Supporting Materials to

Palladium-catalyzed tandem cyclization/Suzuki

coupling of 1,6- enynes

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A. General: All reactions and manipulations were conducted under Ar atmosphere using standard Schlenk techniques. Column chromatography was performed using EM Silica gel 60 (300-400 mesh). ^1H and ^{13}C were recorded on a Bruker AMX-300 spectrometers. Chemical shifts were reported in ppm downfield from tetramethylsilane with the solvent resonance as the internal standard. MS spectra were recorded on the HP-5973N mass spectrometer. Microanalysis was recorded on the CarloERBA1106 spectrometer.

B. Materials: Toluene was distilled from sodium prior to use. K_2CO_3 , Cs_2CO_3 , $\text{K}_3\text{PO}_4 \cdot 3\text{H}_2\text{O}$, CsF, Na_2CO_3 were used directly as obtained commercially unless otherwise noted. $\text{Pd}(\text{PPh}_3)_4$ and $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$ were prepared according to the literature.^{1,2} All boronic acids were prepared according to the literature.³ 1, 6-enyne substrates were prepared according to the literature.⁴

C. General procedure for palladium-catalyzed tandem cyclization/Suzuki coupling of 1, 6-enynes

Under argon atmosphere, a Schlenk reaction tube was placed with enyne substrate **1** (0.25 mmol), boronic acid **2** (0.5 mmol), KF (29 mg, 0.5 mmol), $\text{Pd}(\text{PPh}_3)_4$ (14 mg, 0.0125 mmol) and toluene (5 mL). After the mixture was heated at 60°C for a specified time (usually 2-4 h), the solvent was evaporated under reduced pressure and the residue was purified by chromatography on a silica gel column to give the product **3**.

D. Analytical data for 3

^1H NMR (300MHz, CDCl_3): δ 0.84 (t, $J = 6.9$ Hz, 3H), 1.16-1.38 (m, 4 H), 2.26 (t, $J = 6.9$ Hz, 2 H), 3.23-3.33 (m, 1 H), 3.72 (dd, $J = 8.4, 3.0$ Hz, 1 H), 3.87 (dd, $J = 8.4, 6.0$ Hz, 1 H), 4.44-4.57 (m, 2 H), 4.62 (dt, $J = 17.1, 1.5$ Hz, 1 H), 4.76 (ddd, $J = 9.9, 1.5, 0.9$ Hz, 1 H), 5.59 (ddd, $J = 17.1, 9.9, 7.5$ Hz, 1 H); ^{13}C NMR (75MHz, CDCl_3): 141.8, 138.1, 136.8, 134.4, 128.2, 127.8, 126.4, 114.4, 74.0, 69.8, 46.6, 35.5, 29.9, 22.4, 13.9; IR (neat, cm^{-1}): 1637, 991, 917; MS (EI) m/z (rel): 242 (M^+ , 26), 211 (22), 185 ($\text{M}^+ - 57$, 100), 155 (86), 129 (53), 115 (45), 91 (64); Anal. Calcd. for $\text{C}_{17}\text{H}_{22}\text{O}$: C, 84.25, H, 9.15. Found: C, 84.41, H, 9.17.

^1H NMR (300MHz, CDCl_3): δ 0.79-0.92 (m, 3 H), 1.19-1.38 (m, 4 H), 2.24 (t, $J = 7.2$ Hz, 2 H), 2.33 (s, 3 H), 3.23-3.32 (m, 1 H), 3.72 (dd, $J = 8.4, 3.0$ Hz, 1 H), 3.86 (dd, $J = 8.4, 6.0$ Hz, 1 H), 4.42-4.56 (m, 2 H), 4.65 (dt, $J = 17.4, 1.5$ Hz, 1 H), 4.79 (ddd, $J = 10.2, 1.5, 0.9$ Hz, 1 H), 5.61 (ddd, $J = 17.4, 10.2, 7.8$ Hz, 1 H), 6.92-7.06 (m, 3 H), 7.17 (t, $J = 7.5$ Hz, 1 H); ^{13}C NMR (75MHz, CDCl_3): 141.7, 138.3, 137.2, 136.5, 134.5, 128.9, 127.7, 127.1, 125.2, 114.3, 73.9, 69.8, 46.6, 35.4, 29.9, 22.5, 21.4, 13.9; IR (neat, cm^{-1}): 1636, 992, 910; MS (EI) m/z (rel): 256 (M^+ , 46), 225 (33), 199 ($\text{M}^+ - 57$, 85), 187 (71), 169 (78), 143 (68), 115 (56), 91 (56); Anal. Calcd. for $\text{C}_{18}\text{H}_{24}\text{O}$: C, 84.32, H, 9.44. Found: C, 84.20, H, 9.58.

