Novel Enantioselective Synthesis of Both Enantiomers of Furan-2-yl Amines and Amino Acids

by **Ayhan S. Demir*** and **Özge Sesenoglu**

Department of Chemistry, Middle East Technical University, TR-06531 Ankara (e-mail: asdemir@metu.edu.tr)

and

Dinçer Ülkü[1]) and **Cengiz Arıcı**[1])

Department of Engineering Physics, Hacettepe University, Beytepe, TR-06532 Ankara

A new enantioselective synthesis of furan-2-yl amines and amino acids is described, in which the key step is the oxazaborolidine-catalyzed enantioselective reduction of *O*-benzyl (*E*)- and (*Z*)-furan-2-yl ketone oximes to the corresponding chiral amines. The chirality of the furan-2-yl amines is fully controlled by the appropriate choice of the geometrical isomer of the *O*-benzyl oxime. Oxidation of the furan ring furnished amino acids in high yields.

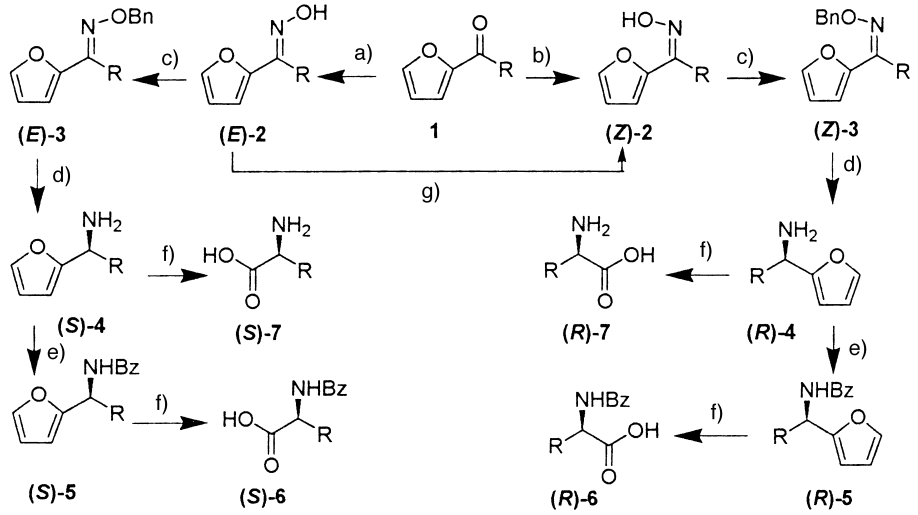
Introduction. – Optically active furan-2-yl amines are important synthetic building blocks for various biologically important molecules [1]. Oxidative cleavage of a furan ring under mild conditions can yield amino acids [2]. By employment of the aza-*Achmatowicz* reaction, furan can be converted to piperidines, and, in particular, to aza sugars [3]. There are a few methods for the synthesis of optically active furan-2-yl amines; the kinetic resolution of racemic amines [4], the addition of organometallics to furfural imines [5], and the asymmetric aminohydroxylation of vinylfuran afford optically active furyl amines [6]. Adducts from diastereoselective *Mannich*-type reactions of aldehydes, (furan-2-yl) boronic acid and the chiral amine template have been used in the synthesis of a series of chiral furan-2-yl amines [7]. Development of an enantioselective procedure capable of producing both enantiomers of furan-2-yl amines can give rise to many interesting compounds. In this work, we describe the selective formation of (*E*)- and (*Z*)-oximino derivatives of some representative furan-2-yl ketones and their enantioselective reduction, which gives access to both enantiomers of furan-2-yl amines, followed by an oxidative cleavage of the furan ring to yield amino acids in high enantiomeric excess. Some preliminary results in the asymmetric synthesis of furan-2-yl amines, α-amino acids, cyclopropaneaminocarboxylic acids, and aminophosphonic acids were reported previously [8].

Results and Discussion. – Ketones **1a**–**1g**, required for the preparation of *O*-benzyl oximes **3a**–**3g**, were prepared from the corresponding acid chloride and furan in good yields according to published methods [9] (*Scheme 1*).

Ketones **1a**–**1g** were converted selectively to the (*E*)- and (*Z*)-oximes **2a**–**2g** in good yields under following conditions (*Table 1*). Reactions of ketones with $H_2NOH\cdot$

[1]) Authors responsible for the X-ray crystal-structure analysis.

Scheme 1



a) $NH_2OH \cdot HCl$, NaOH. b) $NH_2OH \cdot HCl$, AcONa, EtOH. c) NaH, BnBr, DMF. d) $BH_3 \cdot THF$, cat. e) BzCl, Pyridine. f) O_3, MeOH or $RuO_2 \cdot H_2O$, $NaIO_4$, MeCN, CCl_4. g) Et_2O, HCl(g).

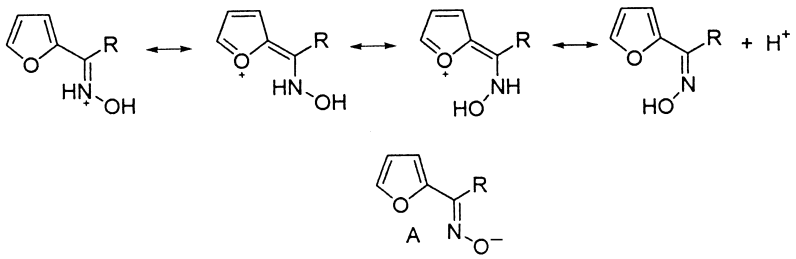
HCl/NaOH gave (*E*)-oximes (*Method A*; 71–86%), whereas reactions with $H_2NOH \cdot$ HCl/AcONa/EtOH yielded (*Z*)-oximes (*Method B*; 69–77%). From both methods, the opposite isomers were isolated as minor products. Additional purification was achieved by recrystallization. Alternatively, (*E*)-oximes were converted to corresponding (*Z*)-oximes with HCl gas in Et_2O at 0° (*Method C*). The ethereal suspension of (*E*)-oxime gave a clear solution with HCl gas, in which the subsequent precipitate formed was regarded as (*Z*)-oxime. Additional recrystallization gave (*Z*)-oxime in 68–78% yields. (*E*)- and (*Z*)-Isomers were identified by their ^{1}H- and ^{13}C-NMR spectra. For example, (*E*)-**2a** displays a *doublet* for the H–C(3) of the furan ring at 6.54 ppm, whereas (*Z*)-**2a** displays a *multiplet* for the same H-atom at 7.42 ppm, which is probably the result of the anisotropy effect of the oxime O-atom. In addition, the ^{13}C-NMR shift for C(3) of the (*E*)-isomer is 111.6 ppm, whereas for the (*Z*)-isomer the shift is 118.1 ppm. The purity of (*E*)- and (*Z*)-isomers was apparent by GLC analysis of the corresponding *O*-benzyl derivatives of oximes. Both methods gave the same results regarding the ratio and purity of the isomers for all synthesized oximes. The formation of (*Z*)-oxime in acidic medium could be explained by the use of the resonance structures of protonated imine, as shown in *Scheme 2*. The oxime anion **A**, which can form during the conversion of ketone to oxime in alkali medium, could be responsible for the selective formation of (*E*)-oxime.

Oximes are converted to *O*-benzyl oximes in high yields (83–94%) with NaH and BnBr. No isomerization was observed during this conversion. All of the *O*-benzyl oximes are viscous oils and are purified by flash column chromatography. *O*-Benzyl oximes are also synthesized from ketones and *O*-benzylhydroxylamine hydrochloride. This procedure gave mixtures of isomers. The separation of isomers by flash column

Table 1. *Synthesis of Oximes and* O*-Benzyl Oximes*

Furan-2-yl ketone		Oximes **2**					*O*-Benzyl oximes **3**		
	R		*Method*	Config.	Yield [%]	M.p. [°] (Lit.)		Config.	Yield [%]
1a	Me	**2a**	*A*	(*E*)	82	104–105 ([9a]: 104)	**3a**	(*E*)	83
			B	(*Z*)	77	76 ([9a]: 74)		(*Z*)	84
			C	(*Z*)	78	76			
1b	Et	**2b**	*A*	(*E*)	73	74 ([9a]: 73)	**3b**	(*E*)	92
			B	(*Z*)	69	77 ([9a]: 77–78)		(*Z*)	89
			C	(*Z*)	68	77			
1c	i-Pr	**2c**	*A*	(*E*)	71	96	**3c**	(*E*)	93
			B	(*Z*)	73	70		(*Z*)	91
1d	*t*-Bu	**2d**	*B*	(*Z*)	76	92	**3d**	(*Z*)	91
1e	Bn	**2e**	*A*	(*E*)	77	127	**3e**	(*E*)	91
1f	Ph	**2f**	*A*	(*E*)	81	160–162 ([9a]: 161)	**3f**	(*E*)	93
			B	(*Z*)	69	150–151 ([9a]: 149)		(*Z*)	91
1g	3,4-Dimethoxy-phenyl	**2g**	*A*	(*E*)	86	149–150	**3g**	(*E*)	94
			C	(*Z*)	78	112–113		(*Z*)	91

Scheme 2



chromatography afforded the *O*-benzyl (*E*)- and (*Z*)-oxime in yields of 28 and 36%, respectively.

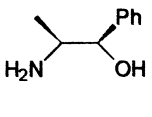
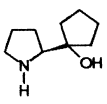
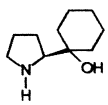
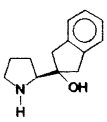
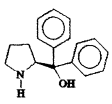
The stereoselective reduction of the C=N bond is widely used in the construction of saturated N-containing compounds. Nonracemic target chiral compounds can be obtained by homo- and heterogeneous hydrogenation, and hydrosilylation, as well as hydride reduction [10]. These synthetic techniques make the desired products available with high stereoisomeric ratios, and they open convenient routes to the preparation of various compounds. *O*-Substituted oximes are readily available compounds for the conversion of C=O groups to amines. Some of the most important work in this area was reported by *Itsuno et al.* [11]. They showed that *O*-substituted acetophenone oxime can be converted to amines using BH_3-oxazaborolidine complexes in high enantiomeric excess.

