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SUPPORTING INFORMATION

Title: Selective Palladium-Catalysed *ipso* Arylation of α,α-Disubstituted Benzo[*b*]thien-2-ylmethanols with Aryl Bromides using PCy_3 as Ligand

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Synthetic procedures and characterization data for known compounds

***α,α*-Diphenyl-thien-3-ylmethanol (4):**[1] In a flame dried Schlenk flask 0.028 mol (2.62 mL) 3-bromothiophene was dissolved in abs. Et_2O (15 mL) under argon and the solution was cooled to -78 ^oC. After the dropwise addition of 0.028 mol ^nBuLi (17.5 mL, 1.6 M solution in hexane) the mixture was left to stir at -78 ^oC for 10 min. followed by the addition of 0.028 mol (5.10 g) benzophenone dissolved in dry Et_2O (25 mL) and than it was allowed to warm to room temperature. After complete conversion (by TLC) the reaction mixture was quenched by saturated aqueous ammonium chloride, and extracted with DCM. The combined organic extracts were dried over $MgSO_4$, and the solvent was removed in vacuum. The residue was purified by recrystallization from cyclohexane to give white crystals. m = 4.98 g (66%).
m.p.: 147-148^{o}C (Lit. m.p.: 148-149 ^{o}C); ^{1}H NMR δ= 2.82 (s, 1H), 6.91-6.93 (dd, J_1 = 1.2 Hz, J_2 = 3.1 Hz, 1H), 7.01-7.99 (dd, J_1 = 1.2 Hz, J_2 = 5.0 Hz, 1H), 7.30-7.34 (m, 11H); ^{13}C NMR δ= 79.8, 123.5, 125.8, 127.2, 127.3, 127.8, 127.9, 146.5, 148.5; MS (EI, *m/z*) 182 (M^+, 20%), 164 (90%), 135 (100%).

***α,α*-Diphenyl-benzo[*b*]thien-2-ylmethanol (9):**[2] In a flame dried Schlenk flask 4.47 mmol (0.6 g) benzo[*b*]thiophen was dissolved in abs. THF (7 mL) under argon and the solution was cooled to -78 ^oC. After the dropwise addition of 4.47 mmol ^nBuLi (2.8 mL, 1.6 M solution in hexane) the mixture was left to stir at -78 ^oC for 10 min. followed by the addition of 4.47 mmol (0.819 g) benzophenone dissolved in dry THF (6 mL) and than it was allowed to warm to room temperature. After complete conversion (by TLC) the reaction mixture was quenched by saturated aqueous ammonium chloride, and extracted with DCM. The combined organic extracts were dried over $MgSO_4$, and the solvent was removed in vacuum. The residue was purified by column chromatography on silica gel using hexane–ethyl acetate mixtures (gradient from 100:0 to 80:20) as eluent to give a white solid. m = 2.28 g (97 %); m.p.: 70-72 ^{o}C; ^{1}H NMR δ= 2.98 (s, 1H), 6.81 (s, 1H), 7.16-7.3 (m, 12H), 7.51 (d, *J* = 8.5 Hz, 1H), 7.64 (d, *J* = 8.2 Hz, 1H); ^{13}C NMR δ= 80.4, 122.2, 123.5, 123.7, 124.2, 124.3, 127.3, 127.7, 128.0, 139.2, 140.1, 145.8, 152.6; MS (EI, *m/z*) 316 (M^+, 30%), 299 (25%), 239 (35%), 221 (20%), 161 (32%), 133 (20%), 105 (100%), 77 (75%).

***α,α*-Diphenyl-benzo[*b*]thien-3-ylmethanol (11):**[3] In a flame dried Schlenk flask 18.7 mmol (4.00 g) 3-bromo-benzo[*b*]thiophene[4] was dissolved in abs. Et_2O (70 mL) under argon and the solution was cooled to -78 ^oC. After the dropwise addition of 18.7 mmol ^nBuLi (7.48 mL, 2.5 M solution in hexane) the mixture was left to stir at -78 ^oC for 10 min. Following the addition of 18.7 mmol (3.40

