Intramolecular Anti-Hydrosilylation and Silicon-Assisted Cross-Coupling: Highly Regio- and Stereoselective Synthesis of Trisubstituted Homoallylic Alcohols

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SUPPORTING INFORMATION

All reactions were performed in oven (140 °C) or flame-dried glassware under an inert atmosphere of dry N₂. Solvents, pentane and Et₂O, for extraction and chromatography were technical grade and redistilled. Reaction solvents were distilled from the indicated drying agents: methylene chloride (P₂O₅); diethylether (sodium, benzophenone); hexane (sodium); tetrahydrofuran (THF) (sodium, benzophenone); and toluene (sodium). Flash column chromatography was performed by the method of Still¹, using 230-400 mesh silica gel purchased from EM Science. *n*-Butyllithium was titrated according to the method of Gilman.² Kugelrohr distillations were performed on a Büchi GKR-50 Kugelrohr; boiling points (bp) correspond to uncorrected air-bath temperatures (ABT); Melting points (mp) were performed in sealed tubes and were determined on a Thomas-Hoover capillary melting point apparatus and were uncorrected.

¹H NMR spectra and ¹³C NMR spectra were recorded on a Varian Unity 500 (500 MHz, ¹H; 125.6 MHz, ¹³C) in CDCl₃ (unless otherwise noted). Spectra are referenced to residual chloroform (d 7.26 ppm, ¹H; d 77.23 ppm, ¹³C) unless otherwise specified.

Chemical shifts are reported in ppm (); multiplicities are indicated by s (singlet), d (doublet), t (triplet), q (quartet), qn (quintet), sext (sextet), m (multiplet) and br (broad). Coupling constants, *J*, are reported in Hertz. Mass spectroscopy was performed by the University of Illinois Mass Spectrometer Center. Electron impact (EI) or chemical impact (CI) spectra were performed on a Finnigan-MAT CH-5 spectrometer. Data are reported in the form of *m/z* (intensity relative to base peak = 100). Infrared spectra (IR) were recorded on a Mattson Galaxy 5020 spectrophotometer. Peaks are reported in cm⁻¹ with indicated relative intensities: s (strong, 67-

100%); m (medium, 34-66%); w (weak, 0-33%). Elemental analyses were performed by the University of Illinois Microanalytical Service Laboratory.

Analytical thin-layer chromatography was performed on Merck silica gel plates with QF-254 indicator. Visualization was accomplished with UV light and/or iodine. Analytical capillary gas chromatography (GC) was performed on a Hewlett Packard 5890 Series II gas chromatography fitted with a flame ionization detector (H_2 carrier gas, 1 mL/min). The columns used are specified in each experiment. The detector temperature was 300 °C. Retention times (t_R) and integrated ratios were obtained from Hewlett Packard 3393A integrators.

Most commercial reagents were purified by distillation or recrystallization prior to use. The 1.0 M solution of TBAF in dioxane was prepared as follows: crystalline TBAF $\cdot$ 3H $_2$ O (31.6 g, 100.0 mmol) was placed into a 100.00 mL of dry volumetric flask in dry box and the flask was capped with a rubber septum before it was removed from the dry box; dry dioxane was added through syringe to the volume mark.

Silanes **1a** and **1b** were prepared following the literature procedure from the corresponding alkynols.³ [RuCl $_2$ (benzene)] $_2$ was prepared following the literature procedure.⁴ 1-Bromo-4-*tert*-butyl-1-cyclohexane was prepared following the literature procedure.⁵

Preparation of (Z)-3-Ethyliden-2,2-diisopropyl-1-oxa-2-silacyclopentane (**3a**)

A solution of [RuCl $_2$ (C $_6$ H $_6$)] $_2$ (63 mg, 0.12 mmol, 0.063 equiv) in dry dichloromethane (19 mL) was placed into a flask equipped with a condenser, which was affixed with an Y-adaptor fitted with a rubber septum and a gas inlet tube. The catalyst was heated to reflux for 10 min. To the refluxing solution was added a solution of silane **1a** (396 mg, 2.0 mmol) in 1.0 mL of dry dichloromethane by syringe pump over 60 min. The reaction mixture gradually turned red. The solvent was then evaporated *in vacuo* and pentane (20 mL) was then added to precipitate the Ru catalyst. The supernatant was carefully decanted and the residue was extracted with pentane (2 x 10 mL) and 10 mL of pentane/ether, 9/1. The combined organic extracts were filtered through SiO $_2$ (0.3 g). Removal of solvent afforded 0.33 g of a pale yellow oil. Kugelrohr distillation of this oil afforded 290 mg (71%) of **3a** as a colorless oil.

Data for 3a:bp: 50 °C (0.3 mmHg)¹H NMR: (500 MHz, CDCl₃)6.31 (qt, *J* = 2.4, 6.6, 1 H, HC(6)); 3.94 (t, *J* = 6.6, H₂C(5), 2 H); 2.52-2.49 (m, 2 H, H₂C(4)); 1.77 (dt, *J* = 2.0, 6.6, 3 H, H₃C(7)); 1.16-1.13 (m, 2 H, HC(8)); 1.08 (distorted d, *J* = 6.6, 6 H, H₃C(9)); 1.03 (distorted d, *J* = 6.6, 6 H, H₃C(9'))¹³C NMR: (125.6 MHz, CDCl₃)

136.93 (C(3)), 133.92 (C(6)), 67.26 (C(5)), 38.35 (C(4)), 20.88 (C(8)), (17.70/17.49 (C(9)/C(9')), 12.96 (C(7))

IR: (neat)

