

Supporting Information

A Mild and Efficient Copper-catalyzed Amination of Aryl Bromides with Primary Alkyl Amines

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General considerations:

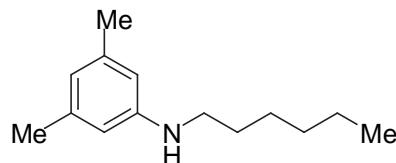
Copper(I) iodide (98%, fine powder) was purchased from Strem Chemical. Anhydrous potassium phosphate free flowing was purchased from Fluka. Anhydrous DMF was purchased from Aldrich (Sure-seal® bottle). All aryl halides and amines were used as received. *N,N*-Diethylsalicylamide was purchased from Aldrich and used as received (it has been discontinued in the 2002 Aldrich Catalog). *N,N*-Dialkylsalicylamides were prepared according to the literature procedures.¹ Silica gel (230-400 mesh) and ethyl acetate were purchased from Merck. Elemental analyses were performed by Atlantic Microlabs, Inc., Norcross, GA 30091. ¹H NMR and ¹³C NMR were recorded on a Varian 300 MHz instrument with chemical shifts reported relative to residual deuterated solvent peaks. Gas chromatographic analyses were performed on a Hewlett Packard 6890 instrument with FID detector and a Hewlett Packard 10 m × 0.2 mm i.d. HP-1 capillary column. Mass spectra (GC-MS) were recorded on a Hewlett Packard model GCD. HPLC were conducted on a Hewlett Packard Series 1100 system using Daicel OD column (0.46 cm × 25 cm). All yields reported in the publication represent an average of at least two independent runs. Characterization data for previously unknown compounds were determined from a single run with isolated yields. Compounds described in the literature were characterized by comparing their ¹H, ¹³C NMR or MS to the previously reported data.

General Procedure A: Cu-Catalyzed Amination of Functionalized Aryl Bromides

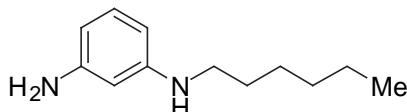
CuI (10 mg, 0.05 mmol), *N,N*-diethylsalicylamide (39 mg, 0.20 mmol), aryl bromide (if solid; 1.0 mmol), and K₃PO₄ (425 mg, 2.0 mmol) were added to a screw-capped test tube with a Teflon-lined septum. The tube was then evacuated and backfilled with argon (3 cycles). Aryl bromide (if liquid; 1.0 mmol), amine (1.5 mmol), and DMF (0.5 mL) were added by syringe at room temperature. The reaction mixture was stirred at 90 °C for 18-22 h. The reaction mixture was allowed to reach room temperature. Ethyl acetate (~2 mL), water (~10 mL), ammonium hydroxide (~0.5 mL) and dodecane (227 µL, GC standard) were added. The organic phase was analyzed by GC or GC-MS. The reaction mixture was further extracted with ethyl acetate (4 × 10 mL). The combined organic phases were washed with brine and dried over Na₂SO₄. Solvent was removed in *vacuo* and the residue was purified by flash column chromatography on silica gel to afford the desired product.

General Procedure B: Solvent-free Cu-Catalyzed Amination of Aryl Bromides

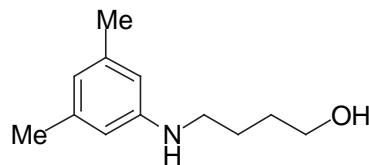
CuI (10 mg, 0.05 mmol), *N,N*-diethylsalicylamide (10 mg, 0.05 mmol), aryl bromide (if solid; 1.0 mmol), and K₃PO₄ (425 mg, 2.0 mmol) were added to a screw-capped test tube with a Teflon-lined septum. The tube was then evacuated and backfilled with argon (3 cycles). Aryl bromide (if liquid; 1.0 mmol) and amine (1.5 mmol) were added by syringe at room temperature. The reaction mixture was stirred at 100 °C for 22 h. The reaction mixture was allowed to reach room temperature. Ethyl acetate (~2 mL), water (~10 mL), ammonium hydroxide (~0.5 mL) and dodecane (227 µL, GC standard) were added. The organic phase was analyzed by GC or GC-MS. The reaction mixture was further extracted with ethyl acetate (4 × 10 mL). The combined organic phases were washed with brine and dried over Na₂SO₄. Solvent was removed in *vacuo* and the residue was purified by flash column chromatography on silica gel to afford the desired product.

Table 1. Copper-Catalyzed Amination of Functionalized Aryl Bromides**3,5-Dimethyl-N-hexylaniline² (Table 1, entry 1).**

Using general procedure A, 5-bromo-*m*-xylene (136 mg, 1.0 mmol), *n*-hexylamine (198 μ L, 1.5 mmol), 90 °C, 18 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (20:1) as the eluent to afford the title product as a colorless liquid (186 mg, 91% yield). R_f = 0.4 (hexane/ethyl acetate = 20:1). 1 H NMR (300 MHz, CDCl₃) δ 6.35 (s, 1 H), 6.24 (s, 2 H), 3.52 (brs, 3 H), 3.05 (t, 2 H, J = 6.9 Hz), 1.51-1.64 (m, 2 H), 1.27-1.42 (m, 6 H), 0.89 (t, 3 H, J = 6.6 Hz). MS (EI) *m/z* (relative intensity) 205 (M⁺, 100).

