Strained Silacycles in Organic Synthesis: The Tandem Aldol Allylation Reaction

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Supporting Information

General Information. All reactions were carried out under an atmosphere of nitrogen in flame- or oven-dried glassware with magnetic stirring unless otherwise indicated. Degassed solvents were purified by passage through an activated alumina column. ^1H NMR spectra were recorded on a Bruker DPX-300 (300 MHz) spectrometer and are reported in ppm from CDCl_3 internal standard (7.26 ppm). Data are reported as follows: (s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, m = multiplet, dd = doublet of doublets; coupling constant(s) in Hz; integration; assignment). Proton decoupled ^{13}C NMR spectra were recorded on a Bruker DPX-300 (75 MHz) and are reported in ppm from CDCl_3 internal standard (77.0 ppm). Infrared spectra were recorded on a Perkin Elmer Paragon 1000 FT-IR spectrometer.

Procedure for the Synthesis of Allylenolsilane 2: To a cooled (0 °C) solution of allyltrichlorosilane (4.9 mL; 34 mmol) in CH_2Cl_2 (50 mL) was added 1,8-Diazabicyclo[5.4.0]undec-7-ene (13 mL; 84 mmol). A solution of pinacol (4.0 g; 34 mmol) in CH_2Cl_2 (50 mL) was then added *SLOWLY* and the resultant solution was warmed to room temperature and stirred for 12 hours. The solution was concentrated and the residue was treated with diethylether (100 mL). The mixture was stirred for 1 hour during which time the formation of a precipitate was observed. The mixture was then filtered and the filtrate was concentrated. The residue was distilled *in vacuo* to give 5.2 g (72%) of allylchlorosilane **1** as a clear, colorless liquid.

To a cooled (0 °C) solution of MeLi (16.2 mL; 23 mmol; 1.4 M in Et_2O) was added trimethylvinylloxysilane (2.7 g; 23 mmol). The solution was warmed to room temperature and was stirred for 1 hour. The solution was cooled to -78 °C, and allylchlorosilane **1** (5.5 g; 25 mmol) was added. The solution was warmed to room temperature and stirred for 2 hours. The solution was diluted with pentane (20 mL), and the mixture was then filtered through a pad of celite. The filtrate was concentrated, and the residue was distilled *in vacuo* to give 3.8 g (70%) of allylenolsilane **2** as a clear, colorless liquid.

This same procedure may be used to prepare allyl(crotyl)enolsilanes **5**, **6**, **9**, **10**, **13**, **14** and **17**. In all cases the yields are in the 55-75% range.

General Procedure for the Tandem Aldol-Allylation Reaction: To a solution of the allyl(crotyl)enolsilane (0.63 mmol) in toluene (0.4 mL) is added cyclohexanecarboxaldehyde (48 mg; 0.42 mmol). The solution is heated to 40 °C and stirred at that temperature for the indicated time. The solution is cooled and 1 M HCl (5 mL) is added followed by ethyl acetate (5 mL). The mixture is stirred for 20 min and the layers are separated. The organic layer is washed with saturated aqueous NaHCO₃ (5 mL), washed with brine (5 mL), dried (Na₂SO₄), filtered, and concentrated. The residue is purified by chromatography on silica gel to give the diol product typically as a clear colorless oil.

This same procedure is used for all tandem aldol-allylation reactions described in the text, with the reaction time as indicated.

Data for 2: ¹H NMR (400 MHz, CDCl₃) δ 6.45 (dd, *J* = 13.6, 5.8 Hz, 1H, OCH=CH₂), 5.86-5.74 (m, 1H, CH₂CH=CH₂), 5.08-4.96 (m, 2H, CH₂CH=CH₂), 4.60 (d, *J* = 13.6 Hz, 1H, one of OCH=CH₂), 4.27 (d, *J* = 5.8 Hz, 1H, one of OCH=CH₂), 1.82 (dt, *J* = 7.8, 1.2 Hz, 2H, CH₂), 1.28 (s, 6H, two CH₃), 1.26 (s, 6H, two CH₃); ¹³C NMR (100 MHz, CDCl₃) δ 144.1, 130.8, 116.1, 96.9, 81.8, 25.6, 25.5, 18.5; ²⁹Si NMR (59 MHz, CDCl₃, TMS) δ -32.5; IR (thin film) 3081, 2980, 2933, 1634, 1461, 1390, 1370, 1318, 1187, 1033 cm⁻¹.

Data for 3: Diol **3** is a known compound.¹ Comparison of spectral data confirmed its identity.

