Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

Supporting Information for

Cp*Co(III)-Catalyzed, N-N Bond-Based Redox-Neutral Synthesis of Isoquinolines

Jie Wang, Shanke Zha, Kehao Chen and Jin Zhu*

Department of Polymer Science and Engineering, School of Chemistry and Chemical Engineering, State Key Laboratory of Coordination Chemistry, Nanjing National Laboratory of Microstructures, Nanjing University, Nanjing 210093, China

*Corresponding author. Email: jinz@nju.edu.cn; Phone: +86-25-89686291; Fax: +86-25-83317761

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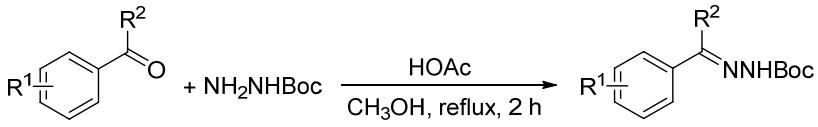
1. General Information

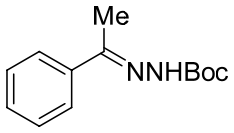
Unless otherwise noted, commercial reagents were purchased from Aldrich, Alfa Aesar, and other commercial suppliers and were used as received. All reactions were carried out without any particular precautions to extrude moisture or oxygen. $AgSbF_6$ were stored and weighed in a nitrogen-filled glovebox. All reactions beyond room temperature (rt) were run in oil baths with the temperatures calibrated with a thermometer. Prior to an experiment, the oil bath was allowed to equilibrate to the desired temperature for 15 min. Analytical thin-layer chromatography (TLC) was performed on Merck 60 F254 silica gel plates. Flash chromatography was performed using 40-63 μm silica gel (Si 60, Merck). ^1H and ^{13}C nuclear magnetic resonance (NMR) spectra were recorded on Bruker AV-400 (400 MHz) NMR spectrometers. ^1H and ^{13}C NMR spectra are reported in parts per million (ppm) downfield from an internal standard, tetramethylsilane (0 ppm) and $CHCl_3$ (77.0 ppm), respectively. The following notations were used: br – broad, s – singlet, d – doublet, t – triplet, q – quartet, m – multiplet, dd – doublet of doublet, dt – doublet of triplet, td – triplet of doublet, ddd – doublet of doublet of doublet. High-resolution mass spectra (HRMS) were obtained on a Waters Micromass GCT Premier facility.

2. Synthesis of Substrates

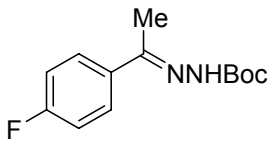
2.1 General Procedure for the Synthesis of *Tert*-butyl-2-(1-phenylethylidene)hydrazine-1-carboxylate



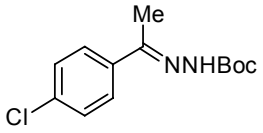
Following the literature procedure,[S1, S2] to a stirred solution of tertiary butyl carbazate (1.32 g, 10 mmol) and HOAc (0.12g, 2 mmol) in CH_3OH (5.0 mL) was added corresponding ketones (e.g. acetophenone, 1.2 g, 10 mol) and allowed to stir the reaction mixture at reflux for about 2 h. The completion of the reaction was monitored by TLC chromatography. After the completion of reaction, the reaction mixture was cooled and filtered to remove the solvent. The filtered solid was triturated with hexane to get the pure corresponding *tert*-butyl-2-(1-phenylethylidene) hydrazine-1-carboxylate (e.g. *tert*-butyl-2-(1-phenylethylidene)hydrazine-1-carboxylate, **1a**, 2.3g, 98% yield).



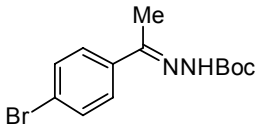
***Tert*-butyl-2-(1-phenylethylidene)hydrazine-1-carboxylate (1a):** The title compound was obtained as a white solid in 98% yield. **^1H NMR (400 MHz, DMSO)** δ 9.81 (s, 1H), 7.75 – 7.73 (m, 1H), 7.71 (t, J = 2.2 Hz, 1H), 7.42 – 7.33 (m, 3H), 2.19 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.63, 148.57, 138.96, 129.13, 128.67 (2C), 126.38 (2C), 79.80, 28.59 (3C), 14.22. **HRMS (ESI)** Calcd. For $C_{13}H_{18}N_2O_2$: $[M + H]^+$, 235.1441. Found: *m/z,* 235.1440.



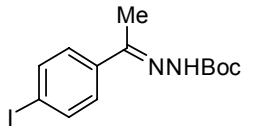
***Tert*-butyl-2-(1-(4-fluorophenyl)ethylidene)hydrazine-1-carboxylate (1b):** The title compound was obtained as a white solid in 95% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.83 (s, 1H), 7.81 – 7.72 (m, 2H), 7.27 – 7.16 (m, 2H), 2.18 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 162.93 (d, *J* = 246.44 Hz), 153.61, 147.63, 135.44 (d, *J* = 2.93 Hz), 128.49 (d, *J* = 8.08 Hz, 2C), 115.50 (d, *J* = 22.22 Hz, 2C), 79.82, 28.55 (3C), 14.21. **HRMS (ESI)** Calcd. For $C_{13}H_{17}FN_2O_2$: $[M+H]^+$, 253.1347. Found: *m/z,* 253.2346.



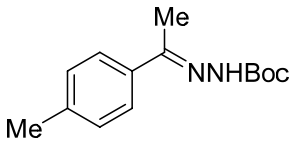
***Tert*-butyl-2-(1-(4-chlorophenyl)ethylidene)hydrazine-1-carboxylate (1c):** The title compound was obtained as a white solid in 96% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.89 (s, 1H), 7.75 (d, *J* = 8.7 Hz, 2H), 7.45 (d, *J* = 8.7 Hz, 2H), 2.18 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.55, 147.24, 137.76, 133.82, 128.67, 128.08, 79.91, 28.55 (3C), 14.03. **HRMS (ESI)** Calcd. For $C_{13}H_{17}ClN_2O_2$: $[M+H]^+$, 269.1051. Found: *m/z,* 269.1051.



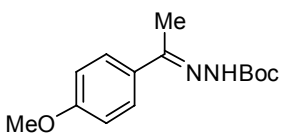
***Tert*-butyl-2-(1-(4-bromophenyl)ethylidene)hydrazine-1-carboxylate (1d):** The title compound was obtained as a white solid in 95% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.89 (s, 1H), 7.68 (dd, *J* = 9.2, 4.4 Hz, 2H), 7.58 (dd, *J* = 9.2, 4.4 Hz, 2H), 2.18 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.53, 147.34, 138.13, 131.61, 128.38, 122.54, 79.94, 28.56 (3C), 14.00. **HRMS (ESI)** Calcd. For $C_{13}H_{17}BrN_2O_2$: $[M+H]^+$, 313.0546. Found: *m/z,* 313.0546.



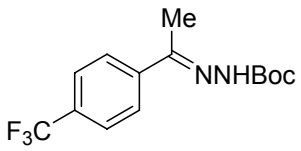
***Tert*-butyl-2-(1-(4-iodophenyl)ethylidene)hydrazine-1-carboxylate (1e):** The title compound was obtained as a white solid in 90% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.88 (s, 1H), 7.81 – 7.70 (m, 2H), 7.58 – 7.46 (m, 2H), 2.16 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.52, 147.55, 138.47, 137.49, 128.43, 95.76, 79.94, 28.58 (3C), 13.93. **HRMS (ESI)** Calcd. For $C_{13}H_{17}IN_2O_2$: $[M+H]^+$, 361.0407. Found: *m/z,* 361.0404.



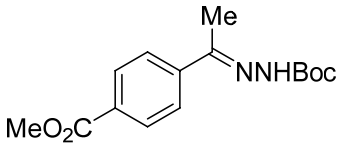
***Tert*-butyl-2-(1-(p-tolyl)ethylidene)hydrazine-1-carboxylate (1f):** The title compound was obtained as a white solid in 85% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.75 (s, 1H), 7.63 (d, *J* = 8.2 Hz, 2H), 7.19 (d, *J* = 8.0 Hz, 2H), 2.31 (s, 3H), 2.16 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.65, 148.65, 138.59, 136.20, 129.25, 126.31, 79.70, 28.58 (3C), 21.23, 14.13. **HRMS (ESI)** Calcd. For $C_{14}H_{20}N_2O_2$: $[M+H]^+$, 249.1598. Found: *m/z,* 249.2597.



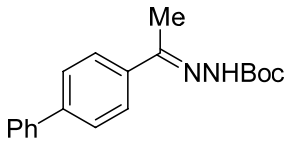
***Tert*-butyl-2-(1-(4-methoxyphenyl)ethylidene)hydrazine-1-carboxylate (1g):** The title compound was obtained as a white solid in 84% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.68 (s, 1H), 7.74 – 7.62 (m, 2H), 6.99 – 6.89 (m, 2H), 3.78 (s, 3H), 2.15 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 160.26, 153.68, 148.60, 131.41, 127.79, 114.02, 79.63, 55.97, 55.61, 28.60 (3C), 14.11. **HRMS (ESI)** Calcd. For $C_{14}H_{20}N_2O_3$: $[M+H]^+$, 265.1547. Found: *m/z,* 265.1545.



