A Sakurai – Prins – Ritter Sequence for the Three-Component Diastereoselective Synthesis of 4-Amino Tetrahydropyrans

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Supporting Information

General Methods. 3-Acetoxy-1,4-dioxanes **1** were prepared according to the published procedures.¹ All reactions were carried out under an atmosphere of argon in flame-dried glassware with magnetic stirring. Column chromatography was performed on EM Science silica gel 60 (230-400 mesh). Thin layer chromatography was performed on EM Science 0.25 mm silica gel 60-F plates. Infrared spectra were obtained on a Nicolet Avatar 320 FT-IR spectrometer. ¹H NMR spectra were recorded on a Varian 300 or 400 MHz spectrometers at ambient temperature. Data are reported as follows: chemical shift in parts per million (δ , ppm) from deuterated chloroform (CDCl₃) taken as 7.26 ppm, integration, multiplicity (s = singlet, d = doublet, t = triplet, quint = quintet, and m = multiplet), and coupling constant (Hz). ¹³C NMR spectra were recorded on a Varian 300 or 400 MHz spectrometers at ambient temperature. Chemical shifts are reported in ppm from CDCl₃ taken as 77.0 ppm. Mass spectra were obtained on Fisons VG Autospec. GCMS analysis was performed on Agilent 5890 system.

General procedure for one-pot Sakurai–Prins–Ritter reaction using allyltrimethylsilane (Procedure A). To a stirred solution of 4-acetoxy-1,3-dioxane **1** (0.1 mmol) and allylsilane (19 μ L, 0.12 mmol) in a mixture of corresponding nitrile (0.5 mL) and dichloromethane (0.5 mL) TMSOTf (18 μ L, 0.1 mmol) was added dropwise at $-45\text{ }^{\circ}\text{C}$ (dry ice–acetonitrile bath). The mixture was stirred for 30 min at the same temperature and TfOH (18 μ L, 0.2 mmol) was added dropwise. The mixture was allowed to reach $-15\text{ }^{\circ}\text{C}$ in 20 min, and acetic anhydride (20 μ L, 0.2 mmol) was added. The mixture was warmed up to $0\text{ }^{\circ}\text{C}$ in 20 min and quenched with saturated sodium bicarbonate solution. The resulting mixture was diluted with ether (5 mL) and aqueous layer was separated. Organic extract was filtered through short plug (2x1 cm) of neutral alumina. After removal of solvents the residue was purified by column chromatography on silica gel.

3aa: isolated in 79% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 1:1 gradient as the eluent) as a 97:3 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3285, 2930, 1732, 1651, 1557, 1370, 1243 cm^{-1} ; ¹H NMR (300 MHz, CDCl₃) δ 5.33 (1H, d, J = 8.4 Hz), 4.99 (1H, ddd, J = 9.3, 5.1, 2.9 Hz), 3.97 (1H, ddddd, J = 12.6, 12.6, 8.4, 4.2, 4.2 Hz), 3.27 (1H, dddd, J = 11.3, 8.8, 2.3, 2.3 Hz), 2.90 (1H, dd, J = 11.2, 1.7 Hz), 2.02 (3H, s), 1.95 (3H, s), 1.80-1.90 (2H, m), 1.44-1.78 (8H, m), 0.90-1.28 (7H, m), 0.86 (9H, s); ¹³C NMR (75 MHz, CDCl₃) δ 170.6, 169.2, 83.5, 74.5, 72.4, 41.7, 38.9, 37.7, 34.0, 32.4, 28.6, 28.0, 26.4, 26.1, 26.0, 23.4, 21.1; HRMS (FAB+) m/e calcd (M+H⁺) 368.2801, found 368.2792.

¹ (a) Kopecky, D. J.; Rychnovsky, S. D. *J. Org. Chem.* **2000**; 65, 191-198; (b) Zhang, Y.; Rovis, T. *Tetrahedron*, **2003**, 59, 8979-8987.

