Effective Enantiocontrol in Conjugate Additions of Organocuprates. Highly Selective 1,5-Chiral Induction in the Conjugate Additions of Cuprates to α,β-Unsaturated Amide Derivatives of 2,2-Dimethyloxazolidine Chiral Auxiliaries

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α,β-Unsaturated amide derivatives of 2,2-dimethyloxazolidines, developed as new chirality-controlling auxiliaries based on the restricted rotation of the amide linkage, have been applied to the enantiocontrol of conjugate additions of lithium and magnesium cuprates. High selectivities of 1,5-chiral inductions are attained, indicating their promising synthetic potential in asymmetric synthesis. The diastereofacial selectivities depend upon the efficiency of steric shielding by the 4-substituent of the chiral auxiliary, and the reaction of (*S*)-4-benzyl-3-[(*E*)-2-butenoyl]-2,2,5,5-tetramethyloxazolidine with $Ph_2CuMgBr{\cdot}MgBrI$ is exclusively *lk*-1,5-inductive. Use of organolithium and organomagnesium show opposite low selectivities. It is concluded that the stereochemistry of cuprate conjugate addition is determined at the step of formation of the d,π* type charge transfer complexes.

Conjugate addition reaction of organometallic nucleophiles to α,β-unsaturated carbonyl compounds offers an important method of carbon–carbon bond formation so that this reaction has enjoyed wide synthetic applications as a key step in the synthesis of complex organic molecules.[1] Its development to asymmetric reactions has been recently studied to open a useful route to optically active carbonyl compounds bearing a chiral center at β-position.[2,3] Among them, cuprate additions using chiral acceptors such as α,β-unsaturated esters[4] and amides[5] are still most effective, while enantioselective reactions using the cuprates modified by chiral ligands[6–9] are recently becoming more important. Although a variety of organozinc nucleophiles are hardly available, the nickel-catalyzed asymmetric conjugate additions of dialkylzincs have a promising synthetic potential.[10]

We[11] and others[12] have recently developed a new type of chiral auxiliary, 4-chiral 2,2-dialkyloxazolidines, whose chirality control is based on the conformational control of amide linkage. In their α,β-unsaturated amide derivatives, the amide moiety predominantly occupies *syn/s-cis* conformation in order to minimize the steric hindrance around this bond[11b] so that one of the diastereofaces of the unsaturated reaction site may be effectively shielded by the proximate 4-substituent.

Actually, nitrile oxides underwent the exclusively *lk*-1,4-inductive 1,3-dipolar cycloadditions to α,β-unsaturated amide derivatives of 2,2-dimethyloxazolidine chiral auxiliaries.[11c] In such dipolar cycloadditions using these oxazolidine unsaturated amide derivatives, a 1,3-dipole reacts across the carbon–carbon double bond activated

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(1) Perlmutter, P. *Conjugate Addition Reactions in Organic Synthesis*; as Vol. 9 of Tetrahedron Organic Chemistry Series; Pergamon Press: Oxford, 1992.

(2) Recent reviews: (a) Rossiter, B. E.; Swingle, N. M. *Chem. Rev.* **1992**, *92*, 771–806. (b) Tomioka, K.; Koga, K. *Asymmetric Synthesis*; Morrison, J. D., Ed.; Academic Press: New York, 1983; Vol. 2, pp 201–224.

(3) (a) Yamaguchi, M.; Hasebe, K.; Tanaka, S.; Minami, T. *Tetrahedron Lett.* **1986**, *27*, 959–962. (b) Corey, E. J.; Peterson, R. T. *Ibid.* **1985**, *26*, 5025–5028. (c) Kanemasa, S.; Tatsukawa, A.; Wada, E. *J. Org. Chem.* **1991**, *56*, 2875–2883. (d) Yamamoto, H.; Kanemasa, S.; Wada, E. *Bull. Chem. Soc. Jpn.* **1991**, *64*, 2739–2743.

(4) (a) Fuji, K.; Tanaka, K.; Mizuchi, M.; Hosoi, S. *Tetrahedron Lett.* **1991**, 7277–7280. (b) Fang, C.; Ogawa, T.; Suemune, H.; Sakai, K. *Tetrahedron Asymm.* **1991**, *2*, 389–398. (c) Oppolzer, W.; Stevenson, T. *Tetrahedron Lett.* **1986**, *27*, 1139–1140. (d) Helmchen, G.; Wegner, G. *Ibid.* **1985**, *26*, 6051–6054. (e) Oppolzer, W.; Dudfield, P.; Stevenson, T.; Godel, T. *Helv. Chim. Acta* **1985**, *68*, 212–215. (f) Oppolzer, W.; Moretti, R.; Godel, T.; Meunier, A.; Löher, H. *Tetrahedron Lett.* **1983**, *24*, 4971–4974.

(5) (a) Nicolas, E.; Russell, K. C.; Hruby, V. J. *J. Org. Chem.* **1993**, *58*, 766–770. (b) Melnyk, O.; Stephen, E.; Pourcelot, G.; Cresson, P. *Tetrahedron*, **1992**, *48*, 841–850. (c) Oppolzer, W.; Kingma, A. J. *Helv. Chim. Acta* **1989**, *72*, 1337–1345. (d) Oppolzer, W.; Kingma, A. J.; Poli, G. *Tetrahedron* **1989**, *45*, 479–488. (e) Oppolzer, W.; Poli, G.; Kingma, A. J. *Helv. Chim. Acta* **1987**, *70*, 2201–2204. (f) Oppolzer, W.; Mills, R. J.; Pachinger, W.; Stevenson, T. *Ibid.* **1986**, *69*, 1542–1545. (g) Tomioka, K.; Suenaga, T.; Koga, K. *Tetrahedron Lett.* **1986**, *27*, 369–372.

(6) (a) Tanaka, K.; Suzuki, H. *J. Chem. Soc., Chem. Commun.* **1991**, 101–102. (b) Corey, E. J.; Naef, R.; Hannon, F. J. *J. Am. Chem. Soc.* **1986**, *108*, 7114–7116.

(7) (a) Rossiter, B. E.; Eguchi, M.; Miao, G.; Swingle, N. M.; Hernandez, A. E.; Vickers, D.; Fluckiger, E.; Patterson, R. G.; Reddy, K. V. *Tetrahedron* **1993**, *49*, 965–986. (b) Dieter, R. K.; Lagu, B.; Deo, N.; Dieter, J. W. *Tetrahedron Lett.* **1991**, *32*, 4105–4108. (c) Rossiter, B. E.; Eguchi, M.; Hernandez, A. E.; Vickers, D.; Medich, J.; Marr, J.; Heinis, D. *Ibid.* **1991**, *32*, 3973–3976. (d) Rossiter, B. E.; Eguchi, M. *Ibid.* **1990**, *31*, 965–968. (e) Dieter, R. K.; Tokles, M. *J. Am. Chem. Soc.* **1987**, *109*, 2040–2046.

(8) Kanai, M.; Koga, K.; Tomioka, K. *Tetrahedron Lett.* **1992**, *33*, 7193–7196.

(9) Villacorta, G. M.; Rao, C. P.; Lippard, S. J. *J. Am. Chem. Soc.* **1988**, *110*, 3175–3182.

