Supporting Information

A New Trifluoromethylated Sulfonamide Phosphine Ligand for Ag(I)-Catalyzed
Enantioselective [3+2] Cycloaddition of Azomethine Ylides

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1. General Information

All reactions were carried out under an atmosphere of nitrogen in flame-dried glassware with magnetic stirring. \(^1\)H NMR spectra, \(^{19}\)F NMR spectra, \(^{31}\)P NMR spectra, \(^{13}\)C NMR spectra were recorded on a Bruker 300, 400 and 500 MHz spectrometer in CDCl\(_3\). All signals are reported in ppm with the internal TMS signal at 0 ppm as a standard. Data for \(^1\)H NMR spectra are reported as follows: chemical shift (ppm, referenced to TMS; s = singlet, d = doublet, t = triplet, q = quarte, dd = doublet of doublets, dt = doublet of triplets, m = multiplet), coupling constant (Hz), and intergration. Data for \(^{13}\)C NMR are reported in terms of chemical shift (ppm) relative to residual solvent peak (CDCl\(_3\): 77.0 ppm). Reactions were monitored by thin layer chromatography (TLC) using silica gel plates. Flash column chromatography was performed over silica gel (300-400 mesh). The substrates (\(R, Rs\))-M1, M7, (\(S, Rs\))-M1, M3, M4,\(^{[1]}\) 1b-1e,\(^{[2]}\) 2a-2p,\(^{[3]}\) 4a-4f,\(^{[4]}\) 6\(^{[2]}\) were synthesized according to published procedures. The spectral data of the substrates were consisted with that reported in the literature. The enantionmeric excesses of the products were determined by chiral stationary phase HPLC using a Chiralpak AS-H, AD-H, IE.

2. General Procedure for the Synthesis of products 3ab-3ak, 3ca-3ea, 5ab-5ap, 5ca-5fa, 7ab-7ap, 8

Typical procedure for asymmetric silver-catalyzed cycloaddition of azomethine ylides with maleimides, cyclopentene-1,3-diones, and \(N\)-(2-\(t\)-butylphenyl)maleimide.

**General Procedure A**

A solution of (\(S,Rs\))-M8 (5.5 mol\%) and AgOAc (5 mol\%) in Xylene (2 mL) was stirred at room temperature for 2 h. The reaction mixture was cooled to -30 °C and then the imino ester 2 (0.15 mmol), Cs\(_2\)CO\(_3\) (0.045 mmol) and maleimide 1 (0.165 mmol) were added sequentially. Following complete consumption of the imino ester 2, the solvent was removed under reduced pressure. The crude product was then purified
by flash column chromatography on silica gel to afford the desired product.

**General Procedure B**
A solution of \((S,Rs)-M8\) (5.5 mol\%) and AgOAc (5 mol\%) in Xylene (2 mL) was stirred at room temperature for 2 h. The reaction mixture was cooled to -30 °C and then the imino ester 2 (0.15 mmol), Cs₂CO₃ (0.045 mmol) and cyclo-pentenedione 4 (0.165 mmol) were added sequentially. Following complete consumption of the imino ester 2, the solvent was removed under reduced pressure. The crude product was then purified by flash column chromatography on silica gel to afford the desired product. Configuration of the 5 was determined by \(^1\)H, \(^{13}\)C NMR, HPLC Spectra, in comparison with the literature, see: [4].

**General Procedure C**
A solution of \((S,Rs)-M8\) (5.5 mol\%) and AgOAc (5 mol\%) in Xylene (2 mL) was stirred at room temperature for 2 h. The reaction mixture was cooled to -30 °C and then the imino ester 2 (0.15 mmol), Cs₂CO₃ (0.045 mmol) and \(N\)-(2-t-butyphenyl)maleimide 6 (0.165 mmol) were added sequentially. Following complete consumption of the imino ester 2, the solvent was removed under reduced pressure. The crude product was then purified by flash column chromatography on silica gel to afford the desired product. Configuration of the 7 was determined by \(^1\)H, \(^{13}\)C NMR, HPLC Spectra, in comparison with the literature, see: [5].

3.1 Synthesis of methyl (1R,3S,3aR,6aS)-3-(4-chlorophenyl)-4,6-dioxo-5-phenyloctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ab).

![Structure of 3ab](image)

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2b (31.7 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ab as a white solid (67.1 mg, 99% yield) and 91% ee. Mp: 155-156 °C. \(^1\)H NMR (400 MHz, CDCl₃) δ 7.42-7.38 (m, 4 H), 7.33 (t, \(J = 7.1\) Hz, 3 H), 7.13 (d, \(J = 7.5\) Hz, 2 H), 4.55 (dd, \(J = 8.5, 4.9\) Hz, 1 H), 4.12-4.10 (m, 1 H), 3.86 (s, 3 H), 3.71 (t, \(J = 7.2\) Hz, 1 H), 3.53 (t, \(J = 82 / 132\))
3.2 Synthesis of methyl (1R,3S,3aR,6aS)-3-(4-iodophenyl)-4,6-dioxo-5-phenyloctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ac).

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2c (45.5 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ac as a white solid (64.8 mg, 91% yield) and 90% ee. Mp: 209-210 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.67 (d, $J = 8.1$ Hz, 1H), 7.40 (t, $J = 7.4$ Hz, 1H), 7.33 (t, $J = 7.3$ Hz, 1H), 7.19 (d, $J = 8.1$ Hz, 1H), 7.12 (d, $J = 7.5$ Hz, 1H), 4.49 (d, $J = 8.6$ Hz, 1H), 4.09 (d, $J = 6.6$ Hz, 1H), 3.85 (s, 1H), 3.68 (t, $J = 7.2$ Hz, 1H), 3.51 (t, $J = 8.2$ Hz, 1H), 2.46 (s, 1H). $^{13}$C NMR (126 MHz, CDCl$_3$) δ 174.85, 173.41, 169.86, 137.43, 136.46, 131.41, 129.03, 129.00, 128.53, 125.98, 93.95, 63.49, 61.69, 52.28, 48.97, 47.89. ESI-MS calculated for C$_{20}$H$_{18}$IN$_2$O$_4$: m/z (%): 477.0306 (M+H$^+$), found: 477.0316. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 220 nm); minor enantiomer tr = 20.2 min, major enantiomer tr = 47.7 min. $[\alpha]_D^{25} = -117.2$ ($c = 0.25$, CHCl$_3$).

3.3 Synthesis of methyl (1R,3S,3aR,6aS)-3-(3-fluorophenyl)-4,6-dioxo-5-
phenyloctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ad).

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2d (29.3 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ad as a white solid (46.7 mg, 85% yield) and 90% ee. Mp: 154-155 °C. $^1$H NMR (400 MHz, CDCl$_3$) $\delta$ 7.39 (t, $J = 7.6$ Hz, 2 H), 7.34-7.30 (m, 2 H), 7.21 (dd, $J = 14.4$, 8.9 Hz, 2 H), 7.13 (d, $J = 8.0$ Hz, 2 H), 6.99 (t, $J = 8.2$ Hz, 1 H), 4.56 (dd, $J = 8.5$, 4.8 Hz, 1 H), 4.12-4.09 (m, 1 H), 3.86 (s, 3 H), 3.70 (t, $J = 7.2$ Hz, 1 H), 3.54 (t, $J = 8.2$ Hz, 1H), 2.51 (s, 1 H). $^{19}$F NMR (282 MHz, CDCl$_3$) $\delta$ -112.48 - -112.56 (m).$^{13}$C NMR (126 MHz, CDCl$_3$) $\delta$ 174.90, 173.41, 169.84, 162.82 (d, $J = 246.3$ Hz), 139.47 (d, $J = 7.2$ Hz), 131.46, 129.96 (d, $J = 8.2$ Hz), 129.04, 128.54, 126.05, 122.77 (d, $J = 2.8$ Hz), 115.27 (d, $J = 21.1$ Hz), 114.09 (d, $J = 22.4$ Hz), 63.37 (d, $J = 1.7$ Hz), 61.65, 52.29, 49.08, 47.93. ESI-MS calculated for C$_{20}$H$_{17}$FN$_2$NaO$_4$: m/z (%): 391.1065 (M+H$^+$), found: 391.1072. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 220 nm); minor enantiomer $\text{tr} = 14.9$ min, major enantiomer $\text{tr} = 31.6$ min. [$\alpha$]$_D^{25}$ = -84.9 ($c = 0.25$, CHCl$_3$).

