Supporting Information for:

Highly Diastereoselective Samarium Diiodide Induced Cyclizations of New 3-Substituted Indole Derivatives

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General Remarks:
Reactions were generally performed under argon in dried flasks. Solvents and reagents were added by syringes. Solvents were dried using standard procedures. Triethylamine and diisopropylamine were distilled from potassium hydroxide and stored over potassium hydroxide under an atmosphere of argon. Dichloromethane was distilled from calcium hydride and stored over molecular sieves (4 Å) under an atmosphere of argon. Methanol was distilled from magnesium oxide and stored over molecular sieves (4 Å) under an atmosphere of argon. Hexamethylphosphoramide (HMPA) was distilled from calcium hydride (130 °C, 12 mbar) and stored over molecular sieves (4 Å) under argon.

Warning: HMPA has been identified as a carcinogenic reagent. Appropriate glove protection is required during handling. Reactions and chromatography should be performed in a well-vented hood.

Other reagents were purchased and were used as received without further purification unless otherwise stated.

Products were purified by flash chromatography on silica gel (32-63 µm) or HPLC (Nucleosil 50–5, diameter 16 mm, length 244 mm) and detection was carried out with a Knauer variable UV-detector (λ = 255 nm) and a Knauer refractometer. Unless otherwise stated, yields refer to analytically pure samples. Yields refer to chromatographically and spectroscopically (\(^1\)H-NMR) homogeneous materials, unless otherwise stated. Reactions were monitored by thin-layer chromatography (TLC). NMR spectra were recorded on Bruker (AM 250, AC 500) and JOEL (Eclipse 500) instruments. Chemical shifts are reported relative to TMS (\(^1\)H: \(\delta = 0.00\) ppm) and CDCl\(_3\) (\(^{13}\)C: \(\delta = 77.0\) ppm). Integrals are in accordance with assignments; coupling constants are given in Hz. All \(^{13}\)C spectra are proton-decoupled. Multiplicity is indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), m\(_c\) (centered multiplet), dd (doublet of doublet), br s (broad singlet). For detailed peak assignments 2D spectra were measured (COSY, HMQC, HMBC, NOESY and NOE if necessary). IR spectra were measured with a Nicolet 5 SXC FT-IR spectrometer or with a Nexus FT-IR spectrometer equipped with a Nicolet Smart DuraSampII ATR. MS and HRMS analyses were performed with Finnigan MAT 711 (EI, 80 eV, 8 kV), MAT CH7A (EI, 80 eV, 3 kV) and Varian Ionspec QFT-7 (ESI-FT ICRMS) instruments. Elemental analyses were carried out with Vario EL III. Melting points were measured with a Reichert apparatus Thermovar and are uncorrected.
General Procedures:

General Procedure for Acylation Reaction

SOCl₂ (1.3 equiv.) was added dropwise to the corresponding acid (1.0 equiv.). The resulting solution was stirred for 2 h under exclusion of water. The excess of SOCl₂ was evaporated under reduced pressure. The obtained acid chloride was dissolved in CH₂Cl₂ and added to a mixture of indole derivative (0.8-0.6 equiv.), DMAP (0.10-0.05 equiv.) and TEA (1.3-1.1 equiv.) in CH₂Cl₂ (5 mL/1.0 mmol). The resulting mixture was stirred overnight, then quenched with sat. aq. NH₄Cl solution and washed several times with water and brine. The organic phase was dried (MgSO₄), filtrated and the organic solvent evaporated under reduced pressure. The obtained residue was purified by column chromatography on silica gel.

General Procedure Samarium Diiodide Stock Solution:

SmI₂ was taken from a previously prepared stock solution (0.1 M in THF), which was prepared according to the following procedure: iodine (15.0 mmol, 1 equiv.) and samarium (18.0 mmol, 1.2 equiv.) were suspended in THF (150 mL, 10 mL/mmol I₂) under an argon atmosphere and stirred at room temperature until the colour of the solution turned into dark blue (1–5 h). The flask was then wrapped in aluminium foil to exclude light and stored at room temperature.

General Procedure for Samarium Diiodide-Induced Cyclizations with Proton Source:

To a solution of SmI₂ (2.4 equiv.) in THF was added HMPA (10.0 equiv.). The corresponding indole derivative (1.0 equiv.) and tBuOH (10.0 equiv.) were dissolved in THF (16 mL/mmole indole) and argon was bubbled through the solution for 10-20 min. The solution was added to the deep violet solution of SmI₂ in THF/HMPA. The mixture was stirred at room temperature for at least one hour (in most cases SmI₂ was consumed after a few minutes, the colour of the mixture turned from violet to yellow-grey). Sat. aq. NaHCO₃ solution was added, the organic layer was separated and the aq. layer was extracted three times with Et₂O. The combined organic layers were washed with water and brine, dried with MgSO₄ and the solvent was removed under reduced pressure. The crude product, which was contaminated with HMPA, was purified by flash-chromatography on silica gel and in singular cases additional purification by HLPC yielded the pure compounds.
General Procedure for Samarium Diiodide-Induced Cyclizations and Subsequent Alkylation:

To a solution of SmI$_2$ (2.4 equiv.) in THF was added HMPA (10.0 equiv.). The corresponding indole derivative (1.0 equiv.) and tBuOH (10.0 equiv.) were dissolved in THF (16 mL/mmol indole) and argon was bubbled through the solution for 10-20 min. The solution was added to the deep violet solution of SmI$_2$ in THF/HMPA. After the solution colour changed yellow-grew the alkylation reagent was added in one portion. The mixture was stirred at room temperature for at least one hour. Following work-up was done as stated above.

General Hydrogenation Procedure:

Hydrogen was bubbled either through a suspension washed Raney-Ni in MeOH (5-10 mL/mmol) for 2 h. Then a solution of the cyano compound in MeOH (3 mL/mmol) was added, and the mixture was stirred at room temperature under an atmosphere of hydrogen. Completion of the reaction was followed by TLC analysis. The solid residue was filtered off through a pad of silica gel and thoroughly washed with CH$_2$Cl$_2$/MeOH. The organic solvent was removed under reduced pressure, and the crude product was purified by column chromatography on silica gel.

General Alkylation Procedure with LDA

Freshly prepared LDA (0.5 M, THF) solution was added to indole derivative (5 mL THF/ 0.5 mmol indole) at -78 °C. After addition of HMPA (2.0-3.0 equiv) the solution was stirred at -78 °C for 20 min, then shortly warmed up to 0 °C and cooled to -78 °C again. Allyl iodide was added and the reaction was slowly warmed up to room temperature over night. The mixture was quenched with sat. aq. NH$_4$Cl and extracted three times with Et$_2$O. The combined organic phases were washed with water and brine, dried with MgSO$_4$ and evaporated. The crude mixture was purified by column chromatography on silica gel (hexane/EtOAc 9:1, 3:1).
Characterization: Starting Material for Samarium Diiodide Induced Cyclization

1-(4-Oxopentanoyl)-1H-indole-3-carbonitrile (1)

Yellow solid: 91%; 135-137 °C (Calcd for C_{14}H_{12}N_{2}O_{2}: C, 69.99; H, 5.03; N, 11.66%; found: C, 70.25; H, 5.17; N, 12.03%; $\nu_{\text{max}}$/cm$^{-1}$ = 3120-3070 (ArH), 2930 (CH), 2230 (CN), 1720, 1700 (CO), 1550 (CH); $\delta_{H}$(400 MHz, CDCl$_3$, Me$_4$Si): 2.28 (3H, s, 5-H), 2.99 (2H, t, $J$ = 5.9 Hz, 2-H), 3.21 (2H, t, $J$ = 5.9 Hz, 3-H), 7.43 (2H, m, ArH), 7.70 (1H, d, $J$ = 7.8 Hz, ArH), 8.11 (1H, s, ArH), 8.38 (1H, d, $J$ = 7.8 Hz, ArH); $\delta_{C}$(100 MHz, CDCl$_3$, Me$_4$Si): 29.6 (t, C-2), 29.9 (q, C-5), 37.1 (t, C-3), 94.2 (s, CN), 113.9 (s, Ar), 116.9, 119.7, 125.2, 127.1 (4d, Ar), 127.8 (s, Ar), 131.9 (d, Ar), 134.7, 170.0, 206.1 (3s, Ar, C-1, C-4); m/z (ESI-Tof): calcd for C$_{14}$H$_{12}$N$_2$O$_2$: 263.0791 [M+Na]$^+$; found 263.0800 [M+Na]$^+$).