(10) (a) Bolm, C. *Tetrahedron Asymm.* **1991**, *2*, 701–704. (b) Soai, K.; Okudo, M.; Okamoto, M. *Tetrahedron Lett.* **1991**, *32*, 95–96. (c) Bolm, C.; Ewald, M. *Ibid.* **1990**, *31*, 5011–5012. (d) Soai, K.; Hayasaka, T.; Ugajin, S. *J. Chem. Soc., Chem. Commun.* **1989**, 516–517. (e) Soai, K.; Yokoyama, S.; Hayasaka, T.; Ebihara, K. *J. Org. Chem.* **1988**, *53*, 4148–4149. (f) Soai, K.; Hayasaka, T.; Ugajin, S.; Yokoyama, S. *Chem. Lett.* **1988**, 1571–1572.

(11) (a) Kanemasa, S.; Onimura, K.; Wada, E.; Tanaka, J. *Tetrahedron Asymm.* **1991**, *2*, 1185–1188. (b) Kanemasa, S.; Onimura, K. *Tetrahedron* **1992**, *48*, 8631–8644. (c) Kanemasa, S.; Onimura, K. *Tetrahedron* **1992**, *48*, 8645–8658.

(12) (a) Porter, N. A.; Bruhnke, J. D.; Wu, W.-X.; Rosenstein, I. J.; Breyer, R. A. *J. Am. Chem. Soc.* **1991**, *113*, 7788–7790. (b) Askin, D.; Wallace, M. A.; Vacca, J. P.; Reamer, R. A.; Volante, R. P.; Shinkai, I. *J. Org. Chem.* **1992**, *57*, 2771–2773. (c) Narukawa, Y.; Juneau, K. N.; Snustad, D.; Miller, D. B.; Hegedus, L. S. *Ibid.* **1992**, *57*, 5453–5462. (d) Porter, N. A.; Allen, T. R.; Breyer, R. A. *J. Am. Chem. Soc.* **1992**, *114*, 7676–7683. (e) Scott, D. M.; McPhail, A. T.; Porter, N. A. *J. Org. Chem.* **1993**, *58*, 1178–1186.

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Table 1. Abstracted ^{1}H NMR Data[a] and *Syn/Anti* Conformer Ratios of 3-Alkenoyl-2,2-dimethyloxazolidines 1a–f

entry	amide 1	R^4	R^5	R	=C*H*CO,[b] δ	RC*H*=,[b] δ	isomer ratio
1	**1a**	Ph	H	Me	5.79	6.84	*syn* only
2	**1b**	Ph	H	Ph	6.40	7.58	*syn* only
3	**1c**	$PhCH_2$	H	Me	6.10	6.95	*syn*:*anti* = 90:10
4	**1d**	$PhCH_2$	Me	Me	5.54	6.54	*c*
5	**1e**	$PhCH_2$	Me	Ph	6.05	7.00	*c*
6	**1f**	Ph_2CH	H	Me	5.38	6.39	*syn*:*anti* = 97:3

[a] Measured in $CDCl_3$ at 27 °C. [b] Chemical shift for the major conformer is given. [c] Ratio was not determined due to signal broadening.

by the amide carbonyl group, and the amide functionality remains intact during the reaction course. Accordingly, a restricted rotation around the amide linkage should still be retained in the transition state. We believe this may be a major reason for the exclusively high diastereofacial selectivities observed.

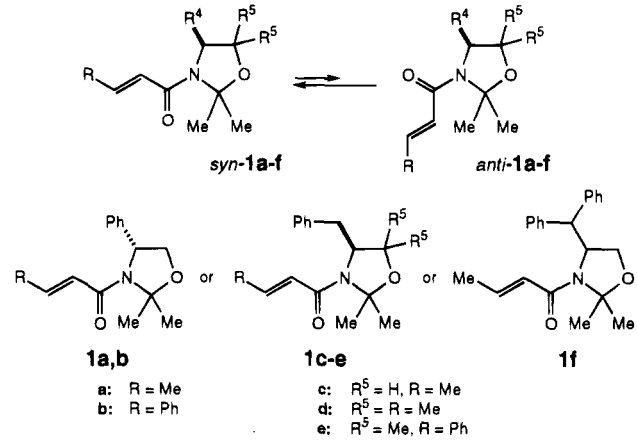
To raise the synthetic potential of 2,2-dialkyloxazolidine chiral auxiliaries, it is necessary to open their wide synthetic applications in other fields of asymmetric reactions. We therefore selected conjugate addition reactions of organocuprates to the α,β-unsaturated amide derivatives of 4-chiral 2,2-dialkyloxazolidines. Although the detailed reaction mechanism of cuprate conjugate addition to α,β-unsaturated carbonyl acceptors has not been confirmed yet, the carbonyl group formally changes to a metal enolate functionality after the completion of reaction. It is interesting in such a case to know whether fixation of the amide linkage by restricted rotation, and hence effective selection of either of diastereofaces by cuprate nucleophiles, can be achieved in the transition state.

This paper reports that 2,2-dimethyloxazolidine chiral auxiliaries can be effectively utilized to control the chiral induction of conjugate additions using lithium and magnesium cuprates. The 2,2-dimethyloxazolidine auxiliaries are introduced in the acceptor molecules as α,β-unsaturated amide derivatives whose reactions with cuprates show excellent 1,5-chiral inductions. The absolute configurations generated at the newly formed chiral center in the adducts are unambiguously predictable.

Chiral α,β-unsaturated amides **1a–f** were readily available by either the *N*-cinnamoylation of rather unstable 2,2-dimethyloxazolidine chiral auxiliaries[11b] with cinnamoyl chloride and triethylamine or the *N*-crotonoylation of the corresponding β-substituted glycinols followed by acetalization. The direct *N*-crotonoylation of 2,2-dimethyloxazolidines using crotonoyl chloride and triethylamine leads to the undesired formation of deconjugated amides, *N*-(3-butenoyl) derivatives. Optically pure unsaturated amides **1a–e** were employed in the present work since optically active β-amino alcohols could be readily available by simple transformations of the corresponding α-amino acids, while the diphenylmethyl-substituted oxazolidine amide **1f** was used in a racemic form (Scheme 1).[13]

These unsaturated amide derivatives of 2,2-dimethyloxazolidines **1a–f** exist, in chloroform solution at room temperature, mostly as *syn/s-cis* conformers (Table 1) just like *N*-acryloyl derivatives.[11b] Especially efficient steric shieldings were observed in the cases of 4-benzyl-2,2,5,5-tetramethyloxazolidine amides **1e,f** and 2,2-dimethyl-4-(diphenylmethyl)oxazolidine amide **1f**. The carbon–

Scheme 1



carbon double bonds as reaction sites (MeCH=CH or PhCH=CH) are located to face the phenyl plane contained as a part of the 4-substituent so that they are magnetically shielded. Based on the previous work,[11b] the ratio of conformational isomers (*syn/anti* ratio) should be shifted at a lower temperature in favor of the major *syn/s-cis* conformers. Accordingly, lock of conformation can be attained sufficiently with respect to the amide linkage of **1a–f**, at least in the ground state. Effective steric shielding of a diastereoface is expected also in the transition state of conjugate additions.

