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SHORT COMMUNICATION

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Chiral Auxiliary Induced Diastereoselective Synthesis of (*R*,*R*)-*N*,*N*′-Di(*tert*-butoxycarbonyl)cyclohex-4-ene-1,2-diamine

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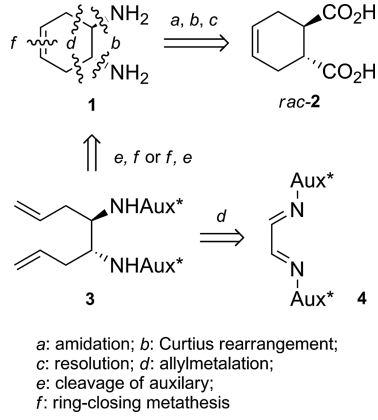
The synthesis of optically pure *N*,*N*′-di(*tert*-butoxycarbonyl)-*trans*-cyclohex-4-ene-1,2-diamine was accomplished from the diimine, which was obtained by condensation of glyoxal and (*R*)-1-(4-methoxyphenyl)ethanamine. The synthetic sequence involved the highly diastereoselective addition of allylzinc bromide to the diimine to give the *N*,*N*′-disubstituted octa-1,7-diene-4,5-diamine, followed by removal of the N-substituents by using an excess amount of boron trichloride, routine conversion to the di(*N*-*tert*-butoxycarbonyl) derivative, and final ring-closing metathesis by using Grubbs Ru catalyst. The sequence of the two latter steps could be inverted. Removal of the chiral auxiliaries with trifluoroacetic acid or hydrochloric acid gave less satisfactory results. Moreover, *N*,*N*′-dibenzoylocta-1,7-diene-4,5-diamine was similarly prepared.

Introduction

Optically pure cyclohex-4-ene-1,2-diamine, for example, (*R*,*R*)-**1**, is a valuable chiral synthon that has found use in a variety of applications. For example, (*R*,*R*)-**1** has been employed as a building block for the preparation of large chiral cages by dynamic imine reaction with tris(4-formylphenyl)amine,[1] tetraazamacrocycles useful as magnetic resonance contrast agents in hepatobiliary systems.[2] Moreover, the preparation of antitumoral platinum complexes[3] from **1** has been reported in several patents.[3] Therein, optically pure **1** was obtained by exploiting resolution processes of *rac*-**1**, which was synthesized from *trans*-cyclohex-4-ene-1,2-dicarboxylic acid by sequential formation of the di(carbonyl hydrazide) and di(carbonyl azide) and final Curtius rearrangement. On the other hand, only two asymmetric syntheses of a di(*N*-*tert*-butoxycarbonyl) [di(*N*-Boc)] derivative of **1**, see **9** in Scheme 2, have been reported, and both required a long sequence of steps. Then, **9** was converted into Oseltamivir phosphate (Tamiflu). One of these routes involved the ring-opening desymmetrization of *meso*-*N*-(3,5-dinitrobenzoyl)cyclohexa-1,4-diene-substituted aziridine,[4] whereas the other route exploited the chemoenzymatic resolution of *trans*-*N*,*N*-diallylcyclohex-4-ene-1,2-diamine and its precursor *trans*-6-(diallylamino)cyclohex-3-enol.[5]

As an alternative, we envisioned that optically pure **1** could be synthesized by exploiting the ring-closing metathesis (RCM)[7] of hepta-1,7-diene-4,5-diamine or *N*,*N*′-disubstituted derivative **3**, which can be diastereoselectively prepared by the auxiliary-induced double allylmetalation of chiral glyoxal diimine **4** (Scheme 1). As a matter of fact, compound **3** was obtained with 85% diastereoselectivity by the Barbier-type double allylzincation of glyoxal diimine **4** derived from (*R*)-*tert*-butylsulfinamide. Then, the chiral auxiliary could be removed by acidic hydrolysis.[6] This report constitutes a formal total synthesis of cyclohex-4-ene-1,2-diamine (**1**), although the required RCM reactions were not performed.



