Supporting Information

Versatile Ruthenium(II)-Catalyzed C–H Cyanations of Benzamides

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**General Remarks**

1,2-Dichloroethane (DCE), 1,4-dioxane and toluene were distilled over CaH₂. The following starting materials were synthesized according to previously described methods: 1a-x¹, [D]₃-1a¹ and 2². Other chemicals were obtained from commercial sources and were used without further purification. Yields refer to isolated compounds, estimated to be > 95% pure as determined by ¹H-NMR and GC. TLC: Macherey-Nagel, TLC plates Alugram® Sil G/UV254. Detection under UV light at 254 nm. Chromatography: Separations were carried out on Merck Silica 60 (0.040–0.063 mm, 70–230 mesh ASTM). All IR spectra were recorded on a BRUKER ALPHA-P spectrometer. MS: EI-MS: Finnigan MAT 95, 70eV; ESI-MS: Finnigan LCQ. High resolution mass spectrometry (HRMS): APEX IV 7T FTICR, Bruker Daltonic. M. p. Stuart® Melting Point Apparatus SMP3 melting point apparatus, values are uncorrected. ¹H, ¹³C, ¹⁹F NMR-spectra were recorded at 300 (¹H), 600 (¹H), 75 {¹³C, APT (Attached Proton Test)} and 283 MHz (¹⁹F), respectively, on Varian Unity-300 (600) and AMX 300 instruments in CDCl₃ solutions. If not otherwise specified, chemical shifts (δ) are given in ppm.
**General Procedure for Direct Cyanation of Benzamides:**

Benzamides (1) (0.50 mmol), *N*-cyano-*N*-phenyl-4-methylbenzenesulfonamide (2) (272 mg, 1.0 mmol), [RuCl₂(p-cymene)]₂ (15.4 mg, 5.0 mol %), AgSbF₆ (34.4 mg, 20 mol %), NaOAc (8.2 mg, 20 mol %) and DCE (2.0 mL) were placed in a 20 mL sealed tube under N₂ and stirred at 120 °C for 24 h. At ambient temperature, the reaction mixture was diluted with H₂O (15 mL) and extracted with EtOAc (3 x 15 mL). The combined organic layer was dried with Na₂SO₄ and concentrated under reduced pressure. The crude products were purified by column chromatography on silica gel to afford the desired products.
2-Cyano-N,N-diisopropylbenzamide (3a): The representative procedure was followed using N,N-diisopropylbenzamide (1a) (103 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 5/1→2/1) yielded 3a (97 mg, 84%) as a colorless solid. M.p. = 109–111 °C. \(^1\)H-NMR (300 MHz, CDCl\(_3\)): \(\delta = 7.62\) (dd, \(J = 7.7, 1.3, 0.6\) Hz, 1H), 7.57 (dd, \(J = 7.7, 7.7, 1.3\) Hz, 1H), 7.40 (dd, \(J = 7.7, 7.7, 1.3\) Hz, 1H), 7.29 (dd, \(J = 7.7, 1.3, 0.6\) Hz, 1H), 3.52 (hept, \(J = 7.7, 1.3\) Hz, 1H), 1.15 (s, \(J = 7.7, 1.3\) Hz, 6H), 1.03 (t, \(J = 7.7, 1.3\) Hz, 3H), 0.90 (t, \(J = 7.7, 1.3\) Hz, 3H), 0.87 (t, \(J = 7.7, 1.3\) Hz, 3H), 0.86 (t, \(J = 7.7, 1.3\) Hz, 3H). \(^1^3\)C-NMR (75 MHz, CDCl\(_3\)): \(\delta = 166.7\) (C\(_q\)), 142.4 (C\(_q\)), 132.8 (C\(_q\)), 128.5 (C\(_q\)), 116.8 (C\(_q\)), 108.9 (C\(_q\)), 51.4 (CH), 46.1 (CH), 20.6 (CH\(_3\)), 20.2 (CH\(_3\)). IR (neat): 2964, 2225, 1625, 1437, 1341, 1031, 788, 552 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 230 (5) [M\(^+\)], 187 (24), 173 (25), 130 (100), 102 (36). HR-MS (EI) \(m/z\) calcd for C\(_{14}\)H\(_{18}\)N\(_2\)O [M\(^+\)] 230.1419, found 230.1424. The spectral data are in accordance with those reported in the literature.\(^3\)

2-Cyano-N,N-diethylbenzamide (3b): The representative procedure was followed using N,N-diethylbenzamide (1b) (89 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 5/1→2/1) yielded 3b (75 mg, 74%) as a colorless oil. \(^1\)H-NMR (300 MHz, CDCl\(_3\)): \(\delta = 7.63\) (dd, \(J = 7.7, 1.3, 0.6\) Hz, 1H), 7.58 (dd, \(J = 7.7, 7.7, 1.3\) Hz, 1H), 7.42 (dd, \(J = 7.7, 7.7, 1.3\) Hz, 1H), 7.35 (dd, \(J = 7.7, 1.3, 0.6\) Hz, 1H), 3.53 (q, \(J = 7.1\) Hz, 2H), 3.12 (q, \(J = 7.1\) Hz, 2H), 1.22 (t, \(J = 7.1\) Hz, 3H), 1.03 (t, \(J = 7.1\) Hz, 3H). \(^1^3\)C-NMR (75 MHz, CDCl\(_3\)): \(\delta = 167.0\) (C\(_q\)), 140.9 (C\(_q\)), 132.8 (CH), 132.7 (CH), 129.0 (CH), 126.6 (CH), 116.5 (C\(_q\)), 109.6 (C\(_q\)), 43.0 (CH\(_2\)), 39.1 (CH\(_2\)), 13.9 (CH\(_3\)), 12.4 (CH\(_3\)). IR (neat): 2976, 2228, 1628, 1429, 1292, 1080, 762, 546 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 202 (20) [M\(^+\)], 173 (15), 130 (100), 102 (40). HR-MS (ESI) \(m/z\) calcd for C\(_{12}\)H\(_{14}\)N\(_2\)O [M + Na\(^+\)] 225.1004, found 225.1003.
2-Cyano-N,N-dimethylbenzamide (3c): The representative procedure was followed using N,N-dimethylbenzamide (1c) (75 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 5/1→1/1) yielded 3c (58 mg, 67%) as a colorless oil. $^1$H-NMR (300 MHz, CDCl$_3$): $\delta = 7.66$–$7.57$ (m, 2H), $7.47$–$7.39$ (m, 2H), 3.10 (s, 3H), 2.88 (s, 3H). $^{13}$C-NMR (75 MHz, CDCl$_3$): $\delta = 167.5$ (C$_q$), 140.3 (C$_q$), 133.0 (CH), 132.7 (CH), 129.4 (CH), 127.4 (CH), 116.7 (C$_q$), 109.7 (C$_q$), 38.5 (CH$_3$), 34.9 (CH$_3$). IR (neat): 2933, 2228, 1632, 1396, 1069, 760, 542 cm$^{-1}$. MS (EI) $m/z$ (relative intensity) 174 (35) [M$^+$], 130 (100), 102 (65), 75 (23). HR-MS (ESI) $m/z$ calcd for C$_{10}$H$_{11}$N$_2$O [M + H$^+$] 175.0871, found 175.0866. The spectral data are in accordance with those reported in the literature.$^4$

