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Optical Resolution of (±)-1,2-Bis(2-methylphenyl)ethylene-1,2-diamine as a Chiral Framework for 2-Iminoimidazolidine with 2-Methylphenyl Pendant and the Guanidine-Catalyzed Asymmetric Michael Reaction of *tert*-Butyl Diphenyliminoacetate and Ethyl Acrylate

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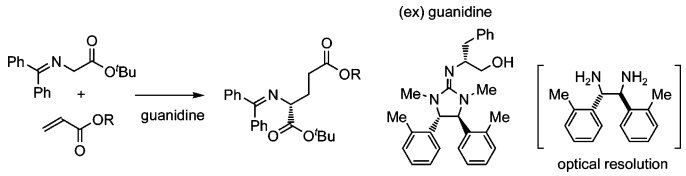

(±)-1,2-Bis(2-methylphenyl)ethylene-1,2-diamine, prepared from benzil and ammonium acetate, was optically resolved as a chiral framework for 2-(1-benzyl-2-hydroxyethyl)imino-1,3-dimethylimidazolidine with 2-methylphenyl pendants at the 4,5-positions. Catalysis ability of the 1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine and the related 1,3-dibenzyl-4,5-diphenylimidazolidine was examined in the asymmetric Michael reaction of *t*-butyl diphenyliminoacetate and ethyl acrylate.

Introduction

Guanidines are classified into powerful organic bases and act as base catalysts in variety of organic synthesis.[1] One of the typical guanidines is tetramethylguanidine, and pentaalkylguanidines such as *tert*-butyltetramethylguanidine are known to be Barton's bases.[2] Introduction of chiral centers as the guanidinyl moiety can create new types of chiral organocatalysts. Thus, we have prepared several types of guanidine compounds with chiral center(s)[3] and examined their catalysis ability in asymmetric synthesis.[3a,4] As a part of this study, we had preliminarily reported that 2-(1-benzyl-2-hydroxyethyl)imino-1,3-dimethyl-4,5-diphenylimidazolidine acted as an efficient catalyst in the asymmetric Michael reaction of *tert*-butyl diphenyliminoacetate and active vinyl compounds such as methyl vinyl ketone and acrylate.[4b] For further tuning of this guanidine catalyst, structural modifications of either the phenyl pendant on the imidazolidine ring or methyl substituent on the imidazolidine nitrogen atom were carried out. In this paper, we present the optical resolution of (±)-1,2-bis(2-methylphenyl)-

[†] Chiba University.
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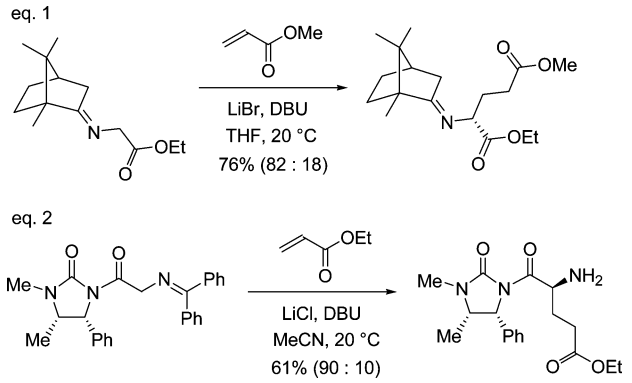
SCHEME 1. Reported Diastereoselective Michael Reactions of Chiral Iminoacetates and Acrylates



ethylene-1,2-diamine as a chiral framework for 2-(1-benzyl-2-hydroxyethyl)imino-1,3-dimethylimidazolidine with 2-methylphenyl pendants at the 4,5-positions and catalysis ability of the 1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine and the related 1,3-dibenzyl-4,5-diphenylimidazolidine in the asymmetric Michael reaction of *tert*-butyl diphenyliminoacetate and ethyl acrylate.

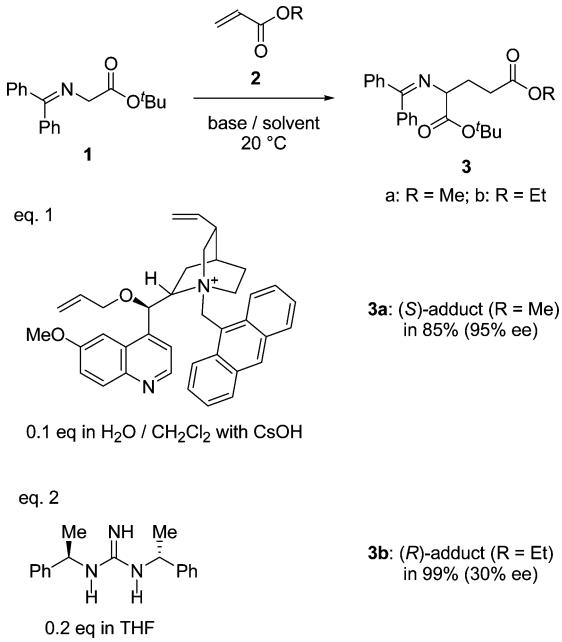
Results and Discussion

Four examples on asymmetric Michael reactions of iminoacetate and acrylate had appeared in the literature before our preliminary study.[4b] Thus, for diastereoselective versions (Scheme 1), Kanemasa et al.[5] observed moderate diastereoselectivity in the reaction of a camphor-derived iminoacetate and methyl acrylate (eq 1, Scheme 1), and Najera et al.[6] improved the selectivity from 64% to 80% by using chiral diphenyliminoacetamide (eq 2, Scheme 1).

For catalytic versions (Scheme 2), Corey et al.[7] had reported an effective enantioselectivity in the reaction of *tert*-butyl diphenyliminoacetate (**1**) and methyl acrylate (**2a**) using a quinine-derived quaternary ammonium salt as phase-transfer catalyst (eq 1, Scheme 2), in which an adduct **3a** was produced in 85% yield with 95% ee, and Ma et al.[8] had observed moderate asymmetric induction in a similar Michael reaction catalyzed with a C_2-symmetrical guanidine (eq 2, Scheme 2).[9]

We had attempted the Michael reaction of cyclopentenone and dibenzyl malonate and the nucleophilic epoxidation of chalcone using several types of chiral guanidines prepared by us and observed that (4*S*,5*S*)-2-[(*R*)-1-benzyl-2-hydroxyethyl]-

SCHEME 2. Reported Enantioselective Michael Reactions of *tert*-Butyl Diphenyliminoacetate (1) and Acrylates 2



imino-1,3-dimethyl-4,5-diphenylimidazolidine (**4**) (or its enantiomer *ent*-**4**), a guanidine carrying a hydroxyethyl function on the 2-imino nitrogen atom, acts as an effective catalyst in the former Michael reaction.[4f] Furthermore, the guanidine **4** was also found to effectively catalyze the asymmetric Michael reaction of *tert*-butyl diphenyliminoacetate (**1**) and active vinyl compounds such as methyl vinyl ketone (MVK) and acrylates **2**, in which satisfactory addition with MVK was observed when the reaction was carried out in tetrahydrofuran (THF) solution, whereas an adduct with **2** was effectively obtained in the absence of solvent, as preliminarily reported.[4b] We intended to optimize the guanidine-catalyzed Michael reaction of **1** and **2**, especially in solution, by structural modification based on the 1,3-dimethyl-4,5-diphenylimidazolidine **4**, focusing on the diphenyl pendants of the imidazolidine ring and the methyl substituent on the imidazolidine nitrogen. Thus, the target guanidines were (4*S*,5*S*)-2-[(*R*)-1-benzyl-2-hydroxyethyl]imino-1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine (**5**) and (4*S*,5*S*)-2-[(*R*)-1-benzyl-2-hydroxyethyl]imino-1,3-dibenzyl-4,5-diphenylimidazolidine (**6**) as shown in Figure 1.

