One-Pot Synthesis of Symmetrical and Unsymmetrical Bisarylethynes by a Modification of the Sonogashira Coupling Reaction

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Submitted for publication as a letter to the journal *Organic Letters*

Supporting Information

Experimental Procedures

General. Unless otherwise indicated, all starting materials were obtained from commercial suppliers (Aldrich, Fischer, EM Science, Lancaster, Mallinkrodt) and were used without further purification, including acetone, ethyl acetate, hexanes, methylene chloride, trimethylsilylethynylene, triethylamine, DBU and DBN. Benzene was vacuum distilled over calcium hydride prior to use, and all reaction solvents were stored over 4 molecular sieves. All reactions were performed under an atmosphere of dry argon. Analytical thin-layer chromatography (TLC) was performed on Kieselgel F-254 pre-coated plastic TLC plates from EM Science. Visualization was performed with a 254 nm ultraviolet lamp. Silica gel column chromatography was carried out with silica gel (60 μ m, 230-400 mesh) from ICN Silitech. Melting point transitions were determined using a Fisher-Johns melting point apparatus and were uncorrected. All melting point values are reported as the midpoint of the thermal transition. The ^1H and ^{13}C NMR spectra were recorded on a Varian Gemini 300 in CDCl_3 . Chemical shifts are expressed in parts per million (δ) using residual solvent protons as internal standards: chloroform (δ 7.26 for ^1H , δ 77.00 for ^{13}C). Coupling constants (J) are reported in Hertz (Hz). Splitting patterns are designated as s (singlet), d (doublet), t (triple), q (quartet), bs (broad singlet), m (multiplet). Combination gas chromatography and low-resolution mass spectrometry were obtained on a Hewlett-Packard 5890 Series II Gas Chromatograph - 5971A Mass Selective Detector.

Synthetic Procedures. General Procedure for Room Temperature Sonogashira Reaction Modification (Symmetrical): A 25 mL round bottom flask with teflon-coated magnetic stir bar is fitted with a rubber septum and flame dried under vacuum. The flask is purged with dry argon, and charged with $\text{PdCl}_2(\text{PPh}_3)_2$ (16.8 mg, 6 mol%), CuI (15.2 mg, 10 mol%) and starting material iodide or triflate (1 equiv, 0.80 mmol). Septum is parafilmed after solids are added. While stirring, dry benzene (4.0 mL, starting material is 0.20 M in dry benzene) sparged with dry argon is added by syringe. Argon-sparged DBU (718 μL , 6 equiv) is then added by syringe, followed by a purge of the reaction flask with argon. Ice-chilled trimethylsilylethynylene (57 μL , 0.50 equiv) is then added by syringe, followed immediately by distilled water (5.8 μL , 40 mol%). The reaction flask is covered in aluminum foil and left stirring at a high rate of speed for 18 h, at the end of which the reaction mixture is partitioned in ethyl ether and distilled water (50 mL each). The organic layer is washed with 10% HCl (3X 75 mL), saturated aqueous NaCl (1X 75 mL), dried over MgSO_4 , gravity-filtered and the solvent removed in vacuo. The crude product is purified by silica gel column chromatography.

General Procedure for Elevated Temperature Sonogashira Reaction Modification (Symmetrical): An 8 mL thick-walled sealed tube with teflon-coated magnetic stir bar is fitted with a rubber septum and flame dried under vacuum. The tube is purged with dry argon, and charged with $\text{PdCl}_2(\text{PPh}_3)_2$ (27.4 mg, 6 mol%), CuI (24.8 mg, 10 mol%) and starting material iodide or bromide or triflate (1 equiv, 1.3 mmol). While stirring, dry benzene (6.5 mL, starting material is 0.20 M in dry benzene) sparged with dry argon is added by syringe. Argon-sparged DBU (1.17 mL, 6 equiv) is then added by syringe, followed by a purge of the reaction tube with argon. Distilled water (5.6 μL , 40 mol%) is added by syringe, and the septum is removed. Immediately, ice-chilled trimethylsilylethynylene (92 μL , 0.50 equiv) is added by syringe and the sealed tube is capped tightly. The reaction tube is submerged in a 60 $^\circ\text{C}$ or

80 °C mineral oil bath, blocked from incidental light, and left stirring at a high rate of speed for 18 h, at the end of which the tube is removed from the oil bath and cooled to room temperature. The reaction mixture is partitioned in ethyl ether and distilled water (50 mL each). The organic layer is washed with 10% HCl (3X 75 mL), saturated aqueous NaCl (1X 75 mL), dried over MgSO₄, gravity-filtered and the solvent removed in vacuo. The crude product is purified by silica gel column chromatography.

General Procedure for Room Temperature Sonogashira Reaction Modification (Unsymmetrical): A 25 mL round bottom flask with teflon-coated magnetic stir bar is fitted with a rubber septum and flame dried under vacuum. The flask is purged with dry argon, and charged with PdCl₂(PPh₃)₂ (16.8 mg, 6 mol%), CuI (15.2 mg, 10 mol%) and starting material #1 iodide or bromide (1 equiv, 0.80 mmol). Septum is parafilm after solids have been added. While stirring, dry benzene (4.0 mL, starting material is 0.20 M in dry benzene) sparged with dry argon is added by syringe. Argon-sparged NEt₃ (669 µL, 6 equiv) is then added by syringe, followed by a purge of the reaction flask with argon. Ice-chilled trimethylsilylethynylene (119 µL, 1.05 equiv) is then added by syringe. The reaction flask is covered in aluminum foil and left stirring at a high rate of speed for 18 h. Starting material #2 iodide or bromide (1 equiv, 0.80 mmol), argon-sparged DBU (1.44 mL, 12 equiv), distilled water (5.8 µL, 40 mol%) and are then added. The mixture is stirred at room temperature for another 18 h, at the end of which the reaction is partitioned in ethyl ether and distilled water (50 mL each). The organic layer is washed with 10% HCl (3X 75 mL), saturated aqueous NaCl (1X 75 mL), dried over MgSO₄, gravity-filtered and the solvent removed in vacuo. The crude product is purified by silica gel column chromatography.

