Enantioselective Addition of Diethylzinc to Aldehydes Catalyzed by *N*-(9-Phenylfluoren-9-yl) β-Amino Alcohols

M. Rita Paleo, Isabel Cabeza, and F. Javier Sardina*

Departamento de Química Orgánica. Facultad de Química. Universidad de Santiago de Compostela. 15706 Santiago de Compostela, Spain

Received November 1, 1999

A set of secondary *N*-phenylfluorenyl β-amino alcohols have been prepared and evaluated as catalysts for the enantioselective addition of diethylzinc to benzaldehyde. The influence of the substituents on the stereogenic centers of the ligand has been studied, and enantioselectivities up to 97% have been obtained. Those ligands with bulky groups in the carbinol stereocenter and small groups α to the nitrogen atom displayed the best catalytic activity and enantioselectivity. The most enantioselective ligand (**4e**) was found to possess general applicability for the enantioselective addition of diethylzinc to a variety of aromatic and aliphatic aldehydes.

Introduction

The enantioselective addition of diorganozinc reagents to aldehydes in the presence of catalytic amounts of a chiral ligand provides an excellent method for the preparation of enantiomerically enriched secondary alcohols.[1] The discovery that certain β-amino alcohols can promote the ethylation of benzaldehyde by Et_2Zn initiated a search for efficient chiral auxiliaries for this type of reaction.[2] A myriad of β-tertiary amino alcohols have been investigated as catalysts; among them derivatives of natural products such as ephedrine,[3] norephedrine,[4] camphor,[5] proline,[6] pinane,[7] and cinchona alkaloids[8] have attracted widespread attention. The catalytic abilities of nonnaturally occurring β-amino alcohols have been probed as well, and the results were used to study the effects of the substituents on the nitrogen atom[9] and the hydroxyl-bearing carbon of the ligand on the enantioselectivity of the addition.[10,11] Ferrocenyl amino alcohols,[9] chiral piperazines,[12] γ-amino alcohols,[13] δ-amino alcohols,[14] and derivatives of 2-amino-2′-hydroxy-1,1′-binaphthyls[15] have also been used as catalysts for this reaction. The mechanism of the process has been discussed for tertiary β-amino alcohols,[5b,16] and it has been shown that the absolute configurations of the products correlate with the configuration of the hydroxyl-bearing stereocenter of the ligand, and that *anti* tertiary β-amino alcohols are usually better ligands than the corresponding *syn* stereoisomers.[1c,10a] Although less intensively investigated, there have appeared some reports describing the successful use of secondary β-amino alcohols,[17] which showed that the secondary amine group present in the catalyst is not deprotonated under the reaction conditions. The flow of reports in the literature dealing with new catalysts for the enantioselective addition of organozinc reagents to aldehydes continues unabated, showing the importance and interest of this reaction nowadays. But, despite this continued interest, there have been no general studies on the combined influence of the substituents on the amino- and hydroxyl-bearing carbons of the catalyst in the outcome of the reaction, probably due to the lack of an efficient and versatile method for the systematic preparation of chiral, enantiomerically pure β-amino alcohols. This situation is specially poignant since the model proposed to account for the rate acceleration in this reaction implicates a five-membered ring Zn(II) aminoalkoxide complex **1** as the actual catalyst, and, as Figure 1 clearly shows, the influence of the

(1) (a) Noyori, R. *Asymmetric Catalysis in Organic Synthesis*; John Wiley & Sons: New York, 1994, Chapter 5. (b) Soai, K.; Niwa, S. *Chem. Rev.* **1992**, *92*, 833. (c) Noyori, R.; Kitamura, M. *Angew. Chem., Int. Ed. Engl.* **1991**, *30*, 49. (d) Seyden-Penne, J. *Chiral Auxiliaries and Ligands in Asymmetric Synthesis*; John Wiley & Sons: New York, 1995.

(2) (a) Mukaiyama, T.; Soai, K.; Sato, T.; Shimizu, H.; Suzuki, K. *J. Am. Chem. Soc.* **1979**, *101*, 1455. (b) Oguni, N.; Omi, T. *Tetrahedron Lett.* **1984**, *25*, 2823.

(3) (a) Chaloner, P. A.; Perera, S. A. R. *Tetrahedron Lett.* **1987**, *28*, 3013. (b) Chaloner, P. A.; Langadianou, E. *Tetrahedron Lett.* **1990**, *31*, 5185. (c) Corey, E. J.; Hannon, F. J. *Tetrahedron Lett.* **1987**, *28*, 5233. (d) Corey, E. J.; Hannon, F. J. *Tetrahedron Lett.* **1987**, *28*, 5237. (e) Soai, K.; Nishi, M.; Ito, Y. *Chem. Lett.* **1987**, 2405. (f) Itsuno, S.; Fréchet, J. M. J. *J. Org. Chem.* **1987**, *52*, 4140.

(4) (a) Soai, K.; Yokoyama, S.; Ebihara, K.; Hayasaka, T. *J. Chem Soc., Chem. Commun.* **1987**, 1690. (b) Soai, K.; Yokoyama, S.; Hayasaka, T. *J. Org. Chem.* **1991**, *56*, 4264.

(5) (a) Kitamura, M.; Suga, S.; Kawai, K.; Noyori, R. *J. Am. Chem. Soc.* **1986**, *108*, 6071. (b) Kitamura, M.; Okada, S.; Suga, S.; Noyori, R. *J. Am. Chem. Soc.* **1989**, *111*, 4028.

(6) (a) Soai, K.; Ookawa, A.; Ogawa, K.; Kaba, T. *J. Chem Soc., Chem. Commun.* **1987**, 467. (b) Soai, K.; Ookawa, A.; Kaba, T.; Ogawa, K. *J. Am. Chem. Soc.* **1987**, *109*, 7111. (c) Asami, M.; Inoue, S. *Chem. Lett.* **1991**, 685.

(7) Cherng, Y.-J.; Fang, J.-M.; Lu, T.-J. *J. Org. Chem.* **1999**, *64*, 3207.

(8) Smaardijk, A. A.; Wynberg, H. *J. Org. Chem.* **1987**, *52*, 135.

(9) Watanabe, M.; Araki, S.; Butsugan, Y.; Uemura, M. *J. Org. Chem.* **1991**, *56*, 2218.

(10) (a) Vidal-Ferran, A.; Moyano, A.; Pericàs, M. A.; Riera, A. *J. Org. Chem.* **1997**, *62*, 4970. (b) Solà, L.; Reddy, K. S.; Vidal-Ferran, A.; Moyano, A.; Pericàs, M. A.; Riera, A.; Alvarez-Larena, A.; Piniella, J.-F. *J. Org. Chem.* **1998**, *63*, 7078. (c) Reddy, K. S.; Solà, L.; Moyano, A.; Pericàs, M. A.; Riera, A. *J. Org. Chem.* **1999**, *64*, 3969.

(11) (a) Wilken, J.; Gröger, H.; Kossenjans, M.; Martens, J. *Tetrahedron: Asymmetry* **1997**, *8*, 2761. (b) Sibi, M. P.; Chen, J.; Cook, G. R. *Tetrahedron Lett.* **1999**, *40*, 3301.

