Supporting Information

Highly Regioselective Copper-Catalyzed *cis*- and *trans*-1-Propenyl Grignard Cleavage of Hindered Epoxides. Application in Propionate Synthesis

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General Procedure B: Copper catalyzed cleavage of epoxides using *trans*-1-propenylmagnesium bromide.

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(*Z*)-1-(4-methoxyphenoxy)-4-hexen-2-ol (**10a**)

(*E*)-1-(4-methoxyphenoxy)-4-hexen-2-ol (**10b**)

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(1*R**,2*S**)-2-[(*E*)-1-propenyl]cyclohexanol (**12b**)

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Experimental

General Comments. All reactions were carried out under nitrogen. All solvents were dried and distilled before use. Toluene, THF and ether were distilled from sodium/benzophenone prior to use. All commercially available compounds were used as received. Compounds **13**, **15**, **17**, **19**, **21**, and **16** were prepared by published procedures.¹² Unless otherwise noted, all products were purified by silica gel column chromatography and fully characterized by 1D and 2D (standard COSY and HMQC) NMR. ¹H NMR (500 or 300 MHz) and ¹³C NMR (125 or 75 MHz) spectra were obtained as solutions in deuteriochloroform. NMR chemical shifts (δ) are given in ppm relative to TMS and coupling constants (J) in Hz. HRFABMS and Elemental analyses were done by commercial or institutional laboratories.

General Procedure A: Copper catalyzed cleavage of epoxides using Alkenylmagnesium bromide. Mg powder (7 equiv) was added to a round bottom flask assembled with a dry ice condenser. Freshly distilled THF (2.3 M with respect to Mg) was added to the flask and spiked with I₂. After several minutes the reaction mixture turned from yellow to turbid gray. Then, the dry ice condenser was cooled to -78 °C and *cis*-1-bromopropene (6 equiv) was added. After several minutes, the reaction warmed and refluxed vigorously. The reaction was stirred for 1 hr. The solution was transferred via a double-ended needle to a three neck round bottom flask containing CuI (10 mol%) in ether (0.04 M) at -78 °C. The CuI was previously heated overnight under reduced pressure to remove moisture. After 30 min the epoxide was added at -78 °C. The reaction mixture was allowed to reach room temperature and stirred overnight. At this point the reaction mixture was quenched with a saturated solution of NH₄Cl and diluted in ether. The layers were separated and the aqueous phase was extracted with ether. The combined organic phase was dried over MgSO₄, filtered through Celite and concentrated under reduced pressure to yield the crude alkenol.

General Procedure B: Copper catalyzed cleavage of epoxides using *trans*-1-propenylmagnesium bromide. Mg powder (7 equiv) was added to a round bottom flask assembled with a dry ice condenser. Freshly distilled THF (2.3 M with respect to Mg) was added to the flask and spiked with I₂. After several minutes the reaction mixture turned from yellow to turbid gray. Then, the dry ice condenser was cooled to -78 °C and *trans*-1-bromopropene (6 equiv) was added. After several minutes, the reaction started to warm. Immediately the reaction was cooled to -25 °C to avoid reflux. The reaction mixture was stirred for 40 min. The solution was transferred via a double-ended needle to a three neck round bottom flask containing the CuI (10 mol%) in ether (0.04 M) at -78 °C. The CuI was previously heated overnight under reduced pressure to remove moisture. After 30 min the epoxide was added at -78 °C. The reaction mixture was allowed to reach room temperature and stirred overnight. The reaction mixture was quenched with a saturated solution of NH₄Cl and diluted in ether. The layers were separated and the aqueous phase was extracted with ether. The combined organic phase was dried over MgSO₄, filtered through Celite and concentrated under reduced pressure to yield the crude alkenol.

(2*R**,3*S**,4*S**,5*R**, 6*Z*)-2-methoxy-3,5-dimethyl-1-[(triisopropylsilyl)oxy]-6-octen-4-ol (**8**)

¹H NMR (CDCl₃) δ 5.40 (dq, J = 11.0, 6.7 Hz, 1H, CH=CHCH₃), 5.23 (ddq, J = 11.0, 8.1, 1.6 Hz, 1H, CH=CHCH₃), 3.85 (dd, J = 12.2, 7.9 Hz, 1H, TIPSOCH₂), 3.63 (dd, J = 12.2, 5.3 Hz, 1H, TIPSOCH₂), 3.60 (ddd, J = 7.9, 5.3, 2.6 Hz, 1H, CH₂CH(OCH₃)), 3.50 (s, 3H, OCH₃), 3.27 (dd, J = 7.7, 4.4 Hz, 1H, CHCH(OH)CH), 2.60 (m, 1H, CHCH=CHCH₃), 1.92 (m, 1H, CH(CH₃)CH(OH)), 1.65 (dd, J = 6.7, 1.6 Hz, 3H, CH=CHCH₃), 1.05 (d, J = 6.4 Hz, 3H, CH(CH₃)CH(OH)), 1.05 (21H, ((CH₃)₂CH)₃Si), 0.99 (d, J = 7.2 Hz, 3H, CH(OCH₃)CH(CH₃)CH). ¹³C NMR (CDCl₃) δ 133.7 (CH=CHCH₃), 122.9 (CH=CHCH₃), 83.3 (CH₂CH(OCH₃)), 80.0 CH(CH₃)CH(OH), 64.1 (CH₂CH(OCH₃)), 58.4 (OCH₃), 36.1 CHCH=CHCH₃, 35.7 CH(CH₃)CH(OH), 17.9 ((CH₃)₂CH)₃Si, 16.6 CH(CH₃)CH=CHCH₃, 13.0 (CH=CHCH₃), 12.0 (CH(OCH₃)CH(CH₃)), 11.8 ((CH₃)₂CH)₃Si. IR (neat, cm⁻¹) 3500 (OH), 2940-2865 (CH), 1109, 1066 (C-O), 881 (Si-O), 680 (HC=CH). HRMS-FAB (m/z): [M+H]⁺ calcd for C₂₀H₄₃O₃Si, 359.2981; found, 359.2978. Anal. Calcd for C₂₀H₄₂O₃Si: C, 66.98; H, 11.80. Found: C, 67.33; H, 11.60.