^1H NMR (300MHz, CDCl_3): δ 0.79-0.93 (m, 3 H), 1.20-1.38 (m, 4 H), 2.24 (t, J = 7.2 Hz, 2 H), 2.33 (s, 3 H), 3.24-3.32 (m, 1 H), 3.73 (dd, J = 8.4, 3.0 Hz, 1 H), 3.85 (dd, J = 8.4, 6.0 Hz, 1 H), 4.42-4.56 (m, 2 H), 4.68 (dt, J = 17.1, 1.5 Hz, 1 H), 4.80 (ddd, J = 10.2, 1.5, 0.9 Hz, 1 H), 5.62 (ddd, J = 17.1, 10.2, 7.5 Hz, 1 H), 7.02-7.15 (m, 4 H); ^{13}C NMR (75MHz, CDCl_3): 139.1, 138.6, 136.7, 136.2, 134.6, 128.8, 128.3, 114.6, 74.2, 70.1, 46.8, 35.7, 30.2, 22.7, 21.4, 14.2; IR (neat, cm^{-1}): 1637, 991, 913; MS (EI) m/z (rel): 256 (M^+ , 43), 225 (26), 199 (M^+ -57, 100), 187 (52), 169 (72), 143 (58), 115 (56), 91 (56); Anal. Calcd. for $\text{C}_{18}\text{H}_{24}\text{O}$: C, 84.32, H, 9.44. Found: C, 84.27, H, 9.72.

^1H NMR (300MHz, CDCl_3): δ 0.79-0.91 (m, 3 H), 1.19-1.33 (m, 4 H), 2.23 (t, J = 6.9 Hz, 2 H), 3.24-3.33 (m, 1 H), 3.72 (dd, J = 8.4, 3.0 Hz, 1 H), 3.80 (s, 3 H), 3.86 (dd, J = 8.4, 6.0 Hz, 1 H), 4.40-4.53 (m, 2 H), 4.68 (dt, J = 17.1, 1.5 Hz, 1 H), 4.80 (ddd, J = 10.2, 1.5, 0.9 Hz, 1 H), 5.61 (ddd, J = 17.1, 10.2, 7.2 Hz, 1 H), 6.79-6.87 (m, 2 H), 7.06-7.12 (m, 2 H); ^{13}C NMR (75MHz, CDCl_3): 158.1, 138.3, 136.5, 134.2, 134.0, 129.3, 114.4, 113.1, 73.9, 69.9, 55.1, 46.6, 35.5, 29.9, 22.4, 13.9; IR (neat, cm^{-1}): 1636, 992, 918; MS (EI) m/z (rel): 272 (M^+ , 66), 241 (22), 215 (M^+ -57, 100), 185 (66), 121 (58), 115 (42), 91 (38); Anal. Calcd. for $\text{C}_{18}\text{H}_{24}\text{O}_2$: C, 79.37, H, 8.88. Found: C, 79.62, H, 9.03.

