Supporting Information

Multicomponent Type II Anion Relay Chemistry (ARC): One-Pot Syntheses of 2, 3-Disubstituted Furans and Thiophenes

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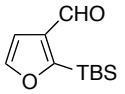
Materials and Methods: Reactions were carried out in oven or flame-dried glassware under an argon atmosphere, unless otherwise noted. All solvents were reagent grade. Anhydrous diethyl ether and tetrahydrofuran were obtained from a Pure Solve^{TM} PS-400 or distilled from sodium/benzophenone under an argon atmosphere. Reactions were magnetically stirred and monitored by thin layer chromatography (TLC) with 0.25 mm pre-coated silica gel plates. Flash chromatography was performed with silica gel 60 (particle size 0.040 – 0.062mm). Yields refer to chromatographically and spectroscopically pure compounds, unless otherwise stated. Proton and carbon-13 NMR spectra were recorded on 300 and 500 MHz spectrometer. Chemical shifts are reported relative to chloroform (δ 7.26) for ^{1}H NMR and chloroform (δ 77.0) ^{13}C NMR.

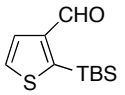
Experimental Procedures and Compound Characterization Data



2a

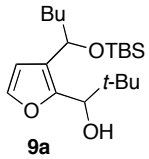
2a: To a solution of 2-TBS-3-(hydroxymethyl)-furan[9] (3.34 g, 15.7 mmol) in CH_2Cl_2 (150 mL) was added PCC (6.77 g, 31.4 mmol) at rt. After being stirred for 30 min, the reaction mixture was filtered through celite with Et_2O. The filtrate was then evaporated *in vacuo* and the crude oil was purified by flash chromatography (Hexane:Et_2O = 100:1) to give the desired product (2.88 g, 87%). ^{1}H NMR (500 MHz, $CDCl_3$) δ 10.07 (s, 1H), 7.63 (d, *J*=2.0Hz, 1H), 6.81 (d, *J*=2.0 Hz, 1H), 0.93 (s, 9H), 0.39 (s, 6H) ^{13}C NMR (125 MHz, $CDCl_3$) δ 186.2, 170.3, 147.6, 138.5, 107.4,

26.2, 17.1, –5.5; IR (neat, cm^{-1}) 2931, 2859, 1685, 1468, 1255; HRMS (ES^+) m/z 233.0969, [$(M+Na)^+$; calcd for $C_{11}H_{18}NaO_2Si$: 233.0974].



2b

2b: 3-Bromo-2-*t*-butyldimethylsilyl thiophene[6] (1.00 g, 3.61 mmol) in Et_2O (20 mL) was cooled to –78 ºC. To this mixture was added *t*-BuLi (2.35 mL, 1.7 M in pentane, 3.97 mmol) dropwise *via* syringe. The mixture was stirred at –78 ºC for 30 min, before a solution of DMF in Et_2O (316 mg/3 mL, 4.33 mmol) was added *via* syringe over 3 min. The reaction mixture was allowed to warm to rt and stir for 3 h. The reaction was then quenched with a saturated solution of NH_4Cl, and the mixture was extracted with Et_2O. The combined organic layers were washed with water (3 times), then dried over $MgSO_4$ and concentrated *in vacuo*. The crude oil was purified by flash chromatography (Hexane:EtOAc = 100:1) to give the product (790 mg, 97%). ^1H NMR (300 MHz, $CDCl_3$) δ 10.06 (d, *J*= 0.6 Hz, 1H), 7.75 (d, *J*= 4.8Hz, 1H), 7.67 (dd, *J*= 4.8 Hz, 0.9Hz, 1H), 0.94 (s, 9H), 0.47 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 186.2, 150.8, 149.1, 131.0, 128.2, 26.4, 17.2, –3.4; IR (neat, cm^{-1}) 2928, 2856, 1686, 1470, 1253; HRMS (ES^+) m/z 227.0932, [$(M+H)^+$; calcd for $C_{11}H_{19}OSSi$: 227.0926].

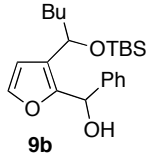


9a

General procedure for the three-component coupling reactions of furans:

Preparation of 9a from 2a in one pot: Compound **2a** (101 mg, 0.48 mmol) in Et_2O (1 mL) was cooled to –78 ºC. To this solution was added *n*-BuLi (0.25 mL, 2.1 M in hexanes, 0.53 mmol) dropwise *via* syringe. The mixture was stirred at –78 ºC for 30 min. Then, a solution of