Relative stereochemistry of the major diastereomer was confirmed by nOe experiments.

3ba: isolated in 80% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 1:1 gradient as the eluent) as a 97:3 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3281, 2930, 1736, 1651, 1548, 1371, 1243 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 5.39 (1H, d, $J = 8.1$ Hz), 5.00 (1H, ddd, $J = 9.1, 5.1, 2.9$ Hz), 3.98 (1H, dddd, $J = 12.1, 12.1, 8.1, 4.0, 4.0$ Hz), 3.19-3.24 (2H, m), 2.02 (3H, s), 1.94 (3H, s), 1.82-1.90 (2H, m), 1.54-1.76 (8H, m), 1.24-1.54 (4H, m), 0.90-1.24 (7H, m), 0.88 (3H, t, $J = 6.6$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 170.5, 169.2, 75.8, 74.2, 72.5, 46.3, 41.8, 38.7, 38.4, 38.2, 37.6, 28.7, 27.8, 26.4, 26.1, 23.5, 21.2, 18.6, 14.0; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 354.2644, found 354.2638.

3ca: isolated in 77% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 1:1 gradient as the eluent) as a 97:3 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3283, 3063, 3027, 2953, 1738, 1651, 1548, 1371, 1242 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 7.21-7.30 (2H, m), 7.12-7.20 (3H, m), 5.44 (1H, d, $J = 8.0$ Hz), 5.15 (1H, dddd, $J = 6.3, 6.3, 6.3, 6.3$ Hz), 3.98 (1H, dddd, $J = 12.0, 12.0, 8.0, 4.0, 4.0$ Hz), 3.30-3.41 (1H, m), 2.92 (1H, dd, $J = 11.4, 1.7$ Hz), 2.63 (1H, d, $J = 10.1$ Hz), 2.61 (1H, d, $J = 10.1$ Hz), 2.01 (3H, s), 1.96 (3H, s), 1.63-1.70 (2H, m), 0.97 (2H, apt quint, $J = 12.1$ Hz), 0.86 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 170.5, 169.2, 141.6, 128.3, 128.2, 125.8, 83.6, 72.4, 71.0, 46.7, 40.7, 38.8, 36.5, 34.0, 32.4, 31.6, 26.0, 23.5, 21.1; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 390.2644, found 390.2632.

Relative stereochemistry of the major diastereomer was confirmed by nOe experiments.

3da: isolated in 75% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 1:1 gradient as the eluent) as a 98:2 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3288, 3063, 3027, 2953, 1738, 1651, 1548, 1372, 1242 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 7.21-7.30 (2H, m), 7.12-7.20 (3H, m), 5.40 (1H, d, $J = 8.0$ Hz), 5.18 (1H, dddd, $J = 6.3, 6.3, 6.3, 6.3$ Hz), 4.00 (1H, dddd, $J = 12.0, 12.0, 8.0, 4.0, 4.0$ Hz), 3.23-3.42 (2H, m), 2.52-2.70 (2H, m), 2.02 (3H, s), 1.95 (3H, s), 1.78-1.92 (4H, m), 1.64-1.72 (2H, m), 1.00 (2H, apt quint, $J = 12.1$ Hz), 0.88 (3H, t, $J = 7.0$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 170.6, 169.3, 141.6, 128.3, 128.3, 125.8, 75.8, 72.4, 70.8, 46.2, 40.7, 38.6, 36.6, 31.6, 23.4, 21.1, 18.6, 14.0; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 376.2488, found 376.2493.

