A General Solution for Unstable Boronic Acids: Slow-Release Cross-Coupling from Air-Stable MIDA Boronates

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Supporting Information

Part A

Part B

Part C

I. General methods

Materials. Commercial reagents were purchased from Sigma-Aldrich, Fisher Scientific, Alfa Aesar, TCI America, Frontier Scientific, Oakwood Products or Combi-Blocks and were used without further purification unless otherwise noted. Solvents were purified via passage through packed columns as described by Pangborn and coworkers[1] (THF, Et_2O, CH_3CN, CH_2Cl_2: dry neutral alumina; hexane, benzene, and toluene: dry neutral alumina and Q-5 reactant (copper(II) oxide on alumina); DMSO, DMF: activated molecular sieves). All water was deionized prior to use. Triethylamine, diisopropylamine, diethylamine, pyridine, and 2,6-lutidine were freshly distilled under an atmosphere of nitrogen from CaH_2. The following compounds were prepared according to procedures reported in the literature: N-methyliminodiacetic acid,[2] vinyl MIDA boronate **1g**,[3] 5-bromo-2-thiopheneboronic acid MIDA ester.[4] The following MIDA boronates utilized in this paper are now commercially-available from Sigma-Aldrich http://sigma-aldrich.com/mida: **2a** (701017), **2b** (701106), **2f** (697443), **2g** (704415), **2h** (697311), 5-bromo-2-thiopheneboronic acid MIDA ester (701092).

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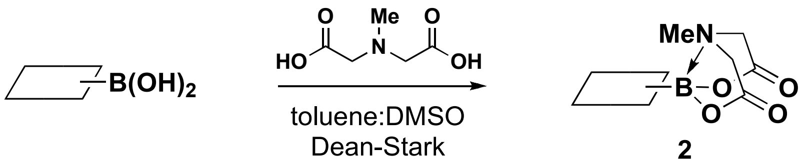
[1] Pangborn, A. B.; Giardello, M. A; Grubbs, R. H.; Rosen, R. K.; Timmers, F.J. *Organometallics* **1996**, *15*, 1518-1520.
[2] Ballmer, S. G.; Gillis, E. P.; Burke, M. D. *Org. Syn.*, in press.
[3] Uno, B.E.; Gillis, E.P.; Burke, M.D. *Tetrahedron* **2009**, *65*, 3130-3138.
[4] Gillis, E.P.; Burke, M.D. *J. Am. Chem. Soc.* **2007**, *129*, 6716-6717.

General Experimental Procedures. Unless otherwise noted, all reactions were performed in flame-dried glassware under argon. Organic solutions were concentrated via rotary evaporation under reduced pressure with a bath temperature of 35-40 ºC. Reactions were monitored by analytical thin layer chromatography (TLC) performed using the indicated solvent on E. Merck silica gel 60 F254 plates (0.25mm). Compounds were visualized by: exposure to a UV lamp (λ = 254 or 366 nm), incubation in a glass chamber containing iodine, and/or treatment with a solution of $KMnO_4$, an acidic solution of p-anisaldehyde or a solution of ceric ammonium molybdate (CAM) followed by brief heating with a Varitemp heat gun. MIDA boronates are compatible with standard silica gel chromatography, including standard loading techniques. Column chromatography was performed using standard methods[5] or with a Teledyne-Isco CombiFlash R_f purification system. Both methods were performed using Merck silica gel grade 9385 60 Å (230-400 mesh). For loading, compounds were adsorbed onto non acid-washed Celite 545 (app. 10 g/mmol crude product) *in vacuo* from an acetone solution. Specifically, in each case the crude residue was dissolved/suspended in acetone and to the mixture was added Celite. The mixture was concentrated *in vacuo* to afford a free flowing powder which was then loaded on top of a silica gel column. To ensure quantitative transfer, this procedure was repeated with a small amount of acetone and Celite to transfer any remaining residue.

Structural analysis. ^{1}H-NMR spectra were recorded at 23 °C on a Varian Unity or a Varian Unity Inova 500 MHz spectrometer. Chemical shifts (δ) are reported in parts per million (ppm) downfield from tetramethylsilane and referenced to residual protium in the NMR solvent ($CHCl_3$, $\delta = 7.26$; CD_2HCN, $\delta = 1.93$, center line; acetone-d_6 $\delta = 2.04$, center line). Alternatively, NMR-solvents designated as "w/ TMS" were referenced to tetramethylsilane (δ = 0.00 ppm) added as an internal standard. Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, quint = quintet, sept = septet, m = multiplet, br = broad, app = apparent), coupling constant (J) in Hertz (Hz), and integration. ^{13}C NMR spectra were recorded at 23 °C on a Varian Unity 500 MHz spectrometer. Chemical shifts (δ) are reported in ppm downfield from tetramethylsilane and referenced to carbon resonances in the NMR solvent ($CDCl_3$, $\delta = 77.0$, center line; CD_3CN, $\delta = 1.30$, center line, acetone-d_6 $\delta = 29.80$, center line) or to added tetramethylsilane ($\delta = 0.00$). Carbons bearing boron substituents were not observed (quadrupolar relaxation). ^{11}B NMR spectra were recorded using a General Electric GN300WB instrument and referenced to an external standard of ($BF_3{\cdot}Et_2O$). High resolution mass spectra (HRMS) were performed by Furong Sun and Dr. Steve Mullen at the University of Illinois School of Chemical Sciences Mass Spectrometry Laboratory. Infrared spectra were collected from a thin film on NaCl plates or as KBr pellets on a Perkin-Elmer Spectrum BX FT-IR spectrometer, a Mattson Galaxy Series FT-IR 5000 spectrometer or a Mattson Infinity Gold FT-IR spectrometer. Absorption maxima (ν_{max}) are reported in wavenumbers (cm^{-1}). X-ray crystallographic analysis of **2i** was carried out by Dr. Scott Wilson and Dr. Danielle Gray at the University of Illinois George L. Clark X-Ray facility.

II. Synthesis of MIDA boronates



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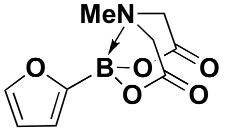
[5] Still, W.C.; Kahn, M.; Mitra, A.; *J. Org. Chem.* **1978**, *43*, 2923-2925.

General procedure for the synthesis of MIDA boronates. To a round-bottom flask equipped with a stir bar was added the boronic acid (1 equiv), *N*-methyliminodiacetic acid (1-1.5 equiv), DMSO and either toluene or benzene. The flask was fitted with a Dean-Stark trap and the Dean-Stark trap was fitted with a reflux condenser vented to ambient atmosphere. The stirred mixture was heated to reflux with azeotropic removal of water for 2-18 h. The solution was concentrated *in vacuo* (1 Torr, 100 °C). Unless otherwise noted, the resulting residue was adsorbed onto Celite *in vacuo* from an acetone suspension and the resulting powder was subjected to flash chromatography ($Et_2O \rightarrow Et_2O$:MeCN).

2-furyl MIDA boronate (**2a**). The general procedure was followed using furan-2-boronic acid (5.029 g, 44.95 mmol, purchased from Sigma-Aldrich), *N*-methyliminodiacetic acid (7.275 g, 49.44 mmol), toluene (210 mL) and DMSO (40 mL). The mixture was refluxed for 8 h. The product was eluted with $Et_2O \rightarrow Et_2O$:acetone 1:1. The solid thus obtained was dissolved in a minimum of acetone to which Et_2O was slowly added to promote crystallization. Filtration of the mixture afforded **2a** as an off-white crystalline solid (8.98 g, 90%).



2a

TLC (EtOAc)
$R_f = 0.33$, stained with $KMnO_4$

^{1}H-NMR (500 MHz, CD_3CN)
δ 7.66 (dd, *J* = 2.0, 1.0 Hz, 1H), 6.71 (dd, *J* = 3.0, 1.0 Hz, 1H), 6.43 (dd, *J* = 3.0, 2.0 Hz, 1H), 4.06 (d, *J* = 17 Hz, 2H), 3.89 (d, *J* = 17 Hz, 2H), 2.60 (s, 3H)

^{13}C-NMR (125 MHz, CD_3CN)
δ 169.2, 147.0, 119.1, 110.8, 62.4, 47.9

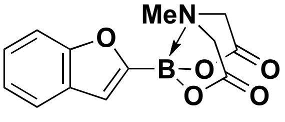
^{11}B-NMR (96 MHz, CH_3CN)
δ 9.5

HRMS (EI+)

Calculated for $C_9H_{10}BNO_5$ $(M)^+$:	223.0652
Found:	223.0651

IR (thin film, cm^{-1})
3136, 3109, 3002, 2990, 2962, 1751, 1570, 1481, 1457, 1419, 1346, 1336, 1302, 1245, 1227, 1197, 1153, 1085, 1057, 1004, 965, 932, 873, 839, 828, 823

2-benzofuranyl MIDA boronate (**2b**). The general procedure was followed using benzofuran-2-boronic acid (5.247 g, 32.39 mmol, purchased from Sigma-Aldrich), *N*-methyliminodiacetic acid (5.005 g, 34.02 mmol), toluene (135 mL) and DMSO (15 mL). The mixture was refluxed for 8 h. The product was eluted with $Et_2O \rightarrow Et_2O$:MeCN 2:1. The solid thus obtained was dissolved in a minimum of acetone to which Et_2O was slowly added to promote crystallization. Filtration of the mixture afforded **2b** as a colorless crystalline solid (7.61 g, 86%).



2b

TLC (EtOAc)

R_f = 0.45, visualized by UV (λ = 254 nm) and $KMnO_4$ stain

^{1}H-NMR (500 MHz, CD_3CN)

δ 7.63 (app dq, *J* = 7.5, 1.0 Hz, 1H), 7.51 (app. dt, *J* = 8.5, 1.0 Hz, 1H), 7.30 (m, 1H), 7.22 (app tt, *J* = 7.5, 0.5 Hz, 1H), 7.11 (s, 1H), 4.14 (d, *J* = 17 Hz, 2H), 3.97 (d, *J* = 17 Hz, 2H), 2.69 (s, 3H)

^{13}C-NMR (125 MHz, CD_3CN)

δ 169.2, 158.2, 129.1, 125.7, 123.6, 122.4, 115.8, 112.2, 62.6, 48.1

^{11}B-NMR (96 MHz, CD_3CN)

δ 9.5

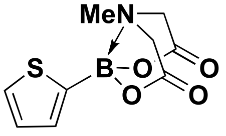
HRMS (EI+)

Calculated for $C_{13}H_{12}BNO_5$ $(M)^+$: 273.0809
Found: 273.0810

IR (thin film, cm^{-1})

3008, 2956, 1765, 1560, 1448, 1335, 1282, 1249, 1191, 1157, 1138, 1052, 1005, 942, 853

2-thiophenyl MIDA boronate (**2c**). The general procedure was followed using thiophene-2-boronic acid (4.871 g, 38.06 mmol, purchased from Sigma-Aldrich), *N*-methyliminodiacetic acid (5.884 g, 39.99 mmol), benzene (180 mL) and DMSO (20 mL). The mixture was refluxed for 8 h. The product was eluted with Et_2O → Et_2O:MeCN 2:1. The solid thus obtained was dissolved in a minimum of acetone to which Et_2O was slowly added to promote crystallization. Filtration of the mixture afforded **2c** as a colorless crystalline solid (7.13 g, 78%).



2c

TLC (EtOAc)

R_f = 0.34, visualized by UV (λ = 254 and 366 nm) and $KMnO_4$ stain

^{1}H-NMR (500 MHz, CD_3CN)

δ 7.62 (dd, *J* = 5.0, 1.0 Hz, 1H), 7.28 (dd, *J* = 3.5, 1.0 Hz, 1H), 7.19 (dd, *J* = 5.0, 3.5 Hz, 1H), 4.07 (d, *J* = 17 Hz, 2H), 3.90 (d, *J* = 18 Hz, 2H), 2.58 (s, 3H)

^{13}C-NMR (125 MHz, CD_3CN)

δ 169.1, 134.2, 130.7, 129.5, 62.4, 48.3

^{11}B-NMR (96 MHz, CD_3CN)

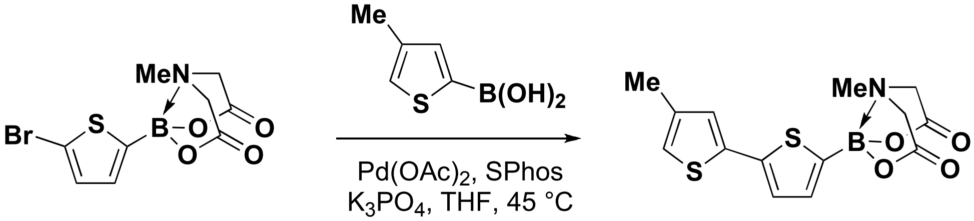
δ 11.2

HRMS (EI+)

Calculated for $C_9H_{10}BNO_4S$ $(M)^+$: 239.0424
Found: 239.0432

IR (thin film, cm^{-1})

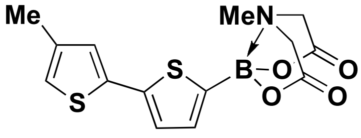
3007, 2954, 1773, 1704, 1514, 1457, 1421, 1337, 1285, 1226, 1172, 1029, 979, 894, 860, 814, 713



bis-thiophenyl MIDA boronate (2d).

Preparation of catalyst stock solution: In a glove box, to a 40 mL vial equipped with a stir bar was added $Pd(OAc)_2$ (0.137 g, 0.610 mmol), dicyclohexylphosphino-2',6'-dimethoxy-1,1'-biphenyl (SPhos) (0.502 g, 1.22 mmol) and THF (25 mL). The solution was stirred for 30 minutes upon which the color of the solution changed from orange to yellow.

Cross-coupling reaction: To a 500 mL two-neck flask equipped with a stir bar was added 2-bromothiophene-5-MIDA boronate ester[6] (4.862 g, 15.29 mmol), 4-methylthiophene-2-boronic acid (4.808 g, 30.58 mmol) and K_3PO_4 (anhydrous, finely ground, 9.739 g, 45.89 mmol). The flask was fitted with a reflux condenser and the second arm was fitted with a rubber septum. The flask was placed under Ar atm. and to the flask was added THF (150 mL). To the flask was added via cannula the catalyst stock solution (25 mL). The mixture was heated to 45 °C with stirring for 12 h. The mixture was cooled to room temperature and then was filtered through a thin pad of silica gel eluting with a copious volume of MeCN. The filtrate was concentrated *in vacuo* and the crude residue was adsorbed onto Celite from an acetone solution. The resulting powder was subjected to flash chromatography on silica gel (Et_2O, then Et_2O:MeCN 2:1) to afford a green foam, which was further purified by dissolving the product in a minimum of acetone followed by slow addition of Et_2O to promote crystallization. Filtration of the resulting mixture afforded **2d** as a pale green solid (3.744 g, 73%).



2d

TLC (EtOAc)

$R_f = 0.38$, visualized by UV (λ = 254 and 366 nm) and $KMnO_4$ stain

^{1}H-NMR (500 MHz, CD_3CN)

δ 7.24 (d, *J* = 3.5 Hz, 1H), 7.17 (d, *J* = 3.5 Hz, 1H), 7.09 (d, *J* = 1.5 Hz, 1H), 6.91 (app quint, *J* = 1.0 Hz, 1H), 4.07 (d, *J* = 17 Hz, 2H), 3.91 (d, *J* = 17 Hz, 2H), 2.66 (s, 3H), 2.22 (d, *J* = 1.0

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[6] Gillis, E.P.; Burke, M.D. *J. Am. Chem. Soc.* **2007**, *129*, 6716-6717.

Hz, 3H)

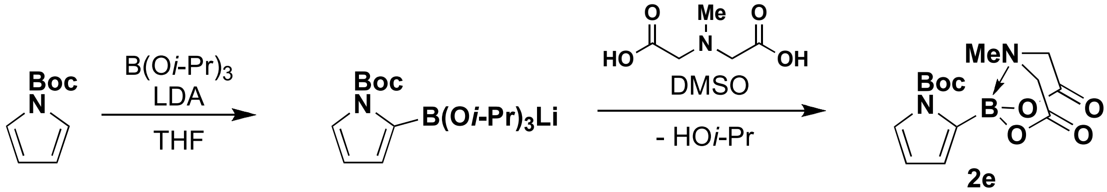
^{13}C-NMR (125 MHz, CD_3CN)
δ 169.1, 142.5, 139.8, 137.6, 135.3, 127.3, 125.9, 121.2, 62.4, 48.4, 15.7

^{11}B-NMR (96 MHz, CD_3CN)
δ 10.9

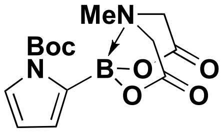
HRMS (EI+)

Calculated for $C_{14}H_{14}BNO_4S_2$ $(M)^+$:	335.0457
Found:	335.0457

IR (thin film, cm^{-1})
3004, 2953, 1773, 1453, 1419, 1336, 1285, 1231, 1193, 1169, 1037, 980, 858, 806



2-(N-*tert*-butoxycarbonyl)pyrrole MIDA boronate (**2e**). In an unoptimized procedure, to a 50 mL Schlenk flask equipped with a stir bar was added THF (15 mL) and diisopropylamine (920 µL). The solution was cooled to -78 °C and then to the stirred solution was added dropwise *n*-BuLi (2.5 M in hexanes, 2.75 mL). The solution was maintained at -78 °C for 10 min, and then was allowed to warm to room temperature with stirring for 3 h. The solution was cooled to -78 °C, and to the stirred solution was added dropwise via cannula N-*tert*-butoxycarbonylpyrrole (1.016 g, 6.074 mmol) as a solution in THF (15 mL + 10 mL washing). The solution was stirred for 30 min. To the yellow solution was added dropwise triisopropylborate (1.40 mL, 6.07 mmol). The solution was stirred for 10 min at -78 °C and then was allow to warm to room temperature with stirring overnight (11 h). To the near-black solution was added DMSO (15 mL). The THF was then removed *in vacuo* and the resulting DMSO solution was transferred to a 50 mL pressure-equalizing addition funnel. The funnel was fitted onto a 100 mL 3-neck round-bottom flask charged with N-methyliminodiacetic acid (1.407 g, 9.563 mmol) and DMSO (20 mL). To a second neck was fitted a short-path distillation apparatus connected to vacuum. The third neck of the flask was sealed with a septum. The system was placed under vacuum (1 Torr) and the mixture was heated to 75 °C upon which the DMSO began to distill. The DMSO solution of lithium triisopropyl 2-(N-*tert*-butoxycarbonyl)pyrrole borate was added to the distilling mixture dropwise over 1 h. The mixture was further distilled to near dryness (1 h). The resulting residue was suspended in acetone and concentrated *in vacuo* onto Celite (10 g). The resulting powder was lyophilized for one day to remove additional DMSO and then was subjected to flash chromatography on silica gel (Et_2O:MeCN, 100:0 → 80:20) to afford **2e** as an off-white crystalline solid (565 mg, 29%).