3.4 Synthesis of methyl (1R,3S,3aR,6aS)-4,6-dioxo-5-phenyl-3-(4-(trifluoromethyl)phenyl)octahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ae).
Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2e (36.8 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ae as a white solid (58.5 mg, 97% yield) and 91% ee. Mp: 122-123 °C. 

\[ \delta 7.59 \ (q, J = 8.4 \text{ Hz}, 4 \text{ H}), 7.40 \ (t, J = 7.4 \text{ Hz}, 2 \text{ H}), 7.33 \ (t, J = 7.3 \text{ Hz}, 1 \text{ H}), 7.12 \ (d, J = 7.5 \text{ Hz}, 2 \text{ H}), 4.63 \ (dd, J = 8.2, 5.1 \text{ Hz}, 1 \text{ H}), 4.16 - 4.14 \ (m, 1 \text{ H}), 3.87 \ (s, 3 \text{ H}), 3.74 \ (t, J = 7.3 \text{ Hz}, 1 \text{ H}), 3.60 \ (t, J = 8.2 \text{ Hz}, 1 \text{ H}), 2.53 \ (s, 1 \text{ H}) \]

\[ ^{19}F \text{ NMR (282 MHz, CDCl}_3) \delta -62.44 \]

\[ ^{13}C \text{ NMR (126 MHz, CDCl}_3) \delta 174.77, 173.30, 169.82, 140.77, 131.40, 130.43 \ (q, J = 32.4 \text{ Hz}), 129.10, 128.65, 127.56, 126.02, 125.38 \ (q, J = 3.7 \text{ Hz}), 123.96 \ (q, J_{C, F} = 272.2 \text{ Hz}), 63.54, 61.82, 52.37, 49.07, 47.86. \]

ESI-MS calculated for C_{21}H_{18}F_{3}N_{2}O_{4}: m/z (%): 419.1213 (M+H^+), found: 419.1220.

Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 220 nm); minor enantiomer tr = 12.2 min, major enantiomer tr = 20.8 min. [\alpha]^25_D = -78.8 \ (c = 0.25, CHCl_3). 

3.5 Synthesis of methyl (1R,3S,3aR,6aS)-3-(4-cyanophenyl)-4,6-dioxo-5-phenyloctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3af).

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2f (30.3 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3af as a white solid (49.5 mg, 88% yield) and 98% ee. Mp: 109-110 °C. 

\[ \delta 7.61 \ (dd, J = 20.7, 8.2 \text{ Hz}, 4 \text{ H}), 7.42-7.34 \ (m, 3 \text{ H}), 7.10 \ (d, J = 7.6 \text{ Hz}, 2 \text{ H}), 4.63 \ (dd, J = 8.4, 4.4 \text{ Hz}, 1 \text{ H}), 4.17-4.14 \ (m, 1 \text{ H}), 3.86 \ (s, 3 \text{ H}), 3.74 \ (t, J = 7.3 \text{ Hz}, 1 \text{ H}), 3.60 \ (t, J = 8.2 \text{ Hz}, 1 \text{ H}), 2.53 \ (s, 1 \text{ H}) \]

\[ ^{13}C \text{ NMR (126 MHz, CDCl}_3) \delta 174.63, 173.19, 169.81, 140.70, 131.40, 130.43 \ (q, J = 32.4 \text{ Hz}), 129.10, 128.65, 127.56, 126.02, 125.38 \ (q, J = 3.7 \text{ Hz}), 123.96 \ (q, J_{C, F} = 272.2 \text{ Hz}), 63.54, 61.82, 52.37, 49.07, 47.86. \]
169.67, 142.27, 132.20, 131.29, 129.10, 128.69, 127.91, 125.95, 118.57, 112.14, 63.33, 61.75, 52.39, 48.99, 47.64. ESI-MS calculated for C_{21}H_{18}N_{3}O_{4}: m/z (%): 376.1292 (M+H^+), found: 376.1305. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 220 nm); minor enantiomer tr = 23.8 min, major enantiomer tr = 37.2 min. \([\alpha]_D^{25} = -167.6\) (c = 0.25, CHCl_3).

3.6 Synthesis of methyl (1R,3S,3aR,6aS)-3-(4-(methylthio)phenyl)-4,6-dioxo-5-phenyloctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ag).

![3ag](image)

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2g (49.8 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ag as a white solid (55.2 mg, 93% yield) and 92% ee. Mp: 202-203 °C. \(^1\)H NMR (300 MHz, CDCl_3) δ 7.42-7.32 (m, 5 H), 7.21 (d, J = 8.4 Hz, 2 H), 7.16-7.13 (m, 2 H), 4.51 (d, J = 8.7 Hz, 1 H), 4.08 (d, J = 6.7 Hz, 1 H), 3.86 (s, 3 H), 3.71-3.66 (m, 1 H), 3.53-3.48 (m, 1 H), 2.45 (s, 3 H), 1.26 (s, 1 H). \(^13\)C NMR (126 MHz, CDCl_3) δ 175.02, 173.57, 170.01, 138.61, 133.32, 131.53, 129.00, 128.47, 127.56, 126.23, 126.04, 63.79, 61.75, 52.27, 49.20, 48.15, 15.51. ESI-MS calculated for C_{21}H_{20}N_{2}Na_{2}O_{4}S: m/z (%): 419.1036 (M+H^+), found: 419.1042. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 254 nm); minor enantiomer tr = 26.4 min, major enantiomer tr = 59.5 min. \([\alpha]_D^{25} = -166.6\) (c = 0.25, CHCl_3).

3.7 Synthesis of methyl (1R,3S,3aR,6aS)-3-[[1,1'-biphenyl]-4-yl]-4,6-dioxo-5-
phenyloctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ah).

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2h (38 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ah as a white solid (63.3 mg, 99% yield) and 98% ee. Mp: 244-245 °C. 1H NMR (300 MHz, CDCl₃) δ 7.61-7.59 (m, 4 H), 7.52 (d, J = 8.3 Hz, 2 H), 7.45-7.32 (m, 6 H), 7.19-7.16 (m, 2 H), 4.64 (d, J = 8.6 Hz, 1 H), 4.15 (d, J = 6.6 Hz, 1 H), 3.88 (s, 1H), 3.77-3.72 (m, 1 H), 3.63-3.57 (m, 1 H), 2.54 (s, 1 H). 13C NMR (126 MHz, CDCl₃) δ 175.04, 173.61, 170.04, 141.14, 140.56, 135.63, 131.57, 129.04, 128.69, 128.50, 127.69, 127.32, 127.13, 127.08, 126.08, 64.06, 61.89, 52.34, 49.37, 48.31. ESI-MS calculated for C₂₆H₂₂N₂NaO₄: m/z (%): 449.1472 (M+H⁺), found: 449.1478. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 254 nm); minor enantiomer tr = 22.4 min, major enantiomer tr = 53.6 min. [α]D²⁵ = -164.8 (c = 0.25, CHCl₃).

3.8 Synthesis of methyl (1R,3S,3aR,6aS)-4,6-dioxo-5-phenyl-3-(o-tolyl)octahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ai).

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2i (28.7 mg, 0.15 mmol) at -30 °C, after flash column
chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 3ai as a white solid (33.9 mg, 62% yield) and 84% ee. Mp: 175-176 °C. $^1$H NMR (300 MHz, CDCl$_3$) δ 7.65 (dd, $J = 7.0$, 2.5 Hz, 1 H), 7.38-7.28 (m, 3 H), 7.22-7.21 (m, 3 H), 7.07-7.03 (m, 2 H), 4.71 (dd, $J = 8.6$, 4.3 Hz, 1 H), 4.14 – 4.10 (m, 1 H), 3.88 (s, 3 H), 3.75 – 3.70 (m, 1 H), 3.66-3.60 (m, 1 H), 2.43 (d, $J = 7.1$ Hz, 4 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 175.13, 173.35, 170.06, 135.76, 135.32, 131.56, 130.23, 128.89, 128.35, 127.94, 126.05, 125.27, 61.48, 60.51, 52.24, 48.27, 46.89, 19.34. ESI-MS calculated for C$_{21}$H$_{20}$N$_2$NaO$_4$: m/z (%): 387.1315 (M+H$^+$), found: 387.1320. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 210 nm); minor enantiomer tr = 14.6 min, major enantiomer tr = 39.0 min. $[\alpha]_D^{25}$ = -102.6 ($c = 0.25$, CHCl$_3$).

3.9 Synthesis of tert-butyl (1R,3S,3aR,6aS)-4,6-dioxo-5-phenyl-3-(o-tolyl)octahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3aj).

![3aj](image)

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2j (35 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 3aj as a white solid (51.5 mg, 81% yield) and 94% ee. Mp: 208-209 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.70-7.58 (m, 1 H), 7.35 (t, $J = 7.5$ Hz, 2 H), 7.29 (d, $J = 7.2$ Hz, 1 H), 7.21 (d, $J = 2.2$ Hz, 3 H), 7.06 (d, $J = 7.3$ Hz, 2 H), 4.66 (d, $J = 8.7$ Hz, 1 H), 3.99 (d, $J = 6.0$ Hz, 1 H), 3.71-3.65 (m, 1 H), 3.64-3.58 (m, 1 H), 2.44 (s, 3 H), 2.28 (s, 1 H), 1.59 (s, 9 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 174.83, 173.55, 168.45, 135.73, 135.47, 131.60, 130.12, 128.85, 128.24, 127.79, 126.14, 125.95, 125.17, 82.24, 62.17, 60.23, 48.17, 47.12, 28.06, 19.35. MS (EI): m/z (%) = 406 (M+, 1.78), 305 (100): HRMS
calculated for $[C_{24}H_{26}O_{4}N_{2}]^{+}$: 406.1895 found: 406.1983. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 90:10, 1.0 mL/min, 190 nm); minor enantiomer $t_r = 16.3$ min, major enantiomer $t_r = 24.1$ min. $[\alpha]_{D}^{25} = -93.8 (c = 0.4, \text{CHCl}_3)$.

