# Expanding Pd-catalyzed C-N Bond-Forming Processes: The First Amidation of Aryl Sulfonates, Aqueous Amination and Complementarity With Cu-Catalyzed Reactions

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## Supporting Information

## General Considerations

**Reagents:** $Pd(OAc)_2$, $Pd_2(dba)_3$ and CuI were purchased from Strem Chemical Co. and used without further purification. Ligands **4-8** were prepared as previously described.[1] Ligands **1**, **7, 8** and **9** are also commercially available from Strem Chemical Co. Racemic *trans*-1,2-cyclohexanediamine and *N,N'*-dimethylethylenediamine were purchased from Aldrich. Anhydrous $Cs_2CO_3$ was purchased from Chemetall and NaO*t*Bu was purchased from Aldrich; the bulk of the material was stored under nitrogen in a Vacuum Atmosphere glovebox. Small portions (1-2 g) were removed from the glovebox in glass vials, stored in the air in desiccators filled with anhydrous calcium sulfate, and weighed in the air. Powdered $K_2CO_3$ was used directly from the bottle that was bought from Aldrich, or bought from Mallinckrodt and finely ground before use. KOH was purchased from Mallinckrodt and was finely ground before use. Dialkylchlorophosphine and magnesium powder (50 mesh) were purchased from Aldrich and used without further purification. Aryl benzenesulfonates or tosylates were prepared by treating the corresponding phenols with the benzenesulfonyl chloride or tosyl chloride in methylene chloride containing a slight excess of triethylamine at room temperature. 1-Cyclohexenyl

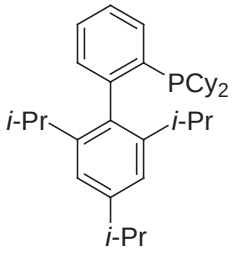
[1] (a) Tomori, H.; Fox, J. M.; Buchwald, S. L. *J. Org. Chem.* **2000**, *65*, 5334-5341. (b) Kaye, S.; Fox, J. M.; Hicks, F. A.; Buchwald, S. L. *Adv. Syn. Catal.* **2001**, *343*, 789-794.

tosylate was prepared following a literature procedure.[2] Toluene, THF, and $Et_2O$ were purchased from J. T. Baker in CYCLE-TAINER® solvent delivery kegs, which were vigorously purged with argon for 2 h, and further purified by passing the solvent through two packed columns of neutral alumina and copper (II) oxide under argon pressure. Anhydrous dioxane and *t*-butanol were purchased from Aldrich in Sure/Seal™ bottles and used without further purification. All other reagents were purchased from Alfa Aesar or Aldrich, and used without further purification. Flash column chromatography was performed with EM Science silica gel 60 (230-400 mesh).

**Analytical methods:** All reactions were carried out under an argon atmosphere in oven-dried glassware (except that no drying is required for the reactions performed in water). IR spectra were obtained by placing neat samples directly on the DiComp probe of an ASI REACTIR *in situ* IR instument. $^{1}H$ NMR and $^{13}C$ NMR spectra were recorded on a Varian XL 300, Varian XL 500, or Bruker 400 MHz with chemical shifts reported in ppm relative to the residual deuterated solvent, the internal standard tetramethylsilane, or external 85% $H_3PO_4$ for $^{31}P$. Elemental analyses were performed by Atlantic Microlabs, Norcross, GA. Gas chromatography analyses were performed on a Hewlett Packard 5890 instrument with a FID detector and a Hewlett Packard 25 m x 0.2 mm i.d. HP-5 capillary column or a Hewlett Packard 6890 instrument with a FID detector and a Hewlett Packard 10 m x 0.1 mm i.d. HP-1 column. Yields refer to isolated yields of compounds greater than 95% purity as determined by capillary gas chromatography (GC), and proton Nuclear Magentic Resonance spectroscopy ($^{1}H$ NMR) analysis. Yields for the preparation of starting materials and ligands refer to a single experiment whereas those reported in Tables 1 to 6 are an average of two or more runs. The procedures described in this section are representative; thus, the yields may differ slightly from those given in Tables 2 to 6. All new compounds were further characterized by elemental analysis or HRMS.

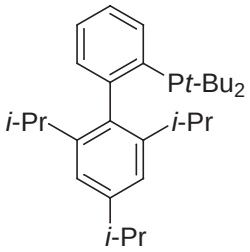
[2] Frydman, N.; Bixon, R.; Sprecher, M.; Mazur, Y. *Chem. Commun.* **1969**, 1044-1045.

## Experimental procedures for Table 1

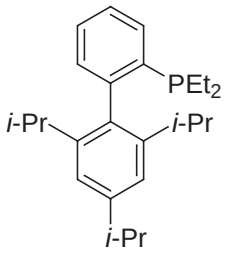



**2-Dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl**[1] **(Table 1, 1igand 1).** A flame dried 500 mL, 3-neck, round bottom flask equipped with a Teflon coated magnetic stir bar, reflux condenser, glass stopper, gas inlet adapter and rubber septum was purged with argon and charged with Mg powder, -50 mesh (2.9 g, 120 mmol), THF (70 mL) and 1-bromo-2,4,6-triisopropylbenzene (14.2 g, 50.0 mmol). While stirring vigorously under argon, the reaction mixture was then heated to 65 °C in an oil bath and 1,2-dibromoethane (45 μL) was added dropwise via syringe to initiate the reaction. After 40–60 min, Grignard formation of 1-bromo-2,4,6-triisopropylbenzene was complete as judged by GC analysis, and 2-bromochlorobenzene (6.4 mL, 55 mmol) was added at 65 °C over 1 h via syringe pump. After an additional 1 h of stirring at 65 °C, the reaction mixture was cooled to room temperature. Anhydrous CuCl (0.25 g, 2.5 mmol) was weighed out in a nitrogen-filled glove box and removed from the glove box prior to its addition by removing the septum from the reaction vessel (from above) and adding the CuCl as rapidly as possible. To this, $ClPCy_2$ (11.0 mL, 50.0 mmol) was added via syringe; the addition was performed dropwise to control the exotherm (CAUTION!). The resulting mixture was allowed to stir at ambient temperature for 20 h. The reaction mixture was placed in an ice bath, and methanol (2 mL) was added (CAUTION!). The mixture was diluted with warm ethyl acetate (250 mL, ca. 40 °C), stirred for 15 min and filtered by gravity through a pad of Celite. An additional portion of warm ethyl acetate (250 mL, ca. 40 °C) and $CH_2Cl_2$ (700 mL, ambient temperature) was used to wash through the pad of Celite. The solvent was removed *in vacuo* and the crude product was dissolved in diethyl ether / $CH_2Cl_2$ (2:1, 400 mL), using sonication to facilitate dissolution. Once a homogeneous mixture was obtained, methanol (15 mL) and a seed crystal of **1** were added to facilitate crystal formation. The solution was allowed to stand in a refrigerator (-40 °C) for 24 h. The resulting crystals (14.7 g) were collected via vacuum filtration and washed with ice-cold diethyl ether. A second crop of crystals was also harvested from the

mother liquor, however a different recrystallization protocol was used in an effort to use less solvent. The mother liquor was concentrated and diluted with hot methanol (100 mL, 65 °C); even with vigorous stirring this volume of solvent was not sufficient to dissolve all of the crude material, so the solution was cooled to room temperature, the stir bar was removed and the solution was sonicated. While sonicating, portions of diethyl ether / $CH_2Cl_2$ (2:1, 6×50 mL) were added until the solution was homogeneous. A seed crystal was then added and the solution was allowed to stand in a refrigerator (-40 °C) for 24 h. The resulting crystals (5.3 g) were collected via vacuum filtration and washed with cold diethyl ether. The crops of crystals were then combined and dried under vacuum for 24 h, yielding 19.8 g of the title compound (19.8 g, 83%) as a white crystalline solid: mp 182-184 °C. $^1$H NMR (300 MHz, $C_6D_6$) δ 7.48-7.42 (m, 1H), 7.24-7.06 (m, 5H), 2.85 (septet, *J* = 6.9 Hz, 1H), 2.71 (septet, *J* = 6.9 Hz, 2H), 1.94-1.52 (m, 12H), 1.42 (d, *J* = 6.9 Hz, 6H), 1.24 (d, *J* = 6.9 Hz, 6H), 1.30-1.02 (m, 10H), 1.12 (d, *J* = 6.9 Hz, 6H); $^{31}$P NMR (121 MHz, $C_6D_6$) δ -11.5; $^{13}$C NMR (75 MHz, $C_6D_6$) δ 148.7, 148.6, 148.2, 147.01, 146.99, 137.8, 137.7, 137.60, 137.58, 132.92, 132.88, 132.3, 132.2, 128.2, 127.0, 121.0, 35.4, 35.3, 35.1, 32.1, 31.9, 31.68, 31.66, 30.3, 30.1, 28.6, 28.4, 28.3, 28.2, 27.4, 26.9, 25.0, 23.92, 23.90 (observed complexity due to P-C splitting). IR (neat, cm$^{-1}$) 2923, 1461, 1449, 876, 768. Anal. Calcd for $C_{33}H_{49}P$: C, 83.14; H, 10.36. Found: C, 82.76; H, 10.33.




**2-Di-*t*-butylphosphino-2',4',6'-triisopropylbiphenyl (Table 1, ligand 2).** Following the procedure as previously described,[1] the title compound was obtained in 32% yield as a white crystalline solid: mp 144-145 °C. $^1$H NMR (300 MHz, $C_6D_6$) δ 7.83-7.76 (m, 1H), 7.32-7.24 (m, 1H), 7.14-7.04 (m, 4H), 2.87-2.72 (m, 3H), 1.35 (d, *J* = 6.9 Hz, 6H), 1.21 (d, *J* = 6.9 Hz, 6H), 1.12 (d, $J_{HP}$= 11.1 Hz, 18H), 1.07 (d, *J* = 6.9 Hz, 6H); $^{31}$P NMR (121 MHz, $C_6D_6$) δ 21.4; $^{13}$C NMR (75 MHz, $C_6D_6$) δ 149.7, 149.2, 148.7, 147.20, 147.19, 138.2, 138.0, 137.9, 137.8, 136.69, 136.66, 133.2, 133.1, 128.6, 128.2, 126.2, 121.1, 35.2, 33.6, 33.3, 31.85, 31.81, 31.79, 31.6, 27.4, 25.0, 23.65, 23.62 (observed complexity due to P-C splitting). IR (neat, cm$^{-1}$) 2956, 1457, 1360, 874, 764, 745. Anal. Calcd for $C_{29}H_{45}P$: C, 82.02; H, 10.68. Found: C, 81.81; H, 10.80.




**2-Diethylphosphino-2',4',6'-triisopropylbiphenyl (Table 1, 1igand 3).** Following the procedure as previously described,[1] the title compound was obtained in 50% yield as a white crystalline solid: mp 80-82 °C. $^{1}$H NMR (300 MHz, $C_6D_6$) δ 7.37-7.31 (m, 1H), 7.18-7.07 (m, 5H), 2.83 (septet, *J* = 6.9 Hz, 1H), 2.66 (septet, *J* = 6.9 Hz, 2H), 1.50-1.38 (m, 4H), 1.34 (d, *J* = 6.6 Hz, 6H), 1.23 (d, *J* = 6.6 Hz, 6H), 1.09 (d, *J* = 6.6 Hz, 6H), 0.91 (t, *J* = 7.5 Hz, 3H), 0.86 (t, *J* = 7.5 Hz, 3H). $^{31}$P NMR (121 MHz, $C_6D_6$) δ -28.9; $^{13}$C NMR (75 MHz, $C_6D_6$) δ 148.8, 147.8, 147.4, 147.09, 147.07, 139.2, 138.9, 137.5, 137.4, 131.6, 131.5, 131.03, 131.00, 128.5, 128.3, 127.6, 121.1, 35.3, 31.64, 31.62, 26.6, 25.0, 23.70, 23.67, 20.6, 20.4, 10.8, 10.6 (observed complexity due to P-C coupling). IR (neat, $cm^{-1}$) 2958, 1459, 1360, 878, 768, 675. Anal. Calcd for $C_{25}H_{37}P$: C, 81.48; H, 10.12. Found: C, 81.42; H, 10.21.

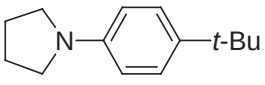
## General procedure for the ligand screening (Table 1)

An oven-dried resealable Schlenk tube containing a stir bar was charged with ligand (0.025 mmol) and $Cs_2CO_3$ (408 mg, 1.25 mmol). The tube was capped with a rubber septum, evacuated and backfilled with argon. A solution of pyrrolidine (65 μL, 0.75 mmol) and 4-*t*-butylphenyl tosylate (152 mg, 0.500 mmol) in toluene (0.5 mL) and *t*-butanol (0.2 mL) was added through the septum via syringe, followed by the addition of a solution of $Pd(OAc)_2$ (2.3 mg, 0.010 mmol) in toluene (0.5 mL). The septum was replaced with a Teflon screw cap. The Schlenk tube was sealed and put into a pre-heated oil bath at 110 °C, and the reaction mixture was stirred for 18 h. The resulting mixture was allowed to cool down to room temperature and was analyzed by GC to determine the extent of conversion of 4-*t*-butylphenyl tosylate and the GC yield of the desired product, *N*-(4-*t*-butylphenyl)pyrrolidine. The results are shown in Table 1.

## Experimental procedures for Table 2

**General Procedure A (Table 2).** An oven-dried resealable Schlenk tube containing a stir bar was charged with Pd precursor, $Pd(OAc)_2$ (2.3 mg, 0.010 mmol) or $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl **1** (11.9 mg, 0.0250 mmol), the solid reactant(s) (0.5 mmol aryl sulfonate or halide, 0.75 mmol amine) and base. The tube was capped with a rubber septum, evacuated and backfilled with argon. The liquid reactant(s) and solvent were added through the septum via syringe. The septum was replaced with a Teflon screw cap. The Schlenk tube was sealed and put into a pre-heated oil bath at 110 °C. The reaction mixture was stirred for the time specified and the resulting mixture was allowed to cool down to room temperature and filtered through Celite with the aid of ethyl acetate. The filtrate was concentrated under reduced pressure and the residue was purified by chromatography on a silica gel column.