2-(Piperidine-1-carbonyl)benzonitrile (3d): The representative procedure was followed using phenyl(piperidin-1-yl)methanone (1d) (95 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 5/1→2/1) yielded 3d (81 mg, 76%) as a colorless solid. M.p. = 108–110 °C. $^1$H-NMR (300 MHz, CDCl$_3$): $\delta = 7.64$ (d, $J = 7.7$ Hz, 1H), 7.59 (dd, $J = 7.7$, 7.6 Hz, 1H), 7.43 (dd, $J = 7.6$, 7.6 Hz, 1H), 7.38 (d, $J = 7.6$ Hz, 1H), 3.72–3.69 (m, 2H), 3.18 (t, $J = 5.6$ Hz, 2H), 1.64–1.62 (m, 4H), 1.54–1.48 (m, 2H). $^{13}$C-NMR (75 MHz, CDCl$_3$): $\delta = 166.0$ (C$_q$), 140.5 (C$_q$), 132.9 (CH), 132.8 (CH), 129.2 (CH), 127.1 (CH), 116.8 (C$_q$), 109.6 (C$_q$), 48.1 (CH$_2$), 42.9 (CH$_2$), 26.2 (CH$_2$), 25.2 (CH$_2$), 24.2 (CH$_2$). IR (neat): 2928, 2228, 1621, 1437, 1292, 1254, 779, 554 cm$^{-1}$. MS (EI) $m/z$ (relative intensity) 214 (45) [M$^+$], 213 (100), 130 (100), 102 (50), 84 (23). HR-MS (ESI) $m/z$ calcd for C$_{13}$H$_{13}$N$_2$O [M + H$^+$] 215.1184,
found 215.1179.

![Chemical Structure](image)

**2-(Pyrrrolidine-1-carbonyl)benzonitrile (3e):** The representative procedure was followed using phenyl(pyrrolidin-1-yl)methanone (1e) (88 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 5/1→1/1) yielded 3e (67 mg, 66%) as a colorless oil. \(^1\)H-NMR (300 MHz, CDCl₃): \(\delta = 7.68–7.52\) (m, 2H), \(7.46–7.40\) (m, 2H), \(3.60\) (t, \(J = 6.8\) Hz, 2H), \(3.22\) (t, \(J = 6.4\) Hz, 2H), \(1.96–1.79\) (m, 4H). \(^{13}\)C-NMR (75 MHz, CDCl₃): \(\delta = 165.7\) (Cₚ), \(141.2\) (Cₚ), \(132.9\) (CH), \(132.8\) (CH), \(129.4\) (CH), \(127.1\) (CH), \(116.9\) (Cₚ), \(109.5\) (Cₚ), \(48.3\) (CH₂), \(45.8\) (CH₂), \(25.9\) (CH₂), \(24.1\) (CH₂). IR (neat): \(2973, 2879, 2228, 1623, 1594, 1448, 760, 650\) cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 200 (55) [M⁺], 171 (35), 130 (100), 102 (65), 70 (50). HR-MS (EI) \(m/z\) calcd for C₁₂H₁₂N₂O [M⁺] 200.0950, found 200.0951.

![Chemical Structure](image)

