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Supporting Information

Stereoselective Cyclization of Highly Enantio-Enriched Allylsilanes with Aldehydes via Acetal Formation: New Asymmetric Access to Tetrahydropyrans and Piperidines

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Experimental Procedures and Spectral Data for New Compounds

General

All reactions were carried out in dried solvents under a nitrogen atmosphere. The NMR mesurments were performed with Varian Gemini-2000 (7.0 T magnet: 300 MHz for ^1H NMR; 75.4 MHz for ^{13}C NMR). The proton chemical shifts (ppm) are referenced to internal residual solvent protons ($CHCl_3$, 7.26) or TMS (0.00). The carbon chemical shifts are referenced to the carbon signal of the deuterated solvents ($CDCl_3$, 77.0).

(*E*)-5-(Dimethylphenylsilyl)-1-tetrahydropyranyloxy-4-nonene (4a). To a mixture of **2a** (6.9 g, 28 mmol), triethylamine (6 mL, 43 mmol), and 4-(dimethyamino)pyridine (71 mg, 0.58 mmol) was added 1-chloro-1,1,2-triphenyl-2,2-dimethyldisilane (10 g, 28 mmol) at room temperature; the mixture was stirred at room temperature for 12 h. After the completion of the reaction, hexane was added to the mixture and the precipitate formed was filtered off. Distillation under reduced pressure gave **3a** (14.7 g, 93%). To a mixture of $Pd(acac)_2$ (123 mg, 0.40 mmol), 1,1,3,3-tetramethylbutyl isonitrile (0.53 mL, 3.0 mmol) were added toluene (40 mL) and **3a** (12.4 g, 22.2 mmol) successively at room temperature; the mixture was heated under reflux for 1 h. After the volatile material was evaporated under reduced pressure, THF (50 mL) was added to the residue. To the mixture was added *n*-BuLi (1.53 M in hexane, 22 mL, 34 mmol) dropwise at 0 °C; the mixture was stirred for 20 min at 0 °C. Saturated NH_4Cl aq was added to the solution, and organic material was extracted with ether. Column chromatography on silica gel (hexane: ether = 50:1-1:1) afforded **4a** (5.8 g, 73%). **4a** (a 1:1 mixture of the two diastereomers): ^{1}H NMR ($CDCl_3$) δ 0.21 (s, 3H), 0.23 (s, 3H), 0.79 (t, J = 6.9 Hz, 3H), 1.02-1.73 (m, 12H), 1.76-1.85 (m, 1H), 3.29-3.38 (m, 1H), 3.45-3.52 (m, 1H), 3.64-3.73 (m, 1H), 3.82-3.89 (m, 1H), 4.55-4.59 (m, 1H), 5.13-5.28 (m, 2H), 7.29-7.34 (m, 3H), 7.44-7.48 (m, 2H); IR (neat) 2950, 2920, 1250, 1140, 1120, 1080, 1030 cm^{-1}. Anal Calcd for $C_{22}H_{36}O_2Si$: C, 73.28; H, 10.06. Found: C, 73.20; H, 10.16.

(*S*)-(*E*)-6-(Dimethylphenylsilyl)-1-tetrahydropyranyloxy-4-decene (4b). To a mixture of (*R*)-**2b** (3.6 g, 14 mmol), triethylamine (3.0 mL, 22 mmol), and 4-(dimethyamino)pyridine (34 mg, 0.28 mmol) was added 1-chloro-1,1,2-triphenyl-2,2-dimethyldisilane (5.1 g, 14.4 mmol) at room temperature; the mixture was stirred at room temperature for 12 h. Column chromatography on silica gel afforded (*R*)-**3b** (8.0 g, quantitative). To a mixture of Pd(acac)$_2$ (81 mg, 0.27 mmol), 1,1,3,3-tetramethylbutyl isonitrile (0.34 mL, 2.0 mmol) were added toluene (25 mL) and (*R*)-**3b** (7.68 g, 13.4 mmol) successively at room temperature; the mixture was heated under reflux for 1 h. After the volatile material was evaporated under reduced pressure, THF (30 mL) was added to the residue. To the mixture was added *n*-BuLi (1.52 M in hexane, 13 mL, 20 mmol) dropwise at 0 °C; the mixture was stirred for 20 min at 0 °C. Saturated NH_4Cl aq was added to the solution, and organic material was extracted with ether. Column chromatography on silica gel (hexane: ether = 15:1-10:1) afforded (*S*)-**4b** (3.79 g, 75%). **4b** (a 1:1 mixture of the two diastereoisomers): ^{1}H NMR ($CDCl_3$) δ 0.21 (s, 3H), 0.23 (s, 3H), 0.80 (t, J = 6.9 Hz, 3H), 1.03-1.42 (m, 6H), 1.46-1.74 (m, 8H), 1.77-1.86 (m, 1H), 2.01-2.08 (m, 2H), 3.34 (dt, J = 9.6, 6.6 Hz, 1H), 3.44-3.51 (m, 1H), 3.71 (dt, J = 9.6, 6.6 Hz, 1H), 3.82-3.89 (m, 1H), 4.53-4.56 (m, 1H), 5.11-5.25 (m, 2H), 7.31-7.33 (m, 3H), 7.45-7.48 (m, 2H); IR (neat) 2950, 1250, 1140, 1120, 1080, 1065, 1040 cm^{-1}. Anal Calcd for $C_{23}H_{38}O_2Si$: C, 73.74; H, 10.22. Found: C, 73.69; H, 10.34.