General Procedure for Elevated Temperature Sonogashira Reaction Modification (Unsymmetrical): An 8 mL thick-walled sealed tube with teflon-coated magnetic stir bar is fitted with a rubber septum and flame dried under vacuum. The tube is purged with dry argon, and charged with PdCl₂(PPh₃)₂ (16.8 mg, 6 mol%), CuI (15.2 mg, 10 mol%) and starting material #1 iodide or bromide (1 equiv, 0.80 mmol). While stirring, dry benzene (4.0 mL, starting material is 0.20 M in dry benzene) sparged with dry argon is added by syringe. Argon-sparged NEt₃ (669 µL, 6 equiv) is then added by syringe, followed by a purge of the reaction tube with argon. The septum is then removed. Immediately, ice-chilled trimethylsilylethynylene (119 µL, 1.05 equiv) is added by syringe and the sealed tube is capped tightly. The reaction tube is submerged in a 60 °C mineral oil bath, blocked from incidental light, and left stirring at a high rate of speed for 18 h, at the end of which the tube is removed from the oil bath and cooled to room temperature. Starting material #2 iodide or bromide (1 equiv, 0.80 mmol), argon-sparged DBU (1.44 mL, 12 equiv) and distilled water (5.8 µL, 40 mol%) and are then added. The mixture is stirred at room temperature for another 18 h, at the end of which the reaction is partitioned in ethyl ether and distilled water (50 mL each). The organic layer is washed with 10% HCl (3X 75 mL), saturated aqueous NaCl (1X 75 mL), dried over MgSO₄, gravity-filtered and the solvent removed in vacuo. The crude product is purified by silica gel column chromatography.

Optimization Study - Variation of Catalyst, Base, Solvent, Amount of Added Distilled Water, and Ethynylsilane Protecting Group. Except where otherwise noted, all reactions were performed according to the room temperature (symmetrical) general procedure detailed above, where catalyst, base and trialkylsilylethynylene stoichiometry remain the same upon variation. (DBU = 1,8-diazabicyclo[5.4.0]undec-7-ene; DBN = 1,5-

diazabicyclo[4.3.0]non-5-ene; DABCO = 1,4-diazabicyclo[2.2.2]octane; TEA = triethylamine; GUAN = 1,3,4,6,7,8-hexahydro-2*H*-pyrimido(1,2-*a*)pyrimidine; TMSA = trimethylsilyl acetylene; TESA = triethylsilyl acetylene; TBDMSA = *tert*-butyl dimethylsilyl acetylene) All relative product ratios were characterized by GC-MS after reaction mixture workup and are reported as the average of duplicate runs. Observation of only trace amounts of products (below instrumental threshold) are recorded as such.

Table 1.

Case	Catalyst	Base	Solvent	mol % H ₂ O ^a	HC≡CSiR ₃	Yield (%) ^b			
						1	2	3	4
cat/base 1A	PdCl ₂ (PPh ₃) ₂	DBU	benzene	0	TMSA	22.5	0	4.90	72.7
cat/base 2A	PdCl ₂ (PPh ₃) ₂	DBN	benzene	0	TMSA	63.1	trace	0	36.9
cat/base 3A	PdCl ₂ (PPh ₃) ₂	DABCO	benzene	0	TMSA	83.5	0	16.5	0
cat/base 1B	PdCl ₂ (PhCN) ₃ ^c	DBU	benzene	0	TMSA	58.5	0	5.70	35.8
cat/base 2B	PdCl ₂ (PhCN) ₃ ^c	DBN	benzene	0	TMSA	100	0	trace	0
cat/base 3B	PdCl ₂ (PhCN) ₃ ^c	DABCO	benzene	0	TMSA	68.2	0	31.8	0
cat/base 1C	PdCl ₂ dppf	DBU	benzene	0	TMSA	22.6	0	12.0	65.6
cat/base 2C	PdCl ₂ dppf	DBN	benzene	0	TMSA	42.2	trace	10.3	47.5
cat/base 3C	PdCl ₂ dppf	DABCO	benzene	0	TMSA	58.0	0	42.0	0
cat/base 1D	Pd(PPh ₃) ₄	DBU	benzene	0	TMSA	14.2	0	4.00	81.8
cat/base 2D	Pd(PPh ₃) ₄	DBN	benzene	0	TMSA	26.4	11.0	8.40	54.0
cat/base 3D	Pd(PPh ₃) ₄	DABCO	benzene	0	TMSA	88.1	0	11.9	0
cat/base 1E	Pd ₂ (dba) ₃ ^d	DBU	benzene	0	TMSA	31.0	0	trace	69.0
cat/base 2E	Pd ₂ (dba) ₃ ^d	DBN	benzene	0	TMSA	46.1	trace	11.5	42.4
cat/base 3E	Pd ₂ (dba) ₃ ^d	DABCO	benzene	0	TMSA	84.2	0	15.8	0
solvent 1A	PdCl ₂ (PPh ₃) ₂	DBU	toluene	0	TMSA	27.8	0	41.8	30.4
solvent 1B	PdCl ₂ (PPh ₃) ₂	DBU	toluene	40	TMSA	8.40	0	0	91.6
solvent 2A	PdCl ₂ (PPh ₃) ₂	DBU	dioxane	0	TMSA	20.9	0	15.0	66.1
solvent 2B	PdCl ₂ (PPh ₃) ₂	DBU	dioxane	40	TMSA	4.60	0	0	95.4
solvent 3A	PdCl ₂ (PPh ₃) ₂	DBU	THF	0	TMSA	7.90	0	3.60	88.5
solvent 3B	PdCl ₂ (PPh ₃) ₂	DBU	THF	40	TMSA	6.20	0	0	93.8
solvent 4A	PdCl ₂ (PPh ₃) ₂	DBU	DMF	0	TMSA	18.2	0	0	81.8
solvent 4B	PdCl ₂ (PPh ₃) ₂	DBU	DMF	40	TMSA	4.10	0	0	95.9
solvent 5A	PdCl ₂ (PPh ₃) ₂	DBU	CH ₃ CN	0	TMSA	10.6	0	trace	89.5
solvent 5B	PdCl ₂ (PPh ₃) ₂	DBU	CH ₃ CN	40	TMSA	trace	0	0	99
water 1	PdCl ₂ (PPh ₃) ₂	TEA	benzene	40	TMSA	43.9	0	56.1	0
water 2	PdCl ₂ (PPh ₃) ₂	DABCO	benzene	40	TMSA	18.5	0	81.5	0
water 3	PdCl ₂ (PPh ₃) ₂	DBN	benzene	40	TMSA	14.2	0	1.40	84.4
water 4	PdCl ₂ (PPh ₃) ₂	GUAN	benzene	40	TMSA	38.0	0	trace	62.0
water 5	PdCl ₂ (PPh ₃) ₂	DBU	benzene	10	TMSA	6.20	0	trace	93.8

