Supporting Information for

Copper-Catalyzed *anti*-Stereocontrolled Ring-Opening of Oxabicyclic Alkenes with Grignard Reagents

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General methods.

All the reactions were carried out in anhydrous solvents and under argon atmosphere. All Grignard reagents and copper salts were purchased from commercially available sources and used as received. CuTC was prepared according to the literature procedure.¹ Melting points are uncorrected. ¹H NMR spectra were acquired at 200 or 300 MHz and ¹³C NMR were acquired at 50 or 75 MHz (indicated in each case). Chemical shifts (δ) are reported in ppm relative to CDCl₃ (7.26 and 77.0 ppm). For fluoro-containing compounds, the observed list of peaks is given as ¹³C NMR data. The coupling-constants J_{C-F} have not been determined. Mass spectra (MS) were determined at an ionizing voltage of 70 eV.

General procedure for the copper-catalyzed ring-opening of oxabicyclic alkenes with Grignard reagents: To a solution of CuCl (2.3 mg, 0.02 mmol) [or CuTC (4.4 mg, 0.02 mmol)], PPh₃ (6.0 mg, 0.02 mmol) and the corresponding oxabicyclic alkene (0.2 mmol) in anhydrous toluene (2 mL), was slowly added at room temperature the Grignard reagent (1.5 equiv). The mixture was stirred at room temperature (or 60 °C) and it was monitored by TLC. Saturated aqueous NH₄Cl solution (2 mL) was added, the organic layer were separated and the aqueous layer was extracted with CH₂Cl₂. The combined organic layers were dried over MgSO₄, filtered and concentrated to dryness. The residue was purified by flash chromatography.

(1S*, 2R*)-2-Methyl-1,2-dihydronaphth-1-ol (1a).² Chromatography: *n*-hexane-EtOAc 4:1. Yield: 92%. White solid; mp= 63-64 °C (Lit.² mp= 63-64 °C). ¹H NMR (300 MHz): 7.41 (dd, J = 6.5, 2.4 Hz, 1H), 7.31-7.22 (m, 2H), 7.11 (dd, J = 6.5, 2.4 Hz,

¹ Alfred, G. D.; Liebeskind, L. S. *J. Am. Chem. Soc.* **1996**, *118*, 2748-2749.

² Bertozzi, F.; Pineschi, M.; Macchia, F.; Arnold, L. A.; Minnaard, A. J.; Feringa, B. L. *Org. Lett.* **2002**, *4*, 2703-2705.

1H), 6.47 (d, J = 9.3 Hz, 1H), 5.94 (dd, J = 9.3, 4.4 Hz, 1H), 4.47 (t, J = 6.5 Hz, 1H), 2.70-2.59 (m, 1H), 1.74 (d, J = 6.9 Hz, 1H), 1.07 (d, J = 7.3 Hz, 3H).

(1S*, 2R*)-2-Ethyl-1,2-dihydronaphth-1-ol (1b).² Chromatography: *n*-hexane-EtOAc 4:1. Yield: 76%. White solid; mp = 34-35 °C (Lit.² mp = 34-35 °C). ¹H NMR (300 MHz): 7.37 (dd, J = 6.9, 2.0 Hz, 1H), 7.29-7.19 (m, 2H), 7.11 (dd, J = 6.9, 2.0 Hz, 1H), 6.51 (d, J = 9.7 Hz, 1H), 6.02 (dd, J = 9.7, 4.5 Hz, 1H), 4.56 (d, J = 4.5 Hz, 1H), 2.54-2.46 (m, 1H), 1.70 (bs, 1H), 1.55-1.25 (m, 2H), 0.97 (t, J = 7.3 Hz, 3H).

