

Palladium Catalyzed Cross-Coupling Reactions of Heterocyclic Silanolates with Substituted Aryl Iodides and Bromides

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SUPPORTING INFORMATION

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General Experimental:

Reactions were conducted using glassware that had been oven-dried for at least 12 h or flame-dried under vacuum. Syringes and needles were dried for at least 12 h and flushed with argon prior to use. All reactions were conducted under an atmosphere of dry argon using a drying tube equipped with phosphorus pentoxide and calcium sulfate. Solvents used for extraction were reagent grade, and chromatography solvents were reagent grade except for ethyl acetate which was technical grade and distilled using K_2CO_3 as the drying agent. Reaction solvent toluene (Fisher, ACS grade) was dried by percolation through a column packed with neutral alumina and a column packed with Q5 reactant, a supported copper catalyst for scavenging oxygen, under a positive pressure of argon. *n*-BuLi was titrated using a modification of Gilman's double titration method.¹ All reaction temperatures were measured internally with Teflon coated thermocouple probes.

All ^1H NMR, ^{13}C NMR, and ^{19}F NMR spectra were obtained on Varian Unity 400 and Unity 500 MHz spectrometers using deuteriochloroform with residual chloroform as the internal reference (δ 7.26 ppm, ^1H ; δ 77.0 ppm, ^{13}C), deuterobenzene with residual benzene as the

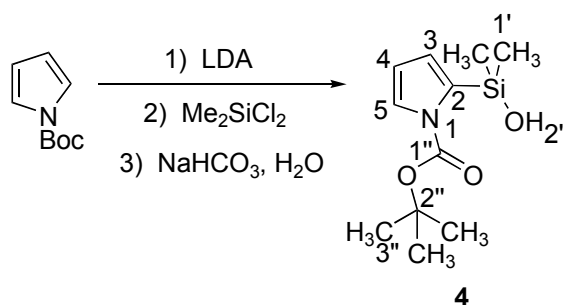
internal reference (δ 7.15 ppm, ^1H ; δ 128.62 ppm, ^{13}C) or deuteriotetrahydrofuran with residual tetrahydrofuran as the internal reference (δ 3.58 ppm, ^1H ; δ 67.4 ppm, ^{13}C). Hexafluorobenzene was used as an internal reference for ^{19}F NMR (-160.0 ppm, ^{19}F). All chemical shifts are reported in ppm (δ) while multiplicities are indicated as s (singlet), d (doublet), t (triplet), q (quartet), or m (multiplet). All coupling constants (J) are reported in Hertz. Infrared spectra (IR) were obtained using a Mattson Galaxy 5020 spectrophotometer, and peaks are reported in reciprocal cm along with relative signal intensities: s (strong); m (medium); w (weak). Mass spectrometry data was performed by the University of Illinois School for Chemical Sciences and molecular ion peaks are listed with relative abundances. Elemental analyses were conducted by the University of Illinois Microanalytical Service Laboratory. Retention factors, R_f , are reported for analytical thin layer chromatography performed on Merck silica gel plates treated with F-254 indicator. Visualization was accomplished by UV light or aqueous KMnO_4 solution. Column chromatography was conducted using 230-400 mesh silica gel purchased from Silicycle using the eluent and pressure given.

Analytical capillary gas chromatography (GC) was performed on a Hewlett Packard 5890 Series II instrument equipped with a flame ionization detector (H_2 carrier gas, 1 mL/min) and a HP-5 50-m column cross-linked 5%-Phenyl methyl silicone gum stationary phase. The following program was used for GC analysis: initial temperature of 100 $^\circ\text{C}$ and an initial time of 1 min. A ramp of 50 $^\circ\text{C}/\text{min}$ was employed with a final temperature of 250 $^\circ\text{C}$ and a final time of 15 min. The injector port was set to 250 $^\circ\text{C}$ and the detector port at 300 $^\circ\text{C}$.

Commercial reagents were purified by recrystallization or distillation before use. Distillations were performed using a short-path, 3 cm, Vigreux column under reduced pressure. Bulb-to-bulb distillations were conducted using a Büchi GKR-50 Kugelrohr apparatus at the pressure specified. All reported boiling points are recorded air-bath temperatures (ABT). Melting points were conducted in vacuum-sealed glass tubes using a Thomas-Hoover Uni-MeltTM melting point apparatus and are corrected. Sodium hydride was purchased from Aldrich as a 60% suspension in mineral oil which was washed with hexanes and titrated using No D-NMR spectroscopy.²

Literature Preparations:

N-Boc(2-indolyl)dimethylsilanol³ was prepared according to the literature procedure.

Preparation of *N*-Boc(2-pyrrolyl)dimethylsilanol (4**)**

To a flame-dried, three-necked, 250-mL, round-bottomed flask fitted with an argon inlet adaptor, thermocouple, magnetic stir bar and septum was placed 3.00 g (17.9 mmol, 1.0 equiv) of *N*-BOCpyrrole followed by 10.0 mL of dry THF. The solution was cooled to $-71\text{ }^{\circ}\text{C}$ (internal) in a dry ice/acetone bath and a solution of LDA (prepared as described below) was slowly added via cannula over 20 min.

The lithium diisopropylamide (LDA) solution was prepared by placing a solution of 3.14 mL (22.4 mmol, 1.25 equiv) of dry diisopropylamine in 10.0 mL of dry THF in a flame-dried, 50-mL two-necked round bottom flask fitted with an argon inlet adapter, magnetic stir bar and septum. The solution was cooled to $-71\text{ }^{\circ}\text{C}$ in a dry ice/2-propanol bath for 15 min and 18.67 mL (1.20 M in hexane, 22.4 mmol, 1.25 equiv) of a *n*-BuLi solution was slowly added. The resulting mixture was stirred for 5 min before being allowed to warm to $0\text{ }^{\circ}\text{C}$ (ice bath) slowly. The solution was stirred for 20 min at $0\text{ }^{\circ}\text{C}$ before being cooled to $-70\text{ }^{\circ}\text{C}$ and added to the solution prepared above.

The reaction mixture was stirred at $-71\text{ }^{\circ}\text{C}$ for 6 h whereupon 3.26 mL of Me_2SiCl_2 was added. The reaction mixture was allowed to warm to room temperature slowly over a period of 10 h. The reaction mixture was cooled to $0\text{ }^{\circ}\text{C}$ in an ice bath and 20.0 mL of sat. aq. NaHCO_3 solution was added. The aqueous layer was separated and extracted with EtOAc (4 x 25 mL). The combined organic layers were washed with brine (1 x 15 mL) and H_2O (1 x 15 mL) and dried over MgSO_4 and filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give an oil which was immediately purified by silica gel chromatography (60 X 100 mm) by first eluting with 300 mL of hexane followed by hexane/EtOAc, 9/1 (30 X 50 mL fractions) to give a yellow oil which was purified by Kugelrohr distillation to afford 2.183 g (50%) of **4** as a clear, colorless semi-solid.

Data for 4:

bp: 125 °C (0.5 mmHg, ABT)

¹H NMR: (500 MHz, CHCl₃)7.34 (dd, *J* = 3.0, 1.5, 1 H, HC(5)), 6.51 (dd, *J* = 3.1, 1.4, 1 H, HC(3)), 6.23 (t, *J* = 3.1, 1 H, HC(4)), 2.96 (s, 1 H, HC(2')), 1.61 (s, 9 H, HC(3'')), 0.37 (s, 6 H, HC(1'))¹³C NMR: (125 MHz, CHCl₃)

150.84 (C(1')), 134.28 (C(3)), 124.27 (C(2)), 123.58 (C(5)), 112.24 (C(4)), 84.23 (C(2'')), 27.92 (C(3'')), -0.13 (C(1'))

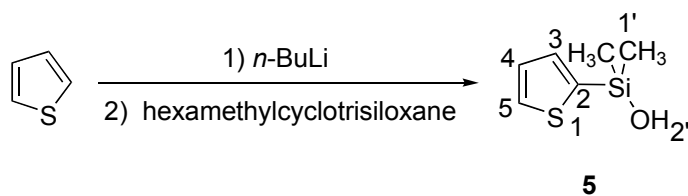
IR: (neat)

3373 (s), 2979 (m), 2905 (w), 2826 (w), 2361 (w), 1906 (w), 1841 (w), 1731 (s), 1536 (m), 1478 (w), 1459 (w), 1391 (s), 1370 (w), 1342 (s), 1250 (m), 1207 (w), 1157 (m), 1104 (m), 1057 (w), 1000 (m), 882 (w), 842 (w), 820 (w), 781 (w), 732 (w), 661 (w)

MS: (EI, 70 eV)241 (M⁺, 6), 185 (11), 170 (39), 168 (14), 141 (47), 133 (11), 126 (88), 75 (15), 67 (13), 57 (100)TLC: *R_f* 0.20 (hexane/EtOAc, 9/1) [silica gel, UV]Analysis: C₁₁H₁₉NO₃Si (241.36)

Calcd: C, 54.74; H, 7.93; N, 5.80

Found: C, 54.76; H, 8.10; N, 6.15

Preparation of (2-Thienyl)dimethylsilanol (5)

To a flame-dried, three-necked, 100-mL round-bottomed flask fitted with an argon inlet adaptor, thermocouple, magnetic stir bar and septum was placed 3.00 g (35.6 mmol, 1.0 equiv) of thiophene followed by 20.0 mL of dry diethyl ether. The solution was cooled to -70 °C

(internal) in a dry ice/acetone bath and 30.9 mL of *n*-BuLi (1.21 M in hexane, 37.4 mmol, 1.05 equiv) was slowly added. Upon complete addition, the resulting solution was allowed to stir at -70 °C for 5 min before being allowed to warm to room temperature and stir for 2 h. The resulting cloudy solution was cooled to -71 °C and 2.612g (11.75 mmol, 0.33 equiv) of hexamethylcyclotrisiloxane was added. The resulting solution was allowed to warm to room temperature and stir for a period of 16 h whereupon the mixture was cooled to 0 °C and 35.0 mL of 1.0 M sodium acetate buffer pH = 5.0 was added. The aqueous layer was separated and extracted with EtOAc (3 x 25 mL). The combined organic layers were washed with brine (20 mL), water (15 mL) and dried over MgSO₄ and filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give a red oil which was immediately purified by silica gel chromatography (60 X 100 mm) by first eluting with 300 mL of hexane followed by hexane/EtOAc, 9/1 (30 X 50 mL fractions). The combined fractions gave a light yellow oil that was distilled to afford 4.049 g (72%) of **5** as a clear, colorless oil. The physical and spectroscopic data matched those from the literature.⁴

Data for **5**:

bp: 95 °C (0.5 mmHg, ABT)

¹H NMR: (500 MHz, CHCl₃)

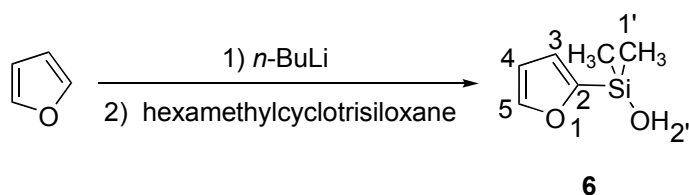
7.64 (d, *J* = 4.5, 1 H, HC(5)), 7.36 (d, *J* = 3.3, 1 H, HC(3)), 7.22 (dd, *J* = 4.5, 3.3, 1 H, HC(4)), 3.11 (s, 1 H, HC(2')), 0.45 (s, 6 H, HC(1'))

¹³C NMR: (100 MHz, CHCl₃)

138.50 (C(4)), 134.64 (C(3)), 130.98 (C(5)), 128.11 (C(2)), 0.82 (C(1'))

TLC: *R*_f 0.25 (hexane/EtOAc, 4/1) [silica gel, UV]

Preparation of (2-furyl)dimethylsilanol (6**)**



To a flame-dried, three-necked, 100 mL round-bottomed flask fitted with an argon inlet adaptor, thermocouple, magnetic stir bar and septum was placed 10.00 g (147 mmol, 1.0 equiv) of furan followed by 15.0 mL of dry diethylether. The solution was cooled to -71 °C (internal) in

a dry ice/acetone bath and 128.5 mL of *n*-BuLi (1.20 M in hexane, 154 mmol, 1.05 equiv) was slowly added. Upon complete addition, the resulting solution was allowed to stir at -71 °C for 5 min before being allowed to warm to room temperature and stir for 4 h. The resulting cloudy solution was cooled to -71 °C and 10.792 g (48.5 mmol, 0.33 equiv) of hexamethylcyclotrisiloxane was added. The resulting solution was allowed to warm to room temperature and stir for a period of 16 h whereupon the mixture was cooled to 0 °C and 100.0 mL of 1.0 M sodium acetate buffer pH = 5.0 was added. The aqueous layer was separated and extracted with EtOAc (3 x 50 mL). The combined organic layers were washed with brine (30 mL), water (30 mL) and dried over MgSO₄ and filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give a yellow oil which was immediately purified by silica gel chromatography (60 X 100 mm) by first eluting with 300 mL of hexane followed by hexane/EtOAc, 9/1 (30 X 50 mL fractions). The combined fractions gave a light yellow oil that was distilled to afford 4.64 g (22%) of **6** as a clear, colorless oil.

