Supporting Information for

**“New Versatile Route to the Synthesis of Tetrahydro- β -Carbolines
and Tetrahydro-pyrano[3,4-*b*]indoles via an Intramolecular Michael
Addition Catalyzed by InBr₃.”**

Marianna Agnusdei, Marco Bandini,* Alfonso Melloni, Achille Umani-Ronchi*

Dipartimento di Chimica “G. Ciamician”, via Selmi 2, 40126 - Bologna, Italy

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Synthesis of allyl ether **8**

In a flamed two-necked flask were added, under a nitrogen atmosphere, 15 mL of anhydrous THF and NaH (69 mg, 3.0 mmol). This suspension was cooled to 0°C and 322 mg (2.0 mmol) of indolyl alcohol **7** were carefully added at once. After 2 h stirring at 0°C, 345 μ L of allylbromide (4.0 mmol) were introduced by syringe and the temperature was allowed to warm at room temperature by removing the cooling bath. The reaction course was monitored by TLC and after 20 h 10 mL of a saturated NaHCO₃ were added to the solution at 0°C to quench the reaction. After evaporation of THF and usual work-up (Et₂O, brine, Na₂SO₄) the crude mixture was purified by flash chromatography to give **8** as a yellow viscous oil in 56% yield.

2-Allyloxymethyl-1-methyl-1H-indole (8): M.W. = 201.26; R_f 0.35

(cyclohexane/Et₂O 70:30); ¹H NMR (200 MHz, CDCl₃) δ 7.56-7.65 (d, J = 16.0 Hz, 1 H); 7.25-7.40 (m, 1 H); 7.01-7.21 (m, 2 H); 6.49 (s, 1 H); 5.85-

6.05 (m, 1 H); 5.22-5.41 (m, 2 H); 4.71 (s, 2 H); 4.02 (dt, J₁ = 1.8 Hz, J₂ =

5.6 Hz, 2 H); 3.81 (s, 3 H); ¹³C NMR (50 MHz, CDCl₃) δ 138.0; 135.6; 134.4; 127.1; 121.7; 120.6; 119.3; 117.3; 109.0; 102.8; 70.2; 63.9; 29.8; IR (neat) 3050; 2949; 2853; 1738, 1649; 1546; 1462; 1064; 738 cm⁻¹; Anal. calcd for (C₁₃H₁₅NO): C, 77.58; H, 7.51; N, 6.96; Found: C, 77.52; H, 7.45; N, 6.96.

Dihydroxylation of **8**

A two-necked flask was charged with 20 mL of *t*BuOH/H₂O (1:1), K₂OsO₂(OH)₄ (36 mg, 0.1 mmol), DABCO (11 mg, 0.1 mmol), K₂CO₃ (828 mg, 6.0 mmol) and K₃Fe(CN)₆ (1.98 g, 6.0 mmol). The mixture was then cooled to 0°C and **8** (402 mg, 2.0 mmol) was added at once. With a vigorous stirring at 0°C the mixture color turned from orange to brown (2 h) when the reaction was quenched by adding 1.5 g of Na₂SO₃. AcOEt (20 mL) was added, the two phases were separated and the aqueous layer was extracted with AcOEt (3 x 15 mL). The organic phases were collected, dried over Na₂SO₄ and evaporated under reduced pressure. The crude **9** was utilized in the next step without further purification.

3-(1-Methyl-1H-indol-2-ylmethoxy)-propane-1,2-diol (9): white

solid. mp = 130-132 °C; Yield: 71%; M.W. = 235.28; R_f 0.25 (cyclohexane/AcOEt 2:8); ¹H NMR (200 MHz, CDCl₃) δ 7.59 (d, J =

8.2 Hz, 1 H); 7.25-7.35 (m, 2 H); 7.07-7.15 (m, 1 H); 6.49 (s, 1 H);

4.72 (s, 2 H); 3.77-3.89 (m, 1 H); 3.78 (s, 3 H); 3.60-3.68 (m, 2 H); 3.51-3.56 (m, 2 H); 2.46 (br, 1 H); 1.96 (br, 1 H); ¹³C NMR (50 MHz, CDCl₃) δ 137.9; 135.1; 126.9; 121.8; 120.6; 119.3; 109.0;

102.9; 70.8; 70.6; 65.2; 63.7; 15.1; IR (nujol) 3053; 2951; 2850; 1660; 1551; 1465 1064; 728 cm^{-1} ; Anal. calcd for ($\text{C}_{13}\text{H}_{17}\text{NO}_3$): C, 66.36; H, 7.28; N, 5.95; Found: C, 66.31; H, 7.23; N, 5.94.