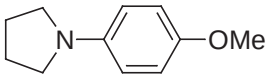
**General Procedure B for Examples with Aromatic Amines and Phenylboronic Acid (Table 2).** An oven-dried resealable Schlenk tube containing a stir bar was charged with $Pd(OAc)_2$ (2.3 mg, 0.010 mmol), 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl **1** (11.9 mg, 0.0250 mmol), phenylboronic acid (3.1 mg, 0.025 mmol), the solid reactant(s) (0.5 mmol aryl sulfonate or halide, 0.75 mmol amine), and base. The tube was capped with a rubber septum, evacuated and backfilled with argon. The liquid reactant(s) and solvent were added through the septum via syringe. The septum was replaced with a Teflon screw cap, and the Schlenk tube was sealed and put into a pre-heated oil bath at 110 °C. The reaction mixture was stirred for the time specified and the resulting mixture was allowed to cool down to room temperature and then filtered through Celite with the aid of ethyl acetate. The filtrate was concentrated under reduced pressure and the residue was purified by chromatography on a silica gel column.



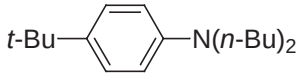

***N*-(4-*t*-Butylphenyl)pyrrolidine**[3] **(Table 2).** Following general procedure A with a reaction time of 18 h, 4-*t*-butylphenyl benzenesulfonate (145 mg, 0.500 mmol) was coupled with

[3] Wolfe, J. P.; Buchwald, S. L. *J. Org. Chem.* **2000**, *65*, 1144-1157.

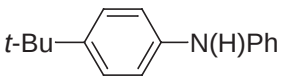
pyrrolidine (65 μL, 0.75 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 20:1 hexane : ethyl acetate gave 100 mg (98%) of the title compound as a white solid: mp 40-41 °C (lit.[3] 38-40 °C). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.24 (d, *J* = 9.0 Hz, 2H), 6.51 (d, *J* = 9.0 Hz, 2H), 3.29-3.22 (m, 4H), 2.00-1.94 (m, 4H), 1.29 (s, 9H).




***N*-(4-Methoxyphenyl)pyrrolidine (Table 2).**[4] Following general procedure A with a reaction time of 24 h, 4-methoxyphenyl benzenesulfonate (145 mg, 0.500 mmol) was coupled with pyrrolidine (65 μL, 0.75 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base, toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent and the exception that 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl **1** (19.0 mg, 0.040 mmol) was used as the ligand. Chromatography on silica gel column with 20:1 hexane : ethyl acetate gave 77 mg (87%) of the title compound as a white solid: mp 44-46 °C (lit.[4] 40-41 °C). $^1$H NMR (300 MHz, $CDCl_3$) δ 6.83 (d, *J* = 9.3 Hz, 2H), 6.52 (d, *J* = 9.3 Hz, 2H), 3.75 (s, 3H), 3.25-3.20 (m, 4H), 2.01-1.95 (m, 4H).



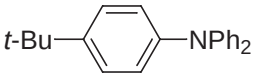

***N*,*N*-(Di-*n*-butyl)-4-*t*-butylaniline**[4] **(Table 2).** Following general procedure A with a reaction time of 20 h, 4-*t*-butylphenyl benzenesulfonate (145 mg, 0.500 mmol) was coupled with di-*n*-butylamine (126 μL, 0.750 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 30:1 hexane : ethyl acetate gave 120 mg (92%) of the title compound as a colorless oil: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.22 (d, *J* = 9.0 Hz, 2H), 6.60 (d, *J* = 9.0 Hz, 2H), 3.23 (t, *J* = 7.5 Hz, 4H), 1.63-1.48 (m, 4H), 1.42-1.22 (m, 4H), 1.28 (s, 9H), 0.94 (t, *J* = 7.5 Hz, 6H). $^{13}$C NMR (75 MHz, $CDCl_3$) δ 146.0, 137.6, 126.0, 111.4, 51.1, 33.9, 31.9, 29.8, 20.7, 14.4.



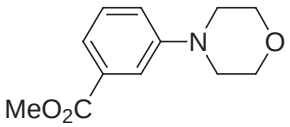

***N*-(4-*t*-Butylphenyl)aniline**[3] **(Table 2).** Following general procedure B with a reaction time of 20 h, 4-*t*-butylphenyl benzenesulfonate (145 mg, 0.500 mmol) was coupled with aniline (70 μL,

[4] Wolfe J. P.; Tomori, H.; Sadighi, J. P.; Yin, J.; Buchwald, S. L. *J. Org. Chem.* **2000**, *65*, 1158-1174.

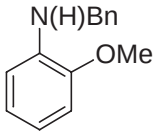
0.75 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 4:1 hexane : dichloromethane gave 107 mg (95%) of the title compound as a white solid: mp 66-67 °C (lit.[3] 64-67 °C). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.27 (d, *J* = 8.7 Hz, 2H), 7.26-7.18 (m, 2H), 7.01 (d, *J* = 8.7 Hz, 4H), 6.87 (t, *J* = 7.2 Hz, 1H), 5.62 (br s, 1H), 1.31 (s, 9H). $^{13}$C NMR (75 MHz, $CDCl_3$) δ 144.2, 143.7, 140.4, 129.4, 126.2, 120.5, 118.2, 117.2, 34.5, 31.8.



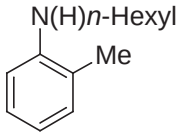

***N*-(4-*t*-Butylphenyl)diphenylamine (Table 2).** Following general procedure B with a reaction time of 24 h, 4-*t*-butylphenyl benzenesulfonate (145 mg, 0.500 mmol) was coupled with diphenylamine (127 mg, 0.750 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 10:1 hexane : dichloromethane gave 139 mg (92%) of the title compound as a white solid: mp 77-79 °C. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.25-7.15 (m, 6H), 7.10-6.90 (m, 8H), 1.30 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 148.0, 145.8, 145.0, 129.2, 126.1, 124.1, 123.9, 122.4, 34.6, 31.8; IR (neat, $cm^{-1}$) 2960, 1592, 1492, 1275, 752, 695, 623. Anal. Calcd for $C_{22}H_{23}N$: C, 87.66; H, 7.69. Found: C, 87.44; H, 7.98.



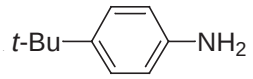

***N*-(3-Methoxycarbonylphenyl)morpholine (Table 2).**[4] Following general procedure A with a reaction time of 20 h, 3-methoxycarbonylphenyl tosylate (153 mg, 0.500 mmol) was coupled with morpholine (66 μL, 0.75 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 4:1 hexane : ethyl acetate gave 110 mg (99%) of the title compound as a colorless oil: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.60-7.54 (m, 1H), 7.52 (d, *J* = 7.5 Hz, 1H), 7.31 (t, *J* = 7.8 Hz, 1H), 7.08 (ddd, *J* = 8.1, 2.7, 0.9 Hz, 1H), 3.89 (s, 3H), 3.86 (t, *J* = 4.8 Hz, 4H), 3.19 (t, *J* = 4.8 Hz, 4H).




***N*-(2-Methoxyphenyl)benzylamine (Table 2).**[4] Following general procedure A with a reaction time of 18 h, 2-methoxyphenyl benzenesulfonate (132 mg, 0.500 mmol) was coupled with benzylamine (82 μL, 0.75 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 30:1 hexane : ethyl acetate gave 95 mg (90%) of the title compound as a pale yellow oil: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.40-7.20 (m, 5H), 6.85-6.77 (m, 1H), 6.77 (dd, *J* = 7.8, 1.2 Hz, 1H), 6.69-6.62 (m, 1H), 6.57 (dd, *J* = 7.8, 1.2 Hz, 1H), 4.61 (br s, 1H), 4.34 (s, 2H), 3.83 (s, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 146.8, 139.6, 138.1, 128.6, 127.6, 127.2, 121.3, 116.7, 110.1, 109.4, 55.6, 48.2.

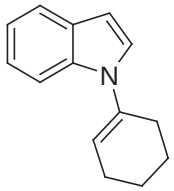



***N*-(2-Methyphenyl)-*n*-hexylamine (Table 2).** Following general procedure A with a reaction time of 20 h, 2-methyphenyl benzenesulfonate (132 mg, 0.500 mmol) was coupled with *n*-hexylamine (100 μL, 0.750 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 4:1 hexane : dichloromethane gave 83 mg (87%) of the title compound as a colorless oil: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.10 (t, *J* = 7.5 Hz, 1H), 7.02 (d, *J* = 7.5 Hz, 1H), 6.62 (t, *J* = 7.5 Hz, 1H), 6.58 (d, *J* = 7.5 Hz, 1H), 3.42 (s, 1H), 3.18-3.09 (m, 2H), 2.12 (s, 3H), 1.70-1.60 (m, 2H), 1.50-1.28 (m, 6H), 0.90 (t, *J* = 6.9 Hz, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 146.4, 130.1, 127.2, 121.7, 116.7, 109.7, 44.2, 32.0, 29.9, 27.2, 23.0, 17.8, 14.4. IR (neat, $cm^{-1}$) 3431, 2925, 1607, 1513, 1316, 1260, 1052, 743. Anal. Calcd for $C_{13}H_{21}N$: C, 81.61; H, 11.06. Found: C, 81.70; H, 11.07.

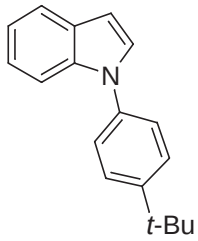



**4-*t*-Butylaniline (Table 2).** An oven-dried resealable Schlenk tube containing a stir bar was charged with $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl **1** (11.9 mg, 0.0250 mmol), 4-*t*-butylphenyl benzenesulfonate (145 mg, 0.500 mmol) and $Cs_2CO_3$ (408 mg, 1.25 mmol). The tube was capped with a rubber septum,

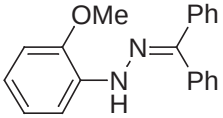
evacuated and backfilled with argon. Benzophenone imine (130 μL, 0.750 mmol) and *t*-butanol (1.0 mL) were added through the septum via syringe. The septum was replaced with a Teflon screw cap. The Schlenk tube was sealed and placed into a pre-heated oil bath at 110 °C. The reaction mixture was stirred for 22 h and the resulting mixture was allowed to cool down to room temperature. Aqueous 1 M HCl (5 mL) was added and the reaction mixture was stirred at room temperature for 15 min. The resulting solution was neutralized by the addition of aqueous NaOH solution. The aqueous phase was extracted with ethyl acetate three times, the organic layers were combined, dried over $Na_2SO_4$, and concentrated *in vacuo*. Flash chromatography on silica gel column with 2:1 hexane : ethyl acetate gave 70 mg (94%) of the title compound as a yellow oil. This compound is commercially available from Aldrich and its identity was confirmed by comparison of $^1$H NMR data to an authentic sample. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.16 (d, *J* = 8.4 Hz, 2H), 6.62 (d, *J* = 8.4 Hz, 2H), 3.54 (s, 2H), 1.28 (s, 9H).




***N*-(1-Cyclohexenyl)indole (Table 2).** Following general procedure B with a reaction time of 3 h, 1-cyclohexenyl tosylate[2] (126 mg, 0.500 mmol) was coupled with indole (88 mg, 0.75 mmol) using $K_3PO_4$ (265 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 10:1 hexane : dichloromethane gave 98 mg (99%) of the title compound as a colorless oil: $^1$H NMR (300 MHz, $C_6D_6$) δ 7.72-7.64 (m, 1H), 7.50-7.42 (m, 1H), 7.25-7.12 (m, 3H), 6.88 (d, *J* = 3.3 Hz, 1H), 6.54 (dd, *J* = 3.3, 0.3 Hz, 1H), 5.63-5.57 (m, 1H), 2.08-1.99 (m, 2H), 1.90-1.81 (m, 2H), 1.47-1.28 (m, 4H); $^{13}$C NMR (75 MHz, $C_6D_6$) δ 136.6, 136.5, 130.1, 126.9, 122.5, 121.8, 121.4, 120.7, 111.9, 103.1, 29.4, 25.2, 23.6, 22.7. IR (neat, $cm^{-1}$) 2929, 1671, 1455, 1322, 1219, 735. Anal. Calcd for $C_{14}H_{15}N$: C, 85.24; H, 7.66. Found: C, 85.05; H, 7.72.

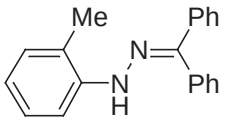



***N*-(4-*t*-Butylphenyl)indole (Table 2).**[5] Following general procedure B with a reaction time of 20 h, 4-*t*-butylphenyl benzenesulfonate (145 mg, 0.500 mmol) was coupled with indole (88 mg, 0.75 mmol) using $K_3PO_4$ (265 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 4:1 hexane : dichloromethane gave 124 mg (99%) of the title compound as a white solid: mp 111-113 °C (lit.[5] 108-110 °C). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.66 (d, *J* = 6.9 Hz, 1H), 7.55 (d, *J* = 7.8 Hz, 1H), 7.51 (d, *J* = 8.4 Hz, 2H), 7.41 (d, *J* = 9.0 Hz, 2H), 7.31 (d, *J* = 3.3 Hz, 1H), 7.23-7.10 (m, 2H), 6.64 (d, *J* = 3.3 Hz, 1H), 1.39 (s, 9H).