(*E*)-5-(Dimethylphenylsilyl)-3-nonen-1-ol (1a). To the THP ether **4a** (5.5 g, 15.3 mmol) in EtOH (110 mL) was added pyridinium *p*-toluenesulfonate (0.40 g, 1.6 mmol) at room temperature; the mixture was stirred at 55 °C for 3 h. Addition of hexane to the mixture led to the formation of precipitate, which was removed by filtration. Distillation under reduced pressure afforded **1b** (4.1 g, 96%). ^{1}H NMR ($CDCl_3$) δ 0.23 (s, 3H), 0.24 (s, 3H), 0.81 (t, J = 7.2 Hz, 3H), 1.05-1.45 (m, 6H), 1.56 (br s, 1H), 1.63-1.71 (m, 1H), 2.15-2.23 (m, 2H), 3.47 (dt, J = 3.6, 6.0 Hz, 2H), 5.06 (dt, J = 15.6, 7.2 Hz, 1H), 5.26 (ddt, J = 15.6, 9.6, 0.9 Hz, 1H), 7.31-7.36 (m, 3H), 7.43-7.47

(m, 2H); ^{13}C NMR ($CDCl_3$) δ –5.0, –4.9, 13.9, 22.3, 28.4, 31.6, 32.9, 36.2, 62.2, 124.1, 127.7, 129.0, 134.0, 135.4, 138.1; IR (neat) 3360, 2970, 2940, 1430, 1250, 1110, 1050 cm^{-1}. Anal Calcd for $C_{17}H_{28}OSi$: C, 73.85; H, 10.21. Found: C, 73.82; H, 10.34.

(*S*)-(*E*)-6-(Dimethylphenylsilyl)-4-decen-1-ol (1b). To the THP ether (*S*)-**4b** (3.9 g, 10 mmol) in EtOH (90 mL) was added pyridinium *p*-toluenesulfonate (0.5 g, 2 mmol) at room temperature; the mixture was stirred at 55 °C for 3 h. Addition of hexane to the mixture led to the formation of precipitate, which was removed by filtration. Distillation under reduced pressure afforded **1b** (2.7 g, 90%). ^1H NMR ($CDCl_3$) δ 0.22 (s, 3H), 0.23 (s, 3H), 0.80 (t, J = 6.9 Hz, 3H), 1.03-1.43 (m, 6H), 1.50-1.66 (m, 4H), 1.98-2.10 (m, 2H), 3.58 (t, J = 6.9 Hz, 2H), 5.12-5.23 (m, 2H), 7.30-7.34 (m, 3H), 7.44-7.47 (m, 2H); ^{13}C NMR ($CDCl_3$) δ –5.1, –4.5, 13.9, 22.3, 28.4, 29.0, 31.4, 32.4, 32.8, 62.5, 127.6, 127.9, 128.8, 131.9, 134.1, 138.3; ; IR (neat) 3380, 2960, 2930, 1430, 1240, 1110, 1050 cm^{-1}. Anal Calcd for $C_{18}H_{30}OSi$: C, 74.42; H, 10.41. Found: C, 74.33; H, 10.42.