Data for 4: ¹H NMR (400 MHz, CDCl₃) δ 5.83-5.70 (m, 1H, CH=CH₂), 5.11-5.00 (m, 2H, CH=CH₂), 3.87-3.78 (m, 1H, CHOH), 3.65 (br s, 2H, two OH), 3.60-3.52 (m, 1H, CHOH), 2.24-2.15 (m, 2H, CH₂), 1.78-0.85 (m, 13H, CH₂, C₆H₁₁); ¹³C NMR (100 MHz, CDCl₃) δ 134.4, 117.8, 77.1, 72.2, 44.2, 42.5, 38.8, 28.7, 27.9, 26.4, 26.2, 26.0; IR (thin film) 3350, 3077, 2925, 2853, 1642, 1450, 1322, 1087, 1066 cm⁻¹; LRMS (FAB+) calcd for C₁₂H₂₂O₂ 198, found (M+H)⁺ 199.

Data for 5: ¹H NMR (300 MHz, CDCl₃) δ 6.45 (dd, *J* = 13.6, 5.8 Hz, 1H, H₂C=CHOSi), 5.55-5.38 (m, 2H, CH=CHCH₃), 4.58 (dd, *J* = 13.6, 1.1 Hz, 1H, one of H₂C=CHOSi), 4.24 (dd, *J* = 5.8, 1.1 Hz, 1H, one of H₂C=CHOSi), 1.69-1.63 (m, 2H, CH₂CH=CHCH₃), 1.64-1.62 (m, 3H, CH=CHCH₃), 1.27 (s, 6H, two CH₃),

(1) Hoffmann, R.; Brückner, R. *Chem. Ber.* **1992**, *125*, 1471-1484.

1.24 (s, 6H, two CH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 144.2, 126.6, 122.6, 96.8, 81.8, 25.6, 17.7, 15.5; ^{29}Si NMR (59 MHz, C_6D_6 , TMS) δ -32.6; IR (thin film) 2980, 1631, 1450, 1381, 1317, 1170, 1032 cm^{-1} .

Data for 6: ^1H NMR (300 MHz, CDCl_3) δ 6.45 (dd, $J = 13.6, 5.8$ Hz, 1H, $\text{H}_2\text{C}=\text{CHOSi}$), 5.55-5.38 (m, 2H, $\text{CH}=\text{CHCH}_3$), 4.58 (d, $J = 13.7$ Hz, 1H, one of $\text{CH}_2=\text{CHOSi}$), 4.25 (d, $J = 5.8$ Hz, 1H, one of $\text{CH}_2=\text{CHOSi}$), 1.78-1.76 (m, 2H, $\text{CH}_2\text{CH}=\text{CHCH}_3$), 1.62-1.60 (m, 3H, $\text{CH}=\text{CHCH}_3$), 1.27 (s, 6H, two CH_3), 1.25 (s, 6H, two CH_3); ^{13}C NMR (75 MHz, CDCl_3) δ 144.1, 124.6, 121.8, 96.7, 81.8, 25.6, 12.6, 12.3; ^{29}Si NMR (59 MHz, CDCl_3 , TMS) δ -32.2; IR (thin film) 2981, 1629, 1453, 1378, 1318, 1169, 1007 cm^{-1} .

Data for 7: ^1H NMR (300 MHz, CDCl_3) δ 5.83-5.71 (m, 1H, $\text{CH}=\text{CH}_2$), 5.09-5.03 (m, 2H, $\text{CH}=\text{CH}_2$), 3.71-3.55 (m, 2H, two CHOH), 3.32 (s, 2H, two OH), 2.28-2.21 (m, 1H, $\text{CH}(\text{CH}_3)\text{CH}=\text{CH}_2$), 1.75-1.08 (m, 13H, C_6H_{11} and CH_2), 1.02 (d, $J = 6.9$ Hz, 3H, CH_3); ^{13}C NMR (75 MHz, CDCl_3) δ 140.6, 115.3, 78.2, 77.5, 76.3, 44.3, 36.3, 28.8, 27.9, 26.5, 26.2, 26.1, 14.6; IR (thin film) 3372, 3068, 2920, 2852, 1636, 1450, 1322, 1263, 1053 cm^{-1} ; LRMS (FAB+) calcd for $\text{C}_{13}\text{H}_{24}\text{O}_2$ 212, found $(\text{M}+\text{H})^+$ 213.