Data for 6:

bp: 90 °C (0.5 mmHg, ABT)

¹H NMR: (500 MHz, CHCl₃)

7.66 (d, *J* = 1.0, 1 H, HC(5)), 6.75 (d, *J* = 3.2, 1 H, HC(3)), 6.41 (dd, *J* = 3.3, 1.6, 1 H, HC(4)), 1.90 (s, 1 H, HC(2')), 0.42 (s, 6 H, HC(1'))

¹³C NMR: (100 MHz, CHCl₃)

158.69 (C(5)), 146.83 (C(2)), 120.41 (C(3)), 109.40 (C(4)), -0.52 (C(1'))

IR: (neat)

3293 (m), 2963 (m), 2903 (w), 2606 (w), 2359 (w), 1630 (w), 1551 (m), 1456 (m), 1404 (w), 1361 (w), 1256 (s), 1204 (m), 1149 (w), 1112 (s), 1070 (w), 1007 (s), 872 (s), 825 (s), 786 (s), 746 (s), 663 (m)

MS: (EI, 70 eV)

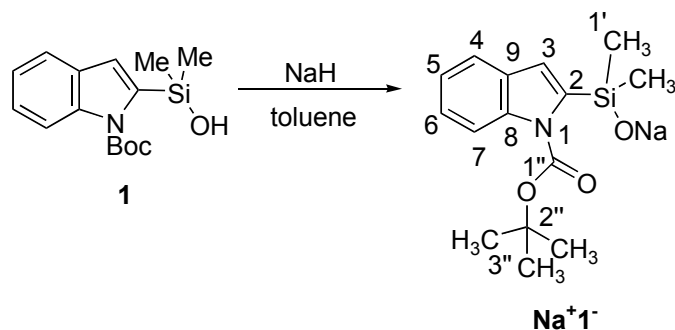
142 (M⁺, 20), 135 (12), 133 (32), 127 (100), 109 (11), 99 (11), 75 (19)

TLC: *R_f* 0.26 (hexane/EtOAc, 4/1) [silica gel, KMnO₄]

Analysis: C₆H₁₀O₂Si (142.23)

Calcd: C, 50.67; H, 7.09%

Found: C, 50.35; H, 7.19%

Preparation of Sodium Silanolate:**Preparation of Sodium *N*-BOC(2-indolyl)dimethylsilanolate ($\text{Na}^+\mathbf{1}^-$)**

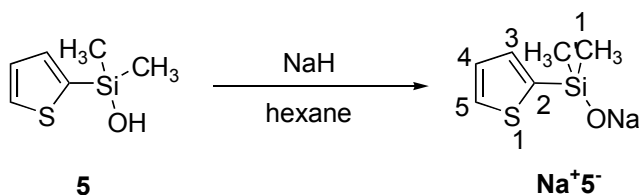
To a flame-dried, 25-mL, conical flask with stir bar was added 93 mg (3.86 mmol, 1.0 equiv) of NaH and 2.0 mL of dry toluene inside a drybox. In a separate flame-dried 5 mL conical flask was prepared a solution of 1.199 g (4.1 mmol, 1.06 equiv) of *N*-BOC(2-indolyl)dimethylsilanol in 2.0 mL of toluene. The silanol solution was added dropwise to the stirred suspension of NaH. The resulting suspension was stirred for 30 min before allowing the precipitate to settle. The supernatant was removed carefully with a pipet and the precipitate was washed with 1.0 mL of toluene, and the supernatant removed. Residual solvent was removed under high vacuum to afford 520 mg (43%) of a white powder that was stored in a drybox.

Data for $\text{Na}^+\mathbf{1}^-$:

^1H NMR: (500 MHz, C_6D_6)

7.98 (d, $J = 8.3$, 1 H, HC(7)), 7.47 (d, $J = 7.6$, 1 H, HC(4)), 7.26 (t, $J = 7.7$, 1 H, HC(6)), 7.17 (t, $J = 7.6$, 1 H, HC(5)), 6.86 (s, 1 H, HC(3)), 1.31 (s, 9 H, HC(3'')), 0.49 (s, 6 H, HC(1'))

HRMS: calcd for $\text{C}_{15}\text{H}_{20}\text{NNaO}_3\text{Si}$ (M^{+1}): 314.1188; found: 314.1183

Preparation of Sodium (2-thienyl)dimethylsilanolate (Na⁺5⁻)

To a flame-dried, 50-mL conical flask with a stir bar was added 441 mg (86%, 15.8 mmol, 1.0 equiv) of NaH and 2.0 mL of dry hexane inside a drybox. In a separate flame-dried 25 mL conical flask was prepared a solution of 2.50 g (15.8 mmol, 1.0 equiv) of (2-thienyl)dimethylsilanol in 12.0 mL of hexane. The silanol solution was added dropwise to the stirred suspension of NaH. The flask that contained the silanol was washed with 3.0 mL of hexane and this rinse was added to the solution. The resulting solution was stirred for 30 min before the solvent was removed under high vacuum to afford 2.911 g (102%) of an off-white wax that was stored in a freezer in a drybox.

Data for Na⁺5⁻:

¹H NMR: (500 MHz, THF)

7.47 (d, $J = 4.5$, 1 H, HC(5)), 7.22 (d, $J = 3.2$, 1 H, HC(3)), 7.06 (dd, $J = 4.5$, 3.2, 1 H, HC(4)), 0.18 (s, 6 H, HC(1'))

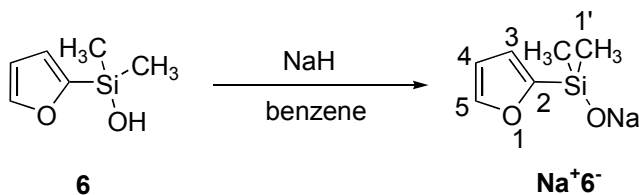
¹³C NMR: (125 MHz, THF)

149.56 (C(4)), 132.62 (C(3)), 128.92 (C(5)), 128.13 (C(2)), 5.56 (C(1'))

Analysis: C₆H₉NaOSSi (180.28)

Calcd: Na, 12.75%

Found: Na, 13.33%

Preparation of Sodium (2-furyl)dimethylsilanolate (Na⁺6⁻)

To a flame-dried, 100-mL, conical flask with stir bar was added 374 mg (98%, 15.3

mmol, 1.0 equiv) of NaH and 2.0 mL of dry benzene inside a drybox. In a separate flame-dried 25-mL conical flask was prepared a solution of 2.17 g (15.3 mmol, 1.0 equiv) of (2-furyl)dimethylsilanol in 12.0 mL of benzene. The silanol solution was added dropwise to the stirred suspension of NaH. The flask that contained the silanol was washed with 6.0 mL of benzene and this rinse was added to the solution. The resulting solution was stirred for 1 h before the solvent was removed under high vacuum to afford 2.4522 g (98%) of a red wax that was stored in a freezer in a drybox.

Data for Na⁺6⁻:

¹H NMR: (500 MHz, THF)

7.46 (s, 1 H, HC(5)), 6.46 (d, *J* = 3.2, 1 H, HC(3)), 6.25 (dd, *J* = 2.9, 1.6 1 H, HC(4)), 0.07 (s, 6 H, HC(1'))

¹³C NMR: (125 MHz, THF)

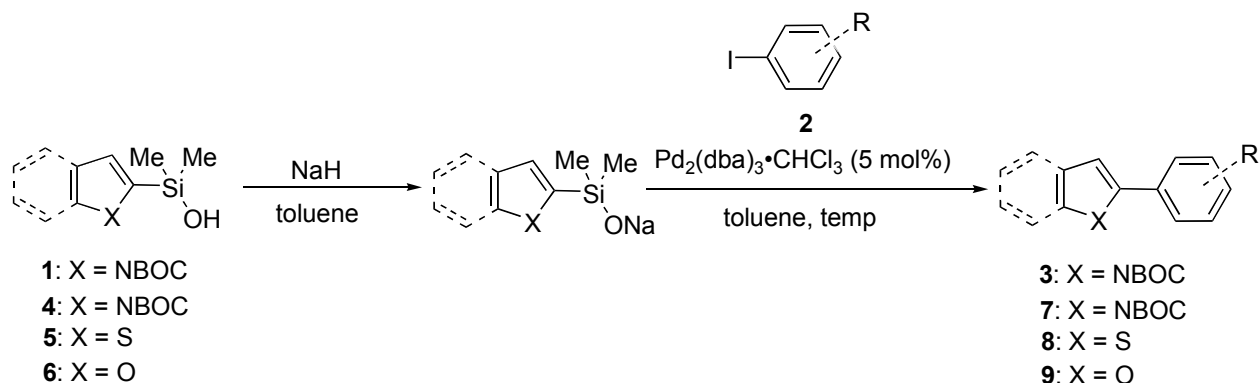
168.50 (C(5)), 145.26 (C(2)), 117.04 (C(3)), 109.52 (C(4)), 4.22 (C(1'))

Analysis: C₆H₉NaO₂Si (164.21)

Calcd: Na, 14.00%;

Found: Na, 13.44%;

General Procedure I: Cross-Coupling Reactions of *in situ* prepared Na⁺1⁻ or Na⁺4⁻ or Na⁺5⁻ or Na⁺6⁻ with Various Aryl Iodides:

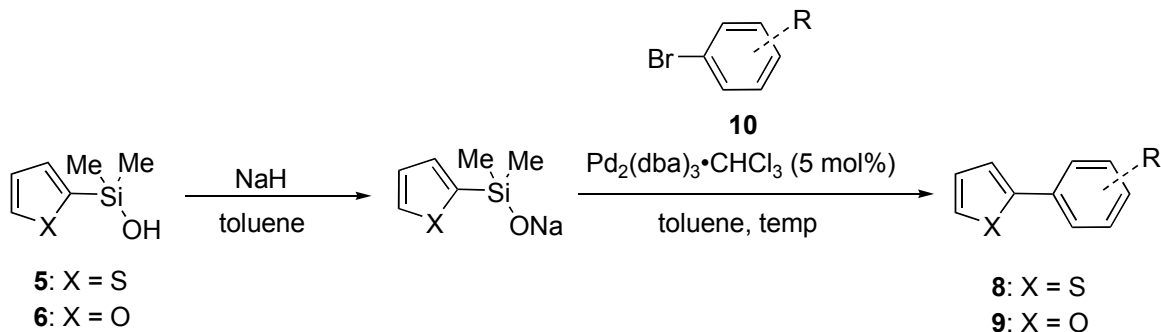


To a flame-dried, 5-mL, round-bottomed flask equipped with a stir bar was added 29 mg (1.2 mmol, 1.2 equiv) of sodium hydride and 0.2 mL of dry toluene under dry argon atmosphere inside a dry box. In a separate flame-dried, 5-mL conical flask was added 1.2 mmol of silanol

(1.2 equiv) which was dissolved in 0.4 mL of dry toluene and this silanol solution was added dropwise to the NaH suspension by glass pipet. The round-bottomed flask containing the silanol was washed with 0.4 mL of dry degassed toluene and that rinse was added to the reaction mixture. The resulting mixture was stirred for 10 min before 1.0 mmol of aryl iodide, and 52 mg (0.05 mmol, 0.05 equiv) of $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$ were added. The flask was sealed with a rubber septum and removed from the drybox.

After being stirred at the given temperature for the time specified, the crude reaction mixture was diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). The combined organic layers were dried over MgSO_4 and were filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give a dark red residue. A solution of the residue in 0.5 mL of toluene was loaded onto a silica gel column (20 X 100 mm) which was eluted with toluene (20 X 10 mL fractions), or eluted with 150 mL of hexane followed by hexane/EtOAc, 9/1 (20 X 10 mL fractions). Evaporation of the solvent and purification by recrystallization or sublimation provided the products.

