmol) and benzylamine (0.055 ml, 0.50 mmol) in $CDCl_3$ (4 ml). The solution was stirred under a nitrogen atmosphere for 36 hours at room temperature. A sample was removed and examined by ^1H NMR, which showed the presence of title compound **27** (1 : 8, starting material ketone **26g** : product imine **27**); δ_H (360 MHz; $CDCl_3$) 3 : 5, mixture of diastereoisomers, major diastereoisomer: 1.01 (2 H, t, *J* 7.3, CH_2B), 1.54–1.76 (16 H, m, CH_2 cyclopentyl), 2.79–2.83 (2 H, m, $CH_2C{=}N$), 3.14 (6 H, s, 2 × OCH_3), 4.21 (2 H, s, 2 × CHO), 4.67 (2 H, ABq, *J* 14.9, separation 98.3, CH_2Ph), 7.05–7.83 (10 H, m, H aromatic); minor diastereoisomer: 1.04–1.09 (2 H, m, CH_2B), 1.54–1.76 (16 H, m, CH_2 cyclopentyl), 2.82–2.88 (2 H, m, $CH_2C{=}N$), 3.24 (6 H, s, 2 × OCH_3), 4.31 (2 H, s, 2 × CHO), 4.81 (2 H, s, CH_2Ph), 7.05–7.83 (10 H, m, H aromatic).

Method B. β-Keto boronate ester **26g** (0.13 g, 0.32 mmol) was dissolved in benzylamine (8 ml). A Kugelrohr apparatus (50 °C, 2.0 mmHg) was used to distil excess benzylamine and water, leaving an orange oil residue. A sample was removed from the reaction and examined by ^1H NMR, which showed the presence of imine **27** (1 : 1, starting material ketone **26g** : product imine **27**): ^1H NMR was as reported in Method A for imine **27**.

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