3014 (m), 3010 (m), 3001 (s), 2943 (s), 2868 (s), 1649 (m), 1464 (m), 1448 (m), 1429 (m), 1244 (w), 1059 (m), 1028 (s), 995 (s), 881 (s)

MS: (EI, 70 eV)198 (M⁺, 10), 173 (15), 155 (100), 127 (60), 105 (26), 77 (45)TLC: *R_f* 0.63 (pentane/ether, 4/1, SiO₂)GC: *t_R* **3a**, 7.75 min (99.1%). (Ultra-2, injector 225 °C, column 150 °C, 15 psi).HRMS: calcd for C₁₁H₂₂OSi: 198.1440; found: 198.1443**Preparation of (Z)-3-Pentyliden-2,2-dimethyl-1-oxa-2-silacyclopentane (3b)**

A solution of [RuCl₂(C₆H₆)]₂ (400 mg, 0.80 mmol, 0.080 equiv) in dry dichloromethane (100 mL) was placed into a flask equipped with a condenser, which was affixed with an Y-adaptor fitted with a rubber septum and a gas inlet tube. The catalyst was heated to reflux for 10 min. To the reflux solution was added silane **1b** (from 1.26 g of alcohol 10.0 mmol) in 4.0 mL of dry dichloromethane by syringe pump over 150 min. The reaction mixture gradually turned red. The solvent was then evaporated *in vacuo* and hexane (100 mL) was then added to precipitate the ruthenium catalyst, which was removed by filtration. The filtrate was then passed through charcoal to remove final traces of ruthenium. After removal of solvent, an yellow oil was obtained (1.63 g, 8.86 mmol, 86%) which was used directly without further purification.

General Procedure for Coupling of Oxasilacyclopentanes

In a two-necked flask fitted with a rubber septum and gas inlet tube, was placed a solution of oxasilacyclopentane, **3b** and tetrabutylammonium fluoride (1.0 M in dioxane), at ambient temperature under nitrogen. The electrophile (1.0 equiv) was added portionwise or in one portion as specified below. The palladium catalyst (5 mol% of Pd) was added in one portion to the mixture following the first portion of electrophile and the mixture was stirred at designated temperature for a designated period of time. The reaction mixture was purified with a specified amount of silica gel as indicated below by column chromatography. The products were further purified by Kugelrohr distillation and/or sublimation.

Preparation of (Z)-3-Phenyl-3-octen-1-ol (**6a**)

Following the General Procedure, **3b** (250 mg, 1.35 mmol, 1.35 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 2.0 mL, 2.0 mmol, 2.0 equiv) and the mixture was stirred at rt for 10 min. Iodobenzene (204 mg, 1.0 mmol) was added in one portion and Pd(dba)₂ (29.0 mg, 0.050 mmol, 0.050 equiv) was then added. The mixture was stirred at 45 °C for 490 min. The solvent was removed in vacuo and the residue was then loaded onto 2 g of silica gel and was purified by column chromatography (10 g SiO₂, pentane/ether, 1/0 20/1 10/1). Removal of the solvent and Kugelrohr distillation of the resulting yellow oil afforded 133 mg (65%) of **6a** as a colorless oil.

Data for **6a**:

bp: 115 °C (ABT 0.1 mmHg)

¹H NMR: (500 MHz, CDCl₃)

7.38-7.34 (m, 2 H); 7.30-7.26 (m, 1 H, HC(4')); 7.18-7.16 (m, 2 H); 5.58 (t, *J* = 7.3, 1 H, HC(4),); 3.58 (q, *J* = 6.1, 2 H, H₂C(1)); 2.63 (dt, *J* = 0.8, 6.1, 2 H, H₂C(2)); 1.99 (q, *J* = 7.1, 2 H, H₂C(5)), 1.38 (t, *J* = 6.1, 1 H, OH); 1.36-1.24 (m, 4 H, H₂C(6), H₂C(7)); 0.84 (t, *J* = 7.3, H₃C(8), 3 H); minor isomer: 5.40 (t, 4.7%)

¹³C NMR: (125.6 MHz, CDCl₃)

140.57, 137.20, 131.08, 128.68, 128.44, 126.97, 60.78 (C(1)), 42.68, 32.44, 28.91, 22.53, 14.19 (C(8))

IR: (CHCl₃)

3622 (w), 3012 (m), 2970 (s), 2929 (s), 2873 (m), 2858 (m), 1610 (w), 1493 (m), 1466 (m), 1390 (w), 1379 (w), 1230 (w), 1041 (s), 908 (s)

MS: (EI, 70 eV)

204 (M⁺, 43), 159 (45), 143 (100), 128 (41), 117 (62), 105 (17), 91 (46), 77 (13)

TLC: *R_f* 0.60 (Et₂O, SiO₂)

GC: *t_R* **6a**, 6.59 min (Ultra-2, injector 225 °C, detector 300 °C, column 180 °C, 15 psi)

HRMS: calcd for C₁₄H₂₀O: 204.1514; found: 204.1515

Preparation of (Z)-3-(2-Methoxyphenyl)-3-octen-1-ol (**6b**)

Following the General Procedure, **3b** (235 mg, 1.28 mmol, 1.28 equiv) was dissolved in a solution of TBAF in dioxane (1.0 M, 1.0 mL, 1.0 mmol, 1.0 equiv) and the mixture was stirred at rt for 10 min. 2-Iodoanisole (235 mg, 1.0 mmol) was added followed by Pd(dba)₂ (26 mg, 0.045 mmol, 0.045 equiv). The mixture was stirred at rt for 90 min before another portion of TBAF in dioxane (1.0 M, 0.50 mL, 0.50 mmol, 0.50 equiv) was added and the mixture was stirred at rt for another 27 h then it was stirred at 35 °C for 21 h. After evaporation of solvent, the residue was then loaded onto 4 g of silica gel and was purified by column chromatography (30 g SiO₂, pentane/ether, 1/0 20/1 10/1). Removal of the solvent and Kugelrohr distillation of the resulting oil afforded 160 mg (68%) of **6b** as a colorless oil.

