Catalytic Multicomponent Synthesis of Highly Substituted Pyrroles Utilizing a One-Pot Sila-Stetter/Paal-Knorr Strategy

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Supporting Information

General Information: All reactions were carried out under a nitrogen atmosphere in flame-dried glassware with magnetic stirring. THF, Et₂O, CH₂Cl₂, DMF and toluene were purified by passage through a bed of activated alumina.¹ Reagents were purified prior to use unless otherwise stated following the guidelines of Perrin and Armarego.² Purification of reaction products was carried out by flash chromatography using EM Reagent silica gel 60 (230-400 mesh). Analytical thin layer chromatography was performed on EM Reagent 0.25 mm silica gel 60-F plates. Visualization was accomplished with UV light and anisaldehyde, ceric ammonium nitrate stain, potassium permanganate, or phosphomolybdic acid followed by heating. Melting points were obtained on a Thomas Hoover capillary melting point apparatus and are uncorrected. Infrared spectra were recorded on a Bio-Rad Win FT-IR spectrometer. ¹H-NMR spectra were recorded on a Varian Inova 500 (500 MHz) or Mercury 400 (400 MHz) spectrometer and are reported in ppm using solvent as an internal standard (CDCl₃ at 7.26 ppm). Data are reported as (ap = apparent, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, b = broad); coupling constant(s) is/are reported in Hz. Proton-decoupled ¹³C-NMR spectra were recorded on a Varian Inova 500 (125 MHz) or Mercury 400 (100 MHz) spectrometer and are reported in ppm using solvent as an internal standard (CDCl₃ at 77.0 ppm). Laser desorption mass spectra were obtained with PE BioSystems time-of-flight MALDI mass spectrometer with 2,5-dihydroxybenzoic acid as matrix. Microwave reaction was done on a Biotage Emrys™ Creator.

Benzoyltrimethylsilane (**1a**), *p*-chlorobenzoyltrimethylsilane, and *p*-toluoyltrimethylsilane were prepared according to the procedure of Yamamoto and coworkers.³ Alkylacylsilanes were prepared using the procedure developed by Fleming and Ghosh.⁴ Chalcones were prepared according to the procedure of Murphy and Wattansin.⁵

1. Pangborn, A. B.; Giardello, M. A.; Grubbs, R. H.; Rosen, R. K.; Timmers, F. J. *Organometal.* **1996**, *15*, 1518-1520.

2. Perrin, D. D. and Armarego, W. L. *Purification of Laboratory Chemicals*; 3rd Ed., Pergamon Press, Oxford.1988.

3. Yamamoto, K.; Hayashi, A.; Suzuki S.; Tsuji, J. *Organometal.* **1987**, *6*, 974-979.

4. Fleming, I.; Ghosh U. *J. Chem. Soc., Perkin Trans. 1.* **1994**, 257-262.

5. Murphy, W.S.; Wattansin, S. *Synthesis* **1980**, 647-650.

General Procedure for Thiazolium Catalyzed Pyrrole Synthesis:

A screw-capped test tube was charged with the thiazolium salt (14 mg, 0.055 mmol, 0.20 equiv) in a nitrogen-filled drybox. The reaction vessel was removed from the box and placed under a positive pressure of nitrogen. Benzoyltrimethylsilane (100 mg, 0.55 mmol, 2.0 equiv) in THF (0.25 mL) was added by syringe to the test tube followed by the addition of DBU (13 μ L, 0.083 mmol, 0.30 equiv). The reaction mixture was heated to 70°C after which the chalcone (0.275 mmol, 1.0 equiv) in THF (0.25 mL) was added by syringe followed by the addition of 2-propanol (83 μ L, 1.10 mmol, 4.0 equiv). The reaction was allowed to stir at 70°C for 12 hours or until completion as determined by TLC (40% ether/hexanes). To the solution amine (0.825 mmol, 3.0 equiv) was added followed by addition of *p*-toluenesulfonic acid (104 mg, 0.55 mmol, 2.0 equiv) in ethanol (0.5 mL) and 4Å molecular sieves (spatula tip). The reaction mixture remained heating at 70°C for an additional 6 to 12 hours or until consumption of diketone as determined by TLC (25% ethyl acetate/ hexane). Upon cooling to room temperature, the reaction mixture was diluted with ethyl acetate (30 mL) and washed with water (10 mL). The aqueous layer was washed with ethyl acetate (3 X 30 mL) and the combined the organic extracts were washed with brine (10 mL) and dried over sodium sulfate, filtered, and concentrated *in vacuo*. The resulting residue was purified by flash column chromatography on silica gel.