2e

TLC (EtOAc)

R_f = 0.35 stained with $KMnO_4$

^{1}H-NMR (500 MHz, CD_3CN)

δ 7.38 (dd, *J* = 3.0, 1.5 Hz, 1H), 6.61 (dd, *J* = 3.0, 1.5 Hz, 1H), 6.20 (t, *J* = 3.0 Hz, 1H), 4.09 (d, *J* = 17 Hz, 2H), 4.05 (d, 17 Hz, 2H), 2.79 (s, 3H), 1.54 (s, 9H)

^{13}C-NMR (125 MHz, CD_3CN)

δ 169.9, 151.2, 126.2, 124.9, 112.1, 84.9, 65.9, 49.9, 28.0

^{11}B-NMR (96 MHz, CD_3CN)

δ 11.1

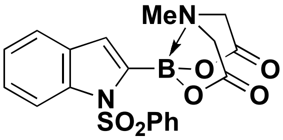
HRMS (ESI+)

Calculated for $C_{14}H_{20}BN_2O_6$ $(M+H)^+$:	323.1414
Found:	323.1414

IR (KBr, cm^{-1})

3174, 3118, 3012, 2982, 2941, 1743, 1457, 1337, 1304, 1296, 1253, 1235, 1146, 1027, 1008, 815, 747

1-(Phenylsulfonyl)-2-indole MIDA boronate (2f). The general procedure was followed using 1-(phenylsulfonyl)-2-indoleboronic acid (1.396 g, 4.64 mmol, purchased from Sigma-Aldrich), N-methyliminodiacetic acid (0.717 g, 4.88 mmol), toluene (30 mL) and DMSO (15 mL). The mixture was refluxed for 3 h. The mixture was cooled to room temperature and the toluene was removed *in vacuo*. The resulting DMSO solution was transferred to a separatory funnel and was diluted with H_2O (50 mL). The aqueous phase was extracted with THF:Et_2O (1:1, 3 × 25 mL). The combined organics were washed with brine (2 × 25 mL), dried over $MgSO_4$, filtered and concentrated *in vacuo*. The residue was adsorbed onto Celite from an acetone solution and the resulting powder was subjected to flash chromatography on silica gel (Et_2O:MeCN 100:0 → 2:1) to afford **2f** as a colorless crystalline solid (1.326 g, 69%).



2f

TLC (EtOAc)

R_f = 0.42, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, CD_3CN)

δ 8.18 (d, *J* = 8.5 Hz, 1H), 7.99 (d, *J* = 7.0, 2H), 7.59 (m, 2H), 7.49 (t, *J* = 8.5 Hz, 2H), 7.36 (ddd, *J* = 8.5, 7.5, 1.5 Hz, 1H), 7.26 (app. td, *J* = 7.0, 1.0 Hz, 1H), 7.16 (d, *J* = 0.5 Hz, 1H), 4.16 (d, *J* = 18 Hz, 2H), 4.11 (d, *J* = 18 Hz, 2H), 3.00 (s, 3H)

^{13}C-NMR (125 MHz, CD_3CN)

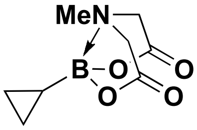
δ 140.4, 139.7, 135.3, 131.3, 130.4, 127.8, 126.6, 124.8, 123.8, 122.6, 115.7, 65.9, 50.7

^{11}B-NMR (96 MHz, CD_3CN)
δ 10.9

HRMS (EI+)
Calculated for $C_{19}H_{17}O_6N_2SB$ $(M)^+$: 412.0900
Found: 412.0897

IR (KBr, cm^{-1})
3068, 3014, 1769, 1528, 1469, 1448, 1363, 1340, 1299, 1228, 1176, 1124, 1091, 1042, 1010, 966, 865, 750, 727, 686, 656, 589, 573, 561

cyclopropyl MIDA boronate (**2h**).[7] The general procedure was followed using cyclopropyl boronic acid (5.139 g, 59.82 mmol, purchased from Oakwood Products), N-methyliminodiacetic acid (10.56 g, 71.79 mmol), DMSO (20 mL) and toluene (20 mL). The mixture was refluxed for 2 h. The mixture was cooled to room temperature and then was concentrated *in vacuo* (1 Torr, 100 °C). Although the product is stable to chromatography, for convenience the purification step was modified to employ crystallization. The residue oil was suspended in EtOAc (500 mL) and was transferred to a 2 L separatory funnel. The mixture was washed with water (250 mL). The aqueous phase was extracted with EtOAc (3 x 250 mL). The combined organics were washed with brine (50 mL) and then were dried over $MgSO_4$, filtered, and concentrated *in vacuo*. The resulting crude product was dissolved in acetone (app. 100 mL), and then was diluted slowly over 1 h with Et_2O (1.5 L) to promote crystallization of the product. The mixture was filtered to isolate **2h** as a colorless, crystalline solid (8.775 g, 74%).



2h

TLC (EtOAc)
$R_f = 0.21$, stained with $KMnO_4$

^{1}H-NMR (500 MHz, CD_3CN)
δ 3.92 (d, *J* = 17 Hz, 2H), 3.80 (d, *J* = 17 Hz, 2H), 2.98 (s, 3H), 0.46 (dq, *J* = 9.5, 3.0 Hz, 2H), 0.12 (m, 2H), -0.33 (m, 1H)

^{13}C-NMR (125 MHz, acetone-d_6)
δ 169.0, 62.7, 46.8, 1.2

^{11}B-NMR (96 MHz, CD_3CN)
δ 13.2

HRMS (FAB+)
Calculated for $C_8H_{13}BNO_4$ $(M+H)^+$: 198.0938
Found: 198.0937

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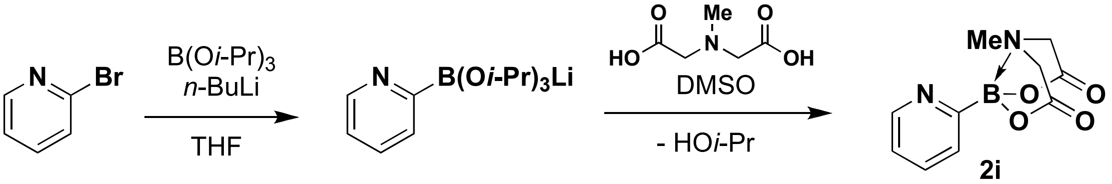
[7] Uno, B.E.; Gillis, E.P.; Burke, M.D. *Tetrahedron* **2009**, *65*, 3130-3138.

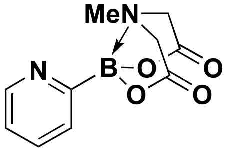
IR (thin film, cm^{-1})

2998, 1744, 1457, 1358, 1337, 2197, 1246, 1129, 1048, 985, 956, 892, 880, 845, 704

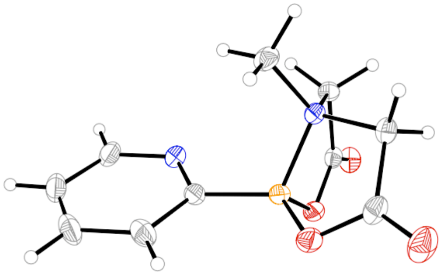


2i

2-pyridyl MIDA boronate (**2i**). In an unoptimized procedure, to a 250 mL Schlenk flask equipped with a stir bar was added 2-bromopyridine (6.00 mL, 62.9 mmol), triisopropylborate (15.0 mL, 65.2 mmol) and THF (100 mL). The solution was cooled to -78 °C. To the stirred solution was added dropwise *n*-BuLi (25.0 mL, 2.5 M in hexanes) at a rate sufficiently slow as to avoid the accumulation of a red color in the mixture (app. 20 minutes). The resulting beige mixture was stirred for 30 min and then was allowed to warm to room temperature with stirring overnight (12 h). The mixture was concentrated *in vacuo* onto Celite (10 g) to afford a free-flowing powder. Separately, a 500 mL 3-neck round-bottom flask equipped with a stir bar was charged with N-methyliminodiacetic acid (15.77 g, 107.2 mmol) and DMSO (100 mL). To one neck of the flask was fitted a solid addition funnel charged with the Celite-adsorbed lithium triisopropyl 2-pyridylborate. To a second neck was fitted a short-path distillation apparatus connected to vacuum. The third neck of the flask was sealed with a septum. The system was placed under vacuum (1 Torr) and the mixture was heated to 75 °C upon which the DMSO began to distill. The lithium triisopropyl 2-pyridylborate was added to the distilling mixture portion-wise over 1 h. The mixture was further distilled to near dryness (1 h). The resulting residue was suspended in acetone, and then concentrated *in vacuo* onto additional Celite (10 g). The resulting powder was lyophilized for 3 days to remove additional DMSO, and then was subjected to flash chromatography on silica gel (40 g silica gel, Et_2O:MeCN, 100:0 → 0:100). The product thus obtained was suspended in acetone (5 mL) and then diluted with Et_2O (100 mL) to promote crystallization. The mixture was filtered to isolate **2i** as an off-white crystalline solid (4.024 g, 27%).



2i



TLC (MeCN)

R_f = 0.26, visualized by UV (λ = 254 nm) and $KMnO_4$ stain

^{1}H-NMR (500 MHz, CD_3CN)

δ 8.67 (ddd, *J* = 2.5, 1.5, 1.0 Hz, 1H), 7.70 (td, *J* = 7.5, 1.5 Hz, 1H), 7.62 (dt, *J* = 7.5, 1.0 Hz, 1H), 7.28 (ddd, *J* = 8.5, 1.5 Hz, 1H), 8.67 (ddd, *J* = 4.5, 1.5, 1.0 Hz, 1H), 4,09 (d, *J* = 17 Hz, 2H), 3.98 (d, *J* = 17 Hz, 2H), 2.55 (s, 3H)

^{13}C-NMR (125 MHz, CD_3CN)

δ 169.6, 150.8, 135.8, 128.1, 124.3, 62.9, 47.6

^{11}B-NMR (96 MHz, CD_3CN)

δ 10.3

HRMS (CI+)

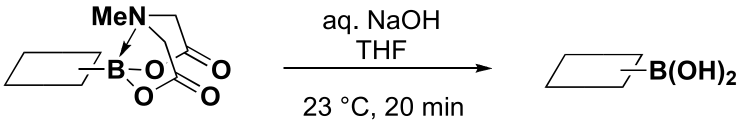
Calculated for $C_{10}H_{12}O_4N_2B$ $(M+H)^+$: 235.0890

Found: 235.0895

IR (KBr, cm^{-1})

3004, 2956, 1774, 1749, 1633, 1590, 1466, 1340, 1289, 1279, 1214, 1152, 1095, 1054, 1045, 998, 964, 894, 866, 775, 754, 708, 683

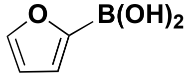
III. Synthesis of boronic acids



2 **1**

General Procedure:
Under ambient atmosphere, to a 100 mL flask equipped with a stir bar and charged with MIDA boronate (**2**) (5 mmol) as a solution in THF (50 mL) was added aq NaOH (1.0 M, 15 mL). The mixture was vigorously stirred for 20 min. The mixture was then transferred to a separatory funnel and was diluted with Et_2O (50 mL) and 0.5 M pH 7 sodium phosphate buffer (50 mL). The mixture was shaken, and the phases were separated. The aqueous phase was extracted with THF:Et_2O (1:1, 2 × 25 mL). The combined organics were dried over $MgSO_4$, filtered and concentrated *in vacuo*. Residual solvent was co-evaporated with MeCN, and the resulting solid was placed under vacuum (~1 Torr) for 30 min. All boronic acids thus obtained were judged to be >95% pure by ^{1}H-NMR and were utilized in cross-coupling reactions immediately after preparation.

Boronic acid 1a. The general procedure was followed using MIDA boronate **2a** (1.127 g, 5.002 mmol) to yield the **1a** as an off white solid (0.531 g, 95%).



1a

TLC (EtOAc)
R_f = 0.46, stained with $KMnO_4$

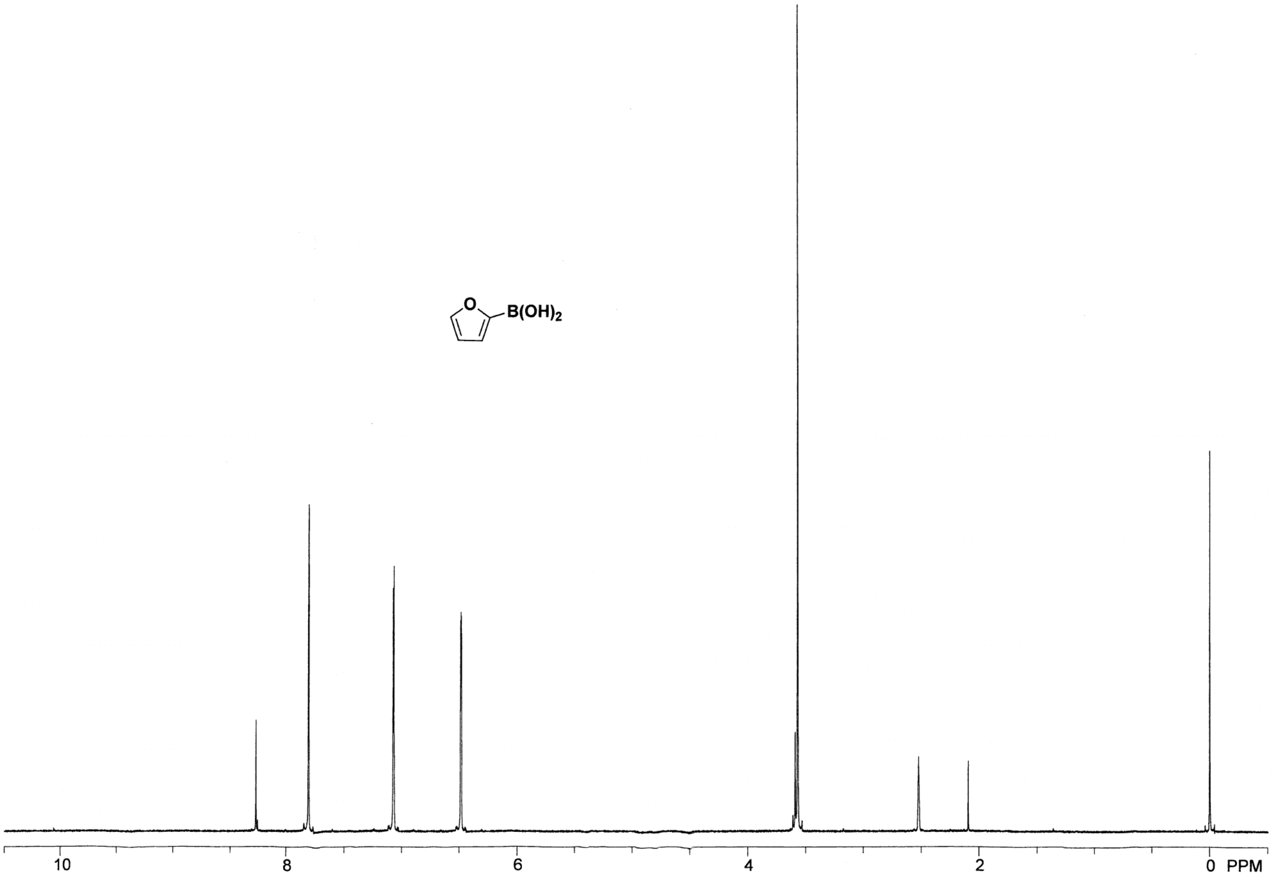
^{1}H-NMR (500 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)
δ 7.81 (dd, *J* = 1.5, 0.5 Hz, 1H), 7.07 (dd, *J* = 3.0, 0.5 Hz, 1H), 6.48 (dd, *J* = 3.5, 2.0 Hz, 1H)

^{13}C-NMR (125 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)
δ 146.4, 121.5, 110.3

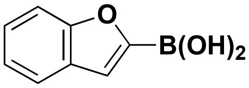
HRMS (EI+)

Calculated for $C_4H_5O_3B$ $(M)^+$:	112.0332
Found:	112.0332

^{1}H-NMR spectrum:



Boronic acid 1b. The general procedure was followed using MIDA boronate **2b** (1.374 g, 5.033 mmol) to yield **1b** as an off white solid (0.728 g, 89%).



1b

TLC (EtOAc)

$R_f = 0.14$, visualized by UV ($\lambda = 254$ and 366 nm) and $KMnO_4$ stain

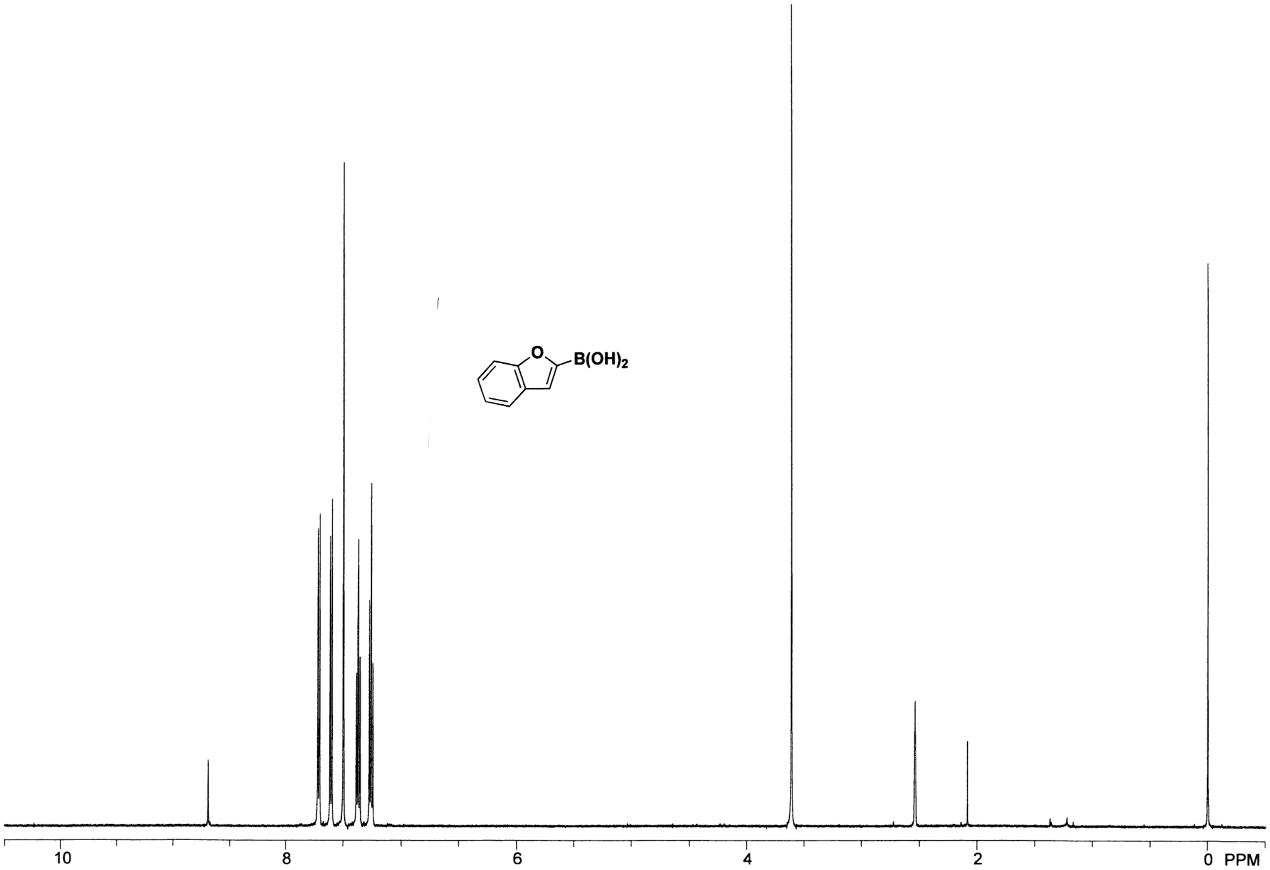
^{1}H-NMR (500 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)

δ 7.71 (d, *J* = 8.0 Hz, 1H), 7.60 (d, *J* = 8.5 Hz, 1H), 7.50 (s, 1H), 7.37 (t, *J* = 8.0 Hz, 1H), 7.26 (t, *J* = 7.5 Hz, 1H)

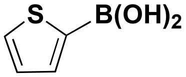
^{13}C-NMR (125 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)

δ 156.4, 127.6, 125.3, 122.5, 121.8, 117.5, 111.4

^{1}H-NMR spectrum:



Boronic acid 1c. The general procedure was followed using MIDA boronate **2c** (1.207 g, 5.048 mmol) to yield **1c** as a white solid (0.641 g, 99%).