3ea: isolated in 59% yield by column chromatography on silica gel (hexane – EtOAc 1:1 as the eluent) as a 90:10 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3286, 2959, 1732, 1651, 1548, 1371, 1243, 1158 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3) δ 5.25 (1H, d, $J = 8.0$ Hz), 5.00 (1H, dddd, $J = 7.6, 7.6, 5.3, 5.3$ Hz), 4.05 (2H, t, $J = 6.0$ Hz), 4.00 (1H,

dddd, $J = 12.0, 12.0, 8.0, 4.0, 4.0$ Hz), 3.55 (2H, t, $J = 5.8$ Hz), 3.26-3.37 (2H, m), 2.03 (3H, s), 1.96 (3H, s), 1.78-1.92 (5H, m), 1.50-1.72 (5H, m), 1.18 (9H, s), 0.96-1.08 (2H, m); ^{13}C NMR (100 MHz, CDCl_3) δ 178.4, 170.3, 169.3, 75.2, 72.2, 67.6, 46.1, 45.2, 40.8, 38.7, 38.4, 38.3, 33.7, 33.1, 28.4, 27.1, 23.4, 21.1; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 434.2309, found 434.2302.

9a: isolated in 84% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 96:4 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3291, 2928, 1734, 1646, 1542, 1371, 1244 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 5.31 (1H, d, $J = 8.2$ Hz), 4.99 (1H, ddd, $J = 2.9, 5.3, 9.3$ Hz), 3.97 (1H, dddd, $J = 12.3, 12.3, 8.2, 4.1, 4.1$ Hz), 3.27 (1H, dddd, $J = 11.9, 9.1, 2.3, 2.3$ Hz), 2.90 (1H, dd, $J = 11.1, 1.7$ Hz), 2.18 (2H, q, $J = 7.7$ Hz), 2.02 (3H, s), 1.79-1.89 (2H, m), 1.40-1.78 (8H, m), 1.14 (3H, t, $J = 7.7$ Hz) 0.90-1.22 (7H, m), 0.86 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 172.9, 170.6, 83.5, 74.5, 72.4, 46.6, 41.7, 39.0, 37.7, 34.0, 32.5, 29.9, 28.6, 28.0, 26.4, 26.1, 26.0, 21.2, 9.9; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 382.2957, found 382.2958.

9b: isolated in 81% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 94:6 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3296, 2930, 1734, 1641, 1543, 1370, 1244 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 5.33 (1H, d, $J = 8.0$ Hz), 4.99 (1H, ddd, $J = 3.0, 5.3, 9.1$ Hz), 3.98 (1H, dddd, $J = 12.0, 12.0, 8.0, 4.0, 4.0$ Hz), 3.27 (1H, dddd, $J = 11.5, 8.5, 2.3, 2.3$ Hz), 2.89 (1H, dd, $J = 11.1, 1.5$ Hz), 2.28 (1H, sept, $J = 6.6$ Hz), 2.02 (3H, s), 1.79-1.88 (2H, m), 1.42-1.76 (8H, m), 1.12 (6H, t, $J = 6.6$ Hz) 0.90-1.22 (7H, m), 0.86 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 176.1, 170.6, 83.5, 74.5, 72.4, 46.4, 41.7, 38.9, 37.7, 35.7, 34.0, 32.4, 28.6, 28.0, 26.4, 26.1, 26.0, 21.1, 19.6, 19.5; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 396.3114, found 396.3106.

9c: isolated in 71% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 95:5 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3344, 2931, 1734, 1639, 1529, 1370, 1245 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 5.42 (1H, d, $J = 8.1$ Hz), 4.99 (1H, ddd, $J = 3.1, 5.5, 9.1$ Hz), 3.94 (1H, dddd, $J = 12.1, 12.1, 8.1, 4.0, 4.0$ Hz), 3.27 (1H, dddd, $J = 11.5, 8.5, 2.3, 2.3$ Hz), 2.90 (1H, dd, $J = 11.0, 1.7$ Hz), 2.02 (3H, s), 1.79-1.88 (2H, m), 1.42-1.78 (8H, m), 1.17 (9H, s), 0.90-1.26 (7H, m), 0.86 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 177.6, 170.6, 83.6, 74.6, 72.4, 46.5, 41.7, 38.9, 37.7, 34.0, 32.4, 28.6, 28.0, 27.5, 26.4, 26.1, 26.0, 21.2; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 410.3270, found 410.3260.