(12) Shono, T.; Kise, N.; Shirakawa, E.; Matsumoto, H.; Okazaki, E. *J. Org. Chem.* **1991**, *56*, 3063.

(13) Oppolzer, W.; Radinov, R. N. *Tetrahedron Lett.* **1988**, *29*, 5645.

(14) Genov, M.; Dimitrov, V.; Ivanova, V. *Tetrahedron: Asymmetry* **1997**, *8*, 3703.

(15) Vyskočil, S.; Jaracz, S.; Smrčina, M.; Štícha, M.; Hanuš, V.; Polášek, M.; Kočovský, P. *J. Org. Chem.* **1998**, *63*, 7727.

(16) Yamakawa, M.; Noyori, R. *J. Am. Chem. Soc.* **1995**, *117*, 6327.

(17) (a) Tanaka, K.; Ushio, H.; Suzuki, H. *J. Chem Soc., Chem. Commun.* **1989**, 1700. (b) Corey, E. J.; Yuen, P.-W.; Hannon, F. J.; Wierda, D. A. *J. Org. Chem.* **1990**, *55*, 784. (c) Soai, K.; Watanabe, M.; Yamamoto, A.; Yamashita, T. *J. Mol. Catal.* **1991**, *64*, L27.

10.1021/jo9917083 CCC: $19.00
Published on Web 03/04/2000

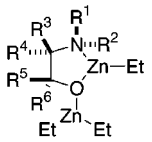

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Figure 1.

substituents R^1-R^6 on the β-amino alcohol must be paramount on the feasibility of complexation with the Zn atom.[1,16]

Results and Discussion

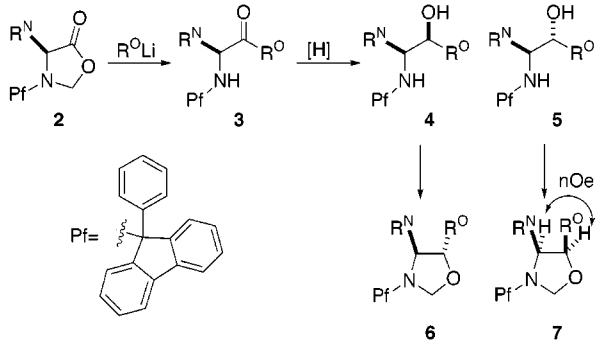
We have recently reported[18] a method for the preparation of *N*-(9-phenylfluoren-9-yl) secondary amino alcohols **4**, **5** which possess the structure present in most of the catalysts used for the addition of diorganozinc reagents to aldehydes. The bulky phenylfluorenyl group (Pf) present in these molecules should act as a conformational lock at the aminoalkoxide catalyst stage, thus allowing the effects of the interactions among the R^3-R^6 groups on the enantioselectivity of the additions to come to the fore. Herein we present the results obtained when a series of Pf-amino alcohols were used as catalysts for the addition of Et_2Zn to aldehydes.

β-Amino alcohols **4** and **5** were easily obtained from α-amino ketones **3** using a variety of reducing agents. The α-amino ketones were obtained from oxazolidinones **2**, which were prepared from the corresponding amino acid by *N*-phenylfluorenylation followed by reaction with aq formaldehyde. Treatment of **2** with a variety of organolithium reagents afforded α-amino ketones **3** in excellent yields and without loss of enantiomeric purity.[18] By using this route, both the *syn* and *anti* epimers of the desired β-amino alcohols could be prepared, which allowed us to study the influence of the substituents at the amino- (R^N) and hydroxyl-bearing carbons (R^O), as well as the importance of the configuration of the hydroxyl-bearing stereocenter on the outcome of the addition.[1] Alanine and leucine were chosen as the starting amino acids since they provide R^N groups with very different steric demands. The introduction of six different R^O aliphatic and aromatic groups, covering a wide range of sizes, provided the 18 ligands used for this study.

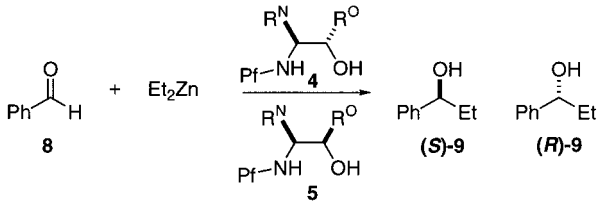
The stereochemistries of the amino alcohols **4** and **5** were determined as follows: the configuration of the carbon bearing the amino group was fixed by the starting amino acid (*S*), and the configuration of the carbinol stereocenter was established by analysis of the coupling constants between the hydrogens of the stereocenters.[18] The assignments were corroborated by NOE experiments on the oxazolidines[18] derived from amino alcohols **4a,b,f** and **5a,b,f** (R^O = Ph, ferrocenyl, and trityl, respectively). No diagnostic NOE enhancements were observed for the *tert*-butyl-substituted oxazolidinones **6e** and **7e**, and their relative stereochemistries were determined by X-ray crystallography.[19]

Amino alcohols **4** and **5** were studied as catalysts for the addition of Et_2Zn to benzaldehyde, using 3 mol % of ligand in toluene at room temperature. The amino alcohols were prepared (Scheme 1), and the enantioselectivities and configuration of the products resulting from the Et_2Zn addition to benzaldehyde are shown in Scheme 2.

Scheme 1. Synthesis of β-Amino Alcohols 4 and 5



Scheme 2. Enantioselective Addition of Et_2Zn to Benzaldehyde: Effect of R^N and R^O Substituents



Entry	Ligand	R^N	R^O	% ee	Config. **9**
1	**4a**	Me	Ph	76[a]	*S*
2	**4b**	Me	Fe	76[a]	*S*
3	**4c**	Me	1-naphthyl	40[a], 45[b]	*S*
4	**4d**	Me	2-naphthyl	50[a]	*S*
5	**4e**	Me	tBu	97[b]	*S*
6	**4f**	Me	Ph_3C	90[b]	*S*
7	**4g**	Me_2CHCH_2-	1-naphthyl	24[b]	*S*
8	**4h**	Me_2CHCH_2-	Ph	62[a]	*S*
9	**4i**	Me_2CHCH_2-	tBu	84[a]	*S*
10	**5a**	Me	Ph	29[b]	*R*
11	**5b**	Me	Ferrocenyl	17[a]	*R*
12	**5c**	Me	1-naphthyl	66[a], 67[b]	*R*
13	**5d**	Me	2-naphthyl	12[b]	*R*
14	**5e**	Me	tBu	14[b]	*S*
15	**5f**	Me	Ph_3C	18[b]	*S*
16	**5g**	Me_2CHCH_2-	1-naphthyl	38[b]	*R*
17	**5h**	Me_2CHCH_2-	Ph	65[a]	*R*
18	**5i**	Me_2CHCH_2-	tBu	37[a]	*S*