3.10 Synthesis of methyl (1R,3S,3aR,6aS)-4,6-dioxo-3,5-diphenyloctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ak).

![3ak]

Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2k (26.6 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ak as a white solid (51.5 mg, 98% yield) and 85% ee. Mp: 170-171 °C. $^1H$ NMR (300 MHz, CDCl$_3$) $\delta$ 7.47-7.29 (m, 8H), 7.16-7.13 (m, 2H), 4.59 (dd, $J = 8.7$, 5.3 Hz, 1H), 4.12 (dd, $J = 6.4$, 5.2 Hz, 1H), 3.87 (s, 3 H), 3.71 (t, $J = 6.9$ Hz, 1H), 3.54 (t, $J = 8.3$ Hz, 1H), 2.51 (t, $J = 5.0$ Hz, 1H). $^{13}C$ NMR (126 MHz, CDCl$_3$) $\delta$ 175.06, 173.58, 170.03, 136.64, 131.56, 128.96, 128.43, 128.43, 128.39, 127.06, 126.05, 64.16, 61.82, 52.27, 49.34, 48.26. ESI-MS calculated for $C_{20}H_{18}N_{2}NaO_{4}$: m/z (%): 373.1159 (M+H$^+$), found: 373.1167. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 210 nm); minor enantiomer $t_r = 15.8$ min, major enantiomer $t_r = 28.1$ min. $[\alpha]_{D}^{25} = -91.6 (c = 0.25, \text{CHCl}_3)$.

3.11 Synthesis of benzyl (1R,3S,3aR,6aS)-3-(4-bromophenyl)-4,6-dioxo-5-phenyloctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3al).
Prepared according to general procedure A from N-Phenylmaleimide 1a (28.6 mg, 0.165 mmol) and imino ester 2l (49.8 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3al as a white solid (63.2 mg, 83% yield) and 95% ee. Mp: 200-201 °C. $^1$H NMR (300 MHz, CDCl$_3$) δ 7.48-7.30 (m, 12 H), 7.16-7.13 (m, 2 H), 5.29 (dd, $J = 28.7$, 12.1 Hz, 2 H), 4.49 (dd, $J = 8.7$, 4.7 Hz, 1 H), 4.11 (dd, $J = 6.7$, 4.6 Hz, 1 H), 3.70 (t, $J = 7.2$ Hz, 1 H), 3.50 (t, $J = 8.2$ Hz, 1 H), 2.48 (t, $J = 4.5$ Hz, 1 H). $^{13}$C NMR (126 MHz, CDCl$_3$) δ 174.85, 173.43, 169.36, 135.77, 135.30, 131.53, 131.45, 129.06, 128.77, 128.72, 128.57, 128.53, 128.43, 126.05, 122.20, 67.39, 63.41, 61.83, 48.97, 48.78. ESI-MS calculated for C$_{26}$H$_{21}$BrN$_2$NaO$_4$: m/z (%): 527.0577 (M+H$^+$), found: 527.0587. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 210 nm); minor enantiomer tr = 20.5 min, major enantiomer tr = 49.5 min. [α]$_D^{25} = -98.3$ (c = 0.25, CHCl$_3$).

3.12 Synthesis of methyl (1R,3S,3aR,6aS)-3-(4-bromophenyl)-5-(4-chlorophenyl)-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ca).

Prepared according to general procedure A from maleimide 1c (34.3 mg, 0.165 mmol) and imino ester 2a(38.4 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ca as a white
solid (66.9 mg, 96% yield) and 84% ee. Mp: 245-246 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.47 (d, $J = 8.4$ Hz, 2 H), 7.38-7.35 (m, 2 H), 7.31 (d, $J = 8.4$ Hz, 2 H), 7.09 (d, $J = 8.7$ Hz, 2 H), 4.54 (d, $J = 8.7$ Hz, 1 H), 4.12 (d, $J = 6.7$ Hz, 1 H), 3.86 (s, 3 H), 3.73-3.69 (m, 1 H), 3.54 (t, $J = 8.2$ Hz, 1 H), 2.48 (s, 1 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 174.59, 173.13, 169.79, 135.65, 134.35, 131.63, 129.90, 129.26, 128.73, 127.23, 122.35, 63.47, 61.77, 52.37, 49.03, 47.90. ESI-MS calculated for C$_{20}$H$_{17}$BrClN$_2$O$_4$: m/z (%): 463.0055 (M+N$^+$), found: 463.0064. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 210 nm); minor enantiomer $t_r = 15.4$ min, major enantiomer $t_r = 31.3$ min. [$\alpha$]$_D^{25} = -73.6$ (c = 0.25, CHCl$_3$).

3.13 Synthesis of tert-butyl (1R,3S,3aR,6aS)-3-(4-bromophenyl)-5-(4-chlorophenyl)-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3cm).

Prepared according to general procedure A from maleimide 1c (34.3 mg, 0.165 mmol) and imino ester 2m (44.7 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3cm as a white solid (66.9 mg, 80% yield) and 96% ee. Mp: 243-244 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.46 (d, $J = 8.4$ Hz, 2 H), 7.37 (d, $J = 8.7$ Hz, 2 H), 7.31 (d, $J = 8.4$ Hz, 2 H), 7.10 (d, $J = 8.7$ Hz, 2 H), 4.51 (d, $J = 8.7$ Hz, 1 H), 4.00 (d, $J = 6.6$ Hz, 1 H), 3.72-3.62 (m, 1 H), 3.56-3.48 (m, 1 H), 2.36 (s, 1 H), 1.56 (s, 9 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 174.37, 173.13, 168.26, 135.77, 134.27, 131.58, 129.95, 129.27, 128.69, 127.34, 122.24, 82.68, 63.24, 62.50, 49.32, 47.86, 28.06. ESI-MS calculated for C$_{23}$H$_{22}$BrClN$_2$NaO$_4$: m/z (%): 527.0349 (M+Na$^+$), found: 527.0342. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol
= 90:10, 0.8 mL/min, 230 nm); minor enantiomer tr = 29.7 min, major enantiomer tr = 34.0 min. $[\alpha]_D^{25} = -146.6$ ($c = 0.4$, CHCl$_3$).

3.14 Synthesis of methyl (1R,3S,3aR,6aS)-3-(4-bromophenyl)-5-(3-chlorophenyl)-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3da).

![3da]

Prepared according to general procedure A from maleimide 1d (34.3 mg, 0.165 mmol) and imino ester 2a (38.4 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3da as a white solid (78 mg, >99% yield) and 92% ee. Mp: 140-141 °C. $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.47 (d, $J = 8.4$ Hz, 2 H), 7.32-7.30 (m, 4 H), 7.16 (s, 1 H), 7.05-7.02 (m, 1 H), 4.52 (d, $J = 8.7$ Hz, 1 H), 4.10 (d, $J = 6.7$ Hz, 1 H), 3.85 (s, 3 H), 3.71-3.67 (m, 1 H), 3.52 (t, $J = 8.2$ Hz, 1 H), 2.44 (s, 1 H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 174.47, 173.03, 169.76, 135.67, 134.50, 132.44, 131.57, 129.98, 128.72, 128.72, 126.24, 124.20, 122.28, 63.37, 61.70, 52.31, 48.97, 47.85. ESI-MS calculated for C$_{20}$H$_{17}$BrClN$_2$O$_4$: m/z (%): 463.0055 (M+H$^+$), found: 463.0067. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 210 nm); minor enantiomer tr = 15.3 min, major enantiomer tr = 39.4 min. $[\alpha]_D^{25} = -114.2$ ($c = 0.25$, CHCl$_3$).

3.15 Synthesis of methyl (1R,3S,3aR,6aS)-3-(4-bromophenyl)-4,6-dioxo-5-(p-tolyl)octahydropyrrolo[3,4-c]pyrrole-1-carboxylate (3ea).
Prepared according to general procedure A from maleimide 1e (31 mg, 0.165 mmol) and imino ester 2a (38.4 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 3ea as a white solid (62.9 mg, 95% yield) and 91% ee. Mp: 193-194 °C. $^1$H NMR (300 MHz, CDCl$_3$) δ 7.46 (d, $J$ = 8.4 Hz, 2 H), 7.31 (d, $J$ = 8.4 Hz, 2 H), 7.19 (d, $J$ = 8.2 Hz, 2 H), 7.00 (d, $J$ = 8.3 Hz, 2 H), 4.50 (d, $J$ = 8.7 Hz, 1 H), 4.08 (d, $J$ = 6.7 Hz, 1 H), 3.85 (s, 3 H), 3.67 (t, $J$ = 7.2 Hz, 1 H), 3.50 (t, $J$ = 8.2 Hz, 1 H), 2.45 (s, 1 H), 2.33 (s, 3 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 174.96, 173.52, 169.89, 138.60, 135.86, 131.49, 129.65, 128.82, 128.79, 125.79, 122.13, 63.38, 61.69, 52.25, 49.01, 47.91, 21.09. ESI-MS calculated for C$_{21}$H$_{20}$BrN$_2$O$_4$: m/z (%): 443.0601 (M+H$^+$), found: 443.0613. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 210 nm); minor enantiomer tr = 17.2 min, major enantiomer tr = 34.7 min. $[\alpha]_D^{25}$ = -130.7 (c = 0.25, CHCl$_3$).