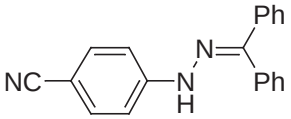



***N*-(2-Methoxyphenyl)benzophenone hydrazone(Table 2).**[4] Following general procedure A with a reaction time of 20 h, 2-methoxyphenyl benzenesulfonate (132 mg, 0.500 mmol) was coupled with benzophenone hydrazone (150 mg, 0.750 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 20:1 hexane : ethyl acetate gave 144 mg (95%) of the title compound as a yellow solid: mp 101-103 °C (lit.[4] mp 101.5-102.5 °C). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.97 (s, 1H), 7.65 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.62-7.43 (m, 5H), 7.38-7.20 (m, 5H), 6.96 (dt, *J* = 7.8, 1.5 Hz, 1H), 6.82-6.68 (m, 2H), 3.67 (s, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 145.4, 144.8, 138.6, 134.3, 133.1, 129.6, 129.14, 129.11, 128.2, 128.0, 126.6, 121.6, 119.2, 112.4, 110.1, 55.7. Anal. Calcd for $C_{20}H_{18}N_2O$: C, 79.44; H, 6.00. Found: C, 79.59; H, 6.06.

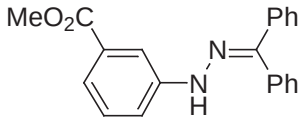
[5] Old, D. W.; Harris, M. C.; Buchwald, S. L. *Org. Lett.* **2000**, *2*, 1403-1406.




***N*-(2-Methylphenyl)benzophenone hydrazone (Table 2).** Following general procedure A with a reaction time of 24 h, 2-methylphenyl benzenesulfonate (124 mg, 0.500 mmol) was coupled with benzophenone hydrazone (150 mg, 0.750 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent. Chromatography on silica gel column with 50:1 hexane : ethyl acetate gave 128 mg (90%) of the title compound as a yellow solid: mp 100-101 °C. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.66 (d, *J* = 8.1Hz, 1H), 7.64-7.46 (m, 5H), 7.43 (s, 1H), 7.37-7.22 (m, 5H), 7.21 (t, *J* = 7.2 Hz, 1H), 6.98 (d, *J* = 6.9 Hz, 1H), 6.76 (dt, *J* = 7.5, 1.2 Hz, 1H), 1.84 (s, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 145.2, 142.4, 138.3, 133.0, 130.3, 129.8, 129.4, 128.9, 128.3, 128.1, 127.4, 126.6, 120.4, 119.7, 112.5, 16.8. IR (neat, $cm^{-1}$) 3357, 1509, 1258, 1131, 747, 706, 693. Anal. Calcd for $C_{20}H_{18}N_2$: C, 83.88; H, 6.34. Found: C, 83.52; H, 6.35.



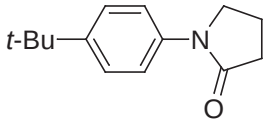

***N*-(4-Cyanophenyl)benzophenone hydrazone (Table 2).** Following general procedure A with a reaction time of 21 h, 4-cyanophenyl tosylate (137 mg, 0.500 mmol) was coupled with benzophenone hydrazone (150 mg, 0.750 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent at 90 °C. Chromatography on silica gel column with 50:1 hexane : ethyl acetate gave 138 mg (93%) of the title compound as a white solid: mp 184-185 °C. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.68 (s, 1H), 7.63-7.52 (m, 5H), 7.49 (d, *J* = 8.7 Hz, 2H), 7.36-7.28 (m, 5H), 7.08 (d, *J* = 8.7 Hz, 2H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 147.6, 147.5, 137.6, 133.7, 132.0, 129.9, 129.8, 128.98, 128.96, 128.4, 126.9, 120.1, 113.0, 102.0. IR (neat, $cm^{-1}$) 3286, 2219, 1602, 1517, 1258, 1171, 834, 770, 695. Anal. Calcd for $C_{20}H_{15}N_3$: C, 80.78; H, 5.08. Found: C, 80.86; H, 5.15.



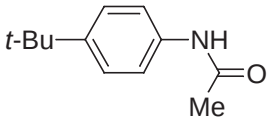

***N*-(3-Methoxycarbonylphenyl)benzophenone hydrazone (Table 2).** Following general procedure A with a reaction time of 21 h, 3-methoxycarbonylphenyl tosylate (153 mg, 0.500 mmol) was coupled with benzophenone hydrazone (150 mg, 0.750 mmol) using $Cs_2CO_3$ (408 mg, 1.25 mmol) as the base and toluene / *t*-butanol (1.0 mL / 0.2 mL) as the solvent at 90 °C. Chromatography on silica gel column with 15:1 hexane : ethyl acetate gave 158 mg (96%) of the title compound as a yellow solid: mp 81-83 °C. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.64-7.48 (m, 8H), 7.44-7.28 (m, 7H), 3.90 (s, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 167.1, 145.1, 144.7, 138.0, 132.5, 131.0, 129.8, 129.43, 129.36, 129.0, 128.29, 128.25, 126.6, 121.0, 117.3, 113.9, 52.3. IR (neat, $cm^{-1}$) 3301, 1717, 1590, 1486, 1443, 1285, 1229, 1102, 768, 693. Anal. Calcd for $C_{21}H_{18}N_2O_2$: C, 76.34; H, 5.49. Found: C, 76.03; H, 5.60.

## Experimental procedures for Table 3

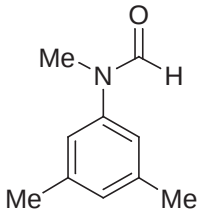
**General Procedure C for Examples in Table 3.** An oven-dried resealable Schlenk tube containing a stir bar was charged with $Pd(OAc)_2$ (2.3 mg, 0.010 mmol), 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl **1** (11.9 mg, 0.0250 mmol) and phenylboronic acid (3.1 mg, 0.025 mmol). The tube was capped with a rubber septum, evacuated and backfilled with argon. *t*-Butanol (0.5 mL) was added through the septum via a syringe. The reaction mixture was stirred at room temperature for 20 min. Aryl sulfonate (0.5 mmol), amide (0.75 mmol) and finely ground $K_2CO_3$ (173 mg, 1.25 mmol) were added into the Schlenk tube under a flow of argon, followed by the addition of *t*-butanol (0.5 mL) via a syringe. The septum was replaced with a Teflon screw cap. The Schlenk tube was sealed and placed into a preheated oil bath at 110 °C. The reaction mixture was stirred for the time specified and the resulting mixture was allowed to cool down to room temperature and filtered through Celite eluting with ethyl acetate. The filtrate was concentrated under reduced pressure and the residue was purified by chromatography on a silica gel column.




***N*-(4-*t*-Butylphenyl)-2-pyrrolidinone (Table 3).**[6] Following general procedure C, 4-*t*-butylphenyl benzenesulfonate (145 mg, 0.500 mmol) was coupled with 2-pyrrolidinone (57 μL, 0.75 mmol) with the reaction time of 21 h. Chromatography on silica gel column with 1:1 hexane : ethyl acetate gave 103 mg (95%) of the title compound as a white solid: mp 70-71 °C (lit.[5] 67-69 °C). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.49 (d, *J* = 8.7 Hz, 2H), 7.36 (d, *J* = 8.7 Hz, 2H), 3.85 (t, *J* = 7.2 Hz, 2H), 2.60 (t, *J* = 8.1 Hz, 2H), 2.22-2.10 (m, 2H), 1.31 (s, 9H).




***N*-(4-*t*-Butylphenyl)acetamide (Table 3).**[6] Following general procedure C, 4-*t*-butylphenyl benzenesulfonate (145 mg, 0.500 mmol) was coupled with acetamide (74 mg, 1.25 mmol) with the reaction time of 21 h. Chromatography on silica gel column with 1:1 hexane : ethyl acetate gave 84 mg (88%) of the title compound as a white solid: mp 168-169 °C (lit.[6] 165-166°C). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.41 (d, *J* = 8.7 Hz, 2H), 7.33 (d, *J* = 8.7 Hz, 2H), 7.12 (s, 1H), 2.17 (s, 3H), 1.30 (s, 9H).




***N*-(3,5-dimethylphenyl)-*N*-methylformamide (Table 3).** Following general procedure C, 3,5-dimethylphenyl benzenesulfonate (131 mg, 0.500 mmol) was coupled with *N*-methylformamide (45 mg, 0.75 mmol) with the reaction time of 20 h. Chromatography on silica gel column with 4:1 hexane : ethyl acetate gave 76 mg (93%) of the title compound as a colorless oil. $^1$H NMR (300 MHz, $CDCl_3$) δ 8.42 (s, 1H), 6.90 (s, 1H), 6.76 (s, 2H), 3.28 (s, 3H), 2.33 (s, 6H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 162.4, 142.1, 139.4, 128.1, 120.3, 32.4, 21.6. IR (neat, $cm^{-1}$) 2919, 1671, 1594, 1478, 1337, 1040, 843, 754. Anal. Calcd for $C_{10}H_{13}NO$: C, 73.59; H, 8.03. Found: C, 73.22; H, 8.17.

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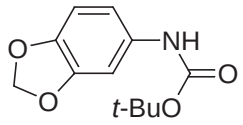
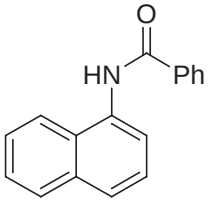
[6] Yin, J.; Buchwald, S. L. *Org. Lett.* **2000**, *2*, 1101-1104.



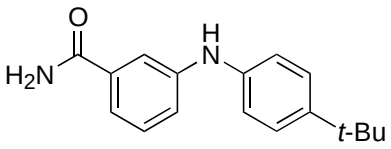

***t*-Butyl *N*-(3,4-methylenedioxyphenyl)carbamate (Table 3).** Following general procedure C, 3,4-methylenedioxyphenyl tosylate (146 mg, 0.500 mmol) was coupled with *t*-butyl carbamate (90 mg, 0.75 mmol) with the reaction time of 24 h and the exception that 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl **1** (19.0 mg, 0.040 mmol) was used as ligand. Chromatography on silica gel column with 10:1 hexane : ethyl acetate gave 101 mg (85%) of the title compound as a white solid: mp 80-82 °C. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.05 (br s, 1H), 6.69 (d, *J* = 8.4 Hz, 1H), 6.63 (dd, *J* = 8.4, 2.1 Hz, 1H), 6.31 (br s, 1H), 5.91 (s, 2H), 1.50 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 153.2, 148.0, 143.6, 132.8, 111.9, 108.2, 101.9, 101.3, 80.6, 28.5. IR (neat, $cm^{-1}$) 3350, 1690, 1519, 1495, 1231, 1160, 1040, 934, 639. Anal. Calcd for $C_{12}H_{15}NO_4$: C, 60.75; H, 6.37. Found: C, 60.68; H, 6.34.



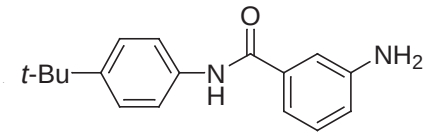

***N*-(1-Naphthyl)benzamide (Table 3).**[7] Following general procedure C, 1-naphthyl tosylate (149 mg, 0.500 mmol) was coupled with benzamide (90 mg, 0.75 mmol) with the reaction time of 20 h. Chromatography on silica gel column with 4:1 hexane : ethyl acetate gave 117 mg (95%) of the title compound as a white solid: mp 159-160 °C. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 8.24 (br s, 1H), 8.02-7.84 (m, 5H), 7.73 (d, *J* = 8.1 Hz, 1H), 7.62-7.44 (m, 6H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 166.3, 134.8, 134.2, 132.4, 132.0, 128.9, 128.8, 127.6, 127.3, 126.4, 126.2, 126.1, 125.8, 121.5, 120.9.

[7] Tsutsui, H.; Ichikawa, T.; Narasaka, K. *Bull. Chem. Soc. Jpn.* **1999**, *72*, 1869-1878.

## Experimental procedures for Table 4

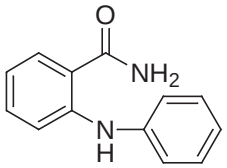



**3-(4-*tert*-Butylphenylamino)benzamide (Table 4, entry 1, product from Pd catalysis).** An oven-dried resealable Schlenk tube was evacuated and backfilled with argon. The Schlenk tube was charged with $Pd_2dba_3$ (4.6 mg, 0.0050 mmol, 1 mol % Pd), ligand **1** (9.4 mg, 0.020 mmol, 2 mol %), ground $K_2CO_3$ (193 mg, 1.40 mmol), and 3-aminobenzamide (204 mg, 1.49 mmol). The Schlenk tube was evacuated and backfilled with argon (three times) and then capped with a rubber septum. To the Schlenk tube was added 4-*t*-butyl-1-bromobenzene (0.173 mL, 1.00 mmol) and *t*-BuOH (2 mL). The septum was replaced with a Teflon screwcap, the Schlenk tube was sealed, and the mixture was heated to 100 °C (the reaction mixture was heterogeneous) with stirring until the starting aryl chloride was consumed according to GC analysis (12 h; 25:1 selectivity by GC analysis). The reaction was cooled to room temperature, diluted with ethyl acetate, filtered through Celite, and concentrated under reduced pressure. The crude material was purified by column chromatography on silica gel (eluting with ethyl acetate/hexanes, 9:1) to give the desired product as a white solid (233 mg, 87 %), mp 187-188 °C. $^1$H NMR (400 MHz, $d_6$-DMSO) δ 8.22 (s, 1H), 7.95 (s, 1H), 7.63 (s, 1H), 7.36-7.24 (m, 5H), 7.16 (d, *J* = 7.8 Hz, 1H), 7.07 (d, *J* = 8.55 Hz, 2H), 1.26 (s, 9H); $^{13}$C NMR (100 MHz, $d_6$-DMSO) δ 168.5, 144.2, 142.7, 140.3, 135.5, 128.9, 125.9, 118.6, 117.9, 117.5, 114.8, 38.8, 31.4; IR (neat, cm$^{-1}$): 3450, 3344, 1639, 1600, 1575, 1525, 1485, 1432, 830, 751. Anal. Calcd for $C_{17}H_{20}N_2O$: C, 76.09; H, 7.51. Found: C, 75.80; H, 7.67.