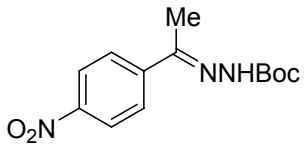
***Tert*-butyl-2-(1-(4-(trifluoromethyl)phenyl)ethylidene)hydrazine-1-carboxylate (1h):** The title compound was obtained as a white solid in 80% yield. **^{1}H NMR (400 MHz, DMSO)** δ 10.03 (s, 1H), 7.94 (d, *J* = 8.2 Hz, 2H), 7.75 (d, *J* = 8.3 Hz, 2H), 2.23 (s, 3H), 1.49 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 152.98, 146.37, 142.30, 128.61 (q, *J* = 32.32 Hz), 126.52 (2C), 125.10 (q, *J* = 4.04 Hz, 2C), 124.24 (q, *J* = 243.41 Hz), 79.62, 28.03 (3C), 13.62. **HRMS (ESI)** Calcd. For $C_{14}H_{17}F_3N_2O_2$: $[M + H]^+$, 303.1315. Found: *m/z,* 303.1314.



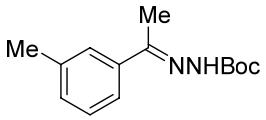
***Tert*-butyl-2-(1-(4-(methoxycarbonyl)phenyl)ethylidene)hydrazine-1-carboxylate (1i):** The title compound was obtained as a white solid in 72% yield. **^{1}H NMR (400 MHz, DMSO)** δ 10.00 (s, 1H), 8.01 – 7.93 (m, 2H), 7.91 – 7.83 (m, 2H), 3.86 (s, 3H), 2.22 (s, 3H), 1.49 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 165.94, 152.97, 142.80, 129.28, 129.09, 126.07, 79.62, 52.12, 28.04 (3C), 13.60. **HRMS (ESI)** Calcd. For $C_{15}H_{20}N_2O_4$: $[M + H]^+$, 293.1496. Found: *m/z,* 392.1494.



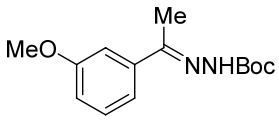
***Tert*-butyl-2-(1-([1,1'-biphenyl]-4-yl)ethylidene)hydrazine-1-carboxylate (1j):** The title compound was obtained as a white solid in 67% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.86 (s, 1H), 7.83 (d, *J* = 8.5 Hz, 2H), 7.71 (s, 2H), 7.69 (d, *J* = 2.1 Hz, 2H), 7.48 (t, *J* = 7.6 Hz, 2H), 7.38 (t, *J* = 7.3 Hz, 1H), 2.22 (s, 3H), 1.50 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.61, 140.66, 139.93, 137.96, 129.46 (2C), 128.13, 127.06 (2C), 126.97 (2C), 126.91 (2C), 79.87, 28.60 (3C), 14.14. **HRMS (ESI)** Calcd. For $C_{19}H_{22}N_2O_2$: $[M + H]^+$,311.1754. Found: *m/z,* 311.1753.



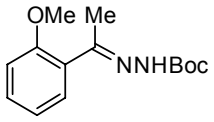
***Tert*-butyl-2-(1-(4-nitrophenyl)ethylidene)hydrazine-1-carboxylate (1k):** The title compound was obtained as a light yellow solid in 83% yield. **^{1}H NMR (400 MHz, DMSO)** δ 10.14 (s, 1H), 8.29 – 8.20 (m, 2H), 8.03 – 7.94 (m, 2H), 2.25 (s, 3H), 1.50 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.37, 147.54, 146.04, 145.07, 127.32 (2C), 123.88 (2C), 80.28, 28.48 (3C), 14.02. **HRMS (ESI)** Calcd. For $C_{13}H_{17}N_3O_4$: $[M + H]^+$, 280.1292. Found: *m/z,* 280.1291.



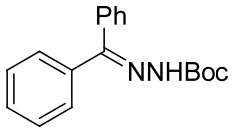
***Tert*-butyl-2-(1-(*m*-tolyl)ethylidene)hydrazine-1-carboxylate (1l):** The title compound was obtained as a white solid in 88% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.79 (s, 1H), 7.55 (s, 1H), 7.50 (d, *J* = 7.8 Hz, 1H), 7.27 (t, *J* = 7.6 Hz, 1H), 7.17 (d, *J* = 7.5 Hz, 1H), 2.33 (s, 3H), 2.17 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.14, 148.16, 138.46, 137.16, 129.26, 128.03, 126.42, 123.15, 79.23, 28.07 (3C), 21.01, 13.73. **HRMS (ESI)** Calcd. For $C_{14}H_{20}N_2O_2$: $[M + H]^+$, 249.1598. Found: *m/z,* 249.1597.



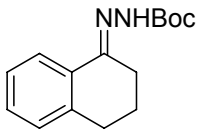
***Tert*-butyl-2-(1-(3-methoxyphenyl)ethylidene)hydrazine-1-carboxylate (1m):** The title compound was obtained as a white solid in 80% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.81 (s, 1H), 7.30 (dd, *J* = 6.3, 4.9 Hz, 1H), 7.29 (s, 1H), 7.28 – 7.26 (m, 1H), 6.97 – 6.91 (m, 1H), 3.77 (s, 3H), 2.17 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 159.13, 153.09, 139.94, 129.21, 118.44, 114.29, 111.16, 79.32, 54.99, 28.07 (3C), 13.80. **HRMS (ESI)** Calcd. For $C_{14}H_{20}N_2O_3$: $[M + H]^+$, 265.1547. Found: *m/z,* 265.1545.



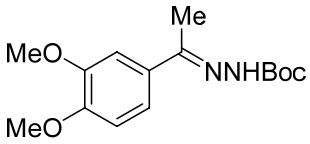
***Tert*-butyl-2-(1-(2-methoxyphenyl)ethylidene)hydrazine-1-carboxylate (1n):** The title compound was obtained as a white solid in 76% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.67 (s, 1H), 7.34 (ddd, *J* = 8.3, 7.4, 1.8 Hz, 1H), 7.21 (dd, *J* = 7.5, 1.8 Hz, 1H), 7.04 (d, *J* = 8.2 Hz, 1H), 6.93 (td, *J* = 7.4, 1.0 Hz, 1H), 3.79 (s, 3H), 2.09 (s, 3H), 1.46 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 156.93, 153.18, 150.37, 129.75, 129.43, 129.15, 120.12, 111.42, 79.15, 55.41, 28.09 (3C), 17.75. **HRMS (ESI)** Calcd. For $C_{14}H_{20}N_2O_3$: $[M + H]^+$, 265.1547. Found: *m/z,* 265.1544.



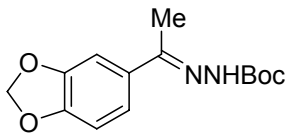
***Tert*-butyl-2-(diphenylmethylene)hydrazine-1-carboxylate (1o):** The title compound was obtained as a white solid in 90% yield. **^{1}H NMR (400 MHz, DMSO)** δ 8.60 (s, 1H), 7.63 – 7.51 (m, 3H), 7.45 – 7.39 (m, 2H), 7.39 – 7.34 (m, 3H), 7.28 (t, *J* = 1.9 Hz, 1H), 7.27 (t, *J* = 1.4 Hz, 1H), 1.43 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 152.08, 149.96, 137.41, 132.11, 129.48 (2C), 129.44, 129.13 (2C), 128.37 (2C), 128.29 (2C), 126.82, 80.01, 27.90 (3C). **HRMS (ESI)** Calcd. For $C_{18}H_{20}N_2O_2$: $[M + H]^+$, 297.1598. Found: *m/z,* 297.1596.



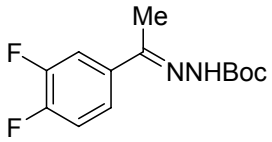
***Tert*-butyl-2-(3,4-dihydronaphthalen-1(2*H*)-ylidene)hydrazine-1-carboxylate (1p):** The title compound was obtained as a white solid in 92% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.74 (s, 1H), 7.96 (dd, *J* = 7.6, 1.1 Hz, 1H), 7.22 (pd, *J* = 7.2, 1.6 Hz, 2H), 7.15 (dd, *J* = 7.2, 1.2 Hz, 1H), 2.76 – 2.65 (m, 2H), 2.57 (t, *J* = 6.5 Hz, 2H), 1.85 – 1.71 (m, 2H), 1.49 (s, 9H). ^{13}C NMR (101 MHz, DMSO) δ 153.15, 148.07, 139.30, 132.60, 128.50, 128.40, 126.05, 124.19, 79.26, 28.87, 28.09 (3C), 25.56, 21.32. **HRMS (ESI)** Calcd. For $C_{15}H_{20}N_2O_2$: $[M + H]^+$, 261.1598. Found: *m/z,* 161.1595.



