Supporting information for:

Titanium- and Lewis Acid-Mediated Cyclopropanation of Imides

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I - General

All reactions were conducted under an atmosphere of dry argon using standard Schlenk techniques. Diethylether and THF were distilled from sodium benzophenone ketyl prior to use. Ti(Oi-Pr)₄ was used as received. Grignard reagents were titrated in THF by menthol in the presence of orthophenanthroline. Flash chromatography was performed with silica gel 60 (Merck, 40–63 μm). ¹H and ¹³C NMR spectra were recorded in CDCl₃ on a Bruker AC-250 or DRX-500 spectrometer. Chemical shifts were measured in δ (ppm) and coupling constants *J* in Hz (solvent peak reference: δ = 7.26 for ¹H, 77.0 for ¹³C). IR spectra were recorded on a Nicolet Avatar 320 instrument. Mass spectra were recorded on a ThermoFinnigan Trace MS spectrometer. High Resolution Mass Spectra (HRMS) were performed on Q-TOF Micro micromass positive ESI (CV=30 V).

II – Preparation of imides

Known *N*-substituted imides **1a-1d** were prepared by alkylation of succinimide, glutarimide or *cis*-hexahydrophthalimide with benzyl bromide or 1-bromobutane following a reported procedure.¹ **7a-7e** were obtained similarly from 3-butenyl methanesulfonate or 4-pentenyl methanesulfonate.

***N*-Benzyl- α -(diethylamino)succinimide (1e)**

¹ - Gesson, J. P.; Jacquesy, J. C.; Rambaud, D. *Bull. Chem. Soc. Fr.* **1992**, 129, 227-231.

Diethylamine (3 mL) was added to *N*-benzylmaleimide (2.24 g, 12 mmol). The mixture was stirred overnight. After evaporation of the excess amine, the crude material was purified by chromatography (hexanes – EtOAc 70/30) to afford 2.12 g (68%) of **1e** as a white solid.

Mp 83 °C

IR (KBr): ν (cm⁻¹) 1772, 1694, 1423, 1401, 1333, 1190, 1164.

¹H NMR (CDCl₃, 500 MHz): δ (ppm) 1.06 (t, *J* = 7.1 Hz, 6 H), 2.49-2.65 (m, 5 H), 2.81 (dd, *J* = 18.5, 9.0 Hz, 1 H), 4.01 (dd, *J* = 8.9, 5.2 Hz, 1 H), 4.63 (d, *J* = 14.0 Hz, 1 H), 4.68 (d, *J* = 14.0 Hz, 1 H), 7.12-7.31 (m, 5 H).

¹³C NMR (CDCl₃, 125 MHz): δ (ppm) 13.4 (2 CH₃), 31.9 (CH₂), 42.1 (CH₂), 44.6 (2 CH₂), 59.0 (CH), 127.9 (CH), 128.6 (2 CH), 128.8 (2 CH), 135.7 (C), 175.0 (C), 177.1 (C).

MS (EI): *m/z* (%) 245 (M-15, 5), 187 (100), 159 (23), 130 (42), 106 (43), 58 (60).

HRMS (ES): *m/z* (%) 261.1596 (MH⁺ C₁₅H₂₁N₂O₂ requires 261.1603)

III - Cyclopropanation of imides 1a-1e

General procedure: To a solution of the imide (1 mmol) and MeTi(Oi-Pr)₃ (1.5 mmol) in THF (10 mL) was added dropwise under argon the Grignard reagent (1.5 mmol). The yellow solution darkened gradually within 5 minutes. After stirring for 1.5 h, BF₃•OEt₂ was added (2 mmol). After 30 min, the dark mixture was quenched with water (10 mL). EtOAc (20 mL) was added, followed by a saturated aqueous solution of NaHCO₃ (ca 10 mL, basic pH). The mixture was stirred until the blue aqueous solution become white. The aqueous phase was extracted twice with EtOAc. After drying (MgSO₄) and evaporation of the solvents, the crude material was purified by flash-chromatography (hexanes-EtOAc).

4-benzyl-4-azaspiro[2.4]heptan-5-one (4a)

Mp 45-46 °C

IR (film): ν (cm⁻¹) 1684, 1408, 1350, 1225.