3.16 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-3-(4-chlorophenyl)-5-methyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5ab).

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2b (31.7 mg, 0.15 mmol) at -30 °C, after flash column chromatography Petroleum ether : AcOEt = 2:1) afforded the product 5aa as a white
solid (58.4mg, 95% yield) and 94% ee. Mp: 157-158 °C. \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\) 7.35-7.29 (m, 4 H), 7.22 (dd, \(J = 5.0, 1.8\) Hz, 3 H), 6.95 (dd, \(J = 6.5, 3.0\) Hz, 2 H), 4.35 (d, \(J = 5.5\) Hz, 1 H), 3.93 (t, \(J = 5.3\) Hz, 1 H), 3.89 (s, 3 H), 2.87 (s, 2 H), 2.8-2.78 (m, 2H), 2.26 (s, 1 H), 1.15 (s, 3 H). \(^1^3\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 217.32, 215.48, 170.54, 135.64, 135.64, 133.59, 129.64, 128.52, 128.36, 128.29, 127.12, 65.37, 63.44, 60.24, 55.85, 54.28, 52.11, 43.85, 18.22. ESI-MS calculated for C\(_{23}\)H\(_{23}\)ClNO\(_4\): m/z (%): 412.1310 (M+H\(^+\)), found: 412.1318. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 210 nm); minor enantiomer tr = 8.8 min, major enantiomer tr = 12.1 min. \([\alpha]_{D}^{25}\) = -4.6 (c = 0.25, CHCl\(_3\)).

3.17 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-3-(4-iodophenyl)-5-methyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5ac).

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2c (45.5 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ac as a white solid (58.4mg, 85% yield) and 94% ee. Mp: 160-161 °C. \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\) 7.64 (d, \(J = 8.4\) Hz, 2 H), 7.18 (dd, \(J = 5.0, 1.8\) Hz, 3 H), 7.04 (d, \(J = 8.3\) Hz, 2 H), 6.91 (dd, \(J = 6.4, 3.1\) Hz, 2 H), 4.28-4.25 (m, 1 H), 3.89-3.87 (m, 1 H), 3.84 (s, 3 H), 2.82 (s, 2 H), 2.74 (dd, \(J = 4.0, 3.2\) Hz, 2 H), 2.21 (s, 1 H), 1.11 (s, 3 H). \(^1^3\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 217.28, 215.43, 170.51, 137.22, 136.87, 135.63, 129.63, 128.87, 128.51, 127.11, 93.42, 65.51, 63.45, 60.23, 55.78, 54.26, 52.10, 43.83, 18.22. ESI-MS calculated for C\(_{23}\)H\(_{22}\)INNaO\(_4\): m/z (%): 526.0486 (M+H\(^+\)), found: 526.0497. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column.
hexanes: 2-propanol = 50:50, 0.8 mL/min, 210 nm); minor enantiomer tr = 9.8 min,
major enantiomer tr = 14.8 min. \([\alpha]_D^{25} = 4.4 \ (c = 0.25, \text{CHCl}_3)\).

3.18 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-3-(3-fluorophenyl)-5-methyl-4,6-dioxo-octahydrocyclopenta[c]pyrrole-1-carboxylate (5ad).

\[
\begin{align*}
\text{MeO}_2\text{C} & \\
& \text{HN} \\
& \text{O} \\
& \text{O} \\
& \text{Ph} \\
& \text{F} \\
\end{align*}
\]

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2d (29.3 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ad as a yellow solid (36.8 mg, 62% yield) and 90% ee. Mp: 157-158 °C. \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\) 7.31 (dd, \(J = 10.8, 4.9\) Hz, 1 H), 7.19 (dd, \(J = 5.0, 1.8\) Hz, 3 H), 7.11-6.91 (m, 5 H), 4.34 (d, \(J = 7.8\) Hz, 1 H), 3.91 (d, \(J = 6.9\) Hz, 1 H), 3.86 (s, 3 H), 2.84 (s, 2 H), 2.78-2.75 (m, 2 H), 2.24 (s, 1 H), 1.14 (s, 3 H). \(^{19}\)F NMR (282 MHz, CDCl\(_3\)) \(\delta\) -112.81 (td, \(J = 8.7, 5.6\) Hz). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 217.33, 215.34, 170.52, 162.75 (d, \(J = 245.9\) Hz), 139.87 (d, \(J = 7.1\) Hz), 135.70, 129.72-129.64 (m), 129.67, 128.55, 127.14, 122.72 (d, \(J = 2.8\) Hz), 114.83 (d, \(J = 21.2\) Hz), 113.96 (d, \(J = 22.4\) Hz), 65.47, 63.45, 60.27, 55.88, 54.27, 52.14, 43.91, 18.29. ESI-MS calculated for C\(_{23}\)H\(_{23}\)FNO\(_4\): m/z (%): 396.1606 (M+H\(^+\)), found: 396.1609. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 0.8 mL/min, 210 nm); minor enantiomer tr = 12.9 min, major enantiomer tr = 25.4 min. \([\alpha]_D^{25} = -5.2 \ (c = 0.25, \text{CHCl}_3)\).

3.19 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-5-methyl-4,6-dioxo-3-(4-(trifluoromethyl)phenyl)octahydrocyclopenta[c]pyrrole-1-carboxylate (5ae).
Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2e (36.8 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ae as a white solid (46.7 mg, 70% yield) and 94% ee. Mp: 155-156 °C. $^1$H NMR (300 MHz, CDCl$_3$) δ 7.59 (d, $J = 8.1$ Hz, 2 H), 7.43 (d, $J = 8.0$ Hz, 2 H), 7.19 (d, $J = 4.8$ Hz, 3 H), 6.94-6.91 (m, 2 H), 4.39 (d, $J = 7.0$ Hz, 1 H), 3.93 (d, $J = 6.0$ Hz, 1 H), 3.86 (s, 3 H), 2.84 (s, 2 H), 2.78 (t, $J = 7.6$ Hz, 2 H), 2.27 (s, 1 H), 1.13 (s, 3 H). $^{19}$F NMR (282 MHz, CDCl$_3$) δ -62.47. $^{13}$C NMR (101 MHz, CDCl$_3$) δ 217.17, 215.40, 170.47, 141.26, 141.26, 135.61, 130.07 (q, $J = 33.3$ Hz), 129.63, 129.63, 128.56, 127.37, 127.18, 125.12 (q, $J = 3.7$ Hz), 124.04 (q, $J_{C,F} = 272.3$ Hz), 65.48, 63.51, 60.27, 55.80, 54.23, 52.16, 43.91, 18.23. ESI-MS calculated for C$_{24}$H$_{23}$F$_3$NO$_4$: m/z (%): 446.1574 (M+H$^+$), found: 446.1585. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 0.8 mL/min, 220 nm); minor enantiomer tr = 6.9 min, major enantiomer tr = 8.2 min. [α]$_D^{25} = -13.5$ (c = 0.25, CHCl$_3$).

3.20 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-3-(4-cyanophenyl)-5-methyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5af).

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2f (30.3 mg, 0.15 mmol) at -30 °C, after flash column...
chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5af as a white solid (50.1 mg, 83% yield) and 95% ee. Mp: 148-149 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.61 (d, $J = 8.0$ Hz, 2 H), 7.43 (d, $J = 8.0$ Hz, 2 H), 7.19 (d, $J = 4.7$ Hz, 3 H), 6.91-6.90 (m, 2 H), 4.39 (d, $J = 6.3$ Hz, 1 H), 3.93 (d, $J = 5.2$ Hz, 1 H), 3.85 (s, 3 H), 2.86-2.81 (m, 2 H), 2.78 (d, $J = 6.3$ Hz, 2 H), 2.28 (s, 1 H), 1.09 (s, 3 H). $^{13}$C NMR (126 MHz, CDCl$_3$) δ 216.92, 215.44, 170.31, 142.80, 135.45, 131.92, 129.53, 128.56, 127.74, 127.20, 118.65, 111.65, 65.25, 63.40, 60.23, 55.69, 53.99, 52.16, 43.91, 18.17. ESI-MS calculated for C$_{20}$H$_{13}$N$_2$O$_4$: m/z (%): 403.1652 (M+H$^+$), found: 403.1664. Enantiomeric excess was determined by HPLC with a Chiralpak IE column (hexanes: 2-propanol = 70:30, 0.8 mL/min, 210 nm); major enantiomer tr = 14.6 min, minor enantiomer tr = 17.7 min. [$\alpha$]$_D^{25}$ = -4.8 (c = 0.25, CHCl$_3$).

3.21 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-5-methyl-3-(4-(methylthio)phenyl)-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5ag).