At first, we focused on the preparation of the guanidine **5** carrying 2-methylphenyl pendant, for which (*S*,*S*)-1,2-bis(2-methylphenyl)ethylene-1,2-diamine (**7**) was needed as a chiral source. Voegtle and Goldschmitt[10] had reported the synthesis of *meso*-1,2-bis(2-methylphenyl)ethylene-1,2-diamine by aza-Cope rearrangement of the imine derived from 2-methylbenzaldehyde and *meso*-1,2-bis(2-hydroxyphenyl)ethylene-1,2-diamine. The *meso*-diamine had also been prepared by hydrolysis of 2,4,5-tris(2-methylphenyl)imidazoline prepared from 2-methylbenzaldehyde and ammonium acetate.[11] Racemic diamine had been prepared by oxidative coupling of *N*-trimethylsilylimine in the presence of niobium tetrachloride and tetrahydrofuran complex followed by alkaline hydrolysis.[12] On the

(5) Kanemasa, S.; Tatsukawa, A.; Wada, E. *J. Org. Chem.* **1991**, *56*, 2875−2883.
(6) Guillena, C.; Najera, C. *Tetrahedron: Asymmetry* **1998**, *9*, 3935−3938.
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(8) Ma, D.; Cheng, K. *Tetrahedron: Asymmetry* **1999**, *10*, 713−719.
(9) After our preliminary report,[4b] four groups presented the enantioselective Michael reaction of **1** and **2** using phase-transfer catalysts [O'Donnell, M. J.; Delgado, F.; Dominguez, E.; de Blas, J.; Scott, W. L. *Tetrahedron: Asymmetry* **2001**, *12*, 821−828. Arai, S.; Tsuji, R.; Nishida, A. *Tetrahedron Lett.* **2002**, *43*, 9535−9537. Shibuguchi, T.; Fukuta, Y.; Akachi, Y.; Sekine, A.; Ohshima, T.; Shibasaki, M. *Tetrahedron Lett.* **2002**, *43*, 9539−9543 (Ohshima, T.; Shibuguchi, T.; Fukuta, Y.; Shibasaki, M. *Tetrahedron* **2004**, *60*, 7743−7754). Akiyama, T.; Hara, M.; Fuchibe, K.; Sakamoto, S.; Yamaguchi, K. *Chem. Commun.* **2003**, 1734−1735]. Quite recently, it was shown that a combination of alkaline earth metal alkoxide and chiral ligand is effective for the Michael reaction and that applicable to [3 + 2] cycloaddition through intramolecular cyclization yielding proline derivatives (Saito, S.; Tsubogo, T.; Kobayashi, S. *J. Am. Chem. Soc.* **2007**, *129*, 5364−5365).
(10) Voegtle, F.; Goldschmitt, E. *Chem. Ber.* **1976**, *109*, 1−40.
(11) Shum, P.; Gross, A.; Ma, L.; McGarry, D. G.; Merriman, G. H.; Rampe, D.; Ringheim, G.; Sabol, J. S.; Volz, F. A. WO 014555 A1, 2005.
(12) Pedersens, F.; Roskamp, E. J. *J. Am. Chem. Soc.* **1987**, *109*, 3152−3154.

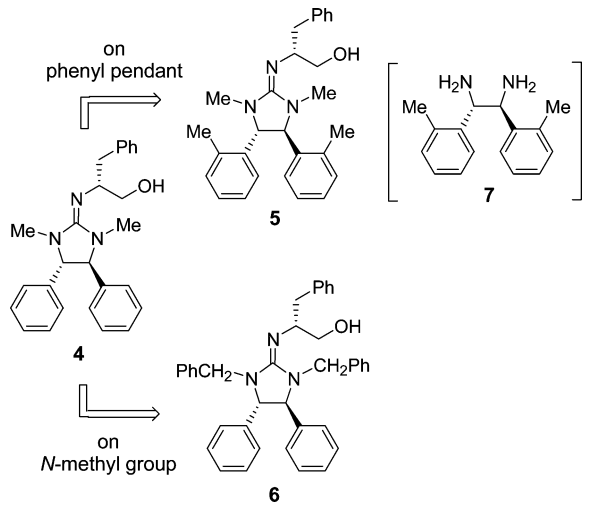


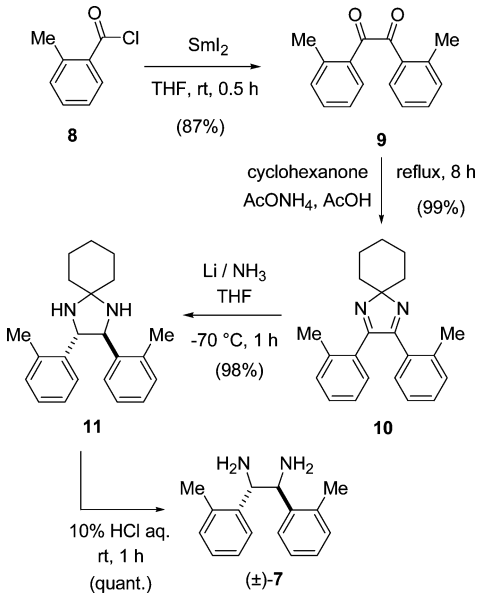
FIGURE 1. Structural modifications of (4*S*,5*S*)-2-[(*R*)-1-benzyl-2-hydroxyethyl]imino-1,3-dimethyl-4,5-diphenylimidazolidine (**4**) to the corresponding 1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine **5** and the related 1,3-dibenzyl-4,5-diphenylimidazolidine **6**.

other hand, optically active diamine had been prepared by two methods: (1) coupling of (2-methylphenyl)lithium and bis(*tert*-butylsulfinylimine), derived from chiral *tert*-butylsulfinamide,[13] and (2) application of the Voegtle's protocol using chiral bis-(2-hydroxyphenyl)ethylenediamine as a starting diamine.[14]

Corey et al.[15] had reported traditional optical resolution of (±)-1,2-diphenylethylene-1,2-diamine, in which benzil and ammonium acetate were used as carbon and nitrogen sources, respectively. We decided to apply Corey's method in the synthesis of the optically active diamine **7** because not only were both enantiomers concomitantly available but also large-scale preparation was applicable. The benzil **9** was prepared by applying the samarium iodide (SmI_2)-induced reductive coupling[16] of 2-methylbenzoyl chloride (**8**), in which **9** was given in 93% yield[17] by decomposition of excess of SmI_2 with bubbling dry air into the reaction mixture, as reported by Curran's group.[21]

Condensation of **9** with cyclohexanone and ammonium chloride followed by reduction under Birch conditions afforded an acetal **11**, acid hydrolysis of which yielded racemic diamine (±)-**7** in total 84% yield from **8** through four steps (Scheme 3). The ^{1}H NMR spectrum showed that the diamine was, as expected, formed as the (±)-derivative, not the *meso* one, by

SCHEME 3. Preparation of the (±)-1,2-Bis(2-methylphenyl)ethylene-1,2-diamine [(±)-7]



comparison with reported data. Both enantiomers were separable to two peaks by chiral HPLC.

(±)-1,2-Diphenylethylene-1,2-diamine itself had been successfully resolved by salt formation with a chiral tartaric acid;[15] however, application of Corey's protocol to the optical resolution of (±)-**7** led to unsatisfactory results (~14% yield with ~16% ee). Further trials using other chiral acids such as mandelic and malic acids were unsuccessful. Fortunately, it was found that dibenzoyltartaric acid (DBTA) was a suitable acid-counter part in the diastereomeric salt formation of (±)-**7** and that careful fractional recrystallization of the salt afforded an enantiomerically acceptable (+)- and (−)-**7**, as shown in Chart 1.

The operation was recommended using a <3 g scale of (±)-**7**. (*S*,*S*)-DBTA was added to a solution of (±)-**7** in a limited amount of ethyl acetate. The whole was mixed well at room temperature (rt) and evaporated under reduced pressure. The residual mixture was dissolved in ethyl acetate, stirred at 90−100 °C until completely dissolved, kept at 0 °C for 1 day, and then divided into two fractions of precipitate (ppt-1) and mother liquor (fil-1) by filtration, in which (+)- and (−)-riched diamines were mainly contained, respectively. The same operation was repeated on ppt-1 to afford ppt-2 in ca. 30% yield, the optical purity of which was estimated to be ca. 95% ee. Desalting of the salt with 10% NaOH aq afforded an oily (+)-**7** with $[\alpha]^{20}_D$ +18.8 (c = 1.1, $CHCl_3$). On the other hand, partially resolved diamine salts obtained from mother liquors (fil-1 and -2), after the alkali desalting, were similarly treated with (*R*,*R*)-DBTA to finally give an enantiomeric (−)-**7**. Optical purity of the salts formed during the above operation was estimated by ^{1}H NMR measurement of a salt (in DMSO-d_6) and/or by chiral HPLC measurement after desalting, in which comparable evaluations were given. In the former analysis, diastereoisomeric signal due to an aryl methyl group was observed at higher field (δ 1.75−1.82) in the complex of (+)-diamine and (*R*,*R*)-DBTA (or the enantiomeric complex), whereas at lower field (δ 1.83−1.88) in the complex of (−)-diamine and (*R*,*R*)-DBTA (or the enantiomeric complex), respectively.