¹H NMR (CDCl₃, 250 MHz): δ (ppm) 0.45-0.53 (m, 2 H), 0.75-0.83 (m, 2 H), 2.06 (t, *J* = 8.0 Hz, 2 H), 2.62 (t, *J* = 8.0 Hz, 2 H), 4.20 (s, 2 H), 7.13-7.35 (m, 5 H).

¹³C NMR (CDCl₃, 63 MHz): δ (ppm) 7.5 (2 CH₂), 28.9 (CH₂), 30.5 (CH₂), 41.5 (CH₂), 42.9 (C), 126.7 (2 CH), 127.0 (CH), 128.4 (2 CH), 137.7 (C), 175.1 (C).

MS (EI): *m/z* (%) 201 (M⁺, 55), 173 (38), 145 (49), 143 (49), 117 (46), 91 (100).

HRMS (ES): 202.1239 (MH⁺ C₁₃H₁₆NO requires 202.1232)

4-Butyl-4-azaspiro[2.4]heptan-5-one (4b)

IR (film): ν (cm⁻¹) 1683, 1469, 1413, 1224.

¹H NMR (CDCl₃, 250 MHz): δ (ppm) 0.55-0.60 (m, 2 H), 0.83-0.88 (m, 2 H), 0.88 (t, *J* = 7.2 Hz, 3 H), 1.21-1.49 (m, 4 H), 2.02 (t, *J* = 8.0 Hz, 2 H), 2.48 (t, *J* = 8.0 Hz, 2 H), 2.81 (dd, *J* = 7.8, 7.3 Hz, 2 H).

¹³C NMR (CDCl₃, 63 MHz): δ (ppm) 7.8 (2 CH₂), 13.5 (CH₃), 20.0 (CH₂), 28.7 (CH₂), 30.2 (CH₂), 30.9 (CH₂), 37.8 (CH₂), 42.2 (C), 174.5 (C).

MS (EI): *m/z* (%) 167 (M⁺, 10), 138 (100), 112 (49).

HRMS (ES): 190.1200 (MNa⁺ C₁₀H₁₇NONa requires 190.1208)

cis 2'-Benzylhexahydrospiro[cyclopropane-1,1'-isoindol]-3'(2'H)-one (4c)

Mp 91-92 °C.

IR (KBr): ν (cm⁻¹) 1671, 1415, 1343, 1228.

¹H NMR (CDCl₃, 250 MHz): δ (ppm) 0.46-0.62 (m, 3 H), 0.76-0.80 (m, 1 H), 1.04-1.31 (m, 3 H), 1.45-1.65 (m, 4 H), 1.75-1.84 (m, 1 H), 2.20-2.29 (m, 1 H), 2.75-2.82 (m, 1 H), 3.91 (d, *J* = 15.7 Hz, 1 H), 4.47 (d, *J* = 15.7 Hz, 1 H), 7.18-7.28 (m, 5 H).

¹³C NMR (CDCl₃, 63 MHz): δ (ppm) 3.4 (CH₂), 6.3 (CH₂), 23.2 (CH₂), 23.2 (CH₂), 23.7 (CH₂), 26.3 (CH₂), 40.2 (CH), 41.5 (CH), 42.1 (CH₂), 46.4 (C), 127.1 (CH), 127.2 (2 CH), 128.5 (2 CH), 138.3 (C), 176.3 (C).

MS (EI): *m/z* (%) 255 (M⁺, 44), 145 (74), 144 (36), 91 (100).

HRMS (ES): 278.1509 (MNa⁺ C₁₇H₂₁NONa requires 278.1521)

4-Benzyl-4-azaspiro[2.5]octan-5-one (4d)

Mp 44-45 °C.

IR (film): ν (cm⁻¹) 1628, 1404, 1325, 1252.

¹H NMR (CDCl₃, 500 MHz): δ (ppm) 0.53-0.56 (m, 2 H), 0.86-0.88 (m, 2 H), 1.63 (t, J = 6.8 Hz, 2 H), 1.93 (q, J = 6.9 Hz, 2 H), 2.63 (t, J = 7.1 Hz, 2 H), 4.45 (s, 2 H), 7.17-7.22 (m, 3 H), 7.27-7.30 (m, 2 H).