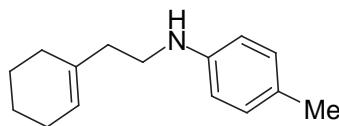
**3-Amino-N-hexylaniline (Table 1, entry 2).**

Using general procedure A, 3-bromoaniline (172 mg, 1.0 mmol), *n*-hexylamine (198 μ L, 1.5 mmol), 90 °C, 18 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (2:1) as eluent to afford the title product as a colorless oil (154 mg, 80% yield). R_f = 0.4 (hexane/ethyl acetate = 2:1). 1 H NMR (300 MHz, CDCl₃) δ 6.92 (t, 1 H, J = 8.1 Hz), 6.04 (d, 1 H, J = 2.4 Hz), 6.02 (d, 1 H, J = 1.8 Hz), 5.93 (t, 1 H, J = 2.1 Hz), 3.52 (brs, 3 H), 3.05 (t, 2 H, J = 6.9 Hz), 1.51-1.64 (m, 2 H), 1.27-1.42 (m, 6 H), 0.89 (t, 3 H, J = 6.6 Hz). 13 C NMR (75 MHz, CDCl₃) δ 149.9, 147.6, 130.2, 104.8, 104.2, 99.5, 44.3, 32.1, 30.0, 27.3, 14.5. IR (neat, cm⁻¹) 3357 (broad), 3213, 2954, 2927, 2856. MS (EI) *m/z* (relative intensity) 192 (M⁺, 30), 121 (100). Anal. Cald. for C₁₂H₂₀N₂; C: 74.95, H: 10.48; Found C: 74.65, H: 10.53.



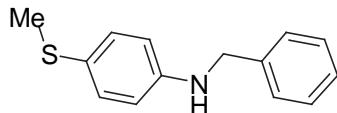
4-(N-(3,5-Dimethylphenyl))aminobutanol (Table 1, entry 3).

Using general procedure A, 5-bromo-*m*-xylene (136 μ L, 1.0 mmol), 4-aminobutanol (138 μ L, 1.5 mmol), 90 °C, 22 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (2:1) as the eluent to afford the title product as a colorless oil (174 mg, 90% yield). R_f = 0.4 (hexane/ethyl acetate = 1:1). ^1H NMR (300 MHz, CDCl_3) δ 6.35 (s, 1 H), 6.24 (s, 2 H), 3.67 (t, 2 H, J = 6.3 Hz), 3.12 (t, 2 H, J = 6.3 Hz), 2.23 (s, 6 H), 1.65-1.70 (m, 4 H). ^{13}C NMR (75 MHz, CDCl_3) δ 148.5, 139.1, 119.7, 111.2, 63.0, 44.3, 30.8, 26.6, 21.9. IR (neat, cm^{-1}) 3369 (broad), 3022, 2937, 2919, 2863. MS (EI) m/z (relative intensity) 193 (M^+ , 20), 174 (100), 134 (80). Anal. Cald. for $\text{C}_{12}\text{H}_{19}\text{NO}$; Cald. C: 74.57, H: 9.91; Found C: 74.21, H: 9.87.



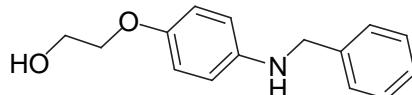
***N*-[2-(1-Cyclohexenyl)ethyl]-4-methylaniline³ (Table 1, entry 4).**

Using general procedure A, 4-bromotoluene (171 mg, 1.0 mmol), 2-(1-cyclohexenyl)ethylamine (209 μ L, 1.5 mmol), 90 °C, 20 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (20:1) as the eluent to afford the titled product as a colorless liquid (205 mg, 95% yield). R_f = 0.6 (hexane/ethyl acetate = 10:1). ^1H NMR (300 MHz, CDCl_3) δ 6.99 (d, 2 H, J = 8.1 Hz), 6.56 (d, 2 H, J = 8.3 Hz), 5.52 (m, 1 H), 3.59 (brs, 1 H), 3.14 (t, 2 H, J = 6.9 Hz), 2.25 (t, 2 H, J = 6.8 Hz), 2.24 (s, 3 H), 2.02 (m, 2 H), 1.95 (m, 2 H), 1.62 (m, 2 H), 1.58 (m, 2 H). ^{13}C NMR (75 MHz, CDCl_3) δ 146.1, 143.9, 129.7, 126.4, 123.5, 113.1, 41.8, 37.6, 27.8, 25.2, 22.8, 22.4, 20.4.