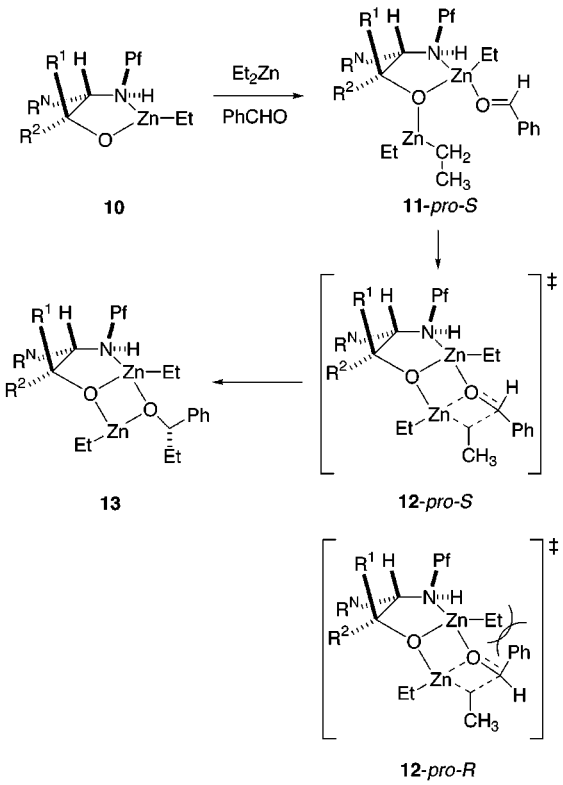
[a] 110 mol % of Et_2Zn. [b] 250 mol % of Et_2Zn

Perusal of the data shown in the table (Scheme 2) points to some interesting trends. With regards to the *syn* ligands, **4**, it can be seen that increasing the size of R^N (Me_2CHCH_2 vs Me), while keeping the same R^O group, is detrimental for the enantioselectivity of the catalyst (compare entries 1 and 8, 3 and 7, 5 and 9). On the other hand, the % ee values obtained when the R^O group was varied, while holding constant R^N, increased in the following order, 1-naphthyl < 2-naphthyl < ferrocenyl ~ phenyl < trityl < *tert*-butyl, showing that bulky R^O groups combined with small R^N substituents favored the enantioselectivity of the process. (*S*)-Selectivity was always favored with *syn* ligands.

(18) (a) Paleo, M. R.; Sardina, F. J. *Tetrahedron Lett.* **1996**, *37*, 3403. (b) Paleo, M. R.; Calaza, M. I.; Sardina, F. J. *J. Org. Chem.* **1997**, *62*, 6862.

(19) See Supporting Information for details.

Scheme 3



Anti amino alcohols **5** showed a different, more erratic behavior and, overall, they gave poorer enantioselectivities than their *trans* counterparts. The (*R*)-ethyl carbinol (*R*)-**9** was the predominant product in most cases, the exception being the reactions catalyzed by the ligands possessing bulky R^O groups (*tert*-butyl and trityl, **5e**, **5f**, **5i**), where (*S*)-**9** was the main product.

Theoretical calculations have been used to study the mechanism of the addition of dialkylzinc compounds to aldehydes and the origin of the enantioselectivity of the process.[16,20] These studies have established the nature of the intermediates, transition states, and the energetics of the reaction profile. The mechanistic picture that emerged from this work is depicted in Scheme 3. Complexation of the reactants with the true catalyst, ethylzinc aminoalkoxide **10**, leads to a di-zinc complex (**11**) which undergoes intramolecular ethyl migration, through transition state **12**, to give a catalyst/product complex (**13**); regeneration of the catalyst **10** and liberation of the product take place in a subsequent step.[16,20d] The energy differences, calculated at ab initio or semiempirical levels, of the corresponding transition states leading to the *R*- and *S*-reaction products have been used to explain the enantioselectivies displayed by the different catalysts.[20] The interaction of the substituents of the carbonyl group with the ethyl group attached to the aminoalkoxide Zn atom in the transition state appears to be the cause of the observed enantioselection (compare transition states **12**-*pro-S* and **12**-*pro-R*).[20c,d]

Analysis of the transition structures **12** (R^1 = H, R^2 = R^O) originated from *anti* amino alcohols **5** provided a clue to explain the lack of clear trends in the enantioselectivity displayed by the reactions catalyzed by these ligands. In these systems there should exist a strong steric interaction between R^O (= R^2) and R^N, which would lead to destabilization of the chelate. The fact that ligands **5** in which the R^O group is very bulky (trityl or *tert*-butyl) give products with *S* configuration, instead of the expected *R* alcohols, might even indicate that the formation of the chelate does not take place and that the true catalyst is a Zn alkoxide in which the N atom remains uncomplexed.

In the case of the transition structures derived from *syn* amino alcohols **4** (**12**, $R^1 = R^O$, R^2 = H) this steric repulsion is absent, and thus the Et_2Zn addition should proceed exclusively through the chelated form of the catalyst. The transition structures **12**-*pro-S*, the favored ones, can provide an explanation for the decrease in enantioselectivity observed for catalysts bearing bulky R^N groups: the steric interacions of R^N with the Et_2Zn and PhCHO groups should result in the elongation of both O−Zn bonds, thus isolating the reactants from the influence of the chiral centers of the catalyst. The increased enantioselectivity observed with the increasing bulkiness of R^O could be the result of steric compression by this group onto the Et bound to the Zn to which the PhCHO is attached; this effect should reduce the Et−Zn−O angle and thus bring the Et group in closer proximity to one of the carbonyl substituents, thus increasing the enantiodifferentiation between **12**-*pro-S* and **12**-*pro-R*.

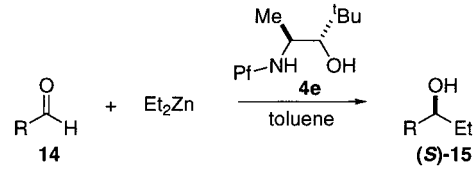
Once we had developed a ligand (**4e**) that promoted the highly enantioselective addition of Et_2Zn to benzaldehyde very efficiently, we decided to explore its general applicability, and thus we used it to induce the addition of Et_2Zn to a series of aromatic and aliphatic aldehydes (Scheme 4). The reactions were performed using 3 mol % of the catalyst in toluene at different temperatures, and very good enantioselectivities were obtained in most cases. We observed that, in the majority of cases, lower temperatures favored the enantioselectivity of the reaction; thus, when the reactions were carried out at 40 °C, lower ee values were obtained compared to room temperature or 0 °C. In these two latter cases the ee values were high and quite similar but slightly better for the reactions carried out at 0 °C. With regard to the additions to aromatic aldehydes, we observed that steric hindrance plays an important role in determining the degree of enantioselection of the reaction: *ortho*-substituted benzaldehydes underwent addition with lower enantioselectivities compared to their *meta* or *para* analogues, and 1-naphthaldehyde (86% ee) gave lower enantioselectivity compared to 2-naphthaldehyde (97% ee), although the effect for the bromobenzaldehydes is less dramatic (94 vs 96% ee, entries 11 and 13). Electronic effects of the aromatic ring substituents do not appear to have a large influence on the enantioselectivity of the addition, with the notable exception of the dialkoxybenzaldehydes where the ee obtained were only moderate-to-good. Linear and branched aliphatic aldehydes underwent Et_2Zn addition catalyzed by **4e** in a highly enantioselective fashion (entries 24 and 25) as well.