(Z)-1-(4-methoxyphenoxy)-4-hexen-2-ol (10a)

Following the general procedure A, Mg powder (0.019 g atom, 0.49 g, 14 equiv), THF (9 mL), *cis*-1-bromopropene (8.34 mmol, 0.71 mL, 6 equiv), CuI (0.14 mmol, 0.03 g, 0.1 equiv) in ether (3.5 mL) and epoxide **9** (1.4 mmol, 0.25 g) were used. After workup and Kugelrohr distillation (160 °C, 0.5 mmHg), 0.22 g (75%) of pure product was obtained. ¹H NMR (CDCl₃) δ 6.81(m, 4H, C₆H₄-), 5.62 (dqt, *J* = 10.8, 6.7, 1.3 Hz, 1H, CH=CH-CH₃), 5.45 (dtq, *J* = 10.9, 7.1, 1.6 Hz, 1H, -CH=CH-CH₃), 4.00 (dtd, *J* = 7.0, 6.7, 3.4 Hz, 1H, CH(OH)-), 3.91 (dd, *J* = 9.3, 3.4 Hz, 1H, PhOCH₂CH(OH)-), 3.80 (dd, *J* = 9.3, 7.0 Hz, 1H, PhOCH₂CH(OH)-), 3.74 (s, 3H, -OCH₃), 2.79 (s, 1H, -OH), 2.37 (dd, *J* = 7.1, 6.7, 1.3 Hz, 2H, -CH₂-CH=CHCH₃), 1.61 (dd, *J* = 6.7, 1.6 Hz, 3H, -CH=CH-CH₃). ¹³C NMR (CDCl₃) δ 153.8 (ipso), 152.6 (para), 126.9 (CH=CH-CH₃), 125.1 (CH=CH-CH₃), 115.4, 114.5 (4-MeOPhO-, meta and ortho), 72.0 (-CH-OH), 69.8 (PhOCH₂-), 55.5 (CH₃O-), 30.8 (CH₂CH=), 12.8 (CH=CH-CH₃). IR (neat, cm⁻¹) 3427 (OH), 3014 (CH=C), 1234 (C-O arom.), 1106 (C-O alcohol), 827 (oop para), 750 (oop cis). HRMS-FAB (*m/z*): [M+H]⁺ calcd for C₁₃H₁₉O₃: 223.1334; found, 223.1329 *m/z*.

(E)-1-(4-methoxyphenoxy)-4-hexen-2-ol (10b)

Following the general procedure B, Mg powder (0.019 g atom, 0.47 g, 14 equiv), THF (9 mL) and *trans*-1-bromopropene (8.34 mmol, 0.70 mL, 6 equiv) were added. To a three neck round bottom flask containing CuI (1.9 mmol, 0.36 g, 1.3 equiv), ether (45 mL) and epoxide **9** (1.4 mmol, 0.25 g) were added at -78 °C. To the reaction mixture was added 5 mL of a saturated NH₄Cl solution and diluted with ether (15 mL). After workup, 0.30 g (98%) of product was obtained. This crude was purified by Kugelrohr distillation (160 °C, 0.5 mmHg) providing 0.20 g (65 %) of a 86:14 *trans/cis* mixture pure product. ¹H NMR (CDCl₃) δ 6.80(m, 4H, C₆H₄-), 5.51 (m, 2H, -CH=CH-CH₃), 3.97 (tdd, *J* = 7.0, 6.5, 3.5 Hz, 1H, CH(OH)-), 3.90 (dd, *J* = 9.3, 3.5 Hz, 1H, PhOCH₂CH(OH)-), 3.80 (dd, *J* = 9.3, 7.0 Hz, 1H, PhOCH₂CH(OH)-), 3.73 (s, 3H, -OCH₃), 2.6 (s, 1H, -OH), 2.28 (ddd, *J* = 7.0, 6.5, 1.2 Hz, 2H, -CH₂-CH=CHCH₃), 1.67 (dd, *J* = 6.0, 1.0 Hz, 3H, -CH=CH-CH₃). ¹³C NMR (CDCl₃) δ 153.9 (ipso), 152.7 (para), 128.6 (CH=CH-CH₃), 126.1 (CH=CH-CH₃), 115.5, 114.5 (4-MeOPhO-, meta and ortho), 72.1 (-CH-OH), 69.6 (PhOCH₂-), 55.5 (CH₃O-), 36.5 (CH₂CH=), 17.9 (CH=CH-CH₃). IR (neat, cm⁻¹) 3436 (OH), 3049 (=CH), 2997-2839 (CH), 1596, 1507 (aromatic), 1229 (C-O arom), 1037 (C-O), 826 (oop, para), 971 (oop, *trans*). HRMS-FAB (*m/z*): [M+H]⁺ calcd for C₁₃H₁₉O₃: 223.1334; found, 223.1328.

