The Effects of a Remote Stereogenic Center in the Lewis Base Catalyzed Aldol Additions of Chiral Trichlorosilyl Enolates

Scott E. Denmark* and Shinji Fujimori

*Roger Adams Laboratory, Department of Chemistry, University of Illinois,
Urbana-Champaign, Illinois 61801*

SUPPORTING INFORMATION

General Experimental

^1H , ^{13}C and ^{31}P NMR spectra were recorded on Varian Unity-400 (400 MHz ^1H , 100 MHz ^{13}C , 162 MHz ^{31}P), Unity-500 (500 MHz ^1H , 125 MHz ^{13}C , 202 MHz ^{31}P) and Varian Unity Inova 500 (500 MHz ^1H) spectrometers in deuteriochloroform unless otherwise stated. Data are reported in the following order: chemical shift in ppm (); multiplicities are indicated (br (broadened), s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet)); coupling constants, J , are reported in hertz (Hz); integration is provided; and assignment is indicated. Mass spectrometry was performed by the University of Illinois Mass Spectrometry Center. Electron impact (EI) spectra were performed on a Finnigan-MAT CH-5 spectrometer, chemical ionization (CI) spectra were obtained on a VG 70-VSE spectrometer using methane as the carrier gas, and field ionization (FI) spectra were obtained from VG 70-VSE A spectrometer. Data are reported in the form of m/z (intensity relative to base peak = 100). Infrared spectra (IR) were recorded on a Mattson Galaxy 5020 spectrophotometer. Peaks are reported in cm^{-1} with indicated intensities: s (strong, 67 – 100% absorption), m (medium, 34 – 66%), w (weak, 0 – 33%). Optical rotations were measured on a Jasco DIP-360 digital polarimeter and are reported in the standard format for []. Elemental analyses were performed by the University of Illinois Microanalytical Service Laboratory.

Analytical thin-layer chromatography was performed on Merck silica gel plates with F-254 indicator. Visualization was accomplished by UV light, iodine, potassium permanganate solution (KMnO_4), phosphomolibdic acid stain (PMA), *p*-anisaldehyde stain or dinitrophenylhydrazine (DNP) solution. Column chromatography was performed by the method

of Still¹ with 32-63 mm silica gel (Merck). Bulb-to-bulb distillations were performed on a Buchi GKR-50 Kugelrohr and boiling points (bp) correspond to uncorrected, air bath temperatures. Analytical supercritical fluid chromatography (SFC) was performed on a Berger Instruments packed-column SFC with built in photometric detector. Analytical columns used were Daicel Chiralpak AD and AS, Chiralcel OJ and OD and Regis (*R,R*)-Welk-01. Melting points (mp) were determined on a Thomas-Hoover melting point apparatus and are uncorrected.

All reactions were performed in oven (140 °C) and/or flame-dried glassware under an atmosphere of dry nitrogen, unless otherwise stated. Solvents for extraction and chromatography were technical grade and distilled from the indicated drying agents: dichloromethane (CH₂Cl₂), pentane, hexane: CaCl₂; ethyl acetate (EtOAc): K₂CO₃; acetone and methanol (MeOH) were reagent grade. *n*-Butyllithium was titrated according to the method of Gilman.² “Brine” refers to a saturated solution of NaCl.

Literature Preparations

The enolisation using LiTMP followed the procedure described by Collum *et al.*³ The enolization using DBU to synthesize (*Z*)-enol ethers followed the procedure described by Yamaguchi, *et. al.*⁴ *tert*-Butyltritylamine (TBTA) was prepared according to the procedure described by Corey, *et. al.*⁵

Experimental Procedures

(*S*)-*N*-Methoxy-*N*-methyl-3-hydroxybutyramide (**13**)⁶

To a suspension of *N*,*O*-dimethylhydroxylamine hydrochloride (6.46 g, 66.2 mmol, 2.5 equiv) in 50 mL of benzene was added a solution of trimethylaluminum (6.35 mL, 66.2 mmol, 2.5 equiv) in 40 mL benzene via cannula at 0 °C. The reaction mixture was stirred at rt for 1 h. To the reaction mixture was added ethyl (*S*)-3-hydroxybutyrate (3.50 g, 26.5 mmol), and the

reaction mixture was heated to reflux for 3 h. The reaction mixture was cooled to 0 °C and was quenched carefully with 50 mL of 1 M aq. HCl solution. The layers were separated and the aqueous phase was extracted with 300 mL of CH₂Cl₂. The combined organic layers were dried (MgSO₄), filtered, and concentrated. Distillation of the residue afforded 3.32 g of **13** (22.6 mmol, 85%) as a clear, colorless, viscous oil.

Data for **13:**

bp: 82 °C (0.5 mmHg)

¹H NMR: (500 MHz, CDCl₃)

4.21 (m, 1 H, HC(3)); 3.87 (d, *J* = 1.7, 1 H, OH); 3.69 (s, 3 H, H₃C(6)); 3.20 (s, 3 H, H₃C(5)); 2.69 – 2.42 (ABX, 2 H, H₂C(2)); 1.24 (d, *J* = 6.3, 3 H, H₃C(4))

¹³C NMR: (126 MHz, CDCl₃)

173.77 (C(1)); 64.02 (C(3)); 61.15 (C(6)); 39.54 (C(5)); 31.71 (C(2)); 22.26 (C(4))

Opt. Rot.: [α]_D²⁴ + 57.4 (c = 0.51, CHCl₃)

(S)-N-Methoxy-N-methyl-3-*tert*-butyldimethylsilyloxybutyramide (14**)**

To a solution of hydroxy amide **13** (3.24 g, 22.0 mmol) in 30 mL of DMF was added *tert*-butyldimethylchlorosilane (4.97 g, 33.0 mmol, 1.5 equiv), 4-dimethylaminopyridine (269 mg, 2.20 mmol, 0.1 equiv) and imidazole (4.49 g, 66.0 mmol, 3 equiv). The reaction mixture was stirred at rt for 36 h and then was diluted with 30 mL of water and was stirred for 1 h. The product was extracted with 200 mL of pentane and the solution was dried (MgSO₄), filtered, and concentrated. The crude product was distilled using a Vigreux column to afford 5.75 g of silyloxy amide **14** (22.0 mmol, 99%) as a clear, colorless oil.

Data for 14:bp: 88 °C (0.1 mmHg)¹H NMR: (500 MHz, CDCl₃)4.36 (sextd, *J* = 6.1, 1.0, 1 H, HC(3)); 3.70 (s, 3 H, H₃C(6)); 3.17 (s, 3 H, H₃C(5)); 2.96 - 2.33 (ABX, 2 H, H₂C(2)); 1.22 (d, *J* = 6.1, 3 H, H₃C(4)); 0.87 (s, 9 H, H₃C(9)); 0.05 (d, *J* = 12.9, 6 H, H₃C(7))¹³C NMR: (126 MHz, CDCl₃)

172.36 (C(1)); 65.98 (C(3)); 61.30 (C(6)); 41.67 (C(5)); 31.87 (C(2)); 25.77 (C(9)); 24.14 (C(8)); 17.99 (C(4)); -4.74, -4.95 (C(7))

IR: (neat)

2957 (s); 2931 (s); 2898 (m); 2857 (m); 1666 (s); 1464 (m); 1385 (m); 1255 (m); 1136 (m); 1123 (m); 1092 (s); 1068 (m); 1004(s)

MS: (FI)262.2 (5, M⁺); 204.1 (100)Opt. Rot.: [α]_D²⁴ + 24.1 (c = 0.77, CHCl₃)TLC: *R_f* 0.25 (pentane/ether, 1/1) [silica gel, KMnO₄]Analysis: C₁₂H₂₇NO₃Si (261.43)

Calcd: C, 55.13; H, 10.41; N, 5.36%

Found: C, 55.01; H, 10.61; N, 5.46%

(S)-N-Methoxy-N-methyl-3-triisopropylsilyloxybutyramide (15)

To a solution of hydroxy amide **13** (3.60 g, 24.5 mmol) in 30 mL of DMF was added triisopropylchlorosilane (10.5 mL, 49.0 mmol, 2 equiv), 4-dimethylaminopyridine (399 mg, 2.45 mmol, 0.1 equiv) and imidazole (5.00 g, 73.5 mmol, 3 equiv). The reaction mixture was stirred

at rt for 48 h and then was diluted with 30 mL of water and was stirred for 1 h. The product was extracted with 200 mL of pentane and the solution was dried (MgSO₄), filtered, and concentrated. The crude product was distilled using a Vigreux column to afford 6.90 g of silyloxy amide **15** (22.7 mmol, 93%) as a clear, colorless oil.

Data for 15:

bp: 110 °C (0.1 mmHg)

¹H NMR: (500 MHz, CDCl₃)

4.46 (sext, *J* = 6.1, 1 H, HC(3)); 3.69 (s, 3 H, H₃C(6)); 3.17 (s, 3 H, H₃C(5)); 2.78 - 2.44 (ABX, 2 H, H₂C(2)); 1.25 (d, *J* = 5.8, 3 H, H₃C(4)); 1.08 – 1.04 (m, 21 H, H₃C(8), HC(7))

¹³C NMR: (126 MHz, CDCl₃)

164.78 (C(1)); 66.10 (C(3)); 61.50 (C(6)); 42.33 (C(5)); 24.52 (C(2)); 18.28 (C(8)); 17.91 (C(4)); 12.57 (C(7))

IR: (neat)

2962 (s); 2943 (s); 2895 (m); 2868 (s); 1668 (s); 1464 (m); 1414 (w); 1385 (m); 1178 (w); 1122 (m); 1093 (m); 1066 (m); 1009 (m)

MS: (EI)

305.2 (13); 304.2 (M⁺, 60); 261.2 (19); 260.2 (100); 157.2 (13); 130.09 (19)

Opt. Rot.: [α]_D²⁴ + 14.5 (c = 0.61, CHCl₃)

TLC: *R*_f 0.15 (hexane/ether, 3/1) [silica gel, KMnO₄]

Analysis: C₁₅H₃₃NO₃Si (303.51)

Calcd: C, 59.36; H, 10.96; N, 4.61%

Found: C, 59.17; H, 11.01; N, 4.67%

(S)-4-tert-Butyldimethylsilyloxy-2-pentanone (1)

Amide **14** (2.00 g, 7.65 mmol) was dissolved in 20 mL of Et₂O at 0 °C. To this solution was slowly added a solution of methylmagnesium bromide (3.0 M in Et₂O, 3.83 mL, 11.5 mmol, 1.5 equiv). The reaction mixture was stirred at 0 °C for 1 h, then was gradually allowed to warm to rt over 11 h. The reaction mixture was quenched by slow addition of sat. aq. ammonium chloride solution (ca. 15 mL). The layers were separated and the aqueous layer was extracted with Et₂O (2 x 50 mL). The extracts were combined, dried (MgSO₄), filtered, and concentrated to give 842 mg of an oil. The crude product was purified by chromatography (hexane/ether, 5/1, SiO₂) and afforded 1.39 g of **1** (6.42 mmol, 84%) as a clear, colorless liquid after Kugelrohr distillation.