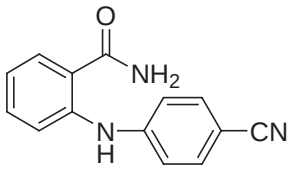



**3-Amino-*N*-(4-*tert*-butylphenyl)benzamide (Table 4, entry 1, product from Cu catalysis).** A Schlenk tube was charged with CuI (9.6 mg, 0.050 mmol, 5.0 mol%), 3-aminobenzamide (165 mg, 1.21 mmol), $K_2CO_3$ (280 mg, 2.03 mmol), evacuated and backfilled with argon. *N*,*N*′-dimethylethylenediamine (11 μL, 0.10 mmol, 10 mol%), 1-bromo-4-*tert*-butylbenzene (175 μL, 1.01 mmol) and dioxane (1.0 mL) were added under argon. The Schlenk tube was sealed with a

Teflon valve and the reaction mixture was stirred at 100 °C for 22 h. GC analysis of the crude reaction mixture revealed complete conversion of substrate with <2% of the isomeric 3-(4-*tert*-butylphenylamino)benzamide. The resulting pale green-tan suspension was allowed to reach room temperature and filtered through a silica gel plug (0.5×0.5 cm) eluting with ethyl acetate (50 mL). The filtrate was concentrated and the residue was purified by column chromatography on silica gel (hexane-ethyl acetate 1:1) to provide the desired product as a white, solid foam (263 mg, 97% yield). $^1$H NMR (400 MHz, $CDCl_3$): δ 7.95 (br s, 1H), 7.54 (d, *J* = 8.6 Hz, 2H), 7.36 (d, *J* = 8.6 Hz, 2H), 7.21-7.11 (m, 3H), 6.81-6.76 (m, 1H), 3.80 (br s, 2H), 1.31 (s, 9H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 166.0, 147.4, 146.9, 136.2, 135.3, 129.5, 125.8, 120.0, 118.1, 116.3, 113.7, 34.3, 31.3. IR (neat, $cm^{-1}$): 3345, 1651, 1621, 1588, 1520, 1490, 1404, 1325. HRMS-ESI calcd for $C_{17}H_{20}N_2O$ ($M+H^+$), 269.1648; found, 269.1653.



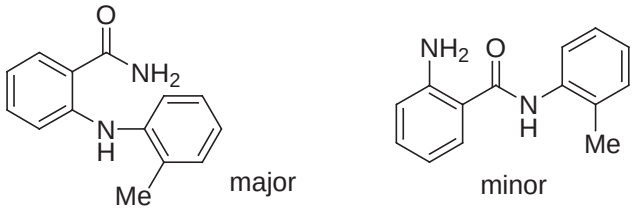

**2-Phenylaminobenzamide (Table 4, Entry 2, product from Pd catalysis).**[8] Following general procedure A with a reaction time of 15 h, bromobenzene (55 μL, 0.50 mmol) was coupled with 2-aminobenzamide (172 mg, 1.25 mmol) using $K_2CO_3$ (173 mg, 1.25 mmol) as the base and *t*-butanol (1.0 mL) as the solvent. Chromatography on silica gel column with 1:1 hexane : ethyl acetate gave 85 mg (80%) of the title compound as a white solid: mp 101-102 °C. $^1$H NMR (300 MHz, $CDCl_3$) δ 9.48 (s, 1H), 7.44 (dd, *J* = 8.1, 1.2 Hz, 1H), 7.34-7.16 (m, 6H), 7.01 (tt, *J* = 7.5, 1.2 Hz, 1H), 6.76-6.68 (m, 1H), 6.00 (br s, 2H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 171.9, 146.5, 141.3, 133.0, 129.4, 128.4, 122.9, 121.6, 117.6, 116.0, 115.4.



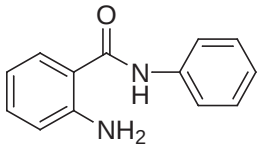

**2-(4-Cyanophenylamino)benzamide (Table 4, Entry 2, product from Pd catalysis).** Following general procedure A with a reaction time of 17 h, 4-bromobenzonitrile (91 mg, 0.50 mmol) was coupled with 2-aminobenzamide (102 mg, 0.750 mmol) using $K_2CO_3$ (173 mg, 1.25

[8] Pentassuglia, G.; Bertani, B.; Donati, D.; Ursini, A. *J. Heterocyclic. Chem.* **1996**, *33*, 1163-1170.

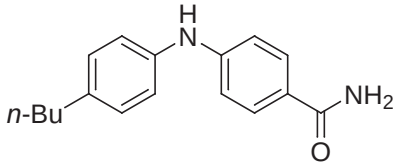
mmol) as the base and *t*-butanol (1.0 mL) as the solvent. Chromatography on silica gel column with 2:1 hexane : ethyl acetate gave 108 mg (91%) of the title compound as a pale yellow solid: mp 171-173 °C. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 9.78 (s, 1H), 7.51 (d, *J* = 8.7 Hz, 2H), 7.55-7.45 (m, 1H), 7.43-7.35 (m, 1H), 7.18 (d, *J* = 8.7 Hz, 2H), 6.98-6.90 (m, 1H), 6.10 (br s, 1H), 5.60 (br s, 1H); $^{13}$C NMR (75 MHz, DMSO-$d_6$) δ 170.3, 146.6, 140.9, 133.5, 131.7, 129.2, 122.0, 120.9, 119.5, 118.5, 116.5, 100.8. IR (neat, $cm^{-1}$) 3361, 3161, 2219, 1656, 1586, 1515, 1320, 745. HRMS (ESI): calcd for $C_{14}H_{11}N_3O$ $[M + H]^+$: 238.0975; Found: 238.0971.




**2-(2-Methylphenylamino)benzamide and 2-amino-*N*-(2-methylphenyl)benzamide (Table 4, Entry 2, products from Pd catalysis).** Following general procedure A with a reaction time of 17 h, 2-chlorotoluene (60 μL, 0.50 mmol) was coupled with 2-aminobenzamide (172 mg, 1.25 mmol) using $K_2CO_3$ (173 mg, 1.25 mmol) as the base and *t*-butanol (1.0 mL) as the solvent. Chromatography on silica gel column with 4:1 hexane : ethyl acetate gave 98 mg (87%) of 2-(2-methylphenylamino)benzamide as a white solid and 11 mg (10%) of 2-amino-*N*-(2-methylphenyl)benzamide as a white solid. **2-(2-Methylphenylamino)benzamide**, mp 86-88 °C. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 9.44 (s, 1H), 7.46 (dd, *J* = 7.8, 1.5 Hz, 1H), 7.35-7.14 (m, 4H), 7.07-6.98 (m, 2H), 6.74-6.67 (m, 1H), 5.80 (br s, 2H), 2.29 (s, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 172.2, 147.3, 139.5, 133.0, 131.9, 131.1, 128.4, 126.6, 123.8, 122.5, 116.9, 115.1, 115.0, 18.4. IR (neat, $cm^{-1}$) 3435, 3278, 3161, 1659, 1588, 1378, 1297, 737. HRMS (ESI): calcd for $C_{14}H_{14}N_2O$ $[M + Na]^+$: 249.0998; Found: 249.1001. **2-Amino-*N*-(2-methylphenyl)benzamide**, mp 109-110 °C. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.1 Hz, 1H), 7.58 (br s, 1H), 7.50 (dd, *J* = 8.4, 1.5 Hz, 1H), 7.31-7.22 (m, 3H), 7.16-7.08 (m, 1H), 6.76-6.69 (m, 2H), 5.54 (br s, 2H), 2.33 (s, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 167.6, 149.2, 135.8, 132.9, 130.7, 129.9, 127.2, 126.9, 125.5, 123.6, 117.7, 116.9, 116.2, 18.3. IR (neat, $cm^{-1}$) 3419, 3271, 1638, 1619, 1513, 1306, 743. Anal. Calcd for $C_{14}H_{14}N_2O$: C, 74.31; H, 6.24. Found: C, 74.20; H, 6.29.



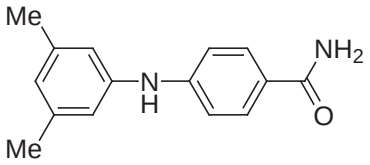
**2-Amino-*N*-phenylbenzamide (Table 4, Entry 2, product from Cu catalysis).** A Schlenk tube was charged with CuI (9.6 mg, 0.050 mmol, 5.0 mol%), 2-aminobenzamide (165 mg, 1.21 mmol), $K_2CO_3$ (280 mg, 2.03 mmol), evacuated and backfilled with argon. *N,N'*-dimethylethylenediamine (11 μL, 0.10 mmol, 10 mol%), bromobenzene (106 μL, 1.01 mmol) and toluene (1.0 mL) were added under argon. The Schlenk tube was sealed with a Teflon valve and the reaction mixture was stirred at 110 °C for 22 h. GC analysis of the crude reaction mixture revealed complete conversion of substrate with <2% of the isomeric 2-(phenylamino)benzamide. The resulting gray suspension was allowed to reach room temperature and filtered through a silica gel plug (0.5×0.5 cm) eluting with ethyl acetate (50 mL). The filtrate was concentrated, the residue was dissolved in $CH_2Cl_2$ (0.5 mL) and purified by column chromatography on silica gel (hexane-ethyl acetate 2:1) to provide the desired product as a pale yellow solid (207 mg, 97% yield). Mp: 115-116 °C (lit,[9] 116-118 °C). The $^1$H and $^{13}$C spectra matched the ones reported in literature.[10]



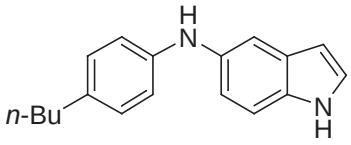
**4-(4-*n*-Butylphenylamino)benzamide (Table 4, entry 3, product from Pd catalysis).** An oven-dried resealable Schlenk tube was evacuated and backfilled with argon. The Schlenk tube was charged with $Pd_2dba_3$ (4.6 mg, 0.0050 mmol, 1 mol % Pd), ligand **1** (9.4 mg, 0.020 mmol, 2 mol %), ground $K_2CO_3$ (193 mg, 1.39 mmol), and 4-aminobenzamide (163 mg, 1.19 mmol). The Schlenk tube was evacuated and backfilled with argon (three times) and then capped with a rubber septum. To the Schlenk tube was added 4-*n*-butylchlorobenzene (168 mg, 0.990 mmol) and *t*-BuOH (2 mL). The septum was replaced with a Teflon screwcap, the Schlenk tube was sealed, and the mixture was heated to 100 °C with stirring (reaction was heterogeneous) until the starting aryl chloride was consumed according to GC analysis (19 h; >20:1 selectivity by GC analysis). The reaction was cooled to room temperature, diluted with ethyl acetate, filtered

[9] Moffett, R. B.; Robert, A.; Skaletzky, L. L. *J. Med. Chem.* **1971**, *14*, 963.
[10] Hamuro, Y.; Geib, S. J.; Hamilton, A. D. *J. Am. Chem. Soc.* **1996**, *118*, 7529.

through Celite, and concentrated under reduced pressure. The crude material was purified by column chromatography on silica gel (eluting with ethyl acetate/hexanes, 8:2) to give the desired product as a white solid (235 mg, 88 %), mp 135-136 °C. $^{1}$H NMR (400 MHz,$CDCl_3$) δ 7.70 (d, *J* = 8.6 Hz, 2H), 7.15 (d, *J* = 8.2 Hz, 2H), 7.08 (d, *J* = 8.2 Hz, 2H), 6.96 (d, *J* = 8.6 Hz, 2H), 6.04 (s, 1 H), 5.98 (s, 2H), 2.60 (t, *J* = 7.7 Hz, 2H), 1.61 (m, *J* = 7.8 Hz, 2H), 1.37 (m, *J* = 7.4 Hz, 2H), 0.95 (t, *J* = 7.3 Hz, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) δ: 169.4, 148.2, 138.6, 138.2, 129.6, 129.4, 123.7, 121.0, 114.6, 35.2, 33.9, 22.6, 14.2; IR (neat, $cm^{-1}$): 3410, 3300, 3204, 1652, 1605, 1525, 1514, 1405, 1326, 822. Anal. Calcd for $C_{17}H_{20}N_2O$: C, 76.09; H, 7.51. Found: C, 75.90; H, 7.54.

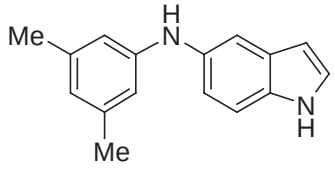



**4-(3,5-Dimethylphenylamino)benzamide (Table 4, Entry 3, product from Pd catalysis).** Following general procedure A with a reaction time of 3 h, 3,5-dimethylphenyl benzenesulfonate (131 mg, 0.500 mmol) was coupled with 4-aminobenzamide (102 mg, 0.750 mmol) using $K_2CO_3$ (173 mg, 1.25 mmol) as the base, *t*-butanol (1.0 mL) as the solvent and $Pd(OAc)_2$ as the Pd precursor. Chromatography on silica gel column with ethyl acetate gave 115 mg (96%) of the title compound as a white solid: mp 193-194 °C. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.68 (d, *J* = 6.9 Hz, 2H), 6.98 (d, *J* = 6.9 Hz, 2H), 6.77 (s, 2H), 6.69 (s, 1H), 5.90 (s, 1H), 5.70 (br s, 2H), 2.29 (s, 6H); $^{13}$C NMR (75 MHz, DMSO-$d_6$) δ 167.4, 146.5, 141.7, 138.0, 128.9, 124.0, 122.7, 116.1, 114.2, 21.2. IR (neat, $cm^{-1}$) 3350, 3184, 1638, 1590, 1329, 822. HRMS (ESI): calcd for $C_{15}H_{16}N_2O$ $[M + Na]^+$: 263.1155; Found: 263.1159.