2-(1-(4-Oxopentanoyl)-1H-indol-3-yl)acetonitrile (5)

Colourless solid: 55%; 98-99 °C (Calcd for C$_{15}$H$_{14}$N$_2$O$_2$: C, 70.85; H, 5.55; N, 11.02%; found: C, 71.02; H, 5.72; N, 10.86%; $\nu_{\text{max}}$/cm$^{-1}$: 3120-2900 (ArH, CH), 2250 (CN), 1785, 1710 (CO), 1565 (C=C); $\delta_{H}$(400 MHz, CDCl$_3$, Me$_4$Si): 2.30 (3H, s, 5-H), 2.98 (2H, t, $J$ = 6.0 Hz, 2-H), 3.22 (2H, t, $J$ = 6.0 Hz, 3-H), 3.80 (2H, s, CH$_2$CN), 7.34 (1H, dd, $J$ = 1.1, 7.6 Hz, ArH), 7.41 (1H, dt, $J$ = 1.1, 7.6 Hz, ArH), 7.51 (1H, dd, $J$ = 1.1, 7.6 Hz, ArH), 7.60 (1H, s, ArH), 8.42 (1H, d, $J$ = 8.4 Hz, ArH); $\delta_{C}$(100 MHz, CDCl$_3$, Me$_4$Si): 14.4 (t, CH$_2$CN), 29.5 (t, C-2), 29.9 (q, C-5), 37.1 (t, C-3), 111.6 (s, CN), 116.8, 118.0, 122.8, 123.9, 126.1 (5d, Ar), 128.3, 135.9 (2s, Ar), 169.9, 206.3 (2s, C-1, C-4)).
1-(5-Oxohexanoyl)-1H-indole-3-carbonitrile (9)

![Chemical structure of 9](image)

Colourless solid: 67%; 119-122 °C (Calcd for C_{15}H_{14}N_{2}O_{2}: C, 70.85; H, 5.55; N, 11.02%; found C, 70.50; H, 5.66; N, 11.03%; ν\text{max}/cm\(^{-1}\): 3110-3055 (ArH), 2990-2900 (CH), 2225 (CN), 1730, 1705 (CO), 1550 (C=C); δ\text{H} (500 MHz, CDCl\(_3\), Me\(_4\)Si): 2.11 (2H, t, J = 6.6 Hz, 3-H), 2.19 (3H, s, 6-H), 2.68 (2H, t, J = 6.6 Hz, 2-H), 3.01 (2H, t, J = 6.6 Hz, 4-H), 7.43 (1H, dd, J = 0.8, 7.8 Hz, ArH), 7.48 (1H, t, J = 7.8 Hz, ArH), 7.73 (1H, d, J = 7.8 Hz, ArH), 8.11 (s, 1H, ArH), 8.45 (1H, d, J = 8.3 Hz, ArH); δ\text{C} (100 MHz, CDCl\(_3\), Me\(_4\)Si): 18.3 (t, C-3), 30.0 (q, C-6), 34.6, 41.7 (2t, C-4, C-2), 94.1 (s, CN), 116.9, 119.7, 125.1, 127.0 (4d, Ar), 127.8 (s, Ar), 131.8 (d, Ar), 134.6, 170.5, 207.8 (3s, Ar, C-1, C-5); m/z (ESI-Tof): calcd for C_{15}H_{14}N_{2}O_{2}: 277.0947 [M+Na]^+, found: 277.0949 [M+Na]^+).

1-(3-(2-Oxocyclopentyl)propanoyl)-1H-indole-3-carbonitrile (13)

![Chemical structure of 13](image)

Colourless solid: 42%; 138-140 °C; (ν\text{max}/cm\(^{-1}\): 3120-3070 (ArH), 2960-2875 (CH), 2225 (CN), 1725 (br.s CO), 1555 (C=C); δ\text{H} (400 MHz, CDCl\(_3\), Me\(_4\)Si): 1.61 (1H, ddd, J = 5.1, 9.5, 17.0 Hz, 8-H), 1.85 (1H, m, 8-H), 1.98 (1H, td, J = 6.4, 14.3 Hz, 3-H), 2.00-2.40 (7H, m, 3-H, 4-H, 6-H, 7-H), 3.12 (1H, ddd, J = 6.4, 8.5, 16.6 Hz, 2-H), 3.21 (1H, ddd, J = 6.4, 8.5, 16.6 Hz, 2-H), 7.42 (1H, dt, J = 1.1, 7.6 Hz, ArH), 7.47 (1H, dt, J = 1.1, 7.6 Hz, ArH), 7.74 (1H, dd, J = 1.4, 7.6 Hz, ArH), 8.11 (1H, s, ArH), 8.45 (1H, d, J = 8.2 Hz, ArH); δ\text{C} (100 MHz, CDCl\(_3\), Me\(_4\)Si): 20.5, 24.4, 29.9, 33.2, 38.0 (5t, C-7, C-8, C-3, C-2, C-6 ), 47.5 (d, C-4), 94.0 (s, CN), 113.7, 116.9, 119.6, 125.1, 127.0 (4d, Ar), 127.9 (s, Ar), 131.9 (d, Ar), 134.7, 170.7, 220.7 (3s, Ar, C-1, C-5); m/z (ESI-Tof): calcd for C_{17}H_{16}N_{2}O_{2}: 303.1104 [M+Na]^+, found: 303.1132 [M+Na]^+).
Characterization:

Products of Samarium Diiodide Induced Cyclization

rac-(9S*,9aR*,10R*)-9-Hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile (2)

![Chemical structure of rac-(9S*,9aR*,10R*)-9-Hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile (2)](attachment:image)

Colourless solid: 89%; 195-200 °C (Calcd for C_{14}H_{14}N_{2}O_{2}: C 69.41, H 5.82, N 11.56%; found C 69.04, H 5.12, N 11.48%; \( \nu_{\text{max}}/\text{cm}^{-1} \): 3270 (OH), 3070 (ArH), 2990-2985 (CH), 2250 (CN), 1630 (CO), 1480 (C=C); \( \delta_{\text{H}} \) (500 MHz, CDCl\textsubscript{3}+ 5% DMSO-d\textsubscript{6}, Me\textsubscript{4}Si): 1.31 (3H, s, 9-CH\textsubscript{3}), 2.01 (1H, ddd, \( J = 2.0, 7.9, 13.2 \) Hz, 8-H), 2.11 (1H, m\textsubscript{c}, 8-H), 2.58 (1H, ddd \( J = 7.9, 11.5, 18.8 \) Hz, 7-H), 2.74 (1H, ddd, \( J = 2.0, 7.9, 18.8 \) Hz, 7-H), 4.39 (1H, d, \( J = 10.6 \) Hz, 10-H), 4.51 (1H, d, \( J = 10.6 \) Hz, 9a-H), 4.72 (1H, s, OH), 7.17 (1H, dt, \( J = 1.0, 7.6 \) Hz, 2-H), 7.34 (1H, t, \( J \sim 7.6 \) Hz, 3-H), 7.44 (1H, d, \( J = 7.6 \) Hz, 1-H), 8.18 (1H, d, \( J = 8.1 \) Hz, 4-H); \( \delta_{\text{C}} \) (100 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): 19.5 (q, 9-CH\textsubscript{3}), 30.9 (t, C-7), 33.1 (d, C-10), 35.6 (t, C-8), 68.9 (s, C-9), 71.1 (d, C-9a), 117.1 (d, C-4), 118.9 (s, CN), 124.0 (s, Ar), 124.2, 124.7, 129.7 (3d, C-1, C-3, C-2), 141.7, 167.2 (2s, Ar, C-6); m/z (ESI-Tof): calcd for C_{14}H_{14}N_{2}O_{2}: 243.1134 [M+H]\textsuperscript{+}, 265.0948 [M+Na]\textsuperscript{+}; found 243.1137 [M+H]\textsuperscript{+}, 265.0958 [M+Na]\textsuperscript{+}).

rac-(9S*,9aR*,10S*)-9-Hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile (3)

![Chemical structure of rac-(9S*,9aR*,10S*)-9-Hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile (3)](attachment:image)