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2g (33.5 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ag as a white solid (44.7 mg, 70% yield) and 94% ee. Mp: 159-160 °C. $^1$H NMR (300 MHz, CDCl$_3$) δ 7.20-7.11 (m, 7 H), 6.92 (dd, $J = 6.5$, 3.0 Hz, 2 H), 4.28 (dd, $J = 5.9$, 2.6 Hz, 1 H), 3.88 (dd, $J = 5.3$, 1.8 Hz, 1 H), 3.85 (s, 3 H), 2.83 (s, 2 H), 2.75 (dd, $J = 5.6$, 2.2 Hz, 2 H), 2.46 (s, 3 H), 2.14 (s, 1H), 1.13 (s, 3 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 217.52, 215.50, 170.63, 138.06, 135.69, 133.79, 129.65, 128.45, 127.41, 127.04, 126.09, 65.77, 63.46, 60.21, 55.95, 54.40, 52.05, 43.75, 18.23, 15.60. ESI-MS calculated for
C_{29}H_{28}NO_4S: m/z (%): 424.1577 (M+H^+), found: 424.1579. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 60:40, 0.8 mL/min, 210 nm); minor enantiomer tr = 11.9 min, major enantiomer tr = 18.5 min. \([\alpha]_D^{25} = -14.2\ (c = 0.25, \text{CHCl}_3)\).

3.22 Synthesis of methyl (1R,3S,3aR,5R,6aS)-3-[[1,1'-biphenyl]-4-yl]-5-benzyl-5-methyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5ah).

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2h (38 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ah as a white solid (61.1 mg,90% yield) and 95% ee. Mp: 186-187 °C. ¹H NMR (300 MHz, CDCl₃) δ 7.63-7.56 (m, 4 H), 7.40 (dt, J = 14.4, 6.7 Hz, 5 H), 7.19 (dd, J = 5.0, 1.7 Hz, 3 H), 6.95 (dd, J = 6.4, 2.9 Hz, 2 H), 4.38 (d, J = 7.9 Hz, 1 H), 3.92 (d, J = 6.8 Hz, 1 H), 3.87 (s, 3 H), 2.86 (s, 2 H), 2.81 (t, J = 6.5 Hz, 2 H), 2.21 (s, 1H), 1.17 (s, 3 H). ¹³C NMR (101 MHz, CDCl₃) δ 217.57, 215.52, 170.67, 140.66, 140.61, 136.08, 135.74, 129.69, 128.66, 128.48, 127.43, 127.24, 127.07, 127.02, 126.80, 65.97, 63.56, 60.26, 56.07, 54.50, 52.09, 43.79, 18.29. ESI-MS calculated for C_{29}H_{28}NO_4: m/z (%): 454.2013 (M+H^+), found: 454.2023. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 0.8 mL/min, 254 nm); minor enantiomer tr = 17.4 min, major enantiomer tr =33.2 min. \([\alpha]_D^{25} = -6.8\ (c = 0.25, \text{CHCl}_3)\).

3.23 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-3-(4-fluorophenyl)-5-methyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5an).
HN
MeO₂C
\[\text{5an}\]

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2n (29.3 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5an as a yellow solid (43.1 mg, 73% yield) and 92% ee. Mp: 135-136 °C. \(^1\)H NMR (300 MHz, CDCl₃) δ 7.30-7.25 (m, 2 H), 7.18 (dd, \(J = 5.0, 1.7\) Hz, 3 H), 7.02 (t, \(J = 8.7\) Hz, 2 H), 6.92 (dd, \(J = 6.5, 3.0\) Hz, 2 H), 4.34 (d, \(J = 8.1\) Hz, 1 H), 3.92-3.90 (m, 1 H), 3.86 (s, 3 H), 2.84 (s, 2 H), 2.75 (dd, \(J = 5.0, 2.7\) Hz, 2 H), 2.23 (s, 1 H), 1.12 (s, 3 H). \(^{19}\)F NMR (282 MHz, CDCl₃) δ -114.06 – -114.11 (m). \(^{13}\)C NMR (101 MHz, CDCl₃) δ 217.41, 215.59, 170.61, 162.31 (d, \(J = 246.4\) Hz), 135.68, 132.82 (d, \(J = 3.2\) Hz), 129.67, 128.59, 128.52, 127.12, 115.11 (d, \(J = 21.5\) Hz), 65.42, 63.45, 60.27, 55.96, 54.34, 52.11, 43.89, 18.22. ESI-MS calculated for C\(_{23}\)H\(_{23}\)FNO\(_4\): m/z (%): 396.1606 (M+H\(^{+}\)), found: 396.1613. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 0.8 mL/min, 220 nm); minor enantiomer \(t_r = 15.2\) min, major enantiomer \(t_r = 20.7\) min. [\(\alpha\)]\(_D^{25}\) = -18.9 (c = 0.25, CHCl₃).

3.24 Synthesis of ethyl (1R,3S,3aR,5R,6aS)-5-benzyl-3-(4-chlorophenyl)-5-methyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5ao).

\[\text{5ao}\]

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol)\]
mmol) and imino ester 2o (33.8 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ao as a white solid (52.1 mg, 82% yield) and 94% ee. Mp: 170-171 °C. 1H NMR (300 MHz, CDCl3) δ 7.31-7.22 (m, 4 H), 7.18 (dd, J = 5.0, 1.7 Hz, 3 H), 6.92 (dd, J = 6.7, 2.9 Hz, 2 H), 4.35-4.28 (m, 3 H), 3.89-3.86 (m, 1 H), 2.83 (s, 2 H), 2.75 (dd, J = 5.7, 2.1 Hz, 2 H), 2.22 (s, 1 H), 1.37 (t, J = 7.2 Hz, 3 H), 1.11 (s, 3 H). 13C NMR (101 MHz, CDCl3) δ 217.03, 215.52, 170.04, 135.72, 135.69, 133.55, 129.64, 128.48, 128.33, 128.29, 127.10, 65.33, 63.58, 61.20, 60.19, 55.93, 54.28, 43.82, 18.19, 14.11. ESI-MS calculated for C24H25ClNO4: m/z (%):426.1467 (M+H+), found: 426.1471. Enantiomeric excess was determined by HPLC with a Chiralpak ADH column (hexanes: 2-propanol = 80:20, 1.0 mL/min, 254 nm); major enantiomer tr = 11.2 min, minor enantiomer tr = 16.7 min. [α]D25 = -7.1 (c = 0.25, CHCl3).

3.25 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-3-(4-bromophenyl)-1,5-dimethyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5ap).

![5ap](image)

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2p (40.5 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ap as a white solid (59.1 mg, 89% yield) and 92% ee. Mp: 187-188 °C. 1H NMR (300 MHz, CDCl3) δ 7.43 (d, J = 8.4 Hz, 2 H), 7.18 (dd, J = 5.5, 3.0 Hz, 5 H), 6.90 (dd, J = 6.6, 2.9 Hz, 2 H), 4.62 (d, J = 9.3 Hz, 1 H), 3.83 (s, 3 H), 2.89 (t, J = 9.6 Hz, 1 H), 2.80 (s, 2 H), 2.47 (d, J = 9.8 Hz, 1 H), 2.10 (s, 1 H), 1.45 (s, 3 H), 1.01 (s, 3 H). 13C NMR (101 MHz, CDCl3) δ 216.21, 215.07, 170.04, 135.72, 135.69, 133.55, 129.64, 128.48, 128.33, 128.29, 127.10, 126.15, 121.61, 68.75, 63.07, 61.96, 60.16, 56.41, 52.39, 44.02, 24.12, 18.13.
ESI-MS calculated for C$_{24}$H$_{25}$BrNO$_4$: m/z (%): 470.0961 (M+H$^+$), found: 470.0975. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 90:10, 0.8 mL/min, 210 nm); minor enantiomer tr = 15.2 min, major enantiomer tr = 17.5 min. [$\alpha$]$_D^{25}$ = -33.2 (c = 0.25, CHCl$_3$).

3.26 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-3-(4-chlorophenyl)-1,5-dimethyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5aq).

Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2q (33.9 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5aq as a white solid (54.2 mg, 91% yield) and 90% ee. Mp: 180-181 °C. $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.30-7.22 (m, 4 H), 7.20-7.17 (m, 3 H), 6.91 (dd, $J$ = 6.6, 2.9 Hz, 2 H), 4.64 (d, $J$ = 9.4 Hz, 1 H), 3.84 (s, 3 H), 2.90 (t, $J$ = 9.6 Hz, 1 H), 2.80 (s, 2 H), 2.48 (d, $J$ = 9.8 Hz, 1 H), 2.11 (s, 1 H), 1.45 (s, 3 H), 1.01 (s, 3 H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 216.23, 215.09, 173.12, 135.93, 135.50, 133.44, 129.61, 128.48, 128.39, 128.27, 127.15, 68.74, 63.02, 61.97, 60.16, 56.47, 52.39, 44.02, 24.12, 18.11. ESI-MS calculated for C$_{24}$H$_{25}$ClNO$_4$: m/z (%): 426.1467 (M+H$^+$), found: 426.1476. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 95:5, 0.8 mL/min, 210 nm); minor enantiomer tr = 23.6 min, major enantiomer tr = 29.0 min. [$\alpha$]$_D^{25}$ = -32.6 (c = 0.25, CHCl$_3$).