Data for 8: ^1H NMR (300 MHz, CDCl_3) δ 5.82-5.71 (m, 1H, $\text{CH}=\text{CH}_2$), 5.14-5.07 (m, 2H, $\text{CH}=\text{CH}_2$), 3.69-3.60 (m, 2H, two CHOH), 3.07 (br s, one of OH), 2.91 (br s, one of OH), 2.26-2.20 (m, 1H, $\text{CH}(\text{CH}_3)\text{CH}=\text{CH}_2$), 1.80-1.07 (br m, 13H, C_6H_{11} and CH_2), 1.04 (d, $J = 6.9$ Hz, 3H, $\text{CH}(\text{CH}_3)\text{CH}=\text{CH}_2$); ^{13}C NMR (75 MHz, CDCl_3) δ 140.1, 116.3, 77.4, 76.3, 44.8, 44.3, 36.6, 28.9, 27.9, 26.5, 26.3, 26.2, 15.7; IR (thin film) 3372, 3068, 2920, 2852, 1636, 1450, 1322, 1263, 1053 cm^{-1} ; LRMS (FAB+) calcd for $\text{C}_{13}\text{H}_{24}\text{O}_2$ 212, found $(\text{M}+\text{H})^+$ 213.

Data for 9: ^1H NMR (400 MHz, C_6D_6) δ 6.37-6.50 (dq, 1H, $J = 1.8, 5.9$ Hz, $\text{CH}=\text{CHO}$), 5.82-5.92 (m, 1H, $\text{CH}_2=\text{CH}$), 5.01-5.07 (m, 1H, one of $\text{CH}_2=\text{CH}$), 4.94-4.97 (m, 1H, one of $\text{CH}_2=\text{CH}$), 4.57 (dq, 1H, $J = 6.0, 6.7$ Hz, $\text{CH}=\text{CHO}$), 1.76 (dt, 2H, $J = 1.2, 7.8$ Hz, CH_2Si), 1.66 (dd, 3H, $J = 1.8, 6.8$ Hz, CH_3CH), 1.16 (s, 6H, six of $(\text{CH}_3)_2\text{CC}(\text{CH}_3)_2$), 1.09 (s, 6H, six of $(\text{CH}_3)_2\text{CC}(\text{CH}_3)_2$); ^{13}C NMR (100 MHz, C_6D_6) δ 137.9, 131.6, 115.9, 107.1, 81.6, 25.8, 25.7, 19.2, 9.3; ^{29}Si NMR (59 MHz, CDCl_3) δ -32.7; IR (film) 3081, 3048, 2980, 2932, 1664, 1634, 1461, 1447, 1391, 1369, 1260, 1128, 1074, 1008, 974, 928, 881, 818, 614 cm^{-1} .

Data for 11: ^1H NMR (400 MHz, CDCl_3) δ 5.83-5.93 (m, 1H, $\text{CH}=\text{CH}_2$), 5.14-5.18 (m, 2H, $\text{CH}=\text{CH}_2$), 3.69 (dt, 1H, $J = 3.0, 8.1$ Hz, CHOHCH_2), 3.39 (dd, 1H, $J = 1.9, 8.8$ Hz, $\text{c-C}_6\text{H}_{11}\text{CHOH}$), 3.20-3.24 (br s, 1H, OH), 3.13-3.18 (br s, 1H, OH), 2.44-2.49 (m, 1H, one of $\text{CH}_2\text{CH}=\text{CH}_2$), 2.14-2.20 (m, 1H, one of $\text{CH}_2\text{CH}=\text{CH}_2$),

1.62-1.80 (m, 5H, CHCH_3 and four of $\text{c-C}_6\text{H}_{11}$), 1.48-1.54 (m, 2H, two of $\text{c-C}_6\text{H}_{11}$), 1.12-1.41 (m, 5H, five of C_6H_{11}), 0.81 (d, 3H, $J = 6.9$ Hz, CH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 134.8, 118.4, 80.8, 75.4, 40.4, 40.0, 39.4, 30.6, 26.7, 26.5, 26.3, 24.5, 13.1; IR (KBr) 3321, 3078, 2978, 2930, 2853, 1645, 1446, 1338, 1266, 1111, 1046, 982, 912, 861, 702 cm^{-1} ; LRMS (FAB+) calc'd for $\text{C}_{13}\text{H}_{24}\text{O}_2$ 212, found $(\text{M}+\text{H})^+$ 213.