Data for 6b:

bp: 135 °C (ABT, 0.15 mmHg)

¹H NMR: (500 MHz, CDCl₃)
7.28 (ddd, $J = 1.9, 7.3, 8.1$, 1 H, HC(4'/5')); 7.03 (dd, $J = 1.9, 7.3$, 1 H, HC(3'/6'));
6.98 (dt, $J = 1.0, 8.1$, 1 H, HC(5'/4')), 6.92 (br d, $J = 8.1$, 1 H, HC(6'/3')); 5.66 (t, $J = 7.3$, 1 H, HC(4)); 3.82 (s, 3 H, H₃C(7')), 3.48 (t, $J = 5.8$, 2 H, H₂C(1)); 2.56 (br s, 2 H, H₂C(2)); 1.80 (q, $J = 7.3$, 2 H, H₂C(5)); 1.33-1.21 (m, 4 H, H₂C(6), H₂C(7)); 0.82 (t, $J = 7.3$, 3 H, H₃C(8)); minor isomer: 5.55 (t, 4.5%)

¹³C NMR: (125.6 MHz, CDCl₃)
156.63, 133.25, 132.91, 130.34, 129.39, 128.42, 121.11, 110.67, 60.04 (C(1)), 55.61 (C(7')), 42.68 (C(2)), 31.87, 29.09, 22.48, 14.17 (C(8))

IR: (CHCl₃)
3545 (w), 3608 (s), 2960 (s), 2935 (s), 2873 (m), 2838 (m), 1599 (m), 1578 (w),
1491 (s), 1435 (s), 1388 (w), 1292 (m), 1279 (m), 1242 (s), 1180 (m), 1115 (m),
1045 (s)

MS: (EI, 70 eV)
234 (M⁺, 60), 216 (7), 201 (8), 189 (100), 173 (52), 161 (32), 147 (40), 131 (23),
121 (36), 105 (13), 91 (32), 77 (17)

TLC: R_f 0.44 (pentane/ether, 2/3, SiO₂)

GC: t_R **6b**, 4.76 min (97%), minor isomer, 5.15 min (3%) (HP-5, injector 225 °C, detector 300 °C, column 250 °C, 15 psi)

Analysis: C₁₅H₂₂O₂ (234.34)

Calcd.: C, 76.88; H, 9.46%

Found: C, 76.80; H, 9.50%

Preparation of Methyl 2-[1-(2-Hydroxyethyl)-(Z)-1-octenyl]benzoate (**6c**)

Following the General Procedure, **3b** (238 mg, 1.29 mmol, 1.28 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 1.0 mL, 1.0 mmol, 1.0 equiv) and the mixture was stirred at rt for 10 min. Methyl-2-iodobenzoate was added to the warm solution (35 °C) in three portions over 30-minute intervals (90.4 mg, 83.6 mg, 91.0 mg, for a total of 1.01 mmol, 1.0 equiv) and Pd(dba)₂ (24.6 mg, 0.043 mmol, 0.042 equiv) was added following the first portion. The mixture was stirred at 35 °C for another 43 h. After evaporation of the solvent, the residue was then loaded onto 3 g of silica gel and was purified by column chromatography (24 g SiO₂, pentane/ether, 19/1 to 5/1). Removal of the solvent and Kugelrohr distillation of the resulting yellow oil afforded 169 mg (64%) of **6c** as a pale yellow oil.

Data for **6c**:

bp: 160 °C (ABT 0.15 mmHg)

¹H NMR: (500 MHz, CDCl₃)

7.85 (ddd, *J* = 0.5, 1.5, 8.2, 1 H, HC(3'')); 7.51 (dt, *J* = 1.3, 7.4, 1 H, HC(5'')); 7.34 (ddd, *J* = 1.3, 7.4, 8.0, 1 H, HC(4'')); 7.19 (dt, *J* = 0.5, 8.0, 1 H, HC(6'')); 5.56 (t, *J* = 8.0, 1 H, HC(4)); 3.88 (s, 3 H, H₃C(8'')); 3.60-3.50 (m, 3 H, H₂C(2), H(-OH)); 2.67-2.64 (m, 2 H, H₂C(2)); 1.76-1.71 (m, 2 H, H₂(5)); 1.26-1.16 (m, 4 H, H₂C(6), H₂C(7)); 0.78 (t, *J* = 7.3, 3 H, H₃C(8)); minor isomer: 5.37 (t, 3.8%)

¹³C NMR: (125.6 MHz, CDCl₃)

168.92 (C(7'')), 142.03, 135.69, 132.24, 131.15, 130.87, 130.29, 130.12, 126.98, 59.85 (C(1)), 52.70 (C(8'')), 43.60, 31.62, 28.70, 22.39, 14.05 (C(5))

IR: (CHCl₃)

3477 (w), 3008 (m), 2956 (s), 2933 (s), 2873 (m), 2862 (m), 1718 (s), 1597 (w), 1570 (w), 1487 (m), 1458 (m), 1435 (m), 1410 (m), 1379 (s), 1294 (s), 1273 (s), 1259 (s), 1219 (m), 1194 (m), 1130 (m), 1093 (s), 1047 (s), 966 (m)