The absolute configuration of the bis(2-methylphenyl)-ethylenediamine obtained by aza-Cope rearrangement[14] had been

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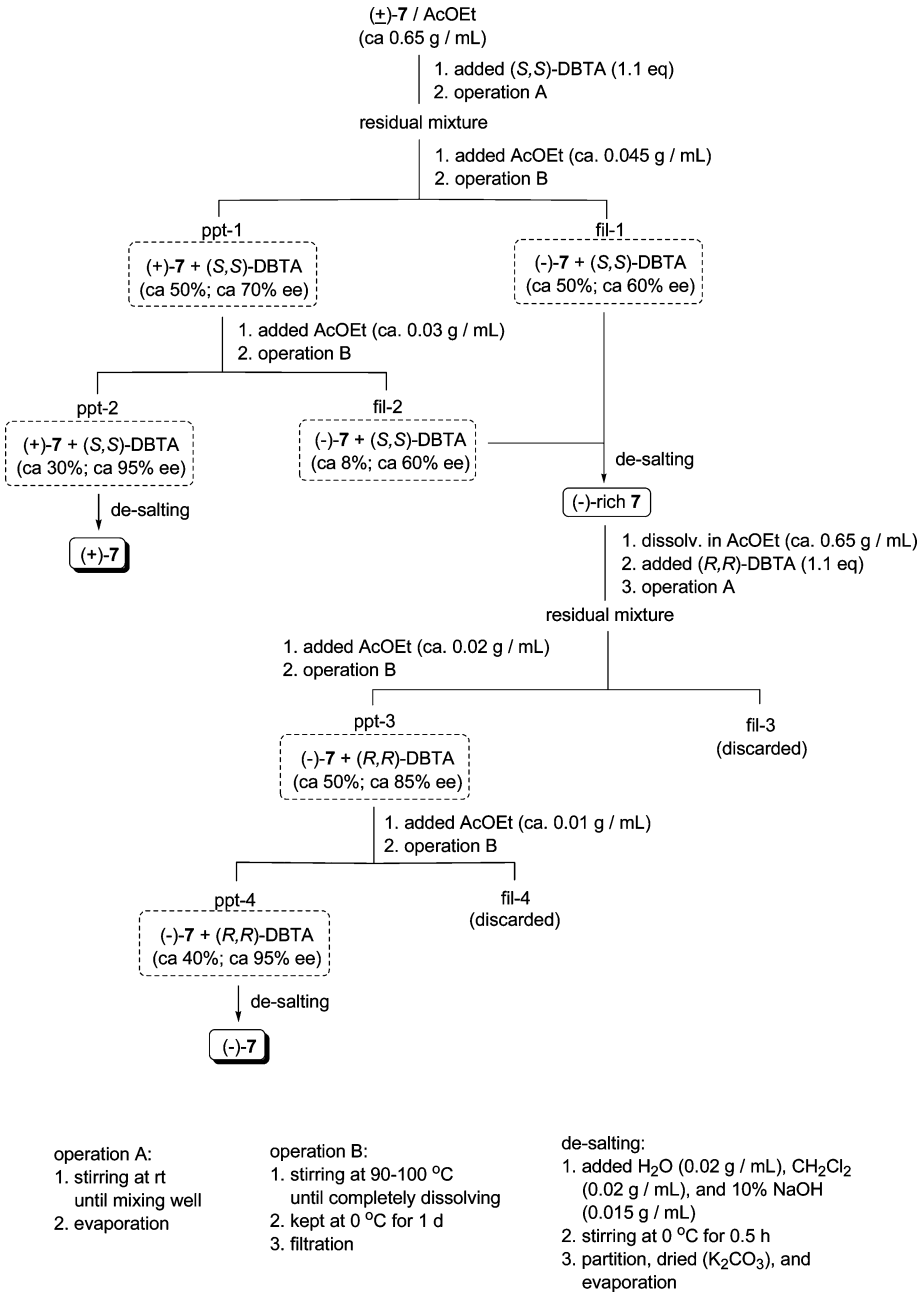
(15) Pikul, S.; Corey, E. J. *Org. Synth.* **1992**, *71*, 22−29.
(16) Girard, P.; Namy, J. L.; Kagan, H. B. *J. Am. Chem. Soc.* **1980**, *102*, 2693−2698.
(17) The following three methods afforded **9** only in low yields (10−20%): (1) oxidation of benzoin,[18] prepared by the 1-methylimidazolium iodide-catalyzed condensation of 2-methylbenzaldehyde, (2) coupling reaction of oxalyl chloride with the corresponding copper reagent prepared from 2-methylphenylmagnesium bromide,[19] and (3) indium-induced reductive coupling of 2-methylbenzonitrile under sonication.[20]
(18) Miyashita, A.; Suzuki, Y.; Iwamoto, K.; Higashino, T. *Chem. Pharm. Bull.* **1994**, *42*, 2633−2635.
(19) Babudri, F.; Fiandanese, V.; Marchese, G.; Punzi, A. *Tetrahedron Lett.* **1995**, *36*, 7305−7308.
(20) Baek, H. S.; Lee, S. J.; Yoo, B. W.; Ko, J. J.; Kim, S. H.; Kim, J. H. *Tetrahedron Lett.* **2000**, *41*, 8097−8099.
(21) Hasegawa, E.; Curran, D. P. *J. Org. Chem.* **1993**, *58*, 5008−5010.

CHART 1. Optical Resolution of (±)-7 by Careful Fractional Recrystallizations of the Salt with DBTA



deduced to be opposite to that of the starting bis(2-hydroxyphenyl)ethylenediamine based on opposite signs in their circular dichroism (CD) spectra. However, $[\alpha]_D$ value of the produced diamine had never been given. The (*R*,*R*)-diamine had been obtained from (*R*)-*tert*-butylsulfinylimine;[13] however, no correlation between absolute configuration and optical rotation had been given, either. Thus, the absolute configuration of the optically resolved 1,2-bis(2-methylphenyl)ethylene-1,2-diamine itself has to be determined independently. We successfully prepared a single crystal of the complex salt of the (−)-diamine and D-(+)-camphorsulfonic acid.[22] The X-ray crystallographic analysis[23] shows that (−)-**7** has an (*S*,*S*)-configuration (Figure 2).

(−)-(*S*,*S*)-Diamine [(−)-**7**] was converted into (4*S*,5*S*)-2-[(*R*)-1-benzyl-2-hydroxyethyl]imino-1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine (**5**) by successive reactions of carbonylation, methylation, chlorination, and amination with (*R*)-phenylalaninol (Scheme 4). An enantiomer *ent*-**5** could be also prepared from (+)-**7** under the same reaction scheme (not shown).

Second, the related 1,3-dibenzyl-4,5-diphenylimidazolidine **6** was prepared as shown in Scheme 5. The *N*,*N*-dibenzylurea **16**, derived from (*S*,*S*)-4,5-diphenylimidazolidin-2-one[4a] (**15**), was converted into the corresponding thiourea **17** by treatment

(22) Trials for salt formations using tartaric acid, ammonium hexafluorophosphate, or hydrochloric acid failed.