(2*R,3*S**)-3-(1-Hexenyl)-2-(1-methylethyl)terahydrofuran (5).** To a mixture of **1a** (56 mg, 0.20 mmol) and isobutyraldehyde (19 μL, 0.21 mmol) in CH_2Cl_2 (4 mL) was added TMSOTf (37 μL, 0.21 mmol) at –78°C under a nitrogen atmosphere; the mixture was stirred for 2 h at –78 °C. The mixture was treated with NaOH aq. (1 mol/dm^3) at –78°C, warmed to room temperature, and extracted with ether. Column chromatography on silica gel (hexane:ether = 20:1) afforded **5** (41 mg, quantitative) as a mixture of the *E* and Z-isomers. **5**: ^1H NMR ($CDCl_3$) δ 0.75 (d, J = 6.6 Hz, 3H for isomer A), 0.78 (d, J = 6.6 Hz, 3H for isomer A), 0.83-0.89 (m, 3H for both isomers), 0.97 (d, J = 6.3 Hz, 6H for isomer B), 1.24-1.34 (m, 4H for both isomer), 1.58-1.76 (m, 2H for both isomer), 1.94-2.21 (m, 3H for both isomer), 2.63-2.69 (m, 1H for isomer A or B), 2.97-3.05 (m, 1H for isomer A or B), 3.19 (dd, J = 9.6, 4.8 Hz, 1H for isomer A or B), 3.24 (dd, J = 9.6, 4.8 Hz, 1H for isomer A of B), 3.71-3.79 (m, 1H for both isomer), 3.91 (q, J = 8.1 Hz, 1H for both isomer), 5.23-5.48 (m, 2H for both isomer); ^{13}C NMR ($CDCl_3$) δ 13.8, 13.9, 18.6, 19.0, 20.4, 20.5, 22.0, 22.3, 27.0, 29.1, 29.2, 31.6, 31.8, 32.2, 33.4, 33.9, 38.5, 44.3, 66.20, 66.24, 88.4, 128.5, 128.9, 129.7, 131.3. Anal Calcd for $C_{13}H_{24}O$: C, 79.53; H, 12.32. Found: C, 79.25; H, 12.16.

(2*S*,3*S*)-(*E*)-3-(1-Hexenyl)-2-(1-methylethyl)tetrahydropyran (6a). To a mixture of (*S*)-**1b** (100 mg, 0.34 mmol) and isobutyraldehyde (35 μL, 0.38 mmol) in CH_2Cl_2 (8 mL) was added TMSOTf (70 μL, 0.39 mmol) at –78°C under a nitrogen atmosphere; the mixture was stirred for 2 h at –78 °C. The mixture was treated with NaOH aq. (1 mol/dm^3) at –78°C, warmed to room temperature, and extracted with ether. Preparative TLC on silica gel (hexane:ether = 20:1) afforded (2*S*,3*S*)-**6a** (71 mg, 98%). **6a**: ^{1}H NMR ($CDCl_3$) δ 0.81 (d, J = 6.9 Hz, 3H), 0.86 (t, J = 7.2 Hz, 3H), 0.93 (d, J = 6.9 Hz, 3H), 1.23-1.41 (m, 5H), 1.44-1.63 (m, 2H), 1.65-1.76 (m, 1H), 1.80 (d of septet, J = 2.1, 6.9 Hz, 1H), 1.91-2.10 (m, 3H), 2.84 (dd, J = 2.1, 9.9 Hz, 1H), 3.30 (dt, J = 3.0, 11.4 Hz, 1H), 3.95 (ddt, J = 11.4, 4.2, 2.1 Hz, 1H), 5.12 (dd, J = 15.3, 9.0 Hz, 1H), 5.42 (dt, J = 15.3, 6.9 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 13.8, 14.6, 20.3, 22.1, 26.1, 29.3, 31.5, 31.6, 32.3, 42.5, 68.5, 85.7, 131.0, 131.6. Anal Calcd for $C_{14}H_{26}O$: C, 79.94; H, 12.46. Found: C, 79.65; H, 12.48.

(2*S*,3*S*)-(*E*)-3-(1-Hexenyl)-2-methyltetrahydropyran (6b). By a procedure similar to that for **6a**, (2*S*,3*S*)-**6b** (57 mg, 89%) was synthesized from (*S*)-**1b** (103 mg, 0.36 mmol), 1,1-diethoxyethane (56 μL, 0.39 mmol), and TMSOTf (71 μL, 0.39 mmol). The compound was isolated by column chromatography on silica gel (hexane:ether = 40:1–10:1). **6b**: ^{1}H NMR ($CDCl_3$) δ 0.85 (t, J = 6.9 Hz, 3H), 1.10 (d, J = 6.3 Hz, 3H), 1.22-1.36 (m, 5H), 1.48-1.84 (m, 4H), 1.91-1.98 (m, 2H), 3.08 (dq, J = 9.3, 6.3 Hz, 1H), 3.36 (dt, J = 3.0, 11.7 Hz, 1H), 3.88-3.94 (m, 1H), 5.12 (dd, J = 15.0, 8.4 Hz, 1H), 5.42 (dt, J = 15.0, 6.9 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 13.8, 20.1, 22.0, 25.9, 30.7, 31.5, 32.3, 47.1, 68.1, 77.6, 131.58, 131.62. Anal Calcd for $C_{12}H_{22}O$: C, 79.06; H, 12.16. Found: C, 78.91; H, 12.08.