Scheme 1. Retrosynthetic routes to optically pure *trans*-cyclohex-4-ene-1,2-diamines.

On the other hand, we described the preparation of *N*,*N*′-disubstituted **1**, as well as ring-disubstituted cyclohex-4-ene-1,2-diamine derivatives, by RCM reactions of the 4,5-diaminoocta-1,7-dienes, for example, **3**, obtained by addition of (substituted)allylzinc reagents to glyoxal diimine **4** derived from (*S*)-1-phenylethylamine.[8] However, unsatu-

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rated primary diamine **1** could not be prepared by that route because the hydrogenolysis conditions that are required to remove the *N*-(1-phenylethyl) substituent are not tolerant of the alkene double bond. Consequently, the chiral auxiliaries could be removed only after functionalization reactions of the C=C bond.[9]

Results and Discussion

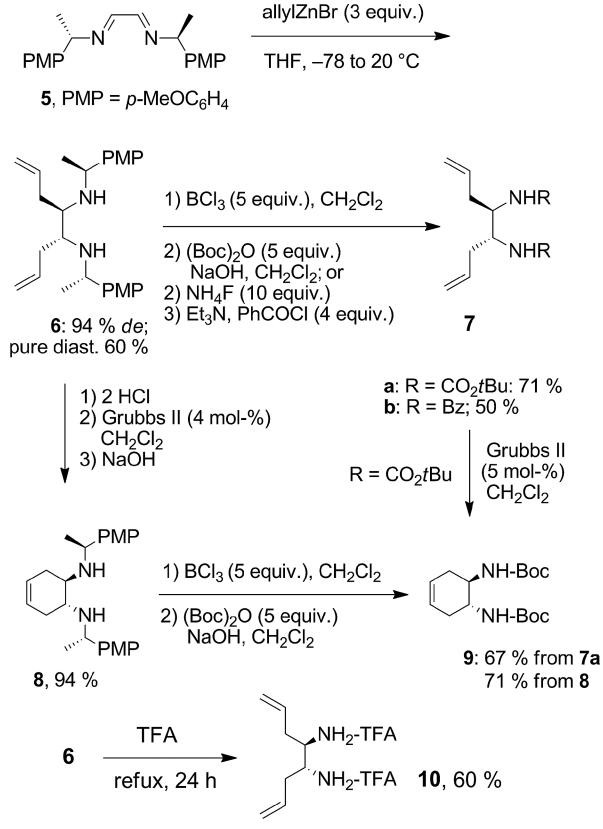
We considered that NH_2-free diamine **1** has a larger potential of synthetic transformations with respect to the *N*,*N*′-disubstituted derivatives. For example, **1** can be easily converted into symmetrical and unsymmetrical diamides, upon which electrophile-promoted cyclizations and C=C bond oxidation reactions, for example, should be easily performed, whereas the double acylation of diamines **3**, e.g. **6**, is often incomplete (unpublished results from our laboratory). For this reason, with the aim of preparing target compound **1**, we looked for another chiral auxiliary to be used as an alternative to *tert*-butyl sulfinamide, which is commercially available although relatively expensive; it can also be prepared by a tedious procedure, and copper sulfate must be added to the reaction to obtain moderately efficient condensation with aqueous glyoxal solution to give the corresponding diimine in 71% yield.