(23) All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were included at their calculated positions. Crystal data for the complex of (−)-**7** and D-(+)-camphorsulfonic acid: $C_{102}H_{134}N_4O_{16}S_4$; M = 1800.37 g mol^{-1}, triclinic, P_1, colorless needle measuring 0.40 × 0.08 × 0.05 mm, T = 90 K, a = 13.038(3) Å, b = 14.627(3) Å, c = 16.662(6) Å, V = 2649.2(13) Å^3, Z = 1, D_{calcd} = 1.128 Mg m^{-3}, μ = 0.150 mm^{-1}, T_{max} = 0.9925, T_{min} = 0.9423, GOF on F^2 = 1.070, R1 = 0.0481, wR2 = 0.1146 [$I > 2\sigma(I)$], R1 = 0.0598, and wR2 = 0.1207 (all data), absolute structure parameter = 0.04(6). CCDC-656808.

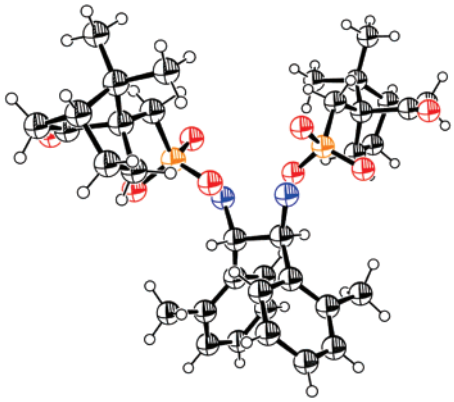
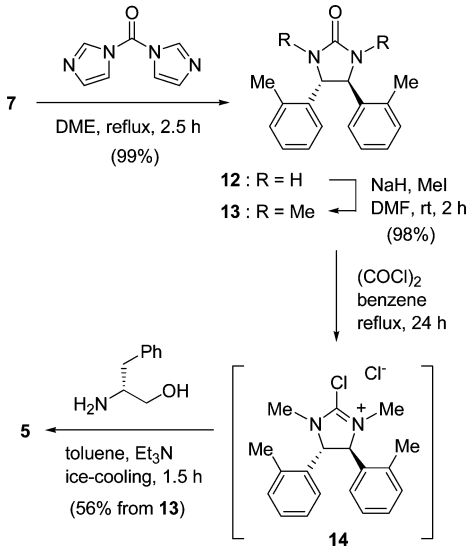
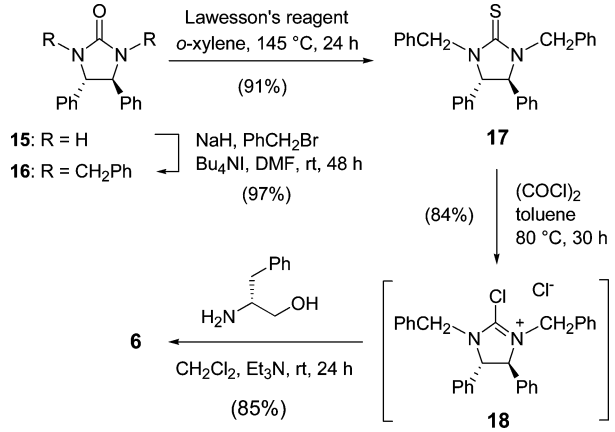


FIGURE 2. X-ray structure of the 1:2 complex salt of (−)-**7** and D-(+)-camphorsulfonic acid.

SCHEME 4. Preparation of (4*S*,5*S*)-2-[(*R*)-1-Benzyl-2-hydroxyethyl]imino-1, 3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine (5) from (−)-(*S*,*S*)-Diamine [(−)-7]

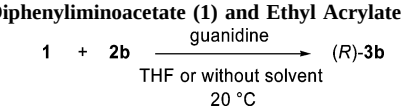


SCHEME 5. Preparation of the 1,3-Dibenzyl-4,5-diphenylimidazolidine 6



with Lawesson's reagent because of the failure of direct chlorination of **16** with oxalyl chloride. Chlorination of **17** with oxalyl chloride followed by amination with (*R*)-phenylalaninol afforded a desired guanidine **6**.

TABLE 1. Modified Guanidine-Catalyzed Michael Reaction of *tert*-Butyl Diphenyliminoacetate (1) and Ethyl Acrylate (2b)[a]



entry	guanidine	solvent	time (d)	yield[b] (%)	ee (%)
1[c]	**4**	THF	7 (7)	26 (15)	79 (79)
2[c]	**4**	none	5 (3)	77 (85)	93 (97)
3	**5**	THF	7	62	90
4	**5**	none	5	79	97
5	**6**	THF	7	27	98
6	**6**	none	7	NR[d]	

[a] The reaction was carried out using **1** (0.1 mmol) and **2b** (0.4 mmol) either in THF (0.26 mmol/mL for **1**) or without solvent in the presence of guanidine (0.02 mmol). [b] Isolated yield. [c] The data in parentheses were cited from ref 4b. [d] No reaction.

Modified guanidines **5** and **6** newly prepared here were subjected to the Michael reaction of *tert*-butyl diphenyliminoacetate (**1**) and ethyl acrylate (**2b**) either in THF solution or without solvent, in order to evaluate their catalysis ability (Table 1). The reaction was carried out according to the conditions of guanidine-catalyzed Michael reaction reported by Ma et al.,[8] as preliminarily reported.[4b] At first, we recognized that re-examinations of reactions using the original guanidine **4** under both conditions afforded almost the same results as in the preliminary report[4b] (entries 1 and 2). In the solution state reaction in the presence of the 1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine **5**, the adduct **3b** was, as expected, formed in acceptable yield (62%) with satisfactory asymmetric induction (90% ee) (entry 3). Similar to the original catalyst **4**, the guanidine **5** showed effective catalysis ability in solvent-free reaction (entry 4). Great improvement of asymmetric induction (98% ee) was observed in THF solution when the 1,3-dibenzyl-4,5-diphenylimidazolidine **6** was applied, but the chemical conversion was low (entry 5). Unfortunately, no reaction was observed in the case of without solvent (entry 6).

Thus, introduction of a bulky substituent on either the ring carbon of imidazolidine system or the nitrogen atom improved asymmetric induction and, additionally, acceleration of reaction in solution state was observed in place of the phenyl pendant in **4** to the 2-methylphenyl one in **5**. These facts suggest that effective chiral environment by complexation between substrate and each catalyst forms in the transition states. In the case of the 1,3-dibenzyl derivative **6**, expected steric repulsion between the *N*-benzyl group and the phenyl pendant resulted in reasonably playing an important role for good asymmetric induction. However, other factors than stereochemical demand should be attributable to the acceleration of reaction and effective asymmetric induction in the 1,3-dimethyl-4,5-bis(2-methylphenyl)-imidazolidine **5**-catalyzed reaction in solution. The X-ray crystal structures of (4*R*,5*R*,1′*S*)-1,3-dimethyl-4,5-diphenyl-[4b,24] *ent*-**4** and (4*R*,5*R*,1′*S*)-1,3-dimethyl-4,5-bis(2-methylphenyl)imidazo-

(24) All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were included at their calculated positions. Crystal data for *ent*-**4**: $C_{26}H_{29}N_3O$; M = 399.52 g mol^{-1}, orthorhombic, $P2_12_12_1$, colorless cube measuring 0.38 × 0.30 × 0.20 mm, T = 173 K, a = 27.759(4) Å, b = 7.6628(10) Å, c = 10.4877(14) Å, V = 2230.9(5) Å^3, Z = 4, D_{calcd} = 1.190 Mg m^{-3}, μ = 0.073 mm^{-1}, T_{max} = 0.9855, T_{min} = 0.9727, GOF on F^2 = 1.080, R1 = 0.0468, wR2 = 0.1180 [$I > 2\sigma(I)$], R1 = 0.0725, and wR2 = 0.1355 (all data), absolute structure parameter = -4(2). CCDC-656810.