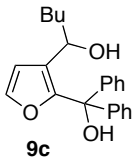
pivaldehyde (62.0 mg, 0.72 mmol) in HMPA/Et_2O (1 mL/1 mL) was added quickly at –78 ºC. The reaction mixture was slowly warmed to rt for 3h. The reaction was quenched with a saturated aqueous solution of NH_4Cl, and extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$, concentrated *in vacuo*. The residue was purified by flash chromatography (Hexane:EtOAc = 40:1) to give a 1:0.96 diastereomeric mixture of **9a** (133.6 mg, 78%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.28 (d, *J*=2.0 Hz, 1H), 7.26 (d, *J*=1.5 Hz, 1H), 6.35 (d, *J*=2.0 Hz, 1H), 6.33 (d, *J*=1.5 Hz, 1H), 4.70 (t, *J*=6.5 Hz, 1H), 4.60 (dd, *J*=9.0, 4.5 Hz, 1H), 4.36 (d, *J*=5.0 Hz, 1H), 4.32 (d, *J*= 5.5 Hz, 1H), 2.18 (d, *J*=6.0 Hz, 1H), 1.99 (d, *J*=6.0 Hz, 1H), 1.76-1.67 (m, 2H), 1.59-1.50 (m, 2H), 1.49-1.41 (m, 1H), 1.36-1.23 (m, 7H), 1.12 (s, 9H), 0.98 (s, 9H), 0.90-0.87 (m, 15H), 0.85 (s, 9H), 0.05 (s, 3H), 0.04 (s, 3H), –0.07 (s, 3H), –0.11 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 148.8 (2C), 141.0, 140.7, 127.1, 126.8, 109.9, 109.7, 74.3, 74.1, 67.8, 66.8, 40.1, 39.2, 36.4, 36.3, 28.2, 27.7, 26.4, 26.3, 25.8, 25.7, 22.6, 22.4, 18.1 (2C), 14.0 (2C), –4.5, –4.7, –4.8, –5.0; IR (neat, cm^{-1}) 3481, 2955, 2860, 1468, 1391, 1254, 1084; HRMS (ES^+) m/z 377.2480, [$(M+Na)^+$; calcd for $C_{20}H_{38}NaO_3Si$: 377.2488].



9b

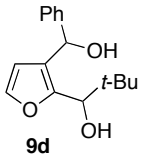
9b was prepared in an analogous method as **9a**. Isolated yield: 73% (dr 1:0.93); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.43-7.41 (m, 4H), 7.39-7.36 (m, 4H), 7.32-7.28 (m, 4H), 6.34-6.33 (m, 2H), 5.94 (br, 1H), 5.89 (br, 1H), 4.71 (t, *J*= 6.5 Hz, 1H), 4.62 (t, *J*= 6.5 Hz, 1H), 3.68 (br, 1H), 3.22 (br, 1H), 1.77- 1.73 (m, 2H), 1.66-1.59 (m, 2H), 1.33-1.23 (m, 8H), 0.91-0.90 (m, 12H), 0.88-0.85 (m, 12H), 0.09 (s, 3H), 0.06 (s, 3H), –0.03 (s, 3H), –0.07 (s, 3H); ^{13}C NMR (125 MHz,

$CDCl_3$) δ 149.7, 149.3, 141.54, 141.52, 141.1, 140.9, 128.3, 128.2, 127.6 (2C), 126.6, 126.5, 126.1, 125.7, 110.6, 110.4, 69.2, 69.0, 68.32, 68.29, 39.7, 39.6, 27.9, 27.8, 25.8, 25.7, 22.5, 22.4, 18.14, 18.12, 14.0, 13.9, -4.7, -4.8, -5.0, -5.1; IR (neat, cm^{-1}) 3407, 2955, 2857, 1463, 1361, 1254, 1083; HRMS (ES^+) m/z 397.2187 [$(M+Na)^+$; calcd for $C_{22}H_{34}O_3NaSi$: 397.2175].



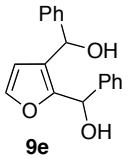
9c

9c: Compound **2a** (110 mg, 0.52 mmol) in Et_2O (1 mL) was cooled to –78 ºC. To this solution was added *n*-BuLi (0.27 mL, 2.1 M in hexanes, 0.57 mmol) dropwise *via* syringe. The mixture was stirred at –78 ºC for 30 min before a solution of acetophenone (142.1 mg, 0.78 mmol) in HMPA/Et_2O (1 mL/1 mL) was added quickly at –78 ºC. The reaction mixture was slowly warmed to rt for 3h. The reaction was quenched with a saturated aqueous solution of NH_4Cl, and extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$ and concentrated *in vacuo*. The residue was dissolved in THF (2 mL) and treated with TBAF (0.78 mL, 0.78 mmol) for 30 min at rt. The reaction mixture was then quenched with H_2O and extracted with Et_2O. After drying with anhydrous $MgSO_4$ and evaporation of the solvent, the residue was purified by flash chromatography (Hexane:EtOAc = 7:1) to give **9c** (133.2 mg, 76%); ^1H NMR (500 MHz, $CDCl_3$) δ 7.36-7.29 (m, 10H), 7.28 (d, *J*= 1.5 Hz, 1H), 6.35 (d, *J*= 1.5 Hz, 1H), 4.40 (t, *J*= 6.5 Hz, 1H), 1.74-1.65 (m, 2H), 1.35-1.23 (m, 5H), 1.20-1.14 (m, 1H), 0.89 (t, *J*= 7.0 Hz, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 153.2, 145.6, 145.2, 140.0, 127.9, 127.8, 127.6, 127.56, 127.54, 127.3, 125.0, 110.4, 78.8, 67.2, 37.0, 27.9, 22.4, 13.9; IR (neat, cm^{-1}) 3345, 2955, 2859, 1448, 1379, 1175, 1107; HRMS (ES^+) m/z 359.1635 [$(M+Na)^+$; calcd for $C_{22}H_{24}NaO_3$: 359.1647].