Conclusion

Our studies have shown that the nature and stereochemistry of the substituents in a series of *N*-phenylfluorenyl β-amino alcohols have a profound influence in their

(20) (a) Vidal-Ferran, A.; Moyano, A.; Pericàs, M. A.; Riera, A. *Tetrahedron Lett.* **1997**, *38*, 8773. (b) Nakano, H.; Kumagai, N.; Matsuzaki, H.; Kabuto, C.; Hongo, H. *Tetrahedron: Asymmetry* **1997**, *8*, 1391. (c) Goldfuss, B.; Houk, K. N. *J. Org. Chem.* **1998**, *63*, 8998. (d) Yamakawa, M.; Noyori, R. *Organometallics* **1999**, *18*, 128.

Scheme 4. Catalytic Enantioselective Addition of Et_2Zn to Aldehydes Mediated by 4e



Entry	R	Time	Temp	Yield (%)	ee (%)
1	Ph	1.5 h	40 °C	98	94
2		20 min	18 °C	98	97
3		3 h	0 °C	98	97
4	1-Naphyl	70 min	18 °C	85	86
5		14 h	0 °C	84	86
6	2-Naphthyl	40 min	18 °C	90	96
7		16 h	0 °C	91	97
8	4-Ph-C_6H_4	1 h	18 °C	91	96
9		1.5 h	0 °C	98	98
10	2-Br-C_6H_4	5 h	18 °C	83	92
11		16 h	0 °C	82	94
12	4-Br-C_6H_4	3h	18 °C	93	94
13		18 h	0 °C	73	96
14	4-Cl-C_6H_4	40 min	18 °C	96	96
15	4-MeO-C_6H_4	1.5 h	40 °C	98	78
16		2.5 h	18 °C	98	89
17		16 h	0 °C	98	93
18	3-MeO-C_6H_4	1 h	18 °C	97	97
19		1.5 h	0 °C	85	97
20	3,4-(OCH_2O)-C_6H_3	7 h	18 °C	98	88
21		7 h	0 °C	98	83
22	3,4-$(MeO)_2$-C_6H_3	1 h	18 °C	99	54
23		1 h	0 °C	99	44
24	Cyclohexyl	4 h	18 °C	94	97
25	*n*-Octyl	18 h	18 °C	98	98

ability to act as catalysts for the enantioselective addition of diethylzinc to aldehydes. Those ligands with bulky groups in the carbinol stereocenter and small groups α to the nitrogen atom displayed the best catalytic activity and enantioselectivity.

Experimental Section

General Methods. General experimental aspects have been published elsewhere.[18] Amino ketones **3** and amino alcohols **4a,b** and **5a,b** were prepared according to the published procedure.[18]

(1*S*,2*S*)-1-(1-Naphthyl)-2-[*N*-(9′-phenylfluoren-9′-yl)-amino]propan-1-ol (4c) and (1*R*,2*S*)-1-(1-Naphthyl)-2-[*N*-(9′-phenylfluoren-9′-yl)amino]propan-1-ol (5c). A 0 °C solution of **3c** (240 mg, 0.55 mmol) in MeOH/THF (6/2 mL) was treated with $NaBH_4$ (31 mg, 0.825 mmol). After stirring for 4 h under Ar, the reaction mixture was quenched by slow addition of 10% HCl. The resulting solution was extracted with EtOAc, and the organic layer was washed with water and brine, dried, filtered, and evaporated. Column chromatography (CH_2Cl_2/hexane 1/1) afforded **4c** (157 mg, 65% yield) and **5c** (77 mg, 32% yield). **4c**: mp 156−158 °C (EtOH); $[\alpha]^{20}_D = +235$ (*c* 1.0, $CHCl_3$); ^{1}H NMR δ 0.48 (d, J = 6.3, 3H), 2.80 (m, 1H), 3.35 (bs, 1H), 4.74 (d, J = 8.8, 1H), 7.19−7.94 (m, 20H); ^{13}C NMR δ 20.2, 53.4, 72.6, 78.3, 120.0, 120.1, 124.6, 124.9, 125.1, 125.2, 125.3, 125.7, 125.9, 126.4, 127.3, 127.7, 128.1, 128.2, 128.3, 128.4, 131.1, 134.0, 136.9, 140.3, 140.7, 144.7, 148.7, 150.7. Anal. Calcd for $C_{32}H_{27}NO$: C, 87.04; H, 6.16; N, 3.17. Found: C, 86.78; H, 5.77; N, 3.11. **5c**: mp 213-214 °C (EtOAc); $[\alpha]^{20}_D = +174$ (*c* 1.0, $CHCl_3$); ^{1}H NMR δ 0.58 (d, J = 6.7, 3H), 2.28 (bs, 1H), 2.69 (m, 1H), 3.70 (bs, 1H), 4.96 (d, J = 2.7, 1H), 6.31 (d, J = 8.5, 1H), 7.04−7.91 (m, 19H); ^{13}C NMR δ 15.6, 52.1, 71.6, 73.2, 120.1, 120.2, 122.6, 123.0, 124.5, 124.9, 125.2, 125.3, 125.8, 126.0, 127.0, 127.5, 128.2, 128.3, 128.4, 128.5, 128.6, 128.9, 129.8, 133.2, 136.5, 140.2, 141.3, 144.8, 149.4, 149.5. Anal. Calcd for $C_{32}H_{27}NO$: C, 87.04; H, 6.16; N, 3.17. Found: C, 86.81; H, 5.97; N, 3.08.