General Procedure II: Cross-Coupling Reactions of *in situ* prepared Na^+5^- or Na^+6^- with Various Aryl Bromides:

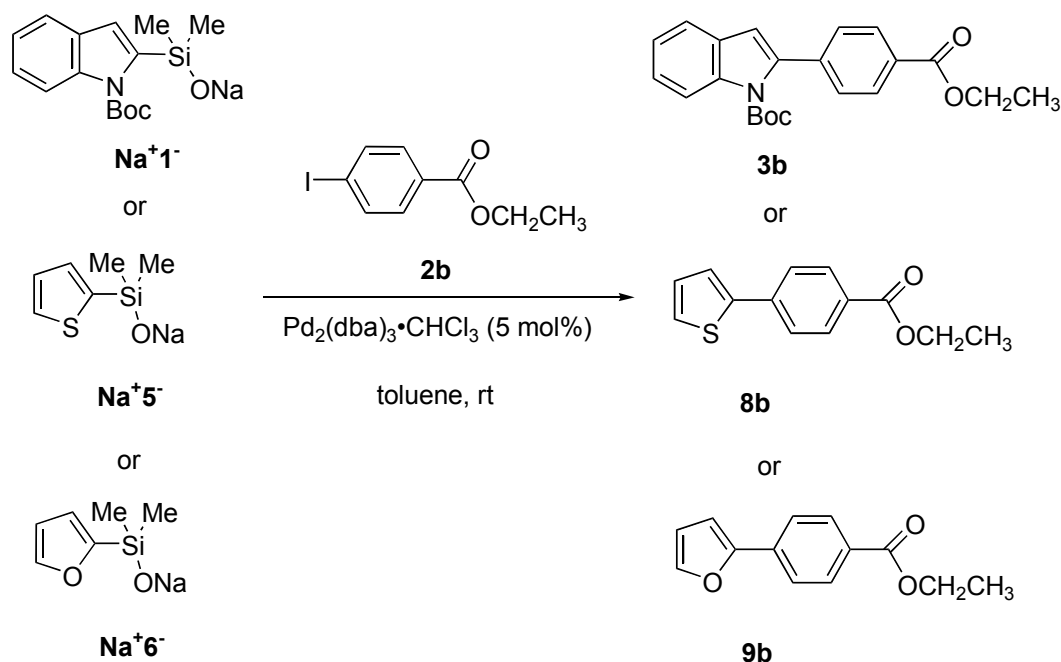


To a flame-dried, 5-mL, round-bottomed flask equipped with a stir bar was added 29 mg (1.2 mmol, 1.2 equiv) of sodium hydride and 0.2 mL of dry toluene under dry argon atmosphere inside a dry box. In a separate flame-dried 5-mL, conical flask was added 1.2 mmol of silanol (1.2 equiv) which was dissolved in 0.4 mL of dry toluene and this silanol solution was added dropwise to the above suspension by glass pipet. The round-bottomed flask containing the silanol was washed with 0.4 mL of dry degassed toluene and that rinse was added to the reaction

mixture. The resulting mixture was stirred for 10 min before 1.0 mmol of aryl bromide, and 18 mg (0.025 mmol, 0.025 equiv) of **12** were added. The flask was sealed with a rubber septum and removed from the drybox.

After being stirred at 50 °C for the time specified, the crude reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). The combined organic layers were dried over MgSO₄ and were filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give a dark red residue. A solution of the residue in 0.5 mL of toluene was loaded onto a silica gel column (20 X 100 mm) which was eluted with toluene (20 X 10 mL fractions), or eluted with 150 mL of hexane followed by hexane/EtOAc, 9/1 (20 X 10 mL fractions). Evaporation of the solvent and purification by sublimation provided the products.

General Procedure III: Cross-Coupling Reactions of pre-formed Na⁺1⁻ or Na⁺5⁻ or Na⁺6⁻ with 2b:

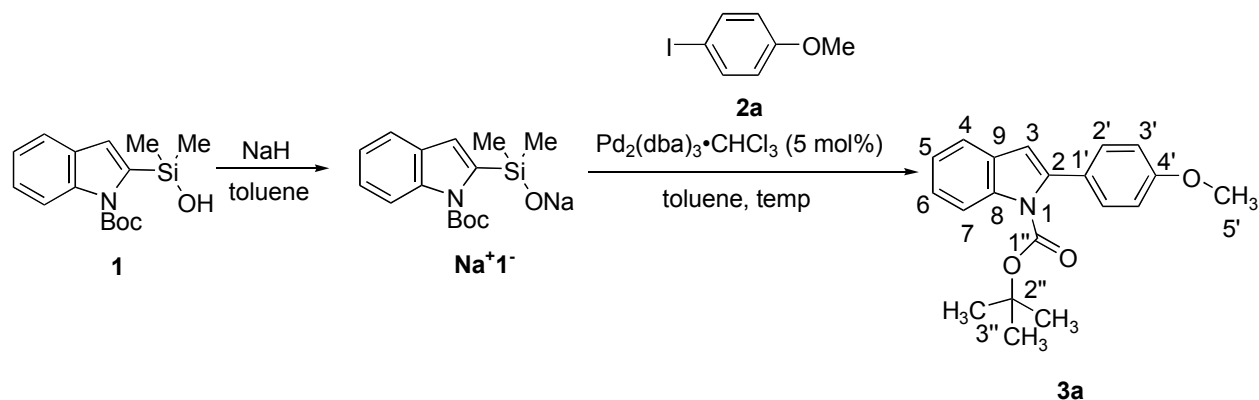


To a flame-dried, 5-mL, round-bottomed flask equipped with a stir bar was added 1.2 mmol of sodium silanolate in 1.0 mL of dry toluene under dry argon atmosphere inside a dry box. To this mixture was added 168 μ L (1.0 mmol, 1.0 equiv) of ethyl-4-iodobenzoate and 52

mg (0.05 mmol, 0.05 equiv) of $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$. The flask was sealed with a rubber septum and removed from the drybox.

After being stirred at rt for the time specified, the reaction mixture was diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). The combined organic layers were dried over MgSO_4 and were filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give a dark red residue. A solution of the residue in 0.5 mL of toluene was loaded onto a silica gel column (20 X 100 mm) which was eluted with toluene (20 X 10 mL fractions). Evaporation of the solvent and further purification by recrystallization or sublimation provided the products.

Preparation of 2-(4'-Methoxyphenyl)indole-1-carboxylic Acid *tert*-Butyl Ester (**3a**)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 349 mg of *N*-Boc(2-indolyl)dimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 234 mg (1.0 mmol) of 1-iodo-4-methoxybenzene, and 52 mg (0.05 mmol, 0.05 equiv) of $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$ whereupon the mixture was stirred at 80 °C for 3 h, diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO_2 (20 mm X 100 mm), toluene) and recrystallization (hexane) gave 220 mg (68%) of **3a** as a white solid. The physical and spectroscopic data matched those from the literature.³

Data for **3a**:

mp: 85-87 °C (hexane)

¹H NMR: (500 MHz, CHCl₃)

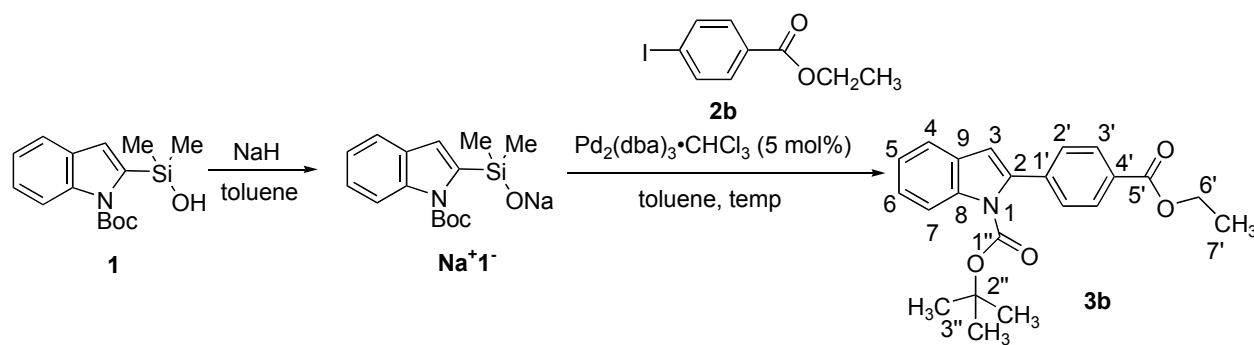
8.18 (d, *J* = 8.3, 1 H, HC(7)), 7.54 (d, *J* = 7.1, 1 H, HC(4)), 7.35 (d, *J* = 8.8, 2 H, HC(2')), 7.31 (t, *J* = 8.5, 1 H, HC(6)), 7.24 (t, *J* = 7.5, 1 H, HC(5)), 6.94 (d, *J* = 8.8, 2 H, HC(3')), 6.51 (s, 1 H, HC(3)), 3.86 (s, 3 H, HC(5')), 1.36 (s, 9 H, HC(X))

¹³C NMR: (125 MHz, CHCl₃)

159.21 (C(1')), 150.26 (C(4')), 140.36 (C(8)), 137.26 (C(1')), 129.84 (C(9)), 129.24 (C(2')), 127.33 (C(2)), 124.00 (C(5)), 122.81 (C(4)), 120.24 (C(6)), 115.14 (C(3')), 113.20 (C(7)), 109.43 (C(3)), 83.25 (C(2')), 55.27 (C(5')), 27.59 (C(3''))

TLC: *R_f* 0.33 (hexane/EtOAc, 9/1) [silica gel, UV]

Preparation of 2-(4'-Ethoxycarbonylphenyl)indole-1-carboxylic Acid *tert*-Butyl Ester (**3b**)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 349 mg of *N*-Boc(2-indolyl)dimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 276 mg (1.0 mmol) of ethyl-4-iodobenzoate, and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃·CHCl₃ whereupon the mixture was stirred at rt for 3 h, diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100 mm), toluene) and recrystallization from boiling hexane/ toluene (20/1) gave 298 mg (82%) of **3b** as a white solid. The physical and spectroscopic data matched those from the literature.⁵

Data for 3b:

mp: 104-105 °C (hexane/ toluene (20/1))

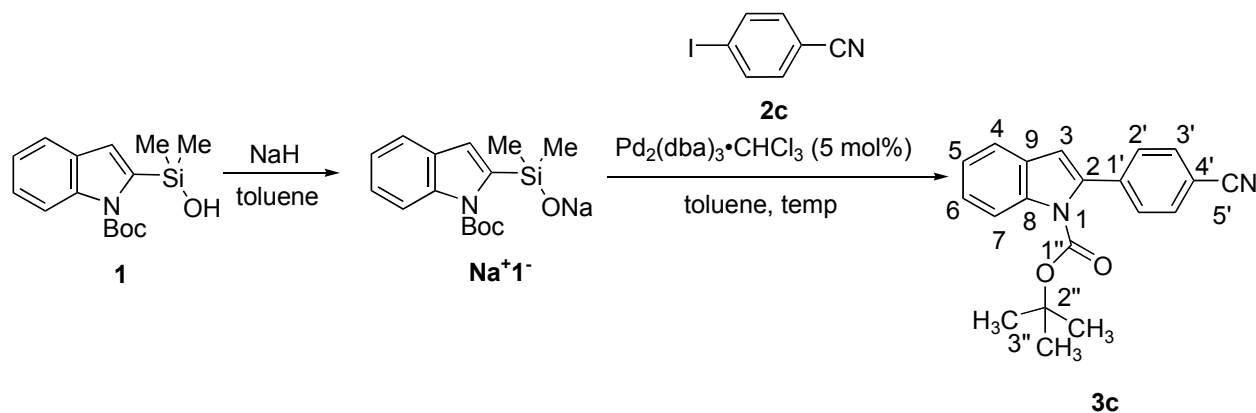
¹H NMR: (500 MHz, CHCl₃)

8.21 (d, *J* = 8.3, 1 H, HC(7)), 8.09 (d, *J* = 8.5, 2 H, HC(3')), 7.57 (d, *J* = 7.3, 1 H, HC(4)), 7.50 (d, *J* = 8.5, 2 H, HC(2')), 7.35 (t, *J* = 8.4, 1 H, HC(6)), 7.26 (t, *J* = 8.1, 1 H, HC(5)), 6.63 (s, 1 H, HC(3)), 4.41 (q, *J* = 7.1, 2 H, HC(6')), 1.42 (t, *J* = 7.2, 3 H, HC(7')), 1.34 (s, 9 H, HC(3''))

¹³C NMR: (125 MHz, CHCl₃)

165.52 (C(5')), 150.03 (C(1'')), 139.54 (C(1')), 138.87 (C(8)), 137.60 (C(4')), 130.91 (C(3')), 129.08 (C(9)), 128.93 (C(2')), 128.35 (C(2)), 124.72 (C(5)), 123.08 (C(4)), 120.67 (C(6)), 115.25 (C(7)), 110.87 (C(3)), 83.87 (C(6')), 81.08 (C(2'')), 28.17 (C(7')), 27.62 (C(3''))

TLC: *R_f* 0.12 (hexane/EtOAc, 9/1) [silica gel, UV]

Preparation of 2-(4'-Cyanophenyl)indole-1-carboxylic Acid *tert*-Butyl Ester (3c)

Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 349 mg of *N*-Boc(2-indolyl)dimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 229 mg (1.0 mmol) of 1-iodo-4-cyanobenzene, and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃·CHCl₃ whereupon the mixture was stirred at rt for 3 h, diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X

100 mm), toluene) and recrystallization (toluene) gave 257 mg (81%) of **3c** as a white solid. The physical and spectroscopic data matched those from the literature.⁵

Data for 3c:

mp: 122-123 °C (toluene)