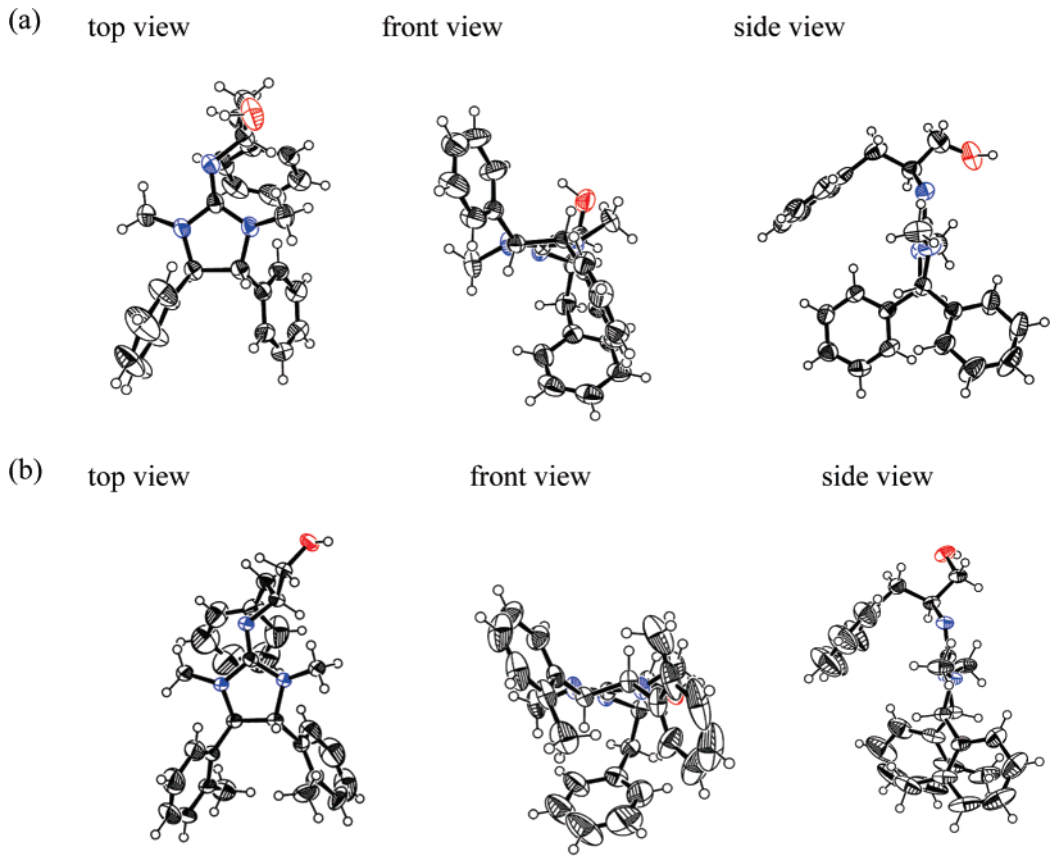


FIGURE 3. X-ray structures of (a) (4*R*,5*R*,1′*S*)-1,3-dimethyl-4,5-diphenyl-*ent*-**4** and (b) (4*R*,5*R*,1′*S*)-1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine *ent*-**5**.

lidines[25] *ent*-**5** are shown in Figure 3 and the selected angle data in Table 2.

Nearly the same angles (Δ 4°) around the both imidazolidine ring nitrogens (N_1 and N_3) were calculated in *ent*-**4** and *ent*-**5**. On the other hand, dihedral angles through the imidazolidine ring constituents ($N_1-C_5-C_4-N_3$) and between the 4,5-diaryl pendants [Ar($C_{1'}$)-C_4-C_5-Ar($C_{1''}$)] were calculated to be Δ −23° and Δ +20°, respectively. These data show that the imidazolidine ring is rather planar and the both phenyl pendants are apart from each other in *ent*-**4**, whereas the imidazolidine ring is distorted and the both pendants are more closely oriented in *ent*-**5** (side views in Figure 3). Furthermore, average of two dihedral angles of Ar($C_{2'}$)−Ar($C_{1'}$)−C_4-C_5 and Ar($C_{2''}$)−Ar-($C_{1''}$)−C_5-C_4 could be calculated to be 83° and 78° in *ent*-**4** and *ent*-**5**, respectively. These facts suggested that the phenyl pendant is nearly perpendicularly located to the imidazolidine ring in *ent*-**4**, whereas the 2-methylphenyl pendant is slightly bended from the imidazolidine ring in *ent*-**5** (front views in Figure 3).

We have tentatively proposed a relatively tight complexation between nucleophile and guanidine catalyst through three point-interactions in the transition state,[4b] in order to explain good enantioselectivity in the guanidine-catalyzed Michael reaction

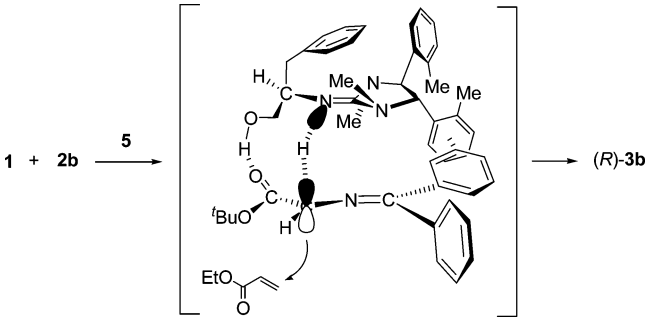
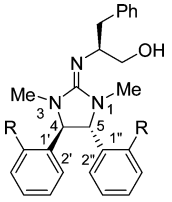


FIGURE 4. Supposed transition state of the 1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine **5**-catalyzed Michael reaction.

of *tert*-butyl diphenyliminoacetate (**1**) with an active vinyl compound (see Figure 4). As a result, an active vinyl compound approaches from the less hindered open site of the guanidine−iminoacetate complex, yielding an (*R*)-adduct when the (4*S*,5*S*,1′*R*)-1,3-dimethyl-4,5-diphenylimidazolidine **4** was used as a catalyst, in which (i) the imino nitrogen atom of guanidine forms hydrogen bond to the *pro-S* hydrogen of the methylene group in the iminoacetate, (ii) alcoholic hydrogen of the substituent on the imino nitrogen forms hydrogen bond to the ester carbonyl group of the iminoacetate, and (iii) the phenyl pendant on the imidazolidine ring forms weak bond with one of the diphenyl functions of diphenyliminoacetate through phenyl−phenyl interaction. In the most stable conformation of the diphenyliminoacetate, the diphenyl functions was suggested to be located nearly perpendicular each other,[26] strongly indicating that our previously proposed π−π interaction[4b] should

(25) All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were included at their calculated positions. Crystal data for *ent*-**5**: $C_{28}H_{33}N_3O$; M = 427.57 g mol^{-1}, orthorhombic, $P2_12_12_1$, colorless cube measuring 0.40 × 0.08 × 0.05 mm, T = 90 K, a = 8.1113(12) Å, b = 14.058(2) Å, c = 21.632(3) Å, V = 2466.7(7) Å^3, Z = 4, D_{calcd} = 1.151 Mg m^{-3}, μ = 0.070 mm^{-1}, T_{max} = 0.9895, T_{min} = 0.9724, GOF on F^2 = 1.035, R1 = 0.0537, wR2 = 0.1368 [$I > 2\sigma(I)$], R1 = 0.0714, and wR2 = 0.1521 (all data), absolute structure parameter = 1(2) CCDC-656809.

TABLE 2. Selected Angle Data (deg) of Crystal Structures of the (4*R*,5*R*,1′*S*)-1,3-Dimethyl-4,5-diphenyl- *ent*-4 and (4*R*,5*R*,1′*S*)-1,3-Dimethyl-4,5-bis(2-methylphenyl)imidazolidines *ent*-5



ent-**4**: R = H
ent-**5**: R = Me

	ent-**4**	*ent*-**5**	Δ (*ent*-**4** − *ent*-**5**)
around N_1	+349	+345	+4
around N_3	+349	+345	+4
$N_1-C_5-C_4-N_3$	−8	−31	−23
$Ar(C_{1'})-C_4-C_5-Ar(C_{1''})$	+105	+85	+20
$Ar(C_{2'})-Ar(C_{1'})-C_4-C_5$	+71	+83	−12
$Ar(C_{2''})-Ar(C_{1''})-C_5-C_4$	+96	+72	+24

be revised to CH−π interaction. Recently, Sinnokrot and Sherrill[27] reported that a pair of phenyl and 2-methylphenyl groups mutually attracts more strongly than that of phenyl and phenyl ones in aromatic CH-π interactions and in the former pair an electron-rich 2-methylphenyl group works as proton acceptor to form T-shape CH-π interaction. The bent 2-methylphenyl pendants and their close location to the imidazolidine ring in the 1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine **5**, deduced by the above X-ray analysis, could be responsible for more effective interaction with the phenyl ring of diphenyliminoacetate through CH-π interaction than the corresponding phenyl pendant in the 1,3-dimethyl-4,5-diphenylimidazolidine **4**, resulting in rigid hydrogen bonding formations between guanidine catalyst and the iminoacetate substrate, as illustrated in Figure 4, to be responsible for improvement in both reactivity and selectivity.