Data for 13: ^1H NMR (400 MHz, CDCl_3) δ 6.29-6.25 (m, 1H, $\text{OCH}=\text{CH}$), 5.54-5.41 (m, 2H, $\text{CH}_2\text{CH}=\text{CH}$), 4.67-4.59 (m, 1H, $\text{OCH}=\text{CH}$), 1.78 (d, $J = 7.2$ Hz, 2H, $\text{CH}_2\text{CH}=\text{CH}$), 1.63 (d, $J = 5.3$ Hz, 3H, CHCH_3), 1.58 (dd, $J = 6.8, 1.7$ Hz, 3H, CHCH_3), 1.28 (s, 6H, two CH_3), 1.26 (s, 6H, two CH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 137.2, 124.4, 122.1, 107.0, 81.6, 25.6, 12.6, 12.5, 9.0; ^{29}Si NMR (59 MHz, CDCl_3 , TMS) δ -32.4; IR (thin film) 3022, 2980, 2935, 1664, 1391, 1369, 1260, 1142, 1128, 1073 cm^{-1} .

Data for 14: ^1H NMR (400 MHz, CDCl_3) δ 6.33-6.23 (m, 1H, $\text{OCH}=\text{CH}$), 5.53-5.35 (m, 2H, $\text{CH}_2\text{CH}=\text{CH}$), 4.69-4.56 (m, 1H, $\text{OCH}=\text{CH}$), 1.73 (d, $J = 6.0$ Hz, 2H, $\text{CH}_2\text{CH}=\text{CH}$), 1.65 (d, $J = 4.8$ Hz, 3H, CHCH_3), 1.58 (dd, $J = 6.8, 1.5$ Hz, 3H, CHCH_3), 1.29 (s, 6H, two CH_3), 1.26 (s, 6H, two CH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 137.2, 126.4, 122.9, 107.1, 81.6, 25.61, 25.58, 18.0, 16.8, 9.0; ^{29}Si NMR (59 MHz, CDCl_3 , TMS) δ -32.2; IR (thin film) 3020, 2980 2936, 1664, 1452, 1340, 1378, 1260, 1280, 1007 cm^{-1} .

Data for 15: ^1H NMR (400 MHz, CDCl_3) δ 5.98-5.85 (m, 1H, $\text{CH}=\text{CH}_2$), 5.16-5.04 (m, 2H, $\text{CH}=\text{CH}_2$), 3.80 (br s, 2H, two OH), 3.50-3.37 (m, 2H, two CH), 2.56-2.44 (m, 1H, CH), 1.84-1.07 (m, 12H, CH and C_6H_{11}), 1.12 (d, $J = 6.9$ Hz, 3H, CHCH_3), 0.80 (d, $J = 6.8$ Hz, 3H, CHCH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 138.8, 115.7, 81.3, 80.7, 40.6, 40.5, 38.1, 30.5, 26.7, 26.5, 26.2, 24.5, 17.7, 13.3; IR (KBr) 3316, 3072, 2979, 2928, 2850, 1640, 1446, 1350, 1264, 1185, 1128 cm^{-1} ; LRMS (FAB+) calcd for $\text{C}_{14}\text{H}_{26}\text{O}_2$ 226, found $(\text{M}+\text{H})^+$ 227.

Data for 16: ^1H NMR (400 MHz, CDCl_3) δ 5.99-5.88 (m, 1H, $\text{CH}=\text{CH}_2$), 5.17-5.07 (m, 2H, $\text{CH}=\text{CH}_2$), 3.70 (br s, 1H, OH), 3.58 (dd, $J = 8.8, 2.7$ Hz, 1H, CH), 3.41 (dd, $J = 8.6, 1.9$ Hz, 1H, CH), 3.32 (br s, 1H, OH), 2.55-2.45 (m, 1H, CH), 1.85-1.08 (m, 12H, CH and C_6H_{11}), 1.01 (d, $J = 6.9$ Hz, 3H, CHCH_3), 0.81 (d, $J = 6.9$ Hz, 3H, CHCH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 142.1, 114.9, 81.1, 79.5, 40.6, 39.6, 37.4, 30.6, 26.8, 26.5, 26.3, 24.6, 13.4, 10.5; IR (KBr) 3271, 2980, 2928, 2853, 1643, 1448, 1265, 1149, 1118 cm^{-1} ; LRMS (APCI+) calcd for $\text{C}_{14}\text{H}_{26}\text{O}_2$ 226, found $(\text{M}+\text{H})^+$ 227.