Unfortunately, these α,β-unsaturated amides **1a–f** were very sluggish in conjugate additions with organocuprates even at room temperature; no conjugate addition took place without activator. Since the unsaturated amides derived from a sterically less hindered secondary amine, such as dimethylamine, showed some more increased reactivity under comparable conditions, such an extreme deactivation must be due to the steric hindrance caused by the bulky oxazolidine chiral auxiliaries. It was found that these conjugate addition reactions occurred smoothly when chlorotrimethylsilane (TMSCl) was present, while coexistence of hexamethylphosphoric triamide (HMPT) was totally ineffective.[14]

Several homocuprates $R'_2CuMtl{\cdot}MtlX$ were used to react with unsaturated amides **1a–f** in the presence of TMSCl (1.2 equimolar amount, Scheme 2). Since the reactivity of cuprates sensitively depended upon the nature of ligand R′ of cuprates, choice of reaction solvents and temperatures was optimized in each case so as to give satisfactory results (Table 2). Reaction of a highly reactive cuprate could be performed at a low temperature to show the exclusively high diastereofacial selectivity (entry 5), while reactions of less reactive cuprates were performed at room temperature where satisfactory selectivities were also observed (entries 1–4, 7, 8, 10).

(13) Optically pure 2-amino-3,3-diphenylpropanoic acid is known. See (a) Josien, H.; Martin, A.; Chassaing, G. *Tetrahedron Lett.* **1991**, *32*, 6547–6550. (b) Chen, H. G.; Beylin, V. G.; Marlatt, M.; Leja, B.; Goel, O. P. *Ibid.* **1992**, *33*, 3293–3296.

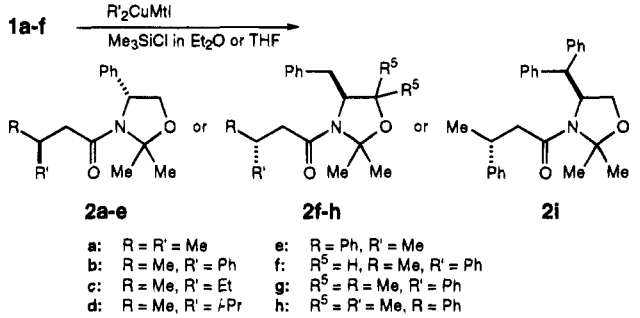
(14) (a) Commercon, M. B.; Foulon, J. P.; Normant, J. F. *J. Organomet. Chem.* **1982**, *228*, 321–326. (b) Alexakis, A.; Berln, J.; Besace, Y. *Tetrahedron Lett.* **1986**, *27*, 1047–1050.

Table 2. Chlorotrimethylsilane-Promoted Asymmetric Conjugate Additions of Lithium or Magnesium Cuprates to Chiral 3-(2-Alkenoyl)-2,2-dimethyloxazolidines 1a–f

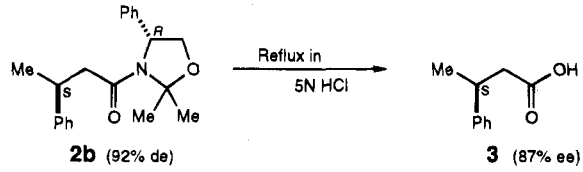
entry	amide 1	RMtl	CuX	solvent	temp/°C	time/h	product	yield/%[a]	isomer ratio[b]
1	**1a**	MeLI	CuI	Et_2O	rt	40	**2a**	78	–
2	**1a**	PhLi	CuI	Et_2O	rt	17	**2b**	32(68)[c]	94:6 (*R*)
3	**1a**	PhMgBr	CuI	THF	−20	5	**2b**	49	>99:1 (*R*)
4	**1a**	PhMgBr	CuBr·Me_2S	THF	rt	25	**2b**	70	91:9 (*R*)
5	**1a**	EtMgBr	CuI	THF	−78	6	**2c**	94	>99:1 (*S*)
6	**1a**	*i*-PrMgBr	CuI	THF	−50	48	**2d**	85(10)[c]	95:5 (*R*)
7	**1b**	MeLi	CuI	Et_2O	rt	24	**2e**	91	87:13 (*S*)
8	**1c**	PhMgBr	CuI	THF	rt	2	**2f**	44	94:6 (*R*)
9	**1d**	PhMgBr	CuI	THF	rt	24	**2g**	56	>99:1 (*R*)
10	**1e**	MeLi	CuI	Et_2O	rt	24	**2h**	84	92:8 (*S*)
11	**1f**[d]	PhMgBr	CuI	THF	rt	36	**2i**	56(38)[c]	>99:1[e]

[a] Yield of isolated mixture of diastereomers. [b] Based on ^{13}C NMR spectrum of the crude reaction mixture. Absolute configuration of the alkanoic acids derived from major enantiomers in parenthesis. [c] Recovered amide in parenthesis. [d] Racemate was used. [e] (4*RS*,3′*SR*)-Diastereomer is the major isomer of **2i**.

Scheme 2



Scheme 3

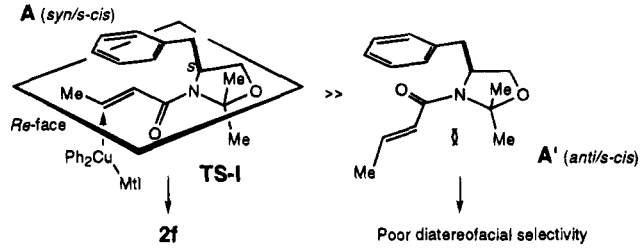


When the α,β-unsaturated amide derivatives **1d–f** of the oxazolidine chiral auxiliary bearing a highly effective shielding substituent at 4-position were employed, excellent to exclusive diastereofacial selectivities were recorded depending upon the bulkieness of ligand R′ of cuprates (entries 9–11).

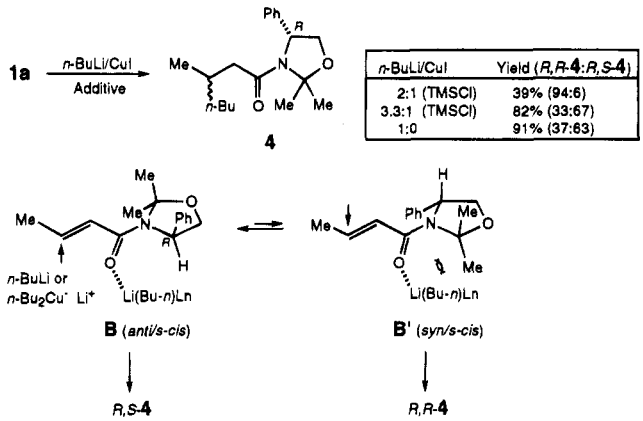
Absolute configurations at the newly formed stereogenic carbon center of the major diastereomers of **2a–h** were determined on the basis of the typical transformation of **2b**, which includes the acid-catalyzed hydrolytic removal of the oxazolidine chiral auxiliary to the known (*S*)-3-phenylbutanoic acid (**3**) in 80% yield (Scheme 3). The conjugate additions of diphenylcuprates, Ph_2CuLi·LiI (Br) or $Ph_2CuMgBr$·MgBrI, to the crotonamide **1a** produced a diastereomer **2b** as major adducts (entries 2–4). This compound is diastereomeric to the adduct **2d** which was produced in the reaction of Me_2CuLi·LiI with the cinnamamide **1b** (entry 7). Similarly, the adduct **2g** produced as a single diastereomer from **1d** and $Ph_2CuMgBr$·MgBrI (entry 9) was also diastereomeric to the major isomer of **2h** produced from **1e** and Me_2CuLi·LiI (entry 10). Hydrolytic removal of the oxazolidine chiral auxiliaries from **2b** and **2d** or **2g** and **2h** led to enantiomeric 3-phenylbutanoic acids, respectively.