It is reasonable to suppose that these modified guanidines are suitable catalysts for other Michael type reactions. In fact, we have also observed that the guanidine **5** carrying 2-methylphenyl pendants acts as a more effective catalyst than **4** with phenyl pendants for the construction of quaternary carbon center in chroman ring system by intramolecular Michael-type cyclization but that asymmetric induction in the product formation is not improved by the use of the 1,3-dibenzyl derivative **6**.[28] Thus, in this stage preparation of a hybrid catalyst with 1,3-dibenzyl substitutents and 2-methylphenyl pendants in the guanidine system was not attempted in spite of an alternative promising candidate.

In conclusion, introduction of methyl group on the ortho position of the phenyl pendant in (4*S*,5*S*)-2-[(*R*)-1-benzyl-2-hydroxyethyl]imino-1,3-dimethyl-4,5-diphenylimidazolidine (or its enantiomer), a promising guanidine catalyst for asymmetric Michael reaction of *tert*-butyl diphenyliminoacetate and ethyl acrylate, improved not only reactivity but also selectivity, especially in solution state. Studies toward further structural modification of this type of guanidine for optimization of the Michael reaction and application to other asymmetric reactions are in progress.

(26) Calculation was done by ab initio (RHF/3-21G) method using Gaussian 03.

(27) Sinnokrot, M. O.; Sherrill, C. D. *J. Phys. Chem. A* **2006**, *110*, 10656−10668.

(28) The guanidine-catalyzed intramolecular Michael addition for chroman ring construction will be reported elsewhere in the future.

Experimental Section

Optical Resolution of (±)-1,2-Bis(2-methylphenyl)ethylene-1,2-diamine [(±)-7]: (i) (*R*,*R*)-1,2-Bis(2-methylphenyl)ethylene-1,2-diammonium (*S*,*S*)-Dibenzoyltartarate. A solution of (*S*,*S*)-DBTA·H_2O (4.67 g, 13.0 mmol) in ethyl acetate (10 mL) was added to a stirred solution of (±)-diamine (±)-**7** (2.85 g, 11.9 mmol) in ethyl acetate (4 mL) under ice cooling, and the solvent was evaporated in vacuo. After division of the residue to 28 fractions (ca. 250 mg), each was dissolved in ethyl acetate (ca. 5 mL) at 90−100 °C and then kept at 0 °C for 1 day. The precipitates separated in the mixture were collected by filtration to give colorless solids [total 3.52 g, 49%, 69% de for (*R*,*R*)-**7**]. Evaporation of the filtrate gave colorless solids [total 3.67 g, 52%, 63% de for (*S*,*S*)-**7**]. The solids obtained from the precipitates, after division to 12 fractions (ca. 250 mg in each), were recrystallized from ethyl acetate (ca. 5 mL) under the above conditions to give colorless solids [total 2.50 g, 35%, 94% de for (*R*,*R*)-**7**] and the mother liquor [total 627 mg, 9%, 48% de for (*S*,*S*)-**7**]. The same fractional recrystallization was carried out using a mixture of (±)-diamine (±)-**7** (1.27 g, 5.29 mmol), (*S*,*S*)-DBTA·H_2O (2.08 g, 5.82 mmol), and ethyl acetate (80 mL) to finally afford three components: colorless solids [825 mg, 26%, 94% de for (*R*,*R*)-**7**] as precipitates and colorless solids from two mother liquors [1.97 g, 62%, 56% de for (*S*,*S*)-**7** and 286 mg, 9%, 44% de for (*S*,*S*)-**7**, respectively]. The (*R*,*R*)-diammnoium (*S*,*S*)-tartarate was obtained from precipitates, and the total yield was 3.325 g (31%). Mp: 142−144 °C. IR ν_{max} cm^{-1}: 1714 (C═O). ^1H NMR (400 MHz, DMSO-d_6): δ (ppm) 1.88 (*s*, 6H), 4.49 (s, 2H), 5.63 (s, 2H), 6.90 (d, J = 7.3 Hz, 2H), 7.05 (dd, J = 7.8, 7.5 Hz, 2H), 7.14 (dd, J = 7.7, 7.5 Hz, 2H), 7.48 (dd, J = 7.7, 7.7 Hz, 4H), 7.60 (dd, J = 7.1, 7.1 Hz, 4H), 7.93 (d, J = 8.0 Hz, 4H). ^{13}C NMR (100 MHz, DMSO-d_6): δ (ppm) 18.6, 54.0, 72.9, 126.1, 126.7, 127.8, 128.7, 129.3, 129.8, 129.9, 133.3, 135.6, 136.6, 165.0, 169.2. Anal. Calcd for $C_{16}H_{20}N_2$·$C_{18}H_{14}O_8$·$^1/_2H_2O$: C, 67.20; H, 5.80; N, 4.61. Found: C, 67.10; H, 5.79; N, 4.47. $[\alpha]^{24}_D$: +95.8 (c = 0.51, MeOH) (the ee was estimated to be almost 100% by ^1H NMR). **(+)-(*R*,*R*)-Diamine (+)-7.** A mixture of the (+)-**7**·(*S*,*S*)-DBTA salt (672 mg, 1.12 mmol), CH_2Cl_2 (34 mL), and 10% NaOH (44 mL, 11.0 mmol) was stirred at 0 °C for 30 min. The organic layer was separated and dried (K_2CO_3). Evaporation of the solvent in vacuo gave (+)-**7** (247 mg, 92%) as a colorless oil. $[\alpha]^{20}_D$: +18.8 (c = 1.1, $CHCl_3$) (the ee was estimated to be 94% by HPLC). **(ii) (*S*,*S*)-1,2-Bis(2-methylphenyl)ethylene-1,2-diammonium (*R*,*R*)-Dibenzoyltartarate.** To combined residues (total 6.34 g, 10.6 mmol) derived from four mother liquors in the above recrystallizations, water (32 mL), CH_2Cl_2 (320 mL), and 10% NaOH (410 mL, 0.10 mol) were added at 0 °C, and the whole was stirred at 0 °C for 30 min. The organic solution was separated, dried (K_2CO_3), and evaporated in vacuo to give a colorless oil (1.93 g, 76% from DBTA salt). The oil was dissolved in ethyl acetate (3 mL), a solution of (*R*,*R*)-DBTA·H_2O (3.29 g, 8.74 mmol) in ethyl acetate (6 mL) was added, and the solvent was evaporated. After division of the residue to 24 fractions (ca. 250 mg), each fraction was similarly treated as above using ethyl acetate (10 mL) to give colorless solids [total 3.47 g, 55%, 87% de for (*S*,*S*)-**7**]. Additional fractional recystallization of each using ethyl acetate (5 mL), after division to 14 fractions (ca. 250 mg), gave the (*S*,*S*)-diammonium (*R*,*R*)-tartarate (2.43 g, 38%, 96% de) as colorless solids. Mp: 142−144 °C. IR ν_{max} cm^{-1}: 1712 (C═O). ^1H NMR (400 MHz, DMSO-d_6): δ (ppm) 1.86 (dif s, 6H), 4.49 (dif s, 2H), 5.65 (s, 2H), 6.89 (dif d, J = 7.5 Hz, 2H), 7.04 (dd, J = 7.4, 7.4 Hz, 2H), 7.15 (dif dd, J = 7.4, 7.4 Hz, 2H), 7.49 (dd, J = 7.7, 7.7 Hz, 4H), 7.92 (d, J = 8.2 Hz, 4H). ^{13}C NMR (100 MHz, DMSO-d_6): δ (ppm) 18.5, 53.9, 73.4, 126.0, 126.8, 127.8, 128.6, 129.3, 129.9, 130.3, 133.2, 135.6, 136.3, 165.1, 169.8. Anal. Calcd for $C_{16}H_{20}N_2$·$C_{18}H_{14}O_8$·H_2O: C, 66.22; H, 5.88; N, 4.54. Found: C, 66.26; H, 5.67; N,

4.30. $[\alpha]^{24}_D$: −98.1 (c = 0.51, MeOH). **(−)-(*S,S*)-Diamine (−)-7.** The similar desalting of the above salt afforded (−)-**7**, $[\alpha]^{26}_D$: −20.3 (c = 0.1, $CHCl_3$) (the ee was estimated to be 96% by HPLC).