water 6	PdCl ₂ (PPh ₃) ₂	DBU	benzene	20	TMSA	trace	0	0	99
water 7	PdCl ₂ (PPh ₃) ₂	DBU	benzene	30	TMSA	5.20	0	trace	94.8
water 8	PdCl ₂ (PPh ₃) ₂	DBU	benzene	40	TMSA	trace	0	0	99
water 9	PdCl ₂ (PPh ₃) ₂	DBU	benzene	50	TMSA	9.90	0	0	90.1
water 10	PdCl ₂ (PPh ₃) ₂	DBU	benzene	60	TMSA	10.4	0	0	89.6
water 11	PdCl ₂ (PPh ₃) ₂	DBU	benzene	80	TMSA	3.80	0	0	96.2
water 12	PdCl ₂ (PPh ₃) ₂	DBU	benzene	100	TMSA	6.40	0	0	93.6
silane 1	PdCl ₂ (PPh ₃) ₂	DBU	benzene	30	TESA	37.4	0	62.6	trace
silane 2	PdCl ₂ (PPh ₃) ₂	DBU	benzene	30	TBDMSA	53.1	0	46.9	0
scale up 1 (0.5 g)	PdCl ₂ (PPh ₃) ₂	DBU	benzene	40	TMSA	-	-	-	78 ^e
scale up 2 (1.0 g)	PdCl ₂ (PPh ₃) ₂	DBU	benzene	40	TMSA	-	-	-	80 ^e
scale up 3 (2.0 g)	PdCl ₂ (PPh ₃) ₂	DBU	benzene	40	TMSA	-	-	-	85 ^e
mech 1 (no CuI)	PdCl ₂ (PPh ₃) ₂	DBU	benzene	40	TMSA	100	0	0	0
mech 2 (no "H ⁺ ") ^f	PdCl ₂ (PPh ₃) ₂	DBU	benzene	0	-	31.6	0	38.7	29.7
mech 3 (added HI)	PdCl ₂ (PPh ₃) ₂	DBU	benzene	0	TMSA	trace	- ^g	- ^g	67

^a relative to 1 equiv (ca. 200 mg) 1-bromo-3-iodobenzene. ^b yields are averages of two runs. ^c 6 mol% P(*t*-Bu)₃ added. ^d 10 mol % PPh₃ added. ^e isolated yield. ^f starting materials = **1** and **3**, no added silane. ^g not analyzed for.

Physical Characterization Data. Syntheses of symmetrical and unsymmetrical products were performed by either the room temperature or elevated temperature methods described above and are noted as such. Individual case modifications are also detailed below. All reactions were performed on ca. 200 mg scale unless otherwise specified. References are supplied for previously reported compounds. ¹H and ¹³C NMR chemical shifts were confirmed using the prediction scripts in CambridgeSoft's ChemDraw Ultra[®] (2000).

1: Room Temperature (Symmetrical), starting material = 1-bromo-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 128 mg (0.38 mmol, 96%) of **1** as a white crystalline solid: TLC R_f = 0.20 (hexanes); mp 102 °C; ¹H NMR (300 MHz, CDCl₃) δ 7.67 (t, *J* = 1.6, 2H), 7.45 (m, 4H), 7.27 (t, *J* = 8.0, 2H); ¹³C NMR (300 MHz, CDCl₃) δ 135.5, 131.2, 130.7, 130.4, 124.7, 122.4, 89.36; GC-MS R_t 15.16 min, single peak - *m/z* for C₁₄H₈Br₂ (% relative intensity, ion): 338 (50, [M+4]⁺), 336 (100, [M+2]⁺), 334 (50, [M]⁺), 176 (100, [M-158]⁺).

1: Room Temperature (Symmetrical), ca. 500 mg starting material = 1-bromo-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 194 mg (0.58 mmol, 78%) of **1** as a white crystalline solid: TLC R_f = 0.20 (hexanes); mp 102-103 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.67 (t, J = 1.6, 2H), 7.45 (m, 4H), 7.27 (t, J = 8.0, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 135.5, 131.2, 130.7, 130.4, 124.7, 122.4, 89.36; GC-MS R_t 15.16 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Br}_2$ (% relative intensity, ion): 338 (50, $[\text{M}+4]^+$), 336 (100, $[\text{M}+2]^+$), 334 (50, $[\text{M}]^+$), 176 (100, $[\text{M}-158]^+$).

1: Room Temperature (Symmetrical, Modification - Procedure remains the same, but work-up step is altered - reaction mixture was poured over NH_4Cl (80, 160 mL) and extracted with CH_2Cl_2 (3X 80, 160 mL)), ca. 1 g starting material = 1-bromo-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 401 mg (1.20 mmol, 80%) of **1** as a white crystalline solid: TLC R_f = 0.20 (hexanes); mp 102-103 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.67 (t, J = 1.6, 2H), 7.45 (m, 4H), 7.27 (t, J = 8.0, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 135.5, 131.2, 130.7, 130.4, 124.7, 122.4, 89.36; GC-MS R_t 15.16 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Br}_2$ (% relative intensity, ion): 338 (50, $[\text{M}+4]^+$), 336 (100, $[\text{M}+2]^+$), 334 (50, $[\text{M}]^+$), 176 (100, $[\text{M}-158]^+$).

1: Room Temperature (Symmetrical, Modification - Procedure remains the same, but work-up step is altered - reaction mixture was poured over NH_4Cl (80, 160 mL) and extracted with CH_2Cl_2 (3X 80, 160 mL)), ca. 2 g starting material = 1-bromo-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 848 mg (2.54 mmol, 85%) of **1** as a white crystalline solid: TLC R_f = 0.20 (hexanes); mp 102-103 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.67 (t, J = 1.6, 2H), 7.45 (m, 4H), 7.27 (t, J = 8.0, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 135.5, 131.2, 130.7, 130.4, 124.7, 122.4, 89.36; GC-MS R_t 15.16 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Br}_2$ (% relative intensity, ion): 338 (50, $[\text{M}+4]^+$), 336 (100, $[\text{M}+2]^+$), 334 (50, $[\text{M}]^+$), 176 (100, $[\text{M}-158]^+$).