1c

TLC (EtOAc)

$R_f = 0.23$, visualized by UV (λ = 254 nm) and $KMnO_4$ stain

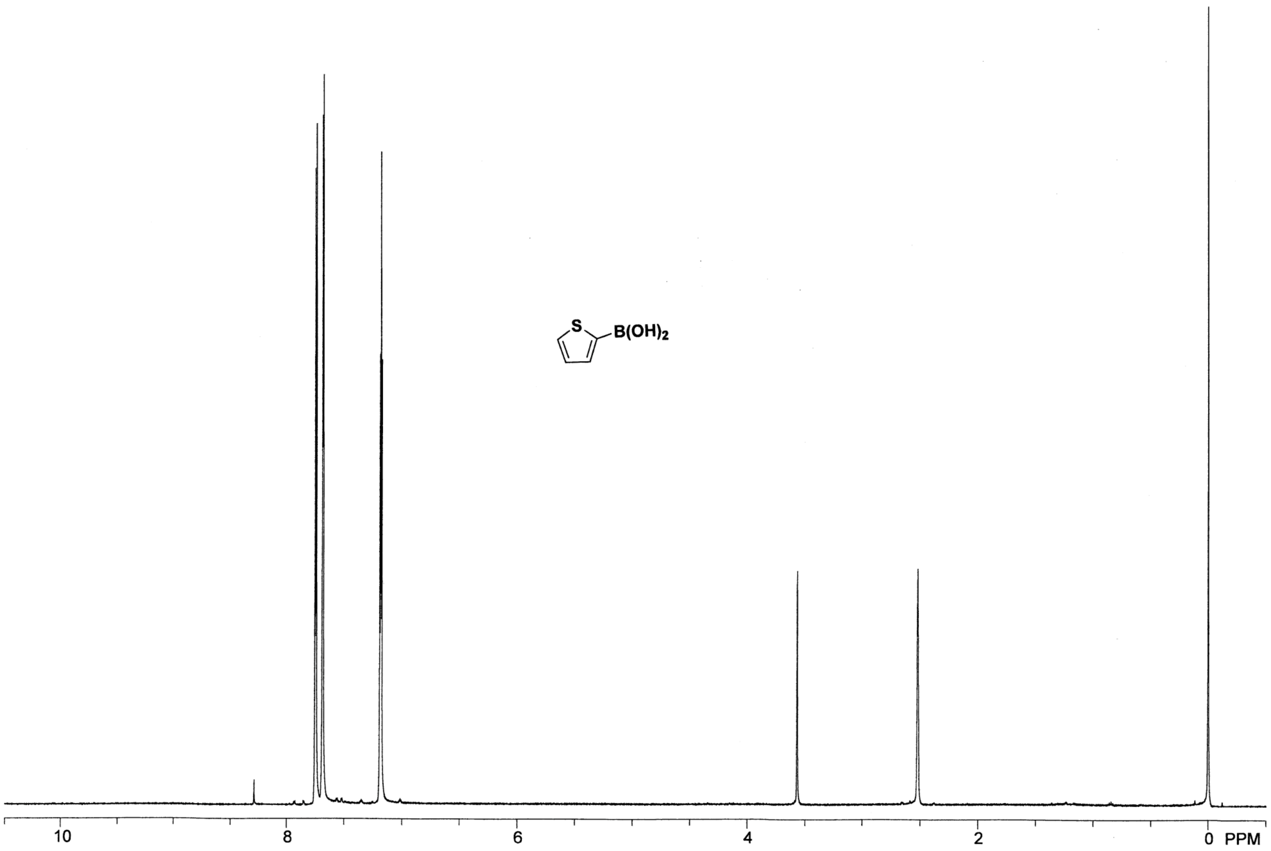
^{1}H-NMR (500 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)

δ 7.75 (d, *J* = 5.0 Hz, 1H), 7.69 (d, *J* = 3.5 Hz, 1H), 7.18 Hz (app t, *J* = 4.0 Hz, 1H)

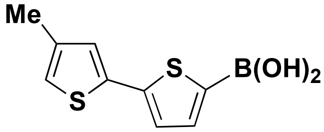
^{13}C-NMR (125 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)

δ 135.9, 131.5, 128.1

^{1}H-NMR spectrum:



Boronic acid 1d. The general procedure was followed using MIDA boronate **2d** (1.099 g, 3.277 mmol) and aq NaOH (1.0 M, 10 mL). Reaction and workup volumes were scaled accordingly. Boronic acid **1d** was isolated as a green solid (0.667 g, 91%).



1d

TLC (EtOAc)

$R_f = 0.34$, visualized by UV ($\lambda = 254$ and 366 nm) and $KMnO_4$ stain

^{1}H-NMR (500 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)

δ 7.59 (d, $J = 3.5$ Hz, 1H), 7.29 (d, $J = 3.5$ Hz, 1H), 7.17 (d, $J = 1.0$ Hz, 1H), 7.08 (s, 1H), 2.22 (s, 3H)

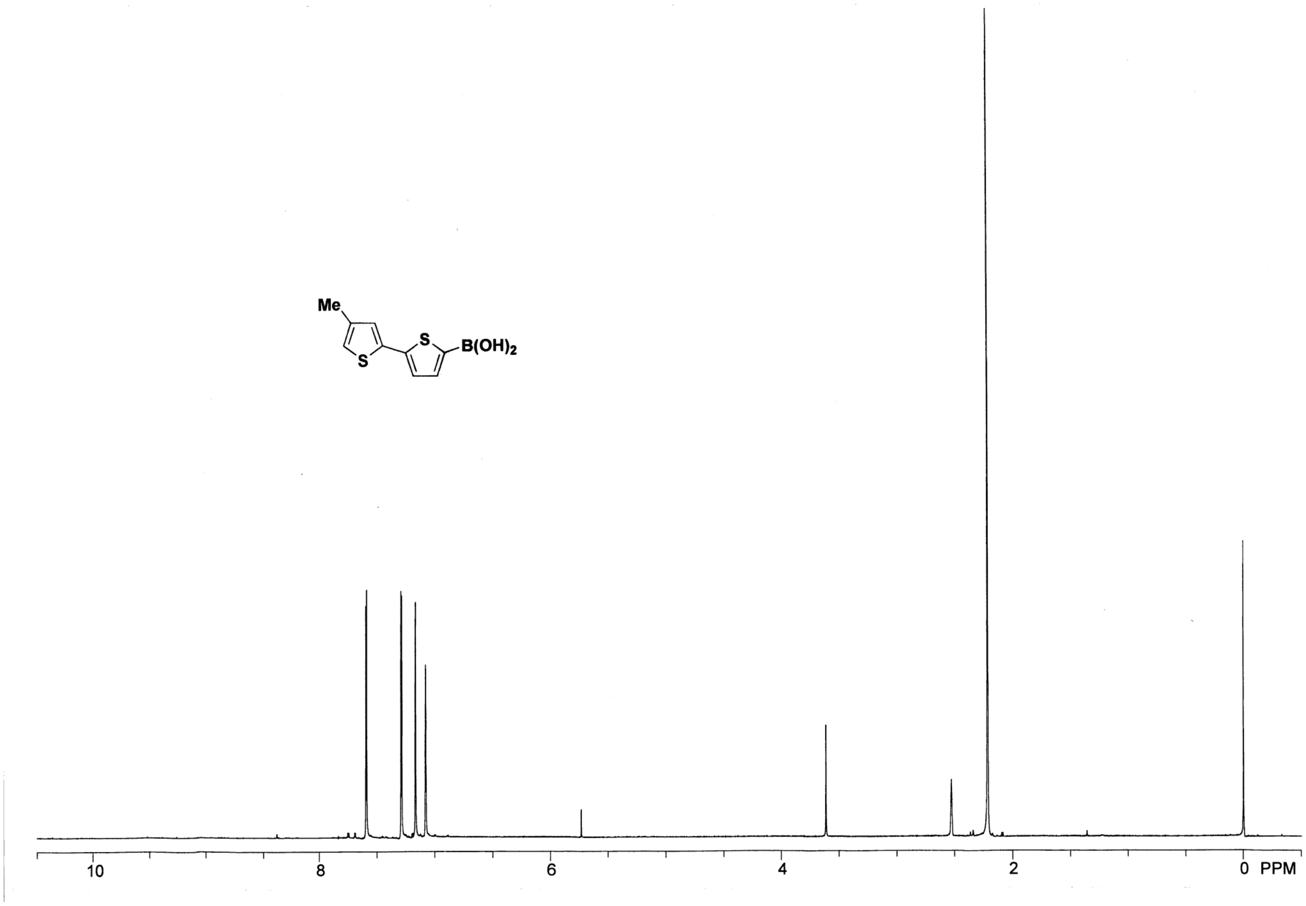
^{13}C-NMR (125 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)

δ 142.0, 138.3, 137.0, 136.3, 126.3, 124.6, 120.6, 15.3

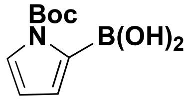
HRMS (ESI+)

Calculated for $C_9H_{10}O_2S_2B$ $(M+H)^+$:	225.0215
Found:	225.0204

^{1}H-NMR spectrum:



Boronic acid 1e. The general procedure was followed using MIDA boronate **2e** (0.691 g, 2.144 mmol) and aq NaOH (1.0 M, 6.5 mL). Reaction volumes were scaled accordingly. After addition of NaOH, the reaction was stirred at 23 °C for 10 min. The reaction mixture was transferred to a separatory funnel and was diluted with Et_2O (20 mL) and 1M aq NaOH (20 mL). The mixture was shaken and the organic phase was separated and discarded. The aqueous phase was diluted with THF:Et_2O (1:1, 20 mL) and saturated aq NH_4Cl (20 mL). The mixture was shaken and the phases were separated. The aqueous phase was extracted with THF:Et_2O (1:1, 2 × 10 mL). The combined organics were dried over $MgSO_4$, filtered and concentrated *in vacuo* to afford **1e** as a colorless solid (0.403 g, 89%).



1e

TLC (EtOAc)

$R_f = 0.50$, visualized by UV ($\lambda = 254$ nm) and $KMnO_4$ stain

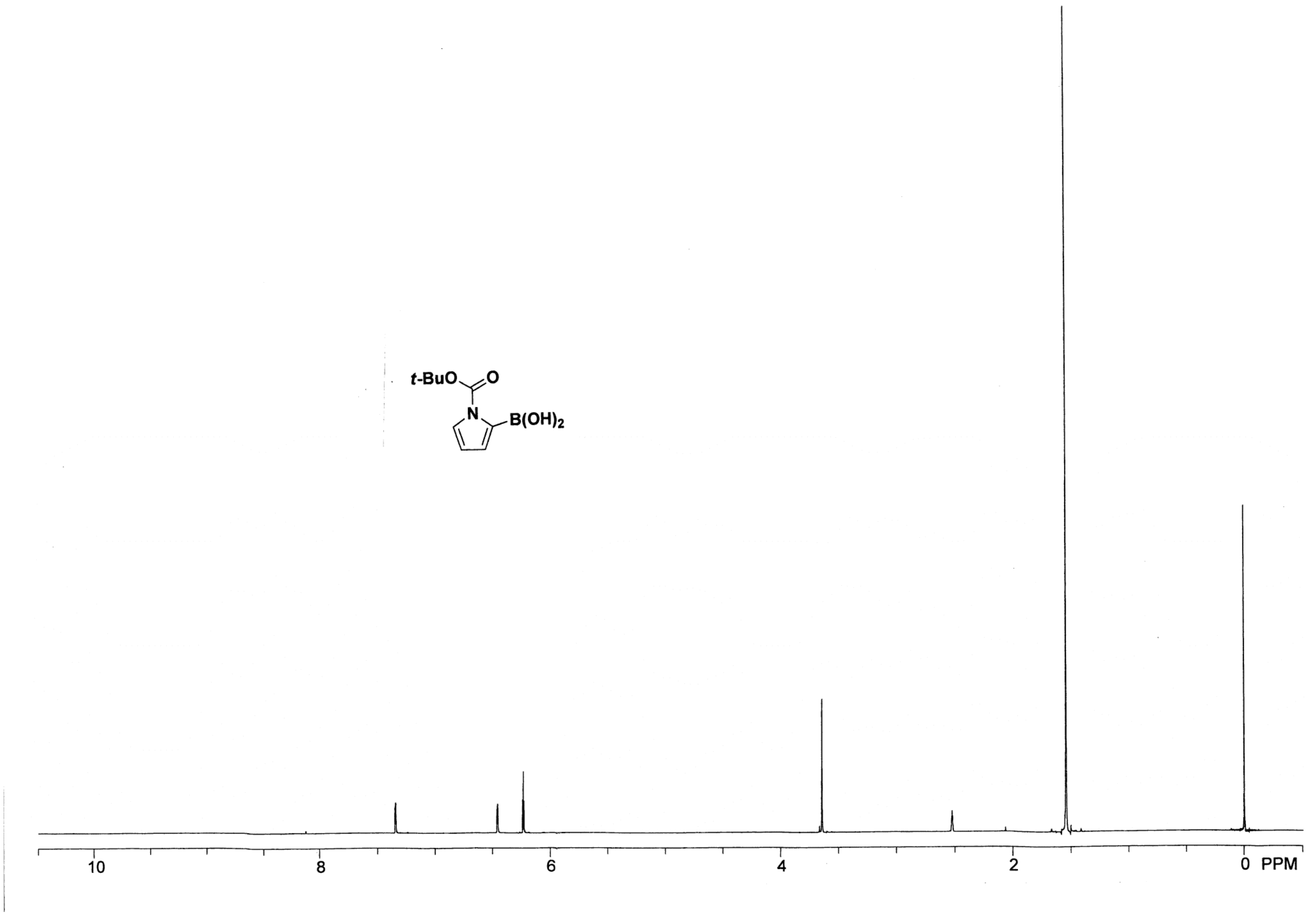
^{1}H-NMR (500 MHz, DMSO-d$_6$:D_2O 95:5 w/ TMS)

δ 7.34 (dd, *J* = 1.5 Hz, 1H), 6.46 (dd, *J* = 3.5, 2.0 Hz, 1H), 6.23 (t, *J* = 3.0 Hz, 1H), 1.54 (s, 9H)

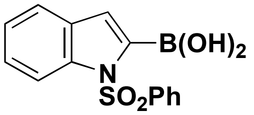
^{13}C-NMR (125 MHz, DMSO-d$_6$:D_2O 95:5 w/ TMS)

δ 149.8, 123.0, 120.6, 111.7, 84.1, 27.3

^{1}H-NMR spectrum:



Boronic acid 1f. The general procedure was followed using MIDA boronate **2f** (1.236 g, 2.999 mmol) THF (30 mL), and aq NaOH (1.0 M, 9 mL). The mixture was stirred 5 min. The mixture was transferred to a separatory funnel and was diluted with Et_2O (30 mL) and aq NaOH (1.0 M, 30 mL). The mixture was shaken and the organic phase was separated and discarded. The aqueous phase was diluted with THF:Et_2O (1:1, 30 mL) and saturated aq NH_4Cl (30 mL). The mixture was shaken and the phases were separated. The aqueous phase was extracted with THF:Et_2O (1:1, 2 × 15 mL). The combined organics were dried over $MgSO_4$, filtered and concentrated *in vacuo* to afford **2f** as a pale yellow solid (584 mg, 65%).



1f

TLC (EtOAc)

R_f = 0.53, visualized by UV (λ = 254 and 366 nm)

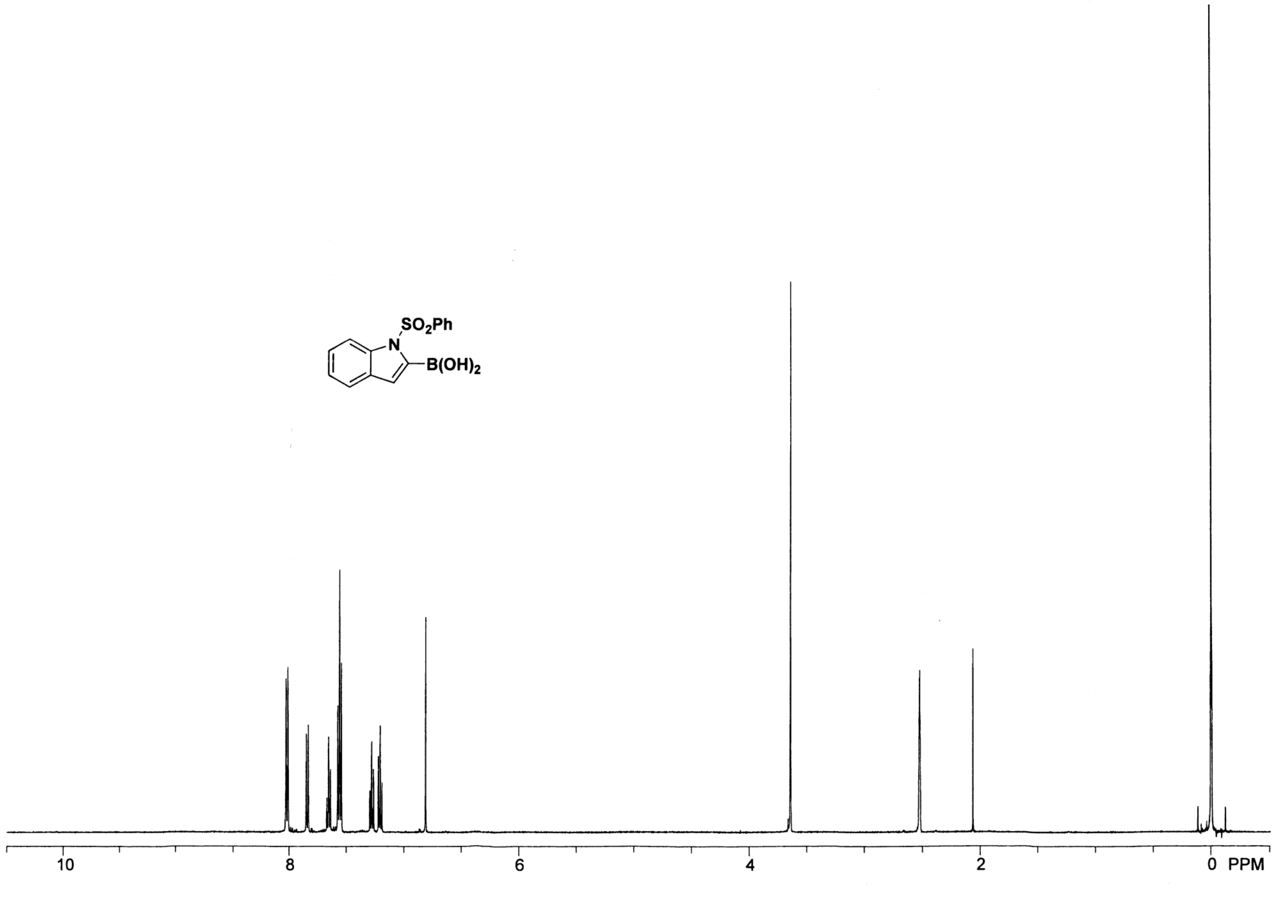
^{1}H-NMR (500 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)

δ 8.02 (d, J = 7.5 Hz, 2H), 7.84 (d, J = 8.0 Hz, 1H), 7.65 (t, J = 7.5 Hz, 1H), 7.56 (t, J = 7.5 Hz, 3H), 7.28 (t, J = 7.5 Hz, 1H), 7.20 (t, J = 8.0 Hz, 1H), 6.81 (s, 1H)

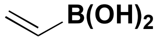
^{13}C-NMR (125 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)

δ 137.1, 135.4, 134.2, 131.1, 129.4, 126.9, 124.3, 123.3, 121.1, 114.4, 113.3

^{1}H-NMR spectrum:



Boronic acid 1g. The general procedure was followed using MIDA boronate **2g** (0.915 g, 5.00 mmol) and aq NaOH (1.0 mL, 15 mL). Due to the volatility of the product, solvent removal was performed at 23 °C. Residual solvent was co-evaporated with CH_2Cl_2. To further remove solvent, the product was briefly (< 1 minute) placed under vacuum (~1 Torr). Boronic acid **1g** was isolated as a white solid (0.161 g, 45%).