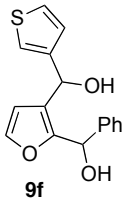
9d

9d was prepared in an analogous method as **9c**. Isolated yield: 83% (dr 1:0.90); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.41-7.33 (m, 8H), 7.31-7.24 (m, 3H), 7.23 (s, 1H), 6.16 (d, *J*=2.0 Hz, 1H), 6.08 (d, *J*=1.5 Hz, 1H), 5.93 (s, 1H), 5.78 (s, 1H), 4.50 (s, 1H), 4.48 (s, 1H), 3.39 (br, 4H), 1.00 (s, 9H), 1.00 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 151.5, 151.3, 143.0, 142.9, 141.3, 140.6, 128.35, 128.33, 127.5, 127.4, 126.2 (2C), 125.1, 124.7, 110.4, 109.7, 76.0, 73.9, 68.5, 67.8, 36.6, 36.1, 26.3, 26.0; IR (neat, cm^{-1}) 3373, 3063, 2956, 2870, 1480, 1363, 1240, 1045; HRMS (ES^+) m/z 283.1316, [$(M+Na)^+$; calcd for $C_{16}H_{20}NaO_3$: 283.1310].



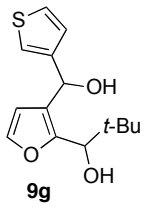
9e

9e was prepared in an analogous method as **9c**. Isolated yield: 74% (dr 1:0.81); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.40-7.27 (m, 20H), 7.24 (s, 1H), 7.23 (s, 1H), 6.13 (d, *J*=1.5 Hz, 1H), 6.10 (d, *J*=1.5 Hz, 1H), 5.93 (s, 1H), 5.93 (s, 1H), 5.85 (s, 1H), 5.79 (s, 1H), 3.97 (br, 2H), 3.47 (br, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 151.6, 151.0, 142.8, 142.7, 141.6, 141.2, 141.1, 140.9, 128.44, 128.43, 128.38, 128.36, 127.72, 127.70, 127.6 (2C), 126.4, 126.2 (3C), 124.5, 124.2, 110.9, 110.4, 69.5, 69.0, 68.73, 68.70; IR (neat, cm^{-1}) 3360, 3061, 2923, 1494, 1245, 1012; HRMS (ES^+) m/z 263.1069, [$(M-OH)^+$; calcd for $C_{18}H_{15}O_2$: 263.1072].



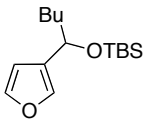
9f

9f was prepared in an analogous method as **9c**. Isolated yield: 62% (dr 1:0.97); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.37-7.30 (m, 10H), 7.28-7.26 (m, 4H), 7.13 (s, 2H), 6.97-6.94 (m, 2H), 6.21 (d, *J*=2.0 Hz, 1H), 6.19 (d, *J*=2.0 Hz, 1H), 5.90-5.88 (m, 3H), 5.84 (s, 1H), 3.96 (br, 2H), 3.62(br, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 151.4, 150.8, 144.3 (2C), 141.6, 141.2, 141.0, 140.8, 128.4 (2C), 127.8, 127.7, 126.3 (2C), 126.22, 126.21, 126.18, 126.15, 124.1, 123.9, 121.5, 121.4 110.7, 110.3, 69.4, 68.6, 65.4, 65.2; IR (neat, cm^{-1}) 3360, 3030, 2886, 1451, 1416, 1242, 1015; HRMS(ES^-) m/z 285.0571, [$(M-H)^-$; calcd for $C_{16}H_{13}O_3S$: 285.0585].



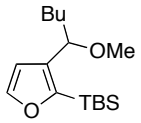
9g

9g was prepared in an analogous method as **9c**. Isolated yield: 65% (dr 1:0.87); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31-7.26 (m, 4H), 7.22-7.21 (m, 1H), 7.19-7.18 (m, 1H), 7.04 (dd, *J*=5.0, 1.0 Hz, 1H), 7.02 (dd, *J*=5.0, 1.0 Hz, 1H), 6.28 (d, *J*=2.0 Hz, 1H), 6.19 (d, *J*=1.5 Hz, 1H), 5.98 (s, 1H), 5.87 (s, 1H), 4.49 (s, 1H), 4.46 (s, 1H), 2.91 (br, 4H), 0.99 (s, 9H), 0.97 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 151.3, 151.0, 144.5, 144.4, 141.4, 140.8, 126.3, 126.28, 126.1 (2C), 124.7, 124.4, 121.5, 121.3, 110.2, 109.7, 75.9, 74.3, 65.3, 64.8, 36.6, 36.2, 26.2, 26.0; IR (neat, cm^{-1}) 3375, 2956, 2906, 1477, 1238, 1045; HRMS(ES^-) m/z 265.0903, [$(M-H)^-$; calcd for $C_{14}H_{17}O_3S$: 265.0898].