^1H NMR (300MHz, CDCl_3): δ 0.84 (t, $J = 6.9$ Hz, 3 H), 1.15-1.33 (m, 4 H), 2.23 (t, $J = 6.9$ Hz, 2 H), 3.19-3.29 (m, 1 H), 3.71 (dd, $J = 8.4, 3.0$ Hz, 1 H), 3.87 (dd, $J = 8.4, 6.0$ Hz, 1 H), 4.40-4.54 (m, 2 H), 4.64 (dt, $J = 17.1, 1.2$, Hz, 1 H), 4.79 (ddd, $J = 10.2, 1.2, 0.9$ Hz, 1 H), 5.57 (ddd, $J = 17.1, 10.2, 7.8$ Hz, 1 H), 7.05-7.13 (m, 2 H), 7.23-7.31 (m, 2 H); ^{13}C NMR (75MHz, CDCl_3): 140.1, 137.9, 137.6, 133.3, 132.2, 129.6, 128.0, 114.8, 74.0, 69.9, 46.7, 35.3, 29.8, 22.4, 13.9; IR (neat, cm^{-1}): 1636, 991, 917; MS (EI) m/z (rel): 278 $[(M+2)^+, 9]$, 276 ($M^+, 25$), 245 (16), 219 ($M^+ - 57, 100$), 187 (36), 152 (54), 125 (59), 115 (41), 41 (89); Anal. Calcd. for $\text{C}_{17}\text{H}_{21}\text{ClO}$: C, 73.76, H, 7.65, Cl, 12.81. Found: C, 73.90 H, 7.94, Cl, 12.87.

^1H NMR (300MHz, CDCl_3): δ 0.85 (t, $J = 6.9$ Hz, 3 H), 1.14-1.29 (m, 4 H), 2.20 (t, $J = 7.2$ Hz, 2 H), 3.25-3.35 (m, 1 H), 3.71 (dd, $J = 8.4, 3.3$ Hz, 1 H), 3.87 (dd, $J = 8.4, 5.7$ Hz, 1 H), 4.40-4.52 (m, 2 H), 4.71 (d, $J = 17.7$ Hz, 1 H), 4.81 (d, $J = 9.9$ Hz, 1 H), 5.60 (ddd, $J = 17.7, 9.9, 7.2$ Hz, 1 H), 5.90-5.96 (m, 2 H), 6.58- 6.77 (m, 3 H). ^{13}C NMR (75MHz, CDCl_3): 147.1, 145.9, 138.1, 136.9, 135.6, 133.9, 121.5, 114.5, 108.8, 107.7, 100.7, 73.9, 69.8, 46.6, 35.5, 29.8, 22.4, 13.9; IR (neat, cm^{-1}): 1636; MS (EI) m/z (rel): 287 $[(M+1)^+, 23]$, 286 ($M^+, 100$), 255 (16), 232 (58), 229 (67), 199 (43), 175 (32), 115 (31); HRMS (EI): Calcd. for $\text{C}_{18}\text{H}_{22}\text{O}_3$ 286.15689, Found: 286.15827.

^1H NMR (300MHz, CDCl_3): δ 0.87 (t, $J = 6.9$ Hz, 3 H), 1.15-1.38 (m, 4 H), 2.30 (t, $J = 7.5$ Hz, 2 H), 3.14- 3.25 (m, 1 H), 3.67 (dd, $J = 8.7, 4.2$ Hz, 1 H), 3.93 (dd, $J = 8.7, 6.3$ Hz, 1 H), 4.46-4.58 (m, 3 H), 4.74 (dt, $J = 10.2, 0.6$ Hz, 1 H), 5.51 (ddd, $J = 18.3, 10.2, 8.7$ Hz, 1 H), 7.61 (s, 2 H), 7.75 (s, 1 H); F NMR: -63.3; ^{13}C NMR (75MHz, CDCl_3): 143.6, 140.3, 137.3, 132.0, 131.2 ($J = 32.85$ Hz), 127.0 ($J = 264.45$ Hz), 120.4, 115.4, 74.2, 70.2, 47.5, 35.1, 29.8, 22.4, 13.8; IR (neat, cm^{-1}): 1637; MS (EI) m/z (rel): 379 $[(M+1)^+, 18]$, 378 (M^+ , 38), 348 (29), 323 (89), 321 (95), 305 (38), 292 (38), 291 (39), 227 (40); HRMS (EI): Calcd. for $\text{C}_{19}\text{H}_{20}\text{F}_6\text{O}$ 378.14183, Found: 378.14280.