Data for 17: ^1H NMR (300 MHz, CDCl_3) δ 6.21-6.19 (m, 1H, $\text{OCH}=\text{CH}$), 5.54-5.29 (m, 2H, $\text{CH}_2\text{CH}=\text{CH}$), 5.20-5.07 (m, 1H, $\text{OCH}=\text{CH}$), 1.72 (d, $J = 6.0$ Hz, 2H, $\text{CH}_2\text{CH}=\text{CH}$), 1.65 (d, $J = 4.7$ Hz, 3H, CHCH_3), 1.54

(dd, $J = 6.8, 1.7$ Hz, 3H, CHCH₃), 1.29 (s, 6H, two CH₃), 1.25 (s, 6H, two CH₃); ¹³C NMR (75 MHz, CDCl₃) δ 138.3, 126.4, 122.9, 108.3, 81.7, 25.7, 25.6, 18.0, 16.7, 12.0; ²⁹Si NMR (59 MHz, CDCl₃, TMS) δ -32.2; IR (thin film) 3021, 2980, 2936, 1671, 1456, 1377, 1269, 1182, 1143, 1007 cm⁻¹.

Data for 18: ¹H NMR (300 MHz, CDCl₃) δ 5.75-5.59 (m, 1H, CH=CH₂), 5.13-5.00 (m, 2H, CH=CH₂), 3.70 (dd, $J = 9.4, 1.7$ Hz, 1H, CH), 3.43-3.33 (m, 1H, CH), 2.80 (d, $J = 6$ Hz, 1H, OH), 2.55-2.40 (m, 2H, 2CH), 2.06 (d, $J = 12.8$ Hz, 1H, OH), 1.98-0.69 (m, 11H, C₆H₁₁), 1.12 (d, $J = 6.6$ Hz, 3H, CHCH₃), 1.00 (d, $J = 7.2$ Hz, 3H, CHCH₃); ¹³C NMR (100 MHz, CDCl₃) δ 141.7, 115.3, 80.4, 76.1, 42.5, 41.2, 34.9, 30.4, 29.1, 26.8, 26.4, 26.3, 16.8, 11.1; IR (KBr) 3368, 3083, 2968, 2922, 1640, 1448, 1392, 1338, 1090, 1052 cm⁻¹; LRMS (FAB+) calcd for C₁₄H₂₆O₂ 226, found (M+H)⁺ 227.

Stereochemical Determinations.

Diol 4: Diol **4** was treated with 2,2-dimethoxypropane and a catalytic amount of (+)-camphorsulfonic acid (CSA) in CH₂Cl₂ to give acetonide **A** (eq 1). The ¹³C NMR spectrum of acetonide **A** was analyzed using the method of Rychnovsky² to reveal that the acetonide possessed the *syn* relative configuration, establishing the *syn* stereochemistry of diol **4**.

Data for acetonide A: ¹H NMR (400 MHz, CDCl₃) δ 5.85-5.72 (m, 1H, CH=CH₂), 5.10-4.99 (m, 2H, CH=CH₂), 3.85-3.77 (m, 1H, CH), 3.52-3.45 (m, 1H, CH), 2.33-2.24 (m, 1H, one of CH₂), 2.17-2.08 (m, 1H, one of CH₂), 1.92-1.83 (m, 1H, one of CH₂), 1.74-1.58 (m, 4H, one of CH₂ and three of C₆H₁₁), 1.51-0.81 (m, 8H, eight of C₆H₁₁), 1.38 (s, 3H, CH₃), 1.36 (s, 3H, CH₃); ¹³C NMR (100 MHz, CDCl₃) δ 134.4, 116.9, 98.3, 73.2, 68.8, 42.8, 41.0, 33.4, 30.2, 28.9, 27.9, 26.6, 26.1, 25.9, 19.8; IR (thin film) 3077, 2992, 2925, 2853, 1643, 1451, 1379, 1262, 1200, 1171 cm⁻¹.

(2) Rychnovsky, S. D.; Rogers, B.; Yang, G. *J. Org. Chem.* **1993**, 58, 3511-3515.

Diol **7**: Diol **7** was treated with 2,2-dimethoxypropane and a catalytic amount of (+)-camphorsulfonic acid in CH_2Cl_2 to give acetonide **B** (eq 2). The ^{13}C NMR spectrum of this acetonide was analyzed using the method of Rychnovsky² to reveal that the acetonide possessed the *syn* relative configuration, establishing the *syn* stereochemistry of diol **7**. The relative configuration of the allylic methyl group was assigned as described below.