For the reduction of furan-2-yl ketone *O*-benzyl oximes **3a**–**3g**, different reaction conditions are applied, as described below. First enantioselective reduction was carried out with BH_3 in the presence of oxazaborolidine complexes [12] prepared from different chiral amino alcohols according to the following procedures.

Procedure A. A solution of BH_3 (20 mmol) in THF (20 ml) was added under Ar dropwise to a solution of 10 mmol of (*R*,*S*)-norephedrine dissolved in 10 ml of THF at $-20°$. The resulting mixture was warmed to $-5°$, and stirring was continued at this temperature for 16 h, before 8 mmol of *O*-benzyl oxime (*E*)-**3a** in 10 ml of THF was added dropwise. The resulting solution was stirred at 30° for 48 h (monitored by TLC) and was decomposed by the slow addition of 2M HCl. The product amine **4a** was purified by bulb-to-bulb distillation.

The amine is characterized by NMR and IR spectroscopy. The enantiomeric excess (ee) of the product was found to be 96% and determined *via Mosher* amide by ^{19}F-NMR and (*S*)-acetyllactylamide by HPLC analysis. In addition to these methods, by applying a new synthetic method [13] to amines, we obtained excellent separation properties with a chiral HPLC column. We developed this method for the efficient preparation of 2-methyl-1*H*-pyrroles from 5-chloropent-3-en-2-one and amines without racemization. Enantiomeric excesses of the amines were determined by comparing their chiral 2-methyl-1*H*-pyrrole derivatives with racemic mixtures by means of a chiral HPLC column (*Chiralpak AD* column, UV detection at 220 nm, isohexane/i-PrOH 9 : 1, flow rate 0.75 ml min^{-1}) [13]. The absolute configuration of **4a** was found to be (*S*) by comparing its α- value with known data [5b]. The same reaction was carried out with oxazaborolidines prepared from amino alcohols **8**–**12**, and **4a** was obtained in 71–81% yields and 51–97% ee as shown in *Table 2*. The highest ee was found with amino alcohols **8**, **11**, and **12**. Under similar conditions, *O*-benzyl (*Z*)-oxime (*Z*)-**3a** furnished the amine **4a** in 71–80% yields and 53–96% ee, depending on the amino alcohol used (*Table 2*). Interestingly, *O*-benzyl (*Z*)-oxime furnished (*R*)-**4a**.

Table 2. *Reduction of* O-*Benzyl Oxime* **3** *with Different Amino Alcohols* (*Procedure A*)

O-Benzyl oxime	Furan-2-yl amine	Amino alcohols				
						
		(*R*,*S*)-**8**	(*S*)-**9**	(*S*)-**10**	(*S*)-**11**	(*S*)-**12**
(*E*)-**3a**	(*S*)-**4a**					
	Yield [%]	77	81	78	71	74
	ee [%]	96	51	53	94	97
(*Z*)-**3a**	(*R*)-**4a**					
	Yield [%]	72	77	80	73	71
	ee [%]	94	53	54	95	96

Reduction reactions were applied to different *O*-benzyl oximes with amino alcohols **8**, **11**, and **12**, and the corresponding amines were obtained in 71–91% yields and 90–97% ee (*Table 3*). The X-ray crystal structure of (*S*)-**4g** is shown in *Fig. 1.*

Table 3. *Oxazaborolidine-Catalyzed Reduction of* O*-Benzyl Oximes*

O-Benzyl oxime	Amine	*Procedure A*		*Procedure B*		*Procedure C*	
		Yield [%] (cat.)	ee [%] (cat.)	Yield [%] (cat.)	ee [%] (cat.)	Yield [%] (cat.)	ee [%] (cat.)
(*E*)-**3a**	(*S*)-**4a**	77(8), 71(11), 74(12)	96(8), 94(11), 97(12)	81(8), 78(11), 73(12)	44(8), 51(11), 58(12)	77(8), 74(11), 71(12)	68(8), 78(11), 83(12)
(*Z*)-**3a**	(*R*)-**4a**	72(8), 73(11), 71(12)	94(8), 95(11), 96(12)	83(8), 81(11), 77(12)	41(8), 52(11), 56(12)	76(8), 73(11), 72(12)	61(8), 73(11), 81(12)
(*E*)-**3b**	(*S*)-**4b**	81(8), 83(11), 80(12)	96(8), 94(11), 96(12)	75(12)	61(12)	76(8), 74(11), 72(12)	69(8), 77(11), 88(12)
(*Z*)-**3b**	(*R*)-**4b**	78(8), 81(11), 76(12)	93(8), 91(11), 95(12)	75(12)	58(12)	73(8), 73(11), 74(12)	66(8), 71(11), 84(12)
(*E*)-**3c**	(*S*)-**4c**	81(8), 78(11), 77(12)	96(8), 96(11), 96(12)	78(12)	62(12)	81(8), 80(11), 82(12)	63(8), 71(11), 84(12)
(*Z*)-**3c**	(*R*)-**4c**	83(8), 81(11), 76(12)	95(8), 92(11), 96(12)	79(12)	64(12)	78(8), 78(11), 82(12)	61(8), 70(11), 83(12)
(*Z*)-**3d**	(*R*)-**4d**	76(8), 73(11), 78(12)	90(8), 92(11), 92(12)	75(12)	41(12)	77(8), 78(11), 73(12)	57(8), 59(11), 58(12)
(*E*)-**3e**	(*S*)-**4e**	88(8), 84(11), 81(12)	92(8), 94(11), 96(12)	79(12)	47(12)	79(8), 80(11), 77(12)	63(8), 68(11), 73(12)
(*E*)-**3f**	(*S*)-**4f**	87(8), 84(11), 83(12)	95(8), 96(11), 97(12)	87(12)	46(12)	88(8), 87(11), 88(12)	61(8), 71(11), 77(12)
(*Z*)-**3f**	(*R*)-**4f**	91(8), 81(11), 84(12)	91(8), 93(11), 92(12)	85(12)	43(12)	83(8), 81(11), 81(12)	58(8), 70(11), 75(12)
(*E*)-**3g**	(*S*)-**4g**	88(12)	93(12)	82(12)	57(12)	86(12)	73(12)
(*Z*)-**3g**	(*R*)-**4g**	84(12)	87(12)	81(12)	41(12)	78(12)	61(12)

Amino alcohols, used for the preparation of oxazaborolidines, are recovered as their HCl salts in 87–95% yield during the workup procedure.

The reduction of *O*-benzyl oxime (*E*)-**3a** under similar conditions with catalytic amounts of oxazaborolidine complexes prepared with amino alcohols (*S*)-**8** and (*S*)-**12** (0.1–0.2 equiv.) afforded 22–31% enantiomeric excess.

Procedure B. To a solution of amino alcohol (*R*,*S*)-**8** (0.1 mmol) in THF was added 10 equiv. of $BH_3 \cdot Me_2S$ complex at room temperature, and the resulting mixture was stirred at this temperature for 12 h. To this mixture was added a solution of the *O*-benzyl oxime (*E*)-**3a** (5 mmol) in THF over 1 h. This was followed by stirring at 35°, until the starting material disappeared (TLC), and then under reflux for 48 h. After workup, the reaction gave the amine in 81% yield and 44% ee. Under similar conditions, amino alcohol (*S*)-**11** furnished (*S*)-**4a** in 51% ee and (*R*)-**4a** in 52% ee, while amino alcohol (*S*)-**12** furnished (*S*)-**4a** in 58% ee and (*R*)-**4a** in 56% ee, starting

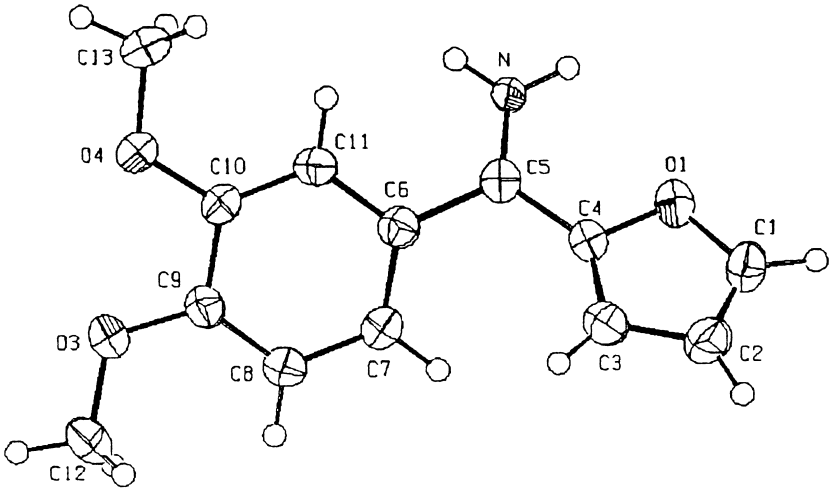


Fig. 1. *X-Ray structure of* (S)-**4g**

from the corresponding *O*-benzyl oxime. Application of this method to different *O*-benzyl oximes with (*S*)-**12** furnished the amines in 75–87% yields and 41–64% ee as summarized in *Table 3*. Amino alcohol (*S*)-**12** gave a higher ee value than (*R*,*S*)-**8** and (*S*)-**11**.

Procedure C. As described in *Procedure B*, with 0.5 equiv. of trimethyl borate and (*S*)-**8**, and adding *O*-benzyl oxime solution over 2 h furnished (*S*)-**4a** in 77% yield and 68% ee. The same reaction was applied to different *O*-benzyl oximes with **8**, **11**, and **12**, and the corresponding amines were obtained in 71–88% yields and 57–88% ee (*Table 3*). In all cases, the *O*-benzyl (*Z*)-oximes gave the (*R*)-enantiomer.

The effect of the *O*-protecting group on the reduction of ketone *O*-benzyl oximes **3a** was also investigated. The reductions described in *Procedure A* were carried out with (*E*)-*O*-methyloxime, and the determination of the enantiomeric excesses of product amines showed low selectivity (52% ee).