(1*R,2*S**)-2-[(*Z*)-1-propenyl]cyclohexanol (12a)**

Following the general procedure A, Mg powder (0.036 g atom, 0.89 g, 14 equiv), THF (16 mL), *cis*-1-bromopropene (15.3 mmol, 1.3 mL, 6 equiv), CuI (0.25 mmol, 0.05 g, 0.1 equiv) in ether (6.3 mL), and epoxide **11** (2.55 mmol, 0.25 g) were used. After workup, the crude was purified by Kugelrohr distillation (110 °C, 0.5 mmHg) providing 0.25 g (70%) of pure product. ¹H NMR (CDCl₃) δ 5.61 (ddq *J* = 9.9, 6.9, 1.6 Hz, 1H, -CH=CHCH₃), 5.17 (ddq, *J* = 10.9, 9.9, 1.0 Hz, 1H, -CH=CHCH₃), 3.17 (ddd, *J* = 11.5, 9.6, 4.8 Hz, 1H, CH-OH), 2.23 (m, 1H, CH-CH=CH), 1.99 (m, 2H, CH₂CH-OH), 1.75 (m, 1H, CH-CH₂), 1.64 (d, *J* = 6.8 Hz, 3H), 1.63 (m, 2H), 1.25 (m, 4H, CH₂CH₂CH₂CH₂-). ¹³C NMR (CDCl₃) δ 132.7 (-CH=CHCH₃), 126.8 (-CH=CHCH₃), 73.8 (-CHOH), 44.3 (-CHCH=CH), 33.5 (-

CH_2CHOH), 31.1 ($-\text{CH}_2\text{CHCH}=\text{CH}$), 25.1 (CH_2), 24.7 (CH_2), 13.3 ($\text{CH}=\text{CHCH}_3$). IR (neat, cm^{-1}) 3392 (OH), 2926 (CH), 1446 (CH_2), 1374 (CH_3), 1058 (C-O), 713 ($\text{CH}=\text{CH}$). HRMS-FAB (m/z): $[\text{M}+\text{H}-\text{H}_2]$ calcd for $\text{C}_9\text{H}_{15}\text{O}$, 139.1123; found, 139.1117. The spectral data was identical to that reported in the literature.^{S1}

(1*R,2*S**)-2-[(*E*)-1-propenyl]cyclohexanol (12b)**

Following the general procedure B, Mg powder (0.071 g atom, 1.8 g, 14 equiv), THF (32 mL), *trans*-1-bromopropene (30.6 mmol, 2.6 mL, 6 equiv), CuI (6.64 mmol, 1.3 g, 1.3 equiv) in ether (166 mL), and epoxide **11** (5.1 mmol, 0.5 g) were used. After workup, the crude was purified by Kugelrohr distillation (110 °C, 0.5 mmHg) providing 0.46 g (64 %) of a 71:29 *trans*/*cis* mixture of products. ¹H (CDCl₃) δ 5.59 (ddq, J = 15.0, 6.4, 0.6 Hz, 1H, $-\text{CH}=\text{CHCH}_3$), 5.25 (ddq, J = 15.0, 8.8, 1.6 Hz, 1H, $-\text{CH}=\text{CHCH}_3$), 3.18 (ddd, J = 9.9, 4.0 Hz, 1H, $\text{CH}-\text{OH}$), 2.00 (m, 1H, $\text{CH}-\text{CH}=\text{CH}$), 1.70 (m, 3H), 1.69 (dd, J = 6.4, 1.6 Hz, 3H, $\text{CH}=\text{CH}-\text{CH}_3$), 1.22 (m, 6H, $(\text{CH}_2)_3$). ¹³C NMR (CDCl₃) δ 133.4 ($-\text{CH}=\text{CHCH}_3$), 127.8 ($-\text{CH}=\text{CHCH}_3$), 73.0 ($-\text{CHOH}$), 50.2 ($-\text{CHCH}=\text{CH}$), 33.6 ($-\text{CH}_2\text{CHOH}$), 31.5 ($-\text{CH}_2\text{CHCH}=\text{CH}$), 25.3 (CH_2), 24.8 (CH_2), 18.1 ($\text{CH}=\text{CHCH}_3$). IR (neat, cm^{-1}) 3387 (OH), 3137 ($=\text{CH}$), 2930, 2855 (CH), 1448 (CH_2), 1057 (C-O), 966 ($\text{CH}=\text{CH}$). HRMS-FAB (m/z): $[\text{M}+\text{H}-\text{H}_2]$ calcd for $\text{C}_9\text{H}_{15}\text{O}$, 139.1123; found, 139.1118. The spectral data was identical to that reported in the literature.^{S1}