Colorless solid: 22%; 135°C (\( \nu_{\text{max}}/\text{cm}^{-1} \): 3310 (OH), 3120 (ArH), 2990-2850 (CH), 2240 (CN), 1735 (CO), 1640 (CO), 1590 (C=C); \( \delta_{\text{H}} \) (400 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): 1.67 (1H, s, 9-CH\textsubscript{3}), 2.04 (2H, m\textsubscript{c}, 8-H), 2.64 (1H, m\textsubscript{c}, 7-H), 2.79 (1H, ddd, \( J = 4.5, 7.5, 18.1 \) Hz, 7-H), 4.41 (1H, d, \( J = 9.7 \) Hz, 9a-H), 4.51 (1H, d, \( J = 9.7 \) Hz, 10-H), 7.17 (1H, dt, \( J = 0.6, 7.6 \) Hz, 2-H), 7.37 (1H, t, \( J = 7.9 \) Hz, 3-H), 7.42 (1H, d, \( J = 7.5 \) Hz, 1-H), 8.23 (1H, d, \( J = 8.2 \) Hz, 4-H); \( \delta_{\text{C}} \) (100 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): 21.0 (q, 9-CH\textsubscript{3}), 30.9 (t, C-7), 32.6 (d, C-10), 37.3 (t, C-8), 67.0 (d, C-9a), 70.8 (s, C-9), 117.3 (s, CN), 117.8 (d, C-4), 123.6 (s, Ar), 124.8, 125.1, 130.4 (3d,
C-1, C-2, C-3), 142.3, 167.7 (2s, Ar, C-6); m/z (ESI-Tof): calcd for C_{14}H_{14}N_{2}O_{2}: 243.1134 [M+H]^+, 265.0948 [M+Na]^+; found 243.1139 [M+H]^+, 265.0956 [M+Na]^+.

**rac-(9S*,9aR*,10S*)-10-Allyl-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile (4, entry 1)**

![Chemical structure of rac-(9S*,9aR*,10S*)-10-Allyl-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile](image)

Colourless solid: 48 %, based on recovered starting material; 120-123 °C (Calcd for C_{17}H_{18}N_{2}O_{2}: C 72.32, H 6.43, N 9.92%; found: C 71.85, H 6.19, N 9.80%; \(\nu_{\text{max}}/\text{cm}^{-1}\): 3460 (OH), 3115-3020 (ArH), 2975-2880 (CH), 1655 (CO), 1595 (C=C); \(\delta_{H}\) (500 MHz, CDCl\(_3\), Me\(_4\)Si): 1.50 (3H, s, 9-CH\(_3\)), 1.94 (1H, m, 8-H), 2.04 (1H, m, 8-H), 2.59 (1H, td, \(J = 8.2, 18.0\) Hz, 7-H), 2.76 (1H, ddd, \(J = 4.6, 9.1, 18.0\) Hz, 7-H), 2.82 (2H, m, 10-CH\(_2\)), 4.14 (1H, s, 9a-H), 5.25 (2H, m, CH=CH\(_2\)) 5.73 (1H, dddd, \(J = 6.6, 9.1, 18.0\) Hz, 7-H), 7.15 (1H, dt, \(J = 1.1, 7.6\) Hz, 2-H), 7.33 (1H, ddd, \(J = 1.3, 7.6, 8.2\) Hz, 3-H), 7.39 (1H, ddd, \(J = 0.5, 1.2, 7.6\) Hz, 1-H), 8.20 (1H, dd, \(J = 0.4, 8.2\) Hz, 4-H); \(\delta_{C}\) (100 MHz, CDCl\(_3\), Me\(_4\)Si): 20.7 (q, 9-CH\(_3\)), 31.0, 37.6, 44.4 (3t, C-7, C-8, 10-CH\(_2\)), 46.4 (s, C-10), 71.0 (d, C-9a), 71.3 (s, C-9), 116.7 (d, C-4), 120.3 (s, CN), 121.9 (t, CH=CH\(_2\)), 123.8, 124.8, 128.0 (3d, C-1, C-2, CH=CH\(_2\)), 130.1 (s, Ar), 130.3 (d, C-3), 141.5, 168.2 (2s, Ar, C-6); m/z (ESI-Tof): calcd for C_{17}H_{18}N_{2}O_{2}: 305.1266 [M+Na]^+, found: 305.1256 [M+Na]^+.

**rac-(9S*,9aR*,10S*)-10-(Cyanomethyl)-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile (4, entry 2)**

![Chemical structure of rac-(9S*,9aR*,10S*)-10-(Cyanomethyl)-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile](image)

Colourless solid: 43%; 163-165 °C (Calcd for C_{16}H_{15}N_{3}O_{2}: C 68.31, H 5.37, N 14.94%; found: C 67.89, H 5.49, N 14.29%; \(\nu_{\text{max}}/\text{cm}^{-1}\): 3470 (OH), 3110-3010 (ArH), 2970-2855 (CH), 2270, 2240 (CN), 1665 (CO), 1600 (C=C); \(\nu_{\text{max}}/\text{cm}^{-1}\): 3470 (OH), 3110-3010 (ArH), 2970-2855 (CH), 2270, 2240 (CN), 1665 (CO), 1600 (C=C); \(\delta_{H}\) (500 MHz, CDCl\(_3\), Me\(_4\)Si): 1.64 (1H, s, 9-CH\(_3\)), 1.97 (1H, ddd, \(J = 2.5, 7.7, 13.0\) Hz, 8-H), 2.06 (1H, m, 8-H), 2.63 (1H, ddd, \(J = 7.8, 11.1, 18.7\) Hz, 7-H), 2.74 (1H, ddd, \(J = 2.5, 7.7, 18.7\) Hz, 7-H), 3.32 (1H, d, \(J = 16.8\) Hz, 10-CH\(_2\)), 3.46 (1H, d, \(J = 16.8\) Hz, 10-CH\(_2\)), 4.17 (1H, s, 9a-H), 4.36 (1H, s, OH), 7.23 (1H, dt, \(J = 7.8, 11.1\) Hz, 2-H), 7.33 (1H, ddd, \(J = 1.3, 7.6, 8.2\) Hz, 3-H), 7.39 (1H, ddd, \(J = 0.5, 1.2, 7.6\) Hz, 1-H), 8.20 (1H, dd, \(J = 0.4, 8.2\) Hz, 4-H); \(\delta_{C}\) (100 MHz, CDCl\(_3\), Me\(_4\)Si): 20.7 (q, 9-CH\(_3\)), 31.0, 37.6, 44.4 (3t, C-7, C-8, 10-CH\(_2\)), 46.4 (s, C-10), 71.0 (d, C-9a), 71.3 (s, C-9), 116.7 (d, C-4), 120.3 (s, CN), 121.9 (t, CH=CH\(_2\)), 123.8, 124.8, 128.0 (3d, C-1, C-2, CH=CH\(_2\)), 130.1 (s, Ar), 130.3 (d, C-3), 141.5, 168.2 (2s, Ar, C-6); m/z (ESI-Tof): calcd for C_{17}H_{18}N_{2}O_{2}: 305.1266 [M+Na]^+, found: 305.1256 [M+Na]^+.


= 1.2, 7.7 Hz, 2-H), 7.41 (1H, dt, J = 1.2, 8.2 Hz, 3-H), 7.55 (1H, d, J = 7.7 Hz, 1-H), 8.28 (1H, d, J = 8.2 Hz, 4-H); δC (100 MHz, CDCl₃, Me₄Si): 19.9 (q, 9-CH₃), 28.9, 31.0, 38.3 (3t, 10-CH₂, C-7, C-8), 42.5 (s, C-10), 70.3 (s, C-9), 72.3 (d, C-9a), 114.7 (s, CN), 117.4 (d, C-4), 117.9 (s, CN), 123.2, 125.4 (2d, C-1, C-2), 125.9 (s, Ar), 131.4 (d, C-3), 141.8, 167.4 (2s, Ar, C-6); m/z (ESI-Tof): calcd for C₁₆H₁₅N₃O₂: 304.1057 [M+Na]+, 320.0801 [M+K]+, found: 304.1077 [M+Na]+, 320.0794 [M+K]+).

rac-(9S*,9aR*,10S*)-tert-Butyl-2-(10-cyano-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indol-10-yl)acetate (4, entry 3)