One-pot oxidative cleavage and Wittig reaction of **9**¹

In a flamed two-necked flask were added 6 mL of dry CH_2Cl_2 and 180 mg (0.75 mmol) of diol **9**. Then NaIO_4 on silica (2.1 g, 20% by weight) were added followed by ylide **10a** (1.86 mmol). The slurry was stirred for 20 h at rt then the solid was filtered off and washed with CH_2Cl_2 . After evaporation of the solvent, the crude was purified by flash chromatography.

4-(1-Methyl-1H-indol-2-ylmethoxy)-1-phenylbut-2-en-1-one (**4**):

Orange oil. Yield: 41%; M.W. = 305.37; *E/Z* > 98%; R_f 0.28 (cyclohexane/ Et_2O 80:20); ^1H NMR (200 MHz, CDCl_3) δ : 7.93 (dd, $J_1 = 1.6$ Hz, $J_2 = 7.0$ Hz, 2H); 7.46-7.63 (m, 4 H); 7.25-7.32 (m, 3

H); 7.07-7.15 (m, 2 H); 6.52 (s, 1 H); 4.78 (s, 2 H); 4.26 (dd, $J_1 = 1.6$ Hz, $J_2 = 3.2$ Hz, 2 H); 3.82 (s, 3H); ^{13}C NMR (50 MHz, CDCl_3) δ : 190.1; 144.0; 139.1; 137.5; 135.0; 132.8; 128.5; 127.0; 124.9; 122.0; 120.7; 119.5; 109.2; 103.3; 68.2; 64.8; 32.0; 30.0; IR (neat) 3058; 2919; 2853; 1719; 1686; 1613; 1533; 1469; 1394; 1334; 1068; 991; 736 cm^{-1} ; Anal. calcd for ($\text{C}_{20}\text{H}_{19}\text{NO}_2$): C, 78.66; H, 6.27; N, 4.59; Found: C, 78.61; H, 6.22; N, 4.58.

Synthesis of **14b**

In a flamed two-necked flask connected with the N_2 line and equipped with a condenser, were added 50 mL of dry toluene, 500 mg (3.5 mmol) of aldehyde **12**, 2.0 g (17.5 mmol) of MgSO_4 and 260 μL (3.5 mmol) of allylamine. The reaction was refluxed for 24 h then, after elimination of MgSO_4 by filtration on pad of celite, the solvent was evaporated under reduced pressure and the crude imine **13** was isolated as a brown viscous oil. M.W. = 184.24; R_f 0.31 (*c*-Hex/ AcOEt 70:30); ^1H NMR (200 MHz, CDCl_3) δ 9.22 (br, 1 H); 8.27 (t, $J = 1.2$ Hz, 1 H); 7.65 (d, $J = 7.4$ Hz, 1 H); 7.39-7.06 (m, 1 H); 6.79 (s, 1 H); 6.21-5.96 (m, 1 H); 5.31-5.08 (m, 2 H); 4.27-4.23 (m, 2 H); IR (neat) 2923; 2853; 1713; 1633; 1447; 1221; 1001 cm^{-1} . In a one-necked flask were added CH_3OH (20mL) and 650 mg of crude **13** (3.5 mmol, based on a 100% yield of the previous reaction). After cooling to 0°C , 195 mg of NaBH_4 (5.3 mmol) were slowly added and the ice bath was removed. After 18 h stirring at rt, the starting material disappeared (checked by TLC), the excess of reductant was quenched with water (15 mL) the methanol was evaporated under vacuum and the aqueous phase was extracted with AcOEt (3 x 10 mL). The collected organic phases were dried with Na_2SO_4 and by removing the solvent by reduced pressure the crude desired crude allylamine (**14a**) was obtained as a solid. M.W. = 186.25; R_f 0.30 (*c*-Hex/ AcOEt 70:30); ^1H NMR (200 MHz, CDCl_3) δ

8.66 (br, 1 H); 7.57 (d, $J = 7.4$ Hz, 1 H); 7.44 (d, $J = 7.4$ Hz, 1 H); 7.39-7.06 (m, 2 H); 6.37 (s, 1 H); 5.88-6.01 (m, 1 H); 5.15-5.28 (m, 2 H); 4.00 (s, 2 H); 3.31 (d, $J = 5.8$ Hz, 2 H); ^{13}C NMR (50 MHz, CDCl_3) δ 137.2; 136.0; 128.3; 121.4; 120.0; 119.8; 119.5; 116.4; 110.7; 110.4; 51.6; 46.1. IR (neat) 3277, 2923, 2853, 1447, 1221, 1001 cm^{-1} . In a flamed two-necked 250 mL flask connected with the N_2 line were added 100 mL of anhydrous CH_2Cl_2 and the unpurified allylamine **14a** (3.5 mmol, based on a 100% yield of the previous reaction). To the suspension were added under nitrogen Et_3N (1.02 mL, 7.7 mmol), 85 mg of DMAP (20 mol%) and $(\text{Boc})_2\text{O}$ (1.33 g, 17.5 mmol). After 24 h stirring at rt, the reaction was quenched with H_2O (20 mL), the two layer separated and the aqueous phase extracted with CH_2Cl_2 (2 x 25 mL). The collected organic phases were dried (Na_2SO_4), evaporated under reduced pressure and the crude was purified by flash chromatography (*c*-Hex-Et₂O 90:10) to leave **14b** as a yellow solid in 65% overall yield (referred to **12**).

M.W. = 386.48; mp = 95-98 °C; R_f 0.32 (*c*-Hex/Et₂O 90:10); ^1H NMR (300 MHz, CDCl_3) δ 8.01 (d, $J = 7.8$ Hz, 1 H); 7.47 (d, $J = 6.9$ Hz, 1 H); 7.22 (m, 2 H); 6.36 (s, 1 H); 5.85-5.78 (m, 1 H); 5.10-5.16 (m, 2 H); 4.78 (br, 2 H); 3.99 (br, 2 H); 1.68 (s, 9 H); 1.47 (s, 9 H); ^{13}C NMR (75 MHz, CDCl_3) δ 155.5; 150.4; 133.7; 129.1; 123.5; 122.7; 120.0; 116.7; 116.2; 115.4; 106.5; 84.2; 79.9; 50.0; 49.2; 28.2; IR (neat) 3164; 2922; 1732; 1679; 1458; 1377; 1327; 1134; 1109; 1069 cm^{-1} ; Anal. calcd for $(\text{C}_{22}\text{H}_{30}\text{N}_2\text{O}_4)$: C, 68.37; H, 7.82; N, 7.25; Found: C, 68.35; H, 7.77; N, 7.24.

Synthesis of 17

The diBoc-allyl-amine **14b** (2 mmol) was transformed to the corresponding diol **15** with the procedure already described for **9** (reaction condition: rt/4 h). Yellow oil. M.W. = 420.50; R_f 0.25 (cyclohexane/Et₂O 40:60); ^1H NMR (200 MHz, CDCl_3) δ 8.62 (d, $J = 8.8$ Hz, 1 H); 7.45-7.52 (m, 1 H); 7.23-7.30 (m, 2 H); 6.36 (s, 1 H); 4.34-4.88 (m, 2 H); 3.83 (br, 1 H); 3.59-3.62 (m, 2 H); 3.48-3.51 (m, 2 H); 1.71 (s, 9 H); 1.46 (s, 9 H); ^{13}C NMR (50 MHz, CDCl_3) δ (diagnostic signals) 155.6; 150.4; 138.0; 129.0; 124.6; 123.8; 122.8; 120.1; 116.6; 106.5; 83.9; 81.1; 71.0; 63.6; 48.5; 28.2. The crude **15** was then dissolved in dry CH_2Cl_2 (50 mL) and NaIO_4 on silica (4.0 mmol, 20% by weight) was added at once. The suspension was stirred for 18 h at rt and the solid was removed by filtration. After evaporation of the solvent, the indolyl-aldehyde **16** was isolated in 60% yield (referred to **14**) as a yellow oil by flash chromatography (*c*-Hex/AcOEt 70:30).

M.W. = 388.46; ^1H NMR (200 MHz, CDCl_3) δ 9.62 (d, J = 2.4 Hz, 1 H); 8.06 (d, J = 8.6 Hz, 1 H); 7.49 (d, J = 6.6 Hz, 1 H); 7.25-7.31 (m, 2 H); 6.45 (d, J = 7.6 Hz, 1 H); 4.90 (d, J = 9.8 Hz, 2 H); 4.08 (d, J = 9.0 Hz, 2 H); 1.69 (s, 9 H); 1.47 (d, J = 2.2 Hz, 9 H); ^{13}C NMR (50 MHz, CDCl_3) δ 198.2; 155.8; 154.8; 137.4; 136.7; 128.7; 123.8; 122.7; 120.1; 115.4; 107.5; 84.4; 81.1; 48.0; 47.8; 28.2; IR (neat) 3447; 2976; 2931; 1734; 1700; 1454; 1390; 1369; 1328; 1305; 1249; 1214; 1163; 1118; 1084; 769; 748 cm^{-1} ; Anal. calcd for $(\text{C}_{21}\text{H}_{28}\text{N}_2\text{O}_5)$: C, 64.93; H, 7.27; N, 7.21; Found: C, 64.95; H, 7.22; N, 7.20.

Synthesis of indolyl-ketones **17a,b**

A two necked-flask equipped with a condenser and connected to the N_2 line, was charged with 10 mL of anhydrous toluene, 50 mg (0.13 mmol) of **16** and 0.26 mmol of the preformed desired ylide **10a,b**.² The mixture was refluxed for 20 h then the solvent was removed under vacuum and the indolyl-ketone **17a,b** was isolated by flash chromatography.

17a: viscous oil. Yield: 90%; M.W. = 490.59; E/Z > 98%; R_f 0.28 (cyclohexane/AcOEt 60:40); ^1H NMR (300 MHz, CDCl_3) δ 8.04 (d, J = 8.7 Hz, 1 H); 7.86 (d, J = 7.2 Hz, 2 H); 7.53-7.55 (m, 1 H); 7.41-7.48 (m, 3 H); 7.21-7.26 (m, 2 H); 6.86-6.96 (m, 2 H); 6.43 (s, 1 H); 4.92-4.83 (m, 2 H); 4.22 (d, J = 10.8 Hz, 2 H); 1.68 (d, J = 8.1 Hz, 9 H);

1.46 (d, J = 6.0 Hz, 9 H); ^{13}C NMR (75 MHz, CDCl_3) δ 190.2; 156.2; 155.9; 151.3; 144.5; 138.0; 134.4; 129.4; 129.0; 125.7; 125.4; 124.4; 124.2; 123.3; 120.6; 116.0; 140.2; 85.2; 81.0; 50.1; 46.8; 28.6; IR (neat) 2979; 2924; 2853; 1734; 1700; 1447; 1328; 1255; 1164; 1083; 1070; 721 cm^{-1} ; Anal. calcd for $(\text{C}_{29}\text{H}_{34}\text{N}_2\text{O}_5)$: C, 71.00; H, 6.99; N, 5.71; Found: C, 70.96; H, 6.93; N, 5.70.

17b: yellow viscous oil. Yield: 96%; M.W. = 524.21; E/Z > 98%; R_f 0.28 (cyclohexane/AcOEt 80:20); ^1H NMR (200 MHz, CDCl_3) δ 8.02 (d, J = 6.6 Hz, 1 H); 7.72 (d, J = 8.4 Hz, 2 H); 7.47-7.58 (m, 1 H); 7.42 (m, J = 8.4 Hz, 2 H); 7.23-7.27 (m, 2 H); 6.94-7.05 (m, 1 H); 6.78-7.86 (m, 1 H);

6.44 (s, 1 H); 4.87 (d, J = 9.2 Hz, 2 H); 4.23 (br, 2 H); 1.67 (s, 9 H); 1.48 (s, 9 H); ^{13}C NMR (50 MHz, CDCl_3) δ 189.0; 155.4; 150.3; 144.4; 137.5; 136.6; 135.8; 129.8; 128.8; 125.7; 124.6; 123.8; 122.8; 120.2; 115.5; 107.5; 107.0; 84.5; 80.7; 49.0; 48.3; 28.4; IR (neat) 2975; 2929; 2840; 1733; 1700; 1624; 1588; 1453; 1393; 1367; 1327; 1287; 1250; 1213; 1162; 1118; 1084; 998 cm^{-1} ; Anal. calcd for $(\text{C}_{29}\text{H}_{33}\text{ClN}_2\text{O}_5)$: C, 66.34; H, 6.34; N, 5.34; Found: C, 66.30; H, 6.29; N, 5.33.

Catalytic cyclization in aqueous media catalyzed by InBr₃

In a 50 mL flask were added 12 mL of H₂O/THF mixture (1:1), 0.2 mmol of **17a** and InBr₃ (10 mol%). The reaction mixture was allowed to stir at rt for 12 h then THF was evaporated under reduced pressure. The aqueous phase was extracted with AcOEt (3 x 5 mL), dried over Na₂SO₄ and concentrated. Purification by flash chromatography furnished **18a** in 70% yield as a pale yellow oil.

M.W. = 490.25; R_f 0.30 (*c*-Hex/AcOEt 90:10); ¹H NMR (300 MHz, CDCl₃) δ 8.13 (dd, J₁ = 7.2 Hz, J₂ = 19.8 Hz, 2 H); 7.97 (d, J = 6.9 Hz, 1 H); 7.60-7.46 (m, 3 H); 7.35-7.26 (m, 4 H); 5.49 (s, 2 H); 5.14 (s, 2 H); 4.65 (d, J = 6.3 Hz, 2 H); 3.76 (d, J = 7.2 Hz, 2 H); 1.76 (s, 9 H);

1.50 (s, 9 H); ¹³C NMR (75 MHz, CDCl₃) δ 198.5; 156.9; 154.8; 137.8; 136.9; 133.1; 131.6; 130.9; 129.0; 128.7; 128.4; 126.0; 124.2; 121.8; 116.6; 115.7; 86.2; 58.9; 46.8; 44.6; 39.2; 28.7; 25.7; IR (neat) 2966; 2906; 2840; 1731; 1447; 1328; 1259; 1161; 1116; 1083, 1023; 800; 789 cm⁻¹; Anal. calcd for (C₂₉H₃₄N₂O₅): C, 71.00; H, 6.99; N, 5.71; Found: C, 71.02; H, 6.94; N, 5.70.

Catalytic cyclization of 18b catalyzed by InBr₃

The reaction was carried out following the procedure described for enone **4**.

18b: yellow oil. Yield: 85%; M.W. = 525.04; R_f 0.30 (*c*-Hex/AcOEt 80:20); ¹H NMR (200 MHz, CDCl₃) 8.18 (d, J = 8.2 Hz, 1 H); 7.89 (d, J = 6.0 Hz, 1 H); 7.39-7.43 (d, J = 7.8 Hz, 2 H); 7.16-7.29 (m, 3 H); 5.28-5.32 (m, 2 H); 4.37-4.22 (m, 2 H); 3.75-3.70 (m, 2 H); 3.28-3.21 (m, 2 H); 1.68 (s, 9 H); 1.43 (s, 9 H); ¹³C NMR (50 MHz, CDCl₃) δ

197.8; 161.2; 156.9; 138.2; 136.9; 135.4; 132.2; 130.0; 129.3; 128.9; 127.5; 124.2; 122.9; 117.6; 115.7; 85.4; 58.9; 46.8; 44.7; 39.2; 29.7; 28.3; 26.9; IR (neat) 2972; 2924; 2872; 1732; 1690; 1593; 1454; 1401; 1367; 1260, 1142; 1114; 1009; 791 cm⁻¹; Anal. calcd for (C₂₉H₃₃ClN₂O₅): C, 66.34; H, 6.34; N, 4.90; Found: C, 66.28; H, 6.48; N, 4.89.

¹ Dunlap, N. K.; Mergo, W.; Jones, J. M.; Carrick, J. D. *Tetrahedron Lett.* **2002**, 43, 3923.

² J. Font; P. De March, *Tetrahedron* **1981**, 37, 2391.