(2*S*,3*S*)-(*E*)-3-(1-Hexenyl)-2-hexyltetrahydropyran (6c). By a procedure similar to that for **6a**, (2*S*,3*S*)-**6c** (80 mg, 92%) was synthesized from (*S*)-**1b** (101 mg, 0.35 mmol), heptanal (53 μL, 0.38 mmol), and TMSOTf (125 μL, 0.69 mmol). The compound was isolated by column chromatography on silica gel (hexane:ether = 50:1–30:1). **6c**: ^{1}H NMR ($CDCl_3$) δ 0.82-0.88 (m, 6H), 1.22-1.75 (m, 18H), 1.82-1.99 (m, 3H), 2.90-3.30 (m, 1H), 3.33 (dt, J = 3.0, 12.0 Hz, 1H), 3.94 (ddt, J = 12.0, 4.5, 1.8 Hz, 1H), 5.11 (dd, J = 15.0, 9.0 Hz, 1H), 5.41 (dt, J = 15.0, 6.9 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 13.8, 14.0, 22.0, 22.5, 25.3, 26.0, 29.4, 31.1, 31.6, 31.8, 32.2, 33.9, 45.3, 68.2, 81.4, 131.4, 131.8. Anal Calcd for $C_{17}H_{32}O$: C, 80.88; H, 12.78. Found: C, 80.61; H, 12.78.

(2*S*,3*S*)-(*E*)-2-Cyclohexyl-3-(1-hexenyl)tetrahydropyran (6d). By a procedure similar to that for **6a**, (2*S*,3*S*)-**6d** (47 mg, 99%) was synthesized from (*S*)-**1b** (55 mg, 0.19 mmol), cyclohexanecarboxaldehyde (25 μL, 0.21 mmol), and TMSOTf (38 μL, 0.21 mmol). The compound was isolated by column chromatography on silica gel (hexane:ether = 150:1–50:1). **6d**: ^{1}H NMR ($CDCl_3$) δ 0.86 (t, J = 6.9 Hz, 3H), 1.10-1.70 (m, 19H), 1.96 (q, J = 6.6 Hz, 2H), 2.04-2.16 (m, 1H), 2.81 (d, J = 9.9 Hz, 1H), 3.29 (dt, J = 3.0, 10.8 Hz, 1H), 3.94 (ddt, J = 10.8, 4.5, 2.1 Hz, 1H), 5,11 (dd, J = 15.6, 8.7 Hz, 1H), 5.39 (dt, J = 15.6, 6.6 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 13.8, 22.0, 25.2, 26.1, 26.6, 26.8, 30.7, 31.5, 31.6, 32.2, 39.7, 41.7, 68.6, 85.9, 131.1, 131.7. Anal Calcd for $C_{17}H_{30}O$: C, 81.54; H, 12.08. Found: C, 81.51; H, 12.07.

(2*R*,3*S*)-(*E*)-2-(1,1-Dimethylethyl)-3-(1-hexenyl)tetrahydropyran (6e). By a procedure similar to that for **6a**, (2*R*,3*S*)-**6e** (69 mg, 88%) was synthesized from (*S*)-**1b** (102 mg, 0.35 mmol), pivalaldehyde (42 μL, 0.39 mmol), and TMSOTf (70 μL, 0.39 mmol). The compound was isolated by preparative TLC on silica gel (hexane:ether = 50:1). **6e**: ^{1}H NMR ($CDCl_3$) δ 0.82-0.87 (m, 3H), 0.88 (s, 9H), 1.21-1.38 (m, 5H), 1.42-1.65 (m, 3H), 1.90-1.97 (m, 2H), 2.11 (ddt, J = 11.1, 3.6, 9.3 Hz, 1H), 2.69 (d, J = 9.3 Hz, 1H), 3.26 (dt, J = 2.1, 11.4 Hz, 1H), 3.93 (ddt, J = 11.4, 4.8, 1.5 Hz, 1H), 5.20 (dd, J = 15.3, 9.3 Hz, 1H), 5.31 (dt, J = 15.3, 6.3 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 13.9, 22.2, 26.0, 27.3, 31.4, 32.2, 33.6, 35.6, 43.3, 68.6, 89.0, 128.6, 134.5. Anal Calcd for $C_{15}H_{28}O$: C, 80.29; H, 12.58. Found: C, 80.54; H, 12.87.