1: Elevated Temperature (60 °C, Symmetrical), starting material = 1-bromo-3-trifluoromethane sulfonylbenzene: The crude product was purified by preparative thin layer chromatography (95:5 hexanes/ethyl acetate) to afford 55 mg (0.16 mmol, 48%) of **1** as a white crystalline solid: TLC R_f = 0.48 (95:5 hexanes/ethyl acetate); ^1H NMR (300 MHz, CDCl_3) δ 7.68 (t, J = 1.75, 2H), 7.49 (ddd, J = 8.0, 2.0, 1.1, 2H), 7.44 (dt, J = 7.8, 1.3, 2H), 7.23 (t, J = 7.9, 2H); ^{13}C NMR (75 MHz, CDCl_3) δ 134.4, 131.7, 130.2, 129.8, 124.7, 122.2, 89.00; HRMS-EI (m/z): $[\text{M}]^+$ calcd for $\text{C}_{14}\text{H}_8\text{Br}_2$ 333.8993, found 333.8986.

2¹: Elevated Temperature (60 °C, Symmetrical), starting material = 1-fluoro-2-iodobenzene: The crude product was purified by silica gel column chromatography (98:2 hexanes/ethyl acetate) to afford 129 mg (0.60 mmol, 93%) of **2** as a white crystalline solid: TLC R_f = 0.30 (98:2 hexanes/ethyl acetate); mp 48 °C (lit. 49-51 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.55 (t, J = 6.8, 2H), 7.33 (t, J = 6.3, 2H), 7.15 (d, J = 7.1, 2H), 7.10 (d, J = 7.1, 2H);

^{13}C NMR (300 MHz, CDCl_3) δ 164.3, 134.5, 129.3, 122.9, 114.6, 111.7, 87.65; GC-MS R_t 11.79 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{F}_2$ (% relative intensity, ion): 214 (100, $[\text{M}]^+$).

3²: Elevated Temperature (60 °C, Symmetrical), starting material = 1-chloro-2-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 139 mg (0.57 mmol, 87%) of **3** as an off-white crystalline solid: TLC R_f = 0.24 (hexanes); mp 86 °C (lit. 84-85 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.52 (dd, J = 6.6, 2.2, 2H), 7.35 (dd, J = 6.8, 2.2, 2H), 7.19 (m, 2H), 7.17 (m, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 136.1, 134.7, 130.8, 130.5, 127.6, 123.1, 91.30; GC-MS R_t 13.83 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Cl}_2$ (% relative intensity, ion): 248 (65, $[\text{M}+2]^+$), 246 (100, $[\text{M}]^+$), 176 (65, $[\text{M}-70]^+$).

4³: Elevated Temperature (60 °C, Symmetrical), starting material = 1-bromo-2-iodobenzene: The crude product was purified by silica gel column chromatography (90:10 hexanes/ethyl acetate) to afford 200 mg (0.60 mmol, 92%) of **4** as an off-white crystalline solid: TLC R_f = 0.38 (90:10 hexanes/ethyl acetate); mp 81 °C (lit. 81-83 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.55 (m, 2H), 7.52 (m, 2H), 7.22 (t, J = 7.4, 2H), 7.11 (t, J = 7.1, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 134.8, 133.7, 130.9, 128.9, 128.2, 126.2, 92.41; GC-MS R_t 14.87 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Br}_2$ (% relative intensity, ion): 338 (50, $[\text{M}+4]^+$), 336 (100, $[\text{M}+2]^+$), 334 (45, $[\text{M}]^+$), 176 (100, $[\text{M}-158]^+$).

5⁴: Elevated Temperature (60 °C, Symmetrical), starting material = 1-fluoro-4-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 124 mg (0.58 mmol, 89%) of **5** as a white crystalline solid: TLC R_f = 0.14 (hexanes); mp 92 °C (lit. 94-96 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.50 (dt, J = 8.5, 3.2, 4H), 7.05 (t, J = 8.6, 4H); ^{13}C NMR (300 MHz, CDCl_3) δ 160.9, 133.5, 119.2, 115.8, 87.95; GC-MS R_t 11.51 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{F}_2$ (% relative intensity, ion): 214 (100, $[\text{M}]^+$).

6⁴: Room Temperature (Symmetrical), starting material = 1-chloro-4-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 97.4 mg (0.40 mmol, 99%) of **6** as a yellow crystalline solid: TLC R_f = 0.28 (hexanes); mp 179 °C (lit. 174-176 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.46 (d, J = 8.5, 4H), 7.33 (d, J = 8.5, 4H); ^{13}C NMR (300 MHz, CDCl_3) δ 133.8, 129.7, 127.7, 121.35, 89.14; GC-MS R_t 13.84 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Cl}_2$ (% relative intensity, ion): 248 (60, $[\text{M}+2]^+$), 246 (100, $[\text{M}]^+$), 176 (50, $[\text{M}-70]^+$).

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7⁵: Room Temperature (Symmetrical), starting material = 1-bromo-4-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 119 mg (0.36 mmol, 89%) of **7** as an off-white crystalline solid: TLC R_f = 0.23 (hexanes); mp 186 °C (lit. 184-185 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.49 (d, J = 8.3, 4H), 7.38 (d, J = 8.3, 4H); ^{13}C NMR (300 MHz, CDCl_3) δ 133.0, 131.7, 122.8, 121.9, 89.40; GC-MS R_t 15.13 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Br}_2$ (% relative intensity, ion): 338 (50, $[\text{M}+4]^+$), 336 (100, $[\text{M}+2]^+$), 334 (50, $[\text{M}]^+$), 176 (100, $[\text{M}-158]^+$).