(1S*, 2R*)-2-(*Iso*-Butyl)-1,2-dihydronaphth-1-ol (1c). Chromatography: *n*-hexane-EtOAc 4:1. Yield: 89%. White solid; mp = 84-85 °C. ¹H NMR (200 MHz): 7.36-7.19 (m, 3H), 7.12 (dd, J = 7.0, 2.1 Hz, 1H), 6.51 (d, J = 9.7 Hz, 1H), 6.03 (dd, J = 9.7, 4.8 Hz, 1H), 4.47 (t, J = 4.5 Hz, 1H), 2.74-2.62 (m, 1H), 1.82-1.63 (m, 2H), 1.21-1.13 (m, 2H), 0.93 (d, J = 4.8 Hz, 3H), 0.90 (d, J = 4.8 Hz, 3H). ¹³C NMR (50 MHz): 135.5, 132.3, 131.0, 128.6, 128.2, 127.6, 126.5, 125.7, 72.7, 40.7, 40.2, 25.5, 23.3, 22.1.

(1S*, 2R*)-2-Decyl-1,2-dihydronaphth-1-ol (1d). Chromatography: *n*-hexane-EtOAc 6:1. Yield: 66%. White solid; mp = 49-50 °C. ¹H NMR (300 MHz): 7.35 (dd, J = 6.9, 2.0 Hz, 1H), 7.30-7.20 (m, 2H), 7.11 (dd, J = 6.9, 2.0 Hz, 1H), 6.50 (d, J = 9.7 Hz, 1H), 6.02 (dd, J = 9.7, 4.8 Hz, 1H), 4.53 (t, J = 4.8 Hz, 1H), 2.60-2.51 (m, 1H), 1.77 (d, J = 6.9 Hz, 1H), 1.41-1.25 (m, 18H), 0.88 (t, J = 6.9 Hz, 3H). ¹³C NMR (75 MHz): 135.7, 132.4, 131.1, 128.5, 127.9, 127.6, 126.5, 125.8, 72.5, 42.5, 31.8, 31.6, 29.8, 29.6 (2C), 29.5, 29.3, 27.1, 22.7, 14.1. IE MS m/z 286 (M^+ , 19), 268 (49), 257 (27), 145 (90), 142 (75), 141 (100), 128 (21). EI EMAR for C₂₀H₃₀O (M^+): Calcd: 286.2297. Found: 286.2284.

(1S*, 2R*)-2-Cyclohexyl-1,2-dihydronaphth-1-ol (1e). Chromatography: *n*-hexane-EtOAc 4:1. Yield: 64%. White solid; mp = 81-82 °C. ¹H NMR (300 MHz): 7.34 (dd, J = 6.9, 2.0 Hz, 1H), 7.30-7.20 (m, 2H), 7.11 (dd, J = 6.9, 2.0 Hz, 1H), 6.55 (d, J = 10.0 Hz, 1H), 5.99 (dd, J = 10.0, 4.8 Hz, 1H), 4.69 (dd, J = 6.9, 4.7 Hz, 1H), 2.48-2.43 (m, 1H), 1.71-1.57 (m, 7H), 1.46-1.38 (m, 1H), 1.18-1.01 (m, 4H). ¹³C NMR (75 MHz): 136.3, 132.5, 129.3, 128.5, 127.7, 127.6, 126.5, 126.4, 70.4, 48.4, 40.0, 30.8, 29.9, 26.5, 26.4. EI MS m/z 228 (M^+ , 26), 210 (48), 145 (93), 128 (100), 115 (34). EI EMAR for C₁₆H₂₀O (M^+): Calcd: 228.1514. Found: 228.1507.

(1S*, 2R*)-2-Benzyl-1,2-dihydronaphth-1-ol (1f). Chromatography: *n*-hexane-EtOAc 4:1. Yield: 47%. White solid; mp= 115-116 °C. ¹H NMR (200 MHz): 7.39-7.14 (m, 9H), 6.54 (d, *J*= 9.7 Hz, 1H), 5.94 (dd, *J*= 9.7, 4.8 Hz, 1H), 4.54 (bs, 1H), 2.98-2.84 (m, 1H), 2.66-2.62 (m, 2H), 1.94 (bs, 1H). ¹³C NMR (50 MHz): 139.4, 135.2, 132.2, 130.2, 129.1, 128.6, 128.3, 127.9, 127.8, 126.6, 126.3, 126.2, 71.5, 44.0, 37.6.