(4*S*,5*S*)-Bis(2-methylphenyl)imidazolin-2-one (12). A solution of the (−)-(*S,S*)-diamine **7** (191 mg, 0.80 mmol) and *N,N′*-carbonyldiimidazole (170 mg, 1.05 mmol) in 1,2-dimethoxyethane (8 mL) was refluxed for 2.5 h. After evaporation of the solvent, the residue was purified by column chromatography ($CHCl_3$) to afford **12** (210 mg, 99%) as colorless prisms, mp 220−223 °C, which were recrystallized from hexane−ethyl acetate. IR ν_{max} cm^{-1}: 3215 (NH), 1707 (C═O). ^{1}H NMR (400 MHz): δ (ppm) 1.77 (s, 6H), 4.84 (br, 2H), 4.95 (s, 2H), 7.05 (d, J = 7.5 Hz, 2H), 7.20 (ddd, J = 7.4, 7.4, 1.4 Hz, 2H), 7.30 (ddd, J = 7.5, 7.5, 0.9 Hz, 2H), 7.70 (dd, J = 7.9, 1.3 Hz, 2H). ^{13}C NMR (100 MHz): δ (ppm) 18.7, 62.1, 126.4, 126.8, 128.1, 130.6, 135.7, 137.9, 162.8. HREIMS m/z: 266.1426 (calcd for $C_{17}H_{18}N_2O$ 266.1419). Anal. Calcd for $C_{17}H_{18}N_2O$: C, 76.66; H, 6.81; N, 10.52. Found: C, 76.69; H, 6.71; N, 10.56. $[\alpha]^{21}_D$: +18.1 (c = 1.0, $CHCl_3$).

(4*S*,5*S*)-1,3-Dimethyl-4,5-bis(2-methylphenyl)imidazolidin-2-one (13). To a mixture of sodium hydride (60% in oil, 78 mg, 1.96 mmol), which was washed with dry hexane under argon, in DMF (0.2 mL) was added a solution of the urea **12** (201 mg, 0.76 mmol) in DMF (2.1 mL) followed by methyl iodide (0.15 mL, 2.42 mmol), and the whole was stirred at rt for 22 h. After acidification with 5% HCl aq, the mixture was extracted with ethyl acetate (10 mL × 3). The combined organic solutions were washed with water (30 mL × 5) and brine (100 mL), dried ($MgSO_4$), and evaporated. Purification of the residue by column chromatography (hexane/ethyl acetate = 1:1) gave **13** (217 mg, 98%) as colorless prisms, mp 133−134.5 °C, which were recrystallized from hexane−ethyl acetate. ^{1}H NMR (400 MHz): δ (ppm) 1.69 (s, 6H), 2.67 (s, 6H), 4.43 (s, 2H), 7.05 (d, J = 7.5 Hz, 2H), 7.20 (dd, J = 7.4, 1.2 Hz, 2H), 7.24 (br, 2H), 7.47 (br, 2H). ^{13}C NMR (100 MHz): δ (ppm) 18.6, 29.8, 65.8, 126.3, 126.8, 127.4, 127.8, 127.9, 136.6, 162.2. $[\alpha]^{25}_D$ +128.1 (c = 1.0, $CHCl_3$). HREIMS m/z: 294.1732 (calcd for $C_{19}H_{22}N_2O$ 294.1732).

(4*S*,5*S*)-2-Chloro-1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolium Chloride (14). A mixture of the urea **13** (740 mg, 2.51 mmol) and oxalyl chloride (1.1 mL, 12.7 mmol) in benzene (17 mL) was refluxed for 24 h, and the excess of oxalyl chloride and benzene were evaporated. The residual brownish solids obtained were used for next step without further purification. ^{1}H NMR (400 MHz): δ (ppm) 1.78 (s, 6H), 3.21 (s, 6H), 5.69 (s, 2H), 7.09−7.44 (m, 6H), 8.13 (br, 2H).

(4*S*,5*S*)-2-[(*R*)-1-Benzyl-2-hydroxyethyl]imino-1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine (5). To an ice-cooled solution of (*R*)-phenylalaninol (309 mg, 2.04 mmol) and triethylamine (0.7 mL, 4.08 mmol) in dry CH_2Cl_2 (0.2 mL) was added a solution of the (*S,S*)-chloroamidine **14** (714 mg, 2.04 mmol) in dry CH_2Cl_2 (10 mL), and the whole was stirred under ice cooling for 1.5 h. The mixture was diluted with CH_2Cl_2 (48 mL) and washed with 10% citric acid aq (48 mL). The aqueous solution was extracted with CH_2Cl_2 (50 mL × 3). The combined organic solutions were evaporated, and the residue was partitioned with water (80 mL) and toluene (80 mL). The aqueous solution was basified with a small amount of 30% NaOH aq and extracted with CH_2Cl_2 (20 mL × 4). The combined organic solutions were washed with brine, dried (K_2CO_3), and evaporated to give **5** (605 mg, 56% from **13**) as colorless needles, mp 142−144 °C, which were recrystallized from hexane-benzene. IR ν_{max} cm^{-1}: 1630 (C═N). ^{1}H NMR (400 MHz): δ (ppm) 1.55 (dif s, 6H), 2.58 and 2.72 (dif s, each 3H), 2.83 (dif dq, J = 6.8, 6.8 Hz, 2H), 3.56 and 3.58 (dd, J = 10.0, 5.9 Hz, each 1H), 3.99 and 4.00 (dif s, each 1H), 4.23−4.29 (m, 1H), 6.97 (br d, J = 7.6 Hz, 2H),7.15 (dd, J = 7.3, 7.3 Hz, 2H), 7.21 (m, 4H), 7.26−7.35 (m, 5H), 7.56 (br s, 1H). ^{13}C NMR (125 MHz): δ (ppm) 18.5, 33.2, 36.9, 40.3, 59.0, 66.1, 67.8, 70.6, 125.8, 126.6, 126.9, 127.6, 128.1, 129.7, 130.3, 136.4, 136.8, 140.1, 158.0. LRFABMS m/z: 429 [$(M + 2H)^+$]. Anal. Calcd for $C_{28}H_{33}N_3O$: C, 78.65; H, 7.78; N 9.83. Found: C, 78.19; H, 7.74; N, 9.73. $[\alpha]^{24}_D$: +106.2 (c = 1.01, $CHCl_3$). **PF_6 Salt.** NH_4PF_6 (20 mg, 0.12 mmol) was added to a solution of **5** (50 mg, 0.12 mmol) in acetone (0.45 mL) at 0 °C, and the whole was stirred at 0 °C for 1 min. The solvent was evaporated in vacuo, and the residue was triturated with H_2O (0.4 mL). After removal of the supernatant, the residue was dried under vacuum at 100 °C for 24 h and then recrystallized from hexane−CH_2Cl_2 to give the PF_6 salt (51 mg, 76%) as a colorless powder. Mp: 174−175 °C. IR ν_{max} cm^{-1}: 1622 (C═N). ^{1}H NMR (500 MHz): δ (ppm) 1.66 (s, 6H), 2.83 (s, 6H), 2.86 (m, 1H), 3.09 (dd, J = 14.6, 2.4 Hz, 1H), 3.48 (br, 1H), 4.02 (d, J = 6.1 Hz, 2H), 4.32−4.35 (m, 1H), 4.48 (s, 2H), 5.90 (d, J = 10.7 Hz, 1H), 6.99 (d, J = 6.1 Hz, 2H), 7.04 (d, J = 7.3 Hz, 2H), 7.20−7.28 (m, 4H), 7.39 (dif. d, J = 6.1 Hz, 3H), 7.46 (dif t, J = 7.3 Hz, 2H). ^{13}C NMR (125 MHz): δ (ppm) 18.5, 34.0, 38.5, 59.9, 64.2, 70.2, 126.4, 127.2, 127.5, 129.0, 129.1, 129.5, 131.0, 133.2, 136.4, 137.5, 160.2. LRFABMS m/z: 429 [$(M - PF_6)^+$]. $[\alpha]^{23}_D$: +61.8 (c = 0.1, $CHCl_3$). Anal. Calcd for $C_{28}H_{34}N_3O\cdot PF_6$: C, 58.64; H, 5.98; N, 7.33. Found: C, 58.32; H, 5.94; N, 7.14.