^1H NMR (300MHz, CDCl_3): δ 3.65-3.75 (m, 1 H), 3.89-4.00 (m, 2 H), 4.40-4.48 (m, 1 H), 4.56-4.64 (m, 1 H), 5.11-5.23 (m, 2 H), 5.90 (ddd, $J = 16.8, 10.2, 6.6$ Hz, 1 H), 6.46-6.50 (m, 1 H), 7.18-7.40 (m, 5 H); ^{13}C NMR (75MHz, CDCl_3): 141.8, 136.9, 136.6, 128.3, 128.2, 126.8, 121.8, 116.2, 74.9, 72.8, 45.8; IR (neat, cm^{-1}): 1635, 990, 915; MS (EI) m/z (rel): 186 (M^+ , 46), 156 (51), 141 (64), 131 (88), 115 (100), 91 (88); HRMS (EI): Calcd. for $\text{C}_{13}\text{H}_{14}\text{O}$ 186.10447. Found: 186.10459.

3ca

^1H NMR (300MHz, CDCl_3): δ 1.92-1.99 (m, 3 H), 3.29-3.42 (m, 1 H), 3.75 (dd, J = 8.4, 3.0 Hz, 1 H), 3.88 (dd, J = 8.4, 6.0 Hz, 1 H), 4.40-4.56 (m, 2 H), 4.70 (dt, J = 17.1, 1.5 Hz, 1 H), 4.81 (ddd, J = 10.2, 1.5, 0.9 Hz, 1 H), 5.63 (ddd, J = 17.1, 10.2, 7.8 Hz, 1 H), 7.17-7.35 (m, 5 H); ^{13}C NMR (75MHz, CDCl_3): 143.0, 138.1, 136.9, 128.8, 127.9, 127.6, 126.5, 114.6, 74.3, 70.4, 46.6, 21.4; IR (neat, cm^{-1}): 1636, 990, 916; MS (EI) m/z (rel): 200 (M^+ , 24), 199 (17), 185 (21), 169 (32), 155 (45), 145 (100), 129 (61), 115 (37); HRMS (EI): Calcd. for $\text{C}_{14}\text{H}_{16}\text{O}$: 200.12012, Found: 200.11878.

3da

^1H NMR (300MHz, CDCl_3): δ 3.67-3.77 (m, 2 H), 4.04 (dd, J = 8.4, 6.6 Hz, 1 H), 4.32 (d, J = 13.8 Hz, 1 H), 4.59 (d, J = 13.8 Hz, 1 H), 4.68 (dt, J = 17.1, 1.2, Hz, 1 H), 4.79 (ddd, J = 10.2, 1.2, 0.9 Hz, 1 H), 5.61 (ddd, J = 17.1, 10.2, 7.5 Hz, 1 H), 7.08-7.35 (m, 10 H); ^{13}C NMR (75MHz, CDCl_3): 141.8, 141.3, 140.0, 136.7, 135.4, 129.2, 128.5, 128.1, 128.0, 127.0, 126.8, 115.3, 73.5, 70.7, 47.2; IR (neat, cm^{-1}): 1635, 989, 917; MS (EI) m/z (rel): 262 (M^+ , 12), 231 (28), 207 (M^+ -57, 100), 191 (37), 178 (20), 165 (24), 115 (16), 102(16); Anal. Calcd. for $\text{C}_{19}\text{H}_{18}\text{O}$: C, 86.99, H, 6.92. Found: C, 87.16 H, 6.99.

