

[Supporting Information]

Enantioselective Total Synthesis of (-)-Taxol

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Experimental Section

General Techniques.

All reactions were carried out under a dry nitrogen atmosphere with dry, distilled solvents under anhydrous conditions, unless otherwise noted. Tetrahydrofuran (THF) and ethyl ether (Et₂O) were distilled from sodium-benzophenone ketyl before use. All other solvents were distilled according to the usual procedures and stored over molecular sieves 4A. All reagents were purchased at highest commercial quality and used without further purification unless otherwise noted. Merck silica gel 60, Kanto N60 (spherical, neutral), and Fuji silysia FL100DX were used for flash column chromatography. Preparative thin-layer chromatography separations were carried out using Wakogel B-5F or Merck Kieselgel 60 F254. IR spectra were recorded on a JASCO FT/IR-200 spectrometer. NMR spectra were recorded on a JEOL GSX-270 (¹H at 270 MHz, ¹³C at 67.5 MHz), a JEOL Lambda-300 (¹H at 300 MHz, ¹³C at 75 MHz), a JEOL Lambda-400 (¹H at 400 MHz, ¹³C at 100 MHz), or a Bruker DRX-500 (¹H at 500 MHz, ¹³C at 125 MHz) spectrometer (CDCl₃ was used as solvent). High resolution mass analyses (FAB) were performed on a JEOL JMS-AX 505HA mass spectrometer. Elemental analyses were performed on a Perkin-Elmer 2400 instrument. Optical rotations were recorded on a JASCO DIP-1000 digital polarimeter.

Preparation of the optically active A-ring fragment 1

The A-ring fragment **8** was prepared according to the previous report.^{11b} Experimental procedures and their spectral data of the compounds **4** to **8** are described below.

Oxidation of the alcohol to the aldehyde 4

To a mixture of oxalyl chloride (66.3 mL, 0.76 mol) and DMSO (83.0 mL, 1.17 mol) in CH₂Cl₂ (700 mL) was added a CH₂Cl₂ solution (290 mL) of the alcohol (157 g, 0.59 mol) slowly at -78 °C, and the mixture was stirred for 2 h. To this was added triethylamine (245 mL, 1.78 mol) carefully through 3 h and the mixture was gradually warmed to ambient temperature over night. The reaction was quenched with water and the layers were separated. The organic layer was washed with saturated aqueous NaHCO₃ and brine. The aqueous layer was extracted with ether and the combined

extracts were also washed with saturated aqueous NaHCO_3 and brine. After being dried over MgSO_4 , the mixture was filtered and the solvent was removed under reduced pressure. The residue was purified by flash chromatography (silica gel, 15% AcOEt /hexane) to give the aldehyde **4** (143 g, 92%).

4: IR (neat) 2980, 2940, 2880, 1750, 1720, 1665, 1480, 1460, 1380, 1365, 1320, 1270, 1160, 1100, 1030, 1005 cm^{-1} . ^1H NMR (300 MHz) δ 1.08 (s, 3H), 1.27 (s, 9H), 1.38 (s, 3H), 1.65 (t, $J = 1.7$ Hz, 3H), 2.45–2.60 (m, 1H), 2.72–2.88 (m, 2H), 9.81 (s, 1H). ^{13}C NMR (67.5 MHz) δ 8.6, 20.6, 23.2, 25.3, 26.9, 39.2, 42.4, 54.2, 122.9, 160.3, 175.1, 200.9, 201.2. Anal. Calcd for $\text{C}_{15}\text{H}_{22}\text{O}_4$: C, 67.65; H, 8.33. Found: C, 67.42; H, 8.63.

Preparation of the enol silyl ether **5**

To a CH_2Cl_2 (700 mL) solution of the aldehyde **4** (85.2 g, 0.32 mol) and DMAP (39.1 g, 0.32 mol) were added DBU (67.0 mL, 0.45 mol) and TIPSOTf (120 mL, 0.45 mol) at -78°C . The cooling bath was removed and the mixture was gradually warmed to ambient temperature. After being stirred for 4 h, the reaction mixture was treated with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with hexane. The combined organic extracts were washed with brine and dried over MgSO_4 . The crude reaction mixture was filtered and concentrated under reduced pressure. Purification of the resultant residue by flash chromatography (silica gel, 5% AcOEt /hexane), followed by recrystallization from MeOH, gave the enol silyl ether **5** (96 g, 71%) as a white crystal. The obtained product consists of the *E*-isomer exclusively.

5: mp 51°C . IR (CH_2Cl_2) 2950, 1755, 1680, 1670, 1470, 1380, 1320, 1260, 1220, 1170, 1120, 1100, 1020, 1000 cm^{-1} . ^1H NMR (270 MHz) δ 1.03–1.20 (m, 21H), 1.25 (s, 6H), 1.32 (s, 9H), 1.65 (t, $J = 2.0$ Hz, 3H), 3.33 (dq, $J = 1.0, 2.0$ Hz, 2H), 6.34 (t, $J = 1.0$ Hz, 1H). ^{13}C NMR (67.5 MHz) δ 8.9, 11.9, 17.6, 23.7, 26.2, 27.0, 39.2, 44.6, 117.4, 121.9, 134.8, 161.2, 175.2, 202.3. Anal. Calcd for $\text{C}_{24}\text{H}_{42}\text{O}_4\text{Si}$: C, 68.20; H, 10.02. Found: C, 68.14; H, 10.32.

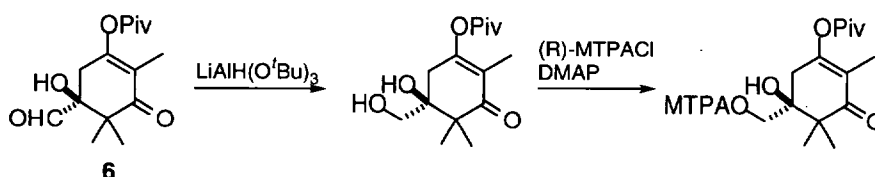
Asymmetric dihydroxylation of the enol silyl ether **5**

To an aqueous solution (1.0 L) of $\text{K}_2\text{OsO}_2(\text{OH})_4$ (0.84 g, 2.3 mmol), $\text{K}_2\text{Fe}(\text{CN})_6$ (205 g, 0.62 mol), and K_2CO_3 (85 g, 0.61 mol) was added DHQ-PHN (2.1 g, 4.1 mmol), and the mixture was cooled to 0°C . To this was added a *t*-BuOH solution (1.0 L) of the enol silyl ether **5** (86.2 g, 0.20 mol) at that temperature. After being stirred for 11 h, Na_2SO_3 (153 g) and AcOEt (1.0 L) were added, and then the reaction mixture was warmed to room temperature. After being stirred for an additional 1 h, the organic layer was separated and the aqueous layer was extracted with AcOEt . The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. Purification of the resultant residue by flash chromatography (silica gel, 20% AcOEt /hexane) gave the corresponding hydroxyaldehyde **6** (56.5 g, 98%). (In some cases, a dimer of the hydroxyaldehyde was contaminated with the desired product **6**. Conversion of the products containing the dimers to the monomeric **6** could be carried out as follows: A benzene solution of the products and *N,N'*-dimethylethylenediamine was heated to reflux with a Dean-Stark

trap. After 30 min, the reaction mixture was cooled to room temperature. Removal of solvent and purification by flash chromatography (silica gel, 20% AcOEt/hexane) afforded the pure monomeric hydroxyaldehyde **6**.) The optical purity of **6** was checked by ^1H NMR analysis of the corresponding MTPA ester as 90% ee. Recrystallization of **6** from benzene-hexane in a refrigerator gave the optically pure **6**.

optically pure 6: $[\alpha]_{\text{D}}^{16}$: $+43^\circ$ ($c = 1.02$, CH_2Cl_2). IR (neat) 3470, 2970, 1740, 1660, 1480, 1380, 1270, 1220, 1150, 1120, 1100 cm^{-1} . ^1H NMR (270 MHz) δ 1.14 (s, 3H), 1.22 (s, 3H), 1.31 (s, 9H), 1.73 (t, $J = 2.2$ Hz, 3H), 2.73 (dq, $J = 2.2, 18.2$ Hz, 1H), 2.81 (dq, $J = 2.2, 18.2$ Hz, 1H), 3.63 (s, 1H), 9.73 (s, 1H). ^{13}C NMR (67.5 MHz) δ 8.7, 19.4, 19.5, 26.9, 34.3, 39.2, 48.0, 80.7, 123.6, 157.6, 175.5, 200.3, 201.3. Anal. Calcd for $\text{C}_{15}\text{H}_{22}\text{O}_5$: C, 63.81; H, 7.85. Found: C, 63.59; H, 7.72.

Determination of the optical purity of the hydroxyaldehyde **6**



To a THF solution (0.34 mL) of the recrystallized hydroxyaldehyde **6** (26.4 mg, 0.094 mmol) was added $\text{LiAlH}(\text{O}^t\text{Bu})_3$ (0.14 mL, 1.0 M in THF, 0.14 mmol) at -78°C , and the mixture was stirred for 0.5 h. To this was added water and the aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO_4 . The crude reaction mixture was filtered and concentrated under reduced pressure to give the crude diol.

^1H NMR (270 MHz) δ 1.12 (s, 3H), 1.22 (s, 3H), 1.32 (s, 9H), 1.68 (t, $J = 2.0$ Hz, 3H), 2.68 (dq, $J = 2.0, 18.0$ Hz, 1H), 2.82 (dq, $J = 2.0, 18.0$ Hz, 1H), 3.62 (d, $J = 10.0$ Hz, 1H), 3.68 (d, $J = 10.0$ Hz, 1H).

To a CCl_4 solution (0.48 mL) of the crude diol and DMAP (21.8 mg, 0.17 mmol) was added (*R*)-MTPACl (21 μL , 0.11 mmol) at 0°C . The mixture was stirred for 1 h and then saturated aqueous NaHCO_3 was added. The aqueous layer was extracted with AcOEt and the combined extracts were washed with brine. After being dried over MgSO_4 , the crude reaction mixture was filtered and concentrated under reduced pressure to give the crude MTPA ester. ^1H NMR analysis of the MTPA ester derived from racemic **6** showed two doublet signals at 4.46 ppm and 4.56 ppm ($J = 11.4$ Hz). The present optically active compound (recrystallized) showed only one doublet signal at 4.46 ppm. Thus, the optical purity of **6** was determined as $>98\%$ ee.

MTPA ester: ^1H NMR (400 MHz) δ 1.15 (s, 3H), 1.24 (s, 3H), 1.28 (s, 9H), 1.66 (s, 3H), 2.22 (brs, 1H, OH), 2.52 (d, $J = 18.3$ Hz, 1H), 2.78 (d, $J = 18.3$ Hz, 1H), 3.54 (s, 3H), 4.31 (d, $J = 11.4$ Hz, 1H), 4.46 (d, $J = 11.4$ Hz, 1H), 7.35–7.57 (m, 5H).

Preparation of 7

A benzene solution (410 mL) of the hydroxyaldehyde **6** (58.4 g, 0.21 mol) and *N, N'*-dimethylethylenediamine (22.0 mL, 0.21 mol) was heated to reflux with a Dean-Stark trap to protect the aldehyde moiety of **6** as an aminor. After 30 min, the reaction mixture was cooled to room temperature and the solvent was removed under reduced pressure. To a THF solution (410 mL) of the residue was added KOMe (35.6 g, 0.51 mol) at $-23\text{ }^{\circ}\text{C}$ and, after 1.5 h, additional KOMe (6.2 g, 0.09 mol) was added. After being stirred for 1.5 h, the mixture was treated with Et_3N (28.9 mL, 0.21 mol) and TIPSCl (140 mL, 0.65 mol) and stirred for 3 h at that temperature. The reaction was quenched with saturated aqueous NaHCO_3 and the mixture was extracted with ether. The combined extracts were washed with brine and dried over MgSO_4 . The crude reaction mixture was filtered and concentrated under reduced pressure. Purification of the resultant residue by flash chromatography (silica gel, hexane then 50% AcOEt/hexane) gave the product **7** (45.6 g, 62%).

7: $[\alpha]_{\text{D}}^{20}$: -8.3° ($c = 1.17$, CH_2Cl_2). IR (CH_2Cl_2) 3425, 2950, 2870, 1735, 1620, 1465, 1380, 1350, 1260 cm^{-1} . ^1H NMR (300 MHz) δ 1.04 (s, 3H), 1.04–1.11 (m, 21H), 1.16 (s, 3H), 1.76 (s, 3H), 2.58 (d, $J = 17.9$ Hz, 1H), 2.75 (d, $J = 17.9$ Hz, 1H), 3.71 (s, 1H), 9.68 (s, 1H). ^{13}C NMR (75 MHz) δ 8.9, 13.1, 17.8, 19.3, 20.2, 37.1, 47.0, 80.6, 116.5, 161.9, 200.9, 202.2. Anal. Calcd for $\text{C}_{19}\text{H}_{34}\text{O}_4\text{Si}$: C, 64.36; H, 9.67. Found: C, 64.34; H, 9.53.

Preparation of the A-ring fragment 8

A benzene solution of the hydroxyaldehyde **7** (31.3 g, 88 mmol) and *N, N'*-dimethylethylenediamine (8.9 mL, 84 mmol) was heated to reflux with a Dean-Stark trap to protect the aldehyde moiety of **7** as an aminor. After 30 min, the reaction mixture was cooled to room temperature and the solvent was removed under reduced pressure. To a cooled ($-23\text{ }^{\circ}\text{C}$) THF solution (150 mL) of the residue was added a THF solution of (phenylthio)trimethylsilylmethyl lithium, which was prepared by treatment of (phenylthiomethyl)trimethylsilane (44.8 mL, 221 mmol) in THF (150 mL) with BuLi (141.4 mL, 1.56 M in hexane, 221 mmol) at $0\text{ }^{\circ}\text{C}$ for 1 h. After being stirred for 3 h at $0\text{ }^{\circ}\text{C}$, the reaction mixture was poured into a vigorously stirred mixture of ether and saturated aqueous NaHCO_3 . The aqueous layer was extracted with ether and the combined extracts were washed with brine. After being dried over MgSO_4 , the crude reaction mixture was filtered and concentrated under reduced pressure. Purification of the resultant residue by flash chromatography (silica gel, hexane then 3% AcOEt/hexane) gave the A-ring fragment **8** (26.2 g, 64%) as a mixture of geometrical isomers (*E*:*Z* = 1.5:1).

8: IR (CH_2Cl_2) *E*-isomer; 3495, 2945, 2865, 1720, 1630, 1460, 1385, 1350, 1335, 1250 cm^{-1} , *Z*-isomer; 3500, 2945, 2870, 1720, 1630, 1460, 1380, 1350, 1330, 1260 cm^{-1} . ^1H NMR (300 MHz) *E*-isomer; δ 1.05–1.15 (m, 21H), 1.29 (s, 3H), 1.40 (s, 3H), 1.87 (s, 3H), 2.24 (d, $J = 17.7$ Hz, 1H), 2.77 (d, $J = 17.7$ Hz, 1H), 3.65 (s, 1H), 6.24 (s, 1H), 7.20–7.43 (m, 5H), 9.74 (s, 1H); *Z*-isomer; δ 1.03 (s, 3H), 1.06–1.16 (m, 21H), 1.17 (s, 3H), 2.19 (s, 3H), 2.33 (d, $J = 18.0$ Hz, 1H), 2.58 (d, $J = 18.0$ Hz, 1H), 3.49 (s, 1H), 6.07 (s, 1H), 7.20–7.38 (m, 5H), 9.62 (s, 1H). ^{13}C NMR (75 MHz) *E*-isomer; δ 12.8, 13.1, 18.0, 21.6, 21.7, 37.0, 41.7, 79.7, 114.5, 118.9, 126.7,

129.2, 129.2, 137.9, 140.2, 142.2, 205.0; *Z*-isomer; δ 13.2, 15.4, 18.0, 21.3, 23.2, 37.3, 43.5, 79.5, 112.9, 118.3, 126.6, 129.2, 129.2, 137.7, 140.7, 145.3, 204.5. Anal (*E, Z* mixture). Calcd for $C_{26}H_{40}O_3SSi$: C, 67.25; H, 8.47; S, 4.99. Found: C, 67.45; H, 8.58; S, 5.11.

Preparation of the C-ring fragment 12

2-Bromo-6-triethylsiloxy-2-cyclohexenone 9

To a stirred and cooled (-78°C) solution of 2-bromocyclohexenone (3.74 g, 21.4 mmol) in THF (50 mL) were added chlorotriethylsilane (4.44 mL, 23.5 mmol) and a THF (50 mL) solution of lithium diisopropylamide [prepared from diisopropylamine (3.60 mL, 25.7 mmol) and butyllithium (1.69 M in hexane, 15.2 mL, 25.7 mmol) at 0°C]. After being stirred for 30 min, the reaction mixture was treated with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with ether. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The crude enol silyl ether was directly used in the next step.

To a CH_2Cl_2 (50 mL) solution of the crude enol silyl ether were added potassium hydrogencarbonate (10.7 g, 107 mmol) and *m*-chloroperbenzoic acid (4.44 g, 25.7 mmol) at 0°C . After being stirred for 30 min, the reaction mixture was poured into a vigorously stirred mixture of hexane and saturated aqueous $\text{Na}_2\text{S}_2\text{O}_3$. The layers were separated, and the aqueous layer was extracted with AcOEt . The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. Purification of the residue by column chromatography (Fuji silysia, FL-100DX, 16% AcOEt /hexane) afforded 2-bromo-6-triethylsiloxy-2-cyclohexenone **9** (6.30 g, 96%) as a colorless oil.

9: IR (neat) 1705, 1600, 1140, 1000, 795, 740 cm^{-1} . ^1H NMR (270 MHz) δ 0.64 (q, $J = 8.0$ Hz, 6H), 0.96 (t, $J = 8.0$ Hz, 9H), 2.06–2.25 (m, 2H), 2.36–2.66 (m, 2H), 4.28 (dd, $J = 5.0, 9.6$ Hz, 1H), 7.34 (t, $J = 4.2$ Hz, 1H). ^{13}C NMR (67.5 MHz) δ 4.7, 6.7, 26.2, 32.2, 73.8, 122.0, 150.2, 191.3. Anal. Calcd for $\text{C}_{12}\text{H}_{21}\text{BrO}_2\text{Si}$: C, 47.21; H, 6.93. Found: C, 47.37; H, 7.21.

2-Bromo-1,6-dihydroxy-2-cyclohexenecarbaldehyde Dimethyl Acetal 10

To a solution of butyllithium (1.69 M in hexane, 4.77 mL, 8.06 mmol) in THF (20 mL) were added tetramethylethylenediamine (1.21 mL, 8.06 mmol) and methoxyphenylthiomethane (1.14 mL, 8.06 mmol) at -78°C , and the mixture was stirred for 1 h. To this was added a THF solution (10 mL) of 2-bromo-6-triethylsiloxy-2-cyclohexenone **12** (2.05 g, 6.72 mmol) and the mixture was stirred for 2 h. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with hexane. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered through a short pad of silica gel (Fuji silysia, FL-100DX). Removal of the solvent under reduced pressure afforded the crude adducts (2.71 g) as a mixture of diastereomers.

The crude 1,2-adduct (1.20 g) was treated with copper(II) oxide (0.883 g, 11.8 mmol) and copper(II) chloride (0.796 g, 5.92 g) in a mixed solution of THF (10 mL) and MeOH (8 mL), and the mixture was heated to reflux for 4 h. Then the mixture was cooled to room temperature. Inorganic materials were filtered off through a short pad of Celite and the filtrate was washed with saturated aqueous potassium sodium tartrate. The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO₄. Removal of the solvent under reduced pressure followed by chromatographic purification (Fuji silysia, FL-100DX, 12%-20% AcOEt/hexane, gradient elution) of the residue afforded (1*R**,6*R**)-2-bromo-1,6-dihydroxy-2-cyclohexenecarbaldehyde dimethyl acetal **10** (0.430 g, 54%) and its stereoisomer, (1*R**,6*S**)-2-bromo-1,6-dihydroxy-2-cyclohexenecarbaldehyde dimethyl acetal (0.056 g, 7%).

(1*R,6*R**)-2-Bromo-1,6-dihydroxy-2-cyclohexenecarbaldehyde Dimethyl Acetal 10:** IR (neat) 3460, 1640, 1160, 1060, 980, 765 cm⁻¹. ¹H NMR (270 MHz) δ 1.65–1.85 (m, 2H), 2.00–2.20 (m, 2H), 3.38 (s, 1H), 3.44 (s, 1H), 3.58 (s, 3H), 3.65 (s, 3H), 4.26 (dd, *J* = 4.4, 11.0 Hz, 1H), 4.70 (s, 1H), 6.29 (dd, *J* = 3.6, 5.0 Hz, 1H). ¹³C NMR (67.5 MHz) δ 24.7, 25.3, 58.5, 60.0, 69.0, 74.6, 111.5, 123.5, 134.7. Anal. Calcd for C₉H₁₄BrO₄: C, 40.62; H, 5.30. Found: C, 40.72; H, 5.57.

(1*R,6*S**)-2-Bromo-1,6-dihydroxy-2-cyclohexenecarbaldehyde Dimethyl Acetal:** IR (neat) 3430, 1635, 1185, 1065, 995, 740 cm⁻¹. ¹H NMR (270 MHz) δ 1.88–1.97 (m, 2H), 2.34–2.49 (m, 2H), 2.56 (s, 1H), 3.64 (s, 3H), 3.67 (s, 3H), 4.12 (dd, *J* = 7.3, 7.5 Hz, 1H), 4.74 (s, 1H), 6.37 (dd, *J* = 3.4, 5.4 Hz, 1H).

(1*R,2*R**)-3-Bromo-2-dibenzyloxymethyl-3-cyclohexene-1,2-thionocarbonate 11**

A mixture of **10** (11.2 g, 41.9 mmol), benzyl alcohol (21.7 mL, 210 mmol), and *p*-toluenesulfonic acid (71.3 mg, 0.419 mmol) in benzene (100 mL) was heated to reflux for 6 h with azeotropic removal of methanol. Then the solution was cooled to room temperature and triethylamine (1 mL) was added. Removal of benzene by evaporation, and benzyl alcohol by distillation under reduced pressure afforded the crude dibenzyl acetal. The crude product was directly used in the next step.

To a CH₂Cl₂ (100 mL) solution of the crude dibenzyl acetal were added dimethylaminopyridine (12.8 g, 105 mmol) and thiophosgene (3.95 mL, 50.3 mmol) at 0 °C. The mixture was slowly warmed to room temperature and stirred for 30 min. The reaction was quenched with saturated aqueous NaHCO₃. The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash chromatography (silica gel, 10% AcOEt/hexane) to afford (1*R**,2*R**)-3-bromo-2-dibenzyloxymethyl-3-cyclohexene-1,2-thionocarbonate **11** (12.4 g, 64%) as a colorless oil.

