Supporting information

Room Temperature and Solvent-Free Iridium-Catalyzed Selective Alkylation of Anilines with Alcohols

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General methods

All reactions were conducted under dry Argon atmosphere using magnetic stirring. DCM was freshly distilled from CaH₂ under nitrogen. Diglyme was freshly distilled from LiAlH₄ under reduced pressure. Toluene, DIPE, THF, DME, and dioxane were freshly distilled from sodium-benzophenone under nitrogen. KOtBu was bought from Sigma-Aldrich as sublimed grade, 99.99% trace metals basis. The 3-(2-aminophenyl)propanol was synthesized according to the literature.¹ The 1-Naphthylmethanol and 2-naphthylmethanol were prepared by reduction of the corresponding acid by LiAlH₄. Dapsone was bought from Sigma-Aldrich and used as received. Except reagents mentioned above, all commercial reagents (amines and alcohols) were purified by vacuum distillation before using.

Chromatographic separations were performed on Kiesel gel 60 H silica gel (particle size: 0.063-0.100 mm). Thin layer chromatography (TLC) was performed on aluminum plates coated with Kieselgel 60 (0.20 mm, UV254) and visualized under ultraviolet light (ν = 254 nm), or by staining with ethanolic nihydrin (2,2-dihydroxyindane-1,3-dione) and heating.

¹H NMR spectra were recorded at 500 MHz in CDCl₃ and referenced internally to the residual CHCl₃ peak (7.26 ppm). ¹³C NMR spectra were recorded at 75 MHz in CDCl₃ and referenced to the central peak of CDCl₃ (77.0 ppm). ³¹P NMR spectra were recorded at 121 MHz in CDCl₃ and referenced to external H₃PO₄. Chemical shifts are reported in ppm (δ scale). Coupling constants, J, are reported in Hertz.

IR spectra were measured using a Perkin Elmer FT-IR apparatus.

High resolution mass spectrometric (HRMS) data were obtained using a Bruker microTOF-Q II instrument operating at ambient temperatures, using a sample concentration of approximately 1 ppm.

The synthesis of Ir and Rh complexes

Imidazolium salt 1 (3 mmol) was dissolved in DCM (15 mL). NaBArF·3H₂O (3.3 mmol) was added in one portion and the solution was stirred at r.t. for 1h. After the reaction was completed by TLC, the solution was dried under vacuum and the residual was purified by flash chromatographic on silica gel with CH₂Cl₂ as the eluent to afford BArF salt 2 as clear oil.

¹H NMR (CDCl₃, 500 MHz): δ 7.97 (s, 1H), 7.73-7.68 (m, 8H), 7.57-7.38 (m, 11H), 7.36-7.04 (m, 12H), 7.01-6.98 (m, 1H), 6.96-6.90 (m, 2H), 5.61 (s, 1H).

¹³C NMR (CDCl₃, 75 MHz): δ 161.6 (q, J = 49.8), 137.6 (d, J = 15.5), 136.0, 134.0-134.5 (br), 134.3, 133.5, 133.3, 133.0, 132.4-132.2 (m), 131.6 (d, J =11.9), 131.3, (d, J = 3.8), 130.8, 130.7, 130.0, 129.8, 129.6-129.4 (m), 129.1, 128.8-128.2 (m), 126.3, 122.8, 122.7, 121.7, 121.6, 119.1, 117.7-117.3 (m), 53.7 (d, J = 21.6).
31P NMR (CDCl₃, 121 MHz): δ -17.6.
IR (neat, cm⁻¹): 1353, 1272, 1112, 886, 681.
HRMS (ESI) m/z = 419.1820, calcd for C₂₈H₂₄N₂P [M- BArF]⁺ = 419.1672.

BArF salt 2 (3 mmol) was co-evaporated with dry toluene (3 × 20 mL) and dissolved in dry THF (30 mL) under Ar. [M(COD)Cl]₂ (M = Ir or Rh)(1.5 mmol) and KOTBu (3.15 mmol) were added. The atmosphere in the flask was evacuated and replenished with Ar three times. The mixture was stirred at r.t. for 3h. After the reaction was completed by TLC, the solution was dried under vacuum and the residual was purified by flash chromatographic on silica gel with CH₂Cl₂ : pentane (2 : 1) as the eluent to afford iridium complex 3 as red solid or rhodium complex 4 as yellow solid.