3fa

^1H NMR (300MHz, CDCl_3): δ 0.82 (t, $J = 6.9$ Hz, 3 H), 1.25-1.33 (m, 4 H), 2.21 (t, $J = 7.2$ Hz, 2 H), 2.46 (s, 3 H), 3.12-3.28 (m, 3 H), 3.89 (d, $J = 13.8$ Hz, 1 H), 4.02 (d, $J = 13.8$ Hz, 1 H), 4.59 (d, $J = 17.1$ Hz, 1 H), 4.74 (d, $J = 10.2$ Hz, 1 H), 5.48 (ddd, $J = 17.1, 10.2, 6.9$ Hz, 1 H), 6.97-7.06 (m, 2 H), 7.16-7.39 (m, 5 H), 7.71-7.80 (m, 2 H); ^{13}C NMR (75MHz, CDCl_3): 143.6, 141.0, 137.5, 137.1, 132.8, 132.5, 129.6, 128.0, 127.9, 127.8, 126.7, 114.8, 53.5, 49.9, 45.2, 35.5, 29.7, 22.5, 21.5, 13.9; IR (neat, cm^{-1}): 1638, 920; MS (EI) m/z (rel): 395 (M^+ , 5), 338 ($\text{M}^+ - 57$, 26), 248 (17), 240 (43), 186 (28), 155 (56), 115 (19), 91 (100); Anal. Calcd. for $\text{C}_{24}\text{H}_{29}\text{NO}_2\text{S}$: C, 72.87, H, 7.39, N, 3.54. Found: C, 72.90 H, 7.35, N, 3.28.

^1H NMR (300MHz, CDCl_3): δ 1.90-1.96 (m, 3 H), 2.48 (dd, $J = 9.0, 5.4$ Hz, 1 H), 2.77 (dd, $J = 9.0, 6.3$ Hz, 1 H), 3.27-3.50 (m, 3 H), 3.68 (s, 2 H), 4.50 (dt, $J = 17.1, 0.9$ Hz, 1 H), 4.58 (ddd, $J = 10.2, 1.2, 0.9$ Hz, 1 H), 5.51 (ddd, $J = 17.1, 10.2, 8.1$ Hz, 1 H), 7.13-7.41 (m, 10 H); ^{13}C NMR (75MHz, CDCl_3): 143.3, 139.1, 138.9, 137.2, 129.4, 128.7, 128.2, 127.9, 127.8, 126.9, 126.2, 113.7, 60.7, 60.5, 58.3, 45.9, 21.9; IR (neat, cm^{-1}): 1637, 910; MS (EI) m/z (rel): 290 ($(\text{M}+1)^+$, 7), 289 (M^+ , 27), 274 (15), 261 (7), 198 (5), 155 (19), 129 (25), 91 (100); HRMS (EI): Calcd. for $\text{C}_{21}\text{H}_{23}\text{N}$: 289.18305, Found: 289.18141.

^1H NMR (300MHz, CDCl_3): δ 1.26 (t, $J = 6.9$ Hz, 3 H), 1.28 (t, $J = 7.2$ Hz, 3 H), 1.98-2.02 (m, 3 H), 2.11 (dd, $J = 13.2, 6.0$ Hz, 1 H), 2.53 (dd, $J = 13.2, 7.8$ Hz, 1 H), 3.00-3.17 (m, 2 H), 3.33-3.46 (m, 1 H), 4.19 (q, $J = 6.9$ Hz, 2 H), 4.23 (q, $J = 7.2$ Hz,

2 H), 4.52-4.64 (m, 2 H), 5.39 (ddd, $J = 17.1, 10.5, 7.2$ Hz, 1 H), 7.10-7.29 (m, 5 H). ^{13}C NMR (75MHz, CDCl_3): 171.9, 171.7, 143.5, 139.7, 136.3, 131.2, 127.8, 127.7, 126.2, 113.8, 61.5, 61.4, 58.8, 45.3, 40.3, 38.7, 22.1, 14.01, 13.96; IR (neat, cm^{-1}): 3080, 2982, 1732, 1637, 1600, 1494, 1444, 1367, 1251, 1182, 911, 863, 766, 702; MS (EI) m/z (rel): 342 (M^+ , 13), 297 (4), 269 (19), 268 (84), 195 (100), 179 (31), 165 (26), 105 (33); Anal. Calcd. for $\text{C}_{21}\text{H}_{26}\text{O}_4$: C, 73.66, H, 7.65. Found: C, 73.52, H, 7.81.