Data for acetonide **B**: ^1H NMR (300 MHz, CDCl_3) δ 5.73-5.60 (m, 1H, $\text{CH}=\text{CH}_2$), 5.00-4.91 (m, 2H, $\text{CH}=\text{CH}_2$), 3.50-3.37 (m, 2H, two $\text{CHOC}(\text{CH}_3)_2$), 2.17-2.05 (m, 1H, $\text{CH}(\text{CH}_3)\text{CH}=\text{CH}_2$), 1.85-1.00 (br m, 13H, CH_2 and C_6H_{11}), 1.31 (s, 3H, one of CH_3), 1.30 (s, 3H, one of CH_3), 0.95 (d, $J = 6.7$ Hz, 3H, $\text{CH}(\text{CH}_3)\text{CH}=\text{CH}_2$); ^{13}C NMR (75 MHz, CDCl_3) δ 140.4, 114.7, 98.2, 73.3, 72.5, 43.5, 42.9, 31.5, 30.2, 28.9, 28.0, 26.6, 26.1, 26.0, 19.7, 15.7; IR (thin film) 3078, 2921, 2852, 1636, 1450, 1376, 1259, 1200, 1106 cm^{-1} .

Diol **8**: Diol **8** was treated with 2,2-dimethoxypropane and a catalytic amount of (+)-camphorsulfonic acid in CH_2Cl_2 to give acetonide **C** (eq 3). The ^{13}C NMR spectrum of this acetonide was analyzed using the method of Rychnovsky² to reveal that the acetonide possessed the *syn* relative configuration, establishing the *syn* stereochemistry of diol **8**. The relative configuration of the allylic methyl group was assigned as described below.

Data for acetonide **C**: ^1H NMR (300 MHz, CDCl_3) δ 5.90-5.78 (m, 1H, $\text{CH}=\text{CH}_2$), 5.04-4.98 (m, 2H, $\text{CH}=\text{CH}_2$), 3.70-3.64 (m, 1H, one of $\text{CHOC}(\text{CH}_3)_2$), 3.52-3.45 (m, 1H, one of $\text{CHOC}(\text{CH}_3)_2$), 2.24-2.20 (m, 1H, $\text{CH}(\text{CH}_3)\text{CH}=\text{CH}_2$), 1.93-0.88 (m, 13H, C_6H_{11} and CH_2), 1.38 (s, 3H, one of CH_3), 1.36 (s, 3H, one of CH_3), 1.00 (d, $J = 6.9$ Hz, 3H, $\text{CH}(\text{CH}_3)\text{CH}=\text{CH}_2$); ^{13}C NMR (75 MHz, CDCl_3) δ 140.6, 114.2, 98.0, 73.1, 72.4, 42.8,

42.4, 30.4, 30.0, 28.8, 28.0, 26.6, 26.0, 25.9, 19.6, 14.8; IR (thin film) 3078, 2921, 2852, 1636, 1450, 1376, 1259, 1200, 1106 cm^{-1} .

Acetonide **C** was subjected to ozonolysis with a reductive (NaBH_4) workup, and the resulting alcohol was treated with PPTS in CH_2Cl_2 to give acetonide **D** (eq 4). As shown, analysis of the coupling constants in the ^1H NMR spectrum established the *anti* relative configuration of the allylic methyl group of **8**. Since **7** and **8** were both shown to have the *syn* diol stereochemistry and since they are different compounds, the *syn* relative configuration of the allylic methyl group in **7** is also thereby proven.

Data for acetonide **D**: ^1H NMR (300 MHz, acetone- d_6) δ 3.75-3.67 (m, 1H, $\text{CHOC}(\text{CH}_3)_2$ or CHOH), 3.57 (dd, $J = 5.4, 11.6$ Hz, 1H, one of $\text{CH}_2\text{OC}(\text{CH}_3)_2$), 3.48 (dd, $J = 11.0, 11.0$ Hz, 1H, one of $\text{CH}_2\text{OC}(\text{CH}_3)_2$), 3.50-3.45 (m, 1H, $\text{CHOC}(\text{CH}_3)_2$ or CHOH), 3.36 (br s, 1H, OH), 1.83-0.98 (m, 14H, C_6H_{11} , CH_2 , and CHCH_3), 1.41 (s, 3H, one of CH_3), 1.25 (s, 3H, one of CH_3), 0.72 (d, $J = 6.7$ Hz, 3H, $\text{CH}(\text{CH}_3)$); ^{13}C NMR (100 MHz, CDCl_3) δ 98.2, 77.6, 76.4, 65.8, 43.9, 36.4, 34.5, 29.7, 28.9, 27.8, 26.6, 26.3, 26.2, 19.2, 12.6; IR (thin film) 3522, 2925, 1450, 1377, 1264, 1200, 1111 cm^{-1} .