These results indicate that the major routes of all these conjugate addition reactions between organocuprates and the oxazolidine α,β-unsaturated amides **1a–f** have occurred, in the *syn/s-cis* conformations of acceptor molecules **1a–f**, at the diastereotopic face remote from the

Scheme 4



Scheme 5



4-shielding substituent R^4 (a benzyl substituent in the given case) as shown with a transition state model **TS-1** (Scheme 4). The modes of diastereofacial selections in these cuprate conjugate additions are *ul*-1,5-inductive for **1a,c,d,f** and *lk*-1,5-inductive for **1b,e**. This means that the greater stability of *syn/s-cis* conformer **A** rather than *anti/s-cis* conformer **A′** observed in the ground state has reflected also in the transition state of organocuprate conjugate additions.

The reaction of **1a** with *n*-Bu_2CuLi·LiI produced a 94:6 mixture of (*R*,*R*)-**4** and (*R*,*S*)-**4** when the cuprate was prepared, prior to the conjugate addition reaction, from 2 mol equiv of butyllithium and an equimolar amount of copper(I) iodide (Scheme 5). However, when the cuprate nucleophile was prepared by using a large excess (3.3 equiv) of butyllithium, the yield of adduct **4** was improved and to our surprise a reversed selectivity resulted ((*R*,*R*)-**4**:(*R*,*S*)-**4** = 33:67). Free butyllithium was found to be much more reactive to the bulky unsaturted amide **1a** than the corresponding cuprate/TMSCl, and that the reaction of butyllithium showed a similar preference for the production of (*R*,*S*)-**4** (yield: 91%, (*R*,*R*)-**4**:(*R*,*S*)-**4** = 37:63). Accordingly, the presence of free organolithium

nucleophiles should be avoided to accomplish a high chiral induction.

Although the reason for the reversal of diasterofacial selectivity has not been solved yet, metal coordination onto the carbonyl oxygen atom was presumably involved to form an equilibrium mixture of complexes **B** and **B'**. The *anti/s-cis* conformation **B** should have higher stability than the *syn/s-cis* one **B'** since the carbonyl oxygen becomes bulky by its coordination to the metal ion. Conjugate addition of *n*-Bu_2CuLi·LiI or *n*-BuLi to **B** takes place intermolecularly from the sterically less hindered *si*-face of the β-carbon leading to the more favored formation of (*R*,*S*)-**4** diastereomer. Another possible course involves the intramolecular alkyl group transfer in **B** giving a similar diasterofacial selectivity. There are several examples known for the change of stereoselection depending upon the nature of nucleophiles in the conjugate addition reactions using organocuprates and related nucleophiles.[15]

Thus, 2,2-dimethyloxazolidines are formed to work as excellent chirality controlling auxiliaries in asymmetric conjugate addition reactions of organocuprates. Organocuprates presumably form the d,π^* type charge transfer complexes[16] *without the metal coordination to the carbonyl oxygen atom of the unsaturated amide acceptors*, being very different from alkyllithiums as hard nucleophilic organometallics. Selection of one of the diastereofaces may have been performed in this complex formation step where rotation around the amide linkage is still restricted to the *syn/s-cis* conformation. Even chlorotrimethylsilane does not coordinate to the amide oxygen.

Experimental Section

Preparation of *N*-Alkenoyloxazolidines 1a–f. Method A: *N*-Crotonoyl derivatives **1a,c,d,f** of 2,2-dimethyloxazolidines were prepared by *N*-crotonoylation of the corresponding β-aminoethanol derivatives followed by acetonization (method A). Preparation of (*R*)-3-crotonoyl-2,2-dimethyl-4-phenyloxazolidine (**1a**) is presented as a typical example: To a solution of (*R*)-2-phenylglycinol (10 g, 72.9 mmol) and Et_3N (12 mL, 87.5 mmol) in CH_2Cl_2 (150 mL) was added slowly at 0 °C crotonoyl chloride (7.62 g, 72.9 mmol). The mixture was stirred for 5 h, treated with saturated aqueous $NaHCO_3$, and then extracted with $CHCl_3$ (50 mL × 3). The combined extracts were dried over $MgSO_4$ and evaporated in vacuo. The residue was chromatographed on silica gel by using EtOAc as eluent to give (*R*)-*N*-crotonoyl-2-phenylglycinol (11.2 g, 75%). To a solution of this compound (10 g, 48.7 mmol) in toluene (250 mL) were added 2,2-dimethoxypropane (42 mL, 340 mmol) and a catalytic amount of BF_3·Et_2O. The mixture was allowed to stir at 75–80 °C for 3 h, treated with saturated aqueous $NaHCO_3$, and then extracted with CH_2Cl_2 (50 mL × 2). The combined extracts were dried over $MgSO_4$ and evaporated in vacuo. The residue was chromatographed on silica gel by using hexane–EtOAc (4:1 v/v) as eluent to give **1a** (8.02 g, 67%) which was purified by crystallization from hexane. **Method B**: *N*-Cinnamoyl derivatives **1b,e** of 2,2-dimethyloxazolidines were prepared by acetalization of the corresponding β-aminoethanol derivatives followed by *N*-cinnamoylation (method B). Preparation of (*R*)-3-cinnamoyl-2,2-dimethyl-4-phenyloxazolidine (**1b**) is presented as a typical example: A solution of (*R*)-2-phenylglycinol (8 g, 58.3 mmol) in acetone (200 mL) in the presence of a catalytic amount of *p*-toluenesulfonic acid was heated under reflux for 24 h. After cooling to room temperature, the mixture was treated with saturated aqueous $NaHCO_3$ and then extracted with CH_2Cl_2 (50 mL × 2). The combined extracts were dried over $MgSO_4$ and evaporated in vacuo. The residue (10.18 g) was dissolved in CH_2Cl_2 (100 mL), and Et_3N (9.6 mL, 69 mL) was added. A solution of cinnamoyl chloride (9.58 g, 57.5 mmol) in CH_2Cl_2 (100 mL) was slowly added at −30 °C and then stirring was continued at 0 °C for 20 h. The mixture was treated with saturated aqueous $NaHCO_3$ and extracted with CH_2Cl_2 (50 mL × 2). The combined extracts were dried over magnesium sulfate and evaporated in vacuo. The residue was chromatographed on silica gel by using hexane–ethyl acetate (7:1 v/v) as eluent to give **1b** (9.53 g, 54%) as a colorless liquid.

(*R*)-3-Crotonoyl-2,2-dimethyl-4-phenyloxazolidine (1a): colorless prisms (hexane); mp 47–48 °C; $[\alpha]^{24}_D = -106.3°$ (*c* 1.06, $CHCl_3$); IR (KBr), 2930, 2890, 1610, 1360, 1240, 1200, 1140, 1050, 950, 830, 760, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.68 (6H, overlapping, one of 2-Me and *Me*CH=), 1.88 (3H, s, the other of 2-Me), 3.92 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 1.5 Hz, one of H-5), 4.37 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 6.6 Hz, the other of H-5), 5.00 (1H, dd, J_{4-5} = 6.6 and 1.5 Hz, H-4), 5.79 (1H, d, J_{trans} = 14.7 Hz, COC*H*=), 6.84 (1H, dq, J_{trans} = 14.7 and J = 7.0 Hz, MeC*H*=), 7.27–7.36 (5H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 17.88 (*Me*CH=), 23.37, 25.43 (each 2-Me), 61.15 (C-5), 71.42 (C-4), 96.14 (C-2), 124.27, 125.93, 127.73, 128.89, 141.56, 141.74 (each Ph and *C*H=*C*HCO), 163.94 (CON); mass *m/z* (rel intensity, %) 245 (M^+, 7), 230 (54), 163 (11), 162 (base peak), 120 (16), 69 (34). Anal. Found: C, 73.46; H, 7.73; N, 5.66%. Calcd for $C_{15}H_{19}NO_2$: C, 73.44; H, 7.81; N, 5.71%.