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8⁶: Room Temperature (Symmetrical), starting material = 1-fluoro-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 83.0 mg (0.39 mmol, 97%) of **8** as a yellow crystalline solid: TLC R_f = 0.25 (hexanes); mp 63 °C (lit. 62 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.31 (m, 2H), 7.27 (m, 8H), 7.06 (m, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 164.0, 131.0, 128.9, 119.4, 116.7, 115.2, 88.87; GC-MS R_t 11.50 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{F}_2$ (% relative intensity, ion): 214 (100, $[\text{M}]^+$).

9

9⁷: Room Temperature (Symmetrical), starting material = 1-chloro-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 91.5 mg (0.37 mmol, 93%) of **9** as an off-white crystalline solid: TLC R_f = 0.48 (hexanes); mp 80 °C (lit. 81-82 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.46 (m, 2H), 7.35 (m, 2H), 7.25 (m, 4H); ^{13}C NMR (300 MHz, CDCl_3) δ 134.2, 131.5, 129.7, 129.6, 128.8, 124.5, 89.00; GC-MS R_t 13.89 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Cl}_2$ (% relative intensity, ion): 248 (50, $[\text{M}+2]^+$), 246 (100, $[\text{M}]^+$), 176 (50, $[\text{M}-70]^+$).

10

10⁸: Elevated Temperature (80 °C, Symmetrical), starting material = bromobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 77.5 mg (0.44 mmol, 67%) of **10** as an off-white crystalline solid: TLC R_f = 0.23 (hexanes); mp 61 °C (lit. 59-61 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.45 (dd, J = 7.6, 3.8, 4H), 7.25 (dd, J = 7.6, 3.9, 4H), 7.17 (s, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 132.7, 129.3, 127.2, 123.2, 89.35; GC-MS R_t 11.77 min, single peak - m/z for $\text{C}_{14}\text{H}_{10}$ (% relative intensity, ion): 178 (100, $[\text{M}]^+$).

10⁸: Elevated Temperature (60 °C, Symmetrical), starting material = trifluoromethane sulfonylbenzene: The crude product was purified by preparative thin layer chromatography (95:5 hexanes/ethyl acetate) to afford 48.0

mg (0.27 mmol, 84%) of **15** as an off-white crystalline solid: TLC R_f = 0.50 (95:5 hexanes/ethyl acetate); mp 61 °C (lit. 59-61 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.45 (dd, J = 7.6, 3.8, 4H), 7.25 (dd, J = 7.6, 3.9, 4H), 7.17 (s, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 132.7, 129.3, 127.2, 123.2, 89.35; GC-MS R_t 11.77 min, single peak - m/z for $\text{C}_{14}\text{H}_{10}$ (% relative intensity, ion): 178 (100, $[\text{M}]^+$).

11: Elevated Temperature (80 °C, Symmetrical, Modification - Procedure remains the same, but catalyst system used is $\text{Pd}_2(\text{dibenzylideneacetone})_3$ (18 mg, 1.5 mol%) and PPh_3 (34.1 mg, 10 mol%)), starting material = 3-bromobenzonitrile: The crude product was purified by silica gel column chromatography (80:20 hexanes/ethyl acetate) to afford 130 mg (0.57 mmol, 88%) of **11** as an off-white crystalline solid: TLC R_f = 0.23 (80:20 hexanes/ethyl acetate); mp 115 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.82 (s, 2H), 7.75 (d, J = 7.8, 2H), 7.66 (d, J = 7.8, 2H), 7.50 (t, J = 7.8, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 136.8, 133.3, 130.7, 128.6, 124.1, 118.0, 113.2, 89.23; HRMS-EI (m/z): $[\text{M}]^+$ calcd for $\text{C}_{16}\text{H}_8\text{N}_2$ 228.0689, found 228.0932; GC-MS R_t 15.19 min, single peak - m/z for $\text{C}_{16}\text{H}_8\text{N}_2$ (% relative intensity, ion): 228 (100, $[\text{M}]^+$).

12⁹: Room Temperature (Symmetrical), starting material = 4'-iodoacetophenone: The crude product was purified by silica gel column chromatography (85:15 hexanes/ethyl acetate) to afford 95.4 mg (0.36 mmol, 91%) of **12** as an off-white crystalline solid: TLC R_f = 0.10 (85:15 hexanes/ethyl acetate); mp 201 °C (lit. 198-200 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.96 (d, J = 8.3, 4H), 7.63 (d, J = 8.3, 4H), 2.62 (s, 6H); ^{13}C NMR (300 MHz, CDCl_3) δ 197.2, 136.5, 132.7, 129.2, 127.4, 91.60, 27.40; GC-MS R_t 17.30 min, single peak - m/z for $\text{C}_{18}\text{H}_{14}\text{O}_2$ (% relative intensity, ion): 262 (50, $[\text{M}]^+$), 247 (100, $[\text{M}-15]^+$).

12⁹: Elevated Temperature (80 °C, Symmetrical), starting material = 4'-bromoacetophenone: The crude product was purified by silica gel column chromatography (80:20 hexanes/ethyl acetate) to afford 118 mg (0.45 mmol, 69%) of **12** as an off-white crystalline solid: TLC R_f = 0.13 (80:20 hexanes/ethyl acetate); mp 201 °C (lit. 198-200 °C); ^1H NMR (300 MHz, CDCl_3) δ 7.96 (d, J = 8.3, 4H), 7.63 (d, J = 8.1, 4H), 2.62 (s, 6H); ^{13}C NMR (300 MHz, CDCl_3) δ 197.2, 136.5, 132.7, 129.2, 127.4, 91.60, 27.40; GC-MS R_t 17.03 min, single peak - m/z for $\text{C}_{18}\text{H}_{14}\text{O}_2$ (% relative intensity, ion): 262 (60, $[\text{M}]^+$), 247 (100, $[\text{M}-15]^+$).

13¹⁰: Elevated Temperature (60 °C, Symmetrical), starting material = 4-bromoanisole: The crude product was purified by silica gel column chromatography (95:5 hexanes/ethyl acetate) to afford 110 mg (0.46 mmol, 71%) of **13** as a white crystalline solid: TLC R_f = 0.24 (95:5 hexanes/ethyl acetate); mp 142 °C (lit. 141-143 °C); ^1H NMR

(300 MHz, CDCl₃) δ 7.45 (d, J = 8.8, 4H), 6.87 (d, J = 8.8, 4H), 3.83 (s, 6H); ¹³C NMR (300 MHz, CDCl₃) δ 159.6, 134.1, 115.4, 113.7, 88.11, 56.61; GC-MS R_t 14.93 min, single peak - m/z for C₁₆H₁₄O₂ (% relative intensity, ion): 238 (100, [M]⁺), 223 (90, [M-15]⁺).