(1S*, 2S*)-2-Phenyl-1,2-dihydronaphth-1-ol (1g). Chromatography: *n*-hexane-EtOAc 6:1. Yield: 90%. White solid; mp= 86-87 °C. ¹H NMR (300 MHz): 7.42 (dd, *J*= 7.3, 2.4 Hz, 1H), 7.34-7.24 (m, 7H), 7.18 (dd, *J*= 7.3, 2.4 Hz, 1H), 6.67 (dd, *J*= 9.7, 2.0 Hz, 1H), 6.04 (dd, *J*= 9.7, 3.6 Hz, 1H), 4.84 (dd, *J*= 7.7, 5.3 Hz, 1H), 3.83-3.79 (m, 1H), 1.96 (d, *J*= 5.3 Hz, 1H). ¹³C NMR (75 MHz): 140.8, 135.6, 132.6, 129.8, 128.8 (2C), 128.4, 128.2, 128.1, 127.6, 127.2, 126.4, 74.3, 50.1. EI MS *m/z* 222 (*M*⁺, 76), 204 (65), 131 (75), 118 (100), 115 (33). EI EMAR for C₁₆H₁₄O (*M*⁺): Calcd: 222.1045. Found: 222.1038.

(1S*, 2S*)-2-(*p*-Methoxyphenyl)-1,2-dihydronaphth-1-ol (1h). Chromatography: CH₂Cl₂. Yield: 92%. White solid; mp= 73-74 °C. ¹H NMR (300 MHz): 7.42-7.39 (m, 1H), 7.32-7.23 (m, 2H), 7.19-7.14 (m, 3H), 6.86-6.83 (m, 2H), 6.65 (dd, *J*= 9.5, 2.0 Hz, 1H), 6.02 (dd, *J*= 9.5, 3.8 Hz, 1H), 4.78 (dd, *J*= 7.7, 5.2 Hz, 1H), 3.79 (s, 3H), 3.78-3.73 (m, 1H), 1.98 (d, *J*= 5.5 Hz, 1H). ¹³C NMR (75 MHz): 158.7, 135.6, 132.6 (2C), 130.1, 129.3, 128.2, 128.0, 127.4, 126.4, 114.1, 74.4, 55.2, 49.2.

(1S*, 2S*)-2-(*p*-Fluorophenyl)-1,2-dihydronaphth-1-ol (1i). Chromatography: *n*-hexane-EtOAc 6:1. Yield: 94%. White solid; mp= 125-126 °C. ¹H NMR (300 MHz): 7.40-7.17 (m, 6H), 7.02-6.94 (m, 2H), 6.68 (dd, *J*= 9.7, 2.0 Hz, 1H), 6.01 (dd, *J*= 9.7, 4.0 Hz, 1H), 4.77 (dd, *J*= 6.8, 6.1 Hz, 1H), 3.81-3.77 (m, 1H), 2.00 (d, *J*= 6.1 Hz, 1H). ¹³C NMR (75 MHz): 164.6, 161.3, 136.3, 135.3, 132.4, 129.8, 129.7, 129.5, 128.4, 128.1, 127.7, 126.6, 126.5, 115.6, 115.3, 74.3, 49.2. EI MS *m/z* 240 (*M*⁺, 54), 222 (35), 131 (73), 118 (100), 90 (28). EI EMAR for C₁₆H₁₃OF (*M*⁺): Calcd: 240.0950. Found: 240.0939.

(1S*, 2R*)-6,7-Difluoro-2-methyl-1,2-dihydronaphth-1-ol (4a). Chromatography: *n*-hexane-EtOAc 4:1. Yield: 77%. White solid; mp= 110-111 °C. ¹H NMR (300 MHz): 7.29-7.23 (m, 1H), 6.90 (dd, *J*= 10.7, 7.7 Hz, 1H), 6.35 (dd, *J*= 9.5, 1.6 Hz, 1H), 5.92 (dd, *J*= 9.5, 4.0 Hz, 1H), 4.41 (t, *J*= 7.1 Hz, 1H), 2.63-2.54 (m, 1H), 1.83 (d, *J*= 6.9 Hz,

1H), 1.09 (d, J = 7.3 Hz, 3H). ^{13}C NMR (75 MHz): 151.0, 150.9, 148.2, 147.8, 147.6, 133.1, 133.0, 129.4 (2C), 129.3 (2C), 124.3, 116.2, 116.0, 115.0, 114.8, 73.4, 37.2, 16.9.