MS: (EI, 70 eV)

262 (M^+ , 30), 244 (30), 232 (51), 212 (67), 197 (82), 183 (85), 175 (71), 157 (76), 144 (100), 129 (87), 120 (100), 115 (67), 103 (22), 91 (32), 77 (29)

TLC: R_f 0.53 (ether, SiO_2)

GC: t_R **6c**, 7.02 min (94.9%); t_R minor isomer, 7.49 min (5.1%) (HP-5, injector 225 °C, detector 300 °C, column 270 °C, 15 psi)

Analysis: $C_{16}H_{22}O_2$ (262.35)

Calculated: C, 73.25; H, 8.45

Found: C, 73.20; H, 8.79

Preparation of (Z)-3-(2-Nitrophenyl)-3-octen-1-ol (**6d**)

Following the General Procedure, **3b** (265 mg, 1.44 mmol, 1.4 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 1.0 mL, 1.0 mmol, 1.0 equiv) and the mixture was stirred at rt for 10 min. 2-Iodonitrobenzene (249 mg, 1.0 mmol) was added in one portion and $Pd(dba)_2$ (28.0 mg, 0.053 mmol, 0.050 equiv) was then added. The mixture was stirred at rt for 15 h. Then, an additional 0.25 mL of TBAF (0.25 mmol) was added and stirring continued for another 7 h. The mixture was then heated at 40 °C for 24 h before another portion of TBAF (0.25 mL, 0.25 mmol, 0.25 equiv) was added. The heating was continued for another 23 h. After evaporation of the solvent, the residue was loaded onto 3 g of silica gel and was purified by column chromatography (32 g SiO_2 , pentane/ether, 9/1 to 1/1). Removal of the solvent and Kugelrohr distillation of the resulting yellow oil afforded 166 mg (66%) of **6d** as a yellow oil.

Data for **6d**:bp: 170 °C (ABT 0.1 mmHg)¹H NMR: (500 MHz, CDCl₃)

7.96 (dd, $J = 1.2, 8.0$, 1 H, HC(3')); 7.62 (dt, $J = 1.5, 7.6$, 1 H, HC(5')); 7.46 (ddd, $J = 1.5, 7.6, 8.0$, 1 H, HC(4')); 7.28 (dd, $J = 1.2, 7.6$, 1 H, HC(6')); 5.64 (t, $J = 7.3$, 1 H, HC(4)); 3.70-3.66 (m, 2 H); 2.68-2.66 (m, 2 H); 1.88 (t, $J = 7.3$, 1 H, -OH); 1.76-1.73 (m, 2 H), 1.28-1.19 (m, 4 H), 0.80 (t, $J = 7.3$, 3 H, H₃C(8)); minor isomer: 5.50 (t, 3.8%)

¹³C NMR: (125.6 MHz, CDCl₃)

149.36, 135.96 (2 C), 133.16, 132.38, 131.73, 128.27, 124.65, 60.51 (C(1)), 42.16 (C(2)), 31.66, 29.10, 22.40, 14.50 (C(8))

IR: (CHCl₃)

3616 (w), 3010 (w), 2960 (m), 2931 (m), 2873 (m), 2862 (m), 1608 (w), 1572 (w), 1527 (s), 1466 (w), 1354 (s), 1051 (m)

MS: (EI, 70 eV)

249 (M⁺, 1), 232 (5), 214 (10), 202 (12), 176 (36), 160 (30), 146 (32), 130 (37), 120 (100), 104 (37), 91 (30), 77 (35)

TLC: R_f 0.41 (ether, SiO₂)HRMS: calcd for C₁₄H₁₉NO₃: 249.1365; found: 249.1362

GC: t_R **6d**, 12.36 min (100%) (Ultra-2, injector 225 °C, detector 300 °C, column 220 °C, 15 psi)

Analysis: C₁₄H₁₉NO₃ (249.31)

Calculated: C, 67.45; H, 7.68; N, 5.62%

Found: C, 67.12; H, 7.79; N, 5.55%

Preparation of (Z)-3-(3-Hydroxymethylphenyl)-3-octen-1-ol (6e)

Following the General Procedure, **3b** (250 mg, 1.39 mmol, 1.2 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 2.16 mL, 2.16 mmol, 2.0 equiv) and the mixture was stirred at

rt for 10 min. 3-Iodobenzyl alcohol (252 mg, 1.08 mmol) was added followed by Pd(dba)₂ (29.2 mg, 0.051 mmol, 0.047 equiv). The mixture was stirred at rt for a total of 13.5 h and at 45 °C for 33 h. After evaporation of the solvent, the residue was loaded onto 2 g of silica gel and was purified by column chromatography (15 g SiO₂, pentane/ether, 1/0 → 1/1 → 0/1). Removal of the solvent and Kugelrohr distillation of the resulting oil afforded 148 mg (59%) of **6e** as a colorless oil.