¹H NMR: (500 MHz, CHCl₃)

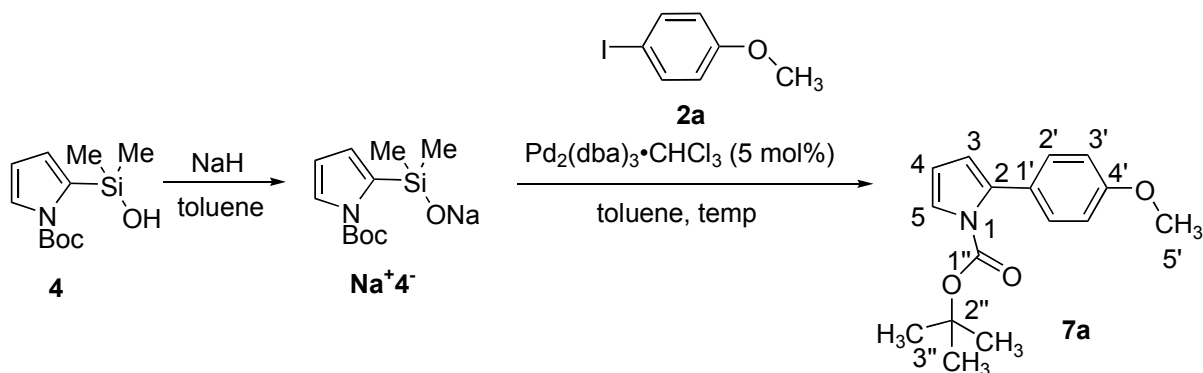
8.20 (d, *J* = 8.3, 1 H, HC(7)), 7.70 (d, *J* = 8.1, 2 H, HC(2')), 7.58 (d, *J* = 7.8, 1 H, HC(4)), 7.54 (d, *J* = 8.3, 2 H, HC(3')), 7.38 (t, *J* = 8.4, 1 H, HC(6)), 7.28 (t, *J* = 7.9, 1 H, HC(5)), 6.64 (s, 1 H, HC(3)), 1.37 (s, 9 H, HC(3''))

¹³C NMR: (125 MHz, CHCl₃)

149.78 (C(1')), 139.42 (C(1')), 138.27 (C(8)), 137.64 (C(3')), 131.56 (C(2')), 129.17 (C(9)), 128.86 (C(2)), 125.17 (C(5)), 123.28 (C(6)), 120.87 (C(4)), 118.78 (C(5')), 115.39 (C(4')), 111.64 (C(7)), 110.98 (C(3)), 84.17 (C(2')), 27.60 (C(3''))

TLC: *R_f* 0.24 (hexane/EtOAc, 9/1) [silica gel, UV]

Preparation of 2-(4'-Methoxyphenyl)pyrrole-1-carboxylic Acid *tert*-Butyl Ester (7a)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 290 mg of *N*-Boc(2-pyrrolyl)dimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 234 mg (1.0 mmol) of 1-iodo-4-methoxybenzene, and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃•CHCl₃ whereupon the mixture was stirred at 50 °C for 36 h, diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography

(SiO₂ (20 mm X 100 mm), hexane/EtOAc, 9/1) afforded 196 mg (72%) of **7a** as a white semi-solid. The physical and spectroscopic data matched those from the literature.⁶

Data for 7a:

¹H NMR: (500 MHz, CHCl₃)

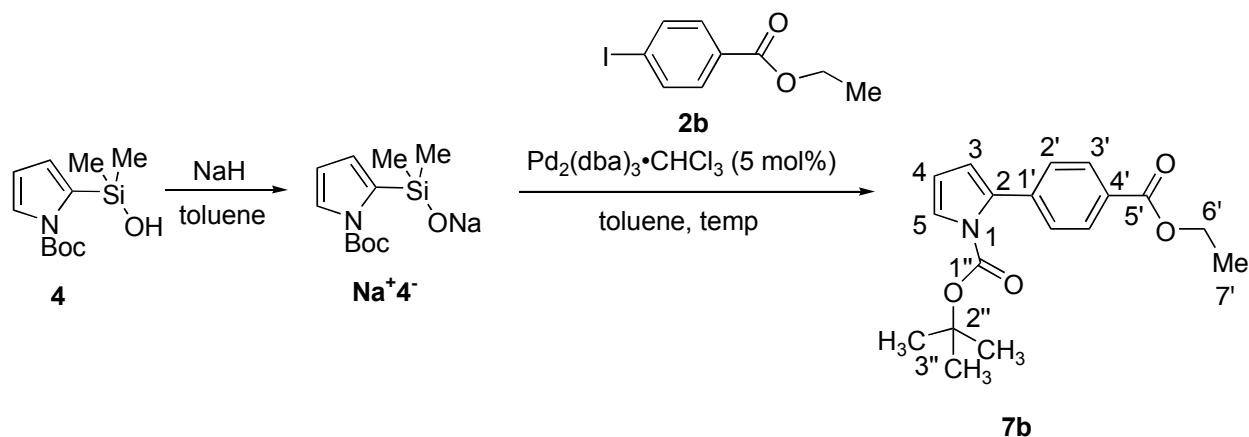
7.32 (dd, *J* = 3.3, 1.8, 1 H, HC(5)), 7.27 (d, *J* = 8.8, 2 H, HC(2')), 6.89 (d, *J* = 8.6, 2 H, HC(3')), 6.21 (t, *J* = 3.3, 1 H, HC(4)), 6.13 (dd, *J* = 3.2, 1.7, 1 H, HC(3)), 3.83 (s, 3 H, HC(5')), 1.387 (s, 9 H, HC(3'))

¹³C NMR: (125 MHz, CHCl₃)

158.87 (C(4')), 149.39 (C(1')), 134.85 (C(2')), 130.38 (C(1')), 126.85 (C(2)), 122.14 (C(5)), 113.97 (C(3')), 113.00 (C(3)), 110.44 (C(4)), 83.39 (C(2')), 55.23 (C(5')), 27.65 (C(3'))

TLC: *R*_f 0.28 (hexane/EtOAc, 9/1) [silica gel, UV]

Preparation of 2-(4'-Ethoxycarbonylphenyl)pyrrole-1-carboxylic Acid *tert*-Butyl Ester (7b)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 290 mg of *N*-Boc(2-pyrrolyl)dimethylsilanol (**4**) (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 168 μL (1.0 mmol) of ethyl 4-iodobenzoate (**2b**), and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃•CHCl₃ whereupon the mixture was stirred at rt for 3 h, diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous

layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100 mm), toluene), afforded 239 mg (76%) of **7b** as a clear semi-solid for which correct microanalytical data could not be obtained.

Data for 7b:

¹H NMR: (500 MHz, CHCl₃)

8.03 (dd, *J* = 6.7, 1.8, 2 H, HC(3')), 7.42 (dd, *J* = 6.6, 1.7, 2 H, HC(2')), 7.38 (dd, *J* = 3.2, 2.0, 1 H, HC(5)), 6.25 (m, 2 H, HC(3), HC(4)), 4.39 (q, *J* = 7.2, 2 H, HC(6')), 1.40 (t, *J* = 7.0, 3 H, HC(7')), 1.38 (s, 9 H, HC(3'))

¹³C NMR: (125 MHz, CHCl₃)

166.47 (C(5')), 149.14 (C(1')), 138.75 (C(1')), 134.00 (C(4')), 128.91 (C(2)), 128.85 (C(2')), 128.85 (C(3')), 123.43 (C(5)), 115.37 (C(3)), 110.80 (C(4)), 84.01 (C(2')), 60.89 (C(6')), 27.63 (C(3')), 14.33 (C(7'))

IR: (neat)

2981 (m), 2936 (w), 1741 (s), 1716 (s), 1611 (m), 1572 (w), 1512 (w), 1466 (m), 1413 (m), 1394 (s), 1369 (s), 1337 (s), 1313 (s), 1273 (s), 1177 (m), 1147 (s), 1101 (s), 1075 (m), 1040 (m), 1021 (m), 974 (m), 881 (w), 861 (m), 849 (m), 818 (w), 774 (m), 731 (m), 704 (m), 667 (w)

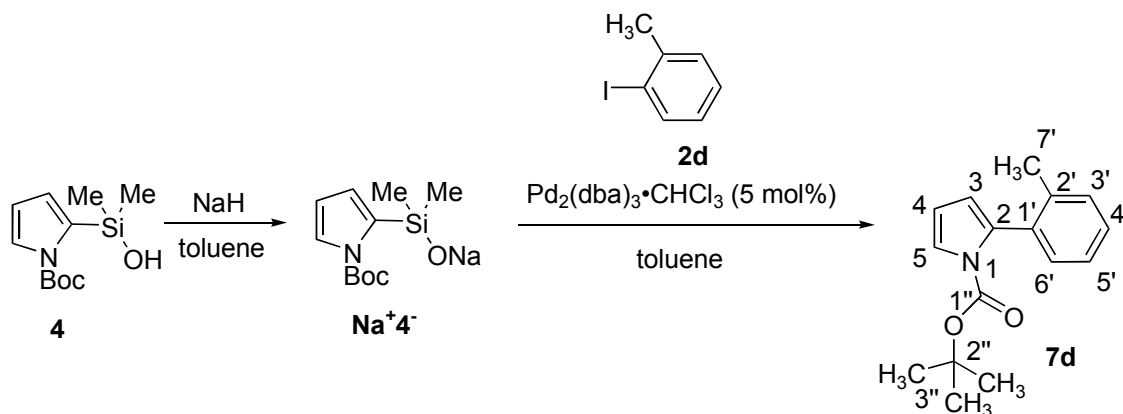
MS: (EI, 70 eV)

316 (M⁺, 2), 315 (10), 259 (26), 215 (73), 187 (31), 170 (18), 88 (12), 86 (67), 84 (100), 57 (95)

TLC: *R*_f 0.24 (hexane/EtOAc, 9/1) [silica gel, UV]

HRMS: calcd for C₁₈H₂₁NO₄: 315.1471; found: 315.1468

Preparation of 2-(2'-Methylphenyl)pyrrole-1-carboxylic Acid *tert*-Butyl Ester (**7d**)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 290 mg of *N*-Boc(2-pyrrolyl)dimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 218 mg (1.0 mmol) of 1-iodo-2-methylbenzene, and 52 mg (0.05 mmol, 0.05 equiv) of $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$ whereupon the mixture was stirred at rt for 3 h, diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO_2 (20 mm X 100 mm), hexane/EtOAc (9/1)) afforded 205 mg (80%) of **7d** as a clear, colorless semi-solid.

Data for **7d**:

¹H NMR: (500 MHz, CHCl_3)

7.37 (dd, $J = 3.4, 1.7$, 1 H, HC(5)), 7.21 (m, 4 H, HC(3'), HC(4'), HC(5'), HC(6')), 6.25 (t, $J = 3.3$, 1 H, HC(4)), 6.08 (dd, $J = 3.2, 1.7$, 1 H, HC(3)), 2.12 (s, 3 H, HC(7')), 1.24 (s, 9 H, HC(3''))

¹³C NMR: (125 MHz, CHCl_3)

149.35 (C(1')), 137.84 (C(2')), 134.95 (C(1'')), 133.59 (C(3')), 130.12 (C(4')), 129.22 (C(6')), 127.81 (C(5')), 125.09 (C(2)), 121.30 (C(5)), 113.65 (C(3)), 110.46 (C(4)), 83.07 (C(2'')), 27.39 (C(3'')), 19.85 (C(7'))

IR: (neat)

3461 (w), 3152 (w), 3110 (w), 3062 (w), 2980 (m), 2933 (w), 2645 (w), 1739 (s), 1606 (w), 1444 (w), 1502 (w), 1473 (m), 1458 (m), 1395 (s), 1371 (s), 1340 (s),

1313 (s), 1258 (m), 1153 (s), 1117 (m), 1074 (m), 1032 (w), 871 (m), 952 (w),
882 (w), 850 (m), 842 (m), 816 (w), 796 (w), 773 (w), 762 (m), 726 (s), 664 (w)

MS: (EI, 70 eV)

258 (M^{+1} , 6), 257 (27), 201 (47), 184 (15), 158 (12), 157 (90), 156 (37), 129
(11), 128 (11), 57 (100)

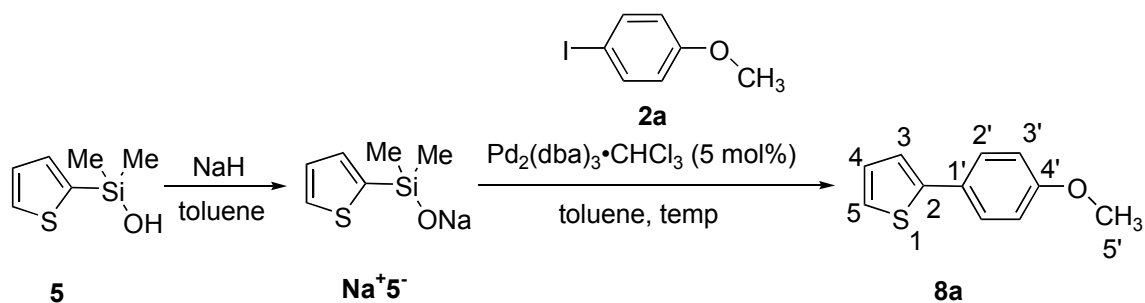
TLC: R_f 0.44 (hexane/EtOAc, 9/1) [silica gel, UV]