(1S*,2S*)-2-(*p*-Fluorophenyl)-6,7-difluoro-1,2-dihydronaphth-1-ol (4i).

Chromatography: *n*-hexane-EtOAc 4:1. Yield: 91%. White solid; mp = 117-118 °C. ^1H NMR (300 MHz): 7.31-7.20 (m, 3H), 7.06-6.94 (m, 3H), 6.55 (dd, J = 9.7, 2.2 Hz, 1H), 6.01 (dd, J = 9.7, 3.6 Hz, 1H), 4.73 (dd, J = 8.7, 4.8 Hz, 1H), 3.76-3.72 (m, 1H), 1.92 (d, J = 5.5 Hz, 1H). ^{13}C NMR (75 MHz): 163.7, 160.5, 151.6, 151.5, 151.3, 148.4, 148.2, 148.1, 148.0, 136.1, 136.0, 132.6, 132.5, 132.4, 130.5, 129.9, 129.8, 129.4, 129.3, 129.2, 126.2, 115.9, 115.7, 115.6, 115.5, 115.1, 114.9, 73.7, 49.0.

(1S*, 2R*)-5,8-Dimethoxy-2-methyl-1,2-dihydronaphth-1-ol (5a).

Chromatography: *n*-hexane-EtOAc 4:1. Yield: 75%. White solid; mp = 63-64 °C. ^1H NMR (300 MHz): 6.84 (d, J = 10.1 Hz, 1H), 6.78 (part A of AB system, J_{AB} = 8.9 Hz, 1H), 6.76 (part B of AB system, J_{AB} = 8.9 Hz, 1H), 6.04 (dd, J = 10.1, 5.3 Hz, 1H), 4.91 (bs, 1H), 3.83 (s, 3H), 3.80 (s, 3H), 2.76-2.66 (m, 1H), 2.18 (d, J = 5.2 Hz, 1H), 0.94 (d, J = 7.7 Hz, 3H). ^{13}C NMR (75 MHz): 151.6, 149.4, 131.7, 123.4, 122.0, 118.5, 111.0, 110.2, 66.7, 56.0, 36.2, 17.1. EI MS m/z 220 (M^+ , 9), 202 (63), 187 (100), 157 (18), 115 (17).

(1S*,2S*)-2-(*p*-Fluorophenyl)-5,8-dimethoxy-1,2-dihydronaphth-1-ol (5i).

Chromatography: *n*-hexane-EtOAc 4:1. Yield: 86%. Colorless oil. ^1H NMR (300 MHz): 7.14-7.08 (m, 3H), 6.92-6.86 (m, 2H), 6.80 (part A of AB system, J_{AB} = 8.9 Hz, 1H), 6.74 (part B of AB system, J_{AB} = 8.9 Hz, 1H), 6.10 (dd, J = 10.9, 5.2 Hz, 1H), 5.12 (bs, 1H), 3.89 (d, J = 4.8 Hz, 1H), 3.84 (s, 3H), 3.73 (s, 3H), 2.45 (d, J = 4.4 Hz, 1H). ^{13}C NMR (75 MHz): 163.3, 160.1, 151.2, 149.5, 135.5, 135.4, 129.5, 129.3, 127.9, 122.9, 122.2, 120.6, 115.3, 115.1, 111.3, 110.6, 67.4, 56.1, 55.9, 47.2. EI MS m/z 300 (M^+ , 30), 282 (93), 267 (100), 224 (31), 178 (31).

(1S*,2R*)-2-Methyl-6,7-methylenedioxy-1,2-dihydronaphth-1-ol (6a).