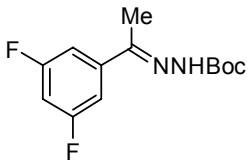
***Tert*-butyl-2-(1-(3,4-dimethoxyphenyl)ethylidene)hydrazine-1-carboxylate (1q):** The title compound was obtained as a white solid in 80% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.70 (s, 1H), 7.38 (d, *J* = 2.0 Hz, 1H), 7.23 (dd, *J* = 8.4, 2.1 Hz, 1H), 6.94 (d, *J* = 8.5 Hz, 1H), 3.78 (s, 3H), 3.77 (s, 3H), 2.16 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.15, 149.65, 148.38, 131.11, 119.06, 110.94, 108.84, 79.13, 55.41, 55.29, 28.08 (3C), 13.55. **HRMS (ESI)** Calcd. For $C_{15}H_{22}N_2O_4$: $[M + H]^+$, 295.1652. Found: *m/z,* 295.1651.



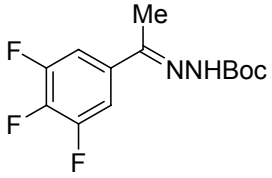
***Tert*-butyl-2-(1-(benzo[*d*][1,3]dioxol-5-yl)ethylidene)hydrazine-1-carboxylate (1r):** The title compound was obtained as a white solid in 84% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.74 (s, 1H), 7.31 (d, *J* = 1.7 Hz, 1H), 7.21 (dd, *J* = 8.2, 1.8 Hz, 1H), 6.91 (d, *J* = 8.2 Hz, 1H), 2.14 (s, 3H), 1.48 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.13, 147.83, 147.43, 132.81, 120.27, 107.68, 105.65, 101.20, 79.22, 28.07 (3C), 13.71. FTMS Calcd. For $C_{14}H_{18}N_2O_4$: exact mass, 278.1, $[M + H]^+$, 279.1.



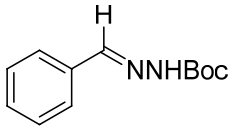
***Tert*-butyl-2-(1-(3,4-difluorophenyl)ethylidene)hydrazine-1-carboxylate (1s):** The title compound was obtained as a white solid in 90% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.94 (s, 1H), 7.73 (td, *J* = 10.3, 2.2 Hz, 1H), 7.61 – 7.54 (m, 1H), 7.45 (dd, *J* = 18.4, 9.3 Hz, 1H), 2.18 (s, 3H), 1.49 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 153.00, 149.65 (q, *J* = 250.68 Hz), 149.27 (q, *J* = 247.55 Hz) 145.80, 136.14 (t, *J* = 9.50 Hz), 122.74 (t, *J* = 9.90 Hz), 117.20 (q, *J* = 13.84 Hz), 114.53 (t, *J* = 19.19 Hz), 79.50, 28.02 (3C), 13.52. **HRMS (ESI)** Calcd. For $C_{13}H_{16}F_2N_2O_2$: $[M + H]^+$, 271.1253. Found: *m/z,* 271.1252.



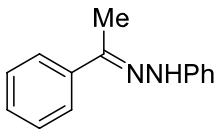
***Tert*-butyl-2-(1-(3,5-difluorophenyl)ethylidene)hydrazine-1-carboxylate (1t):** The title compound was obtained as a white solid in 93% yield. **^{1}H NMR (400 MHz, DMSO)** δ 10.04 (s, 1H), 7.46 – 7.36 (m, 2H), 7.24 (tt, *J* = 9.1, 2.3 Hz, 1H), 2.18 (s, 3H), 1.49 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 162.40 (q, *J* = 245.94 Hz, 2C), 152.90, 145.25, 142.25 (t, *J* = 18.99 Hz), 108.79 (q, *J* = 19.39 Hz, 2C), 103.70 (t, *J* = 52.42 Hz,), 79.64, 27.97 (3C), 13.44. **HRMS (ESI)** Calcd. For $C_{13}H_{16}F_2N_2O_2$: $[M + H]^+$, 271,1253. Found: *m/z,* 271.1252.



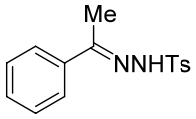
***Tert*-butyl-2-(1-(3,4,5-trifluorophenyl)ethylidene)hydrazine-1-carboxylate (1u):** The title compound was obtained as a white solid in 88% yield. **^{1}H NMR (400 MHz, DMSO)** δ 10.06 (s, 1H), 7.68 – 7.55 (m, 2H), 2.18 (s, 3H), 1.49 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 152.88, 150.13 (m, *J* = 247.15 Hz, 2C), 144.55, 138.12 (m, *J* = 251.15 Hz), 135.30 (m, *J* = 4.04 Hz), 110.19 (q, *J* = 6.06 Hz, 2C), 79.67, 27.96 (3C), 13.26. **HRMS (ESI)** Calcd. For $C_{13}H_{15}F_3N_2O_2$: $[M + H]^+$, 289.1156. Found: *m/z,* 289.1152.



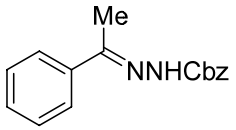
***Tert*-butyl-2-benzylidenehydrazine-1-carboxylate (1v):** The title compound was obtained as a white solid in 95% yield. **^{1}H NMR (400 MHz, DMSO)** δ 10.91 (s, 1H), 8.00 (s, 1H), 7.60 (dd, *J* = 7.9, 1.4 Hz, 2H), 7.44 – 7.33 (m, 3H), 1.47 (s, 9H). **^{13}C NMR (101 MHz, DMSO)** δ 152.36, 143.04, 134.59, 129.32, 128.68 (2C), 126.44 (2C), 79.38, 28.05 (3C).



1-phenyl-2-(1-phenylethylidene)hydrazine (1w): The title compound was obtained as a white solid in 77% yield. **^{1}H NMR (400 MHz, DMSO)** δ 9.27 (s, 1H), 7.79 (dt, *J* = 8.4, 1.8 Hz, 2H), 7.38 (t, *J* = 7.5 Hz, 2H), 7.32 – 7.19 (m, 5H), 6.76 (tt, *J* = 6.7, 1.8 Hz, 1H), 2.26 (s, 3H). **^{13}C NMR (101 MHz, DMSO)** δ 146.12, 140.42, 139.26, 128.88 (2C), 128.22 (2C), 127.42, 125.14 (2C), 118.84, 112.83 (2C), 12.78.

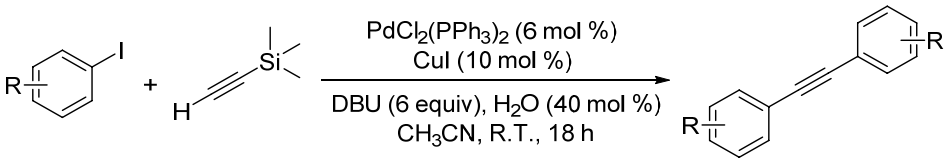


4-methyl-*N′*-(1-phenylethylidene)benzenesulfonohydrazide (1x): The title compound was obtained as a white solid in 82% yield. **^{1}H NMR (400 MHz, DMSO)** δ 10.51 (s, 1H), 7.82 (d, *J* = 8.3 Hz, 2H), 7.62 (ddd, *J* = 4.0, 3.0, 1.5 Hz, 2H), 7.41 (d, *J* = 8.0 Hz, 2H), 7.37 (dd, *J* = 6.7, 3.6 Hz, 3H), 2.36 (s, 3H), 2.18 (s, 3H). **^{13}C NMR (101 MHz, DMSO)** δ 153.13, 143.31, 137.36, 136.20, 129.42 (2C), 129.34, 128.32 (2C), 127.55 (2C), 125.92 (2C), 20.96, 14.25.



Benzyl-2-(1-phenylethylidene)hydrazine-1-carboxylate (1y): The title compound was obtained as a white solid in 81% yield. **^{1}H NMR (400 MHz, DMSO)** δ 10.25 (s, 1H), 7.79 – 7.74 (m, 1H), 7.74 – 7.71 (m, 1H), 7.47 – 7.43 (m, 2H), 7.43 – 7.41 (m, 1H), 7.40 (s, 2H), 7.38 (s, 2H), 7.37 – 7.33 (m, 1H), 5.21 (s, 2H), 2.23 (s, 3H). **^{13}C NMR (101 MHz, DMSO)** δ 154.13, 149.28, 138.29, 136.65, 128.84 (2C), 128.40 (2C), 128.22 (2C), 127.99 (2C), 126.01 (2C), 65.95, 13.89.