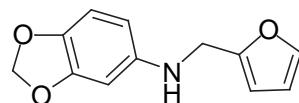
4-(N-Benzyl)aminothioanisole (Table 1, entry 5).

Using general procedure A, 4-bromothioanisole (203 mg, 1.0 mmol), benzylamine (164 μ L, 1.5 mmol), 90 °C, 20 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (15:1) as the eluent to afford the title product as a white solid (201 mg, 88% yield). R_f = 0.4 (hexane/ethyl acetate = 10:1). Melting point: 63-65 °C. 1 H NMR (300 MHz, CDCl₃) δ 7.26-7.37 (m, 5 H), 7.22 (d, 2 H, J = 8.4 Hz), 6.59 (d, 2 H, J = 8.7 Hz), 4.33 (d, 2 H, J = 5.4 Hz), 4.09 (brs, 1 H), 2.42 (s, 3 H). 13 C NMR (75 MHz, CDCl₃) δ 147.1, 139.3, 131.6, 128.9, 127.6, 127.5, 124.6, 113.7, 48.6, 19.6. IR (neat, cm⁻¹) 3213, 2954, 2927, 2856. MS (EI) *m/z* (relative intensity) 229 (M⁺, 100), 138 (85), 91 (80). Anal. Cald. for C₁₄H₁₅NS; C: 73.32, H: 6.59; Found C: 73.09, H: 6.67.



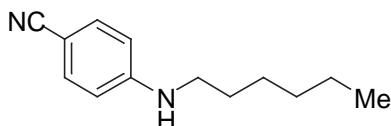
2-(4-(N-Benzyl)amino)phenoxyethanol (Table 1, entry 6).

Using general procedure A, 2-(4-bromophenoxy)ethanol (217 mg, 1.0 mmol), benzylamine (164 μ L, 1.5 mmol), 90 °C, 22 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (2:1) as the eluent to afford the title product as a white solid (201 mg, 84% yield). R_f = 0.5 (hexane/ethyl acetate = 1:1). Melting point: 71-72 °C. 1 H NMR (300 MHz, CDCl₃) δ 7.21-7.33 (m, 5 H), 6.76 (d, 2 H, J = 8.7 Hz), 6.56 (2 H, J = 9.0 Hz), 4.26 (s, 2 H), 3.87-3.99 (m/brs, 5 H), 2.23 (brs, 1 H). 13 C NMR (75 MHz, CDCl₃) δ 151.2, 143.0, 139.7, 128.8, 127.7, 127.4, 116.1, 114.3, 70.3, 62.0, 49.5. IR (neat, cm⁻¹) 3050, 3006, 2989. MS (EI) *m/z* (relative intensity) 243 (M⁺, 40), 91 (100). HRMS (EI) Cald. for C₁₅H₁₇NO₂, 243.1254; Found 243.1262.

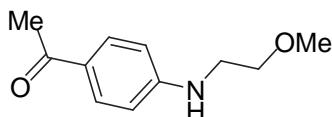


3,4-(Methylenedioxy)-N-furfurylaniline (Table 1, entry 7).

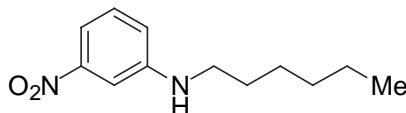
Using general procedure A, 4-bromo-1,2-(methylenedioxy)benzene (120 μ L, 1.0 mmol), furfurylamine (132 μ L, 1.5 mmol), 90 °C, 22 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (8:1) as the eluent to afford the title product as a colorless oil (187 mg, 87% yield). R_f = 0.5 (hexane/ethyl acetate = 5:1). ^1H NMR (300 MHz, CDCl_3) δ 7.36-7.37 (m, 1 H), 6.66 (d, 1 H, J = 8.4 Hz), 6.30-6.33 (m, 2 H), 6.21-6.23 (m, 1 H), 6.11 (dd, 2 H, J = 2.4 Hz, 8.4 Hz), 5.85 (s, 2 H), 4.25 (s, 2 H), 3.83 (brs, 1 H). ^{13}C NMR (75 MHz, CDCl_3) δ 152.8, 148.4, 143.4, 142.1, 140.2, 110.5, 108.8, 107.3, 105.1, 100.9, 96.7, 42.8. IR (neat, cm^{-1}) 3233, 2984, 2947, 2866. MS (EI) m/z (relative intensity) 217 (M^+ , 55), 136 (50), 81 (100). Anal. Cald. for $\text{C}_{12}\text{H}_{11}\text{NO}_3$; C: 66.35, H: 5.10; Found C: 66.50, H: 5.12.