1,2,5-triphenyl-3-*p*-tolyl-1-*H*-pyrrole (6): Purified with 2% ethyl acetate/hexanes, yielding 74 mg (70%) of **6** as a white solid. R_f = 0.83 (25/75 ethyl acetate/hexanes); mp: 156-160°C. ^1H NMR (500 MHz, CDCl_3) δ 7.22-7.01 (m, 19 H), 6.73 (s, 1H), 2.34 (s, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ 139.1, 135.3, 134.9, 133.4, 133.2, 133.1, 131.8, 129.4, 129.2, 128.8, 128.7, 128.3, 128.2, 128.1, 127.2, 126.6, 123.7, 110.3, 21.4; MALDI: Mass (m/e) calculated for $\text{C}_{29}\text{H}_{23}\text{N}$: 385.5. Found 385.4.

1,2,3,5-tetraphenyl-1-*H*-pyrrole (9): Purified with 1% ethyl acetate/hexanes, yielding 67 mg (66%) of **9** as a white solid. R_f = 0.88 (25% ethyl acetate/hexanes); mp: 200-201°C (lit, 200-202°C). ^1H NMR (500 MHz, CDCl_3) δ 7.26- 6.97 (m, 20H), 6.74 (s, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 139.0, 136.4, 133.2, 132.9, 132.4, 131.7, 129.4, 128.8, 128.7, 128.4, 128.2, 127.8, 127.4, 126.6, 125.7, 124.1, 123.7, 110.2; All other spectral information are similar to those reported by Stetter and coworkers.⁶

1,3,5-triphenyl-2-*p*-tolyl-1-*H*-pyrrole (10): Purified with 2% ethyl acetate/hexanes, yielding 75 mg (71%) of **10** as a clear oil. R_f = 0.82 (25% ethyl acetate/hexanes); ^1H NMR (500 MHz, CDCl_3) δ 7.22- 7.05 (m, 19 H), 6.89 (s, 1H), 2.36 (s, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ 139.5, 135.8, 135.0, 133.4, 133.0, 132.8, 132.2, 131.8, 130.0, 129.8, 129.5, 128.9, 128.7, 127.2, 126.1, 125.4, 122.7, 109.2, 20.3; MALDI: Mass (m/e) calculated for $\text{C}_{29}\text{H}_{23}\text{N}$: 385.5. Found 385.8.

6. Stetter, H.; Schmitz, P.; Schreckenber, M. *Chem. Ber.* **1977**, 110, 1971-1977.

2-(4-chlorophenyl)-1,3,5-triphenyl-1H-pyrrole (11): Purified with 2% ethyl acetate/hexanes, yielding 68 mg (61%) of **11** as a yellow solid. $R_f = 0.61$ (25% ethyl acetate/hexanes); ^1H NMR (500 MHz, CDCl_3) δ 7.19-7.02 (m, 14H), 6.91-6.86 (m, 5H), 6.61 (s, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 138.8, 136.1, 135.5, 133.1, 132.9, 132.8, 131.6, 131.4, 130.9, 129.3, 129.0, 128.8, 128.4, 127.6, 126.8, 125.9, 124.2, 110.4; All other spectral information are similar to those reported by Stetter and Schreckenberg.⁷

2-cyclohexyl-1,3,5-triphenyl-1H-pyrrole (12): Purified with 2% ethyl acetate/hexanes yielding 71 mg (69%) of **12** as a white solid. $R_f = 0.77$ (25% ethyl acetate/hexanes); mp: 162-163°C. IR (film); ^1H NMR (500 MHz, CDCl_3) δ 7.50-7.38 (m, 8H), 7.10-7.08 (m, 7H), 6.40 (s, 1H), 2.61 (t, $J = 12.1$, 1H), 1.73-0.90 (m, 10H); ^{13}C NMR (125 MHz) δ 140.0, 138.6, 137.3, 133.6, 130.2, 130.0, 128.3, 128.2, 126.1, 125.9, 123.2, 111.5, 37.8, 33.5, 27.4, 26.1; MALDI: Mass (m/e) calculated for $\text{C}_{28}\text{H}_{27}\text{N}$: 377.5. Found 377.2.