Data for 6e:

bp: 185 °C (ABT 0.1 mmHg)

¹H NMR: (500 MHz, CDCl₃)

7.34 (distorted t, *J* = 7.6, 1 H, HC(2')); 7.27 (distorted d, *J* = 7.6, 1 H, HC(4'/6')); 7.17 (s, 1 H, HC(2')); 7.09 (distorted d, *J* = 7.6, 1 H, HC(6'/4')); 5.57 (t, *J* = 7.1, 1 H, HC(4)); 4.70 (s, 2 H, H₂C(7)); 3.55 (t, *J* = 6.3, 2 H, H₂C(1)); 2.62 (t, *J* = 6.3, 2 H, H₂C(2)); 2.12 (br s, OH, 1 H); 1.97 (q, *J* = 7.3, 2 H, H₂C(5)); 1.60 (br s, 1 H, OH); 1.36-1.22 (m, 4 H, H₂C(6), H₂C(7)); 0.83 (t, *J* = 7.3, 3 H, H₃C(8)); minor isomer: 5.82 (t, 1.6%)

¹³C NMR: (125.6 MHz, CDCl₃)

141.09, 140.80, 137.02, 131.15, 128.65, 128.03, 127.18, 125.61, 65.50 (C(7')), 60.82 (C(1)), 42.60 (C(2)), 32.41 (C(2)), 28.94, 22.51, 14.58 (C(8))

IR: (CHCl₃)

3610 (m), 3012 (s), 2958 (s), 2929 (s), 2875 (m), 2860 (m), 1603 (w), 1466 (m), 1381 (m), 1234 (m), 1184 (m), 1039 (s)

MS: (EI, 70 eV)

234 (M⁺, 24), 216 (73), 185 (27), 173 (83), 159 (60), 143 (100), 129 (70), 117 (87), 105 (22), 91 (57), 77 (23)

TLC: *R_f* 0.30 (ether, SiO₂)

GC: *t_R* **6e**, 12.62 min (100%) (Ultra-2, injector 225 °C, detector 300 °C, column 220 °C, 15 psi)

HRMS: calcd for C₁₅H₂₂O₂: 234.1620; found: 234.1628

Preparation of (Z)-3-(4-Methoxyphenyl)-3-octen-1-ol (6f)

Following the General Procedure, **3b** (250 mg, 1.36 mmol, 1.1 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 1.0 mL, 1.0 mmol, 1.0 equiv) and the mixture was stirred at rt for 10 min. 4-Iodoanisole (235 mg, 1.0 mmol) was added followed by Pd(dba)₂ (27 mg, 0.047 mmol, 0.047 equiv). The mixture was stirred at rt for 30 min before another portion of TBAF in dioxane was added (1.0 mL, 1.0 mmol, 1.0 equiv). The stirring was continued at rt for 40.5 h and mixture was then loaded onto 3 g of silica gel and was purified by column chromatography (35 g SiO₂, pentane/ether, 1/0 → 9/1). Removal of the solvent and Kugelrohr distillation of the resulting oil afforded 141 mg (60%) of **6f** as a colorless oil.

Data for 6f:

bp: 130 °C (ABT 0.10 mmHg)

¹H NMR: (500 MHz, CDCl₃)

7.10 (dt, *J* = 2.2, 8.8, 2 H, HC(2')); 6.90 (dt, *J* = 2.2, 8.8, 2 H, HC(3')); 5.54 (t, *J* = 6.9, HC(4), 1 H); 3.83 (s, 3 H, H₃C(5')); 3.56 (t, *J* = 6.3, 2 H, H₂C(1)); 2.60 (t, *J* = 6.3, 2 H, H₂C(2)); 1.99 (q, *J* = 7.3, 2 H, H₂C(5)); 1.60 (br s, 1 H, OH); 1.36-1.25 (m, 4 H, H₂C(6), H₂C(7)); 0.85 (t, *J* = 7.3, 3 H, H₃C(8)); minor isomer: 6.69 (t, 0.7%)

¹³C NMR: (125.6 MHz, CDCl₃)

158.53, 136.68, 132.76, 130.71, 129.75, 113.81, 60.87 (C(1)), 55.43 (C(5')), 42.76 (C(2)), 32.51, 28.96, 22.55, 14.52 (C(8))

IR: (CHCl₃)

3616 (w), 3010 (m), 2960 (s), 2937 (m), 2873 (m), 2858 (m), 2839 (m), 1608 (m), 1512 (s), 1466 (m), 1442 (w), 1379 (w), 1288 (m), 1246 (s), 1176 (m), 1036 (s), 837(m)

MS: (EI, 70 eV)

192 (M⁺, 100), 147 (99), 135 (45), 121 (55), 91 (42), 77 (47)

HRMS: calcd for C₁₅H₂₂O₂: 234.1620; found: 234.1620

TLC: R_f 0.50 (ether, 2/3, SiO₂)

GC: t_R **6f**, 9.92 min (100%) (Ultra-2, injector 225 °C, detector 300 °C, column 270 °C, 15 psi)

Analysis: C₁₅H₂₂O₂ (234.34)

Calculated: C, 76.88; H, 9.46%

Found: C, 76.50; H, 9.32%

Preparation of 1-[(4-[1-(2-Hydroxyethyl)-(Z)-1-hexenyl)]phenyl]ethanone (6g**)**

Following the General Procedure, **3b** (235 mg, 1.28 mmol, 1.28 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 1.5 mL, 1.5 mmol, 1.5 equiv) and the mixture was stirred at rt for 10 min. 4-Iodoacetophenone (249 mg, 1.01 mmol) was added in two portions over 33-min intervals and Pd(dba)₂ (24.5 mg, 0.043 mmol, 0.042 equiv) was added following the first portion of iodide. The mixture was stirred at rt for a total of 46 h. The crude mixture was then loaded onto 5 g of silica gel and was purified by column chromatography (40 g SiO₂, pentane/ether, 9/1 7/1 4/1 3/1). Removal of the solvent and Kugelrohr distillation of the resulting oil afforded 164 mg (66%) of **6g** as a colorless oil.