9d: isolated in 83% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 99:1 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3309, 2930, 1726, 1663, 1547, 1372, 1246 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 6.13 (1H, d, $J = 8.0$ Hz), 4.99 (1H, ddd, $J = 2.8, 5.3, 9.3$ Hz), 4.76 (2H, d, $J_{\text{HF}} = 47.2$ Hz), 4.06 (1H, dddd, $J = 12.0, 12.0, 8.0, 4.0, 4.0$ Hz), 3.25 (1H, dddd, $J = 11.3, 9.1, 2.2, 2.2$ Hz), 2.93 (1H, dd, $J = 11.3, 1.2$ Hz), 2.02 (3H, s), 1.82-1.92 (2H, m), 1.60-1.76 (6H, m), 1.46-1.60 (2H, m), 0.90-1.22 (7H, m), 0.88 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 171.0, 167.0 (d, $J_{\text{CF}} = 17$ Hz), 83.5, 80.4 (d, $J_{\text{CF}} = 186$ Hz), 74.5, 72.4, 46.4, 41.7, 38.6, 37.7, 34.1, 32.3, 28.6, 28.0, 26.4, 26.1, 26.0, 21.1; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 386.2707, found 386.2791.

9e: isolated in 79% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 97:3 mixture of diastereomers (GC-MS). Major diastereomer: IR

(Thin Film) ν 3294, 2930, 1732, 1661, 1537, 1372, 1246 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 6.39 (1H, d, $J = 8.0$ Hz), 5.01 (1H, ddd, $J = 2.9, 5.1, 9.1$ Hz), 4.02 (2H, s), 3.99 (1H, dddd, $J = 12.0, 12.0, 8.0, 4.0, 4.0$ Hz), 3.29 (1H, dddd, $J = 11.3, 9.1, 2.2, 2.2$ Hz), 2.92 (1H, dd, $J = 11.4, 1.5$ Hz), 2.03 (3H, s), 1.80-1.90 (2H, m), 1.46-1.80 (8H, m), 0.90-1.28 (7H, m), 0.88 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 171.0, 165.0, 83.5, 74.5, 72.4, 47.3, 42.6, 41.7, 38.4, 37.7, 34.0, 32.1, 28.6, 28.0, 26.4, 26.1, 26.0, 21.1; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 402.2411, found 402.2407.

9f: isolated in 89% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 95:5 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3317, 2930, 1732, 1667, 1532, 1372, 1244 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 6.37 (1H, d, $J = 8.4$ Hz), 5.00 (1H, ddd, $J = 2.9, 5.1, 9.1$ Hz), 3.95 (1H, dddd, $J = 12.1, 12.1, 8.1, 4.0, 4.0$ Hz), 3.85 (2H, s), 3.24 (1H, dddd, $J = 11.3, 9.1, 2.2, 2.2$ Hz), 2.93 (1H, dd, $J = 11.1, 1.5$ Hz), 2.02 (3H, s), 1.80-1.90 (2H, m), 1.46-1.80 (8H, m), 0.90-1.28 (7H, m), 0.88 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 171.0, 164.5, 83.5, 74.5, 72.4, 47.6, 41.7, 38.4, 37.7, 34.0, 32.1, 29.3, 28.6, 28.0, 26.4, 26.1, 26.0, 21.2; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 446.1906, found 446.1909.