2-methyl-1,3,5-triphenyl-1H-pyrrole (13): Purified with 2% ethyl acetate/hexanes, yielding 42 mg (71%) of **13** as a white solid. $R_f = 0.58$ (25% ethyl acetate/hexanes); mp: 171-172°C (lit, 173-175°C). ^1H NMR (500 MHz, CDCl_3) δ 7.55-7.24 (m, 8H), 7.15-7.12 (m, 7H), 6.59 (s, 1H), 2.27 (s, 3H); ^{13}C NMR (125 MHz) δ 139.5, 137.1, 134.1, 133.4, 132.3, 129.2, 128.9, 128.6, 128.3, 128.2, 128.1, 127.8, 126.1, 125.7, 122.9, 109.5, 12.7; All spectral data are similar to those report by Stetter and Schreckenberg.⁷

1,2,5-triphenyl-3-m-1H-pyrrole (14): Purified with 2-3% ethyl acetate/hexanes yielding 65 mg (62%) of **14** as clear oil. $R_f = 0.81$ (25% ethyl acetate/hexanes); ^1H NMR (500 MHz, CDCl_3) δ 7.32-7.24 (m, 19H), 6.81(s, 1H), 2.45(s, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 137.8, 133.0, 133.7, 132.2, 131.9, 131.7, 130.9, 130.5, 129.1, 128.1, 127.9, 127.5, 127.4, 127.0, 126.9, 125.9, 125.3, 122.3, 109.0, 20.2; MALDI: Mass (m/e) calculated for $\text{C}_{29}\text{H}_{23}\text{N}$: 385.5. Found 385.7.

3-(4-chlorophenyl)-1,2,5-triphenyl-1H-pyrrole (15): Purified with 2-3% ethyl acetate/hexanes yielding 64 mg (58%) of **15** as an oil. $R_f = 0.63$ (25% ethyl acetate/hexanes); ^1H NMR (500 MHz, CDCl_3) δ 7.17- 7.11 (m, 15H), 7.03-6.98 (m, 4H), 6.68 (s, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 139.1, 136.2, 135.9, 131.6, 131.4, 129.8, 129.6, 129.6, 129.3, 128.8, 128.7, 128.5, 128.3, 127.5, 127.4, 126.7, 122.5, 109.9; MALDI: Mass (m/e) calculated for $\text{C}_{28}\text{H}_{20}\text{ClN}$: 405.9. Found 405.4.

2-(4-chlorophenyl)-3-(4-methoxyphenyl)-1,5-diphenyl-1 *H*-pyrrole (16):

Purified with 5% ethyl acetate/hexanes, yielding 58 mg (69%) of **16** as white solid. R_f = 0.55 (25% ethyl acetate/hexanes); mp: 189-192°C. ^1H NMR (500 MHz, CDCl_3) δ 7.21-7.10 (m, 14H), 7.09- 6.79 (m, 4H), 6.64 (s, 1H), 3.80 (s, 3H); ^{13}C NMR (125 MHz) δ 158.0, 138.9, 135.3, 133.0, 132.9, 131.5, 129.6, 129.3, 128.9, 128.8, 128.6, 128.4, 128.2, 127.5, 126.7, 123.9, 114.0, 110.4,

55.4; MALDI: Mass (m/e) calculated for $\text{C}_{29}\text{H}_{22}\text{ClNO}$: 435.9. Found 435.3.