Data for 1:

bp: 75 °C (0.1 mmHg, ABT)

¹H NMR: (400 MHz, CDCl₃)

4.28 (sextd, *J* = 6.0, 1.0, 1 H, HC(4)); 2.66 – 2.40 (ABX, 2 H, H₂C(3)); 2.16 (s, 3 H, H₃C(1)); 1.17 (d, *J* = 6.1, 3 H, H₃C(5)); 0.86 (s, 9 H, H₃C(8)); 0.06, 0.03 (s, 6 H H₃C(6))

¹³C NMR: (101 MHz, CDCl₃)

208.15 (C(2)); 65.64 (C(4)); 53.13 (C(3)); 31.69 (C(1)); 25.77 (C(8)); 24.02 (C(7)); 17.96 (C(5)); -4.52, -5.01 (C(6))

IR: (neat)

2957 (s); 2931 (s); 2896 (m); 2858 (s); 1720 (s); 1374 (m); 1360 (m); 1255 (s); 1135 (s); 1091 (s); 1022 (s)

MS: (FI)

217.7 (4, M⁺); 184.2 (2); 168.1 (2); 159.0 (100); 114.1 (2)

Opt. Rot.: $[\alpha]_{\text{D}}^{24} + 32.5$ ($c = 0.70$, CHCl_3)

TLC: R_f 0.18 (hexane/ether, 5/1) [silica gel, KMnO_4]

Analysis: $\text{C}_{11}\text{H}_{24}\text{O}_2\text{Si}$ (216.39)

Calcd: C, 61.05; H, 11.18%

Found: C, 61.14; H, 11.41%

(S)-4-Triisopropylsilyloxy-2-pentanone (2)

Amide **15** (1.23 g, 4.05 mmol) was dissolved in 10 mL of Et_2O at 0 °C. To this solution was slowly added a solution of methylmagnesium bromide (3.0 M in Et_2O , 2.03 mL, 6.08 mmol, 1.5 equiv). The reaction mixture was stirred at 0 °C for 1 h, then was gradually warmed over 11 h to rt. The reaction mixture was quenched by slow addition of sat. aq. ammonium chloride solution (ca. 10 mL). The layers were separated and the aqueous layer was extracted with Et_2O (2 x 50 mL). The extracts were combined, dried (MgSO_4), filtered, and concentrated. The crude product was purified by chromatography (hexane/ether, 5/1, SiO_2) and afforded 811 mg of **2** (3.14 mmol, 77%) as a clear, colorless liquid.

Data for 2:

bp: 75 °C (0.1 mmHg)

^1H NMR: (500 MHz, CDCl_3)

4.40 (sext, $J = 6.1$, 1 H, $\text{HC}(4)$); 2.70 – 2.51 (ABX, 2 H, $\text{H}_2\text{C}(3)$); 2.17 (s, 3 H, $\text{H}_3\text{C}(1)$); 1.21 (d, $J = 6.1$, 3 H, $\text{H}_3\text{C}(5)$); 1.07 – 1.00 (m, 21 H, $\text{H}_3\text{C}(7)$, $\text{HC}(6)$)

^{13}C NMR: (126 MHz, CDCl_3)

208.0 ($\text{C}(2)$); 65.39 ($\text{C}(4)$); 53.57 ($\text{C}(3)$); 31.49 ($\text{C}(1)$); 24.04 ($\text{C}(5)$); 18.06 ($\text{C}(7)$); 12.33 ($\text{C}(6)$)

IR: (neat)

2945 (s); 2894 (m); 2868 (s); 1720 (s); 1464 (m); 1372 (m); 1246 (w); 1133 (s);
1098 (m); 1023 (m)

MS: (FI)

258.1 (2, M⁺); 217.1 (5); 216.1 (17); 215.1 (100)

Opt. Rot.: $[\alpha]_D^{24} + 11.3$ (c = 0.63, CHCl₃)

TLC: *R_f* 0.35 (hexane/ether, 5/1) [silica gel, KMnO₄]

Analysis: C₁₄H₂₀O₂Si (258.47)

Calcd: C, 65.06; H, 11.70%

Found: C, 65.21; H, 12.01%

(4*S*)-4-(*tert*-Butyldimethylsilyloxy)-2-trimethylsilyloxy-1-pentene (16)

A solution of *n*-butyllithium (1.54 M in hexane, 4.20 mL, 6.47 mmol, 1.4 equiv) was added dropwise to a solution of diisopropylamine (0.971 mL, 6.93 mmol, 1.5 equiv) in 15 mL of THF at 0 °C. The reaction mixture was stirred at 0 °C for 10 min then was cooled to −78 °C. To the reaction mixture was added trimethylchlorosilane (0.879 mL, 6.93 mmol, 1.5 equiv) and ketone **1** (1.00 g, 4.62 mmol) and the reaction mixture was stirred for 30 min. The reaction mixture was gradually warmed to 0 °C and was quenched with 20 mL of cold, deionized water. The layers were separated and the aqueous layer was extracted with pentane (2 x 30 mL). The combined extracts were washed with 20 mL of sat. aq. copper sulfate solution, 15 mL of water and 20 mL of brine. The combined organic extracts were dried (Na₂SO₄), filtered, and were concentrated to give 1.61 g of an oil. Kugelrohr distillation afforded 1.18 g of enolate **16** (4.09 mmol, 89%) as clear, colorless oil.

Data for 16:bp: 75 °C (0.5 mmHg, ABT)¹H NMR: (500 MHz, CDCl₃)4.04 (d, *J* = 7.6, 2 H, H₂C(1)); 4.04 (sext, *J* = 6.5, 1 H, HC(4)); 2.26-2.01 (ABX, 2 H, H₂C(3)); 1.15 (d, *J* = 6.1, 3 H, H₃C(5)); 0.88 (s, 9 H, H₃C(9)); 0.20 (s, 9 H, H₃C(6)); 0.05 (d, *J* = 1.9, 6 H, H₃C(7))¹³C NMR: (126 MHz, CDCl₃)

156.70 (C(2)); 91.75 (C(1)); 66.41 (C(4)); 47.50 (C(3)); 25.90 (C(9)); 23.36 (C(8)); 18.20 (C(5)); 0.05 (C(6)); -4.67, -4.83 (C(7))

IR: (neat)

2959 (s); 2930 (m); 2898 (m); 2858 (m); 1660 (m); 1637 (m); 1464 (m); 1377 (m); 1304 (m); 1254 (s); 1211 (m); 1128 (m); 1087 (m); 1014 (m)

MS: (FI)289.2 (61, M⁺); 273.1 (8); 254.2 (4); 231.1 (100); 199.1 (1); 185.1 (3); 159.1 (41); 131.1 (3); 115.1 (6); 73.1 (40)Opt. Rot.: [α]_D²⁴ + 6.81 (c = 3.5, CHCl₃)Analysis: Calc for C₁₄H₃₂O₂Si₂ (288.57)

Calcd: C, 58.27; H, 11.18%

Found: C, 58.15; H, 11.41%

(4S)-4-Triisopropylsilyloxy-2-trimethylsilyloxy-1-pentene (17)

A solution of *n*-butyllithium (1.54 M in hexane, 2.29 mL, 3.53 mmol, 1.4 equiv) was added dropwise to a solution of diisopropylamine (0.53 mL, 3.78 mmol, 1.5 equiv) in 10 mL of THF at 0 °C. The reaction mixture was stirred at 0 °C for 10 min and then was cooled to −78 °C.

To the reaction mixture was added trimethylchlorosilane (048 mL, 3.78 mmol, 1.5 equiv) and ketone **2** (651 mg, 2.52 mmol) and the reaction mixture was stirred for 30 min. The reaction mixture was gradually warmed to 0 °C and was quenched with 20 mL of cold, deionized water. The layers were separated and the aqueous layer was extracted with pentane (2 x 50 mL). The combined extracts were washed with 20 mL of sat. aq. copper sulfate solution, 15 mL of water and 20 mL of brine. The organic extracts were dried (Na₂SO₄), filtered, and concentrated to give 1.61 g of an oil. Kugelrohr distillation afforded 688 mg of the enol ether **17** (2.08 mmol, 83%) was obtained as clear, colorless oil.

Data for **17**:

bp: 125 °C (1.0 mmHg, ABT)

¹H NMR: (500 MHz, CDCl₃)

4.12 (sext, $J = 6.5, 1.5$, 1 H, HC(4)); 4.04 (d, $J = 11.7$, 2 H, H₂C(1)); 2.38-2.02 (ABX, 2 H, H₂C(3)); 1.18 (d, $J = 6.1$, 3 H, H₃C(5)); 1.06 – 1.01 (m, 21 H, H₃C(8), HC(7)); 0.19 (d, $J = 1.9$, 6 H, H₃C(6))

¹³C NMR: (126 MHz, CDCl₃)

156.89 (C(2)); 91.63 (C(1)); 66.45 (C(4)); 47.78 (C(3)); 23.17 (C(5)); 18.08 (C(8)); 12.34 (C(7)); -0.01 (C(6))

IR: (neat)

2962 (s); 2945 (s); 2885 (m); 2868 (s); 1659 (w); 1624 (w); 1464 (w); 1378 (w); 1303 (m); 1254 (m); 1211 (w); 1126 (m); 1090 (m); 1014 (s)

MS: (FI)

332.2 (21); 331.2 (65, M⁺); 289.2 (11); 288.2 (25); 287.2 (100); 201.2 (60); 73.0 (25)

Opt. Rot.: [α]_D²⁴ + 11.5 (c = 0.95, CHCl₃)

Analysis: C₁₇H₃₈O₂Si₂ (288.57)

Calcd: C, 61.75; H, 11.58%

Found: C, 61.79; H, 11.80%

(4*S*)- 4-(*tert*-Butyldimethylsilyloxy)-2-trichlorosilyloxy-1-pentene (5)

Silicon tetrachloride (0.46 mL, 4.02 mmol, 2.0 equiv) was added to a solution of palladium(II) acetate (22.6 mg, 0.10 mmol, 0.05 equiv) in 2.00 mL of CH₂Cl₂. To the reaction mixture was added trimethylsilyl enol ether **16** (580 mg, 2.01 mmol) using a cannula, and the reaction mixture was stirred at rt for 30 min. Kugelrohr distillation of the reaction mixture afforded 526 mg of trichlorosilyl enol ether **5** (1.50 mmol, 75%) as clear, colorless liquid.