Yellow oil: 32% (νmax/cm⁻¹: 3430 (OH), 3180-3070 (ArH), 2975-2930 (CH), 2240 (CN), 1725 (CO), 1665-1645 (CO), 1595 (C=C); δH (500 MHz, CDCl₃, Me₄Si): 1.39 (9H, s, C(CH₃)₃), 1.55 (3H, s, 9-CH₃), 1.99 (1H, ddd, J = 4.1, 8.2, 13.3 Hz, 8-H), 2.05 (1H, dtd, J = 0.7, 8.8, 13.3 Hz, 8-H), 2.62 (1H, mc, 7-H), 2.77 (1H, ddd, J = 4.2, 8.6, 18.1 Hz, 7-H), 2.99 (1H, d, J = 15.8 Hz, 10-CH₂), 3.16 (1H, d, J = 15.8 Hz, 10-CH₂), 3.29 (1H, br.s, OH), 4.47 (1H, s, 9a-H), 7.17 (1H, dt, J = 1.0, 7.7 Hz, 2-H), 7.36 (1H, dt, J = 1.3, 8.2 Hz, 3-H), 7.42 (1H, dd, J = 0.7, 7.7 Hz, 1-H), 8.24 (1H, dd, J = 0.4, 8.2 Hz, 4-H); δC (125 MHz, CDCl₃, Me₄Si): 20.5 (q, 9-CH₃), 27.8 (q, C(CH₃)₃), 30.8, 37.7, 42.4 (3t, C-7, C-8, 10-CH₂), 45.9 (s, C-10), 71.1 (s, C-9), 72.5 (d, C-9a), 83.4 (s, CO₂C(CH₃)₃), 116.9 (d, C-4), 119.2 (s, CN), 123.5, 124.8 (2d, C-1, C-2), 127.5 (s, Ar), 130.6 (d, C-3), 141.5, 168.0, 168.3 (3s, Ar, C-6, CO₂C(CH₃)₃); m/z (ESI-Tof): calcd for C₂₉H₃₄N₂O₄: 537.1814 [M+H]+, 379.1634 [M+Na]+, 395.1373 [M+K]+, found: 357.1824 [M+H]+, 379.1643 [M+Na]+, 395.1386 [M+K]+).

rac-((9S*,9aR*,10R*)- Ethyl (10-cyano-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indol-10-yl)acetate (4, entry 4)

Yellow oil: 41%; based on recovered starting material (νmax/cm⁻¹: 3430 (OH), 3180-3070 (ArH), 2985-2935 (CH), 2240 (CN), 1720 (CO), 1670-1645 (CO), 1595 (C=C); δH (700 MHz,
CDCl$_3$, Me$_4$Si): 1.19 (2H, t, $J = 7.16$ Hz, CH$_2$CH$_3$), 1.55 (3H, s, 9-CH$_3$), 1.96 (1H, ddd, $J = 3.8$, 8.2, 13.3 Hz, 1H, 8-H), 2.03 (1H, td, $J = 9.3$, 13.3 Hz, 8-H), 2.68-2.55 (1H, m, c, 7-H), 2.74 (1H, ddd, $J = 3.8$, 8.6, 18.1, Hz, 7-H), 3.08 (1H, d, $J = 16.2$ Hz, 10-CH$_2$), 3.23 (1H, s, 9a-H), 4.25-4.09 (2H, m, C$_2$H$_5$CH$_3$), 4.43 (1H, s, 9a-H), 7.15 (1H, dt, $J = 1.1$, 7.6 Hz, 1-H), 7.35 (1H, ddd, $J = 1.3$, 7.6, 8.2 Hz, 3-H), 7.41 (1H, dd, $J = 0.8$, 7.6 Hz, 2-H), 8.22 (1H, d, $J = 8.2$ Hz, 4-H); $\delta$C (100 MHz, CDCl$_3$, Me$_4$Si): 13.9 (q, CH$_2$C$_2$H$_3$), 20.3 (q, 9-CH$_3$), 30.8, 37.8 (2t, C-7, C-8), 42.3 (s, C-10), 44.5 (t, 10-CH$_2$), 61.8 (t, C$_2$H$_5$CH$_3$), 72.5 (d, C-9a), 80.0 (s, C-9), 116.9 (d, C-4), 119.1 (s, CN), 123.4, 124.9 (2d, C-2, C-3), 127.5 (s, Ar), 130.6 (d, C-1), 141.5, 168.1, 169.0 (3s, Ar, CO$_2$Et); m/z (ESI-Tof): calcd for C$_{18}$H$_{20}$N$_2$O$_4$: 351.1315 [M+Na]$^+$, found: 351.1328 [M+Na]$^+$.

rac-(9$^S$*,9a$^R$*,10R*)-10-Cyano-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carboxylic acid ethyl ester (4, entry 5)

![Chemical structure](image)

Yellow oil: 67% ($\nu_{\text{max}}$/cm$^{-1}$: 3400 (OH), 3120-3075 (ArH), 2980-2940 (CH), 2245 (CN), 1745 (CO), 1660, 1645 (CO), 1590 (C=C); $\delta$H (500 MHz, CDCl$_3$, Me$_4$Si): 1.39 (3H, t, $J = 14.3$ Hz, CH$_2$CH$_3$), 1.63 (3H, s, 9-CH$_3$), 2.02 (2H, m, 8-H), 2.63 (1H, m, 7-H), 2.81 (1H, ddd, $J = 4.1$, 7.3, 18.4 Hz, 7-H), 2.97 (1H, s, OH), 4.39 (2H, ddd, $J = 7.1$, 14.2, 14.3 Hz, C$_2$H$_5$CH$_3$), 4.97 (1H, s, 9a-H), 7.16 (1H, dt, $J = 1.0$, 7.7 Hz, 2-H), 7.39 (1H, dt, $J = 1.3$, 8.0 Hz, 3-H), 7.43 (1H, dd, $J = 0.7$, 7.7 Hz, 1-H), 8.22 (1H, d, $J = 8.0$ Hz, 4-H); $\delta$C (100 MHz, CDCl$_3$, Me$_4$Si): 13.9 (q, CH$_2$CH$_3$), 20.5 (q, 9-CH$_3$), 30.8, 37.5 (2t, C-7, C-8), 50.9, 64.4 (2t, CH$_2$CH$_3$), 70.2 (s, C-9), 71.5 (d, C-9a), 116.2 (s, CN), 117.6 (d, C-4), 123.7 (d, C-1), 125.0 (s, Ar), 125.3, 131.2 (d, C-2, C-3), 141.7, 166.2, 167.8 (3s, Ar, C-6, CO$_2$Et); m/z (ESI-Tof): calcd for C$_{17}$H$_{18}$N$_2$O$_4$: 315.1339 [M+H]$^+$, 337.1159 [M+Na]$^+$, found: 315.1369 [M+H]$^+$, 337.1189 [M+Na]$^+$.

rac-(9$^S$*,9a$^R$*,10S*)-10-Benzyl-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carbonitrile (4, entry 6)

rac-(9$^S$*,9a$^R$*,10R*)-10-Cyano-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-carboxylic acid ethyl ester (4, entry 5)

![Chemical structure](image)