1g

TLC (EtOAc)
$R_f = 0.31$, stained with $KMnO_4$

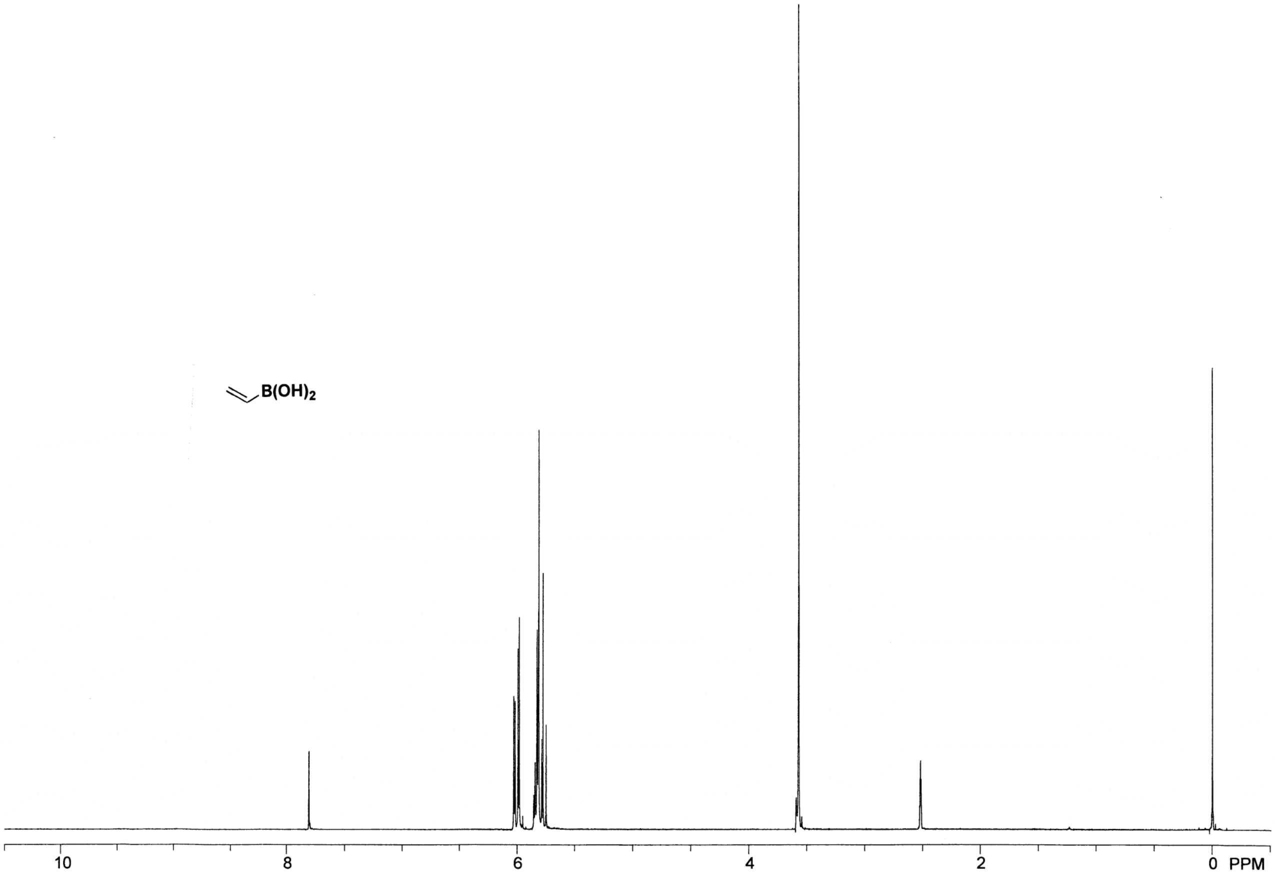
^{1}H-NMR (500 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)
δ 6.01 (dd, *J* = 19, 5.5 Hz, 1H), 5.80 (m, 2H)

^{13}C-NMR (125 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)
δ 133.7

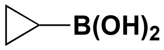
HRMS (CI+)

Calculated for $C_2H_6O_2B$ $(M+H)^+$:	73.04609
Found:	73.04602

^{1}H-NMR spectrum:



Boronic acid 1h. The general procedure was followed using boronate **2h** (0.789 g, 4.00 mmol) and aq NaOH (1.0 M, 12 mL). Reaction and workup volumes were scaled accordingly. Boronic acid **1h** was isolated as an off-white solid (0.183 g, 53%).



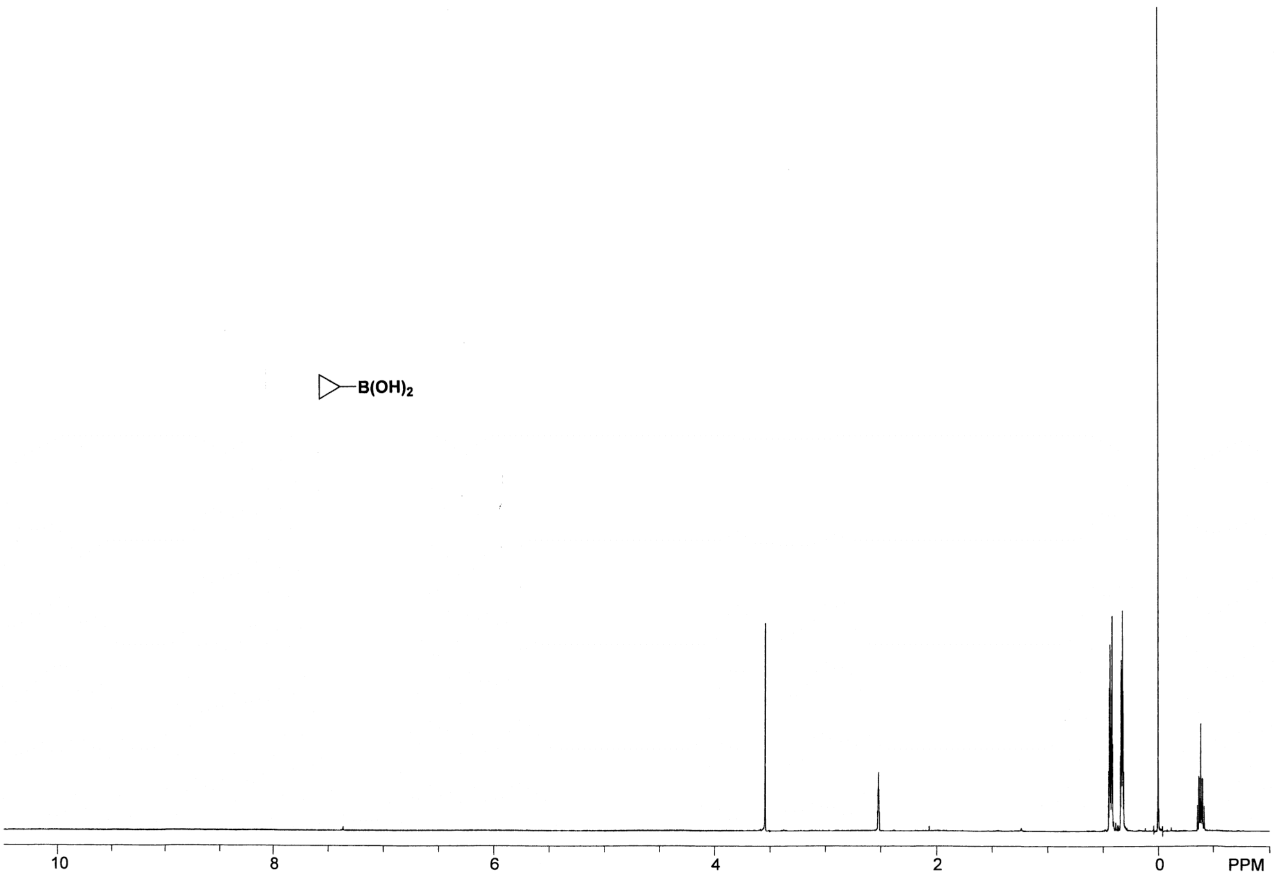
1h

TLC (EtOAc)
$R_f = 0.22$, stained with $KMnO_4$

^{1}H-NMR (500 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)
δ 0.43 (m, 2H), 0.33 (m, 2H), -0.39 (m, 1H)

^{13}C-NMR (125 MHz, DMSO-d_6:D_2O 95:5 w/ TMS)
δ 3.29

^{1}H-NMR spectrum:



IV. Kinetics Studies

Kinetics of slow-release of boronic acids from MIDA boronates

Stock solutions of the MIDA boronate and 4-bromoanisole (internal std.) in dioxane-d$_8$ were prepared as follows: 4-tolyl MIDA boronate[4] (16 mg, 0.064 mmol) and 4-bromoanisole (12 mg, 0.065 mmol) were dissolved in dioxane-d$_8$ (800 µL); 2-furyl MIDA boronate (**2a)** (54 mg, 0.24 mmol) and 4-bromoanisole (45 mg, 24 mmol) were dissolved in dioxane-d$_8$ (3.0 mL); vinyl MIDA boronate (**2g)** (11.7 mg, 0.064 mmol) and 4-bromoanisole (12 mg, 0.065 mmol) were dissolved in dioxane-d$_8$ (800 µL); cyclopropyl MIDA boronate (**2h**) (12.8 mg, 0.065 mmol) and 4-bromoanisole (12.0 mg, 0.064 mmol) were dissolved in dioxane-d$_8$ (800 µL). To each 1.5 mL vial equipped with a small stir bar was added the boronate stock solution (100 µL) followed by a solution of K_3PO_4 in D_2O (3.0 M, 20 µL). The mixtures were stirred at the specified temperature (23 °C, 60 °C, or 100 °C) for the specified time (0.5 h, 1.0 h, 2.0 h, etc.). The mixtures were then immediately cooled to room temperature and were diluted with CD_3CN (0.5 mL containing TMS internal std). The solutions were immediately analyzed by ^{1}H-NMR. The percent MIDA boronate remaining was calculated by comparing the ratio of the integrated 4-bromoanisole OCH_3 singlet (3.76 ppm, internal std) to that of the MIDA boronate NCH_3 singlet (tolyl = 2.47 ppm; furyl = 2.60 ppm; vinyl = 2.77 ppm; cyclopropyl = 2.98 ppm).

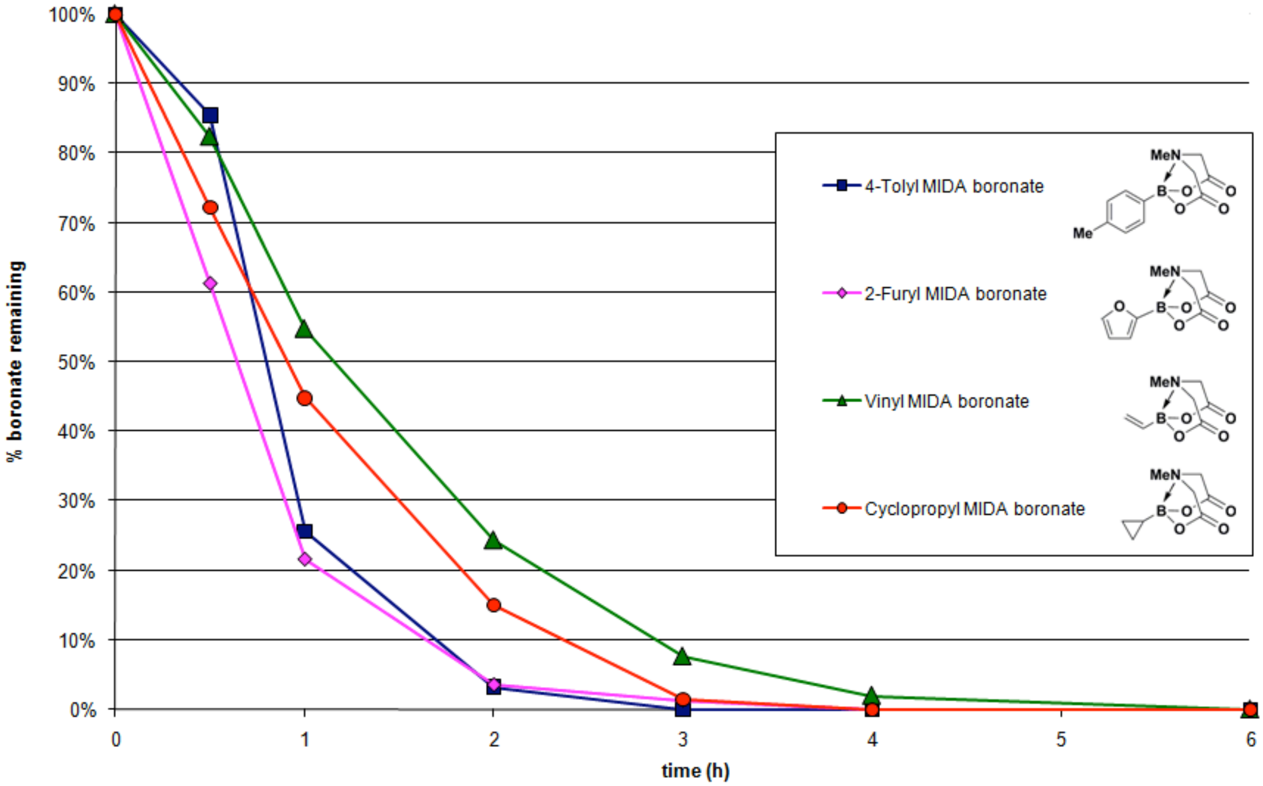


Figure S1. In situ hydrolysis of aryl, heteroaryl, vinyl and alkyl MIDA boronates at 60 °C.

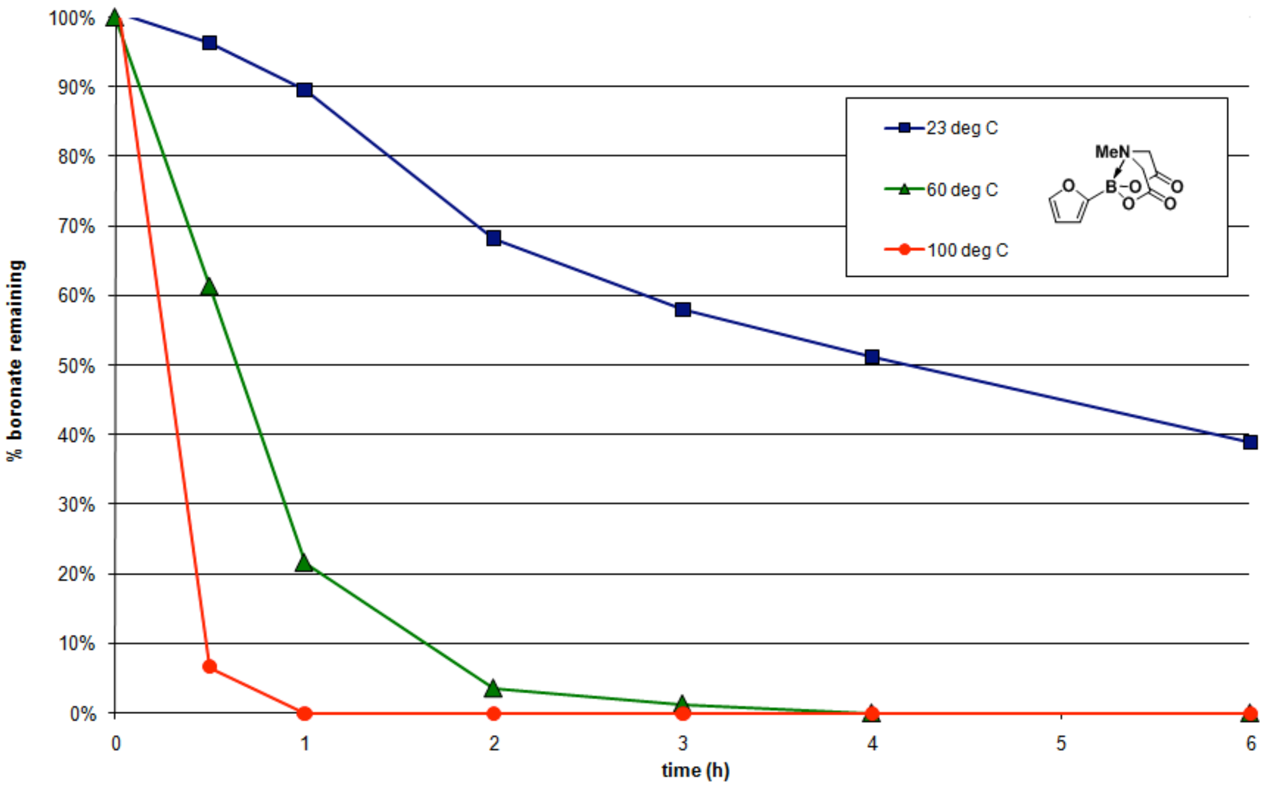


Figure S2. In situ hydrolysis of 2-furyl MIDA boronate at various temperatures.

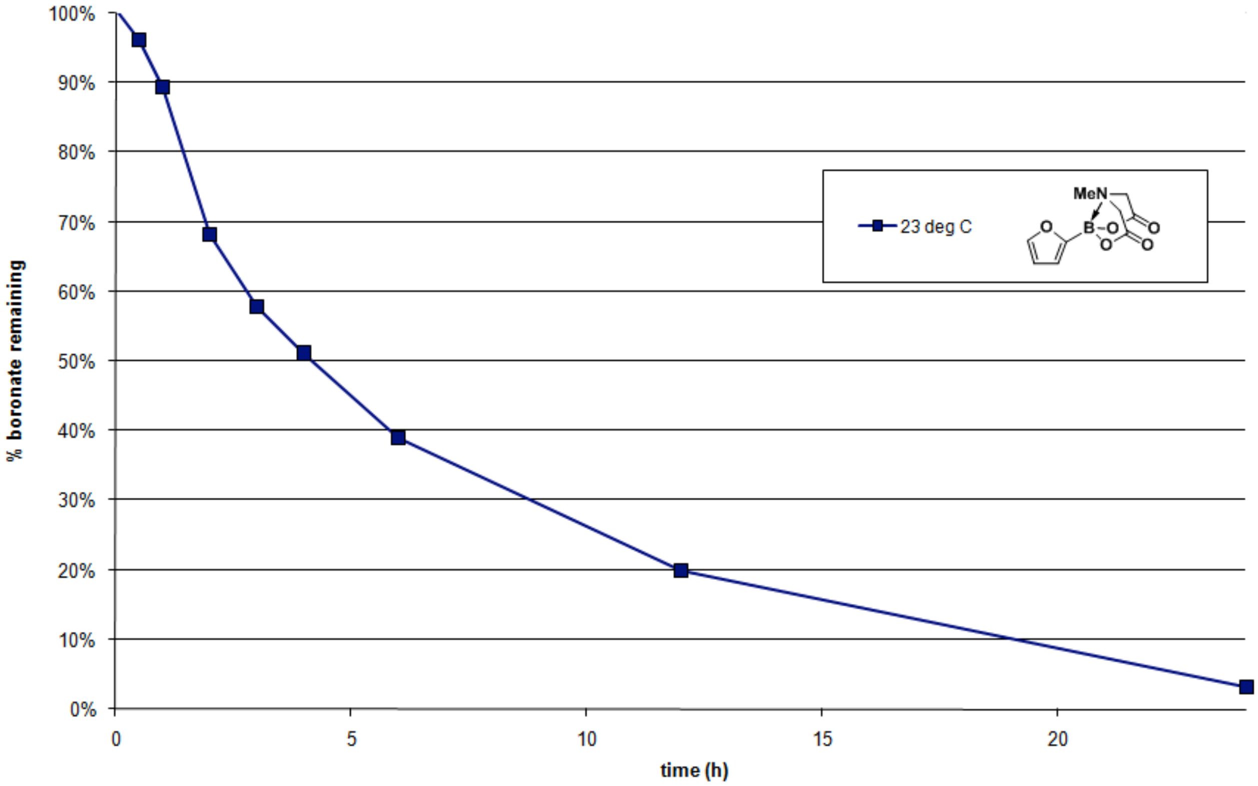


Figure S3. In situ hydrolysis of 2-furyl MIDA boronate at 23 °C.

