Supporting Information

Pd-Catalyzed Aminocarbonylation of Alkynes with Amines using \( \text{Co}_2(\text{CO})_8 \) as a Carbonyl Source

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General Information

$^1$H and $^{13}$C NMR spectra were recorded on a Bruker DPX-400 spectrometer or Bruker DPX-300 spectrometer with CDCl$_3$ as the solvent and TMS as an internal standard. Melting points were measured using a WC-1 microscopic apparatus and were uncorrected. GC analysis was performed on Agilent 4890D gas chromatograph. Mass spectra were measured on an LC-MSD-Trap-XCT instrument. High resolution mass spectra were ensured on a MALDI-FTMS. All solvents were used after further purification. Ethyl acetate and hexane were used for column chromatography. The commercials were obtained from commercial sources and used as-received without further purification unless otherwise noted.

Preparation of Substrates

Bromoalkynes and terminal alkynes were prepared from the corresponding aryl iodides with ethynyltrimethylsilane. Arylpropionic acids were prepared from the corresponding arylboronic acids with ethyl propiolate according to the reported procedure.$^{1-2}$

Optimization of Reaction Conditions

A 25 mL sealed tube was equipped with a magnetic stir bar and charged with amine 1a (0.3 mmol), alkyne 2a (0.6 mmol), palladium catalyst (0.01 mmol Pd), ligand (0.02 mmol), Co$_2$(CO)$_8$ (0.075 mmol) and base (0.4 mmol) in solvent (1.0 ml). The resulting mixture was stirred at room temperature for 5 h. Upon completion, the resulting mixture was filtered through a pad of celite, washed with dichloromethane. After evaporation of the solvent under vacuum, the residue was purified by column chromatography on silica gel (100–200 mesh) using hexane/ethyl acetate as an eluent (3:2, V/V) to afford the pure product 3aa.

Table S1 Screening of reaction conditions$^a$

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<th>Solvent</th>
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* Reaction conditions: 1a (0.3 mmol), 2a (0.6 mmol), palladium catalyst (0.01 mmol Pd), ligand (0.02 mmol), Co$_2$(CO)$_8$ (0.075 mmol) and base (0.4 mmol) in solvent (1.0 ml) under air for 5 h in a sealed tube. b GC yield (isolated yield) based on the amount of morpholine. c For 4 h. d For 3h.

**General Procedure for the Products**

A 25 mL sealed tube was equipped with a magnetic stir bar and charged with amine 1 (0.3 mmol), alkyne 2 (0.6 mmol), palladium catalyst (0.01 mmol Pd), ligand (0.02 mmol), Co$_2$(CO)$_8$ (0.075 mmol) and base (0.4 mmol) in solvent (1.0 ml). The resulting mixture was stirred at room
temperature for 5 h. Upon completion, the resulting mixture was filtered through a pad of celite, washed with dichloromethane. After evaporation of the solvent under vacuum, the residue was purified by column chromatography on silica gel (100–200 mesh) using hexane/ethyl acetate as an eluent to afford the pure product 3.

**Characterization Data of the Products**

1-morpholino-3-phenylprop-2-yn-1-one (3aa):

\[
\text{yellow oil; } ^1H\text{ NMR (CDCl}_3, 400 MHz): \delta [ppm] = 7.56-7.53 (m, 2H), 7.45-7.31 (m, 3H), 3.85-3.83 (m, 2H), 3.75-3.73 (m, 2H), 3.69 (s, 4H); ^13C\text{ NMR (CDCl}_3, 100 MHz): \delta [ppm] = 153.2, 132.4, 130.2, 128.6, 120.2, 91.2, 80.7, 66.9, 66.5, 47.3, 42.0.}
\]

3-(4-chlorophenyl)-1-morpholinoprop-2-yn-1-one (3ab):

\[
\text{light red solid; mp 111-112 °C; } ^1H\text{ NMR (CDCl}_3, 400 MHz): \delta [ppm] = 7.49-7.46 (m, 2H), 7.37-7.34 (m, 2H), 3.84-3.81 (m, 2H), 3.77-3.74 (m, 2H), 3.70 (s, 4H); ^13C\text{ NMR (CDCl}_3, 100 MHz): \delta [ppm] = 152.9, 136.5, 133.6, 129.0, 118.7, 89.9, 81.6, 66.9, 66.4, 47.3, 42.0; \text{ HRMS (ESI}^+) \text{ calcd for C}_{13}H_{12}ClNO}_2 [M+H]^+: 250.0630, \text{ found: 250.0634.}
\]