9g: isolated in 66% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 94:6 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3286, 2930, 1732, 1651, 1553, 1372, 1245 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 6.32 (1H, d, $J = 8.1$ Hz), 5.00 (1H, ddd, $J = 2.8, 5.1, 9.1$ Hz), 4.01 (1H, dddd, $J = 12.1, 12.1, 8.1, 4.0, 4.0$ Hz), 3.86 (2H, s), 3.40 (3H, s), 3.24 (1H, dddd, $J = 11.3, 9.1, 2.2, 2.2$ Hz), 2.92 (1H, dd, $J = 11.0, 1.4$ Hz), 2.02 (3H, s), 1.80-1.90 (2H, m), 1.44-1.78 (8H, m), 0.90-1.26 (7H, m), 0.87 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 170.8, 168.9, 83.8, 74.8, 72.6, 72.2, 59.3, 46.3, 41.9, 39.0, 37.9, 34.3, 32.6, 28.6, 28.0, 26.4, 26.1, 26.0, 21.1; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 398.2906, found 398.2900.

9h: isolated in 75% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 98:2 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3275, 2930, 1732, 1657, 1626, 1547, 1372, 1246 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 6.27 (1H, dd, $J = 16.8, 1.4$ Hz), 6.05 (1H, dd, $J = 16.8, 9.8$ Hz), 5.62 (1H, dd, $J = 9.8, 1.4$ Hz), 5.51 (1H, d, $J = 8.0$ Hz), 5.00 (1H, ddd, $J = 2.9, 5.2, 8.8$ Hz), 4.06 (1H, dddd, $J = 12.0, 12.0, 8.0, 4.0, 4.0$ Hz), 3.30 (1H, dddd, $J = 11.3, 9.2, 2.3, 2.3$ Hz), 2.92 (1H, dd, $J = 11.0, 1.4$ Hz), 2.03 (3H, s), 1.84-1.94 (2H, m), 1.44-1.76 (8H, m), 0.90-1.27 (7H, m), 0.87 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 170.6, 162.0, 130.9, 126.5, 83.5, 74.5, 72.4, 46.8, 41.7, 38.8, 37.7, 34.0, 32.4, 28.6, 28.0, 26.4, 26.1, 26.0, 21.2; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 380.2801, found 380.2798.

9i: isolated in 42% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 95:5 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3287, 2930, 1736, 1651, 1636, 1548, 1370, 1244 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3) δ 5.91 (1H, ddt, $J = 17.2, 10.0, 7.3$ Hz), 5.39 (1H, d, $J = 8.0$ Hz), 5.17-5.27 (2H, m), 5.00 (1H, ddd, $J = 3.0, 5.1, 9.0$ Hz), 3.97 (1H, dddd, $J = 12.0, 12.0, 8.0, 4.0, 4.0$ Hz), 3.27 (1H, dddd, $J = 11.0, 8.5, 2.3, 2.3$ Hz), 2.97 (2H, d, $J = 7.3$ Hz), 2.90 (1H, dd, $J = 11.0, 1.5$ Hz), 2.02 (3H, s), 1.80-1.88 (2H, m), 1.40-1.78 (8H, m), 0.90-1.28 (7H, m), 0.86 (9H, s); ^{13}C NMR (100 MHz,

CDCl₃) δ 170.6, 169.7, 131.3, 120.0, 83.5, 74.5, 72.4, 46.8, 41.7, 41.6, 38.8, 37.7, 34.0, 32.4, 28.6, 28.0, 26.4, 26.1, 26.0, 21.2; HRMS (FAB+) m/e calcd (M+H⁺) 394.2957, found 394.2951.