3.27 Synthesis of methyl (1R,3S,3aR,5R,6aS)-5-benzyl-1,5-dimethyl-4,6-dioxo-3-(p-tolyl)octahydrocyclopenta[c]pyrrole-1-carboxylate (5ar).
Prepared according to general procedure B from cyclo-pentenedione 4a (33 mg, 0.165 mmol) and imino ester 2p (30.8 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ap as a white solid (45.6 mg, 80% yield) and 91% ee. Mp: 156-157 °C. $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.16 (dt, $J$ = 12.6, 5.8 Hz, 7 H), 6.92 (dd, $J$ = 6.6, 2.9 Hz, 2 H), 4.65 (d, $J$ = 9.4 Hz, 1 H), 3.85 (s, 3 H), 2.92 (t, $J$ = 9.6 Hz, 1 H), 2.80 (s, 2 H), 2.50 (d, $J$ = 9.8 Hz, 1 H), 2.34 (s, 3 H), 2.18 (s, 1H), 1.46 (s, 3 H), 1.03 (s, 3 H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 216.65, 215.22, 173.28, 137.48, 135.62, 134.02, 129.69, 128.86, 128.44, 127.08, 126.87, 68.94, 63.90, 62.48, 60.21, 57.05, 52.41, 43.98, 24.19, 21.14, 18.13. ESI-MS calculated for C$_{26}$H$_{28}$NO$_4$: m/z (%):406.2013 (M+H$^+$), found: 406.2015. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 90:10, 0.8 mL/min, 254 nm); minor enantiomer tr = 12.5 min, major enantiomer tr = 15.9 min. $[\alpha]_{D}^{25}$ = -44.1 ($c$ = 0.25, CHCl$_3$).

3.28 Synthesis of methyl (1R,3S,3aR,5R,6aS)-3-(4-bromophenyl)-5-(4-fluorobenzyl)-5methyl-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5ca).

Prepared according to general procedure B from cyclo-pentenedione 4e (36 mg, 0.165 mmol) and imino ester 2a (38.4 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ca as a white
solid (58.7 mg, 83% yield) and 95% ee. Mp: 169-170 °C. \(^1\)H NMR (300 MHz, CDCl\(_3\)) \(\delta\) 7.44 (d, \(J = 8.4 \) Hz, 2 H), 7.18 (d, \(J = 8.4 \) Hz, 2 H), 6.88-6.85 (m, 4 H), 4.32 (d, \(J = 7.8 \) Hz, 1 H), 2.94-2.92 (m, 1 H), 3.84 (s, 3 H), 2.81-2.78 (m, 4 H), 2.25 (s, 1 H), 1.11 (s, 3 H). \(^{19}\)F NMR (282 MHz, CDCl\(_3\)) \(\delta\) -115.08 - -115.13 (m). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 217.18, 215.35, 170.40, 161.85 (d, \(J = 246.1 \) Hz), 136.04, 131.47 (d, \(J = 3.3 \) Hz), 131.31 (d, \(J = 1.9 \) Hz), 131.24, 128.59, 121.77, 115.33 (d, \(J = 21.2 \) Hz), 65.46, 63.52, 55.77, 54.21, 52.11, 42.44, 18.28. ESI-MS calculated for C\(_{23}\)H\(_{22}\)BrFNO\(_4\): m/z (%): 474.0711 (M+H\(^+\)), found: 474.0722. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 0.8 mL/min, 210 nm); minor enantiomer \(t_r = 14.8 \) min, major enantiomer \(t_r = 18.4 \) min. \([\alpha]_{D}^{25} = -2.2 (c = 0.25, \text{CHCl}_3)\).

3.29 Synthesis of methyl (1R,3S,3aR,5R,6aS)-3-(4-bromophenyl)-5-methyl-5-(4-methylbenzyl)-4,6-dioxooctahydrocyclopenta[c]pyrrole-1-carboxylate (5da).

![5da](image)

Prepared according to general procedure B from cyclo-pentenedione 4d (35.4 mg, 0.165 mmol) and imino ester 2a (38.4 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5da as a white solid (56.9 mg, 81% yield) and 95% ee. Mp: 131-132 °C. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.43 (d, \(J = 8.4 \) Hz, 2 H), 7.17 (d, \(J = 8.3 \) Hz, 2 H), 6.98 (d, \(J = 7.8 \) Hz, 2 H), 6.79 (d, \(J = 7.9 \) Hz, 2 H), 4.28-4.27 (m, 1 H), 3.88 (d, \(J = 6.8 \) Hz, 1 H), 3.84 (s, 3 H), 2.77-2.73 (m, 4 H), 2.23 (d, \(J = 17.7 \) Hz, 4 H), 1.08 (s, 3 H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 217.39, 215.55, 170.54, 136.66, 136.25, 132.42, 131.21, 129.44, 129.14, 128.62, 121.64, 65.34, 63.37, 60.25, 55.77, 54.25, 52.04, 43.56, 20.93, 18.03. ESI-MS calculated for C\(_{24}\)H\(_{25}\)BrNO\(_4\): m/z (%): 470.0961 (M+H\(^+\)), found: 470.0967.
Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 0.8 mL/min, 210 nm); minor enantiomer tr = 13.2 min, major enantiomer tr = 18.6 min. $[\alpha]_D^{25} = -14.3$ ($c$ = 0.25, CHCl$_3$).

3.30 Synthesis of methyl (1R,3S,3aR,5R,6aS)-3-(4-bromophenyl)-5-(3-chlorobenzyl)-5-methyl-4,6-dioxoctahydrocyclopenta[c]pyrrole-1-carboxylate (5ea).

Prepared according to general procedure B from cyclo-pentenedione 4e (38.7 mg, 0.165 mmol) and imino ester 2a (38.4 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5ea as a white solid (60.4 mg, 82% yield) and 95% ee. Mp: 159-160 °C. $^1$H NMR (300 MHz, CDCl$_3$) δ 7.45 (d, $J$ = 8.4 Hz, 2 H), 7.20-7.08 (m, 4 H), 6.91 (s, 1 H), 6.80 (d, $J$ = 6.9 Hz, 1 H), 4.34 (d, $J$ = 7.8 Hz, 1 H), 3.95 (d, $J$ = 7.0 Hz, 1 H), 3.84 (s, 3 H), 2.88-2.84 (m, 2 H), 2.79 (s, 2 H), 2.27 (s, 1 H), 1.13 (s, 3 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 216.69, 214.84, 170.38, 137.81, 135.98, 134.23, 131.31, 129.74, 129.57, 128.60, 128.00, 127.36, 121.80, 65.46, 63.52, 59.89, 55.75, 54.20, 52.13, 42.52, 18.50. ESI-MS calculated for C$_{23}$H$_{22}$BrClNO$_4$: m/z (%): 490.0415 (M+H$^+$), found: 490.0433. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 0.8 mL/min, 210 nm); minor enantiomer tr = 16.6 min, major enantiomer tr = 21.6 min. $[\alpha]_D^{25} = -18.7$ ($c$ = 0.25, CHCl$_3$).

3.31 Synthesis of methyl (1R,3S,3aR,5R,6aS)-3-(4-bromophenyl)-5-(2-chlorobenzyl)-5-methyl-4,6-dioxoctahydrocyclopenta[c]pyrrole-1-carboxylate (5fa).
Prepared according to general procedure B from cyclo-pentenedione 4f (38.7 mg, 0.165 mmol) and imino ester 2a (38.4 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 5fa as a white solid (63.2 mg, 86% yield) and 85% ee. Mp: 198-199 °C. $^1$H NMR (300 MHz, CDCl$_3$) $\delta$ 7.43 (d, $J$ = 8.4 Hz, 2 H), 7.31-7.28 (m, 1 H), 7.19-7.12 (m, 4 H), 7.00 (dd, $J$ = 6.9, 2.4 Hz, 1 H), 4.39 (d, $J$ = 9.0 Hz, 1 H), 3.97 (d, $J$ = 6.8 Hz, 1 H), 3.86 (s, 3 H), 3.32 (dd, $J$ = 9.8, 6.9 Hz, 1 H), 3.23-3.17 (m, 1 H), 3.06 (d, $J$ = 13.5 Hz, 1 H), 2.93 (d, $J$ = 13.5 Hz, 1 H), 2.26 (s, 1 H), 1.06 (s, 3 H). $^{13}$C NMR (101 MHz, CDCl$_3$) $\delta$ 215.06, 213.48, 170.65, 136.40, 134.53, 133.18, 131.90, 131.35, 129.91, 128.77, 128.77, 126.75, 121.81, 65.20, 62.93, 58.76, 55.52, 53.70, 52.12, 39.80, 17.15. ESI-MS calculated for C$_{23}$H$_{22}$BrClNO$_4$: m/z (%): 490.0415 (M+H$^+$), found: 490.0422. Enantiomeric excess was determined by HPLC with a Chiralpak IE column (hexanes: 2-propanol = 70:30, 0.8 mL/min, 200 nm); major enantiomer tr = 12.3 min, minor enantiomer tr = 20.1 min. [$\alpha$]$_{D}^{25}$ = -30.7 (c = 0.25, CHCl$_3$).