**2-Cyano-N-methyl-N-phenylbenzamide (3f):** The representative procedure was followed using N-methyl-N-phenylbenzamide (1f) (106 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 10/1→2/1) yielded 3f (63 mg, 53%) as a colorless solid. M.p. = 75–77 °C. \(^1\)H-NMR (300 MHz, CDCl₃): \(\delta = 7.48–7.08\) (m, 9H), \(3.49\) (s, 3H). \(^{13}\)C-NMR (75 MHz, CDCl₃): \(\delta = 167.4\) (Cₚ), \(142.8\) (Cₚ), \(140.8\) (Cₚ), \(132.7\) (CH), \(132.0\) (CH), \(129.2\) (CH), \(129.1\) (CH), \(128.4\) (CH), \(127.3\) (CH), \(127.0\) (CH), \(117.1\) (Cₚ), \(110.5\) (Cₚ), \(37.7\) (CH₃). IR (neat): 3053, 2227, 1632, 1592, 1495, 1380, 769, 699, 553 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 236 (35) [M⁺], 143 (22), 130 (100), 102 (35), 77 (18). HR-MS (EI) \(m/z\) calcd for C₁₅H₁₂N₂O [M⁺] 236.0950, found 236.0946.
2-Cyano-\(N,N\)-diisopropyl-4-methylbenzamide (3g): The representative procedure was followed using \(N,N\)-diisopropyl-4-methylbenzamide (1g) (110 mg, 0.50 mmol). Isolation by column chromatography (\(n\)-hexane/EtOAc: 10/1→2/1) yielded 3g (98 mg, 80%) as a colorless solid. M.p. = 92–94 °C. \(^1\)H-NMR (300 MHz, CDCl\(_3\)): \(\delta = 7.42\) (s, 1H), 7.36 (d, \(J = 7.9\) Hz, 1H), 7.17 (d, \(J = 7.9\) Hz, 1H), 3.52 (hept, \(J = 6.8\) Hz, 2H), 2.34 (s, 3H), 1.52 (d, \(J = 6.8\) Hz, 6H), 1.12 (\(s_{br}\), 6H). \(^{13}\)C-NMR (75 MHz, CDCl\(_3\)): \(\delta = 167.0\) (C\(_q\)), 139.7 (C\(_q\)), 138.8 (C\(_q\)), 133.7 (CH), 133.0 (CH), 125.6 (CH), 116.9 (C\(_q\)), 108.8 (C\(_q\)), 51.3 (CH), 46.0 (CH), 20.8 (CH\(_3\)), 20.6 (CH\(_3\)), 20.2 (CH\(_3\)). IR (neat): 2970, 1617, 1440, 1342, 1037, 822, 597 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 244 (10) [M\(^+\)], 201 (50), 187 (22), 144 (100), 116 (20), 89 (18). HR-MS (EI) \(m/z\) calcd for C\(_{13}\)H\(_{20}\)N\(_2\)O [M\(^+\)] 244.1576, found 244.1571.

2-Cyano-\(N,N\)-diisopropyl-4-methoxybenzamide (3h): The representative procedure was followed using \(N,N\)-diisopropyl-4-methoxybenzamide (1h) (118 mg, 0.50 mmol). Isolation by column chromatography (\(n\)-hexane/EtOAc: 5/1→1/1) yielded 3h (117 mg, 90%) as a colorless solid. M.p. = 118–120 °C. \(^1\)H-NMR (300 MHz, CDCl\(_3\)): \(\delta = 7.19\) (d, \(J = 8.0\) Hz, 1H), 7.08 (d, \(J = 2.6\) Hz, 1H), 7.07 (dd, \(J = 8.0, 2.6\) Hz, 1H), 3.78 (s, 3H), 3.53 (\(s_{br}\), 2H), 1.50 (\(s_{br}\), 6H), 1.12 (\(s_{br}\), 6H). \(^{13}\)C-NMR (75 MHz, CDCl\(_3\)): \(\delta = 166.8\) (C\(_q\)), 159.0 (C\(_q\)), 134.9 (C\(_q\)), 127.2 (CH), 119.2 (CH), 117.3 (CH), 116.7 (C\(_q\)), 109.9 (C\(_q\)), 55.6 (CH\(_3\)), 51.3 (CH), 46.0 (CH), 20.4 (CH\(_3\)), 20.3 (CH\(_3\)). IR (neat): 2978, 2228, 1622, 1441, 1372, 1248, 1026, 848, 593 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 260 (10) [M\(^+\)], 217 (50), 160 (100), 117 (15), 77 (10). HR-MS (EI) \(m/z\) calcd for C\(_{13}\)H\(_{20}\)N\(_2\)O\(_2\) [M\(^+\)] 260.1525, found 260.1532.
Methyl 3-cyano-4-(diisopropylcarbamoyl)benzoate (3i): The representative procedure was followed using methyl 4-(diisopropylcarbamoyl)benzoate (1i) (132 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 10/1→2/1) yielded 3i (94 mg, 65%) as a colorless solid. M.p. = 81–83 °C. $^1$H-NMR (300 MHz, CDCl$_3$): $\delta$ = 8.28 (d, $J$ = 1.6 Hz, 1H), 8.20 (dd, $J$ = 8.0, 1.6 Hz, 1H), 7.38 (d, $J$ = 8.0 Hz, 1H), 3.89 (s, 3H), 3.52 (hept, $J$ = 6.7 Hz, 1H), 3.44 (hept, $J$ = 6.7 Hz, 1H), 1.52 (d, $J$ = 6.8 Hz, 6H), 1.13 ($s_{br}$, 6H). $^{13}$C-NMR (75 MHz, CDCl$_3$): $\delta$ = 165.8 (C$_q$), 164.5 (C$_q$), 145.8 (C$_q$), 134.0 (CH), 133.9 (CH), 130.6 (C$_q$), 126.0 (CH), 115.9 (C$_q$), 109.5 (C$_q$), 52.6 (CH$_3$), 51.5 (CH), 46.3 (CH), 20.5 (CH$_3$), 20.1 (CH$_3$). IR (neat): 2958, 2231, 1719, 1635, 1433, 1295, 1261, 1107, 769, 555 cm$^{-1}$. MS (EI) $m$/z (relative intensity) 288 (10) [M$^+$], 245 (65), 231 (50), 188 (100), 101 (10). HR-MS (ESI) $m$/z calcd for C$_{16}$H$_{21}$N$_2$O$_3$ [M + H$^+$] 289.1552, found 289.1547.

3-Cyano-$N,N$-diisopropyl-[1,1'-biphenyl]-4-carboxamide (3j): The representative procedure was followed using $N,N$-diisopropyl-[1,1'-biphenyl]-4-carboxamide (1j) (141 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc/Et$_3$N: 200/10/1→200/60/1) yielded 3j (140 mg, 92%) as a colorless solid. M.p. = 114–116 °C. $^1$H-NMR (300 MHz, CDCl$_3$): $\delta$ = 7.81 (d, $J$ = 1.8 Hz, 1H), 7.77 (dd, $J$ = 8.0, 1.8 Hz, 1H), 7.53–7.34 (m, 6H), 3.64 (hept, $J$ = 6.7 Hz, 1H), 3.56 (hept, $J$ = 6.7 Hz, 1H), 1.58 (d, $J$ = 6.8 Hz, 6H), 1.18 ($s_{br}$, 6H). $^{13}$C-NMR (75 MHz, CDCl$_3$): $\delta$ = 166.6 (C$_q$), 141.7 (C$_q$), 140.8 (C$_q$), 138.0 (C$_q$), 131.5 (CH), 131.1 (CH), 129.0 (CH), 128.4 (CH), 126.8 (CH), 126.2 (CH), 116.8 (C$_q$), 109.5 (C$_q$), 51.4 (CH), 46.1 (CH), 20.6 (CH$_3$), 20.2 (CH$_3$). IR (neat): 2970, 1627, 1442, 1342, 1034, 753, 695 cm$^{-1}$. MS (EI) $m$/z (relative intensity) 306 (10) [M$^+$], 263 (60), 206 (100), 151 (15). HR-MS (EI)
m/z calcd for C$_{20}$H$_{22}$N$_{2}$O [M$^+$] 306.1732, found 306.1730.