(2*R,3*R**,4*Z*)-3-methyl-1-[(triisopropylsilyl)oxy]-4-hexene-2-ol (14)**

Following the general procedure A, Mg powder (0.030 g atom, 0.73 g, 14 equiv), THF (13 mL), *cis*-1-bromopropene (12.3 mmol, 1.05 mL, 6 equiv), CuI (2.7 mmol, 0.53 g, 1.3 equiv) in ether (69 mL) and epoxide **13** (2.1 mmol, 0.5 g) were used. After workup, and silica gel column chromatography (9:1 hexane : ethyl acetate), 0.42 g (71%) of a 2:1 inseparable mixture of product : starting material was obtained. ¹H NMR (CDCl₃) δ 5.44 (ddq, J = 10.8, 6.8, 0.8 Hz, 1H, $\text{CH}=\text{CH}-\text{CH}_3$), 5.17 (ddq, J = 10.8, 9.9, 1.7 Hz, 1H, $-\text{CH}=\text{CH}-\text{CH}_3$), 3.74 (dd, J = 9.5, 3.0 Hz, 1H, $\text{TIPSOCH}_2\text{CH}(\text{OH})-$), 3.47 (dd, J = 9.5, 7.6 Hz, 1H, $\text{TIPSOCH}_2\text{CH}(\text{OH})-$), 3.38 (ddd, J = 10.9, 7.6, 3.0 Hz, 1H, $\text{TIPSOCH}_2\text{CH}(\text{OH})-$), 2.66 (s, 1H, $-\text{OH}$); 2.55 (qdd, J = 10.9, 9.9, 7.0 Hz, 1H, $-\text{CH}(\text{CH}_3)$); 1.60 (dd, J = 6.8, 1.7 Hz, 3H, $-\text{CH}=\text{CH}-\text{CH}_3$), 1.05 (m, 24 H, $-\text{CH}(\text{CH}_3)$ and $[(\text{CH}_3)_2\text{CH}]_3\text{SiO}$). ¹³C NMR δ 132.5 ($\text{CH}=\text{CH}-\text{CH}_3$), 124.2 ($\text{CH}=\text{CH}-\text{CH}_3$), 75.6 ($-\text{CH}-\text{OH}$), 65.9 TIPSOCH_2- , 33.6 ($-\text{CH}-\text{CH}_3$), 17.9 $[(\text{CH}_3)_2\text{CH}]_3\text{SiO}$, 17.1 ($-\text{CH}-\text{CH}_3$), 13.1 ($\text{CH}=\text{CH}-\text{CH}_3$), 11.9 $[(\text{CH}_3)_2\text{CH}]_3\text{SiO}$. The spectral data for **14** was identical to that reported in the literature.^{S2}

(2*S,3*R**,4*Z*)-3-methyl-1-[(triisopropyl)oxy]-4-hexene-2-ol (16)**

Following the general procedure A, Mg powder (0.030 g atom, 0.73 g, 14 equiv), THF (13 mL), *cis*-1-bromopropene (12.3 mmol, 1.05 mL, 6 equiv), CuI (2.7 mmol, 0.53 g, 1.3 equiv) in ether (69 mL) and epoxide **15** (2.1 mmol, 0.5 g) were used. After workup, the crude was purified by silica gel column chromatography (9:1 hexane/ethyl acetate) providing 0.37 g (63%) of pure product. ¹H NMR (CDCl₃) δ 5.50 (ddq, J = 10.9, 6.8, 1.1 Hz, 1H, $\text{CH}=\text{CH}-\text{CH}_3$), 5.33 (ddq, J = 10.9, 10.0, 1.6 Hz, 1H, $-\text{CH}=\text{CH}-\text{CH}_3$), 3.73 (dd, J = 8.9, 3.0 Hz, 1H, $\text{TIPSOCH}_2\text{CH}(\text{OH})-$), 3.55 (dd, J = 8.9, 7.7 Hz, 1H, $\text{TIPSOCH}_2\text{CH}(\text{OH})-$), 3.50 (ddd, J = 7.7, 7.7, 3.0 Hz, 1H, $\text{TIPSOCH}_2\text{CH}(\text{OH})-$), 2.63 (qdd, J = 9.6, 6.9, 1.1 Hz, 1H, $-\text{CH}(\text{CH}_3)$); 2.50 (s, 1H, $-\text{OH}$); 1.69 (dd, J = 6.7, 1.7 Hz, 3H, $-\text{CH}=\text{CH}-\text{CH}_3$), 1.13 (m, $[(\text{CH}_3)_2\text{CH}]_3\text{SiO}$), 0.96 (d, J = 6.9, $\text{CH}(\text{CH}_3)$). ¹³C NMR (CDCl₃) δ 132.9 ($\text{CH}=\text{CH}-\text{CH}_3$), 124.6 ($\text{CH}=\text{CH}-\text{CH}_3$),

75.5 (-CH-OH), 65.5 TIPSCH₂-), 33.7 (-CH-CH₃), 17.9 [(CH₃)₂CH]₃SiO), 17.0 (CH-CH₃), 13.0 (CH=CH-CH₃), 11.9 9 [(CH₃)₂CH]₃SiO). IR (neat, cm⁻¹) 3580, 3482 (OH), 3011(=CH), 1655 (w, C=C), 1104 (C-O), 681 (cis C=C). Anal. Calcd for C₁₆H₃₄O₂Si: C, 67.07; H, 11.96. Found: C, 67.27; H, 12.15. The spectral data was identical to that reported in the literature.⁵²