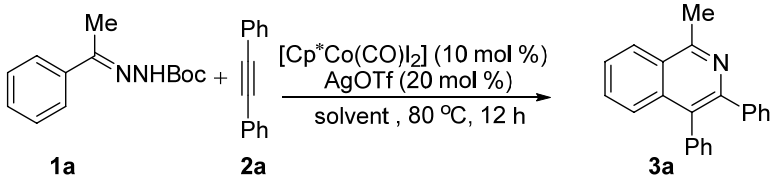
2.2 General Procedure for the Synthesis of Diaryl Substituted Alkynes



Following the literature procedure,[S3] a 25 mL round bottom flask with magnetic stir bar is fitted with a rubber septum and flame dried under vacuum. The flask is purged with dry argon, and charged with $PdCl_2(PPh_3)_2$ (16.8 mg, 6 mol%), CuI (15.2 mg, 10 mol%) and starting material substituted iodobenzene (1 equiv, 0.80 mmol). Septum is parafilmed after solids are added. While stirring, dry CH_3CN (4.0 mL) sparged with dry argon is added by syringe. Argon-sparged DBU (718 μL, 6 equiv) is then added by syringe, followed by a purge of the reaction flask with argon. 1-Trimethylsilylethyne (57 μL, 0.50 equiv) is then added by syringe, followed immediately by distilled water (5.8 μL, 40 mol %). The reaction flask is covered in aluminum foil and left stirring at a high rate of speed for 18 h, at the end of which the reaction mixture is partitioned in ethyl ether and distilled water (3 × 50 mL). The organic layer is washed with 10% HCl (3 × 75 mL), saturated aqueous NaCl (1 × 75 mL), dried over Na_2SO_4, gravity-filtered and the solvent removed in vacuo. The crude product is purified by silica gel column chromatography. For the known substrates, their spectroscopic data for the synthesized diacetylenes can be found on reference.[S3]

3. Optimization of Reaction Conditions

3.1 Table 1. Screening of Solvent[a,b]

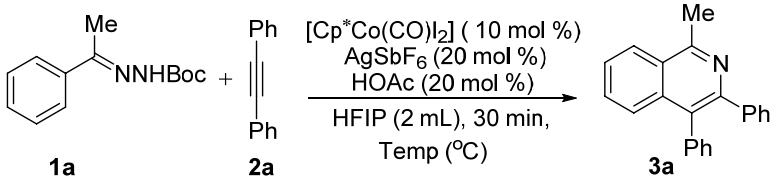


1a **2a** **3a**

entry	solvent	yield[b] (%)
1	DCE	0
2	CH3OH	0
3	CH3CN	0
4	THF	0
5	DMF	0
6	1,4-Dioxine	0
7	Toluene	0
8	TFE	34
9	HFIP	42

[a]Reaction conditions: **1a** (47 mg, 0.2 mmol), **2a** (53 mg, 0.3 mmol), [Cp*Co(CO)I2] (9.6 mg, 10 mol %), AgOTf (10.3 mg, 20 mol %), solvent (2 mL). [b]Isolated yields.

3.2 Table 2. Screening of the Reaction Temperature[a,b]

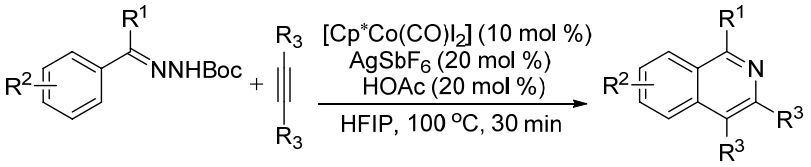


1a **2a** **3a**

entry	Temp (°C)	yield[b] (%)
1	50	34
2	80	56
3	100	83
4	120	81

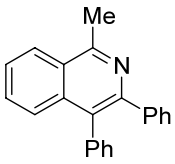
[a]Reaction conditions: **1a** (47 mg, 0.2 mmol), **2a** (53 mg, 0.3 mmol), [Cp*Co(CO)I2] (9.6 mg, 10 mol %), $AgSbF_6$ (13.7 mg, 20 mol %), HOAc (2.4 mg, 20 mol %), HFIP (2 mL). [b]Isolated yields.

4. Synthesis and Characterization of Isoquinolines

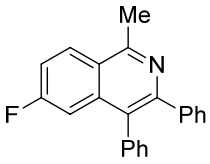


1a-1u **2a-2g** **3a-3u, 4b-4g**

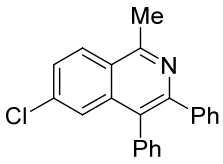
A 15 mL pressure pipe was equipped with a magnetic stir bar. Additionally the *tert*-butyl-2-(1-phenylethylidene) hydrazine-1-carboxylate (e.g. **1a**, 47 mg, 0.2 mmol), [Cp*Co(CO)I_2] (9.6 mg, 10 mol %) and the diaryl substituted alkyne (e.g. **2a**, 53 mg, 0.3 mmol) were added. $AgSbF_6$ (13.7 mg, 20 mol %) was added in the Glovebox. Under an Argon-atmosphere HOAc (2.4 mg, 20 mol %) and HFIP (2.0 mL) were added and the resulting mixture was stirred at 100 °C for 30 min in an oil bath. The reaction was cooled to room temperature and diluted in EtOAc (5.0 mL). The resulting mixture was transferred to a round bottom flask and adsorbed on silica gel and the residue was purified by flash column chromatography on silica gel with hexanes/EtOAc as the eluent to give the corresponding isoquinolines (e.g. **3a**, 50 mg, 85% yield). For the known substrates, their high-resolution mass spectra (HRMS) can be found on reference.[S4-S9]



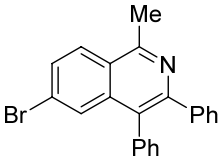
1-methyl-3,4-diphenylisoquinoline (3a): The title compound was obtained as a white solid in 85% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.24 – 8.17 (m, 1H), 7.66 (dt, *J* = 6.9, 3.1 Hz, 1H), 7.62 – 7.56 (m, 2H), 7.38 (d, *J* = 1.9 Hz, 1H), 7.37 – 7.34 (m, 2H), 7.34 – 7.29 (m, 2H), 7.23 (d, *J* = 2.1 Hz, 1H), 7.22 (dd, *J* = 3.4, 1.9 Hz, 1H), 7.20 (d, *J* = 5.9 Hz, 1H), 7.19 – 7.13 (m, 2H), 3.09 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.81, 149.52, 141.14, 137.72, 136.10, 131.53 (2C), 130.43 (2C), 130.03, 129.29, 128.34 (2C), 127.74 (2C), 127.25, 127.06, 126.64, 126.32, 126.25, 125.61, 22.89.



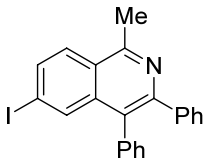
6-fluoro-1-methyl-3,4-diphenylisoquinoline (3b): The title compound was obtained as a white solid in 73% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.22 (dd, *J* = 9.1, 5.7 Hz, 1H), 7.41 – 7.29 (m, 6H), 7.25 (dd, *J* = 7.4, 5.9 Hz, 1H), 7.19 (ddd, *J* = 6.9, 5.1, 2.7 Hz, 5H), 3.07 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ163.25 (d, *J* = 252.5 Hz) 157.57, 150.39, 140.62, 138.10 (d, *J* = 17.17 Hz), 137.15, 131.24 (2C), 130.26 (2C), 129.06 (d, *J* = 5.05 Hz), 128.69 (d, *J* = 10.1 Hz), 128.46 (2C), 127.70 (2C), 127.44, 127.23, 123.47, 116.76 (d, *J* = 252.5 Hz), 109.93 (d, *J* = 252.5 Hz), 22.83.



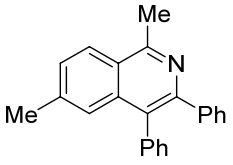
6-chloro-1-methyl-3,4-diphenylisoquinoline (3c): The title compound was obtained as a white solid in 75% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.13 (d, *J* = 8.9 Hz, 1H), 7.63 (d, *J* = 2.0 Hz, 1H), 7.52 (dd, *J* = 8.9, 2.1 Hz, 1H), 7.39 – 7.31 (m, 5H), 7.19 (ddd, *J* = 6.6, 5.1, 2.6 Hz, 5H), 3.06 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.72, 150.63, 140.63, 137.16, 136.90, 136.44, 131.32 (2C), 130.25 (2C), 128.51, 128.48 (2C), 127.71 (2C), 127.50, 127.40, 127.24, 125.15, 124.44, 22.77.



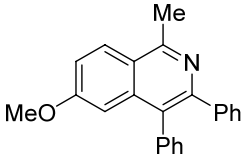
6-bromo-1-methyl-3,4-diphenylisoquinoline (3d): The title compound was obtained as a white solid in 81% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.06 (d, *J* = 8.9 Hz, 1H), 7.81 (d, *J* = 1.9 Hz, 1H), 7.67 (dd, *J* = 8.9, 1.9 Hz, 1H), 7.40 – 7.30 (m, 5H), 7.24 – 7.13 (m, 5H), 3.06 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.83, 150.61, 140.59, 137.44, 136.83, 131.32 (2C), 130.24 (2C), 130.07, 128.47 (2C), 128.45, 128.37, 127.70 (2C), 127.51, 127.35, 127.24, 125.14, 124.62, 22.69.



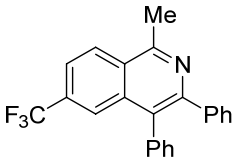
6-iodo-1-methyl-3,4-diphenylisoquinoline (3e): The title compound was obtained as a white solid in 83% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.04 (d, *J* = 1.4 Hz, 1H), 7.91 (d, *J* = 8.7 Hz, 1H), 7.86 (dd, *J* = 8.8, 1.6 Hz, 1H), 7.38 – 7.31 (m, 5H), 7.19 (tt, *J* = 4.0, 1.9 Hz, 5H), 3.06 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.93, 150.42, 140.57, 137.57, 136.77, 135.41, 135.11, 131.35 (2C), 130.24 (2C), 128.46 (2C), 128.04, 127.70 (2C), 127.51, 127.24, 127.04, 124.89, 97.82, 22.60.