**4-(*N*-Hexyl)aminobenzonitrile (Table 1, entry 8).**

Using general procedure A, 4-bromobenzonitrile (182 mg, 1.0 mmol), *n*-hexylamine (198 μ L, 1.5 mmol), 90 °C, 20 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (6:1) as the eluent to afford the title product as a light yellow solid (145 mg, 72% yield). R_f = 0.6 (hexane/ethyl acetate = 3:1). Melting point: 32-34 °C. ^1H NMR (300 MHz, CDCl_3) δ 7.38 (d, 2 H, J = 8.7 Hz), 6.52 (d, 2 H, J = 9.0 Hz), 4.20 (brs, 1 H), 3.12 (q, 2 H, J = 5.4 Hz), 1.62 (quint, 2 H, J = 7.2 Hz), 1.31-1.41 (m, 6 H), 0.90 (t, 3 H, J = 6.3 Hz). ^{13}C NMR (75 MHz, CDCl_3) δ 151.6, 133.8, 120.8, 112.2, 98.4, 43.6, 31.9, 29.5, 27.1, 23.0, 14.5. IR (neat, cm^{-1}) 3213, 2954, 2927, 2856. MS (EI) m/z (relative intensity) 202 (M^+ , 15), 131 (100). Anal. Cald. for $\text{C}_{13}\text{H}_{18}\text{N}_2$; C: 77.18, H: 8.97, Found C: 77.24, H: 9.11.

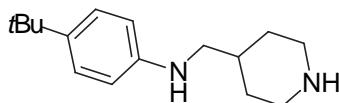
***N*-(2-Methoxyethyl)-4-acetylaniline (Table 1, entry 9).**

Using general procedure A, 4-bromoacetophenone (199 mg, 1.0 mmol), 2-methoxyethylamine (130 μ L, 1.5 mmol), 90 °C, 20 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (1:1) as the eluent to afford the title product as a light yellow solid (148 mg, 77% yield). R_f = 0.6 (hexane/ethyl acetate = 2:3). Melting point: 30-32 °C. 1 H NMR (300 MHz, CDCl₃) δ 7.82 (d, 2 H, J = 8.7 Hz), 6.58 (d, 2 H, J = 8.7 Hz), 4.63 (brs, 1 H), 3.61 (t, 2 H, J = 5.1 Hz), 3.39 (s, 3 H), 3.34 (t, 2 H, J = 5.1 Hz), 2.49 (s, 3 H). 13 C NMR (75 MHz, CDCl₃) δ 160.3, 151.6, 133.8, 120.8, 112.2, 43.6, 31.9, 29.5, 27.1. IR (neat, cm⁻¹) 3213, 2954, 2927, 2856, 1703. MS (EI) m/z (relative intensity) 193 (M⁺, 15), 178 (100). Anal. Cald. for C₁₁H₁₅NO₂; C: 68.37, H: 7.82, Found C: 68.08, H: 7.83.



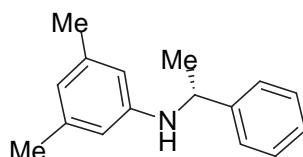
3-Nitro-N-hexylaniline (Table 1, entry 10).

Using general procedure A, 3-bromonitrobenzene (202 mg, 1.0 mmol), *n*-hexylamine (198 μ L, 1.5 mmol), 90 °C, 22 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (6:1) as the eluent to afford the title product as light yellow solid (174 mg, 78% yield). R_f = 0.5 (hexane/ethyl acetate = 5:1). Melting point: 43-45 °C. 1 H NMR (300 MHz, CDCl₃) δ 7.47 (ddd, 1 H, J = 1.2 Hz, 2.4 Hz, 8.4 Hz), 7.34 (t, 1 H, J = 2.1 Hz), 7.23 (t, 1 H, J = 8.1 Hz), 6.82 (ddd, 1 H, J = 0.6 Hz, 2.4 Hz, 8.1 Hz), 3.97 (brt, 1 H, J = 2.0 Hz), 3.14 (dt, 2 H, J = 1.5 Hz, 5.7 Hz), 1.58-1.66 (m, 2 H), 1.29-1.43 (m, 6 H), 0.91 (t, 3 H, J = 7.2 Hz). 13 C NMR (75 MHz, CDCl₃) δ 149.4, 149.3, 129.8, 118.8, 111.8, 106.2, 44.1, 31.9, 29.6, 27.1, 23.0, 14.5. IR (neat, cm⁻¹) 3413, 2956, 2929, 2858. MS (EI) m/z (relative intensity) 222 (M⁺, 10), 151 (100). Anal. Cald. for C₁₂H₁₉N₂O₂; C: 64.84, H: 8.16; Found C: 64.89, H: 8.14.



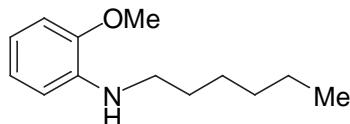
4-[N-(4-*tert*-Butylphenyl)aminomethyl]piperidine (Table 1, entry 11).