g) benzophenone dissolved in dry Et_2O (30 mL) at -78 ^oC the mixture was allowed to warm to room temperature. The reaction mixture was quenched by saturated aqueous ammonium chloride, and extracted with DCM. The combined organic extracts were dried over $MgSO_4$, and the solvent was removed in vacuum. The residue was purified by column chromatography on silica gel using hexane–ethyl acetate mixtures (gradient from 100:0 to 80:20) as eluent to give a white solid. m = 4.67g (79 %); m.p.: 124-126 ^oC; (Lit. m.p.: 125-126 ^oC);[3] ^1H NMR δ= 3.08 (s, 1H), 6.79 (s, 1H), 7.15-7.22 (dtd, J_1 = 1.1 Hz, J_2 = 1.1 Hz, J_3 = 1.3 Hz, 1H), 7.29-7.38 (m, 11H), 7.57 (d, J = 8.0 Hz, 1H), 7.84 (d, J = 8.7 Hz, 1H); ^{13}C NMR δ= 80.0, 122.6, 123.7, 124.1, 125.3, 126.8, 127.1, 127.2, 127.9, 137.3, 141.0, 141.6, 145.4; MS (EI, *m/z*) 316 (M^+, 40%), 299 (10%), 239 (75%), 221 (40%), 161 (30%), 133 (30%), 105 (80%), 77 (100%).

2-Phenyl-benzo[*b*]thiophene (10a):[5] white solid, 31 mg (77%), m.p.:168-169 ^oC; (Lit. m.p.: 171.5-172 ^oC); ^1H NMR δ= 7.31-7.53 (m, 6H), 7.57-7.62 (m, 2H), 7.91-7.95 (m, 2H); ^{13}C NMR δ= 122.6, 124.4, 124.5, 127.2, 128.2, 128.6, 129.1, 130.0, 132.4, 137.5, 138.0, 196.7; IR ν_{max}: 3052, 2923, 1446, 858, 757, 724, 686 cm^{-1};MS (EI, *m/z*) 210 (M^+, 100%), 135 (15%).

2-(4-Chlorophenyl)-benzo[*b*]thiophene (10c):[6] white solid, 41 mg (97%), m.p.:190-191 ^oC; (Lit. m.p.: 191-191.5 ^oC); ^1H NMR δ= 7.30-7.45 (m, 4H), 7.55 (s, 1H), 7.64 (d, J = 8.6 Hz, 2H), 7.78 (d, J = 8.9 Hz, 1H) 7.83 (d, J = 8.9 Hz, 1H); ^{13}C NMR δ= 119.8, 122.3, 123.6, 124.6, 124.7, 127.6, 129.1, 132.8, 134.1, 139.5, 140.5, 142.8; IR ν_{max}: 3058, 1487, 1457, 1095, 818, 746, 728 cm^{-1}; MS (EI, *m/z*) 244 (M^+, 100%), 208 (25%), 165 (30%), 134 (5%).

2-(*o*-Tolyl)-benzo[*b*]thiophene (10d):[7] white solid, 32 mg (76%), m.p.: 69-70 ^oC; ^1H NMR δ= 2.47 (s, 3H), 7.23-7.38 (m, 6H), 7.48 (d, J = 5.6 Hz, 1H), 7.78 (d, J = 6.9 Hz, 1H), 7.84 (d, J = 7.3 Hz, 1H); ^{13}C NMR δ= 21.5, 122.4, 123.4, 123.9, 124.5, 124.7, 126.3, 128.7, 131.0, 131.2, 134.6, 136.8, 140.5, 140.6, 143.9; MS (EI, *m/z*) 224 (M^+, 100%), 208 (10%), 134 (3%), 77 (2), 63 (4%), 51 (6%).

2-(*m*-Tolyl)-benzo[*b*]thiophene (10e):[1] white solid, 40 mg (95%), m.p.: 77-78 ^oC; ^1H NMR δ= 2.45 (s, 3H), 7.18 (d, J = 7.5 Hz, 1H), 7.35 (m, 3H), 7.54 (s, 1H), 7.56 (s, 2H), 7.79 (d, J = 6.3 Hz, 1H), 7.84 (d, J = 6.9 Hz, 1H); ^{13}C NMR δ= 21.4, 119.3, 122.2, 123.5, 123.6, 124.2, 124.4, 127.2, 128.8, 129.0, 134.2, 138.6, 139.4, 140.7, 144.4; IR ν_{max}: 3051, 1525, 831, 783, 746, 725 cm^{-1}; MS (EI, *m/z*) 224 (M^+, 100%), 208 (20%), 134 (5%), 63 (8%), 51 (4%).