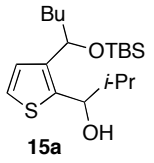
9h

9h: Compound **2a** (105 mg, 0.50 mmol) in Et_2O (1 mL) was cooled to –78 ºC. To this solution was added *n*-BuLi (0.26 mL, 2.1 M in hexanes, 0.55 mmol) dropwise *via* syringe. The mixture was stirred at –78 ºC for 30 min before a solution of isobutyraldehyde (54.0 mg, 0.75 mmol) in HMPA/Et_2O (1 mL/1 mL) was added quickly at –78 ºC. The reaction mixture was slowly warmed to rt for 3h. The reaction was quenched with a saturated aqueous solution of NH_4Cl, extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$, concentrated *in vacuo*. The residue was purified by flash chromatography (Hexane:EtOAc = 200:1) to give **9h** (109.6 mg, 82%) ; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 (t, *J*=1.5 Hz, 1H), 7.27 (t, *J*=1.0 Hz, 1H), 6.33 (d, *J*=1.0, 1H), 4.64 (t, *J*=6.0 Hz, 1H), 1.72-1.69 (m, 1H), 1.68-1.57 (m, 1H), 1.34-1.23 (m, 4H), 0.90-0.87 (m, 12H), 0.05 (s, 3H), 0.04 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 142.7, 138.6, 130.1, 108.8, 67.7, 39.2, 27.5, 25.8, 25.6, 18.2, 14.1, –4.7, –4.9; IR (neat, cm^{-1}) 2956, 2858, 1468, 1361, 1256, 1085; HRMS (ES^+) m/z 269.1934, [$(M+H)^+$; calcd for $C_{15}H_{29}O_2Si$: 269.1937].



9i

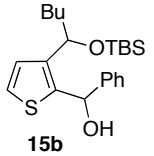
9i was prepared in an analogous method as **9a**. Isolated yield: 85%; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.59 (d, *J*=1.5 Hz, 1H), 6.40 (d, *J*=1.5 Hz, 1H), 4.23 (dd, *J*=7.5, 5.5 Hz. 1H), 3.17 (s, 3H), 1.82-1.78 (m, 1H), 1.59-1.52 (m, 1H), 1.43-1.39 (m, 1H), 1.35-1.24 (m, 3H), 0.93 (s, 9H), 0.88 (t, *J* = 7.0 Hz, 3H), 0.28 (s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 154.7, 146.8, 138.1, 108.3, 75.6, 56.2, 37.4, 28.4, 26.7, 22.8, 17.6, 14.2, –4.9, –4.95; IR (neat, cm^{-1}) 2955, 2859, 1467, 1362, 1251, 1097; HRMS (ES^+) m/z 305.1909, [$(M+Na)^+$; calcd for $C_{16}H_{30}NaO_2Si$: 305.1913].



15a

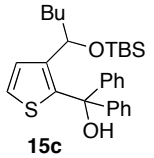
General procedure for the three-component coupling reactions of thiophenes:

Preparation of 15a from 2b in one pot: Compound **2b** (100 mg, 0.44 mmol) in THF (3 mL) was cooled to –78 ºC. To this solution was added *n*-BuLi (0.30 mL, 1.6 M in hexanes, 0.49 mmol) dropwise *via* syringe. The mixture was stirred at –78 ºC for 30 min before a solution of isobutyraldehyde (47.6 mg, 0.66 mmol) in DMPU/THF (1 mL/1 mL) was added quickly at –78 ºC. The reaction mixture was slowly warmed to rt for 3h. The reaction was quenched with a saturated aqueous solution of NH_4Cl. The mixture was extracted with Et_2O. Combined organic layers were washed with $NaHSO_4$ (1.0 N) and brine. After drying with anhydrous $MgSO_4$ and evaporation of the solvent, the residue was purified by flash chromatography (Hexane:EtOAc = 100:1) to give a 1:0.96 diastereomeric mixture of **15a** (88 mg, 56%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.17 (d, *J*=5.1 Hz, 1H), 7.15 (d, *J*= 5.1Hz, 1H), 7.01 (d, *J*=5.1 Hz, 1H), 6.99 (d, *J*= 5.1Hz, 1H), 4.88-4.78 (m, 2H), 4.66-4.59 (m, 2H), 2.08-1.93 (m, 4H), 1.77-1.55 (m, 4H), 1.35-1.21 (m, 8H), 1.15 (d, *J*= 6.3Hz, 3H), 1.13 (d, *J*=6.3 Hz, 3H), 0.9-0.7 (m, 30H), 0.06 (s, 3H), 0.05 (s, 3H), –0.10 (s, 3H), -0.13 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.1, 143.5, 140.6, 140.2, 127.5, 127.3, 123.4, 123.2, 73.4 (2C), 70.1, 69.2, 40.3, 39.8 (2C), 36.6, 36.1, 28.2, 28.0, 25.8, 25.7, 22.6, 22.5, 19.9, 19.7, 19.2, 18.8, 18.2, 18.1, 14.1, –4.6, –4.8, –4.9, –5.0; IR (neat, cm^{-1}) 3462, 2986, 2857, 1471, 1387, 1255, 1082; (HRMS) m/z 379.2098 [$(M+Na)^+$; $C_{19}H_{36}NaO_2SSi$: calcd for: 379.2103].