**2-Cyano-4-fluoro-N,N-diisopropylbenzamide (3k):** The representative procedure was followed using 4-fluoro-N,N-diisopropylbenzamide (1k) (112 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 10/1→5/1) yielded 3k (101 mg, 81%) as a colorless solid. M.p. = 129–131 °C. $^1$H-NMR (300 MHz, CDCl$_3$): δ = 7.37–7.29 (m, 3H), 3.54 (hept, $J = 6.7$ Hz, 2H), 1.55 (d, $J = 6.7$ Hz, 6H), 1.17 (sbr, 6H). $^{13}$C-NMR (75 MHz, CDCl$_3$): δ = 165.8 (C$_q$), 161.3 ($^1$J$_{C-F}$ = 256 Hz, C$_q$), 138.9 ($^1$J$_{C-F}$ = 4 Hz, C$_q$), 128.0 ($^3$J$_{C-F}$ = 8 Hz, CH), 120.7 ($^2$J$_{C-F}$ = 21 Hz, CH), 119.7 ($^2$J$_{C-F}$ = 24 Hz, CH), 115.6 ($^4$J$_{C-F}$ = 3 Hz, C$_q$), 110.7 ($^3$J$_{C-F}$ = 9 Hz, C$_q$), 51.6 (CH), 46.4 (CH), 20.8 (CH$_3$), 20.3 (CH$_3$). $^{19}$F-NMR (283 MHz, CDCl$_3$): δ = -(110.0–110.1) (m). IR (neat): 2973, 2231, 1617, 1443, 1372, 1342, 1156, 1032, 829, 597 cm$^{-1}$. MS (EI) m/z (relative intensity) 248 (5) [M$^+$], 205 (35), 191 (40), 148 (100), 120 (25), 58 (17). HR-MS (EI) m/z calcd for C$_{14}$H$_{17}$F$\text{N}_2$O [M$^+$] 248.1325, found 248.1323.

**4-Chloro-2-cyano-N,N-diisopropylbenzamide (3l):** The representative procedure was followed using 4-chloro-N,N-diisopropylbenzamide (1l) (120 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc/Et$_3$N: 100/10/1→100/20/1) yielded 3l (91 mg, 68%) as a colorless solid. M.p. = 131–133 °C. $^1$H-NMR (300 MHz, CDCl$_3$): δ = 7.64 (d, $J = 1.6$ Hz, 1H), 7.57 (dd, $J = 8.2$, 1.6 Hz, 1H), 7.28 (d, $J = 8.2$ Hz, 1H), 3.53 (hept, $J = 6.0$ Hz, 2H), 1.55 (d, $J = 6.0$ Hz, 6H), 1.17 (sbr, 6H). $^{13}$C-NMR (75 MHz, CDCl$_3$): δ = 165.7 (C$_q$), 140.7 (C$_q$), 134.5 (C$_q$), 133.3 (CH), 132.4 (CH), 127.2 (CH), 115.5 (C$_q$), 110.7 (C$_q$), 51.6 (CH), 46.4 (CH), 20.8 (CH$_3$), 20.3 (CH$_3$). IR (neat): 2981, 2231, 1626, 1442, 1339, 1033, 847, 589 cm$^{-1}$. MS (EI)}
m/z (relative intensity) 264 (5) [M⁺], 221 (48), 207 (45), 164 (100), 136 (20), 100 (10).
HR-MS (EI) m/z calcld for C₁₄H₁₇ClN₂O [M⁺] 264.1029, found 264.1028.

**4-Bromo-2-cyano-N,N-diisopropylbenzamide (3m):** The representative procedure was followed using 4-bromo-N,N-diisopropylbenzamide (1m) (142 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc/Et₃N: 100/10/1→100/20/1) yielded 3m (110 mg, 71%) as a colorless solid. M.p. = 121–123 °C. ¹H-NMR (300 MHz, CDCl₃): δ = 7.78 (d, J = 2.0 Hz, 1H), 7.72 (dd, J = 8.2, 2.0 Hz, 1H), 7.20 (d, J = 8.2 Hz, 1H), 3.53 (hept, J = 6.7 Hz, 2H), 1.55 (d, J = 6.7 Hz, 6H), 1.16 (sbr, 6H).

1³C-NMR (75 MHz, CDCl₃): δ = 165.8 (C_q), 141.2 (C_q), 136.3 (CH), 135.3 (CH), 127.3 (CH), 122.1 (C_q), 115.5 (C_q), 110.9 (C_q), 51.6 (CH), 46.4 (CH), 20.7 (CH₃), 20.3 (CH₃). IR (neat): 2966, 2218, 1630, 1443, 1344, 1037, 850, 554 cm⁻¹. MS (EI) m/z (relative intensity) 310 (10) [M⁺] (⁸¹Br), 308 (10) [M⁺] (⁷⁹Br), 267 (55) (⁸¹Br), 265 (55) (⁷⁹Br), 210 (100) (⁸¹Br), 208 (100) (⁷⁹Br), 182 (20) (⁸¹Br), 180 (20) (⁷⁹Br). HR-MS (EI) m/z calcld for C₁₄H₁₇BrN₂O [M⁺] 308.0524, found 308.0529.