(1*S*,2*S*)-1-(2-Naphthyl)-2-[*N*-(9′-phenylfluoren-9′-yl)-amino]propan-1-ol (4d) and (1*R*,2*S*)-1-(2-Naphthyl)-2-[*N*-(9′-phenylfluoren-9′-yl)amino]propan-1-ol (5d). To a −78 °C solution of **3d** (200 mg, 0.45 mmol) in THF (5 mL) was added L-Selectride (0.9 mL, 0.9 mmol) and stirred for 4 h at 0 °C, and then it was quenched with AcOH (0.1 mL, 1.76 mmol). After 5 min of stirring, $LiOH\cdot H_2O$ (95 mg, 2.26 mmol) and H_2O_2 (2.6 mL) were added, and the resulting mixture was stirred for 25 min and then partitioned between CH_2Cl_2 (15 mL) and 1 M H_3PO_4 (15 mL). The aqueous phase was extracted with CH_2Cl_2 (15 mL), and the combined organic phase was washed with brine (20 mL), dried, and concentrated to give a residue which was purified by column chromatography (CH_2Cl_2/hexane 1/1) to give **4d** (150 mg, 74%) and **5d** (49 mg, 25% yield). **4d**: $[\alpha]^{20}_D = +172$ (*c* 1.0, CH_2Cl_2); ^{1}H NMR δ 0.45 (d, J = 6.2, 3H), 2.31 (m, 1H), 3.46 (bs, 2H), 4.19 (d, J = 8.6, 1H), 6.99 (dd, J = 1.9, 8.5, 1H), 7.15−7.71 (m, 19H); ^{13}C NMR δ 19.3, 54.8, 72.6, 78.4, 120.0, 120.1, 124.8, 125.1, 125.6, 125.8, 125.9, 126.0, 126.4, 127.3, 127.5, 127.8, 128.1, 128.4, 132.9, 139.7, 140.1, 140.6, 144.6, 148.4, 150.7. Anal. Calcd for $C_{32}H_{27}NO$: C, 87.04; H, 6.16; N, 3.17. Found: C, 87.14; H, 5.97; N, 2.97. **5d**: $[\alpha]^{20}_D = +151$ (*c* 1.0, CH_2Cl_2); ^{1}H NMR δ 0.56 (d, J = 6.5, 3H), 1.90 (bs, 1H), 2.49 (m, 1H), 3.58 (bs, 1H), 4.28 (d, J = 2.8, 1H), 6.85 (d, J = 8.8, 1H), 7.23−7.50 (m, 14H), 7.62 (d, J = 8.5, 1H), 7.76 (m, 4H); ^{13}C NMR δ 15.9, 53.9, 72.9, 74.8, 120.0, 120.1, 124.0, 124.2, 124.6, 125.3, 125.5, 125.8, 126.0, 127.3, 127.4, 127.5, 127.8, 128.0, 128.1, 128.4, 128.5, 128.7, 132.4, 133.0, 138.7, 139.9, 141.2, 144.7, 149.1, 149.7. Anal. Calcd for $C_{32}H_{27}NO$: C, 87.04; H, 6.16; N, 3.17. Found: C, 86.91; H, 6.07; N, 3.33.

(3*S*,4*S*)-2,2-Dimethyl-4-[*N*-(9′-phenylfluoren-9′-yl)amino]pentan-3-ol (4e) and (3*R*,4*S*)-2,2-Dimethyl-4-[*N*-(9′-phenylfluoren-9′-yl)amino]pentan-3-ol (5e). Method A: To a −78 °C solution of ketone **3e** (200 mg, 0.54 mmol) in THF (6 mL) was added $Li(tBuO)_3AlH$ (0.91 mL, 1.08 mmol, 1.19 M in cyclohexane). The resulting solution was stirred for 3 h at −78 °C and 40 h at room temperature, and then it was cooled to 0 °C and quenched by addition of EtOAc (1 mL). After 3 min, the cooling bath was removed and CH_2Cl_2 (9 mL) was added followed successively by saturated aqueous Na_2CO_3, KH_2PO_4, and Na_2SO_4. The resulting suspension was stirred for 30 min, filtered, and concentrated in vacuo. The ^{1}H NMR spectrum of the crude product showed a mixture of **3e**/**4e**/**5e** in a 2.8/24/1 ratio. Purification by column chromatography afforded 171 mg of amino alcohol **4e** (85% yield) as a white foam. Method B: A 0 °C solution of **3e** (50 mg, 0.13 mmol) in THF (1.5 mL) was treated with $LiBH_4$ (3 × 6 mg, 0.27 mmol) at intervals of 1.5 h each. After 4.5 h the reaction was quenched by addition of 10% H_3PO_4 (0.5 mL). The reaction mixture was partitioned between EtOAc and saturated aqueous $NaHCO_3$. The aqueous layer was extracted with EtOAc (10 mL), and the combined organic layer was washed with water and brine, dried, filtered, and concentrated to give a residue which was purified by column chromatography (CH_2Cl_2/hexane 3/2) to give **4e** (15 mg, 29%) and **5e** (34 mg, 67% yield). **4e**: $[\alpha]^{20}_D = +292$ (*c* 1.0, $CHCl_3$); ^{1}H NMR δ 0.55 (s, 9H), 0.82 (d, J = 6.3, 3H), 2.13 (m, 1H), 2.75 (d, J = 7.1, 1H), 7.19−7.79 (m, 13H); ^{13}C NMR δ 24.8, 26.0, 34.4, 47.8, 72.6, 81.1, 119.6, 120.0, 125.3, 125.7, 126.3, 127.3, 127.5, 128.1, 128.3, 128.4, 139.8, 141.1, 144.5, 148.0, 149.8. Anal. Calcd for $C_{26}H_{29}NO$: C, 84.06; H, 7.87; N, 3.77. Found: C, 83.80; H, 7.63; N, 3.64. **5e**: $[\alpha]^{20}_D = +155$ (*c* 1.9, $CHCl_3$); ^{1}H NMR δ 0.52 (s, 9H), 0.83 (d, J = 6.7, 3H), 1.85 (bs, 1H), 2.27 (m, 1H), 2.80 (d, J = 1.9, 1H), 7.16−7.43 (m, 11H), 7.65 (d, J = 7.6, 1H), 7.72 (d, J = 7.2, 1H); ^{13}C NMR δ 17.2, 26.6 (3C), 33.3, 49.8, 73.2, 81.1, 119.8, 119.9, 124.6, 125.8, 126.0, 127.2, 127.6, 127.8, 128.3, 139.9, 141.2, 145.0, 149.3, 149.7. Anal. Calcd for $C_{26}H_{29}NO$: C, 84.06; H, 7.87; N, 3.77. Found: C, 83.83; H, 8.02; N, 3.80.

(2*S*,3*S*)-1,1,1-Triphenyl-3-[*N*-(9′-phenylfluoren-9′-yl)-amino]butan-2-ol (4f) and (2*R*,3*S*)-1,1,1-Triphenyl-3-[*N*-(9′-phenylfluoren-9′-yl)amino]butan-2-ol (5f). A solution