11: IR (neat) 1805, 1450, 1285, 1060, 735, 695 cm^{-1} . ^1H NMR (270 MHz) δ 1.95–2.40 (m, 4H), 4.48 (d, J = 11.6 Hz, 1H), 4.66 (d, J = 7.6 Hz, 1H), 4.70 (d, J = 7.6 Hz, 1H), 4.84 (d, J = 11.6 Hz, 1H), 5.28 (s, 1H), 5.46 (t, J = 4.0 Hz, 1H), 6.60 (t, J = 4.2 Hz, 1H), 7.18–7.42 (m, 10H). ^{13}C NMR (67.5 MHz) δ 22.2, 24.0, 71.2, 73.2, 80.8, 87.4, 100.1, 117.2, 127.7, 127.8, 128.1, 128.3, 128.3, 128.4, 128.6, 136.3, 138.0, 190.0. Anal. Calcd for $\text{C}_{22}\text{H}_{21}\text{BrO}_4\text{S}$: C, 57.27; H, 4.59; S, 6.95. Found: C, 57.39; H, 4.87; S, 6.85.

6-Bromocyclohexa-1,5-dienecarbaldehyde dibenzyl acetal **12**.

To a THF (27 mL) solution of the thionocarbonate **11** (12.5g, 27.0 mmol) was added 1,3-dimethyl-2-phenyl-1,3,2-diaza-phospholidine (15.7 g, 81.0 mmol, prepared according to the literature method³) at room temperature, and the mixture was stirred for 2 days. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with hexane. The combined organic extracts were washed with brine and dried over MgSO_4 . After being added 2,6-di-*t*-butylphenol (0.557 g, 2.7 mmol) to the mixture to prevent from polymerization of a product, the mixture was concentrated under reduced pressure. Chromatographic purification (silica gel, 7.5% AcOEt /hexane) of the residue without separation of 2,6-di-*t*-butylphenol afforded 6-bromocyclohexa-1,5-dienecarbaldehyde dibenzyl acetal **12** (82% NMR yield) as a colorless oil. The yield was determined by ^1H NMR analysis based on the integration value of acetal methine proton (5.45 ppm) using 2,6-di-*t*-butyl-4-methylphenol as an internal standard. The product should be kept in the presence of 2,6-di-*t*-butyl-4-methylphenol in a refrigerator under a nitrogen atmosphere.

12: ^1H NMR (270 MHz) δ 2.10–2.30 (m, 4H), 4.56 (d, J = 11.6 Hz, 2H), 4.64 (d, J = 11.6 Hz, 2H), 5.45 (s, 1H), 6.21 (t, J = 4.5 Hz, 1H), 6.38 (t, J = 4.0 Hz, 1H), 7.23–7.40 (m, 10H). ^{13}C NMR (67.5 MHz) δ 21.7, 24.5, 67.6, 67.8, 99.3, 117.2, 127.6, 127.9, 128.1, 128.3, 129.3, 131.8, 137.9.

Preparation of the aromatic C-ring fragment **22**.

To a CH_2Cl_2 solution (500 mL) of 2-bromobenzaldehyde (32.4 mL, 278 mmol) and benzyloxytrimethylsilane (137 mL, 695 mmol) was added trimethylsilyl trifluoromethanesulfonate (2.7 mL, 3.1 mmol) at -78°C , and the mixture was stirred at -45°C for 3 hrs. To this was added triethylamine (5 mL), and the solvent was removed under reduced pressure. Saturated aqueous NaHCO_3 was added to the resultant mixture, and the organic materials were extracted with hexane three times. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, 15% AcOEt /hexane) to give the C-ring fragment **22** (104.4 g, 98%).

22: IR (neat) 3025, 2900, 2860, 1590, 1570, 1495, 1465, 1450, 1440, 1395, 1380, 1350, 1265, 1200 cm^{-1} . ^1H NMR (270 MHz): δ 4.62 (s, 4H), 5.93 (s, 1H), 7.17–7.38 (m, 12H), 7.56

(d, $J = 8.0$ Hz, 1H), 7.80 (d, $J = 8.0$ Hz, 1H). ^{13}C NMR (67.5 MHz): δ 68.2, 100.3, 127.2, 127.7, 127.9, 128.3, 128.8, 130.0, 130.1, 132.9, 137.1, 137.6. Anal. Calcd for $\text{C}_{21}\text{H}_{19}\text{O}_2\text{Br}$: C, 65.81; H, 4.99; Found: C, 65.88; H, 5.13.

Diene-type C-ring route for the preparation of 30c

Coupling reaction between A-ring and C-ring fragments

Magnesium alkoxide of **8** was prepared by treatment of **8** (26.4 g, 58 mmol, a 1.5 : 1 mixture of *E* and *Z* geometrical isomers) in THF (550 mL) with *t*-butylmagnesium chloride (0.9 M in THF, 61 mL, 55 mmol) at -78 °C for 30 min. A pentane solution of *t*-butyl lithium (1.64 M, 103 mL, 169 mmol) was added to a mixture of 6-bromo-cyclohexa-1,5-dienecarbaldehyde dibenzyl acetal **12** (40.0 g, 104 mmol) and 2,6-di-*t*-butylphenol (2.5 g) in THF (240 mL) at -94 °C and the mixture was stirred for 15 min. To this was added a THF solution of the magnesium alkoxide prepared as described above. The mixture was immediately warmed to -78 °C and stirred for 1 h. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash chromatography (Fuji-silycia, FL-100DX, 5%-10% AcOEt/hexane, gradient elution) to afford the coupling product **13a** (30.0 g, 68%) as a slightly yellowish oil.

^1H NMR (270 MHz, the signals could not be fully identified because of the broadening of the spectrum) δ 0.80–2.50 (m, 34H, $^i\text{Pr}_3\text{Si}$, methyl x 3 (C16, 17, and 18), and methylene x 2 (C5 and 6)), 4.20–4.80 (m, 5H, methine x 1 (C2) and benzylic methylene x 2), 5.60–6.50 (m, 4H, olefinic proton x 3 and acetal methine x 1), 7.10–7.50 (m, 15H).

To a benzene (100 mL) solution of the diol **13a** (3.68 g, 4.80 mmol) were added pyridine (1.94 mL, 24.0 mmol) and trimethylboroxine (0.335 g, 2.40 mmol) at room temperature, and the mixture was stirred for 30 min. Removal of the solvent under reduced pressure and chromatographic purification (Fuji-silycia, FL-100DX, 3% AcOEt/hexane) of the resultant residue afforded the methyl boronate **14** (2.62 g, 77%) as a mixture of geometrical isomers (*E* : *Z* = 1.5 : 1).

14: IR (neat), *E*-isomer; 2945, 2865, 1630, 1580, 1455, 1360, 1260, 1210 cm^{-1} , *Z*-isomer; 2945, 2870, 1635, 1455, 1360, 1260, 1210 cm^{-1} . ^1H NMR (300 MHz) *E*-isomer; δ 0.40 (s, 3H), 1.00–1.20 (m, 24H) 1.28 (brs, 3H), 1.59 (brs, 3H), 1.90–2.30 (m, 4H), 2.56 (brs, 2H), 4.38 (m, 2H), 4.45 (d, $J = 11.9$ Hz, 1H), 4.73 (d, $J = 11.9$ Hz, 1H), 5.31 (s, 1H), 5.37 (s, 1H), 5.93–6.01 (m, 1H), 6.04 (s, 1H), 6.25–6.35 (m, 1H), 7.12–7.40 (m, 15H); *Z*-isomer; δ 0.42 (s, 3H), 1.02–1.12 (m, 27H), 2.03 (s, 3H), 2.00–2.24 (m, 4H), 2.48 (d, $J = 17.7$ Hz, 1H), 2.59 (d, $J = 17.7$ Hz, 1H), 4.33 (d, $J = 11.2$ Hz, 1H), 4.41 (d, $J = 11.2$ Hz, 1H), 4.67 (d, $J = 11.9$ Hz, 1H), 4.74 (d, $J = 11.9$ Hz, 1H), 5.27 (s, 1H), 5.43 (s, 1H), 5.83–5.90 (m, 1H), 6.04 (s, 1H), 6.34–6.41 (m, 1H), 7.06–7.44 (m, 15H). Anal. Calcd for $\text{C}_{48}\text{H}_{63}\text{BrO}_5\text{Si}$ (*E*, *Z* mixture): C, 72.89; H, 8.03; S, 4.05. Found: C, 72.64; H, 8.30; S, 4.26.

Cyclization reaction of **14**

To a CH₂Cl₂ (610 mL) solution of the dienol silyl ether **14** (24.1 g, 30.5 mmol, a 1.5 : 1 mixture of *E* and *Z* geometrical isomers) was added a CH₂Cl₂ solution of Ti₂(O^{*i*}Pr)₂ (1.0 M, 183 mL, 183 mmol, prepared from equimolar amounts of TiCl₄ and Ti(O^{*i*}Pr)₄) at -78 °C. The reaction mixture was warmed to 0 °C and stirred for 1.5 h. Then the mixture was cooled to -78 °C and the reaction was quenched with saturated aqueous NaHCO₃. The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO₄. BHT (2.0 g) was added to the mixture and then the solvent was removed under reduced pressure to afford a crude cyclized product **15**.

boronate 15: ¹H NMR (270 MHz) δ 0.35 (s, 3H), 1.23 (s, 3H), 1.55 (s, 6H), 1.60–2.40 (m, 4H), 2.55 (d, *J* = 19.0 Hz, 1H), 2.72 (d, *J* = 19.0 Hz, 1H), 4.40–4.47 (m, 2H), 4.48 (d, *J* = 12.0 Hz, 1H), 4.67 (d, *J* = 12.0 Hz, 1H), 4.89 (s, 1H), 5.96 (dd, *J* = 2.5, 2.5 Hz, 1H), 6.19 (dd, *J* = 2.8, 2.8 Hz, 1H), 7.10–7.55 (m, 10H).

A benzene solution (180 mL) of the crude boronate **15** was treated with pinacol (10.8 g, 92 mmol) and a catalytic amount (0.7 g) of DMAP at room temperature. The mixture was stirred for 1h and the solvent was removed under reduced pressure. The resultant residue was purified by column chromatography (silica gel, 10%-20% AcOEt/benzene, gradient elution) to afford the diol **16** (9.0 g, 59%) as a colorless oil. The pure product should be kept in the presence of BHT to prevent from polymerization.

diol 16: IR (neat) 3440, 2930, 1665, 1580, 1315, 1085 cm⁻¹. ¹H NMR (300 MHz, containing a small amount of BHT) δ 1.25 (s, 3H), 1.56 (s, 6H), 1.82–2.14 (m, 4H), 2.21 (s, 1H, OH), 2.53 (d, *J* = 19.1 Hz, 1H), 2.93 (d, *J* = 19.1 Hz, 1H), 3.00 (s, 1H, OH), 4.31 (s, 1H), 4.42 (d, *J* = 10.5 Hz, 1H), 4.53 (d, *J* = 10.5 Hz, 1H), 4.56 (d, *J* = 11.5 Hz, 1H), 4.71 (d, *J* = 11.5 Hz, 1H), 5.92–5.99 (m, 1H), 6.22–6.29 (m, 1H), 7.18–7.55 (m, 10H). ¹³C NMR (75 MHz, containing a small amount of BHT) δ 14.0, 19.7, 21.6, 21.7, 31.9, 41.9, 43.1, 60.6, 70.6, 72.3, 78.1, 78.5, 120.8, 123.7, 127.2, 127.8, 128.1, 128.4, 128.9, 132.2, 134.2, 137.3, 137.3, 137.7, 139.1, 156.4, 198.6. Anal. Calcd for C₃₁H₃₄O₄S: C, 74.07; H, 6.82; S, 6.38. Found: C, 74.28; H, 7.00; S, 6.56.

Conversion of **16** to **20b**.

To a solution of **16** (0.74 g, 1.48 mmol) in THF (15.0 mL) was added BuLi (1.20 mL, 1.51 M in hexane, 1.81 mmol) at -78 °C, and the mixture was stirred for 10 min. To this was added di-*t*-butylchlorosilane (0.36 mL, 1.78 mmol). After being stirred for 10 min, the reaction mixture was warmed to 0 °C and stirred for 1.5 h. The reaction was quenched by phosphate buffer solution (pH = 7.4). The layers were separated and the aqueous layer was extracted with ether. The combined organic extracts were washed with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure to give the crude product, which was directly used in the next step. The product should be kept in the presence of BHT.

IR (neat) 2935, 1670, 1480, 1075, 1020 cm^{-1} . ^1H NMR (300 MHz, containing a small amount of BHT) δ 1.08 (s, 9H), 1.13 (s, 9H), 1.17 (s, 3H), 1.53 (s, 3H), 1.58 (s, 3H), 1.92–2.30 (m, 4H), 2.57 (d, $J = 18.8$ Hz, 1H), 2.85 (d, $J = 18.8$ Hz, 1H), 4.43 (d, $J = 11.7$ Hz, 1H), 4.41–4.50 (m, 2H), 4.59 (brs, 1H), 4.72 (d, $J = 11.7$ Hz, 1H), 5.95–6.00 (m, 1H), 6.15–6.20 (m, 1H), 7.19–7.54 (m, 10H). ^{13}C NMR (75 MHz, containing a small amount of BHT) δ 14.5, 20.6, 21.4, 21.6, 21.7, 22.0, 28.0, 28.4, 32.1, 44.2, 44.7, 60.5, 71.4, 75.5, 77.1, 83.6, 121.7, 123.0, 127.0, 127.8, 128.3, 128.4, 128.9, 131.8, 133.6, 134.9, 137.2, 137.4, 137.5, 157.0, 199.1

A solution of the silylene derivative in CH_2Cl_2 (15.0 mL) was treated with DIBAL (4.71 mL, 0.95 M in hexane, 4.47 mmol) at -78°C , and the mixture was stirred for 1 h. Then $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ (2.39 g, 7.42 mmol) was added to the solution. The mixture was diluted with ether and warmed to room temperature. After being stirred for 1.5 h, the mixture was filtered through a short pad of Celite. The filtrate was concentrated under reduced pressure to give the crude alcohol.

alcohol: $[\alpha]_{\text{D}}^{24}$: $+16^\circ$ ($c = 0.98$, CH_2Cl_2). IR (neat) 3480, 2940, 2860, 1580, 1480, 1075, 1025, 980 cm^{-1} . ^1H NMR (300 MHz) δ 0.99 (s, 3H), 1.07 (s, 9H), 1.13 (s, 9H), 1.47 (s, 3H), 1.58 (s, 3H), 2.05 (dd, $J = 3.5, 15.1$ Hz, 1H), 2.00–2.36 (m, 4H), 2.39 (dd, $J = 9.8, 15.1$ Hz, 1H), 4.29–4.44 (m, 4H), 4.52 (brs, 1H), 4.66 (d, $J = 11.7$ Hz, 1H), 6.00–6.06 (m, 1H), 6.12–6.18 (m, 1H), 7.13–7.53 (m, 10H). ^{13}C NMR (75 MHz) δ 17.3, 20.7, 21.7, 22.0, 22.0, 22.2, 27.1, 28.1, 28.5, 41.7, 42.9, 58.9, 68.8, 71.4, 76.2, 78.7, 85.0, 120.5, 122.2, 126.3, 127.6, 128.2, 128.2, 128.6, 131.4, 134.5, 134.9, 137.8, 138.1, 138.6, 138.7. Anal. Calcd for $\text{C}_{39}\text{H}_{52}\text{O}_4\text{SSi}$: C, 72.63; H, 8.13; S, 4.97. Found: C, 72.67; H, 8.36; S, 5.25.

To a CH_2Cl_2 solution (15.0 mL) of the crude alcohol were added 2,6-lutidine (1.10 mL, 9.44 mmol) and TBSOTf (1.05 mL, 4.57 mmol) at -23°C . After 30 min, the reaction was quenched by phosphate buffer solution ($\text{pH} = 7.4$). The layers were separated and the aqueous layer was extracted with hexane. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, 2.5% AcOEt/hexane) to afford the silyl ether (0.70 g, 62%).

TBS ether: $[\alpha]_{\text{D}}^{22}$: $+33^\circ$ ($c = 0.52$, CH_2Cl_2). IR (CH_2Cl_2) 2935, 2860, 1580, 1480, 1255, 1085, 1010, 980 cm^{-1} . ^1H NMR (300 MHz) δ 0.02 (s, 3H), 0.03 (s, 3H), 0.87 (s, 9H), 1.01 (s, 3H), 1.08 (s, 9H), 1.12 (s, 9H), 1.47 (s, 3H), 1.54 (s, 3H), 2.08–2.32 (m, 6H), 4.33 (d, $J = 10.5$ Hz, 1H), 4.39 (d, $J = 12.0$ Hz, 1H), 4.45 (d, $J = 10.5$ Hz, 1H), 4.49 (s, 1H), 4.49–4.56 (m, 1H), 4.65 (d, $J = 12.0$ Hz, 1H), 5.96–6.02 (m, 1H), 6.05–6.11 (m, 1H), 7.11–7.52 (m, 10H). ^{13}C NMR (75 MHz) δ -5.3 , -4.5 , 17.6, 18.0, 20.8, 21.8, 21.9, 21.9, 22.7, 25.7, 26.1, 28.1, 28.4, 42.4, 43.1, 58.8, 69.0, 71.4, 76.3, 79.1, 85.3, 121.5, 122.1, 126.0, 127.4, 128.1, 128.2, 128.5, 131.2, 132.8, 134.3, 135.7, 138.0, 138.9, 140.1. Anal. Calcd for $\text{C}_{45}\text{H}_{66}\text{O}_4\text{SSi}_2$: C, 71.19; H, 8.76; S, 4.22. Found: C, 70.91; H, 9.02; S, 4.42.

Under an oxygen atmosphere, tetraphenylporphine (63.0 mg) was added to a solution of the silyl ether (7.78 g, 10.3 mmol) in CH_2Cl_2 (100 mL) at room temperature. The mixture was irradiated by fluorescent lamp for 7 h at ambient temperature. The solvent was removed under reduced pressure to give the endoperoxide, which was directly used in the next step.

endoperoxide: IR (CH_2Cl_2) 2925, 2855, 1580, 1460, 1390, 1365, 1255, 1090, 1040 cm^{-1} . ^1H NMR (300 MHz) δ 0.03 (s, 6H), 0.84 (s, 9H), 1.09 (s, 3H), 1.10 (s, 9H), 1.12 (s, 9H), 1.48 (s, 3H), 1.60 (s, 3H), 1.68 (dd, $J = 7.5, 16.4$ Hz, 1H), 1.78–2.23 (m, 4H), 2.34 (dd, $J = 9.6, 16.4$ Hz, 1H), 4.36 (d, $J = 11.5$ Hz, 1H), 4.60–4.78 (m, 4H), 4.82 (s, 1H), 4.98 (brs, 1H), 5.16 (brs, 1H), 7.18–7.55 (m, 10H).

To a benzene solution (510 mL) of the crude endoperoxide were added a catalytic amount of AIBN and tributyltinhydride (16.8 mL, 62.5 mmol). The mixture was heated to reflux and stirred overnight. Then the reaction mixture was cooled to room temperature and concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, 10–25% AcOEt/hexane) to give the diol (5.63 g, 80%).

diol: $[\alpha]_{\text{D}}^{23}$: +122° ($c = 1.87$, CH_2Cl_2). IR (CH_2Cl_2) 3490, 2935, 2860, 1470, 1260, 1080, 1040, 1005 cm^{-1} . ^1H NMR (300 MHz) δ 0.05 (s, 3H), 0.06 (s, 3H), 0.89 (s, 9H), 0.99 (s, 3H), 1.01 (s, 9H), 1.03 (s, 3H), 1.11 (s, 9H), 1.52 (s, 3H), 1.79–1.96 (m, 4H), 2.16–2.32 (m, 2H), 2.47–2.58 (m, 1H), 2.67–2.79 (m, 1H), 4.30 (s, 1H), 4.40 (s, 1H), 4.42–4.70 (m, 5H), 4.65 (d, $J = 11.7$ Hz, 1H), 4.76 (d, $J = 11.7$ Hz, 1H), 7.28–7.38 (m, 5H). ^{13}C NMR (75 MHz) δ -5.2, -4.5, 16.6, 18.0, 20.7, 21.7, 21.9, 25.7, 26.0, 26.1, 26.8, 27.9, 28.3, 34.4, 42.9, 43.8, 65.6, 65.7, 68.9, 71.8, 78.5, 80.1, 84.5, 128.2, 128.3, 128.7, 132.5, 136.6, 136.8, 138.9, 139.1. Anal. Calcd for $\text{C}_{39}\text{H}_{64}\text{O}_6\text{Si}_2$: C, 68.37; H, 9.42. Found: C, 68.46; H, 9.56.

Under a hydrogen atmosphere, an ethanol solution (8.0 mL) of the diol (0.268 g, 0.39 mmol) was added to an ethanol suspension (8.0 mL) of 10% Pd-C (0.524 g) at room temperature and the mixture was stirred for 4.5 h. Inorganic materials were filtered off through a short pad of Celite and the filtrate was concentrated under reduced pressure. The resulting crude triol **20b** was directly used in the next step.

20b: $[\alpha]_{\text{D}}^{26}$: +113° ($c = 0.63$, CH_2Cl_2). IR (neat) 3320, 2935, 2860, 1470, 1390, 1260, 1080, 1005 cm^{-1} . ^1H NMR (300 MHz) δ 0.05 (s, 3H), 0.06 (s, 3H), 0.89 (s, 9H), 1.03 (s, 3H), 1.07 (s, 9H), 1.11 (s, 9H), 1.29 (s, 3H), 1.49 (s, 3H), 1.75–2.05 (m, 4H), 2.20 (dd, $J = 4.3, 14.8$ Hz, 1H), 2.28 (dd, $J = 9.1, 14.8$ Hz, 1H), 2.52 (dd, $J = 10.1, 12.2$ Hz, 1H), 2.72 (dd, $J = 7.2, 12.2$ Hz, 1H), 3.64 (brs, 1H), 4.26 (s, 1H), 4.42–4.90 (m, 5H), 4.87 (dd, $J = 7.2, 10.1$ Hz, 1H). ^{13}C NMR (75 MHz) δ -5.2, -4.5, 16.5, 18.0, 20.7, 21.9, 22.1, 25.7, 25.7, 26.8, 27.0, 27.9, 28.3, 38.4, 43.0, 43.8, 65.1, 66.5, 68.9, 73.8, 78.2, 84.6, 133.2, 137.4, 138.7, 139.1. Anal. Calcd for $\text{C}_{32}\text{H}_{58}\text{O}_6\text{Si}_2$: C, 64.60; H, 9.83. Found: C, 64.43; H, 10.13.