Using general procedure A, 4-*tert*-butylbromobenzene (173 μ L, 1.0 mmol), 4-(aminomethyl)piperidine (173 mg, 1.5 mmol), 90 °C, 22 h. The crude product was purified by column chromatography on silica gel using CH_2Cl_2 (saturated with NH_3)/MeOH = 10:1 as eluent afforded the title product as a white solid (196 mg, 80% yield). R_f = 0.3 (CH_2Cl_2 (saturated with NH_3)/MeOH = 10:1). Melting point; 112-114 °C. ^1H NMR (300 MHz, CDCl_3) δ 7.20 (d, 2 H, J = 8.7 Hz), 6.55 (d, 2 H, J = 8.7 Hz), 3.66 (brs, 1 H), 2.98-3.12 (m, 4 H), 2.60 (t, 2 H, J = 12.0 Hz), 1.91 (brs, 1 H), 1.68-1.81 (m, 2 H), 1.29 (s, 9 H), 1.05-1.15 (m, 3 H). ^{13}C NMR (75 MHz, CDCl_3) δ 146.2, 139.9, 126.2, 112.5, 50.9, 46.8, 36.5, 34.2, 31.9, 21.5. IR (neat, cm^{-1}) 3357 (broad), 3203, 2959, 2937, 2854. MS (EI) m/z (relative intensity) 246 (M^+ , 100). Anal. Cald. for $\text{C}_{16}\text{H}_{26}\text{N}_2$; C: 77.99, H: 10.64; Found C: 77.59, H: 10.60.

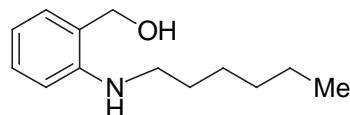


(R)-Methyl-N-(3,5-dimethylphenyl)benzylamine (Table 1, entry 12).

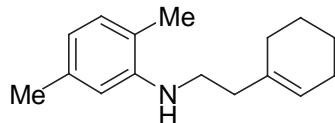
Using general procedure A, 5-bromo-*m*-xylene (136 μ L, 1.0 mmol), (*R*)- α -methylbenzylamine (193 μ L, 1.5 mmol, 98% ee), 100 °C, 30 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (20:1) as the eluent to afford the title product as a colorless liquid (160 mg, 71% yield, 98% ee). R_f = 0.4 (hexane/ethyl acetate = 20:1). HPLC conditions: Daicel OD column (0.46 cm \times 25 cm), 0.7 mL/min, UV lamp (254 nm), hexane/2-propanol (9:1), T_s = 6.41 min; T_R = 7.80 min. ^1H NMR (300 MHz, CDCl_3) δ 7.17-7.36 (m, 5 H), 6.29 (s, 1 H), 6.14 (s, 2 H), 4.46 (q, 1 H, J = 6.9 Hz), 3.89 (brs, 1 H), 2.15 (s, 6 H), 1.48 (d, 3 H, J = 6.6 Hz). ^{13}C NMR (75 MHz, CDCl_3) δ 147.5, 145.6, 138.9, 128.8, 126.9, 126.0, 119.5, 111.4, 53.6, 25.4, 21.9. IR (neat, cm^{-1}) 3406, 3060, 3025, 2966, 2919, 2865. MS (EI) m/z (relative intensity) 225 (M^+ , 50), 210 (100), 121 (90). Anal. Cald. for $\text{C}_{16}\text{H}_{19}\text{N}$; C: 85.28, H: 8.50; Found C: 85.41, H: 8.63.

Table 2. Copper-catalyzed Amination of *o*-Substituted and Heterocyclic Aryl Bromides.**2-Methoxy-N-hexylaniline⁴ (Table 2, entry 1).**

Using general procedure A, 2-bromoanisole (125 μ L, 1.0 mmol), *n*-hexylamine (198 μ L, 1.5 mmol), 100 °C, 22 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (20:1) as the eluent to afford the title product as a colorless liquid (184 mg, 89% yield). R_f = 0.5 (hexane/ethyl acetate = 15:1). ^1H NMR (300 MHz, CDCl_3) δ 7.16-7.22 (m, 1 H), 7.01 (dd, 1 H, J = 1.8, 7.2 Hz), 6.59-6.65 (m, 2 H), 4.78 (brs, 1 H), 3.11 (t, 2 H, J = 7.2 Hz), 1.65 (quint, 2 H, J = 7.5 Hz), 1.28-1.44 (m, 6 H), 0.90 (t, 3 H, J = 6.9 Hz). ^{13}C NMR (75 MHz, CDCl_3) δ 148.0, 129.9, 129.3, 124.3, 116.3, 110.8, 53.2, 43.9, 32.1, 29.8, 27.3, 23.1, 14.5.

