Supporting Information

Gallium-Mediated Allyl Transfer from Bulky Homoallylic Alcohol to Aldehydes via Retro-Allylation: Stereoselective Synthesis of Both *erythro*- and *threo*-Homoallylic Alcohols

Sayuri Hayashi, Koji Hirano, Hideki Yorimitsu, and Koichiro Oshima*

*Department of Material Chemistry, Graduate School of Engineering, Kyoto University,
Kyoto-daigaku Katsura, Nishikyo-ku, Kyoto 615-8510, Japan*

Instrumentation and Chemicals

^1H NMR (300 MHz) and ^{13}C NMR (75.3 MHz) spectra were taken on Varian Mercury 300 spectrometers and were recorded in CDCl_3 . Chemical shifts (δ) are in parts per million relative to tetramethylsilane at 0.00 ppm for ^1H and relative to residual CHCl_3 at 77.0 ppm for ^{13}C unless otherwise noted. IR spectra were determined on a SHIMADZU FTIR-8200PC spectrometer. TLC analyses were performed on commercial glass plates bearing 0.25-mm layer of Merck Silica gel 60F₂₅₄. Silica gel (Wakogel 200 mesh) was used for column chromatography. Elemental analyses were carried out at the Elemental Analysis Center of Kyoto University.

Unless otherwise noted, materials obtained from commercial suppliers were used without further purification. Aldehydes were purified by distillation prior to use. Methylmagnesium iodide was prepared from magnesium metal and iodomethane in ether. Dioxane was purchased from Wako Pure Chemical Co. and stored over slices of sodium. Gallium trichloride was purchased from Aldrich and was diluted in a glove box under argon to prepare 1.0 M hexane solution. All reactions were carried out under argon atmosphere.

All the compounds in this article are known compounds. All the products showed reasonable spectra according to the literature. However, stereochemical assignment of *erythro*- and *threo*-**1f** had not been established, which we have now clarified by X-ray crystallographic analysis (*vide infra*). Homoallylic alcohols **1a–1e** were prepared by procedures similar to the preparation of **1f** (*vide infra*).

Experimental Section

Typical Procedure for Allyl Transfer Reaction via Allylic Gallium Reagent (Scheme 1)

Under an argon atmosphere, a solution of **1a** (0.204 g, 1.20 mmol) in 1,4-dioxane (10 mL) was placed in a 30-mL reaction flask. Methylmagnesium iodide (1.0 M ether solution, 1.20 mL, 1.2 mmol) was added dropwise to the solution at ambient temperature. After the mixture was stirred for 1 h, gallium trichloride (1.0 M hexane solution, 1.20 mL, 1.2 mmol) and benzaldehyde (0.106 g, 1.00 mmol) were sequentially added to the resulting suspension. The mixture was stirred for an additional 30 min at ambient temperature, 1 M

hydrochloric acid (10 mL) was added. The products were extracted with hexane/ethyl acetate (5:1, 10 mL $\times$ 3). The combined organic layer was dried over anhydrous MgSO_4 , and concentrated in vacuo. Silica gel column purification (hexane/ethyl acetate = 10:1) gave homoallylic alcohol **2a** (0.152 g, 0.94 mmol, *erythro/threo* = 48:52) in 94% yield.

Preparation of *erythro*- and *threo*-1f

Under an atmosphere of argon, 2,4,6-trimethylbenzaldehyde (2.96 g, 20.0 mmol) was added dropwise to methylmagnesium bromide (1.17 M THF solution, 20.5 mL, 24.0 mmol) in 30 mL of ether at 0 °C in a 100-mL reaction flask. After being stirred for 2 h at 25 °C, the mixture was poured into 1 M hydrochloric acid (30 mL). The products were extracted with ether (30 mL $\times$ 3). The organic layer was dried over MgSO_4 , and solvent was removed under reduced pressure. Chromatographic purification on silica gel (hexane/ethyl acetate = 5:1) afforded 2.96 g of 1-mesitylethanol (18.3 mmol) in 91% yield as a white solid.

Pyridinium chlorochromate (5.82 g, 27 mmol) and silica gel (Wako Pure Chemical C-200, 5.82 g) were ground in a mortar. The resulting orange powder was transferred to a 100-mL reaction flask. Dichloromethane (50 mL) and 1-mesitylethanol (2.96 g, 18.3 mmol) were added with swirling under argon at 0 °C. The mixture turned black and was stirred for 12 h at room temperature. The mixture was diluted with ether (30 mL) and filtered through a pad of Celite. The filtrate was evaporated in vacuo. Silica gel column

purification (hexane/ethyl acetate = 5:1) provided mesityl methyl ketone (2.43 g, 15.3 mmol, 85% yield) as a colorless oil.

Diethyl ether (40 mL) and crotylmagnesium chloride (0.95 M THF solution, 17.4 mL, 16.5 mmol) were added to a 100-mL reaction flask under argon. At 0 °C, the ketone (2.43 g, 15.3 mmol) was added dropwise to the solution. After being stirred for 2 h at room temperature, the mixture was poured into 30 mL of 1 M HCl. The products were extracted with ether three times (30 mL each). Concentration left a colorless oil. Silica gel column purification with toluene as an eluent twice allowed complete separation of *erythro*-**1f** (1.80 g, 8.26 mmol, 54%, faster moving band, $R_f = 0.31$) and *threo*-**1f** (0.77 g, 3.52 g, 23%, slower moving band, $R_f = 0.24$).