Data for **5**:

bp: 125 °C (1 mmHg, ABT)

¹H NMR: (400 MHz, CDCl₃)

4.59 (d, *J* = 1.9, 1 H, H₂C(1)); 4.46 (d, *J* = 2.0, 1 H, H₂C(1)); 4.04 (sext, *J* = 6.2, 1 H, HC(4)); 2.35-2.16 (ABX, 2 H, H₂C(3)); 1.18 (d, *J* = 5.8, 3 H, H₃C(5)); 0.88 (s, 9 H, H₃C(8)); 0.06 (d, *J* = 3.6, 6 H, H₃C(6))

General Procedure I: (1*R*,5*S*)-5-*tert*-Butyldimethylsilyloxy-1-hydroxy-1-phenyl-3-hexanone (*anti*-9a**)**

To a suspension of mercury(II) acetate (3.2 mg, 0.01 mmol, 0.01 equiv) in 1 mL of CH₂Cl₂ was added silicon tetrachloride (0.23 mL, 2.0 mmol, 2.0 equiv) and trimethylsilyl enol ether **16** (289 mg, 1.00 mmol). The reaction mixture was stirred at rt for 30 min. The excess

silicon tetrachloride and the solvent were removed under vacuum. To the residue was added solution of the chiral phosphoramidate (*R,R*)-**20a** (36.9 mg, 0.10 mmol, 0.10 equiv) in 2 mL of CH₂Cl₂ via cannula. The reaction mixture was cooled to -78 °C before the addition of benzaldehyde (102 µL, 1.00 mmol). The reaction mixture was stirred at -78 °C for 4 h, and then was quenched by pouring it into a vigorously stirring solution of cold sat. aq. sodium bicarbonate solution (5 mL). The resulting slurry was stirred for 3 h and then was filtered through Celite. The layers were separated and the aqueous layer was extracted with 20 mL of CH₂Cl₂. The combined organic extracts were washed with 5 mL of brine, dried (Na₂SO₄), filtered, and concentrated. The crude product was purified by chromatography (pentane/ether, 3/1, SiO₂) to 198 mg of give **9a** (0.61 mmol, 61%) as viscous, colorless oil.

Data for *anti*-**9a**:

¹H NMR: (500 MHz, CDCl₃)

7.35 – 7.34 (m, 4 H, HC(8), HC(9)); 7.29 – 7.26 (m, 1 H, HC(10)); 5.15 (dt, *J* = 8.6, 3.5, 1H, HC(1)); 4.32 (sext, *J* = 6.1, 1 H, HC(5)); 3.36 (d, *J* = 3.2, 1 H, OH); 2.92 – 2.82 (ABX, 2H, H₂C(2)); 2.67 – 2.41 (ABX, 2H, H₂C(4)); 1.17 (d, *J* = 6.2, 3H, H₃C(6)); 0.86 (s, 9H, H₃C(13)); 0.05 (d, *J* = 12.4, 6H, H₃C(11))

¹³C NMR: (125 MHz, CDCl₃)

210.56 (C(3)); 142.71 (C(7)); 128.49 (C(9)); 127.59 (C(10)); 125.59 (C(8)); 69.63 (C(5)); 65.64 (C(1)); 53.30 (C(4)); 52.85 (C(2)); 25.73 (C(13)); 23.99 (C(6)); 17.89 (C(12)); -4.53, -5.00 (C(11))

IR: (neat)

3438 (m, br); 3064 (w); 3032 (w); 2956 (s); 2929 (s); 2895 (m); 2850 (m); 1711 (s); 1495 (w); 1462 (m); 1377 (m); 1255 (m); 1134 (m); 1090 (m); 1066 (s); 1041 (m); 1007 (m)

MS: (FI)

323.1 (5, M⁺); 265.1 (100); 159.1 (3); 106.1 (3)

Opt. Rot.: [α]_D²⁴ + 47.1 (c = 0.64, EtOH)

TLC: *R*_f 0.10 (pentane/ether, 3/1) [silicagel, *p*-anisaldehyde]

SFC: *t*_R 4.695 min (OD, 150 bar, 3 mL/min, 2% MeOH)

Analysis: C₁₈H₃₀O₃Si (322.51)

Calcd: C, 67.03; H, 9.38%

Found: C, 66.94; H, 9.52%

(1*S*,5*S*)-5-*tert*-Butyldimethylsilyloxy-1-hydroxy-1-phenyl-3-hexanone (*syn*-9a**)**

Following General Procedure I from **16** (289 mg, 1.00 mmol), SiCl₄ (0.23 mL, 2.00 mmol), Hg(OAc)₂ (3.2 mg, 0.01 mmol), benzaldehyde (102 μ L, 1.00 mmol), (*S,S*)-**20a** (37 mg, 0.10 mmol) in 2 mL of CH₂Cl₂, was obtained 188 mg (0.58 mmol, 58%) of *syn*-**9a** as a clear, colorless, viscous oil after column chromatography (3/1 pentane/ether, SiO₂).

Data for *syn*-**9a**:

¹H NMR: (500 MHz, CDCl₃)

7.36 – 7.34 (m, 4 H, HC(8), HC(9)); 7.29 – 7.26 (m, 1 H, HC(10)); 5.16 – 5.13 (m, 1H, HC(1)); 4.32 (sext, *J* = 6.1, 1 H, HC(5)); 3.38 (d, *J* = 3.2, 1 H, OH); 2.88 – 2.85 (ABX, 2H, H₂C(2)); 2.68 – 2.43 (ABX, 2H, H₂C(4)); 1.17 (d, *J* = 6.1, 3H, H₃C(6)); 0.86 (s, 9H, H₃C(13)); 0.06 (d, *J* = 10.3, 6H, H₃C(11))

¹³C NMR: (126 MHz, CDCl₃)

210.50 (C(3)); 142.74 (C(7)); 128.49 (C(9)); 127.59 (C(10)); 125.62 (C(8)); 69.80 (C(5)); 65.47 (C(1)); 52.97 (C(4)); 52.79 (C(2)); 25.75 (C(13)); 23.95 (C(6)); 17.91 (C(12)); -4.55, -4.97 (C(11))

IR: (neat)

3441 (m, br); 3064 (w); 3032 (w); 2956 (s); 2930 (s); 2895 (m); 2858 (m); 1710 (m); 1495 (w); 1462 (m); 1376 (m); 1253 (m); 1132 (m); 1090 (m); 1068 (m); 1032 (m); 1007 (m)

MS: (FI)323.2 (5, M⁺); 265.1 (100); 159.1 (3); 106.1 (3)**Opt. Rot.:** $[\alpha]_D^{24} + 1.61$ (c = 0.95, EtOH)**TLC:** R_f 0.11 (pentane/ether, 3/1) [silica gel, *p*-anisaldehyde]**SFC:** t_R 4.984 min (OD, 150 bar, 3 mL/min, 2% MeOH)**Analysis:** C₁₈H₃₀O₃Si (322.51)

Calcd: C, 67.03; H, 9.38%

Found: C, 67.00; H, 9.57%

(1*R*,5*S*)-5-Triisopropylsilyloxy-1-hydroxy-1-phenyl-3-hexanone (*anti*-10a)

Following General Procedure I from **17** (331 mg, 1.00 mmol), SiCl₄ (0.23 mL, 2.00 mmol), Hg(OAc)₂ (3.2 mg, 0.01 mmol), benzaldehyde (102 μ L, 1.00 mmol), (*R,R*)-**20a** (37 mg, 0.10 mmol) in 2 mL of CH₂Cl₂, was obtained 325 mg (0.89 mmol, 89%) of *anti*-**10a** as a clear, colorless, viscous oil after column chromatography (3/1 pentane/ether, SiO₂).

Data for *anti*-10a:**¹H NMR:** (500 MHz, CDCl₃)

7.37 (m, 4 H, HC(8), HC(9)); 7.30 (m, 1 H, HC(10)); 5.17 (dt, $J = 9.0, 3.1$, 1H, HC(1)); 4.47 (sext, $J = 6.1$, 1 H, HC(5)); 3.35 (d, $J = 3.2$, 1 H, OH); 2.96 – 2.85 (ABX, 2H, H₂C(2)); 2.73 – 2.52 (ABX, 2H, H₂C(4)); 1.24 (d, $J = 6.1$, 3H, H₃C(6)); 1.07 (s, 21H, H₃C(12), HC(11))

¹³C NMR: (126 MHz, CDCl₃)
 210.31 (C(3)); 142.72 (C(7)); 128.47 (C(9)); 127.58 (C(10)); 125.60 (C(8)); 69.69 (C(1)); 65.40 (C(5)); 53.32 (C(4)); 52.76 (C(2)); 24.05 (C(6)); 18.05 (C(12)); 12.35 (C(11))

IR: (neat)
 3441 (m, br); 2961 (s); 2944 (s); 2893 (s); 2867 (s); 1710 (s); 1463 (m); 1375 (m); 1130 (s); 1092 (s); 1066 (s); 1040 (m); 1013 (s)

MS: (FI)
 365.2 (2, M⁺); 321.0 (100); 215.0 (7); 143.7 (2); 106.0 (3)

Opt. Rot.: [α]_D²⁴ + 11.5 (c = 0.43, EtOH)

TLC: R_f 0.15 (pentane/ether, 3/1) [silica gel, *p*-anisaldehyde]

SFC: t_R 3.745 min (OD, 150 bar, 3 mL/min, 5% MeOH)

Analysis: C₂₁H₃₆O₃Si (364.59)
 Calcd: C, 69.18; H, 9.95%
 Found: C, 69.04; H, 10.05%

(1*S*,5*S*)-5-Triisopropylsilyloxy-1-hydroxy-1-phenyl-3-hexanone (*syn*-10a**)**

Following General Procedure I from **17** (331 mg, 1.00 mmol), SiCl₄ (0.23 mL, 2.00 mmol), Hg(OAc)₂ (3.2 mg, 0.01 mmol), benzaldehyde (102 μL, 1.00 mmol), (*S,S*)-**20a** (37 mg, 0.10 mmol) in 2 mL of CH₂Cl₂, was obtained 315 mg (0.86 mmol, 86%) of *syn*-**10a** as a clear, colorless, viscous oil after column chromatography (3/1 pentane/ether, SiO₂).