14

14¹¹: Elevated Temperature (60 °C, Symmetrical), starting material = 4-bromotoluene: The crude product was purified by silica gel column chromatography (95:5 hexanes/ethyl acetate) to afford 125 mg (0.60 mmol, 93%) of **14** as a white crystalline solid: TLC R_f = 0.48 (95:5 hexanes/ethyl acetate); mp 138 °C (lit. 136 °C); ¹H NMR (300 MHz, CDCl₃) δ 7.42 (d, J = 7.8, 4H), 7.15 (d, J = 7.8, 4H), 3.37 (s, 6H); ¹³C NMR (300 MHz, CDCl₃) δ 138.15, 132.40, 130.39, 120.34, 88.90, 20.53; HRMS-EI (m/z): [M]⁺ calcd for C₁₆H₁₄ 206.1096, found 206.1110; GC-MS R_t 13.18 min, single peak - m/z for C₁₆H₁₄ (% relative intensity, ion): 206 (100, [M]⁺).

15

15¹²: Room Temperature (Symmetrical), starting material = 1-iodonaphthalene: The crude product was purified by silica gel column chromatography (hexanes) to afford 76.7 mg (0.28 mmol, 69%) of **15** as an off-white crystalline solid: TLC R_f = 0.19 (hexanes); mp 125 °C (lit. 127-129 °C); ¹H NMR (300 MHz, CDCl₃) δ 8.56 (m, 4H), 7.86 (m, 4H), 7.54 (m, 6H); ¹³C NMR (300 MHz, CDCl₃) δ 133.3, 131.3, 129.6, 127.9, 127.5, 126.3, 124.3, 121.0, 92.40; GC-MS R_t 21.71 min, single peak - m/z for C₂₂H₁₄ (% relative intensity, ion): 278 (100, [M]⁺), 138 (40, [M-140]⁺).

16

16¹³: Room Temperature (Symmetrical), starting material = 1-iodothiophene: The crude product was purified by silica gel column chromatography (hexanes) to afford 66.9 mg (0.35 mmol, 88%) of **16** as a yellow crystalline solid: TLC R_f = 0.24 (hexanes); mp 96 °C (lit. 95 °C); ¹H NMR (300 MHz, CDCl₃) δ 7.29 (m, 4H), 7.01 (m, 2H); ¹³C NMR (300 MHz, CDCl₃) δ 133.1, 128.7, 127.9, 126.4, 86.15; GC-MS R_t 12.01 min, single peak - m/z for C₁₀H₆S₂ (% relative intensity, ion): 190 (100, [M]⁺).

17

17¹²: Room Temperature (Symmetrical), starting material = 4-iodobenzotrifluoride: The crude product was purified by silica gel column chromatography (98:2 hexanes/ethyl acetate) to afford 117 mg (0.37 mmol, 93%) of **17** as an off-white crystalline solid: TLC R_f = 0.33 (98:2 hexanes/ethyl acetate); mp 105 °C; ¹H NMR (300 MHz, CDCl₃) δ 7.66 (d, J = 9.5, 4H), 7.63 (d, J = 9.3, 4H); ¹³C NMR (300 MHz, CDCl₃) δ 133.1, 130.9, 126.5, 124.4, 98.34, 90.10; GC-MS R_t 11.52 min, single peak - m/z for C₁₆H₈F₆ (% relative intensity, ion): 314 (100, [M]⁺).

18

18¹⁴: Room Temperature (Symmetrical), starting material = methyl-4-iodobenzoate: The crude product was purified by silica gel column chromatography (90:10 hexanes/ethyl acetate) to afford 106 mg (0.36 mmol, 90%) of **18** as an off-white crystalline solid: TLC R_f = 0.35 (90:10 hexanes/ethyl acetate); mp 223 °C (lit. 219-220 °C); ^1H NMR (300 MHz, CDCl_3) δ 8.04 (d, J = 8.1, 4H), 7.60 (d, J = 8.3, 4H), 3.93 (s, 6H); ^{13}C NMR (300 MHz, CDCl_3) δ 166.6, 132.9, 130.7, 128.7, 127.5, 91.50, 52.40; GC-MS R_t 17.73 min, single peak - m/z for $\text{C}_{18}\text{H}_{14}\text{O}_4$ (% relative intensity, ion): 294 (90, $[\text{M}]^+$), 263 (100, $[\text{M}-31]^+$).

19

19¹⁵: Room Temperature (Symmetrical, Modification - Procedure remains the same, but work-up step is altered - acidic wash is replaced by wash with distilled water (6X 75 mL)), starting material = 2-chloro-5-iodopyridine: The crude product was purified by silica gel column chromatography (80:20 hexanes/ethyl acetate) to afford 94.2 mg (0.38 mmol, 95%) of **19** as an off-white crystalline solid: TLC R_f = 0.40 (80:20 hexanes/ethyl acetate); mp 231 °C (lit. 229-230 °C); ^1H NMR (300 MHz, CDCl_3) δ 8.55 (s, 2H), 7.78 (dd, J = 8.1, 2.2, 2H), 7.36 (d, J = 8.1, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 152.9, 151.3, 141.9, 123.0, 118.3, 88.91; GC-MS R_t 14.51 min, single peak - m/z for $\text{C}_{12}\text{H}_6\text{Cl}_2\text{N}_2$ (% relative intensity, ion): 248 (100, $[\text{M}]^+$), 207 (50, $[\text{M}-41]^+$).