**2-Cyano-4-iodo-N,N-diisopropylbenzamide (3n):** The representative procedure was followed using 4-iodo-N,N-diisopropylbenzamide (1n) (166 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/CH₂Cl₂: 1/1) yielded 3n (162 mg, 91%) as a colorless solid. M.p. = 157–159 °C. ¹H-NMR (300 MHz, CDCl₃): δ = 7.94 (d, J = 1.6 Hz, 1H), 7.88 (dd, J = 8.1, 1.6 Hz, 1H), 7.03 (d, J = 8.1 Hz, 1H), 3.50 (hept, J = 6.6 Hz, 2H), 1.50 (d, J = 6.6 Hz, 6H), 1.12 (sbr, 6H). ¹³C-NMR (75 MHz, CDCl₃): δ = 165.8 (C_q), 141.9 (CH), 141.5 (C_q), 140.8 (CH), 127.1 (CH), 115.1 (C_q), 110.8 (C_q), 92.8 (C_q), 51.4 (CH), 46.2 (CH), 20.6 (CH₃), 20.1 (CH₃). IR (neat): 2966, 2223, 1631,
1439, 1338, 825, 557 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 356 (15) [M\(^+\)], 313 (80), 299 (40), 256 (100), 227 (12), 101 (17). HR-MS (EI) \(m/z\) calcd for C\(_{14}\)H\(_{17}\)IN\(_2\)O [M\(^+\)] 356.0386, found 356.0388.

![Chemical Structure](image)

**3-Cyano-\(N,N\)-diisopropyl-2-naphthamide (3o)**: The representative procedure was followed using \(N,N\)-diisopropyl-2-naphthamide (1o) (128 mg, 0.50 mmol). Isolation by column chromatography \((n\)-hexane/EtOAc: 10/1→2/1\) yielded 3o (109 mg, 78%) as a colorless solid. M.p. = 133–135 °C. \(\text{\(^1\)H-NMR (300 MHz, CDCl}_3\)): \(\delta = 8.20\) (s, 1H), 7.83 (d, \(J = 8.5\) Hz, 2H), 7.74 (s, 1H), 7.64–7.53 (m, 2H), 3.36–3.54 (m, 2H), 1.60 (d, \(J = 6.0\) Hz, 6H). \(\text{\(^{13}\)C-NMR (75 MHz, CDCl}_3\)): \(\delta = 167.0\) (C\(_q\)), 136.5 (C\(_q\)), 135.1 (CH), 134.1 (C\(_q\)), 131.4 (C\(_q\)), 129.6 (CH), 128.2 (CH), 128.0 (CH), 127.9 (CH), 124.9 (CH), 117.1 (C\(_q\)), 106.7 (C\(_q\)), 51.4 (CH), 46.1 (CH), 20.5 (CH\(_3\)), 20.3 (CH\(_3\)). IR (neat): 2972, 2229, 1617, 1474, 1342, 1152, 901, 756, 481 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 280 (20) [M\(^+\)], 237 (45), 180 (100), 152 (40). HR-MS (EI) \(m/z\) calcd for C\(_{14}\)H\(_{20}\)O\(_2\) [M\(^+\)] 280.1576, found 280.1576.

![Chemical Structure](image)

**2-Cyano-\(N,N\)-diisopropyl-1-methyl-1\(H\)-indole-3-carboxamide (3p)**: The representative procedure was followed using \(N,N\)-diisopropyl-1-methyl-1\(H\)-indole-3-carboxamide (1p) (129 mg, 0.50 mmol). Isolation by column chromatography \((n\)-hexane/EtOAc: 10/1→10/3\) yielded 3p (122 mg, 86%) as a colorless solid. M.p. = 202–204 °C. \(\text{\(^1\)H-NMR (300 MHz, CDCl}_3\)): \(\delta = 7.56\) (d, \(J = 8.1\) Hz, 1H), 7.38 (dd, \(J = 8.3, 6.7\) Hz, 1H), 7.30 (d, \(J = 8.3\) Hz, 1H), 7.20 (dd, \(J = 8.1, 6.7\) Hz, 1H), 3.83 (s, 3H), 3.73 (hept, \(J = 6.7\) Hz, 2H), 1.39 (s\(_{br}\), 12H). \(\text{\(^{13}\)C-NMR (75 MHz, CDCl}_3\)): \(\delta = 163.2\)
(C₆H₅), 137.2 (C₆H₅), 126.4 (CH), 124.0 (C₆H₅), 123.9 (C₆H₅), 121.9 (CH), 120.9 (CH), 112.2
(C₆H₅), 110.2 (CH), 107.1 (C₆H₅), 48.8 (CH), 31.5 (CH₃), 20.9 (CH₃). IR (neat): 2979, 2224, 1616, 1536, 1371, 1311, 1045, 745 cm⁻¹. MS (EI) m/z (relative intensity) 283 (10) [M⁺], 240 (15), 183 (100), 128 (10). HR-MS (EI) m/z calcd for C₁₇H₂₁N₃O [M⁺] 283.1685, found 283.1679.

2-Cyano-N,N-diisopropylthiophene-3-carboxamide (3q): The representative procedure was followed using N,N-diisopropylthiophene-3-carboxamide (1q) (106 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 10/1→3/1) yielded 3q (91 mg, 77%) as a colorless solid. M.p. = 76–78 °C. ¹H-NMR (300 MHz, CDCl₃): δ = 7.58 (d, J = 5.0 Hz, 1H), 7.05 (d, J = 5.0 Hz, 1H), 3.59 (sbr, 2H), 1.52 (sbr, 6H), 1.20 (sbr, 6H). ¹³C-NMR (75 MHz, CDCl₃): δ = 163.0 (C(q)), 148.3 (C(q)), 132.8 (CH), 126.1 (CH), 112.7 (C(q)), 106.2 (C(q)), 51.4 (CH), 46.4 (CH), 20.7 (CH₃), 20.5 (CH₃). IR (neat): 3072, 2221, 1629, 1444, 1323, 1203, 1038, 776 cm⁻¹. MS (EI) m/z (relative intensity) 236 (5) [M⁺], 221 (15), 193 (25), 179 (45), 136 (100), 58 (8). HR-MS (EI) m/z calcd for C₁₂H₁₆N₂OS [M⁺] 236.0983, found 236.0981.