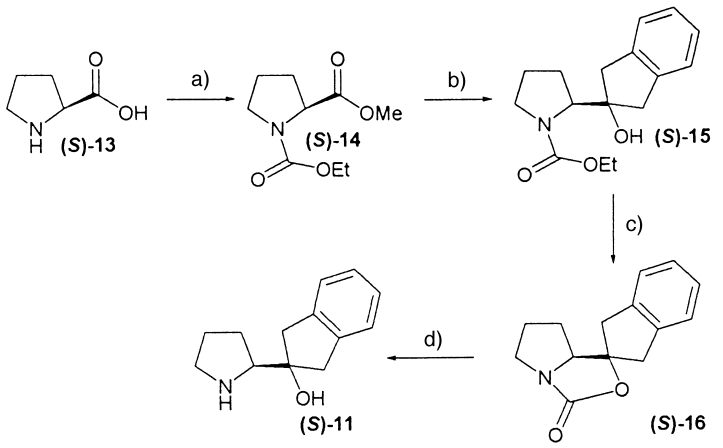
As we reported earlier [8a][12a][2]), compounds **9**, **10**, and **11** can readily be synthesized in three steps from (*S*)-proline, and their enantiomers are also synthesized starting from (*R*)-proline by the same procedure. In *Scheme 3*, gram-scale synthesis of amino alcohols is illustrated by the synthesis of (*S*)-**11**. The reaction of (*S*)-proline with ethyl chloroformate in MeOH with K_2CO_3 gave *N*- and *O*-protected proline **14** in a one-pot operation [8a]. The *Grignard* reaction of protected proline with 1,2-bis(chloromethyl)benzene afforded hydroxy derivative **15**. Deprotection of the *N*-carbamate was carried out by alkaline hydrolysis.

By the mechanism of the alkaline hydrolysis of carbamate, first we observed the formation of intermediate **16** (monitored by TLC), which we isolated and fully characterized by X-ray analysis (*Fig. 2*).

---

[2]) The synthesis and application of the amino alcohols **9**–**11** in assymmetric syntheses was reported for the first time at the 35th IUPAC Congress, Istanbul, Turkey, August 14–19, 1995.

Scheme 3



a) K_2CO_3, ClCOOEt, MeOH. b) 1,2-bis(chloromethyl)benzene, Mg, THF. c) KOH, MeOH, 1 h reflux. d) KOH, MeOH, 4 h reflux.

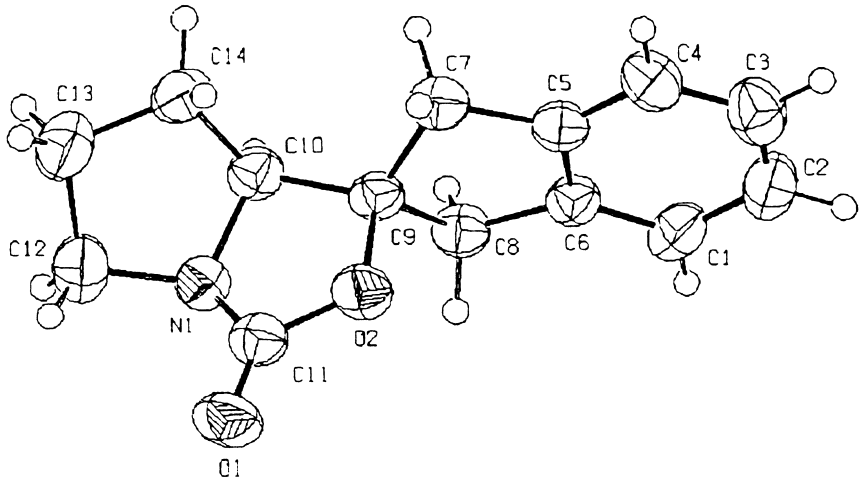


Fig. 2. *X-Ray structure of* (S)-**16**

Additional reflux of **16** with KOH gave proline derivative **11** in good yield. By the same procedure, both enantiomers of **9**, **10**, and **11** were also synthesized *via* their *N*-ethoxycarbonyl derivatives in good yield.

The crystals are composed of discrete molecules as shown in *Figs. 1* and *2*. As can be detected from crystallographic data (*Table 4*), the structural indicators have good values. No unusual values exist concerning the bond lengths, bond angles, and displacement parameters.

In the compound (*S*)-**16**, if one considers the two moieties of the molecule on both sides of the central C(9)-atom, these moieties are fairly planar within themselves and

Table 4. *Crystallographic Data of* (S)-**16** *and* (S)-**4g**[a])

	(*S*)-**16**	(*S*)-**4g**
Crystallized from	Et_2O/hexane	Et_2O/hexane
Empirical formula	$C_{14}H_{10}NO_2$	$C_{13}H_{13}NO_4$
Formula weight [g·mol^{-1}]	224.23	247.24
Crystal size [mm]	0.25 × 0.30 × 0.35	0.10 × 0.25 × 0.30
Unit-cell dimensions *a* [Å]	8.4920(12)	8.9233(11)
b [Å]	10.0448(11)	7.7431(12)
c [Å]	13.8248(13)	16.3528(13)
α [°]	90	90.00
β [°]	90	93.977(3)
γ [°]	90	90.00
Cell volume [Å^3]	1179.3(2)	1127.2(2)
Crystal system	Orthorhombic	Monoclinic
Space group	*P*212121	*P*21/*a*
Cell formula units *Z*	4	4
Calc. density D_x [g·cm^{-3}]	1.263	1.457
μ(MoK_α) [mm^{-}1]	0.088	0.109
Scan type	$\omega/2\theta$	$\omega/2\theta$
θ_{max}[°]	26.29	26.30
Absorption correction	none	ψ scan
Total reflections measured	2137	2447
Symmetry-independent refl.	1431	2288
Reflections used [$I \geq 2\sigma(I)$]	1234	1744
Parameters refined	155	155
Final *R*	0.051	0.056
wR	0.144	0.169
$\Delta\rho$ (max; min) [eÅ^{-3}]	0.289; −0.231	0.375; −0.509

[a]) Crystallographic data (excluding structure factors) for structures reported in this paper have been deposited with the *Cambridge Crystallographic Data Centre* as deposition No. CCDC 185707 for (*S*)-**16** and CCDC 185708 for (*S*)-**4g**. Copies of the data can be obtained, free of charge, on application to the CCDC, 12 Union Road, Cambridge CB2 IEZ UK (fax: + 44(1223)36033; e-mail: deposit@ccdc.com.ac.uk).

have a dihedral angle of 67.16(2)°. The bond angles around C(9) change from 103.2(2)° (O(2)–C(9)–C(10)) to 117.4(3)° (C(7)–C(9)–C(10)). That the maximum deviation from the ideal tetrahedral angle is observed between C(7)–C(9)–C(10) could be explained with the steric hindrances in the molecule. In the compound (*S*)-**4g**, the sum of the bond angles around C(5) is 360° within experimental error. The two planar ring moieties are twisted with respect to each other *ca.* 22° as the torsion angles indicate.

As shown in *Scheme 1*, furan-2-yl amines **4a**–**4g** were converted to *N*-benzoyl derivatives with PhCOCl in pyridine, and **5a**–**5g** were obtained in 86–93% yield after purification of the crude products by column chromatography. Oxidation of the furan ring by ozonolysis or by RuO_2/$NaIO_4$ periodate [14] furnished (*S*)- and (*R*)-*N*-benzoylamino acids in 83–91% yields. The oxidation of amines to amino acids without benzoylation was also carried out by ozonolysis. As a representative example, amines **4a** and **4f** were converted to amino acids **7a** and **7b**, respectively, in 78–84% yields.

The suggested mechanism outlined in *Fig. 3* shows that the formation of low-energy *cis*-pentalane is favored because β-binding of $BH_3 \cdot THF$ to oxazaborolidine forms very

strained *trans*-pentalane, which is disfavored. As shown in *Table 3*, the geometry of oxime becomes a dominant factor in the stereoselectivity by the formation of amines, and the substitution pattern has a minor effect on the stereoselectivity. It appears that the prochiral N moiety is responsible for the high selectivity, not the prochiral C.

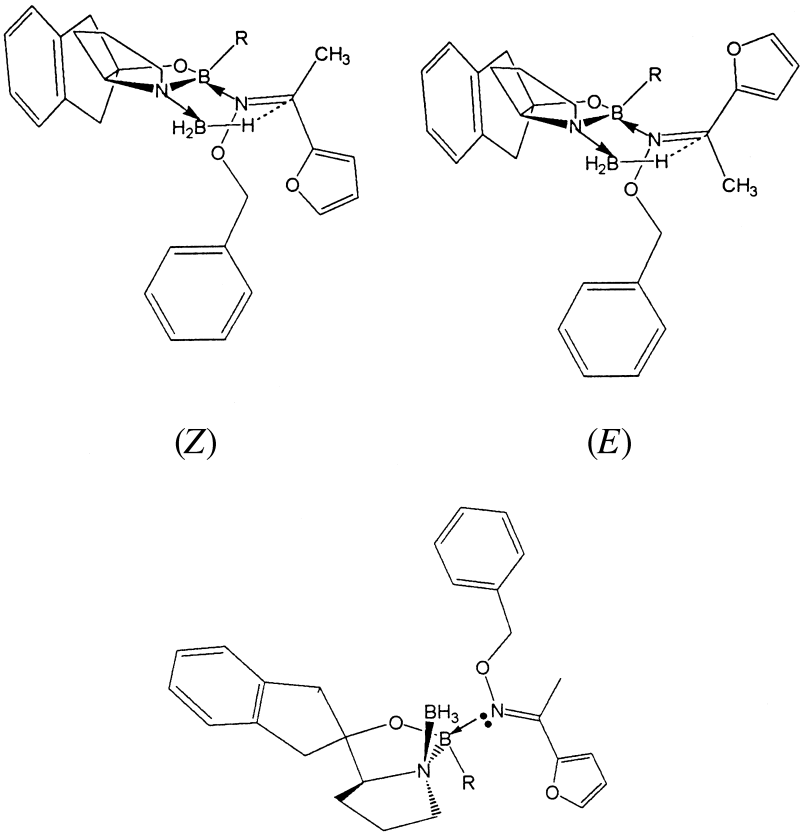


Fig. 3. *Suggested mechanism for the reduction of* O-*benzyl oxime*

In summary, furan-2-yl ketones can be converted to (*E*)- and (*Z*)-oximes selectively in good yield, and the enantioselective reduction of the corresponding *O*-substituted derivatives affords both enantiomers of the furan-2-yl amines in three steps, in 35–41% overall yields from readily available starting materials. The geometry of the *O*-substituted oximes is a dominant factor for the absolute configuration of product amines. This method represents a simple, selective, and flexible synthesis of both enantiomers of the furan-2-yl amines and amino acids. With catalytic amounts of oxazaborolidines, the increase in time for the addition of the *O*-substituted oximes increases the ee values slightly, but the addition of trimethylborate affords good ee values. The chirality of furan-2-yl amines is fully controlled by an appropriate choice of geometric isomer of the *O*-substituted oximes, and the substitution pattern had a minor effect on the stereoselectivity.