(2*R,3*S**,4*Z*)-1-benzyloxy-3-methyl-4-hexen-2-ol (18a)**

Following the general procedure A, Mg powder (0.040 g atom, 1.0 g, 14 equiv.), THF (18 mL), *cis*-1-bromopropene (16.7 mmol, 1.42 mL, 6 equiv), CuI (3.75 mmol, 0.71 g, 1.3 equiv) in ether (94 mL) and epoxide **17** (2.78 mmol, 0.5 g) were used. After workup, the crude was purified by silica gel column chromatography (6:1 hexane/ethyl acetate) providing 0.38 g (62%) of a 75:25 mixture of external:internal cleavage products. Data for major product: ¹H NMR (CDCl₃) δ 7.35 (m, 5H, C₆H₅-), 5.45 (qdd, *J* = 10.9, 6.8, 0.6 Hz, 1H, CH=CH-CH₃), 5.20 (ddq, *J* = 10.9, 9.0, 1.7 Hz, 1H, -CH=CH-CH₃), 4.55 (s, 2H, C₆H₅CH₂O-), 3.58 (ddd, *J* = 10.0, 7.9, 5.9 Hz, 1H, BnOCH₂CH(OH)-), 3.55 (m, 1H, BnOCH₂CH(OH)-), 3.36 (ddd, *J* = 10.0, 9.0, 1.5 Hz, 1H, BnOCH₂CH(OH)-), 2.62 (m, 1H, -CH(CH₃)), 2.44 (s, 1H, -OH), 1.62 (dd, *J* = 6.8, 1.7 Hz, 3H, -CH=CH-CH₃), 1.06 (d, *J* = 6.8 Hz, 3H, CH(CH₃)). ¹³C NMR (CDCl₃) δ 138.0 (Ipso), 132.5 (CH=CH-CH₃); 128.4 (meta); 127.7 (ortho and para); 124.4 (CH=CH-CH₃); 74.2 (-CH-OH); 73.3 (C₆H₅CH₂O-); 73.0 (BnOCH₂-); 34.7 (-CH-CH₃); 17.0 (CH-CH₃); 13.1 (CH=CH-CH₃). IR (neat, cm⁻¹): 3456 (OH), 3006-3061 (C-H arom.), 1654 (C=C), 1103 (C-O), 1025 (C-O), 734 and 697 (oop mono). HRMS-FAB (*m/z*): [M + H]⁺ calcd for C₁₄H₂₁O₂: 221.1542; found, 221.1539.

(2*R,3*S**,4*Z*)-3-methyl-1-[(2-trimethylsilyl)ethoxymethoxy]-4-hexen-2-ol (20a)**

Following the general procedure A, Mg powder (0.032 g atom, 0.78 g, 14 equiv), THF (15 mL), *cis*-1-bromopropene (1.2 mL, 13.7 mmol, 6 equiv), CuI (0.044 g, 0.23 mmol, 0.1 equiv) in ether (6 mL) and epoxide **19** (0.50 g, 2.29 mmol) were used. After workup, a crude mixture (5:1 external / internal cleavage) was obtained. This crude was purified by silica gel column chromatography (4: 1) Hexane/EtOAc providing 0.39 g (65%) of the mixture. ¹H NMR (CDCl₃) δ 5.44 (dq, *J* = 10.8, 6.8 Hz, 1H, CH=CHCH₃), 5.16 (m, 1H, CH=CHCH₃), 4.67 (s, 2H, CH₂OCH₂OCH₂), 3.67 (dd, *J* = 10.1, 2.2 Hz, 1H, SEMOCH₂), 3.61 (t, *J* = 8.4 Hz, 2H, CH₂OCH₂OCH₂), 3.47 (ddd, *J* = 10.0, 7.6, 2.2 Hz, 1H, CH₂CH(OH)CH), 3.38 (dd, *J* = 10.1, 7.6 Hz, 1H, SEMOCH₂), 2.70 (s, 1H, OH), 2.59 (m, 1H, CH=CHCH₃), 1.60 (dd, *J* = 6.8, 1.7 Hz, 3H, CH=CHCH₃), 1.05 (d, *J* = 6.7 Hz, 3H, CH(CH₃)CH=CHCH₃), 0.93 (t, *J* = 8.4 Hz, 2H, TMSCH₂CH₂), 0.00 (s, 9H, Si(CH₃)₃). ¹³C NMR (CDCl₃) δ 132.5 (CH=CHCH₃), 124.4 (CH=CHCH₃), 95.5 (CH₂OCH₂OCH₂), 72.0 (CH₂OCH₂OCH₂), 71.7 (CH₂CH(OH)), 65.2 (CH₂CH(OH)), 34.7 (CH(CH₃)CH=CHCH₃), 18.0 (TMSCH₂CH₂), 17.0 (CH(CH₃)CH=CHCH₃), 13.0 (CH=CHCH₃), -1.5 ((CH₃)₃Si). IR (neat, cm⁻¹): 3461 (OH), 3008 (=CH), 2953-2875 (CH), 1058, 1026 (C-O), 833 (Si-C), 724 (HC=CH). Anal. Calcd for C₁₃H₂₈O₃Si: C, 59.95; H, 10.84. Found: C, 59.85; H, 10.94.

(2*R,3*S**)-2-[(*Z*)-1-propenyl]-4-[(triisopropylsilyl)oxy]-1,3-butanediol (22)**

Following the general procedure A, Mg powder (0.005 g atom, 0.136 g, 14 eq.), THF (2.5 mL), *cis*-1-bromopropene (0.19 mL, 2.35 mmol, 6 equiv), CuI (0.95 g, 0.50 mmol, 1.3 equiv) in ether (12.5 mL), and epoxide **21** (0.10 g, 0.39