20

20: Room Temperature (Unsymmetrical), starting material #1 = 1-bromo-4-iodobenzene, starting material #2 = 1-bromo-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 163 mg (0.49 mmol, 61%) of **20** as a white crystalline solid: TLC R_f = 0.36 (hexanes); mp 111 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.67 (s, 1H), 7.43 (m, 6H), 7.22 (m, 1H); ^{13}C NMR (300 MHz, CDCl_3) δ 134.3, 133.0, 131.7, 131.6, 130.1, 129.8, 124.9, 122.9, 122.2, 121.7, 88.87, 88.55; HRMS-EI (m/z): $[\text{M}]^+$ calcd for $\text{C}_{14}\text{H}_8\text{Br}_2$ 333.8993, found 333.8999; GC-MS R_t 15.10 min, single peak - m/z for $\text{C}_{14}\text{H}_8\text{Br}_2$ (% relative intensity, ion): 338 (50, $[\text{M}+4]^+$), 336 (100, $[\text{M}+2]^+$), 334, (50, $[\text{M}]^+$), 176 (100, $[\text{M}-158]^+$).

21

21: Room Temperature (Unsymmetrical), starting material #1 = 1-bromo-3-iodobenzene, starting material #2 = 1-chloro-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 183 mg (0.63 mmol, 79%) of **21** as an off-white crystalline solid: TLC R_f = 0.25 (hexanes); mp 91 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.68 (s, 1H), 7.43 (m, 4H), 7.28 (m, 3H); ^{13}C NMR (300 MHz, CDCl_3) δ 135.5, 135.2, 132.8, 131.2, 130.8, 130.6, 129.9, 129.8, 128.8, 124.8, 124.4, 122.3, 89.10, 88.80; HRMS-EI (m/z): $[\text{M}]^+$ calcd for

$C_{14}H_8BrCl$ 289.9498, found 289.9495; GC-MS R_t 14.45 min, single peak - m/z for $C_{14}H_8BrCl$ (% relative intensity, ion): 292 (100, $[M+2]^+$), 290 (80, $[M]^+$), 176 (100, $[M-114]^+$).

22: Room Temperature (Unsymmetrical), starting material #1 = 1-chloro-4-iodobenzene, starting material #2 = 1-bromo-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 209 mg (0.72 mmol, 90%) of **22** as an off-white crystalline solid: TLC R_f = 0.23 (hexanes); mp 101 °C; 1H NMR (300 MHz, $CDCl_3$) δ 7.62 (m, 1H), 7.40 (m, 4H), 7.28 (d, J = 8.5, 2H), 7.17 (t, J = 8.1, 1H); ^{13}C NMR (300 MHz, $CDCl_3$) δ 134.7, 134.3, 132.8, 131.6, 130.1, 129.8, 128.7, 124.9, 122.2, 121.2, 89.49, 88.69; HRMS-EI (m/z): $[M]^+$ calcd for $C_{14}H_8BrCl$ 289.9498, found 289.9496; GC-MS R_t 14.46 min, single peak - m/z for $C_{14}H_8BrCl$ (% relative intensity, ion): 292 (100, $[M+2]^+$), 290 (60, $[M]^+$), 207 (50, $[M-83]^+$), 176 (100, $[M-114]^+$).

23: Room Temperature (Unsymmetrical), starting material #1 = 1-bromo-3-iodobenzene, starting material #2 = 1-iodonaphthalene: The crude product was purified by silica gel column chromatography (hexanes) to afford 198 mg (0.65 mmol, 81%) of **23** as a pale yellow crystalline solid: TLC R_f = 0.28 (hexanes); mp 79 °C; 1H NMR (300 MHz, $CDCl_3$) δ 8.38 (d, J = 8.3, 2H), 7.87 (dd, J = 8.3, 2.7, 1H), 7.80 (s, 1H), 7.76 (d, J = 7.1, 1H), 7.57 (m, 5H), 7.25 (t, J = 7.8, 1H); ^{13}C NMR (300 MHz, $CDCl_3$) δ 134.3, 133.1, 131.4, 130.6, 130.1, 129.8, 129.1, 128.3, 126.9, 126.5, 126.0, 125.4, 125.2, 122.2, 120.3, 92.64, 88.88; HRMS-EI (m/z): $[M]^+$ calcd for $C_{18}H_{11}Br$ 306.0044, found 306.0044; GC-MS R_t 17.35 min, single peak - m/z for $C_{18}H_{11}Br$ (% relative intensity, ion): 308 (80, $[M+2]^+$), 306 (100, $[M]^+$), 226 (100, $[M-80]^+$), 113 (70, $[M-193]^+$).

24: Room Temperature (Unsymmetrical), starting material #1 = 2-iodothiophene, starting material #2 = 1-bromo-3-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 130 mg (0.50 mmol, 62%) of **24** as a yellow crystalline solid: TLC R_f = 0.29 (hexanes); mp 39 °C; 1H NMR (300 MHz, $CDCl_3$) δ 7.67 (s, 1H), 7.45 (t, J = 8.8, 1H), 7.36 (m, 3H), 7.21 (t, J = 8.0, 1H), 7.02 (t, J = 4.9, 1H); ^{13}C NMR (300 MHz, $CDCl_3$) δ 134.0, 132.3, 131.5, 129.9, 129.8, 127.7, 125.2, 127.1, 124.9, 122.7, 91.43, 83.96; HRMS-EI (m/z): $[M]^+$ calcd for $C_{12}H_7BrS$ 261.9452, found 261.9459; GC-MS R_t 13.54 min, single peak - m/z for $C_{12}H_7BrS$ (% relative intensity, ion): 264 (100, $[M+2]^+$), 262 (90, $[M]^+$), 139 (80, $[M-123]^+$).

25

25: Room Temperature (Unsymmetrical), starting material #1 = 1-iodonaphthalene, starting material #2 = 1-chloro-4-iodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford 134 mg (0.51 mmol, 64%) of **25** as a yellow crystalline solid: TLC R_f = 0.15 (hexanes); mp 91 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.40 (d, J = 8.1, 2H), 7.87 (m, 1H), 7.76 (d, J = 7.1, 1H), 7.54 (m, 5H), 7.38 (d, J = 8.3, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 134.4, 133.2, 132.8, 130.5, 129.0, 128.7, 128.3, 126.8, 126.5, 126.1, 125.2, 121.9, 120.5, 93.12, 88.50; HRMS-EI (m/z): $[\text{M}]^+$ calcd for $\text{C}_{18}\text{H}_{11}\text{Cl}$ 262.0549, found 262.0557; GC-MS R_t 16.35 min, single peak - m/z for $\text{C}_{18}\text{H}_{11}\text{Cl}$ (% relative intensity, ion): 264 (40, $[\text{M}+2]^+$), 262 (100, $[\text{M}]^+$), 227 (70, $[\text{M}-35]^+$).