“Fast-Release” kinetics

To a 1.5 mL vial equipped with a small stir bar was added the 2-furyl MIDA boronate stock solution (100 µL) followed by a solution of NaOH in D_2O (3.0 M, 20 µL). The mixture was stirred at 60 °C for 10 min. The mixture was diluted with CD_3CN (0.5 mL containing TMS internal std) and was immediately analyzed by ^{1}H-NMR. This analysis revealed complete hydrolysis of the MIDA boronate.

Kinetics of boronic acid cross-coupling

Under ambient atmosphere, to a 25 mL Schlenk flask equipped with a stir bar was added 2-dicyclohexylphosphino-2’,6’-dimethoxybiphenyl (SPhos) (41 mg, 0.10 mmol), $Pd(OAc)_2$ (11 mg, 0.050 mmol) and freshly-prepared 2-furylboronic acid (**1a**) (106 mg, 0.949 mmol). The flask was placed under Ar atmosphere and to the flask was added dioxane (12.5 mL). To the solution was added dodecane (100 µL, internal standard) and 1-*tert*-butoxy-4-chlorobenzene (**3a**) (175 µL, 0.980 mmol), and the solution was stirred at 23 °C for 10 minutes. The solution was sampled and analyzed by GC to determine the ratio of halide:dodecane. To the dark amber solution was added aq. K_3PO_4 (3.0 M, 2.5 mL, degassed by sparging with Ar for 30 min) and the dark mixture was stirred for 5 minutes. The organic phase was sampled as the initial time-point (t=0), and the mixture was then immediately placed in a 60 °C oil bath with stirring. The organic phase was sampled periodically and the consumption of the halide was determined by GC analysis versus the internal standard.

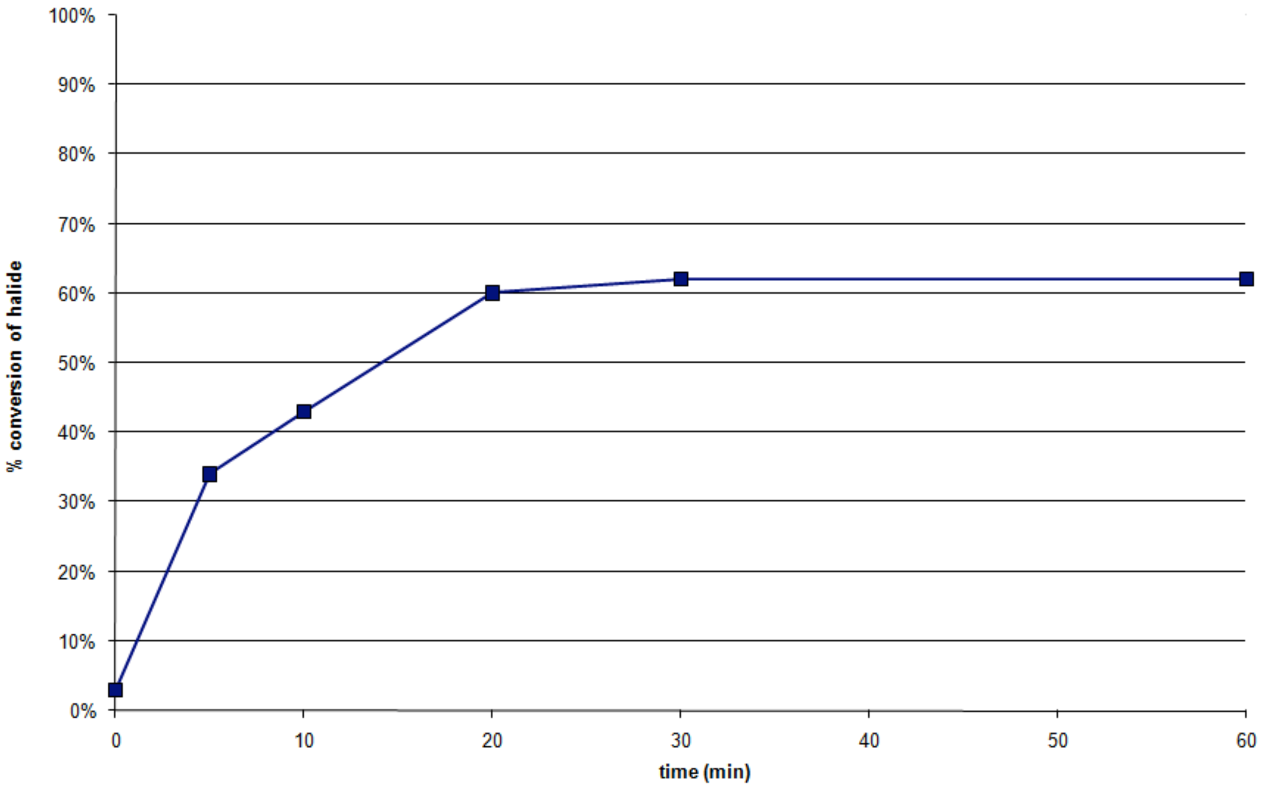


Figure S4. Suzuki-Miyaura coupling between freshly-prepared **1a** and **3a** under the conditions described in Table 1.

Kinetics of in-situ boronic acid decomposition

A stock solution of 2-furylboronic acid (**1a**) and 4-bromoanisole (internal std) in dioxane-d_8 was prepared as follows: 2-furylboronic acid (9 mg, 0.08 mmol) and 4-bromoanisole (15 mg, 0.080 mmol) were dissolved in dioxane-d_8 (1.0 mL). To each of eight argon-filled 1.5 mL vials equipped with stir bars and sealed with PTFE-lined septum-screwcaps was added the boronic acid stock solution (100 μL), followed by a solution of K_3PO_4 in D_2O (3.0 M, 20 μL) by syringe. The mixtures were heated to 60 °C with stirring for the specified time (10 min, 20 min, 30 min, 1 h, etc.) The mixtures were then immediately quenched by the addition of a solution of pH 7 potassium phosphate buffer in D_2O (2M, 120 μL) and were diluted with DMSO-d_6 (0.5 mL, containing TMS internal std). The resulting solutions, once cooled to 23 °C, were immediately analyzed by ^{1}H NMR. The percent boronic acid remaining was calculated by comparing the ratio of the integrated 4-bromoanisole C-H signal (doublet, 7.41 ppm) to that of the boronic acid C-H signal (doublet, 7.74 ppm).

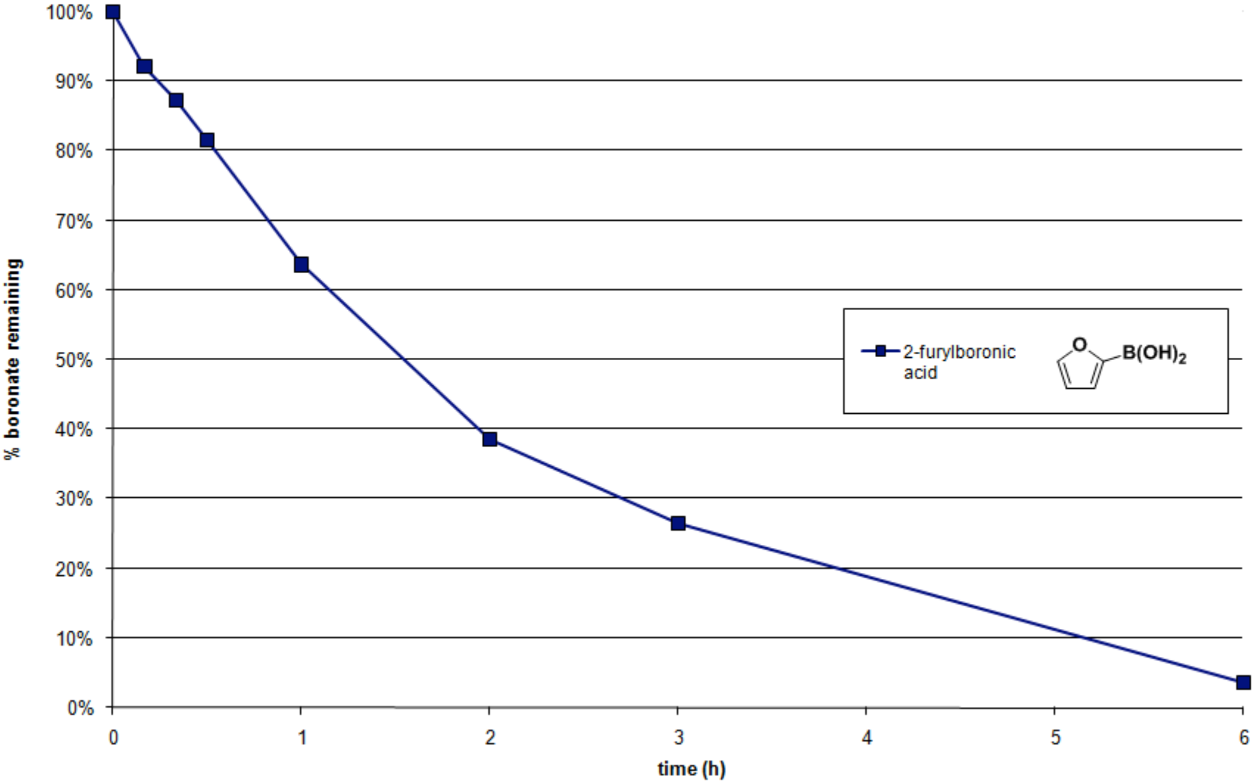


Figure S5. In situ decomposition of 2-furylboronic acid at 60 °C.

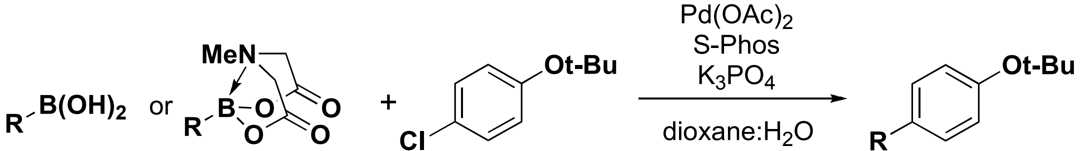
V. Determination of benchtop stability of boronic acids and MIDA boronates (Table 1)

The stability of boronic acids or MIDA boronates to storage as solids under air at 23 °C was quantified using the following general procedure:

Two 7-mL vials were charged with 10 mg of freshly prepared boronic acid or MIDA boronate at 23 °C under ambient atmosphere. The vials containing these solid samples were then sealed with PTFE-lined screwcaps under ambient atmosphere and placed on the benchtop at 23 ºC. The solid sample present in one of the vials was then immediately analyzed by ^{1}H-NMR to verify the purity and quantity of boronic acid present at time zero (the NMR assay is described below). After 15 days (boronic acids) or 60 days (MIDA boronates), the solid sample in the second vial was analyzed by ^{1}H NMR, again by the method described below, to determine the quantity of boronic acid remaining at the indicated time.

NMR assay: An NMR stock solution was prepared as follows: To a 25 mL volumetric flask was added bromoacetophenone (0.336 g, 1.69 mmol, internal standard for quantification of the boronic acid), tetramethylsilane (1 mL, internal standard for the NMR shifts), and DMSO-d_6:D_2O 95:5 to a final solution volume of 25.0 mL. To a vial containing solid boronic acid or solid MIDA boronate (see above) was added 1.00 mL of this NMR stock solution, and the resulting solution was analyzed by ^{1}H NMR. The mmol of boronic acid or MIDA boronate present in the sample was determined by comparing the ratio of the integrated 4-bromoacetophenone aryl C–H doublets (7.90 ppm relative to TMS) to that of the boronic acid or MIDA boronate C–H signals.

VI. Comparison of cross-coupling yields of boronic acids vs. MIDA boronates (Table 1)

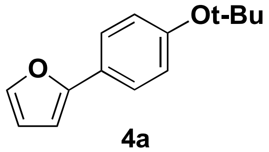


1 2 3a 4

General Procedure:
Under ambient atmosphere, to a 40 mL I-Chem vial equipped with a stir bar was added 1-*tert*-butoxy-4-chlorobenzene (**3a**) (185 mg, 1.00 mmol), the MIDA boronate or freshly-prepared boronic acid (1.00 mmol), 2-dicyclohexylphosphino-2',6'-dimethoxybiphenyl (SPhos) (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.050 mmol). The vial was sealed with a PTFE-lined septum screw-cap and was placed under Ar atmosphere. To the vial was added dioxane (12.5 mL) and the resulting mixture was stirred at 23 °C for 10 min. To the vial was then added aq K_3PO_4 (3.0 M, 2.5 mL, degassed by sparging with Ar for 30 min). The vial was placed in a 60 °C oil bath with stirring for 6 h. After cooling to room temperature the mixture was transferred to a 60 mL separatory funnel and was diluted with aq NaOH (1.0 M, 10 mL) and Et_2O (10 mL). The mixture was shaken and the phases were separated. The aqueous phase was extracted with Et_2O (3 × 10 mL). The combined organic fractions were dried over $MgSO_4$, filtered and concentrated *in vacuo*. The crude residue was subjected to flash-chromatography on silica gel (hexanes:EtOAc).

2-(4-*tert*-butoxyphenyl)furan (**4a**) [Table 1, Entry 1]. The general procedure was followed using MIDA boronate **2a** (223 mg, 1.00 mmol) to afford **4a** as a colorless oil (203 mg, 94%).

A parallel reaction using freshly-prepared boronic acid **1a** (112 mg, 1.00 mmol) under otherwise identical conditions afforded **4a** as a colorless oil (147 mg, 68%).



4a

TLC (hexanes:EtOAc 20:1)
R_f = 0.33, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$)
δ 7.60 (d, J = 8.5 Hz, 2H), 7.45 (dd, J = 1.5, 0.5 Hz, 1H), 7.04 (d, J = 8.5 Hz, 2H), 6.58 (d, J = 3.0 Hz, 1H), 6.46 (dd, J = 3.0, 1.5 Hz, 1H), 1.38 (s, 9H)

^{13}C-NMR (125 MHz, $CDCl_3$)
δ 154.8, 153.9, 141.6, 126.3, 124.4, 124.3, 111.5, 104.0, 78.7, 28.8

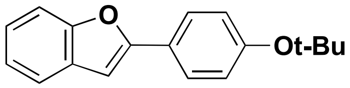
HRMS (CI+)

Calculated for $C_{14}H_{16}O_2$ $(M)^+$:	216.1150
Found:	216.1151

IR (thin film, cm^{-1})
2977, 1612, 1587, 1566, 1512, 1481, 1414, 1390, 1366, 1245, 1162, 1106, 1078, 1007, 904, 895, 854, 798, 730, 667, 594

2-(4-*tert*-butoxyphenyl)benzofuran (**4b**) [Table 1, Entry 2]. The general procedure was followed using MIDA boronate **2b** (273 mg, 1.00 mmol) to afford **4b** as a colorless solid (246 mg, 92%).

A parallel reaction using freshly-prepared boronic acid **1b** (162 mg, 1.00 mmol) under otherwise identical conditions afforded **4b** as a pale yellow solid (134 mg, 50%).



4b

TLC (hexanes:EtOAc 20:1)
R_f = 0.28, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$)
δ 7.83 (d, J = 8.5 Hz, 2H), 7.62 (d, J = 8.0 Hz, 1H), 7.58 (d, J = 8.0 Hz, 1H), 7.33 (t, J = 7.0 Hz, 1H), 7.29 (t, J = 7.0 Hz, 1H), 7.14 (d, J = 8.5 Hz, 2H), 6.96 (s, 1H), 1.46 (s, 9H)

^{13}C-NMR (125 MHz, $CDCl_3$)
δ 156.0, 156.9, 154.7, 129.3, 125.6, 125.5, 124.1, 123.8, 122.8, 120.6, 111.0, 110.3, 78.9, 28.8

HRMS (EI+)

Calculated for $C_{18}H_{18}O_2$ $(M)^+$: 266.1307

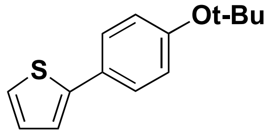
Found: 266.1303

IR (thin film, cm^{-1})

2978, 1609, 1499, 1451, 1364, 1298, 1239, 1209, 1157, 1099, 1029, 1007, 918, 893, 853, 806, 750, 713

2-(4-*tert*-butoxyphenyl)thiophene[8] (**4c**) [Table 1, Entry 3]. The general procedure was followed using MIDA boronate **2c** (239 mg, 1.00 mmol) to afford **4c** as a pale yellow solid (217 mg, 94%).

A parallel reaction using freshly-prepared boronic acid **1c** (128 mg, 1.00 mmol) under otherwise identical conditions afforded **4c** as a pale yellow oil (87 mg, 37%).



4c

TLC (hexanes:EtOAc (10:1)

$R_f = 0.50$, visualized by UV ($\lambda = 254$ nm)

^{1}H-NMR (500 MHz, $CDCl_3$)

δ 7.52 (d, $J = 7.0$ Hz, 2H), 7.24 (s, 1H), 7.23 (d, $J = 1.0$ Hz, 1H), 7.06 (dd, $J = 5.0, 4.0$ Hz, 1H), 7.00 (d, $J = 8.5$ Hz, 2H), 1.37 (s, 9H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 154.9, 144.1, 129.6, 127.9, 126.4, 124.4, 124.2, 122.4, 78.7, 28.8

HRMS (EI+)

Calculated for $C_{14}H_{16}OS$ $(M)^+$: 232.0922

Found: 232.0921

IR (thin film, cm^{-1})

2978, 1604, 1534, 1498, 1432, 1366, 1243, 1164, 1102, 922, 895, 850, 819, 694, 606, 540

5'-(4-*tert*-butoxyphenyl)-4-methyl-2,2'-bithiophene (**4d**) [Table 1, Entry 4]. The general procedure was followed using MIDA boronate **2d** (335 mg, 1.00 mmol) to afford **4d** as a yellow solid (317 mg, 96%).

A parallel reaction using freshly-prepared boronic acid **1d** (224 mg, 1.00 mmol) under otherwise identical conditions afforded **4d** as a yellow solid (158 mg, 45%; yield corrected for residual **3a**).

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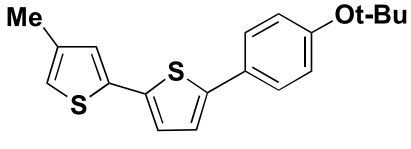
[8] Messmore, B. W.; Hulvat, J. F.; Sone, E. D.; Stupp, S. I. *J Am. Chem. Soc.* **2004**, *126*, 14452-14458.



4d

TLC (hexanes:EtOAc 10:1)

$R_f = 0.41$, visualized by UV (λ = 254 and 366 nm)

^{1}H-NMR (500 MHz, $CDCl_3$)

δ 7.50 (d, *J* = 8.5 Hz, 2H), 7.14 (d, *J* = 4.0 Hz, 1H), 7.10 (d, *J* = 4.0 Hz, 1H), 7.01 (m, 3H), 6.79 (s, 1H), 2.27 (s, 3H), 1.39 (s, 9H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 155.0, 142.6, 138.3, 137.1, 136.3, 129.2, 126.0, 125.6, 124.3, 124.2, 123.0, 119.4, 78.7, 28.7, 15.6

HRMS (EI+)

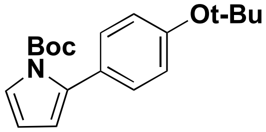
Calculated for $C_{19}H_{20}OS_2$ $(M)^+$:	328.0956
Found:	328.0958

IR (thin film, cm^{-1})

2973, 1502, 1466, 1365, 1246, 1160, 1106, 897, 850, 836, 804, 733, 717, 589, 528

N-(*tert*-butoxycarbonyl)-2-(4-*tert*-butoxyphenyl)pyrrole (**4e**) [Table 1, Entry 5]. The general procedure was followed using MIDA boronate **2e** (322 mg, 1.00 mmol) to afford **4e** as a pale yellow solid (284 mg, 90%).

A parallel reaction using freshly-prepared boronic acid **1e** (211 mg, 1.00 mmol) under otherwise identical conditions afforded **4e** as a pale yellow oil (192 mg, 61%).