Analysis: $C_{16}H_{19}NO_2$ (257.33)

Calcd: C, 74.68; H, 7.44; N, 5.44%

Found: C, 74.44; H, 7.47; N, 5.79%

Preparation of 2-(4'-Methoxyphenyl)furan (8a)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 234 mg (1.0 mmol) of 1-iodo-4-methoxybenzene, and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃·CHCl₃ whereupon the mixture was stirred at 80 °C for 24 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100 mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 137 mg (72%) of **8a** as a white solid. The physical and spectroscopic data matched those from the literature.⁷

Data for 8a:

mp: 103-104 °C

$^1\text{H NMR}$: (500 MHz, CHCl_3)

7.55 (d, $J = 8.8$, 2 H, HC(2')), 7.21 (m, 2 H, HC(5), HC(3)), 7.05 (dd, $J = 5.0$, 3.5, 1 H, HC(4)), 6.92 (d, $J = 8.8$, 2 H, HC(3')), 3.84 (s, 3 H, HC(5'))

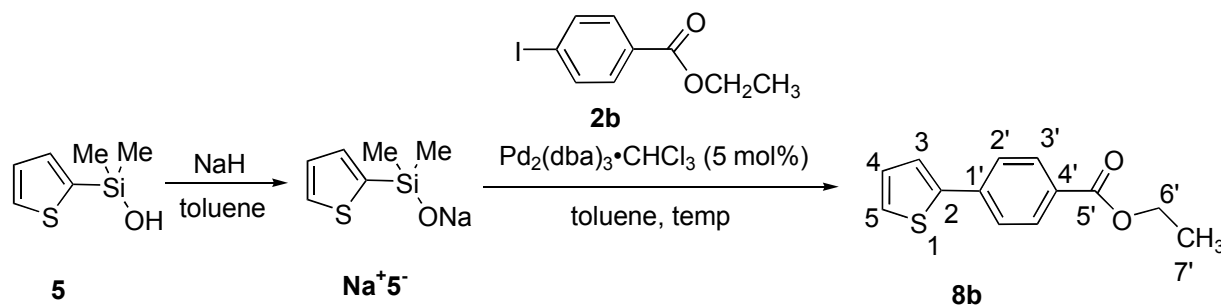
$^{13}\text{C NMR}$: (125 MHz, CHCl_3)

159.14 (C(4')), 144.30 (C(2)), 127.91 (C(2')), 127.25 (C(4)), 127.18 (C(3)), 123.80 (C(1')), 122.05 (C(5)), 114.22 (C(3')), 55.28 (C(5'))

TLC: R_f 0.47 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: t_R **8a**, 8.47 min (100.0%) (HP-5, 15 psi)

Preparation of 2-(4'-Ethoxycarbonylphenyl)thiophene (**8b**)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 276 mg (1.0 mmol) of ethyl 4-iodobenzoate, and 52 mg (0.05 mmol, 0.05 equiv) of $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$ and the mixture was stirred at rt for 3 h. The reaction mixture was diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO_2 (20 mm), toluene) and sublimation (0.5 mmHg, 50 $^\circ\text{C}$) afforded 180 mg (78%) of **8b** as a white solid.

Data for **8b**:

mp: 67-68 $^\circ\text{C}$

$^1\text{H NMR}$: (500 MHz, CHCl_3)

8.04 (d, $J = 8.8$, 2 H, HC(3')), 7.67 (d, $J = 8.8$, 2 H, HC(2')), 7.42 (dd, $J = 3.6$,

1.3, 1 H, HC(5)), 7.36 (dd, $J = 5.1, 1.1$, 1 H, HC(3)), 7.12 (dd, $J = 4.9, 3.6$, 1 H, HC(4)), 4.39 (q, $J = 7.1$, 2 H, HC(6')), 1.41 (t, $J = 7.2$, 3 H, HC(7'))

^{13}C NMR: (125 MHz, CHCl_3)

166.31 (C(5')), 143.13 (C(2)), 138.52 (C(1')), 130.23 (C(3')), 129.12 (C(4')), 128.30 (C(4)), 126.23 (C(3)), 125.48 (C(2')), 124.43 (C(5)), 60.97 (C(6')), 14.31 (C(7'))

IR: (Nujol)

3422 (m), 3088 (w), 3066 (w), 2962 (s), 2871 (m), 1722 (w), 1703 (s), 1604 (m), 1564 (w), 1534 (w), 1462 (w), 1424 (w), 1411 (w), 1391 (w), 1364 (w), 1317 (w), 1277 (s), 1262 (s), 1184 (m), 1169 (w), 1110 (s), 1016 (w), 959 (w), 862 (w), 856 (w), 832 (w), 773 (s), 727 (s), 710 (w), 697 (w)

MS: (EI, 70 eV)

232 (M^+ , 80), 204 (28), 187 (100), 159 (17), 115 (37), 93 (8), 79 (10), 62 (5)

TLC: R_f 0.35 (hexane/EtOAc, 9/1) [silica gel, UV]

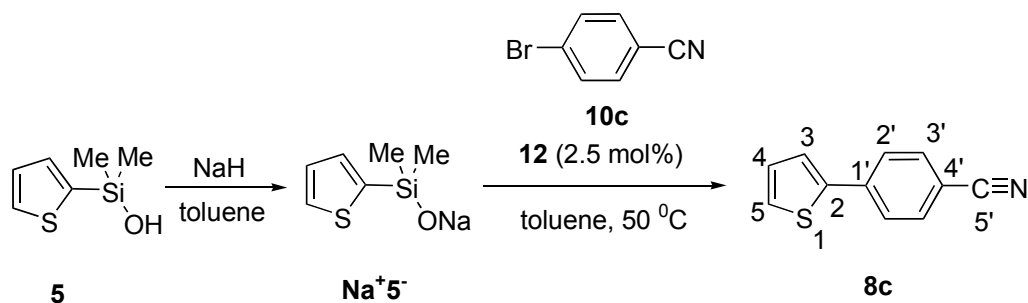
GC: t_R **8b**, 10.97 min (100.0%) (HP-5, 15 psi)

Analysis: $\text{C}_{13}\text{H}_{12}\text{O}_2\text{S}$ (232.30)

Calcd: C, 67.21; H, 5.21%

Found: C, 67.10; H, 5.51%

Preparation of 2-(4'-Cyanophenyl)thiophene (**8c**)



Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 182 mg (1.0 mmol) of 1-bromo-4-cyanobenzene, and 18 mg (0.025 mmol, 0.025 equiv) of

12 and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 144 mg (78%) of **8c** as a white solid. The physical and spectroscopic data matched those from the literature.⁸

Data for **8c**:

mp: 91-92 °C

¹H NMR: (500 MHz, CHCl₃)

7.70 (d, *J* = 8.5, 2 H, HC(2')), 7.66 (d, *J* = 8.8, 2 H, HC(3')), 7.43 (dd, *J* = 3.7, 1.2, 1 H, HC(5)), 7.40 (dd, *J* = 5.1, 1.2, 1 H, HC(3)), 7.13 (dd, *J* = 4.9, 3.7, 1 H, HC(4))

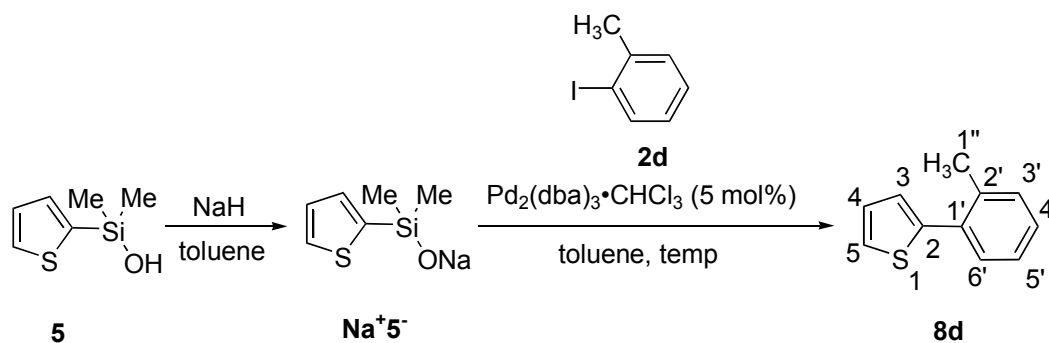
¹³C NMR: (125 MHz, CHCl₃)

141.94 (C(2)), 138.52 (C(1')), 132.63 (C(3')), 128.47 (C(2')), 127.00 (C(4)), 125.95 (C(3)), 125.04 (C(5)), 118.78 (C(5')), 110.34 (C(4'))

TLC: *R_f* 0.24 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: *t_R* **8c**, 9.17 min (97.3%) (HP-5, 15 psi)

Preparation of 2-(2'-Methylphenyl)thiophene (8d)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 218 mg (1.0 mmol) of 1-iodo-2-methylbenzene, and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃•CHCl₃ and the mixture was stirred at rt for 3 h. The reaction mixture was diluted with

25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), toluene) and Kugelrohr distillation afforded 138 mg (79%) of **8d** as a clear, colorless oil. The physical and spectroscopic data matched those from the literature.⁹

Data for **8d**:

bp: 125 °C (0.5 mm Hg, ABT)

¹H NMR: (500 MHz, CHCl₃)

7.42 (dd, *J* = 7.2, 1.6, 1 H, HC(6')), 7.35 (dd, *J* = 5.1, 1.2, 1 H, HC(5)), 7.25 (m, 3 H, HC(3'), HC(4'), HC(5')), 7.11 (dd, *J* = 5.0, 3.5, 1 H, HC(4)), 7.08 (dd, *J* = 3.4, 1.2, 1 H, HC(3)), 2.44 (s, 3 H, HC(1'))

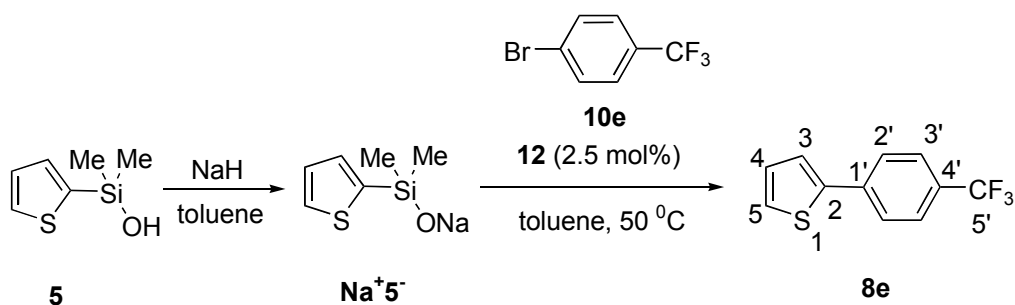
¹³C NMR: (125 MHz, CHCl₃)

143.09 (C(2)), 136.07 (C(2')), 134.14 (C(1')), 130.70 (C(3')), 130.46 (C(4')), 127.77 (C(4)), 127.04 (C(3)), 126.35 (C(6')), 125.87 (C(5')), 125.07 (C(5)), 21.10 (C(1'))

TLC: *R_f* 0.57 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: *t_R* **8d**, 7.00 min (98.7%) (HP-5, 15 psi)

Preparation of 2-(4'-Trifluoromethylphenyl)thiophene (8e)



Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 140 μ L (1.0 mmol) of 4-bromobenzotrifluoride, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer

was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100 mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 197 mg (86%) of **8e** as a white solid.