(3*S*)-(*E*)-3-(1-Hexenyl)-2,2-dimethyltetrahydropyran (6f). By a procedure similar to that for **6a**, (3*S*)-**6f** (65 mg, 95%) was synthesized from (*S*)-**1b** (101 mg, 0.35 mmol), acetone (28 μL, 0.38 mmol), and TMSOTf (126 μL, 0.70 mmol). The compound was isolated by column chromatography on silica gel (hexane:ether = 80:1–30:1). **6f**: ^{1}H NMR ($CDCl_3$) δ 0.86 (t, J = 7.2 Hz, 3H), 1.08 (s, 3H), 1.15 (s, 3H), 1.23-1.35 (m, 4H), 1.45-1.62 (m, 4H), 1.92-2.06 (m, 3H), 3.54-3.69 (m, 2H), 5.20 (ddt, J = 15.3, 8.4, 1.5 Hz, 1H), 5.41 (dt, J = 15.3, 6.6 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 13.9, 18.3, 22.1, 25.8, 26.1, 29.1, 31.6, 32.3, 49.1, 61.4, 74.3, 131.4, 131.8. Anal Calcd for $C_{13}H_{24}O$: C, 79.53; H, 12.32. Found: C, 79.81; H, 12.56.

(2*R*,3*S*)-(*E*)-3-(1-Hexenyl)-2-(2-methylpropen-1-yl)tetrahydropyran (6g). To a mixture of (*S*)-**1b** (55 mg, 0.19 mmol) and 3-methyl-2-butenal (19 μL, 0.20 mmol) in acetonitrile (4 mL) was added TMSOTf (4 μL, 0.02 mmol) at –30 °C under a nitrogen atmosphere; the mixture was stirred for 3 h at –30 °C and 1 h at room temperature. The mixture was treated with NaOH aq. (1 mol/dm^3) and extracted with ether. Column chromatography on silica gel (hexane:ether = 60:1) afforded (2*R*,3*S*)-**6g** (30 mg, 72%). **6g**: ^{1}H NMR ($CDCl_3$) δ 0.84 (t, J = 6.9 Hz, 3H), 1.20-1.42

(m, 5H), 1.49-1.70 (m, 2H), 1.62 (s, 3H), 1.68 (s, 3H), 1.78-1.99 (m, 4H), 3.39 (dt, J = 2.1, 11.7 Hz, 1H), 3.64 (t, J = 9.0 Hz, 1H), 3.91-3.96 (m, 1H), 5.06-5.14 (m, 2H), 5.35 (dt, J = 15.3, 6.9 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 13.8, 18.7, 21.8, 25.6, 25.8, 30.1, 31.5, 32.3, 44.9, 67.9, 78.3, 125.4, 131.0, 131.1, 136.4. Anal Calcd for $C_{15}H_{26}O$: C, 81.02; H, 11.79. Found: C, 80.75; H, 11.63.

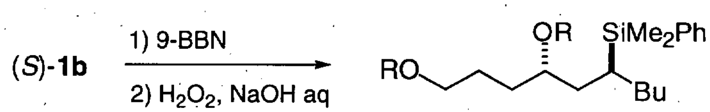
(1*R,6*R**,7*R**,8*S**,9*R**)-8-Butyl-7-(dimethylphenylsilyl)-9-(1-methylethenyl)-2-oxabicyclo[4.3.0]nonane (7).** By a procedure similar to that for **6a**, **7** (39 mg, 52%) was synthesized from racemic **1b** (60 mg, 0.21 mmol), 3-methyl-2-butenal (20 μL, 0.21 mmol), and TMSOTf (41 μL, 0.23 mmol). The compound was isolated by preparative TLC on silica gel (hexane:ether = 8:1). **7**: ^1H NMR ($CDCl_3$) δ 0.29 (s, 3H), 0.32 (s, 3H), 0.78 (t, J = 6.9 Hz, 3H), 1.00-1.32 (m, 8H), 1.42-1.60 (m, 3H), 1.63 (s, 3H), 1.75-1.91 (m, 2H), 2.35 (dd, J = 6.3, 4.8 Hz, 1H), 3.33-3.41 (m, 1H), 3.55 (t, J = 4.8 Hz, 1H), 3.72-3.78 (m, 1H), 4.59 (s, 1H), 4.68-4.69 (m, 1H), 7.31-7.35 (m, 3H), 7.49-7.52 (m, 2H); ^{13}C NMR ($CDCl_3$) δ –4.1, –3.3, 14.0, 21.1, 22.3, 22.9, 26.0, 29.6, 32.2, 37.4, 39.3, 42.9, 56.5, 65.1, 110.9, 127.7, 128.9, 133.9, 138.9, 147.0. Anal Calcd for $C_{23}H_{36}OSi$: C, 77.46; H, 10.18. Found: C, 77.51; H, 10.16.