Data for syn-10a:¹H NMR: (500 MHz, CDCl₃)

7.37 (m, 4 H, HC(8), HC(9)); 7.30 (m, 1 H, HC(10)); 5.17 (m, 1H, HC(1)); 4.45 (sext, $J = 6.1$, 1 H, HC(5)); 3.35 (d, $J = 2.9$, 1 H, HO); 2.96 – 2.85 (ABX, 2H, H₂C(2)); 2.73 – 2.59 (ABX, 2H, H₂C(4)); 1.24 (d, $J = 6.1$, 3H, H₃C(6)); 1.07 (s, 21 H, H₃C(13), HC(11))

¹³C NMR: (126 MHz, CDCl₃)

210.23 (C(3)); 142.75 (C(7)); 128.47 (C(9)); 127.58 (C(10)); 125.60 (C(8)); 69.73 (C(1)); 65.26 (C(5)); 53.42 (C(4)); 52.51 (C(2)); 24.00 (C(6)); 18.00 (C(12)); 12.33 (C(11))

IR: (neat)

3438 (m, br); 2961 (s); 2944 (s); 2893 (s); 2867 (s); 1710 (s); 1463 (m); 1375 (m); 1130 (m); 1092 (m); 1066 (m); 1038 (m); 1014 (m)

MS: (FI)

365.1 (2, M⁺); 321.1 (100); 215.0 (6)

Opt. Rot.: [$\alpha \right]_D^{24}$ - 5.84 (c = 1.07, EtOH)TLC: R_f 0.14 (pentane/ether, 3/1) [silica gel, *p*-anisaldehyde]SFC: t_R 4.163 min (OD, 150 bar, 3 mL/min, 5% MeOH)Analysis: C₂₁H₃₆O₃Si (364.59)

Calcd: C, 69.18; H, 9.95%

Found: C, 69.03; H, 10.20%

(S)-5-tert-Butyldimethylsilyloxy-3-hexanone (3)

Amide **14** (2.00 g, 7.65 mmol) was dissolved in 20 mL of Et₂O at 0 °C. To this solution was slowly added a solution of ethylmagnesium chloride (2.0 M in Et₂O, 5.75 mL, 11.5 mmol, 1.5 equiv). The reaction mixture was stirred at 0 °C for 1 h, then was gradually allowed to warm to rt and was stirred overnight. The reaction mixture was quenched by slow addition of sat. aq. ammonium chloride solution (ca. 15 mL). The layers were separated and the aqueous layer was extracted with Et₂O (2 x 50 mL). The extracts were combined, dried (MgSO₄), filtered, and concentrated. The crude product was purified by chromatography (hexane/ether, 5/1, SiO₂) and by distillation to afford 1.60 g of **3** (6.94 mmol, 91%) as clear, colorless liquid.

Data for **3**:

bp: 105 °C (0.01 mmHg)

¹H NMR: (400 MHz, CDCl₃)

4.28 (sext, *J* = 6.3, 1 H, HC(5)); 2.65 – 2.34 (ABX, 2 H, H₂C(4)); 2.45 (q, *J* = 7.4, 2 H, H₂C(2)); 1.15 (d, *J* = 6.1, 3 H, H₃C(6)); 1.02 (t, *J* = 7.3, 3 H, H₃C(1)); 0.85 (s, 9 H, H₃C(9)); 0.03 (d, *J* = 16.1, 6 H, H₃C(7))

¹³C NMR: (100 MHz, CDCl₃)

210.58 (C(3)); 65.82 (C(5)); 51.92 (C(4)); 37.78 (C(2)); 25.74 (C(9)); 24.09 (C(8)); 17.92 (C(6)); 7.40 (C(1)); -4.56, -5.06 (C(7))

IR: (neat)

2958 (s); 2932 (s); 2896 (m); 2858 (m); 1718 (s); 1376 (m); 1255 (m); 1135 (m); 1095 (m); 1046 (s)

MS: (FI)

231.1 (2, M⁺); 173.0 (100)

Opt. Rot.: [α]_D²⁴ + 49.0 (c = 0.92, CHCl₃)

TLC: R_f 0.21 (pentane/ether, 5/1) [silica gel, KMnO_4]

Analysis: $\text{C}_{12}\text{H}_{26}\text{O}_2\text{Si}$ (230.42)

Calcd: C, 62.55; H, 11.37%

Found: C, 62.57; H, 11.45%

((2Z,5S)- 5-tert-Butyldimethylsilyloxy-3-trimethylsilyloxy-2-hexene ((Z)-18) (Using DBU/TMSCl)

In a 50-mL, three-neck flask equipped with a stopper and a reflux condenser, DBU (1.30 mL, 8.68 mmol, 2 equiv) was dissolved in 20 mL of CH_2Cl_2 . To this solution were added TMSCl (1.10 mL, 8.68 mmol, 2 equiv) and ketone **3** (1.00 g, 4.34 mmol) and the mixture was heated to reflux for 4 h. The reaction mixture was cooled to rt and was quenched with 20 mL of cold, sat. aq. NaHCO_3 solution. The product was extracted with 50 mL of hexane and the hexane was washed with 25 mL of brine. The extracts were dried (Na_2SO_4), filtered, and concentrated. The crude product was purified by chromatography (hexane/ CH_2Cl_2 , 5/1) and Kugelrohr distillation to give 820 mg of (Z)-**18** (2.71 mmol, 62%) as clear colorless oil.

Data for (Z)-18:

bp: 125 °C (0.5 mmHg, ABT)

^1H NMR: (500 MHz, CDCl_3)

4.54 (q, $J = 6.6$, 1 H, HC(2)); 3.99 (sext, $J = 6.2$, 1 H, HC(4)); 2.21-1.97 (ABX, 2 H, $\text{H}_2\text{C}(4)$); 1.48 (d, $J = 6.7$, 3 H, $\text{H}_3\text{C}(1)$); 1.13 (d, $J = 6.0$, 3 H, $\text{H}_3\text{C}(6)$); 0.87 (s, 9 H, $\text{H}_3\text{C}(10)$); 0.18 (s, 9 H, $\text{H}_3\text{C}(7)$); 0.03 (d, $J = 6.2$, 6 H, $\text{H}_3\text{C}(8)$)

^{13}C NMR: (126 MHz, CDCl_3)

148.47 (C(3)); 104.68 (C(2)); 66.44 (C(5)); 47.48 (C(4)); 25.84 (C(10)); 23.54 (C(9)); 18.12 (C(6)); 10.82 (C(1)); 0.64 (C(7)); -4.71, -4.86 (C(8))

IR: (neat)

2958 (s); 2929 (m); 2899 (m); 2858 (m); 1680 (m); 1473 (m); 1377 (m); 1323 (m); 1254 (s); 1194 (m); 1128 (m); 1093 (m); 1070 (m); 1030 (m)

MS: (FI)

302.1 (100, M⁺)

Opt. Rot.: $[\alpha]_D^{24} + 4.61$ (c = 0.97, CHCl₃)

TLC: *R_f* 0.20 (hexane/CH₂Cl₂, 5/1) [silica gel, KMnO₄]

Analysis: C₁₅H₃₄O₂Si₂ (302.60)

Calcd: C, 59.54; H, 11.33%

Found: C, 59.67; H, 11.61%

(S)-5-Triisopropylsilyloxy-3-hexanone (4)

Amide **15** (3.34 g, 11.0 mmol) was dissolved in 20 mL of Et₂O at 0 °C. To this solution was slowly added a solution of ethylmagnesium chloride (2.0 M in Et₂O, 8.25 mL, 16.5 mmol, 1.5 equiv). The reaction mixture was stirred at 0 °C for 1 h, then was gradually allowed to warm to rt and was stirred overnight. The reaction mixture was quenched by slow addition of sat. aq. ammonium chloride solution (ca. 20 mL). The layers were separated and the aqueous layer was extracted with Et₂O (2 x 50 mL). The extracts were combined, dried (MgSO₄), filtered, and concentrated. The crude product was purified by chromatography (hexane/ether, 5/1, SiO₂) and by distillation to afford 2.60 g of **4** (9.54 mmol, 87%) as clear, colorless liquid.

Data for 4:

bp: 104 °C (0.1 mmHg)

¹H NMR: (500 MHz, CDCl₃)

4.42 (sext, *J* = 6.1, 1 H, HC(5)); 2.69 – 2.44 (ABX, 2 H, H₂C(4)); 2.46 (q, *J* = 7.1, 2 H, H₂C(2)); 1.20 (d, *J* = 5.9, 3 H, H₃C(6)); 1.07 – 1.02 (m, 24 H, H₃C(1), H₃C(8), HC(7))

¹³C NMR: (126 MHz, CDCl₃)

210.45 (C(3)); 65.57 (C(5)); 52.36 (C(4)); 37.49 (C(2)); 24.15 (C(6)); 18.05 (C(8)); 12.34 (C(7)); 7.45 (C(1))

IR: (neat)

2964 (s); 2944 (s); 2894 (m); 2868 (s); 1718 (s); 1463 (m); 1412 (m); 1375 (m); 1134 (m); 1098 (m); 1044 (m)

MS: (EI)

273.2 (2, M⁺); 231.2 (5); 230.2 (19); 229.2 (100)

Opt. Rot.: [α]_D²⁴ + 12.8 (c = 0.65, CHCl₃)

TLC: *R*_f 0.25 (hexane/ether, 5/1) [silica gel, KMnO₄]

Analysis: C₁₅H₃₂O₂Si (272.50)

Calcd: C, 66.11; H, 11.84%

Found: C, 66.22; H, 11.93%

(2Z,5S)- 5-Triisopropylsilyloxy-3-trimethylsilyloxy-2-hexene ((Z)-19)

In a 50-mL, three-neck flask equipped with a stopper and a reflux condenser, DBU (0.89 mL, 6.06 mmol, 1.5 equiv) was dissolved in 15 mL of CH₂Cl₂. To this solution were added TMSCl (0.77 mL, 6.06 mmol, 1.5 equiv) and ketone **4** (1.10 g, 4.04 mmol) and the reaction mixture was heated to reflux for 4 h. The reaction mixture was cooled to rt and was quenched with 20 mL of cold, sat. aq. NaHCO₃ solution. The product was extracted with 50 mL of hexane

and the hexane was washed with 25 mL of brine. The extracts were dried (Na_2SO_4), filtered, and concentrated. The crude product was purified by chromatography (hexane/ CH_2Cl_2 , 8/1) and Kugelrohr distillation to give 800 mg of (Z)-**19** (2.32 mmol, 57%) as clear, colorless oil.