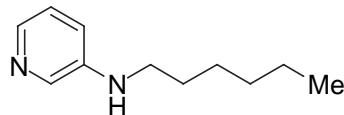
**2-(N-Hexylamino)benzylalcohol (Table 2, entry 2).**

Using general procedure A, 2-bromobenzylalcohol (187 mg, 1.0 mmol), *n*-hexylamine (198 μ L, 1.5 mmol), 90 °C, 22 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (6:1) as eluent to afford the title product as a colorless liquid (168 mg, 81% yield). R_f = 0.7 (hexane/ethyl acetate = 2:1). ^1H NMR (300 MHz, CDCl_3) δ 7.16-7.22 (m, 1 H), 7.01 (dd, 1 H, J = 1.8, 7.2 Hz), 6.59-6.65 (m, 2 H), 4.79 (brs, 1 H), 4.69 (s, 2 H), 3.11 (t, 2 H, J = 7.2 Hz), 1.65 (quint, 2 H, J = 7.5 Hz), 1.28-1.44 (m, 6 H), 0.90 (t, 3 H, J = 6.9 Hz). ^{13}C NMR (75 MHz, CDCl_3) δ 148.0, 129.9, 129.3, 124.3, 116.3, 110.8, 65.2, 43.9, 32.1, 29.8, 27.3, 23.1, 14.5. IR (neat, cm^{-1}) 3390 (broad), 2954, 2927, 2858. MS (EI) m/z (relative intensity) 207 (M^+ , 20), 136 (25), 118 (100). Anal. Calcd. for $\text{C}_{13}\text{H}_{21}\text{NO}$; C: 75.32, H: 10.21; Found C: 75.60, H: 10.25.



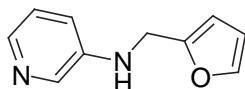
2-(N-2-(1-Cyclohexenyl)ethyl)amino-*para*-xylene (Table 2, entry 3)

Using general procedure A, 2-bromo-*p*-xylene (138 μ L, 1.0 mmol), 2-(1-cyclohexenyl)ethylamine (209 μ L, 1.5 mmol), 100 $^{\circ}$ C, 24 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (30:1) as the eluent to afford the title product as a colorless oil (180 mg, 79% yield). R_f = 0.5 (hexane/ethyl acetate = 20:1). 1 H NMR (300 MHz, CDCl₃) δ 6.90 (d, 1 H, J = 7.2 Hz), 6.44 (d, 1 H, J = 7.5 Hz), 6.42 (s, 1 H), 5.54-5.55 (m, 1 H), 3.50 (brs, 1 H), 3.16 (t, 2 H, J = 6.6 Hz), 2.31 (t, 2 H, J = 7.8 Hz), 2.29 (s, 3 H), 2.04 (s, 3 H), 2.01-2.02 (m, 2 H), 1.91-1.98 (m, 2 H), 1.54-1.62 (m, 4 H). 13 C NMR (75 MHz, CDCl₃) δ 146.4, 136.9, 135.3, 129.9, 124.1, 119.1, 117.4, 110.9, 99.9, 41.4, 38.0, 28.0, 25.8, 23.3, 22.8, 22.0, 17.3. IR (neat, cm⁻¹) 3413, 3016, 2923, 2856, 2836. MS (EI) *m/z* (relative intensity) 229 (M⁺, 20), 134 (100). Anal. Calcd. for C₁₆H₂₃N; C: 83.79, H: 10.11, Found C: 83.82, H: 10.29.



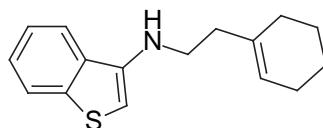
N-Hexyl-3-aminopyridine⁵ (Table 2, entry 4).

Using general procedure A, 3-bromopyridine (96 μ L, 1.0 mmol), *n*-hexylamine (198 μ L, 1.5 mmol), 90 $^{\circ}$ C, 20 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (1:1) as the eluent to afford the title product as a light brown solid (162 mg, 91% yield). R_f = 0.2 (hexane/ethyl acetate = 1:1). Melting Point: 72-74 $^{\circ}$ C. 1 H NMR (300 MHz, CDCl₃) δ 8.19 (d, 1 H, J = 2.7 Hz), 8.01 (dd, 1 H, J = 1.5 Hz, 4.8 Hz), 7.09 (dd, 1 H, J = 4.8 Hz, 8.4 Hz), 6.92-6.96 (m, 1 H), 4.13 (brs, 1 H), 3.11 (t, 2 H, J = 7.2 Hz), 1.65-1.69 (m, 2 H), 1.28-1.44 (m, 6 H), 0.90 (t, 3 H, J = 6.9 Hz). MS (EI) *m/z* (relative intensity) 178 (M⁺, 100).



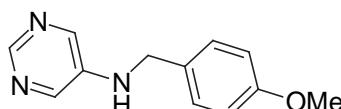
3-N-(furfuryl)aminopyridine (Table 2, entry 5).