3.32 Synthesis of methyl (1R,3S,3aR,6aS)-5-(2-(tert-butyl)phenyl)-3-(4-chlorophenyl)-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7ab).

Prepared according to general procedure C from N-(2-t-butylphenyl)maleimide 6 (37.8 mg, 0.165 mmol) and imino ester 2b (31.7 mg, 0.15 mmol) at -30 °C, after flash
column chromatography (Petroleum ether : AcOEt = 1:1) afforded the product 7ab as a white solid (48.1 mg, 73% yield) and 90% ee. Mp: 191-192 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.49 (d, $J = 7.3$ Hz, 1 H), 7.41 (d, $J = 8.4$ Hz, 2 H), 7.33 (dd, $J = 12.3$, 8.0 Hz, 3 H), 7.28-7.24 (m, 1 H), 6.86 (dd, $J = 7.6$, 0.9 Hz, 1 H), 4.53 (dd, $J = 7.8$, 3.0 Hz, 1 H), 4.12 (dd, $J = 6.7$, 3.2 Hz, 1 H), 3.84 (s, 3 H), 3.68 (t, $J = 7.5$ Hz, 1 H), 3.54 (t, $J = 8.1$ Hz, 1 H), 2.48 (s, 1 H), 1.22 (s, 9 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 176.05, 174.64, 169.87, 147.67, 135.09, 133.89, 130.81, 129.90, 129.79, 128.77, 128.54, 128.37, 127.55, 63.51, 61.81, 52.30, 49.05, 47.72, 35.59, 31.57. ESI-MS calculated for C$_{24}$H$_{25}$ClN$_2$NaO$_4$: m/z (%): 463.1395 (M+H$^+$), found: 463.1402. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 1.0 mL/min, 220 nm); minor enantiomer $t_r = 5.6$ min, major enantiomer $t_r = 8.8$ min. [$\alpha$]$_D^{25} = -88.6$ ($c = 0.25$, CHCl$_3$).

3.33 Synthesis of methyl (1R,3S,3aR,6aS)-5-(2-(tert-butyl)phenyl)-3-(3-fluorophenyl)-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7ad).

![7ad](attachment:7ad.png)

Prepared according to general procedure C from N-(2-t-butylphenyl)maleimide 6 (37.8 mg, 0.165 mmol) and imino ester 2d (29.3 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 7ad as a white solid (45.7 mg, 72% yield) and 90% ee. Mp: 203-204 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.49 (dd, $J = 8.1$, 1.3 Hz, 1 H), 7.35-7.30 (m, 2 H), 7.28-7.21 (m, 3 H), 6.98-6.93 (m, 1 H), 6.88 (dd, $J = 7.7$, 1.4 Hz, 1 H), 4.54 (dd, $J = 8.2$, 3.3 Hz, 1 H), 4.11 (dd, $J = 6.8$, 3.4 Hz, 1 H), 3.84 (s, 3 H), 3.68 (t, $J = 7.5$ Hz, 1 H), 3.54 (t, $J = 8.1$ Hz, 1 H), 2.49 (s, 1 H), 1.22 (s, 9 H). $^{19}$F NMR (282 MHz, CDCl$_3$) δ -112.65 (td, $J = 8.8$, 5.3 Hz). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 176.05, 174.53, 169.84, 162.78 (d, $J = 246.1$ Hz), 147.63, 139.32 (d, $J = 7.2$ Hz), 130.86, 129.90 (d, $J = 3.9$ Hz), 129.80,
129.75, 128.72, 127.54, 122.72 (d, \( J = 2.8 \) Hz), 115.08 (d, \( J = 21.1 \) Hz), 114.03 (d, \( J = 22.5 \) Hz), 63.47, 61.71, 52.28, 49.05, 47.71, 35.58, 31.56. ESI-MS calculated for \( \text{C}_{24}\text{H}_{25}\text{FN}_{3}\text{NaO}_{4} \); m/z (%): 447.1691 (M+H\(^+\)), found: 447.1704. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 1.0 mL/min, 210 nm); minor enantiomer tr = 11.3 min, major enantiomer tr = 24.4 min. \([\alpha]_{D}^{25} = -75.5 \) (c = 0.25, CHCl\(_3\)).

3.34 Synthesis of methyl (1R,3S,3aR,6aS)-5-(2-(tert-butyl)phenyl)-3-(4-cyanophenyl)-4,6-dioxo-octahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7af).

\[
\begin{align*}
\text{MeO}_2\text{C} & \quad \text{O} \\
\text{HN} & \quad \text{O} \\
\text{N} & \quad \text{N} \\
\text{Me} & \quad \text{Bu} \\
\text{Ph} & \quad \text{NC}
\end{align*}
\]

7af

Prepared according to general procedure C from \( N-(2-\text{t-butylphenyl})\text{maleimide} \) \( 6 \) (37.8 mg, 0.165 mmol) and imino ester \( 2f \) (30.3 mg, 0.15 mmol) at -30 °C, after flash column chromatography (hexanes : AcOEt = 1:1) afforded the product 7af as a white solid (63.2 mg, 98% yield) and 95% ee. Mp: 123-124 °C. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \( \delta \) 7.63-7.58 (m, 4 H), 7.49 (dd, \( J = 8.1, 1.2 \) Hz, 1 H), 7.33 (t, \( J = 7.7 \) Hz, 1 H), 7.25 (t, \( J = 7.5 \) Hz, 1 H), 6.82 (dd, \( J = 7.7, 1.4 \) Hz, 1 H), 4.61 (dd, \( J = 8.2, 4.3 \) Hz, 1 H), 4.16 (dd, \( J = 7.2, 4.1 \) Hz, 1 H), 3.83 (s, 3 H), 3.72 (t, \( J = 7.5 \) Hz, 1 H), 3.60 (t, \( J = 8.1 \) Hz, 1 H), 2.55 (s, 1 H), 1.21 (s, 9 H). \(^1\)C NMR (101 MHz, CDCl\(_3\)) \( \delta \) 175.78, 174.46, 169.65, 147.64, 142.22, 132.06, 130.68, 129.85, 129.76, 128.78, 127.84, 127.53, 118.57, 111.90, 63.42, 61.79, 52.33, 48.97, 47.45, 35.54, 31.52. ESI-MS calculated for \( \text{C}_{25}\text{H}_{25}\text{N}_{3}\text{NaO}_{4} \); m/z (%): 454.1737 (M+H\(^+\)), found: 454.1749. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 1.0 mL/min, 220 nm); minor enantiomer tr = 8.3 min, major enantiomer tr = 10.0 min. \([\alpha]_{D}^{25} = -140.6 \) (c = 0.25, CHCl\(_3\)).
3.35 Synthesis of methyl (1R,3S,3aR,6aS)-5-(2-(tert-butyl)phenyl)-3-(4-(methylthio)phenyl)-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7ag).

Prepared according to general procedure C from N-(2-tert-butylphenyl)maleimide 6 (37.8 mg, 0.165 mmol) and imino ester 2g (33.5 mg, 0.15 mmol) at -30 °C, after flash column chromatography (hexanes : AcOEt = 1:1) afforded the product 7ag as a white solid (66.7 mg, 98% yield) and 98% ee. Mp: 219-220 °C. \[\text{1H NMR (400 MHz, CDCl}_3\text{)} \delta 7.49 (d, J = 7.1 Hz, 1 H), 7.38 (d, J = 8.2 Hz, 2 H), 7.35-7.31 (m, 1 H), 7.28-7.24 (m, 1 H), 7.21 (d, J = 8.3 Hz, 2 H), 6.88 (dd, J = 7.6, 1.1 Hz, 1 H), 4.51 (d, J = 8.1 Hz, 1 H), 4.10 (d, J = 6.9 Hz, 1 H), 3.84 (s, 3 H), 3.67 (t, J = 7.5 Hz, 1 H), 3.52 (t, J = 8.1 Hz, 1 H), 2.46 (s, 1 H), 2.43 (s, 3 H), 1.22 (s, 9 H). \[\text{13C NMR (101 MHz, CDCl}_3\text{)} \delta 176.19, 174.76, 170.00, 147.69, 138.46, 133.14, 130.90, 129.99, 129.75, 128.75, 127.56, 127.51, 126.22, 63.97, 61.88, 52.29, 49.16, 47.87, 35.61, 31.58, 15.49. \]ESI-MS calculated for C\(_{25}\)H\(_{28}\)N\(_2\)NaO\(_4\)S: m/z (%): 475.1662 (M+H\(^+\)), found: 475.1675. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 50:50, 1.0 mL/min, 210 nm); minor enantiomer tr = 7.0 min, major enantiomer tr = 12.2 min. \[\alpha\]D\(_{25}\) = -106.4 (c = 0.25, CHCl\(_3\)).