5-(4-chlorophenyl)-1,2,3-triphenyl-1 *H*-pyrrole (17):

Purified with 2-3% ethyl acetate/hexanes, yielding 89 mg (80%) of **17** as a white solid. R_f = 0.68 (25% ethyl acetate/hexanes); mp: 198-201°C. ^1H NMR (500 MHz, CDCl_3) δ 7.29-7.00 (m, 19H), 6.74 (s, 1H); ^{13}C NMR (125 MHz) δ 138.8, 136.2, 133.8, 132.8, 132.7, 131.7, 131.6, 129.9, 129.3, 128.9, 128.5, 128.4, 128.2, 127.6, 127.4, 125.9, 123.9, 110.5; MALDI: Mass (m/e) calculated for $\text{C}_{28}\text{H}_{20}\text{ClN}$:

405.9. Found 405.0.

1-(4-Chlorophenyl)-2,3,5-triphenyl-1-*H*-pyrrole (18):

Purified with 2% ethyl acetate/hexanes, yielding 48 mg (57%) of **18** as a yellow oil. R_f = 0.61 (25% ethyl acetate/hexanes). ^1H NMR (500 MHz, CDCl_3) δ 7.24-6.91 (m, 19H), 6.71 (s, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 137.3, 134.6, 132.2, 131.3, 131.2, 130.9, 130.1, 128.4, 127.7, 127.4, 126.9, 126.8, 126.6, 126.0, 125.8, 124.3, 122.3, 108.9; MALDI: Mass (m/e) calculated for $\text{C}_{28}\text{H}_{20}\text{ClN}$: 405.9. Found 405.1.

1-(4-bromophenyl)-2,3,5-triphenyl-1-*H*-pyrrole (19):

Purified with 2% ethyl acetate/hexanes, yielding 62 mg (71%) of **19** as a white solid. R_f = 0.58 (25% ethyl acetate/hexanes); mp: 173-176°C. IR (film) 3056, 3030, 1601, 1489, 1373; ^1H NMR (400 MHz, CDCl_3) δ 7.22-6.94 (m, 17H), 6.75 (d, J = 8.5 Hz, 2H), 6.62 (s, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 138.1, 136.0, 134.9, 132.8, 132.5, 131.9, 131.7, 130.7, 128.9, 128.4, 128.3, 127.4, 126.8, 125.8, 121.1, 110.6; MALDI: Mass (m/e) calculated for $\text{C}_{28}\text{H}_{20}\text{BrN}$: 450.4. Found 450.9.

4-(2,3,5-triphenyl-1*H*-pyrrol-1-yl)-phenol (20):

Purified with 15% ethyl acetate/hexanes, yielding 65 mg (61%) of **20** as oil. R_f = 0.32 (25% ethyl acetate/hexanes); IR (film) 3394, 2962, 1598, 1513, 1261 cm^{-1} ; ^1H NMR (500 MHz, CDCl_3) δ 7.27- 7.14 (m, 15H), 6.86 (m, 2H), 6.70 (s, 1H), 6.63 (m, 2H), 4.71 (bs, 1H); ^{13}C NMR (125 MHz) δ 154.6, 136.4, 135.1, 133.2, 133.0, 132.6, 132.2, 131.8, 130.5, 128.8, 128.4, 128.2, 128.1, 127.2, 126.6, 125.7, 123.5, 115.5, 109.9; MALDI: Mass (m/e) calculated for $\text{C}_{28}\text{H}_{21}\text{NO}$: 387.4. Found 387.1.

2,3,5-triphenyl-1H-pyrrole (21): Purified with 10% ethyl acetate/hexanes, yielding 50 mg (62%) of **21** as a white solid. $R_f = 0.45$ (25% ethyl acetate/hexanes); mp 134-135°C (lit. 135-137°C). ^1H NMR (500 MHz, CDCl_3) δ 8.36 (s, 1H), 7.50 (m, 2H), 7.38-7.10 (m, 13H), 6.70 (s, 1H); ^{13}C NMR (125 MHz) δ 136.5, 132.9, 132.1, 129.1, 128.9, 128.6, 128.4, 128.2, 127.7, 126.9, 126.0, 125.8, 122.9, 108.2; All other spectral information are similar to those reported by Fürstner and coworkers.⁸

1-methyl-2,3,5-triphenyl-1H-pyrrole (22): Purified with 2% ethyl acetate/hexanes, yielding 59 mg (70%) of **22** as a white solid. $R_f = 0.73$ (25% ethyl acetate/hexanes); Mp: 181-183°C (lit.⁹ 178-179°C). ^1H NMR (500 MHz, CDCl_3) δ 7.53-7.19 (m, 15 H), 6.51 (s, 1H), 3.50 (s, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ 136.6, 135.9, 133.6, 131.3, 130.2, 129.1, 128.8, 128.3, 128.1, 127.8, 127.2, 125.4, 122.0, 109.0, 34.0; All spectral information are similar to those reported by Horspool and coworkers.¹⁰