Chromatography: *n*-hexane-EtOAc 4:1. Yield: 57%. White solid; mp = 124-125 °C. ^1H NMR (300 MHz): 6.91 (s, 1H), 6.61 (s, 1H), 6.33 (dd, J = 9.7, 1.2 Hz, 1H), 5.94 (s, 2H), 5.84 (dd, J = 9.7, 4.4 Hz, 1H), 4.36 (t, J = 6.5 Hz, 1H), 2.64-2.53 (m, 1H), 1.75 (d, J = 6.9 Hz, 1H), 1.03 (d, J = 7.3 Hz, 3H). ^{13}C NMR (75 MHz): 147.3, 146.7, 130.4, 129.6, 126.7, 125.3, 108.5, 107.0, 100.9, 74.2, 37.4, 16.8. EI MS m/z 186 ($\text{M}^+ - \text{H}_2\text{O}$, 100), 149 (23), 128 (39), 83 (40).

(1S*,2S*)-2-(*p*-Fluorophenyl)-6,7-methylenedioxy-1,2-dihydronaphth-1-ol (6i).

Chromatography: *n*-hexane-EtOAc 4:1. Yield: 82%. White solid; mp= 133-134 °C. ¹H NMR (300 MHz): 7.20-7.15 (m, 2H), 7.00-6.94 (m, 2H), 6.87 (s, 1H), 6.68 (s, 1H), 6.55 (dd, *J*= 9.7, 2.0 Hz, 1H), 5.96-5.90 (m, 3H), 4.63 (t, *J*= 6.5 Hz, 1H), 3.77-3.73 (m, 1H), 1.93 (d, *J*= 6.1 Hz, 1H). ¹³C NMR (75 MHz): 163.6, 160.3, 147.2, 136.0, 129.8, 129.7, 129.3, 127.5, 127.3, 126.7, 115.6, 115.3, 108.1, 107.1, 101.1, 74.4, 49.0. IE MS *m/z* 284 (M⁺, 3), 266 (100), 207 (45), 103 (11). EI EMAR for C₁₇H₁₃O₃F (M⁺): Calcd: 284.0849. Found: 284.0849.

(1S*,2R*,5R*,6S*)-5,6-Bis(methoxymethyl)-2-methylcyclohex-3-en-1-ol (8a).³

Chromatography: *n*-hexane-Et₂O 1:3. Yield: 74%. Colorless oil. ¹H NMR (300 MHz): 5.60 (dt, *J*= 10.1, 2.6 Hz, 1H), 5.43 (ddd, *J*= 10.1, 3.0, 2.0 Hz, 1H), 4.10 (d, *J*= 9.9 Hz, 1H), 3.56 (dd, *J*= 9.3, 8.0 Hz, 1H), 3.52 (dd, *J*= 9.3, 7.2 Hz, 1H), 3.50-3.41 (m, 1H), 3.34 (s, 3H), 3.33 (s, 4H), 3.32 (s, 1H), 2.61-2.54 (m, 1H), 2.43 (dq, *J*= 7.3, 2.6 Hz, 1H), 2.29-2.20 (m, 1H), 1.04 (d, *J*= 7.1 Hz, 3H).

(1S*,2R*,5R*,6S*)-5,6-Bis(methoxymethyl)-2-ethylcyclohex-3-en-1-ol (8b).

Chromatography: *n*-hexane-Et₂O 1:3. Yield: 52%. Colorless oil. ¹H NMR (300 MHz): 5.72 (dt, *J*= 10.1, 3.4 Hz, 1H), 5.51 (ddd, *J*= 10.1, 3.0, 1.8 Hz, 1H), 4.13 (d, *J*= 9.7 Hz, 1H), 3.71-3.43 (m, 4H), 3.36 (s, 3H), 3.35 (s, 3H), 2.61-2.54 (m, 1H), 2.43 (dq, *J*= 7.5, 2.8 Hz, 1H), 2.11-2.03 (m, 1H), 1.63-1.49 (m, 1H), 1.42-1.24 (m, 1H), 0.96 (t, *J*= 7.5 Hz, 3H). ¹³C NMR (75 MHz): 130.5, 126.2, 72.4, 72.2, 71.2, 59.0, 58.9, 44.3, 38.1, 37.5, 26.2, 11.4.

(1S*,2R*,5R*,6S*)-5,6-Bis(methoxymethyl)-2-(*iso*-butyl)cyclohex-3-en-1-ol (8c).