Experimental Part

General. Optical rotations: *Bellingham & Stanley P20* polarimeter or *Autopol IV* automatic polarimeter. Column chromatography (CC): silica gel *60* (mesh size 40–63 μm). NMR Spectra: *Bruker DPX-400*. GC/MS: *Phenomenex Zebron ZB-5* cap. column (5% phenylmethylsiloxane). Enantiomeric excesses (ee) were determined by HPLC analysis with a *Thermo Quest* (TSP) LC/MS equipped with an appropriate optically active column. X-Ray diffraction data were collected with a *CAD-4* diffractometer with graphite monochromated MoK_α radiation ($\lambda = 0.71073$ Å). *Lorentz* polarization and extinction corrections were applied. The structures were determined by direct methods and refined by full-matrix least-squares techniques to a conventional *R* value of 0.051 for the compound (*S*)-**16**, and 0.056 for the compound (*S*)-**4g**. All non-H-atoms were refined with anisotropic displacement parameters. The H-atoms were placed geometrically 0.95 to 0.99 Å from their parent C-atoms, and a riding model was used with $U_{iso}(H) = 1.3U_{eq}(C)$. Scattering factors were taken from International Tables for X-Ray crystallography. For data collection and cell parameters *CAD-4* EXPRESS [15], for structure solution and refinement SHELXL package [16], for molecular graphics PLATON 2000 [17] computer programs were utilized (more details in *Table 4*).

General Procedure for Oximes. Method A. Ketone **1a**–**1g** (5 mmol), $NH_2OH \cdot HCl$ (6 mmol), and NaOH (6 mmol) were mixed in abs. EtOH (15 ml) and stirred under reflux for 12 h. The reaction was monitored by TLC. After 12 h, the hot soln. was filtered, and EtOH was evaporated. The remaining solid was dissolved in H_2O and extracted with Et_2O. The Et_2O layer was washed with H_2O and brine, and dried ($MgSO_4$). Evaporation of the solvent afforded crude product, which was purified either by CC or crystallization to give (*E*)-oximes in 71–86% yields.

Method B. Ketone **1a**–**1g** (5 mmol), $NH_2OH \cdot HCl$ (6 mmol), and AcONa (6 mmol) were mixed in abs. EtOH (15 ml) and stirred under reflux for 12 h. The reaction was monitored by TLC. After 12 h, the hot soln. was filtered, and EtOH was evaporated. The remaining solid was dissolved in H_2O and extracted with Et_2O. The Et_2O layer was washed with H_2O and brine, and dried ($MgSO_4$). Evaporation of the solvent afforded crude product, which was purified either by CC or crystallization to give (*Z*)-oximes in 69–77% yields.

Method C: Isomerization of Oximes. Oxime **2a**–**2g** (1 mmol) ((*E*)/(*Z*)-mixture or (*E*)-oxime)) was suspended in dry Et_2O (15 ml), and HCl gas was bubbled through the soln. at 0°. Initially, a clear soln. was obtained, and then a white precipitate formed. Evaporation of the solvent afforded crude products that were purified either by CC or crystallization to give (*Z*)-oximes in 68–78% yields.

*(*E*)-1-(Furan-2-yl)ethanone Oxime* ((*E*)-**2a**). ^{1}H-NMR (400 MHz, $CDCl_3$): 2.14 (*s*, 3 H); 6.34 (*dd*, *J* = 1.7, 3.3, 1 H); 6.54 (*d*, *J* = 3.3, 1 H); 7.39 (*s*, 1 H); 9.95 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 11.5; 110.1; 111.6; 143.8; 147.5; 150.6. Anal. calc. for $C_6H_7NO_2$: C 57.59, H 5.64, N 11.19; found: C 57.31, H 5.82, N 11.36.

*(*Z*)-1-(Furan-2-yl)ethanone Oxime* ((*Z*)-**2a**). ^{1}H-NMR (400 MHz, $CDCl_3$): 2.24 (*s*, 3 H); 6.48 (*dd*, *J* = 1.1, 3.3, 1 H); 7.42–7.46 (*m*, 2 H); 8.71 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 11.7; 111.3; 118.1; 144.3; 148.0; 152.4. Anal. calc. for $C_6H_7NO_2$: C 57.59, H 5.64, N 11.19; found: C 57.51, H 5.44, N 11.36.

*(*E*)-1-(Furan-2-yl)propan-1-one Oxime* ((*E*)-**2b**). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.14 (*t*, *J* = 7.6, 3 H); 2.64 (*q*, *J* = 7.6, 2 H); 6.36 (*dd*, *J* = 1.7, 3.4, 1 H); 6.55 (*d*, *J* = 3.4, 1 H); 7.4 (*s*, 1 H); 9.62 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 11.5; 19.6; 110.5; 111.8; 144.1; 150.1; 152.8. Anal. calc. for $C_7H_9NO_2$: C 60.42, H 6.52, N 10.07; found: C 60.12, H 6.31, N 10.32.

*(*Z*)-1-(Furan-2-yl)propan-1-one Oxime* ((*Z*)-**2b**). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.15 (*t*, *J* = 7.6, 3 H); 2.64 (*q*, *J* = 7.6, 2 H); 6.47 (*dd*, *J* = 1.9, 3.2, 1 H); 7.42 (br. *s*, 2 H); 8.61 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 12.4; 25.4; 110.4; 118.8; 144.2; 148.9; 152.9. Anal. calc. for $C_7H_9NO_2$: C 60.42, H 6.52, N 10.07; found: C 60.11, H 6.23, N 10.33.

*(*E*)-1-(Furan-2-yl)-2-methylpropan-1-one Oxime* ((*E*)-**2c**). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.23 (*d*, *J* = 7.4, 6 H); 3.01–3.41 (*m*, 1 H); 6.34–6.45 (*m*, 1 H); 6.54–6.66 (*m*, 1 H); 7.37–7.49 (*m*, 1 H); 9.86 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 12.3; 12.4; 30.1; 110.2; 111.5; 143.5; 147.1; 150.7. Anal. calc. for $C_8H_{11}NO_2$: C 62.73, H 7.24, N 9.14; found: C 62.45, H 7.38, N 9.33.

*(*Z*)-1-(Furan-2-yl)-2-methylpropan-1-one Oxime* ((*Z*)-**2c**). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.26 (*d*, *J* = 7.4, 6 H); 3.06–3.43 (*m*, 1 H); 6.46–6.55 (*m*, 1 H); 7.36–7.53 (*m*, 2 H); 10.06 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 12.1; 12.3; 30.5; 110.1; 111.3; 143.2; 147.1; 150.5. Anal. calc. for $C_8H_{11}NO_2$: C 62.73, H 7.24, N 9.14; found: C 62.68, H 7.21, N 9.36.

*(*Z*)-1-(Furan-2-yl)-2,2-dimethylpropan-1-one Oxime* ((*Z*)-**2d**). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.29 (*s*, 9 H); 6.44 (*dd*, *J* = 1.7, 3.4, 1 H); 7.35 (*d*, *J* = 3.4, 1 H); 7.42 (*s*, 1 H); 9.51 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 29.1; 38.2; 111.7; 119.2; 142.3; 145.7; 154.1. Anal. calc. for $C_9H_{13}NO_2$: C 64.65, H 7.84, N 8.38; found: C 64.43, H 7.62, N 8.58.

*(*E*)-1-(Furan-2-yl)-2-phenylethanone Oxime* ((*E*)-**2e**). ^{1}H-NMR (400 MHz, $CDCl_3$): 3.87 (*s*, 2 H); 6.42 (*dd*, *J* = 1.6, 3.3, 1 H); 6.50 (*d*, *J* = 3.4, 1 H); 7.10–7.31 (*m*, 6 H); 8.92 (*s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 37.8; 111.4; 112.7; 128.9; 129.1; 129.4; 143.2; 146.9; 149.8; 149.9. Anal. calc. for $C_{12}H_{11}NO_2$: C 71.63, H 5.51, N 6.96; found: C 71.78, H 5.32, N 6.68.

*(*E*)-(Furan-2-yl)phenylmethanone Oxime* ((*E*)-**2f**). ^{1}H-NMR (400 MHz, $CDCl_3$): 6.22–6.46 (*m*, 2 H); 7.16–7.60 (*m*, 6 H); 9.22 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 111.2; 119.6; 128.2; 129.5; 132.5; 142.1; 147.2; 154.2. Anal. calc. for $C_{11}H_9NO_2$: C 70.58, H 4.85, N 7.48; found: C 70.52, H 4.95, N 7.41.

*(*Z*)-(Furan-2-yl)phenylmethanone Oxime* ((*Z*)-**2f**). ^{1}H-NMR (400 MHz, $CDCl_3$): 6.46–6.63 (*m*, 1 H); 7.31–7.66 (*m*, 7 H); 9.83 (br. *s*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 111.1; 119.4; 128.6; 129.7; 132.3; 142.3; 146.2; 146.5; 154.4. Anal. calc. for $C_{11}H_9NO_2$: C 70.58, H 4.85, N 7.48; found: C 70.33, H 4.88, N 7.21.

*(*E*)-(3,4-Dimethoxyphenyl)(furan-2-yl)methanone Oxime* ((*E*)-**2g**). ^{1}H-NMR (400 MHz, $CDCl_3$): 3.86 (*s*, 3 H); 3.90 (*s*, 3 H); 6.25–6.46 (*m*, 2 H); 6.83–7.53 (*m*, 4 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 56.3; 56.4; 110.5; 115.3; 115.6; 122.4; 124.7; 143.1; 143.4; 147.9; 147.9; 150.1; 155.3. Anal. calc. for $C_{13}H_{13}NO_4$: C 63.15, H 5.30, N 5.67; found: C 63.31, H 5.21, N 5.87.