(*R*)-3-Cinnamoyl-2,2-dimethyl-4-phenyloxazolidine (1b): colorless needles (hexane–CH_2Cl_2); mp 95–96 °C; $[\alpha]^{24}_D = -277.0°$ (*c*, 1.00, $CHCl_3$); IR (KBr) 2940, 2890, 1650, 1610, 1400, 1240, 1140, 1050, 980, 840, 770, 740, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.74, 1.93 (each 3H, s, 2-Me), 3.97 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 2.6 Hz, one of H-5), 4.43 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 6.6 Hz, the other of H-5), 5.10 (1H, dd, J_{4-5} = 6.6 and 2.6 Hz, H-4), 6.40 (1H, d, J_{trans} = 15.4 Hz, COC*H*=), 7.19–7.49 (10H, m, Ph), 7.58 (1H, d, J_{trans} = 15.4 Hz, PhC*H*=); ^{13}C NMR ($CDCl_3$) δ = 23.51, 25.33 (each 2-Me), 61.45 (C-5), 71.45 (C-4), 96.38 (C-2), 120.17, 125.97, 127.76, 127.99, 128.68, 129.11, 129.60, 135.01, 141.70, 142.00 (each Ph and *C*H=*C*HCO), 163.87 (CON); mass *m/z* (rel intensity, %) 307 (M^+, 7), 293 (11), 292 (48), 162 (54), 132 (10), 131 (base peak), 103 (29), 77 (13). Anal. Found: C, 78.43; H, 6.92; N, 4.78%. Calcd for $C_{20}H_{21}NO_2$: C, 78.15; H, 6.89; N, 4.56%.

(*S*)-4-Benzyl-3-crotonoyl-2,2-dimethyloxazolidine (1c): pale yellow liquid (silica gel column chromatography with hexane–EtOAc, 5:1 v/v); $[\alpha]^{24}_D = -176.6°$ (*c* 0.97, $CHCl_3$); IR (neat) 2950, 2850, 1640, 1600, 1490, 1430, 1390, 1360, 1290, 1230, 1200, 1150, 1130, 1080, 1060, 1040, 950, 900, 840, 820, 760, 720, 690 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.58, 1.75 (each 3H, s, 2-Me), 1.89 (3H, dd, J_{Me-CH} = 6.8 and $^{1,3}J$ = 1.3 Hz, *Me*CH=), 2.86 (1H, dd, J_{gem} = 13.6 and J_{CH_2-4} = 10.3 Hz, one of PhCH_2), 3.00 (1H, dd, J_{gem} = 13.6 and J_{CH_2-4} = 4.2 Hz, the other of PhCH_2), 3.87 (2H, br, H-5), 4.12 (1H, m, H-4), 6.10 (1H, dd, J_{trans} = 14.9 and $^{1,3}J$ = 1.3 Hz, COC*H*=), 6.95 (1H, dq, J_{trans} = 14.9 and J_{CH-Me} = 6.8 Hz, MeC*H*=), and 7.19–1.36 (5H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 18.08 (*Me*CH=), 23.08, 26.74 (each 2-Me), 40.77 (Ph*C*H_2), 58.83 (C-4), 66.35 (C-5), 95.46 (C-2), 123.45, 126.83, 128.76, 129.11, 137.42, 141.63 (each Ph and *C*H=*C*HCO), 163.87 (CON). Anal. Found: C, 74.01; H, 8.23; N, 5.41%. Calcd for $C_{16}H_{21}NO_2$: C, 74.10; H, 8.16; N, 5.40%.

(*S*)-4-Benzyl-3-crotonoyl-2,2,5,5-tetramethyloxazolidine (1d): colorless solid (silica gel column chromatography with hexane–EtOAc, 5:1 v/v); mp 95.5–96.5 °C; $[\alpha]^{24}_D = -168.6°$ (*c* 1.05, $CHCl_3$); IR (KBr) 2920, 1610, 1570, 1260, 1200, 1130, 990, 950, 750, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.31, 1.36 (each 3H, s, 5-Me), 1.59 (3H, br, *Me*CH=), 1.74, 1.77 (each 3H, s, 2-Me), 2.85 (1H, br dd, J_{gem} = 13.6 and J_{CH_2-4} = 8.4 Hz, one of PhCH_2), 3.00 (1H, br dd, J_{gem} = 13.6 and J_{CH_2-4} = 6.1 Hz, the other of PhCH_2), 4.00 (1H, br, H-4), 5.54 (1H, br d, COC*H*=), 6.54 (1H, br, MeC*H*=), 7.19–7.29 (5H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 17.90 (*Me*CH=), 24.25, 28.01 (each 2-Me), 29.01, 29.34 (5-Me), 38.66 (Ph*C*H_2), 66.42 (C-4), 80.31 (C-5), 94.47 (C-2), 123.8, 126.73, 128.68, 129.54, 137.79, 139.78 (each

(15) (a) Corey, E. J.; Boaz, N. W. *Tetrahedron Lett.* **1985**, *26*, 6015–6018. (b) Fleming, I.; Kindon, N. D. *J. Chem. Soc., Chem. Commun.* **1987**, 1177–1179. (c) Oppolzer, W.; Poli, G.; Kingma, A. J.; Starkemann, C.; Bernardinelli, G. *Helv. Chim. Acta* **1987**, *70*, 2201–2214.

(16) (a) Corey, E. J.; Hannon, F. J.; Boaz, N. W. *Tetrahedron* **1989**, *45*, 545–555. (b) Bertz, S. H.; Smith, R. A. J. *J. Am. Chem. Soc.* **1989**, *111*, 8276–8277.

Ph and *C*H=*C*HCO), and 163.94 (CON); mass *m/z* (rel intensity, %) 287 (M^+, 5), 204 (29), 197 (12), 196 (base peak), 138 (31), 128 (39), 91 (15), 69 (69). Anal. Found: C, 75.44; H, 8.79; N, 4.74%. Calcd for $C_{18}H_{25}NO_2$: C, 75.22; H, 8.77; N, 4.87%.