Preparation of cyclopropyl ketone 30a.

To a solution of the crude triol **20b** and benzaldehyde dimethyl acetal (0.175 mL, 1.17 mmol) in CH₂Cl₂ (10.0 mL) was added camphorsulfonic acid (11.0 mg, 0.047 mmol) at -23 °C, and the mixture was stirred overnight at that temperature. The reaction was quenched by phosphate buffer solution (pH = 7.4). The layers were separated and the aqueous layer was extracted with hexane. The combined organic extracts were washed with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure. The residue was purified by flash column chromatography (silica gel, 5% AcOEt/hexane) to give the allyl alcohol **21b** as an inseparable mixture of two diastereomers (0.210 g, 79%, α : β = ca 1:4).

21b: IR (CH₂Cl₂, mixture of diastereomers) 3550, 2950, 2860, 1475, 1390, 1360, 1255, 1115, 1040, 1010 cm⁻¹. ¹H NMR (300 MHz, mixture of diastereomers) β -isomer; δ 0.07 (s, 3H), 0.09 (s, 3H), 0.92 (s, 9H), 1.06 (s, 3H), 1.08 (s, 9H), 1.14 (s, 9H), 1.31 (s, 3H), 1.72 (s, 3H), 1.70–2.36 (m, 6H), 2.61–2.72 (m, 1H), 3.10 (t, J = 11.9 Hz, 1H), 3.86 (s, 1H), 4.51 (dd, J = 5.3, 10.7 Hz, 1H), 4.55–4.72 (m, 3H), 4.96–5.02 (m, 1H), 5.89 (s, 1H), 7.30–7.42 (m, 3H), 7.49–7.56 (m, 2H); α -isomer (characteristic peaks) δ 2.82–2.95 (m, 1H), 3.91 (s, 1H), 4.89–4.97 (m, 1H), 5.75 (s, 1H). ¹³C NMR (75 MHz, mixture of diastereomers) δ -5.17, -5.15, -4.51, -4.46, 17.23, 17.84, 18.04, 18.06, 20.73, 20.77, 21.91, 21.96, 22.02, 22.29, 23.10, 24.27, 25.42, 25.76, 25.78, 26.04, 26.75, 27.22, 27.94, 28.40, 28.44, 29.70, 32.83, 35.67, 42.83, 43.11, 43.52, 43.73, 63.93, 63.98, 68.79, 68.97, 69.95, 74.59, 74.80, 77.26, 77.59, 79.09, 84.25, 84.37, 95.84, 97.04, 126.31, 126.36, 128.40, 128.94, 129.01, 131.28, 131.82, 132.03, 135.10, 137.05, 138.27, 138.77, 139.07, 139.18, 140.13. Anal. Calcd for C₃₉H₆₂O₆Si₂ (mixture of diastereomers): C, 68.58; H, 9.15. Found: C, 68.56; H, 9.28.

To the degassed toluene (16.0 mL) were added diethyl zinc (5.05 mL, 1.0 M in hexane, 5.05 mmol) and chloriodomethane (0.74 mL, 10.1 mmol) at 0 °C, and the mixture was stirred for 5 min. The allyl alcohol **21b** (0.692 g, 1.01 mmol) was added to this solution at 0 °C and stirred for 25 min. The reaction was quenched by phosphate buffer solution (pH = 7.4). The layers were separated and the aqueous layer was extracted with ether. The combined organic extracts were washed with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, hexane then 10% AcOEt/hexane) to give the cyclopropyl alcohol **29** (0.468 g, 66%) as a single diastereomer.

29: [α]_D¹⁹: +83° (c = 0.62, CH₂Cl₂). IR (CDCl₃) 2950, 1475, 1365, 1255, 1085, 1000, 910 cm⁻¹. ¹H NMR (270 MHz) δ 0.10 (s, 3H), 0.12 (s, 3H), 0.46 (d, J = 5.0 Hz, 1H), 0.92 (s, 9H), 1.06 (s, 12H), 1.13 (s, 9H), 1.21 (s, 3H), 1.32–1.68 (m, 4H), 1.73 (d, J = 5.0 Hz, 1H), 1.94 (s, 3H), 2.37 (dd, J = 9.6, 15.0 Hz, 1H), 2.45–2.59 (m, 2H), 2.75 (s, 1H, OH), 3.41–3.53 (m, 1H), 3.51 (s, 1H), 4.11–4.22 (m, 2H), 4.59 (brd, J = 9.6 Hz, 1H), 4.67 (brd, J = 4.0 Hz, 1H), 6.09 (s, 1H), 7.29–7.42 (m, 3H), 7.50–7.57 (m, 2H). ¹³C NMR (67.5 MHz) δ -5.1, -4.4, 18.1, 18.7, 20.3, 20.5, 21.9, 22.0, 22.2, 25.8, 26.2, 27.3, 28.0, 28.4, 28.8, 31.2, 37.5, 43.2, 43.3, 62.2, 69.5, 72.7, 80.7, 83.5, 85.4, 95.5, 126.3, 128.3, 128.9, 134.6, 135.2, 138.5. Anal. Calcd for

C₄₀H₆₄O₆Si₂: C, 68.92; H, 9.25. Found: C, 69.02; H, 9.33.

To a CH₂Cl₂ solution of the cyclopropyl alcohol **29** (0.26 g, 0.37 mmol) was added Dess-Martin periodinane (0.35 g, 0.83 mmol), and the mixture was stirred overnight at room temperature. The reaction was quenched by saturated aqueous Na₂S₂O₃ and saturated aqueous NaHCO₃. The layers were separated and the aqueous layer was extracted with ether. The combined organic extracts were washed with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, 10% AcOEt/hexane) to afford the cyclopropyl ketone **30a** (0.20 g, 77%).

30a: [α]_D¹⁹: +54° (c = 0.91, CH₂Cl₂). IR (neat) 2930, 2855, 1700, 1460, 1365, 1255, 1095, 1010 cm⁻¹. ¹H NMR (270 MHz): δ 0.08 (s, 3H), 0.09 (s, 3H), 0.91 (s, 9H), 1.04 (s, 9H), 1.07 (s, 3H), 1.16 (d, *J* = 6.0 Hz, 1H), 1.19 (s, 9H), 1.21 (s, 3H), 1.50–1.61 (m, 1H), 1.85–2.02 (m, 1H), 1.89 (d, *J* = 6.0 Hz, 1H), 2.01 (s, 3H), 2.15–2.43 (m, 3H), 2.53–2.67 (m, 2H), 3.36 (s, 1H), 3.58 (dd, *J* = 11.1, 13.2 Hz, 1H), 4.26 (dd, *J* = 7.0, 11.1 Hz, 1H), 4.53 (dd, *J* = 5.4, 11.1 Hz, 1H), 4.61 (brd, *J* = 8.6 Hz, 1H), 6.18 (s, 1H), 7.31–7.44 (m, 3H), 7.50–7.57 (m, 2H). ¹³C NMR (67.5 MHz) δ -5.1, -4.3, 18.2, 19.2, 20.7, 21.6, 22.1, 22.5, 23.3, 26.0, 26.1, 27.9, 28.2, 28.4, 32.0, 37.4, 39.9, 42.6, 43.7, 69.9, 79.5, 83.4, 83.9, 95.2, 126.2, 128.4, 129.1, 134.4, 136.5, 138.1, 201.4 (1 peak missing). Anal. Calcd for C₄₀H₆₂O₆Si₂: C, 69.12; H, 8.99. Found: C, 68.99; H, 9.00.

Conversion of **30a** to **30c**.

Under a hydrogen atmosphere, an ethanol solution (14 mL) of **30a** (0.968 g, 1.39 mmol) was added to an ethanol suspension (14 mL) of 20% Pd(OH)₂ (1.00 g) at room temperature, and the mixture was stirred for 30 min. Inorganic materials were filtered off through a short pad of Celite and the filtrate was concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, 45-50% AcOEt/hexane) to give the C_{7,9}-diol (0.706 g, 84%).

C_{7,9}-diol: [α]_D¹⁸: +66° (c = 0.91, CH₂Cl₂). IR (neat) 3380, 2950, 2860, 1700, 1470, 1390, 1365, 1255, 1040, 1010 cm⁻¹. ¹H NMR (300 MHz): δ 0.05 (s, 3H), 0.07 (s, 3H), 0.88 (s, 9H), 1.05 (s, 9H), 1.06 (s, 3H), 1.08 (d, *J* = 6.1 Hz, 1H), 1.17 (s, 9H), 1.20 (s, 3H), 1.30–1.45 (m, 1H), 1.73 (d, *J* = 6.1 Hz, 1H), 1.89 (s, 3H), 1.92–2.04 (m, 1H), 2.12–2.28 (m, 2H), 2.41 (dd, *J* = 4.3, 15.3 Hz, 1H), 2.40–2.63 (m, 2H), 2.95 (dd, *J* = 10.9, 13.0 Hz, 1H), 3.47 (s, 1H), 3.90–4.00 (m, 1H), 4.02 (brs, 2H, OH), 4.52–4.64 (m, 2H). ¹³C NMR (75 MHz) δ -5.2, -4.4, 18.2, 18.5, 20.7, 22.0, 22.5, 25.9, 26.3, 26.7, 27.9, 28.2, 35.2, 36.0, 37.8, 39.5, 43.1, 43.7, 65.6, 69.9, 78.1, 83.6, 84.2, 135.1, 136.4, 203.8 (1 peak missing). Anal. Calcd for C₃₃H₅₈O₆Si₂: C, 65.30; H, 9.63. Found: C, 65.04; H, 9.87.

To a solution of the diol (0.967 g, 1.59 mmol) and pyridine (1.25 mL, 15.9 mmol) in CH₂Cl₂ (30.0 mL) was added triphosgene (0.421 g, 1.59 mmol) at -45 °C, and the mixture was stirred for 2 h at that temperature. The reaction was quenched by phosphate buffer solution (pH = 6.86). The

layers were separated and the aqueous layer was extracted with hexane. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure to give the crude carbonate, which was directly used in the next step.

carbonate: $[\alpha]_{\text{D}}^{25}$: $+44^\circ$ ($c = 0.82$, CH_2Cl_2). IR (neat) 2935, 2860, 1760, 1705, 1475, 1365, 1200, 1100, 1010 cm^{-1} . ^1H NMR (300 MHz): δ 0.06 (s, 3H), 0.08 (s, 3H), 0.89 (s, 9H), 1.05 (s, 9H), 1.07 (s, 3H), 1.18 (m, 13H), 1.52–1.68 (m, 1H), 1.87 (d, $J = 6.4$ Hz, 1H), 1.90 (s, 3H), 2.07–2.18 (m, 1H), 2.24 (dd, $J = 9.8, 15.5$ Hz, 1H), 2.31–2.44 (m, 2H), 2.50 (dd, $J = 4.1, 15.5$ Hz, 1H), 2.90–3.08 (m, 2H), 3.33 (s, 1H), 4.46–4.62 (m, 2H), 4.99 (dd, $J = 5.9, 11.0$ Hz, 1H). ^{13}C NMR (75 MHz) δ -5.2, -4.5, 18.2, 19.2, 20.6, 20.7, 22.1, 22.4, 22.9, 25.9, 26.1, 27.8, 28.1, 28.9, 33.6, 36.5, 39.5, 42.5, 43.4, 69.7, 71.1, 83.1, 83.3, 84.0, 133.4, 138.3, 147.9, 199.1. Anal. Calcd for $\text{C}_{34}\text{H}_{56}\text{O}_7\text{Si}_2$: C, 64.51; H, 8.92. Found: C, 64.30; H, 9.08.

A solution of the carbonate in THF (15.0 mL) was treated with TBAF (4.80 mL, 1.0 M in THF, 4.80 mmol) and AcOH (0.29 mL, 4.77 mmol) at room temperature and stirred for 2.5 h. The reaction was quenched by buffer solution (pH = 6.86). The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, 40% AcOEt/hexane) to afford the C1,2-diol (0.742 g, 95% in 2 steps).

C1,2-diol: $[\alpha]_{\text{D}}^{22}$: $+66^\circ$ ($c = 0.83$, CH_2Cl_2). IR (neat) 3510, 3390, 2950, 1760, 1680, 1470, 1370, 1260, 1205, 1110, 1045 cm^{-1} . ^1H NMR (270 MHz): δ 0.09 (s, 6H), 0.90 (s, 9H), 1.05 (s, 3H), 1.12 (s, 3H), 1.33 (d, $J = 6.5$ Hz, 1H), 1.50–1.69 (m, 1H), 1.80 (d, $J = 6.5$ Hz, 1H), 1.89 (s, 3H), 2.09 (dd, $J = 4.8, 15.8$ Hz, 1H), 2.09–2.24 (m, 1H), 2.28 (dd, $J = 9.7, 15.8$ Hz, 1H), 2.37 (ddd, $J = 2.6, 5.0, 17.9$ Hz, 1H), 2.55 (ddd, $J = 6.2, 14.8, 17.9$ Hz, 1H), 3.02 (d, $J = 9.5$ Hz, 2H), 3.15 (d, $J = 9.8$ Hz, 1H), 3.97 (s, 1H, OH), 4.48–4.59 (m, 2H), 5.02 (dd, $J = 5.8, 11.2$ Hz, 1H), 6.42 (d, $J = 9.8$ Hz, 1H, OH). ^{13}C NMR (75 MHz) δ -5.1, -4.5, 18.1, 19.1, 20.1, 21.0, 22.0, 25.8, 26.3, 29.5, 33.4, 36.3, 39.1, 40.3, 41.7, 69.2, 70.5, 75.7, 81.1, 82.2, 134.5, 136.2, 147.5, 208.3. Anal. Calcd for $\text{C}_{26}\text{H}_{40}\text{O}_7\text{Si}$: C, 63.38; H, 8.18. Found: C, 63.63; H, 8.48.

To a solution of the diol (0.719 g, 1.46 mmol) and benzaldehyde dimethyl acetal (0.33 mL, 2.19 mmol) in benzene (30.0 mL) was added pyridinium *p*-toluenesulfonate (33.4 mg, 0.146 mmol). The mixture was heated to reflux with azeotropic removal of methanol. After being stirred for 1 h, the reaction mixture was cooled to room temperature and triethyl amine (0.102 mL, 0.730 mmol) was added. The solvent was removed under reduced pressure and the resultant residue was purified by flash chromatography (silica gel) to give the benzylidene acetal (0.733 g, 86%) as a single diastereomer.

acetal: $[\alpha]_{\text{D}}^{24}$: $+21^\circ$ ($c = 1.50$, CH_2Cl_2). IR (neat) 2955, 2855, 1750, 1710, 1460, 1365, 1260, 1210, 1100 cm^{-1} . ^1H NMR (300 MHz): δ 0.08 (s, 3H), 0.09 (s, 3H), 0.92 (s, 9H), 1.07 (s,

3H), 1.25 (s, 3H), 1.33 (d, $J = 6.6$ Hz, 1H), 1.56–1.72 (m, 1H), 1.83 (d, $J = 6.6$ Hz, 1H), 1.95 (s, 3H), 2.12–2.28 (m, 2H), 2.32–2.60 (m, 3H), 2.96–3.12 (m, 1H), 3.11 (dd, $J = 10.2, 13.7$ Hz, 1H), 3.37 (s, 1H), 4.50–4.62 (m, 1H), 4.62 (dd, $J = 7.2, 10.2$ Hz, 1H), 5.06 (dd, $J = 5.9, 11.2$ Hz, 1H), 5.69 (s, 1H), 7.35–7.46 (m, 3H), 7.58–7.67 (m, 2H). ^{13}C NMR (75 MHz) δ –5.1, –4.3, 18.2, 19.2, 20.5, 20.8, 22.9, 25.9, 26.0, 28.5, 33.9, 36.6, 36.7, 40.8, 41.9, 69.4, 70.9, 83.3, 84.3, 85.9, 103.5, 127.1, 128.5, 129.5, 133.4, 137.8, 139.0, 147.7, 198.7. Anal. Calcd for $\text{C}_{33}\text{H}_{44}\text{O}_7\text{Si}$: C, 68.24; H, 7.64. Found: C, 68.08; H, 7.75.

To a solution of the benzylidene acetal (0.193 g, 0.33 mmol) in THF (3.1 mL) and methanol (3.5 mL) was added K_2CO_3 (71 mg, 0.50 mmol) at room temperature, and the mixture was stirred for 1 h. To this was added saturated aqueous NH_4Cl . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, 60–70% AcOEt/hexane) to give the diol **30c** (0.184 g, quant.).

30c: $[\alpha]_{\text{D}}^{22}$: +47° ($c = 1.05$, CH_2Cl_2). IR (neat) 3450, 2950, 2855, 1700, 1460, 1360, 1255, 1040 cm^{-1} . ^1H NMR (300 MHz): δ 0.07 (s, 6H), 0.91 (s, 9H), 1.04 (s, 3H), 1.10 (d, $J = 5.9$ Hz, 1H), 1.18 (s, 3H), 1.28–1.46 (m, 1H), 1.62 (d, $J = 5.9$ Hz, 1H), 1.91 (s, 3H), 1.90–2.06 (m, 1H), 2.14–2.28 (m, 1H), 2.20 (dd, $J = 10.3, 15.7$ Hz, 1H), 2.39 (dd, $J = 4.4, 15.7$ Hz, 1H), 2.48–2.64 (m, 2H), 2.98 (t, $J = 12.0$ Hz, 1H), 3.42 (s, 1H), 3.85–3.95 (m, 1H), 4.40–4.72 (m, 4H, including OH x 2), 5.61 (s, 1H), 7.33–7.45 (m, 3H), 7.59–7.66 (m, 2H). ^{13}C NMR (75 MHz): δ –5.1, –4.3, 18.2, 18.6, 20.8, 21.8, 25.9, 26.1, 26.5, 35.3, 36.6, 37.8, 41.4, 42.2, 65.4, 69.4, 78.0, 84.7, 86.0, 103.2, 127.3, 128.5, 129.5, 135.0, 137.1, 138.1, 203.8 (1 peak missing). Anal. Calcd for $\text{C}_{32}\text{H}_{46}\text{O}_6\text{Si}$: C, 69.28; H, 8.36. Found: C, 69.14; H, 8.53.

Aromatic C-ring route for the preparation of 30c

Preparation of the cyclization precursor.

Magnesium alkoxide of **8** was prepared by treatment of **8** (9.95 g, 21.6 mmol, a 1.5 : 1 mixture of *E* and *Z* geometrical isomers) in THF (65 mL) with *t*-butylmagnesium chloride (0.9 M in THF, 24 mL, 21.6 mmol) at –78 °C for 10 min. A pentane solution of *t*-butyllithium (1.46 M, 66.1 mL, 96.6 mmol) was added to a THF solution (300 mL) of 2-bromobenzaldehyde dibenzyl acetal **22** (24.67 g, 64.4 mmol) at –78 °C and the mixture was stirred for 30 min. To this was added a THF solution of the magnesium alkoxide prepared as described above, and the mixture was stirred for 1 h at that temperature. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with Et_2O . The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash chromatography (silica gel, 5%–20% AcOEt/hexane, gradient elution) to afford the coupling product (12.30 g, 74%) as a slightly yellowish

oil. This coupling product was immediately converted to the corresponding boronate.

To a mixture of the coupling product (0.34 g, 0.45 mmol) and pyridine (0.184 mL, 2.28 mmol) in benzene (3.0 mL) was added trimethylboroxine (0.06 mL, 0.44 mmol) at room temperature, and the mixture was stirred for 12 h. The solvent was removed under reduced pressure and the resultant residue was purified by flash chromatography (silica gel, 15% AcOEt/hexane) to afford the boronate (0.32 g, 90%) as a mixture of the geometrical isomers (*E:Z*=1.5:1).

boronate: IR (neat) 3060, 3025, 2940, 2860, 1630, 1580, 1450, 1350, 1260, 1200, 1110 cm^{-1} . ^1H NMR (270 MHz): major isomer δ 0.49 (s, 3H), 0.82–0.94 (m, 27H), 1.12 (s, 3H), 1.14 (s, 3H), 1.66 (s, 3H), 2.20 (d, J = 18 Hz, 1H), 2.46 (d, J = 18 Hz, 1H), 4.15 (d, J = 12 Hz, 1H), 4.38 (d, J = 12 Hz, 1H), 4.45 (d, J = 12 Hz, 1H), 4.65 (d, J = 12 Hz, 1H), 4.70 (s, 1H), 5.73 (s, 1H), 6.07 (s, 1H), 6.86 (d, J = 8 Hz, 1H), 6.98–7.40 (m, 12H), 7.68 (d, J = 7 Hz, 1H). Anal. Calcd for $\text{C}_{48}\text{H}_{61}\text{O}_5\text{BSSi}$: C, 73.08; H, 7.79; S, 4.06. Found: C, 72.96; H, 7.97; S, 4.10.

Cyclization reaction.

To a CH_2Cl_2 solution (26 mL) of the boronate (3.64 g, 4.62 mmol) was added SnCl_4 (1.35 mL, 11.55 mmol) at -78°C , and the mixture was warmed to -45°C . The mixture was stirred for 1.5 h at that temperature, and the reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant crude product was dissolved in benzene (50 mL). To this was added pinacol (1.64 g, 13.9 mmol) and DMAP (0.06 g, 0.5 mmol) at room temperature, and the mixture was stirred for 40h. The mixture was concentrated under reduced pressure, and the resulting residue was purified by flash chromatography (silica gel, 30% AcOEt/hexane) to afford the cyclized product **23** (1.75 g, 76% in 2 steps) as a single isomer.

23: IR (neat) 3400, 2925, 1660, 1480, 1450, 1440, 1420, 1390, 1380, 1310, 1110, 1080, 1060, 1030 cm^{-1} . ^1H NMR (270 MHz): δ 0.78 (s, 3H), 1.16 (s, 3H), 1.67 (s, 3H), 2.48 (dd, J = 19, 1 Hz, 1H), 2.97 (d, J = 19 Hz, 1H), 3.03 (bs, 1H, OH), 3.20 (s, 1H, OH), 4.34 (d, J = 11 Hz, 1H), 4.58 (d, J = 12 Hz, 1H), 4.79 (d, J = 12 Hz, 1H), 4.86 (s, 1H), 5.06 (d, J = 11 Hz, 1H), 7.16–7.46 (m, 10H), 7.50–7.58 (m, 3H), 7.73 (dd, J = 6, 2 Hz, 1H). ^{13}C NMR (67.5 MHz): δ 13.0, 19.5, 31.9, 42.4, 43.6, 61.0, 70.6, 72.2, 77.1, 78.4, 124.4, 124.8, 127.2, 127.6, 127.9, 127.9, 128.1, 128.4, 128.9, 132.1, 137.1, 137.5, 137.7, 141.0, 155.7, 198.7. Anal. Calcd for $\text{C}_{31}\text{H}_{32}\text{O}_4\text{S}$: C, 74.37; H, 6.44; S, 6.40. Found: C, 74.14; H, 6.62; S, 6.69.