*(*Z*)-(3,4-Dimethoxyphenyl)(furan-2-yl)methanone Oxime* ((*Z*)-**2g**). ^{1}H-NMR (400 MHz, $CDCl_3$): 3.91 (*s*, 3 H); 4.11 (*s*, 3 H); 6.60 (*dd*, *J* = 1.6, 3.4, 1 H); 6.90 (*d*, *J* = 8.3, 1 H); 7.25 (*d*, *J* = 3.5, 1 H); 7.60 (*d*, *J* = 1.8, 1 H); 7.72 (br. *s*, 1 H); 7.75 (*dd*, *J* = 1.8, 8.3, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 56.4; 56.5; 110.4; 112.3; 112.5; 120.1; 124.6; 130.3; 146.9; 149.4; 152.9; 153.5; 181.6. Anal calc. for $C_{13}H_{13}NO_4$: C 63.15, H 5.30, N 5.67; found: C 63.11, H 5.42, N 5.74.

General Procedure for O-*Benzyloximes.* To a suspension of 50 mmol of NaH in 60 ml of dry DMF at 0° was added 40 mmol of oxime dissolved in 50 ml of DMF. The mixture was stirred (1 h, 0°), and 50 mmol BnBr was added. After stirring for 2 h at r.t., the mixture was hydrolyzed with H_2O, extracted with AcOEt, dried ($MgSO_4$), and concentrated. Further purification was done by CC to yield *O*-benzyloximes as viscous oils.

*(*E*)-1-(Furan-2-yl)ethanone O-Benzyloxime* ((*E*)-**3a**). IR: 3140, 2885, 1600, 1490, 1450. ^{1}H-NMR (400 MHz, $CDCl_3$): 2.15 (*s*, 3 H); 5.23 (*s*, 2 H); 6.40 (*dd*, *J* = 1.6, 3.1, 1 H); 6.58 (*d*, *J* = 3.4, 1 H); 7.25–7.40 (*m*, 6 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 12.5; 76.9; 110.6; 111.7; 128.4; 128.6; 128.9; 138.1; 143.9; 147.8; 150.6. MS: 215 (M^+), 198, 185, 158, 91, 77, 65. Anal. calc. for $C_{13}H_{13}NO_2$: C 72.54, H 6.09, N 6.51; found: C 72.77, H 6.21, N 6.71.

*(*Z*)-1-(Furan-2-yl)ethanone* O-*Benzyloxime* ((*Z*)-**3a**). IR: 3170, 2890, 1600, 1565, 1480, 1450, 1430. ^{1}H-NMR (400 MHz, $CDCl_3$): 2.23 (*s*, 3 H); 5.20 (*s*, 2 H); 6.43–6.50 (*m*, 1 H); 7.10–7.45 (*m*, 7 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 12.5; 76.8; 110.5; 119.6; 128.2; 128.5; 128.7; 138.2; 144.5; 147.8; 151.9. MS: 215 (M^+), 198, 185, 158, 91 (100), 77, 65. Anal. calc. for $C_{13}H_{13}NO_2$: C 72.54, H 6.09, N 6.51; found: C 72.68, H 6.32, N 6.11.

*(*E*)-1-(Furan-2-yl)propan-1-one* O-*Benzyloxime* ((*E*)-**3b**). IR: 3140, 2880, 1600, 1490, 1450. ^{1}H-NMR (400 MHz, $CDCl_3$): 1.15 (*t*, *J* = 7.0, 3 H); 2.65 (*q*, *J* = 7.0, 2 H); 5.23 (*s*, 2 H); 6.35–6.44 (*m*, 1 H); 6.55–6.65 (*m*, 1 H); 7.21–7.50 (*m*, 6 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 12.0; 19.8; 76.8; 111.4; 128.3; 128.6; 128.9; 138.3; 144.2; 147.1; 150.1. MS: 229 (M^+), 212, 189, 158, 91 (100), 77, 65. Anal. calc. for $C_{14}H_{15}NO_2$: C 73.34, H 6.59, N 6.11; found: C 73.63, H 6.41, N 6.38.

*(*Z*)-1-(Furan-2-yl)propan-1-one* O-*Benzyloxime* ((*Z*)-**3b**). IR: 3110, 2890, 1590, 1570, 1490, 1480, 1450. ^{1}H-NMR (400 MHz, $CDCl_3$): 1.23 (*t*, *J* = 7.2, 3 H); 2.67 (*q*, *J* = 7.2, 2 H); 5.20 (*s*, 2 H); 6.43–6.53 (*m*, 1 H); 7.26–7.50 (*m*, 7 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 11.6; 19.6; 77.7; 111.3; 128.2; 128.5; 128.9; 138.3; 144.2; 147.2; 151.2. MS: 229 (M^+), 212, 158, 91, 77, 65. Anal. calc. for $C_{14}H_{15}NO_2$: C 73.34, H 6.59, N 6.11; found C 73.58, H 6.36, N 6.29.

*(*E*)-1-(Furan-2-yl)-2-methylpropan-1-one* O-*Benzyloxime* ((*E*)-**3c**). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.19 (*d*, *J* = 7.4, 6 H); 2.98–3.36 (*m*, 1 H); 5.21 (*s*, 2 H); 6.32–6.45 (*m*, 1 H); 6.51–6.62 (*m*, 1 H); 6.54–6.83, 7.31–7.53 (*m*, 6 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 12.1; 12.3; 31.2; 76.4; 110.3; 111.5; 128.2; 128.5; 128.9; 139.4; 144.2; 146.8; 152.2. Anal. calc. for $C_{15}H_{17}NO_2$: C 74.05, H 7.04, N 5.76; found: C 74.25, H 7.24, N 5.61.

*(*Z*)-1-(Furan-2-yl)-2-methylpropan-1-one* O-*Benzyloxime* ((*Z*)-**3c**). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.21 (*d*, *J* = 7.2, 6 H); 3.03–3.46 (*m*, 1 H); 5.20 (*s*, 2 H); 6.36–6.50 (*m*, 1 H); 6.56–6.83 (*m*, 7 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 12.1; 12.3; 30.2; 76.2; 110.2; 111.4; 128.2; 128.5; 128.8; 139.2; 144.5; 146.9; 150.3. Anal. calc. for $C_{15}H_{17}NO_2$: C 74.05, H 7.04, N 5.76; found: C 74.31, H 7.14, N 5.61.

*(*Z*)-1-(Furan-2-yl)-2,2-dimethylpropan-1-one* O-*Benzyloxime* ((*Z*)-**3d**). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.31 (*s*, 9 H); 5.18 (*s*, 2 H); 6.36–6.50 (*m*, 1 H); 7.16–7.50 (*m*, 7 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 29.1; 38.4; 76.5; 111.5; 119.3; 128.3; 128.5; 138.1; 143.9; 147.9; 150.5. MS: 257 (M^+), 240, 198, 158, 136, 91, 77, 65. Anal. calc. for $C_{16}H_{19}NO_2$: C 74.68, H 7.44, N 5.44; found C 74.71, H 7.31, N 5.63.

*(*E*)-1-(Furan-2-yl)-2-phenylethanone* O-*Benzyloxime* ((*E*)-**3e**). M.p. 56–58°. ^{1}H-NMR (400 MHz, $CDCl_3$): 4.01 (*s*, 2 H); 5.25 (*s*, 2 H); 6.36–6.50 (*m*, 1 H); 6.60–6.70 (*m*, 1 H); 7.13–7.50 (*m*, 11 H). ^{13}C-NMR

(100 MHz, $CDCl_3$): 37.7; 76.2; 111.4; 112.5; 127.4; 128.5; 128.8; 128.9; 129.1; 129.5; 139.2; 143.3; 146.9; 149.6; 149.9. MS: 291 (M^+), 274, 201, 183, 158, 91 (100), 77, 65. Anal. calc. for $C_{19}H_{17}NO_2$: C 78.33, H 5.88, N 4.81; found: C 78.47, H 5.98, N 4.70.

(E)-(Furan-2-yl)(phenyl)methanone O-*Benzyloxime* ((*E*)-**3f**). IR: 3160, 2885, 1600, 1590, 1490, 1480, 1450, 1440. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.23 (*s*, 2 H); 6.23–6.48 (*m*, 2 H); 7.18–7.53 (*m*, 11 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 76.2; 111.2; 119.3; 127.4; 127.5; 128.2; 128.8; 129.3; 133.1; 138.2; 142.8; 146.3; 149.9. Anal. calc. for $C_{18}H_{15}NO_2$: C 77.96, H 5.45, N 5.05; found: C 77.81, H 5.66, N 4.82.

(Z)-(Furan-2-yl)(phenyl)methanone O-*Benzyloxime* ((*Z*)-**3f**). IR: 3150, 2880, 1580, 1560, 1490, 1460, 1450, 1430. ^{1}H-NMR (400 MHz, $CDCl_3$): 5.21 (*s*, 2 H); 6.42 (*dd*, *J* = 1.8, 3.3, 1 H); 7.25–7.50 (*m*, 12 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 77.8; 112.3; 119.4; 128.5; 128.6; 128.7; 128.9; 129.5; 129.6; 134.9; 137.9; 143.3; 145.4; 147.8. MS: 277 (M^+), 260, 158, 128, 102, 91, 77, 65. Anal. calc. for $C_{18}H_{15}NO_2$: C 77.96, H 5.45, N 5.05; found: C 77.78, H 5.36, N 4.87.

(E)-(3,4-Dimethoxyphenyl)(furan-2-yl)methanone O-*Benzyloxime* ((*E*)-**3g**). ^{1}H-NMR (400 MHz, $CDCl_3$): 3.88 (*s*, 3 H); 3.90 (*s*, 3 H); 5.33 (*s*, 2 H); 6.30–6.45 (*m*, 1 H); 6.48–6.56 (*m*, 1 H); 6.90–7.52 (*m*, 9 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 56.3; 56.5; 76.4; 110.2; 110.4; 115.5; 115.8; 122.5; 124.3; 127.4; 128.7; 140.8; 143.3; 143.4; 147.8; 150.2; 155.3. Anal. calc. for $C_{20}H_{19}NO_4$: C 71.20, H 5.68, N 4.15; found: C 71.41, H 5.43, N 4.02.