mmol) were used. After workup and flash chromatography (Alumina, 4 : 1 Hexane/EtOAc), 0.84 g (85%) of pure product was obtained. ^1H NMR (CDCl_3) δ 5.63 (dq, J = 11.4, 6.9, 0.42 Hz, 1H, $\text{CH}=\text{CHCH}_3$), 5.10 (m, 1H, $\text{CH}=\text{CHCH}_3$), 3.80 (dd, J = 9.4, 6.7 Hz, 1H, $(\text{CH}(\text{CH}_2\text{OH}))$), 3.73 (dd, J = 9.4, 3.2 Hz, 1H, TIPSOCH_2), 3.66 (ddd, J = 9.6, 6.7, 3.2 Hz, 1H, $\text{CH}_2\text{CH}(\text{OH})$), 3.57 (dd, J = 10.9, 4.8 Hz, 1H, $(\text{CH}(\text{CH}_2\text{OH}))$), 3.50 (dd, J = 9.4, 6.7 Hz, 1H, TIPSOCH_2), 2.90 (s, 2H, OH), 2.73 (m, 1H, $\text{CHCH}=\text{CHCH}_3$), 1.65 (dd, J = 6.9, 1.8 Hz, 3H, $\text{CH}=\text{CHCH}_3$), 1.05 (21H, $((\text{CH}_3)_2\text{CH})_3\text{Si}$). ^{13}C NMR (CDCl_3) δ 128.8 ($\text{CH}=\text{CHCH}_3$), 126.6 ($\text{CH}=\text{CHCH}_3$), 75.4 ($\text{CH}_2\text{CH}(\text{OH})$), 65.8 ($\text{OCH}_2\text{CH}(\text{OH})$), 65.9 ($\text{CH}(\text{CH}_2\text{OH})$), 41.9 ($\text{CHCH}=\text{CHCH}_3$), 17.9 ($((\text{CH}_3)_2\text{CH})_3\text{Si}$), 13.5 ($\text{CH}=\text{CHCH}_3$), 11.8 ($((\text{CH}_3)_2\text{CH})_3\text{Si}$). IR (neat, cm^{-1}) 3372 (OH), 2941-2865 (CH), 1659 ($=\text{C}$), 1064, 1013 (C-O), 881 (Si-C), 680 ($\text{CH}=\text{CH}$). Anal. Calcd for $\text{C}_{16}\text{H}_{34}\text{O}_3\text{Si}$: C, 63.52; H, 11.33. Found C, 63.19; H, 11.34.

(2*R,3*S**,4*S**,5*R**,6*Z*) 2,4-bis[(triethylsilyl)oxy]-3,5-dimethyl-1-[(triisopropylsilyl)oxy]-6-octene (23-diTES)**

Following the general procedure A, Mg powder (0.009 g atom, 0.23 g, 14 equiv), THF (4 mL), *cis*-1-bromopropene (4.0 mmol, 0.34 mL, 6 equiv), CuI (0.07 mmol, 0.013 g, 0.1 equiv) in ether (1.7 mL), and epoxide **1** (0.66 mmol, 0.2 g) were used. After workup, 0.17 g (74%) of crude product was obtained. The product partially decomposed during silica gel chromatography. To avoid the decomposition and to characterize the product, the crude was submitted to a protection of the diol as follows: The crude was diluted in dry DMF and transferred to a dry round bottom flask. The mixture was cooled to 0 °C and DIEA (1.1 mmol, 0.19 mL) was added. After 30 min, TESOTf (1.0 mmol, 0.23 mL) was added. The reaction was quenched after 10 min with 2 mL of water and diluted with ether (4 mL). The aqueous phase was extracted with ether (2 x 2 mL). The combined organic phase was dried over MgSO_4 and the solvent removed at reduced pressure to produce 0.19 g (68%) of the product. The product was purified by silica gel column chromatography (100:1, hexane : ethyl acetate). ^1H NMR (CDCl_3) δ 5.37 (m, 2H, $\text{CH}=\text{CH}$), 3.94 (ddd, J = 8.5, 7.0, 5.5 Hz, 1H, $\text{TIPSOCH}_2\text{CH}(\text{OTES})$), 3.65 (dd, J = 11.7, 5.5 Hz, 1H, TIPSOCH_2), 3.64 (dd, J = 8.0, 4.1 Hz, 1H, $\text{CH}(\text{CH}_3)-\text{CH}(\text{OTES})\text{CH}(\text{CH}_3)$), 3.60 (dd, J = 11.7, 8.5 Hz, 1H, TIPSOCH_2), 2.66 (qdd, J = 9.2, 8.0, 6.8 Hz, 1H, $-\text{CH}(\text{CH}_3)-\text{CH}=\text{CH}$), 1.86 (qdd, J = 7.0, 7.0, 4.1 Hz, 1H, $-\text{CH}(\text{OTES})-\text{CH}(\text{CH}_3)-\text{CH}(\text{OTES})$), 1.61 (d, J = 5.2 Hz, 3H, $\text{CH}=\text{CH}-\text{CH}_3$), 1.07 (m, 21 H, $(\text{CH}_3)_3\text{CHSiO}-$), 0.96 and 0.95 (t, J = 8 Hz, 18 H, $(\text{OSiCH}_2\text{CH}_3)$), 0.92 (d, J = 6.8 Hz, 3H, $\text{CH}(\text{CH}_3)-\text{CH}(\text{OTES})\text{CH}(\text{CH}_3)$), 0.85 (d, J = 7.0 Hz, 3H, $\text{CH}(\text{CH}_3)-\text{CH}(\text{OTES})\text{CH}(\text{CH}_3)$), 0.61 and 0.58 (q, J = 8 Hz, 12H, $(\text{OSiCH}_2\text{CH}_3)$). ^{13}C NMR (CDCl_3) δ 136.1 ($\text{CH}=\text{CH}$), 122.16 ($\text{CH}=\text{CH}$), 77.2 ($\text{CH}(\text{CH}_3)-\text{CH}(\text{OTES})\text{CH}(\text{CH}_3)$), 73.3 ($\text{TIPSOCH}_2\text{CH}(\text{OTES})$), 66.4 (TIPSOCH_2), 41.2 ($-\text{CH}(\text{OTES})-\text{CH}(\text{CH}_3)-\text{CH}(\text{OTES})$), 34.01 ($-\text{CH}(\text{CH}_3)-\text{CH}=\text{CH}$), 18.0 ($((\text{CH}_3)_3\text{CHSiO})$), 14.8 ($\text{CH}(\text{CH}_3)-\text{CH}=\text{CH}$), 13.0 ($\text{CH}=\text{CH}-\text{CH}_3$), 12.0 ($((\text{CH}_3)_3\text{CHSiO})$), 9.8 ($\text{CH}(\text{OTES})-\text{CH}(\text{CH}_3)-\text{CH}(\text{OTES})$), 7.1 ($\text{CH}_3\text{CH}_2\text{SiO}$), 5.8, 5.6 ($\text{CH}_3\text{CH}_2\text{SiO}$). IR (neat, cm^{-1}) : 2957 – 2879 (CH), 1462 (CH_2), 1378 (CH_3), 1102-1008 (C-O), 881 (Si-O), 682 (oop $\text{CH}=\text{CH}$).