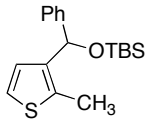
15b

15b was prepared in an analogous method as **15a**. Isolated yield: 79% (dr 1:0.88); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.42-7.21 (m, 10H), 7.06 (d, *J*= 5.4 Hz, 1H), 7.03 (d, *J*= 5.1 Hz, 1H), 6.91 (d, *J*= 5.4 Hz, 1H), 6.90 (d, *J*= 5.1 Hz, 1H) 6.10 (s, 1H), 6.03 (s, 1H), 4.75-4.70 (m, 2H), 3.15 (s, 1H), 2.99 (s, 1H), 1.74-1.49 (m, 4H) 1.28-1.09 (m, 8H), 0.86-0.79 (m, 21H), 0.73 (t, *J*= 6.6 Hz, 3H) –0.02 (s, 3H), –0.09 (s, 3H), –0.16 (s, 3H), –0.24 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 143.3, 142.8, 142.7, 142.5, 141.4, 140.5, 128.4, 128.3, 128.2, 128.0, 127.9, 127.7, 126.7, 126.6, 125.9, 123.5, 70.8, 70.6, 70.2, 70.0, 39.4, 39.0, 30.3, 28.1, 28.0, 25.8, 22.5, 22.4, 18.2, 18.1, 14.1, 14.0, –4.8, –4.9, –5.0, –5.1; IR (neat, cm^{-1}) 3396, 2955, 2856, 1462, 1360, 1250, 1079; HRMS (ES^+) m/z 413.1987 [$(M+Na)^+$; calcd for $C_{22}H_{34}NaOSSi$: 413.1946].



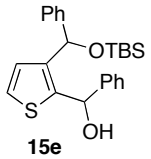
15c

15c was prepared in an analogous method as **15a**. Isolated yield: 87% ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.40-7.28 (m, 10H), 7.07 (d, *J*= 5.1 Hz, 1H), 6.91 (d, *J*= 5.1 Hz, 1H), 6.06 (s, 1H), 4.78 (t, *J*= 6.9 Hz, 1H), 1.59-1.37 (m, 2H), 1.10-1.04 (m, 4H), 0.89 (s, 9H), 0.78 (t, *J*= 6.9 Hz, 3H), 0.01 (s, 3H), –0.12 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 148.0, 147.9, 146.5, 141.1, 129.7, 128.1, 127.7, 127.6, 127.5, 127.4, 127.3, 122.7, 79.4, 72.6, 38.1, 28.1 25.8, 22.4, 18.2, 14.0, –4.8, –5.0; IR (neat, cm^{-1}) 3341, 2954, 2856, 1471, 1360, 1254, 1108; HRMS (ES^+) m/z 467.2448 [$(M+H)^+$; calcd for $C_{28}H_{39}O_2SSi$: 467.2440].



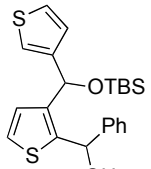
15d

15d was prepared in an analogous method as **15a**. Isolated yield: 48%. ^{1}H, ^{13}C, IR, Mass data were matched with previously published results: *Org. Lett*, **2007**, *47*, 7082.



15e

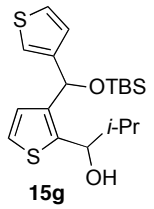
15e was prepared in an analogous method as **15a**. Isolated yield: 77% (dr 1:0.84); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.54-7.34 (m, 23H), 7.14 (d, *J*= 5.1 Hz, 1H), 6.35 (d, *J*= 3.6 Hz, 1H), 6.13 (s, 1H), 6.10 (s, 1H) 6.03 (d, *J*= 2.7 Hz, 1H), 3.36 (d, *J*= 2.7 Hz, 1H), 2.57 (d, *J*= 3.6 Hz, 1H), 1.05 (s, 9H), 1.04 (s, 9H), 0.17 (s, 3H), 0.16 (s, 3H), 0.11 (s, 3H), 0.08 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 144.3, 143.5, 142.8, 142.3, 142.2, 142.1, 142.0, 128.5 (2C), 128.4, 128.3, 128.2, 127.9 (2C), 127.8, 127.2, 127.1, 126.6, 126.4, 126.0, 125.8 (2C), 124.2, 123.9, 71.8, 71.5, 69.9, 69.4, 25.84, 25.81, 18.3 (2C), –4.8, –4.9, –4.96, –5.0; IR (neat, cm^{-1}) 3414, 3029, 2955, 2884, 1472, 1361, 1256, 1066; HRMS (ES^{+}) m/z 393.1711, [$(M\text{-}OH)^{+}$; calcd for $C_{24}H_{29}OSSi$: 393.1708].