(Z)-(3,4-Dimethoxyphenyl)(furan-2-yl)methanone O-*Benzyloxime* ((*Z*)-**3g**). ^{1}H-NMR (400 MHz, $CDCl_3$): 3.89 (*s*, 3 H); 3.91 (*s*, 3 H); 5.21 (*s*, 2 H); 6.43–6.60 (*m*, 1 H); 6.81–6.94, 7.13–7.73 (*m*, 10 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 56.3; 56.5; 76.4; 109.2; 110.3; 115.7; 122.5; 124.2; 127.5; 128.7; 140.8; 143.1; 143.4; 147.7; 149.9; 155.1. MS: 337, 320, 307, 246, 218, 216, 201, 155, 107, 91, 77. Anal. calc. for $C_{20}H_{19}NO_4$: C 71.20, H 5.68, N 4.15; found: C 71.36, H 5.77, N 4.33.

General Procedure for Reductions. Procedure A. A soln. of BH_3 (20 mmol) in 20 ml of THF was added under Ar dropwise to a soln. of 10 mmol of amino alcohol (**8**, **11**, or **12**) dissolved in 10 ml of THF at $-20°$. The resulting mixture was warmed to $-5°$, and stirring was continued at this temp. for 16 h, before 8 mmol of *O*-benzyloxime in 10 ml of THF was added dropwise. The resulting soln. was stirred at 30° for 48 h (monitored by TLC) and was decomposed by the slow addition of 2M HCl. Crude product was purified by bulb-to-bulb distillation to yield amines in 71–91% yields with 90–97% ee.

Procedure B. To a soln. of amino alcohol (0.1 mmol of **8**, **11**, or **12**) in 20 ml of THF was added 1 mmol of $BH_3 \cdot Me_2S$ complex at r.t., and the resulting mixture was stirred at this temp. for 12 h. To this mixture was added a soln. of the *O*-benzyloxime (5 mmol) in 10 ml of THF over 1 h. This was followed by stirring at 35° until the starting material disappeared on TLC, and then under reflux for 48 h. After the usual workup, amines were obtained in 73–87% yields with 41–64% ee.

Procedure C. To a soln. of amino alcohol (0.1 mmol of **8**, **11**, or **12**) and trimethyl borate (0.5 mmol) in 20 ml THF was added 1 mmol $BH_3 \cdot Me_2S$ complex at r.t., and the resulting mixture was stirred at this temp. for 12 h. To this mixture was added a soln. of the *O*-benzyloxime (5 mmol) in 10 ml of THF over 2 h. This was followed by stirring at 35°, until the starting material disappeared on TLC, and then under reflux for 48 h. After the usual workup, amines were obtained in 71–88% yields with 57–88% ee.

(S)-1-(Furan-2-yl)ethanamine ((*S*)-**4a**). B.p: 80–95°/11 Torr (bulb-to-bulb distillation). $[\alpha]_D^{20} = -24.9$ (*c* = 1, EtOH) [5b]: $[\alpha]_D^{20} = +22.7$ (*c* = 1, EtOH) for 92% ee (*R*)-enantiomer). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.38 (*d*, *J* = 7.5, 3 H); 1.63 (*s*, 2 H); 4.03 (*q*, *J* = 7.5, 1 H); 6.01–6.10 (*m*, 1 H); 6.26–6.33 (*m*, 1 H); 7.28–7.33 (*m*, 1 H).

(R)-1-(Furan-2-yl)ethanamine ((*R*)-**4a**). $[\alpha]_D^{20} = +24.6$ (*c* = 1, EtOH).

(S)-1-(Furan-2-yl)propanamine ((*S*)-**4b**). B.p: 85–100°/12 Torr (bulb-to-bulb distillation) [18]: 63–65°/7 Torr). $[\alpha]_D^{20} = -23.4$ (*c* = 1, $CHCl_3$). IR: 3380, 3110, 2980, 2875, 1590, 1500. ^{1}H-NMR (400 MHz, $CDCl_3$): 0.39 (*t*, *J* = 7.4, 3 H); 1.61 (*s*, 2 H); 1.46–1.90 (*m*, 2 H); 3.81 (*t*, *J* = 7.4, 1 H); 6.05–6.16 (*m*, 1 H); 6.23–6.33 (*m*, 1 H); 7.26–7.36 (*m*, 1 H). The spectroscopic data are in agreement with the data in [19].

(R)-1-(Furan-2-yl)propanamine ((*R*)-**4b**). $[\alpha]_D^{20} = +23.7$ (*c* = 1, EtOH).

(R)-1-(Furan-2-yl)-2-methylpropanamine ((*R*)-**4c**). B.p: 90–105°/12 Torr (bulb-to-bulb distillation) ([20]: 68–69°/9 Torr). $[\alpha]_D^{20} = -9.2$ (*c* = 1, EtOH) ([5b]: $[\alpha]_D^{20} = -7.8$ (*c* = 1, EtOH) for 92.5% ee). IR: 3390, 3110, 2990, 2885, 1600, 1510, 1470. ^{1}H-NMR (400 MHz, $CDCl_3$): 0.91 (*dd*, *J* = 7.2, 6 H); 1.46 (*s*, 2 H); 1.76–2.21 (*m*, 1 H); 3.53–3.78 (*m*, 1 H); 6.03–6.16 (*m*, 1 H); 6.23–6.34 (*m*, 1 H); 7.23–7.38 (*m*, 1 H).

(S)-1-(Furan-2-yl)-2-methylpropanamine ((*S*)-**4c**). $[\alpha]_D^{20} = +9.6$ (*c* = 1, EtOH).

(R)-1-(Furan-2-yl)-2,2-dimethylpropanamine ((*R*)-**4d**). B.p: 95–110°/12 Torr (bulb-to-bulb distillation). $[\alpha]_D^{20} = +7.2$ (*c* = 1, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): 0.26 (*s*, 9 H); 1.50 (*s*, 2 H); 3.73 (*s*, 1 H); 6.06–6.16

(*m*, 1 H); 6.26–6.41 (*m*, 1 H); 7.28–7.41 (*m*, 1 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 20.8; 36.9; 103.5; 109.3; 138.6; 156.5. Combustion analysis of this compound was carried out with its *N*-benzoyl derivative.

(S)-1-(Furan-2-yl)-2-phenylethanamine ((*S*)-**4e**). B.p: 140–150°/0.1 Torr (bulb-to-bulb distillation) ([21]: 167–168°/0.4 Torr). $[\alpha]_D^{20} = -18.8$ ($c = 0.1$, EtOH). ^{1}H-NMR (400 MHz, $CDCl_3$): 2.14 (*s*, 2 H); 2.73–3.28 (*m*, 2 H); 4.03–4.31 (*m*, 1 H); 6.03–6.13 (*m*, 1 H); 6.25–6.36 (*m*, 1 H); 7.05–7.46 (*m*, 6 H).

(S)-(Furan-2-yl)(phenyl)methanamine ((*S*)-**4f**). B.p: 125–135°/12 Torr (bulb-to-bulb distillation). $[\alpha]_D^{20} = -23.2$ ($c = 1$, $CHCl_3$) ([5b][19]: $[\alpha]_D^{20} = +18.3$ ($c = 1$, EtOH) for (*R*)-enantiomer). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.85 (*s*, 2 H); 5.11 (br. *s*, 1 H); 6.01–6.13 (*m*, 1 H); 6.20–6.33 (*m*, 1 H); 7.16–7.49 (*m*, 6 H).

(R)-(Furan-2-yl)(phenyl)methanamine ((*R*)-**4f**). Yield 91%. $[\alpha]_D^{20} = +22.1$ ($c = 1$, $CHCl_3$).

(S)-(3,4-Dimethoxyphenyl)(furan-2-yl)methanamine ((*S*)-**4g**). $[\alpha]_D^{20} = +8.6$ ($c = 0.5$, $CHCl_3$). IR: 3380, 3105, 3000, 2820, 1590, 1510, 1460. ^{1}H-NMR (400 MHz, $CDCl_3$): 2.03 (*s*, 2 H); 3.83 (*s*, 6 H); 5.08 (*s*, 1 H); 6.02–6.13 (*m*, 1 H); 6.21–6.36 (*m*, 1 H); 6.71–7.0 (*m*, 4 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 56.3; 56.5; 58.8; 104.3; 110.2; 113.8; 114.9; 120.6; 135.8; 140.5; 145.7; 147.3; 157.7. Anal. calc. for $C_{13}H_{15}NO_3$: C 66.94, H 6.48, N 6.00; found: C 66.88, H 6.33, N 5.83.

(R)-(3,4-Dimethoxyphenyl)(furan-2-yl)methanamine ((*R*)-**4g**). $[\alpha]_D^{20} = -9.3$ ($c = 0.5$, $CHCl_3$).

General Procedure for N-*Protection*. The amine (2.5 mmol; **4a**–**4g**) was dissolved in 5 ml of pyridine, and to this soln. was added PhCOCl (0.35 ml) dropwise at 0°. The mixture was stirred at r.t. for 2 h, then 6N HCl (4 ml), H_2O (4 ml), and Et_2O (20 ml) were added. The org. layer was separated, and washed with brine and dried (Na_2SO_4). Crude product was purified by crystallization or CC.

(S)-N-*[1-(Furan-2-yl)ethyl]benzamide* ((*S*)-**5a**). Yield 93%. $[\alpha]_D^{20} = -51.6$ ($c = 1$, $CHCl_3$). IR (KBr): 3450, 3090, 2910, 1660, 1510, 1480. ^{1}H-NMR (400 MHz, $CDCl_3$): 1.50 (*d*, $J = 7.1$, 3 H); 5.30–5.33 (*q*, $J = 7.1$, 1 H); 6.14 (*d*, $J = 2.9$, 1 H); 6.23 (br. *s*, 1 H); 6.41 (*d*, $J = 7.0$, 1 H); 7.25–7.75 (*m*, 6 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 20.1; 43.7; 106.2; 110.6; 127.4; 128.9; 131.9; 134.8; 142.3; 155.8; 166.9. Anal. calc. for $C_{13}H_{13}NO_2$: C 72.54, H 6.09, N 6.51; found: C 72.71, H 6.24, N 6.32.