(2*S,3*S**)-3-methyl-1-[(triisopropylsilyl)oxy]-4-penten-2-ol (24)**

Following the general procedure A, Mg powder (0.057 g atom, 1.43 g, 14 equiv), THF (26 mL), vinyl bromide (25 mmol, 1.73 mL, 6 equiv), CuI (5.5 mmol, 1.05 g, 1.3 equiv), and epoxide **15** (4.1 mmol, 1.0 g) in ether (138 mL) were used. After workup and column chromatography (4:1 hexane/ethyl acetate), 0.81 g (73%) of pure product was obtained. ^1H NMR (CDCl_3) δ 5.86 (ddd, J = 17.0, 10.0, 7.0 Hz, 1H, $-\text{CH}=\text{CH}_2$), 5.07 (dd, J = 17, 1.7 Hz, 1H, $\text{CH}=\text{CH}_2$), 5.02 (dd, J = 10.0, 1.7 Hz, 1H, $-\text{CH}=\text{CH}_2$), 3.72 (dd, J = 9.2, 3.1 Hz, 1H, $\text{TIPSO}-\text{CH}_2-$), 3.55 (m, 2H, $\text{TIPSO}-\text{CH}_2-\text{CH}(\text{OH})-$), 2.53 (s, 1H, alcohol), 2.32 (qdd, J = 12.6, 7.0, 6.7 Hz, 1H, $-\text{CH}(\text{CH}_3)-$), 1.06 (m, 21H, $((\text{CH}_3)_2\text{CH})_3\text{SiO}-$), 1.04 (d, J = 6.7 Hz, 3H, $-\text{CH}(\text{CH}_3)-$). ^{13}C NMR (CDCl_3) δ 140.4 ($-\text{CH}=\text{CH}_2$), 114.9 ($-\text{CH}=\text{CH}_2$), 74.9 ($-\text{CH}(\text{OH})-$), 65.5 ($\text{TIPSO}-\text{CH}_2-$), 40.3 ($-\text{CH}(\text{CH}_3)-$), 17.9 ($((\text{CH}_3)_2\text{CH})_3\text{SiO}-$), 16.1 ($-\text{CH}(\text{CH}_3)-$), 12.1 ($((\text{CH}_3)_2\text{CH})_3\text{SiO}-$). HRMS-FAB (m/z): $[\text{M} + \text{H}]^+$ calcd for $\text{C}_{15}\text{H}_{33}\text{O}_2\text{Si}$, 273.2250; found, 273.2252. Anal. Calcd for

C₁₅H₃₂O₂Si: C, 66.11; H, 11.84. Found: C, 66.07; H, 11.81.

(2R*,3S*,4S*,5R*)-4-hydroxy-3,5-dimethyl-6-trimethylsilyl-2-methoxy-1-[(triisopropylsilyl)oxy]-6-heptene (25)

Following the general procedure A, Mg powder (0.46 g, 0.019 g atom, 15 equiv), THF (8 mL), 1-bromovinyl-1-trimethylsilane (1.2 mL, 10.86 mmol, 8 equiv), CuI (0.313 g, 1.64 mmol, 1.3 equiv) in ether, and epoxide **3** were used. After workup and flash chromatography (12:1 hexane / EtOAc), 0.395 g (75%) of pure product was obtained. ¹H NMR (CDCl₃) δ 5.70 (dd, *J* = 2.4, 1.0 Hz, 1H, C(TMS)=CH₂), 5.50 (d, *J* = 2.4 Hz, 1H, C(TMS)=CH₂), 3.85 (dd, *J* = 9.6, 6.3 Hz, 1H, TIPSOCH₂), 3.72 (ddd, *J* = 6.3, 5.3, 2.2 Hz, 1H, TIPSOCH₂CH(OCH₃)), 3.63 (dd, *J* = 9.6, 5.3 Hz, 1H, TIPSOCH₂), 3.52 (dd, *J* = 5.3, 4.1 Hz, 1H, CH(CH₃)CH(OH)CH(CH₃)), 3.49 (s, 3H, OCH₃), 2.70 (s, 1H, OH), 2.59 (m, 1H, CH(CH₃)C(TMS)=CH₂), 1.86 (m, 1H, CH(CH₃)CH(OH)CH(CH₃)), 1.05 (m, 21H, [(CH₃)₂CH]₃Si), 1.04 (d, *J* = 6.6 Hz, CH(CH₃)CH(OH)CH(CH₃)), 0.91 (d, *J* = 7.1 Hz, 1H, CH(CH₃)C(TMS)=CH₂), 0.11 (s, 9H, TMS). ¹³C NMR (CDCl₃) δ 155.6 (C(TMS)=CH₂), 125.5 (C(TMS)=CH₂), 82.4 (CH₂OCH(OCH₃)), 77.4 (CH(CH₃)CH(OH)CH(CH₃)), 64.4 (TIPSOCH₂), 59.1 (OCH₃), 42.1 (CH(CH₃)C(TMS)=CH₂), 36.1 (CH(CH₃)CH(OH)CH(CH₃)), 18.0 ([CH(CH₃)₂CH]₃Si), 13.5 (CH(CH₃)C(TMS)=CH₂), 11.9 [(CH₃)₂CH]₃Si, 10.9 [CH(CH₃)CH(OH)], -0.6 (TMS).