4e

TLC (hexanes:EtOAc 10:1)

$R_f = 0.37$, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$)

δ 7.36 (dd, *J* = 3.0, 1.5 Hz, 1H), 7.23 (d, *J* = 8.5 Hz, 2H), 6.97 (d, *J* = 8.5 Hz, 2H), 6.22 (t, *J* = 1.5 Hz, 1H), 6.15 (dd, *J* = 3.5, 2.0 Hz, 1H), 1.38 (s, 9H), 1.34 (s, 9H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 154.5, 149.5, 134.6, 129.7, 129.6, 123.1, 122.3, 114.2, 110.4, 83.5, 78.4, 28.8, 27.6

HRMS (CI+)

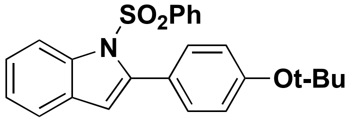
Calculated for $C_{19}H_{25}O_3N$ $(M)^+$:	315.1834
Found:	315.1834

IR (thin film, cm^{-1})

.2978, 2934, 1739, 1511, 1474, 1392, 1369, 1337, 1314, 1238, 1162, 1074, 1040, 975, 897, 855, 814, 773, 7.29

N-phenylsulfonyl-2-(4-*tert*-butoxyphenyl)indole (**4f**) [Table 1, Entry 6]. The general procedure was followed using MIDA boronate **2f** (412 mg, 1.00 mmol). Purification by flash chromatography (SiO_2 hexanes:EtOAc 100:0 → 80:20 followed by C_{18} silica gel (H_2O:MeCN 1:1 → 1:9) afforded **4f** as a colorless solid (376 mg, 93%).

A parallel reaction using freshly-prepared boronic acid **1f** (301 mg, 1.00 mmol) under otherwise identical reaction and purification conditions afforded **4f** as a colorless solid (59 mg, 14%).



4f

TLC (hexanes:EtOAc 10:1)

$R_f = 0.20$, visualized by UV (λ = 254 and 366 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)

δ 8.32 (d, *J* = 8.5 Hz, 1H), 7.43 (m, 2H), 7.34 (m, 5H), 7.25 (m, 3H), 7.01 (d, *J* = 9.0 Hz, 2H), 6.50 (s, 1H), 1.43 (s, 9H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 156.1, 141.8, 138.2, 137.7, 133.4, 131.1, 130.4, 128.5, 126.7, 126.6, 124.6, 124.2, 122.6, 120.5, 116.5, 112.9, 78.8, 28.9

HRMS (EI+)

Calculated for $C_{24}H_{23}O_3NS$ $(M)^+$:	405.13987
Found:	405.13919

IR (thin film, cm^{-1})

2979, 2971, 1496, 1446, 1367, 1256, 1238, 1217, 1182, 1171, 1163, 1152, 1120, 1087, 1055, 992, 899, 858, 822, 756, 729, 682, 593, 568, 547

1-*tert*-butoxy-4-vinylbenzene[9] (**4g**) [Table 1, Entry 7]. The general procedure was followed using MIDA boronate **2g** (183 mg, 1.00 mmol) with the modification that the reaction was run at 100 ºC to afford **4g** as a pale yellow liquid (172 mg, 98%).

A parallel reaction using freshly-prepared boronic acid **1g** (72 mg, 1.0 mmol) under otherwise identical conditions afforded **4g** as pale yellow liquid (0.17 g, 79%; yield corrected for residual **3a**).

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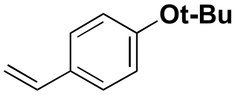
[9] Conlon, D. A; Crivello, J. V.; Lee, J. L.; O'Brien, M. J. *Macromolecules*, **1989**, *22*, 509-516.



4g

TLC (hexanes:EtOAc 10:1)
R$_f$ = 0.51, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, CDCl$_3$)
δ 7.34 (d, *J* = 8.5 Hz, 2H), 6.97 (d, *J* = 8.5 Hz, 2H), 6.70 (dd, *J* = 18, 11 Hz, 1H), 5.67 (d, *J* = 18 Hz, 1H), 5.19 (d, *J* = 11 Hz, 1H), 1.37 (s, 9H)

^{13}C-NMR (125 MHz, CDCl$_3$)
δ 155.2, 136.3, 132.7, 126.7, 124.1, 112.4, 78.5, 28.8

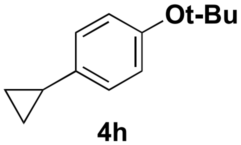
HRMS (CI+)

Calculated for $C_{12}H_{16}O$ (M)$^+$:	176.1201
Found:	176.1198

IR (thin film, cm^{-1})
2978, 2931, 1630, 1603, 1505, 1473, 1390, 1366, 1243, 1161, 1107, 989, 923, 898, 858, 840

1-*tert*-butoxy-4-cyclopropylbenzene (**4h**) [Table 1, Entry 8]. The general procedure was followed using MIDA boronate **2h** (183 mg, 1.00 mmol) with the modification that the reaction was run at 100 ºC to afford **4h** as a pale yellow liquid (183 mg, 96%).

A parallel reaction using freshly-prepared boronic acid **1h** (86 mg, 1.0 mmol) under otherwise identical conditions afforded **4h** as pale yellow liquid (0.18 g, 95%).



4h

TLC (hexanes:EtOAc 10:1)
R$_f$ = 0.51, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, CDCl$_3$)
δ 6.98 (d, *J* = 8.5 Hz, 2H), 6.90 (d, *J* = 8.5 Hz, 2H), 1.87 (m, 1H), 1.34 (s, 9H), 0.94 (m, 2H), 0.67 (m, 2H)

^{13}C-NMR (125 MHz, CDCl$_3$)
δ 152.9, 138.6, 125.9, 124.1, 78.0, 28.7, 14.8, 8.9

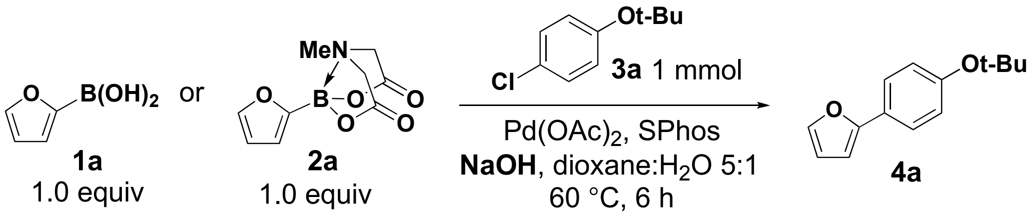
HRMS (CI+)

Calculated for $C_{13}H_{18}O$ (M)$^+$:	190.1358
Found:	190.1357

IR (thin film, cm^{-1})

3082, 2977, 2932, 1609, 1510, 1474, 1460, 1389, 1365, 1239, 1164, 1105, 1046, 1015, 923, 900, 845, 813

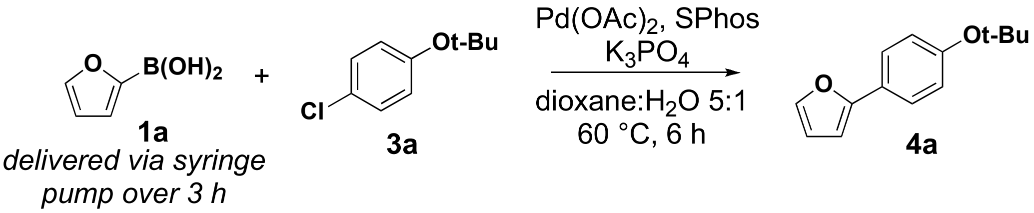
VII. Fast-release cross-coupling



Fast-release cross-coupling. The general procedure from Section VI was followed using MIDA boronate **2a** (225 mg, 1.00 mmol) with the following exception: In place of aq K_3PO_4 was used 3 M aq NaOH (3.0 M, 2.5 mL, degassed by sparging with Ar for 30 min) to afford **4a** as a yellow liquid (127 mg, 59%).

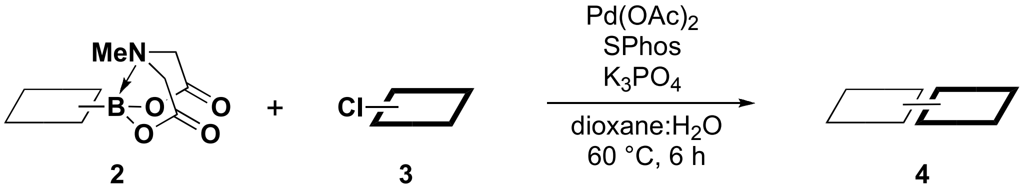
A parallel reaction using freshly-prepared boronic acid **1a** (112 mg, 1.00 mmol) under otherwise identical conditions afforded **4a** as yellow liquid (0.168 g, 64%; yield corrected for residual **3a**).

VIII. Cross-coupling reaction performed with syringe pump addition of boronic acid



Under ambient atmosphere, to a 40 mL I-Chem vial equipped with a stir bar was added 1-*tert*-butoxy-4-chlorobenzene (**3a**) (0.185 g, 1.00 mmol), dicyclohexylphosphino-2',6'-dimethoxy-1,1'-biphenyl (SPhos) (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.050 mmol). The vial was sealed with a PTFE-lined septum screw-cap, and then placed under an Ar atmosphere. To the vial was added dioxane (9.5 mL) and the resulting mixture was stirred at 23 °C for 10 min. To the vial was added aq K_3PO_4 (3.0 M, 2.5 mL, degassed by sparging with Ar for 30 min). The vial was placed in a 60 °C oil bath, and to the stirred mixture was added dropwise over 3 h via syringe pump freshly prepared 2-furylboronic acid (**1a**) (0.112 g, 1.00 mmol) as a solution in dioxane (3.0 mL). After the addition was complete the reaction mixture was stirred at 60 °C for an additional 3 h. The mixture was cooled to room temperature and was then transferred to a 60 mL separatory funnel and was diluted with aq NaOH (1.0 M, 10 mL). The mixture was extracted with Et_2O (3 × 10 mL). The combined organic fractions were dried over $MgSO_4$, filtered and then concentrated *in vacuo*. The resulting residue was purified by flash chromatography (hexanes:EtOAc, 100:0 → 9:1) to afford a colorless oil (0.213 g, 98%).

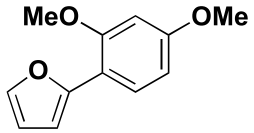
IX. Slow-release cross-coupling with MIDA boronates (Table 2)



General Procedure:

Under ambient atmosphere, to a 40 mL I-Chem vial equipped with a stir bar was added the aryl chloride (1.00 mmol), the MIDA boronate (1.20 mmol), dicyclohexylphosphino-2',6'-dimethoxy-1,1'-biphenyl (SPhos) (41 mg, 0.10 mmol) and Pd(OAc)$_2$ (11 mg, 0.050 mmol). The vial was sealed with a PTFE-lined septum screw-cap, and then placed under an Ar atmosphere. To the vial was added dioxane (12.5 mL) and the resulting mixture was stirred at 23 °C for 10 min. To the vial was added aq K$_3$PO$_4$ (3.0 M, 2.5 mL, degassed by sparging with Ar for 30 min). The vial was placed in a 60 °C oil bath with stirring for 6 h. The mixture was cooled to room temperature, and was then transferred to a 60 mL separatory funnel and diluted with aq NaOH (1.0 M, 10 mL). The mixture was extracted with Et$_2$O (3 × 10 mL). The combined organic fractions were dried over MgSO$_4$, filtered, and then concentrated *in vacuo*. The resulting residue was subjected to flash-chromatography on silica gel (hexanes:EtOAc).

2-(2,4-dimethoxyphenyl)furan[10] (**4i**) [Table 2, Entry 1]. The general procedure was followed using 1-chloro-2,4-dimethoxybenzene (**3b**) (173 mg, 1.00 mmol), 2-furan MIDA boronate (**2a**) (267 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and Pd(OAc)$_2$ (12 mg, 0.052 mmol) to afford **4i** as a pale orange liquid (202 mg, 99%).



4i

TLC (hexanes:EtOAc 9:1)

$R_f = 0.36$, visualized by UV ($\lambda = 254$ nm)

^{1}H-NMR (500 MHz, CDCl$_3$ w/ TMS)

δ 7.74 (d, $J = 8.5$ Hz, 1H), 7.41 (d, $J = 1.0$ Hz, 1H), 6.79 (d, $J = 3.5$ Hz, 1H), 6.55 (dd, $J = 8.5$, 2.5 Hz, 1H), 6.52 (d, $J = 2.0$ Hz, 1H), 6.46 (q, $J = 2.0$ Hz, 1H), 3.89 (s, 3H), 3.82 (s, 3H)

^{13}C-NMR (125 MHz, CDCl$_3$)

δ 159.9, 156.5, 150.4, 140.4, 126.8, 113.4, 111.4, 107.8, 104.6, 98.7, 55.4 (2 carbons)

HRMS (EI+)

Calculated for $C_{12}H_{12}O_3$ (M)$^+$:	204.0787
Found:	204.0790

IR (thin film, cm^{-1})

3002, 2960, 2937, 2836, 1614, 1585, 1514, 1468, 1418, 1307, 1288, 1270, 1208, 1160, 1054,

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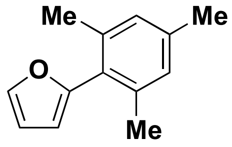
[10] Kang, S-K.; Ryu, H-C.; Choi, S-C. *Chem. Commun.* **1998**, 1317-1318.

1029, 1003, 827, 798, 735

2-(2,4,6-trimethylphenyl)furan[11] (**4j**) [Table 2, Entry 2]. The general procedure was followed using mesityl chloride (**3c**) (154 mg, 1.00 mmol), 2-furyl MIDA boronate (**2a**) (267 mg, 1.20 mmol), SPhos (42 mg, 0.10 mmol) and Pd(OAc)$_2$ (11 mg, 0.049 mmol) to afford **4j** as a colorless crystalline solid (181 mg, 97%).



4j

TLC (hexanes)

R$_f$ = 0.40, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, CDCl$_3$ w/ TMS)

δ 7.46 (s, 1H), 6.90 (s, 2H), 6.44 (t, *J* = 3.0 Hz, 1H), 6.23 (d, *J* = 3.0 Hz, 1H), 2.28 (s, 3H), 2.15 (s, 6H)

^{13}C-NMR (125 MHz, CDCl$_3$)

δ 152.4, 141.4, 138.3, 138.3, 128.2, 128.2, 110.3, 109.0, 21.0, 20.4

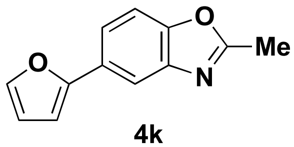
HRMS (EI+)

Calculated for $C_{13}H_{14}O$ (M)$^+$:	186.1045
Found:	186.1043

IR (thin film, cm^{-1})

2975, 2954, 2919, 1612, 1505, 1473, 1440, 1373, 1257, 1212, 1169, 1148, 1028, 1005, 898, 863, 743

5-(2-furanyl)-2-methylbenzoxazole (**4k**) [Table 2, Entry 3]. The general procedure was followed using 5-chloro-2-methylbenzoxazole (**3d**) (168 mg, 1.00 mmol), 2-furyl MIDA boronate (**2a**) (266 mg, 1.19 mmol), SPhos (41 mg, 0.10 mmol) and Pd(OAc)$_2$ (11 mg, 0.049 mmol) to afford **4k** as a pale orange crystalline solid (198 mg, 99%).



4k

TLC (hexanes:EtOAc 3:1)

R$_f$ = 0.30, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, CDCl$_3$ w/ TMS)

δ 7.93 (d, *J* = 1.0 Hz, 1H), 7.61 (dd, *J* = 8.5, 1.5 Hz, 1H), 7.47 (d, *J* = 1.0 Hz, 1H), 7.44 (d, *J* =

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[11] Hashmi, A. S. K.; Salathé, Wolfgang, F. *Chem. Eur. J.* **2006**, *12*, 6991-6996.

8.5 Hz, 1H), 6.63 (d, *J* = 3.5 Hz, 1H), 6.47 (dd, *J* = 3.5, 2.0 Hz, 1H), 2.62 (s, 3H)

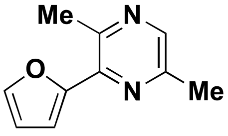
^{13}C-NMR (125 MHz, $CDCl_3$)
δ 164.5, 153.7, 150.3, 141.9, 141.9, 127.6, 120.8, 114.6, 111.6, 110.3, 104.6, 14.5

HRMS (EI+)

Calculated for $C_{12}H_9NO_2$ $(M)^+$:	199.0633
Found:	199.0634

IR (KBr, cm^{-1})
2934, 2857, 1576, 1504, 1458, 1383, 1300, 1269, 1228, 1170, 1011, 885, 811

3-(2-furanyl)-2,5-dimethylpyrazine[12] (**4l**) [Table 2, Entry 4]. The general procedure was followed using 3-chloro-2,5-dimethylpyrazine (**3e**) (143 mg, 1.00 mmol), 2-furyl MIDA boronate (**2a**) (267 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.049 mmol) to afford **4l** as a golden liquid (159 mg, 91%).



4l

TLC (hexanes:EtOAc 3:1)
$R_f = 0.28$, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)
δ 8.20 (s, 1H), 7.61 (d, *J* = 1.0 Hz, 1H), 7.00 (d, *J* = 3.5 Hz, 1H), 6.54 (dd, *J* = 3.0, 1.5 Hz, 1H), 2.74 (s, 3H), 2.54 (s, 3H)

^{13}C-NMR (125 MHz, $CDCl_3$)
δ 151.7, 150.2, 146.5, 143.9, 142.5, 141.2, 112.3, 111.7, 23.3, 21.2

HRMS (EI+)

Calculated for $C_{10}H_{10}N_2O$ $(M)^+$:	174.0793
Found:	174.0799

IR (thin film, cm^{-1})
3116, 3038, 2966, 2926, 2858, 2359, 2228, 1553, 1537, 1449, 1446, 1389, 1357, 1289, 1255, 1220, 1203, 1174, 1149, 1095, 1061, 1012, 973, 928, 886, 867, 821, 735, 596

2-(2,4-dimethoxyphenyl)benzofuran (**4m**) [Table 2, Entry 5]. The general procedure was followed using 1-chloro-2,4-dimethoxybenzene (**3b**) (172 mg, 1.00 mmol), 2-benzofuranyl MIDA boronate (**2b**) (328 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (12 mg, 0.051 mmol) to afford **4m** as a colorless liquid (239 mg, 94%)

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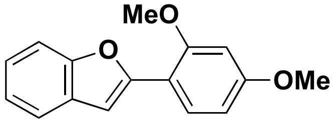
[12] Aoyagi, Y; Inoue, A.; Koizumi, I.; Hashimoto, R.; Tokunaga, K.; Gohma, K.; Komatsu, J.; Sekine, K.; Miyafuji, A.; Kunoh, J.; Honma, R.; Akita, Y.; Ohta, A. *Heterocycles* **1992**, *33*, 257-272.



4m

TLC (hexanes:EtOAc 9:1)

$R_f = 0.25$, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)

δ 7.97 (d, *J* = 8.5 Hz, 1H), 7.56 (d, *J* = 7.5 Hz, 1H), 7.48 (d, *J* = 7.5 Hz, 1H), 7.24-7.17 (m, 3H), 6.60 (dd, *J* = 8.5, 2.5 Hz, 1H), 6.55 (d, *J* = 2.0 Hz, 1H), 3.95 (s, 3H), 3.84 (s, 3H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 160.8, 157.7, 153.6, 152.4, 130.0, 127.9, 123.5, 122.5, 120.7, 112.7, 110.6, 104.8, 104.2, 98.7, 55.4, 55.4

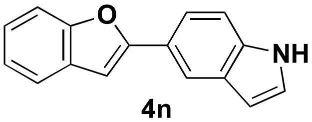
HRMS (EI+)

Calculated for $C_{16}H_{14}O_3$ $(M)^+$:	254.0943
Found:	254.0941

IR (thin film, cm^{-1})

3002, 2960, 2937, 2834, 1611, 1586, 1503, 1452, 1291, 1255, 1211, 1160, 1050, 1032, 1013

5-(2-benzofuranyl)indole[13] (**4n**) [Table 2, Entry 6]. The general procedure was followed using 5-chloroindole (**3f**) (153 mg, 1.01 mmol), 2-benzofuranyl MIDA boronate (**2b**) (329 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (12 mg, 0.053 mmol). The extraction step was modified to use Et_2O (10 mL), then EtOAc (2 x 10 mL). Benzofuran **4n** was isolated as a pale yellow solid (220 mg, 94%).