15f

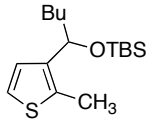
15f was prepared in an analogous method as **15a**. Isolated yield: 76% (dr 1:0.7); ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.34-6.79 (m, 20H), 6.16-5.87 (m, 4H), 3.24-2.48 (m, 2H), 0.98 (s, 18H), 0.03-0.07 (m, 12H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 145.9, 145.1, 143.9, 142.8, 142.3, 142.2, 141.4, 141.3, 128.4, 128.3, 128.2, 128.0, 127.9, 127.8, 126.6, 126.4, 126.2, 126.0, 125.9, 124.2, 123.9

(2C), 120.7, 120.6, 70.0, 69.4, 69.2, 68.4, 25.9, 25.8, 18.3, 18.2, –4.8, –4.9, –5.0, –5.1; IR (neat, cm^{-1}) 3414, 3065, 2954, 1472, 1255, 1069; HRMS (ES^+) m/z 399.1288, [$(M\text{-}OH)^+$; calcd for $C_{22}H_{27}OS_2Si$: 399.1273].

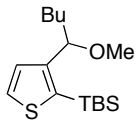


15g

15g was prepared in an analogous method as **15a**. Isolated yield: 76% (dr 1:0.9); ^1H NMR (300 MHz, $CDCl_3$) δ 7.25-7.22 (m, 2H), 7.19 (d, *J*= 5.1 Hz, 2H), 7.14-7.13 (m, 1H), 7.10-7.08 (m, 2H), 7.04 (d, *J*= 5.1 Hz, 1H), 6.97 (dd, *J*= 5.1 Hz, 1.5 Hz, 1H), 6.93 (dd, *J*= 5.1 Hz, 1.2 Hz, 1H), 6.04 (s, 1H), 6.01 (s, 1H), 4.70 (dd, *J*= 8.1 Hz, 3.9 Hz, 1H), 4.61 (dd, *J*= 8.7 Hz, 3.6Hz, 1H), 2.05-1.98 (m, 4H), 1.08 (d, *J*= 6.6 Hz, 3H), 1.06 (d, *J*= 6.6 Hz, 3H), 0.94 (s, 9H), 0.92 (s, 9H), 0.77 (d, *J*= 6.6 Hz, 3H), 0.75 (d, *J*= 6.6 Hz, 3H), 0.09 (s, 3H), 0.08 (s, 3H), 0.01 (s, 3H), –0.01 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 146.23, 146.2, 142.5, 142.4, 141.9, 141.6, 127.9, 127.5, 126.4, 126.3, 125.9, 125.8, 123.6, 123.55, 120.8, 120.3, 73.3, 73.1, 68.7, 68.0, 36.1, 35.6, 25.8 (2C), 19.7, 19.65, 19.1, 18.7, 18.2 (2C), –4.8 (2C), –4.9 (2C); IR (neat, cm^{-1}) 3457, 2958, 2857, 1472, 1362, 1255, 1068; HRMS (ES^+) m/z 365.1428, [$(M\text{-}OH)^+$; cacld for $C_{19}H_{29}OS_2Si$: 365.1429].



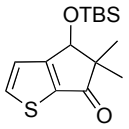
15h



15i

15h and **15i** were prepared in an analogous method as **15a**. Isolated yield: 45% for **15h**, 41% for **15i**; **15h**: ^1H NMR (300 MHz, $CDCl_3$) δ 6.96-6.95 (m, 2H), 4.68 (dd, *J*= 7.5 Hz, 5.4 Hz, 1H),

2.38 (s, 3H), 1.76-1.15 (m, 6H), 0.90-0.84 (m, 12H), 0.001 (s, 3H), -0.16 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 142.0, 131.8, 127.2, 120.9, 69.5, 39.3, 27.9, 25.9, 22.6, 18.2, 14.1, 13.0, –4.9, –5.2; IR (neat, cm^{-1}) 2955, 2857, 1464, 1361, 1250, 1098; HRMS (ES^+) m/z 299.1861, [$(M+H)^+$; calcd for $C_{16}H_{31}OSSi$: 299.1865]. **15i**: ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.55 (d, *J*= 4.8 Hz, 1H), 7.24 (d, *J*= 4.8 Hz, 1H), 4.36 (dd, *J*= 9.0 Hz, 2.4 Hz, 1H), 3.21 (s, 3H), 1.83-1.76 (m, 1H), 1.75-1.52 (m, 2H), 1.37-1.25 (m, 3H), 0.96 (s, 9H), 0.92 (t, *J*= 4.5 Hz, 3H), 0.38 (s, 3H), 0.37 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 152.5, 132.0, 130.4, 127.6, 79.5, 56.4, 38.3, 28.7, 26.8, 22.7, 17.6, 14.1, –3.0, –3.1; IR (neat, cm^{-1}) 2955, 2857, 1464, 1361, 1250, 1098; HRMS (ES^+) m/z 299.1861, [$(M+H)^+$; $C_{16}H_{31}OSSi$: calcd for : 299.1865].