Conversion of **23** to **24**.

To a CH_2Cl_2 solution (36 mL) of **23** (1.81 g, 3.61 mmol) was added DIBAL (0.96M in hexane, 18.8 mL, 18.1 mmol) at -78°C , and the mixture was stirred for 1.5 h. To this was added saturated aqueous Rochelle salt, and the mixture was stirred for 1 h at room temperature. The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced

pressure. The resulting residue was purified by flash chromatography (silica gel, 30%–40% AcOEt/hexane) to afford the triol (1.66 g, 91%).

To a CH₂Cl₂ solution (250 mL) of the triol (12.36 g, 24.6 mmol) were added 2,6-lutidine (17.2 mL, 148 mmol) and TBSOTf (17.0 mL, 73.8 mmol) at 0 °C. After being stirred for 1.5 h at that temperature, the mixture was treated with saturated aqueous NaHCO₃. The layers were separated and the aqueous layer was extracted with hexane. The combined organic extracts were washed with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure, and the resulting residue was purified by thin-layer chromatography (silica gel, 3–5% AcOEt/hexane) to afford the bis-TBS ether **24** (16.2 g, 90%).

24: IR (neat) 2960, 2930, 2860, 1730, 1470, 1260, 1090, 1050, 1030, 1000 cm⁻¹. ¹H NMR (270 MHz): δ -0.27 (s, 3H), -0.10 (s, 6H), 0.02 (s, 3H), 0.69 (d, *J* = 1 Hz, 3H), 0.81 (s, 9H), 0.91 (s, 9H), 1.02 (s, 3H), 1.56 (s, 3H), 2.11 (ddd, *J* = 1, 10, 16 Hz, 1H), 2.21 (dd, *J* = 5, 10 Hz, 1H), 3.35 (s, 1H, OH), 4.39 (d, *J* = 11 Hz, 1H), 4.36–4.42 (m, 1H), 4.53 (d, *J* = 12 Hz, 1H), 4.61 (s, 1H), 4.79 (d, *J* = 12 Hz, 1H), 4.95 (d, *J* = 11 Hz, 1H), 7.10–7.47 (m, 11H), 7.52–7.57 (m, 2H), 7.66 (dd, *J* = 2, 6 Hz, 1H). ¹³C NMR (67.5 MHz): δ -5.5, -5.4, -4.5, -4.3, 16.0, 17.8, 18.2, 20.6, 25.6, 25.8, 26.2, 40.5, 42.3, 59.6, 67.8, 71.9, 73.4, 76.9, 79.7, 124.1, 126.1, 126.4, 126.7, 127.2, 127.6, 127.9, 128.2, 128.5, 131.2, 131.7, 137.6, 137.8, 138.9, 140.8, 142.8. Anal. Calcd for C₄₃H₆₂O₄SSi₂: C, 70.64; H, 8.54; S, 4.39. Found: C, 70.52; H, 8.65; S, 4.16.

Conversion of **24** to **25a**.

To a benzene solution (220 mL) of **24** (16.2 g, 22.2 mmol) were added tributyltinhydride (18.0 mL, 66.5 mmol) and AIBN (0.37 g, 2.2 mmol), and the mixture was heated to reflux. After 3.5 h, the mixture was concentrated under reduced pressure, and the resulting residue was purified by flash chromatography (silica gel, 5% AcOEt/hexane) to afford the product (13.7 g, quant).

IR (neat) 3550, 3060, 3010, 2960, 2920, 2900, 2860, 1470, 1460, 1450, 1390, 1360, 1250, 1080, 1050, 1030, 1000 cm⁻¹. ¹H NMR (270 MHz): δ -0.28 (s, 3H), -0.14 (s, 3H), -0.10 (s, 3H), 0.03 (s, 3H), 0.62 (d, *J* = 1 Hz, 3H), 0.84 (s, 9H), 0.89 (s, 9H), 1.03 (s, 3H), 1.20 (s, 3H), 2.12 (dd, *J* = 10, 15 Hz, 1H), 2.24 (dd, *J* = 5, 15 Hz, 1H), 2.45 (dd, *J* = 10, 12 Hz, 1H), 2.71 (ddd, *J* = 1, 6, 12 Hz, 1H), 3.35 (s, 1H, OH), 4.42 (d, *J* = 12 Hz, 1H), 4.38–4.46 (m, 1H), 4.46 (s, 1H), 4.67 (dd, *J* = 6, 10 Hz, 1H), 4.76 (d, *J* = 12 Hz, 1H), 7.11–7.21 (m, 2H), 7.28–7.48 (m, 6H), 7.57–7.62 (m, 1H). ¹³C NMR (67.5 MHz): δ -5.5, -5.4, -4.5, -4.3, 15.2, 17.9, 18.2, 20.0, 25.3, 25.7, 25.8, 37.0, 40.6, 41.5, 67.9, 71.4, 73.2, 77.5, 77.6, 123.6, 126.1, 126.2, 127.0, 127.7, 127.8, 128.5, 129.9, 137.3, 138.2, 140.0, 142.9. Anal. Calcd for C₃₇H₅₈O₄Si₂: C, 71.33; H, 9.38. Found: C, 71.59; H, 9.50.

Under a hydrogen atmosphere, an ethanol solution (100 mL) of the benzyl ether (5.32 g, 8.54 mmol) was added to an ethanol suspension (100 mL) of 10% Pd-C (9.40 g) at room temperature and the mixture was stirred for 5.5 h. Inorganic materials were filtered off through a short pad of Celite

and the filtrate was concentrated under reduced pressure. The resulting residue was purified by flash chromatography (silica gel, 10–30% AcOEt/hexane) to afford the alcohol (4.16 g, 91%).

IR (neat) 3000, 2960, 2930, 2900, 2860, 1470, 1460, 1390, 1360, 1260, 1080, 1050, 1030, 1000 cm^{-1} . ^1H NMR (270 MHz): δ –0.31 (s, 3H), –0.09 (s, 3H), –0.07 (s, 3H), 0.04 (s, 3H), 0.60 (d, J = 1 Hz, 3H), 0.84 (s, 9H), 0.90 (s, 9H), 1.06 (s, 3H), 1.40 (s, 3H), 2.15 (dd, J = 10, 14 Hz, 1H), 2.27 (dd, J = 5, 14 Hz, 1H), 2.34 (dd, J = 10, 12 Hz, 1H), 2.80 (ddd, J = 2, 7, 12 Hz, 1H), 3.40 (s, 1H, OH), 4.40–4.48 (m, 1H), 4.60 (s, 1H), 5.04–5.14 (m, 1H), 7.08–7.20 (m, 2H), 7.42–7.49 (m, 1H), 7.54–7.62 (m, 1H). ^{13}C NMR (67.5 MHz): δ –5.5, –5.4, –4.5, –4.3, 15.1, 17.8, 18.2, 20.3, 25.2, 25.6, 25.8, 39.2, 40.5, 41.5, 67.9, 71.3, 73.2, 77.8, 122.8, 126.0, 126.1, 126.8, 130.1, 139.8, 140.1, 141.6. Anal. Calcd for $\text{C}_{30}\text{H}_{52}\text{O}_4\text{Si}_2$: C, 67.62; H, 9.83. Found: C, 67.67; H, 10.13.

To a mixture of oxalyl chloride (5.40 mL, 61.5 mmol) and DMSO (8.8 mL, 123 mmol) in CH_2Cl_2 (150 mL) was added a CH_2Cl_2 solution (50 mL) of the alcohol (10.92 g, 20.5 mmol) slowly at -78°C , and the mixture was stirred for 1 h. To this was added triethylamine (25 mL, 184 mmol) carefully, and the mixture was gradually warmed to ambient temperature through 1 h. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated, and the aqueous layer was extracted with ether. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (silica gel, 5% AcOEt/hexane) to give the ketone **25a** (10.72 g, quant.).

25a: IR (neat) 2960, 2930, 2860, 1700, 1475, 1460, 1390, 1360, 1260, 1080, 1060, 1020, 1000 cm^{-1} . ^1H NMR (270 MHz): δ –0.32 (s, 3H), –0.09 (s, 3H), –0.04 (s, 3H), 0.07 (s, 3H), 0.84 (s, 12H), 0.90 (s, 9H), 1.11 (s, 3H), 1.23 (s, 3H), 2.26 (m, 1H), 2.40 (m, 1H), 3.37 (s, 1H, OH), 3.39 (m, 2H), 4.54 (t, J = 8 Hz, 1H), 4.61 (s, 1H), 6.99 (dd, J = 1.5, 8 Hz, 1H), 7.14 (dt, J = 1, 8 Hz, 1H), 7.27 (dt, J = 1.5, 8 Hz, 1H), 7.46 (dd, J = 1, 8 Hz, 1H). ^{13}C NMR (67.5 MHz): δ –5.6, –5.4, –4.8, –4.4, 15.3, 17.8, 18.1, 21.0, 24.6, 25.6, 25.8, 40.1, 42.1, 48.2, 67.7, 74.3, 77.1, 124.0, 126.3, 126.4, 128.1, 128.2, 139.3, 140.8, 141.1, 209.5. Anal. Calcd for $\text{C}_{30}\text{H}_{50}\text{O}_4\text{Si}_2$: C, 67.88; H, 9.49. Found: C, 68.08; H, 9.59.

Birch reduction of arylketone **25a**.

To a mixture of THF (20 mL), liquid ammonia (40 mL), and potassium metal (0.76 g, 19.4 mmol) was added a THF solution of **25a** (1.03 g, 1.94 mmol) and 2,2,4-trimethyl-3-*i*-propyl-3-pentanol (1.50 mL, 7.52 mmol) at -78°C , and the mixture was stirred for 2 h. To this was added degassed ethanol (30 mL), and the mixture was warmed to room temperature with evaporation of ammonia and stirred for 10 h. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated, and the aqueous layer was extracted with ether. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (silica gel, 5–15% AcOEt/hexane) to

give the desired product **26** (0.47 g, 45%) and the alcohol **27** (0.41 g, 40%). **27** was converted to the starting arylketone **25a** by Swern oxidation described above and recycled.

26: IR (neat) 3560, 3400, 2955, 2930, 2890, 2860, 1685, 1630, 1470, 1390, 1360, 1260, 1210, 1080, 1050, 1020 cm^{-1} . ^1H NMR (400 MHz): δ -0.04 (s, 3H), 0.00 (s, 3H), 0.06 (s, 3H), 0.10 (s, 3H), 0.90 (s, 9H), 0.91 (s, 9H), 1.06 (s, 3H), 1.11 (s, 3H), 1.66 (d, J = 1.0 Hz, 3H), 1.80–1.95 (m, 1H), 2.02–2.15 (m, 3H), 2.17 (dd, J = 10.3, 14.7 Hz, 1H), 2.30 (dd, J = 4.4, 14.7 Hz, 1H), 3.18 (s, 1H, OH), 3.20 (d, J = 16.1 Hz, 1H), 3.44 (d, J = 16.1 Hz, 1H), 3.94 (s, 1H), 4.53–4.62 (m, 1H), 5.88–5.94 (m, 1H), 6.13–6.18 (m, 1H). ^{13}C NMR (100 MHz): δ -5.5, -5.2, -4.3, -4.2, 15.9, 18.0, 18.1, 20.8, 21.0, 21.8, 24.2, 25.7, 25.8, 39.1, 41.2, 45.8, 68.1, 73.9, 78.2, 122.7, 128.3, 132.0, 138.3, 139.3, 143.4, 206.5. Anal. Calcd for $\text{C}_{30}\text{H}_{52}\text{O}_4\text{Si}_2$: C, 67.62; H, 9.84. Found: C, 67.40; H, 10.12.

Desilylation of **26**.

To a THF solution (59 mL) of **26** (3.14 g, 5.9 mmol) was added TBAF (1.0M in THF, 7.2 mL, 7.2 mmol) at 0 °C, and the mixture was stirred for 1.5 h. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated, and the aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (silica gel, 10–30% AcOEt/hexane) to give **28** (2.42 g, 98%).

28: IR (neat) 3520, 3450, 2990, 2960, 2930, 2895, 2855, 1680, 1620, 1570, 1470, 1390, 1360, 1350, 1260, 1250, 1240, 1080, 1050 cm^{-1} . ^1H NMR (400 MHz): δ 0.06 (s, 3H), 0.10 (s, 3H), 0.90 (s, 9H), 1.06 (s, 3H), 1.11 (s, 3H), 1.67 (d, J = 1.0 Hz, 3H), 1.85–2.00 (m, 1H), 2.05–2.22 (m, 4H), 2.24 (s, 1H, OH), 2.36 (dd, J = 4.4, 14.6 Hz, 1H), 2.88 (s, 1H, OH), 3.20 (d, J = 16.1 Hz, 1H), 3.45 (d, J = 16.1 Hz, 1H), 4.06 (s, 1H), 4.56–4.63 (m, 1H), 6.00–6.07 (m, 1H), 6.12–6.18 (m, 1H). ^{13}C NMR (100 MHz): δ -5.2, -4.3, 15.9, 18.0, 20.9, 21.0, 21.8, 23.9, 25.7, 38.7, 41.7, 45.8, 68.0, 72.4, 79.0, 121.6, 128.2, 132.3, 138.7, 139.3, 143.2, 206.3. Anal. Calcd for $\text{C}_{24}\text{H}_{38}\text{O}_4\text{Si}$: C, 68.86; H, 9.15. Found: C, 68.56; H, 9.35.

Conversion of **28** to **20a**

To a benzene solution (120 mL) of **28** (2.41 g, 5.76 mmol) were added benzaldehyde dimethylacetal (1.30 mL, 8.63 mmol) and PPTS (0.15 g, 0.57 mmol), and the mixture was heated to reflux with a Dean-Stark trap. After 1 h, triethylamine (1.0 mL) was added to the mixture, and the solvent was removed under reduced pressure. The resulting residue was purified by flash chromatography (silica gel, 5–15% AcOEt/hexane) to give the benzylidene derivative (2.60 g, 89%) as a single isomer. The stereochemistry of the benzylidene moiety was determined by the observed NOE between the acetal methine proton and the $\text{C}2\beta$ -proton.

IR (neat) 3055, 2955, 2930, 2855, 1680, 1605, 1420, 1090, 1060, 1040 cm^{-1} . ^1H NMR (500 MHz): δ 0.08 (s, 3H), 0.10 (s, 3H), 0.92 (s, 9H), 1.15 (s, 3H), 1.26 (s, 3H), 1.72 (s, 3H), 2.04–2.26 (m, 4H), 2.27 (dd, J = 4.8, 14.4 Hz, 1H), 2.35 (dd, J = 9.6, 14.4 Hz, 1H), 3.28 (d, J = 16.6

Hz, 1H), 3.55 (d, $J = 16.6$ Hz, 1H), 4.36 (s, 1H), 4.66–4.70 (m, 1H), 5.75 (s, 1H), 6.01–6.04 (m, 1H), 6.07–6.10 (m, 1H), 7.37–7.42 (m, 3H), 7.48–7.51 (m, 2H). ^{13}C NMR (125 MHz): δ –5.2, –4.3, 16.4, 18.0, 20.8, 21.3, 21.9, 24.3, 25.8, 40.3, 41.1, 46.2, 68.2, 80.1, 86.8, 102.5, 122.0, 126.9, 128.4, 128.5, 129.3, 130.7, 130.9, 138.1, 140.4, 142.5, 206.8. HRFAB (NBA/NaI) Calcd for $\text{C}_{31}\text{H}_{42}\text{O}_4\text{SiNa}$ (MNa^+): 529.2750. Found: 529.2726.

To a solution of the benzylidene derivative (0.41 g, 0.81 mmol) in MeOH (30 mL) and THF (10 mL) were added $\text{CeCl}_3 \cdot 7\text{H}_2\text{O}$ (0.95 g, 2.4 mmol) and NaBH_4 (0.115 g, 2.7 mmol) at 0 °C, and the mixture was stirred for 1 h. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated, and the aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (silica gel, 50% AcOEt/hexane) to give the diene alcohol (0.41 g, quant.) as a single isomer. The stereochemistry of the C9 site was determined by the observed NOE between the C9-proton and the C16-methyl as well as the C2 β -proton.

IR (neat) 3310, 2960, 2930, 2860, 1460, 1410, 1390, 1360, 1260, 1090, 1045 cm^{-1} . ^1H NMR (500 MHz): δ 0.05 (s, 3H), 0.07 (s, 3H), 0.91 (s, 9H), 1.12 (s, 3H), 1.40 (s, 3H), 1.58 (d, $J = 1.1$ Hz, 3H), 2.05–2.28 (m, 6H), 2.49 (dd, $J = 10.0, 12.4$ Hz, 1H), 2.67 (dd, $J = 6.7, 11.2$ Hz, 1H), 4.56–4.60 (m, 1H), 4.61 (s, 1H), 4.68 (t, $J = 8.1$ Hz, 1H), 5.80 (s, 1H), 5.99–6.04 (m, 2H), 7.36–7.41 (m, 3H), 7.48–7.52 (m, 2H). ^{13}C NMR (125 MHz): δ –5.2, –4.3, 16.9, 18.0, 20.8, 21.8, 21.9, 25.2, 25.8, 37.8, 40.7, 41.2, 68.6, 70.9, 79.4, 86.7, 102.4, 120.2, 122.7, 127.0, 128.4, 129.2, 131.7, 131.8, 138.5, 138.6, 139.1. HRFAB (NBA) Calcd for $\text{C}_{31}\text{H}_{45}\text{O}_4\text{Si}$ (MH^+): 509.3087. Found: 509.3065.

Under an oxygen atmosphere, a catalytic amount of Rose bengal was added to a solution of the diene alcohol (0.166 g, 0.33 mmol) in CH_2Cl_2 (18 mL) and MeOH (1 mL), and the mixture was irradiated by fluorescent lamp for 1 h at ambient temperature. The solvent was removed under reduced pressure and the resulting crude product was dissolved in CH_2Cl_2 (9 mL) and MeOH (9 mL). To this was added thiourea (0.11 g), and the mixture was stirred for 17 h. The solvent was removed under reduced pressure and the resulting residue was purified by flash chromatography (silica gel, 50% AcOEt/hexane) to give the triol **20a** (0.131 g, 74%).

20a: IR (neat) 3540, 3360, 3050, 2955, 2930, 2860, 1600, 1460, 1390, 1090, 1060, 1040, 1025 cm^{-1} . ^1H NMR (500 MHz): δ 0.06 (s, 6H), 0.90 (s, 9H), 1.06 (s, 3H), 1.36 (s, 3H), 1.53 (s, 3H), 1.90–1.98 (m, 4H), 2.12 (dd, $J = 4.1, 15.2$ Hz, 1H), 2.34 (dd, $J = 9.5, 15.2$ Hz, 1H), 2.64 (dd, $J = 10.5, 12.6$ Hz, 1H), 2.76 (dd, $J = 5.8, 12.6$ Hz, 1H), 3.74 (s, 1H, OH), 3.78 (bs, 1H, OH), 4.03 (bs, 1H, OH), 4.46–4.49 (m, 1H), 4.58–4.62 (m, 1H), 4.70 (s, 1H), 4.79 (t, $J = 5.4$ Hz, 1H), 4.96 (dd, $J = 7.4, 10.0$ Hz, 1H), 5.79 (s, 1H), 7.38–7.41 (m, 3H), 7.43–7.47 (m, 2H). ^{13}C NMR (125 MHz): δ –5.2, –4.3, 16.5, 18.0, 20.3, 25.8, 26.1, 26.4, 27.0, 38.5, 41.3, 42.5, 65.4, 66.2, 68.5, 73.2, 80.7, 86.1, 102.9, 126.6, 128.6, 129.6, 132.7, 136.1, 137.7, 138.8,

139.6. HRFAB (NBA/NaI) Calcd for $C_{31}H_{46}O_6SiNa$ (MNa^+): 565.2961. Found: 565.2943.

Conversion of 20a to enone 36.

To a CH_2Cl_2 solution (9.0 mL) of **20a** (229 mg, 0.42 mmol) were added *p*-methoxybenzaldehyde dimethylacetal (90 μ L, 0.51 mmol) and CSA (9.6 mg, 0.04 mmol) at $-23^\circ C$, and the mixture was stirred for 1 h. Triethylamine (60 μ L) and saturated aqueous $NaHCO_3$ were added to this mixture. The layers were separated, and the aqueous layer was extracted with ether. The combined extracts were washed with brine and dried over $MgSO_4$. The mixture was filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (silica gel, 3–15% $AcOEt$ /benzene) to give the *p*-methoxybenzylidene derivative (252 mg, 90%) as a mixture of diastereomers ($\alpha:\beta$ = ca 1:5).

To a CH_2Cl_2 solution (9.0 mL) of the *p*-methoxybenzylidene derivative (192 mg, 0.29 mmol) was added Dess–Martin periodinane (566 mg, 1.33 mmol), and the mixture was stirred for 1 h at room temperature. The reaction was quenched with saturated aqueous $Na_2S_2O_3$ and saturated aqueous $NaHCO_3$. The layers were separated, and the aqueous layer was extracted with $AcOEt$. The combined extracts were washed with brine and dried over $MgSO_4$. The mixture was filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (silica gel, 20% $AcOEt$ /hexane) to give the enone **36** (181 mg, 95%) as a mixture of diastereomers ($\alpha:\beta$ = ca 1:5).