(4*R*,5*R*)-2-[(*S*)-1-Benzyl-2-hydroxyethyl]imino-1,3-dimethyl-4,5-bis(2-methylphenyl)imidazolidine (*ent*-5). Similar treatment using a solution of *ent*-**14**, derived from *ent*-**7** (189 mg, 0.65 mmol), in dry CH_2Cl_2 (3.0 mL) and a solution of (*S*)-phenylalaninol (98 mg, 0.65 mmol) and triethylamine (0.2 mL, 1.38 mmol) in dry CH_2Cl_2 (0.2 mL) gave *ent*-**5** (238 mg, 86% from *ent*-**14**) as colorless needles, mp 141−144 °C, which were recrystallized from hexane−benzene. Anal. Calcd for $C_{28}H_{33}N_3O$: C, 78.65; H, 7.78; N, 9.83. Found: C, 78.43; H, 7.74; N, 9.75. $[\alpha]^{25}_D$: −105.0 (c = 1.01, $CHCl_3$).

(4*S*,5*S*)-1,3-Dibenzyl-4,5-diphenylimidazolidin-2-one (16). A mixture of the urea **15** (3.54 g, 14.9 mmol), tetra-*n*-butylammonium iodide (1.65 g, 4.47 mmol), benzyl bromide (5.60 g, 32.8 mmol), and sodium hydride (55% in oil, 1.43 g, 32.8 mmol) in DMF (44.4 mL) was stirred at rt for 2 days, quenched with methanol (0.24 mL, 5.93 mmol) followed by 1.5 N HCl (70 mL), and extracted with ethyl acetate (80 mL and 35 mL). The combined organic solutions were washed with 20% $Na_2S_2O_3$ aq (50 mL), water (59 mL), and brine (59 mL), dried ($MgSO_4$), and evaporated. Purification of the residue by column chromatography (toluene to ethyl acetate/toluene = 3:97) gave **16** (6.0 g, 97%) as colorless solids. Mp: 145.5−147.5 °C (lit.[29] mp 147 °C). ^{1}H NMR (300 MHz): δ (ppm) 3.61 and 5.08 (d, J = 14.9 Hz, each 2H), 4.04 (s, 2H), 6.95−6.97 (m, 4H), 7.13−7.15 (m, 4H), 7.24−7.30 (m, 12H).

(4*S*,5*S*)-1,3-Dibenzyl-4,5-diphenylimidazolidin-2-thione (17). A mixture of the benzylurea **16** (2.0 g, 4.78 mmol) and Lawesson's reagent (3.87 g, 9.56 mmol) in *o*-xylene (20 mL) was heated at 145 °C for 24 h and quenched with methanol (30 mL) and 5% HCl aq (8 mL). The resulting biphasic solution was stirred at rt overnight. The organic layer was separated, and the aqueous phase was extracted with toluene (20 mL). The combined organic solutions were washed with water (30 mL × 9) and brine (30 mL), dried ($MgSO_4$), and evaporated. Purification of the residue by column chromatography (ethyl acetate/hexane = 2:98) gave **17** (1.88 g, 91%) as colorless prisms, mp 177−179 °C, which were recrystallized from ether−hexane. IR: no characteristic absorption. ^{1}H NMR (300 MHz): δ (ppm) 3.77 and 5.88 (d, J = 14.9 Hz, each 2H), 4.31 (s, 2H), 6.95−6.99 (m, 4H), 7.22−7.30 (m, 16H). ^{13}C NMR (75 MHz): δ (ppm) 48.9, 69.1, 127.0, 127.6, 128.4, 128.5, 128.6, 129.0, 135.9, 138.2, 182.4. HREIMS m/z: 434.1824 (calcd for $C_{29}H_{26}N_2S$ 434.1817). $[\alpha]^{22}_D$: −183 (c = 1.02, $CHCl_3$).

(4*S*,5*S*)-1,3-Dibenzyl-2-chloro-4,5-diphenylimidazolium Chloride (18). To a suspension of the thiourea **17** (1.88 g, 4.33 mmol) in dry toluene (24 mL) was added oxalyl chloride (3.4 mL, 39.0 mmol). The resulting solution was heated at 80 °C for 30 h under nitrogen. The separated colorless precipitates were collected by filtration in a stream of nitrogen to afford **18** (1.77 g, 84%) as hygroscopic colorless solids with 97% purity, which were used for next step without further purification. ^{1}H NMR (300 MHz): δ

(29) Ishii, K. Ph.D. Thesis, University of Tokyo, 1997.

(ppm) 4.78 and 4.95 (d, J = 15.6 Hz, each 2H), 5.25 (s, 2H), 7.03−7.07 (m, 4H), 7.26−7.41 (m, 16H).

(4*S*,5*S*)-1,3-Dibenzyl-2-[(*R*)-1-benzyl-2-hydroxyethyl]imino-4,5-diphenylimidazolidine (6). To an ice-cooled solution of (*R*)-phenylalaninol (45 mg, 0.29 mmol) and triethylamine (0.1 mL, 0.72 mmol) in CH_2Cl_2 (0.1 mL) was dropwise added a solution of the chloroamidine **18** (77% purity by ^{1}H NMR, 140 mg, 0.23 mmol) in CH_2Cl_2 (1.3 mL). The whole was stirred at rt for 24 h and evaporated. The residue was made acidic (pH ca. 3) by addition of 10% citric acid aq (10 mL) and then extracted with CH_2Cl_2 (10 mL × 3). After evaporation of the combined organic solutions, the residue was dissolved in water (10 mL) and washed with toluene (8 mL × 3). The aqueous solution was basified to pH >12 with 30% NaOH aq (2 mL) and extracted with CH_2Cl_2 (20 mL × 4). The combined organic solutions were dried (K_2CO_3) and evaporated to dryness to yield **6** (107 mg, 85%) as colorless solids. Mp: 40−43 °C. IR ν_{max} cm^{-1}: 1630 (C═N). ^{1}H NMR (400 MHz): δ (ppm) 2.84 (dd, J = 13.3, 7.8 Hz, 1H), 3.08 (dd, J = 13.1, 6.2 Hz, 1H), 3.40 (s, 2H), 3.82 and 4.10 (br, each 2H), 4.20 (m, 1H), 4.91 (d, J = 15.2 Hz, 2H), 6.95 (br, 4H), 7.18−7.30 (m, 16H). ^{13}C NMR (100 MHz): δ (ppm) 39.7, 47.6 (br), 49.6 (br), 56.3, 65.7, 68.2 (br), 70.7 (br), 126.0, 127.5, 128.1, 128.3, 128.6, 129.6, 137.6 (br), 139.1, 139.6, 152.8. HRFABMS *m*/*z*: 552.3008 (calcd for $C_{38}H_{38}N_3O$ 552.3015). $[\alpha]^{21}_D$: −20.3 (c = 1.02, $CHCl_3$).

Supporting Information Available: Experimental procedures for the preparation of racemic diamine (±)-**7**, NMR charts of new compounds characterized, HPLC charts of (+)- and (−)-**7**, and X-ray data of the complex of (−)-**7** and (+)-camphorsulfonic acid, *ent*-**4**, and *ent*-**5** (CIF). This material is available free of charge via the Internet at http://pubs.acs.org.

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