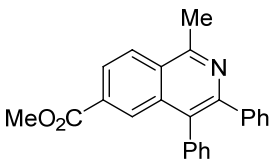
1,6-dimethyl-3,4-diphenylisoquinoline (3f): The title compound was obtained as a white solid in 87% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.10 (d, *J* = 8.3 Hz, 1H), 8.10 (d, *J* = 8.3 Hz, 1H), 7.45 – 7.39 (m, 2H), 7.46 – 7.28 (m, 7H), 7.38 – 7.34 (m, 2H), 7.33 (dd, *J* = 4.9, 2.8 Hz, 3H), 7.24 – 7.21 (m, 1H), 7.21 – 7.19 (m, 1H), 7.26 – 7.12 (m, 6H), 7.19 – 7.17 (m, 1H), 7.18 – 7.11 (m, 2H), 3.05 (s, 3H), 2.43 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.41, 149.60, 141.18, 140.28, 137.78, 136.27, 131.49 (2C), 130.29 (2C), 128.80, 128.75, 128.20 (2C), 127.60 (2C), 127.06, 126.88, 125.50, 125.13, 124.59, 22.68, 22.17.



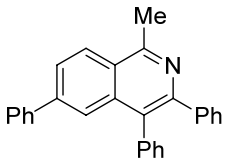
6-methoxy-1-methyl-3,4-diphenylisoquinoline (3g): The title compound was obtained as a white solid in 78% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.11 (d, *J* = 9.1 Hz, 1H), 7.36 (t, *J* = 2.4 Hz, 1H), 7.35 – 7.33 (m, 2H), 7.32 (s, 1H), 7.32 – 7.27 (m, 1H), 7.24 – 7.22 (m, 1H), 7.22 – 7.21 (m, 1H), 7.20 (t, *J* = 2.2 Hz, 1H), 7.19 – 7.17 (m, 1H), 7.17 (d, *J* = 1.9 Hz, 1H), 7.16 – 7.11 (m, 1H), 6.92 (d, *J* = 2.5 Hz, 1H), 3.73 (s, 3H), 3.02 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 160.60, 157.04, 150.13, 141.19, 138.11, 137.89, 131.33 (2C), 130.27 (2C), 128.64, 128.32 (2C), 127.61 (2C), 127.51, 127.14, 126.92, 121.91, 118.75, 104.51, 55.24, 22.67.



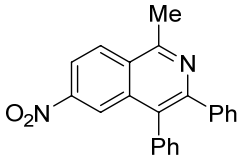
1-methyl-3,4-diphenyl-6-(trifluoromethyl)isoquinoline (3h): The title compound was obtained as a white solid in 69% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.33 (d, *J* = 8.7 Hz, 1H), 7.97 (s, 1H), 7.77 (dd, *J* = 8.8, 1.6 Hz, 1H), 7.42 – 7.32 (m, 5H), 7.25 – 7.18 (m, 5H), 3.12 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.94, 150.86, 140.35, 136.44, 135.48, 131.60 (q, *J* = 33.33 Hz), 131.27 (2C), 130.24 (2C), 129.83, 128.55 (2C), 127.78 (2C), 127.73, 127.40, 127.04, 126.92, 124.03 (q, *J* = 172.71 Hz), 123.95 (q, *J* = 5.05 Hz), 122.29 (q, *J* = 3.03 Hz), 22.76.



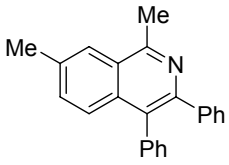
methyl 1-methyl-3,4-diphenylisoquinoline-6-carboxylate (3i): The title compound was obtained as a white solid in 71% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.59 (d, *J* = 9.2 Hz, 1H), 7.40 (d, *J* = 2.5 Hz, 1H), 7.36 (d, *J* = 1.9 Hz, 1H), 7.34 (d, *J* = 1.2 Hz, 2H), 7.32 (d, *J* = 5.2 Hz, 2H), 7.26 (dd, *J* = 9.2, 2.6 Hz, 2H), 7.22 (d, *J* = 2.2 Hz, 1H), 7.20 (t, *J* = 2.2 Hz, 1H), 7.18 (s, 1H), 7.16 (d, *J* = 6.1 Hz, 2H), 3.99 (s, 3H), 3.06 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 166.65, 157.85, 150.38, 140.51, 136.74, 135.53, 131.39 (2C), 131.21, 130.26 (2C), 130.14, 128.94, 128.43 (2C), 127.71 (2C), 127.68, 127.55, 127.24, 126.09, 126.01, 52.49, 22.77.



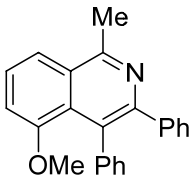
1-methyl-3,4,6-triphenylisoquinoline (3j): The title compound was obtained as a white solid in 89% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.26 (d, *J* = 9.2 Hz, 1H), 7.89 – 7.80 (m, 2H), 7.59 – 7.50 (m, 2H), 7.42 (t, *J* = 7.4 Hz, 2H), 7.38 – 7.35 (m, 3H), 7.34 (d, *J* = 1.2 Hz, 1H), 7.31 (dd, *J* = 4.9, 3.1 Hz, 2H), 7.26 (d, *J* = 1.9 Hz, 1H), 7.24 (d, *J* = 1.5 Hz, 1H), 7.22 (d, *J* = 4.2 Hz, 1H), 7.20 (s, 1H), 7.18 (dd, *J* = 4.7, 2.9 Hz, 2H), 3.09 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.65, 149.96, 142.66, 141.00, 140.47, 137.45, 136.44, 131.48 (2C), 130.31 (2C), 129.57, 128.97 (2C), 128.33 (2C), 128.02, 127.70 (2C), 127.57 (2C), 127.28, 127.07, 126.33, 126.28, 125.29, 124.06, 22.63.



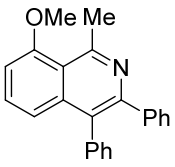
1-methyl-6-nitro-3,4-diphenylisoquinoline (3k): The title compound was obtained as a white solid in 45% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.59 (d, *J* = 1.9 Hz, 1H), 8.38 – 8.30 (m, 2H), 7.40 (dd, *J* = 4.9, 1.7 Hz, 3H), 7.38 (d, *J* = 3.8 Hz, 1H), 7.36 (d, *J* = 2.2 Hz, 1H), 7.22 (dd, *J* = 7.2, 3.2 Hz, 5H), 3.14 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 158.13, 151.52, 148.33, 139.84, 135.94, 135.91, 131.22 (2C), 130.58, 130.24 (2C), 128.76 (2C), 128.08, 127.85 (2C), 127.80, 127.76, 127.67, 122.74, 119.99, 22.92.



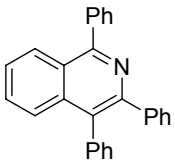
1,7-dimethyl-3,4-diphenylisoquinoline (3l): The title compound was obtained as a white solid in 72% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.95 (s, 1H), 7.55 (d, *J* = 8.6 Hz, 1H), 7.42 (dd, *J* = 8.7, 1.5 Hz, 1H), 7.36 (d, *J* = 1.8 Hz, 1H), 7.35 – 7.33 (m, 2H), 7.33 – 7.28 (m, 2H), 7.22 (d, *J* = 2.1 Hz, 1H), 7.20 (d, *J* = 1.7 Hz, 1H), 7.18 (s, 1H), 7.17 – 7.10 (m, 2H), 3.05 (s, 3H), 2.57 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.05, 148.62, 141.05, 137.77, 136.46, 134.23, 132.14, 131.42 (2C), 130.30 (2C), 129.14, 128.19 (2C), 127.61 (2C), 127.09, 126.86, 126.37, 126.15, 124.55, 22.73, 21.92.



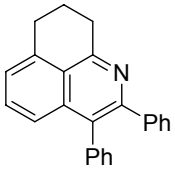
5-methoxy-1-methyl-3,4-diphenylisoquinoline (3m): The title compound was obtained as a white solid in 69% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.58 (d, *J* = 9.2 Hz, 1H), 7.39 (d, *J* = 2.6 Hz, 1H), 7.36 – 7.34 (m, 1H), 7.34 – 7.32 (m, 2H), 7.31 (dd, *J* = 4.6, 2.8 Hz, 2H), 7.24 (dd, *J* = 6.9, 2.3 Hz, 1H), 7.21 (d, *J* = 2.2 Hz, 1H), 7.21 – 7.20 (m, 1H), 7.19 (d, *J* = 3.9 Hz, 1H), 7.16 (dd, *J* = 7.5, 5.2 Hz, 2H), 3.98 (s, 3H), 3.03 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.92, 156.06, 147.71, 141.02, 137.69, 131.38 (2C), 130.26 (2C), 129.29, 128.20 (2C), 128.06, 127.63 (2C), 127.38, 127.14, 126.81, 122.36, 103.53, 55.53, 22.82.



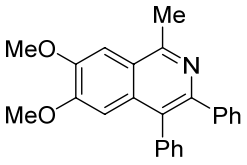
8-methoxy-1-methyl-3,4-diphenylisoquinoline (3n): The title compound was obtained as a white solid in 46% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.45 (dd, *J* = 8.4, 7.9 Hz, 1H), 7.39 – 7.35 (m, 1H), 7.35 (dd, *J* = 2.8, 1.3 Hz, 1H), 7.34 – 7.32 (m, 1H), 7.32 – 7.27 (m, 2H), 7.21 (d, *J* = 2.1 Hz, 1H), 7.20 – 7.19 (m, 1H), 7.17 (ddd, *J* = 6.2, 3.4, 1.3 Hz, 4H), 6.91 (d, *J* = 7.7 Hz, 1H), 4.02 (s, 3H), 3.22 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 158.25, 157.60, 149.20, 140.55, 138.94, 138.02, 131.42 (2C), 130.36, 130.24 (2C), 128.60, 128.21(2C), 127.60 (2C), 127.10, 127.06, 119.10, 118.43, 106.06, 55.62, 29.12.