(*E*)-1-Amino-6-(dimethylphenylsilyl)-4-decene (8). A mixture of **1b** (1.10 g, 3.77 mmol), PPh_3 (1.29 g, 4.92 mmol), NaN_3 (0.49 g, 7.57 mmol), and tetrabromomethane (1.89 g, 5.69 mmol) in DMF (20 mL) was stirred at room temperature for 9 h. Extractive workup with ether followed by a short column on silica gel (hexane:ether = 3/1) afforded (*E*)-1-azido-6-(dimethylphenylsilyl)-4-decene. The azide in THF (5 mL) was added dropwise to a suspension of $LiAlH_4$ (0.15 g, 3.82 mmol) in THF (5 mL) at room temperature. The mixture was stirred at room temperature for 1 h. To the mixture were successively added water (0.15 mL), NaOH aq (3 mol/dm^3, 0.15 mL), and water (0.43 mL) at room temperature. Precipitates were filtered off, and the resulting filtrate was washed with NaOH aq (1 mol/dm^3). Bulb-to-bulb distillation (110 °C/0.1 mmHg) gave **8** (0.81 g, 74% for the two steps). **8**: ^1H NMR ($CDCl_3$) δ 0.21 (s, 3H), 0.22 (s, 3H), 0.79 (t, J = 6.9 Hz, 3H), 1.02-1.49 (m, 8H), 1.56-1.70 (m, 3H), 1.96-2.02 (m, 2H), 2.62 (t, J = 6.9 Hz, 2H), 5.09-5.21 (m, 2H), 7.31-7.33 (m, 3H), 7.44-7.47 (m, 2H); ^{13}C NMR ($CDCl_3$) δ –5.1, –4.5, 13.9, 22.3, 28.5, 30.1, 31.4, 32.4, 33.6, 41.4, 127.6, 128.1, 128.8, 131.6, 134.1, 138.4; IR (neat) 3400, 3000, 2960, 1590, 1480, 1440, 1260, 1120 cm^{-1}. Anal Calcd for $C_{18}H_{31}NSi$: C, 74.67; H, 10.79; N, 4.84. Found: C, 74.76; H, 10.88; N, 4.90.

(2*S*,3*S*)-(*E*)-3-(1-Hexenyl)-2-(1-methylethyl)piperidine (9). A mixture of **8** (107 mg, 0.37 mmol), isobutyraldehyde (100 μL, 1.1 mmol), and CF_3CO_2H (85 μL, 1.1 mmol) in acetonitrile (2 mL) was heated under reflux for 14 h. After evaporation of the volatile material, NaOH aq. (1 mol/dm^3) was added to the residue. Extraction with ether followed by preparative TLC ($CHCl_3$:MeOH:NH_3 aq = 125:10:1) afforded **9** (68 mg, 88%). ^{1}H NMR ($CDCl_3$) δ 0.78 (d, J = 6.9 Hz, 3H), 0.85 (t, J = 6.9 Hz, 3H), 0.91 (d, J = 7.2 Hz, 3H), 1.13-1.72 (m, 10H), 1.82-1.98 (m, 4H), 2.11 (dd, J = 9.9, 2.4 Hz, 1H), 2.53 (dt, J = 2.7, 12.0 Hz, 1H), 3.04-3.10 (m, 1H), 5.14 (dd, J = 15.3, 8.7 Hz, 1H), 5.38 (dt, J = 15.3, 6.6 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 13.8, 14.7, 20.5, 22.1, 26.5, 28.8, 31.7, 32.2, 33.0, 44.0, 47.3, 66.1, 130.4, 133.1. Anal Calcd for $C_{14}H_{27}N$: C, 80.31; H, 13.00; N, 6.69. Found: C, 80.15; H, 12.85; N, 6.67.

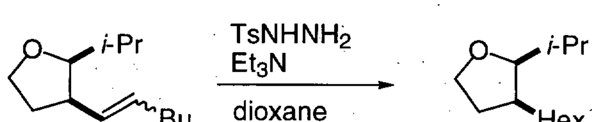
Procedures for the Determination of the Stereochemistries

Enantiomeric Excess of (*S*)-1b. The enantio-enriched allylsilane (*S*)-**1b** was transformed into diol **i** by stereoselective hydroboration with 9-BBN followed by oxidation with basic hydrogen peroxide. The dicarbamate **i'**, which was prepared by reaction of 3,5-dinitrophenylisocyanate with **i** in the presence of pyridine, was subjected to the HPLC analysis with chiral column Sumichiral OA-4000 (hexane:EDC:EtOH = 50:15:2) (EDC: 1,2-dichloroethane).