3.36 Synthesis of benzyl (1R,3S,3aR,6aS)-3-(4-bromophenyl)-5-(2-(tert-butyl)phenyl)-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7al).

\[\text{7al} \]
Prepared according to general procedure C from N-(2-tert-butylphenyl)maleimide 6 (37.8 mg, 0.165 mmol) and imino ester 2l (49.8 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 7al as a white solid (74.6 mg, 89% yield) and 96% ee. Mp: 96-97 °C. 1H NMR (400 MHz, CDCl₃) δ 7.52-7.44 (m, 5 H), 7.41-7.33 (m, 6 H), 7.25 (td, J = 7.6, 1.3 Hz, 1 H), 6.86 (dd, J = 7.7, 1.3 Hz, 1 H), 5.33 (d, J = 12.1 Hz, 1 H), 5.21 (d, J = 12.1 Hz, 1 H), 4.47 (d, J = 8.3 Hz, 1 H), 4.11 (d, J = 7.1 Hz, 1 H), 3.68 (t, J = 7.5 Hz, 1 H), 3.51 (t, J = 8.1 Hz, 1 H), 2.48 (s, 1 H), 1.25 (s, 9 H). 13C NMR (101 MHz, CDCl₃) δ 176.03, 174.59, 169.35, 147.63, 135.67, 135.37, 131.41, 131.41, 130.83, 129.93, 129.77, 128.69, 128.69, 128.47, 128.35, 127.54, 122.00, 67.33, 63.48, 61.85, 48.93, 47.71, 35.55, 31.54. ESI-MS calculated for C₃₀H₂₉BrN₂NaO₄: m/z (%): 583.1203 (M+H⁺), found: 583.1205. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 1.0 mL/min, 220 nm); minor enantiomer tr = 15.1 min, major enantiomer tr = 43.6 min. [α]D²⁵ = -94.1 (c = 0.25, CHCl₃).

3.37 Synthesis of ethyl (1R,3S,3aR,6aS)-5-(2-(tert-butyl)phenyl)-3-(4-chlorophenyl)-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7ao).

Prepared according to general procedure C from N-(2-tert-butylphenyl)maleimide 6 (37.8 mg, 0.165 mmol) and imino ester 2o (33.9 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 7ao as a white solid (49.4 mg, 72% yield) and 91% ee. Mp: 202-203 °C. 1H NMR (400 MHz, CDCl₃) δ 7.49 (dd, J = 8.1, 1.2 Hz, 1 H), 7.41 (d, J = 8.4 Hz, 2 H), 7.35-7.30 (m, 3 H), 7.25 (td, J = 7.5, 1.3 Hz, 1 H), 6.86 (dd, J = 7.7, 1.3 Hz, 1 H), 4.53 (d, J = 8.1 Hz, 1 H), 4.31 (q, J = 6.8 Hz, 2 H), 4.11 (d, J = 7.0 Hz, 1 H), 3.69 (t, J = 7.5 Hz,
1 H), 3.54 (t, J = 8.1 Hz, 1 H), 2.48 (s, 1 H), 1.34 (t, J = 7.2 Hz, 3 H), 1.22 (s, 9 H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 175.89, 174.70, 169.43, 147.67, 135.10, 133.89, 130.87, 129.94, 129.77, 128.79, 128.55, 128.38, 127.53, 63.57, 62.04, 61.54, 49.18, 47.78, 35.62, 31.58, 14.09. ESI-MS calculated for C$_{25}$H$_{27}$ClN$_2$NaO$_4$: m/z (%): 477.1552 (M+H$^+$), found: 477.1565. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 1.0 mL/min, 220 nm); minor enantiomer tr = 9.6 min, major enantiomer tr = 21.2 min. $[\alpha]^D_{25} = -96.6$ (c = 0.25, CHCl$_3$).

3.38 Synthesis of methyl (1R,3S,3aR,6aS)-3-(4-bromophenyl)-5-(2-(tert-butyl)phenyl)-1-methyl-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7ap).

![Image of 7ap](image)

Prepared according to general procedure C from N-(2-t-butylphenyl)maleimide 6 (37.8 mg, 0.165 mmol) and imino ester 2p (40.5 mg, 0.15 mmol) at -30 °C, after flash column chromatography (hexanes : AcOEt = 2:1) afforded the product 7ap as a white solid (52.3 mg, 70% yield) and 88% ee. Mp: 109-110 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.49 (dd, J = 11.5, 4.8 Hz, 3 H), 7.37-7.31 (m, 3 H), 7.25-7.22 (m, 1 H), 6.78 (dd, J = 7.7, 1.3 Hz, 1 H), 4.83-4.79 (m, 1 H), 3.84 (s, 3 H), 3.66 (t, J = 8.3 Hz, 1 H), 3.42 (d, J = 7.9 Hz, 1 H), 2.51 (d, J = 6.6 Hz, 1 H), 1.66 (s, 3 H), 1.21 (s, 9 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 175.83, 174.52, 172.60, 147.63, 135.80, 131.44, 130.66, 129.77, 129.65, 128.88, 128.76, 127.46, 122.05, 67.38, 61.44, 55.32, 52.71, 49.79, 35.63, 31.57, 23.86. ESI-MS calculated for C$_{25}$H$_{27}$BrN$_2$NaO$_4$: m/z (%): 521.1046 (M+H$^+$), found: 521.1056. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 1.0 mL/min, 220 nm); minor enantiomer tr = 9.6 min, major enantiomer tr = 21.2 min. $[\alpha]^D_{25} = -88.2$ (c = 0.25, CHCl$_3$).
3.39 Synthesis of methyl (1R,3S,3aR,6aS)-5-(2-(tert-butyl)phenyl)-3-(4-chlorophenyl)-1-methyl-4,6-dioxooctahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7aq).

Prepared according to general procedure C from N-(2-t-butylphenyl)maleimide 6 (37.8 mg, 0.165 mmol) and imino ester 2q (33.9 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 7aq as a white solid (56.7 mg, 83% yield) and 94% ee. Mp: 99-100 °C. 1H NMR (400 MHz, CDCl3) δ 7.49 (dd, J = 8.1, 1.4 Hz, 1 H), 7.42 (d, J = 8.5 Hz, 2 H), 7.33 (dd, J = 11.4, 5.1 Hz, 3 H), 7.26-7.22 (m, 1 H), 6.78 (dd, J = 7.7, 1.5 Hz, 1 H), 4.83 (d, J = 8.6 Hz, 1 H), 3.84 (s, 3 H), 3.69-3.64 (m, 1 H), 3.42 (d, J = 7.9 Hz, 1 H), 2.52 (s, 1 H), 1.67 (s, 3 H), 1.21 (s, 9 H). 13C NMR (101 MHz, CDCl3) δ 175.86, 174.56, 172.64, 147.66, 135.26, 133.90, 130.67, 129.79, 129.66, 128.91, 128.55, 128.43, 127.47, 67.40, 61.42, 55.36, 52.73, 49.88, 35.65, 31.58, 23.89. ESI-MS calculated for C25H27ClN2NaO4: m/z (%): 477.1552 (M+H+), found: 477.1563. Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 1.0 mL/min, 220 nm); minor enantiomer tr = 7.3 min, major enantiomer tr = 10.8 min. [α]D25 = -87.7 (c = 0.25, CHCl3).

3.40 Synthesis of methyl (1R,3S,3aR,6aS)-5-(2-(tert-butyl)phenyl)-1-methyl-4,6-dioxo-3-(p-tolyl)octahydropyrrolo[3,4-c]pyrrole-1-carboxylate (7ar).
Prepared according to general procedure C from N-(2-t-butylphenyl)maleimide 6 (37.8 mg, 0.165 mmol) and imino ester 2r (30.8 mg, 0.15 mmol) at -30 °C, after flash column chromatography (Petroleum ether : AcOEt = 2:1) afforded the product 7ar as a white solid (46.0 mg, 71% yield) and 88% ee. Mp: 86-87 °C. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.48 (dd, $J$ = 8.1, 1.2 Hz, 1 H), 7.36-7.32 (m, 3 H), 7.26-7.22 (m, 1 H), 7.17 (d, $J$ = 7.9 Hz, 2 H), 6.84 (dd, $J$ = 7.7, 1.3 Hz, 1 H), 4.84 (d, $J$ = 7.1 Hz, 1 H), 3.85 (s, 3 H), 3.68 (dd, $J$ = 19.3, 11.1 Hz, 1 H), 3.43 (d, $J$ = 7.9 Hz, 1 H), 2.67 (s, 1 H), 2.31 (s, 3 H), 1.68 (s, 3 H), 1.21 (s, 9 H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 176.12, 174.76, 172.81, 147.70, 137.91, 133.40, 130.79, 129.80, 129.68, 129.13, 128.89, 127.43, 126.89, 67.55, 62.25, 55.86, 52.73, 50.40, 35.68, 31.61, 23.95, 21.17. ESI-MS calculated for C$_{26}$H$_{30}$N$_2$NaO$_4$: m/z (%): 457.2098 (M+H$^+$), found: 457.2108.

Enantiomeric excess was determined by HPLC with a Chiralpak ASH column (hexanes: 2-propanol = 80:20, 1.0 mL/min, 210 nm); minor enantiomer tr = 6.8 min, major enantiomer tr = 10.7 min. $[\alpha]_D^{25} = -90.8$ (c = 0.25, CHCl$_3$)

3. $^1$H, $^{19}$F, $^{13}$C NMR and HPLC Spectra
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$\text{(S, R)-M8}$
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4. References