2,3,5-triphenyl-1-propyl-1H-pyrrole (23): Purified with 1-3% ethyl acetate/hexanes, yielding 76 mg (82%) of **23** as a white solid. $R_f = 0.72$ (25% ethyl acetate/hexanes); mp: 123-124°C. ^1H NMR (500 MHz, CDCl_3) δ 7.56-7.37 (m, 9H), 7.23-7.11 (m, 6H), 6.51 (s, 1H), 3.93 (t, $J = 7.3$, 2H), 1.30-1.27 (m, 2H), 0.51 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (125 MHz, CDCl_3) δ 136.7, 135.4, 134.3, 133.8, 132.3, 131.5, 129.3, 128.8, 128.7, 128.3, 128.0, 127.8, 127.3, 125.3, 123.1, 109.7, 46.8, 24.4, 11.1; All additional spectral information are similar to those reported by Namy and Farcas.¹¹

1-benzyl-2,3,5-triphenyl-1H-pyrrole (24): Purified with 2% ethyl acetate/hexanes yielding 78 mg (65 %) of **24** white solid. $R_f = 0.57$ (25% ethyl acetate/hexanes); mp: 162-165°C (lit. 165-167°C). ^1H NMR (500 MHz, CDCl_3) δ 7.45-7.12 (m, 18H), 6.69-6.68 (m, 2H), 6.61 (s, 1H), 5.13 (s, 2H); ^{13}C NMR (125 MHz, CDCl_3) δ 139.4, 136.4, 135.8, 133.7, 133.4, 132.6, 131.6, 129.3, 128.7, 128.6, 128.5, 128.3, 127.9, 127.8, 127.4, 126.3, 125.4, 123.5, 109.7, 48.7; All additional spectral information are similar to those reported by Yoshida and coworkers.¹²

8. Fürstner, A.; Weintritt, H.; Hupperts, A. *J. Org. Chem.* **1995**, 60, 6637-6641.

9 Huisgen, R.; Gotthardt, H.; Bayer, O.; Schaefer, F. *Angew. Chem. Int. Ed.* **1964**, 3, 136.

10. Armesto, D.; Horspool, W.; Ortiz, M.; Romano, S. *J. Chem. Soc., Perkin Trans. 1* **1992**, 171-176.

11. Namy, J.; Farcas, S. *Tetrahedron* **2001**, 57, 4881-4888.

12. Yoshida, H.; Utsumi, F.; Suzuki, H.; Ito, S.; Sakashita, S.; Ogata, T.; Matsumoto, K. *Bull Chem. Soc. Jpn.* **1992**, 65, 698-702.

1-cyclohexyl-2,3,5-triphenyl-1H-pyrrole (25): Purified with 2% ether/hexanes, yielding 66 mg (64%) of **25** as a white solid. $R_f = 0.75$ (25% ethyl acetate/hexanes); mp: 165-167°C. ^1H NMR (500 MHz, CDCl_3) δ 7.51-7.39 (m, 9H), 7.13-7.03 (m, 6H), 6.39 (s, 1H), 3.94 (m, 1H), 1.86 (d, $J=11.2$ Hz, 2H), 1.61-0.72 (m, 8H); ^{13}C NMR (125 MHz) δ 136.7, 135.2, 134.8, 132.6, 131.7, 130.6, 128.4, 128.2, 128.1, 127.7, 127.5, 125.0, 123.0, 109.9, 58.9, 34.4, 26.7, 25.5; MALDI: Mass (m/e) calculated for $\text{C}_{28}\text{H}_{27}\text{N}$: 377.5. Found 377.1.