3-(2-fluorophenyl)-1-morpholinoprop-2-yn-1-one (3ac):

\[
\text{reddish brown oil; } ^1H\text{ NMR (CDCl}_3, 400 MHz): \delta [ppm] = 7.59-7.54 (m, 1H), 7.46-7.40 (m, 1H), 7.19-7.10 (m, 2H), 3.89-3.86 (m, 2H), 3.77-3.75 (m, 2H), 3.71 (s, 4H); ^13C\text{ NMR (CDCl}_3, 100 MHz): \delta [ppm] = 163.3 (d, J_{C-F} = 252.4 Hz), 152.7, 134.1, 132.1 (d, J_{C-F} = 8.1 Hz), 124.2 (d, J_{C-F} = 3.8 Hz), 115.6 (d, J_{C-F} = 20 Hz), 109.0 (d, J_{C-F} = 15 Hz), 85.5 (d, J_{C-F} = 3.2 Hz), 84.3, 66.8, 66.3, 47.2, 41.9; \text{ HRMS (ESI}^+) \text{ calcd for C}_{13}H_{12}FNO}_2 [M+H]^+: 234.0925, \text{ found: 234.0928.}
\]

1-morpholino-3-(3-nitrophenyl)prop-2-yn-1-one (3ad):
reddish brown solid; mp 161-162 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta \) [ppm] = 8.39-8.38 (m, 1H), 8.30-8.27 (m, 1H), 7.89-7.86 (m, 1H), 7.62-7.58 (m, 1H), 3.87-3.82 (m, 2H), 3.80-3.77 (m, 2H), 3.72 (s, 4H); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta \) [ppm] = 152.3, 148.1, 137.9, 129.8, 127.0, 124.8, 122.2, 88.0, 82.6, 66.9, 66.4, 47.4, 42.1; HRMS (ESI\(^+\)) calcd for C\(_{13}\)H\(_{12}\)N\(_2\)O\(_4\) [M+H]\(^+\): 261.0871, found: 261.0868.

4-(3-morpholino-3-oxoprop-1-yn-1-yl)benzaldehyde (3ae)

yellow solid; mp 133-134 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta \) [ppm] = 10.0 (s, 1H), 7.89 (d, \(J = 8.4 \) Hz, 2H), 7.70 (d, \(J = 8.2 \) Hz, 2H), 3.86-3.83 (m, 2H), 3.79-3.76 (m, 2H), 3.72 (s, 4H); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta \) [ppm] = 191.2, 152.6, 136.8, 132.9, 129.6, 126.2, 89.5, 83.6, 66.9, 66.4, 47.3, 42.1; HRMS (ESI\(^+\)) calcd for C\(_{14}\)H\(_{13}\)NO\(_3\) [M+H]\(^+\): 244.0968, found: 244.0969.

3-(3-morpholino-3-oxoprop-1-yn-1-yl)benzaldehyde (3af)

red solid; mp 85-86 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta \) [ppm] = 10.0 (s, 1H), 8.0 (t, \(J = 1.3 \) Hz, 1H), 7.96-7.93 (m, 1H), 7.82-7.79 (m, 1H), 7.58 (t, \(J = 7.7 \) Hz, 1H), 3.87-3.84 (m, 2H), 3.78-3.76 (m, 2H), 3.72 (s, 4H); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta \) [ppm] = 191.0, 152.7, 137.7, 136.6, 133.3, 131.0, 129.4, 121.6, 89.3, 81.9, 66.9, 66.5, 47.4, 42.0; HRMS (ESI\(^+\)) calcd for C\(_{14}\)H\(_{13}\)NO\(_3\) [M+H]\(^+\): 244.0968, found: 244.0967.