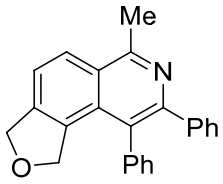
1,3,4-triphenylisoquinoline (3o): The title compound was obtained as a white solid in 85% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.18 (d, *J* = 8.3 Hz, 1H), 7.87 – 7.78 (m, 2H), 7.72 (d, *J* = 8.4 Hz, 1H), 7.64 – 7.47 (m, 5H), 7.45 – 7.40 (m, 2H), 7.36 (dt, *J* = 7.7, 4.6 Hz, 3H), 7.30 (dd, *J* = 7.6, 1.7 Hz, 2H), 7.22 – 7.12 (m, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 159.84, 149.67, 140.90, 139.81, 137.58, 137.03, 131.39 (2C), 130.49 (2C), 130.27 (2C), 130.00, 129.84, 128.58, 128.35 (2C), 128.34 (2C), 127.58 (2C), 127.56, 127.33, 127.04, 126.63, 126.07, 125.49.



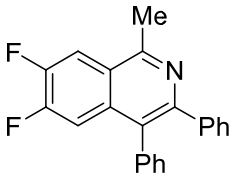
2,3-diphenyl-8,9-dihydro-7*H*-benzo[de]quinoline (3p): The title compound was obtained as a yellow solid in 86% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.52 – 7.44 (m, 2H), 7.38 – 7.33 (m, 4H), 7.33 – 7.27 (m, 2H), 7.22 (d, *J* = 2.0 Hz, 1H), 7.21 (dd, *J* = 3.3, 2.0 Hz, 1H), 7.19 (t, *J* = 3.2 Hz, 1H), 7.17 (t, *J* = 3.8 Hz, 2H), 3.40 (t, *J* = 6.2 Hz, 2H), 3.20 (t, *J* = 6.1 Hz, 2H), 2.34 – 2.21 (m, 2H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 159.31, 149.40, 141.08, 138.58, 137.80, 136.30, 131.39 (2C), 130.29 (2C), 130.08, 129.16, 128.18 (2C), 127.64 (2C), 127.07, 126.95, 124.82, 123.94, 123.60, 34.68, 30.76, 23.44.



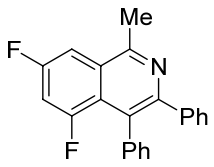
6,7-dimethoxy-1-methyl-3,4-diphenylisoquinoline (3q): The title compound was obtained as a white solid in 50% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.37 (s, 1H), 7.34 (d, *J* = 1.5 Hz, 2H), 7.33 – 7.30 (m, 3H), 7.23 (d, *J* = 1.7 Hz, 1H), 7.22 (s, 1H), 7.21 – 7.14 (m, 3H), 6.93 (s, 1H), 4.08 (s, 3H), 3.77 (s, 3H), 3.02 (s, 3H).**^{13}C NMR (101 MHz, $CDCl_3$)** δ 154.99, 152.44, 149.56, 148.51, 141.05, 137.94, 132.69, 131.24 (2C), 130.21 (2C), 128.52, 128.30 (2C), 127.58 (2C), 127.15, 126.79, 122.10, 104.66, 103.80, 56.07, 55.77, 22.72.



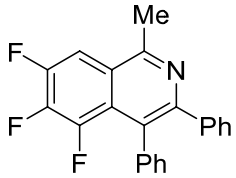
6-methyl-8,9-diphenyl-1,3-dihydrofuro[3,4-*f*]isoquinoline (3r): The title compound was obtained as a white solid in 60% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.84 (d, *J* = 8.8 Hz, 1H), 7.29 (d, *J* = 2.1 Hz, 1H), 7.29 – 7.24 (m, 3H), 7.23 (s, 1H), 7.23 – 7.17 (m, 4H), 7.16 (d, *J* = 6.7 Hz, 2H), 5.85 (s, 2H), 3.01 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.83, 150.11, 147.72, 141.73, 140.73, 138.38, 131.19 (2C), 130.22 (2C), 127.53 (2C), 127.10 (2C), 126.89, 126.83, 124.89, 123.26, 122.54, 121.01, 110.95, 101.48, 23.39.



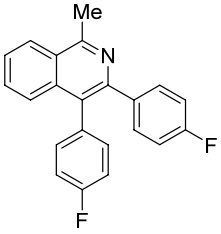
6,7-difluoro-1-methyl-3,4-diphenylisoquinoline (3s): The title compound was obtained as a white solid in 67% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.01 (ddd, *J* = 9.2, 4.9, 1.8 Hz, 1H), 7.46 (td, *J* = 9.4, 6.9 Hz, 1H), 7.29 – 7.23 (m, 5H), 7.19 (ddd, *J* = 11.8, 5.1, 1.9 Hz, 5H), 3.05 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.49, 152.20, 150.54 (q, *J* = 252.40 Hz), 147.20 (d, *J* = 252.40 Hz) 144.64 (d, *J* = 11.21 Hz), 140.40, 138.56 (d, *J* = 3.94 Hz), 130.51 (q, *J* = 3.64 Hz), 130.15 (2C), 127.58 (2C), 127.46 (2C), 127.17, 127.05, 125.77 (q, *J* = 3.54 Hz), 124.17, 122.75 (q, *J* = 2.22 Hz), 117.49, 117.29, 23.10. FTMS Calcd. For $C_{22}H_{15}F_2N$: exact mass, 331.1, $[M+H]^+$, 332.1.



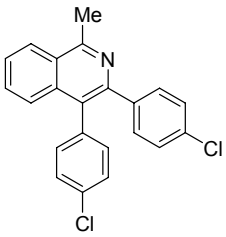
5,7-difluoro-1-methyl-3,4-diphenylisoquinoline (3t): The title compound was obtained as a white solid in 76% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.65 (ddd, *J* = 9.2, 2.4, 1.3 Hz, 1H), 7.27 – 7.23 (m, 5H), 7.20 – 7.13 (m, 5H), 7.09 (ddd, *J* = 11.8, 8.5, 2.5 Hz, 1H), 3.03 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 159.95 (q, *J* = 263.51 Hz), 159.73 (q, *J* = 250.88 Hz), 156.85 (q, *J* = 5.76 Hz), 151.06 (d, *J* = 2.63 Hz), 140.42, 138.82 (d, *J* = 4.04 Hz), 130.42, 130.38, 130.15 (2C), 127.94 (q, *J* = 8.99 Hz), 127.57 (2C), 127.41 (2C), 127.06, 126.99, 125.84 (t, *J* = 4.44 Hz), 123.41 (q, *J* = 9.19 Hz), 106.93 (q, *J* = 28.38 Hz), 105.74 (q, *J* = 20.71 Hz), 23.20. FTMS Calcd. For $C_{22}H_{15}F_2N$: exact mass, 331.1, $[M+H]^+$, 332.1.



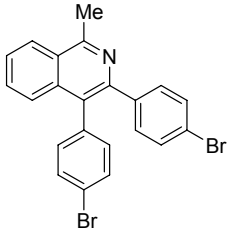
5,6,7-trifluoro-1-methyl-3,4-diphenylisoquinoline (3u): The title compound was obtained as a white solid in 77% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 7.81 – 7.73 (m, 1H), 7.25 (ddd, *J* = 7.2, 6.3, 2.7 Hz, 5H), 7.21 – 7.14 (m, 5H), 3.02 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 156.78 (m, *J* = 5.25 Hz), 151.89 (d, *J* = 2.63 Hz), 151.05 (q, *J* = 12.08 Hz), 148.57 (m, *J* = 21.01 Hz), 146.16 (q, *J* = 71.51 Hz), 142.89 (q, *J* = 33.43 Hz), 140.34 (q, *J* = 33.43 Hz), 140.14, 138.03 (d, *J* = 3.84 Hz), 130.43 (d, *J* = 3.64 Hz), 130.11 (2C), 127.63 (2C), 127.58 (2C), 127.27, 125.61 (m, *J* = 8.69 Hz), 124.29 (q, *J* = 6.26 Hz), 122.03 (m, *J* = 7.27 Hz), 107.13 (q, *J* = 17.07 Hz), 23.05. FTMS Calcd. For $C_{22}H_{14}F_3N$: exact mass, 349.1, $[M+H]^+$, 350.1.



3,4-bis(4-fluorophenyl)-1-methylisoquinoline (4b): The title compound was obtained as a white solid in 61% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.24 – 8.16 (m, 1H), 7.64 – 7.57 (m, 3H), 7.36 – 7.28 (m, 2H), 7.22 – 7.13 (m, 2H), 7.10 – 7.02 (m, 2H), 6.96 – 6.85 (m, 2H), 3.07 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ162.10 (d, *J* = 248.46 Hz), 162.03 (d, *J* = 247.45 Hz), 158.15, 148.59, 136.87 (d, *J* = 4.04 Hz), 136.02, 133.32 (d, *J* = 3.03 Hz), 132.96 (d, *J* = 7.07 Hz, 2C), 132.04, 131.96, (d, *J* = 8.08 Hz, 2C), 130.29, 128.19, 126.82, 126.24, 125.95, 125.71, 115.51 (d, *J* = 21.21 Hz, 2C), 114.73 (d, *J* = 21.21 Hz, 2C), 22.72.