(R)-N-*[1-(Furan-2-yl)ethyl]benzamide* ((*R*)-**5a**). Yield 88%. M.p: 109–111°. $[\alpha]_D^{20} = +52$ ($c = 1$, $CHCl_3$).

(S)-N-*[1-(Furan-2-yl)-propyl]benzamide* ((*S*)-**5b**). Yield 91%. M.p: 52–53°. $[\alpha]_D^{20} = +84.3$ ($c = 1$, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): 0.96 (*t*, $J = 7.1$, 3 H); 1.78–2.13 (*m*, 2 H); 5.11–5.38 (*m*, 1 H); 6.16–6.36 (*m*, 2 H); 6.42–6.71 (br. *s*, 1 H); 7.28–7.58, 7.70–7.86 (*m*, 6 H). Anal. calc. for $C_{14}H_{15}NO_2$: C 73.34, H 6.59, N 6.11; found C 73.56, H 6.71, N 6.23.

(R)-N-*[1-(Furan-2-yl)propyl]benzamide* ((*R*)-**5b**). Yield 87%. $[\alpha]_D^{20} = -81.2$ ($c = 1$, $CHCl_3$).

(R)-N-*[1-(Furan-2-yl)-2-methylpropyl]benzamide* ((*R*)-**5c**). Yield 92%. M.p. 79–80°. $[\alpha]_D^{20} = +81.8$ ($c = 1$, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): 0.85 (*d*, $J = 6.7$, 3 H); 0.95 (*d*, $J = 6.7$, 3 H); 2.10 (*sept.*, $J = 6.9$, 1 H); 5.10 (*t*, $J = 7.7$, 1 H); 6.11 (*d*, $J = 2.5$, 1 H); 6.21 (*t*, $J = 2.8$, 1 H); 6.40 (*d*, $J = 8.0$, 1 H); 7.10 (*s*, 1 H); 7.18–7.71 (*m*, 5 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 19.2; 19.6; 32.8; 53.6; 107.3; 110.5; 127.4; 128.9; 131.9; 134.9; 142.1; 153.9; 167.2. Anal. calc. for $C_{15}H_{17}NO_2$: C 74.05, H 7.04, N 5.76; found: C 74.23, H 6.92, N 5.51.

(R)-N-*[1-(Furan-2-yl)-2,2-dimethylpropyl]benzamide* ((*R*)-**5d**). Yield 86%. M.p. 108–109°. $[\alpha]_D^{20} = +5.2$ ($c = 1$, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.00 (*s*, 9 H); 5.11 (*d*, $J = 9.8$, 1 H); 6.13 (*d*, $J = 2.9$, 1 H); 6.23 (*dd*, $J = 1.8, 2.8$, 1 H); 6.59 (*d*, $J = 9.1$, 1 H); 7.21 (*s*, 1 H); 7.22–7.60 (*m*, 5 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 27.1; 36.4; 56.3; 108.7; 110.6; 127.8; 129.9; 130.5; 135.2; 141.8; 153.5; 172.2. MS: 257 (M^+), 242, 202, 200, 121, 106, 105 (100), 77, 69, 57, 51. Anal. calc. for $C_{16}H_{19}NO_2$: C 74.68, H 7.44, N 5.44; found: C 74.61, H 7.32, N 5.26.

(S)-N-*[1-(Furan-2-yl)-2-phenylethyl]benzamide* ((*S*)-**5e**). Yield 88%. M.p. 112–113°. $[\alpha]_D^{20} = -4.7$ ($c = 0.4$, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): 3.16–3.25 (*m*, 2 H); 5.28–5.68 (*m*, 1 H); 6.01–6.13 (*m*, 1 H); 6.18–6.30 (*m*, 1 H); 6.38–6.61 (*m*, 1 H); 6.96–7.83 (*m*, 11 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 41.2; 53.8; 104.2; 101.7; 125.7; 127.4; 128.6; 158.7; 130.7; 133.8; 137.7; 140.1; 154.4; 167.8. Anal. calc. for $C_{19}H_{17}NO_2$: C 78.33, H 5.88, N 4.81; found: C 78.51, H 5.78, N 4.98.

(S)-N-*[(Furan-2-yl)(phenyl)-methyl]benzamide* ((*S*)-**5f**). Yield 87%. M.p. 136–137°. $[\alpha]_D^{20} = -32.7$ ($c = 0.8$, $CHCl_3$). IR: 3450, 2910, 3090, 1660, 1510, 1480. ^{1}H-NMR (400 MHz, $CDCl_3$): 6.21–6.23 (*m*, 1 H); 6.3–6.4 (*m*, 1 H); 6.5 (*d*, $J = 9$, 1 H); 6.83–7.15 (br. *s*, 1 H); 7.08–7.58 (*m*, 11 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 55.1; 103.8; 109.4; 126.2; 127.2; 128.6; 131.5; 133.4; 136.6; 139.8; 156.8; 167.6. MS: 277 (M^+), 248, 172, 157, 156, 144, 128, 105 (100), 77, 51. Anal. calc. for $C_{18}H_{15}NO_2$: C 77.96, H 5.45, N 5.05; found: C 78.12, H 5.67, N 5.37.

(S)-N-*[(3,4-Dimethoxyphenyl)(furan-2-yl)methyl]benzamide* ((*S*)-**5g**). Yield 87%. M.p. 150–152°. $[\alpha]_D^{20} = -3.8$ ($c = 0.1$, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): 3.77 (*s*, 3 H); 3.79 (*s*, 3 H); 6.21 (*d*, $J = 3.2$, 1 H); 6.32 (*dd*, $J = 1.9, 3.2$, 1 H); 6.42 (*d*, $J = 8.1$, 1 H); 6.70–6.81 (*m*, 4 H); 7.31 (br. *s*, 1 H); 7.40–7.72 (*m*, 5 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 51.8; 56.3; 108.3; 110.8; 111.2; 111.6; 119.6; 127.5; 129.1; 132.2; 132.6; 134.5; 142.9; 149.1; 149.5; 153.9; 166.8. MS: 337 (100, M^+), 308, 232, 217, 216, 204, 201, 188, 173, 164, 105, 94, 77, 51. Anal. calc. for $C_{20}H_{19}NO_4$: C 71.20, H 5.68, N 4.15; found: C 71.36, H 5.81, N 4.36.

General Procedure for the Oxidation of the Furan Ring. Ozonolysis. The soln. of the amine (**4a** and **4f**) or *N*-benzoylamine (**5a** and **5f**) (3 mmol) in 25 ml of MeOH was cooled to $-78°$, and O_3 was passed through this soln. for 15 min (blue color). Then, Ar was bubbled at $-78°$ to remove excess O_3. The soln. was allowed to warm to r.t. and concentrated to give the crude oil, which was purified by crystallization or by CC.

Oxidation with RuO_2/$NaIO_4$. To the mixture of 29.8 mmol of $NaIO_4$, 13 ml of H_2O, 19 ml of MeCN, and 13 ml of CCl_4 was added 0.066 mmol $RuO_2 \cdot H_2O$; this was followed by stirring for 30 min. Then, 1.8 mmol of amide was added, and the mixture was stirred for 2 h. The org. layer was separated, and the aq. phase was washed with CH_2Cl_2 (4×20 ml) and brine, dried (Na_2SO_4), and concentrated. The residue was dissolved in AcOEt (20 ml) and filtered through a small pad of *Celite*. After evaporation of the solvent, the product was purified by crystallization.

*(*S*)-*N*-Benzoylalanine* ((*S*)-**6a**). Yield 91% (O_3), 88% (RuO_2). M.p. 148–149°. $[\alpha]_D^{20} = +33$ ($c = 1$, 0.73M KOH) ([4c]: $[\alpha]_D^{20} = +32.6$ (KOH in H_2O)).

*(*R*)-*N*-Benzoyl(phenyl)glycine* ((*R*)-**6b**). Yield 89% (O_3), 83% (RuO_2). M.p. 196–197°. $[\alpha]_D^{20} = -110$ ($c = 0.7$, EtOH) ([5a][22]: 196–198°, $[\alpha]_D^{20} = -119.3$ ($c = 1.2$, EtOH)).

The purities and chemical properties of (*S*)-alanine (*S*)-**7a** (82%), (*R*)-alanine (*R*)-**7a** (81%), (*S*)-phenylglycine (*S*)-**7b** (82%), and (*R*)-phenylglycine (*R*)-**7b** (78%) were in agreement with those of commercially available products.

*Synthesis of (*S*)-Proline-*N*-(Ethoxycarbonyl)proline Methyl Ester* (*S*)-**14**. (*S*)-Proline (5.75 g, 50 mmol) was dissolved in 80 ml of dry MeOH. Then, 6.6 g (50 mmol) of anh. K_2CO_3 was added, followed by the addition of 12.5 g (110 mmol) of ClCOOEt (over 20 min at r.t.). The mixture was stirred for an additional 12 h at r.t., and, then, MeOH was evaporated, 25 ml of H_2O was added and extracted with $CHCl_3$ (3×50 ml). The combined org. layers were washed with brine (2×25 ml) and dried ($MgSO_4$). After evaporation of the solvent under reduced pressure, flash CC (AcOEt/hexane 1:5 to 1:3) was performed to obtain the desired compound as yellow viscous oil [12a].

*Synthesis of Ethyl 2-(2,3-Dihydro-2-hydroxy-1*H*-inden-2-yl)pyrrolidine-1-carboxylate* ((*S*)-**15**). To a suspension of Mg turnings (1.44 g, 60 mmol) in dry THF (10 ml) was added dropwise, from a dropping funnel, a soln. of 1,2-bis(chloromethyl)benzene (1.5 g, 8.57 mmol) in 125 ml of THF over a period of 4 h (at the beginning of this procedure, a small amount of I_2 was added, and the mixture was heated gently from time to time during this 4-h period). The mixture was stirred 3 h at r.t., and then (*S*)-**14** (0.68 g, 3.43 mmol) in 50 ml of THF was added at r.t. and stirred for 12 h. Finally, sat. NH_4Cl (40 ml) was added. After the separation of the phases, the H_2O phase was extracted with $CHCl_3$ (3×40 ml). The combined org. extracts were dried ($MgSO_4$) and concentrated under reduced pressure. Further purification was performed by flash CC (AcOEt/hexane 1:1) to give (*S*)-**15**.