¹³C NMR (CDCl₃, 125 MHz): δ (ppm) 11.1 (2 CH₂), 19.2 (CH₂), 32.1 (CH₂), 33.2 (CH₂), 39.7 (C), 44.6 (CH₂), 126.5 (2 CH), 126.7 (CH), 128.3 (2 CH), 138.5 (C), 173.1 (C).

MS (EI): m/z (%) 215 (M⁺, 74), 187 (94), 186 (86), 104 (61), 91 (100).

HRMS (ES): 216.1385 (MH⁺ C₁₄H₁₈NO requires 216.1388)

4-Benzyl-6-(diethylamino)-4-azaspiro[2.4]heptan-5-one (4e)

IR (film): ν (cm⁻¹) 1684, 1410, 1345, 1227.

¹H NMR (CDCl₃, 500 MHz): δ (ppm) 0.44-0.53 (m, 2 H), 0.72-0.76 (m, 1 H), 0.84-0.89 (m, 1 H), 1.13 (t, J = 7.1 Hz, 6 H), 1.96 (dd, J = 12.7, 8.9 Hz, 1 H), 2.22 (dd, J = 12.7, 9.1 Hz, 1 H), 2.65 (dq, J = 12.8, 7.1 Hz, 2 H), 2.80 (dq, J = 12.8, 7.1 Hz, 2 H), 3.97 (d, J = 15.9 Hz, 1 H), 4.00 (t, J = 8.9 Hz, 1 H), 4.44 (d, J = 15.9 Hz, 1 H), 7.17-7.31 (m, 5 H).

¹³C NMR (CDCl₃, 125 MHz): δ (ppm) 6.9 (CH₂), 8.1 (CH₂), 13.7 (2 CH₃), 32.2 (CH₂), 40.2 (C), 41.6 (CH₂), 44.8 (2 CH₂), 61.4 (CH), 126.9 (2 CH), 127.1 (CH), 128.5 (2 CH), 137.9 (C), 174.3 (C).

MS (EI): m/z (%) 272 (M⁺, 4), 244 (6), 201 (10), 172 (14), 145 (23), 117 (21), 91 (100).

HRMS (ES): 273.1974 (MH⁺ C₁₇H₂₅N₂O requires 273.1967)

(1*R, 3*R**) 4-Benzyl-1-ethyl-4-azaspiro[2.4]heptan-5-one (1*R**, 3*R**-4f)**

Less polar diastereoisomer (relative configuration determined by NOE)

IR (film): ν (cm^{-1}) 1674, 1454, 1413, 1378.

^1H NMR (CDCl_3 , 500 MHz): δ (ppm) 0.65 (t, $J = 6.3$ Hz, 1 H), 0.70-0.74 (m, 1 H), 0.79 (dd, $J = 9.4, 6.4$ Hz, 1 H), 0.97 (t, $J = 7.4$ Hz, 3 H), 1.31-1.35 (m, 1 H), 1.42-1.46 (m, 1 H), 1.68 (dd, $J = 11.7, 8.5$ Hz, 1 H), 2.32-2.36 (m, 1 H), 2.44-2.49 (m, 1 H), 2.63-2.68 (m, 1 H), 3.86 (d, $J = 16.1$ Hz, 1 H), 5.02 (d, $J = 16.1$ Hz, 1 H), 7.18-7.32 (m, 5 H).

^{13}C NMR (CDCl_3 , 125 MHz): δ (ppm) 13.6 (CH_2), 14.2 (CH_3), 21.9 (CH_2), 25.7 (CH), 31.1 (CH_2), 33.0 (CH_2), 44.7 (CH_2), 47.1 (C), 126.7 (2 CH), 127.0 (CH), 128.5 (2 CH), 137.9 (C), 176.7 (C).

MS (EI): m/z (%) 229 ($\text{M}^{+\bullet}$, 10), 200 (36), 159 (31), 91 (100).

HRMS (ES): 252.1354 (MH^+ $\text{C}_{15}\text{H}_{19}\text{NONa}$ requires 252.1364)

(1*R, 3*S**) 4-Benzyl-1-ethyl-4-azaspiro[2.4]heptan-5-one (1*R**, 3*S**-4f)**

More polar diastereoisomer (relative configuration determined by NOE)

IR (film): ν (cm^{-1}) 1684, 1454, 1409.