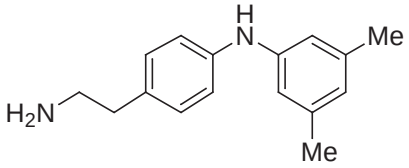



**5-(4-*n*-Butylphenylamino)indole (Table 4, Entry 4, product from Pd catalysis).** Following general procedure A with a reaction time of 3 h, 4-*n*-butylchlorobenzene (85 mg, 0.50 mmol) was coupled with 5-aminoindole (100 mg, 0.750 mmol) using $K_2CO_3$ (173 mg, 1.25 mmol) as the base and *t*-butanol (1.0 mL) as the solvent. Chromatography on silica gel column with 2:1 hexane : ethyl acetate gave 105 mg (80%) of the title compound as a brown solid: mp 66-67 °C.

$^1$H NMR (300 MHz, $CDCl_3$) δ 8.03 (br s, 1H), 7.36 (d, *J* = 2.1 Hz, 1H), 7.29 (d, *J* = 8.7 Hz, 1H), 7.16 (t, *J* = 3.0 Hz, 1H), 7.05-6.94 (m, 3H), 6.90-6.83 (m, 2H), 6.48-6.42 (m, 1H), 5.50 (s, 1H), 2.52 (t, *J* = 7.5 Hz, 2H), 1.62-1.50 (m, 2H), 1.42-1.26 (m, 2H), 0.92 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 143.7, 135.9, 134.0, 132.4, 129.2, 128.6, 125.0, 117.8, 116.0, 112.1, 111.7, 102.4, 35.1, 34.3, 22.7, 14.4. IR (neat, $cm^{-1}$) 3396, 2927, 1613, 1519, 1461, 1322, 803, 756, 720. Anal. Calcd for $C_{18}H_{20}N_2$: C, 81.78; H, 7.63. Found: C, 81.60; H, 7.60.

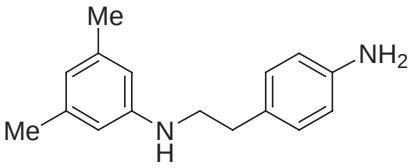



**5-(3,5-Dimethylphenylamino)indole (Table 4, Entry 4, product from Pd catalysis).** Following general procedure B with a reaction time of 3 h, 3,5-dimethylphenyl benzenesulfonate (131 mg, 0.500 mmol) was coupled with 5-aminoindole (100 mg, 0.750 mmol) using $K_2CO_3$ (173 mg, 1.25 mmol) as the base and *t*-butanol (1.0 mL) as the solvent. Chromatography on silica gel column with 6:1 hexane : ethyl acetate gave 16 mg (14%) of 1-(3,5-dimethylphenyl)-5-aminoindole as a white solid and 88 mg (74%) of the title compound as a pale brown solid: mp 94-96 °C. $^1$H NMR (300 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.38 (d, *J* = 1.8 Hz, 1H), 7.32 (d, *J* = 8.4 Hz, 1H), 7.19 (t, *J* = 3.0 Hz, 1H), 7.00 (dd, *J* = 8.7, 2.1 Hz, 1H), 6.55 (s, 2H), 6.50-6.42 (m, 2H), 5.51 (s, 1H), 2.23 (s, 6H). $^{13}$C NMR (75 MHz, $CDCl_3$) δ 146.2, 139.0, 135.3, 132.7, 128.6, 125.0, 121.1, 118.6, 113.4, 113.2, 111.7, 102.6, 21.8. IR (neat, $cm^{-1}$) 3471, 3425, 3354, 1600, 1457, 1335, 731. HRMS (ESI): calcd for $C_{16}H_{16}N_2$ $[M + H]^+$: 237.1386; Found: 237.1388.




**4-(2-Aminoethyl)-*N*-(3,5-dimethylphenyl)aniline (Table 4, Entry 5, product from Pd catalysis).** A Schlenk tube was charged with $Pd_2dba_3$ (9.2 mg, 0.010 mmol, 2.0 mol% Pd), ligand **1** (24 mg, 0.050 mmol, 5.0 mol%), $K_2CO_3$ (280 mg, 2.03 mmol), evacuated and backfilled with argon. *tert*-Butanol (2.0 mL), 5-bromo-*m*-xylene (136 μL, 1.00 mmol), and 2-(4-aminophenyl)ethylamine (160 μL, 1.21 mmol) were added under argon. The Schlenk tube was sealed with a Teflon valve and the reaction mixture was stirred at 100 °C for 22 h. GC analysis of the crude reaction mixture revealed complete conversion of substrate with <2% of the

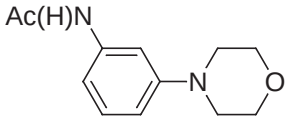
isomeric 4-(3,5-dimethylphenyl-aminoethyl)aniline. The resulting dark gray-brown suspension was allowed to reach room temperature and filtered through a silica gel plug (0.5×0.5 cm) eluting with $CH_2Cl_2$ (50 mL). The filtrate was concentrated and the residue was purified by column chromatography on silica gel using $CH_2Cl_2$ (saturated with 30% aq $NH_3$) / MeOH 10:1 as eluent to provide the desired product as a light yellow solid (209 mg, 87% yield). Mp: 104-105 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ 7.10 (d, *J* = 8.2 Hz, 2H), 7.01 (d, *J* = 8.2 Hz, 2H), 6.67 (s, 2H), 6.57 (s, 1H), 5.60 (br s, 1H), 2.94 (t, *J* = 6.7 Hz, 2H), 2.69 (t, *J* = 6.7 Hz, 2H), 2.26 (s, 6H), 1.22 (br s, 2H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 143.4, 141.3, 138.9, 132.3, 129.6, 122.4, 118.4, 114.9, 43.7, 39.3, 21.4. IR (neat, $cm^{-1}$): 3350, 3262, 1597, 1512, 1473, 1340, 1263, 815. HRMS-ESI calcd for $C_{16}H_{20}N_2$ ($M+H^+$), 241.1699; found, 241.1702.



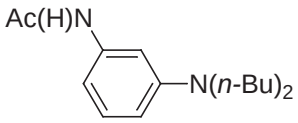

**4-[2-(3,5-Dimethylphenylamino)ethyl]aniline (Table 4, Entry 5, product from Cu catalysis).** A Schlenk tube was charged with CuI (9.6 mg, 0.050 mmol, 5.0 mol%), *N*,*N*-diethylsalicylamide (39 mg, 0.20 mmol, 20 mol%), $K_3PO_4$ (430 mg, 2.03 mmol), evacuated and backfilled with argon. 5-Bromo-*m*-xylene (136 μL, 1.00 mmol), 2-(4-aminophenyl)ethylamine (160 μL, 1.21 mmol) and DMF (0.5 mL) were added under argon. The Schlenk tube was sealed with a Teflon valve and the reaction mixture was stirred at 110 °C for 24 h. GC analysis of the crude reaction mixture revealed complete conversion of substrate with <2% of the isomeric 4-aminoethyl-*N*-(3,5-dimethylphenyl)aniline. The resulting light green-brown suspension was allowed to reach room temperature, diluted with 30% aq ammonia (3 mL), poured into water (20 mL), and extracted with dichloromethane (3×15 mL). The combined organic phases were dried ($Na_2SO_4$), concentrated, and the residue was purified by column chromatography on silica gel (hexane-ethyl acetate 4:3). The early fractions contained the product of *bis*-arylation, **4-(3,5-dimethylphenylaminoethyl)-*N*-(3,5-dimethylphenyl)aniline** (6 mg, 2% yield). $^1$H NMR (400 MHz, $CDCl_3$): δ 7.14-7.09 (m, 2H), 7.04-6.99 (m, 2H), 6.68 (s, 2H), 6.57 (s, 1H), 6.37 (s, 1H), 6.26 (s, 2H), 5.57 (br s, 1H), 3.59 (br s, 1H), 3.36 (t, *J* = 7.0 Hz, 2H), 2.84 (t, *J* = 6.7 Hz, 2H), 2.27 (s, 6H), 2.23 (s, 6H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ 148.2, 143.3, 141.5, 139.0, 138.9, 131.7, 129.6, 122.6, 119.4, 118.4, 115.1, 110.9, 45.2, 34.8, 21.5, 21.4. IR (neat, $cm^{-1}$): 3388,

1599, 1516, 1473, 1334, 822. The later fractions, containing a mixture of the desired product and the *O*-arylated ligand, were concentrated and the solid residue was recrystallized from hot hexane (5 mL) to provide the desired **4-(3,5-dimethylphenylaminoethyl)aniline** as pale yellow needles (176 mg, 73% yield). The $^{1}H$ and $^{13}C$ spectra matched the ones reported in literature.[11]

## Experimental procedures for Table 5



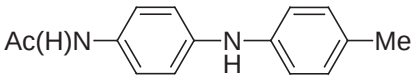

***N*-(3-Acetylaminophenyl)morpholine (Table 5).**[12] Following general procedure A with a reaction time of 20 h, 3-acetylaminophenyl tosylate (153 mg, 0.500 mmol) was coupled with morpholine (66 μL, 0.75 mmol) using $K_2CO_3$ (173 mg, 1.25 mmol) as the base, *t*-butanol (1.0 mL) as the solvent and $Pd(OAc)_2$ as the Pd precursor. Chromatography on silica gel column with ethyl acetate gave 110 mg (100%) of the title compound as a white solid: mp 159-160 °C (lit.[12] 154-155 °C). $^{1}H$ NMR (300 MHz, $CDCl_3$) δ 7.32 (t, *J* = 2.1 Hz, 1H), 7.18 (t, *J* = 8.1 Hz, 1H), 7.16 (br s, 1H), 6.80 (d, *J* = 7.5 Hz, 1H), 6.64 (dd, *J* = 8.1, 2.1 Hz, 1H), 3.83 (t, *J* = 4.8 Hz, 4H), 3.15 (t, *J* = 4.8 Hz, 4H), 2.16 (s, 3H).



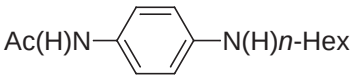

***N*-(3-Di-*n*-butylaminophenyl)acetamide (Table 5).** An oven-dried resealable Schlenk tube containing a stir bar was charged with $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl **1** (11.9 mg, 0.0250 mmol), 3-chloroacetanilide (85 mg, 0.50 mmol) and sodium *t*-butoxide (120 mg, 1.25 mmol). The tube was capped with a rubber septum, evacuated and backfilled with argon. Di-*n*-butylamine (126 μL, 0.750 mmol) and toluene (1 mL) were added through the septum via syringe. The septum was replaced with a Teflon screw cap. The Schlenk tube was sealed and put into a preheated oil bath at 90 °C. The reaction mixture was stirred for 2 h, allowed to cool down to room

[11] Kwong, F. Y.; Klapars, A.; Buchwald, S. L. *Org. Lett.* **2002**, *4*, 581-584.
[12] Harris, M. C.; Huang, X.; Buchwald, S. L. *Org. Lett.* **2002**, *4*, 2885-2888.

temperature and quenched with water. Extraction with ethyl acetate (three times) followed by chromatography on silica gel column with 4:1 hexane : ethyl acetate gave 124 mg (95%) of the title compound as a colorless oil: $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.33 (br s, 1H), 7.07 (t, *J* = 8.1 Hz, 1H), 7.01 (s, 1H), 6.58 (d, *J* = 7.8 Hz, 1H), 6.36 (dd, *J* = 8.1, 2.1 Hz, 1H), 3.23 (t, *J* = 7.5 Hz, 4H), 2.14 (s, 3H), 1.62-1.48 (m, 4H), 1.42-1.22 (m, 4H), 0.94 (t, *J* = 7.2 Hz, 6H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 168.3, 148.8, 139.1, 129.5, 107.9, 106.7, 103.3, 51.1, 29.7, 25.1, 20.7, 14.4. IR (neat, $cm^{-1}$) 3296, 2956, 1659, 1609, 1497, 1368, 762. Anal. Calcd for $C_{16}H_{26}N_2O$: C, 73.24; H, 9.99. Found: C, 72.94; H, 9.98. The title compound was obtained in 71% yield if *t*-BuOH was used as solvent instead of toluene.

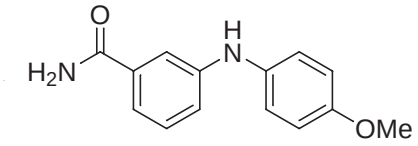



***N*-(4-*p*-Tolylaminophenyl)acetamide (Table 5).**[12] Following general procedure A with a reaction time of 14 h, 4-chloroacetanilide (85 mg, 0.50 mmol) was coupled with *p*-toluidine (80 mg, 0.75 mmol) at 90 °C using $K_2CO_3$ (173 mg, 1.25 mmol) as the base and *t*-butanol (1.0 mL) as the solvent. Chromatography on silica gel column with 2:1 hexane : ethyl acetate gave 118 mg (98%) of the title compound as a pink solid: mp 143-144 °C (lit.[12] 139-141 °C). $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.32 (d, *J* = 8.4 Hz, 2H), 7.21 (br s, 1H), 7.04 (d, *J* = 8.1 Hz, 2H), 6.95 (d, *J* = 8.4 Hz, 2H), 6.92 (d, *J* = 8.1 Hz, 2H), 5.56 (br s, 1H), 2.28 (s, 3H), 2.14 (s, 3H); $^{13}$C NMR (75 MHz, DMSO-$d_6$) δ 167.3, 141.2, 139.1, 131.6, 129.4, 127.7, 120.3, 116.8, 116.3, 23.9, 20.3.