Among the commercially available chiral primary amines, we chose 1-(4-methoxyphenyl)ethylamine because the N-substituent can be removed from the derived secondary amines either oxidatively[10] or by the action of Lewis[11] or Brønsted acids.[12] Although this chiral auxiliary was never been employed for the organometallic addition to derived imines, we supposed that it would provide a level of diastereoselectivity close to that previously obtained in the double allylation of the glyoxal bisimine derived from 1-phenylethylamine (93% diastereoselectivity.[13]

Bisimine **5** was efficiently prepared by heating glyoxal trimer dihydrate and (*S*)-1-(4-methoxyphenyl)ethylamine in absolute ethanol at reflux for 20 min. The crude diimine was obtained as a yellow-orange sticky solid and appeared almost pure by analysis by ^{1}H NMR spectroscopy, so it was directly used in the successive allylmetalation step. We were delighted to find that the double addition of freshly prepared allylzinc bromide to a solution of diimine **5** in anhydrous THF at –78 °C occurred cleanly to afford desired diaminodiene **6** in 93% yield with high diastereoselectivity (*dr* = 96.8:3:0.2 according to the order of elution in GC–MS analysis). Column chromatography afforded the main diastereomer of **6** in 60% yield as a pure compound. Several attempts to obtain pure crystals from different solvents were unsuccessful. The (*R*,*R*) configuration of the main diastereomer was assigned on the basis of our previous report by considering that the sense of asymmetric induction should not be reversed by the presence of the *p*-methoxy substituent in the phenyl group of the chiral auxiliary. On the other hand, the addition of allylmagnesium chloride to the same diimine occurred with an unsatisfactory level of diastereoselectivity; the *dr* was highly affected by the temperature, although any of the three diastereomers could be isolated by column chromatography of the enriched reaction mixtures (see the Supporting Information).

Cleavage of the *N*,*N*′-substituents in **6** was then accomplished by treatment with BCl_3,[10a] which promoted the heterolytic cleavage of the N–C benzyl bond to form the relatively stable *p*-MeO-benzylic carbenium ion intermediate and the primary diamine–BCl_3 complex. This was immediately converted into di(*N*-Boc) derivative **7a** in 71% yield by routine treatment with base and $(Boc)_2O$. Then, RCM by using the second-generation Grubbs catalyst (Grubbs II, 5 mol-%, r.t., 12 h) in CH_2Cl_2 afforded protected cyclohex-4-ene-1,2-diamine **9** in 67% yield.

An alternative approach to compound **9** from **6** was possible by inverting the previously described steps. In fact, the RCM reaction of diamine dihydrochloride **6**·2HCl by using the Grubbs II catalyst (4 mol-%, r.t., 12 h) gave cyclized diamine **8** in 94% yield, in consequence of the precipitation of **8**·2HCl in the reaction medium, filtration, and then basic treatment. The RCM reaction was repeated by using 0.5 and 1 mol-% of the same catalyst at room temperature, but incomplete conversions of 50 and 84%, respectively, were observed after 24 h. Moreover, a run performed with a catalyst loading of 0.5 mol-% at reflux in CH_2Cl_2 for 7 h gave 78% conversion, but unidentified byproducts were also formed (18%). Surprisingly, the cheaper first-generation ruthenium catalyst was poorly effective in the same reaction. Finally, removal of the chiral auxiliaries by treatment



Scheme 2. Stereoselective synthesis of octa-1,7-diene-4,5-diamine and cyclohex-4-ene-1,2-diamine derivatives.

of **8** with BCl_3 and protection of the amine groups gave desired **9** in overall 71% yield (two steps).

We also removed the benzylic substituents of diaminodiene **6** by heating a trifluoroacetic acid (TFA) solution at reflux for 24 h according to a reported procedure.[12b] In this way, salt **10**·2TFA was obtained as a pure solid in 60% yield (Scheme 2). Moreover, cleavage of the auxiliaries was performed by heating **6** with 3 M HCl at reflux, but the reaction was incomplete after 24 h; on the other hand, heating with 6 M HCl resulted in the complete consumption of the starting material, but the isolated cyclohex-4-ene-1,2-diamine dihydrochloride was accompanied by unidentified impurities and could not be satisfactorily purified. Cleavage of the auxiliaries in protic acid is advantageous with respect to the Lewis acid procedure, because in certain applications the free diamine can be liberated in situ from its salt by treatment with triethylamine.