Diol **11**: Diol **11** was treated with 2,2-dimethoxypropane and a catalytic amount of (+)-camphorsulfonic acid in CH_2Cl_2 to give acetonide **E** (eq 5). The ^{13}C NMR spectrum of this acetonide was analyzed using the method of Rychnovsky² to reveal that the acetonide possessed the *syn* relative configuration, establishing the *syn* stereochemistry of diol **11**. As shown, analysis of the coupling constants (from decoupling experiments) in the ^1H NMR spectrum established the *anti* relative configuration of the methyl group.

Data for acetone **E**: ^1H NMR (400 MHz, CDCl_3) δ 5.86-5.96 (m, 1H, $\text{CH}=\text{CH}_2$), 5.01-5.08 (m, 2H, $\text{CH}=\text{CH}_2$), 3.50 (m, 1H, OCHCH_2), 3.28 (d, 1H, $J = 10.3$ Hz, $\text{c-C}_6\text{H}_{11}\text{CHO}$), 2.34-2.41 (m, 1H, one of $\text{CH}_2\text{CH}=\text{CH}_2$), 2.13-2.21 (m, 1H, one of $\text{CH}_2\text{CH}=\text{CH}_2$), 1.71-1.77 (m, 2H, two of $\text{c-C}_6\text{H}_{11}$), 1.37 (s, 3H, three of $\text{C}(\text{CH}_3)_2$), 1.34 (s, 3H, three of $\text{C}(\text{CH}_3)_2$), 1.11-1.65 (m, 10H, CHCH_3 and nine of $\text{c-C}_6\text{H}_{11}$), 0.74 (d, 3H, $J = 6.6$ Hz, CHCH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 135.3, 116.1, 97.7, 77.7, 74.2, 38.4, 37.6, 34.2, 30.4, 30.1, 26.9, 26.6, 26.5, 24.8, 19.5, 11.8; IR (film) 3075, 2991, 2931, 2853, 1641, 1451, 1379, 1264, 1203, 1176, 1131, 1051, 1015, 987, 935, 910 cm^{-1} .

Diol **15**: Diol **15** was treated with 2,2-dimethoxypropane and a catalytic amount of (+)-camphorsulfonic acid in CH_2Cl_2 to give acetone **F** (eq 6). The ^{13}C NMR spectrum of this acetone was analyzed using the method of Rychnovsky² to reveal that the acetone possessed the *syn* relative configuration, establishing the *syn* stereochemistry of diol **15**. As shown, analysis of the coupling constants in the ^1H NMR spectrum established the *anti* relative configuration of the methyl group between the two OH groups.

Data for acetone **F**: ^1H NMR (400 MHz, CDCl_3) δ 5.96-5.82 (m, 1H, $\text{CH}=\text{CH}_2$), 5.07-4.94 (m, 2H, $\text{CH}=\text{CH}_2$), 3.35 (dd, $J = 10.1, 1.7$ Hz, 1H, CHO), 3.28 (d, $J = 10.8$ Hz, 1H, CHO), 2.51-2.39 (m, 1H, CH), 1.84-1.12 (m, 12H, CH and C_6H_{11}), 1.37 (s, 3H, CH_3), 1.34 (s, 3H, CH_3), 1.07 (d, $J = 6.9$ Hz, 3H, CHCH_3), 0.72 (d, $J = 6.6$ Hz, 3H, CHCH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 140.1, 114.5, 97.5, 77.8, 77.6, 39.6, 38.5, 32.4, 30.5, 30.1, 26.9, 26.6, 24.9, 19.3, 18.1, 11.2; IR (thin film) 3072, 2990, 2930, 2853, 1642, 1451, 1378, 1256, 1202, 1176 cm^{-1} .

To establish the relative configuration of the allylic methyl group of diol **15**, diol **15** was first protected as its mono benzyl ether. The resulting mixture of benzyl ethers was treated with $\text{Hg}(\text{OAc})\text{Cl}$ in acetone to give tetrahydropyran **G** (along with other products derived from the isomeric benzyl ether) (eq 7). As shown, analysis of the coupling constants and nOe studies established the stereochemistry of the allylic methyl group of diol **15**.