Data for 6g:

bp: 175°C (ABT 0.20 mmHg)

¹H NMR: (500 MHz, CDCl₃)

7.94 (dt, $J = 1.9, 8.4$, 2 H, HC(3')); 7.26 (br d, $J = 1.9, 8.6$, 2 H, HC(2')); 5.62 (t, $J = 7.5$, 1 H, HC(4)); 3.56 (t, $J = 6.4$, 2 H, H₂C(1)); 2.64-2.61 (m, 2 H, H₂C(2)); 2.61 (s, 3 H, H₃C(6')), 1.96 (q, $J = 7.5$, 2 H, H₃C(5)); 1.62 (br s, 1 H, -OH); 1.33-1.32 (m, 4 H, HC(6), HC(7)), 0.82 (t, $J = 7.3$, 3 H, H₃C(8)); minor isomer: 5.95 (t, 2.8%)

¹³C NMR: (125.6 MHz, CDCl₃)
 198.15 (C(5')), 146.07, 136.46, 135.80, 131.96, 128.98, 128.60, 61.79 (C(1)), 42.24 (C(2)), 32.25, 28.93, 26.81, 22.46, 14.10 (C(8))

IR: (CHCl₃)
 3620 (w), 3469 (w), 3010 (s), 2960 (s), 2931 (s), 2873 (m), 2860 (m), 1680 (s), 1558 (w), 1466 (m), 1429 (m), 1379 (m), 1360(s), 1306 (m), 1269 (s), 1182 (m), 1041 (s), 1016 (m), 958 (m), 847 (m), 837 (m)

MS: (EI, 70 eV)
 246 (M⁺, 70), 231 (14), 215 (15), 201 (22), 185 (100), 175 (25), 157 (22), 143 (45), 128 (32), 115 (25), 105 (8), 84 (47)

TLC: *R_f* 0.44 (ether, SiO₂)

GC: *t_R* **6g**, 7.04 min (97.4%); *t_R* minor isomer, 8.73 min (2.6%) (HP-5, injector 225 °C, detector 300 °C, column 270 °C, 15 psi).

Analysis: C₁₆H₂₂O₂ (246.27)
 Calculated: C, 78.01; H, 9.00%
 Found: C, 78.05; H, 9.08%

Preparation of (Z)-3-(4-Nitrophenyl)-3-octen-1-ol (**6h**)

Following the General Procedure, **3b** (250 mg, 1.36 mmol, 1.1 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 2.0 mL, 2.0 mmol, 2.0 equiv) and the mixture was stirred at rt for 10 min. 4-Iodonitrobenzene (252 mg, 1.01 mmol) was added followed by Pd(dba)₂ (29.5 mg, 0.051 mmol, 0.050 equiv). The mixture was stirred at 45 °C for a total of 460 min. The crude mixture was then loaded onto 2 g of silica gel and was purified by column chromatography (10 g SiO₂, pentane/ether, 1/0 → 9/1 → 3/1). The resulting oil was dissolved in 5 mL of pentane/ether (9/1) to crystallize out the homo-coupling product. Removal of the solvent and Kugelrohr distillation of the resulting oil afforded 171 mg (68%) of **6h** as an yellow oil.

Data for 6h:**bp:** 195 °C (ABT 0.1 mmHg)

¹H NMR: (500 MHz, CDCl₃)
 8.19 (d, *J* = 8.3, 2 H, HC(3')); 7.32 (br d, *J* = 8.5, 2 H, HC(2')); 5.66 (t, *J* = 7.4, 1 H, HC(4)); 3.56 (t, *J* = 6.4, 2 H, H₂C(1)); 2.62 (t, *J* = 6.4, 2 H, H₂C(2)); 1.92 (q, *J* = 7.4, 2 H, H₂C(5)); 1.49 (br s, *J* = 4.7, 1 H, OH); 1.33-1.29 (m, 2 H, H₂C(6)); 1.28-1.19 (m, 2 H, H₂C(7)), 0.81 (t, *J* = 7.2, 2 H, H₃C(8)); minor isomer: 5.98 (t, 4.7%)

¹³C NMR: (125.6 MHz, CDCl₃)
 147.98, 146.82, 135.54, 132.74, 129.58, 123.71, 60.99 (C(1)), 41.96, 32.07, 28.82, 22.39, 14.88 (C(8))

IR: (CHCl₃)
 3621 (w), 3026 (w), 3012 (w), 2960 (m), 2931 (m), 2875 (w), 2860 (w), 1597 (m), 1520 (s), 1348 (s), 1108 (m), 1043 (w), 1016 (w), 856 (m)

MS: (EI, 70 eV)
 249 (M⁺, 8), 214 (5), 202 (13), 188 (100), 172 (5), 156 (20), 142 (33), 128 (33), 116 (35)

TLC: *R_f* 0.56 (ether, SiO₂)

GC: *t_R* **6h**, 8.83 min (96.4%); *t_R* a minor isomer, 10.41 min (3.6%) (HP-5, injector 225 °C, detector 300 °C, column 270 °C, 15 psi)

Analysis: C₁₄H₁₉NO₃ (249.31)
 Calculated: C, 67.45; H, 7.68; N, 5.62%
 Found: C, 67.19; H, 7.76; N, 5.74%

Preparation of 4-[1-(2-Hydroxyethyl)-(Z)-1-hexenyl]benzonitrile (6i)

Following the General Procedure, **3b** (250 mg, 1.36 mmol, 1.36 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 2.0 mL, 2.0 mmol, 2.0 equiv) and the mixture was stirred at rt for 10 min. 4-Iodobenzonitrile (229 mg, 1.00 mmol) was added in one portion and Pd(dba)₂ (26

mg, 0.050 mmol, 0.050 equiv) was added. The mixture was stirred at rt for a total of 25.5 h. The crude mixture was then loaded onto 2 g of silica gel and was purified by column chromatography (SiO₂, pentane/ether, 1/0 10/1 5/1 3/1). Removal of the solvent and Kugelrohr distillation of the resulting product afforded 147 mg (64%) of **6i** as a colorless oil.