Conclusions

(*S*)-1-(4-Methoxyphenyl)ethanamine proved to be a convenient chiral auxiliary for the preparation of 1,2-diamines from glyoxal through the corresponding 1,2-diimine. Compared to optically pure *tert*-butyl sulfinamide, this commercially available benzylic amine is less expensive and the 1-(4-methoxyphenyl)ethyl substituent can be removed from the derived secondary amines by treatment with boron trichloride. Moreover, it provides a high level of asymmetric induction, comparable to that offered by the more commonly used 1-phenylethanamine, which cannot be applied to the asymmetric synthesis of unsaturated primary amines because it can be removed by secondary amines exclusively by hydrogenolysis protocols that are incompatible with the presence of unsaturation.

The choice of this chiral auxiliary allowed us to achieve the asymmetric syntheses of *N*,*N*′-unsubstituted octa-1,7-diene-4,5-diamine, cyclohex-4-ene-1,2-diamine, and their *N*-protected derivatives. Noteworthy, *N*,*N*′-di(Boc)-cyclohex-4-ene-1,2-diamine **9**, which is a valuable building block and, importantly, a precursor of Oseltamivir, was prepared from the glyoxal diimine by a three-step sequence involving a ring-closing metathesis step, which should be further optimized by examining the activity of other recently developed ruthenium catalysts.

Experimental Section

(1*S*,1′*S*)-*N*,*N*′-(Ethane-1,2-diylidene)bis[1-(4-methoxyphenyl)ethanamine] (5): Glyoxal trimer dihydrate (240 mg, 3.42 mmol) was added to a solution of (*S*)-1-(4-methoxyphenyl)ethylamine (900 μL, 6 mmol) in EtOH (12 mL). The mixture was heated at reflux for 20 min and then cooled; it was filtered through a Celite pad and washed with dichloromethane (2 × 10 mL). After cooling, the solvent was removed under reduced pressure to leave diimine **5** as an orange-yellow sticky solid (933 mg, 96%): $[\alpha]_D^{20}$ = –198 (*c* = 0.99, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 8.04 (s, 2 H), 7.29–7.26 (m, 4 H), 6.91–6.88 (m, 4 H), 4.50 (q, *J* = 6.4 Hz, 2 H), 3.80 (s, 6 H), 1.58 (d, *J* = 6.4 Hz, 6 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 160.4, 158.7, 135.6, 127.7, 113.9, 68.9, 55.2, 23.7 ppm. MS (ESI): *m*/*z* = 325 $[M + H]^+$.

Activation of Zinc Dust: Zinc dust was suspended in 2 M HCl and vigorously stirred for 2 min. After filtration, the dust was washed with plenty of water, then with ethanol, and lastly with diethyl ether. The moist zinc was transferred into a round-bottomed flask and flamed under vacuum until a fine powder was obtained.

Allylzinc Bromide (ca. 1 M in THF): Under a nitrogen atmosphere, a 100 mL, three-necked, round-bottomed flask equipped with a dropping funnel and containing activated zinc (3.92 g, 60 mmol) was flamed for 5 min. When cooled, anhydrous THF (40 mL) was added; then allyl bromide (5.44 g, 45 mmol) was slowly added dropwise, and the mixture was stirred at room temperature for 1.5 h.