36: IR (neat) 3055, 2985, 2960, 2930, 1685, 1615, 1520, 1460, 1425, 1390, 1170, 1130, 1100, 1060, 1040 cm^{-1} . 1H NMR (500 MHz): β -isomer δ 0.07 (s, 3H), 0.11 (s, 3H), 0.93 (s, 9H), 1.08 (s, 3H), 1.39 (s, 3H), 1.75 (s, 3H), 2.04–2.13 (m, 1H), 2.20 (dd, J = 9.7, 15.2 Hz, 1H), 2.26–2.39 (m, 2H), 2.64 (ddd, J = 2.6, 4.1, 17.1 Hz, 1H), 2.79 (dd, J = 4.1, 15.2 Hz, 1H), 2.86–2.93 (m, 1H), 3.22 (dd, J = 11.1, 12.6 Hz, 1H), 3.82 (s, 3H), 4.59 (s, 1H), 4.60–4.66 (m, 1H), 4.84 (dd, J = 4.7, 11.0 Hz, 1H), 5.39 (t, J = 9.0 Hz, 1H), 5.73 (s, 1H), 5.94 (s, 1H), 6.93–6.96 (m, 2H), 7.35–7.45 (m, 3H), 7.46–7.50 (m, 2H), 7.68–7.71 (m, 2H). α -isomer δ 0.06 (s, 3H), 0.11 (s, 3H), 0.92 (s, 9H), 1.09 (s, 3H), 1.40 (s, 3H), 1.61 (s, 3H), 2.04–2.39 (m, 4H), 2.57–2.61 (m, 1H), 2.75 (dd, J = 4.2, 15.0 Hz, 1H), 2.86–2.93 (m, 1H), 3.08 (dd, J = 8.5, 11.9 Hz, 1H), 3.82 (s, 3H), 4.60–4.66 (m, 2H), 4.90–4.94 (m, 1H), 5.26 (t, J = 8.8 Hz, 1H), 5.68 (s, 1H), 5.75 (s, 1H), 6.93–6.96 (m, 2H), 7.35–7.45 (m, 3H), 7.46–7.50 (m, 2H), 7.68–7.71 (m, 2H). ^{13}C NMR (125 MHz): β -isomer δ –5.2, –4.2, 17.7, 18.1, 20.5, 25.7, 26.0, 28.8, 34.4, 37.0, 40.6, 42.2, 55.4, 68.7, 73.7, 75.2, 78.8, 86.1, 95.2, 104.2, 113.9, 127.4, 127.5, 128.5, 129.4, 130.0, 131.1, 132.5, 138.1, 140.9, 153.2, 160.4, 192.0. HRFAB (NBA/NaI) Calcd for $C_{39}H_{50}O_7SiNa$ (MNa^+): 681.3224. Found: 681.3215.

Conjugate addition of cyano group onto 36.

To a toluene solution (1.2 mL) of the enone **36** (79.6 mg, 0.12 mmol) was added Et_2AlCN (1.0M in toluene, 0.36 mL, 0.36 mmol) at room temperature, and the mixture was stirred for 3 h. The reaction was quenched with saturated aqueous Rochelle salt. The layers were separated, and the

aqueous layer was extracted with ether. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 5% AcOEt/benzene) to give the enol **37** (61.4 mg, 74%) along with the another enol containing β -benzylidene moiety (12.3 mg, 15%).

37: IR (neat) 3380, 3055, 2955, 2930, 2860, 2230, 1660, 1620, 1520, 1460, 1420, 1390, 1365, 1210, 1170, 1100, 1040 cm^{-1} . ^1H NMR (500 MHz): δ 0.03 (s, 3H), 0.07 (s, 3H), 0.89 (s, 9H), 1.16 (s, 3H), 1.42 (s, 3H), 1.93 (s, 3H), 2.10–2.27 (m, 3H), 2.36–2.46 (m, 3H), 2.68 (dd, $J = 7.0, 13.7$ Hz, 1H), 3.56 (dd, $J = 11.7, 13.7$ Hz, 1H), 3.82 (s, 3H), 4.26 (dd, $J = 4.2, 11.4$ Hz, 1H), 4.49 (s, 1H), 4.59–4.64 (m, 1H), 4.97 (dd, $J = 7.1, 11.5$ Hz, 1H), 5.98 (s, 1H), 6.04 (s, 1H), 6.91–6.94 (m, 2H), 7.39–7.44 (m, 3H), 7.47–7.51 (m, 2H), 7.51–7.55 (m, 2H), 8.07 (s, 1H, enol-OH). ^{13}C NMR (125 MHz): δ -5.2, -4.2, 18.0, 18.3, 20.5, 25.8, 25.9, 26.2, 26.3, 28.1, 41.0, 42.0, 47.5, 55.3, 68.9, 71.1, 76.3, 81.5, 88.0, 95.0, 96.9, 103.2, 113.9, 121.6, 126.2, 128.1, 128.6, 129.5, 129.5, 129.7, 137.7, 138.7, 154.5, 160.6. HRFAB (NBA) Calcd for $\text{C}_{40}\text{H}_{52}\text{NO}_7\text{Si}$ (MH^+): 686.3513. Found: 686.3508.

Conversion of **37** to **38**.

To a THF solution (0.3 mL) of **37** (12.6 mg, 0.018 mmol) were added TBSCl (13.8 mg, 0.092 mmol) and KHMDS (1.0M in THF, 55 μL , 0.055 mmol, prepared from KH and hexamethyldisilazane) at 0 $^\circ\text{C}$, and the mixture was stirred for 0.2 h. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated, and the aqueous layer was extracted with ether. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 5% AcOEt/benzene) to give the enol TBS ether **38** (13.0 mg, 88%).

38: IR (neat) 3060, 2960, 2930, 2860, 2230, 1640, 1615, 1520, 1465, 1390, 1380, 1225, 1100, 1040 cm^{-1} . ^1H NMR (500 MHz): δ -0.15 (s, 3H), 0.04 (s, 3H), 0.13 (s, 3H), 0.14 (s, 3H), 0.72 (s, 9H), 0.96 (s, 9H), 1.20 (s, 3H), 1.43 (s, 3H), 1.92 (s, 3H), 2.08–2.27 (m, 3H), 2.32 (dd, $J = 10.6, 14.7$ Hz, 1H), 2.36–2.45 (m, 1H), 2.66 (dd, $J = 6.8, 13.7$ Hz, 1H), 2.98 (dd, $J = 5.4, 14.7$ Hz, 1H), 3.56 (dd, $J = 11.8, 13.7$ Hz, 1H), 3.82 (s, 3H), 4.27 (dd, $J = 4.4, 11.5$ Hz, 1H), 4.30 (s, 1H), 4.77–4.82 (m, 1H), 5.05 (dd, $J = 6.8, 11.8$ Hz, 1H), 5.79 (s, 1H), 6.05 (s, 1H), 6.92–6.95 (m, 2H), 7.35–7.39 (m, 3H), 7.52–7.56 (m, 4H). ^{13}C NMR (125 MHz): δ -5.0, -3.8, -3.7, -1.0, 18.2, 18.3, 19.3, 21.3, 25.2, 26.3, 26.5, 26.6, 27.9, 29.5, 40.7, 42.2, 48.3, 55.3, 69.4, 70.8, 76.7, 81.0, 87.9, 94.7, 103.3, 105.6, 113.9, 121.2, 127.6, 127.9, 128.2, 129.2, 129.2, 129.9, 137.5, 139.3, 151.4, 160.6. HRFAB (NBA) Calcd for $\text{C}_{46}\text{H}_{66}\text{NO}_7\text{Si}_2$ (MH^+): 800.4378. Found: 800.4380.

Reduction of **38** to **39**.

To a CH_2Cl_2 solution (0.3 mL) of **38** (9.1 mg, 0.014 mmol) was added DIBAL (0.96M in hexane, 24 μL , 0.023 mmol) at -78 $^\circ\text{C}$, and the mixture was stirred for 0.2 h. To this were added 1M HCl (0.1 mL) and THF (0.2 mL), and the mixture was stirred for 0.5 h at room temperature.

Saturated aqueous NaHCO_3 was added and the layers were separated. The aqueous layer was extracted with ether, and the combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 20% AcOEt /hexane) to give the aldehyde (7.1 mg, 78%).

aldehyde: IR (neat) 2955, 2930, 2860, 1720, 1620, 1520, 1460, 1390, 1375, 1250, 1220, 1110, 1090, 1065, 1040 cm^{-1} . ^1H NMR (500 MHz): δ -0.2 (s, 3H), 0.0 (s, 3H), 0.13 (s, 3H), 0.14 (s, 3H), 0.67 (s, 9H), 0.96 (s, 9H), 1.19 (s, 3H), 1.48 (s, 3H), 1.95 (s, 3H), 2.05–2.11 (m, 1H), 2.22–2.39 (m, 3H), 2.48–2.56 (m, 1H), 2.64 (dd, J = 7.0, 13.3 Hz, 1H), 2.97 (dd, J = 5.4, 14.7 Hz, 1H), 3.52 (dd, J = 12.0, 13.3 Hz, 1H), 3.80 (s, 3H), 4.05 (s, 1H), 4.47 (dd, J = 5.7, 12.3 Hz, 1H), 4.78–4.83 (m, 1H), 5.45 (dd, J = 7.0, 12.0 Hz, 1H), 5.65 (s, 1H), 6.02 (s, 1H), 6.87–6.90 (m, 2H), 7.31–7.39 (m, 5H), 7.46–7.50 (m, 2H), 9.72 (s, 1H). ^{13}C NMR (125 MHz): δ -4.9, -3.8, -3.7, -1.3, 18.2, 18.3, 19.8, 21.4, 23.2, 25.2, 26.3, 26.4, 27.3, 29.5, 40.9, 42.3, 54.1, 55.3, 69.5, 71.9, 74.3, 79.9, 87.8, 95.0, 103.0, 103.1, 113.8, 127.6, 127.8, 127.9, 129.0, 130.4, 130.5, 137.8, 138.4, 152.5, 160.3, 193.5. HRFAB (NBA) Calcd for $\text{C}_{46}\text{H}_{67}\text{O}_8\text{Si}_2$ (MH^+): 803.4375. Found: 803.4381.

To a THF solution (0.4 mL) of the aldehyde (16.6 mg, 0.021 mmol) was added LiAlH_4 (1.0M in THF, 0.1 mL, 0.1 mmol) at -78°C , and the mixture was stirred for 0.3 h. The reaction was quenched with saturated aqueous Rochelle salt. The layers were separated, and the aqueous layer was extracted with AcOEt . The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 30% AcOEt /hexane) to give the alcohol **39** (15.8 mg, 95%).

39: IR (neat) 3050, 2960, 2930, 2860, 1610, 1520, 1420, 1380, 1090, 1040, 1025 cm^{-1} . ^1H NMR (500 MHz): δ -0.05 (s, 3H), 0.02 (s, 3H), 0.12 (s, 3H), 0.13 (s, 3H), 0.65 (s, 9H), 0.96 (s, 9H), 1.20 (s, 3H), 1.41 (s, 3H), 1.83–1.90 (m, 1H), 1.95 (s, 3H), 1.94–1.99 (m, 1H, OH), 2.06–2.18 (m, 2H), 2.27 (dd, J = 9.6, 14.6 Hz, 1H), 2.34–2.44 (m, 1H), 2.57 (dd, J = 7.0, 13.5 Hz, 1H), 3.13 (dd, J = 5.7, 14.6 Hz, 1H), 3.57 (dd, J = 11.4, 13.5 Hz, 1H), 3.81 (s, 3H), 4.07 (dd, J = 4.8, 11.3 Hz, 1H), 4.20–4.25 (m, 1H), 4.22 (s, 1H), 4.37 (dd, J = 5.0, 11.9 Hz, 1H), 4.77 (dd, J = 7.0, 11.4 Hz, 1H), 4.82–4.88 (m, 1H), 5.68 (s, 1H), 6.07 (s, 1H), 6.90–6.93 (m, 2H), 7.33–7.37 (m, 3H), 7.44–7.48 (m, 2H), 7.48–7.52 (m, 2H). ^{13}C NMR (125 MHz): δ -4.9, -3.7, -3.4, -1.5, 18.1, 18.3, 19.4, 21.8, 24.0, 24.8, 26.4, 26.5, 28.4, 29.7, 40.3, 42.9, 45.1, 55.4, 68.0, 69.6, 72.8, 78.2, 80.9, 87.9, 94.6, 102.9, 107.7, 113.9, 127.5, 127.7, 127.9, 129.1, 130.2, 130.8, 137.6, 139.1, 149.9, 160.2. HRFAB (NBA/NaI) Calcd for $\text{C}_{46}\text{H}_{68}\text{O}_8\text{Si}_2\text{Na}$ (MNa^+): 827.4350. Found: 827.4351.

Conversion of **39** to cyclopropylketone **30c**.

To a solution of **39** (2.9 mg, 0.004 mmol) in benzene (0.35 mL) and pyridine (0.05 mL) were added triphenylphosphine (8.0 mg, 0.031 mmol) and carbon tetrabromide (10.8 mg, 0.033 mmol),

and the mixture was warmed at 50 °C. After 0.5 h, the reaction was quenched with saturated aqueous NaHCO₃. The layers were separated, and the aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 20% AcOEt/hexane) to give **40** (2.5 mg, 88%).

40: IR (neat) 2960, 2930, 2860, 1650, 1615, 1520, 1460, 1395, 1370, 1310, 1250, 1200, 1170, 1090, 1040 cm⁻¹. ¹H NMR (500 MHz): δ -0.10 (s, 3H), -0.09 (s, 3H), 0.11 (s, 3H), 0.12 (s, 3H), 0.70 (s, 9H), 0.93 (s, 9H), 1.15 (d, *J* = 4.8 Hz, 1H), 1.20 (s, 3H), 1.28 (s, 3H), 1.52 (d, *J* = 4.8 Hz, 1H), 1.83 (ddd, *J* = 2.1, 8.9, 16.3 Hz, 1H), 1.96 (s, 3H), 2.33 (dd, *J* = 9.6, 15.2 Hz, 1H), 2.34–2.39 (m, 1H), 2.58 (dd, *J* = 7.2, 13.2 Hz, 1H), 3.07 (dd, *J* = 6.0, 15.2 Hz, 1H), 3.40 (s, 1H), 3.57 (dd, *J* = 10.8, 13.2 Hz, 1H), 3.81 (s, 3H), 4.32 (dd, *J* = 7.2, 10.8 Hz, 1H), 4.40 (t, *J* = 8.9 Hz, 1H), 4.43 (dd, *J* = 2.1, 6.0 Hz, 1H), 4.77–4.81 (m, 1H), 5.59 (s, 1H), 6.17 (s, 1H), 6.89–6.92 (m, 2H), 7.32–7.36 (m, 3H), 7.46–7.53 (m, 4H). ¹³C NMR (125 MHz): δ -5.1, -3.7, -3.7, -3.2, 18.2, 18.7, 18.8, 21.9, 25.6, 25.8, 26.2, 26.3, 26.4, 28.6, 29.1, 31.5, 40.7, 43.2, 55.4, 67.4, 69.5, 82.2, 84.8, 87.1, 94.8, 97.4, 102.5, 113.8, 127.5, 127.7, 127.9, 129.0, 131.1, 131.8, 137.6, 138.4, 150.8, 160.1. HRFAB (NBA) Calcd for C₄₆H₆₇O₇Si₂ (MH⁺): 787.4425. Found: 787.4440.

To an acetone solution (1 mL) of **40** (2.5 mg, 0.0031 mmol) was added 1M HCl (0.5 mL), and the mixture was stirred for 0.5 h at room temperature. The reaction was quenched with saturated aqueous NaHCO₃. The layers were separated, and the aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 60% AcOEt/hexane) to give **30c** (1.8 mg, quant.), whose spectral data were completely agreed with that obtained via the diene-type C-ring route.

Conversion of **30c** to (-)-taxol.

Reductive cleavage of cyclopropylketone **30c.**

Under an argon atmosphere, SmI₂ (8.7 mL, 0.1 M in THF, 0.87 mmol) was added to a mixture of **30c** (96 mg, 0.17 mmol) and methanol (35.0 μL, 0.87 mmol) in HMPA (0.87 mL) at room temperature. The mixture was stirred for 5 h and then the reaction was quenched by saturated aqueous Na₂S₂O₃. The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO₄. A small amount of 2, 6-di-*t*-butyl-4-hydroxytoluene (BHT) was added to the mixture to prevent from decomposition of the product. The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by flash column chromatography (silica gel, 60-70% AcOEt/hexane) to give the enol (96 mg, quant.). The pure product should be kept in the presence of BHT under nitrogen atmosphere.

enol: IR (CDCl₃, containing a small amount of BHT) 3400, 2955, 2930, 1655, 1460, 1390,

1255, 1220, 1205, 1090, 1040 cm^{-1} . ^1H NMR (270 MHz, containing a small amount of BHT): δ 0.05 (s, 3H), 0.07 (s, 3H), 0.91 (s, 9H), 1.12 (s, 3H), 1.32 (s, 3H), 1.41 (s, 3H), 1.79–2.06 (m, 3H), 1.84 (s, 3H), 2.29–2.47 (m, 2H), 2.53–2.66 (m, 2H), 2.91 (dd, $J = 11.5, 13.4$ Hz, 1H), 3.13 (brs, 1H, OH), 3.85 (brs, 1H, OH), 4.16–4.29 (m, 1H, C9), 4.32–4.44 (m, 1H, C7), 4.39 (s, 1H, C2), 4.56–4.66 (m, 1H, C13), 5.85 (s, 1H, PhCH), 7.36–7.52 (m, 5H), 7.88 (s, 1H, enol-OH). ^{13}C NMR (67.5 MHz, containing a small amount of BHT): δ -5.1, -4.2, 18.1, 18.2, 20.7, 22.7, 25.9, 26.5, 26.6, 27.2, 35.7, 41.4, 42.1, 44.2, 69.6, 70.4, 78.6, 82.0, 88.8, 103.0, 105.8, 126.5, 128.6, 129.5, 131.9, 137.7, 137.8, 150.0.

Isomerization of enol **31** to ketone **32**.

To a mixture of the enol (24.2 mg, 0.044 mmol) and BHT (small amount) in degassed THF (0.50 mL) was added TBAF (53.0 μL , 1.0 M, 0.053 mmol), and the mixture was stirred at room temperature for 3 h. To this was added sodium methoxide (0.50 mL, 0.5 M in degassed methanol, 0.50 mmol), and the reaction vessel was sealed. The mixture was stirred at room temperature for 2.5 days. Water was added and the layers were separated. The aqueous layer was extracted with AcOEt and the combined organic extracts were dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by preparative TLC (silica gel, 80% AcOEt/hexane) to give the enol **31** (10.6 mg, 55%) and the desired ketone **32** (8.6 mg, 45%). A mixture of the recovered enol **31** and BHT (small amount) in degassed methanol (1.0 mL) was again treated with sodium methoxide (0.11 mL, 0.5 M in degassed methanol, 0.11 mmol) at room temperature for 1 weeks in a sealed-tube. The reaction mixture was treated by the same procedure as above. The crude products were purified by thin-layer chromatography (silica gel, 80% AcOEt/hexane) to give the enol **31** (2.6 mg, 24%) and the ketone **32** (4.0 mg, 38%). Total yield of **32** was 65% based on the starting material. (The pure enol **31** should be kept in the presence of BHT under nitrogen atmosphere.)

31: IR (CH_2Cl_2 , containing a small amount of BHT) 3390, 2970, 1660, 1440, 1390, 1370, 1055 cm^{-1} . ^1H NMR (400 MHz, containing a small amount of BHT): δ 1.11 (s, 3H), 1.34 (s, 3H), 1.42 (s, 3H), 1.77 (d, $J = 7.0$ Hz, 1H, C13-OH), 1.84–1.95 (m, 2H, C6 x 2), 1.88 (s, 3H), 2.00–2.10 (m, 1H, C5), 2.19–2.38 (m, 2H, C5 and C14), 2.55–2.70 (m, 2H, C10 and C14), 2.94 (t, $J = 8.0$ Hz, 1H, C10), 3.43 (brs, 1H, C7-OH), 3.80 (brs, 1H, C9-OH), 4.24–4.32 (m, 1H, C9), 4.36–4.48 (m, 2H, C7 and C13), 4.39 (s, 1H, C2), 5.94 (s, 1H, PhCH), 7.36–7.44 (m, 3H), 7.46–7.52 (m, 2H), 7.69 (s, 1H, enol-OH). ^{13}C NMR (100 MHz, containing a small amount of BHT): δ 17.8, 20.4, 21.9, 26.4, 26.7, 27.9, 35.4, 40.9, 41.3, 44.2, 69.3, 70.0, 78.3, 81.0, 87.9, 102.7, 109.4, 126.1, 128.6, 129.5, 133.2, 136.3, 137.8, 147.7.

32: $[\alpha]_D^{21}$: +60° ($c = 0.38$, CH_2Cl_2). IR (neat) 3400, 2920, 1725, 1455, 1390, 1260, 1220, 1115, 1090, 1030 cm^{-1} . ^1H NMR (300 MHz): δ 1.10 (s, 3H), 1.21 (s, 3H), 1.40 (s, 3H), 1.80–1.96 (m, 2H, including C13-OH), 1.86 (dd, $J = 3.9, 15.6$ Hz, 1H, C14 α), 2.04 (s, 3H), 2.13–2.26 (m, 2H), 2.39 (dd, $J = 9.5, 15.6$ Hz, 1H, C14 β), 2.48–2.62 (m, 1H, C5 α), 2.63–2.73 (m, 1H, C10 β), 3.06 (dd, $J = 11.3, 13.3$ Hz, 1H, C10 α), 3.52 (d, $J = 2.7$ Hz, 1H, C7-OH), 3.56 (d, $J =$

6.8 Hz, 1H, C9-OH), 3.61 (d, $J = 5.6$ Hz, 1H, C3), 4.00 (d, $J = 5.6$ Hz, 1H, C2), 4.10–4.20 (m, 1H, C9), 4.49–4.61 (m, 1H, C7), 4.61–4.73 (m, 1H, C13), 5.81 (s, 1H, PhCH), 7.29–7.39 (m, 3H), 7.43–7.51 (m, 2H). ^{13}C NMR (67.5 MHz): δ 14.5, 17.0, 20.3, 28.4, 31.4, 35.8, 40.8, 40.9, 42.3, 49.6, 52.2, 68.7, 72.5, 77.2, 77.7, 85.4, 102.7, 126.8, 128.2, 129.0, 135.3, 136.6, 138.2, 205.8. Anal. Calcd for $\text{C}_{26}\text{H}_{34}\text{O}_6$: C, 70.56; H, 7.74. Found: C, 70.26; H, 8.00.

Conversion of 32 to 41.

To a CH_2Cl_2 solution (1.0 mL) of the triol **32** (7.6 mg, 0.016 mmol) was added $\text{PhB}(\text{OH})_2$ (2.0 mg, 0.016 mmol) at room temperature, and the mixture was stirred for 15 min. The solvent was removed under reduced pressure to afford the crude boronate.

To a CH_2Cl_2 solution (0.8 mL) of the crude boronate were added 2,6-lutidine (17 μL , 0.16 mmol) and TBSOTf (36 μL , 0.16 mmol) at -45°C . The mixture was stirred for 12 h and the reaction was quenched by saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure to give the crude silyl ether.