Data for **6i**:

bp: 130 °C (ABT 0.003 mmHg)

¹H NMR: (500 MHz, CDCl₃)

7.65 (d, *J* = 8.1, 2 H, HC(3')); 7.29 (d, *J* = 8.1, 2 H, HC(2')); 5.65 (t, *J* = 7.3, 1 H, HC(4)); 3.57 (t, *J* = 6.3, 2 H, H₂C(1)); 2.62 (t, *J* = 6.3, 2 H, H₂C(2)); 1.94 (q, *J* = 7.3, 2 H, H₂C(5)); 1.50 (br s, 1 H, OH), 1.30-1.21 (m, 4 H, H₂C(6), H₂C(7)); 0.83 (t, *J* = 7.3, 3 H, H₃C(8))

¹³C NMR: (125.6 MHz, CDCl₃)

145.94, 135.90, 132.50, 132.32, 129.55, 119.17, 110.76 (-CN), 60.74 (C(1)), 42.04 (C(2)), 32.18 (C(5)), 28.94, 22.46, 14.12 (C(8))

IR: (CHCl₃)

3624 (w), 3030 (w), 3012 (w), 2960 (s), 2930 (s), 2873 (m), 2231 (s), 1606 (m), 1043 (m), 845 (s)

MS: (EI, 70 eV)

229 (M⁺, 13), 204 (7), 182 (20), 168 (100), 154 (24), 142 (31), 130 (16), 116 (27)

TLC: *R_f* 0.09 (ether, SiO₂)

GC: *t_R* **6i**, 12.71 min (100%) (Ultra-2, injector 225 °C, detector 300 °C, column 220 °C, 15 psi)

HRMS: calcd for C₁₅H₁₉NO (229.32): 229.1467; found: 229.1468

Preparation of Ethyl 4-[1-(2-Hydroxyethyl)-(Z)-1-octenyl]benzoate (6j**)**

Following the General Procedure, **3b** (250 mg, 1.36 mmol, 1.1 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 1.0 mL, 1.0 mmol, 1.0 equiv) and the mixture was stirred at rt for 10 min. Ethyl 4-iodobenzoate (277 mg, 1.00 mmol) was added followed by Pd(dba)₂ (29 mg, 0.05 mmol, 0.050 equiv). Another 1.0 mL of TBAF (1.0 mmol, 1.0 equiv) was added to the mixture after it was stirred at rt for 10 min. The mixture was then stirred at 40 °C for a total of 15.5 h, whereupon another 12 mg of **3b** was added. The heating was continued for 4 h, then the crude mixture was loaded onto 2 g of silica gel and was purified by column chromatography (SiO₂, 10 g, pentane/ether, 1/0 19/1 4/1). Removal of the solvent and Kugelrohr distillation of the resulting product afforded 200 mg (72%) of **6j** as a colorless oil.

Data for 6j:

bp: 160 °C (ABT 0.1 mmHg)

¹H NMR: (500 MHz, CDCl₃)

8.03 (dd, *J* = 1.7, 6.6, HC(3'), 2 H); 7.24 (dt, *J* = 1.7, 6.6, HC(2'), 2 H); 5.61 (t, *J* = 7.3, HC(4), 1 H); 4.39 (q, *J* = 7.0, 2 H, H₂C(6')); 3.56 (t, *J* = 6.3, 2 H, H₂C(1)); 2.63 (t, *J* = 6.3, 2 H, H₂C(2)); 1.95 (q, *J* = 7.3, 2 H, H₂C(5)); 1.62 (br s, 1 H, OH), 1.41 (t, *J* = 7.0, 3 H, H₃C(7')); 1.39-1.29 (m, 2 H, H₂C(6)); 1.26-1.22 (m, 2 H, H₂C(7)); 0.82 (t, *J* = 7.3, 3 H, H₃C(8)); minor isomer: 5.95 (t, 3.5%)

¹³C NMR: (125.6 MHz, CDCl₃)

166.68 (C(5')), 145.56, 136.45, 131.70, 129.64, 128.99, 128.63, 61.08, 60.67, 42.21 (C(2)), 32.18 (C(5)), 28.83, 22.38, 14.49, 14.03

IR: (CHCl₃)

3628 (w), 3012 (w), 2960 (w), 2931 (m), 2875 (w), 2860 (w), 1711 (s), 1608 (w), 1402 (w), 1369 (w), 1308 (m), 1277 (s), 1219 (w), 1178 (m), 1105 (m), 1022 (m), 860 (w)

MS: (EI, 70 eV)

276 (M^+ , 27), 231 (31), 215 (55), 203 (11), 185 (22), 143 (30), 129 (25), 117 (20), 84 (100)

TLC: R_f 0.56 (ether, SiO_2)

GC: t_R **6j**, 8.92 min (96.5%); t_R a minor isomer, 10.73 min (3.5%) (HP-5, injector 225 °C, detector 300 °C, column 270 °C, 15 psi)

Analysis: $C_{17}H_{24}O_3$ (276.38)

Calculated: C, 71.78; H, 7.74%

Found: C, 71.85; H, 7.86%

Preparation of (*E*)-3-(4-*tert*-Butyl-1-cyclohexenyl)-3-octen-1-ol (**6k**)