Yellow oil: 67% ($\nu_{\text{max}}$/cm$^{-1}$: 3400 (OH), 3120-3075 (ArH), 2980-2940 (CH), 2245 (CN), 1745 (CO), 1660, 1645 (CO), 1590 (C=C); $\delta$H (500 MHz, CDCl$_3$, Me$_4$Si): 1.39 (3H, t, $J = 14.3$ Hz, CH$_2$CH$_3$), 1.63 (3H, s, 9-CH$_3$), 2.02 (2H, m, 8-H), 2.63 (1H, m, 7-H), 2.81 (1H, ddd, $J = 4.1$, 7.3, 18.4 Hz, 7-H), 2.97 (1H, s, OH), 4.39 (2H, ddd, $J = 7.1$, 14.2, 14.3 Hz, C$_2$H$_5$CH$_3$), 4.97 (1H, s, 9a-H), 7.16 (1H, dt, $J = 1.0$, 7.7 Hz, 2-H), 7.39 (1H, dt, $J = 1.3$, 8.0 Hz, 3-H), 7.43 (1H, dd, $J = 0.7$, 7.7 Hz, 1-H), 8.22 (1H, d, $J = 8.0$ Hz, 4-H); $\delta$C (100 MHz, CDCl$_3$, Me$_4$Si): 13.9 (q, CH$_2$CH$_3$), 20.5 (q, 9-CH$_3$), 30.8, 37.5 (2t, C-7, C-8), 50.9, 64.4 (2t, CH$_2$CH$_3$), 70.2 (s, C-9), 71.5 (d, C-9a), 116.2 (s, CN), 117.6 (d, C-4), 123.7 (d, C-1), 125.0 (s, Ar), 125.3, 131.2 (d, C-2, C-3), 141.7, 166.2, 167.8 (3s, Ar, C-6, CO$_2$Et); m/z (ESI-Tof): calcd for C$_{17}$H$_{18}$N$_2$O$_4$: 315.1339 [M+H]$^+$, 337.1159 [M+Na]$^+$, found: 315.1369 [M+H]$^+$, 337.1189 [M+Na]$^+$.
Colourless oil: 35% ($\nu_{\text{max}}$/cm$^{-1}$: 3390 (OH), 3085-3030 (ArH), 2925-2850 (CH), 2235 (CN), 1640 (CO), 1595 (C=C); $\delta_{\text{H}}$ (400 MHz, CDCl$_3$, Me$_4$Si): 1.46 (3H, s, 9-CH$_3$), 1.92 (1H, ddd, $J$ = 5.1, 8.4, 13.5 Hz, 8-H), 2.00 (1H, m, 8-H), 2.56 (1H, ddd, $J$ = 7.5, 8.4, 17.7 Hz, 7-H), 2.72 (1H, ddd, $J$ = 5.1, 9.3, 17.7 Hz, 7-H), 3.26 (1H, d, $J$ = 13.5 Hz, 10-CH$_2$), 3.45 (1H, d, $J$ = 13.5 Hz, 10-CH$_2$), 4.23 (1H, s, 9a-H), 7.06 (1H, dd, $J$ = 1.3, 7.6 Hz, 1-H), 7.10 (3H, m, Ph), 7.28 (3H, m, 2-H, Ph), 7.33 (1H, m, 3-H), 8.16 (1H, d, $J$ = 8.2 Hz, 4-H); $\delta_{\text{C}}$ (100 MHz, CDCl$_3$, Me$_4$Si): 21.0 (q, 9-CH$_3$), 30.8, 37.3 (2t, C-7, C-8), 45.8 (s, C-10), 48.1 (t, 10-CH$_2$), 71.1 (d, C-9a), 71.5 (s, C-9), 116.5 (d, Ar), 120.5 (s, Ar), 124.3, 124.6 (2d, Ar), 127.6 (s, Ar), 128.0, 128.4, 130.3, 130.9 (4d, Ar), 133.1, 141.5, 168.2 (3s, Ph, Ar, C-6); m/z (ESI-Tof): calcd C$_{21}$H$_{20}$N$_2$O$_2$: 355.1417 [M+Na]$^+$, found 355.1429 [M+Na]$^+$.

\textit{rac-(9S*,9aR*,10R*)-Benzyl 10-Cyano-9-hydroxy-9-methyl-6-oxo-7,8,9a,10-hexahydropyrido[1,2-ajindole-10-carboxylate (4, entry 7) }

Colourless oil: 61% ($\nu_{\text{max}}$/cm$^{-1}$: 3390 (OH), 3090-3030 (ArH), 2970-2890 (CH), 2245 (CN), 1750 (CO), 1645 (CO), 1590 (C=C); $\delta_{\text{H}}$ (500 MHz, CDCl$_3$, Me$_4$Si): 1.62 (3H, s, 9-CH$_3$), 2.04 (2H, m, 8-H), 2.64 (1H, m, 7-H), 2.81 (1H, ddd, $J$ = 4.9, 6.9, 18.3 Hz, 7-H), 4.96 (1H, s, 9a-H), 5.33 (1H, d, $J$ = 12.1 Hz, CH$_2$Bn), 5.40 (1H, d, $J$ = 12.1 Hz, CH$_2$Bn), 7.09 (1H, dt, $J$ = 0.9, 7.6 Hz, 2-H), 7.31 (1H, dd, $J$ = 0.7, 7.8 Hz, 1-H), 7.38 (6H, m, Ph, 3-H), 8.22 (1H, dd, $J$ = 0.5, 8.2 Hz, 4-H); $\delta_{\text{C}}$ (100 MHz, CDCl$_3$, Me$_4$Si): 20.6 (q, 9-CH$_3$), 30.7, 37.5 (2t, C-7, C-8), 51.0 (s, C-10), 69.7 (t, CH$_2$Bn), 70.4 (s, C-9), 71.4 (d, C-9a), 116.0 (s, CN), 117.5 (d, C-4), 123.9 (d, C-1) 124.6 (s, Ar), 125.2, 128.3, 128.7, 128.9, 131.3 (5d, C-2, Ph, C-3), 134.0, 141.7, 166.0, 167.5 (4s, Ar, 10-CO$_2$Bn, C-6); m/z (ESI-Tof): calcd C$_{22}$H$_{20}$N$_2$O$_4$: 377.1496 [M+H]$^+$, 399.1315 [M+Na]$^+$, 415.1055 [M+K]$^+$; found: 377.1495 [M+H]$^+$, 399.1313 [M+Na]$^+$, 415.1051 [M+K]$^+$.
rac-(9S*, 9aR*, 10S*)-9-Hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indole-10-yl-acetonitrile (6)

![Structural formula of 6]

Colourless solid: 90%; 193-194 °C (Calcd for C_{15}H_{16}N_{2}O_{2}: C 70.29, H 6.29, N 10.93%; found C 70.01, H 6.34, N 10.87%; ν_{max}/cm\(^{-1}\): 3210 (OH), 3045 (ArH), 2965-2900 (CH), 2245 (CN), 1635 (CO), 1600-1590 (C=C); δ_{H} (400 MHz, CDCl\(_3\), Me\(_4\)Si): 1.33 (3H, s, 9-CH\(_3\)), 1.86 (1H, s, OH), 1.99 (1H, ddd, J = 2.5, 7.9, 13.0 Hz, 8-H), 2.07 (1H, m\(_{c}\), 8-H), 2.59 (1H, ddd, J = 8.0, 11.3, 18.5 Hz, 7-H), 2.75 (1H, ddd, J = 2.5, 8.0 18.5 Hz, 7-H), 2.93 (1H, dd, J = 6.5, 17.0 Hz, 10-CH\(_2\)), 3.09 (1H, dd, J = 4.3, 17.0 Hz, 10-CH\(_2\)), 3.74 (1H, m\(_{c}\), 10-H), 4.00 (1H, d, J = 9.7 Hz, 9a-H), 7.14 (1H, dd, J = 1.0, 7.5 Hz, 2-H), 7.31 (1H, t, J = 7.8 Hz, 3-H), 7.39 (1H, d, J = 7.5 Hz, 1-H), 8.20 (1H, d, J = 8.1 Hz, 4-H); δ_{C} (100 MHz, CDCl\(_3\), Me\(_4\)Si): 20.6 (q, 9-CH\(_3\)), 21.4 (q, 9-CH\(_3\)), 31.0, 36.5 (2t, C-7, C-8), 68.7 (d, C-9a), 72.1 (s, C-9), 104.2 (t, =CH\(_2\)), 116.9, 120.1, 124.1 (3d, C-4, C-1, C-2), 128.9 (s, Ar), 130.1 (d, C-3), 141.7, 143.7 (2s, Ar), 168.0 (s, C-6); m/z (ESI-Tof): calcd for C\(_{15}\)H\(_{16}\)N\(_2\)O\(_2\): 230.1176 [M+H]\(^+\), 252.0995 [M+Na]\(^+\), found 230.1177 [M+H]\(^+\), 252.0996 [M+Na]\(^+\).

rac-(9S*, 9aR*)-9-Hydroxy-9-methyl-10-methylene-8,9,9a,10-tetrahydropyrido[1,2-a]indol-6(7H)-one (8)

![Structural formula of 8]

Colourless oil: 60% (ν_{max}/cm\(^{-1}\): 3370 (OH), 3120-3050 (ArH), 2970-2855 (CH, C=CH\(_2\)), 1635 (CO), 1595 (C=C); δ_{H} (400 MHz, CDCl\(_3\), Me\(_4\)Si): 1.17 (3H, s, 9-CH\(_3\)), 2.01 (1H, ddd, J = 4.1, 7.7, 13.7 Hz, 8-H), 2.12 (1H, ddd, J = 7.7, 8.8, 13.7 Hz, 8-H), 2.60 (1H, m\(_{c}\), 7-H), 2.78 (1H, ddd, J = 6.2, 8.8, 17.4 Hz, 7-H), 4.68 (1H, t, J = 2.8 Hz, 9a-H), 5.44 (1H, d, J = 2.6 Hz, 10-CH\(_2\)), 5.64 (1H, d, J = 2.6 Hz, 10-CH\(_2\)), 7.09 (1H, t, J = 7.6 Hz, 2-H), 7.29 (1H, d, J = 8.6 Hz, 3-H), 7.49 (1H, d, J = 7.6 Hz, 1-H), 8.22 (1H, d, J = 8.6 Hz, 4-H); δ_{C} (100 MHz, CDCl\(_3\), Me\(_4\)Si): 21.4 (q, 9-CH\(_3\)), 31.0, 36.5 (2t, C-7, C-8), 68.7 (d, C-9a), 72.1 (s, C-9), 104.2 (t, =CH\(_2\)), 116.9, 120.1, 124.1 (3d, C-4, C-1, C-2), 128.9 (s, Ar), 130.1 (d, C-3), 141.7, 143.7 (2s, Ar), 168.0 (s, C-6); m/z (ESI-Tof): calcd for C\(_{14}\)H\(_{15}\)NO\(_2\): 230.1176 [M+H]\(^+\), 252.0995 [M+Na]\(^+\), found 230.1177 [M+H]\(^+\), 252.0996 [M+Na]\(^+\).
**rac-(9S*,9aR*,10R*)-10-Hydroxy-10-methyl-6-oxo-7,8,9,10a,11-hexahydro-6H-azepino[1,2-a]indole-11-carbonitrile (10)**