^1H NMR (CDCl_3 , 500 MHz): δ (ppm) 0.13 (t, $J = 6.3$ Hz, 1 H), 0.85-0.89 (m, 4 H), 0.95-0.99 (m, 1 H), 1.21-1.27 (m, 2 H), 1.85-1.90 (m, 1 H), 2.15-2.24 (m, 1 H), 2.52-2.64 (m, 2 H), 4.08 (d, $J = 16.1$ Hz, 1 H), 4.33 (d, $J = 16.1$ Hz, 1 H), 7.15-7.30 (m, 5 H).

^{13}C NMR (CDCl_3 , 125 MHz): δ (ppm) 13.5 (CH_2), 13.6 (CH_3), 19.2 (CH), 22.3 (CH_2), 24.5 (CH_2), 30.5 (CH_2), 41.6 (CH_2), 46.3 (C), 126.6 (2 CH), 127.0 (CH), 128.5 (2 CH), 137.9 (C), 174.9 (C).

MS (EI): m/z (%) 229 ($\text{M}^{+\bullet}$, 7), 200 (22), 159 (31), 91 (100).

HRMS (ES): 252.1363 (MH^+ $\text{C}_{15}\text{H}_{19}\text{NONa}$ requires 252.1364)

(1*R, 3*R**) 1,4-Dibenzyl-4-azaspiro[2.4]heptan-5-one (1*R**, 3*R**-4g)**

Less polar diastereoisomer (relative configuration determined by NOE)

IR (film): ν (cm^{-1}) 1694, 1495, 1453, 1407.

^1H NMR (CDCl_3 , 500 MHz): δ (ppm) 0.86 (t, $J = 7.0$ Hz, 1 H), 0.93 (dd, $J = 9.6, 7.1$ Hz, 1 H), 1.06 (dq, $J = 9.6, 7.2$ Hz, 1 H), 1.68 (dd, $J = 11.7, 7.9$ Hz, 1 H), 2.33 (td, $J = 11.8, 8.6$ Hz, 1 H), 2.42 (ddd, $J = 16.1, 8.6, 1.0$ Hz, 1 H), 2.53 (ddd, $J = 16.1, 11.8, 7.9$ Hz, 1 H), 2.66 (dd, $J = 15.0, 7.5$ Hz, 1 H), 2.70 (dd, $J = 15.0, 7.2$ Hz, 1 H), 4.00 (d, $J = 16.1$ Hz, 1 H), 5.10 (d, $J = 16.1$ Hz, 1 H), 7.12-7.30 (m, 10 H).

^{13}C NMR (CDCl_3 , 125 MHz): δ (ppm) 13.9 (CH_2), 25.0 (CH), 31.1 (CH_2), 32.5 (CH_2), 34.4 (CH_2), 45.0 (CH_2), 47.2 (C), 126.2 (CH), 126.7 (2 CH), 127.1 (CH), 127.9 (2 CH), 128.5 (2 CH), 128.6 (2 CH), 137.8 (C), 141.1 (C), 176.8 (C).

MS (EI): m/z (%) 291 ($\text{M}^{+\bullet}$, 1), 200 (28), 187 (13), 91 (100).

HRMS (ES): 292.1698 (MH^+ $\text{C}_{20}\text{H}_{22}\text{NO}$ requires 292.1701)

(1*R, 3*S**) 1,4-Dibenzyl-4-azaspiro[2.4]heptan-5-one (1*R**, 3*S**-4g)**

More polar diastereoisomer (relative configuration determined by NOE)

IR (film): ν (cm^{-1}) 1684, 1453, 1409.

^1H NMR (CDCl_3 , 500 MHz): δ (ppm) 0.36 (t, $J = 6.5$ Hz, 1 H), 1.05 (dd, $J = 10.1, 6.4$ Hz, 1 H), 1.40 (ddt, $J = 10.1, 7.9, 6.7$ Hz, 1 H), 1.96 (ddd, $J = 12.7, 9.6, 5.1$ Hz, 1 H), 2.23 (ddd, $J = 12.7, 9.6, 7.9$ Hz, 1 H), 2.49 (ddd, $J = 16.9, 9.7, 5.1$ Hz, 1 H), 2.51 (dd, $J = 15.6, 7.9$ Hz, 1 H), 2.61 (ddd, $J = 16.9, 9.5, 7.9$ Hz, 1 H), 2.68 (dd, $J = 15.6, 6.7$ Hz, 1 H), 4.10 (d, $J = 15.9$ Hz, 1 H), 4.40 (d, $J = 15.9$ Hz, 1 H), 7.00 (d, $J = 6.9$ Hz, 2 H), 7.15-7.29 (m, 8 H).