Following the General Procedure, **3b** (230 mg, 1.36 mmol, 1.36 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 1.0 mL, 1.0 mmol, 1.0 equiv) and the mixture was stirred at rt for 10 min. 1-Bromo-4-*tert*-butyl-1-cyclohexene⁵ (226 mg, 1.0 mmol) was added in one portion and $[allylPdCl]_2$ (9.0 mg, 0.025 mmol, 0.050 equiv of Pd) was then added. The mixture was stirred at 40 °C for a total of 3 days. Another portion of $[allylPdCl]_2$ (4.5 mg, 0.013 mmol, 0.025 equiv of Pd) was added and stirring at 40 °C was continued for another 22 h. The crude mixture was then loaded onto 3 g of silica gel and was purified by column chromatography (10 g SiO_2 , pentane/ether, 1/0 20/1). Removal of the solvent and Kugelrohr distillation of resulting product afforded 85 mg (32%) of **6k** as a colorless oil.

Data for 6k:

mp: 56-58 °C

¹H NMR: (500 MHz, CDCl₃)

5.42-5.41 (m, HC(2')), 1 H); 5.24 (q, *J* = 7.3, 1 H, HC(4)); 3.60 (t, *J* = 6.1, 2 H, H₂C(1)); 2.32 (t, *J* = 6.2, 2 H, H₂C(2)); 2.14-2.02 (m, 4 H), 1.90-1.82 (m, 2 H); 1.55 (br s, 1 H, OH); 1.34-1.14 (m, 6 H); 1.20 (m, 2 H), 0.90-0.88 (m, 9 H, H₃C(8), H₃C(8'))

¹³C NMR: (125.6 MHz, CDCl₃)

139.40 (C(1'/3)), 136.49(C(3/1')), 129.18, 125.51, 61.04 (C(1)), 44.19, 40.00, 32.68, 32.48, 29.98, 28.69, 27.44, 27.06, 24.52, 22.58, 14.28 (C(5))

IR: (CHCl₃)

3695 (w), 3616 (w), 2974 (s), 2929 (s), 1602 (w), 1457 (m), 1384 (m), 1242 (m), 1111 (s), 1044 (m)

MS: (EI, 70 eV)

264 (M⁺, 72), 219 (27), 207 (60), 193 (15), 189 (22), 177 (24), 163 (32), 149 (17), 133 (23), 119 (39), 105 (41), 91 (59), 79 (37), 67 (34), 57 (100)

TLC: *R_f* 0.61 (ether, SiO₂)

GC: *t_R* **6k**, 11.10 min (100%) (Ultra-2, injector 225 °C, detector 300 °C, column 220 °C, 15 psi)

HRMS: calcd for C₁₈H₃₂O: 264.2453; found: 264.2447

Preparation of (*E*)-3-(3-Pyridyl)-3-octen-1-ol (**6l**)

Following the General Procedure, **3b** (250 mg, 1.36 mmol, 1.36 equiv), was dissolved in a solution of TBAF in dioxane (1.0 M, 1.5 mL, 1.5 mmol, 1.5 equiv) and the mixture was stirred at rt for 10 min. 3-Iodopyridine (205 mg, 1.0 mmol) was added in one portion and Pd(dba)₂ (29 mg, 0.050 mmol, 0.050 equiv) was then added. The mixture was stirred at 45 °C for a total of 7 days. The crude mixture was then loaded onto 2 g of silica gel and was purified by column chromatography (10 g SiO₂, pentane/ether, 1/0 9/1 4/1 3/1 1/1 1/2 0/1). Removal

of the solvent and Kugelrohr distillation of resulting product afforded 120 mg (59%) of **6l** as a colorless oil.

Data for 6l:

bp: 150 °C (ABT 0.1 mmHg)

¹H NMR: (400 MHz, CDCl₃)
8.53 (d, *J* = 3.9, 1 H, HC(6')); 8.44 (s, 1 H, HC(4')); 7.51 (dt, *J* = 2.0, 7.8, 1 H, HC(4')), 7.24 (dd, *J* = 4.9, 7.8, 1 H, HC(5')), 5.69 (q, *J* = 7.3, HC(4), 1 H); 3.59 (t, *J* = 6.3, 2 H, H₂C(1)); 2.63 (t, *J* = 6.3, 2 H, H₂C(2)); 1.97 (q, *J* = 7.3, 2 H, H₂C(5)); 1.68 (br s, 1 H, OH); 1.36-1.22 (m, 4 H, H₂C(6), H₂C(7)); 0.84 (t, *J* = 7.0, 3 H, H₃C(8)); minor isomer: 5.88 (t, 3.3%)

¹³C NMR: (100.5 MHz, CDCl₃)
149.68, 148.23, 136.23, 133.74, 132.92, 123.47, 60.66 (C(1)), 42.24 (C(2)), 32.27 (C(5)), 28.94, 22.48, 14.12 (C(8))

IR: (CHCl₃)
36221 (w), 3008 (m), 2960 (s), 1568 (w), 1475 (w), 1412 (m), 1236 (w), 1028 (m), 813 (w)

MS: (EI, 70 eV)
205 (100), 174 (13), 160 (27), 144 (100), 139 (27), 118 (33), 104 (8), 92 (13)

TLC: *R_f* 0.14 (ether, SiO₂)

GC: *t_R* **6l**, 7.61 min (96.2%), *t_R* minor isomer, 5.56 min (3.9%) (HP-5, injector 225 °C, detector 300 °C, column 270 °C, 15 psi)

HRMS: calcd for C₁₀H₁₃NO: 205.1467; found: 205.1468

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