2-(*p*-Tolyl)-benzo[*b*]thiophene (10f):[7] light yellow solid, 33 mg (78%), m.p.: 162-163 ^{o}C; (Lit. m.p.: 163 ^{o}C); ^{1}H NMR δ= 2.38 (s, 3H), 7.20 (d, *J* = 8.0 Hz, 2H), 7.28-7.34 (m, 2H), 7.49 (s, 1H), 7.60 (d, *J* = 8.0 Hz, 2H), 7.75 (d, *J* = 8.8 Hz, 1H), 7.81 (d, *J* = 9.2 Hz, 1H); ^{13}C NMR δ= 21.2, 118.8, 122.2, 123.4, 124.1, 124.4, 126.4, 129.6, 131.5, 138.3, 139.3, 140.8, 144.4; IR ν_{max}: 3053, 2911, 1499, 1455, 809, 740, 725 cm^{-1}; MS (EI, *m/z*) 224 (M^{+}, 100%), 208 (10%), 134 (2%), 134 (8%), 63 (6%), 51 (2%).

2-Anisyl-benzo[*b*]thiophene (10g):[8] white solid, 35 mg (67%), m.p.: 198.5-199.5 ^{o}C; (Lit. m.p.: 200-202 ^{o}C); ^{1}H NMR δ= 3.86 (s, 3H), 6.96 (d, *J* = 8.6Hz, 2H), 7.26-7.34 (m, 2H), 7.43 (s, 1H), 7.65 (d, *J* = 9.1 Hz, 2H), 7.74 (d, *J* = 7.9 Hz, 1H), 7.81 (d, *J* = 8.2 Hz, 1H); ^{13}C NMR δ= 55.8, 114.8, 118.6, 122.6, 123.7, 124.3, 124.9, 127.5, 128.2, 139.6, 141.3, 144.6, 160.2; IR ν_{max}: 3058, 2931, 1604, 1495, 1246, 1018, 821, 735, 698 cm^{-1}; MS (EI, *m/z*) 240 (M^{+}, 100%), 225 (70%), 208 (5%), 63 (10%).

2-(1'-Naphthyl)-benzo[*b*]thiophene (10j):[9] white solid, 34 mg (69%), m.p.: 102-103^{o}C; (Lit. m.p.: 105 ^{o}C); ^{1}H NMR δ= 7.29-7.61 (m, 7H), 7.69-7.95 (m, 4H), 8.23-8.33 (m, 1H); ^{13}C NMR δ= 127.3, 122.1, 123.6, 124.0, 124.2, 124.5, 125.2, 125.7, 126.1, 126.6, 126.7, 127.1, 128.4, 128.9, 129.9, 132.4, 133.8, 142.1; IR ν_{max}: 3052, 1505, 806, 792, 777, 752 cm^{-1}; MS (EI, *m/z*) 260 (M^{+}, 100%), 207 (10%), 134 (5%), 63 (2%), 51 (4%).

2-(2'-Naphthyl)-benzo[*b*]thiophene (10k):[9] white solid, 36 mg (73 %), m.p.: 196-197 ^{o}C; ^{1}H NMR δ= 7.38-7.42 (m, 2H), 7.51-7.57 (m, 2H), 7.89-8.03 (m, 7H), 8.30 (s, 1H); We were unable to record a reasonable ^{13}C NMR spectra due to the limited solubility of **10k** in $CDCl_3$ or dmso-d_6; IR ν_{max}: 2963, 1261, 832, 802, 747, 723 cm^{-1}; MS (EI, *m/z*) 260 (M+, 100%), 208 (5%), 134 (8%), 63 (2%), 51 (6%).

2-(2'-Thienyl)-benzo[*b*]thiophene (10m):[10] white solid, 38 mg (95%), m.p.: 155-156 ^{o}C (Lit. m.p.: 156 ^{o}C); ^{1}H NMR δ= 6.96 (t, *J* = 5.1 Hz, 1H), 7.13-7.31 (m, 5H), 7.63 (d, *J* = 6.9 Hz, 1H), 7.69 (d, *J* = 6.9 Hz, 1H); ^{13}C NMR δ= 119.7, 122.1, 123.4, 124.5, 124.8, 125.0, 125.4, 127.9, 137.2, 137.4, 139.0, 140,3; IR ν_{max}: 3050, 1416, 816, 724, 693 cm^{-1}; MS (EI, *m/z*) 216 (M^{+}, 100%), 184 (15%), 171 (25%), 158 (10%), 77 (2), 63 (4%), 51 (3%).