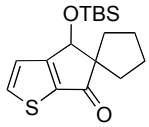


18a

General procedure for the reaction with enolized ester:

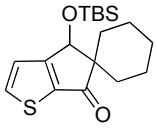
Preparation of 18a from 2b in one pot: Compound **2b** (100 mg, 0.44 mmol) in THF (2 mL) was cooled to –78 ºC. In another flask the ester (61.5 mg, 0.48 mmol) in THF (2 mL) was cooled to –78 ºC and was treated with freshly prepared LDA (1.1 eq). The mixture was stirred at –78 ºC for 1 h. Then, the linchpin **2b** was added via cannula to the flask containing ester enolate solution. The reaction was stirred at –78 ºC for 25 min. DMPU (2 mL) was added quickly to the reaction mixture. The reaction was allowed warm to room temperature overnight and then quenched with saturated solution of NH_4Cl. The mixture was extracted with Et_2O. The combined organic layers were washed with $NaHSO_4$ (1.0 N) and brine. After drying with anhydrous $MgSO_4$ and evaporation of the solvent, the residue was purified by flash chromatography (Hexane:EtOAc = 100:1) to give **18a** (90 mg, 69%); mp: 96-99 ºC, ^{1}H NMR (300 MHz, $CDCl_3$)

δ 7.91 (d, *J*= 4.8 Hz, 1H), 7.10 (d, *J*= 4.8 Hz, 1H), 4.85 (s, 1H), 1.29 (s, 3H), 1.17 (s, 3H), 0.96 (s, 9H), 0.24 (s, 3H), 0.20 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 199.4, 166.8, 140.5, 136.0, 123.4, 75.6, 56.9, 25.7, 23.3, 21.5, 18.2, –4.46, –5.0; IR (neat, cm^{-1}) 2955, 2857, 1689, 1463, 1258, 1108; HRMS (ES^+) m/z 297.1350, $[(M+H)^+$; calcd for $C_{25}H_{25}O_2SSi$: 297.1345].



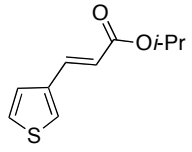
18b

18b was prepared in an analogous method as **18a**. Isolated yield: 88%; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.87 (d, *J*= 4.8 Hz, 1H), 7.09 (d, *J*= 4.8 Hz, 1H), 4.89 (s, 1H), 2.23-2.10 (m, 2H), 1.89-1.65 (m, 6H), 0.94 (s, 9H), 0.23 (s, 3H), 0.19 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 199.5, 167.0, 140.5, 139.9, 123.3, 75.4, 67.8, 36.7, 31.9, 26.8, 26.1, 25.7, 18.0, –4.1, –4.5; IR (neat, cm^{-1}) 2930, 2857, 1705, 1462, 1254, 1078; HRMS (ES^+) m/z 323.1509, $[(M+H)^+$; calcd for $C_{17}H_{27}OSSi$: 323.1501].



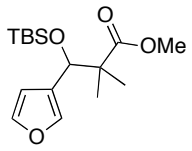
18c

18c was prepared in an analogous method as **18a**. Isolated yield: 73%; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.86 (d, *J*= 4.8 Hz, 1H), 7.10 (d, *J*= 4.8 Hz, 1H), 4.88 (s, 1H), 1.87-1.44 (m, 10H), 0.93 (s, 9H), 0.23 (s, 3H), 0.20 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 199.9, 165.9, 140.5, 139.5, 123.8, 74.4, 59.9, 33.9, 28.2, 25.8, 25.3, 22.8, 21.8, 18.1, –3.7, –4.2; IR (neat, cm^{-1}) 2928, 2855, 1705, 1462, 1256, 1083; HRMS (ES^+) m/z 337.1655, $[(M+H)^+$; calcd for $C_{18}H_{29}O_2SSi$: 337.1658].



18d

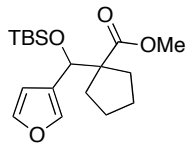
18d was prepared in an analogous method as **18a**. Isolated yield: 65%; ^{1}H NMR (300 MHz, $CDCl_3$) δ 7.67 (d, *J*= 15.9 Hz, 1H), 7.50 (d, *J*= 0.9 Hz, 1H), 7.34-7.29 (m, 2H), 6.26 (d, *J*= 15.9 Hz, 1H), 5.17-5.12 (septet, *J*= 5.6 Hz, 1H), 1.32 (d, *J*= 6.0 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.8, 137.8, 137.6, 127.8, 126.9, 125.1, 118.4, 67.7, 21.9; IR (neat, cm^{-1}) 3090, 2979, 1707, 1634, 1278, 1173, 1109; HRMS (ES^+) m/z 197.0644, [$(M+H)^+$; calcd for $C_{10}H_{13}O_2S$: 197.0636].