![Structure of rac-(9S*,9aR*,10R*)-10-Hydroxy-10-methyl-6-oxo-7,8,9,10a,11-hexahydro-6H-azepino[1,2-a]indole-11-carbonitrile (10)](image)

Colourless solid: 42%; 198-200 °C (for C_{15}H_{16}N_{2}O_{2}: C 70.29, H 6.29, N 10.93%; found C 69.98, H 6.31, N 10.84%; ν_{max}/cm^{-1}: 3315 (OH), 3125-3035 (ArH), 2995-2865 (CH), 2240 (CN), 1635 (CO), 1595 (C=C); δ_{H} (400 MHz, CDCl_{3}, Me_{4}Si): 0.89 (3H, s, 10-CH_{3}), 1.70 (1H, dddd, J = 1.7, 3.7, 11.3, 14.0 Hz, 8-H), 1.87 (1H, dt, J = 3.5, 13.1 Hz, 9-H), 1.95 (1H, m, 8-H), 2.04 (1H, dt, J = 3.4, 13.1 Hz, 9-H), 2.64 (2H, m, 7-H), 4.62 (1H, d, J = 3.9 Hz, 10a-H), 4.76 (1H, d, J = 3.9 Hz, 11-H), 7.09 (1H, t, J = 7.5 Hz, 2-H), 7.29 (1H, t, J = 7.5 Hz, 3-H), 7.33 (1H, d, J = 7.5 Hz, 1-H), 8.17 (1H, d, J = 8.3 Hz, 4-H); δ_{C} (100 MHz, CDCl_{3}, Me_{4}Si): 18.6 (q, 10-CH_{3}), 20.3 (t, C-9), 32.6 (d, C-11), 38.5, 45.1 (2t, C-8, C-7), 71.3 (d, C-10a), 71.6 (s, C-10), 117.6 (d, C-4), 119.9 (s, CN), 124.1 (s, Ar), 124.5, 124.9, 130.0 (3d, C-1, C-2, C-3), 142.8, 172.4 (2s, Ar, C-6); m/z (ESI-Tof): calcd for C_{15}H_{16}N_{2}O_{2}: 257.1285 [M+H]^{+}, 279.1104 [M+Na]^{+}, 295.0843 [M+K]^{+}, found: 257.1292 [M+H]^{+}, 279.1112 [M+Na]^{+}, 295.0853 [M+K]^{+}).

**rac-(2aS*,10bS*,10cR*)-2a-Methyl-2a,3,4,5,10b,10c-hexahydro-2-oxa-6a-azabenzo[a]cyclopenta[cd]azulene-1,6-dione (11)**

![Structure of rac-(2aS*,10bS*,10cR*)-2a-Methyl-2a,3,4,5,10b,10c-hexahydro-2-oxa-6a-azabenzo[a]cyclopenta[cd]azulene-1,6-dione (11)](image)

Colourless solid: 39%; 157-160 °C (for C_{15}H_{15}NO_{3}: C 70.02, H 5.88, N 5.44%; found C 69.52, H 5.77, N 5.89%; ν_{max}/cm^{-1}: 3105-3050 (ArH), 3000-2855 (CH), 1775 (CO), 1670 (CO), 1595 (C=C); δ_{H} (500 MHz, CDCl_{3}, Me_{4}Si): 1.02 (3H, s, 2a-CH_{3}), 1.25 (1H, br.s, OH), 1.92 (1H, m, 4-H), 2.04 (1H, m, 3-H), 2.11 (1H, m, 4-H), 2.21 (1H, ddd, J = 2.4, 4.1, 12.1 Hz, 3-H), 2.70 (1H, ddd, J = 2.2, 5.6, 14.3 Hz, 5-H), 2.93 (1H, dt, J = 2.9, 13.9 Hz, 5-H), 4.47 (1H, d, J = 10.3 Hz, 10b-H), 4.88 (1H, d, J = 10.3 Hz, 10c-H), 7.14 (1H, dt, J = 0.8, 7.5 Hz, 7-H), 7.34 (1H, t, J = 7.8 Hz, 8-H), 7.49 (1H, d, J = 7.6 Hz, 10-H), 8.10 (1H, d, J = 8.1 Hz, 7-H); δ_{C} (100 MHz, CDCl_{3}, Me_{4}Si): 19.9 (q, 2a-CH_{3}), 20.7, 38.4, 38.6 (3t, C-3, C-4, C-5), 46.6, 67.0 (2d, C-10b, C-10c), 86.4 (s, C-2a), 116.3 (d, C-7), 124.6 (s, Ar), 124.8, 124.8, 129.6 (3d, C-10, C-9, C-8), 143.0, 171.4, 172.9 (3s, Ar, C-6, C-1); m/z (ESI-Tof): Calcd for...
C_{15}H_{15}NO_{3}: 258.11247 [M+H]^+; 280.0944 [M+Na]^+; found: 258.1130 [M+H]^+; 280.0950 [M+Na]^+.

rac-(10S\textsuperscript{a})-10-Hydroxy-10-methyl-6-oxo-7,8,9,10-tetrahydro-6H-azepino[1,2-a]indole-11-carboxylic acid (12)

Colourless solid: 7%; (\nu_{\text{max}}/\text{cm}^{-1}): 3400 (OH), 3100-3030 (ArH), 3005-2850 (CH), 1775 (CO), 1700 (CO), 1595 (C=C); \delta_H (500 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): 0.90 (3H, s, 10-CH\textsubscript{3}), 1.89 (1H, m, 8-H), 2.09 (2H, m, 8-H, 9-H), 2.21 (1H, m, 9-H), 2.68 (1H, m, 7-H), 2.94 (1H, dt, J = 2.7, 14.0 Hz, 7-H), 4.65 (1H, s, OH), 4.77 (1H, s, CO\textsubscript{2}H), 7.20 (1H, dt, J = 0.9, 7.5 Hz, 7-H), 7.45 (dt, 1H, J = 1.3, 7.9 Hz, 3-H), 7.60 (1H, dd, J = 0.7, 7.6 Hz, 1-H), 8.14 (d, 1H, J = 8.2 Hz, 4-H); \delta_C (100 MHz, CDCl\textsubscript{3} + 10% d\textsubscript{6}-Aceton, Me\textsubscript{4}Si): 19.6 (q, 10-CH\textsubscript{3}), 20.8, 38.2, 39.1 (3t, C-9, C-8, C-7), 74.4, 79.8, 82.9 (3s, C-10, C-10a, C-11), 116.4, 124.8, 124.9 (3d, C-4, C-3, C-2), 128.8 (s, Ar), 131.5 (d, C-1), 143.7, 171.6, 173.8 (3s, Ar, C-6, 11-CO\textsubscript{2}H); m/z (ESI-Tof): Calcd for C_{15}H_{15}NO_{3}: 296.0893 [M+Na]^+; found 296.0884 [M+Na]^+.

rac-(3aR\textsuperscript{a},11R\textsuperscript{a},11aR\textsuperscript{a},11bS\textsuperscript{a})-11b-Hydroxy-6-oxo-1,2,3,3a,4,5,6,11a,11b-decahydrocyclopenta[3,4]azepino[1,2-a]indole-11-carbonitrile (14)