3-(1'-Naphthyl)-benzo[*b*]thiophene (12j):[11] white solid, 22 mg (44%), m.p.: 89-91 ^{o}C (Lit. m.p.: 90-92 ^{o}C); ^{1}H NMR δ= 7.25 (dd, J_1 = 8.2 Hz, J_2 = 6.7 Hz, 1H), 7.32-7.35 (m, 3H), 7.46 (s, 1H), 7.49-7.59 (m, 3H), 7.70 (d, *J* = 8.5 Hz, 1H), 7.92 (t, *J* = 8.0 Hz, 3H); ^{13}C NMR δ= 122.7, 123. 5,

124.2, 124.4, 125.0, 125.4, 125.9, 126.1, 126.2, 127.8, 128.2, 128.3, 132.4, 133.6, 133.7, 136.3, 139.5, 139.9; IR ν_{max}: 3049, 1500, 803, 793, 763; MS (EI, *m/z*) 260 (M^+, 100%), 213 (20%), 129 (50%).

3-(2'-Naphthyl)-benzo[*b*]thiophene (12k):[12] white solid, 27 mg (55%), m.p.: 53-54 ^oC ^1H NMR δ= 7.15-7.37 (m, 8H), 7.40-7.47 (m, 1H), 7.62-7.65 (m, 1H), 7.83-8.89 (m, 2H); ^{13}C NMR δ= 123.0, 123.8, 124.4, 124.5 126.0, 126.3, 126.4, 127.0, 127.4, 127.7, 128.1, 128.2, 128.3, 132.7, 133.4, 133.5, 138.0, 140.7; IR ν_{max}: 3015, 1492, 853, 812, 754; MS (EI, *m/z*) 260 (M^+, 100%), 207 (35%), 129 (25%).

3-(2'-Thienyl)-benzo[*b*]thiophene (12m):[9] white solid, 15 mg (37%), m.p.: 152.5-153.5 ^oC; ^1H NMR δ= 7.18 (dd, J_1 = 3.8 Hz, J_2 = 5.0 Hz, 1H), 7.35-7.47 (m, 4H), 7.52 (s, 1H), 7.91 (d, J = 7.0 Hz, 1H), 8.14 (d, J = 7.0 Hz, 1H); ^{13}C NMR δ= 123.3, 123.9, 124.3, 124.4, 125.0, 125.2, 125.6, 128,0. 131.0, 133.3, 137.7, 140.9; MS (EI, *m/z*) 216 (M^+, 100%), 184 (15%), 171 (30%), 158 (10%), 101 (5%).

References

[1] A. Belen, A. Gregorio, B. Rafael, V. Teresa, *J. Org. Chem.* **1991**, 56(10), 3224-3229.
[2] C. Avendao, C. de Diego, J. Elguero, *Magn. Reson. Chem.* **1990**, *28*, 1011-1017.
[3] S. Anizar Bistrizycki, *Helv. Chim. Acta* **1931**, 28(12), 141-153.
[4] H. Arnault; *Synthesis* **2002,** 213-216.
[5] D. L. Klayman, R. J. Shine, J. D. Bower, *J. Org. Chem.* **1972**, *37*, 1537-1541.
[6] M. V. Patel, J. J. Rohde, V. Gracias, T. Kolasa, *Tetrahedron Letters* **2003**, *44*, 6665-6667.
[7] Y. Uozumi, Y. Nakai, *Org. Lett.* **2002**, *4*, 2997-3000.
[8] J. E. Banfield, W. Davies, N. W. Gamble, S. Middleton, *J.Chem.Soc*. **1956**, 4791-4798.
[9] A. Ohta, Y. Akita, T. Ohkuwa, M. Chiba, R. Fukunaga, *Heterocycles E.N.* **1990**, *31*, 1951-1958.
[10] B. D. Tilak, *Tetrahedron*, **1960**, *9*, 76-95.
[11] D. Robert, L. C. Schuetz, *J. Org. Chem.* **1958**, *23*, 206-208.
[12] H. Blatt, J.J. Brophy, L.J. Colman, W.J. Tairych, *J. Sci. Ind. Res. Sect. B.* **1960**, *19*, 395-398.