2-Cyano-N,N-diisopropylfuran-3-carboxamide (3r): The representative procedure was followed using N,N-diisopropylfuran-3-carboxamide (1r) (98 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 10/1→5/1) yielded 3r (89 mg, 81%) as a colorless oil. ¹H-NMR (300 MHz, CDCl₃): δ = 7.51 (d, J = 1.9 Hz, 1H), 6.50 (d, J = 1.9 Hz, 1H), 3.66 (sbr, 2H), 1.29 (sbr, 12H). ¹³C-NMR (75 MHz, CDCl₃): δ = 160.6 (C(q)), 146.9 (CH), 133.8 (C(q)), 123.2 (C(q)), 110.7 (CH), 110.2 (C(q)), 51.3 (CH), 46.5 (CH), 20.6 (CH₃). IR (neat): 2973, 2229, 1628, 1484, 1372, 1336, 1026, 1019,
3-Cyano-N,N-diisopropylbenzo[b]thiophene-2-carboxamide (3s): The representative procedure was followed using \(N,N\)-diisopropylbenzo[b]thiophene-2-carboxamide (1s) (131 mg, 0.50 mmol). Isolation by column chromatography (\(n\)-hexane/CH\(_2\)Cl\(_2\): 1/1) yielded 3s (129 mg, 90%) as a colorless solid. M.p. = 134–136 °C. \(^1\)H-NMR (300 MHz, CDCl\(_3\)): \(\delta = 7.93\) (dd, \(J = 7.6, 1.4\) Hz, 1H), 7.85 (dd, \(J = 7.4, 1.3\) Hz, 1H), 7.55–7.45 (m, 2H), 3.72 (s\(\text{br}\), 2H), 1.40 (s\(\text{br}\), 12H). \(^{13}\)C-NMR (75 MHz, CDCl\(_3\)): \(\delta = 160.5\) (C\(_q\)), 149.2 (C\(_q\)), 137.3 (C\(_q\)), 136.8 (C\(_q\)), 126.7 (CH), 126.4 (CH), 122.8 (CH), 122.7 (CH), 113.0 (C\(_q\)), 104.0 (C\(_q\)), 20.6 (CH\(_3\)). CH(CH\(_3\))\(_2\) is not detectable. IR (neat): 2969, 2224, 1633, 1452, 1343, 1316, 1037, 751, 611 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 286 (8) [M\(^+\)], 271 (10), 243 (15), 186 (75), 158 (13), 114 (15), 43 (100). HR-MS (EI) \(m/z\) calc'd for C\(_{16}\)H\(_{18}\)N\(_2\)O\(_2\)S [M\(^+\)] 286.1140, found 286.1149.

3-Cyano-N,N-diisopropylbenzofuran-2-carboxamide (3t): The representative procedure was followed using \(N,N\)-diisopropylbenzofuran-2-carboxamide (1t) (123 mg, 0.50 mmol). Isolation by column chromatography (\(n\)-hexane/EtOAc/Et\(_3\)N: 100/5/1→100/20/1) yielded 3t (105 mg, 78%) as a colorless solid. M.p. = 99–101 °C. \(^1\)H-NMR (300 MHz, CDCl\(_3\)): \(\delta = 7.70–7.67\) (m, 1H), 7.53 (d, \(J = 8.0\) Hz, 1H), 7.48–7.36 (m, 2H), 3.80 (s\(\text{br}\), 2H), 1.40 (s\(\text{br}\), 12H). \(^{13}\)C-NMR (75 MHz, CDCl\(_3\)): \(\delta = 157.6\) (C\(_q\)), 156.9 (C\(_q\)), 153.1 (C\(_q\)), 127.5 (CH), 125.2 (CH), 125.1 (C\(_q\)), 120.5 (CH),
112.2 (CH), 111.7 (C_q), 94.1 (C_q), 50.7 (CH), 47.4 (CH), 20.5 (CH_3). IR (neat): 2972, 2233, 1626, 1440, 1321, 1181, 1036, 738 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 270 (10) [M\(^+\)], 227 (30), 213 (45), 170 (100), 114 (30), 43 (45). HR-MS (EI) \(m/z\) calcd for C_{14}H_{18}N_{2}O_{2} [M\(^+\)] 270.1368, found 270.1368.

3-Cyano-\(N,N\)-diisopropylthiophene-2-carboxamide (3u): The representative procedure was followed using \(N,N\)-diisopropylthiophene-2-carboxamide (1u) (106 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 10/1→5/1) yielded 3u (100 mg, 85%) as a colorless solid. M.p. = 99–101 °C. \(^1\)H-NMR (300 MHz, CDCl_3): \(\delta = 7.35 \ (d, J = 5.2 \text{ Hz}, 1\text{H}), 7.16 \ (d, J = 5.2 \text{ Hz}, 1\text{H}), 7.31–3.62 \ (m, 2\text{H}), 1.36 \ (sbr, 12\text{H}).\) \(^{13}\)C-NMR (75 MHz, CDCl_3): \(\delta = 160.5 \ (C_q), 148.1 \ (C_q), 128.4 \ (CH), 126.3 \ (CH), 113.8 \ (C_q), 108.2 \ (C_q), 49.6 \ (CH), 20.6 \ (CH_3).\) IR (neat): 2980, 2227, 1627, 1455, 1328, 1207, 1029, 766 cm\(^{-1}\). MS (EI) \(m/z\) (relative intensity) 236 (5) [M\(^+\)], 221 (18), 193 (23), 179 (50), 136 (100), 58 (10). HR-MS (EI) \(m/z\) calcd for C_{12}H_{16}N_{2}OS [M\(^+\)] 236.0983, found 236.0982.