(*S*)-4-Benzyl-3-cinnamoyl-2,2,5,5-tetramethyloxazolidine (1e): colorless prisms (hexane); mp 109–110 °C; $[\alpha]^{24}_D$ = 50.4° (*c* 1.03, $CHCl_3$); IR (KBr) 2940, 1640, 1590, 1400, 1250, 1190, 1130, 980, 750, 680 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.36, 1.40 (each 3H, s, 5-Me), 1.80, 1.84 (each 3H, s, 2-Me), 2.89 (1H, br dd, J_{gem} = 13.6 and J_{CH_2-4} = 9.2 Hz, one of PhC*H*$_2$), 3.04 (1H, br dd, J_{gem} = 13.6 and J_{CH_2-4} = 5.3 Hz, the other of PhC*H*$_2$), 4.10 (1H, br, H-4), 6.05 (1H, br d, COC*H*=), 7.00 (1H, br, PhC*H*=), 7.14–7.35 (10H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 24.14, 28.00 (each 2-Me), 28.91, 29.26 (each 5-Me), 38.63 (Ph*C*H$_2$), 66.66 (C-4), 80.31 (C-5), 94.67 (C-2), 119.06, 126.88, 127.71, 128.37, 128.81, 129.18, 129.37, 135.07, 137.56, 140.34 (each Ph and *C*H=*C*HCO), 163.88 (CON); mass *m/z* (rel intensity, %) 349 (M^+, 3), 258 (45), 204 (10), 131 (base peak), 103 (22). Anal. Found: C, 79.33; H. 7.75; N, 3.85%. Calcd for $C_{23}H_{27}NO_2$: C, 79.05; H, 7.79; N, 4.01%.

***rac*-3-Crotonoyl-2,2-dimethyl-4(diphenylmethyl)oxazolidine (1f)**: colorless prisms (EtOAc); mp 174–176 °C; IR (KBr) 2950, 1640, 1600, 1520, 1450, 1400, 1230, 1200, 900, 750, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.48 (3H, d, J_{Me-CH} = 6.6 Hz, *Me*CH=), 1.58, 1.85 (each 3 H, s, 2-Me), 3.88 (1H, br d, J_{gem} = 9.2 Hz, one of H-5), 4.02 (1H, dd, J_{gem} = 9.2 and J_{5-4} = 5.1 Hz, the other of H-5), 4.24 (1H, d, J_{CH-4} = 10.3 Hz, Ph_2CH), 4.63 (1H, dd, J_{4-CH} = 10.3 and J_{4-5} = 5.1 Hz, H-4), 5.38 (1H, d, J_{trans} = 14.7 Hz, COC*H*=), 6.39 (1H, dq, J_{trans} = 14.7 and J_{CH-Me} = 6.6 Hz, MeC*H*=), 7.08–7.39 (10H, m, Ph) ^{13}C NMR ($CDCl_3$) δ = 17.22 (*Me*CH=), 22.76, 26.66 (each 2-Me), 53.89 (Ph_2CH), 60.31, (C-4), 66.73 (C-5), 95.46 (C-2), 122.40, 126.46, 127.90, 128.25, 128.39, 128.88, 138.65, 140.01, 140.38 (each Ph and *C*H=*C*HCO), 163.53 (CON); mass *m/z* (rel intensity, %) 335 (M^+, 1), 168 (base peak), 100 (18). Anal. Found: C, 78.51; H, 7.54; N, 3.86%. Calcd for $C_{16}H_{21}NO_2$: C, 78.77; H, 7.51, N, 4.18%.

General Procedure for the Conjugate Additions of Cuprates to the *N*-Alkenoyl Derivatives of Oxazolidine Chiral Auxiliaries. The reaction of (*R*)-3-crotonoyl-2,2-dimethyl-4-phenyloxazolidine (**1a**) with Ph_2CuLi is described as a typical example: Phenyllithium (1.05 M in cyclohexane–Et_2O solution, 0.92 mL, 0.96 mmol) was added, at −40 °C and under nitrogen, to the suspension of CuI (0.092 g, 0.48 mmol) in dry Et_2O (3 mL) and the mixture was stirred for 15 min to give black-colored suspension. To this suspension at −78 °C were added consecutively Me_3SiCl (0.06 mL, 0.48 mmol) and **1a** (0.097 g, 0.4 mmol). After stirring at room temperature for 17 h, the mixture was treated with saturated aqueous NH_4Cl and extracted with CH_2Cl_2 (15 mL × 3). The combined extracts were dried over anhydrous $MgSO_4$ and evaporated in vacuo. The residue was filtered through a short silica gel column with hexane–EtOAc (7:1 v/v) to give **2b** (0.148 g, 78%) which was found to be a 94:6 mixture of two diastereomers on the basis of ^1H and ^{13}C NMR spectra. All the reaction conditions and results are listed in Table 2.

(*R*)-2,2-Dimethyl-3-(3-methylbutanoyl)-4-phenyloxazolidine (2a): colorless liquid (silica gel column chromatography with hexane–EtOAc, 5:1 v/v); IR (neat) 2920, 1640, 1400, 1230, 1060, 835, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 0.71, 0.86 (each 3H, d, J_{Me-CH} = 6.6 Hz, Me_2CH), 1.65, 1.87 (each 3H, s, 2-Me), 1.80 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 6.6 Hz, one of C*H*$_2$CO), 2.01 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 6.6 Hz, the other of C*H*$_2$CO), 2.07 (1H, m, Me_2CH), 3.90 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 2.2 Hz, one of H-5), 4.36 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 6.2 Hz, the other of H-5), 4.90 (1H, dd, J_{4-5} = 6.2 and 2.2 Hz, H-4), 7.27–7.40 (10H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 22.29, 22.49 (Me_2CH), 23.33, 25.36, 25.54 (2-Me and CH_2CO), 44.76 (Me_2CH), 61.54 (C-5), 71.29 (C-4), 96.51 (C-2), 126.04, 127.80, 128.91, 141.71 (each Ph), 170.65 (CON). Anal. Found: C, 73.07; H, 8.66; N, 5.38%. Calcd for $C_{16}H_{23}NO_2$: C, 73.53; H, 8.87; N, 5.36%.

(*R*)-2,2-Dimethyl-4-phenyl-3-[(*S*)-3-phenylbutanoyl]oxazolidine (2b): colorless plates (hexane); mp 73–74 °C; $[\alpha]^{24}_D$ = −125.3° (*c* 0.98, $CHCl_3$); IR (KBr) 2940, 1630, 1410, 1240, 1065, 845, 740, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.11 (3H, d, J_{Me-CH} = 7.0 Hz, *Me*CH), 1.49, 1.83 (each 3H, s, 2-Me), 2.17 (1H, dd, J_{gem} = 14.3 and J_{CH_2-CH} = 7.0 Hz, one of C*H*$_2$CO), 2.32 (1H, dd, J_{gem} = 14.3 and J_{CH_2-CH} = 8.1 Hz, the other of C*H*$_2$CO), 3.31 (1H, ddq, J_{CH-CH_2} = 8.1, J_{CH-CH_2} = J_{CH-Me} = 7.0 Hz, MeC*H*), 3.74 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 2.2 Hz, one of H-5), 4.01 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 6.6 Hz, the other of H-5), 4.36 (1H, dd, J_{4-5} = 6.6 and 2.2 Hz, H-4), 7.12–7.40 (10H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 21.05 (*Me*CH), 22.95, 25.48 (each 2-Me), 37.03 (CH_2CO), 45.09 (MeCH), 61.18 (C-5), 71.01 (C-4), 96.08 (C-2), 126.60, 126.49, 126.95, 127.83, 128.44, 128.93, 141.75, 145.98 (each Ph), 170.06 (CON). Anal. Found: C, 77.81; H, 7.88; N, 4.18%. Calcd for $C_{21}H_{25}NO_2$: C, 77.99; H, 7.79; N, 4.33%.