2-(3-morpholino-3-oxoprop-1-yn-1-yl)benzonitrile (3ag):

2-(3-morpholino-3-oxoprop-1-yn-1-yl)benzonitrile (3ag):
light red solid; mp 108-109 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta \) [ppm] = 7.77-7.71 (m, 2H), 7.67-7.62 (m, 1H), 7.58-7.53 (m, 1H), 4.00-3.98 (m, 2H), 3.80-3.77 (m, 2H), 3.72 (s, 4H); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta \) [ppm] = 152.2, 133.8, 132.8, 132.7, 130.4, 124.4, 117.3, 115.8, 86.0, 85.8, 67.0, 66.4, 47.5, 42.2; HRMS (ESI\(^+\)) calcd for C\(_{14}\)H\(_{12}\)N\(_2\)O\(_2\) [M+H]\(^+\): 241.0972, found: 241.0973.

1-morpholino-3-(4-(trifluoromethyl)phenyl)prop-2-yn-1-one (3ah):

![3ah]

red solid; mp 122-123 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta \) [ppm] = 7.68-7.63 (m, 4H), 3.86-3.83 (m, 2H), 3.78-3.76 (m, 2H), 3.72 (s, 4H); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta \) [ppm] = 152.6, 132.6, 131.8 (q, \(J_{C-F} = 32.7 \text{ Hz}\)), 125.5 (q, \(J = 3.7 \text{ Hz}\)), 124.1, 123.6 (q, \(J = 271.0 \text{ Hz}\)), 89.2, 82.5, 66.8, 66.4, 47.3, 42.0; HRMS (ESI\(^+\)) calcd for C\(_{14}\)H\(_{12}\)F\(_3\)NO\(_2\) [M+H]\(^+\): 284.0893, found: 284.0898.

1-morpholino-3-(naphthalen-1-yl)prop-2-yn-1-one (3ai):

![3ai]

yellow oil; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta \) [ppm] = 8.28-8.26 (m, 1H), 7.93-7.87 (m, 2H), 7.81-7.79 (m, 1H), 7.63-7.59 (m, 1H), 7.57-7.53 (m, 1H), 7.48-7.44 (m, 1H), 3.96-3.94 (m, 2H), 3.80-3.78 (m, 2H), 3.76-3.74 (m, 4H); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta \) [ppm] = 153.3, 133.3, 133.1, 132.2, 130.8, 128.5, 127.5, 126.9, 125.7, 125.1, 117.9, 89.6, 85.4, 66.9, 66.5, 47.4, 42.1.

1-morpholino-3-(\(p\)-tolyl)prop-2-yn-1-one (3aj):

![3aj]

red solid; mp 90-91 °C; \(^1\)H NMR (CDCl\(_3\), 400 MHz): \(\delta \) [ppm] = 7.43 (d, \(J = 8.1 \text{ Hz}, 2H\)), 7.17 (d, \(J = 8.0 \text{ Hz}, 2H\)), 3.84 (t, \(J = 4.7 \text{ Hz}, 2H\)), 3.74 (t, \(J = 4.8 \text{ Hz}, 2H\)), 3.69 (s, 4H), 2.37 (s, 3H); \(^{13}\)C NMR (CDCl\(_3\), 100 MHz): \(\delta \) [ppm] = 153.3, 140.7, 132.3, 129.3, 117.1, 91.6, 80.4, 66.9, 66.5, 47.3, 41.9, 21.6.

1-morpholino-3-(\(m\)-tolyl)prop-2-yn-1-one (3ak):

![3ak]
yellow oil; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.36-7.34 (m, 2H), 7.28-7.23 (m, 2H), 3.85 (t, $J$ = 4.8 Hz, 2H), 3.75 (t, $J$ = 4.7 Hz, 2H), 3.71 (s, 4H), 2.35 (s, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 153.3, 138.4, 132.9, 131.1, 129.5, 128.5, 120.1, 91.5, 80.5, 66.9, 66.5, 47.3, 42.0, 21.2.

1-morpholino-3-(o-tolyl)prop-2-yn-1-one (3al):

yellow oil; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.52-7.51 (m, 1H), 7.34-7.30 (m, 1H), 7.25-7.23 (m, 1H), 7.21-7.17 (m, 1H), 3.86 (t, $J$ = 4.8 Hz, 2H), 3.75 (t, $J$ = 4.8 Hz, 2H), 3.72 (s, 4H), 2.47 (s, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 153.3, 141.3, 132.9, 130.2, 129.7, 125.8, 120.2, 90.3, 84.6, 66.9, 66.5, 47.3, 42.0, 20.8.