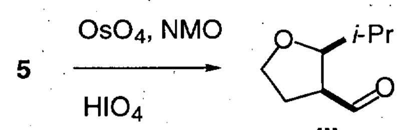
i (R = H)
i' (R = CONHAr: Ar = 3,5-$(NO_2)_2$Ph)

Relative Stereochemistry of 5. The C=C bond of **5** was hydrogenated by diimide, generated from tosylhydrazide in the presence of base, to give 2-isopropyl-3-hexyltetrahydrofuran **ii** in high yield as a single isomer.



5 **ii**

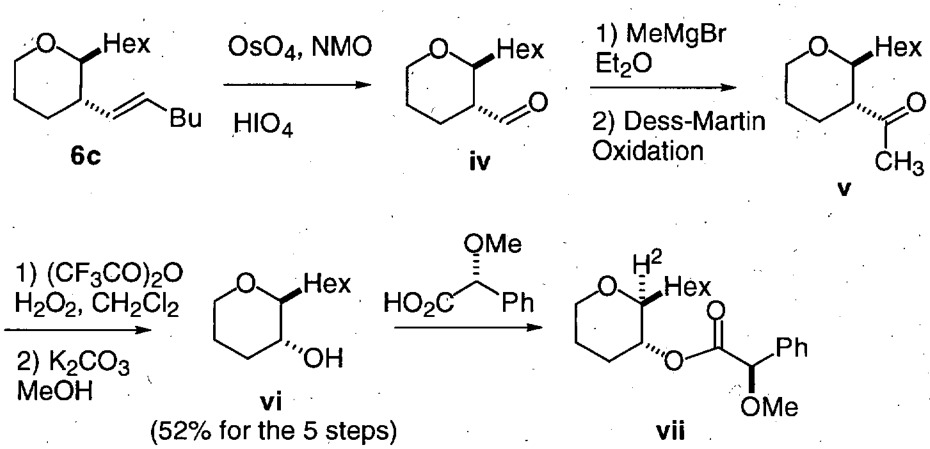
The stereochemistry of *cis* in the five-membered ring was confirmed by transformation to the known compound **iii** (^{1}H NMR). See: Frauenrath, H.; Runsink, J. *J. Org. Chem.* **1987**, *52*, 2707-2712.



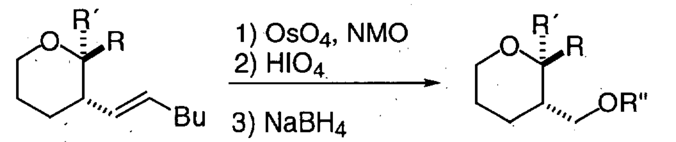
iii

Relative Stereochemistry of 6. The stereochemistry of *trans* in the six-membered ring and that of *E* for the C=C bond were assigned by the ^{1}H NMR coupling constants for ring protons at the 2- and 3-positions (J = 9.3-9.9 Hz) and that for olefinic protons (J = 15.0-15.6 Hz), respectively.

Absolute Configuration of 6c. For the determination of the absolute configuration, **6c** was transformed into **vi**, which was subjected to the mandelate method reported by Trost et al. for determination of absolute configuration of secondary alcohols. Oxidative cleavage of the C=C bond of **6c** afforded aldehyde **iv**. Methylation with methylmagnesium bromide followed by treatment with Dess-Martin periodinane gave methyl ketone **v**. Baeyer-Villiger oxidation with trifluoroacetic anhydride-H_2O_2 followed by deacetylation afforded tetrahydropyranol **vi** in 52% yield from the starting **6c**. Esterification with (*R*)-*O*-methylmandelic acid in the presence of DCC provided the corresponding mandelate **vii** exhibiting the ^{1}H NMR signal for H^2 at 3.03 ppm, which was at higher field than the corresponding signal for the possible diastereomer (3.18 ppm). According to the Trost's report, the stereochemistry at the 3-position was determined to be *S*.



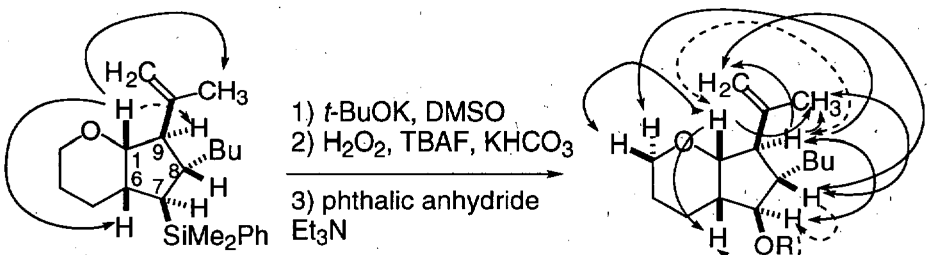
Enantiomeric Excesses of 6a-g. The enantiomeric excess of **6b** was determined by chiral GC with Cyclodextrine-β-236M-19 column (0.25 mm × 50 m). 3-Alkenylpyrans **6a,c-g** were transformed into the corresponding pyran-3-ylmethanol derivatives **viii** as shown in the following equation. The HPLC analyses were carried out for their *N*-(3,5-dinitrophenyl)carbamates **viii'**.