Data for **8e**:

mp: 114-115 °C

¹H NMR: (500 MHz, CHCl₃)

7.71 (d, *J* = 8.3, 2 H, HC(3')), 7.63 (d, *J* = 8.1, 2 H, HC(2')), 7.40 (dd, *J* = 3.7, 1.2, 1 H, HC(5)), 7.36 (dd, *J* = 5.0, 1.1, 1 H, HC(3)), 7.12 (dd, *J* = 5.1, 3.7, 1 H, HC(4))

¹³C NMR: (125 MHz, CHCl₃)

142.58 (C(2)), 137.72 (C(1')), 128.30 (C(4')), 126.21 (C(4)), 125.92 (C(2')), 125.90 (C(4)), 125.85 (C(3')), 125.81 (C(5)), 124.42 (C(5'))

¹⁹F NMR: (470 MHz, CDCl₃)

-60.7 (FC(5'))

IR: (Nujol)

3430 (w), 2953 (s), 2924 (s), 2854 (s), 2361 (w), 2341 (w), 1615 (w), 1460 (w), 1377 (w), 1340 (w), 1326 (w), 1260 (w), 1170 (w), 1132 (w), 1111 (m), 1072 (w), 1016 (w), 959 (w), 855 (w), 844 (w), 823 (w), 708 (w)

MS: (EI, 70 eV)

228 (M⁺, 100), 209 (9), 183 (12), 133 (5), 115 (7), 58 (5)

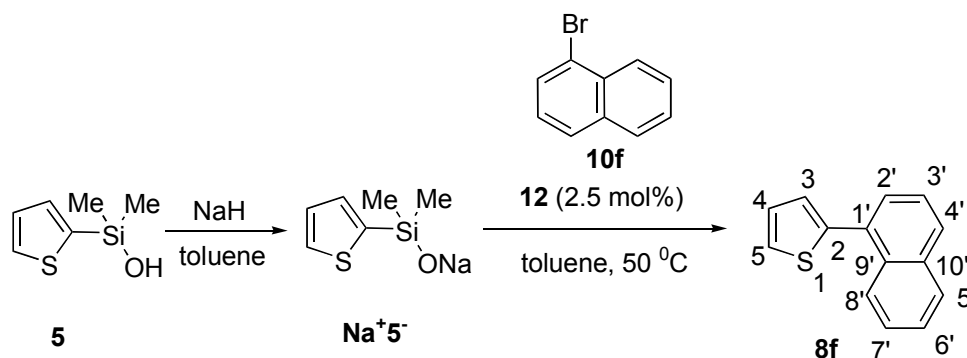
TLC: *R_f* 0.53 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: *t_r* **8e**, 6.82 min (98.5%) (HP-5, 15 psi)

Analysis: C₁₁H₇F₃S (228.23)

Calcd: C, 57.89; H, 3.09%

Found: C, 57.61; H, 3.39%

Preparation of 2-(4'-Naphthyl)thiophene (8f)

Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 139 μ L (1.0 mmol) of 1-bromonaphthalene, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 7 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100 mm), toluene) and distillation afforded 156 mg (74%) of **8f** as a clear, colorless liquid.

Data for **8f**:

bp: 160 °C (0.5 mm Hg, ABT)

¹H NMR: (500 MHz, CHCl₃)

8.23 (m, 1 H), 7.90 (m, 1 H), 7.87 (d, *J* = 8.3, 1 H), 7.58 (d, *J* = 7.1, 1 H), 7.51 (m, 3 H), 7.44 (dd, *J* = 5.2, 1.1, 1 H, HC(5)), 7.26 (dd, *J* = 3.4, 1.2, 1 H, HC(3)), 7.20 (dd, *J* = 5.1, 3.4, 1 H, HC(4))

¹³C NMR: (125 MHz, CHCl₃)

141.77 (C(2)), 133.84 (C(1')), 132.44 (C(10')), 131.87 (C(9')), 128.39 (C(8')), 128.32 (C(5')), 128.20 (C(4')), 127.38 (C(4)), 127.27 (C(3)), 126.44 (C(7')), 126.00 (C(6')), 125.75 (C(3')), 125.63 (C(5)), 125.24 (C(2'))

IR: (neat)

3425 (w), 3104 (w), 3049 (w), 1931 (w), 1813 (w), 1676 (w), 1638 (w), 1590 (w), 1506 (w), 1436 (w), 1390 (m), 1327 (w), 1270 (w), 1244 (w), 1220 (w), 1209 (w),

1175 (w), 1143 (w), 1077 (w), 1043 (w), 1017 (w), 969 (w), 954 (w), 932 (w),
900 (w), 852 (m), 836 (w), 796 (s), 775 (s), 735 (w), 699 (s), 640 (w), 620 (w)

MS: (EI, 70 eV)

210 (M^+ , 100), 209 (41), 208 (18), 165 (22)

TLC: R_f 0.50 (hexane/EtOAc, 9/1) [silica gel, UV]

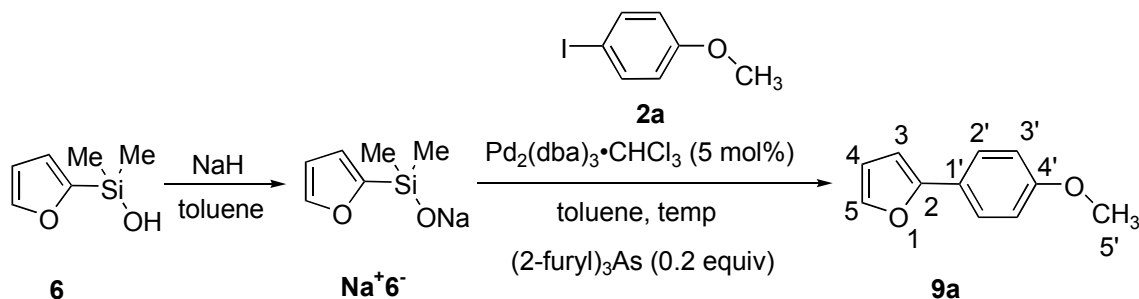
GC: t_R **8f**, 10.46 min (100.0%) (HP-5, 15 psi)

Analysis: $C_{14}H_{10}S$ (210.29)

Calcd: C, 79.96; H, 4.79%

Found: C, 79.70; H, 4.75%

Preparation of 2-(4'-Methoxyphenyl)furan (**9a**)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-furyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 234 mg (1.0 mmol) of 1-iodo-4-methoxybenzene, 46 mg (0.2 mmol, 0.2 equiv) of $(2-furyl)_3P$ and 52 mg (0.05 mmol, 0.05 equiv) of $Pd_2(dba)_3 \cdot CHCl_3$ and the mixture was stirred at 50 °C for 24 h. The reaction mixture was diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO_2 (20 mm X 100mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 124 mg (71%) of **9a** as a white solid. The physical and spectroscopic data matched those from the literature.¹⁰

Data for **9a**:

mp: 54-55 °C

¹H NMR: (500 MHz, CHCl₃)

7.60 (d, *J* = 8.8, 2 H, HC(2')), 7.43 (d, *J* = 1.7, 1 H, HC(5)), 6.92 (d, *J* = 8.5, 2 H, HC(3')), 6.51 (d, *J* = 3.4, 1 H, HC(3)), 6.45 (dd, *J* = 3.4, 1.7, 1 H, HC(4)), 3.84 (s, 3 H, HC(5'))

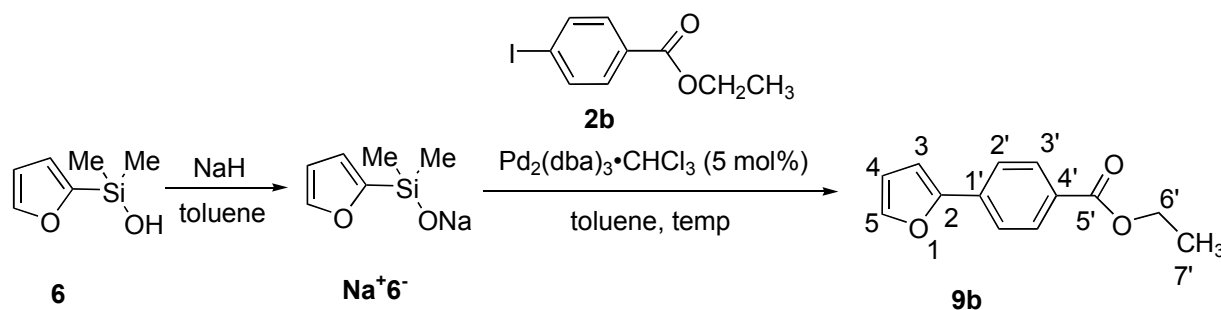
¹³C NMR: (125 MHz, CHCl₃)

159.22 (C(4')), 154.25 (C(2)), 141.61 (C(5)), 125.45 (C(2')), 124.25 (C(1')), 114.32 (C(3')), 111.77 (C(3)), 103.60 (C(4)), 55.54 (C(5'))

TLC: *R_f* 0.34 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: *t_R* **9a**, 7.29 min (98.2%) (HP-5, 15 psi)

Preparation of 2-(4'-Ethoxycarbonylphenyl)furan (9b)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-furyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 276 mg (1.0 mmol) of ethyl-4-iodo-benzoate, and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃•CHCl₃ and the mixture was stirred at rt for 1 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 178 mg (82%) of **9b** as a white solid. The physical and spectroscopic data matched those from the literature.¹⁰

Data for **9b**:

mp: 55-56 °C

¹H NMR: (500 MHz, CHCl₃)

8.06 (d, *J* = 8.6, 2 H, HC(3')), 7.72 (d, *J* = 8.8, 2 H, HC(2')), 7.52 (d, *J* = 1.8, 1 H, HC(5)), 6.79 (d, *J* = 3.3, 1 H, HC(3)), 6.51 (dd, *J* = 3.4, 2.0, 1 H, HC(4)), 4.39 (q, *J* = 7.2, 2 H, HC(6')), 1.41 (t, 3 H, HC(7'))

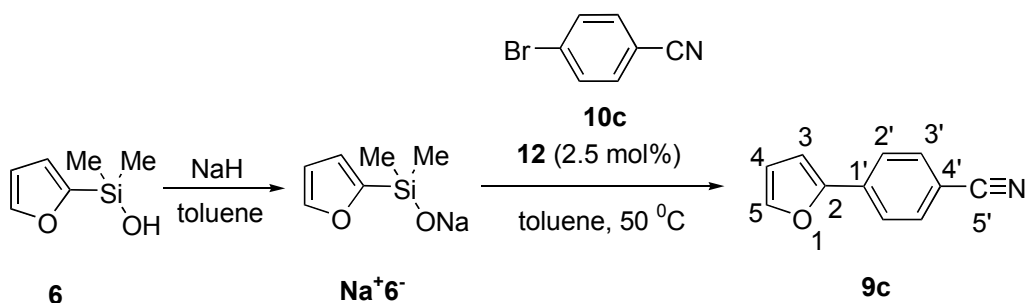
¹³C NMR: (125 MHz, CHCl₃)

166.32 (C(5')), 152.94 (C(2)), 143.067 (C(5)), 134.63 (C(1')), 130.04 (C(3')), 128.85 (C(4')), 123.32 (C(2')), 111.99 (C(3)), 107.14 (C(4)), 60.91 (C(6')), 14.29 (C(7'))

TLC: *R_f* 0.20 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: *t_R* **9b**, 8.99 min (100.0%) (HP-5, 15 psi)

Preparation of 2-(4'-Cyanophenyl)furan (**9c**)



Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-furyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 182 mg (1.0 mmol) of 1-bromo-4-cyanobenzene, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 123 mg (73%) of **9c** as a white solid. The physical and spectroscopic data matched those from the literature.¹¹

Data for 9c:

mp: 54-56 °C

¹H NMR: (500 MHz, CHCl₃)

7.75 (d, *J* = 8.1, 2 H, HC(2')), 7.66 (d, *J* = 8.1, 2 H, HC(3')), 7.54 (d, *J* = 1.7, 1 H, HC(5)), 6.82 (d, *J* = 3.4, 1 H, HC(3)), 6.53 (dd, *J* = 3.4, 1.7, 1 H, HC(4))

¹³C NMR: (125 MHz, CHCl₃)

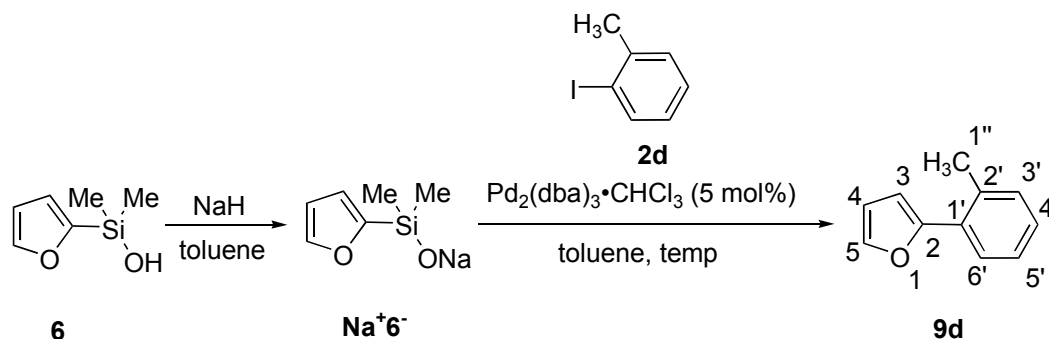
151.85 (C(2)), 143.62 (C(5)), 134.52 (C(1')), 132.48 (C(3')), 123.83 (C(2')), 118.90 (C(5')), 112.18 (C(4')), 110.12 (C(3)), 108.10 (C(4))

MS: (EI, 70 eV)

169 (M⁺, 100), 141 (18), 140 (66), 114 (15), 113 (10), 63 (6)