3-(3,5-dimethylphenyl)-1-morpholinoprop-2-yn-1-one (3am):

yellow solid; mp 85-86 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.17 (s, 2H), 7.06 (s, 1H), 3.86-3.83 (m, 2H), 3.76-3.74 (m, 2H), 3.70 (s, 4H), 2.31 (s, 6H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 153.4, 138.2, 132.2, 130.1, 119.9, 91.8, 80.2, 66.9, 66.5, 47.3, 42.0, 21.1; HRMS (ESI$^+$) calcd for C$_{15}$H$_{17}$NO$_2$ [M+H]$^+$: 244.1332, found: 244.1334.

3-(3-methoxyphenyl)-1-morpholinoprop-2-yn-1-one (3an):

yellow oil; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.29-7.25 (m, 1H), 7.16-7.11 (m, 1H), 7.07-7.06 (m, 1H), 6.99-6.96 (m, 1H), 3.87-3.83 (m, 2H), 3.81 (s, 3H), 3.78-3.74 (m, 2H), 3.70 (s, 4H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 159.4, 153.2, 129.7, 124.8, 121.2, 117.1, 116.9, 91.1,
80.5, 66.9, 66.5, 55.4, 47.3, 42.0; HRMS (ESI+) calcd for C_{14}H_{15}NO_3 [M+H]^+: 246.1125, found: 246.1129.

3-(2-methoxyphenyl)-1-morpholinoprop-2-yn-1-one (3ao):

![3ao](image)
yellow solid; mp 94-95 °C; ^1H NMR (CDCl_3, 400 MHz): δ [ppm] = 7.52-7.50 (m, 1H), 7.41-7.37 (m, 1H), 6.96-6.89 (m, 2H), 3.92 (t, J = 4.8 Hz, 2H), 3.87 (s, 3H), 3.75 (t, J = 3.7 Hz, 2H), 3.70 (s, 4H); ^13C NMR (CDCl_3, 100 MHz): δ [ppm] = 161.1, 153.4, 134.3, 131.9, 120.6, 110.7, 109.5, 87.8, 85.0, 67.0, 66.5, 55.8, 47.3, 41.9.

1-morpholino-3-(thiophen-2-yl)prop-2-yn-1-one (3ap):

![3ap](image)
reddish brown oil; ^1H NMR (CDCl_3, 400 MHz): δ [ppm] = 7.44-7.42 (m, 2H), 7.06-7.04 (m, 1H), 3.82-3.80 (m, 2H), 3.77-3.74 (m, 2H), 3.70 (s, 4H); ^13C NMR (CDCl_3, 100 MHz): δ [ppm] = 153.0, 135.3, 130.2, 127.5, 119.9, 85.0, 84.8, 66.9, 66.5, 47.3, 42.0; HRMS (ESI+) calcd for C_{11}H_{11}NO_2S [M+H]^+: 222.0583, found: 222.0585.

3-(4-(tert-butyl)phenyl)-1-morpholinoprop-2-yn-1-one (3as):

![3as](image)
yellow solid; mp 149-150 °C; ^1H NMR (CDCl_3, 400 MHz): δ [ppm] = 7.49-7.45 (m, 2H), 7.42-7.34 (m,2H), 3.84 (t, J = 4.7 Hz, 2H), 3.75 (t, J = 4.7 Hz, 2H), 3.70 (s, 4H), 1.32 (s, 9H); ^13C NMR (CDCl_3, 100 MHz): δ [ppm] = 153.8, 153.4, 132.2, 125.6, 117.2, 91.6, 80.3, 66.9, 66.5, 47.3, 42.0, 35.0, 31.1; HRMS (ESI+) calcd for C_{17}H_{21}NO_2 [M+H]^+: 272.1645, found: 272.1650.

N-methyl-N,3-diphenylpropiolamide (3ba):^5
red oil; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.47-7.43 (m, 2H), 7.40-7.30 (m, 3H), 7.26-7.21 (m, 3H), 7.15-7.13 (m, 2H), 3.39 (s, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 154.4, 143.3, 132.4, 129.9, 129.2, 128.3, 127.9, 127.4, 120.4, 90.9, 82.6, 36.4.