(4*R*,5*R*)-*N*,*N*′-Bis[(*S*)-1-(4-methoxyphenyl)ethyl]octa-1,7-diene-4,5-diamine [(*R*,*R*)-6]: Diimine **5** (3.1 g, 9.6 mmol) was dissolved in dry THF (30 mL) under a N_2 atmosphere, and the solution was cooled to –78 °C. Then, allylzinc bromide (1 M in THF, 30 mmol, 30 mL), freshly prepared from allyl bromide and zinc dust, was added dropwise over 1 h. The mixture was stirred overnight while the temperature was slowly raised to 20 °C. The reaction was quenched by the addition of 33% NH_4OH/saturated aqueous NH_4Cl (1:1, 50 mL), and the organic material was extracted with Et_2O (3 × 30 mL). The collected layers were combined, dried (Na_2SO_4), and concentrated to leave a brownish sticky solid (3.65 g, 93%). Column chromatography allowed separation of the main diastereomer in high purity. Yellow-orange sticky solid, yield 2.35 g (60%). $[\alpha]_D^{20}$ = –135.1 (*c* = 1.11, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 7.21 (d, *J* = 8.8 Hz, 4 H), 6.84 (d, *J* = 8.8 Hz, 4 H), 5.50–5.40 (m, 2 H), 4.84 (dd, *J* = 2.0, 10.0 Hz, 2 H), 4.74 (d, *J* = 17.2 Hz, 2 H), 3.79 (s, 6 H), 3.71 (q, *J* = 6.0 Hz, 2 H), 2.23–2.15 (m, 4 H), 2.10–2.02 (m, 2 H), 1.25 (d, *J* = 6.0 Hz, 6 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 158.4, 138.4, 136.4, 128.0, 116.3, 113.6, 56.4, 55.3, 55.2, 34.9, 25.2 ppm. MS (ESI): *m*/*z* = 409 $[M + H]^+$. MS (EI, 70 eV): *m*/*z* (%) = 204 (12), 135 (100),105 (12).

***N*,*N*′-Di(Boc)-Octa-1,7-diene-4,5-diamine (7a):** Diamine (*R*,*R*)-**6** (110 mg, 0.27 mmol) was dissolved in CH_2Cl_2 (10 mL) and a solution of BCl_3 (1 M in CH_2Cl_2, 1.35 mL, 1.35 mmol) was added. The solution was stirred at room temperature for 24 h; it slowly turned purple in color. Then, 1 M NaOH (10 mL) was added, and the mixture was stirred for 1 h, after which time $(Boc)_2O$ (290 mg, 1.35 mmol) dissolved in CH_2Cl_2 (2 mL) was added. After vigorous stirring for 12 h, the organic phase was separated, and the organic material was further extracted with CH_2Cl_2 (3 × 15 mL). The collected organic layers were concentrated under reduced pressure, and then a mixture CH_2Cl_2/THF (1:1, 20 mL) was added. The solvents were evaporated under reduced pressure. This operation was repeated four times to obtain a slightly brown solid residue (81 mg). Column chromatography (SiO_2; cyclohexane/ethyl acetate, 95:5) gave compound **7a** as a white sticky solid, yield 65.2 mg (71%). $[\alpha]_D^{20}$ = +4.1 (*c* = 0.12, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 5.82–5.72 (m, 2 H), 5.12–5.08 (m, 4 H), 4.69 (br., 2 H), 3.64 (br., 2 H), 2.40–2.25 (br., 2 H), 2.18–2.13 (m, 2 H), 1.42 (s, 18 H) ppm. ^{13}C NMR (50 MHz, $CDCl_3$, 25 °C): δ = 156.2, 133.9, 118.0, 79.1, 53.2, 37.1, 28.4 ppm. MS (ESI): *m*/*z* = 341 $[M + H]^+$. MS (EI, 70 eV): *m*/*z* (%) = 243 (6), 170 (8), 143(7), 114 (32), 57 (100).

***N*,*N*′-Dibenzoylocta-1,7-diene-4,5-diamine (7b):** BCl_3 (1 M in CH_2Cl_2, 1 mL, 1.0 mmol) was slowly added to a stirred solution of **6** (41 mg, 0.1 mmol) in CH_2Cl_2 (2.5 mL) under a N_2 atmosphere. The purple mixture was stirred for 24 h, after which time the disappearance of the starting material was observed by TLC analysis