TLC: *R_f* 0.18 (hexane/EtOAc, 9/1) [silica gel, UV]

Preparation of 2-(2'-Methylphenyl)furan (9d)



Following General Procedure I, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-furyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 218 mg (1.0 mmol) of 1-iodo-2-methylbenzene, and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃•CHCl₃ and the mixture was stirred at rt for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), toluene) and Kugelrohr distillation afforded 97 mg (61%) of **9d** as a clear, colorless oil. The physical and spectroscopic data matched those from the literature.¹²

Data for 9d:

bp: 105 °C (0.5 mm Hg, ABT)

¹H NMR: (500 MHz, CHCl₃)

7.70 (d, $J = 7.8$, 1 H, HC(6')), 7.51 (d, $J = 1.7$, 1 H, HC(5')), 7.23 (m, 3 H, HC(3'), HC(4'), HC(5')), 6.55 (d, $J = 3.2$, 1 H, HC(3)), 6.51 (dd, $J = 3.3, 1.8$, 1 H, HC(4)), 2.50 (s, 3 H, HC(1''))

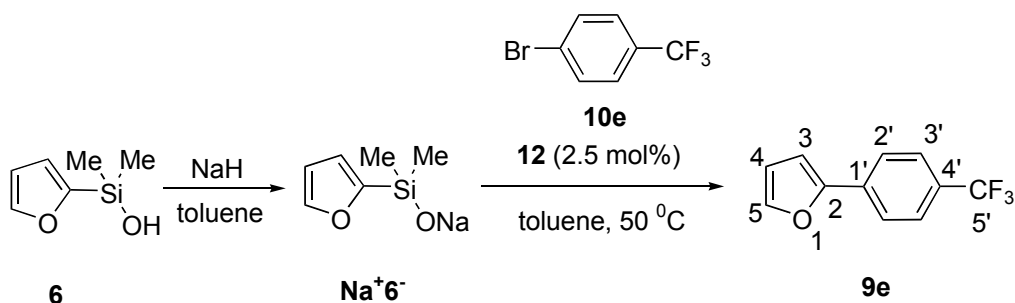
¹³C NMR: (125 MHz, CHCl₃)

153.55 (C(2)), 141.65 (C(5)), 134.55 (C(2')), 131.11 (C(1')), 130.22 (C(3')), 127.44 (C(4')), 127.04 (C(6')), 125.97 (C(5')), 111.28 (C(3)), 108.47 (C(4)), 21.84 (C(1''))

TLC: R_f 0.55 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: t_R **9d**, 6.30 min (100.0%) (HP-5, 15 psi)

Preparation of 2-(4'-Trifluoromethylphenyl)furan (**9e**)



Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-furyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 140 μL (1.0 mmol) of 4-bromobenzotrifluoride, and 18 mg (0.025 mmol, 0.025 equiv) of **12** whereupon the mixture was stirred at 50 $^\circ\text{C}$ for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), toluene) and sublimation (0.5 mmHg, 50 $^\circ\text{C}$) afforded 150 mg (71%) of **9e** as a white solid. The physical and spectroscopic data matched those from the literature.¹³

Data for 9e:

mp: 88-89 $^\circ\text{C}$

$^1\text{H NMR}$: (500 MHz, CHCl_3)

7.77 (d, $J = 8.1$, 2 H, HC(3')), 7.63 (d, $J = 8.3$, 2 H, HC(2')), 7.52 (d, $J = 1.5$, 1 H, HC(5)), 6.77 (d, $J = 3.2$, 1 H, HC(3)), 6.51 (dd, $J = 3.4$, 2.0, 1 H, HC(4))

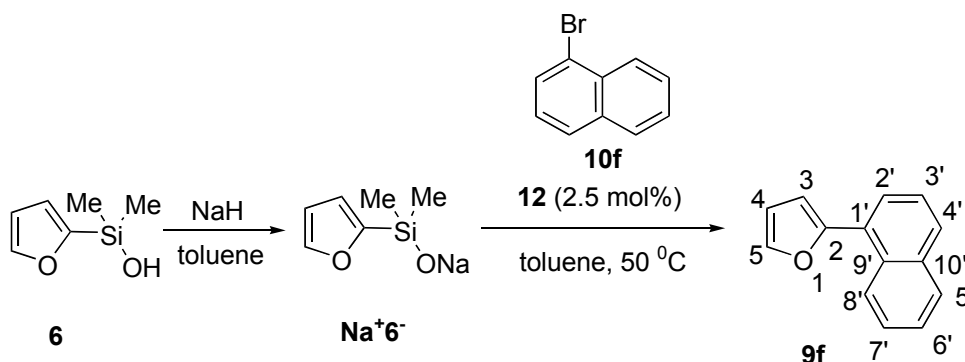
$^{13}\text{C NMR}$: (125 MHz, CHCl_3)

152.51 (C(2)), 143.10 (C(5)), 133.93 (C(1')), 125.72 (C(4')), 125.70 (C(2')), 125.66 (C(3')), 123.75 (C(5')), 111.96 (C(3)), 106.96 (C(4))

TLC: R_f 0.46 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: t_R **9e**, 5.95 min (100.0%) (HP-5, 15 psi)

Preparation of 2-(4'-Naphthyl)furan (**9f**)



Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-furyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 139 μL (1.0 mmol) of 1-bromonaphthalene, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 6 h. The reaction mixture was diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO_2 (20 mm X 100mm), toluene) and distillation afforded 134 mg (69%) of **9f** as a clear, colorless oil. The physical and spectroscopic data matched those from the literature.¹⁴

Data for **9f**:

bp: 130 °C (0.5 mm Hg, ABT)

¹H NMR: (500 MHz, CHCl₃)

8.42 (d, *J* = 7.8, 1 H), 7.90 (d, *J* = 7.3, 1 H), 7.85 (d, *J* = 8.3, 1 H), 7.75 (d, *J* = 7.3, 1 H), 7.64 (d, *J* = 1.7, 1 H, HC(5)), 7.54 (m, 3 H), 6.74 (d, *J* = 3.2, 1 H, HC(3)), 6.60 (dd, *J* = 3.2, 2.0, 1 H, HC(4))

¹³C NMR: (125 MHz, CHCl₃)

153.45 (C(2)), 142.40 (C(5)), 133.93 (C(1')), 130.36 (C(10')), 128.57 (C(9')), 128.54 (C(5')), 128.50 (C(8')), 126.53 (C(4')), 126.14 (C(3')), 125.90 (C(7')), 125.53 (C(6')), 125.30 (C(2')), 111.36 (C(3)), 109.19 (C(4))

TLC: *R_f* 0.62 (hexane/EtOAc, 9/1) [silica gel, UV]

GC: *t_R* **9f**, 8.96 min (98.3%) (HP-5, 15 psi)

Table 4, entry 1

Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 125 μL (1.0 mmol) of 1-bromo-4-methoxybenzene, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X100mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 135 mg (71%) of **8a** as a white solid. *t_R* **8a**, 8.43 min (100.0%) (HP-5, 15 psi).

Table 4, entry 2

Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 163 μL (1.0 mmol) of ethyl-4-bromo-benzoate, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X

100mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 155 mg (67%) of **8b** as a white solid. t_R **8b**, 10.89 min (100.0%) (HP-5, 15 psi).

Table 4, entry 4

Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 190 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 120 μ L (1.0 mmol) of 2-bromotoluene, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), hexane/EtOAc 9/1) and distillation afforded 134 mg (77%) of **8d** as a clear, colorless oil. t_R **8d**, 6.99 min (100.0%) (HP-5, 15 psi).

Table 4, entry 7

Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-furyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 125 μ L (1.0 mmol) of 1-bromo-4-methoxybenzene, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), toluene) and sublimation (0.5 mmHg, 50 °C) afforded 115 mg (66%) of **9a** as a white solid. t_R **9a**, 7.27 min (100.0%) (HP-5, 15 psi).

Table 4, entry 8

Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-furyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 163 μ L (1.0 mmol) of ethyl-4-bromo-benzoate, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of

deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), toluene) and sublimation afforded 130 mg (60%) of **9b** as a white solid. t_R **9b**, 8.94 min (100.0%) (HP-5, 15 psi).

Table 4, entry 10

Following General Procedure II, a solution containing 29 mg (1.2 mmol, 1.2 equiv) of NaH, and 170 mg of 2-thienyldimethylsilanol (1.2 mmol, 1.2 equiv) in 1.0 mL of toluene in a 5-mL round-bottomed flask under an atmosphere of argon was prepared. To this mixture was added 120 μ L (1.0 mmol) of 2-bromotoluene, and 18 mg (0.025 mmol, 0.025 equiv) of **12** and the mixture was stirred at 50 °C for 3 h. The reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). Purification by column chromatography (SiO₂ (20 mm X 100mm), hexane/EtOAc 9/1) and distillation afforded 113 mg (71%) of **9d** as a clear, colorless oil. t_R **9d**, 6.31 min (100.0%) (HP-5, 15 psi).

Cross-Coupling of Pre-formed Sodium Silanolates:

Preparation of 2-(4'-Ethoxycarbonylphenyl)indole-1-carboxylic Acid *tert*-Butyl Ester (**3b**)

Following General Procedure III, a mixture of 376 mg (1.2 mmol, 1.2 equiv) of Na⁺**1**⁻ in 1.0 mL of dry toluene under dry argon atmosphere inside a dry box was prepared. To this mixture was added 168 μ L (1.0 mmol, 1.0 equiv) of ethyl-4-iodobenzoate and 52 mg (0.05 mmol, 0.05 equiv) of Pd₂(dba)₃•CHCl₃. The flask was sealed with a rubber septum and removed from the drybox.

After being stirred at rt for 3 h, the reaction mixture was diluted with 25 mL of deionized H₂O, and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). The combined organic layers were dried over MgSO₄ and were filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give a dark red residue. A solution of the residue in 0.5 mL of toluene was loaded onto a silica gel column (20 X 100 mm) which was eluted with toluene (20 X 10 mL fractions). Evaporation of the solvent and further purification by recrystallization afforded 279 mg (76%) of **3b** as a white solid.

Preparation of 2-(4'-Ethoxycarbonylphenyl)thiophene (8b)

Following General Procedure III, a solution of 216 mg (1.2 mmol, 1.2 equiv) of **Na⁺5⁻** in 1.0 mL of dry toluene under dry argon atmosphere inside a dry box was prepared. To this mixture was added 168 μ L (1.0 mmol, 1.0 equiv) of ethyl-4-iodobenzoate and 52 mg (0.05 mmol, 0.05 equiv) of $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$. The flask was sealed with a rubber septum and removed from the drybox.

After being stirred at rt for 3 h, the reaction mixture was diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). The combined organic layers were dried over MgSO_4 and were filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give a dark red residue. A solution of the residue in 0.5 mL of toluene was loaded onto a silica gel column (20 X 100 mm) which was eluted with toluene (20 X 10 mL fractions). Evaporation of the solvent and further purification by sublimation (0.5 mmHg, 50 $^\circ\text{C}$) afforded 202 mg (87%) of **8b** as a white solid. t_R **8b**, 10.89 min (100.0%) (HP-5, 15 psi)

Preparation of 2-(4'-Ethoxycarbonylphenyl)furan (9b)

Following general procedure III, a solution of 197 mg (1.2 mmol, 1.2 equiv) of **Na⁺6⁻** in 1.0 mL of dry toluene under dry argon atmosphere inside a dry box was prepared. To this mixture was added 168 μ L (1.0 mmol, 1.0 equiv) of ethyl-4-iodobenzoate and 52 mg (0.05 mmol, 0.05 equiv) of $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$. The flask was sealed with a rubber septum and removed from the drybox.