Data for (Z)-**19**:

bp: 125 °C (0.05 mmHg, ABT)

^1H NMR: (400 MHz, CDCl_3)

4.55 (q, $J = 6.8$, 1 H, HC(2)); 4.10 (sextd, $J = 5.6, 2.7$, 1 H, HC(5)); 2.33-1.97 (ABX, 2 H, $\text{H}_2\text{C}(4)$); 1.48 (d, $J = 6.8$, 3 H, $\text{H}_3\text{C}(1)$); 1.17 (d, $J = 5.9$, 3 H, $\text{H}_3\text{C}(6)$); 1.16 – 1.05 (m, 21 H, $\text{H}_3\text{C}(9)$, HC(8)); 0.18 (s, 9 H, $\text{H}_3\text{C}(7)$)

^{13}C NMR: (126 MHz, CDCl_3)

148.71 (C(3)); 104.67 (C(2)); 66.74 (C(5)); 47.80 (C(4)); 23.56 (C(6)); 18.09 (C(9)); 12.44 (C(8)); 10.92 (C(1)); 0.64 (C(7))

IR: (neat)

2961 (s); 2944 (s); 2895 (m); 2867 (s); 1678 (m); 1464 (m); 1377 (m); 1323 (m); 1253 (s); 1193 (m); 1128 (m); 1096 (m); 1069 (m); 1028 (m); 1004 (m)

MS: (FI)

346.3 (12); 345.3 (33); 344.3 (100, M^+); 263.6 (3)

Opt. Rot.: $[\alpha]_{\text{D}}^{24} + 6.57$ ($c = 0.48$, CHCl_3)

TLC: R_f 0.25 (hexane/ CH_2Cl_2 , 8/1) [silica gel, KMnO_4]

Analysis: $\text{C}_{18}\text{H}_{40}\text{O}_2\text{Si}_2$ (344.68)

Calcd: C, 62.72; H, 11.70%

Found: C, 62.53; H, 12.00%

(2*E*,5*S*)- 5-Triisopropylsilyloxy-3-trimethylsilyloxy-2-hexene ((*E*)-19)

In a 25-mL, two-neck flask equipped with a stopper and a septum *tert*-butyltritylamine (TBTA) (946 mg, 3.00 mmol, 1.5 equiv) was dissolved in 10 mL of THF at 0 °C. To this solution was added dropwise a solution of *n*-BuLi (1.54 M in hexane, 1.82 mL, 2.80 mmol, 1.4 equiv) and the solution was stirred for 10 min. The mixture was cooled to -78 °C, whereupon TMSCl (0.381 mL, 3.00 mmol, 1.5 equiv) and **4** (0.55 g, 2.00 mmol) were added. The reaction mixture was stirred for 30 min and then was gradually warmed to 0 °C over 2 h. The reaction mixture was quenched with 10 mL of cold, sat. aq. NaHCO₃ solution. The product was extracted in 50 mL of pentane and the pentane was washed with 25 mL of brine. The extracts were dried (Na₂SO₄), filtered, and concentrated. The residue was redissolved in pentane and was cooled to -15 °C to recover TBTA. The crude product was purified by chromatography (hexane/CH₂Cl₂, 8/1, SiO₂) and Kugelrohr distillation to give 475 mg of (*E*)-**19** (1.38 mmol, 69%) as clear, colorless oil.

Data for (*E*)-19:

bp: 125 °C (0.05 mmHg, ABT)

¹H NMR: (400 MHz, CDCl₃)

4.67 (q, *J* = 6.8, 1 H, HC(2)); 4.14 (m, 1 H, HC(5)); 2.32-2.23 (ABX, 2 H, H₂C(4)); 1.55 (dd, *J* = 6.8, 0.5, 3 H, H₃C(1)); 1.16 (d, *J* = 6.1, 3 H, H₃C(6)); 1.07 (s, 21 H, H₃C(9), HC(8)); 0.15 (s, 9 H, H₃C(7))

¹³C NMR: (126 MHz, CDCl₃)

149.61 (C(3)); 102.60 (C(2)); 67.01 (C(5)); 42.03 (C(4)); 23.15 (C(6)); 18.11 (C(9)); 12.40 (C(8)); 12.06 (C(1)); 0.23 (C(7))

IR: (neat)

2962 (m); 2945 (m); 2895 (m); 2868 (m); 1670 (w); 1464 (m); 1379 (w); 1254 (m); 1198 (m); 1124 (m); 1107 (m); 1088 (m); 1005 (m)

MS: (FI)

347.2 (2); 346.2 (11); 345.2 (30); 344.2 (100, M⁺); 343.7 (2); 264.2 (2); 263.8 (3); 263.6 (5); 263.3 (3)

Opt. Rot.: $[\alpha]_D^{24} + 6.64$ (c = 0.39, CHCl₃)

TLC: R_f = 0.26 (hexane/CH₂Cl₂, 8/1) [silica gel, KMnO₄]

Analysis: C₁₈H₄₀O₂Si₂ (344.68)

Calcd: C, 62.72; H 11.70%

Found: C, 62.38; H, 11.94%

General Procedure II: (2Z,5S)- 5-tert-Butyldimethylsilyloxy-3-trichlorosilyloxy-2-hexene ((Z)-7)

To a solution of silyl enol ether (**(Z)-18**) (972 mg, 3.21 mmol) in 3 mL of Et₂O at 0 °C was slowly added a solution of MeLi (1.5 M in Et₂O, 3.30 mL, 4.82 mmol, 1.5 equiv). The reaction mixture was stirred for 3 h at rt, then was cooled to −78 °C. The reaction mixture was then transferred via cannula to a cold solution of silicon tetrachloride (3.68 mL, 32.1 mmol, 10 equiv) in 2 mL of Et₂O. The reaction mixture was stirred at −78 °C for 1 h and was gradually allowed to warm to rt. The precipitate was allowed to settle to the bottom of the flask, the supernatant was transferred to another flask and was concentrated in vacuo. The product was purified by Kugelrohr distillation to afford 764 mg (2.10 mmol, 65%) of (**(Z)-7**) as a clear, colorless oil.

Data for (Z)-7:

bp: 150 °C (1.0 mmHg, ABT)

¹H NMR: (CDCl₃, 500 MHz)

4.83 (q, $J = 6.9$, 1 H, HC(2)); 4.03 (sext, $J = 7.3$, 1 H, HC(5)); 2.33-2.18 (ABX, 2 H, H₂C(4)); 1.58 (d, $J = 6.8$, 3 H, H₃C(1)); 1.15 (d, $J = 6.2$, 3 H, H₃C(6)); 0.87 (s, 9 H, H₃C(9)); 0.03 (d, $J = 10.5$, 6 H, H₃C(7))

(2Z,5S)- 5-Triisopropylsilyloxy-3-trichlorosilyloxy-2-hexene ((Z)-8)

Following the General Procedure II from (Z)-**19** (1.60 g, 4.64 mmol), MeLi (1.5 M in Et₂O, 4.64 mL, 6.96 mmol, 1.5 equiv) and SiCl₄ (5.32 mL, 46.4 mmol, 10 equiv) in 10 mL of hexane was obtained 1.13 g (2.78 mmol, 60%) of (Z)-**8** as a clear, colorless oil.

Data for (Z)-8:

bp: 175 °C (1.0 mmHg, ABT)

¹H NMR: (500 MHz, CDCl₃)

4.84 (q, $J = 6.8$, 1 H, HC(2)); 4.16 (sext, $J = 7.1$, 1 H, HC(5)); 2.47-2.17 (ABX, 2 H, H₂C(4)); 1.59 (dt, $J = 6.8$, 1.0, 3 H, H₃C(3)); 1.20 (d, $J = 5.9$, 3 H, H₃C(6)); 1.13 – 1.01 (m, 21 H, H₃C(8), HC(7))

(2*E*,5*S*)- 5-Triisopropylsilyloxy-3-trichlorosilyloxy-2-hexene ((*E*)-8)

Following General Procedure II from (*E*)-**19** (678 mg, 1.97 mmol), MeLi (1.5 M in Et₂O, 1.57 mL, 2.36 mmol, 1.2 equiv) and SiCl₄ (2.26 mL, 19.7 mmol, 1.0 equiv) in 5 mL of ether, was obtained 180 mg (0.44 mmol, 23%) of (*E*)-**8** as a clear, colorless oil.

Data for (*E*)-8:

bp: 150 °C (0.5 mmHg, ABT)

¹H NMR: (500 MHz, CDCl₃)

5.17 (q, *J* = 7.1, 1 H, HC(2)); 4.17 (m, 1 H, HC(5)); 2.56-2.31 (ABX, 2 H, H₂C(4)); 1.62 (d, *J* = 7.1, 3 H, H₃C(3)); 1.20 (d, *J* = 6.1, 3 H, H₃C(6)); 1.09 – 1.02 (m, 21 H, H₃C(8), HC(7))

General Procedure III: (1*R*, 2*R*, 5*S*)-5-*tert*-Butyldimethylsilyloxy-2-methyl-1-hydroxy-1-phenyl-3-hexanone (*syn,anti*-11a)

Trichlorosilyl enol ether (*Z*)-**7** (364 mg, 1.00 mmol) was added to a solution of (*R,R*)-**20a** (37 mg, 0.10 mmol, 0.10 equiv) in 1.00 mL of CH₂Cl₂. The reaction mixture was cooled to -78 °C and PhCHO (102 μL, 1.00 mmol, 1 equiv) was added by syringe. After stirring for 6 h, the reaction mixture was quenched by pouring it into a vigorously stirring solution of cold, sat. aq.

NaHCO₃ solution (15 mL). The resulting slurry was stirred for 3 h and was filtered through Celite. The layers were separated, and the aqueous layer was extracted with 20 mL of CH₂Cl₂. The organic phases were combined, washed with 5 mL of brine and were dried (Na₂SO₄), filtered, and concentrated. The crude product was purified by column chromatography (pentane/ether, 3/1, SiO₂) to afford 200 mg (0.59 mmol, 59%) of **11a** as a clear, viscous oil.

Data for (*syn,anti*)-**11a**:

¹H NMR: (500 MHz, CDCl₃)

7.36-7.30 (m, 4 H, HC(8), HC(9)); 7.25 (m, 1 H, HC(10)); 5.15 (t, *J* = 2.9, 1 H, HC(1)); 4.32 (sext, *J* = 6.6, 1 H, HC(5)); 3.16 (d, *J* = 2.6, 1 H, HO); 2.81 (qd, *J* = 7.3, 3.1, 1 H, HC(2)); 2.72-2.43 (ABX, 2 H, H₂C(4)); 1.16 (d, *J* = 6.1, 3 H, H₃C(6)); 1.04 (d, *J* = 7.3, 3 H, H₃C(11)); 0.87 (s, 9H, H₃C(14)); 0.06 (d, *J* = 11.2, 6 H, H₃C(12))

¹³C NMR: (126 MHz, CDCl₃)

214.67 (C(3)); 141.62 (C(7)); 128.22 (C(9)); 127.23 (C(10)); 125.82 (C(8)); 72.33 (C(5)); 65.43 (C(1)); 52.53 (C(2)); 51.30 (C(4)); 25.77 (C(14)); 23.94 (C(6)); 17.91 (C(13)); 9.22 (C(11)); -4.58, -4.92 (C(12))

IR: (neat)

3458 (br, m); 3064 (w); 3032 (w); 2956 (m); 2931 (m); 2895 (m); 2858 (m); 1707 (m); 1454 (m); 1375 (m); 1255 (m); 1134 (m); 1095 (m); 1005 (m)

MS: (EI)

336.2 (M⁺, 7); 279.1 (100); 230.2 (5); 173.1 (3); 107.2 (5)

Opt. Rot.: [α]_D²⁴ -5.55 (c = 0.63, EtOH)

TLC: *R*_f 0.20 (pentane/ether, 5/1) [silica gel, *p*-anisaldehyde]

SFC: *t*_R 2.441 min (OD, 150 bar, 3 mL/min, 5% MeOH)

Analysis: C₁₉H₃₂O₃Si (336.54)

Calcd: C, 67.81; H, 9.58%

Found: C, 67.61; H, 9.59%

(1*S*,2*S*,5*S*)-5-*tert*-Butyldimethylsilyloxy-2-methyl-1-hydroxy-1-phenyl-3-hexanone (*syn,syn*-11a**)**

Following General Procedure III from (Z)-**7** (364 mg, 1.00 mmol), PhCHO (102 μL , 1.00 mmol, 1.0 equiv) and (*S,S*)- **20a** (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH_2Cl_2 , was obtained 203 mg (0.60 mmol, 60%) of **11a** as a clear, viscous oil after column chromatography (pentane/ether, 3/1, SiO_2). The product was further purified by recrystallization from pentane.