4n

TLC (hexanes:EtOAc 3:1)

$R_f = 0.31$, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, acetone-d_6)

δ 10.44 (br s, 1H), 8.23 (s, 1H), 7.74 (dd, *J* = 8.5, 1.5 Hz, 1H), 7.59 (d, *J* = 7.0 Hz, 1H), 7.56 (app. d, *J* = 8.5 Hz, 2H), 7.41 (t, *J* = 3.0 Hz, 1H), 7.26 (td, *J* = 7.5, 1.0 Hz, 1H), 7.22 (td, *J* = 7.5, 1.0 Hz, 1H), 7.13 (s, 1H), 6.62 (t, *J* = 2.0 Hz, 1H)

^{13}C-NMR (125 MHz, acetone-d_6)

δ 158.7, 155.4, 137.4, 130.7, 129.2, 126.9, 124.3, 123.6, 122.6, 121.3, 119.7, 118.0, 112.7, 111.5, 103.1, 100.0

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[13] Kitamura, Y.; Sako, S.; Udzu, T.; Tsutsui, A.; Maegawa, T.; Monguchi, Y.; Hironao, S. *Chem. Commun.* **2007**, *47*, 5069-5071.

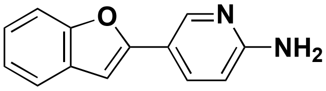
HRMS (EI+)

Calculated for $C_{16}H_{11}NO$ $(M)^+$:	233.0841
Found:	233.0843

IR (KBr, cm^{-1})

3439, 1582, 1475, 1458, 1444, 1417, 1332, 1295, 1254, 1020, 1006, 890, 877, 807, 753, 728, 594, 487, 442, 410

5-(2-benzofuranyl)-2-pyridinamine (**4o**) [Table 2, Entry 7]. The general procedure was followed using 2-amino-5-chloropyridine (**3g**) (128 mg, 1.00 mmol), 2-benzofuranyl MIDA boronate (**2b**) (359 mg, 1.50 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (12 mg, 0.052 mmol). The extraction step was modified to use Et_2O (10 mL), then EtOAc (2 x 10 mL). Benzofuran **4o** was isolated as a pale orange solid (180 mg, 85%).



4o

TLC (EtOAc)

$R_f = 0.45$, visualized by UV ($\lambda = 254$ nm)

^{1}H-NMR (500 MHz, acetone-d_6)

δ 8.57 (d, J = 2.0 Hz, 1H), 7.89 (dd, J = 9.0, 2.5 Hz, 1H), 7.57 (d, J = 8.5 Hz, 1H), 7.50 (d, J = 8.5 Hz, 1H), 7.24 (td, J = 7.5, 1.5 Hz, 1H), 7.20 (td, J = 7.5, 1.5 Hz, 1H), 7.03 (d, J = 1.0 Hz, 1H), 6.66 (d, J = 8.5 Hz, 1H), 5.85 (br s, 2H)

^{13}C-NMR (125 MHz, acetone-d_6)

δ 160.8, 155.9, 155.3, 146.1, 134.6, 130.4, 124.4, 123.8, 121.3, 116.6, 111.5, 108.8, 99.4

HRMS (EI+)

Calculated for $C_{13}H_{10}N_2O$ $(M)^+$:	210.0793
Found:	210.0793

IR (KBr, cm^{-1})

3436, 3308, 3114, 3106, 2964, 1650, 1614, 1574, 1500, 1451, 1399, 1352, 1321, 1294, 1271, 1254, 1207, 1151, 1142, 1040, 1007, 934, 918, 835, 806, 747, 532, 515, 450, 412

2-(3-thienyl)benzofuran[14] (**4p**) [Table 2, Entry 8]. The general procedure was followed using 3-chlorothiophene (**3h**) (119 mg, 1.01 mmol), 2-benzofuranyl MIDA boronate (**2b**) (360 mg, 1.50 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.050 mmol) to afford **4p** as a colorless solid (171 mg, 85%).

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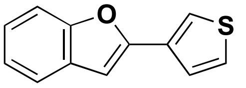
[14] O'Brien, C. J.; Kantchev, E. A. B.; Valente, C.; Hadei, N.; Chass, G. A.; Lough, A.; Hopkinson, A.; Organ, M. G. *Chem. Eur. J.* **2006**, *12*, 4743-4748.



4p

TLC (hexanes:EtOAc 9:1)

R_f = 0.53, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)

δ 7.67 (d, *J* = 1.5 Hz, 1H), 7.52 (d, *J* = 8.0 Hz, 1H), 7.47 (d, *J* = 8.0 Hz, 1H), 7.40 (d, *J* = 4.5 Hz, 1H), 7.32 (dd, *J* = 4.5, 3.0 Hz, 1H), 7.24 (t, *J* = 7.5 Hz, 1H), 7.19 (t, *J* = 7.5 Hz, 1H), 6.77 (s, 1H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 154.5, 152.6, 132.2, 129.0, 126.5, 125.0, 124.0, 122.9, 121.4, 120.8, 111.0, 101.0

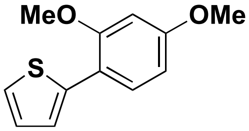
HRMS (EI+)

Calculated for $C_{12}H_8OS$ $(M)^+$:	200.0296
Found:	200.0295

IR (KBr, cm^{-1})

3100, 1607, 1452, 1280, 1255, 1041, 944, 854, 807, 785, 749, 601, 436

2-(2,4-dimethoxyphenyl)thiophene[15] (**4q**) [Table 2, Entry 9]. The general procedure was followed using 1-chloro-2,4-dimethoxybenzene (**3b**) (173 mg, 1.00 mmol), 2-thiophenyl MIDA boronate (**2c**) (285 mg, 1.19 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.051 mmol) to afford **4q** as a pale golden liquid (215 mg, 98%).



4q

TLC (hexanes:EtOAc 9:1)

R_f = 0.27, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)

δ 7.53 (d, *J* = 9.5 Hz, 1H), 7.37 (d, *J* = 3.5 Hz, 1H), 7.25 (d, *J* = 5.5 Hz, 1H), 7.05 (t, *J* = 4.5 Hz, 1H), 6.53-6.51 (m, 2H), 3.88 (s, 3H), 3.82 (s, 3H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 160.1, 156.7, 139.6, 129.3, 126.7, 124.3, 124.2, 116.5, 105.0, 98.9, 55.5, 55.4

HRMS (EI+)

Calculated for $C_{12}H_{12}O_2S$ $(M)^+$:	220.0558
Found:	220.0563

IR (thin film, cm^{-1})

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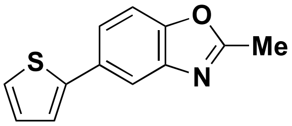
[15] Littke, A. F.; Schwarz, L.; Fu, G. C. *J. Am. Chem. Soc.* **2002**, *124*, 6343-6348.

3102, 3069, 3000, 3959, 3937, 2835, 1610, 1577, 1528, 1464, 1432, 1417, 1354, 1303, 1273, 1242, 1210, 1160, 1114, 1031, 959, 927, 848, 824, 798, 697, 577

2-methyl-5-(2-thienyl)benzoxazole (**4r**) [Table 2, Entry 10]. The general procedure was followed using 5-chloro-2-methylbenzoxazole (**3d**) (168 mg, 1.00 mmol), 2-thiophenyl MIDA boronate (**2c**) (287 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and Pd(OAc)$_2$ (11 mg, 0.051 mmol) to afford **4r** as a crystalline pale yellow solid (213 mg, 99%).



4r

TLC (hexanes:EtOAc 3:1)
$R_f = 0.35$, visualized by UV ($\lambda = 254$ nm)

^{1}H-NMR (500 MHz, CDCl$_3$ w/ TMS)
δ 7.85 (d, *J* = 1.0 Hz, 1H), 7.50 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.39 (d, *J* = 8.5 Hz, 1H), 7.26 (d, *J* = 3.0 Hz, 1H), 7.24 (d, *J* = 5.0 Hz, 1H), 7.04 (dd, *J* = 5.0, 3.5 Hz, 1H), 2.59 (s, 3H)

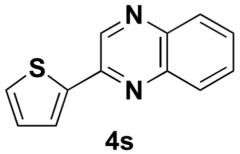
^{13}C-NMR (125 MHz, CDCl$_3$)
δ 164.4, 150.3, 144.0, 142.1, 130.9, 127.9, 124.6, 123.0, 122.8, 116.6, 110.2, 14.4

HRMS (EI+)

Calculated for $C_{12}H_9NOS$ $(M)^+$:	215.0405
Found:	215.0403

IR (KBr, cm^{-1})
3098, 3064, 1622, 1577, 1473, 1428, 1380, 1271, 1160, 1050, 923, 867, 798

2-(2-thienyl)quinoxaline[16] (**4s**) [Table 2, Entry 11]. The general procedure was followed using 1-chloroisoquinoline (**3i**) (165 mg, 1.00 mmol), 2-thiophenyl MIDA boronate (**2c**) (287 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and Pd(OAc)$_2$ (11 mg, 0.050 mmol) to afford **4s** as a yellow solid (206 mg, 97%).



4s

TLC (hexanes:EtOAc 3:1)
$R_f = 0.42$, visualized by UV ($\lambda = 254$ nm)

^{1}H-NMR (500 MHz, CDCl$_3$ w/ TMS)
δ 9.20 (s, 1H), 8.04 (app d, *J* = 8.0 Hz, 2H), 7.82 (s, 1H), 7.71 (t, *J* = 7.0 Hz, 1H), 7.66 (t, *J* = 7.0 Hz, 1H), 7.52 (d, *J* = 4.0 Hz, 1H), 7.17 (s, 1H)

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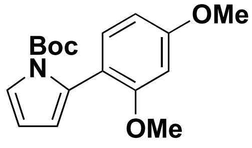
[16] Gazit, A.; App, H.; McMahon, G.; Chen, J.; Levitzki, A.; Bohmer, F. D. *J. Med. Chem.* **1996**, *39*, 2170-2177.

^{13}C-NMR (125 MHz, CDCl$_3$)
δ 147.2, 142.1, 142.0, 141.9, 141.2, 130.3, 129.7, 129.1, 129.0, 129.0, 128.3, 126.8

HRMS (EI+)
Calculated for $C_{12}H_8N_2S$ $(M)^+$: 212.0408
Found: 212.0407

IR (thin film, cm^{-1})
3118, 3093, 1573, 1547, 1491, 1428, 1321, 1238, 1208, 1134, 1054, 998, 941, 926, 852

N-(*tert*-butoxycarbonyl)-2-(2,3-dimethoxyphenyl)pyrrole (**4t**) [Table 2, Entry 12]. The general procedure was followed using 1-chloro-2,4-dimethoxybenzene (**3b**) (87 mg, 0.51 mmol), 2-(N-*tert*-butoxycarbonyl)pyrrole MIDA boronate (**2e**) (196 mg, 0.61 mmol), SPhos (20 mg, 0.048 mmol), Pd(OAc)$_2$ (6 mg, 0.03 mmol), K$_3$PO$_4$ (3.0 M, 1.25 mL) and dioxane (6.0 mL) to afford **4t** as a very pale yellow oil (124 mg, 81%).



4t

TLC (hexanes:EtOAc 3:1)
$R_f = 0.59$, visualized by UV (λ = 254 nm)

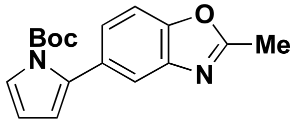
^{1}H-NMR (500 MHz, CDCl$_3$ w/ TMS)
δ 7.32 (s, 1H), 7.17 (d, *J* = 8.0 Hz, 1H), 6.48 (d, *J* = 8.5 Hz, 1H), 6.45 (s, 1H), 6.22 (t, *J* = 3.0 Hz, 1H), 6.10 (s, 1H), 3.82 (s, 3H), 3.72 (s, 3H), 1.36 (s, 9H)

^{13}C-NMR (125 MHz, CDCl$_3$)
δ 160.7, 158.3, 149.4, 131.1, 130.6, 121.6, 117.0, 113.5, 110.2, 103.4, 98.2, 82.6, 55.3, 55.2, 27.6

HRMS (EI+)
Calculated for $C_{17}H_{21}NO_4$ $(M)^+$: 303.1471
Found: 303.1469

IR (thin film, cm^{-1})
2976, 2938, 2834, 1736, 1617, 1584, 1512, 1464, 1437, 1419, 1394, 1370, 1341, 1316, 1209, 1159, 1127, 1034, 974, 840, 726

5-(N-*tert*-butoxycarbonyl-pyrrole)-2-methylbenzoxazole (**4u**) [Table 2, Entry 13]. The general procedure was followed using 5-chloro-2-methylbenzoxazole (**3d**) (84 mg, 0.50 mmol), 2-(N-*tert*-butoxycarbonyl)pyrrole MIDA boronate (**2e**) (195 mg, 0.61 mmol), SPhos (21 mg, 0.050 mmol), Pd(OAc)$_2$ (6 mg, 0.03 mmol), K$_3$PO$_4$ (3.0 M, 1.25 mL) and dioxane (6.0 mL) to afford **4u** as a very pale yellow oil (146 mg, 98%).



4u

TLC (hexanes:EtOAc 3:1)

R_f = 0.42, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)

δ 7.63 (s, 1H), 7.43 (d, *J* = 8.5 Hz, 1H), 7.36 (s, 1H), 7.28 (d, *J* = 8.5 Hz, 1H), 6.23 (t, *J* = 3.0 Hz, 1H), 6.20 (s, 1H), 2.64 (s, 3H), 1.34 (s, 9H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 164.2, 150.2, 149.1, 140.9, 134.4, 130.6, 126.1, 122.4, 120.0, 114.7, 110.4, 109.0, 83.5, 27.5, 14.5

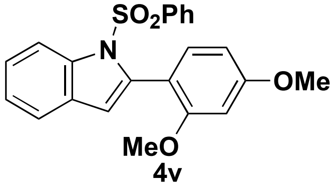
HRMS (EI+)

Calculated for $C_{17}H_{18}N_2O_3$ $(M)^+$: 298.1318
Found: 298.1317

IR (thin film, cm^{-1})

2982, 1739, 1584, 1584, 1456, 1395, 1365, 1370, 1336, 1313, 1264, 1166, 1140, 985, 906, 836, 809

N-phenylsulfonyl-2-(2,3-dimethoxyphenyl)indole (**4v**) [Table 2, Entry 14]. The general procedure was followed using 1-chloro-2,4-dimethoxybenzene (**3b**) (173 mg, 1.00 mmol), 1-(phenylsulfonyl)indole-2-MIDA boronate (**2f**) (495 mg, 1.20 mmol), SPhos (42 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.049 mmol) to afford **4v** as an off-white solid (382 mg, 97%).



4v

TLC (hexanes:EtOAc 3:1)

R_f = 0.37, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, acetone-d_6)

δ 8.19 (d, *J* = 8.0 Hz, 1H), 7.57-7.53 (m, 3H), 7.50 (d, *J* = 7.5 Hz, 1H), 7.43 (t, *J* = 7.5 Hz, 2H), 7.32 (dt, *J* = 7.0, 1.0 Hz, 1H), 7.23 (t, *J* = 7.5 Hz, 1H), 7.17 (d, *J* = 8.0 Hz, 1H), 6.62 (d, *J* = 2.0 Hz, 1H), 6.58 (dd, *J* = 8.0, 2.0 Hz, 1H), 6.56 (s, 1H), 3.87 (s, 3H), 3.72 (s, 3H)

^{13}C-NMR (125 MHz, acetone-d_6)

δ 163.0, 160.6, 139.4, 139.3, 138.1, 134.5, 133.2, 131.3, 129.8, 127.4, 125.0, 124.5, 121.5, 116.1, 115.0, 113.0, 104.7, 98.8, 55.7, 55.7

HRMS (EI+)

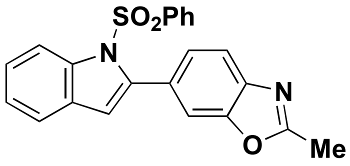
Calculated for $C_{12}H_{19}NO_4S$ $(M)^+$: 393.1035

Found: 393.1036

IR (KBr, cm^{-1})

3000, 2978, 2938, 2842, 1617, 1501, 1449, 1445, 1360, 1284, 1239, 1187, 1163, 1121, 1093, 1069, 1048, 832, 752, 728, 681, 582, 559

5-(N-phenylsulfonyl-indole)-2-methylbenzoxazole (**4w**) [Table 2, Entry 15]. The general procedure was followed using 5-chloro-2-methylbenzoxazole (**3d**) (168 mg, 1.00 mmol), 1-(phenylsulfonyl)indole-2-MIDA boronate (**2f**) (495 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (12 mg, 0.052 mmol) to afford **4w** as an off-white solid (366 mg, 93%).



4w

TLC (hexanes:EtOAc 1:1)

$R_f = 0.36$, visualized by UV ($\lambda = 254$ nm)

^{1}H-NMR (500 MHz, acetone-d_6)

δ 8.27 (d, J = 8.5 Hz, 1H), 7.78 (d, J = 1.0 Hz, 1H), 7.61 (d, J = 8.5 Hz, 1H), 7.55 (t, J = 7.5 Hz, 1H), 7.51 (d, J = 8.0 Hz, 2H), 7.45 (app. d, J = 8.0 Hz, 2H), 7.39 (app. t, J = 8.0 Hz, 3H), 7.28 (dt, J = 7.0, 1.0 Hz, 1H), 6.75 (s, 1H), 2.65 (s, 3H)

^{13}C-NMR (125 MHz, acetone-d_6)

δ 165.6, 152.3, 142.9, 142.4, 139.3, 138.6, 134.8, 131.7, 129.9, 129.6, 128.2, 127.5, 125.8, 125.4, 122.0, 121.9, 117.3, 114.9, 110.1, 14.4

HRMS (EI+)

Calculated for $C_{22}H_{16}N_2O_3S$ $(M)^+$: 388.0882
Found: 388.0880

IR (thin film, cm^{-1})

3063, 3012, 1712, 1623, 1581, 1477, 1449, 1432, 1365, 1262, 1220, 1177, 1157, 1122, 1092, 1065, 1021, 999, 921, 823

2,4,6-trimethylstyrene[17] (**4x**) [Table 2, Entry 16]. The general procedure was followed using mesityl chloride (**3c**) (155 mg, 1.01 mmol), vinyl MIDA boronate (**2g**) (220 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (12 mg, 0.051 mmol). The reaction time and temperature were modified so that the reaction mixture was heated to 100 °C for 2 h. Styrene **4x** was isolated as a colorless liquid (150 mg, 91%; yield corrected for residual **3c**).

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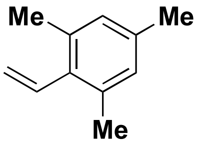
[17] Lando, V. R.; Monteiro, A. L. *Org. Lett.*, **2003**, *5*, 2891-2894.



4x

TLC (hexanes)

R_f = 0.64, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)

δ 6.86 (s, 2H), 6.66 (dd, *J* = 18.0, 11.5 Hz, 1H), 5.50 (dt, *J* = 11.5, 2.0 Hz, 1H), 5.23 (dt, *J* = 18.0, 2.0 Hz, 1H), 2.27 (s, 6H), 2.26 (s, 3H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 136.1, 135.7, 135.0, 134.8, 128.5, 119.0, 20.9, 20.8

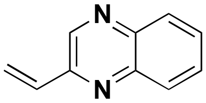
HRMS (EI+)

Calculated for $C_{11}H_{14}$ $(M)^+$:	146.1096
Found:	146.1098

IR (thin film, cm^{-1})

3080, 2999, 2952, 2918, 2856, 1631, 1612, 1481, 1442, 1376, 994, 919, 850

2-vinylquinoxaline (**4y**) [Table 2, Entry 17]. The general procedure was followed using 2-chloroquinoxaline (**3i**) (165 mg, 1.00 mmol), vinyl MIDA boronate (**2g**) (219 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.051 mmol). The reaction time and temperature were modified so that the reaction mixture was heated to 100 °C for 2 h. Following the aqueous workup, the crude residue was subjected to purification on C_{18} silica gel (43g RediSep column) eluting with H_2O:THF (95:5 → 55:45, 24 mL/min over 25 min) to afford **4y** as an orange oil (133 mg, 87%).