Using general procedure A, 3-bromopyridine (96 μ L, 1.0 mmol), furfurylamine (133 μ L, 1.5 mmol), 90 °C, 20 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (1:1) as the eluent to afford the title product as a yellow liquid (158 mg, 91% yield). R_f = 0.2 (hexane/ethyl acetate = 1:1). 1 H NMR (300 MHz, CDCl_3) δ 8.09 (d, 1 H, J = 2.7 Hz), 8.00 (dd, 1 H, J = 1.5 Hz, 4.8 Hz), 7.37 (dd, 1 H, J = 0.6 Hz, 1.8 Hz), 7.09 (dd, 1 H, J = 4.8 Hz, 8.4 Hz), 6.92-6.96 (m, 1 H), 6.32-6.34 (m, 1 H), 6.24 (d, 1 H, J = 3.3 Hz), 4.34 (d, 2 H, J = 5.7 Hz), 4.13 (brs, 1 H). 13 C NMR (75 MHz, CDCl_3) δ 147.5, 145.6, 138.9, 128.8, 126.9, 126.0, 122.4, 119.5, 111.4, 53.6, 25.4, 21.9. IR (neat, cm^{-1}) 3403, 3080, 3020, 2960, 2909, 2865. MS (EI) m/z (relative intensity) 174 (M^+ , 30), 96 (100). Anal. Cald. for $\text{C}_{10}\text{H}_{10}\text{N}_2\text{O}$; C: 68.95, H: 5.79; Found C: 68.70, H: 5.88.



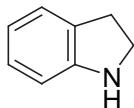
3-(N-(1-Cyclohexenyl)ethyl)aminothianaphthlene (Table 2, entry 6).

Using general procedure A, 3-bromothianaphthlene (131 μ L, 1.0 mmol), 2-(1-cyclohexenyl)ethylamine (209 μ L, 1.5 mmol), 90 °C, 22 h. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (20:1) as the eluent to afford the title product as a colorless liquid (211 mg, 82% yield). R_f = 0.4 (hexane/ethyl acetate = 20:1). 1 H NMR (300 MHz, CDCl_3) δ 7.74-7.77 (m, 1 H), 7.48-7.51 (m, 1 H), 7.30-7.33 (m, 2 H), 6.02 (s, 1 H), 5.58 (s, 1 H), 3.88 (brs, 1 H), 3.26 (t, 2 H, J = 6.6 Hz), 2.37 (t, 2 H, J = 6.6 Hz), 1.97-2.05 (m, 4 H), 1.55-1.66 (m, 4 H). 13 C NMR (75 MHz, CDCl_3) δ 141.7, 139.3, 135.1, 124.8, 123.9, 123.6, 123.4, 119.5, 114.5, 94.8, 43.4, 37.9, 28.3, 25.7, 23.3, 22.8. IR (neat, cm^{-1}) 3413, 3016, 2923, 2856, 2836. MS (EI) m/z (relative intensity) 257 (M^+ , 20), 162 (100). Anal. Cald. for $\text{C}_{16}\text{H}_{19}\text{NS}$; C: 74.66, H: 7.44, Found C: 74.57, H: 7.38.



5-(*N*-(4-Methoxybenzyl))aminopyrimidine (Table 2, entry 7).

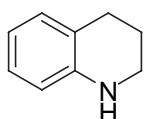
Using general procedure A, 5-bromopyrimidine (159 mg, 1.0 mmol), 4-methoxybenzylamine (196 μ L, 1.5 mmol), 90 °C, 22 h. The crude product was purified by column chromatography on silica gel using dichloromethane (saturated with ammonia)/ethyl acetate (1:1) as the eluent to afford the title product as a white solid (183 mg, 85% yield). R_f = 0.2 (dichloromethane(saturated with ammonia)/ethyl acetate = 1:1). Melting point: 155-157 °C. 1 H NMR (300 MHz, CDCl₃) δ 8.55 (s, 1 H), 8.09 (s, 2 H), 7.25 (d, 2 H, *J* = 8.1 Hz), 6.87 (d, 2 H, *J* = 8.7 Hz), 4.26 (s, 3 H), 3.79 (s, 3 H). 13 C NMR (75 MHz, CDCl₃) δ 159.3, 148.7, 141.6, 141.0, 129.6, 129.0, 114.8, 55.7, 47.3. IR (neat, cm⁻¹) 3113, 2924, 2920, 2806. MS (EI) *m/z* (relative intensity) 215 (M⁺, 30). Anal. Cald. for C₁₂H₁₃N₃O; C: 66.96, H: 6.09; Found C: 66.78, H: 6.06.

Table 3. Intramolecular Copper-catalyzed Amination of Aryl Halides.**Indoline⁶ (Table 3, entry 1).**

Using general procedure A, 2-bromophenylethylamine (200 mg, 1.0 mmol). Reaction time and temperature were according to Table 3. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (10:1) as the eluent to afford the title product as a colorless liquid. $R_f = 0.2$ (hexane/ethyl acetate = 10:1). ^1H NMR (300 MHz, CDCl_3) δ 7.08 (d, 1 H, $J = 7.8$ Hz), 6.96-7.01 (m, 1 H), 6.67 (dt, 1 H, $J = 1.2$ Hz, 7.8 Hz), 6.61 (d, 1 H, $J = 7.5$ Hz), 3.73 (brs, 1 H), 3.52 (t, 2 H, $J = 8.1$ Hz), 3.01 (t, 2 H, $J = 8.1$ Hz). ^{13}C NMR (75 MHz, CDCl_3) δ 151.7, 129.5, 127.4, 124.8, 118.8, 109.7, 47.7, 30.3. MS (EI) m/z (relative intensity) 118 (M^+-1 , 100).