(2R*,3R*,4R*,5S*,6S*,7R*)-4,6-dimethyl-2-[(Z)-1-propenyl]-5,7-[bis(triethylsilyl)oxy]-8-[(triisopropylsilyl)oxy]-1,3-octanediol (27)

Following the general procedure A, magnesium powder (0.58 g, 23.8 mmol, 14 equiv), 10.6 mL of THF, *cis*-2-bromopropene (0.84 mL, 9.9 mmol, 6 equiv), CuI (0.42 g, 1.35 equiv) in ether (56.0 mL), and epoxide **26** were used. After workup and silica gel flash chromatography (4:1 Hexane:EtOAc), 0.77 g (72 %) of pure product was obtained. ¹H NMR (CDCl₃) δ 5.61 (ddq, *J* = 11.0, 6.9, 0.7 Hz, 1H, -CH=CHCH₃), 5.19 (ddq, *J* = 11.0, 9.8, 1.0 Hz, 1H, -CH=CHCH₃), 4.11 (dd, *J* = 6.5, 1.4 Hz, 1H, -(TESO)CH[CH(CH₃)CH₂OTIPS]), 3.77 (dd, *J* = 10.7, 7.4 Hz, 1H, -CH₂OH), 3.68 (ddd, *J* = 8.5, 4.6, 1.0 Hz, 1H, -(TESO)CH[CH(CH₃)CH₂OTIPS]), 3.62 (dd, *J* = 10.7, 8.5 Hz, 1H, -CH₂OH), 3.61 (dd, *J* = 9.1, 8.5 Hz, 1H, -CH₂OTIPS), 3.60 (dd, *J* = 8.5, 4.5 Hz, 1H, -CH(OH)CH[CH(CH₃)CH₂OH]), 3.47 (dd, *J* = 9.1, 4.6 Hz, 1H, -CH₂OTIPS), 2.84 (dddd, *J* = 9.8, 8.5, 7.4, 4.5, 0.7 Hz, 1H, -(CH(OH)CH[CH(CH₃)CH₂OH])), 2.23 (ddq, *J* = 6.9, 6.5, 1.0 Hz, 1H, -(TESO)CHCH[CH(CH₃)CH(OTES)]), 1.92 (ddq, *J* = 8.5, 6.9, 1.4 Hz, 1H, -CH(CH₃)CH(OH)CHCH₂OH), 1.70 (dd, *J* = 6.9, 1.0 Hz, 3H, -CH=CHCH₃), 1.06 (m, 21H, -Si(CH₃)₂CH₃), 1.06 (d, *J* = 6.9 Hz, 3H, CH(CH₃)CH(OH)CHCH₂OH), 0.99 and 0.94 (t, *J* = 8.0 Hz, 18 H, -OSi(CH₂CH₃)₃), 0.89 (d, *J* = 6.9 Hz, 3H, -(TESO)CHCH[CH(CH₃)CH(OTES)]), 0.70 and 0.58 (q, *J* = 8.0 Hz, 12H, -OSi(CH₂CH₃)₃). ¹³C NMR (CDCl₃) δ 128.2 (-CH=CHCH₃), 126.7 (-CH=CHCH₃), 82.5 (-CH(OH)CHCH₂OH), 76.2 ((TESO)CH[CH(CH₃)CH₂OTIPS]), 73.3 (TESOCH[CH(CH₃)CH₂OTIPS]), 66.4 (-CHCH₂OH), 64.5 (-CH₂OTIPS), 42.9 (-CHCH₂OH), 39.6 (-TESO)CHCH[CH(CH₃)CH(OTES)], 38.2 (-CH(CH₃)CH(OH)CHCH₂OH), 17.9 (-Si(CH₃)₂CH₃), 13.5 and 13.6 (-CH=CHCH₃ and -CH(CH₃)CH(OH)CHCH₂OH), 11.9 (-Si(CH₃)₂CH₃), 7.60 (-TESO)CHCH[CH(CH₃)CH(OTES)], 7.0 (-OSi(CH₂CH₃)₃), 5.7 and 5.4 (-OSi(CH₂CH₃)₃). IR (neat, cm⁻¹): 3414 (OH), 1653 (w, C=C), 1112-1006 (C-O), 684 (oop *cis*). HRMS-FAB (*m/z*): [M+H-H₂]⁺ calcd for C₃₄H₇₄O₅Si₃, 645.476; found: 645.476.

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