of Ph_3CH (175 mg, 0.72 mmol) in THF (7 mL) was cooled to 0 °C and treated with ^{n}BuLi (300 mL, 0.67 mmol). The dark red solution was stirred for 2 h at 0 °C, and then a solution of *N*-Pf-alaninal (140 mg, 0.45 mmol) was added. After 4 h of stirring at 0 °C, the reaction was quenched by addition of AcOH (0.5 mL). The cooling bath was removed, and after 3 min the mixture was partitioned between EtOAc and saturated aqueous $NaHCO_3$. The organic layer was washed with saturated aqueous $NaHCO_3$, water, and brine, dried, filtered, and evaporated. The residue was purified to give **4f** (77 mg, 31% yield) and **5f** (74 mg, 30% yield). **4f**: $[\alpha]^{20}_D = -96$ (*c* 1.0, CH_2Cl_2); ^{1}H NMR δ 0.63 (d, $J = 6.6$, 3H), 1.34 (m, 1H), 3.05 (bd, $J = 6.1$, 1H), 5.16 (bs, 1H), 6.94−7.39 (m, 26 H), 7.63 (d, $J = 7.5$, 1H), 7.69 (d, $J = 7.5$, 1H); ^{13}C NMR δ 19.8, 53.4, 61.7, 71.1, 76.1, 120.1, 124.7, 124.9, 125.4, 125.7, 125.9, 127.0, 127.2, 127.3, 127.6, 127.7, 127.9, 128.1, 128.2, 129.5, 138.8, 140.2, 145.1, 148.0, 150.8. Anal. Calcd for $C_{41}H_{35}NO$: C, 84.06; H, 7.87; N, 3.77. Found: C, 84.07; H, 7.63; N, 3.76. **5f** : mp 196 °C (EtOH); $[\alpha]^{20}_D = +75$ (*c* 1.0, $CHCl_3$); ^{1}H NMR δ 0.11 (d, $J = 6.6$, 3H), 1.53 (bs, 1H), 2.66 (bd, $J = 5.2$, 1H), 3.29 (bd, $J = 2.3$, 1H), 4.46 (bs, 1H), 7.04−7.35 (m, 26H), 7.50 (d, $J = 6.6$, 1H), 7.55 (d, $J = 7.5$, 1H); ^{13}C NMR δ 17.5, 51.3, 60.4, 72.6, 76.1, 120.1, 120.2, 124.4, 125.2, 125.7, 125.8, 127.2, 127.3, 127.7, 127.8, 127.9, 128.2, 128.3, 130.1, 139.5, 140.8, 144.9, 145.4, 149.0, 150.0. Anal. Calcd for $C_{41}H_{35}NO$: C, 84.06; H, 7.87; N, 3.77. Found: C, 84.17; H, 7.58; N, 3.76.

(1*S*,2*S*)-4-Methyl-1-(1-naphthyl)-2-[*N*-(9′-phenylfluoren-9′-yl)amino]pentan-1-ol (4g) and (1*R*,2*S*)-4-Methyl-1-(1-naphthyl)-2-[*N*-(9′-phenylfluoren-9′-yl)amino]pentan-1-ol (5g). A 0 °C solution of **3g** (200 mg, 0.4 mmol) in THF (1 mL) was treated with $LiBH_4$ (3 × 20 mg, 0.85 mmol) at intervals of 1.5 h each. After 4 h the reaction was quenched by slow addition of 10% H_3PO_4 (0.5 mL). The reaction mixture was partitioned between EtOAc and saturated aqueous $NaHCO_3$. The aqueous layer was extracted with EtOAc (10 mL), and the combined organic layer was washed with water and brine, dried, filtered, and concentrated to give a residue which was purified by column chromatography (CH_2Cl_2/hexane 1/1) to give **4g** (70 mg, 35%) and **5g** (126 mg, 63% yield). **4g**: $[\alpha]^{20}_D = +235$ (*c* 1.0, $CHCl_3$); ^{1}H NMR δ −0.09 (d, $J = 6.5$, 3H), 0.26 (d, $J = 6.5$, 3H), 0.52 (m, 1H), 0.78 (m, 1H), 1.35 (m, 1H), 2.64 (m, 1H), 3.21 (bs, 2H), 4.93 (d, $J = 5.6$, 1H), 6.46 (d, $J = 7.5$, 1H), 6.70 (t, $J = 7.5$, 1H), 7.05−7.75 (m, 18H); ^{13}C NMR δ 20.7, 23.4, 24.5, 44.3, 54.8, 72.5, 75.1, 119.3, 119.9, 123.4, 124.8, 125.0, 125.2, 125.3, 125.4, 125.7, 125.9 (2C), 127.0, 127.4, 127.5, 127.8, 128.0, 128.2 (3C), 128.5, 130.8, 133.9, 137.7, 140.0, 140.8, 145.0, 148.2, 150.4. Anal. Calcd for $C_{35}H_{33}NO$: C, 86.92; H, 6.88; N, 2.90. Found: C, 86.81; H, 7.13; N, 3.17. **5g**: $[\alpha]^{20}_D = +69$ (*c* 1.0, $CHCl_3$); ^{1}H NMR δ −0.13 (d, $J = 6.3$, 1H), 0.38 (d, $J = 6.3$, 1H), 1.02 (m, 3H), 2.81 (m, 1H), 3.74 (bs, 1H), 4.70 (bs, 1H), 6.37 (d, $J = 9.5$, 1H), 6.99−7.87 (m, 19H); ^{13}C NMR δ 21.3, 23.2, 24.3, 39.0, 54.7, 70.5, 72.8, 120.0, 120.1, 122.6, 123.1, 124.8, 125.0, 125.1, 125.5, 125.6, 126.0, 126.9, 127.4, 128.2, 128.3, 128.5, 128.7, 128.9, 129.7, 133.1, 136.5, 139.9, 141.3, 149.8. Anal. Calcd for $C_{35}H_{33}NO$: C, 86.92; H, 6.88; N, 2.90. Found: C, 86.90; H, 6.98; N, 2.95.

(1*S*,2*S*)-4-Methyl-1-phenyl-2-[*N*-(9′-phenylfluoren-9′-yl)amino]pentan-1-ol (4h) and (1*R*,2*S*)-4-Methyl-1-phenyl-2-[*N*-(9′-phenylfluoren-9′-yl)amino]pentan-1-ol (5h). Method A: A solution of **3h** (250 mg, 0.58 mmol) in THF (5 mL) at −78 °C was treated with BH_3·SMe_2 (1.16 mL, 1.16 mmol, 1 M in THF) and stirred for 48 h while slowly warming to room temperature. MeOH (1 mL) was slowly added to the reaction mixture, and after stirring for 5 min, the resulting mixture was concentrated to dryness and the residue purified by column chromatography (CH_2Cl_2/hexane 1/1) to give **4h**/**5h** in a ratio 1/12. Method B: To a −78 °C solution of **3h** (300 mg, 0.7 mmol) in THF (7 mL) was added L-Selectride (1.4 mL, 1.4 mmol, 1 M in THF) and stirred for 16 h while slowly warming to room temperature, and then it was quenched with AcOH (0.1 mL, 1.76 mmol). After 3 min of stirring, the reaction mixture was cooled to 0 °C, $LiOH·H_2O$ (146 mg, 3.5 mmol) and H_2O_2 (3 mL) were added, and the resulting mixture was stirred for 20 min and then partitioned between EtOAc (15 mL) and 1 M H_3PO_4 (15 mL). The aqueous phase was extracted with EtOAc (15 mL) and the combined organic phase was washed with brine (20 mL), dried, and concentrated to give a residue which was purified by column chromatography (CH_2Cl_2/hexane 1/1) to give **4h** (196 mg, 65%) and **5h** (100 mg, 33% yield). **4h**: $[\alpha]^{20}_D = +209$ (*c* 1.0, CH_2Cl_2); ^{1}H NMR δ 0.07 (d, $J = 6.1$, 3H), 0.37 (d, $J = 6.1$, 3H), 0.79 (m, 1H), 1.24 (t, $J = 8.8$, 1H), 2.31 (m, 1H), 4.24 (d, $J = 5.8$, 1H), 6.95−7.39 (m, 16 H), 7.65 (d, $J = 7.5$, 1H), 7.69 (d, $J = 7.5$, 1H); ^{13}C NMR δ 20.9, 23.3, 24.4, 44.0, 56.6, 72.6, 76.0, 119.6, 120.0, 125.4, 125.9, 126.0, 126.8, 127.1, 127.2, 127.6, 127.9, 128.2, 128.3, 140.1, 140.9, 143.0, 144.9, 148.2, 150.4. Anal. Calcd for $C_{31}H_{31}NO$: C, 85.87; H, 7.21; N, 3.23. Found: C, 86.06; H, 6.95; N, 3.33. **5h** : $[\alpha]^{20}_D = +101$ (*c* 1.3, $CHCl_3$); ^{1}H NMR δ 0.23 (d, $J = 6.4$, 3H), 0.61 (d, $J = 6.6$, 3H), 0.81 (m, 1H), 1.08 (m, 1H), 1.34 (m, 1H), 2.20 (bs, 1H), 2.49 (m, 1H), 3.25 (bs, 1H), 4.04 (d, $J = 2.7$, 1H), 6.87 (d, $J = 7.1$, 2H), 7.09−7.55 (m, 14H), 7.77 (d, $J = 7.6$, 1H), 7.82 (d, $J = 7.6$, 1H); ^{13}C NMR δ 21.4, 23.3, 24.0, 38.5, 56.4, 72.5, 73.1, 119.8, 120.0, 125.2, 125.3, 126.0, 126.2, 127.3, 127.7, 127.9, 128.1, 128.3, 128.4, 128.6, 139.7, 141.1, 141.3, 145.0, 149.4, 149.9. Anal. Calcd for $C_{31}H_{31}NO$: C, 85.87; H, 7.21; N, 3.23. Found: C, 85.96; H, 7.27; N, 3.06.