(*R*)-2,2-Dimethyl-3[(*R*)-3-methylpentanoyl]-4-phenyloxazolidine (2c): pale yellow liquid (silica gel column chromatography with hexane–EtOAc, 7:1 v/v); $[\alpha]^{24}_D$ = −98.9° (*c* 1.12, $CHCl_3$); IR (neat) 2950, 1645, 1400, 1240, 1070, 845, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 0.67 (3H, d, J_{Me-CH} = 6.6 Hz, *Me*CH), 0.81 (3H, t, J_{Me-CH_2} = 7.3 Hz, $MeCH_2$), 1.08, 1.26 (each 1H, m, MeC*H*$_2$), 1.65, 1.87 (each 3H, s, 2-Me), 1.74 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 8.1 Hz, one of C*H*$_2$CO), 2.12, (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 5.1 Hz, the other of C*H*$_2$CO), 3.90 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 2.2 Hz, one of H-5), 4.36 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 6.6 Hz, the other of H-5), 4.90 (1H, dd, J_{4-5} = 6.6 and 2.2 Hz, H-4), 7.27–7.40 (5H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 11.37 (*Me*CH$_2$), 18.99 (*Me*CH), 23.19, 25.50 (2-Me), 29.39 (MeCH$_2$), 31.44 (CH_2CO), 42.79 (MeCH), 61.39 (C-5), 71.20 (C-4), 96.06 (C-2), 125.98, 127.74, 128.82, 141.71 (each Ph), 170.72 (NCO). Found: C, 74.11; H, 9.39; N, 5.11%. Calcd for $C_{17}H_{25}NO_2$: C, 74.14; H, 9.15; N, 5.09%.

(*R*)-2,2-Dimethyl-3[(*S*)-3,4-dimethylpentanoyl]-4-phenyloxazolidine (2d): pale yellow liquid (silica gel column chromatography with hexane–EtOAc, 7:1 v/v); IR (neat) 2940, 1650, 1410, 1255, 1205, 1070, 845, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 0.57 (3H, d, J_{Me-CH} = 6.6 Hz, *Me*CH), 0.71, 0.74 (each 3H, d, J_{Me-CH} = 7.0 Hz, Me_2CH), 1.45 (1H, m, Me_2CH), 1.64, 1.88 (each 3H, s, 2-Me), 1.74 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 9.2 Hz, one of C*H*$_2$CO), 1.89 (1H, m, MeC*H*), 2.13 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 4.4 Hz, the other of C*H*$_2$CO), 3.90 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 2.2 Hz, one of H-5), 4.36 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 6.4 Hz, the other of H-5), 4.88 (1H, dd, J_{4-5} = 6.4 and 2.2 Hz, H-4), and 7.27–7.40 (5H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 15.40, 18.41 (each Me_2CH), 19.72 (*Me*CH), 23.14, 25.51 (each 2-Me), 32.09 (CH_2CO), 35.20 (Me_2CH), 40.16 (MeCH), 61.41 (C-5), 71.15 (C-4), 96.05 (C-2), 126.04, 127.77, 128.82, 141.81 (each Ph), 170.95 (CON). Anal. Found: C, 74.74; H, 9.40; N, 4.70%. Calcd for $C_{18}H_{27}NO_2$: C, 74.70; H, 9.40; N, 4.84%.

(*R*)-2,2-Dimethyl-3-phenyl-3-[(*R*)-3-phenylbutanoyl]oxazolidine (2e): colorless prisms (hexane); mp 87–89 °C; $[\alpha]^{24}_D$ = −82.6° (*c* 1.08, $CHCl_3$, diastereomer ratio = >99:1 by ^{13}C NMR); IR (KBr) 2940, 1650, 1400, 1235, 1065, 840, 760, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.23 (3H, d, J_{Me-CH} = 7.0 Hz, *Me*CH), 1.64, 1.79 (each 3H, s, 2-Me), 2.25 (1H, dd, J_{gem} = 15.0 and J_{CH_2-CH} = 6.2 Hz, one of C*H*$_2$CO), 2.37 (1H, dd, J_{gem} = 15.0 and J_{CH_2-CH} = 7.7 Hz, the other of C*H*$_2$CO), 3.28 (1H, m, MeC*H*), 3.86 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 2.2 Hz, one of H-5), 4.31 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 6.4 Hz, the other of H-5), 4.83 (1H, dd, J_{4-5} = 6.4 and 2.2 Hz, H-4), 6.94–7.40 (10H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 21.42 (*Me*CH), 23.19, 25.37 (each 2-Me), 35.97 (CH_2CO), 43.93 (MeCH), 61.43 (C-5), 71.24 (C-4), 96.13 (C-2), 125.88, 125.97, 126.78, 127.71, 128.22, 128.91, 141.33, 145.95 (each Ph), 169.55 (CON). Anal. Found: C, 78.37; H, 7.90; N, 4.33%. Calcd for $C_{21}H_{25}NO_2$: C, 77.99; H, 7.79; N, 4.33%.

(*S*)-4-Benzyl-2,2-dimethyl-3-[(*R*)-3-phenylbutanoyl]oxazolidine (2f): pale yellow liquid (silica gel column chromatography with hexane-EtOAc, 7:1 v/v); IR (neat) 2950, 1640, 1410, 1240, 1090, 850, 770, 700 cm^{-1}; ^1H NMR ($CDCl_3$) δ = 1.27 (3H, d, J_{Me-CH} = 6.6 Hz, *Me*CH), 1.28, 1.61 (each 3H, s, 2-Me), 2.28 (1H, dd, J_{gem} = 13.9 and J_{CH_2-CH} = 6.2 Hz, one of C*H*$_2$CO), 2.45 (1H, dd, J_{gem} = 13.9 and J_{CH_2-CH} = 8.4 Hz, the other of C*H*$_2$CO), 2.69 (1H, dd, J_{gem} = 13.6 and J_{CH_2-4} = 9.9 Hz, one of PhC*H*$_2$), 2.82 (1H, dd, J_{gem} = 13.6 and J_{CH_2-4} = 4.4

Hz, the other of PhCH_2), 3.28 (2H, m, MeCH and one of H-5), 3.45 (1H, ddd, J_{4-CH_2} = 9.9, 4.4, and J_{4-5} = 8.8 Hz, H-4), 3.53 (1H, d, J_{5-4} = 8.8 Hz, the other of H-5), 7.03–7.35 (10H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 22.04 (*Me*CH), 23.46, 27.53 (each 2-Me), 38.01 (PhCH_2), 41.15 (CH_2CO), 45.50 (MeCH), 59.83 (C-4), 66.82 (C-5), 96.07 (C-2), 127.17, 127.57, 129.08, 129.51, 129.76, 130.08, 138.12, 146.29 (each Ph), 169.38 (CON). Anal. Found: C, 78.51; H, 7.92; N, 4.13%. Calcd for $C_{22}H_{27}NO_2$: C, 78.30; H, 8.06; N, 4.15%.