To a AcOEt solution (0.8 mL) of the crude silyl ether was added saturated aqueous NaHCO_3 and 35% aqueous hydrogen peroxide (50 μL) at room temperature. The mixture was vigorously stirred for 1 h and the reaction was quenched by saturated aqueous $\text{Na}_2\text{S}_2\text{O}_3$. The layers were separated and the aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 75% AcOEt/hexane) to give the diol **41** (6.6 mg, 70% in 3 steps).

boronate: IR (neat) 3495, 2980, 1730, 1600, 1440, 1310, 1140, 1060 cm^{-1} . ^1H NMR (300 MHz): δ 1.13 (s, 6H), 1.47 (s, 3H), 1.87–2.03 (m, 2H), 1.92 (dd, $J = 3.8, 15.7$ Hz, 1H), 2.01 (s, 3H), 2.26–2.48 (m, 3H), 2.49–2.64 (m, 1H), 2.88–2.99 (m, 2H), 3.78 (d, $J = 5.3$ Hz, 1H), 4.06 (d, $J = 5.3$ Hz, 1H), 4.39 (dd, $J = 7.1, 10.0$ Hz, 1H), 4.58–4.71 (m, 1H), 4.63 (dd, $J = 5.1, 11.5$ Hz, 1H), 5.83 (s, 1H), 7.30–7.53 (m, 8H), 7.79–7.86 (m, 2H). ^{13}C NMR (75 MHz): δ 15.2, 17.0, 20.5, 28.1, 29.9, 36.2, 40.7, 40.8, 42.1, 46.8, 52.2, 68.6, 70.7, 76.7, 78.1, 85.1, 102.9, 126.8, 127.6, 128.2, 129.0, 131.0, 133.9, 134.7, 137.4, 138.3, 204.2 (1 peak missing). Anal. Calcd for $\text{C}_{32}\text{H}_{37}\text{BO}_6$: C, 72.73; H, 7.06. Found: C, 72.77; H, 7.31

TBS ether: IR (neat) 2955, 2860, 1730, 1600, 1440, 1310, 1140, 1065 cm^{-1} . ^1H NMR (300 MHz): δ 0.00 (s, 3H), 0.07 (s, 3H), 0.88 (s, 9H), 1.12 (s, 3H), 1.13 (s, 3H), 1.47 (s, 3H), 1.87 (dd, $J = 4.0, 15.5$ Hz, 1H), 1.91–2.00 (m, 1H), 1.96 (s, 3H), 2.30 (dd, $J = 9.5, 15.5$ Hz, 1H), 2.28–2.60 (m, 3H), 2.93 (d, $J = 9.0$ Hz, 2H), 3.78 (d, $J = 5.1$ Hz, 1H), 4.05 (d, $J = 5.1$ Hz, 1H), 4.38 (t, $J = 9.0$ Hz, 1H), 4.52–4.62 (m, 1H), 4.64 (dd, $J = 4.9, 11.5$ Hz, 1H), 5.86 (s, 1H), 7.30–7.52 (m, 8H), 7.78–7.85 (m, 2H). ^{13}C NMR (100 MHz): δ -5.2, -4.4, 15.3, 17.9, 18.0, 20.6, 25.8, 27.9, 29.9, 36.3, 40.7, 40.8, 43.4, 46.8, 52.4, 69.3, 70.8, 76.8, 78.2, 85.3, 102.9, 126.8, 127.6, 128.2, 128.9, 131.0, 133.9, 133.9, 138.6, 203.9 (2 peaks missing). Anal. Calcd for $\text{C}_{38}\text{H}_{51}\text{BO}_6\text{Si}$: C, 71.01; H, 8.00. Found: C, 71.01; H, 8.26

41: $[\alpha]_D^{27}$: +45° ($c = 0.59$, CH_2Cl_2). IR (neat) 3420, 2955, 2860, 1730, 1460, 1390, 1260, 1040 cm^{-1} . ^1H NMR (300 MHz): δ -0.01 (s, 3H), 0.06 (s, 3H), 0.87 (s, 9H), 1.08 (s, 3H), 1.17 (s, 3H), 1.36 (s, 3H), 1.80 (dd, $J = 4.2, 15.6$ Hz, 1H), 1.80–1.95 (m, 1H), 1.97 (s, 3H), 2.12–2.25 (m, 2H), 2.26 (dd, $J = 9.3, 15.6$ Hz, 1H), 2.44–2.59 (m, 1H), 2.63 (brd, $J = 12.6$ Hz, 1H), 3.05 (t, $J = 12.6$ Hz, 1H), 3.61 (d, $J = 5.3$ Hz, 1H), 3.95 (d, $J = 5.3$ Hz, 1H), 4.06–4.22 (m, 3H, including OH x 2), 4.48–4.62 (m, 1H), 4.54 (dd, $J = 5.0, 10.6$ Hz, 1H), 5.80 (s, 1H), 7.29–7.37 (m, 3H), 7.40–7.47 (m, 2H). ^{13}C NMR (75 MHz): δ -5.2, -4.4, 14.6, 17.9, 18.0, 20.4, 25.8, 28.1, 31.5, 36.0, 40.7, 40.8, 43.7, 49.7, 52.4, 69.4, 72.5, 77.1, 77.8, 85.5, 102.6, 126.7, 128.2, 128.9, 134.4, 137.6, 138.4, 205.4. Anal. Calcd for $\text{C}_{32}\text{H}_{48}\text{O}_6\text{Si}$: C, 69.03; H, 8.69. Found: C, 68.81; H, 8.99.

To a CH_2Cl_2 solution (1.0 mL) of the diol **41** (8.6 mg, 0.015 mmol) was added Dess-Martin periodinane (25.8 mg, 0.061 mmol) at room temperature, and the mixture was stirred for 1 h. The reaction was quenched by saturated aqueous NaHCO_3 . The layers were separated and aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 50 % AcOEt/hexane) to give the ketone (7.9 mg, 92%).

$[\alpha]_D^{29}$: -132° ($c = 0.86$, CH_2Cl_2). IR (CH_2Cl_2) 3440, 2955, 1730, 1695, 1460, 1390, 1255, 1060, 1035 cm^{-1} . ^1H NMR (300 MHz): δ 0.01 (s, 3H), 0.08 (s, 3H), 0.89 (s, 9H), 1.08 (s, 3H), 1.14 (s, 3H), 1.16 (s, 3H), 1.88 (dd, $J = 4.4, 15.6$ Hz, 1H), 1.80–2.00 (m, 1H), 2.03 (s, 3H), 2.19–2.34 (m, 2H), 2.32 (dd, $J = 10.0, 15.6$ Hz, 1H), 2.51 (dt, $J = 7.0, 13.6$ Hz, 1H), 3.42 (brd, $J = 15.2$ Hz, 1H), 3.76 (d, $J = 5.1$ Hz, 1H), 3.91 (d, $J = 15.2$ Hz, 1H), 3.99 (d, $J = 5.1$ Hz, 1H), 4.53 (dd, $J = 4.2, 11.0$ Hz, 1H), 4.59–4.69 (m, 1H), 5.75 (s, 1H), 7.29–7.36 (m, 3H), 7.41–7.48 (m, 2H). ^{13}C NMR (75 MHz): δ -5.2, -4.4, 12.0, 17.8, 18.0, 20.5, 25.8, 26.8, 30.7, 40.0, 41.4, 43.1, 46.0, 54.0, 62.9, 68.9, 71.1, 80.0, 85.1, 103.0, 126.7, 128.2, 129.0, 132.0, 138.2, 139.0, 202.5, 208.8. Anal. Calcd for $\text{C}_{32}\text{H}_{46}\text{O}_6\text{Si}$: C, 69.28; H, 8.36. Found: C, 69.10; H, 8.56.

To a CH_2Cl_2 (10 mL) solution of the ketone (760 mg, 1.37 mmol) and PPTS (24 mg, 0.10 mmol) at room temperature was added isopropenyl methyl ether (0.5 mL), and the mixture was stirred for 5 min. To this was added Et_3N (3 mL), and the resultant mixture was filtered through a short pad of silica gel (20% AcOEt/hexane). The mixture was concentrated under reduced pressure to afford the essentially pure product **42** (830 mg, 97%).

42: $[\alpha]_D^{28}$: -131° ($c = 0.34$, CH_2Cl_2). IR (CH_2Cl_2) 2955, 1730, 1695, 1460, 1385, 1260, 1210, 1115, 1060, 1035 cm^{-1} . ^1H NMR (300 MHz) δ 0.01 (s, 3H), 0.08 (s, 3H), 0.89 (s, 9H), 1.07 (s, 3H), 1.15 (s, 3H), 1.18 (s, 3H), 1.32 (s, 3H), 1.43 (s, 3H), 1.84 (dd, $J = 5.4, 15.0$ Hz, 1H), 1.86–1.97 (m, 1H), 2.08 (s, 3H), 2.20–2.30 (m, 1H), 2.31 (dd, $J = 8.9, 15.0$ Hz, 1H), 2.41–2.56 (m, 2H), 3.13 (s, 3H), 3.37 (brd, $J = 14.7$ Hz, 1H), 3.68 (d, $J = 5.1$ Hz, 1H), 4.01 (d, $J = 14.7$ Hz, 1H), 4.06 (d, $J = 5.1$ Hz, 1H), 4.62 (dd, $J = 4.6, 10.7$ Hz, 1H), 4.60–4.69 (m, 1H), 5.71 (s, 1H), 7.28–7.34 (m, 3H), 7.41–7.47 (m, 2H). ^{13}C NMR (67.5 MHz) δ -5.2, -4.4, 13.1, 18.0,

18.0, 20.1, 25.0, 25.4, 25.8, 27.0, 29.3, 40.3, 41.7, 43.2, 46.1, 49.3, 54.6, 63.1, 69.1, 71.6, 80.1, 85.1, 100.7, 102.9, 126.8, 128.1, 128.9, 132.6, 138.3, 138.6, 202.7, 207.6. Anal. Calcd for $C_{36}H_{54}O_7Si$: C, 68.97; H, 8.68. Found: C, 68.97; H, 8.96.

Preparation of allylsilane 44.

To a THF (7 mL) solution of **42** (400 mg, 0.64 mmol) was added a THF solution of KHMDS (1M, 0.64 mL, 0.64 mmol) at $-78\text{ }^{\circ}\text{C}$. After being stirred for 0.5 h at that temperature, the mixture was treated with *N*-phenyltrifluoromethanesulfonimide (470 mg, 0.96 mmol). The mixture was stirred for 1 h and the reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over anhydrous MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by column chromatography (silica gel, 10% AcOEt/hexane) to afford the enol triflate **43** (430 mg, 89%).

43: $[\alpha]_D^{25}$: -146° ($c = 1.40$, CH_2Cl_2). IR (CH_2Cl_2) 2960, 1695, 1425, 1385, 1140, 1055 cm^{-1} . ^1H NMR (300 MHz) δ 0.13 (s, 3H), 0.15 (s, 3H), 0.94 (s, 9H), 1.16 (s, 3H), 1.20 (s, 3H), 1.31 (s, 3H), 1.36 (s, 3H), 1.37 (s, 3H), 1.96 (s, 3H), 2.20–2.32 (m, 1H), 2.33 (dd, $J = 5.0$, 15.6 Hz, 1H), 2.56 (dd, $J = 9.2$, 15.6 Hz, 1H), 2.64–2.77 (m, 1H), 3.18 (s, 3H), 3.37 (brd, $J = 15.0$ Hz, 1H), 3.84 (d, $J = 15.0$ Hz, 1H), 3.89 (d, $J = 3.2$ Hz, 1H), 4.21 (dd, $J = 6.0$, 9.2 Hz, 1H), 4.42–4.48 (m, 1H), 4.78–4.86 (m, 1H), 5.57–5.63 (m, 1H), 5.60 (s, 1H), 7.33–7.39 (m, 3H), 7.44–7.51 (m, 2H). ^{13}C NMR (67.5 MHz) δ -5.2 , -4.2 , 12.3, 16.9, 18.0, 20.8, 25.0, 25.2, 25.8, 26.4, 29.3, 42.1, 42.8, 44.0, 47.3, 49.6, 61.5, 69.0, 80.6, 85.0, 100.9, 104.0, 114.0, 127.8, 128.0, 129.5, 132.3, 136.4, 140.2, 147.8, 208.2 (2 peaks missing). HRFAB (NBA/NaI) Calcd for $\text{C}_{37}\text{H}_{53}\text{F}_3\text{O}_9\text{SSiNa}$ (MNa^+): 781.3029. Found: 781.2999.

To a mixture of the enol triflate **43** (290 mg, 0.37 mmol) and tetrakis(triphenylphosphine)-palladium (150 mg, 0.13 mmol) in ether (15 mL) was added a THF solution of $\text{TMSCH}_2\text{MgCl}$ (0.44 M, 5.0 mL, 2.2 mmol) at room temperature. The mixture was stirred for 1 h and the reaction was quenched with saturated aqueous NaHCO_3 . The organic layer was separated and the aqueous layer was extracted with ether (50 mL). The combined organic extracts were concentrated under reduced pressure and the resultant residue was purified by column chromatography (silica gel, 5% AcOEt/hexane) to afford the allylsilane **44** (250 mg, 91%).

44: $[\alpha]_D^{28}$: -139° ($c = 0.66$, CH_2Cl_2). IR (CH_2Cl_2) 2955, 1690, 1460, 1380, 1255, 1060, 1040 cm^{-1} . ^1H NMR (300 MHz) δ -0.28 (s, 9H), 0.13 (s, 3H), 0.16 (s, 3H), 0.95 (s, 9H), 1.15 (s, 3H), 1.21 (s, 3H), 1.26 (s, 3H), 1.29 (s, 3H), 1.38 (s, 3H), 1.50 (brd, $J = 14.0$ Hz, 1H), 1.94 (s, 3H), 2.01–2.14 (m, 1H), 2.13 (d, $J = 14.0$ Hz, 1H), 2.46 (dd, $J = 4.6$, 15.2 Hz, 1H), 2.50–2.61 (m, 2H), 3.17 (s, 3H), 3.31 (brd, $J = 14.4$ Hz, 1H), 3.80–3.82 (m, 1H), 3.84 (d, $J = 14.4$ Hz, 1H), 3.91–3.98 (m, 1H), 4.22 (dd, $J = 6.6$, 9.8 Hz, 1H), 4.75–4.85 (m, 1H), 5.02–5.10 (m, 1H), 5.54 (s, 1H), 7.31–7.45 (m, 5H). ^{13}C NMR (75 MHz) δ -5.1 , -4.1 , -0.90 , 11.9, 17.1, 18.1, 20.8, 23.9, 25.1, 25.5, 25.9, 26.7, 31.7, 42.7, 43.1, 46.9, 47.5, 49.3, 62.1, 69.3, 70.9, 83.0,

85.5, 100.4, 103.2, 118.4, 127.4, 128.3, 129.5, 132.0, 135.9, 137.7, 139.2, 211.5. Anal. Calcd for $C_{40}H_{65}O_6Si_2$: C, 68.82; H, 9.39. Found: C, 68.53; H, 9.53.

Preparation of allylchloride 45

To a MeOH (1.5 mL) solution of the allylsilane **44** (15.6 mg, 0.021 mmol) was added *N*-chlorosuccinimide (48 mg, 0.36 mmol) at room temperature. After being stirred for 10 h, the reaction mixture was diluted with AcOEt (2 mL) and poured into saturated aqueous Na_2SO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over $MgSO_4$. The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 20% AcOEt/hexane) to afford the allylchloride (10.8 mg, 88 %).

$[\alpha]_D^{26}$: -102° ($c = 0.42$, CH_2Cl_2). IR (CH_2Cl_2) 2955, 2930, 1685, 1460, 1385, 1255, 1040 cm^{-1} . 1H NMR (300 MHz) δ 0.04 (s, 3H), 0.06 (s, 3H), 0.90 (s, 9H), 1.10 (s, 3H), 1.20 (s, 6H), 1.92–2.10 (m, 2H), 2.13 (s, 3H), 2.23–2.38 (m, 2H), 3.41 (brd, $J = 15.2$ Hz, 1H), 3.90 (d, $J = 5.0$ Hz, 1H), 3.92 (d, $J = 15.2$ Hz, 1H), 4.19 (brd, $J = 5.0$ Hz, 1H), 4.51 (dd, $J = 4.4, 11.2$ Hz, 1H), 4.66 (dd, $J = 2.0, 4.2$ Hz, 1H), 4.84–4.93 (m, 1H), 5.25 (s 1H), 5.66 (s 1H), 5.85 (s, 1H), 7.33–7.47 (m, 5H). ^{13}C NMR (75 MHz) δ $-5.2, -4.2, 11.0, 16.6, 18.1, 21.9, 25.9, 25.9, 39.7, 42.2, 42.9, 43.1, 46.3, 63.4, 64.7, 68.4, 69.0, 82.5, 86.2, 102.5, 118.9, 126.8, 128.4, 129.2, 129.3, 138.1, 140.9, 141.8, 212.0$. Anal. Calcd for $C_{33}H_{47}ClO_5Si$: C, 67.49; H, 8.07. Found: C, 67.50; H, 8.37.

To a CH_2Cl_2 (4 mL) solution of the allylchloride (57 mg, 0.097 mmol) were added PPTS (10 mg, 0.040 mmol) and isopropenyl methyl ether (0.2 mL) at room temperature. The mixture was stirred for 3 min and Et_3N (2 mL) was added. The mixture was filtered through a short pad of silica gel (10% AcOEt /hexane) and the filtrate was concentrated under reduced pressure to afford the pure **45** (57 mg 89%).

45: $[\alpha]_D^{28}$: -104° ($c = 0.37$, CH_2Cl_2). IR (CH_2Cl_2) 2955, 2925, 1695, 1465, 1390, 1260, 1205, 1045 cm^{-1} . 1H NMR (300 MHz) δ 0.05 (s, 3H), 0.07 (s, 3H), 0.90 (s, 9H), 1.14 (s, 3H), 1.19 (s, 3H), 1.21 (s, 3H), 1.31 (s, 3H), 1.41 (s, 3H), 1.95–2.10 (m, 1H), 2.09 (dd, $J = 6.6, 15.0$ Hz, 1H), 2.17 (s, 3H), 2.30 (dd, $J = 9.0, 15.0$ Hz, 1H), 2.52–2.63 (m, 1H), 3.12 (s, 3H), 3.35 (brd, $J = 14.6$ Hz, 1H), 3.84 (d, $J = 5.0$ Hz, 1H), 4.01 (d, $J = 14.6$ Hz, 1H), 4.17 (d, $J = 5.0$ Hz, 1H), 4.58–4.66 (m, 2H), 4.85–4.96 (m, 1H), 5.20 (s 1H), 5.62 (s 1H), 5.82 (s, 1H), 7.33–7.39 (m, 3H), 7.39–7.47 (m, 2H). ^{13}C NMR (75 MHz) δ $-5.2, -4.2, 12.1, 16.8, 18.2, 21.5, 25.0, 25.4, 25.9, 26.2, 38.1, 42.6, 43.1, 43.6, 46.3, 49.2, 62.6, 65.4, 69.2, 69.4, 82.5, 86.3, 100.8, 102.5, 118.3, 126.9, 128.4, 129.2, 129.8, 138.1, 140.7, 142.2, 210.8$. Anal. Calcd for $C_{37}H_{55}ClO_6Si$: C, 67.40; H, 8.41. Found: C, 67.30; H, 8.39

Conversion of 45 to 46 β .

To a THF (4.0 mL) solution of **45** (59 mg, 0.089 mmol) was added a THF solution of lithium

diisopropyl amide (0.5 M, 0.70 mL, 0.36 mmol) at 0 °C. After being stirred for 35 min, the reaction mixture was cooled to -23 °C. To this was added MoO₅•pyridine•HMPA (213 mg, 0.49 mmol), and the mixture was stirred for 20 min at that temperature. The reaction was quenched with a saturated aqueous Na₂SO₃. The layers were separated and the aqueous layer was extracted with ether. The combined organic extracts were washed twice with brine and dried over MgSO₄. The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 10 % AcOEt/hexane) to afford the C10 α -alcohol (48 mg, 80 %).

C10 α -alcohol: IR (CH₂Cl₂) 3330, 2955, 1685, 1460, 1380, 1260, 1110, 1045 cm⁻¹. ¹H NMR (300 MHz) δ 0.04 (s, 3H), 0.06 (s, 3H), 0.91 (s, 9H), 1.24 (s, 3H), 1.26 (s, 6H), 1.38 (s, 3H), 1.44 (s, 3H), 2.04–2.16 (m, 1H), 2.13 (dd, *J* = 6.2, 15.1 Hz, 1H), 2.26 (s, 3H), 2.25–2.35 (m, 1H), 2.39 (dt, *J* = 5.0, 14.2 Hz, 1H), 3.17 (s, 3H), 3.92 (d, *J* = 5.0 Hz, 1H), 4.09 (d, *J* = 5.0 Hz, 1H), 4.11 (brs, 1H, OH), 4.60 (t, *J* = 5.0 Hz, 1H), 4.78–4.86 (m, 1H), 4.98 (dd, *J* = 5.0, 10.0 Hz, 1H), 5.12 (brs 1H), 5.25 (s 1H), 5.65 (s 1H), 5.70 (s, 1H), 7.32–7.47 (m, 5H). ¹³C NMR (67.5 MHz) δ -5.2, -4.3, 13.3, 14.9, 18.2, 21.7, 24.7, 25.2, 25.9, 26.5, 39.0, 41.6, 42.5, 44.0, 49.0, 61.7, 63.1, 69.3, 69.8, 81.1, 81.7, 85.8, 101.4, 102.4, 117.5, 126.8, 128.4, 129.2, 138.2, 142.2, 142.7, 209.6 (1 peak missing). Anal. Calcd for C₃₇H₅₅ClO₇Si: C, 65.80; H, 8.21. Found: C, 65.84; H, 8.38.

To a CH₂Cl₂ (1 mL) solution of the alcohol (25.0 mg, 0.040 mmol) were added DMAP (23 mg, 0.18 mmol) and acetic anhydride (0.010 mL, 0.11 mmol) at room temperature. After being stirred for 30 min, the reaction mixture was diluted with AcOEt (2 mL) and poured into saturated aqueous NaHCO₃. The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were dried over anhydrous MgSO₄. The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 20% AcOEt/hexane) to afford the acetate **46 α** (24 mg, 92%).