Chromatography: *n*-hexane-Et₂O 1:3. Yield: 77%. Colorless oil. ¹H NMR (300 MHz): 5.75 (ddd, *J*= 10.1, 3.4, 2.4 Hz, 1H), 5.54 (ddd, *J*= 10.1, 3.6, 1.8 Hz, 1H), 4.30 (d, *J*= 10.1 Hz, 1H), 3.61-3.50 (m, 3H), 3.39 (d, *J*= 3.8 Hz, 2H), 3.37 (s, 3H), 3.36 (s, 3H), 2.57-2.52 (m, 1H), 2.42 (dq, *J*= 7.5, 2.8 Hz, 1H), 2.28-2.19 (m, 1H), 1.80-1.23 (m, 1H), 1.35-1.23 (m, 1H), 1.19-1.09 (m, 1H), 0.92 (s, 3H), 0.90 (s, 3H). ¹³C NMR (75 MHz): 130.8, 126.1, 72.8, 71.8, 71.1, 59.0, 58.9, 43.6, 41.0, 37.7, 37.0, 25.2, 23.2, 22.4.

³ Lautens, M.; Ma, S. *J. Org. Chem.* **1996**, *61*, 7246-7247.

(1S*,2R*,5R*,6S*)-5,6-Bis(methoxymethyl)-2-decylcyclohex-3-en-1-ol (8d).

Chromatography: *n*-hexane-Et₂O 1:3. Yield: 78%. Colorless oil. ¹H NMR (300 MHz):

5.74-5.68 (m, 1H), 5.49 (ddd, *J*= 10.1, 3.4, 2.4 Hz, 1H), 5.54 (ddd, *J*= 10.1, 2.9, 1.8 Hz, 1H), 4.16 (d, *J*= 10.1 Hz, 1H), 3.62-3.46 (m, 4H), 3.36 (s, 3H), 3.35 (s, 3H), 2.57-2.54 (m, 1H), 2.41 (dq, *J*= 7.5, 2.6 Hz, 1H), 2.15-2.08 (m, 1H), 1.57-1.24 (m, 18H), 0.86 (t, *J*= 6.5 Hz, 3H). ¹³C NMR (75 MHz): 130.8, 126.0, 72.5, 72.1, 71.3, 63.0, 59.0, 42.8, 38.0, 37.3, 33.7, 32.8, 31.9, 30.0, 29.6, 29.4, 27.0, 25.7, 22.6, 14.0.

(1S*, 2R*, 5R*, 6S*)-5,6-Bis(methoxymethyl)-2-cyclohexyl-cyclohex-3-en-1-ol (8e).

Chromatography: *n*-hexane-Et₂O 1:3. Yield: 32%. Colorless oil. ¹H NMR (300 MHz):

5.69 (dt, *J*= 10.3, 2.8 Hz, 1H), 5.51 (dt, *J*= 10.3, 2.4 Hz, 1H), 4.02 (d, *J*= 10.3 Hz, 1H), 3.78-3.72 (m, 1H), 3.64-3.50 (m, 2H), 3.36 (s, 3H), 3.35 (s, 3H), 3.34 (d, *J*= 5.3 Hz, 1H), 2.61-2.54 (m, 1H), 2.42 (dq, *J*= 6.7, 3.0 Hz, 1H), 2.04-1.98 (m, 1H), 1.76-1.61 (m, 5H), 1.54-1.48 (m, 1H), 1.31-1.08 (m, 5H).

(1R*,2S*,5R*,6S*)-5,6-Bis(methoxymethyl)-2-phenyl-cyclohex-3-en-1-ol (8g).³

Chromatography: *n*-hexane-Et₂O 1:3. Yield: 79%. Colorless oil. ¹H NMR (300 MHz):

7.27-7.19 (m, 5H), 5.90-5.85 (m, 1H), 5.84-5.78 (m, 1H), 4.46 (d, *J*= 9.7 Hz, 1H), 3.77-3.72 (m, 1H), 3.58-3.48 (m, 3H), 3.46 (d, *J*= 5.9 Hz, 2H), 3.42 (s, 3H), 3.31 (s, 3H), 2.72-2.66 (m, 1H), 2.47-2.39 (m, 1H).