Hydroformylation of Alkenyl-Amines. Concise Approaches towards Piperidines, Quinolizidines and Related Alkaloids.

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**General Information:**

All reagents were used as purchased from commercial suppliers without further purification. The reactions were carried out in oven dried or flamed vessels and performed under argon. Solvents were dried and purified by conventional methods prior use. Et₂O and THF were freshly distilled from sodium/benzophenone and dichloromethane was distilled from CaH₂. Toluene was distilled from sodium. **Caution:** The handling of H₂/CO needs special safety equipment. Flash column chromatography was performed with Merck silica gel 60, 0.040-0.063 mm (230-400 mesh).¹ Merck aluminium backed plates pre-coated with silica gel 60 (UV₂₅₄) were used for thin layer chromatography and were visualized by staining with KMnO₄.

NMR spectra were recorded at 300 or 400 MHz for ¹H and 75 or 100 MHz for ¹³C. Conditions are specified for each spectrum (temperature 25 °C unless specified). Splitting patterns are designated as s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; sex, sextuplet; br, broad. Chemical shifts (δ) are given in ppm relative to the resonance of their respective residual solvent peak, CHCl₃ (7.27 ppm, ¹H; 77.16 ppm, the middle peak, ¹³C).

Infrared spectra were taken with a FT-IR apparatus. High and low resolution mass spectroscopy analyses were recorded at 70 eV by electrospray ionization. Melting points were determined in open capillary tubes and are uncorrected. Specific rotations were measured with a 10 cm cell with a Na 589 nm filter: values are given in 10⁻¹ deg.cm³.g⁻¹.

Hydroformylation reactions under classical heating and hydrogenolysis reactions were carried out in a Parr autoclave equipped with the gas addition kit.

All the hydroformylation reactions under microwave dielectric heating were carried out in a sealed tube (10 or 80 mL) inside the cavity of a Discover synthesizer (CEM corp.) equipped with the gas addition kit, (max internal pressure 10 bar, max power 150 W). The internal temperature was measured by the vertically-focused IR temperature sensor.

**Ligand used for hydroformylation:**

benzyl hept-1-en-4-ylcarbamate (6)

In a dry flask under argon was introduced butyraldehyde 1 (1.50 g, 20.80 mmol) in CH₂Cl₂ (50 mL) and the solution was cooled at 0 °C by means of an ice bath. benzylcarbamate 5 (3.14 g, 20.80 mmol) and allyltrimethylsilane 4 (3.31 mL, 20.80 mmol) were added. BF₃·Et₂O (2.64 mL, 20.80 mmol) was added dropwise and the solution was stirred for 2 hours at 0 °C and allowed to warm to room temperature for 30 min. Na₂CO₃ solution was added and the aqueous layer was extracted with CH₂Cl₂ (3 times). The organic layer was dried over Na₂SO₄, filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (90:10 pentane/Et₂O) to yield 6 (4.63 g, 90%) as white solid. Rf = 0.33 (90:10 pentane/Et₂O); Mp 38-40 °C; IR (film) 3300, 2952, 1686, 1541, 1264, 1234, 1020, 745, 696 cm⁻¹; ¹H NMR (CDCl₃, 400 MHz) δ 7.37-7.30 (m, 5H), 5.78 (ddt, J = 17.8, 9.3, 6.9 Hz, 1H), 5.10-5.05 (m, 4H), 4.55 (br d, J = 6.9 Hz, 1H), 3.75 (m, 1H), 2.32-2.16 (m, 2H), 1.51-1.45 (m, 1H), 1.43-1.34 (m, 3H), 0.92 (t, J = 6.8 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 156.1 (C), 136.8 (C), 134.4 (CH), 128.6 (2*CH), 128.1 (3*CH), 117.9 (CH₂), 66.6 (CH₂), 39.6 (CH₂), 36.9 (CH₂), 19.2 (CH₂), 14.0 (CH₃); LRMS-ESI (m/z) 248.1 (M¹+), 204.1 (M⁻44); HRMS-ESI (m/z): calcd for C₁₃H₂₁NO₂K [M+K]⁺ 286.1217; found 286.1217 (Δ = 3.5 ppm).

benzyl 1-(pyridin-3-yl)but-3-enylcarbamate (7)