26

26: Room Temperature (Unsymmetrical), starting material #1 = 1-chloro-4-iodobenzene, starting material #2 = 2-iodothiophene: The crude product was purified by silica gel column chromatography (hexanes) to afford 108 mg (0.50 mmol, 62%) of **26** as a white crystalline solid: TLC R_f = 0.20 (hexanes); mp 110 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.69 (s, 2H), 7.47 (m, 4H), 7.22 (d, J = 7.1, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 134.4, 132.6, 132.1, 128.7, 127.5, 127.1, 122.9, 121.4, 91.88, 83.58; HRMS-EI (m/z): $[\text{M}]^+$ calcd for $\text{C}_{12}\text{H}_7\text{ClS}$ 217.9957, found 217.9964; GC-MS R_t 13.03 min, single peak - m/z for $\text{C}_{12}\text{H}_7\text{ClS}$ (% relative intensity, ion): 218 (100, $[\text{M}]^+$), 207 (70, $[\text{M}-11]^+$).

27

27¹⁶: Elevated Temperature (60 °C, Unsymmetrical), starting material #1 = 4-iodoanisole, starting material #2 = methyl 4-iodobenzoate: The crude product was purified by silica gel column chromatography (90:10 hexanes/ethyl acetate) to afford 151 mg (0.57 mmol, 71%) of **27** as an off-white crystalline solid: TLC R_f = 0.23 (90:10 hexanes/ethyl acetate); mp 156 °C; ^1H NMR (300 MHz, CDCl_3) δ 8.01 (d, J = 8.1, 2H), 7.56 (d, J = 8.3, 2H), 7.49 (d, J = 8.5, 2H), 6.89 (d, J = 8.5, 2H), 3.93 (s, 3H), 3.84 (s, 3H); ^{13}C NMR (300 MHz, CDCl_3) δ 166.6, 160.0, 133.2, 131.3, 129.5, 129.1, 28.4, 114.7, 114.1, 92.54, 87.48, 55.28, 52.15; HRMS-EI (m/z): $[\text{M}]^+$ calcd for $\text{C}_{17}\text{H}_{14}\text{O}_3$ 266.0943, found 266.0952; GC-MS R_t 16.05 min, single peak - m/z for $\text{C}_{17}\text{H}_{14}\text{O}_3$ (% relative intensity, ion): 266 (100, $[\text{M}]^+$), 207 (100, $[\text{M}-59]^+$).

28

28: Room Temperature (Unsymmetrical), starting material #1 = 1-bromo-3-iodobenzene, starting material #2 = 1,4-diiodobenzene: The crude product was purified by silica gel column chromatography (hexanes) to afford

219 mg (0.50 mmol, 63%) of **28** as an off-white crystalline solid: TLC R_f = 0.10 (hexanes); mp 191 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.69 (s, 2H), 7.47 (m, 8H), 7.22 (d, J = 7.1, 2H); ^{13}C NMR (300 MHz, CDCl_3) δ 134.3, 131.6, 130.2, 129.8, 125.0, 122.9, 122.2, 90.22, 89.78; GC-MS R_t 22.59 min, single peak - m/z for $\text{C}_{22}\text{H}_{12}\text{Br}_2$ (% relative intensity, ion): 438 (50, $[\text{M}+4]^+$), 436 (100, $[\text{M}+2]^+$), 434 (50, $[\text{M}]^+$).

29

29: A 16 mL thick-walled sealed tube with teflon-coated magnetic stir bar was fitted with a rubber septum and flame dried under vacuum. The tube was purged with dry argon, and charged with $\text{PdCl}_2(\text{PPh}_3)_2$ (16.8 mg, 6 mol%), CuI (15.2 mg, 10 mol%) and 1-chloro-3-iodobenzene (1 equiv, 0.80 mmol). While stirring, dry benzene (4.0 mL, starting material is 0.20 M in dry benzene) sparged with dry argon was added by syringe. Argon-sparged NEt_3 (669 μL , 6 equiv) was then added by syringe, followed by a purge of the reaction tube with argon. The septum was then removed. Immediately, ice-chilled trimethylsilylethynylene (119 μL , 1.05 equiv) was added by syringe and the sealed tube was capped tightly. The reaction tube was blocked from incidental light and left stirring at room temperature at a high rate of speed for 18 h. In the second step, 1-bromo-3-iodobenzene (1 equiv, 0.80 mmol), argon-sparged DBU (1.44 mL, 12 equiv) and distilled water (5.8 μL , 40 mol%) were added to the reaction. The mixture was stirred at room temperature for another 18 h. In the third step $\text{PdCl}_2(\text{PPh}_3)_2$ (16.8 mg, 6 mol%), CuI (15.2 mg, 10 mol%), ice-chilled trimethylsilylethynylene (119 μL , 1.05 equiv) and distilled water (5.8 μL , 40 mol%) were added to the reaction. The tube was submerged in a 80 °C mineral oil bath, blocked from incidental light, and left stirring at a high rate of speed for 18 h, at the end of which the tube was removed from the oil bath and cooled to room temperature. The reaction mixture was partitioned in ethyl ether and distilled water (50 mL each). The organic layer was washed with 10% HCl (3X 75 mL), saturated aqueous NaCl (1X 75 mL), dried over MgSO_4 , gravity-filtered and the solvent removed in vacuo. The crude product is purified by silica gel column chromatography (hexanes) to afford 92.8 mg (0.21 mmol, 26%) of **29** as a white crystalline solid: TLC R_f = 0.13 (hexanes); mp 184 °C; ^1H NMR (300 MHz, CDCl_3) δ 7.77 (s, 2H), 7.52-7.29 (m, 14H); ^{13}C NMR (300 MHz, CDCl_3) δ 134.8, 134.4, 132.75, 131.8, 131.7, 130.6, 129.8, 128.9, 128.7, 124.9, 123.6, 123.3, 89.73, 89.27, 88.72; HRMS-EI (m/z): $[\text{M}]^+$ calcd for $\text{C}_{30}\text{H}_{16}\text{Cl}_2$ 446.0629, found 446.0626.

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