^{13}C NMR (CDCl_3 , 125 MHz): δ (ppm) 13.9 (CH_2), 17.7 (CH), 24.7 (CH_2), 30.4 (CH_2), 34.8 (CH_2), 41.8 (CH_2), 46.7 (C), 126.1 (CH), 126.9 (2 CH), 127.2 (CH), 127.8 (2 CH), 128.4 (2 CH), 128.6 (2 CH), 137.9 (C), 140.4 (C), 174.9 (C).

MS (EI): m/z (%) 291 ($\text{M}^{+\bullet}$, 1), 200 (24), 187 (6), 91 (100).

HRMS (ES): 292.1693 (MH^+ $\text{C}_{20}\text{H}_{22}\text{NO}$ requires 292.1701)

IV - 4-Benzyl-4-azadispiro[2.1.2.2]nonane (6)

To a solution of the lactam **4a** (176 mg, 0.87 mmol) and $\text{Ti}(\text{O}i\text{-Pr})_4$ (0.78 mL, 2.6 mmol) in THF (10 mL) was added dropwise under argon the EtMgBr (3.1 mL, 5.22 mmol, 1.7 M in Et_2O). After stirring for 3 h, a few drops of water were added to obtain a white precipitate on the walls of the flask. The precipitate was rinsed with ether (3×10 mL). The organic phase

was dried (MgSO₄). After evaporation of the solvent, the product was purified by flash chromatography (hexanes-EtOAc 98:2) to obtain 100 mg (54%) of **6** as a pale yellow oil.

IR (film): ν (cm⁻¹) 1494, 1453, 1276.

¹H NMR (CDCl₃, 250 MHz): δ (ppm) 0.42-0.50 (m, 4 H), 0.66-0.74 (m, 4 H), 1.92 (s, 4 H), 3.82 (s, 2 H), 7.15-7.32 (m, 5 H).

¹³C NMR (CDCl₃, 63 MHz): δ (ppm) 12.3 (4 CH₂), 32.4 (2 CH₂), 48.4 (2 C), 56.6 (CH₂), 126.3 (CH), 127.9 (2 CH), 128.5 (2 CH), 141.8 (C).

MS (EI): m/z (%) 213 (M⁺, 28), 198 (41), 122 (35), 91 (100).

HRMS (ES): 214.1522 (MH⁺ C₁₅H₂₀N requires 214.1596).

V - Preparation of lactams 8a-8e

General procedure: To a solution of the unsaturated imide **7a-7e** (1 mmol) and MeTi(Oi-Pr)₃ (2 mmol) in THF (10 mL) was added dropwise under argon the cyclohexylmagnesium chloride (2 M solution in THF, 2 mmol). The yellow solution darkened gradually within 5 minutes. After stirring for 2 h, BF₃•OEt₂ was added (2 mmol). After 30 min, the dark mixture was quenched with water (10 mL). EtOAc (20 mL) and a saturated aqueous solution of NaHCO₃ (ca 10 mL, basic pH) were added. The mixture was stirred until the blue aqueous solution become white. The aqueous phase was extracted twice with EtOAc. After drying (MgSO₄) and evaporation of the solvents, the crude material was purified by flash-chromatography (EtOAc).

Tetrahydro-1*H*-cyclopropa[*g*]pyrrolizin-3(2*H*)-one (8a)

IR (film): ν (cm⁻¹) 1634, 1472, 1415.

¹H NMR (CDCl₃, 500 MHz): δ (ppm) 0.76 (dd, J = 8.6, 6.5 Hz, 1 H), 0.88 (dd, J = 6.5, 4.4 Hz, 1 H), 1.38-1.43 (m, 1 H), 1.94 (dd, J = 12.4, 8.1 Hz, 1 H), 2.05-2.12 (m, 1 H), 2.21-2.28 (m, 1 H), 2.30-2.36 (m, 1 H), 2.58-2.66 (m, 2 H), 2.82-2.91 (m, 1 H), 3.85 (dd, J = 11.2, 10.8 Hz, 1 H).