After being stirred at rt for 1 h, the reaction mixture was diluted with 25 mL of deionized H_2O , and 20 mL of EtOAc. The organic layer was separated, and the aqueous layer was washed with EtOAc (5 X 25 mL). The combined organic layers were dried over MgSO_4 and were filtered through #4 Whatman filter paper. The solvent was removed under reduced pressure to give a dark red residue. A solution of the residue in 0.5 mL of toluene was loaded onto a silica gel column (20 X 100 mm) which was eluted with toluene (20 X 10 mL fractions). Evaporation of the solvent and further purification by sublimation (0.5 mmHg, 50 $^\circ\text{C}$) afforded 172 mg (79%) of **9b** as a white solid. t_R **9b**, 8.93 min (100.0%) (HP-5, 15 psi)

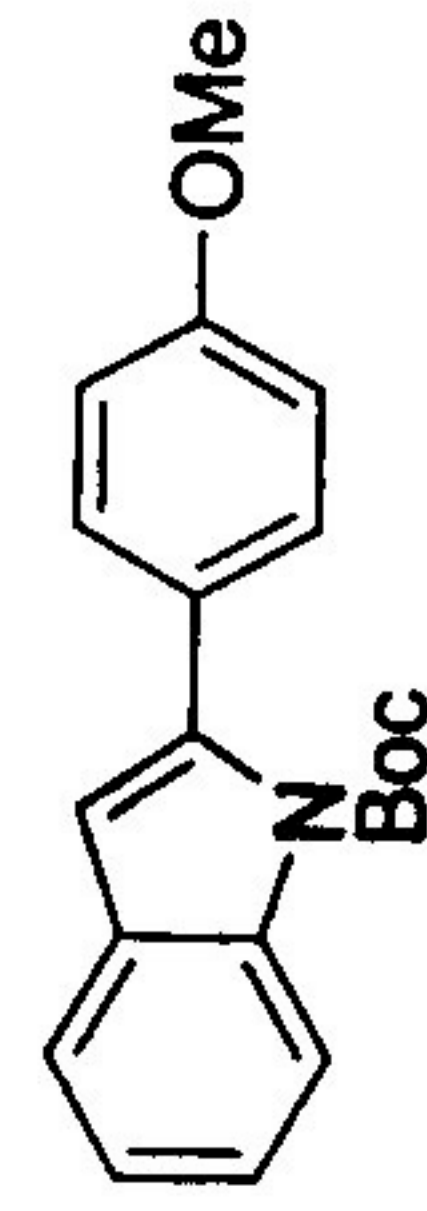
References

- (1) Whitesides, G. M.; Casey, C. P.; Krieger, J. K. *J. Am. Chem. Soc.* **1971**, *93*, 1379-1389.
- (2) Hoye, T. R.; Aspaas, A. W.; Eklov, B. M.; Ryba, T. D. *Org. Lett.* **2005**, *7*, 2205-2208.
- (3) Denmark, S. E.; Baird, J. D. *Org. Lett.* **2004**, *6*, 3649-3652.
- (4) Lee, M.; Ko, S.; Chang, S. *J. Am. Chem. Soc.* **2000**, *122*, 12011-12012.
- (5) Labadie, S.; Teng, E. *J. Org. Chem.* **1994**, *59*, 4250-4254.
- (6) Thoresen, L.; Kim, H.; Welch, M. B.; Burghart, A.; Burgess, K. *Synlett* **1998**, 1276-1278.
- (7) Takahashi, K.; Suzuki, T.; Akiyama, K.; Ikegami, Y.; Fukazawa, Y. *J. Am. Chem. Soc.* **1991**, *113*, 4576-4583.
- (8) Amatore, C.; Jutand, A.; Negri, S. *J. Organomet. Chem.* **1990**, *390*, 389-398.
- (9) Littke, A. F.; Schwarz, L.; Fu, G. C. *J. Am. Chem. Soc.* **2002**, *124*, 6343-6348.
- (10) Clennan, E. L.; Mehrsheikh-Mohammadi, M. E. *Mag. Reson. Chem.* **1985**, *23*, 985-987.
- (11) Majima, T.; Pac, C.; Nakasone, A.; Sakurai, H. *J. Am. Chem. Soc.* **1981**, *103*, 4499-4508.
- (12) Reuter, K. H.; Scott, W. J. *J. Org. Chem.* **1993**, *58*, 4722-4726.
- (13) Tanis, S. P.; Deaton, M. V.; Dixon, L. A.; McMills, M. C.; Raggon, J. W.; Collins, M. A. *J. Org. Chem.* **1998**, *63*, 6914-6928.
- (14) Echavarren, A. M.; Stille, J. K. *J. Am. Chem. Soc.* **1988**, *110*, 1557-1565.

JDS-X-59recr

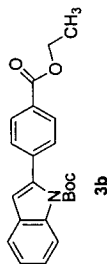
exp1 s2pul

SAMPLE DEC. & VT
date Aug 13 2005 dfrq 499.699
solvent CDCl3 dn H1
file /export/home/- dper 20
data/ui500mb/haird- dof 0
/JDS-X-59recr.fid dm nnn
ACQUISITION dm c
sfrq 499.699 dmf 200
tn H1 dseq
at 4.665 dres 1.0
np 65536 homo n
sw 7024.9 PROCESSING
fb 4000 wtf file
bs 4 proc ft
tpwr 63 fn not used
pw 5.8 math f
dl 0
tof 2.0 verr
nt 16 wexp
ct 16 wbs
alock n wnt
gain not used
FLAGS
il n
in n
cp y
hs nn
DISPLAY
sp -250.0
wp 5496.6
vs 12
sc 0
wc 400
hnm 13.74
is 995.02
xfl 4643.8
rfp 3627.8
th 7
ins 1.000
ai ph



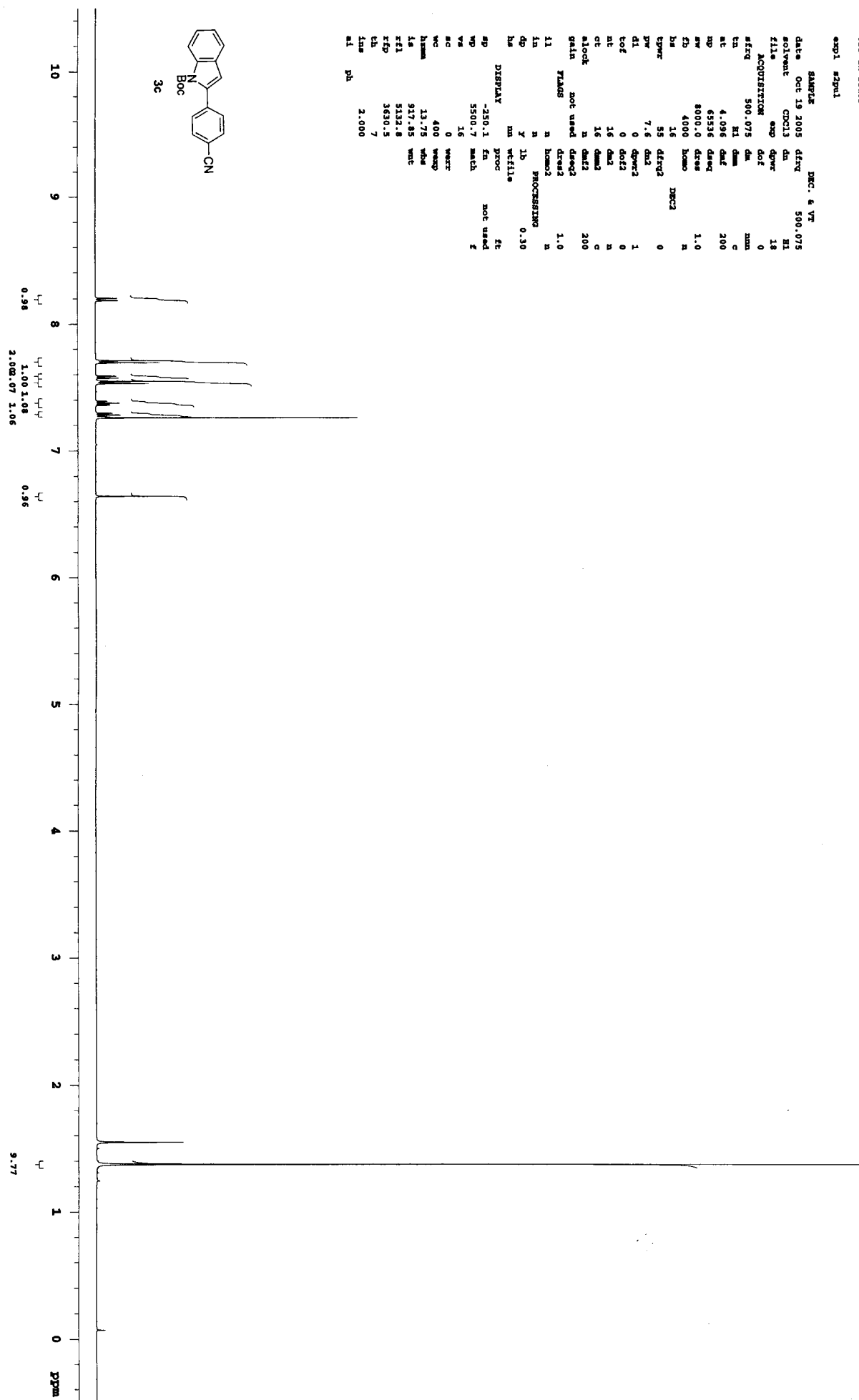
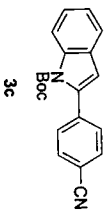
exp1 s2pml

SAMPLE DEC. & VT
 date Oct 19 2005 dfreq 500.075
 solvent CDCl3 dn H1
 file exp dpyr 18
 ACQUISITION
 srfreq 500.075 dm nmn
 tn H1 dm c
 at 4.096 dmf 200
 xp 65536 dseq
 sw 8000.0 dres 1.0
 zb 4000 homo n
 bs 16 DEC2
 tpxr 55 dfreq2 0
 yw 7.6 daz
 dl 0 dpyr2 1
 tof 0 dorf2 0
 nt 16 dm1 n
 ct 16 dm2 c
 elock n dm2 200
 gain not used dseq2
 F1MGS dres2 1.0
 il n homo2 n
 in n PROCESSING
 dp y lb 0.30
 bs nm wfile
 DISPLAY nm proc ft
 sp -250.1 fn not used
 wp 5500.7 math z
 vs 14
 sc 0 warr
 wc 400 wexp
 hsum 13.75 wbs
 ls 888.11 wat
 xfl 5132.6
 xfp 3630.5
 th 7
 ins 1.000
 el ph



exp1 szpu1

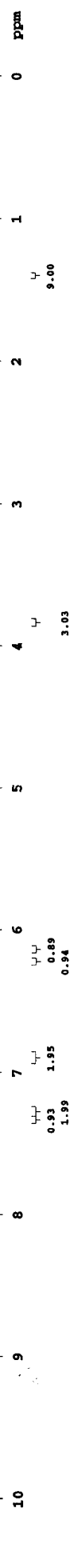
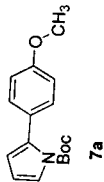
SAMPLE		DATE		DEC. & YR	
file	Oct 19 2005	date	500.075	file	HI
solvent	CHCl3	dm		dm	
ACQUISITION					
freq	500.075	exp	16	acq	0
ns	HI	dm		nm	
tn	4.096	dmf		c	
nd	6536	dsaq		200	
ap	8000	dsaq		1.0	
av	4000	dsao		n	
eb	4000	dsao		n	
bs	16	dmf2		DMC2	
typ	55	dmf2		0	
pr	7.6	dm2		1	
dl	0	dmf2		0	
tof	0	dm2		0	
ct	16	dm2		c	
nt	16	dm2		c	
alock	dm2	dm2		200	
gain	not used	dm2			
PLANS					
i1	n	hmo2		1.0	
in	n	dm2		n	
dp	y	1b		0.30	
hs	nm	wfile			
DISPLAY					
ap	-230.1	fn		fe	
wp	5500.7	mach		not used	
vs	16			f	
ac	0	wext			
wc	400	wexp			
hsum	11.75	whs			
rs	917.85	wnt			
rfl	5132.8				
rfd	3630.7				
ch					
lms	2.000				
l	ph				



JTM-X-35col12

exp1 s2pul

SAMPLE DSC. & VT
date Nov 19 2005 dfrq 499.438
solvent CDCl3 dn H1
file exp dper 25
ACQUISITION dof 0
afreq 499.438 dm nnn
tn H1 dm c
at 4.096 dmf 200
mp 65536 dseq
sw 8000.0 dres 1.0
zb 4400 homo n
bs 4 PROCESSING
tprz 63 lb 0.30
pw 5.0 wtfile
dl 0 proc ft
tof 0 fn not used
nt 16 math f
ct 16
alock n warr
gain not used warr
flags n wnt
il in n
dp y
bs nm
DISPLAY
sp -249.9
wp 5493.6
vs 162
sc 0
wc 400
hazam 13.73
ls 1711.54
xfl 5132.5
xfo 3625.9
th 7
lms 9.000
nm ph



JDB-XI-62xd

exp1 s2pul

SAMPLE DEC. & VT
date Jan 9 2006 dfrq 500.075
solvent CDCl3 dn H1
file exp dpwr 18
ACQUISITION dof 0
sfrq 500.075 dm nm
tn H1 dnm c
at 4.096 dmf 200
np 65536 dseq
sw 8000.0 dres 1.0
fb 4000 homo n
bs 16 DEC2
tpwr 55 dfrq2 0
pw 7.7 dn2
dl 0 dpwr2 1
tof 0 dof2 0
nt 16 dnm2 n
ct 16 dnm2 c
alock n dmf2 200
gain not used dseq2
FLAGS dres2 1.0
il n homo2 n
in n PROCESSING
cp y lb 0.30
hs nm wfile
DISPLAY proc ft
sp -250.1 fn not used
wp 5500.7 math f
vs 20
sc 0 weir
wc 400 wexp
hzmm 13.75 wbs
is 712.59 wnt
rfl 5132.6
xrp 3630.5
th 7
ins 2.000
ai ph