CCDC 902840 (iridium complex 3) and 902841 (rhodium complex 4) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif

Red solid, (yield = 84%), (Rf = 0.50 (tailing), in DCM/pentane 3/1).
1H NMR (CDCl₃, 500 MHz): δ 7.83-7.71 (m, 8H), 7.59-7.38 (m, 15H), 7.36-7.23 (m, 5H), 7.22-7.15 (m, 3H), 7.09-6.99 (m, 3H), 6.73-6.64 (m, 2H), 4.99-4.87 (m, 1H), 4.82-4.70 (m, 1H), 4.27-4.16 (m, 1H), 3.95-3.84 (m, 1H), 3.49-3.29 (m, 1H), 2.37-1.97 (m, 5H), 1.73-1.34 (m, 3H).
13C NMR (CDCl₃, 75 MHz): δ 169.2 (q, J = 10.5), 161.7, 141.0, 140.8, 139.2, 137.7, 134.8 (br), 132.3, 132.2, 132.0, 131.9, 131.8, 131.2-131.0 (m), 130.7, 130.2-129.9 (m), 129.7-129.4 (m), 129.2-129.0 (m), 128.9-128.6 (m), 128.4-128.2 (m), 128.1, 126.3, 124.0, 123.5, 122.7, 120.6, 119.1, 117.9-117.2 (m), 89.3 (d, J = 10.0), 85.5 (d, J = 13.3), 79.6, 79.2, 55.5 (d, J = 7.5), 34.5, 33.9, 33.8, 28.2, 27.9.
31P NMR (CDCl₃, 121 MHz): δ 13.5 (d, J = 151.7).
IR (neat, cm⁻¹): 1353, 1273, 1118, 886, 681.
HRMS (ESI) m/z = 719.2333, calcd for C₃₆H₃₅IrN₂P [M- BArF]⁺ = 719.2167.

Yellow solid, (yield = 86%), (Rf = 0.50 (tailing), in DCM/pentane 3/1).
1H NMR (CDCl₃, 500 MHz): δ 7.79-7.69 (m, 8H), 7.54-7.27 (m, 18H), 7.27-7.18 (m, 5H), 7.09-6.95 (m, 2H), 6.81-6.76 (m, 2H), 5.07-4.94 (m, 2H), 4.55-4.45 (m, 1H), 4.41-4.32 (m, 1H), 3.83-3.67 (m, 1H), 2.59-2.28 (m, 5H), 2.18-2.06 (m, 1H), 2.00-1.67 (m, 2H).
13C NMR (CDCl₃, 75 MHz): δ 173.2 (dd, J = 50.0Rh,C, 15.9P, C), 161.7 (q, J = 50.5), 141.3, 141.1, 138.7, 137.9, 134.8 (br), 132.3 (d, J = 2.3), 132.1, 132.0, 131.8, 131.7, 131.6, 131.0, 130.8, 130.7 (d, J = 2.2), 130.2, 130.0, 129.9, 129.8, 129.6-129.4 (m), 129.2-128.9 (m), 128.8, 128.7-128.6 (m), 128.4-128.2 (m), 124.0, 123.5, 122.7, 120.7, 119.1, 117.6-117.2 (m), 99.3 (m), 96.6 (m), 93.7 (d, J = 8.7), 92.0 (d, J = 7.9), 55.8 (d, J = 10.4), 33.3, 32.9 (d, J = 3.3), 30.9, 28.0, 27.4.
31P NMR (CDCl₃, 121 MHz): δ 13.5 (d, J = 151.7).
IR (neat, cm⁻¹): 1353, 1273, 1117, 886, 681.
HRMS (ESI) m/z = 629.1772, calcd for C₃₆H₃₅N₂PRh [M- BArF]⁺ = 629.1593.
### Table S1. N-Alkylation of aniline with benzyl alcohol under different conditions[a]

![Reaction Scheme](image.png)

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<th>Entry</th>
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<th>KOtBu (mol%)</th>
<th>Conv[b] (%)</th>
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</table>

[a] Reaction conditions: 0.5 mmol aniline, 0.55 mmol benzyl alcohol, iridium catalyst 3 or rhodium 4, KOtBu, solvent, 50 °C, 24 h. [b] Conversion was calculated by ¹H NMR spectroscopy, based on unreacted aniline. [c] DIPE = diisopropyl ether.

**General procedure for alkylation of amine with alcohols**

**Diglyme as solvent**

Method A (When both aniline derivatives and alcohols are liquids)