6

viii (R = H)
viii' (R = CONHAr, Ar = 3,5-$(NO_2)_2$Ph)

Relative Stereochemistry of 7. Relative stereochemistry at the 1, 6, and 9 positions was determined by NOE experiments of **7**. Relative configurations at the 7 and 8 positions were determined by NOE experiments for a phthalate derivative which was prepared by oxidation of the Si-C bond followed by reaction with phthalic anhydride.

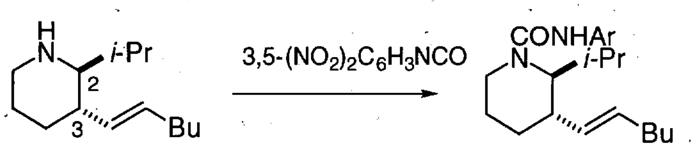


7

: observed NOE
: observed NOE for vicinally trans protons in the five-membered ring

R = $COC_6H_4CO_2H$

Enantiomeric Excess of 9. HPLC analysis was carried out for its *N*-(3,5-dinitrophenyl)urethane derivative **9'**.



9

9' (Ar = 3,5-$(NO_2)_2$Ph)

Absolute Configuration of 9. Trost's method was applied for *N*-tosyl-2-isopropylpiperidin-3-ol, which was obtained according to the following scheme.

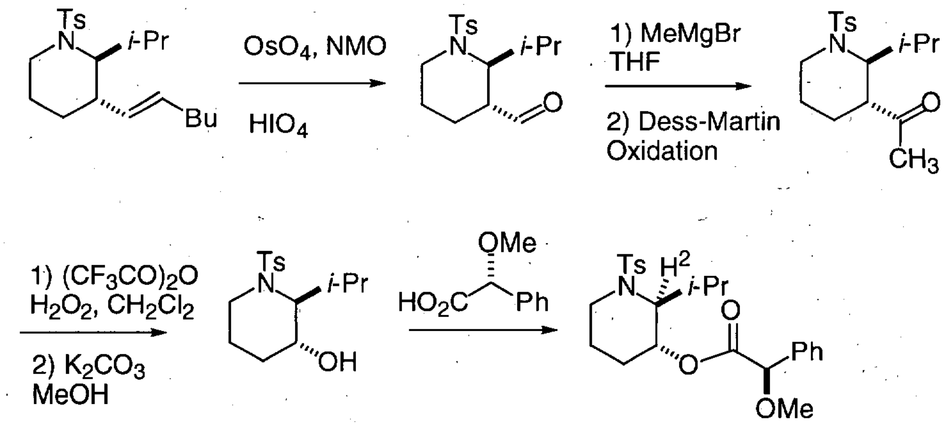


Table. Summary of chiral HPLC analyses.[a]

compd	chiral column (Sumichiral OA series)	eluent (hexane:EDC :EtOH)	1st eluted enantiomer (RT1/s)	2nd eluted enantiomer (RT2/s)	k'1	k'2	k'2/k'1
viiia' (6a)	OA-4500 × 3	15:5:1	2S,3S (45.0)	2R,3R (47.0)	4.45	4.69	1.05
viiic' (6c)	OA-4100 × 2	50:15:1	2R,3R (25.0)	2S,3S (26.5)	3.60	3.87	1.08
viiid' (6d)	OA-4100 × 3	15:5:1	2R,3R (50.2)	2S,3S (52.5)	5.63	5.94	1.05
viiie' (6e)	OA-4500 × 2	15:5:1	2R,3S (33.8)	2S,3R (36.3)	4.56	4.97	1.09
viiif' (6f)	OA-4500 × 3	15:5:1	3S (55.0)	3R (57.4)	5.27	5.54	1.05
viiig' (6g)	OA-4000	50:15:1	2S,3R (17.8)	2R,3S (19.9)	5.41	6.14	1.14
9'	OA-4500 × 2	15:5:1	2S,3S (26.0)	2R,3R (27.4)	3.33	3.56	1.07

[a] Flow rate:1 mL/min; Temp.: 30°C; Detection: UV (254 nm).