(cyclohexane/EtOAc, 7:3). CH_2Cl_2 (2.5 mL) and then Bu_4NF (262 mg, 1.0 mmol), followed by Et_3N (4 mmol, 0.558 mL) were added. After stirring the colorless mixture for 30 min, benzoyl chloride (56 mg, 0.4 mmol) was added and stirring was continued overnight. The reaction was quenched with saturated aqueous $NaHCO_3$ (5 mL), and the organic material was extracted with CH_2Cl_2 (3× 20 mL). The collected organic layers were dried with Na_2SO_4, and then the solvent was removed under vacuum. Product **7b** was recovered as a white solid after chromatography of the residue on a silica gel column (cyclohexane/EtOAc, 8:2), yield 17.5 mg (50%), m.p. 177–185 °C. $[a]_D^{20}$ = –12.8 (*c* = 1.75 in $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 2.48 (m, 4 H), 2.56 (br., 2 H), 4.24 (br., 2 H), 5.14–5.18 (dd, *J* = 1.6, 9.6 Hz, 4 H), 5.88 (m, 2 H), 7.36 (t, *J* = 8.0 Hz, 4 H), 7.42 (d, *J* = 7.2 Hz, 2 H), 7.70 (d, *J* = 7.6 Hz, 4 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 36.2, 52.8, 118.7, 126.9, 128.5, 131.5, 133.5, 134.1, 168.2 ppm. MS (ESI): *m*/*z* = 348 $[M + H]^+$. MS (EI, 70 eV): *m*/*z* (%) = 307 (8), 175 (22), 105 (100), 77 (36).

(1*R*,2*R*)-*N*,*N*′-Bis[(*S*)-1-(4-methoxyphenyl)ethyl]cyclohex-4-ene-1,2-diamine (8): Salt **6**·2HCl (350 mg, 0.73 mmol), prepared by the addition of HCl (2 M in Et_2O) to diamine (*R*,*R*)-**6**, was dissolved in dry CH_2Cl_2 (7 mL) under an argon atmosphere. The solution was deaerated for 5 min, and then the second-generation Grubbs catalyst (25 mg, 0.029 mmol) was added. The mixture was stirred for 12 h, and **8**·2HCl precipitated as a white solid. Then, Et_2O (60 mL) was added and **8**·2HCl was filtered under vacuum, yield 315 mg (95%). Free base **8** was obtained after basification with 5% aq. $NaHCO_3$ (10 mL) and extraction with CH_2Cl_2 (3× 8 mL). White sticky solid, yield 261 mg (94%). $[a]_D^{20}$ = +66.7 (*c* = 2.1, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 7.22 (d, *J* = 8.4 Hz, 4 H), 6.87 (d, *J* = 8.8 Hz, 4 H), 5.50–5.45 (m, 2 H), 3.84 (q overlapped, *J* = 6.4 Hz, 2 H), 3.80 (s, 6 H), 2.50–2.40 (m, 2 H), 2.35–2.27 (m, 2 H), 1.71–1.65 (m, 2 H), 1.33 (d, *J* = 6.8 Hz, 6 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 158.3, 13 7.6, 127.5, 113.8, 55.1, 53.9, 53.7, 31.7, 25.5 ppm. MS (ESI): *m*/*z* = 381 $[M + H]^+$. MS (EI, 70 eV): *m*/*z* (%) = 245 (7), 150 (10), 135 (100), 105 (25).

Preparation of *tert*-Butyl (1*R*,2*R*)-Cyclohex-4-ene-1,2-diyldicarbamate 9

From 7a: Compound **7a** (40 mg, 0.11 mmol) was dissolved in dry CH_2Cl_2 (4 mL) under a N_2 atmosphere; then, the second-generation Grubbs catalyst (5 mg, 0.006 mmol) was added. After 12 h, the mixture was quenched with 5% aq. $NaHCO_3$, and the organic layer was extracted with CH_2Cl_2 (3× 5 mL). Column chromatography of the crude (SiO_2; cyclohexane/ethyl acetate, 95:5) gave **9** as a white sticky solid, yield 23 mg (67%).