2-Cyano-\(N,N\)-diisopropyl-5-methylbenzamide (3v): The representative procedure was followed using \(N,N\)-diisopropyl-3-methylbenzamide (1v) (110 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 10/1→3/1) yielded 3v (95 mg, 78%) as a colorless solid. M.p. = 147–149 °C. \(^1\)H-NMR (300 MHz, CDCl_3): \(\delta = 7.53 \ (d, J = 8.0 \text{ Hz}, 1\text{H}), 7.22 \ (d, J = 8.0 \text{ Hz}, 1\text{H}), 7.12 \ (s, 1\text{H}), 3.57 \ (hept, J = 7.0 \text{ Hz}, 1\text{H}), 3.54 \ (hept, J = 7.0 \text{ Hz}, 1\text{H}), 2.40 \ (s, 3\text{H}), 1.57 \ (d, J = 6.7 \text{ Hz}, 6\text{H}), 1.17 \ (sbr, 6\text{H}).\) \(^{13}\)C-NMR (75 MHz, CDCl_3): \(\delta = 167.0 \ (C_q), 144.2 \ (C_q), 142.4 \ (C_q), 132.7 \ (CH), 129.3 \ (CH), 126.3 \ (CH), 117.1 \ (C_q), 105.9 \ (C_q), 51.4 \ (CH), 46.1 \ (CH), 21.8 \ (CH_3), 20.7 \ (CH_3), 20.3 \ (CH_3).\) IR (neat): 2978, 2228, 1628, 1443, 1338, 1038, 843, 550 cm\(^{-1}\). MS
(EI) m/z (relative intensity) 244 (20) [M⁺], 229 (20), 201 (60), 187 (35), 144 (100), 116 (23), 89 (17). HR-MS (EI) m/z calcd for C₁₃H₂₀N₂O [M⁺] 244.1576, found 244.1566.

![Chemical structure of 2-Cyano-N,N-diisopropyl-3-methoxybenzamide](image)

2-Cyano-N,N-diisopropyl-3-methoxybenzamide (3w): The representative procedure was followed using N,N-diisopropyl-3-methoxybenzamide (1w) (118 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 5:1→1:1) yielded 3w (45 mg, 34%) and 3w' (72 mg, 55%) as colorless solids. M.p. = 163–165 °C. ¹H-NMR (300 MHz, CDCl₃): δ = 7.55 (d, J = 8.7 Hz, 1H), 6.89 (dd, J = 8.7, 2.5 Hz, 1H), 6.77 (d, J = 2.5 Hz, 1H), 3.83 (s, 3H), 3.56 (hept, J = 6.8 Hz, 1H), 3.52 (hept, J = 6.8 Hz, 1H), 1.54 (d, J = 6.8 Hz, 6H), 1.15 (sbr, 6H). ¹³C-NMR (75 MHz, CDCl₃): δ = 166.6 (C₉), 162.9 (C₉), 144.3 (C₉), 134.7 (CH), 117.2 (C₉), 114.4 (CH), 111.4 (CH), 100.5 (C₉), 55.7 (CH₃), 51.4 (CH), 46.2 (CH), 20.7 (CH₃), 20.2 (CH₃). IR (neat): 2964, 2224, 1630, 1457, 1337, 1242, 1027, 850, 680 cm⁻¹. MS (EI) m/z (relative intensity) 260 (20) [M⁺], 217 (50), 203 (35), 160 (100), 117 (14). HR-MS (EI) m/z calcd for C₁₅H₂₀N₂O₂ [M⁺] 260.1525, found 260.1523.

![Chemical structure of 2-Cyano-N,N-diisopropyl-5-methoxybenzamide](image)

2-Cyano-N,N-diisopropyl-5-methoxybenzamide (3w'): M.p. = 165–167 °C. ¹H-NMR (300 MHz, CDCl₃): δ = 7.49 (dd, J = 8.6, 7.6 Hz, 1H), 6.90 (d, J = 8.6 Hz, 1H), 6.81 (d, J = 7.6 Hz, 1H), 3.88 (s, 3H), 3.56 (hept, J = 6.8 Hz, 1H), 3.49 (hept, J = 6.8 Hz, 1H), 1.52 (d, J = 6.8 Hz, 6H), 1.12 (sbr, 6H). ¹³C-NMR (75 MHz, CDCl₃): δ = 166.5 (C₉), 161.4 (C₉), 143.8 (C₉), 134.5 (CH), 117.2 (CH), 114.3 (C₉), 110.7 (CH), 98.3 (C₉), 56.1 (CH₃), 51.3 (CH), 46.0 (CH), 20.5 (CH₃), 20.1 (CH₃). IR (neat): 2971, 2227, 1625, 1461, 1342, 1276, 1030, 800, 605 cm⁻¹. MS (EI) m/z (relative intensity)
260 (13) [M⁺], 217 (50), 203 (25), 160 (100), 117 (18). HR-MS (EI) \(m/z\) calcd for \(\text{C}_{13}\text{H}_{20}\text{N}_2\text{O}_2\)[M⁺] 260.1525, found 260.1523.