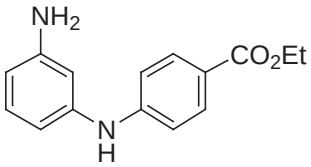



***N*-(4-*n*-Hexylaminophenyl)acetamide (Table 5).** An oven-dried resealable Schlenk tube containing a stir bar was charged with $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl **1** (11.9 mg, 0.0250 mmol), 4-bromoacetanilide (107 mg, 0.500 mmol), and sodium *t*-butoxide (120 mg, 1.25 mmol). The Schlenk tube was capped with a rubber septum, evacuated and backfilled with argon. *n*-Hexylamine (100 μL, 0.750 mmol) and toluene (1 mL) were added through the septum via syringe. The septum was replaced with a Teflon screw cap, and the Schlenk tube was sealed and put into a pre-heated oil bath at 90 °C. The reaction mixture was stirred for 2 h, allowed to cool down to room temperature and quenched with water. Extraction with ethyl acetate (three times) followed by chromatography on silica gel column with 1:1 hexane : ethyl acetate gave 112 mg (96%) of the

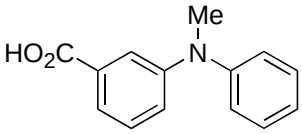
title compound as a white solid: mp 99-101 °C. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.23 (d, *J* = 6.6 Hz, 2H), 6.95 (s, 1H), 6.54 (d, *J* = 6.6 Hz, 2H), 3.55 (br s, 1H), 3.07 (t, *J* = 6.9 Hz, 2H), 2.13 (s, 3H), 1.64-1.52 (m, 3H), 1.45-1.20 (m, 5H), 0.89 (t, *J* = 6.9 Hz, 3H). $^{13}$C NMR (75 MHz, DMSO-$d_6$) δ 166.9, 145.0, 128.2, 120.7, 111.6, 43.3, 31.2, 28.8, 26.5, 23.8, 22.2, 14.1. IR (neat, $cm^{-1}$) 3400, 3296, 2929, 2856, 1652, 1513, 1310, 820. HRMS (ESI): calcd for $C_{14}H_{22}N_2O$ [M + H]$^+$: 235.1805; Found: 235.1796. The title compound was obtained in 60% yield if *t*-BuOH was used as solvent instead of toluene.




**3-(4-Methoxyphenylamino)benzamide.** An oven-dried resealable Schlenk tube was evacuated and backfilled with argon. The Schlenk tube was charged with $Pd_2dba_3$ (9.2 mg, 0.010 mmol, 2 mol % Pd), ligand **1** (19.0 mg, 0.0200 mmol, 4 mol %), ground $K_2CO_3$ (304 mg, 2.19 mmol), 3-chloro-benzamide (156 mg, 1.00 mmol), and 4-methoxyaniline (148 mg, 1.20 mmol). The Schlenk tube was evacuated and backfilled with argon (three times) and then capped with a rubber septum. To the Schlenk tube was added *t*-BuOH (2.5 mL). The septum was replaced with a Teflon screwcap, the Schlenk tube was sealed, and the mixture was heated to 100 °C with stirring (reaction was heterogeneous) until the starting aryl chloride was consumed according to TLC analysis (20 h). The reaction mixture was cooled to room temperature, diluted with ethyl acetate, filtered through Celite, and concentrated under reduced pressure. The crude material was purified by column chromatography on silica gel (eluting with ethyl acetate/hexanes, 8.5:1.5) to give the desired product which was recrystallized from ethyl acetate/hexanes (14/1) to give white, flaky crystals (191 mg, 79 %), mp 153 °C. $^{1}$H NMR (400 MHz, $d_6$-DMSO) δ 7.99 (s, 1H), 7.86 (s, 1H), 7.43 (s, 1H), 7.28 (s, 1H), 7.20 (d, *J* = 5.1 Hz, 2H), 7.07 (d, *J* = 8.8 Hz, 2H), 7.03 (m, 1H), 6.88 (d, *J* = 8.8 Hz, 2H), 3.72 (s, 3H); $^{13}$C NMR (100 MHz, $d_6$-DMSO) δ 168.5, 154.2, 145.4, 135.7, 135.5, 128.9, 120.9, 117.4, 117.1, 114.6, 113.7, 55.2; IR (neat, $cm^{-1}$): 3409, 3373, 3346, 3172, 1657, 1607, 1578, 1528, 1113, 1033. Anal. Calcd for $C_{14}H_{14}N_2O_2$: C, 69.41; H, 5.82. Found: C, 69.42; H, 5.83. The title compound was obtained after a reaction time of 18 h in 81% yield if toluene (3 mL) was used as solvent instead of *t*-BuOH, and NaO*t*-Bu (211 mg, 2.20 mmol) was used as the base.

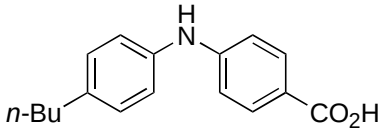



**Ethyl 4-(3-aminophenylamino)benzoate (Table 5).** Following general procedure A with a reaction time of 11 h, 3-bromoaniline (56 μL, 0.50 mmol) was coupled with ethyl 4-aminobenzoate (125 mg, 0.750 mmol) at 80 °C using $K_2CO_3$ (173 mg, 1.25 mmol) as the base, *t*-butanol (1.0 mL) as the solvent and 2-di-*t*-butylphosphino-2',4',6'-triisopropylbiphenyl **2** (17.0 mg, 0.0400 mmol) as the ligand. Chromatography on silica gel column with 4:1 hexane : ethyl acetate gave 103 mg (80%) of the title compound as a pale yellow solid: mp 87-88 °C. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.89 (d, *J* = 8.7 Hz, 2H), 7.08 (t, *J* = 7.8 Hz, 1H), 6.97 (d, *J* = 8.7 Hz, 2H), 6.53 (ddd, *J* = 8.1, 2.1, 0.9 Hz, 1H), 6.49 (t, *J* = 2.1 Hz, 1H), 6.37 (ddd, *J* = 8.1, 2.1, 0.9 Hz, 1H), 5.91 (s, 1H), 4.32 (q, *J* = 7.2 Hz, 2H), 3.68 (s, 2H), 1.37 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (75 MHz, $CDCl_3$) δ 166.6, 148.0, 147.6, 142.0, 131.4, 130.3, 121.2, 114.9, 110.5, 110.0, 106.6, 60.7, 14.7. IR (neat, $cm^{-1}$) 3460, 3423, 3342, 2987, 1681, 1590, 1493, 1281, 1162, 1115, 762, 697. Anal. Calcd for $C_{15}H_{16}N_2O_2$: C, 70.29; H, 6.29. Found: C, 70.07; H, 6.29.

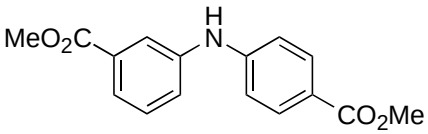



**3-(Methylphenylamino)benzoic acid (Table 5).** An oven-dried resealable Schlenk tube was evacuated and backfiled with argon. The Schlenk tube was charged with $Pd_2dba_3$ (9.2 mg, 0.010 mmol, 2 mol % Pd), ligand **1** (19.0 mg, 0.0400 mmol, 4 mol %), pulverized KOH (168 mg, 3.00 mmol), and 3-chlorobenzoic acid (156 mg, 0.990 mmol). The Schlenk tube was evacuated and backfilled with argon (three times) and then capped with a rubber septum. To the Schlenk tube was added *t*-BuOH (2 mL), *N*-methylaniline (0.163 mL, 1.50 mmol) and *t*-BuOH (0.5 mL). The septum was replaced with a Teflon screwcap, the Schlenk tube was sealed, and the mixture was heated to 100 °C with stirring (the reaction mixture became totally homogeneous) until the starting aryl chloride was consumed according to GC analysis (3 h, monitored by converting small aliquots of the reaction mixture to the corresponding methyl ester). The reaction was cooled to room temperature, diluted with 5 % aqueous NaOH and extracted with diethyl ether. The aqueous layer was cooled to 0 °C and acidified with HCl (12.0 M) to pH ~ 4. The aqueous layer was extracted with diethyl ether, dried over anhydrous magnesium sulfate, filtered, and

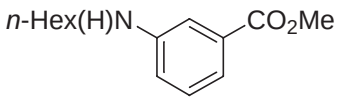
concentrated under reduced pressure to give the crude product (233 mg). The product was purified by recrystallizing from hot hexanes/chloroform (5:1) to give a light yellow solid (191 mg, 84 %), mp 114-115 °C. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 12.96 (s, 1H), 7.78 (s, 1H), 7.71 (d, *J* = 7.6 Hz, 1H), 7.42-7.35 (m, 3H), 7.25-7.12 (m, 4H), 3.42 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) δ: 173.4, 149.7, 148.9, 130.7, 130.0, 129.6, 124.1, 123.6, 123.2, 122.2, 119.6, 40.8; IR (neat, $cm^{-1}$): 1685, 1605, 1582, 1491, 1453, 1294, 751. HRMS calcd for $C_{14}H_{13}NO_2$: 227.0941. Found: 227.0945.




**4-(4-*n*-Butylphenylamino)benzoic acid (Table 5).** An oven-dried resealable Schlenk tube was evacuated and backfiled with argon. The Schlenk tube was charged with $Pd_2dba_3$ (9.2 mg, 0.010 mmol, 2 mol % Pd), ligand **1** (19.0 mg, 0.0400 mmol, 4 mol %), pulverized KOH (168 mg, 3.00 mmol), and 4-aminobenzoic acid (165 mg, 1.20 mmol). The Schlenk tube was evacuated and backfilled with argon (three times) and then capped with a rubber septum. To the Schlenk tube was added *t*-BuOH (2 mL), 4-*n*-butylchlorobenzene (168 mg, 0.990 mmol) and *t*-BuOH (0.5 mL). The septum was replaced with a Teflon screwcap, the Schlenk tube was sealed, and the mixture was heated to 100 °C with stirring (reaction was heterogeneous) until the starting aryl chloride was consumed according to GC analysis (3 h). The reaction mixture was cooled to room temperature, diluted with 5 % aqueous NaOH and extracted with diethyl ether. The aqueous layer was cooled to 0 °C and acidified with HCl (12.0 M) to pH ~ 4. The aqueous layer was extracted with diethyl ether, dried over anhydrous magnesium sulfate, filtered, and concentrated under reduced pressure to give the crude product (248 mg). The product was purified by recrystallizing from hot hexanes/chloroform to give faint brown platelets (209 mg, 78 %), mp 138-140 °C. $^{1}$H NMR (400 MHz, $d_6$-DMSO) δ 12.25 (s, 1H), 8.61 (s, 1H), 7.75 (d, *J* = 7.8 Hz, 2H), 7.13 (d, *J* = 8.4 Hz, 2H), 7.08 (d, *J* = 8.4 Hz, 2H), 6.98 (d, *J* = 7.8 Hz, 2H), 2.49 (t, *J* = 7.2 Hz, 2H), 1.50 (m, *J* = 6.8 Hz, 2H), 1.27 (m, *J* = 7.2 Hz, 2H), 0.87 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (100 MHz, $d_6$-DMSO) δ 167.4, 148.8, 139.1, 136.1, 131.3, 129.1, 119.9, 119.8, 113.6, 34.4, 33.5, 21.9, 13.9; IR (neat, $cm^{-1}$): 3406, 1668, 1601, 1515, 1309. HRMS calcd for $C_{14}H_{13}NO_2$ (M+H): 268.1343. Found: 268.1336.

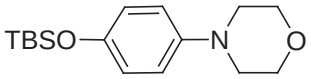



**Methyl 3-(4-methoxycarbonylphenylamino)benzoate (Table 5).** An oven-dried resealable Schlenk tube was evacuated and backfilled with argon. The Schlenk tube was charged with $Pd_2dba_3$ (9.2 mg, 0.010 mmol, 2 mol % Pd), ligand **1** (19.0 mg, 0.0400 mmol, 4 mol %), pulverized KOH (224 mg, 4.00 mmol), 4-aminobenzoic acid (165 mg, 1.20 mmol), and 3-chlorobenzoic acid (156 mg, 0.990 mmol). The Schlenk tube was evacuated and backfilled with argon (three times) and then capped with a rubber septum. To the Schlenk tube was added *t*-BuOH (4 mL). The septum was replaced with a Teflon screwcap, the Schlenk tube was sealed, and the mixture was heated to 100 °C with stirring (the reaction mixture was heterogeneous) until the starting aryl chloride was consumed according to GC analysis (24 h). The reaction mixture was cooled to room temperature, diluted with 5 % aqueous NaOH and extracted with diethyl ether. The aqueous layer was cooled to 0 °C and acidified with HCl (12.0 M) to pH ~ 4. The aqueous layer was extracted with ethyl acetate, dried over anhydrous magnesium sulfate, filtered, and concentrated under reduced pressure to give the crude product. Crude material was diluted with methanol (4 mL), cooled to 0 °C under a $N_2$ atmosphere and TMSCl (1 mL) was added. The solution was allowed to warm to room temperature and stirred for 24 h. The reaction mixture was concentrated under reduced pressure and purified by column chromatography on silica gel (eluting with ethyl acetate/hexanes, 2.5:7.5) to give the desired product as a white solid (259 mg, 90 %), mp 118 °C. $^1$H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, $J$ = 8.4 Hz, 2H), 7.83 (s, 1H), 7.67 (s, 1H), 7.35 (m, 2H), 7.02 (d, $J$ = 8.4 Hz, 2H), 6.77 (s, 1H), 3.89 (s, 3H), 3.86 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) δ 167.1, 166.9, 147.6, 141.5, 131.5, 131.4, 129.5, 123.9, 123.5, 121.4, 120.6, 115.0, 52.3, 51.8; IR (neat, $cm^{-1}$): 3356, 1713, 1592, 1530, 1435, 1282, 1176, 1107, 752. Anal. Calcd for $C_{16}H_{15}NO_4$: C, 67.36; H, 5.30. Found: C, 67.27; H, 5.33.