$N,N$-diethyl-3-phenylpropiolamide (3ca):  

reddish brown oil; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.55-7.53 (m, 2H), 7.43-7.34 (m, 3H), 3.66 (dd, $J = 3.6$ Hz, $J = 10.7$ Hz, 2H), 3.48 (dd, $J = 3.6$ Hz, $J = 10.7$ Hz, 2H), 1.30-1.24 (m, 3H), 1.18 (t, $J = 7.2$ Hz, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 154.0, 132.3, 129.9, 128.5, 120.8, 89.0, 82.0, 43.6, 39.3, 14.4, 12.9.

3-phenyl-1-(piperidin-1-yl)prop-2-yn-1-one (3da):  

red solid; mp 96-97 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.56-7.53 (m, 2H), 7.43-7.33 (m, 3H), 3.77 (t, $J = 5.2$ Hz, 2H), 3.62 (t, $J = 5.6$ Hz, 2H), 1.72-1.55 (m, 6H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 152.9, 132.3, 129.9, 128.5, 120.7, 90.2, 81.5, 48.2, 42.4, 26.4, 25.4, 24.5.

3-phenyl-1-(pyrrolidin-1-yl)prop-2-yn-1-one (3ea):  

reddish brown solid; mp 71-72 °C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.56-7.53 (m, 2H), 7.43-7.33 (m, 3H), 3.73 (t, $J = 6.4$ Hz, 2H), 3.53 (t, $J = 6.5$ Hz, 2H), 2.00-1.91 (m, 4H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 152.7, 132.3, 129.9, 128.5, 120.6, 88.7, 82.7, 48.1, 45.4, 25.4, 24.7. 

$N$-butyl-3-phenylpropiolamide (3fa):
yellow oil; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.53-7.51 (m, 2H), 7.40-7.32 (m, 3H), 6.08 (s, 1H), 3.38-3.32 (m, 2H), 1.57-1.53 (m, 2H), 1.42-1.36 (m, 2H), 0.96-0.92 (m, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 153.5, 132.5, 130.0, 128.5, 120.3, 84.4, 83.2, 39.7, 31.4, 20.0, 13.7; HRMS (ESI$^+$) calcd for C$_{13}$H$_{15}$NO [M+H]$^+$: 202.1227, found: 202.1227.

$N$-cyclohexyl-3-phenylpropiolamide (3ga):

red solid; mp 97-98 $^\circ$C; $^1$H NMR (CDCl$_3$, 400 MHz): $\delta$ [ppm] = 7.53-7.51 (m, 2H), 7.40-7.32 (m, 3H), 5.94 (d, $J = 6.8$ Hz, 1H), 3.91-3.84 (m, 1H), 2.00-1.96 (m, 2H), 1.76-1.60 (m, 3H), 1.43-1.32 (m, 2H), 1.26-1.16 (m, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz): $\delta$ [ppm] = 152.5, 132.4, 129.9, 128.5, 120.4, 84.2, 83.4, 48.9, 32.9, 25.4, 24.8; HRMS (ESI$^+$) calcd for C$_{15}$H$_{17}$NO [M+H]$^+$: 228.1383, found: 228.1385.

$N,N$-diisopropyl-3-phenylpropiolamide (3ha):

yellow oil; $^1$H NMR (CDCl$_3$, 300 MHz): $\delta$ [ppm] = 7.56-7.52 (m, 2H), 7.41-7.36 (m, 3H), 4.46-4.57 (m, 1H), 3.75-3.68 (m, 1H), 1.42 (d, $J = 6.9$ Hz, 6H), 1.32 (d, $J = 6.9$ Hz, 6H); $^{13}$C NMR (CDCl$_3$, 75 MHz): $\delta$ [ppm] = 153.6, 132.2, 129.7, 128.4, 121.0, 88.5, 83.1, 46.1, 45.8, 21.1, 20.1; HRMS (ESI$^+$) calcd for C$_{15}$H$_{19}$NO [M+H]$^+$: 230.1540, found: 230.1543.

References


Copies of $^1$H and $^{13}$C NMR Spectra for the Products