(3*S*,4*S*)-2,2,6-Trimethyl-4-[*N*-(9′-phenylfluoren-9′-yl)-amino]heptan-3-ol (4i) and (3*R*,4*S*)-2,2,6-Trimethyl-4-[*N*-(9′-phenylfluoren-9′-yl)amino]heptan-3-ol (5i). $LiAlH_4$ (28 mg, 0.73 mmol) in THF (5 mL) was cooled to 0 °C and treated with a solution of **3i** (150 mg, 0.36 mmol) in THF (5 mL), the cooling bath was removed, and the resulting mixture was stirred for 30 min. Then it was quenched by slow addition of EtOAc (1 mL) followed by CH_2Cl_2, saturated aqueous $NaHCO_3$ (1 mL), KH_2PO_4, and anhyd Na_2SO_4. The resulting mixture was stirred at room temperature for 1 h and then filtered. The residue was washed with CH_2Cl_2, the combined clear filtrate and washings were concentrated, and the residue was purified by short column chromatography (CH_2Cl_2/hexane 1/1) to give **4i** (97 mg, 64%) and **5i** (48 mg, 32%). **4i**: $[\alpha]^{22}_D = +160$ (*c* 2.3, $CHCl_3$); ^{1}H NMR δ 0.38 (d, $J = 6.5$, 3H), 0.50 (d, $J = 6.5$, 3H), 0.61 (m, 1H), 0.70 (s, 9H), 0.99 (m, 1H), 1.25 (m, 1H), 2.47 (q, $J = 3.8$, 1H), 2.92 (d, $J = 3.9$, 1H), 3.12 (bs, 2H), 7.17−7.38 (m, 11H), 7.67 (m, 2H); ^{13}C NMR δ 21.7, 23.4, 24.3, 26.4, 34.9, 43.9, 50.9, 72.3, 79.0, 119.9, 125.2, 125.8, 126.6, 127.1, 127.7, 128.2, 128.3, 128.4, 140.4, 140.5, 145.5, 148.1, 151.5. Anal. Calcd for $C_{29}H_{35}NO$: C, 84.22; H, 8.53; N, 3.39. Found: C, 84.12; H, 8.76; N, 3.27. **5i**: $[\alpha]^{22}_D = +12$ (*c* 1.5, CH_2Cl_2); ^{1}H NMR δ 0.48 (s, 9H), 0.50 (d, $J = 6.6$, 3H), 0.91 (d, $J = 6.6$, 3H), 1.27 (m, 2H), 1.76 (m, 1H), 2.05 (m, 1H), 2.16 (m, 1H), 2.44 (dd, $J = 1.7$, 9.8, 1H), 2.64 (d, $J = 1.2$, 1H), 7.21−7.74 (m, 13H); ^{13}C NMR δ 21.4, 24.4, 24.5, 27.0, 33.4, 39.8, 52.5, 72.6, 79.3, 119.7, 119.9, 125.6, 126.1, 127.1, 127.7, 127.8, 128.2, 128.3, 139.9, 141.0, 145.6, 149.3, 150.6. Anal. Calcd for $C_{29}H_{35}NO$: C, 84.22; H, 8.53; N, 3.39. Found: C, 84.33; H, 8.21; N, 3.35.

Preparation of Oxazolidines 6/7e,f. General Procedure. A solution of amino alcohol **4e,f** or **5e,f** (0.15 mmol), *p*-TsOH (6 mg, 0.03 mmol), and aq formaldehyde (0.2 mL, 1.5 mmol) in THF (2 mL) was stirred at room temperature for 24 h. The reaction mixture was partitioned between CH_2Cl_2 and saturated aqueous $NaHCO_3$. The organic layer was washed with water and brine, dried, filtered, and evaporated. The residue was purified by column chromatography (EtOAc/hexane 1/20 for **6/7e** and EtOAc/hexane 1/10 for **6/7f**) to give the product as a white solid.

(4*S*,5*R*)-5-(*tert*-Butyl)-4-methyl-3-[*N*-(9′-phenylfluoren-9′-yl)amino]oxazolidine (6e): mp 129−130 °C (EtOH); $[\alpha]^{20}_D = -423$ (*c* 1.0, $CHCl_3$); ^{1}H NMR δ 0.67 (s, 9H), 0.91 (d, $J = 6.6$, 3H), 2.61 (m, 1H), 2.69 (d, $J = 5.6$, 1H), 4.68 (d, $J = 5.3$, 1H), 4.85 (d, $J = 5.3$, 1H), 7.10−7.65 (m, 13H); ^{13}C NMR δ 18.3, 27.0 (3C), 32.8, 56.1, 76.6, 82.3, 86.9, 119.6, 119.7, 125.6, 126.6, 126.9, 127.0, 127.2, 127.6, 127.7, 128.0, 128.2, 128.3, 128.6, 139.2, 141.3, 144.3, 148.1, 149.5. Anal. Calcd for $C_{27}H_{29}NO$: C, 84.55; H, 7.62; N, 3.65. Found: C, 84.23; H, 7.67; N, 3.70.