A Microwave vial (5 mL, tapered style) with a magnetic stirring bar was charged with iridium catalyst 3 (0.5-1.5 mol%) and KOtBu (0.25 mmol). Under an argon atmosphere, aniline (0.5 mmol) and benzyl alcohol (0.55 mmol) were dissolved in diglyme (0.25 mL) and the solution was added. Next, the vial was sealed with a speta (PTFE-faced silicone septa) and the mixture was stirred either 24 h at 50 °C or 48 h at room temperature. The reaction mixture was then quenched by addition of saturated aqueous NH₄Cl solution. The organic phase was extracted three times with 20 mL of chloroform. The combined organic phases were over MgSO₄. Solvent was evaporated under vacuum and the residue was further purified by column chromatography.
Method B (When either aniline derivatives or alcohols is solid)
A Microwave vial (5 mL, tapered style) with a magnetic stirring bar was charged with iridium catalyst 3 (0.5-1.5 mol%), KO\textsubscript{t}Bu (0.25 mmol) and the solid reagent. Under an argon atmosphere, the other liquid reagent was dissolved in diglyme (0.25 mL) and the solution was added. Next, the vial was sealed with a speta (PTFE-faced silicone septa) and the mixture was stirred either 24 h at 50 °C or 48 h at room temperature. The reaction mixture was then quenched by addition of saturated aqueous NH\textsubscript{4}Cl solution. The organic phase was extracted three times with 20 mL of chloroform. The combined organic phases were over MgSO\textsubscript{4}. Solvent was evaporated under vacuum and the residue was further purified by column chromatography.

\textit{Solvent free condition}

Method A (When both aniline derivatives and alcohols are liquid)
A Microwave vial (5 mL, tapered style) with a magnetic stirring bar was charged with iridium catalyst 3 (0.5-1.0 mol%) and KO\textsubscript{t}Bu (0.5 mmol). Under an argon atmosphere, aniline (1.0 mmol) was added followed by addition of benzyl alcohol (1.1 mmol). Next, the vial was sealed with a speta (PTFE-faced silicone septa) and the mixture was stirred either 24 h at 50 °C or 48 h at room temperature. The reaction mixture was then quenched by addition of saturated aqueous NH\textsubscript{4}Cl solution. The organic phase was extracted three times with 20 mL of chloroform. The combined organic phases were over MgSO\textsubscript{4}. Solvent was evaporated under vacuum and the residue was further purified by column chromatography.

Method B (When either aniline derivatives or alcohols is solid)
A Microwave vial (5 mL, tapered style) with a magnetic stirring bar was charged with iridium catalyst 3 (0.5-1.0 mol%), KO\textsubscript{t}Bu (0.5 mmol) and the solid reagent. Under an argon atmosphere, the other liquid reagent was added. Next, the vial was sealed with a speta (PTFE-faced silicone septa) and the mixture was stirred either 24 h at 50 °C or 48 h at room temperature. The reaction mixture was then quenched by addition of saturated aqueous NH\textsubscript{4}Cl solution. The organic phase was extracted three times with 20 mL of chloroform. The combined organic phases were over MgSO\textsubscript{4}. Solvent was evaporated under vacuum and the residue was further purified by column chromatography.

Spectral data match those previously reported\textsuperscript{[2]}

Spectral data match those previously reported\textsuperscript{[3]}

Spectral data match those previously reported\textsuperscript{[4]}
Spectral data match those previously reported.\cite{ref5}

Spectral data match those previously reported.\cite{ref6}

Spectral data match those previously reported.\cite{ref7}

Spectral data match those previously reported.\cite{ref6}

Spectral data match those previously reported.\cite{ref8}

Spectral data match those previously reported.\cite{ref7}

Spectral data match those previously reported.\cite{ref7}

Spectral data match those previously reported.\cite{ref3}

Spectral data match those previously reported.\cite{ref9}
Spectral data match those previously reported.\textsuperscript{[10]}

Spectral data match those previously reported.\textsuperscript{[6]}

Spectral data match those previously reported.\textsuperscript{[4]}

Spectral data match those previously reported.\textsuperscript{[4]}

Spectral data match those previously reported.\textsuperscript{[11]}

Spectral data match those previously reported.\textsuperscript{[12]}

Spectral data match those previously reported.\textsuperscript{[2]}

Spectral data match those previously reported.\textsuperscript{[2]}
Spectral data match those previously reported.\textsuperscript{[2]}

Spectral data match those previously reported.\textsuperscript{[5]}

Spectral data match those previously reported.\textsuperscript{[13]}

Spectral data match those previously reported.\textsuperscript{[13]}

Spectral data match those previously reported.\textsuperscript{[14]}

Spectral data match those previously reported.\textsuperscript{[14]}
Spectra of new compounds

Electronic Supplementary Material (ESI) for Chemical Communications
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13C OBSERVE
Pulse Sequence: s2pul
Solvent: CDCl3
Temp. 25.0 C / 298.1 K
Mercury-300BB  "mercury"
User     Jiaqi
Date     Sep 10 2012
Relax. delay 4.000 sec
Pulse 87.6 degrees
Acq. time 1.815 sec
Width 18761.7 Hz
8304 repetitions
OBSERVE  C13,  75.4421715 MHz
DECOUPLE  H1, 300.0298366 MHz
Power 35 dB
continuously on
WALTZ-16 modulated
DATA PROCESSING
Line broadening 1.0 Hz
FT size 131072
Total time 1697812 hr, 3 min, 7 sec
S11
References

[14] $^1$H NMR was available on the Sigma-Aldrich Library.