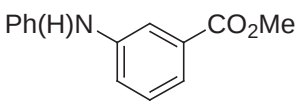



**Methyl 3-(*n*-hexylamino)benzoate (Table 5).** A screw-cap Schlenk tube was charged with $Pd(OAc)_2$ (4.5 mg, 0.020 mmol, 2 mol%), ligand **1** (24.0 mg, 0.0500 mmol, 5 mol%), and cesium carbonate (652 mg, 2.00 mmol). It was evacuated and refilled with argon. To this mixture, methyl 3-chlorobenzoate (170 mg, 1.00 mmol), *n*-hexylamine (122 mg, 1.20 mmol),

and toluene (1 mL) were sequentially added. The Schlenk tube was then capped and stirred in an oil bath at 110 °C for 15 h. The resulting mixture was cooled to room temperature, diluted with ethyl acetate (5 mL), and suction filtered. The filtrate was concentrated in vacuo. Flash chromatography of the crude product (hexanes : EtOAc, 1:1) provided 218 mg (92 %) of the title compound as pale yellow solid, mp 50.5-52.0 °C; $^{1}$H NMR (300 MHz, $CDCl_3$): δ 7.40-7.14 (m, 3H), 6.79 (ddd, *J* = 7.8, 2.0, 1.0 Hz, 1H), 3.96-3.86 (br, 1H), 3.91 (s, 3H), 3.16 (t, *J* = 14.5 Hz, 2H), 1.65 (app quintet, *J* = 14.4 Hz, 2H), 1.5-1.28 (m, 6H), 0.93 (t, *J* = 6.8 Hz, 3H). $^{13}$C NMR (75 MHz, $CDCl_3$): δ 167.4, 148.2, 130.8, 129.0, 118.1, 117.1, 113.1, 52.1, 44.0, 31.7, 29.4, 26.9, 22.7, 14.2. IR (neat, cm $^{-1}$): 3398, 3012, 2952, 2929, 2858, 1725, 1605, 1578, 1439, 1243, 1106, 988, 889. Anal. Calcd. for $C_{14}H_{21}NO_2$: C, 71.46; H, 8.99. Found: C, 71.67; H, 8.70.



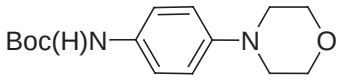

**General Procedure D: Preparation of *N*-[4-(*tert*-butyldimethylsilyloxy)phenyl]morpholine (Table 5).** A screw-cap Schlenk tube was charged with $Pd_2(dba)_3$ (9.2 mg, 0.010 mmol, 2 mol%), ligand **1** (24.0 mg, 0.0500 mmol), sodium *t*-butoxide (135.0 mg, 1.400 mmol). It was evacuated and refilled with argon. To this mixture, 4-(*tert*-butyldimethylsilyloxy)-1-bromobenzene[13] (287 mg, 1.00 mmol), morpholine (105 mg, 1.20 mol), and *t*-butanol (1 mL) were sequentially added. The Schlenk tube was then capped and the reaction mixture was stirred in an oil bath at 100 °C for 30 min. The resulting mixture was cooled to room temperature, diluted with ethyl acetate (5 mL), and suction filtered. The filtrate was concentrated in vacuo. Flash chromatography of the crude product (hexanes : diethyl ether, 2:1) provided 270 mg (92%) of the title compound as pale yellow crystalline solid, mp 49.0-50.0 °C; $^{1}$H NMR (300 MHz, $CDCl_3$): δ 6.86-6.73 (m, 4H), 3.92-3.84 (m, 4H), 3.12-3.05 (m, 4H), 1.00 (s, 9H), 0.20 (s, 6H); $^{13}$C NMR (75 MHz, $CDCl_3$): δ 149.3, 145.7, 120.4, 117.3, 67.0, 50.6, 25.8, 18.3, -4.3; IR (neat, cm $^{-1}$): 2962, 2929, 2858, 1509, 1242, 1123, 922, 822. Anal. Calcd. for $C_{16}H_{27}NO_2Si$: C, 65.48; H, 9.27. Found: C, 65.76; H, 9.25.




**Methyl 3-phenylaminobenzoate (Table 5).** Following general procedure D with a reaction time of 30 min, methyl 3-chlorobenzoate (170 mg, 1.00 mmol), was coupled with aniline (112

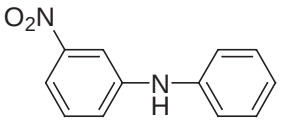
[13] Levacher, V.; Moberg, C. *J. Org. Chem.* **1995**, *60*, 1755-1762.

mg, 1.20 mmol). Chromatography on silica gel column with 1:1 hexanes : diethyl ether gave 189 mg (83% yield) of the desired product as a pale yellow solid, mp 111-112.5 °C (lit.[14] 110-112 °C).




***N*-(4-*tert*-Butoxycarbonylaminophenyl)morpholine (Table 5).** Following general procedure D with a reaction time of 30 min, 4-chloro-*N*-*tert*-butoxycarbonylaniline[15] (228 mg, 1.00 mmol) was coupled with morpholine (105 mg, 1.20 mmol). Chromatography on silica gel column with 1:1 hexanes : diethyl ether gave 225 mg (81% yield) of a colorless crystalline solid, mp 160.0-161.0 °C; $^1$H NMR (300 MHz, $CDCl_3$): δ 7.31-7.22 (m, 2H), 6.90-6.84 (m, 2H), 6.38 (br, 1H), 3.92-3.84 (m, 4H), 3.15-3.06 (m, 4H), 1.53 (s, 9H); $^{13}$C NMR (75 MHz, $CDCl_3$): δ 152.9, 147.2, 131.1, 120.0, 116.4, 80.0, 66.8, 50.0, 28.4; IR (neat, cm $^{-1}$): 3359, 3029, 3006, 2971, 2956, 1739, 1366, 1229, 1218, 932, 820. Anal. Calcd for $C_{15}H_{22}N_2O_3$: C, 64.73; H 7.97. Found: C, 64.48; H, 7.84.

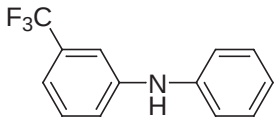
## Experimental procedures for Table 6




***N*-(3-Nitrophenyl)aniline (Table 6).** A resealable Schlenk tube was charged with $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), ligand (9.5 mg, 0.020 mmol), 3-chloronitrobenzene (158 mg, 1.00 mmol) and KOH (84 mg, 1.5 mmol). The Schlenk tube was evacuated, backfilled with argon and then, to it, were added aniline (109 μL, 1.20 mmol) and deionized, degassed water (0.5 mL). The Schlenk tube was sealed with a Teflon screwcap and the mixture was stirred at 60 °C for 8 h. After all starting material had been consumed, as judged by GC, the mixture was allowed to cool to room temperature and then was diluted with ether (40 mL). The resulting suspension was transferred to a separatory funnel and washed with water (10 mL). The organic layer was separated, dried with $MgSO_4$ and concentrated under vacuum. The crude material was purified by flash chromatography on silica gel (hexane : ethyl acetate 10:1) to afford 201 mg (94% yield) of an

[14] Plant, S. G. P.; Worthing, C. R. *J. Chem. Soc*. **1955**, 1278-1280.
[15] Strazzolini, P.; Melloni, T. Giumanini, A. G. *Tetrahedron* **2001**, *57*, 9033-9044.

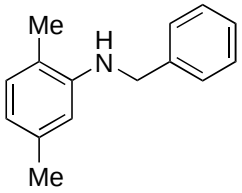
orange solid, mp 110-111 °C. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.09 (t, $J$ = 2.3 Hz, 1H), 7.65-7.69 (m, 1H), 7.31-7.37 (m, 3H), 7.27-7.28 (m, 1H), 7.04-7.14 (m, 3H), 5.92 (br s, 1H); $^{13}$C {$^{1}$H} NMR (125 MHz, $CDCl_3$) δ 150.0, 145.8, 141.6, 130.7, 130.4, 123.9, 122.6, 120.5, 115.4, 110.9; IR (neat, $cm^{-1}$) 3379, 3089, 3033, 1619, 1598, 1534, 1333, 1094; GC-MS (IE, 70 eV) m/z (%) 214 (100, $M^+$), 167 (91), 168 (29), 184 (25), 166 (15), 77 (15), 215 (14), 83 (12); Anal. Calcd for $C_{12}H_{10}N_2O_2$: C, 67.28; H 4.71; N 13.08. Found: C, 66.99; H, 4.57; N, 12.97.



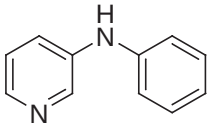

***N*-(3-Trifluoromethylphenyl)aniline (Table 6).** A resealable Schlenk tube was charged with $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), ligand (9.5 mg, 0.020 mmol), and KOH (84 mg, 1.5 mmol). The Schlenk tube was evacuated, backfilled with argon and then, to it, were added 3-chlorotrifluoromethylbenzene (136 μL, 1.00 mmol), aniline (109 μL, 1.20 mmol) and deionized, degassed water (0.5 mL). The Schlenk tube was sealed with a Teflon screwcap and the mixture was stirred at 110 °C for 3 hours. After all starting material had been consumed, as judged by GC, the mixture was allowed to cool to room temperature and then was diluted with ether (40 mL). The resulting suspension was transferred to a separatory funnel and washed with water (10 mL). The organic layer was separated, dried with $MgSO_4$ and concentrated under vacuum. The crude material was purified by flash chromatography on silica gel (hexane : ethyl acetate 10:1) to afford 228 mg (96% yield) of a pale yellow oil. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.27-7.34 (m, 3H), 6.97-7.18 (m, 5H), , 5.80 (s, 1H); $^{13}$C {$^{1}$H} NMR (125 MHz, $CDCl_3$) δ 144.7, 142.5, 132.5 (q, $J_{CF}$ = 32.0 Hz), 130.6, 130.3, 124.9 (q, $J_{CF}$ = 270.6 Hz), 123.0, 120.4 (app d, $J_{CF}$ = 1.4 Hz), 119.7, 117.6 (q, $J_{CF}$ = 12.0 Hz), 113.9 (q, $J_{CF}$ = 12.0 Hz); IR (film, $cm^{-1}$) 3379, 3089, 3033, 1619, 1598, 1534, 1333, 1094; GC-MS (IE, 70 eV) m/z (%) 237 (100, $M^+$), 167 (30), 236 (18), 216 (16), 238 (14), 168 (11), 77 (9), 51 (8); Anal. Calcd for $C_{13}H_{10}F_3N$: C, 65.82; H 4.25; N 5.90. Found: C, 65.95; H, 4.28; N, 5.89.

**General Procedure E for Reactions in Water (Table 6):** An oven-dried resealable Schlenk tube was evacuated and backfilled with argon. The Schlenk tube was charged with $Pd_2dba_3$ (4.6 mg, 0.0050 mmol, 1 mol % Pd), ligand **1** (9.4 mg, 0.020 mmol, 2 mol %), and KOH (78 mg, 1.4

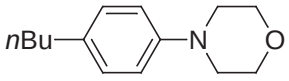
mmol). The Schlenk tube was evacuated and backfilled with argon (three times) and then capped with a rubber septum. To the reaction mixture was added amine (1.2 mmol), aryl chloride (1.0 mmol), and degassed water (0.5 mL). The septum was replaced with a Teflon screwcap, the Schlenk tube was sealed, and the mixture was heated to 110 °C (the reaction mixture was biphasic) with stirring until the starting aryl chloride was consumed according to GC analysis. The reaction mixture was cooled to room temperature, diluted with diethyl ether, filtered through Celite, and concentrated under reduced pressure. The crude material was purified by column chromatography on silica gel (eluting with ethyl acetate/hexane mixtures) to give the desired product.




**Benzyl-(2,5-dimethylphenyl)amine (Table 6).**[4] Following general procedure E with a reaction time of 12 h, 2-chloro-*p*-xylene (0.134 mL, 1.00 mmol) was coupled with benzyl amine (0.130 mL, 1.23 mmol). After chromatography on silica gel (eluting with ethyl acetate/hexanes, 1:20), the desired product was obtained as a colorless oil (179 mg, 85 %).



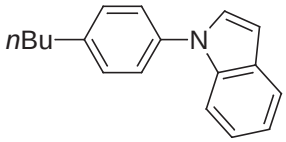

***N*-Phenyl-*N*-pyridin-3-yl-amine (Table 6).**[16] Following general procedure E with a reaction time of 6 h, 3-chloro-pyridine (0.095 mL, 1.00 mmol) was coupled with aniline (0.109 mL, 1.14 mmol). After chromatography on silica gel (eluting with ethyl acetate/hexanes, 8:2), the desired product was obtained as a white solid (162 mg, 95 %), mp 140-141 °C (lit.[16] 141-142 °C).



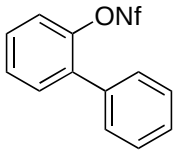

***N*-(4-*n*-Butylphenyl)morpholine (Table 6).** A resealable Schlenk tube was charged with $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), ligand (9.5 mg, 0.020 mmol) and KOH (84 mg, 1.5 mmol). The Schlenk tube was evacuated, backfilled with argon and then, to it, were added the 4-*n*-butylchorobenzene (170 μL, 1.00 mmol), morpholine (104 μL, 1.20 mmol) and deionized,

[16] Schliemann, W.; Buege, A.; *Pharmazie*, **1980**, *35*, 203.