(*S*)-4-Benzyl-2,2,5,5-tetramethyl-3[(*R*)-3-phenylbutanoyl]-oxazolidine (2g): colorless solid (silica gel column chromatography with hexane–EtOAc, 7:1 v/v); mp 83–85 °C; IR (KBr) 2940, 1620, 1400, 1180, 1135, 990, 750, 700 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ = 0.83, 1.19 (each 3H, 5-Me), 1.05 (3H, d, J_{Me-CH} = 7.0 Hz, MeCH), 1.34 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 6.2 Hz, one of CH_2CO), 1.49, 1.71 (each 3H, s, 2-Me), 2.04 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 8.8 Hz, the other of CH_2CO), 2.78 (1H, dd, J_{gem} = 13.9 and J_{CH_2-4} = 9.2 Hz, one of PhCH_2), 2.94 (1H, dd, J_{gem} = 13.9 and J_{CH_2-4} = 5.5 Hz, the other of PhCH_2), 3.15 (1H, ddq, J_{CH-CH_2} = 8.8, 6.6, and J_{CH-Me} = 7.0 Hz, MeCH), 3.65 (1H, J_{4-CH_2} = 9.2 and 5.5 Hz, H-4), 7.09–7.38 (10H, m, Ph); ^{13}C NMR ($CDCl_3$) δ = 21.73 (*Me*CH), 24.12, 27.86, 28.38, 28.87 (2-Me and 5-Me), 36.87 (CH_2CO), 38.59 (PhCH_2), 43.63 (MeCH), 66.58 (C-4), 80.02 (C-5), 94.31 (C-2), 126.29, 126.79, 126.88, 128.39, 128.92, 129.57, 138.01, 146.20 (each Ph), 169.68 (CON). Anal. Found: C, 78.96; H, 8.45; N, 3.60%. Calcd for $C_{24}H_{31}NO_2$: C, 78.87; H, 8.55; N, 3.83%.

(*S*)-4-Benzyl-2,2,5,5-tetramethyl-3-[(*S*)-3-phenylbutanoyl]oxazolidine (2h): colorless prisms (silica gel column chromatography with hexane–EtOAc, 7:1 v/v); mp 117–120 °C; $[\alpha]^{24}_D$ = −114.2° (*c* 1.01, $CHCl_3$, diastereomer ratio = 92:8 by ^{13}C NMR); IR (KBr) 2960, 1620, 1410, 1240, 1195, 1140, 990, 755, 700 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ = 1.21 (3H, d, J_{Me-CH} = 7.0 Hz, *Me*CH), 1.26, 1.35 (each 3H, s, 5-Me), 1.49 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 4.8 Hz, one of CH_2CO), 1.73 (6H, s, 2-Me), 2.10 (1H, dd, J_{gem} = 14.7 and J_{CH_2-CH} = 9.2 Hz, the other of CH_2CO), 2.70 (1H, dd, J_{gem} = 13.9 and J_{CH_2-4} = 8.1 Hz, one of PhCH_2), 2.95 (1H, dd, J_{gem} = 13.9 and J_{CH_2-4} = 6.2 Hz, the other of PhCH_2), 3.22 (1H, m, MeCH), 3.96 (1H, J_{4-CH_2} = 8.1 and 6.2 Hz, H-4), 7.02–7.30 (10H, m, Ph). ^{13}C NMR ($CDCl_3$) δ = 21.12 (*Me*CH), 24.19, 27.99, 28.77, 29.07 (2-Me and 5-Me), 36.22 (CH_2CO), 38.51 (PhCH_2), 42.83 (MeCH), 66.88 (C-4), 80.24 (C-5), 94.47 (C-2), 125.98, 126.66, 126.73, 128.17, 128.74, 129.27, 137.82, 146.16 (each Ph), 169.67 (CON). Anal. Found: C, 79,03; H, 8.56; N, 3.90%. Calcd for $C_{24}H_{31}NO_2$: C, 78.87; H, 8.55; N, 3.83%.

***u*-2,2-Dimethyl-3-[3-phenylbutanoyl]-4-(diphenylmethyl)oxazolidine (2i)**: colorless prisms (silica gel column chromatography with hexane–EtOAc, 7:1 v/v); mp 92–94 °C; IR (KBr) 2940, 1625, 1390, 1240, 1175, 830, 750, 690 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ = 0.89 (3H, d, J_{Me-CH} = 6.6 Hz, *Me*CH), 1.00 (1H, dd, J_{gem} = 14.3 and J_{CH_2-CH} = 5.5 Hz, one of CH_2CO), 1.18, 1.67 (each 3H, s, 2-Me), 1.71 (1H, dd, J_{gem} = 14.3 and J_{CH_2-CH} = 9.5 Hz, the other of CH_2CO), 2.91 (1H, m, MeCH), 3.21 (1H, dd, J_{gem} = 8.8 and J_{5-4} = 4.8 Hz, one of H-5), 3.41 (1H, d, J_{gem} = 8.8 Hz, the other of H-5), 3.88 (1H, dd, J_{4-CH} = 11.0 and J_{4-5} = 4.8 Hz, H-4), 4.00 (1H, d, J_{CH-4} = 11.0 Hz, Ph_2CH), 6.99–7.25 (15H, m, Ph). ^{13}C NMR ($CDCl_3$) δ = 21.73 (*Me*CH), 23.14, 27.21 (each 2-Me), 37.41 (CH_2CO), 43.70 (MeCH), 54.12 (Ph_2CH), 61.47 (C-4), 67.20 (C-5), 95.94 (C-2), 126.48, 126.98, 127.40, 128.04, 128.36, 128.68, 128.82, 129.31, 129.59, 140.95, 140.99, 146.10 (each Ph), 170.58 (CON). Anal. Found: C, 81.02; H, 7.41; N, 3.36%. Calcd for $C_{28}H_{31}NO_2$: C, 81.32; H, 7.56; N, 3.39%.

Removal of the Chiral Auxiliary from the Adducts 2. Either of the following methods was employed. (1) A mixture of adduct **2b** (0.339 g, 1.05 mmol) and 6 N H_2SO_4 (8 mL) in AcOH (4 mL) was heated under reflux for 3 h and cooled to room temperature. To the mixture was added Et_2O (20 mL) and this ethereal solution was washed with water three times. The organic layer was dried over $MgSO_4$ and then evaporated in vacuo. The residue was filtered through a short silica gel column by using hexane–EtOAc (2:1 v/v) as eluent to give optically active (*S*)-3-phenylpropanoic acid (**3**, 0.155 g, 89%). (2) A mixture of **2b** (0.323 g, 1 mmol) and 5 N aqueous HCl (4 mL) was refluxed for 12 h. A similar workup mentioned above gave **3** (0.131 g, 80%).

(*S*)-3-Phenylbutanoic Acid (3): pale yellow liquid (silica gel column chromatography with hexane–EtOAc, 2:1 v/v); $[\alpha]^{24}_D$ = 50.0° (*c* 1.12, C_6H_6, 87% ee); IR (neat) 3000 (br), 1710 (br), 1450, 1410, 1280, 1210, 1180, 1085, 920, 760, 695 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ = 1.31 (3H, d, J_{Me-3} = 7.0 Hz, Me), 2.55 (1H, dd, J_{gem} = 15.6 and J_{2-3} = 8.3 Hz, one of H-2), 2.66 (1H, dd, J_{gem} = 15.6 and J_{2-3} = 6.8 Hz, the other of H-2), 3.26 (1H, m, H-3), 7.16–7.36 (5H, m, Ph), 11.05 (1H, br, COOH); ^{13}C NMR ($CDCl_3$) δ = 21.78 (Me), 36.07 (C-2), 42.57 (C-3), 126.46, 126.65, 128.52, 145.38 (each Ph), 178.93 (COOH).

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