46 α : [α]_D²⁸: +30° (*c* = 1.13, CH₂Cl₂). IR (CH₂Cl₂) 2955, 1745, 1720, 1460, 1380, 1230, 1050 cm⁻¹. ¹H NMR (300 MHz) δ 0.02 (s, 3H), 0.05 (s, 3H), 0.90 (s, 9H), 1.24 (s, 3H), 1.25 (s, 3H), 1.45 (s, 3H), 1.46 (s, 3H), 1.54 (s, 3H), 1.92 (brs, 3H), 2.11 (dd, *J* = 6.0, 15.6 Hz, 1H), 2.14–2.25 (m, 1H), 2.18 (s, 3H), 2.25 (dd, *J* = 8.2, 15.6 Hz, 1H), 2.45 (dt, *J* = 5.5, 14.0 Hz, 1H), 3.18 (s, 3H), 3.44 (d, *J* = 5.4 Hz, 1H), 4.19 (d, *J* = 5.4 Hz, 1H), 4.51–4.61 (m, 2H), 4.69–4.79 (m, 1H), 5.31 (s 1H), 5.40 (s 1H), 5.73 (s 1H), 5.94 (s, 1H), 7.32–7.45 (m, 5H). ¹³C NMR (67.5 MHz) δ -5.2, -4.4, 14.3, 15.4, 18.1, 20.9, 22.0, 24.4, 25.0, 25.9, 38.9, 41.9, 46.0, 48.7, 59.1, 59.9, 68.6, 68.9, 75.8, 80.0, 85.5, 101.1, 102.2, 115.8, 126.7, 127.8, 128.3, 129.1, 138.3, 142.5, 147.1, 169.4, 201.3 (2 peaks missing). Anal. Calcd for C₃₉H₅₇ClO₈Si: C, 65.29; H, 8.01. Found: C, 65.45; H, 8.13.

To a toluene (1.5 mL) solution of the C10 α -acetate **46 α** (24 mg, 0.034 mmol) was added freshly distilled DBN (0.31 mL) at room temperature. The reaction mixture was heated to reflux for 10 h and then cooled to room temperature. The mixture was poured into H₂O (2 mL). The layers

were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over anhydrous MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 25% AcOEt/hexane) to afford the C10 β -acetate **46 β** (17 mg, 68%) and the starting material **46 α** (2.0 mg, 8 %).

46 β : $[\alpha]_D^{28}$: -88° ($c = 1.71$, CH_2Cl_2). IR (CH_2Cl_2) 2955, 1730, 1715, 1460, 1380, 1250, 1050 cm^{-1} . ^1H NMR (300 MHz) δ 0.05 (s, 3H), 0.07 (s, 3H), 0.91 (s, 9H), 1.21 (s, 3H), 1.23 (s, 3H), 1.24 (s, 3H), 1.27 (s, 3H), 1.57 (s, 3H), 2.02 (ddd, $J = 3.8, 11.0, 14.7$ Hz, 1H), 2.12 (dd, $J = 6.8, 15.1$ Hz, 1H), 2.20 (s, 3H), 2.27 (s, 3H), 2.31 (dd, $J = 9.0, 15.1$ Hz, 1H), 2.80 (ddd, $J = 2.4, 4.4, 14.7$ Hz, 1H), 3.12 (s, 3H), 3.86 (d, $J = 5.0$ Hz, 1H), 4.00 (d, $J = 5.0$ Hz, 1H), 4.57 (dd, $J = 4.4, 11.0$ Hz, 1H), 4.64 (dd, $J = 2.4, 3.8$ Hz, 1H), 4.88–4.97 (m, 1H), 5.24 (s 1H), 5.64 (s 1H), 5.83 (s 1H), 6.59 (s, 1H), 7.32–7.47 (m, 5H). ^{13}C NMR (75 MHz) δ $-5.2, -4.2, 11.8, 17.2, 18.1, 20.2, 21.0, 24.1, 24.4, 25.9, 26.8, 37.1, 41.9, 42.8, 43.9, 48.4, 61.1, 65.3, 69.1, 70.2, 76.7, 82.3, 86.0, 101.3, 102.5, 118.5, 126.8, 128.4, 129.3, 129.9, 138.0, 142.1, 146.9, 169.5, 204.5$. Anal. Calcd for $\text{C}_{39}\text{H}_{57}\text{ClO}_8\text{Si}$: C, 65.29; H, 8.01. Found: C, 65.51; H, 8.21.

Dihydroxylation of **46 β** .

To a solution of the allylchloride **46 β** (8.3 mg, 0.012 mmol) in a 1 : 10 mixture of pyridine and ether (1.0 mL) was added an excess amount of OsO_4 (0.68 M solution in THF, 85 μL , 0.058 mmol) at room temperature. The reaction mixture was stirred for 18 h and then H_2O (ca. 1 mL), pyridine (1 mL) and ca. 200 mg of Na_2SO_3 were added. The mixture was vigorously stirred at 50 $^\circ\text{C}$ for 15 h and poured into H_2O . The layers were separated and the aqueous layer was extracted with AcOEt. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 40 % AcOEt / hexane) to afford the diol **47** (7.4 mg, 86%).

47: $[\alpha]_D^{28}$: -76° ($c = 0.67$, CH_2Cl_2). IR (CH_2Cl_2) 3520, 3460, 2955, 2930, 1735, 1715, 1460, 1385, 1370, 1240, 1050 cm^{-1} . ^1H NMR (300 MHz) δ 0.10 (s, 3H), 0.11 (s, 3H), 0.94 (s, 9H), 1.17 (s, 3H), 1.18 (s, 3H), 1.24 (s, 3H), 1.32 (s, 3H), 1.54 (s, 3H), 2.09–2.22 (m, 1H), 2.19 (s, 3H), 2.24 (brs, 3H), 2.32 (dd, $J = 9.8, 15.2$ Hz, 1H), 2.43–2.48 (m, 1H, OH), 2.72 (dd, $J = 5.6, 15.2$ Hz, 1H), 2.87 (dt, $J = 4.0, 15.1$ Hz, 1H), 3.14 (s, 3H), 3.32 (s, 1H, OH), 3.61–3.72 (m, 1H), 3.72 (d, $J = 4.4$ Hz, 1H), 3.79 (d, $J = 4.4$ Hz, 1H), 4.29 (d, $J = 11.8$ Hz, 1H), 4.53 (dd, $J = 4.0, 11.2$ Hz, 1H), 4.68–4.73 (m, 1H), 4.80–4.88 (m, 1H), 5.71 (s 1H), 6.54 (s, 1H), 7.35–7.41 (m, 3H), 7.43–7.49 (m, 2H). ^{13}C NMR (75 MHz) δ $-5.1, -4.4, 13.0, 17.0, 18.2, 19.6, 20.9, 23.8, 24.3, 25.9, 27.0, 33.0, 41.3, 41.7, 45.9, 48.4, 60.4, 64.4, 64.5, 69.3, 69.4, 76.3, 76.5, 82.0, 85.5, 101.5, 102.7, 126.7, 128.5, 129.4, 131.1, 137.9, 146.8, 169.4, 202.6$. Anal. Calcd for $\text{C}_{39}\text{H}_{59}\text{ClO}_{10}\text{Si}$: C, 62.34; H, 7.91. Found: C, 62.51; H, 8.21.

Construction of D-ring oxetane.

To a toluene (3.0 mL) solution of the diol **47** (20.0 mg, 0.027 mmol) was added DBU (0.03

mL) at room temperature. The reaction mixture was heated to reflux for 4 h and then cooled to room temperature. The mixture was diluted with brine. The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were dried over anhydrous MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 30% AcOEt/hexane) to afford the oxetanol **48** (16.4 mg, 86%).

48: $[\alpha]_{\text{D}}^{28}$: -119° ($c = 0.86$, CH_2Cl_2). IR (CH_2Cl_2) 3460, 2955, 2930, 1735, 1715, 1460, 1370, 1240, 1050 cm^{-1} . ^1H NMR (300 MHz) δ 0.07 (s, 3H), 0.11 (s, 3H), 0.93 (s, 9H), 1.11 (s, 3H), 1.21 (s, 3H), 1.28 (s, 3H), 1.50 (s, 3H), 1.74 (s, 3H), 1.98 (ddd, $J = 2.1, 10.6, 15.4$ Hz, 1H), 2.05 (s, 3H), 2.19 (s, 3H), 2.24 (dd, $J = 9.5, 15.7$ Hz, 1H), 2.45 (dd, $J = 3.9, 15.7$ Hz, 1H), 2.84 (ddd, $J = 6.7, 9.4, 15.4$ Hz, 1H), 2.89 (brs, 1H, OH), 2.97 (d, $J = 4.7$ Hz, 1H), 3.17 (s, 3H), 3.87 (d, $J = 4.7$ Hz, 1H), 4.16 (dd, $J = 6.7, 10.6$ Hz, 1H), 4.43 (d, $J = 8.3$ Hz, 1H), 4.62 (d, $J = 8.3$ Hz, 1H), 4.62–4.72 (m, 1H), 4.81 (dd, $J = 2.1, 9.4$ Hz, 1H), 5.74 (s, 1H), 6.43 (s, 1H), 7.30–7.48 (m, 5H). ^{13}C NMR (67.5 MHz) δ $-5.1, -4.3, 10.8, 17.8, 18.2, 19.0, 21.0, 24.0, 24.3, 25.9, 27.9, 35.5, 40.3, 41.3, 49.0, 49.7, 59.2, 69.5, 72.2, 74.4, 79.6, 80.4, 84.6, 87.1, 101.1, 102.5, 126.5, 128.4, 129.1, 133.2, 138.3, 144.2, 169.4, 203.5$ (1 peak missing). Anal. Calcd for $\text{C}_{39}\text{H}_{58}\text{O}_{10}\text{Si}$: C, 65.52; H, 8.18. Found: C, 65.80; H, 8.40.

Conversion of **48** to **49**.

To a MeOH (1 mL) solution of the oxetanol **48** (15.0 mg, 0.021 mmol) was added PPTS (5 mg, 0.020 mmol) at room temperature, and the mixture was stirred for 30 min. To this was added Et_3N (1 mL), and the solvent was removed under reduced pressure. The resultant residue was filtered through a short pad of silica gel (50% AcOEt/hexane). The filtrate was concentrated under reduced pressure to give the crude alcohol, which was directly used in the next step.

alcohol: $[\alpha]_{\text{D}}^{27}$: -115° ($c = 0.82$, CH_2Cl_2). IR (CH_2Cl_2) 3500, 2955, 2930, 1730, 1710, 1600, 1460, 1375, 1240, 1095, 1050 cm^{-1} . ^1H NMR (300 MHz) δ 0.05 (s, 3H), 0.10 (s, 3H), 0.92 (s, 9H), 1.16 (s, 6H), 1.68 (s, 3H), 1.88–2.04 (m, 1H), 2.02 (s, 3H), 2.15–2.25 (m, 1H), 2.23 (s, 3H), 2.33 (brs, 1H, OH), 2.39 (dd, $J = 4.4, 15.6$ Hz, 1H), 2.56 (ddd, $J = 6.9, 9.2, 15.2$ Hz, 1H), 2.81 (brs, 1H, OH), 2.91 (d, $J = 4.8$ Hz, 1H), 3.88 (d, $J = 4.8$ Hz, 1H), 4.18 (dd, $J = 6.9, 10.7$ Hz, 1H), 4.46 (d, $J = 8.2$ Hz, 1H), 4.63 (d, $J = 8.2$ Hz, 1H), 4.65–4.74 (m, 1H), 4.89 (dd, $J = 2.2, 9.2$ Hz, 1H), 5.77 (s, 1H), 6.35 (s, 1H), 7.32–7.47 (m, 5H). ^{13}C NMR (100 MHz) δ $-5.1, -4.3, 9.5, 17.9, 18.2, 19.0, 20.9, 25.9, 27.8, 36.4, 40.6, 41.1, 48.9, 60.1, 69.4, 72.5, 74.4, 79.7, 80.6, 84.6, 87.1, 102.5, 126.3, 128.4, 129.1, 132.3, 138.4, 147.1, 171.0, 205.2$. HRFAB (NBA/NaI) Calcd for $\text{C}_{35}\text{H}_{50}\text{O}_9\text{SiNa}$ (MNa^+): 665.3122. Found: 665.3106.

The crude product was dissolved in DMF (1 mL). To this were added DMAP (10 mg, 0.082 mmol), imidazole (32 mg, 0.47 mmol) and TESCl (0.035 mL, 0.21 mmol) at room temperature. After being stirred for 5 h, the reaction mixture was poured into saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were dried over anhydrous MgSO_4 and concentrated under reduced pressure. The resultant

residue was purified by thin-layer chromatography (silica gel, 20% AcOEt/hexane) to afford the silyl ether **49** (15 mg, 97% in 2 steps).

49: $[\alpha]_D^{26}$: -93° ($c = 0.73$, CH_2Cl_2). IR (CH_2Cl_2) 3420, 2955, 1745, 1715, 1460, 1370, 1235 cm^{-1} . ^1H NMR (500 MHz) δ 0.06 (s, 3H), 0.11 (s, 3H), 0.55–0.62 (m, 6H), 0.91 (t, $J = 7.9$ Hz, 9H), 0.93 (s, 9H), 1.10 (s, 3H), 1.22 (s, 3H), 1.68 (s, 3H), 1.97 (ddd, $J = 2.4, 10.5, 14.7$ Hz, 1H), 2.11 (d, $J = 1.1$ Hz, 3H), 2.17 (s, 3H), 2.23 (dd, $J = 9.5, 15.5$ Hz, 1H), 2.41 (dd, $J = 4.2, 15.5$ Hz, 1H), 2.45 (ddd, $J = 7.0, 9.4, 14.7$ Hz, 1H), 2.87 (s, 1H), 2.94 (d, $J = 4.8$ Hz, 1H), 3.90 (d, $J = 4.8$ Hz, 1H), 4.20 (dd, $J = 7.0, 10.5$ Hz, 1H), 4.43 (d, $J = 8.2$ Hz, 1H), 4.63 (d, $J = 8.2$ Hz, 1H), 4.65–4.70 (m, 1H), 4.82 (dd, $J = 2.4, 9.4$ Hz, 1H), 5.76 (s, 1H), 6.44 (s, 1H), 7.32–7.38 (m, 3H), 7.42–7.45 (m, 2H). ^{13}C NMR (125 MHz) δ $-5.0, -4.3, 5.2, 6.7, 10.1, 17.3, 18.2, 19.0, 20.9, 26.0, 27.9, 38.1, 40.5, 41.2, 49.3, 60.3, 69.5, 72.3, 74.4, 77.1, 79.8, 80.5, 84.6, 87.0, 102.5, 126.4, 128.4, 129.1, 133.3, 138.4, 144.7, 169.4, 203.5$. HRFAB (NBA/NaI) Calcd for $\text{C}_{41}\text{H}_{64}\text{O}_9\text{Si}_2\text{Na}$ (MNa^+): 779.3987. Found: 779.3991.

Conversion of **49** to **50**.

$\text{Pd}(\text{OH})_2$ (15 mg, 0.11 mmol) was added to a dried flask containing **49** (14.5 mg, 0.019 mmol) under a nitrogen atmosphere. EtOH (2 mL) was added and then the flask was gassed by passing hydrogen through a needle. The mixture was stirred at room temperature for 1 h and inorganic materials were filtered off through a short pad of silica gel. The filtrate was concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 50% AcOEt/hexane) to afford the triol (12 mg, 97%).

triol: $[\alpha]_D^{29}$: -79° ($c = 0.27$, CH_2Cl_2). IR (CH_2Cl_2) 3480, 2955, 1735, 1720, 1470, 1370, 1265, 1240, 980 cm^{-1} . ^1H NMR (300 MHz) δ 0.17 (s, 6H), 0.56 (q, $J = 8.0$ Hz, 6H), 0.89 (t, $J = 8.0$ Hz, 9H), 0.96 (s, 9H), 1.04 (s, 3H), 1.09 (s, 3H), 1.55 (s, 3H), 1.92–2.12 (m, 2H), 2.06 (s, 3H), 2.16 (s, 3H), 2.36 (dd, $J = 10.1, 15.7$ Hz, 1H), 2.45 (ddd, $J = 6.5, 9.9, 14.6$ Hz, 1H), 3.12 (brs, 1H, C4-OH), 3.13 (d, $J = 5.8$ Hz, 1H), 3.36 (d, $J = 9.9$ Hz, 1H, C2-OH), 3.64 (s, 1H, C1-OH), 3.78 (dd, $J = 5.8, 9.9$ Hz, 1H, C2), 4.04 (dd, $J = 6.5, 11.3$ Hz, 1H), 4.42 (d, $J = 8.5$ Hz, 1H), 4.60–4.75 (m, 3H), 6.37 (s, 1H). ^{13}C NMR (75 MHz) δ $-4.9, -4.3, 5.2, 6.7, 9.7, 17.2, 18.2, 18.7, 20.9, 26.0, 28.9, 37.5, 38.8, 41.5, 51.5, 58.8, 69.8, 72.8, 73.7, 75.9, 76.1, 76.3, 80.1, 86.0, 135.2, 141.9, 169.4, 202.4$. Anal. Calcd for $\text{C}_{34}\text{H}_{60}\text{O}_9\text{Si}_2$: C, 61.04; H, 9.04. Found: C, 61.19; H, 9.19.

To a cooled (-78°C) solution of the triol (52.6 mg, 0.079 mmol) and pyridine (0.4 mL) in CH_2Cl_2 (3 mL) was added a solution of triphosgene (47.0 mg, 0.16 mmol) in CH_2Cl_2 (0.7 mL). After being stirred for 30 min at that temperature, the mixture was warmed to 0°C and then stirred for 30 min. The mixture was diluted with AcOEt and poured into saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over anhydrous MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer

chromatography (silica gel, 20% AcOEt/hexane) to afford the carbonate (51.4 mg, 94%).

carbonate: $[\alpha]_D^{25}$: -77° ($c = 0.24$, CH_2Cl_2). IR (CH_2Cl_2) 2960, 1800, 1740, 1715, 1600, 1465, 1370, 1235, 1120, 1010 cm^{-1} . ^1H NMR (300 MHz) δ 0.14 (s, 3H), 0.16 (s, 3H), 0.56 (q, $J = 7.6$ Hz, 6H), 0.89 (t, $J = 7.6$ Hz, 9H), 0.94 (s, 9H), 1.16 (s, 3H), 1.19 (s, 3H), 1.64 (s, 3H), 1.88–2.03 (m, 1H), 2.12 (brs, 3H), 2.17 (s, 3H), 2.40–2.56 (m, 2H), 2.65 (brs, 1H, OH), 2.77 (dd, $J = 3.9, 15.6$ Hz, 1H), 2.97 (d, $J = 5.0$ Hz, 1H), 4.14 (dd, $J = 7.0, 10.4$ Hz, 1H), 4.37 (d, $J = 5.0$ Hz, 1H), 4.48 (d, $J = 8.7$ Hz, 1H), 4.58 (d, $J = 8.7$ Hz, 1H), 4.72–4.80 (m, 1H), 4.80 (dd, $J = 2.0, 9.2$ Hz, 1H), 6.42 (s, 1H). ^{13}C NMR (100 MHz) δ $-5.0, -4.3, 5.1, 6.7, 9.9, 17.6, 18.1, 19.2, 20.8, 25.9, 27.3, 35.9, 37.9, 40.7, 48.5, 60.4, 68.8, 71.9, 73.9, 76.7, 79.2, 80.8, 87.5, 90.1, 132.0, 146.5, 153.2, 169.2, 202.4$. Anal. Calcd for $\text{C}_{35}\text{H}_{58}\text{O}_{10}\text{Si}_2$: C, 60.48; H, 8.41. Found: C, 60.71; H, 8.60.

To a solution of the carbonate (27.0 mg, 0.039 mmol) in CH_2Cl_2 (1.5 mL) were added DMAP (100 mg, 0.82 mmol) and acetic anhydride (0.040 mL, 0.42 mmol) at room temperature. After 2 h, DMAP (100 mg, 0.82 mmol) and acetic anhydride (0.040 mL, 0.42 mmol) was again added to the reaction mixture. The mixture was stirred for 4 h and the reaction was quenched with methanol (0.080 mL). The mixture was filtered through a short pad of silica gel (hexane) to remove DMAP. The filtrate was concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 30% AcOEt/hexane) to afford the acetoxoxetane **50** (19.0 mg, 66%).

50: $[\alpha]_D^{27}$: -62° ($c = 0.46$, CH_2Cl_2). IR (CH_2Cl_2) 2955, 1805, 1740, 1720, 1470, 1370, 1240, 1010 cm^{-1} . ^1H NMR (300 MHz) δ 0.13 (s, 3H), 0.15 (s, 3H), 0.57 (q, $J = 8.2$ Hz, 6H), 0.90 (t, $J = 8.2$ Hz, 9H), 0.93 (s, 9H), 1.20 (s, 3H), 1.27 (s, 3H), 1.71 (s, 3H), 1.88 (dd, $J = 10.4, 14.5$ Hz, 1H), 2.08–2.20 (m, 1H), 2.10 (brs, 3H), 2.16 (s, 6H), 2.43 (dd, $J = 8.7, 15.3$ Hz, 1H), 2.55 (ddd, $J = 7.2, 8.7, 14.5$ Hz, 1H), 3.41 (d, $J = 6.0$ Hz, 1H), 4.42 (dd, $J = 7.2, 10.4$ Hz, 1H), 4.46 (d, $J = 8.6$ Hz, 1H), 4.50 (d, $J = 6.0$ Hz, 1H), 4.61 (d, $J = 8.6$ Hz, 1H), 4.94 (brd, $J = 8.7$ Hz, 1H), 5.00–5.10 (m, 1H), 6.42 (s, 1H). ^{13}C NMR (75 MHz) δ $-4.6, -4.6, 5.1, 6.7, 10.1, 15.4, 19.0, 20.8, 21.1, 22.5, 25.4, 26.2, 36.9, 37.7, 41.2, 43.6, 59.8, 68.2, 71.3, 76.2, 76.3, 79.5, 81.7, 84.1, 90.6, 129.4, 148.4, 153.1, 169.0, 170.1, 202.4$. HRFAB (NBA/NaI) Calcd for $\text{C}_{37}\text{H}_{60}\text{O}_{11}\text{Si}_2\text{Na}$ (MNa^+): 759.3572. Found: 759.3549.

Conversion of **50** to **51**.