19a

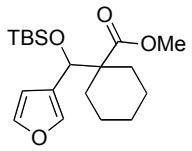
19a: To a solution of DIPA (67.8 mg, 0.68 mmol) in Et_2O (1 mL) at - 15 ºC was added *n*-BuLi (0.32 mL, 2.1 M in hexanes, 0.68 mmol) dropwise *via* syringe. After the addition was complete, the reaction mixture was stirred for 20 min, and then cooled to –78 ºC. To this solution was slowly added the ester (68.6 mg, 0.67 mmol) in Et_2O (1 mL). The resulting solution was stirred for 1 h at –78 ºC before the linchpin **2a** (117 mg, 0.56 mmol) in Et_2O (2 mL) was added via cannula to the reaction mixture. After 30 min at –78 ºC, HMPA (2 mL) was quickly added to the reaction mixture, which was then allowed to warm to room temperature overnight. The reaction was quenched with a saturated aqueous solution of NH_4Cl and extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$, concentrated *in vacuo*. The residue was purified by flash chromatography (Hexane:Et_2O = 40:1) to give **19a** (90.7 mg, 52%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 (t, *J*=1.5 Hz, 1H), 7.25 (s, 1H), 6.31 (d,

J=1.0 Hz, 1H), 4.93 (s, 1H), 3.65 (s, 3H), 1.18 (s, 3H), 0.99 (s, 3H), 0.85 (s, 9H), –0.01 (s, 3H), –0.21 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 177.1, 142.2, 140.0, 125.6, 110.4, 72.3, 51.6, 48.8, 25.6, 21.0, 19.7, 18.0, –4.6, –5.6; IR (neat, cm^{-1}) 2953, 2858, 1729, 1472, 1257, 1191, 1090; HRMS (ES^+) m/z 335.1664, [$(M+Na)^+$; calcd for $C_{16}H_{28}NaO_4Si$: 335.1655].



19b

19b was made in a similar method as **19a** except using DMPU:THF = (3 mL: 3 mL) as the solvent system to trigger the Brook Rearrangement. Isolated yield: 57%; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.29 (t, *J*=1.5 Hz, 1H), 7.23 (br, 1H), 6.31 (d, *J*=1.5 Hz, 1H), 5.06 (s, 1H), 3.62 (s, 3H), 2.04-2.00 (m, 1H), 1.93-1.86 (m, 2H), 1.78-1.73 (m, 1H), 1.54-1.48 (m, 4H), 0.86 (s, 9H), 0.03 (s, 3H), -0.19 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 176.9, 142.3, 139.7, 126.6, 110.0, 70.6, 61.0, 51.6, 32.7, 30.2, 25.7, 25.6 (2C), 18.0, –4.6, –5.4; IR (neat, cm^{-1}) 2954, 2859, 1738, 1468, 1255, 1195, 1091; HRMS (ES^+) m/z 361.1811, [$(M+Na)^+$; calcd for $C_{18}H_{30}NaO_4Si$: 361.1811].



19c

19c: To a solution of (cyclohexylidene(methoxy)methoxy)trimethylsilane[12] (146 mg, 0.68 mol) in Et_2O (1 mL) was added MeLi (0.40 mL, 1.6 M in Et_2O, 0.64 mol) at 0 ºC. After the addition was complete, the reaction mixture was allowed to stir for 1 h at rt. After being cooled to – 78 ºC, **2a** (104.9 mg, 0.50 mol) in Et_2O (1 mL) was slowly added and stirred at –78 ºC for 30 min.

[12] Hatano, M.; Takagi, E.; Ishihara, K. *Org. Lett*. **2007**, *9*, 4527.

HMPA (2 mL) was added quickly to the reaction mixture. The reaction was then allowed to warm to room temperature overnight. The reaction was quenched with a saturated aqueous solution of NH_4Cl and extracted with Et_2O. The combined organic layers were washed with brine, dried over anhydrous $MgSO_4$ and concentrated *in vacuo*. The residue was purified by flash chromatography (Hexane:Et_2O = 40:1) to give **19c** (91.8 mg, 52%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 (t, *J*=1.5 Hz, 1H), 7.21 (t, *J*=1.0 Hz, 1H), 6.28 (d, *J*=1.0 Hz, 1H), 4.67 (s, 1H), 3.64 (s, 3H), 2.11-2.09 (m, 1H), 1.97-1.95 (m, 1H), 1.63-1.58 (m, 3H), 1.38-1.23 (m, 4H), 1.07-0.99 (m, 1H), 0.87 (s, 9H), 0.00 (s, 3H), –0.23 (s, 3H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 175.5, 142.1, 140.0, 125.8, 110.4, 73.4, 54.2, 51.3, 29.6, 29.0, 25.9, 25.7, 23.4, 23.3, 18.0, –4.7 –5.5; IR (neat, cm^{-1}) 2932, 2858, 1739, 1456, 1255, 1132, 1092; HRMS (ES^+) m/z 375.1967, [$(M+Na)^+$; calcd for $C_{19}H_{32}NaO_4Si$: 375.1968].