(4*S*,5*S*)-5-(*tert*-Butyl)-4-methyl-3-[*N*-(9′-phenylfluoren-9′-yl)amino]oxazolidine (7e): mp 127−128 °C (EtOH); $[\alpha]^{20}_D = -489$ (*c* 1.0, $CHCl_3$); ^{1}H NMR δ 0.47 (s, 9H), 0.86 (d, $J = 6.1$, 3H), 2.22 (m, 1H), 3.00 (d, $J = 7.5$, 1H), 4.66 (d, $J = 7.2$,

1H), 4.99 (d, J = 7.2, 1H), 7.07−7.69 (m, 13H); ^{13}C NMR δ 22.7, 26.1 (3C), 32.4, 54.2, 76.9, 82.4, 94.0, 119.2, 119.6, 126.6, 126.9, 127.0, 127.2, 127.8, 127.9, 128.0, 128.3, 128.4, 139.1, 141.8, 145.7, 147.6, 149.0. Anal. Calcd for $C_{27}H_{29}NO$: C, 84.55; H, 7.62; N, 3.65. Found: C, 84.32; H, 7.81; N, 3.62.

(4*S*,5*R*)-4-Methyl-3-[*N*-(9′-phenylfluoren-9′-yl)amino]-5-trityloxazolidine (6f): mp 201−202 °C (EtOH); $[\alpha]^{20}_D$ = +207 (*c* 1.0, CH_2Cl_2); ^{1}H NMR δ 0.23 (d, J = 6.9, 3H), 3.16 (d, J = 6.9, 3H), 4.27 (d, J = 5.7, 2H), 4.75 (d, J = 6.6, 1H), 4.80 (d, J = 6.6, 1H), 6.8−7.68 (m, 28H); ^{13}C NMR δ 18.2, 29.7, 58.2, 59.4, 81.7, 83.2, 119.6, 119.7, 125.3, 125.9, 126.8, 127.0, 127.2, 127.3, 127.5, 127.7, 128.0, 128.2, 128.3, 128.9, 130.4, 139.2, 141.5, 144.1, 148.1, 149.5. Anal. Calcd for $C_{42}H_{35}NO$: C, 88.54; H, 6.19; N, 2.46. Found: C, 88.32; H, 6.39; N, 2.31.

(4*S*,5*S*)-4-Methyl-3-[*N*-(9′-phenylfluoren-9′-yl)amino]-5-trityloxazolidine (7f): mp 201 °C (Et_2O−EtOH); $[\alpha]^{20}_D$ = +187 (*c* 1.0, CH_2Cl_2); ^{1}H NMR δ 0.38 (d, J = 6.0, 3H), 3.22 (m, 1H), 4.40 (d, J = 2.5, 3H), 4.71 (d, J = 2.5, 3H), 5.11 (d, J = 4.4, 3H), 6.77 (d, J = 7.9, 3H), 6.93−7.37 (m, 25H), 7.52 (d, J = 7.6, 3H), 7.62 (d, J = 7.1, 3H); ^{13}C NMR δ 17.9, 54.8, 61.0, 72.5, 79.1, 88.8, 119.6, 120.1, 126.0, 126.1, 126.5, 126.7, 127.0, 127.2, 127.4, 127.5, 127.6, 127.9, 128.1, 130.4, 138.7, 141.0, 143.9, 145.1, 147.6, 148.7. Anal. Calcd for $C_{42}H_{35}NO$: C, 88.54; H, 6.19; N, 2.46. Found: C, 88.35; H, 6.39; N, 2.40.

General Procedure for the Enantioselective Amino Alcohol-Catalyzed Addition of Diethylzinc to Aldehydes. A solution of the amino alcohol **4** or **5** (0.027 mmol) and the aldehyde **8** or **14a**−**l** (0.9 mmol) in anhydrous toluene (1 mL) was cooled to the desired temperature and treated with Et_2-Zn (100 or 250 mol %, 1 M in hexane), and the mixture was stirred under Ar and monitored by TLC. The reaction was cooled to 0 °C, quenched by careful addition of 10% HCl, and extracted with EtOAc (2 × 10 mL), and the combined organic layer was washed with water and brine, dried, and evaporated. The residue was purified by bulb to bulb distillation. Enantiomeric excesses were determined by chiral GC using a Supelco α- or β-DEX 120 column, isotherm temperature program, and He as carrier gas (1.3 mL/min). 1-Phenylpropanol: β-DEX 120 column, 120 °C, t_R *R* isomer 20.8 min, t_R *S* isomer 21.2 min. The absolute configuration was determined by comparison of the known optical rotation of (*S*)-1-phenylpropan-1-ol. 1-(2-Naphthyl)-1-propanol: β-DEX 120 column, 160 °C, t_R *R* isomer 58.3 min, t_R *S* isomer 60.6 min. 1-(1-Naphthyl)-1-propanol: β-DEX 120 column, 160 °C, t_R *R* isomer 52.0 min, t_R *S* isomer 53.0 min. 1-(4-Phenylphenyl)-1-propanol: β-DEX 120 column, 180 °C, t_R *R* isomer 60.7 min, t_R *S* isomer 62.0 min. 1-(2-Bromophenyl)-1-propanol: β-DEX 120 column, 140 °C, t_R *R* isomer 37.5 min, t_R *S* isomer 40.8 min. 1-(4-Bromophenyl)-1-propanol: β-DEX 120 column, 140 °C, t_R *R* isomer 47.9 min, t_R *S* isomer 49.2 min. 1-(4-Chlorophenyl)-1-propanol: β-DEX 120 column, 140 °C, t_R *R* isomer 32.5 min, t_R *S* isomer 33.8 min. 1-(4-Methoxyphenyl)-1-propanol: β-DEX 120 column, 145 °C, t_R *R* isomer 26.2 min, t_R *S* isomer 26.9 min. 1-(3-Methoxyphenyl)-1-propanol: β-DEX 120 column, 135 °C, t_R *R* isomer 39.8 min, t_R *S* isomer 40.7 min. 1-(3,4-Methylenedioxyphenyl)-1-propanol: β-DEX 120 column, 150 °C, t_R *R* isomer 40.6 min, t_R *S* isomer 41.4 min. 1-(3,4-Dimethoxyphenyl)-1-propanol: β-DEX 120 column, 140 °C, t_R *R* isomer 103.6 min, t_R *S* isomer 106.5 min. 1-Cyclohexyl-1-propanol: α-DEX 120 column, 90 °C, t_R *R* isomer 32.4 min, t_R *S* isomer 33.1 min. 3-Dodecanol: α-DEX 120 column, 90 °C, t_R *R* isomer 36.7 min, t_R *S* isomer 37.7 min. The absolute configuration was established by comparison of the optical rotation of the products with the reported values.[10b]

Acknowledgment. Financial support from the CICYT (Spain, grants SAF96-0251 and SAF99-0127) and the *Xunta de Galicia* (grant XUGA 20912B96) is gratefully acknowledged as well as a fellowship from the *Xunta de Galicia* (I.C.). We also thank Prof. Rafael Suau (Universidad de Málaga, Spain) for the elemental analyses and Prof. Miquel A. Pericàs (Universidad de Barcelona, Spain) for advice.

Supporting Information Available: ORTEP drawings and crystal and structural data of compounds **6e** and **7e**. This material is available free of charge via the Internet at http://pubs.acs.org.

JO9917083