Data for (*syn,syn*)-**11a**:

mp: 46 – 48 $^\circ\text{C}$ (pentane)

^1H NMR: (500 MHz, CDCl_3)

7.35-7.31 (m, 4 H, HC(8), HC(9)); 7.27 – 7.25 (m, 1 H, HC(10)); 5.09 (t, $J = 3.4$, 1 H, HC(1)); 4.32 (sext, $J = 6.1$, 1 H, HC(5)); 3.19 (d, $J = 2.5$, 1 H, HO); 2.81 (qd, $J = 7.3, 3.7$, 1 H, HC(2)); 2.76-2.34 (ABX, 2 H, $\text{H}_2\text{C}(4)$); 1.12 (d, $J = 6.1$, 3 H, $\text{H}_3\text{C}(6)$); 1.05 (d, $J = 7.1$, 3 H, $\text{H}_3\text{C}(11)$); 0.85 (s, 9H, $\text{H}_3\text{C}(14)$); 0.05 (d, $J = 16.8$, 6 H, $\text{H}_3\text{C}(12)$)

^{13}C NMR: (126 MHz, CDCl_3)

214.18 (C(3)); 141.70 (C(7)); 128.24 (C(9)); 127.29 (C(10)); 125.89 (C(8)); 72.77 (C(5)); 65.92 (C(1)); 53.26 (C(2)); 51.45 (C(4)); 25.73 (C(14)); 23.81 (C(6)); 17.89 (C(13)); 9.36 (C(11)); -4.65, -4.92 (C(12))

IR: (neat)

3487 (br, m); 2956 (m); 2931 (m); 2885 (m); 2858 (m); 1709 (m); 1454 (m); 1408 (w); 1375 (m); 1254 (m); 1154 (m); 1093 (m)

MS: (FI)

336.2 (M^+ , 8); 279.2 (100); 230.2 (7); 173.1 (10); 106.1 (7)

Opt. Rot.: $[\alpha]_{\text{D}}^{24} + 50.3$ ($c = 0.29$, EtOH)

TLC: R_f 0.20 (pentane/ether, 5/1) [silica gel, *p*-anisaldehyde]

SFC: t_R 3.030 min (OD, 150 bar, 3 mL/min, 5% MeOH)

Analysis: $\text{C}_{19}\text{H}_{32}\text{O}_3\text{Si}$ (336.54)

Calcd: C, 67.81; H, 9.58%

Found: C, 67.78; H, 9.61%

(1*R*,2*R*,5*S*)-5-Triisopropylsilyloxy-2-methyl-1-hydroxy-1-phenyl-3-hexanone (*syn,anti*-12a**)**

Following General Procedure III from (Z)-**8** (456 mg, 1.00 mmol), PhCHO (102 μL , 1.00 mmol, 1.0 equiv) and (*R,R*)-**20a** (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH_2Cl_2 was obtained 317 mg (0.84 mmol, 84%) of **12a** as a clear, viscous oil after column chromatography (pentane/ether, 5/1, SiO_2).

Data for (*syn,anti*)-**12a**:

^1H NMR: (500 MHz, CDCl_3)

7.30 (d, $J = 7.6$, 2 H, HC(9)); 7.17 (t, $J = 7.3$, 2 H, HC(8)); 7.08 (t, $J = 7.2$, 1 H, HC(10)); 5.04 (t, $J = 3.2$, 1 H, HC(1)); 4.44 (sext, $J = 6.1$, 1 H, HC(5)); 2.74 (d, $J = 2.6$, 1 H, HO); 2.55 (qd, $J = 7.3, 3.9$, 1 H, HC(2)); 2.46–2.21 (ABX, 2 H, $\text{H}_2\text{C}(4)$); 1.11 (d, $J = 6.1$, 3 H, $\text{H}_3\text{C}(6)$); 1.10 – 1.02 (m, 21 H, $\text{H}_3\text{C}(13)$, HC(12)); 0.94 (d, $J = 7.0$, 3 H, $\text{H}_3\text{C}(11)$)

^{13}C NMR: (126 MHz, CDCl_3)

214.83 (C(3)); 141.89 (C(7)); 128.50 (C(8)); 127.55 (C(10)); 126.12 (C(9)); 72.83 (C(5)); 65.40 (C(1)); 53.56 (C(2)); 52.21 (C(4)); 24.29 (C(6)); 18.27 (C(13)); 12.60 (C(12)); 9.80 (C(11))

IR: (neat)

3467 (br, m); 3064 (w); 3032 (w); 2962 (s); 2943 (s); 2893 (s); 2868 (s); 1705 (s); 1462 (s); 1375 (s); 1248 (m); 1213 (m); 1198 (m); 1128(s); 1097 (s); 1070 (m); 1012 (s)

MS: (FAB)

379.3 (M^+ , 13); 273.2 (11); 230.2 (18); 229.2 (100); 202.2 (10); 201.2 (49); 185.1 (15); 175.1 (10); 159.1 (12); 157.1 (51); 154.1 (11), 137.0 (11); 136.0 (13); 131.1 (15); 115.1 (24); 107.0 (32); 105.0 (11), 103.0 (11)

Opt. Rot.: $[\alpha]_D^{24}$ -25.9 ($c = 0.24$, EtOH)

TLC: R_f 0.17 (pentane/ether, 5/1) [silica gel, *p*-anisaldehyde]

SFC: t_R 3.645 min (OD, 150 bar, 3 mL/min, 5% MeOH)

Analysis: $C_{22}H_{38}O_3Si$ (378.62)

Calcd: C, 69.79; H, 10.12%

Found: C, 69.63; H, 10.43%

(1*S*,2*S*,5*S*)-1-Triisopropylsilyloxy-2-methyl-5-hydroxy-5-phenyl-3-hexanone (*syn, syn*-12a**)**

Following General Procedure III from (*Z*)-**8** (450 mg, 1.00 mmol), PhCHO (102 μ L, 1.00 mmol, 1.0 equiv) and (*S,S*)-**20a** (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH_2Cl_2 was obtained 327 mg (0.86 mmol, 86%) of **12a** as a clear, colorless, viscous oil after column chromatography (pentane/ether, 5/1, SiO_2).

Data for (syn,syn)-12a:¹H NMR: (500 MHz, CDCl₃)

7.35 – 7.31 (m, 4 H, HC(9), HC(8)); 7.27 (m, 1 H, HC(10)); 5.09 (t, $J = 3.4$, 1 H, HC(1)); 4.40 (sext, $J = 5.9$, 1 H, HC(5)); 3.05 (d, $J = 2.7$, 1 H, HO); 2.85 (qd, $J = 7.3$, 3.9, 1 H, HC(2)); 2.87-2.48 (ABX, 2 H, H₂C(4)); 1.15 (d, $J = 6.1$, 3 H, H₃C(6)); 1.08 – 1.00 (m, 24 H, H₃C(13), HC(12), H₃C(11))

¹³C NMR: (126 MHz, CDCl₃)

214.48 (C(3)); 141.94 (C(7)); 128.51 (C(8)); 127.60 (C(10)); 126.17 (C(9)); 73.11 (C(5)); 65.13 (C(1)); 53.41 (C(2)); 52.27 (C(4)); 24.26 (C(6)); 18.30 (C(13)); 12.59 (C(12)); 10.09 (C(11))

IR: (neat)

3461 (br, m); 2963 (s); 2943 (s); 2893 (s); 2867 (s); 1707 (s); 1461 (m); 1375 (m); 1130 (s); 1097 (m); 1013 (s)

MS: (EI)

379.2 (M⁺, 4); 337.1 (8); 336.1 (30); 335.1 (100); 272.2 (6); 229.2 (13); 157.1 (4); 156.8 (4), 156.7 (5); 156.6 (6)

Opt. Rot.: $[\alpha]_D^{24} + 29.1$ (c = 0.59, EtOH)TLC: R_f 0.17 (pentane/ether, 5/1) [silica gel, *p*-anisaldehyde]SFC: t_R 4.452 min (OD, 150 bar, 3 mL/min, 5% MeOH)Analysis: C₂₂H₃₈O₃Si (378.62)

Calcd: C, 69.79; H, 10.12%

Found: C, 69.54; H, 10.32%

(1*R*,2*R*,5*S*)-5-Triisopropylsilyloxy-2-methyl-1-hydroxy-1-(1-naphthyl)-3-hexanone
(*syn,anti*-12b)

Following General Procedure III from (Z)-**8** (451 mg, 1.00 mmol), 1-naphthaldehyde (136 μL , 1.00 mmol, 1.0 equiv) and (*R,R*)- **20a** (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH_2Cl_2 for 8 h, was obtained 356 mg (0.83 mmol, 83%) of **12b** as a clear, colorless, viscous oil after column chromatography (pentane/ether, 5/1, SiO_2).