Stereoselective Crotylation from Diastereomerically Pure **1f** (Scheme 2)

Carbinol *erythro*-**1f** (0.262 g, 1.20 mmol) was dissolved in ether (10 mL) under argon. Methylmagnesium iodide (1.0 M, 1.20 mL, 1.2 mmol) in ether was added to the solution at –20 °C, and the resulting mixture was stirred for 1 h. At the same temperature, gallium trichloride (1.0 M hexane solution, 1.20 mL, 1.2 mmol) and benzaldehyde (0.11 g, 1.0 mmol) were added. After the mixture was stirred at –20 °C for 17 h, the reaction was quenched with 1 M hydrochloric acid at –20 °C. The mixture was allowed to warm to ambient temperature and was stirred for 10 min. Extraction, evaporation, and purification on silica gel (hexane/ethyl acetate = 10:1) furnished **2a** (0.152 g, 0.94 mmol, 94% yield)

as a 96:4 mixture of *erythro* and *threo* isomers.

Stereochemical Assignment of *erythro*-1f

THF (5.0 mL) was placed in a 30-mL reaction flask under argon. The oil of **1f**, which was the faster moving band of $R_f = 0.31$, was dissolved in THF (1.5 mL), and the solution was added to the reaction flask. 9-Borabicyclo[3.3.1]nonane (9-BBN, 0.183 g, 1.5 mmol) in THF (1.5 mL) was added at ambient temperature. After the mixture was stirred for 3 h, water (0.30 mL), 6 M NaOH (0.25 mL, 1.5 mmol), and 30% hydrogen peroxide (0.50 mL, 4.5 mmol) were sequentially added. A slightly exothermic reaction took place. The reaction was quenched with aqueous sodium thiosulfate, and the products were extracted with ethyl acetate. After removal of solvent, silica gel column purification yielded 0.043 g of 3-methyl-4-(2,4,6-trimethylphenyl)-1,4-pentanediol (0.18 mmol, 36% yield, unoptimized). X-ray quality crystals were grown from pentane/dichloromethane (Figure 1). Crystallographic data for the structure has been deposited with the Cambridge Crystallographic Data Center (CCDC 265711). Copies of the data can be obtained, free of charge, on application to the Director, CCDC, 12 Union Road, Cambridge CB2 1EZ, UK. Fax: 44-1223-3360033 or E-mail: deposit@ccdc.cam.ac.uk

Figure 1. ORTEP Diagram of *erythro*-3-methyl-4-(2,4,6-trimethylphenyl)-1,4-pentanediol.

Some hydrogen atoms are omitted for clarity.

Table 4. Selective synthesis of *erythro* and *threo* homoallylic alcohols (Additional examples for Table 3).

entry	1f	R	2	yield	<i>erythro</i> / <i>threo</i> of 2
1	<i>erythro</i>	PhCH ₂ CH ₂	2c	87%	69:31
2	<i>threo</i>	PhCH ₂ CH ₂	2c	62%	42:58
3	<i>erythro</i>	PhCH=CH	2e	86%	91:9
4	<i>threo</i>	PhCH=CH	2e	66%	21:79

Chart 1. ^1H NMR Spectrum of **2a** (Kobayashi, S.; Nishio, K. *J. Org. Chem.* **1994**, 59, 6620–6628.)

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Chart 2. ^1H NMR Spectrum of **2b** (Shibata, I.; Yoshimura, N.; Yabu, M. Baba, A. *Eur. J.*

Org. Chem. **2001**, 3207–3211.)

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Chart 3. ^1H NMR Spectrum of **2c** (Kobayashi, S.; Nishio, K. *J. Org. Chem.* **1994**, 59, 6620–6628.)

Chart 4. ^1H NMR Spectrum of *threo*-**2d** (Kobayashi, S.; Nishio, K. *J. Org. Chem.* **1994**, 59, 6620–6628.)

Chart 5. ^1H NMR Spectrum of *erythro*-**2d** (Kobayashi, S.; Nishio, K. *J. Org. Chem.* **1994**, 59, 6620–6628.)

Chart 6. ^1H NMR Spectrum of **2e** (Kobayashi, S.; Nishio, K. *J. Org. Chem.* **1994**, 59, 6620–6628.)

Chart 7. ^1H NMR Spectrum of **2f** (Takahara, J.; Masuyama, Y.; Kurusu, Y. *J. Am. Chem. Soc.* **1992**, *114*, 2577–2586.)

2f

Chart 8. ^1H NMR Spectrum of **2g** (Takaki, K.; Kusudo, T.; Uebori, S.; Nishiyama, T.; Kamata, T.; Yokoyama, M.; Takehira, K.; Makioka, Y.; Fujiwara, Y. *J. Org. Chem.* **1998**, *63*, 4299–4304.)

Chart 9. ^1H NMR Spectrum of **2h** (Kobayashi, S.; Nishio, K. *J. Org. Chem.* **1994**, 59, 6620–6628.)

Chart 10. ^1H NMR Spectrum of **2i** (Kobayashi, S.; Nishio, K. *J. Org. Chem.* **1994**, *59*, 6620–6628.)

Chart 11. ^1H NMR Spectrum of **2j** (Kobayashi, S.; Nishio, K. *J. Org. Chem.* **1994**, 59, 6620–6628.)

Chart 12. ^1H NMR Spectrum of **2k** (For *syn* isomer, Denmark, S. E.; Fu, J. *J. Am. Chem. Soc.* **1992**, 114, 2577–2586. For *anti* isomer, Malkov, A. V.; Dufková, L.; Farrugia, L.; Kocovsky, P. *Angew. Chem. Int. Ed.* **2003**, 42, 3674–3677.)

Chart 13. ^1H NMR Spectrum of **2l** (Takahara, J.; Masuyama, Y.; Kurusu, Y. *J. Am. Chem. Soc.* **1992**, *114*, 2577–2586.)