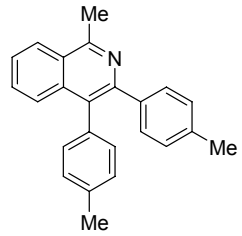


3,4-bis(4-chlorophenyl)-1-methylisoquinoline (4c): The title compound was obtained as a white solid in 65% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.26 – 8.18 (m, 1H), 7.62 (dt, *J* = 5.1, 3.5 Hz, 3H), 7.39 – 7.33 (m, 2H), 7.32 – 7.27 (m, 2H), 7.23 – 7.18 (m, 2H), 7.18 – 7.12 (m, 2H), 3.07 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 158.39, 148.20, 139.18, 135.81, 135.77, 133.50, 133.29, 132.67 (2C), 131.63 (2C), 130.37, 128.77 (2C), 128.09, 128.05 (2C), 126.98, 126.28, 125.90, 125.74, 22.76.

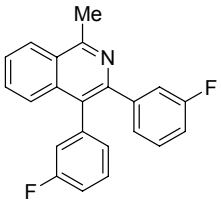


3,4-bis(4-bromophenyl)-1-methylisoquinoline (4d): The title compound was obtained as a white solid in 61% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.24 – 8.17 (m, 1H), 7.65 – 7.57 (m, 3H), 7.51 (d, *J* = 8.4 Hz, 2H), 7.36 (d, *J* = 8.5 Hz, 2H), 7.23 (d, *J* = 8.5 Hz, 2H), 7.09 (d, *J* = 8.4

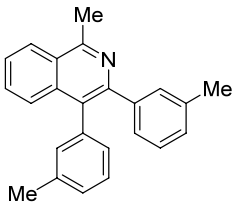
Hz, 2H), 3.06 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 158.44, 148.06, 139.50, 136.23, 135.72, 132.97, 131.93, 131.73, 131.00, 130.43, 128.10, 127.02, 126.27, 125.89, 125.75, 121.69, 22.69.



1-methyl-3,4-di-*p*-tolylisoquinoline (4e): The title compound was obtained as a white solid in 69% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.20 – 8.14 (m, 1H), 7.68 – 7.62 (m, 1H), 7.60 – 7.53 (m, 2H), 7.28 (d, *J* = 8.1 Hz, 2H), 7.16 (d, *J* = 7.9 Hz, 2H), 7.11 (d, *J* = 8.0 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 3.06 (s, 3H), 2.39 (s, 3H), 2.28 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.51, 149.38, 138.27, 136.69, 136.57, 136.34, 134.69, 131.28 (2C), 130.23 (2C), 129.86, 129.05 (2C), 129.02, 128.46 (2C), 126.40, 126.34, 126.13, 125.55, 22.71, 21.39, 21.26.



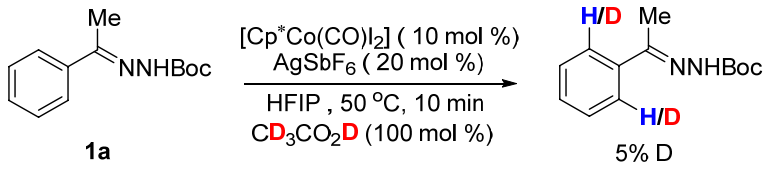
3,4-bis(3-fluorophenyl)-1-methylisoquinoline (4f): The title compound was obtained as a white solid in 51% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.26 – 8.18 (m, 1H), 7.67 – 7.60 (m, 3H), 7.34 (td, *J* = 7.9, 6.0 Hz, 1H), 7.19 – 7.11 (m, 2H), 7.10 (d, *J* = 7.8 Hz, 1H), 7.08 – 7.03 (m, 1H), 7.01 (d, *J* = 7.6 Hz, 1H), 6.98 – 6.93 (m, 1H), 6.90 (td, *J* = 8.0, 1.5 Hz, 1H), 3.08 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 162.72 (d, *J* = 248.46 Hz), 162.42 (d, *J* = 245.43 Hz), 158.47, 148.01, 147.99, 142.89 (d, *J* = 8.08 Hz), 139.45 (d, *J* = 8.08 Hz), 135.65, 130.41, 129.99 (d, *J* = 8.08 Hz), 129.19 (d, *J* = 9.09 Hz), 128.24 (d, *J* = 3.03 Hz), 127.19 (d, *J* = 3.03 Hz), 127.08, 126.33, 125.98, 125.93, 125.71, 118.26 (d, *J* = 22.22 Hz), 117.15 (d, *J* = 22.22 Hz), 114.52 (d, *J* = 21.21 Hz), 114.22 (d, *J* = 21.21 Hz), 22.75.



methyl-3,4-di-*m*-tolylisoquinoline (4g): The title compound was obtained as a white solid in 53% yield. **^{1}H NMR (400 MHz, $CDCl_3$)** δ 8.21 – 8.14 (m, 1H), 7.69 – 7.62 (m, 1H), 7.60 – 7.52 (m, 2H), 7.29 (s, 1H), 7.20 (d, *J* = 7.5 Hz, 1H), 7.12 (d, *J* = 7.6 Hz, 1H), 7.08 (d, *J* = 7.7 Hz, 1H), 7.04 (d, *J* = 7.6 Hz, 2H), 6.98 (dd, *J* = 13.2, 8.0 Hz, 2H), 3.07 (s, 3H), 2.31 (s, 3H), 2.25 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$)** δ 157.54, 149.44, 140.89, 137.66, 137.59, 137.12, 136.17, 132.06, 131.06, 129.88, 129.35, 128.52, 128.10, 127.85, 127.75, 127.42, 127.36, 126.47, 126.42, 126.14, 125.53, 22.77, 21.51 (2C).

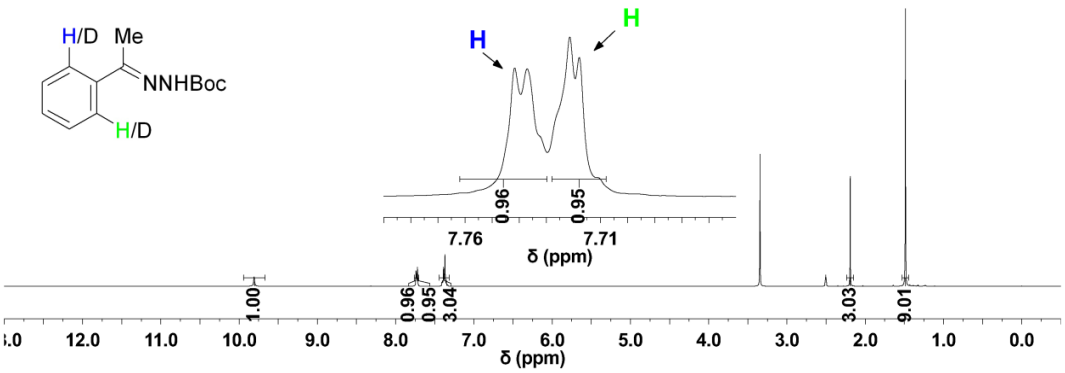
5. Mechanistic Experiments

5.1 H/D Exchange

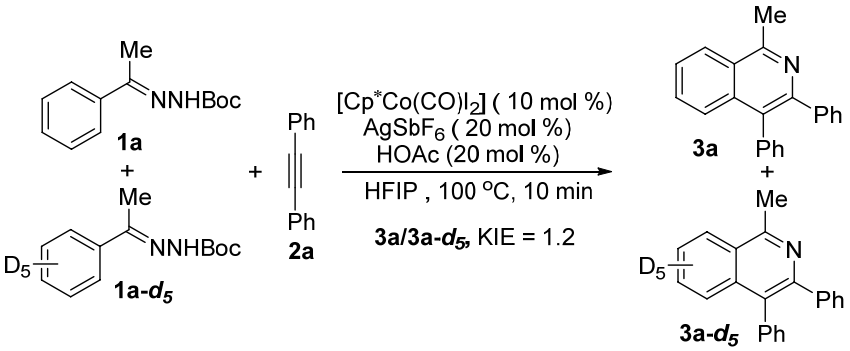


As per general procedure, the reaction was carried out with *tert*-butyl-2-(1-phenylethylidene) hydrazine-1-carboxylate (47 mg, 0.2 mmol), [Cp*Co(CO)I_2] (9.6 mg, 10 mol %), $AgSbF_6$ (13.7 mg, 20 mol %), $CDCO_2D$ (12 mg,