Data for (*syn,anti*)-12b:

^1H NMR: (500 MHz, CDCl_3)

7.89 (d, $J = 6.2$, 1 H, HC(9)); 7.87 (d, $J = 5.9$, 1 H, HC(12)); 7.78 (d, $J = 8.0$, 1 H, HC(14)); 7.72 (d, $J = 7.3$, 1 H, HC(16)); 7.52-7.47 (m, 3 H, HC(11), HC(10), HC(15)); 5.96 (t, $J = 2.4$, 1 H, HC(1)); 4.48 (sext, $J = 6.4$, 1 H, HC(5)); 3.26 (d, $J = 2.4$, 1 H, HO); 3.03 (qd, $J = 7.1, 4.4$, 1 H, HC(2)); 2.81-2.61 (ABX, 2 H, $\text{H}_2\text{C}(4)$); 1.22 (d, $J = 5.8$, $\text{H}_3\text{C}(6)$); 1.10 – 1.04 (m, 24 H, $\text{H}_3\text{C}(17)$, HC(18), $\text{H}_3\text{C}(19)$)

^{13}C NMR: (126 MHz, CDCl_3)

214.42 (C(3)); 136.66 (C(7)); 133.68 (C(13)); 129.62 (C(8)); 129.11 (C(12)); 127.83 (C(14)); 126.04 (C(10)); 125.35 (C(11)); 125.34 (C(15)); 124.27 (C(16)); 122.37 (C(9)); 69.07 (C(1)); 64.85 (C(5)); 51.88 (C(4)); 51.40 (C(2)); 24.08 (C(6)); 18.03 (C(19)); 12.33 (C(18)); 9.62 (C(17))

IR: (CH_2Cl_2)

3468 (br, m); 2962 (s); 2944 (s); 2892 (s); 2867 (s); 1704 (s); 1462 (s); 1374 (s); 1133 (s); 1102 (s); 1056 (m); 1029 (s); 1013 (s)

MS: (FI)

429.2 (M^+ , 4); 411.3 (7); 410.3 (13); 387.2 (7); 387.0 (6); 386.1 (28); 385.1 (100);
 384.2 (4); 299.2 (4); 282.2 (4); 274.2 (4); 273.2 (15); 272.2 (57); 256.2 (4); 254.2
 (4); 231.2 (4); 230.1 (8); 229.1 (58); 192.6 (5); 157.1 (8); 156.0 (44); 136.4 (5);
 136.0 (5)

Opt. Rot.: $[\alpha]_D^{24} - 4.73$ ($c = 0.61$, EtOH)**TLC:** R_f 0.09 (pentane/ether, 5/1) [silica gel, short uv]**SFC:** t_R 5.940 min (OD, 150 bar, 3 mL/min, 15% MeOH)**Analysis:** $C_{26}H_{40}O_3Si$ (428.68)

Calcd: C, 72.85; H, 9.41%

Found: C, 72.68; H, 9.49%

(1*S*,2*S*,5*S*)-5-Triisopropylsilyloxy-2-methyl-1-hydroxy-1-(1-naphthyl)-3-hexanone (*syn, syn*-12b**)**

Following General Procedure III from (Z)-**8** (451 mg, 1.00 mmol), 1-naphthaldehyde (136 μL , 1.00 mmol, 1.0 equiv) and (*S,S*)-**20a** (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH_2Cl_2 for 8 h, was obtained 347 mg (0.75 mmol, 75%) of **12b** as a clear, colorless, viscous oil after column chromatography (pentane/ether, 5/1, SiO_2).

Data for (syn,syn)-12b:¹H NMR: (500 MHz, CDCl₃)

7.88 (d, *J* = 7.4, 1 H, HC(9)); 7.87 (d, *J* = 4.1, 1 H, HC(12)); 7.79 (d, *J* = 8.0, 1 H, HC(14)); 7.72 (d, *J* = 7.1, 1 H, HC(16)); 7.52-7.48 (m, 3 H, HC(11), HC(10), HC(15)); 5.94 (dd, *J* = 3.4, 2.5, 1 H, HC(1)); 4.46 (sext, *J* = 6.1, 1 H, HC(5)); 3.24 (d, *J* = 2.4, 1 H, HO); 3.04 (qd, *J* = 7.3, 4.4, 1 H, HC(2)); 2.87 - 2.57 (ABX, 2 H, H₂C(4)); 1.21 (d, *J* = 6.1, H₃C(6)); 1.09 – 1.02 (m, 24 H, H₃C(17), HC(18), H₃C(19))

¹³C NMR: (126 MHz, CDCl₃)

214.31 (C(3)); 136.63 (C(7)); 133.68 (C(13)); 129.61 (C(8)); 129.12 (C(12)); 127.86 (C(14)); 126.09 (C(10)); 125.37 (C(11)); 125.34 (C(15)); 124.12 (C(16)); 122.31 (C(9)); 69.17 (C(1)); 64.90 (C(5)); 51.82 (C(4)); 51.38 (C(2)); 24.11 (C(6)); 17.99 (C(19)); 12.33 (C(18)); 9.59 (C(17))

IR: (neat)

3470 (br, m); 2963 (s); 2943 (s); 2892 (m); 2867 (s); 1704 (m); 1462 (m); 1374 (m); 1130 (m); 1104 (m); 1013 (s)

MS: (FI)

429.2 (M⁺, 16); 428.1 (10); 386.1 (28); 385.1 (95); 321.1 (17); 303.1 (11); 273.1 (21); 272.1 (58); 230.1 (17); 229.1 (97); 157.0 (20); 156.0 (100)

Opt. Rot.: [α]_D²⁴ + 14.2 (c = 0.63, EtOH)TLC: *R_f* 0.09 (pentane/ether, 5/1) [silica gel, short uv]SFC: *t_R* 3.562 min (OD, 150 bar, 3 mL/min, 15% MeOH)Analysis: C₂₆H₄₀O₃Si (428.68)

Calcd: C, 72.85; H, 9.41%

Found: C, 73.02; H, 9.78%

(2*S*,5*R*,6*R*)-2-Triisopropylsilyloxy-5-methyl-6-hydroxy-8-phenyl-7-octen-4-one (*syn,anti*-12c**)**

Following General Procedure III from (Z)-**8** (451 mg, 1.00 mmol), cinnamaldehyde (126 μL , 1.00 mmol, 1.0 equiv) and (R,R)-**20a** (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH_2Cl_2 for 12 h, was obtained 322 mg (0.80 mmol, 80%) of **12c** as a clear, colorless, viscous oil after column chromatography (pentane/ether, 2/1, SiO_2).

Data for (*syn,anti*)-**12c**:

^1H NMR: (500 MHz, CDCl_3)

7.37 (d, $J = 7.3$, 2 H, HC(13)); 7.31 (t, $J = 7.6$, 2 H, HC(14)); 7.24 (t, $J = 7.1$, 1 H, HC(15)); 6.64 (d, $J = 15.9$, 1 H, HC(8)); 6.14 (dd, $J = 15.8$, 5.9, 1 H, HC(7)); 4.67 (m, 1 H, HC(6)); 4.45 (sext, $J = 6.1$, 1 H, HC(2)); 2.88 (d, $J = 3.2$, 1 H, HO); 2.82-2.59 (ABX, 2 H, $\text{H}_2\text{C}(3)$); 2.76 (qd, $J = 7.3$, 3.4, 1 H, HC(5)); 1.22 (d, $J = 6.1$, 3 H, $\text{H}_3\text{C}(1)$); 1.17 (d, $J = 7.1$, 3 H, $\text{H}_3\text{C}(11)$); 1.05 (m, 21 H, HC(9), $\text{H}_3\text{C}(10)$)

^{13}C NMR: (126 MHz, CDCl_3)

219.29 (C(4)); 136.63 (C(12)); 131.06 (C(7)); 128.90 (C(8)); 128.57 (C(14)); 127.66 (C(15)); 126.46 (C(13)); 71.81 (C(6)); 65.33 (C(2)); 52.00 (C(3)); 51.53 (C(5)); 24.18 (C(1)); 18.07 (C(10)); 12.39 (C(9)); 10.02 (C(11))

IR: (neat)

3442 (br, m); 2963 (s); 2943 (s); 2892 (s); 2867 (s); 1705 (s); 1462 (m); 1374 (m); 1126 (s); 1013 (s)

MS: (FI)

404.1 (M^+ , 9); 361.1 (7); 321.1 (2); 272.1 (13); 229.0 (100); 132.0 (86)

Opt. Rot.: $[\alpha]_{\text{D}}^{24} - 20.5$ ($c = 0.33$, EtOH)

TLC: R_f 0.21 (pentane/ether, 2/1) [silica gel, short uv]

SFC: t_R 2.348 min (OD, 150 bar, 3 mL/min, 15% MeOH)

Analysis: $\text{C}_{24}\text{H}_{40}\text{O}_3\text{Si}$ (404.66)

Calcd: C, 71.23; H, 9.96%

Found: C, 71.20; H, 10.21%

(2*S*,5*S*,6*S*)-2-Triisopropylsilyloxy-5-methyl-6-hydroxy-8-phenyl-7-octen-4-one (*syn,syn*-12c**)**

Following General Procedure III from (Z)-**8** (451 mg, 1.00 mmol), cinnamaldehyde (126 μL , 1.00 mmol, 1.0 equiv) and (S,S)-**1a** (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH_2Cl_2 for 12 h, was obtained 304 mg (0.75 mmol, 75%) of **12c** as a clear, colorless, viscous oil after column chromatography (pentane/ether 2/1).

Data for (*syn,syn*)-**12c**:

^1H NMR: (500 MHz, CDCl_3)

7.37 (d, $J = 7.1$, 2 H, HC(13)); 7.31 (t, $J = 7.8$, 2 H, HC(14)); 7.24 (t, $J = 7.4$, 1 H, HC(15)); 6.64 (dd, $J = 15.9$, 1.2, 1 H, HC(8)); 6.15 (dd, $J = 15.8$, 5.8, 1 H, HC(7)); 4.66 (m, 1 H, HC(6)); 4.45 (sext, $J = 5.6$, 1 H, HC(2)); 2.85 (d, $J = 3.2$, 1 H, HO); 2.78 (m, 1 H, HC(5)); 2.80-2.62 (ABX, 2 H, $\text{H}_2\text{C}(3)$); 1.22 (d, $J = 6.1$, 3 H, $\text{H}_3\text{C}(1)$); 1.18 (d, $J = 7.3$, 3 H, $\text{H}_3\text{C}(11)$); 1.08 – 1.03 (m, 21 H, HC(9), $\text{H}_3\text{C}(10)$)

¹³C NMR: (126 MHz, CDCl₃)
 213.97 (C(4)); 136.61 (C(12)); 131.13 (C(7)); 128.96 (C(8)); 128.57 (C(14));
 127.67 (C(15)); 126.46 (C(13)); 72.00 (C(6)); 65.12 (C(2)); 51.97 (C(3)); 51.44
 (C(5)); 24.06 (C(1)); 18.06 (C(10)); 12.38 (C(9)); 10.16 (C(11))

IR: (neat)
 3436 (br, m); 2963 (s); 2943 (s); 2892 (m); 2867 (s); 1707 (m); 1462 (m); 1374
 (m); 1130 (m); 1013 (s)

MS: (FI)
 404.1 (M⁺, 18); 385.1 (8); 361.1 (7); 321.0 (9); 273.1 (10); 272.1 (21); 245.0 (9);
 230.1 (19); 229.1 (100); 156.0 (8); 133.0 (12); 132.0 (74)

Opt. Rot.: [α]_D²⁴ + 27.7 (c = 0.50, EtOH)

TLC: R_f 0.20 (pentane/ether, 2/1) [silica gel, short uv]

SFC: t_R 3.231 min (OD, 150 bar, 3 mL/min, 15% MeOH)

Analysis: C₂₄H₄₀O₃Si (404.66)
 Calcd: C, 71.23; H, 9.96%
 Found: C, 71.29; H, 10.31%

(2*S*,5*R*,6*R*)-2-Triisopropylsilyloxy-5-methyl-6-hydroxy-7-nonen-4-one (*syn,anti*-12d)

Following General Procedure III from (Z)-8 (451 mg, 1.00 mmol), crotonaldehyde (83 μL, 1.00 mmol, 1.0 equiv) and (R,R)-20a (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH₂Cl₂ for 8 h, was obtained 272 mg (0.79 mmol, 79%) of **12d** as a clear, colorless, viscous oil after column chromatography (pentane/ether, 3/1, SiO₂).