^{13}C NMR (CDCl_3 , 125 MHz): δ (ppm) 12.9 (CH_2), 18.8 (CH), 22.5 (CH_2), 28.5 (CH_2), 34.0 (CH_2), 38.6 (CH_2), 52.1 (C), 174.2 (C).

MS (EI): m/z (%) 137 ($\text{M}^{+\bullet}$, 73), 136 (100), 122 (23), 108 (39).

HRMS (ES): 138.0913 (MH^+ $\text{C}_8\text{H}_{12}\text{NO}$ requires 138.0919)

Hexahydrocyclopropa[*i*]indolizin-5(1*H*)-one (8b)

IR (film): ν (cm^{-1}) 1608, 1487, 1416.

^1H NMR (CDCl_3 , 500 MHz): δ (ppm) 0.61 (dd, $J = 8.7, 5.7$ Hz, 1 H), 0.81 (dd, $J = 5.7, 4.6$ Hz, 1 H), 1.55-1.66 (m, 2 H), 1.86-2.02 (m, 4 H), 2.09 (tdd, $J = 12.9, 3.7, 1.1$ Hz, 1 H), 2.33 (ddd, $J = 17.8, 11.9, 6.7$ Hz, 1 H), 2.43-2.50 (m, 1 H), 2.89 (ddd, $J = 12.8, 9.6, 8.5$ Hz, 1 H), 4.03 (ddd, $J = 12.8, 9.4, 1.9$ Hz, 1 H).

^{13}C NMR (CDCl_3 , 125 MHz): δ (ppm) 15.3 (CH_2), 20.8 (CH_2), 21.7 (CH), 24.0 (CH_2), 28.2 (CH_2), 31.4 (CH_2), 41.6 (CH_2), 46.1 (C), 168.8 (C).

MS (EI): m/z (%) 151 ($\text{M}^{+\bullet}$, 84), 136 (58), 122 (100), 108 (96).

HRMS (ES): 152.1070 (MH^+ $\text{C}_9\text{H}_{14}\text{NO}$ requires 152.1075)

Octahydro-1*H*-cyclopropa[*b*]pyrrolo[2,1-*a*]isoindol-5(9*bH*)-one (8c)

Mp 75-76 °C.

IR (film): ν (cm^{-1}) : 1684, 1450, 1402.

^1H NMR (CDCl_3 , 500 MHz): δ (ppm) 0.76-0.83 (m, 2 H), 1.32-1.57 (m, 6 H), 1.58-1.63 (m, 1 H), 1.72-1.78 (m, 1 H), 1.88-1.93 (m, 1 H), 1.97 (ddd, $J = 12.6, 8.2, 1.5$ Hz, 1 H), 2.02-2.10 (m, 1 H), 2.56-2.65 (m, 2 H), 2.66 (ddd, $J = 12.4, 9.8, 8.1$ Hz, 1 H), 3.83 (ddd, $J = 12.4, 9.5, 1.5$ Hz, 1 H).

^{13}C NMR (CDCl_3 , 125 MHz): δ (ppm) 10.4 (CH_2), 16.7 (CH), 22.2 (CH_2), 23.0 (CH_2), 25.0 (CH_2), 25.4 (CH_2), 28.8 (CH_2), 33.1 (CH), 38.7 (CH_2), 46.5 (CH), 54.4 (C), 176.8 (C).

MS (EI): m/z (%) 191 ($\text{M}^{+\bullet}$, 34), 190 (32), 150 (36), 137 (100), 136 (56).

HRMS (ES): 192.1383 (MH^+ $\text{C}_{12}\text{H}_{18}\text{NO}$ requires 192.1388).

Hexahydrocyclopropa[*h*]indolizin-3(5*H*)-one (8d)

IR (film): ν (cm⁻¹) 1661, 1471, 1417.