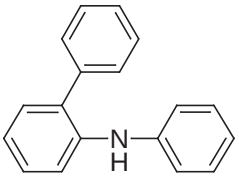
degassed water (0.5 mL). The Schlenk tube was sealed with a Teflon screwcap and the mixture was stirred at 110 °C for 16 hours. After all starting material had been consumed, as judged by GC, the mixture was allowed to cool to room temperature and then was diluted with ether (40 mL). The resulting suspension was transferred to a separatory funnel and washed with water (10 mL). The organic layer was separated, dried with $MgSO_4$ and concentrated under vacuum. The crude material was purified by flash chromatography on silica gel (hexane : ethyl acetate 10:1) to afford 210 mg (96% yield) of a pale yellow solid, mp 39-40 °C. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.09 (d, *J* = 8.4 Hz, 2H), 6.85 (d *J* = 8.4 Hz, 2H), 3.86 (t, *J* = 4.8 Hz, 4H), 3.12 (t, *J* = 4.8 Hz, 4H), 2.54 (t, *J* = 7.7 Hz, 2H), 1.57 (m, 2H), 1.34 (m, 2H), 0.92 (t, *J* = 7.2 Hz, 3H); $^{13}$C {$^1$H} NMR (125 MHz, $CDCl_3$) δ 150.0, 135.4, 129.8, 116.6, 67.7, 50.5, 35.4, 34.5, 23.1, 14.7; IR (neat, $cm^{-1}$) 2958, 2923, 2860, 2827, 1611, 1515, 1231, 1121, 924; GC-MS (IE, 70 eV) m/z (%) 216 (100), 118 (53), 219 (29, $M^+$), 177 (12), 91 (10), 161 (9), 90 (6), 119 (5); Anal. Calcd for $C_{14}H_{21}NO$: C, 76.67; H 9.65; N 6.39. Found: C, 76.67; H, 9.68; N, 6.25.




***N*-(4-*n*-Butylphenyl)indole (Table 6).**[5] A resealable Schlenk tube was charged with $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), ligand **1** (9.5 mg, 0.020 mmol), indole (140 mg, 1.20 mmol), and KOH (84 mg, 1.5 mmol). The Schlenk tube was evacuated, backfilled with argon and then, to it, were added the 4-*n*-butylchorobenzene (170 μL, 1.00 mmol) and deionized, degassed water (0.5 mL). The Schlenk tube was sealed with a Teflon screwcap and the mixture was stirred at 110 °C for 16 h. After all starting material had been consumed, as judged by GC, the mixture was allowed to cool to room temperature and then was diluted with ether (40 mL). The resulting suspension was transferred to a separatory funnel and washed with water (10 mL). The organic layer was separated, dried with $MgSO_4$ and concentrated under vacuum. The crude material was purified by flash chromatography on silica gel (hexane : ethyl acetate 10:1) to afford 235 mg (94% yield) of a yellow oil. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.65-7.68 (m, 1H), 7.51-7.54 (m, 1H), 7.36-7.39 (m, 2H), 7.27-7.30 (m, 3H), 7.11-7.22 (m, 2H), 6.64-6.65 (m, 1H), 2.68 (t, *J* = 7.7 Hz, 2H), 1.60-1.70 (m, 2H), 1.34-1.47 (m, 2H), 0.96 (t, *J* = 7.2 Hz, 3H).

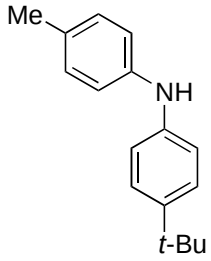



**1,1,2,2,3,3,4,4,4-Nonafluorobutane-1-sulfonic acid biphen-2-yl ester.** A solution of 2-hydroxybiphenyl (2.65 g, 15.6 mmol), cat. DMAP (95 mg, 0.77 mmol), and (*i*-Pr)$_2$NEt (3.25 mL, 18.1 mmol) in dichloromethane (25 mL) was cooled to 0 $^{o}$C in an ice bath and nonafluorobutanesulfonic fluoride (3.07 mL, 17.1 mmol) was added dropwise. The solution was allowed to warm to room temperature and stirred for 12 h after which it was poured over water (10 mL). The organic layer was extracted with dichloromethane, washed with brine, dried over anhydrous magnesium sulfate, filtered, and concentrated under reduced pressure. The product was purified by column chromatography on silica gel (eluting with ethyl acetate/hexanes, 1:10) to give a colorless oil (6.3 g, 90 %). $^{1}$H NMR (400 MHz, $CDCl_3$) δ: 7.58-7.46 (m, 9H); $^{13}$C NMR (100 MHz,$CDCl_3$) δ: 147.4, 136.1, 136.0, 132.2, 129.6, 129.2, 128.75, 128.72, 128.5, 122.2; IR (neat, cm$^{-1}$): 3066, 3037, 1477, 1427, 1203, 1144, 1033, 891, 770, 733. Anal. Calcd for $C_{16}H_9F_9O_3S$: C, 42.49; H 2.01. Found: C, 42.53; H, 1.91.




***N*-(2-Biphenyl)aniline (Table 6).** A resealable Schlenk tube was charged with $Pd_2(dba)_3$ (4.6 mg, 0.0050 mmol), ligand **1** (9.5 mg, 0.020 mmol), 2-biphenylnonaflate (452 mg, 1.00 mmol), and KOH (84 mg, 1.5 mmol). The Schlenk tube was evacuated, backfilled with argon and then, to it, were added aniline (109 μL, 1.20 mmol) and deionized, degassed water (0.5 mL). The Schlenk tube was sealed with a Teflon screwcap and the mixture was stirred at 80 $^{o}$C for 16 hours. After all starting material had been consumed, as judged by GC, the mixture was allowed to cool to room temperature and then was diluted with ether (40 mL). The resulting suspension was transferred to a separatory funnel and washed with water (10 mL). The organic layer was separated, dried with $MgSO_4$ and concentrated under vacuum. The crude material was purified by flash chromatography on silica gel (hexane : ethyl acetate 10:1) to afford 228 mg (96% yield) of a pale yellow oil. $^{1}$H NMR (300 MHz, $CDCl_3$) δ 7.29-7.43 (m, 6H), 7.13-7.23 (m, 4H), 6.85-7.00 (m, 4H), 5.57 (s, 1H); $^{13}$C {$^{1}$H} NMR (75 MHz, $CDCl_3$) δ 143.6, 140.4, 139.2, 131.7,

131.1, 129.6, 129.5, 129.1, 128.4, 127.7, 121.3, 121.2, 118.4, 117.6; IR (film, $cm^{-1}$) 3406, 3047, 3020, 1578, 1590, 1306, 1279, 746; GC-MS (IE, 70 eV) m/z (%) 245 (100, $M^+$), 244 (49), 246 (19), 167 (15), 166 (11), 51 (10), 152 (9), 242 (6); Anal. Calcd for $C_{18}H_{15}N$: C, 88.13; H 6.16; N 5.71. Found: C, 87.83; H, 6.24; N, 5.61.

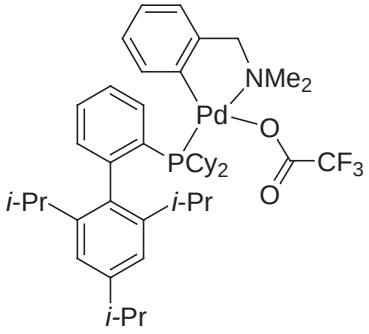



**4-(4-*tert*-Butylphenylamino)toluene (Table 6).**[17] 4-Toluidine (129 mg, 1.20 mmol), $Pd(OAc)_2$ (2.3 mg, 0.010 mmol), ligand (0.025 mmol), phenylboronic acid (3 mg, 0.03 mmol), and NaOH (56 mg, 1.4 mmol) were added to a Schlenk tube. The Schlenk tube was evacuated and refilled with argon twice, then, 4-*t*-butyl-1-bromobenzene (213 mg, 0.177 mL, 1.00 mmol) and water (0.5 mL) were added. The resulting mixture was refluxed at 110 °C for 4 h. The resulting mixture was cooled to room temperature, diluted with ethyl acetate (5 mL), and suction filtered. The filtrate was concentrated *in vacuo*. Flash chromatography of the crude product (hexanes:ethyl acetate 5:1) provided the desired product as a yellow oil. If the reaction was performed using tri-*t*-butylphosphonium tetrafluoroborate as ligand (8 mg), 220 mg (92% yield) of the product was obtained. If the reaction was performed using **1** as ligand (12 mg), 229 mg (96% yield) of the product was obtained.

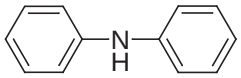
**Synthesis of palladium precursor [{Pd(μ-TFA)-(κ$^2$*N*,*C*-$C_6H_4CH_2NMe_2$)}$_2$].**[18] A 100 mL round bottom flask adapted with a Schlenk type fitting was charged with $Pd(TFA)_2$ (2.02 g, 6.09 mmol). The flask was evacuated, backfilled with argon and then, to it, were added anhydrous THF (60 mL) and *N*,*N*-dimethylbenzylamine (1.0 mL, 6.6 mmol). The mixture was stirred at 50 °C for 4 h and 1 h more at 65 °C. After cooling to room temperature, the solution was filtered through a column of Celite and concentrated *in vacuo* leading to the precipitation of the product. Recrystallization from THF/ethanol gave 1.74 g (81% yield) of a yellow solid. $^1$H NMR (300 MHz, $CDCl_3$) δ 7.02 (m, 1H), 6.90 (m, 3H), 3.50 (d, *J* = 13.8 Hz, 1H), 3.16 (d, *J* = 13.8 Hz, 1H),

[17] Lam, P. Y. S., Vincent, G.; Clark, C. G.; Deudon, S.; Jadhav, P. K. *Tetrahedron Lett.* **2001**, *42*, 3415-3418.
[18] Bedford, R. B.; Cazin, C. S. J. *Organometallics* **2003**, *22*, 987-999.

2.88 (s, 3H), 2.05 (s, 3H), 1.39 (s, 9H), 1.34 (s, 9H); $^{13}$C {$^{1}$H} NMR (75 MHz, $CDCl_3$) δ 165.6 (q, $J_{CF}$ = 37.6 Hz), 146.7, 141.6, 131.4, 125.45, 125.42, 121.7, 115.7 (q, $J_{CF}$ = 285.3 Hz), 72.4, 53.2, 51.5.




**Synthesis of palladium complex 10.** A 25 mL round bottom flask adapted with a Schlenk type fitting was charged with palladium precursor [{Pd(μ-TFA)-(κ$^2$*N*,*C*-$C_6H_4CH_2NMe_2$)}$_2$] (570 mg, 1.60 mmol) and ligand (760 mg, 1.60 mmol). The flask was evacuated, backfilled with argon and then, to it, was added anhydrous $CH_2Cl_2$ (10 mL). The mixture was stirred at room temperature for 2 h. After this time the solvent was removed under vacuum and the complex was precipitated by adding anhydrous methanol (10 mL). The methanol was removed using a syringe, the complex was dissolved in ether (40 mL) and the solution was quickly filtered through a Celite column. The solvent was removed under vacuum to afford 1195 mg (90% yield) of a tan solid. $^{1}$H NMR (500 MHz, $CD_2Cl_2$) δ 9.03 (br s, 1H), 7.28-7.36 (m, 2H), 7.00-7.04 (br m, 3H), 6.87 (d, *J* = 7.0 Hz, 1H), 6.77 (t, *J* = 6.8 Hz, 1H), 6.46 (br s, 2H), 4.11 (br s, 1H), 3.55 (br s, 1H), 2.84 (sept, *J* = 6.9 Hz, 1H) 2.66 (br s, 2H) 2.49 (app d *J* = 24.5 Hz, 5H), 2.37 (br s, 1H), 1.98-2.03 (br m, 4H), 1.82 (br s, 2H), 1.68 (br s, 2H), 1.51 (br s, 4H), 1.19-1.33 (br m, 12H), 1.06-1.15 (br m, 7H), 0.90 (br s, 7H) 0.42-0.61 (br m, 2H); $^{13}$C {$^{1}$H} NMR (125 MHz, $CD_2Cl_2$) δ 162.1 (q, $J_{CF}$ = 34.2 Hz), 149.7, 148.3, 147.3, 146.9, 145.4, 144.3, 141.8 (d, $J_{CP}$ = 27.0 Hz), 137.4, 135.9, 134.7 (d, $J_{CP}$ = 3.8 Hz) 130.1, 129.8, 126.5 (d, $J_{CP}$ = 8.9 Hz), 125.6, 121.5, 124.3, 123.5, 121.9 (d, $J_{CP}$ = 68.7 Hz), 117.3 (q, $J_{CF}$ = 290.8 Hz), 72.5 (d, $J_{CP}$ = 2.3 Hz), 49.7 (d, $J_{CP}$ = 98.2 Hz), 36.2 (br), 36.1 (br), 35.1 (br s), 35.0 (br), 34.9, 33.3 (br), 33.2 (br), 31.1, 29.6, 28.2 (br s), 28.3 (br), 27.7 (br), 27.5 (br), 27.0 (br), 26.9 (br), 26.7, 26.3, 25.7, 24.4, 23.9, 22.7; $^{31}$P {$^{1}$H} NMR (121 MHz, $CD_2Cl_2$) δ 69.79; IR (neat, cm$^{-1}$) 3053, 2964, 2929, 2856, 1686, 1463, 1447, 1266, 1194, 1135, 735; Anal. Calcd for $C_{44}H_{61}F_3NO_2PPd$: C, 63.64; H 7.40; N 1.69. Found: C, 63.62; H, 7.64; N, 1.72.



***N*-Phenylaniline (Table 6).** A resealable Schlenk tube was charged with palladium complex **10** (8.3 mg, 0.010 mmol), phenyl tosylate (240 mg, 1.00 mmol) and KOH (84 mg, 1.5 mmol). The tube was evacuated, backfilled with argon and then, to it, were added aniline (109 μL, 1.20 mmol) and deionized, degassed water (0.5 mL). The tube was sealed with a Teflon screwcap and the mixture was stirred at 80 °C for 16 hours. After all starting material had been consumed, as judged by GC, the mixture was allowed to cool to room temperature and then was diluted with ether (40 mL). The resulting suspension was transferred to a separatory funnel and washed with water (10 mL). The organic layer was separated, dried with $MgSO_4$ and concentrated under vacuum. The crude material was purified by flash chromatography on silica gel to afford 154 mg (91% yield) of a white solid, mp 53-54 °C (lit.[19] 51-53 °C). $^1$H NMR (300 MHz, $CDCl_3$) δ 7.22-7.27 (m, 4H), 7.04-7.08 (m, 4H), 6.88-6.93 (m, 2H), 5.68 (br s, 1H).

[19] Gaylord, N. G. *J. Org. Chem.* **1960**, *25*, 1874.