Data for (syn,anti)-12d:

¹H NMR: (500 MHz, benzene-*d*₆)

5.61 (dq, *J* = 15.2, 6.4, 1.2, 1 H, HC(8)); 5.37 (ddd, *J* = 15.4, 6.1, 1.5, 1 H, HC(7)); 4.51 (sext, *J* = 6.3, 1 H, HC(2)); 4.31 (m, 1 H, HC(6)); 2.68 – 2.34 (ABX, 2 H, H₂C(3)); 2.36 (m, 1 H, HC(5)); 2.10 (d, *J* = 3.5, 1 H, HO); 1.53 (d, *J* = 6.5, 3 H, H₃C(9)); 1.17 (d, *J* = 6.1, 3 H, H₃C(1)); 1.15 – 1.03 (m, 21 H, H₃C(11), HC(10)); 1.01 (d, *J* = 7.3, 3 H, H₃C(12))

¹³C NMR: (126 MHz, CDCl₃)

214.08 (C(4)); 130.48 (C(7)); 127.87 (C(8)); 72.16 (C(6)); 65.15 (C(2)); 52.07 (C(3)); 51.63 (C(5)); 24.09 (C(1)); 18.02 (C(11)); 17.67 (C(9)); 12.32 (C(10)); 10.19 (C(12))

IR: (neat)

3442 (br, m); 2963 (s); 2943 (s); 2893 (s); 2868 (s); 1710 (s); 1463 (m); 1375 (m); 1130 (s); 1102 (m); 1013 (s)

MS: (FI)

343.2 (M⁺, 3); 301.2 (7); 300.2 (22); 299.6 (4); 299.2 (100); 281.2 (4); 272.2 (8); 230.1 (6); 29.1 (36); 176.2 (3); 176.1 (4); 176.0 (4); 175.9 (5); 175.8 (6); 175.6 (6); 175.4 (5); 175.3 (5); 175.1 (4)

Opt. Rot.: [α]_D²⁴ - 15.9 (c = 0.54, EtOH/c = 0.54)

TLC: *R*_f 0.16 (pentane/ether, 3/1) [silica gel, *p*-anisaldehyde]

Analysis: C₁₉H₃₈O₃Si (342.59)

Calcd: C, 66.61; H, 11.18%

Found: C, 66.37; H, 11.36%

(2*S*, 5*S*, 6*S*)-2-Triisopropylsilyloxy-5-methyl-6-hydroxy-7-nonen-4-one (*syn, syn*-12d**)**

Following General Procedure III from (Z)-**8** (451 mg, 1.00 mmol), crotonaldehyde (83 μL , 1.00 mmol, 1.0 equiv) and (*S,S*)-**20a** (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH_2Cl_2 for 8 h, was obtained 285 mg (0.83 mmol, 83%) of **12d** as a clear, colorless, viscous oil after column chromatography (pentane/ether, 3/1, SiO_2).

Data for (*syn, syn*)-**12d**:

^1H NMR: (500 MHz, benzene- d_6)

5.58 (dq, $J = 15.4, 6.4, 1.2$, 1 H, HC(8)); 5.35 (ddd, $J = 15.4, 6.1, 1.7$, 1 H, HC(7)); 4.51 (sext, $J = 5.9$, 1 H, HC(2)); 4.25 (m, 1 H, HC(6)); 2.68 – 2.34 (ABX, 2 H, $\text{H}_2\text{C}(3)$); 2.38 (m, 1 H, HC(5)); 2.00 (d, $J = 3.4$, 1 H, HO); 1.51 (dd, $J = 6.4, 1.0$, 3 H, $\text{H}_3\text{C}(9)$); 1.18 (d, $J = 6.1$, 3 H, $\text{H}_3\text{C}(1)$); 1.16 – 1.00 (m, 21 H, $\text{H}_3\text{C}(11)$, HC(10)); 1.05 (d, $J = 7.1$, 3 H, $\text{H}_3\text{C}(12)$)

^{13}C NMR: (126 MHz, CDCl_3)

213.71 (C(4)); 130.57 (C(7)); 127.97 (C(8)); 72.41 (C(6)); 64.95 (C(2)); 52.15 (C(3)); 51.56 (C(5)); 24.04 (C(1)); 17.97 (C(11)); 17.66 (C(9)); 12.30 (C(11)); 10.36 (C(12))

IR: (neat)

3441 (br, m); 2963 (s); 2944 (m); 2893 (m); 2867 (s); 1710 (m); 1462 (m); 1375 (m); 1132 (m); 1109 (m); 1013 (m)

MS: (FI)

343.2 (2); 342.2 (M^+ , 3); 301.2 (7); 300.2 (22); 299.2 (100); 229.2 (37); 175.3 (5)

Opt. Rot.: $[\alpha]_{\text{D}}^{24} + 30.4$ ($c = 0.54$, EtOH)

TLC: R_f 0.16 (pentane/ether, 3/1) [silica gel, *p*-anisaldehyde]

Analysis: C₁₉H₃₈O₃Si (342.59)

Calcd: C, 66.61; H, 11.18%

Found: C, 66.33; H, 11.33%

(2*S*,5*R*,6*R*)-2-Triisopropylsilyloxy-11,12-dimethyl-6-hydroxy-8-phenyl-7-octen-4-one
(*syn,anti*-12e)

Following General Procedure III from (Z)-8 (436 mg, 1.00 mmol), - methylcinnamaldehyde (140 μL , 1.00 mmol, 1.0 equiv) and (*R,R*)-20a (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH₂Cl₂ for 10 h, was obtained 332 mg (0.79 mmol, 79%) of **12e** as a clear viscous oil after column chromatography (pentane/ether, 3/1, SiO₂).

Data for (*syn,anti*)-12e:

¹H NMR: (500 MHz, CDCl₃)

7.33 (t, *J* = 7.8, 2 H, HC(15)); 7.27 (d, *J* = 7.3, 2 H, HC(14)); 7.21 (t, *J* = 7.0, 1 H, HC(16)); 6.63 (br s, 1 H, HC(8)); 4.53 (m, 1 H, HC(6)); 4.47 (sext, *J* = 6.3, 1 H, HC(2)); 2.99 (d, *J* = 2.7, 1 H, HO); 2.84-2.62 (ABX, 2 H, H₂C(3)); 2.82 (m, 1 H, HC(5)); 1.81 (d, *J* = 1.0, 3 H, H₃C(12)); 1.22 (d, *J* = 5.9, 3 H, H₃C(1)); 1.13 (d, *J* = 7.3, 3 H, H₃C(11)); 1.07 – 1.00 (m, 21 H, HC(9), H₃C(10))

¹³C NMR: (126 MHz, CDCl₃)

214.31 (C(4)); 137.64 (C(13)); 136.34 (C(7)); 128.99 (C(15)); 128.07 (C(14)); 126.35 (C(16)); 125.86 (C(8)); 74.77 (C(6)); 65.28 (C(2)); 51.69 (C(3)); 49.21 (C(5)); 24.11 (C(1)); 18.02 (C(10)); 15.26 (C(12)); 12.36 (C(9)); 9.27 (C(11))

IR: (CHCl₃)

3487 (br, w); 2962 (m); 2945 (m); 2868 (m); 1699 (w); 1464 (w); 1377 (w); 1101 (w)

MS: (FI)

418.2 (M⁺, 100); 375.2 (25); 336.7 (8); 272.2 (22); 229.1 (27); 187.6 (4); 146.1 (29); 115.1 (2)

Opt. Rot.: [α]_D²⁴ - 2.13 (c = 0.63, EtOH)

TLC: R_f 0.22 (pentane/ether, 3/1) [silica gel, short uv]

SFC: t_R 2.03 min (OD, 150 bar, 3 mL/min, 15% MeOH)

Analysis: C₂₅H₄₂O₃Si (418.68)

Calcd: C, 71.72; H, 10.11%

Found: C, 71.34; H, 10.18%

(2*S*,5*S*,6*S*)-2-Triisopropylsilyloxy-11,12-dimethyl-6-hydroxy-8-phenyl-7-octen-4-one
(*syn,syn*-12e)

Following General Procedure III from (Z)-8 (436 mg, 1.00 mmol), - methylcinnamaldehyde (140 μL, 1.00 mmol, 1.0 equiv) and (S,S)-20a (37 mg, 0.10 mmol, 0.1 equiv) in 1 mL of CH₂Cl₂ for 10 h, was obtained 344 mg (0.82 mmol, 82%) of **12e** as a clear, viscous oil after column chromatography (pentane/ether, 3/1, SiO₂).

Data for (syn,syn)-12e:

¹H NMR: (500 MHz, CDCl₃)

7.33 (t, *J* = 7.3, 2 H, HC(15)); 7.27 (d, *J* = 6.6, 2 H, HC(14)); 7.21 (t, *J* = 7.4, 1 H, HC(16)); 6.62 (br s, 1 H, HC(8)); 4.52 (br s, 1 H, HC(6)); 4.45 (sext, *J* = 5.9, 1 H, HC(2)); 2.91 (d, *J* = 2.9, 1 H, HO); 2.86 (qd, *J* = 7.3, 3.6, 1 H, HC(5)); 2.84-2.62 (ABX, 2 H, H₂C(3)); 1.83 (d, *J* = 0.7, 3 H, H₃C(12)); 1.23 (d, *J* = 6.1, 3 H, H₃C(1)); 1.13 (d, *J* = 7.3, 3 H, H₃C(11)); 1.06 (m, 21 H, HC(9), H₃C(10))

¹³C NMR: (126 MHz, CDCl₃)

213.98 (C(4)); 137.61 (C(13)); 136.44 (C(7)); 128.99 (C(15)); 128.08 (C(14)); 126.38 (C(16)); 125.92 (C(8)); 75.01 (C(6)); 65.07 (C(2)); 51.75 (C(3)); 49.03 (C(5)); 24.12 (C(1)); 18.03 (C(10)); 15.25 (C(12)); 12.36 (C(9)); 9.42 (C(11))

IR: (neat)

3467 (br, m); 2943 (s); 2866 (s); 1705 (m); 1462 (m); 1375 (m); 1130 (m); 1097 (m); 1012 (m)

MS: (FI)

418.2 (M⁺, 55); 401.2 (3); 375.2 (14); 337.1 (4); 272.2 (95); 229.1 (100); 201.3 (5); 146.1 (99)

Opt. Rot.: [α]_D²⁴ +15.1 (c = 2.2, EtOH)

TLC: *R_f* 0.22 (pentane/ether, 3/1) [silica gel, short uv]

SFC: *t_R* 2.983 min (OD, 150 bar, 3 mL/min, 15% MeOH)

Analysis: C₂₅H₄₂O₃Si (418.68)

Calcd: C, 71.72; H, 10.11%

Found: C, 71.46; H, 10.04%

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