From 8: A solution of BCl_3 (1 M in CH_2Cl_2, 2.83 mL, 2.83 mmol) was added to a stirred solution of diamine **7** (185 mg, 0.49 mmol) in dry CH_2Cl_2 (5 mL). After 24 h, 1 M NaOH (10 mL) was added, and the mixture was stirred for 3 h. Then a solution of $(Boc)_2O$ (617 mg, 2.83 mmol) in dry CH_2Cl_2 (6 mL) was added, and the resulting mixture was stirred for 12 h. The organic material was extracted with CH_2Cl_2 (3× 20 mL) and the solvent was coevaporated with Et_2O (2× 10 mL). Column chromatography of the residue (SiO_2; cyclohexane/EtOAc, 95:5) gave **9** as a white sticky solid, yield 108 mg (71%). $[a]_D^{20}$ = +28.9 (*c* = 0.93, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 5.60–5.50 (m, 2 H), 4.91 (br., 2 H), 3.70–3.60 (m, 2 H), 2.55–2.40 (m, 2 H), 2.05–1.90 (m, 2 H), 1.41 (s, 18 H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 156.5, 125.0, 79.2, 51.3, 32.8, 28.4 ppm. MS (ESI): *m*/*z* = 313 $[M + H]^+$. MS (EI, 70 eV): *m*/*z* (%) = 195 (7), 139 (55),95 (21), 82 (39), 57 (100).

Preparation of 10: Diamine **6** (156 mg, 0.38 mmol) was dissolved in trifluoroacetic acid (6 mL), and the solution was heated at reflux for 24 h; then, TFA was coevaporated with CH_2Cl_2 (4× 10 mL). The brownish sticky solid residue was triturated and washed with CH_2Cl_2 (2× 5 mL) and then with cyclohexane (3 mL) to give **10** as a white sticky solid, yield 85 mg (60%). $[a]_D^{20}$ = +10.9 (*c* = 0.63, MeOH). ^{1}H NMR (400 MHz, CD_3OD, 25 °C): δ = 5.90–5.75 (m, 2 H), 5.42–5.30 (m, 4 H), 3.70–3.60 (m, 2 H), 2.65–2.55 (m, 2 H), 2.50–2.38 (m, 2 H) ppm. ^{13}C NMR (100 MHz, CD_3OD, 25 °C): δ = 163.2 (q, *J* = 40.3 Hz), 132.2, 121.8, 118.1 (q, *J* = 290.0 Hz), 53.0, 33.3 ppm. ^{19}F NMR (377 MHz, CD_3OD, 25 °C): δ = –77.06 (s) ppm. MS (ESI): *m*/*z* = 141 $[M – CF_3COOH – CF_3COO^-]^+$.

Supporting Information (see footnote on the first page of this article): NMR spectra of all the isolated intermediates and products; procedures for the addition of allylmagnesium chloride to the diimine; analytical data of diastereoisomers (*S*,*S*)-**6** and (*R*,*S*)-**6**.

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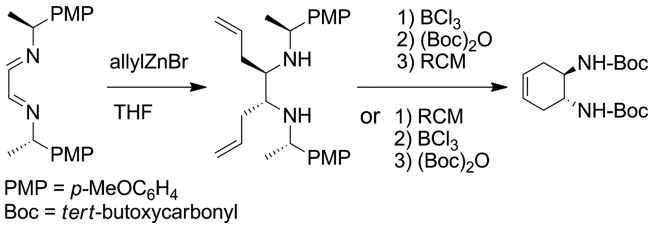

(*R*,*R*)-*N*,*N*′-Di(*tert*-butoxycarbonyl)cyclohex-4-ene-1,2-diamine is synthesized from the glyoxal diimine, which is prepared by using a chiral auxiliary. Double allylation to the diimine proceeds with excellent diastereoselectivity; then, removal of the N-substituents followed by ring-closing metathesis (RCM) of the diene moiety affords the protected cyclohex-4-ene-1,3-diamine in satisfactory overall yield.

Asymmetric Synthesis

Keywords: Asymmetric synthesis / Metathesis / Diastereoselectivity / Chiral auxiliaries / Amines