2,3,5-triphenyl-1-((S)-1-phenylethyl)-1H-pyrrole (26): Purified with 5% ether/hexanes, yielding 60 mg (55%) of **26** as yellow oil. $R_f = 0.71$ (25% ethyl acetate/hexanes); ^1H NMR (500 MHz, CDCl_3) δ 7.29-7.06 (m, 18H), 7.05-6.91 (m, 2H), 6.50 (s, 1H), 5.52 (q, $J = 5.9$ Hz, 1H), 1.58 (d, $J = 7.2$ Hz, 3H); ^{13}C NMR (125 MHz) δ 143.4, 136.5, 135.6, 134.5, 134.2, 132.5, 131.8, 130.5, 128.4, 128.3, 128.2, 127.9, 127.6, 127.5, 127.0, 126.5, 125.2, 123.2, 109.8, 54.0, 20.0; MALDI: Mass (m/e) calculated for $\text{C}_{30}\text{H}_{25}\text{N}$: 399.5. Found 399.2.

(R)-1-sec-butyl-2,3,5-triphenyl-1H-pyrrole (27): Purified with 2% ether/hexanes, yielding 54 mg (56%) of **27** as a yellow oil. $R_f = 0.70$ (25% ethyl acetate/hexanes); ^1H NMR (500 MHz, CDCl_3) δ 7.50-7.36 (m, 10H), 7.12-7.03 (m, 5H), 6.38 (s, 1H), 4.10 (m, 1H), 1.55 (m, 1H), 1.37-1.35 (m, 1H), 1.32 (d, $J = 7.1$ Hz, 3H), 0.62 (t, $J = 7.3$ Hz, 3H); ^{13}C NMR (125 MHz) δ 136.7, 135.3, 134.8, 132.5, 130.6, 128.5, 128.2, 128.1, 128.0, 127.7, 127.5, 125.0, 109.9, 55.6, 30.2, 22.8, 11.3; MALDI: Mass (m/e) calculated for $\text{C}_{26}\text{H}_{25}\text{N}$: 351.4 Found 351.4.

4-(2,3,5-triphenyl-1H-pyrrol-1-yl)benzeneamine (28): Purified with 20% ethyl acetate/hexanes to give 37 mg (70%) of **28** as an oil. $R_f = 0.41$ (25% ethyl acetate/hexanes); IR (film) 3468, 3378, 3054, 2916, 2848, 1621, 1600, 1515 cm^{-1} ; ^1H NMR (500 MHz, CDCl_3) δ 7.37-7.13 (m, 15H), 6.78 (m, 2H), 6.69 (s, 1H), 6.48 (m, 2H); ^{13}C NMR (125 MHz) δ 145.2, 136.6, 135.1, 133.3, 131.8, 130.1, 128.8, 128.6, 128.4, 128.3, 128.0, 127.0, 126.4, 125.6, 123.3, 116.6, 115.1, 109.7; MALDI: Mass (m/e) calculated for $\text{C}_{29}\text{H}_{22}\text{N}_2$: 386.5. Found 386.6.

Procedure for Microwave Reaction (compound 6):

A conical test tube was charged with the thiazolium salt (14 mg, 0.055 mmol, 0.20 equiv). To the conical tube, benzoyltrimethylsilane (100 mg, 0.55 mmol, 2.0 equiv) in THF (0.25 mL) was added by syringe to the test tube followed by the addition of DBU (13 μL , 0.083 mmol, 0.30 equiv). To reaction mixture chalcone (61 mg, 0.275 mmol, 1.0 equiv) in THF (0.25 mL) was added by syringe followed by the addition of 2-propanol (83 μL , 1.10 mmol, 4.0 equiv). The conical tube was capped with septa and crimped aluminum collar and heated for 15 minutes in the microwave at 160 °C. After this first heating cycle, the septa was removed and a solution of amine (77 mg, 0.825 mmol, 3.0 equiv) followed by *p*-toluenesulfonic acid (104 mg, 0.55 mmol, 2.0 equiv) in ethanol (0.5 mL) and 4Å molecular sieves (spatula tip) were added to the reaction mixture and heated in the microwave for an additional 15 minutes at 160 °C. Upon cooling to

room temperature, the reaction mixture was diluted with ethyl acetate (30 mL) and washed with water (10 mL). The aqueous layer was washed with ethyl acetate (3 X 30 mL) and the combined the organic extracts were washed with brine (10 mL) and dried over sodium sulfate, filtered, and concentrated *in vacuo*. The resulting residue was purified by flash column chromatography on silica gel (2% ethyl acetate/hexanes) to give 58 mg (55%) of **6** as a white solid.

Selected NMR (^1H and ^{13}C) Spectra: