Supporting Information

for

Application of 7-azaisatins in enantioselective
Morita–Baylis–Hillman reaction

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1. General methods

NMR data were obtained for $^1$H at 400 MHz and for $^{13}$C at 100 MHz or 150 MHz. Chemical shifts were given in parts per million (δ) from tetramethylsilane with the residual solvent resonance as the internal standard in CDCl$_3$ solution. In all cases, the enantiomeric ratio was determined by HPLC analysis on a chiral column, using a Daicel Chiralpak IC Column (250 x 4.6 mm), Chiralpak ID Column (250 x 4.6 mm), Chiralpak IE Column (250 x 4.6 mm), Chiralpak AD Column (250 x 4.6 mm) or Chiralpak AS Column (250 x 4.6 mm). UV detection was monitored at 254 nm. Optical rotation data were examined in CHCl$_3$ solution at 20 °C. Column chromatography was performed on silica gel (200–300 mesh) eluting with ethyl acetate and petroleum ether. TLC was performed on glass-backed silica plates. UV light and I$_2$ were used to visualize the products. All commercially available chemicals were used without purification unless otherwise noted. THF, ethyl acetate, petroleum ether, methylene chloride (CH$_2$Cl$_2$), and toluene were distilled before use. Cinchona alkaloids catalysts β-ICD and α-IC were prepared according to the literature procedures [1,2].

2. Preparation of N-protected 7-azaisatins 1a–d

The preparation of the known compound 1a: A dried round-bottomed flask equipped with a magnetic stirring bar was charged with 7-azaindole (2 g, 16.95 mmol) and DMF (10 mL) under a nitrogen atmosphere. The mixture was cooled to 0 °C, NaH (1.2 equiv) was added and stirring continued for 1 h. Then, methyl iodide (1.1 equiv) was added and the mixture was stirred for another 1 h. Afterwards the reaction was quenched with ice cold water (100 mL) and extracted with ethyl acetate (3 x 100 mL). The combined organic layers were dried over Na$_2$SO$_4$ and the solvent was removed under reduced pressure to give N-methyl-7-azaindoles in a quantitative yield [3].
PCC (5.37 g, 25 mmol) was ground with silica gel (5.37 g, 70–230 mesh) and transferred to a 250 mL round-bottomed flask containing DCE (40 mL). To the orange suspension was added a solution of \( N \)-methyl-7-azaindole (1.32 g, 10 mmol) in DCE (5 mL) while stirring at room temperature. Then, \( \text{AlCl}_3 \) (15 wt %, 1.3 mol % with respect to \( N \)-methyl-7-azaindole) was added and the mixture was stirred at 80 °C. The progress of the reaction was monitored by TLC. After completion, the solvent was removed under reduced pressure and the black solid was treated with 50 mL of \( n \)-hexane/ethyl acetate (4:1) and filtered under suction through a sintered funnel layered with silica gel (5 cm, 70–230 mesh). The filtrate was evaporated to furnish 1a as a yellow solid (1.29 g, 80%). In addition, 1c was prepared according to the literature procedure [4]. A similar procedure was utilized for the preparation of 1b and 1d.

1b: Yellow solid, \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.54 (d, \( J = 4.4 \) Hz, 1H), 7.91 (d, \( J = 7.2 \) Hz, 1H), 7.17 (dd, \( J = 7.2 \) Hz, \( J = 5.2 \) Hz, 1H), 5.29 (s, 2H), 3.48 (s, 3H) ppm; \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 181.3, 163.2, 158.4, 156.3, 133.4, 120.2, 111.8, 70.0, 57.7 ppm.

1d: Yellow solid, \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 8.47 (d, \( J = 4.8 \) Hz, 1H), 7.97 (d, \( J = 7.6 \) Hz, 1H), 7.52 (s, 4H), 7.20 (dd, \( J = 7.2 \) Hz, \( J = 5.6 \) Hz, 1H), ppm; \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) \( \delta \) 180.9, 163.4, 157.0, 155.9, 134.3, 133.6, 130.0, 129.6, 127.2, 120.6, 112.1 ppm.
3. Preparation of N-protected 7-azaisatin 1e

42% step (5)

1e: Yellow solid, $^1$H NMR (400 MHz, CDCl$_3$) δ 8.67 (d, $J = 2.0$ Hz, 1H), 8.02 (d, $J = 2.0$ Hz, 1H), 7.51-7.44 (m, 5H), 3.39 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ 182.0, 162.9, 158.5, 154.0, 136.1, 133.5, 131.2, 129.3, 128.5, 126.6, 111.9, 25.2 ppm.

4. Preparation of N-protected 7-azaisatins 1f and 1g

To a solution of 1a (0.10 g, 0.6 mmol) in DMF (5 mL) was added NCS or NBS (0.16 g, 0.9 mmol) at room temperature. The solution was stirred for 4 h and then at 50 °C for 41 h. The progress of the reaction was monitored by TLC. After the disappearance of 1a, the mixture was poured into water (30 mL), followed by extraction with CH$_2$Cl$_2$ (10 mL x 3). The combined organic layers were washed three times with distilled water and dried (Na$_2$SO$_4$). After removal of the solvent, the residue was purified by flash chromatography on silica gel with dichloromethane as an eluent to give the pure product 1f and 1g [7].
5. Preparation of N-protected 7-azaisatin 1h

Compound 1h was synthesized by literature procedure [8].

6. Preparation of N-substituted maleimides 2a–i

Maleimides 2a–i were synthesized by known literature procedures [9-13].

7. General procedure for MBH reaction

A solution of N-protected 7-azaisatin 1 (0.1 mmol), N-substituted maleimide 2 (0.6 mmol) and catalyst β-ICD (20 mol %) in dry solvent (1.0 mL) was stirred at 50 °C. Purification by flash chromatography on silica gel (EtOAc/petroleum ether) gave the corresponding MBH product 3a–o.

**Typical procedure for the synthesis of 3p and 3q:** A solution of N-methyl-7-azaisatin (1, 0.1 mmol), acrylate (0.6 mmol) and catalyst β-ICD (20 mol %) in dry DCM (1.0 mL) was stirred at 30 °C. Purification by flash chromatography on silica gel (EtOAc/petroleum ether) gave the corresponding MBH product 3p and 3q.

**Typical procedure for the synthesis of 3r:** Acrolein (0.15 mmol) was added dropwise to a solution of 7-azaisatin (0.1 mmol) and β-ICD (10 mol %) in dry DCM (1.0 mL) at −20 °C. The progress of the reaction was monitored by TLC. After completion, the MBH reaction product 3r was purified by flash chromatography on silica gel with petroleum ether/EtOAc as the eluent.
3a: 98% yield, 33.0 mg, light yellow solid, $[\alpha]_D^{20} = -80.4$ (c = 4.4 in CHCl$_3$), 94% ee, determined by HPLC analysis [Daicel Chiralpak AD, (n-hexane/i-PrOH = 80/20, 1 mL/min, UV 254 nm, $t_{\text{major}} = 9.91$ min, $t_{\text{minor}} = 12.26$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.29 (d, $J = 4.8$ Hz, 1H), 7.66 (d, $J = 6.8$ Hz, 1H), 7.42 (t, $J = 7.6$ Hz, 2H), 7.33 (t, $J = 7.2$ Hz, 1H), 7.27-7.25 (m, 2H), 7.03 (dd, $J = 6.8$ Hz, $J = 5.2$ Hz, 1H), 6.94 (s, 1H), 4.24 (brs, 1H), 3.35 (s, 3H) ppm; $^{13}$C NMR (150 MHz, CDCl$_3$) $\delta$ 174.1, 167.8, 167.5, 157.1, 149.7, 146.1, 132.6, 130.7, 129.4, 129.1, 128.1, 125.8, 122.2, 119.2, 74.0, 25.9 ppm; ESI HRMS: calcd. for C$_{18}$H$_{13}$N$_3$O$_4$Na$^+$ 358.0798, found 358.0796.

3b: 87% yield, 30.0 mg, light yellow solid, $[\alpha]_D^{20} = -69.6$ (c = 6.5 in CHCl$_3$), 90% ee, determined by HPLC analysis [Daicel Chiralpak AD, (n-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, $t_{\text{major}} = 5.40$ min, $t_{\text{minor}} = 6.62$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.28 (d, $J = 5.2$ Hz, 1H), 7.65 (d, $J = 7.2$ Hz, 1H), 7.20 (d, $J = 8.0$ Hz, 2H), 7.12(d, $J = 8.4$ Hz, 2H), 7.04-7.01 (m, 1H), 6.93 (s, 1H), 4.50 (brs, 1H), 3.34 (s, 3H), 2.34 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.1, 167.9, 167.6, 157.2, 149.7, 146.0, 138.2, 132.6, 129.7, 129.3, 128.0, 125.7, 122.2, 119.2, 74.0, 25.9, 21.1 ppm; ESI HRMS: calcd. for C$_{19}$H$_{15}$N$_3$O$_4$Na$^+$ 372.0955, found 372.0952.

3c: 88% yield, 32.0 mg, yellow solid, $[\alpha]_D^{20} = -86.2$ (c = 10 in CHCl$_3$), 92% ee, determined by HPLC analysis [Daicel Chiralpak AD, (n-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, $t_{\text{major}} = 6.80$ min, $t_{\text{minor}} = 8.34$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.27 (d, $J = 5.2$ Hz, 1H), 7.64 (d, $J = 7.2$ Hz, 1H), 7.14 (d, $J = 8.8$ Hz, 2H), 7.04-7.01 (m, 1H), 6.93-6.90 (m, 3H), 4.60-4.54 (brs, 1H), 3.79 (s, 3H), 3.33 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.1, 167.9, 167.6, 157.2, 149.7, 146.0, 138.2, 132.6, 129.7, 129.3, 128.0, 125.7, 122.2, 119.2, 74.0, 25.9, 21.1 ppm; ESI HRMS: calcd. for C$_{19}$H$_{15}$N$_3$O$_4$Na$^+$ 372.0955, found 372.0952.
ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ 174.2, 168.1, 167.7, 159.1, 157.1, 149.6, 146.0, 132.6, 129.3, 127.3, 123.2, 122.3, 119.2, 114.4, 74.0, 55.4, 25.9 ppm; ESI HRMS: calcd. for C$_{19}$H$_{15}$N$_3$O$_5$+Na$^+$ 388.0904, found 388.0909.

3d: 87% yield, 32.1 mg, white solid, $[\alpha]_D^{20} = -94.3$ (c = 5.5 in CHCl$_3$), 92% ee, determined by HPLC analysis [Daicel Chiralpak AS, (n-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, $t_{\text{minor}} = 5.97$ min, $t_{\text{major}} = 8.88$ min]; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.30 (d, $J$ = 5.2 Hz, 1H), 7.65 (d, $J$ = 7.2 Hz, 1H), 7.26-7.23 (m, 2H), 7.12-7.08 (m, 2H), 7.04 (dd, $J$ = 7.2 Hz, $J$ = 1.6 Hz, 1H), 6.95 (s, 1H), 4.29 (brs, 1H), 3.35 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ 174.0, 167.6, 167.4, 157.1, 149.8, 146.2, 132.6, 129.4, 127.7, 127.6, 122.0, 119.2, 116.2, 116.0, 74.0, 25.9 ppm; ESI HRMS: calcd. for C$_{19}$H$_{12}$CIN$_3$O$_4$+Na$^+$ 392.0409, found 392.0403.

3e: 90% yield, 34.0 mg, white solid, $[\alpha]_D^{20} = -71.9$ (c = 4.4 in CHCl$_3$), 79% ee, determined by HPLC analysis [Daicel Chiralpak IE, (n-hexane/i-PrOH = 80/20, 1 mL/min, UV 254 nm, $t_{\text{major}} = 8.80$ min, $t_{\text{minor}} = 9.92$ min]; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.29-8.28 (m, 1H), 7.67 (d, $J$ = 7.2 Hz, 1H), 7.03 (dd, $J$ = 7.2 Hz, $J$ = 1.6 Hz, 1H), 6.92-6.90 (m, 3H), 4.55 (brs, 1H), 3.33 (s, 3H), 2.27 (s, 3H), 2.01 (s, 3H), 1.94 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ 174.0, 168.0, 167.8, 157.2, 149.7, 146.0, 139.5, 136.4, 136.2, 132.4, 129.3, 129.2, 129.0, 125.9, 122.3, 119.2, 74.0, 25.8, 21.0, 17.8, 17.7 ppm; ESI HRMS: calcd. for C$_{21}$H$_{19}$N$_3$O$_4$+Na$^+$ 400.1268, found 400.1275.
3f: 84% yield, 23.0 mg, white solid, $[\alpha]_D^{20} = -114.4$ ($c = 4.0$ in CHCl$_3$), 89% ee, determined by HPLC analysis [Daicel Chiralpak ID, ($n$-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, $t_{\text{major}} = 6.17$ min, $t_{\text{minor}} = 7.48$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.27 (d, $J = 5.2$ Hz, 1H), 7.58 (d, $J = 7.2$ Hz, 1H), 7.03-7.00 (m, 1H), 6.80 (s, 1H), 4.89-4.86 (brs, 1H), 3.33 (s, 3H), 2.92 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.3, 169.1, 168.7, 157.1, 149.6, 146.3, 132.5, 129.2, 122.3, 119.1, 73.9, 25.8, 23.8 ppm; ESI HRMS: calcd. for C$_{13}$H$_{11}$N$_3$O$_4$+Na$^+$ 296.0642, found 296.0656.

3g: 86% yield, 30.0 mg, white solid, $[\alpha]_D^{20} = -79.7$ ($c = 5.0$ in CHCl$_3$), 89% ee, determined by HPLC analysis [Daicel Chiralpak AS, ($n$-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, $t_{\text{minor}} = 6.54$ min, $t_{\text{major}} = 15.29$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.27 (d, $J = 5.2$ Hz, 1H), 7.59 (d, $J = 7.2$ Hz, 1H), 7.26 (m, 5H), 7.02-6.99 (m, 1H), 6.73 (s, 1H), 4.58 (s, 2H), 4.34 (brs, 1H), 3.33 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.0, 168.6, 168.4, 157.1, 149.7, 145.8, 135.6, 132.7, 129.2, 128.7, 128.5, 128.0, 122.0, 119.2, 73.9, 41.7, 25.8 ppm; ESI HRMS: calcd. for C$_{19}$H$_{15}$N$_3$O$_4$+Na$^+$ 372.0955, found 372.0958.

3h: 86% yield, 26.7 mg, white solid, $[\alpha]_D^{20} = -62.8$ ($c = 8.0$ in CHCl$_3$), 66% ee, determined by HPLC analysis [Daicel Chiralpak IC, ($n$-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, $t_{\text{minor}} = 4.97$ min, $t_{\text{major}} = 6.11$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.28 (d, $J = 4.4$ Hz, 1H), 7.60 (d, $J = 7.2$ Hz, 1H), 7.02 (dd, $J = 7.6$ Hz, $J = 1.6$ Hz, 1H), 6.73 (s, 1H), 4.52 (brs, 1H), 3.41 (t, $J = 3.2$ Hz, 2H), 3.34 (s, 3H), 1.51-1.46 (m, 2H), 1.27-1.20 (m, 2H), 0.90-0.86 (m, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 174.2,
169.1, 168.8, 157.1, 149.6, 145.7, 132.6, 129.1, 122.2, 119.1, 73.9, 38.0, 30.4, 25.8, 19.9, 13.5 ppm; ESI HRMS: calcd. for C_{16}H_{17}N_{3}O_{4}+Na^+ 338.1111, found 338.1107.

3i: 84% yield, 28.6 mg, white solid, [α]_{D}^{20} = –80.1 (c = 9.5 in CHCl_{3}), 61% ee, determined by HPLC analysis [Daicel Chiralpak ID, (n-hexane/i-PrOH = 80/20, 1 mL/min, UV 254 nm, t_{major} = 7.10 min, t_{minor} = 8.07 min]; ^{1}H NMR (400 MHz, CDCl_{3}) δ 8.27 (d, J = 5.2 Hz, 1H), 7.61 (d, J = 7.2 Hz, 1H), 7.02 (dd, J = 7.2 Hz, J = 1.6 Hz, 1H), 6.66 (s, 1H), 4.45-4.36 (brs, 1H), 3.82-3.77 (m, 1H), 3.34 (s, 3H), 2.01-1.88 (m, 2H), 1.80-1.77 (m, 2H), 1.62-1.60 (m, 3H), 1.30-1.14 (m, 3H) ppm; ^{13}C NMR (100 MHz, CDCl_{3}) δ 174.1, 169.1, 168.9, 157.1, 149.6, 145.3, 132.6, 129.0, 122.4, 119.1, 73.9, 51.2, 29.8, 25.8, 24.9 ppm; ESI HRMS: calcd. for C_{18}H_{19}N_{3}O_{4}+Na^+ 364.1268, found 364.1275.

3j: 92% yield, 33.6 mg, light yellow solid, [α]_{D}^{20} = –86.3 (c = 4.0 in CHCl_{3}), 91% ee, determined by HPLC analysis [Daicel Chiralpak AD, (n-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, t_{major} = 6.45 min, t_{minor} = 7.32 min]; ^{1}H NMR (400 MHz, CDCl_{3}) δ 8.33 (d, J = 4.8 Hz, 1H), 7.68 (d, J = 7.2 Hz, 1H), 7.44-7.40 (m, 2H), 7.35-7.32 (m, 1H), 7.27-7.25 (m, 2H), 7.08 (dd, J = 5.2 Hz, J = 1.6 Hz, 1H), 7.00 (s, 1H), 5.27 (s, 2H), 4.48 (brs, 1H), 3.47 (s, 3H) ppm; ^{13}C NMR (100 MHz, CDCl_{3}) δ 174.5, 167.8, 167.5, 156.3, 150.1, 146.0, 133.1, 130.6, 129.6, 129.1, 128.1, 125.8, 121.6, 119.7, 73.9, 70.7, 57.5 ppm; ESI HRMS: calcd. for C_{19}H_{15}N_{3}O_{5}+Na^+ 388.0904, found 388.0898.
**3k:** 93% yield, 38.0 mg, light yellow solid, $[\alpha]_{D}^{20} = -99.5$ (c = 5.6 in CHCl$_3$), 87% ee, determined by HPLC analysis [Daicel Chiralpak ID, (n-hexane/i-PrOH = 70/30, 1 mL/min, UV 254 nm, $t_{\text{major}} = 9.66$ min, $t_{\text{minor}} = 10.71$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.26 (d, $J = 4.8$ Hz, 1H), 7.65 (d, $J = 7.2$ Hz, 1H), 7.46 (d, $J = 7.2$ Hz, 2H), 7.42-7.39 (m, 2H), 7.34-7.28 (m, 3H), 7.26-7.24 (m, 3H), 7.01-6.98 (m, 1H), 6.88 (s, 1H), 5.02 (s, 2H), 4.57-4.56 (brs, 1H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 173.7, 167.8, 167.5, 156.7, 149.8, 145.7, 135.5, 132.9, 130.7, 129.4, 129.1, 128.6, 128.3, 128.1, 127.8, 125.8, 122.9, 119.3, 74.0, 43.3 ppm; ESI HRMS: calcd. for C$_{24}$H$_{17}$N$_3$O$_4$+K$^+$ 450.0851, found 450.0862.

**3l:** 37% yield, 16.0 mg, light yellow solid, $[\alpha]_{D}^{20} = -58.1$ (c = 5.0 in CHCl$_3$), 71% ee, determined by HPLC analysis [Daicel Chiralpak AD, (n-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, $t_{\text{major}} = 9.10$ min, $t_{\text{minor}} = 15.10$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.29 (d, $J = 4.8$Hz, 1H), 7.71 (d, $J = 7.6$ Hz, 1H), 7.55-7.49 (m, 4H), 7.45-7.41 (m, 2H), 7.36-7.33 (m, 1H), 7.27-7.26 (m, 2H), 7.13-7.10 (m, 1H), 7.05 (s, 1H), 4.10 (brs, 1H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) $\delta$ 173.2, 167.7, 167.5, 156.9, 145.0, 146.6, 134.5, 133.2, 130.8, 130.6, 129.6, 129.4, 129.1, 128.2, 127.9, 125.8, 121.5, 120.0, 74.0 ppm; ESI HRMS: calcd. for C$_{23}$H$_{14}$ClN$_3$O$_4$+Na$^+$ 454.0565, found 454.0571.

**3m:** 87.8% yield, 36.0 mg, yellowish solid, $[\alpha]_{D}^{20} = +53.9$ (c = 7.5 in CHCl$_3$), 92% ee, determined by HPLC analysis [Daicel Chiralpak AS, (n-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, $t_{\text{minor}} = 6.00$ min, $t_{\text{major}} = 8.88$ min]; $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 8.49 (d, $J = 2.0$ Hz, 1H).
Hz, 1H), 7.86 (d, J = 2.0 Hz, 1H), 7.52 (d, J = 7.6 Hz, 2H), 7.47-7.42 (m, 3H), 7.41-7.37 (m, 3H), 7.32 (t, J = 7.2 Hz, 1H), 7.27-7.25 (m, 2H), 7.00 (s, 1H), 4.42 (brs, 1H), 3.39 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ 174.1, 167.6, 167.5, 156.2, 148.0, 146.1, 137.0, 133.1, 131.6, 130.6, 129.4, 129.2, 129.1, 128.1, 128.1, 126.8, 125.8, 122.2, 74.1, 26.0 ppm; ESI HRMS: calcd. for C$_{24}$H$_{17}$N$_3$O$_4$+Na$^+$ 434.1111, found 434.1108.

3n: 81% yield, 30.0 mg, white solid, [α]$_D^{20} = -18.9$ (c = 10.0 in CHCl$_3$), 85% ee, determined by HPLC analysis [Daicel Chiralpak IE, (n-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, t$_{major}$ = 6.61 min, t$_{minor}$ = 7.91 min]; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.24 (d, J = 2.4 Hz, 1H), 7.63 (d, J = 1.6 Hz, 1H), 7.44-7.40 (m, 2H), 7.36-7.32 (m, 1H), 7.27-7.25 (m, 2H), 7.00 (s, 1H), 4.74 (brs, 1H), 3.32 (s, 3H) ppm; $^{13}$C NMR (100 MHz, CDCl$_3$) δ 173.9, 167.6, 167.4, 155.4, 148.2, 145.6, 133.0, 130.5, 129.7, 129.1, 128.2, 127.1, 125.8, 123.1, 73.9, 26.0 ppm; ESI HRMS: calcd. for C$_{18}$H$_{12}$ClN$_3$O$_4$+Na$^+$ 392.0409, found 392.0412.

3o: 82% yield, 34.0 mg, yellow solid, [α]$_D^{20} = +4.86$ (c = 7.0 in CHCl$_3$), 88% ee, determined by HPLC analysis [Daicel Chiralpak ID, (n-hexane/i-PrOH = 60/40, 1 mL/min, UV 254 nm, t$_{major}$ = 5.36 min, t$_{minor}$ = 6.45 min]; $^1$H NMR (400 MHz, CDCl$_3$) δ 8.34 (d, J = 2.0 Hz, 1H), 7.74 (d, J = 2.4 Hz, 1H), 7.43-7.40 (m, 2H), 7.35-7.32 (m, 1H), 7.27-7.25 (m, 2H), 7.00 (s, 1H), 4.70 (brs, 1H), 3.31 (s, 3H) ppm; $^{13}$C NMR (150 MHz, CDCl$_3$) δ 173.8, 167.6, 167.4, 155.7, 150.4, 145.6, 135.4, 130.6, 129.8, 129.1, 128.1, 125.8, 123.6, 114.6, 73.9, 26.0 ppm; ESI HRMS: calcd. for C$_{18}$H$_{12}$BrN$_3$O$_4$+Na$^+$ 435.9903, found 435.9910.
3p: 93% yield, 23.0 mg, white solid, \([\alpha]_D^{20} = -76.8\) \((c = 7.5\) in CHCl₃), 92% ee, determined by HPLC analysis [Daicel Chiralpak AS, \((n\text{-hexane/}i\text{-PrOH = 60/40, 1 mL/min, UV 254 nm, tminor = 4.65 min, tmajor = 6.67 min}\); \(^1\)H NMR (400 MHz, CDCl₃) \(\delta\) 8.20 (d, \(J = 5.2\) Hz, 1H), 7.42 (dd, \(J = 7.2\) Hz, \(J = 6.0\) Hz, 1H), 6.94 (dd, \(J = 7.2\) Hz, \(J = 2.0\) Hz, 1H), 6.60 (s, 1H), 6.47 (s, 1H), 4.38 (brs, 1H), 3.63 (s, 3H), 3.31(s, 3H) ppm; \(^{13}\)C NMR (100 MHz, CDCl₃) \(\delta\) 176.2, 164.8, 157.8, 148.6, 138.4, 131.2, 128.4, 124.3, 118.5, 75.7, 52.2, 25.5 ppm; ESI HRMS: calcd. for C₁₂H₁₂N₂O₄+Na⁺ 271.0689, found 271.0697.

3q: 98% yield, 26.0 mg, white solid, \([\alpha]_D^{20} = -95.4\) \((c = 5.0\) in CHCl₃), 91% ee, determined by HPLC analysis [Daicel Chiralpak AS, \((n\text{-hexane/}i\text{-PrOH = 60/40, 1 mL/min, UV 254 nm, tminor = 4.49 min, tmajor = 6.13 min}\); \(^1\)H NMR (400 MHz, CDCl₃) \(\delta\) 8.19 (d, \(J = 5.2\) Hz, 1H), 7.41 (d, \(J = 7.2\) Hz, 1H), 6.93 (dd, \(J = 6.8\) Hz, \(J = 1.2\) Hz, 1H), 6.61 (s, 1H), 6.44 (s, 1H), 4.46-4.40 (brs, 1H), 4.06-4.02 (m, 2H), 3.29 (s, 3H), 1.14-1.10 (m, 3H) ppm; \(^{13}\)C NMR (100 MHz, CDCl₃) \(\delta\) 176.3, 164.3, 157.8, 148.5, 138.6, 131.2, 128.5, 124.5, 118.5, 75.6, 61.1, 25.5, 13.8 ppm; ESI HRMS: calcd. for C₁₃H₁₄N₂O₄+Na⁺ 285.0846, found 285.0852.

3r: 96% yield, 20.9 mg, white solid, \([\alpha]_D^{20} = -171.4\) \((c = 7.0\) in CHCl₃), 94% ee, determined by HPLC analysis [Daicel Chiralpak AS, \((n\text{-hexane/}i\text{-PrOH = 60/40, 1 mL/min, UV 254 nm, tminor = 5.62 min, tmajor = 7.13 min}\); \(^1\)H NMR (400 MHz, CDCl₃) \(\delta\) 9.48 (m, 1H), 8.21 (d, \(J = 4.4\) Hz, 1H), 7.39 (d, \(J = 6.8\) Hz, 1H), 7.00 (s, 1H), 6.95-6.92 (m, 1H), 6.44 (s, 1H), 4.19-4.14 (brs, 1H), 3.32 (s, 3H) ppm; \(^{13}\)C NMR (100 MHz, CDCl₃) \(\delta\) 191.7, 175.6, 157.6, 148.8,
148.0, 136.5, 131.3, 123.6, 118.6, 75.0, 25.6 ppm; ESI HRMS: calcd. for C_{11}H_{10}N_{2}O_{3}+Na^+ 241.0584, found 241.0584.

8. References


9 NMR spectra and HPLC chromatograms
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