Colourless solid: 41%; 182-183 °C (Calcd for C_{17}H_{18}N_{2}O_{3}: C 72.32, H 6.43, N 9.92%; found C, 72.35, H 5.58, N 9.81%); (\nu_{\text{max}}/\text{cm}^{-1}): 3310 (OH), 3120-3025 (ArH), 2970-2870 (CH), 2235 (CN), 1650 (br s CO), 1595 (C=C); \delta_H (500 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): 1.33 (1H, m, 3-H), 1.39 (1H, ddd, J = 3.1, 9.5, 12.6 Hz, 1-H), 1.50 (2H, m, 4-H, 3-H), 1.75 (2H, m, 2-H), 1.91 (1H, ddd, J = 2.9, 6.3, 14.6 Hz, 4-H), 2.11 (1H, td, J = 6.1, 12.4 Hz, 1-H), 2.20 (1H, m, 3a-H), 2.61 (1H, dd, J = 7.6, 14.0 Hz, 5-H), 2.76 (1H, t, J = 13.1 Hz, 5-H), 3.01 (s, 1H, OH), 4.71 (1H, d, 1H, J = 4.1 Hz, 11a-H), 4.95 (1H, d, J = 4.1 Hz, 11-H), 7.13 (1H, dt, J = 0.9, 7.6 Hz, 9-H), 7.33 (1H, t, J = 7.9 Hz, 8-H), 7.36 (1H, d, J = 7.6 Hz, 10-H), 8.19 (1H, d, J = 8.2 Hz, 7-H); \delta_C
(100 MHz, CDCl₃, Me₄Si): 19.7, 27.2, 27.3, 30.3 (4t, C-2, C-4, C-3, C-1), 33.5 (d, C-11), 36.5 (t, C-5), 52.0, 68.0 (2d, C-3a, C-11a), 82.4 (s, C-11b), 117.6 (d, C-7), 119.8, 123.8 (2s, CN, Ar), 124.5, 124.6, 129.9 (3d, C-10, C-9, C-8), 142.5, 172.8 (2s, Ar)).

**rac-(3aR*,10bS*,12aS*,12bR*)-1,2,3,3a,4,5,10b,12-Octahydro-6H,11H-12-oxa-6a-azabenzo[adicyclopenta[cd,e]azulene-6,11-dione (15)**

![Chemical Structure](image)

Colourless solid: 40%; decomposition > 110 °C (Calcd for C₁₇H₁₇NO₃: C, 72.07; H, 6.05; N, 4.94%; found: C, 71.85; H, 6.14; N, 5.15%; νmax/cm⁻¹: 3070-3050 (ArH), 2975-2875 (CH), 1770 (br.s. CO), 1660 (CO), 1595 (C=C); δH (400 MHz, CDCl₃, Me₄Si): 1.08 (1H, m, 3-H), 1.47 (3H, m, 3-H, 2-H), 1.60 (1H, s, OH), 1.76 (2H, m, 1-H), 2.02 (2H, m, 4-H, 3-H), 2.36 (1H, m, 3a-H), 2.58 (1H, ddd, J = 2.2, 6.2, 14.1 Hz, 5-H), 3.02 (1H, dt, J = 2.6, 14.1 Hz, 5-H), 4.43 (1H, d, J = 9.8 Hz, 10b-H), 5.18 (1H, d, J = 9.8 Hz, 12b-H), 7.14 (1H, dt, J = 1.0, 7.5 Hz, 9-H), 7.34 (1H, m, 8-H), 7.47 (1H, d, J = 7.6 Hz, 10-H), 8.10 (1H, d, J = 8.1 Hz, 7-H); δC (100 MHz, CDCl₃, Me₄Si): 19.3, 27.9, 28.7, 29.8, 37.3 (5t, C-3a, C-4, C-3, C-2, C-1, C-5), 46.1, 47.4, 62.8 (3d, C-3a, C-10b, C-12b), 96.4 (s, C-12a), 116.6 (d, C-7), 124.4 (s, Ar), 125.1, 125.1, 129.8 (3d, C-10, C-9, C-8), 142.5 (s, Ar), 171.6, 172.9 (2s, C-6, C-11); m/z (ESI-Tof): Calcd for C₁₇H₁₇NO₃: 284.1281 [M+H]⁺, 306.1101 [M+Na]⁺, found: 284.1278 [M+H]⁺, 306.1098 [M+Na]⁺.

**rac-(7R*,9S*,9aR*,10S*)-7,10-Diallyl-9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-ajindole-10-carbonitrile (17)**

![Chemical Structure](image)

Colourless oil: 83 % (νmax/cm⁻¹: 3075-3060 (ArH), 2990-2870 (CH), 1770 (CO), 1620, 1595 (C=C); δH (400 MHz, CDCl₃, Me₄Si): 1.57 (s, 3H, 9-CH₃), 1.78 (1H, ddd, J = 1.0, 10.5, 13.0 Hz, 8-H), 2.03 (1H, dd, J = 8.2, 13.0 Hz, 8-H), 2.26 (1H, s, OH), 2.51 (1H, dddd, J = 1.0, 2.1, 7.3, 13.8 Hz, 7-CH₂), 2.66 (1H, m, 7-CH₂), 2.74 (1H, ddd, J = 4.0, 8.3, 10.5 Hz, 7-H), 2.85 (1H, dd, J = 8.3, 14.0 Hz, 10-CH₂), 2.92 (1H, tdd, J = 1.4, 6.2, 14.0 Hz, 10-CH₂), 5.12 (1H,
tdd, $J = 1.0, 2.0, 10.1$ Hz, CH=CH$_2$), 5.18 (1H, m, CH=CH$_2$), 5.26 (1H, t, J = 1.6, 2.7, 17.0 Hz, CH=CH$_2$), 5.29 (1H, d, J = 1.0, 2.2, 10.1 Hz, CH=CH$_2$), 5.77 (2H, m, CH=CH$_2$), 7.17 (1H, dt, J = 1.1, 7.6 Hz, 2-H), 7.35 (1H, d, J = 1.3, 7.6, 8.2 Hz, 3-H), 7.40 (1H, d, J = 0.6, 1.3, 7.6 Hz, 1-H), 7.28 (1H, dd, J = 0.6, 1.1, 8.2 Hz, 4-H); $\delta_C$ (100 MHz, CDCl$_3$, Me$_4$Si): 20.1 (q, 9-CH$_3$), 37.2 (t, C-8'), 40.9 (d, C-7), 43.9 (t, 10-CH$_2$), 44.3 (s, C-10), 46.6 (t, 7-CH$_2$), 71.0 (s, C-9), 71.2 (d, C-9a), 117.1 (d, C-4), 118.5 (t, =CH$_2$), 120.5 (s, CN), 121.9 (t, =CH$_2$), 123.8, 125.0 (2d, C-1, C-3), 127.9 (s, Ar), 130.4 (d, C-2), 130.5, 134.4 (2d, CH=CH$_2$), 141.9, 169.7 (2s, Ar, C-6); m/z (ESI-Tof): Calcd for C$_{20}$H$_{22}$N$_2$O$_2$: 323.1754 [M+H]$^+$, 345.1573 [M+Na]$^+$; found: 323.1757 [M+H]$^+$, 345.1579 [M+Na]$^+$.

**rac-(9S*,9aR*,10R*)-9-(tert-Butyl-dimethylsilyloxy)-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-ajindole-10-carbonitrile (18)**

![Chemical Structure](image)

Colourless solid: 95%, 115-118 °C (Calcd for C$_{20}$H$_{28}$N$_2$O$_2$Si : C 67.37, H 7.92, N 7.86%; found C 67.35, H 8.02, N 7.76%; $\nu$max/cm$^{-1}$: 2965-2855 (ArH, CH), 2245 (CN), 1660, 1650 (CO), 1600 (C=C); $\delta_H$ (500 MHz, CDCl$_3$, Me$_4$Si): 0.20 (3H, s, SiCH$_3$), 0.21 (3H, s, SiCH$_3$), 0.95 (9H, s, Si(CH$_3$)$_3$), 1.33 (3H, s, 9-CH$_3$), 2.09 (1H, dd, J = 9.2, 4.4 Hz, 8-H), 2.54 (1H, td, J = 9.4, 18.9 Hz, 7-H), 2.76 (1H, d, J = 5.7, 4.2, 18.6 Hz, 7-H), 4.31 (1H, d, J = 10.2 Hz, 10-H), 4.44 (1H, d, J = 10.2 Hz, 9a-H), 7.15 (1H, t, J = 7.5 Hz, 2-H), 7.32 (1H, t, J = 7.8 Hz, 3-H), 7.42 (1H, d, J = 7.5 Hz, 1-H), 8.16 (1H, d, J = 8.1 Hz, 4-H); $\delta_C$ (100 MHz, CDCl$_3$, Me$_4$Si): -1.9, -1.8 (2q, SiCH$_3$), 17.9 (s, Si(CH$_3$)$_3$), 20.4 (q, 9-CH$_3$), 25.6 (q, C(CH$_3$)$_3$), 30.8 (t, C-8), 33.2 (d, C-10), 36.0 (t, C-7), 71.7 (d, C-9a), 72.4 (s, C-9), 117.2 (d, C-4), 118.6 (s, CN), 124.0 (s, Ar), 124.3, 124.9, 129.8 (3d, C-1, C-2, C-3), 141.7, 166.8 (2s, Ar, C-6)).