4y

TLC (hexanes:EtOAc 3:1)

R_f = 0.31, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)

δ 9.00 (s, 1H), 8.08 (app. t, *J* = 9.0 Hz, 2H), 7.77-7.70 (m, 2H), 7.04 (dd, *J* = 17.5, 11.0 Hz, 1H), 6.48 (d, *J* = 17.5 Hz, 1H), 5.79 (d, *J* = 11.0 Hz, 1H)

^{13}C-NMR (125 MHz, $CDCl_3$)

δ 150.4, 143.5, 142.1, 141.7, 134.8, 130.2, 129.5, 129.3, 129.1, 122.1

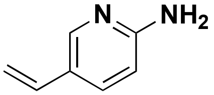
HRMS (ESI+)

Calculated for $C_{10}H_9N_2$ $(M+H)^+$:	157.0766
Found:	157.0768

IR (thin film, cm^{-1})

3064.0, 3018, 2928, 2847, 1631, 1596, 1546, 1492, 1466, 1414, 1365, 1342, 1331, 1303, 1282, 1258, 1212, 1185, 1121, 1065, 1014, 989, 972, 927, 762

2-amino-5-vinylpyridine (**4z**) [Table 2, Entry 18]. The general procedure was followed using 2-amino-5-chloropyridine (**3g**) (129 mg, 1.00 mmol), vinyl MIDA boronate (**2g**) (220 mg, 1.20 mmol), SPhos (42 mg, 0.10 mmol) and Pd(OAc)$_2$ (11 mg, 0.050 mmol). The reaction time and temperature were modified so that the reaction mixture was heated to 100 °C for 2 h. The extraction step was modified to use Et$_2$O (10 mL), then EtOAc (2 x 10 mL). Pyridine **4z** was isolated as a pale orange crystalline solid (91 mg, 76%).



4z

TLC (EtOAc)

R$_f$ = 0.48, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, CDCl$_3$ w/ TMS)

δ 8.05 (s, 1H), 7.56 (dd, *J* = 8.5, 2.0 Hz, 1H), 6.58 (dd, *J* = 17.5, 11.0 Hz, 1H), 6.48 (d, *J* = 9.0 Hz, 1H), 5.56 (d, *J* = 17.5 Hz, 1H), 5.11 (d, *J* = 11.0 Hz, 1H), 4.60 (br s, 2H)

^{13}C-NMR (125 MHz, CDCl$_3$)

δ 157.9, 147.0, 134.4, 133.3, 124.0, 111.2, 108.5

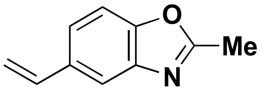
HRMS (EI+)

Calculated for $C_7H_8N_2$ (M)$^+$:	120.0688
Found:	120.0688

IR (KBr, cm^{-1})

3448, 3296, 3128, 1631, 1599, 1509, 1388, 1324, 1274, 1144, 1002, 888, 828

5-vinyl-2-methylbenzoxazole (**4aa**) [Table 2, Entry 19]. The general procedure was followed using 5-chloro-2-methylbenzoxazole (**3d**) (167 mg, 1.01 mmol), vinyl MIDA boronate (**2g**) (218 mg, 1.19 mmol), SPhos (42 mg, 0.10 mmol) and Pd(OAc)$_2$ (11 mg, 0.050 mmol). The reaction time and temperature were modified so that the reaction mixture was heated to 100 °C for 2 h. Benzoxazole **4aa** was isolated as a pale golden liquid (152 mg, 96%).



4aa

TLC (hexanes:EtOAc 3:1)

R$_f$ = 0.46, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, CDCl$_3$ w/ TMS)

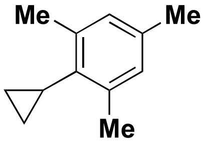
δ 7.67 (s, 1H), 7.38 (d, *J* = 8.0 Hz, 1H), 7.34 (d, *J* = 8.0 Hz, 1H), 6.79 (dd, *J* = 17.5, 11.0 Hz, 1H), 5.74 (d, *J* = 17.5 Hz, 1H), 5.24 (d, *J* = 11.0 Hz, 1H), 2.61 (s, 3H)

^{13}C-NMR (125 MHz, $CDCl_3$)
δ 164.3, 150.6, 141.9, 136.5, 134.2, 122.9, 116.8, 113.4, 109.9, 14.5

HRMS (EI+)
Calculated for $C_{10}H_9NO$ $(M)^+$: 159.0684
Found: 159.0685

IR (thin film, cm^{-1})
3087, 3006, 2984, 2928, 1623, 1622, 1578, 1477, 1433, 1381, 1335, 1262, 1179, 1114, 1040, 989, 918, 881, 840, 815

2,4,6-trimethyl-cyclopropylbenzene[18] (**4bb**) [Table 2, Entry 21]. The general procedure was followed using mesityl chloride (**3c**) (155 mg, 1.00 mmol), cyclopropyl MIDA boronate (**2h**) (296 mg, 1.50 mmol), SPhos (42 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.047 mmol). The reaction time and temperature were modified so that the reaction mixture was heated to 100 °C for 24 h. The title compound was isolated as a colorless liquid (127 mg, 79%).



4s

TLC (hexanes)
$R_f = 0.66$, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)
δ 6.81 (s, 2H), 2.38 (s, 6H), 2.24 (s, 3H), 1.64 (m, 1H), 0.96 (m, 2H), 0.49 (m, 2H)

^{13}C-NMR (125 MHz, $CDCl_3$)
δ 138.8, 136.0, 135.5, 128.6, 20.8, 20.5, 11.7, 8.0

HRMS (EI+)
Calculated for $C_{12}H_{16}$ $(M)^+$: 160.1252
Found: 160.1252

IR (thin film, cm^{-1})
3080, 3003, 2969, 2954, 2918, 2859, 1612, 1485, 1457, 1375, 1223, 1057, 1025, 901, 850, 814

2,4-dimethoxy-cyclopropylbenzene (**4cc**) [Table 2, Entry 20]. The general procedure was followed using 1-chloro-2,4-dimethoxybenzene (**3b**) (173 mg, 1.00 mmol), cyclopropyl MIDA boronate (**2h**) (236 mg, 1.20 mmol), SPhos (41 mg, 0.10 mmol) and $Pd(OAc)_2$ (11 mg, 0.048 mmol). The reaction temperature was modified so that the reaction mixture was heated to 100 °C for 6 h. The title compound was isolated as a colorless liquid (175 mg, 97%).

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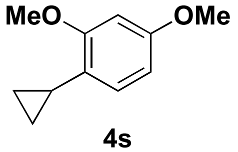
[18] Lemhadri, M.; Doucet, H.; Santelli, M. *Chem. Commun.* **2006**, *36*, 121-128.



4s

TLC (hexanes:EtOAc 9:1)
    R_f = 0.65, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)
    δ 6.77 (d, *J* = 8.5 Hz, 1H), 6.44 (d, *J* = 2.5 Hz, 1H), 6.39 (dd, *J* = 8.5, 2.5 Hz, 1H), 3.83 (s, 3H), 3.77 (s, 3H), 2.03 (m, 1H), 0.85 (m, 2H), 0.57 (m, 2H)

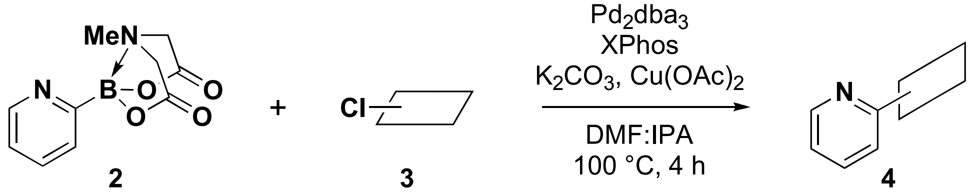
^{13}C-NMR (125 MHz, $CDCl_3$)
    δ 159.2, 158.6, 125.7, 124.2, 103.8, 98.4, 55.5, 55.3, 9.0, 6.9

HRMS (EI+)

Calculated for $C_{11}H_{14}O_2$ $(M)^+$:	178.0994
Found:	178.0995

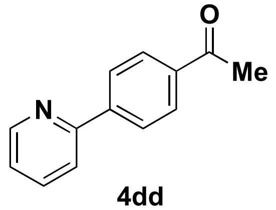
IR (thin film, cm^{-1})
    3080, 3000, 2955, 2940, 2835, 1615, 1585, 1510, 1464, 1439, 1416, 1370, 1319, 1290, 1261, 1209, 1172, 1158, 1117, 1062, 1037, 938, 884, 834, 823, 799

X. Slow-release cross-coupling of 2-pyridyl MIDA boronate 2i (Table 3)



General Procedure:
Under ambient atmosphere, to a 15 mL vial equipped with a stir bar was added the halide (1.0 mmol), 2-pyridyl MIDA boronate (**2i**) (1.5 mmol), K_2CO_3 (5.0 mmol) and $Cu(OAc)_2$ (0.50 mmol). In a glove box, to the vial was added a DMF mixture of 2-dicyclohexylphosphino-2',4',6'-triisopropylbiphenyl (X-Phos) (0.06 mmol) and Pd_2dba_3 (0.015 mmol) (8.0 mL DMF, pre-mixed and incubated for 5 min at 100 °C, then transferred at ~40 °C to avoid incomplete solubility at room temperature.) The reaction mixture was stirred at 100 °C for 4 h. The mixture was cooled to room temperature and then was transferred to a 60 mL separatory funnel and was diluted with aq NaOH (1.0 M, 10 mL). The mixture was extracted with Et_2O (3 × 10 mL). The combined organics were dried over $MgSO_4$, filtered and concentrated *in vacuo*. The crude residue was subjected to flash-chromatography on silica gel (hexanes:EtOAc).

4-(2-pyridinyl)acetophenone[19] (**4dd**) [Table 3, Entry 1]. The general procedure was followed using 4-chloroacetophenone (**3k**) (155 mg, 1.00 mmol), 2-pyridyl MIDA boronate (**2i**) (349 mg, 1.49 mmol), K_2CO_3 (694 mg, 5.02 mmol) and $Cu(OAc)_2$ (90 mg, 0.50 mmol). Flash chromatography on silica gel (hexanes:EtOAc, 100:0 → 80:20) afforded **4dd** as a colorless solid (142 mg, 72%).



4dd

TLC (hexanes:EtOAc 1:1)
$R_f = 0.47$, visualized by UV ($\lambda = 254$ nm)

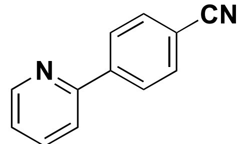
^{1}H-NMR (500 MHz, $CDCl_3$)
δ 8.73 (d, $J = 5.0$ Hz, 1H), 8.10 (d, $J = 8.5$ Hz, 2H), 8.06 (d, $J = 8.5$ Hz, 2H), 7.79 (m, 2H), 7.29 (q, $J = 4.5$ Hz, 1H), 2.65 (s, 3H)

^{13}C-NMR (125 MHz, $CDCl_3$)
δ 197.8, 156.0, 149.9, 143.5, 137.1, 136.9, 128.8, 127.0, 122.9, 121.0, 26.7

HRMS (CI+)
Calculated for $C_{13}H_{12}ON\,(M+H)^+$: 198.0919
Found: 198.0919

IR (KBr, cm^{-1})
3048, 2999, 1679, 1604, 1584, 1574, 1558, 1466, 1434, 1400, 1356, 1315, 1266, 1156, 1113, 1013, 989, 960, 849, 785, 723, 696, 618, 600, 592

4-(2-pyridinyl)benzonitrile[20] (**4ee**) [Table 3, Entry 2]. The general procedure was followed using 4-chlorobenzonitrile (**3k**) (137 mg, 1.00 mmol), 2-pyridyl MIDA boronate (**2i**) (352 mg, 1.50 mmol), K_2CO_3 (693 mg, 5.01 mmol) and $Cu(OAc)_2$ (91 mg, 0.50 mmol). Flash chromatography on silica gel (hexanes:EtOAc, 9:1) afforded **4ee** as a pale yellow solid (109 mg, 60%).



4ee

TLC (hexanes:EtOAc 1:1)
$R_f = 0.59$, visualized by UV ($\lambda = 254$ nm)

^{1}H-NMR (500 MHz, $CDCl_3$)
δ 8.73 (d, $J = 5.0$ Hz, 1H), 8.11 (d, $J = 9.0$ Hz, 2H), 7.81 (td, $J = 7.5, 1.5$ Hz, 1H), 7.75 (m, 3H), 7.31 (ddd, $J = 7, 4.5, 1$ Hz, 1H)

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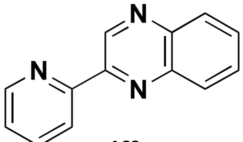
[19] Hitchcock, S. A.; Mayhugh, D. R.; Gregory, G. S. *Tetrahedron Lett.* **1995**, *36*, 9085-9088.
[20] Billingsley, K. L.; Buchwald, S. L. *Angew. Chem. Int. Ed.* **2008**, *47*, 4695-4698.

^{13}C-NMR (125 MHz, CDCl$_3$)
δ 155.2, 150.0, 143.4, 137.1, 132.5, 127.4, 123.3, 121.0, 118.8, 112.5

HRMS (CI+)
Calculated for $C_{12}H_9N_2$ $(M+H)^+$: 181.0766
Found: 181.0765

IR (KBr, cm^{-1})
2228, 1588, 1466, 1433, 1393, 1303, 1152, 1152, 990, 852, 776, 738, 718, 620, 563, 518

2-(2-pyridinyl)quinoxaline[21] (**4ff**) [Table 3, Entry 3]. The general procedure was followed using 2-chloroquinoxaline (**3i**) (165 mg, 1.00 mmol), 2-pyridyl MIDA boronate (**2i**) (353 mg, 1.51 mmol), K_2CO_3 (693 mg, 5.01 mmol) and $Cu(OAc)_2$ (91 mg, 0.50 mmol). Flash chromatography on silica gel (hexanes:EtOAc, 100:0 → 80:20) afforded **4ff** as a pale orange solid (164 mg, 79%).



4ff

TLC (hexanes:EtOAc (1:1)
$R_f = 0.56$, visualized by UV (λ = 254 nm)

^{1}H-NMR (500 MHz, CDCl$_3$)
δ 9.95 (s, 1H), 8.77 (ddd, *J* = 5.0, 1.5, 1.0 Hz, 1H), 8.58 (d, *J* = 8.0 Hz, 1H), 8.15 (m, 2H), 7.88 (td, *J* = 7.5, 1.5 Hz, 1H), 7.77 (m, 2H), 7.39 (ddd, *J* = 7.5, 4.5, 1.0 Hz, 1H)

^{13}C-NMR (125 MHz, CDCl$_3$)
δ 154.5, 150.1, 149.4, 144.1, 142.5, 141.7, 137.1, 130.1, 130.0, 129.7, 129.3, 124.6, 122.0

HRMS (CI+)
Calculated for $C_{13}H_{10}N_3$ $(M+H)^+$: 208.0875
Found: 208.0871

IR (KBr, cm^{-1})
3050, 3004, 1591, 1548, 1492, 1479, 1457, 1437, 1403, 1367, 1143, 1131, 1059, 1043, 996, 961, 806, 785, 772, 742, 716, 670, 556

2,5-dimethyl-3-(2-pyridinyl)pyrazine (**4gg**) [Table 3, Entry 4]. The general procedure was followed using 3-chloro-2,5-dimethylpyrazine (**3e**) (142 mg, 1.00 mmol), 2-pyridyl MIDA boronate (**2i**) (352 mg, 1.50 mmol), K_2CO_3 (694 mg, 5.02 mmol) and $Cu(OAc)_2$ (90 mg, 0.50 mmol). The aqueous phase was extracted an additional time with EtOAc (10 mL). Flash chromatography on silica gel (hexanes:EtOAc, 100:0 → 55:45) afforded **4gg** as a pale amber liquid (96 mg, 52%).

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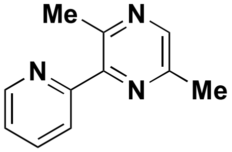
[21] Cui, Y.; Tang, X-B.; Shao, C-X.; Li, J-T.; Sun, W-H. *Chin. J. Chem.* **2005**, *23*, 589-595.



4gg

TLC (hexanes:EtOAc 1:1)
$R_f = 0.39$, visualized by UV ($\lambda = 254$ nm)

^{1}H-NMR (500 MHz, $CDCl_3$ w/ TMS)
δ 8.72 (d, $J = 3.5$ Hz, 1H), 8.38 (s, 1H), 7.83 (m, 2H), 7.33 (m, 1H), 2.73 (s, 3H), 2.59 (s, 3H)

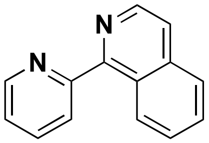
^{13}C-NMR (125 MHz, $CDCl_3$)
δ 157.2, 150.2, 149.9, 149.4, 148.7, 142.6, 136.6, 124.1, 123.0, 120.1, 22.6, 21.0

HRMS (CI+)

Calculated for $C_{11}H_{12}N_3$ $(M+H)^+$:	186.1031
Found:	186.1034

IR (thin film, cm^{-1})
3055, 2927, 1693, 1589, 1561, 1474, 1452, 1422, 1371, 1292, 1171, 1071, 1048, 995, 804, 752, 744

1-(2-pyridinyl)isoquinoline (**4hh**) [Table 3, Entry 5]. The general procedure was followed using 1-chloroisoquinoline (**3l**) (164 mg, 1.00 mmol), 2-pyridyl MIDA boronate (**2i**) (350 mg, 1.49 mmol), K_2CO_3 (697 mg, 5.05 mmol) and $Cu(OAc)_2$ (89 mg, 0.49 mmol). The aqueous phase was extracted an additional time with EtOAc (10 mL). Flash chromatography on silica gel (hexanes:EtOAc, 70:30 → 30:70) afforded **4hh** as an off-white solid (152 mg, 74%).



4hh

TLC (EtOAc)
$R_f = 0.47$, visualized by UV ($\lambda = 254$ and 366 nm)

^{1}H-NMR (500 MHz, $CDCl_3$)
δ 8.79 (ddd, $J = 5.0, 1.5, 1.0$ Hz, 1H), 8.63 (d, $J = 5.5$ Hz, 1H), 8.60 (d, $J = 8.5$ Hz, 1H), 7.99 (dt, $J = 8.0$ Hz, 1.0 Hz, 1H), 7.91 (td, $J = 7.5, 2.0$ Hz, 1H), 7.87 (d, $J = 8.0$ Hz, 1H), 7.70 (d, $J = 5.5$ Hz, 1H), 7.69 (ddd, $J = 8.0, 7.0, 1.5$, 1H), 7.59 (ddd, $J = 8.5, 7.0, 1$ Hz, 1H), 7.40 (ddd, $J = 7.5, 5.0, 1.0$ Hz, 1H)

^{13}C-NMR (125 MHz, $CDCl_3$)
δ 158.2, 157.6, 148.6, 141.8, 137.0, 136.9, 130.0, 127.7, 127.6, 126.8, 126.6, 125.2, 123.2, 121.2

HRMS (CI+)

Calculated for $C_{14}H_{11}N_2$ $(M+H)^+$:	207.0922
Found:	207.0926

IR (KBr, cm^{-1})

3051, 3012, 1581, 1562, 1551, 1470, 1455, 1434, 1379, 1350, 1322, 1245, 1129, 1095, 992, 979, 966, 826, 811, 780, 753, 742, 713, 674, 644, 618, 573, 465, 441