To a THF (1.0 mL) solution of **50** (11 mg, 0.015 mmol) was added a THF solution of phenyl lithium (0.5 M, 0.044 mL, 0.022 mmol) at -78°C , and the mixture was stirred for 20 min. The reaction was quenched with a THF solution of AcOH (1 M, 0.05 mL, 0.05 mmol) and the mixture was poured into a saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over anhydrous MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 20% AcOEt/hexane) to afford the benzoate (10 mg, 83%).

benzoate: $[\alpha]_D^{27}$: -63° ($c = 0.41$, CH_2Cl_2). IR (CH_2Cl_2) 2955, 1740, 1720, 1370, 1265, 1240, 1110 cm^{-1} . ^1H NMR (300 MHz) δ 0.13 (s, 3H), 0.16 (s, 3H), 0.52–0.62 (m, 6H), 0.82 (t, $J = 8.4$ Hz, 9H), 0.95 (s, 9H), 1.12 (s, 3H), 1.19 (s, 3H), 1.66 (s, 3H), 1.86 (ddd, $J = 2.0, 11.0, 14.4$ Hz, 1H), 2.10 (brs, 3H), 2.05–2.25 (m, 2H), 2.18 (s, 3H), 2.29 (s, 3H), 2.51 (ddd, $J = 6.6, 9.8, 14.4$ Hz, 1H), 3.80 (d, $J = 7.2$ Hz, 1H), 4.13 (d, $J = 8.0$ Hz, 1H), 4.30 (d, $J = 8.0$ Hz, 1H), 4.47 (dd, $J = 6.6, 11.0$ Hz, 1H), 4.91–5.02 (m, 2H), 5.63 (d, $J = 7.2$ Hz, 1H), 6.46 (s, 1H), 7.44–7.51 (m, 2H), 7.56–7.63 (m, 1H), 8.06–8.12 (m, 2H). ^{13}C NMR (75 MHz) δ $-4.6, -4.5, 5.2, 6.7, 10.1, 14.9, 18.9, 21.0, 21.5, 22.5, 26.2, 26.5, 37.1, 39.7, 43.1, 46.8, 58.2, 69.2, 72.1, 75.3, 75.6, 76.4, 79.7, 80.7, 84.2, 128.6, 129.4, 130.1, 131.5, 133.6, 145.3, 167.1, 169.3, 169.9, 202.3$. Anal. Calcd for $\text{C}_{43}\text{H}_{66}\text{O}_{11}\text{Si}_2$: C, 63.36; H, 8.16. Found: C, 63.45; H, 8.34.

To a solution of the benzoate (12.2 mg, 0.015 mmol) in THF (1.0 mL) was added $\text{HF}\cdot\text{pyridine}$ (0.2 mL) at room temperature. After being stirred for 2 h, the reaction mixture was poured into a mixture of AcOEt and saturated aqueous NaHCO_3 (10 mL). The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with saturated aqueous CuSO_4 , then with brine and dried over anhydrous MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 50% AcOEt/hexane) to afford the C13-protected baccatin III (9.2 mg, 88%).

C13-protected baccatin III: $[\alpha]_D^{27}$: -79° ($c = 0.59$, CH_2Cl_2). IR (CH_2Cl_2) 2955, 1725, 1715, 1470, 1375, 1240, 1090 cm^{-1} . ^1H NMR (300 MHz) δ 0.14 (s, 3H), 0.16 (s, 3H), 0.95 (s, 9H), 1.11 (s, 3H), 1.19 (s, 3H), 1.66 (s, 3H), 1.86 (ddd, $J = 2.2, 11.1, 14.0$ Hz, 1H), 1.99 (s, 3H), 2.17–2.28 (m, 2H), 2.24 (s, 3H), 2.29 (s, 3H), 2.48–2.62 (m, 2H, including OH x 1), 3.78 (d, $J = 7.2$ Hz, 1H), 4.15 (d, $J = 8.3$ Hz, 1H), 4.31 (d, $J = 8.3$ Hz, 1H), 4.40–4.51 (m, 1H), 4.93–5.08 (m, 2H), 5.63 (d, $J = 7.2$ Hz, 1H), 6.30 (s, 1H), 7.45–7.53 (m, 2H), 7.57–7.66 (m, 1H), 8.05–8.13 (m, 2H). ^{13}C NMR (67.5 MHz) δ $-4.7, -4.5, 9.6, 15.5, 18.8, 20.9, 22.3, 22.5, 26.1, 26.9, 35.4, 40.0, 43.0, 45.7, 58.3, 69.3, 72.2, 75.4, 76.2, 76.3, 80.0, 80.7, 84.4, 128.6, 129.3, 130.1, 130.7, 133.7, 147.9, 167.1, 170.0, 171.4, 204.3$. Anal. Calcd for $\text{C}_{37}\text{H}_{52}\text{O}_{11}\text{Si}$: C, 63.41; H, 7.48. Found: C, 63.24; H, 7.44.

To a solution of the C13-protected baccatin III (16.8 mg, 0.024 mmol) in a mixture of CH_2Cl_2 (0.5 mL) pyridine (0.5 mL) was added TrocCl (0.0020 mL, 0.15 mmol) at room temperature. After 2 h, TrocCl (0.0020 mL, 0.15 mmol) was again added to the reaction mixture. The resultant solution was stirred for 1 h and poured into saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined extracts were washed with saturated aqueous CuSO_4 , then with brine and dried over anhydrous MgSO_4 . The mixture was filtered and the filtrate was concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 30% AcOEt/hexane) to afford **51** (19.8 mg, 94%).

51: $[\alpha]_D^{26}$: -64° ($c = 0.66$, CH_2Cl_2). IR (CH_2Cl_2) 2960, 1760, 1740, 1720, 1370, 1270 cm^{-1} .

1. ^1H NMR (500 MHz) δ 0.15 (s, 3H), 0.17 (s, 3H), 0.96 (s, 9H), 1.14 (s, 3H), 1.17 (s, 3H), 1.81 (s, 3H), 2.03 (ddd, J = 2.0, 10.9, 14.3 Hz, 1H), 2.08 (d, J = 1.1 Hz, 3H), 2.16 (s, 3H), 2.19 (dd, J = 8.7, 15.3 Hz, 1H), 2.25 (dd, J = 8.7, 15.3 Hz, 1H), 2.31 (s, 3H), 2.62 (ddd, J = 7.1, 9.5, 14.3 Hz, 1H), 3.95 (d, J = 7.0 Hz, 1H), 4.15 (d, J = 8.3 Hz, 1H), 4.32 (d, J = 8.3 Hz, 1H), 4.64 (d, J = 12.0 Hz, 1H), 4.95–5.04 (m, 2H), 5.03 (d, J = 12.0 Hz, 1H), 5.61 (dd, J = 7.1, 10.9 Hz, 1H), 5.65 (d, J = 7.0 Hz, 1H), 6.38 (s, 1H), 7.47–7.51 (m, 2H), 7.59–7.64 (m, 1H), 8.07–8.10 (m, 2H). ^{13}C NMR (125 MHz) δ -4.6, -4.5, 10.8, 15.1, 18.9, 20.8, 21.5, 22.4, 26.2, 26.5, 33.2, 39.8, 43.1, 47.0, 55.9, 69.2, 74.8, 75.9, 76.3, 76.5, 77.2, 79.6, 80.5, 83.8, 94.6, 128.7, 129.3, 130.1, 130.6, 133.7, 146.4, 153.2, 167.0, 169.1, 169.9, 202.0. HRFAB (NBA/NaI) Calcd for $\text{C}_{40}\text{H}_{53}\text{Cl}_3\text{O}_{13}\text{SiNa}$ (MNa^+): 897.2219. Found: 897.2220.

Conversion of **51** to Taxol.

THF (1 mL) was added to a dried flask containing TASF (20 mg, 0.073 mmol) at room temperature. To this was added a solution of **51** in THF (1 mL), and the mixture was stirred for 2 days at room temperature. The reaction was quenched with aqueous saturated NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over anhydrous MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by column chromatography (silica gel, 50% AcOEt/hexane) to afford the C7-protected baccatin III (11 mg, 80%).

C7-protected baccatin III: $[\alpha]_{\text{D}}^{25}$: -75° (c = 1.79, CH_2Cl_2). IR (neat) 3520, 2950, 1745, 1720, 1375, 1250 cm^{-1} . ^1H NMR (300 MHz) δ 1.09 (s, 3H), 1.13 (s, 3H), 1.82 (s, 3H), 1.98–2.11 (m, 2H), 2.13 (s, 3H), 2.17 (s, 3H), 2.26–2.32 (m, 1H), 2.30 (s, 3H), 2.64 (ddd, J = 7.1, 9.5, 14.4 Hz, 1H), 4.02 (d, J = 7.0 Hz, 1H), 4.15 (d, J = 8.5 Hz, 1H), 4.33 (d, J = 8.5 Hz, 1H), 4.64 (d, J = 11.9 Hz, 1H), 4.83–4.93 (m, 1H), 4.99 (brd, J = 8.3 Hz, 1H), 5.04 (d, J = 11.9 Hz, 1H), 5.56–5.66 (m, 1H), 5.63 (d, J = 7.0 Hz, 1H), 6.38 (s, 1H), 7.45–7.53 (m, 2H), 7.58–7.66 (m, 1H), 8.07–8.13 (m, 2H). ^{13}C NMR (75 MHz) δ 10.6, 15.2, 20.1, 20.8, 22.5, 26.6, 33.2, 38.4, 42.7, 47.3, 56.1, 67.8, 74.2, 75.9, 76.3, 76.7, 77.2, 78.6, 80.4, 83.8, 94.5, 128.6, 129.2, 130.0, 131.6, 133.7, 145.0, 153.2, 166.9, 169.2, 170.7, 201.9. Anal. Calcd for $\text{C}_{34}\text{H}_{39}\text{Cl}_3\text{O}_{13}$: C, 53.59; H, 5.16. Found: C, 53.65; H, 5.46.

To a THF solution (1.1 mL) of 7-Troc-baccatin III (15.4 mg, 0.02 mmol) and the β -lactam (41.7 mg, 0.11 mmol, prepared according to the literature procedures³¹) was added LHMDs (0.1 mL, 1.0 M solution in THF) at -78°C . The mixture was gradually warmed to 0°C and the mixture was stirred for 0.5 h at that temperature. The reaction was quenched with saturated aqueous NaHCO_3 . The layers were separated and the aqueous layer was extracted with AcOEt. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 50% AcOEt/hexane) to give the C7,2'-protected taxol **52** (17.7 mg, 77%) and the starting material (1.5 mg, 10%).

52: $[\alpha]_D^{25}$: -58° ($c = 0.83$, CH_2Cl_2). IR (neat) 3440, 2955, 1755, 1730, 1670, 1480, 1370, 1245 cm^{-1} . ^1H NMR (300 MHz) δ 0.34–0.54 (m, 6H), 0.81 (t, $J = 8.0$ Hz, 9H), 1.17 (s, 3H), 1.23 (s, 3H), 1.84 (s, 3H), 1.98–2.24 (m, 2H), 1.99 (s, 3H), 2.16 (s, 3H), 2.42 (dd, $J = 9.4, 15.2$ Hz, 1H), 2.56 (s, 3H), 2.57–2.69 (m, 1H), 3.98 (d, $J = 6.8$ Hz, 1H), 4.21 (d, $J = 8.4$ Hz, 1H), 4.36 (d, $J = 8.4$ Hz, 1H), 4.65 (d, $J = 11.9$ Hz, 1H), 4.69 (d, $J = 2.0$ Hz, 1H), 4.99 (brd, $J = 8.0$ Hz, 1H), 5.05 (d, $J = 11.9$ Hz, 1H), 5.60 (dd, $J = 7.1, 10.7$ Hz, 1H), 5.66–5.72 (m, 1H), 5.71 (d, $J = 6.8$ Hz, 1H), 6.20–6.31 (m, 1H), 6.37 (s, 1H), 7.12 (d, $J = 8.8$ Hz, 1H), 7.30–7.66 (m, 11H), 7.73–7.80 (m, 2H), 8.10–8.17 (m, 2H). ^{13}C NMR (75 MHz) δ 4.3, 6.5, 10.8, 14.4, 20.7, 21.5, 22.9, 26.4, 33.2, 35.6, 43.3, 46.8, 55.7, 56.0, 71.3, 74.4, 74.7, 75.3, 76.4, 76.4, 77.3, 78.7, 80.8, 83.8, 94.5, 126.4, 127.0, 128.0, 128.7, 128.7, 128.8, 129.0, 130.2, 131.8, 132.7, 133.7, 134.1, 138.4, 141.2, 153.3, 166.9, 167.0, 169.1, 170.0, 171.6, 201.4. Anal. Calcd for $\text{C}_{56}\text{H}_{66}\text{Cl}_3\text{NO}_{16}\text{Si}$: C, 58.82; H, 5.82. Found: C, 58.52; H, 6.01.

To a AcOH solution (0.5 mL) of **52** (11.8 mg, 0.01 mmol) was added zinc powder (ca. 20 mg) at room temperature. After 0.5 h, water (0.1 mL) was added and the mixture was stirred for 16 h. Inorganic materials were filtered off through a short pad of Celite and the filtrate was concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 70% AcOEt/hexane) to afford (–)-taxol (7.4 mg, 84%).

(–)-**Taxol:** $[\alpha]_D^{34}$: -48° ($c = 0.45$, MeOH). IR (neat) 3440, 2940, 1725, 1655, 1520, 1485, 1370, 1240 cm^{-1} . ^1H NMR (500 MHz) δ 1.15 (s, 3H), 1.25 (s, 3H), 1.69 (s, 3H), 1.80 (s, 3H), 1.89 (ddd, $J = 2.5, 11.0, 14.5$ Hz, 1H), 2.24 (s, 3H), 2.30 (dd, $J = 9.0, 15.5$ Hz, 1H), 2.37 (dd, $J = 9.0, 15.5$ Hz, 1H), 2.39 (s, 3H), 2.44 (d, $J = 4.2$ Hz, 1H, OH), 2.56 (ddd, $J = 6.5, 9.5, 14.5$ Hz, 1H), 3.51 (d, $J = 5.2$ Hz, 1H, OH), 3.81 (d, $J = 7.0$ Hz, 1H), 4.21 (d, $J = 8.5$ Hz, 1H), 4.31 (d, $J = 8.5$ Hz, 1H), 4.40 (ddd, $J = 4.2, 6.5, 11.0$ Hz, 1H), 4.80 (dd, $J = 2.5, 5.2$ Hz, 1H), 4.95 (dd, $J = 2.5, 9.5$ Hz, 1H), 5.68 (d, $J = 7.0$ Hz, 1H), 5.80 (dd, $J = 2.5, 9.0$ Hz, 1H), 6.24 (brt, $J = 9.0$ Hz, 1H), 6.28 (s, 1H), 6.96 (d, $J = 9.0$ Hz, 1H), 7.34–7.54 (m, 10H), 7.61 (brt, $J = 7.5$ Hz, 1H), 7.74 (brd, $J = 8.3$ Hz, 2H), 8.13 (brd, $J = 7.3$ Hz, 2H). ^{13}C NMR (100 MHz) δ 9.5, 14.8, 20.8, 21.8, 22.6, 26.8, 35.6, 35.7, 43.1, 45.6, 55.0, 58.6, 72.2, 72.3, 73.2, 74.9, 75.5, 76.5, 79.0, 81.1, 84.4, 127.0, 127.0, 128.4, 128.7, 128.7, 129.0, 129.1, 130.2, 132.0, 133.2, 133.6, 133.7, 138.0, 142.0, 167.0, 167.0, 170.4, 171.2, 172.7, 203.6.

Conversion of **28** to **20b**.

To a THF solution (0.3 mL) of **28** (17.7 mg, 0.037 mmol) were added butyllithium (1.51M in hexane, 50 μL , 0.075 mmol) and di-*t*-butylchlorosilane (15 μL , 0.075 mmol) at -78°C , and the mixture was warmed to room temperature. After 2 h, the reaction was quenched with phosphate buffer solution (pH = 6.86). The layers were separated and the aqueous layer was extracted with ether. The combined organic extracts were washed with brine and dried over MgSO_4 . The mixture

was filtered and concentrated under reduced pressure. The resultant residue was purified by thin-layer chromatography (silica gel, 30% AcOEt/hexane) to give the di-*t*-butylsilylene (15.3 mg, 67%).

IR (neat) 2940, 2890, 2860, 1685, 1640, 1475, 1390, 1360, 1260, 1210, 1080, 1040, 1010 cm^{-1} . ^1H NMR (400 MHz): δ 0.06 (s, 6H), 0.90 (s, 9H), 1.04 (s, 9H), 1.11 (s, 3H), 1.13 (s, 9H), 1.19 (s, 3H), 1.70 (s, 3H), 2.10–2.32 (m, 6H), 3.20 (d, J = 16.6 Hz, 1H), 3.48 (d, J = 16.6 Hz, 1H), 4.29 (s, 1H), 4.61–4.68 (m, 1H), 5.90–5.96 (m, 1H), 5.96–6.01 (m, 1H). ^{13}C NMR (100 MHz): δ –5.3, –4.5, 16.4, 18.0, 20.8, 20.9, 21.8, 21.9, 22.9, 24.4, 25.7, 28.0, 28.5, 41.9, 42.6, 46.0, 68.6, 77.3, 85.6, 120.9, 128.3, 130.0, 135.6, 140.0, 143.1, 207.2. Anal. Calcd for $\text{C}_{32}\text{H}_{54}\text{O}_4\text{Si}_2$: C, 68.76; H, 9.74; Found: C, 68.72; H, 9.76.

To a MeOH solution (0.7 mL) of the di-*t*-butylsilylene (19.6 mg, 0.035 mmol) were added $\text{CeCl}_3 \cdot 7\text{H}_2\text{O}$ (30.0 mg, 0.081 mmol) and NaBH_4 (5.7 mg, 0.15 mmol) at 0 °C, and the mixture was stirred for 0.2 h. The reaction was quenched with phosphate buffer solution (pH = 6.86). The layers were separated, and the aqueous layer was extracted with ether. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 30% AcOEt/hexane) to give the diene alcohol (15.5 mg, 79%).

IR (neat) 3370, 2940, 2860, 1480, 1390, 1360, 1260, 1080, 1040, 1010, 980 cm^{-1} . ^1H NMR (400 MHz): δ 0.03 (s, 3H), 0.04 (s, 3H), 0.88 (s, 9H), 1.08 (s, 3H), 1.09 (s, 9H), 1.13 (s, 9H), 1.33 (s, 3H), 1.57 (s, J = 1.0 Hz, 3H), 2.10–2.35 (m, 6H), 2.42 (dd, J = 10.1, 12.1 Hz, 1H), 2.60 (dd, J = 6.6, 11.0 Hz, 1H), 4.52–4.62 (m, 3H), 5.89–5.98 (m, 2H). ^{13}C NMR (100 MHz): δ –5.2, –4.5, 16.9, 18.0, 20.8, 21.8, 21.8, 22.0, 22.5, 25.1, 25.7, 28.0, 28.5, 37.7, 42.3, 42.6, 69.0, 70.8, 76.2, 85.7, 119.2, 121.7, 131.2, 136.0, 138.8, 138.9. Anal. Calcd for $\text{C}_{32}\text{H}_{56}\text{O}_4\text{Si}_2$: C, 68.52; H, 10.06; Found: C, 68.29; H, 10.26.

The triol **20b** was prepared by singlet oxygen oxygenation (O_2 , Rose bengal, $h\nu$) in the same manner as the preparation of **20a** in Scheme 9.

Model study for the introduction of C19-methyl via conjugate addition reaction

To a THF solution of $\text{CuBr} \cdot \text{SMe}_2$ (90.1 mg, 0.44 mmol) was added methyllithium (1.10M in ether, 0.80 mL, 0.88 mmol) at –23 °C. The mixture was stirred for 0.5 h at that temperature and then cooled to –45 °C. To this were added HMPA (76 μL , 0.44 mmol), TMSCl (56 μL , 0.44 mmol), and a THF solution (0.3 mL) of the enone **34** (13.4 mg, 0.031 mmol). After 0.5 h, the reaction was quenched with saturated aqueous NH_4Cl . The layers were separated, and the aqueous layer was extracted with hexane. The combined extracts were washed with brine and dried over MgSO_4 . The mixture was filtered and concentrated under reduced pressure. The residue was purified by thin-layer chromatography (silica gel, 10% AcOEt/hexane) to give the 1,4-adduct **35** (13.1 mg, 81%).

34: IR (neat) 3025, 2860, 1670, 1450, 1370, 1230, 1090, 1070, 1030 cm^{-1} . ^1H NMR (270

MHz): δ 0.93 (s, 3H), 1.51 (s, 3H), 1.52 (s, 3H), 1.55 (s, 3H), 1.72 (s, 3H), 1.70 - 1.98 (m, 4H), 2.07 (d, 1H, $J = 13.5$ Hz), 2.16 - 2.35 (m, 3H), 2.38 - 2.60 (m, 2H), 3.10 (dd, 1H, $J = 5.4, 13.5$ Hz), 3.98 (br d, 1H, $J = 10.8$ Hz), 4.27 (d, 1H, $J = 13.5$ Hz), 4.58 (d, 1H, $J = 13.5$ Hz), 4.71 (d, 1H, $J = 10.8$ Hz), 5.02 (d, 1H, $J = 10.8$ Hz), 7.22 - 7.38 (m, 5H). ^{13}C NMR (67.5 MHz): δ 18.0, 21.7, 24.6, 26.4, 26.8, 27.4, 30.1, 32.1, 37.9, 39.1, 40.9, 71.3, 73.5, 80.3, 83.0, 110.2, 127.3, 128.0, 128.1, 131.7, 134.7, 138.9, 141.1, 154.1, 198.4. Anal. Calcd for $\text{C}_{28}\text{H}_{36}\text{O}_4$: C, 77.03; H, 8.31; Found: C, 76.86; H, 8.52.

35: IR (neat) 2925, 2865, 1645, 1455, 1365, 1230, 1040 cm^{-1} . ^1H NMR (400 MHz): δ 0.09 (s, 9H), 0.95 (s, 3H), 1.09 (s, 3H), 1.42 (s, 3H), 1.47 (s, 3H), 1.52 (s, 3H), 1.50 - 1.60 (m, 1H), 1.65 - 1.83 (m, 4H), 1.86 - 1.93 (m, 1H), 1.90 (d, 3H, $J = 1.2$ Hz), 2.21 - 2.42 (m, 2H), 2.52 - 2.63 (m, 2H), 4.12 (br d, 1H, $J = 10.0$ Hz), 4.32 (d, 1H, $J = 9.5$ Hz), 4.37 (d, 1H, $J = 11.7$ Hz), 4.70 (d, 1H, $J = 11.7$ Hz), 4.86 (d, 1H, $J = 9.5$ Hz), 7.21 - 7.43 (m, 5H). ^{13}C NMR (100 MHz): δ 0.9, 17.3, 18.5, 25.5, 27.0, 27.1, 27.3, 27.4, 27.5, 29.8, 30.1, 31.2, 38.1, 39.0, 45.1, 70.7, 74.8, 75.6, 83.2, 106.6, 119.0, 126.9, 127.2, 128.0, 131.6, 139.9, 140.8, 144.6. Anal. Calcd for $\text{C}_{32}\text{H}_{48}\text{O}_4\text{Si}$: C, 73.24; H, 9.22; Found: C, 72.94; H, 9.32.