¹H NMR (CDCl₃, 250 MHz): δ (ppm) 0.67 (dd, J = 9.6, 5.9 Hz, 1 H), 0.73 (t, J = 5.7 Hz, 1 H), 1.15-1.23 (m, 1 H), 1.43-1.55 (m, 2 H), 1.71-1.82 (m, 2 H), 1.85-2.01 (m, 1 H), 2.20-2.40 (m, 2 H), 2.53-2.71 (m, 1 H), 3.08 (dt, J = 13.2, 5.6 Hz, 1 H), 3.32 (ddd, J = 13.2, 7.8, 5.4 Hz, 1 H).

¹³C NMR (CDCl₃, 63 MHz): δ (ppm) 14.2 (CH), 15.6 (CH₂), 19.1 (CH₂), 21.3 (CH₂), 29.6 (CH₂), 30.7 (CH₂), 37.5 (CH₂), 42.1 (C), 174.5 (C).

MS (EI): m/z (%) 151 (M⁺, 67), 136 (100), 122 (44), 94 (23).

HRMS (ES): 152.1079 (MH⁺ C₉H₁₄NO requires 152.1075)

Hexahydro-1*H*-cyclopropa[*i*]quinolizin-4(6*H*)-one (8e)

IR (film): ν (cm⁻¹) 1639, 1463, 1408.

¹H NMR (CDCl₃, 500 MHz): δ (ppm) 0.58 (td, J = 5.8, 1.6 Hz, 1 H), 0.65 (dd, J = 9.5, 5.2 Hz, 1 H), 1.08 (ddd, J = 13.1, 6.5, 3.7 Hz, 1 H), 1.19-1.42 (m, 2 H), 1.57-1.63 (m, 1 H), 1.71-2.12 (m, 5 H), 2.45 (dt, J = 16.7, 7.3 Hz, 1 H), 2.59 (dt, J = 16.7, 7.1 Hz, 1 H), 2.76 (td, J = 12.4, 2.9 Hz, 1 H), 3.88 (dt, J = 13.3, 4.2 Hz, 1 H).

¹³C NMR (CDCl₃, 125 MHz): δ (ppm) 16.6 (CH₂), 17.4 (CH), 18.8 (CH₂), 20.1 (CH₂), 21.0 (CH₂), 31.7 (CH₂), 32.7 (CH₂), 38.1 (CH₂), 38.6 (C), 172.0 (C).

MS (EI): m/z (%) 165 (M⁺, 100), 150 (95), 136 (24), 122 (54).

HRMS (ES): 166.1225 (MH⁺ C₁₀H₁₆NO requires 166.1232)

N-Benzyl- α -(diethylamino)succinimide (1e)

4-benzyl-4-azaspiro[2.4]heptan-5-one (4a)

4-Butyl-4-azaspiro[2.4]heptan-5-one (4b)

cis 2'-Benzylhexahydrospiro[cyclopropane-1,1'-isoindol]-3'(2'H)-one (4c)

4-Benzyl-4-azaspiro[2.5]octan-5-one (4d)

4-Benzyl-6-(diethylamino)-4-azaspiro[2.4]heptan-5-one (4e)

(1*R, 3*R**) 4-Benzyl-1-ethyl-4-azaspiro[2.4]heptan-5-one (1*R**, 3*R**-4f).**

(1*R, 3*S**) 4-Benzyl-1-ethyl-4-azaspiro[2.4]heptan-5-one (1*R**, 3*S**-4f)**

(1*R, 3*R**) 1,4-Dibenzyl-4-azaspiro[2.4]heptan-5-one (1*R**, 3*R**-4g)**

(1*R, 3*S**) 1,4-Dibenzyl-4-azaspiro[2.4]heptan-5-one (1*R**, 3*S**-4g)**

4-Benzyl-4-azadispiro[2.1.2.2]nonane (6)

Tetrahydro-1*H*-cyclopropa[*g*]pyrrolizin-3(2*H*)-one (8a)

Hexahydrocyclopropa[*i*]indolizin-5(1*H*)-one (8b)

Octahydro-1*H*-cyclopropa[*b*]pyrrolo[2,1-*a*]isoindol-5(9*bH*)-one (8c)

Hexahydrocyclopropa[*h*]indolizin-3(5*H*)-one (8d)

Hexahydro-1*H*-cyclopropa[*i*]quinolizin-4(6*H*)-one (8e)