2-Cyano-3-fluoro-N,N-diisopropylbenzamide (3x): The representative procedure was followed using 3-fluoro-N,N-diisopropylbenzamide (1x) (112 mg, 0.50 mmol). Isolation by column chromatography (n-hexane/EtOAc: 5/1→1/1) yielded 3x (100 mg, 80%) as a colorless solid. M.p. = 148–150 °C. \(^1\)H-NMR (300 MHz, CDCl₃): \(\delta = 7.58\) (ddd, \(J = 8.5, 7.6, 5.4\) Hz, 1H), 7.15 (td, \(J = 8.5, 1.0\) Hz, 1H), 7.08 (dd, \(J = 7.6, 0.9\) Hz, 1H), 3.52 (hept, \(J = 6.7\) Hz, 2H), 1.52 (d, \(J = 6.7\) Hz, 6H), 1.14 (s, 6H). \(^1^3\)C-NMR (75 MHz, CDCl₃): \(\delta = 165.3\) (\(^4\)\(J_{\text{C}-\text{F}} = 2\) Hz, \(\text{C}_q\)), 163.1 (\(^4\)\(J_{\text{C}-\text{F}} = 261\) Hz, \(\text{C}_q\)), 143.9 (\(\text{C}_q\)), 135.2 (\(^2\)\(J_{\text{C}-\text{F}} = 9\) Hz, CH), 121.3 (\(^4\)\(J_{\text{C}-\text{F}} = 3\) Hz, CH), 115.8 (\(^2\)\(J_{\text{C}-\text{F}} = 19\) Hz, CH), 111.9 (\(\text{C}_q\)), 98.5 (\(^2\)\(J_{\text{C}-\text{F}} = 16\) Hz, (\(\text{C}_q\)), 51.5 (CH), 46.2 (CH), 20.5 (CH₃), 20.1 (CH₃). \(^1^9\)F-NMR (283 MHz, CDCl₃): \(\delta = -105.0\) (q). IR (neat): 2980, 1629, 1442, 1344, 1256, 809, 583 cm⁻¹. MS (EI) \(m/z\) (relative intensity) 248 (8) [M⁺], 205 (50), 191 (70), 148 (100), 120 (28). HR-MS (EI) \(m/z\) calcd for \(\text{C}_{14}\text{H}_{17}\text{FN}_2\text{O}\)[M⁺] 248.1325, found 248.1333.
**Intermolecular Competition Experiment between 1h and 1k**

\[
\begin{align*}
\text{MeO} & \quad \text{1h} \\
\text{F} & \quad \text{1k}
\end{align*}
\]

\[\text{2} \quad [\text{RuCl}_2(p\text{-cymene})]_2 \quad \text{MeO} \quad \text{3h: 65\%} \]

\[\text{2} \quad \text{MeO} \quad \text{CN} \quad \text{3k: 12\%} \]

\[\text{N,N-Diisopropyl-4-methoxybenzamide (1h)} \quad (118 \text{ mg, } 0.50 \text{ mmol}), \]
\[4\text{-fluoro-N,N-diisopropylbenzamide (1k)} \quad (112 \text{ mg, } 0.50 \text{ mmol}), \]
\[\text{2 (136 mg, 0.50 mmol), } [\text{RuCl}_2(p\text{-cymene})]_2 \quad (15.4 \text{ mg, 5.0 mol \%}), \]
\[\text{AgSbF}_6 \quad (34.4 \text{ mg, 20 mol \%}), \text{NaOAc (8.2 mg, 20 mol \%)} \text{ and DCE (2.0 mL)} \]
\[\text{were placed into a } 20 \text{ mL sealed tube under N}_2 \text{ and stirred at 120 °C for 24 h. At ambient temperature, the reaction mixture was diluted with H}_2\text{O (15 mL) and extracted with EtOAc (3 x 15 mL). The combined organic layer was dried with Na}_2\text{SO}_4 \text{ and concentrated under reduced pressure, purified by column chromatography on silica gel (n-hexane/EtOAc: 20/1→1/1) to afford the products 3h (84 mg, 65\%) and 3k (15 mg, 12\%).} \]

**Ruthenium-Catalyzed H/D Exchange in 1h with D\textsubscript{2}O as the Cosolvent**

\[
\begin{align*}
\text{N,N-Diisopropyl-4-methoxybenzamide (1h)} \quad (0.50 \text{ mmol}), \quad \text{2 (272 mg, 1.0 mmol)}, \\
[\text{RuCl}_2(p\text{-cymene})]_2 \quad (15.4 \text{ mg, 5.0 mol \%}), \text{AgSbF}_6 \quad (34.4 \text{ mg, 20 mol \%}), \text{NaOAc (8.2 mg, 20 mol \%)}, \text{DCE (1.8 mL) and D}_2\text{O (0.2 mL)} \quad \text{were placed into a } 20 \text{ mL sealed tube under N}_2 \text{ and stirred at 120 °C for 24 h. At ambient temperature, the reaction}
\end{align*}
\]
mixture was diluted with H₂O (15 mL) and extracted with EtOAc (3 x 15 mL). The combined organic layer was dried with Na₂SO₄ and concentrated under reduced pressure. The crude products were purified by flash column chromatography on silica gel to afford [D]ₙ-1h (97 mg, 82%) and [D]ₙ-3h (15 mg, 11%). The deuterium incorporation was estimated by ¹H-NMR spectroscopy.

**Kinetic Isotope Effect**

\[ \text{N,N-Diisopropylbenzamide (1a)} \] (51 mg, 0.25 mmol), [D]₅-N,N-diisopropylbenzamide ([D]₅-1a) (53 mg, 0.25 mmol), 2 (68 mg, 0.25 mmol), [RuCl₂(p-cymene)]₂ (7.7 mg, 5.0 mol %), AgSbF₆ (17 mg, 20 mol %), NaOAc (4.1 mg, 20 mol %) and DCE (2.0 mL) were placed into a 20 mL sealed tube under N₂ and stirred at 120 °C for 2 h. At ambient temperature, the reaction mixture was diluted with H₂O (15 mL) and extracted with EtOAc (3 x 15 mL). The combined organic layer was dried with Na₂SO₄ and concentrated under reduced pressure. The crude products were purified by flash column chromatography on silica gel to afford [D]ₙ-3a (36 mg, 62%). The kinetic isotope effect of this reaction was determined to be \( k_{H}/k_D \approx 1.2 \) as estimated by ¹H-NMR spectroscopy.
References

3e (CDCl₃, 300 MHz)

3e (CDCl₃, 75 MHz)
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3u
(CDCl₃, 300 MHz)

3u
(CDCl₃, 75 MHz)
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3x
(CDC13, 300 MHz)

3x
(CDC13, 75 MHz)