Data for tetrahydropyran **G**: ^1H NMR (400 MHz, CDCl_3) δ 7.42-7.28 (m, 5H, C_6H_5), 4.69-4.61 (m, 2H, PhCH_2), 3.80 (ddd, $J = 9.8, 7.6, 4.7$ Hz, 1H, CH), 3.52-3.44 (m, 2H, two CH), 2.35 (dd, $J = 11.7, 4.7$ Hz, 1H, one of CH_2HgCl), 2.08 (dd, $J = 11.7, 7.6$ Hz, 1H, one of CH_2HgCl), 1.85-1.13 (m, 13H, two CH and C_6H_{11}), 1.00 (d, $J = 6.9$ Hz, 3H, CHCH_3), 0.95 (d, $J = 7.0$ Hz, 3H, CHCH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 139.0, 128.2, 127.4, 127.2, 83.4, 80.4, 75.8, 75.7, 46.1, 38.2, 38.0, 37.9, 30.9, 26.9, 26.6, 24.6, 14.5, 13.8; IR (KBr) 3025, 2930, 2855, 1654, 1607, 1450, 1376, 1337, 1193, 1095, 1067 cm^{-1} .

Diol **16**: Diol **16** was treated with 2,2-dimethoxypropane and a catalytic amount of (+)-camphorsulfonic acid in CH_2Cl_2 to give acetonide **H** (eq 8). The ^{13}C NMR spectrum of this acetonide was analyzed using the method of Rychnovsky² to reveal that the acetonide possessed the *syn* relative configuration, establishing the *syn* stereochemistry of diol **16**. As shown, analysis of the coupling constants in the ^1H NMR spectrum established the *anti* relative configuration of the methyl group between the two OH groups. Given that the allylic methyl group stereocenter of **15** has been established, and that **15** and **16** are otherwise identical, the *syn* orientation of the allylic methyl group in diol **16** is therefore established.

Data for acetonide **H**: ^1H NMR (400 MHz, CDCl_3) δ 6.00-5.89 (m, 1H, $\text{CH}=\text{CH}_2$), 5.06-4.95 (m, 2H, $\text{CH}=\text{CH}_2$), 3.47 (dd, $J = 10.1, 2.4$ Hz, 1H, CH), 3.30 (dd, $J = 10.1, 1.2$ Hz, 1H, CH), 2.46-2.37 (m, 1H, CH), 1.83-1.11 (m, 12H, CH and C_6H_{11}), 1.36 (s, 3H, CH_3), 1.33 (s, 3H, CH_3), 1.00 (d, $J = 6.9$ Hz, 3H, CHCH_3), 0.76 (d, $J = 6.7$ Hz, 3H, CHCH_3); ^{13}C NMR (100 MHz, CDCl_3) δ 143.3, 112.8, 97.6, 77.9, 77.3, 38.6, 31.8, 30.5, 30.1, 26.9, 26.6, 24.9, 19.5, 12.5, 11.5; IR (thin film) 3073, 2968, 2931, 2853, 1640, 1451, 1379, 1256, 1202, 1138, 1031 cm^{-1} .

Diol **18**: Diol **18** was treated with HgClOAc in CH₂Cl₂/THF to give tetrahydropyran **I** (eq 9). As illustrated, analysis of the coupling constants and selective 1D NOESY experiments unambiguously confirmed the relative stereochemistry of diol **18**.

Data for tetrahydropyran **I**: ¹H NMR (400 MHz, CDCl₃) δ 3.40 (d, $J = 9.9$ Hz, 1H, **CH**), 3.27 (ddd, $J = 9.4$, 8.2, 4.3 Hz, 1H, **CH**), 3.03 (dd, $J = 9.7$, 1.8 Hz, 1H, **CH**), 2.39 (dd, $J = 11.9$, 4.3 Hz, 1H, one of **CH**₂HgCl), 2.14 (dd, $J = 11.9$, 8.2 Hz, 1H, one of **CH**₂HgCl), 2.16-2.07 (m, 2H, two H of C₆**H**₁₁), 2.07-2.98 (m, 1H, **CH**), 1.82-1.05 (m, 8H, **CH**, **OH**, and six H of C₆**H**₁₁), 0.99 (d, $J = 6.5$ Hz, 3H, **CHCH**₃), 0.89 (d, $J = 6.9$ Hz, 3H, **CHCH**₃), 0.94-0.75 (m, 3H, three H of C₆**H**₁₁); ¹³C NMR (100 MHz, CDCl₃) δ 83.5, 80.4, 42.2, 38.2, 37.3, 35.9, 30.4, 28.0, 26.5, 25.9, 25.7, 13.8, 5.7; IR (KBr) 3434, 2924, 2851, 1720, 1450, 1386, 1334, 1262, 1100, 1027 cm⁻¹.