9j: isolated in 77% yield by column chromatography on silica gel (hexane – EtOAc 9:1 to 2:1 gradient as the eluent) as a 93:7 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3305, 2930, 1732, 1634, 1538, 1372, 1247 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 7.72-7.78 (2H, m), 7.38-7.52 (3H, m), 6.00 (1H, d, J = 8 Hz), 5.03 (1H, ddd, J = 2.9, 5.1, 9.1 Hz), 3.95 (1H, dddd, J = 12.0, 12.0, 8.0, 4.0, 4.0 Hz), 3.35 (1H, dddd, J = 11.0, 9.1, 2.2, 2.2 Hz), 2.97 (1H, dd, J = 11.1, 1.5 Hz), 2.04 (3H, s), 1.92-2.02 (2H, m), 1.46-1.80 (8H, m), 0.94-1.24 (7H, m), 0.89 (9H, s); ¹³C NMR (75 MHz, CDCl₃) δ 170.6, 166.7, 134.6, 131.4, 128.5, 126.8, 83.5, 74.5, 72.4, 47.2, 41.7, 38.8, 37.7, 34.0, 32.5, 28.6, 28.0, 26.4, 26.1, 26.0, 21.2; HRMS (FAB+) m/e calcd (M+H⁺) 430.2957, found 430.2967.

12: isolated in 81% yield by column chromatography on silica gel (hexane – EtOAc 3:1 to 2:1 gradient as the eluent) as a 91:9 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3285, 2930, 1732, 1652, 1548, 1370, 1245 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 5.34 (1H, d, J = 10.2 Hz), 5.01 (1H, ddd, J = 1.7, 5.5, 9.7 Hz), 3.72 (1H, dddd, J = 10.2, 10.2, 10.2, 4.3 Hz), 2.93 (1H, ddd, J = 9.9, 9.9, 1.8 Hz), 2.92 (1H, dd, J = 11.3, 1.8 Hz), 2.01 (3H, s), 1.98 (3H, s), 1.75-1.90 (2H, m), 1.60-1.75 (6H, m), 1.45-1.54 (2H, m), 0.90-1.24 (6H, m), 0.84 (9H, s), 0.83 (3H, d, J = 6.5 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 170.6, 169.6, 83.2, 78.2, 74.6, 52.2, 41.9, 41.8, 34.9, 34.0, 33.3, 28.5, 28.1, 26.4, 26.1, 26.0, 23.5, 21.2, 13.3; HRMS (FAB+) m/e calcd (M+H⁺) 382.2957, found 382.2950.

Relative stereochemistry of the major diastereomer was confirmed by nOe experiments.

Procedure B. To a stirred solution of 4-acetoxy-1,3-dioxane (0.1 mmol) and silane (0.12 mmol) in acetonitrile (1 mL) TMSOTf (18 μ L, 0.1 mmol) was added dropwise at –45 °C (dry ice – acetonitrile bath). The mixture was stirred for 30 min at the same temperature and TfOH (18 μ L, 0.2 mmol) was added. The mixture was allowed to reach 0 °C in about 40 min and quenched with saturated sodium bicarbonate solution and extracted with ether (5 mL). Organic extract was filtered through short plug (2x1 cm) of neutral alumina. After removal of solvents the residue was purified by column chromatography on silica gel.

3ab: isolated in 88% yield by column chromatography on silica gel (hexane – EtOAc 1:1 to 1:3 gradient as the eluent) as a 97:3 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3306, 2926, 1651, 1552, 1449, 1365 cm⁻¹; ¹H NMR (300 MHz, CDCl₃) δ 5.20 (1H, s), 3.71-3.83 (1H), 3.55-3.66 (1H, m), 3.06 (1H, dd, J = 11.7, 1.4 Hz), 2.98 (1H, br s), 2.11 (1H, ddd, J = 1.9, 1.9, 9.5 Hz), 2.06 (1H, ddd, J = 2.1, 2.1, 9.5 Hz), 1.96 (3H, s), 1.50-1.92 (8H, m), 1.39 (3H, s), 0.92-1.35 (9H, m), 0.87 (9H, s); ¹³C NMR (75 MHz, CDCl₃) δ 169.2, 81.0, 72.7, 71.4, 52.8, 43.8, 41.1, 38.6, 36.3, 33.9, 28.3, 26.8, 26.5, 26.4, 26.3, 24.9; HRMS (FAB+) m/e calcd (M+H⁺) 340.2852, found 340.2847.