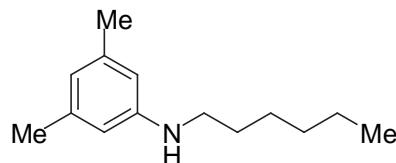
Indoline⁷ (Table 3, entries 3 and 4).

Using general procedure A, 2-chlorophenylethylamine (141 μL , 1.0 mmol) was used. Reaction time and temperature were according to Table 3. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (10:1) as the eluent to afford the title product as a colorless liquid. The characterization data matched that of the compound in Table 3, entry 1.

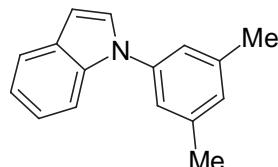
**1,2,3,4-Tetrahydroquinoline⁶ (Table 3, entry 2).**

Using general procedure A, 2-(bromophenyl)propylamine (214 mg, 1.0 mmol) was used. The crude product was purified by column chromatography on silica gel using hexane/ethyl acetate (10:1) as the eluent to afford the title product as a colorless liquid (106 mg, 80% yield). $R_f = 0.4$ (hexane/ethyl acetate = 10:1). ^1H NMR (300 MHz, CDCl_3) δ 6.93 (t, 2 H, $J = 7.5$ Hz), 6.58 (dt, 1 H, $J = 6.9$ Hz, 0.9 Hz), 6.45 (d, 1 H, $J = 7.2$

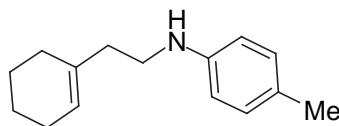
Hz), 3.78 (brs, 1 H), 3.29 (t, 2 H, J = 5.4 Hz), 2.75 (t, 2 H, J = 6.3 Hz), 1.89-1.97 (m, 2 H). MS (EI) m/z (relative intensity) 133 (M^+ -1, 100).

Table 4. Solvent-free Cu-catalyzed Amination of Aryl Bromides.**3,5-Dimethyl-N-hexylaniline² (Table 4, entry 1).**

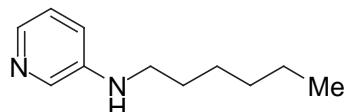
Using general procedure B. All characterization data matched that of the compound in Table 1, entry 1.

***N*-(3,5-Dimethylphenyl)indole⁸ (Table 4, entry 2).**

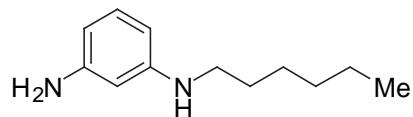
Using general procedure B. All characterization data matched that of the literature data.

***N*-[2-(1-Cyclohexenyl)ethyl]-4-methylaniline³ (Table 4, entry 3).**

Using general procedure B. All characterization data matched that of the compound in Table 1, entry 4.

***N*-Hexyl-3-aminopyridine⁵ (Table 4, entry 4).**

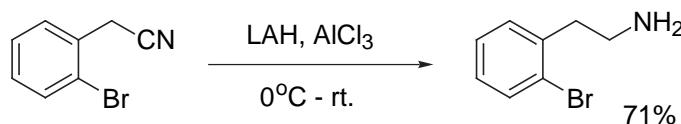
Using general procedure B. All characterization data matched that of the compound in Table 2, entry 4.



3-Amino-N-hexylaniline (Table 4, entry 5).

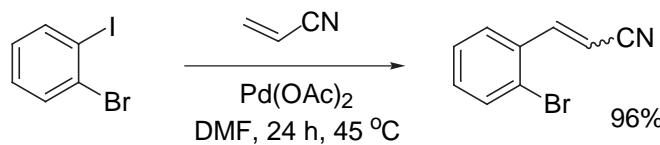
Using general procedure B. All characterization data matched that of the compound in Table 1, entry 2.

Preparation of the substrates for intramolecular amination of aryl halides.



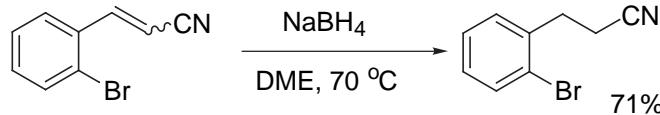
2-(2-Bromophenyl)ethylamine.⁹

The literature procedure was followed without modification.



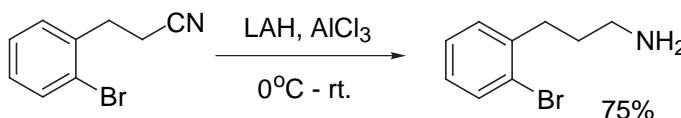
2-Bromocinnamonitrile.^{10,11}

The literature procedure was followed without modification.



3-(2-Bromophenyl)propionitrile.^{12,13}

The literature procedure was followed without modification.



3-(2-Bromophenyl)propylamine.⁶

The literature procedure was followed without modification.

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