**rac-(9S*,9aR*,10S*)-10-Allyl-9-(tert-butyl-dimethylsilyloxy)-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-ajindole-10-carbonitrile (19)**

![Chemical Structure](image)
Colourless solid: 93%, 143-146 °C (ν\textsubscript{max}/cm\textsuperscript{-1}: 3080-3010 (ArH), 2950-2860 (CH), 2235 (CN), 1660 (CO), 1595 (C=C); δ\textsubscript{H} (500 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): 0.19 (3H, s, SiCH\textsubscript{3}), 0.26 (3H, s, SiCH\textsubscript{3}), 0.96 (9H, s, SiC(CH\textsubscript{3})\textsubscript{2}), 1.56 (3H, s, 9-CH\textsubscript{3}), 2.01 (2H, m, 8-H), 2.57 (1H, m, 7-H), 2.73 (1H, ddd, J = 3.7, 8.6, 18.2 Hz, 7-H), 2.79 (1H, dd, J = 8.7, 13.9 Hz, 9-CH\textsubscript{2}), 2.99 (1H, dd, J = 5.8, 13.9 Hz, 9-CH\textsubscript{2}), 4.11 (1H, s, 9a-H), 5.20 (1H, d, J = 17.0 Hz, =CH\textsubscript{2}), 5.24 (1H, d, J = 10.1 Hz, =CH\textsubscript{2}), 5.63 (1H, ddd, J = 5.8, 8.8, 10.0 Hz, CH=CH\textsubscript{2}), 7.14 (1H, t, J = 7.5 Hz, 2-H), 7.32 (1H, t, J = 7.8 Hz, 3-H), 7.39 (1H, d, J = 7.8 Hz, 1-H), 8.22 (1H, d, J = 8.1 Hz, 4-H); δ\textsubscript{C} (100 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): -2.1, -1.6 (2q, SiCH\textsubscript{3}), 18.1 (s, SiC(CH\textsubscript{3})\textsubscript{3}), 20.3 (q, 9-CH\textsubscript{3}), 25.9 (q, C(CH\textsubscript{3})\textsubscript{2}), 30.9, 38.4, 44.2 (3t, C-7, C-8, 10-CH\textsubscript{2}), 46.3 (s, C-10), 71.5 (s, C-9), 73.9 (d, C-9a), 116.7 (d, C-4), 120.2 (s, CN), 121.7 (t, =CH\textsubscript{2}), 123.9, 124.7 (2d, C-1, C-2), 128.3 (s, Ar), 130.1, 130.6 (2d, C-3, CH=CH\textsubscript{2}), 141.6, 167.7 (2s, Ar, C-6); m/z (ESI-Tof): calcd for C\textsubscript{23}H\textsubscript{32}N\textsubscript{2}O\textsubscript{2}Si: 370.2197 [M-CN]\textsuperscript{+}, 419.2125 [M+Na]\textsuperscript{+}, found: 370.2213 [M-CN]\textsuperscript{+}, 419.2148 [M+Na]\textsuperscript{+}.

**rac-(9S*,9aR*,10R*)-tert-Butyl-(9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-ajindol-10-yl)methylcarbamate (20)**

Colourless solid: 91%; 204-206 °C (ν\textsubscript{max}/cm\textsuperscript{-1}: 3310 (OH), 3045 (ArH), 2900-2855 (CH), 1705 (CO), 1625 (CO), 1590 (C=C); δ\textsubscript{H} (400 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): 1.30 (3H, s, 9-CH\textsubscript{3}), 1.44 (9H, s, C(CH\textsubscript{3})\textsubscript{3}), 1.97 (1H, m, 8-H), 2.03 (1H, ddd, J = 2.6, 7.9, 12.9 Hz, 8-H), 2.58 (1H, ddd, J = 7.9, 10.9, 18.6 Hz, 7-H), 2.71 (1H, ddd, J = 2.6, 7.6, 18.6 Hz, 7-H), 3.45 (1H, dd, J = 8.8, 19.4 Hz, 10-CH\textsubscript{2}), 3.57 (1H, m, 10-H), 3.90 (1H, m, 10-CH\textsubscript{2}), 3.96 (1H, d, J = 9.8 Hz, 9a-H), 4.11 (1H, s, OH), 5.34 (1H, s, NH), 7.10 (1H, dt, J = 0.9, 7.4 Hz, 2-H), 7.22 (1H, d, J = 7.4 Hz, 1-H), 7.26 (1H, t, J ~ 7.7 Hz, 3-H), 8.21 (1H, d, J = 8.1 Hz, 4-H); δ\textsubscript{C} (100 MHz, CDCl\textsubscript{3}, Me\textsubscript{4}Si): 20.0 (q, 9-CH\textsubscript{3}), 28.3 (q, C(CH\textsubscript{3})\textsubscript{3}), 31.3, 37.3 (2t, C-7, C-8), 43.2 (d, C-10), 69.8 (t, CH\textsubscript{2}NHBoc), 70.1 (s, C-9), 80.1 (s, CO\textsubscript{2}C(CH\textsubscript{3})\textsubscript{3}), 116.9, 123.1, 124.3, 128.4 (4d, C-4,
C-1, C-2, C-3), 130.6, 142.6, 157.1, 167.8 (4s, 2Ar, CO′Bu, C-6); m/z (ESI-Tof): calcd for C_{19}H_{26}N_{2}O_{4}: 369.1785 [M+Na]^{+}, found: 369.1790 [M+Na]^{+}.

rac-(9S*,9aR*,10R*)-tert-Butyl-2-(9-hydroxy-9-methyl-6-oxo-7,8,9,9a,10-hexahydropyrido[1,2-a]indol-10-yl)ethylcarbamate (21)

Colourless solid: 97%; 136-138 °C (ν_{max}/cm^{-1}: 3330, 3245 (NH, OH), 3065-3005 (ArH), 2975-2880 (CH), 1685-1675, 1640 (CO), 1550 (C=C); δ_{H} (500 MHz, CDCl_{3}, Me_{4}Si): 1.21 (3H, s, 9-CH_{3}), 1.45 (9H, s, C(CH_{3})_{3}), 1.87 (1H, tdd, J = 4.7, 9.3, 14.0 Hz, 10-CH_{2}), 1.95 (1H, m, 8-H), 2.05 (2H, m, 8-H, 10-CH_{2}), 2.55 (2H, td, J = 8.1, 17.7 Hz, 7-H), 2.73 (1H, ddd, J = 5.0, 8.4, 17.7 Hz, 7-H), 3.19 (1H, m, CH_{2}NHBoc), 3.49 (1H, ddd, J = 2.9, 7.0, 16.0 Hz, 10-H), 3.64 (1H, m, CH_{2}NHBoc), 3.97 (1H, d, J = 7.0 Hz, 9a-H), 4.52 (1H, s, OH), 4.94 (1H, t, J = 6.0 Hz, NH), 7.06 (1H, dt, J = 1.0, 7.5 Hz, 2-H), 7.17 (1H, d, J = 7.5 Hz, 1-H), 7.21 (1H, t, J ~ 7.7 Hz, 3-H), 8.18 (1H, d, J = 8.0 Hz, 4-H); δ_{C} (125 MHz, CDCl_{3}, Me_{4}Si): 21.0 (q, 9-CH_{3}), 28.3 (q, C(CH_{3})_{3}), 31.1, 36.3, 37.9, 38.4 (4t, C-7, C-8, 10-CH_{2}, CH_{2}NHBoc), 39.0 (d, C-10), 70.4 (s, C-9), 73.7 (d, C-9a), 80.1 (s, C(CH_{3})_{3}), 116.4, 123.7, 124.0, 127.9 (4d, C-4, C-1, C-2, C-3), 133.5, 142.0, 157.1, 168.5 (4s, 2Ar, CO′Bu, C-6); m/z (ESI-Tof): calcd. for C_{20}H_{28}N_{2}O_{4}: 383.1941 [M+Na]^{+}, 399.1680 [M+K]^{+}, found: 383.1924 [M+Na]^{+}, 399.1593 [M+K]^{+}. 