Relative stereochemistry of the major diastereomer was confirmed by nOe experiments.

3bb: isolated in 71% yield by column chromatography on silica gel (hexane – EtOAc 1:1 to 1:3 gradient as the eluent) as a 97:3 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3309, 2924, 1651, 1552, 1446, 1370 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 5.19 (1H, s), 3.72-3.84 (1H), 3.64 (1H, ddd, $J = 3.5, 5.8, 9.1\text{ Hz}$) 3.38-3.50 (1H, m), 2.71 (1H, d, $J = 4.0\text{ Hz}$), 2.13 (1H, ddd, $J = 2.2, 2.2, 14.0\text{ Hz}$), 2.06 (1H, ddd, $J = 2.2, 2.2, 14.0\text{ Hz}$), 1.95 (3H, s), 1.56-1.92 (8H, m), 1.38 (3H, s), 0.92-1.50 (7H, m), 0.89 (3H, t, $J = 6.9\text{ Hz}$); ^{13}C NMR (75 MHz, CDCl_3) δ 170.0, 73.1, 72.8, 70.9, 52.7, 44.0, 42.1, 41.6, 38.9, 38.2, 29.3, 28.4, 28.0, 26.7, 26.5, 26.4, 24.9, 19.0, 14.3; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 326.2695, found 326.2688.

3cb: isolated in 80% yield by column chromatography on silica gel (hexane – EtOAc 1:1 to 1:3 gradient as the eluent) as a 96:4 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3310, 3084, 3026, 2953, 1655, 1551, 1365 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 7.21-7.30 (2H, m), 7.12-7.20 (3H, m), 5.15 (1H, s), 3.84-3.92 (1H, m), 3.72-3.84 (1H, m), 3.16 (1H, d, $J = 4.0\text{ Hz}$), 3.09 (1H, dd, $J = 11.7, 1.4\text{ Hz}$), 2.83 (1H, ddd, $J = 13.6, 10.3, 5.3\text{ Hz}$), 2.64 (1H, d, $J = 13.6, 9.8, 6.2\text{ Hz}$), 2.05-2.18 (2H, m), 1.95 (3H, s), 1.62-1.90 (4H, m), 1.39 (3H, s), 1.10-1.35 (2H, m), 0.89 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 169.7, 142.4, 128.4, 128.3, 125.7, 80.8, 71.1, 68.5, 52.5, 41.1, 41.0, 39.1, 36.1, 33.7, 32.3, 28.0, 26.1, 24.6; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 362.2695, found 362.2688.

Relative stereochemistry of the major diastereomer was confirmed by nOe experiments.

3db: isolated in 72% yield by column chromatography on silica gel (hexane – EtOAc 1:1 to 1:3 gradient as the eluent) as a 96:4 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3302, 3084, 3026, 2956, 1655, 1552, 1370 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 7.21-7.30 (2H, m), 7.12-7.20 (3H, m), 5.19 (1H, s), 3.85-3.98 (1H, m), 3.74-3.85 (1H, m), 3.40-3.50 (1H, m), 3.00 (1H, d, $J = 5.0\text{ Hz}$), 2.83 (1H, ddd, $J = 13.5, 9.9, 5.5\text{ Hz}$), 2.64 (1H, d, $J = 13.5, 9.9, 6.2\text{ Hz}$), 2.12 (1H, ddd, $J = 9.5, 2.0, 2.0\text{ Hz}$), 2.08 (1H, ddd, $J = 9.5, 2.0, 2.0\text{ Hz}$), 1.96 (3H, s), 1.60-1.86 (5H, m), 1.37 (3H, s), 1.10-1.52 (5H, m), 0.90 (3H, t, $J = 6.9\text{ Hz}$); ^{13}C NMR (75 MHz, CDCl_3) δ 169.8, 142.3, 128.4, 128.3, 125.7, 72.8, 70.6, 68.5, 52.4, 41.9, 41.5, 39.3, 37.9, 32.3, 27.8, 24.6, 18.9, 14.1; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 348.2539, found 348.2529.