^1H NMR (300MHz, CDCl_3): δ 2.58 (d, $J = 1.5$ Hz, 3 H), 3.58-3.69 (m, 1 H), 4.02 (dd, $J = 8.7, 2.7$ Hz, 1 H), 4.31 (dd, $J = 8.7$ Hz, 1 H), 4.74 (dt, $J = 17.1, 1.2$ Hz, 1 H), 4.90 (dt, $J = 10.2, 0.9$ Hz, 1 H), 5.63 (ddd, $J = 17.1, 10.2, 7.8$ Hz, 1 H), 7.19-7.42 (m, 5 H); ^{13}C NMR (75MHz, CDCl_3): 170.4, 153.8, 142.0, 136.8, 128.2, 128.1, 126.3, 123.3, 116.1, 69.8, 43.8, and 20.7.

References:

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3 a b

zgg-7-2-1c				USER: -- DATE: May 20 2003			
F1: 75.450	F2: 300.029	SW1: 18868		OF1: 8278.5		PTS1d: 65536	
EX: s2pul	PW: 4.2 usec	PD: 1.0 sec	NA: 80	LB: 0.0	WinNuts - \$zgg-7-2-1c.fid

txf-6-61

USER: -- DATE: May 20 2003

F1: 300.030

F2: 75.450

SW1: 4803

OF1: 1802.0

PTS1d: 16384

EX: s2pul

PW: 3.7 usec

PD: 1.0 sec

NA: 24

LB: 0.0

WinNuts - \$zgg-7-2-2.fid

zgg-7-2-2c				USER: -- DATE: May 20 2003			
F1: 75.450	F2: 300.029	SW1: 18868		OF1: 8278.8		PTS1d: 65536	
EX: s2pul	PW: 4.2 usec	PD: 1.0 sec	NA: 108	LB: 0.0	WinNuts - \$zgg-7-2-2c.fid

txf-6-78

F1: 300.030

F2: 75.450

SW1: 4803

PW: 3.7 usec

PD: 1.0 sec

OF1: 1792.3

NA: 32

LB: 0.0

PTS1d: 16384

USER: -- DATE: Jun 6 2003

WinNuts - \$zgg-7-10-1a.fid

zgg-7-10-1-c13				USER: -- DATE: Jun 6 2003			
F1: 75.450	F2: 300.029	SW1: 18868		OF1: 8278.7		PTS1d: 65536	
EX: s2pul	PW: 4.2 usec	PD: 1.0 sec	NA: 104	LB: 0.0	WinNuts - \$zgg-7-10-1c.fid

3 c a

3 d a

gmj-8-98-h				USER: -- DATE: May 10 2003			
F1: 300.030	F2: 75.450	SW1: 4803		OF1: 1792.4		PTS1d: 16384	
EX: s2pul		PW: 3.7 usec	PD: 1.0 sec	NA: 20	LB: 0.0	WinNuts - \$zgg-6-73.fid

zgg-6-74-1c				USER: -- DATE: May 10 2003			
F1: 75.450	F2: 300.029	SW1: 18868		OF1: 8275.5		PTS1d: 65536	
EX: s2pul	PW: 4.2 usec	PD: 1.0 sec	NA: 100	LB: 0.0	WinNuts - \$zgg-6-73c.fid

-0.011

0.012

3 j a

Archive directory: /export/home/ASM/vnmrsys/data
Sample directory: zgg-6-52-1-noesy_05May2003

Pulse Sequence: NOESY

Solvent: CDC13
Ambient temperature
File: NOESY
Mercury-300BB "OMC300"

Relax. delay 2.000 sec
Mixing 0.300 sec
Acq. time 0.213 sec
Width 4807.7 Hz
2D Width 4807.7 Hz
32 repetitions
2 x 128 increments
OBSERVE H1, 300.0279812 MHz
DATA PROCESSING
Gauss apodization 0.098 sec
F1 DATA PROCESSING
Gauss apodization 0.025 sec
FT size 2048 x 2048
Total time 6 hr, 15 min, 19 sec

NOESY for 3aa

X-Ray for 3fa