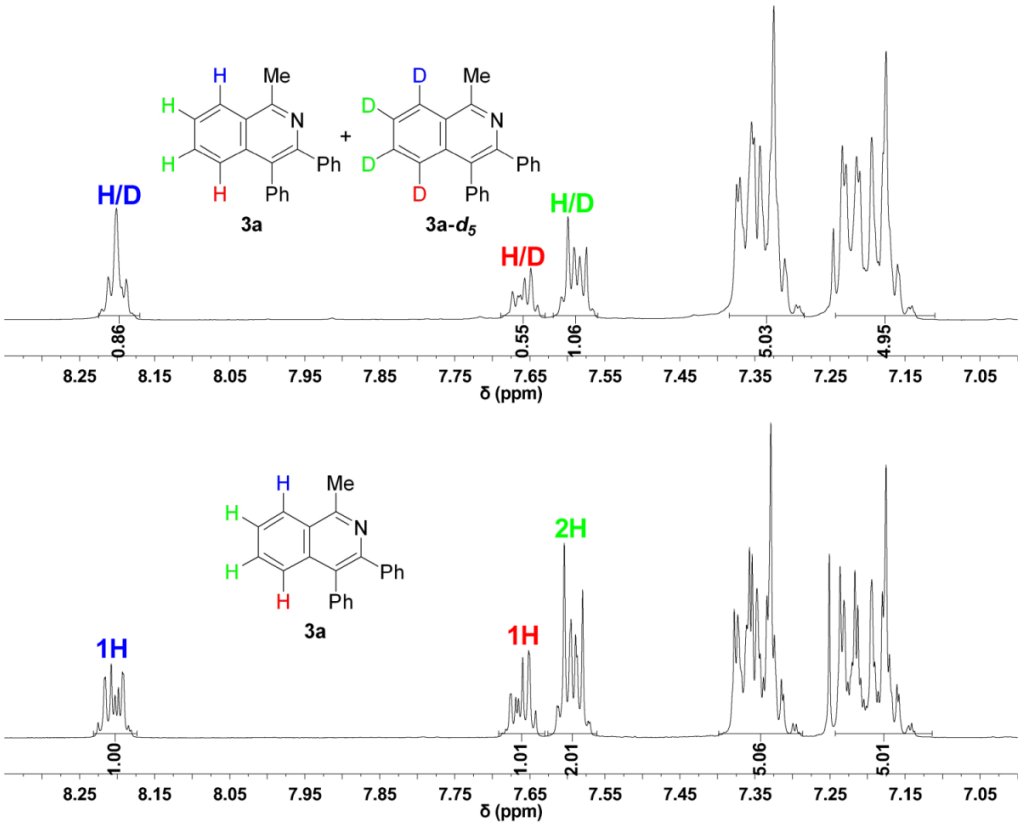
100 mol %) and HFIP (2.0 mL) at 50 °C for 10 min. The reaction was cooled to room temperature and the resulting mixture was transferred to a round bottom flask and adsorbed on silica gel and the residue was purified by flash column chromatography on silica gel with hexanes/EtOAc as the eluent. The H/D exchange (D/H = 23%) was calculated by ^{1}H NMR (400 MHz, DMSO).



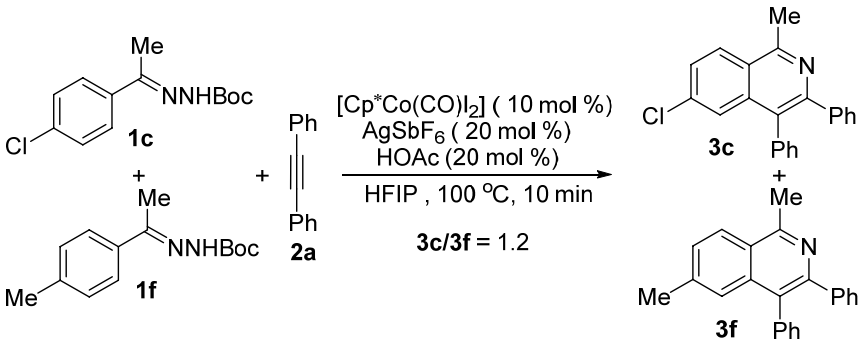
5.2 Kinetic Isotope Effect



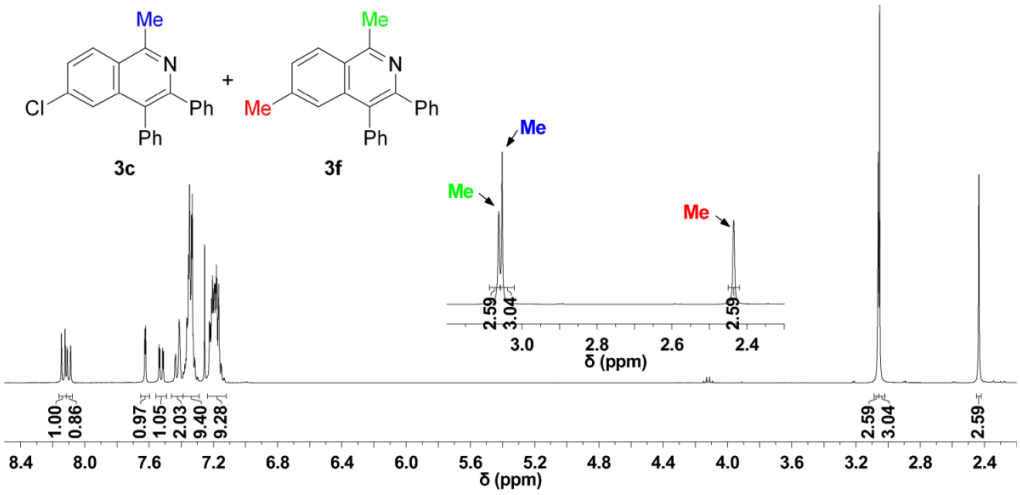
As per general procedure, the reaction was carried out with *tert*-butyl-2-(1-phenylethylidene) hydrazine-1-carboxylate (47 mg, 0.2 mmol), d_5-*tert*-butyl-2-(1-phenylethylidene) hydrazine-1-carboxylate (47.8 mg, 0.2 mmol;), [Cp*Co(CO)I_2] (9.6 mg, 10 mol %), diphenylacetylene (35.6 mg, 0.20 mmol), $AgSbF_6$ (13.7 mg, 20 mol %), HOAc (2.4 mg, 20 mol %) and HFIP (2.0 mL) at 100 °C for 10 min. The reaction was cooled to room temperature and the resulting mixture was transferred to a round bottom flask and adsorbed on silica gel and the residue was purified by flash column chromatography on silica gel with hexanes/EtOAc as the eluent to give the mixed **3a** and **3a-*d_5*** (20 mg, 34% yield). The ratio of H/D (KIE = 1.2) was calculated by ^{1}H NMR (400 MHz, $CDCl_3$).



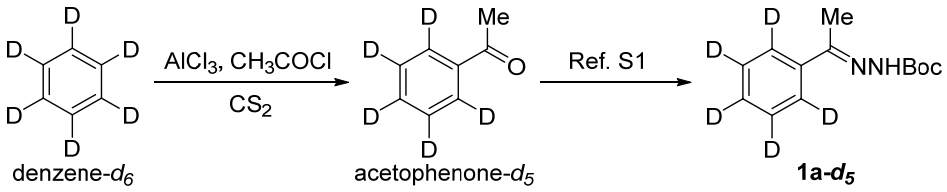
5.3 Competition Experiment



As per general procedure, the reaction was carried out with *tert*-butyl-2-(1-(4-chlorophenyl)ethylidene) hydrazine-1-carboxylate **1c** (53.6 mg, 0.2 mmol), *tert*-butyl-2-(1-(*p*-tolyl)ethylidene)hydrazine-1-carboxylate **1f** (49.6 mg, 0.2 mmol), [Cp*Co(CO)I_2] (9.6 mg, 10 mol %), diphenylacetylene (35.6 mg, 0.2 mmol), $AgSbF_6$ (13.7 mg, 20 mol %), HOAc (2.4 mg, 20 mol %) and HFIP (2.0 mL) at 100 °C for 10 min. The reaction was cooled to room temperature and the resulting mixture was transferred to a round bottom flask and adsorbed on silica gel and the residue was purified by flash column chromatography on silica gel with hexanes/EtOAc as the eluent to give the give the mixed **3c** and **3f** (40 mg). The ratio of **3c** and **3f** (**3c**/**3f** = 1.2) was calculated by ^{1}H NMR (400 MHz, $CDCl_3$).



5.4 Preparation of 1a-d_5



Following the literature procedure,[S10] denzene-d_6 (1.2 ml, 12.8 mmol), $AlCl_3$ (2.14 g, 16 mmol), and anhydrous CS_2 (3.0 mL) were added to a 25-mL flask under N_2 atmosphere. To the mixture was dropwise added a solution of acetyl chloride (1.26 g, 16 mmol) in anhydrous CS_2 (5.0 mL) at 0 °C. The resulting mixture was allowed to warm to ambient temperature and was stirred for 5 h. Then the mixture was heated to 50 °C for 3 h. After cooling to ambient temperature, the resulting mixture was poured into ice water and extracted with CH_2Cl_2 (3 × 30 mL). The organic layer was washed with saturated aqueous Na_2CO_3 (30 mL) and brine (20 mL), and then dried over Na_2SO_4. After concentration under reduced pressure, purification by column chromatography on silica gel (hexanes/EtOAc) afforded acetophenone-d_5 (1.39 g, 87%) as colorless oil. The compound **1a-d_5** was synthesized from acetophenone-d_5 according to previously described methods.[S1]

6. References

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