3ac: isolated in 61% yield by column chromatography on silica gel (hexane – EtOAc 1:1 to 1:5 gradient as the eluent) as a 99:1 mixture of diastereomers (GC-MS). Major diastereomer: IR (Thin Film) ν 3300, 2927, 1742, 1661, 1553, 1449, 1381 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3)

δ 5.36 (1H, s), 4.61 (1H, d, J = 11.7 Hz), 4.56 (1H, d, J = 11.7 Hz), 3.71-3.81 (1H, m), 3.54-3.64 (1H, m), 3.07 (1H, dd, J = 12.1, 1.7 Hz), 2.76 (1H, d, J = 4.4 Hz), 2.07 (3H, s), 2.02-2.14 (2H, m), 1.93 (3H, s), 1.54-1.94 (8H, m), 1.37-1.54 (1H, m), 0.89-1.35 (6H, m), 0.87 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 171.1, 169.2, 81.1, 72.9, 71.7, 63.3, 55.3, 43.7, 38.9, 37.8, 34.2, 32.3, 29.4, 28.7, 26.7, 26.4, 26.3, 26.1, 24.6, 21.0; HRMS (FAB+) m/e calcd ($\text{M}+\text{H}^+$) 398.2906, found 398.2890.

Relative stereochemistry of the major diastereomer was confirmed by nOe experiments.

10: TMSOTf (18 μL , 0.1 mmol) was added dropwise at $-78\text{ }^\circ\text{C}$ (dry ice–acetone bath) to a stirred solution of 4-acetoxy-1,3-dioxane **1a** (28 mg, 0.1 mmol) and (2-triisopropylloxymethyl)allyltrimethylsilane **2d** (36 mg, 0.12 mmol) in dichloromethane (0.5 mL). The mixture was stirred for 30 min at the same temperature and then acetonitrile (0.5 mL) and TfOH (18 μL , 0.2 mmol) were added dropwise at $-45\text{ }^\circ\text{C}$. The mixture was allowed to warm up to $0\text{ }^\circ\text{C}$ in 40 min and quenched with saturated sodium bicarbonate solution. The resultant mixture was diluted with ether (5 mL) and aqueous layer was separated. Organic extract was filtered through short plug (2x1 cm) of neutral alumina. After removal of solvents the residue was purified by column chromatography on silica gel (hexane-EtOAc 2:1 to 1:1 gradient as the eluent) yielding 17 mg (50%) of **11** (98:2 mixture of diastereomers by GC-MS) as colorless oil. Major diastereomer: IR (Thin Film) ν 3318, 2925, 1736, 1668, 1479, 1388, 1238 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3) δ 4.07 (1H, d, J = 8.4 Hz), 4.02 (1H, d, J = 8.4 Hz), 3.58-3.69 (1H, m), 3.48-3.60 (1H, m), 2.82 (1H, dd, J = 11.7, 1.8 Hz), 2.63 (1H, br s), 1.97 (3H, s), 1.82-1.94 (2H, m), 1.56-1.80 (6H, m), 1.37-1.56 (2H, m), 0.90-1.35 (7H, m), 0.88 (9H, s); ^{13}C NMR (75 MHz, CDCl_3) δ 163.8, 82.3, 72.6, 72.3, 69.8, 43.5, 42.4, 39.0, 38.2, 37.1, 34.0, 29.1, 28.4, 26.5, 26.2, 26.1, 26.0, 14.0; HRMS (EI+) m/e calcd ($\text{M}+\text{H}^+$) 388.2695, found 388.2685.

Relative stereochemistry of the major diastereomer was confirmed by converting of the isolated material to the tertiary acetamide **3ac** upon treatment with aqueous acetic acid and acetic anhydride in ether at room temperature overnight.