*Synthesis of (*S*)-2,3,3′,4′,5′,6′,7,7′a-Octahydrospiro[1*H*-indene-2,1′[1*H*]pyrrolo[1.2-c][1.3]oxazol]-3′-one* ((*S*)-**16**). Compound (*S*)-**15** (425 mg, 1.54 mmol) and 778 mg (13.9 mmol) of KOH were mixed in MeOH (15 ml) and refluxed for 1 h. After cooling the mixture, 15 ml of $CHCl_3$ was added, followed by washing with 5% NaOH. The org. layer was dried ($MgSO_4$) and concentrated under reduced pressure. Flash CC (hexane/AcOEt 2:1) was performed to afford 220 mg of (*S*)-**16**, which was then recrystallized from hexane/Et_2O. $[\alpha]_D = -100.1$ ($c = 0.4$, $CHCl_3$). ^{1}H-NMR (400 MHz, $CDCl_3$): 1.40–1.51 (*m*, 1 H); 1.73–1.85 (*m*, 2 H); 1.99–2.07 (*m*, 1 H); 3.15 (br. *s*, 3 H); 3.25 (*d*, $J = 16.4$, 1 H); 3.62 (*m*, 2 H); 3.68 (*dd*, $J = 4.5$, 10.1, 1 H); 7.18 (*s*, 4 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 25.6; 28.2; 41.1; 46.5; 47.3; 68.4; 89.4; 124.8; 125.0; 127.5; 127.6; 139.6; 139.8; 161.4. MS: 70 (100), 78, 104, 115, 128, 229 (M^+), 230 ($[M+1]^+$).

*Synthesis of (*S*)-2,3-Dihydro-2-pyrrolidin-2-yl-1*H*-indan-2-ol* (*S*)-**11**. Compound (*S*)-**16** (70 mg, 0.3 mmol) and 134.4 mg (2.4 mmol) of KOH were mixed in MeOH (20 ml) and refluxed for 4 h. After cooling the mixture, 20 ml of $CHCl_3$ was added, followed by washing with 5% HCl. The org. layer was dried ($MgSO_4$) and concentrated under reduced pressure. Flash CC (hexane/AcOEt 3:1) was performed to afford 48 mg (79%) of (*S*)-**11**. Product. M.p. 71–73°. $[\alpha]_D$ −63.4 ($c = 0.3$, $CHCl_3$) [12a].

REFERENCES

[1] a) W. S. Zhou, Z. H. Lu, Y. M. Xu, L. Y. Liao, Z. M. Wang, *Tetrahedron* **1999**, *55*, 11959; b) M. Cinfolini, C. Y. W. Hermann, Q. Dong, T. Shimizu, S. Swaminathan, N. Yi, *Synlett* **1998**, 105; c) W. P. Chen, S. M. Roberts, *J. Chem. Soc. Perkin Trans. I* **1999**, 103.

[2] a) T. Shono, Y. Matsumura, J. Tsubata, *Chem. Lett*. **1981**, 1121; b) D. Ben-I Shia, I. Satatu, Z. Bernstein, *Tetrahedron Lett*. **1976**, *32*, 1571; c) P. S. Bailey, 'Ozonation in Organic Chemistry', Academic Press, New York, 1982, Vol. 2, Chapt. 6; d) M. Kasai, H. Ziffer, *J. Org. Chem*. **1983**, *48*, 2346.

[3] a) N. Yi, M. A. Cinfolini, *Tetrahedron Lett*. **1995**, *36*, 6595; b) C. F. Yana, Y. M. Xu, L. X. Liao, W. S. Zhou, *Tetrahedron Lett*. **1998**, *39*, 9227; c) O. Achmatowicz, P. Bukowski, B. Szechnev, Z. Zwierzchowska, A. Zamojski, *Tetrahedron* **1971**, *27*, 1973; d) Y. Lefebvre, *Tetrahedron Lett*. **1972**, 133.
[4] a) W. S. Zhou, Z. H. Lu, Z. M. Wang, *Tetrahedron Lett*. **1991**, *32*, 1467; b) W. S. Zhou, Z. H. Lu, Z. M. Wang, *Tetrahedron* **1993**, *49*, 2641; c) A. P. Terent'ev, R. A. Gracheva, L. F. Titova, *Zh. Obshch. Khim*. **1964**, *34*, 5136; d) D. G. Drneckhammer, C. F. Barbas III, K. Nozaki, C. H. Wang, C. Y. Wood, M. A. Cinfolini, *J. Org. Chem*. **1988**, *53*, 1607.
[5] a) G. Alvaro, G. Martelli, D. Savoia, A. Zuffoli, *Synthesis* **1998**, 1773; b) L. Shikui, M. Aigiao, W. Lanjun, J. Yaozhong, *Synth. Commun*. **1993**, *23*, 2485; c) N. Irako, Y. Hamada, T. Shioiri, *Tetrahedron* **1995**, *51*, 46; d) G. L. Liu, W. H. Hu, J. G. Deng, A. Q. Mi, Y. Z. Jiang, *Acta Chim. Sinica* **1994**, *52*, 917; e) S. Kobayashi, H. Ishitani, *Chem. Rev.* **1999**, *99*, 1069.
[6] M. L. Bushey, M. H. Hankaas, G. A. O'Doherty, *J. Org. Chem*. **1999**, *64*, 2984.
[7] G. S. Currie, M. G. B. Drew, L. M. Harwood, D. J. Hughes, R. W. A. Luke, R. J. Vickers, *J. Chem. Soc. Perkin Trans. 1* **2000**, 2982.
[8] a) A. S. Demir, *Pure Appl. Chem*. **1997**, *69*, 105; b) A. S. Demir, C. Tanyeli, A. Cagyr, N. M. Tahir, D. Ulku, *Tetrahedron: Asymmetry* **1998**, *9*, 1035; c) A. S. Demir, C. Tanyeli, O. Sesenoglu, S. Demic, *Tetrahedron Lett.* **1996**, *37*, 407; d) A. S. Demir, O. Sesenoglu, Z. Gerçek-Arkın, *Tetrahedron: Asymmetry* **2001**, *12*, 2309.
[9] a) G. Ocskay , L. Wargha, *Tetrahedron* **1958**, *2*, 140; b) W. Borsche, H. Leditschke, K. Lange, *Chem. Ber.* **1938**, *5*, 62; c) W. Gruber, *Can. J. Chem*. **1953**, *31*, 19; d) H. Gilman, N. O. Calloway, *J. Am. Chem. Soc*. **1933**, *55*, 4197.
[10] a) Q. C. Zhu, R. O. Hutchins, *Org. Prep. Proced. Int*. **1994**, *26*, 193; b) B. R. James, *Chem. Ind. (Dekker)* **1995**, *62*, 167; c) A. Johansson, *Cont. Org. Syn*. **1996**, 393; d) M. A. Yurovskaya, A. V. Karchava, *Tetrahedron: Asymmetry* **1998**, *9*, 3331.
[11] a) S. Itsuno, Y. Sakurai, K. Ito, A. Hirao, S. Nakahama, *Bull. Chem. Soc. Jpn*. **1987**, 395; b) S. Itsuno,Y. Sakurai, K. Shimizu, K. Ito, *J. Chem. Soc., Perkin Trans. 1* **1990**, 1859; c) T. Sakito, Y. Yoneyoshi, G. Suzukamo, *Tetrahedron Lett*. **1988**, *29*, 223; d) A. K. Ghosh, S. P. McKee, W. M. Sanders, *Tetrahedron Lett*. **1991**, *32*, 711.
[12] a) A. S. Demir, C. Tanyeli, I. Mecitoglu, V. Gulbeyaz, *Tetrahedron: Asymmetry* **1996**, *7*, 3359; b) A. S. Demir, H. Hamamci, F. Doganel, E. Ozgul, *J. Mol. Catal. B: Enzymatic* **2000**, *9*, 157; c) A. S. Demir, H. Aksoy-Çam, N. Çamkerten, H. Hamamci, F. Doganel, *Turkish J. Chem*. **2000**, *24*, 141; d) E. J. Corey, C. J. Helal, *Angew. Chem., Int. Ed*. **1998**, *37*, 1986; e) E. J. Corey, R. K. Bakshi, S. Shibata, *J. Am. Chem. Soc.* **1987**, *109*, 5551; f) E. J. Corey, R. K. Bakshi, C. P. Chen, V. K. Singh, *J. Am. Chem. Soc.* **1987**, *109*, 7925; g) E. J. Corey, *Pure Appl. Chem*. **1990**, *62*, 1209.
[13] a) A. S. Demir, I. M. Akhmedov, C. Tanyeli, Z. Gerçek, R. A. Gadzhili, *Tetrahedron: Asymmetry* **1997**, *8*, 753; b) A. S. Demir, I. M. Akhmedov, O. Sesenoglu, O. Alpturk, S. Apaydyn, Z. Gerçek, N. Ibrahimzade, *J. Chem. Soc., Perkin Trans. 1* **2001**, 1162.
[14] a) P. H. J. Carlsen, T. Katsuki, V. S. Martin, K. B. Sharpless, *J. Org. Chem.* **1981**, *46*, 3936; b) N. Xi, M. A. Ciufolini, *Tetrahedron Lett.* **1995**, *36*, 6595.
[15] Enraf-Nonius (1993) CAD-4 EXPRESS, Version 1.1, Enraf-Nonius Delft, The Netherlands.
[16] G. M. Sheldrick, SHELXL97 and SHELXS97, University of Göttingen, Germany, 1997.
[17] A. L. Spek, PLATON, University of Utrecht, The Netherlands, 2000.
[18] B. L. Emling, J. E. Beatty, J. R. Stevens *J. Am. Chem. Soc.* **1949**, *71*, 703.
[19] Y-H. Kuo, K-S. Shih, *Chem. Pharm. Bull.* **1991**, *39*, 183.
[20] A. P. Terent'ev, R. A. Gracheva, *Zh. Obshch. Khim.* **1964**, *34*, 1513.
[21] J. M. Grisar, G. P. Claxton, N. L. Wiech, *J. Med. Chem.* **1976**, *19*, 365.
[22] K. Harda, Y. Nakajima, *Bull. Chem. Soc. Jpn.* **1974**, *47*, 2911.

Received July 10, 2002