In a dry flask under argon was introduced 3-pyridinecarboxaldehyde 2 (200 mg, 1.87 mmol) in CH₂Cl₂ (5 mL) and the solution was cooled at 0 °C by means of an ice bath. benzylcarbamate 5 (282 mg, 1.87 mmol) and allyltrimethylsilane 4 (297 µL, 1.87 mmol) were added. BF₃·Et₂O (473 µL, 3.73 mmol) was added dropwise and the solution was stirred for 2 hours at 0 °C and allowed to warm to room temperature for 30 min. Na₂CO₃ solution was added and the aqueous layer was extracted with CH₂Cl₂ (3 times). The organic layer was dried over Na₂SO₄, filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (96:4 CH₂Cl₂/MeOH) to yield 7 (264 mg, 50%) as pale yellow oil. Rf = 0.45 (95:5 CH₂Cl₂/MeOH); IR (film) 3305, 3033, 1695, 1530, 1328, 1254, 1040, 1025, 713, 696 cm⁻¹; ¹H NMR (CDCl₃, 300 MHz) δ 8.57 (br s, 1H), 8.53 (dd, J = 4.7, 1.3 Hz, 1H), 7.6 (br d, J = 8.0 Hz, 1H), 7.38-7.33 (m, 6H), 5.67 (ddt, J = 17.5, 9.8, 6.7 Hz, 1H), 5.17-5.07 (m, 5H), 4.83 (br d, 2H), 2.56 (br t, J = 6.9 Hz, 2H); ¹³C NMR (CDCl₃, 100 MHz) δ 155.7 (C), 148.7 (CH), 148.2 (CH), 136.4 (C), 134.2 (C), 133.0 (CH), 128.8 (2*CH), 128.7 (CH), 128.4 (CH), 128.2 (2*CH), 123.6 (CH), 119.4 (CH₂), 67.2 (CH₂), 52.7 (CH), 40.8 (CH₂); LRMS-ESI (m/z) 283.1 (M⁺+1); HRMS-ESI (m/z): calcd for C₁₇H₁₈N₂O₂K [M+K]⁺ 321.0999; found 321.1014 (Δ = 3.5 ppm).

benzyl pent-4-en-2-ylcarbamate (8)

In a dry flask under argon was introduced paraldehyde 3 (1.00 g, 7.57 mmol) in CH₂Cl₂ (20 mL) and the solution was cooled at 0 °C by means of an ice bath. benzylcarbamate 5 (3.43 g, 22.70 mmol) and allyltrimethylsilane 4 (3.61 mL, 22.70 mmol) were added. BF₃·Et₂O (5.75 mL, 45.40 mmol) was added dropwise and the solution was stirred for 2 hours at 0 °C and allowed to warm to room temperature for 30 min. Na₂CO₃ solution was added and the aqueous layer was extracted with CH₂Cl₂ (3 times). The organic layer was dried over Na₂SO₄, filtered and concentrated under reduced pressure. The residue was purified by flash chromatography (85:15 pentane/Et₂O) to yield 8 (4.68 g, 94%) as colorless oil. Rf = 0.38 (80:20
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**benzyl 2-propyl-3,4-dihydropyridine-1(2H)-carboxylate (9)**

A solution of Rh(CO)$_2$acac (0.5 mol %, 1.3 mg, 0.005 mmol) and biphephos (1 mol%, 8.0 mg, 0.010 mmol) in anhydrous degassed THF (3 mL), prepared in a Schlenk glassware under inert atmosphere, was introduced under inert atmosphere into a stainless steel autoclave containing 6 (250 mg, 1.011 mmol) and pyridinium p-toluenesulfonate (6.4 mg, 0.025 mmol), in anhydrous degassed THF to reach a final concentration of 0.04 M. The autoclave was flushed with H$_2$/CO (1:1) three times. Then, the autoclave was filled with 5 bar of H$_2$/CO (1:1) and heated to 70 °C with stirring for 12 h. Then, the autoclave was cooled to room temperature and gases were slowly and carefully released. The solvent was evaporated under reduced pressure. The residue was purified by flash chromatography (95:5 pentane/EtO) to give 9 as colorless oil (221 mg, 84%). **RF** = 0.77 (90:10 pentane/EtO); **IR (film)** 2956, 2872, 1694, 1305, 1092, 736, 696 cm$^{-1}$; **H NMR** (CDCl$_3$, 400 MHz) δ 7.40-7.32 (m, 5H), 6.85 (br d, J = 8.1 Hz, 0.4H, rotamers), 6.75 (br d, J = 8.1 Hz, 0.6H, rotamers), 5.20 (2H, 4.95 (br t, J = 5.7 Hz, 0.4H, rotamers), 4.84 (br t, J = 5.7 Hz, 0.6H, rotamers), 4.36 (br s, 0.6H, rotamers), 4.26 (br s, 0.4H, rotamers), 2.13-2.03 (m, 1H), 1.99-1.92 (m, 1H), 1.88-1.68 (m, 2H), 1.58-1.54 (m, 1H), 1.45-1.27 (m, 3H), 0.95 (t, J = 7.1 Hz, 2H, rotamers), 0.88 (t, J = 7.1 Hz, 1H, rotamers); **C NMR** (CDCl$_3$, 100 MHz) δ 153.7/153.1 (C), 136.6/136.5 (C), 128.6 (2*CH), 128.2 (CH), 128.1 (2*CH), 124.1/123.7 (CH), 106.4/106.1 (CH), 67.5 (CH$_2$), 50.6/50.4 (CH), 33.2/32.8 (CH$_2$), 24.2/24.1 (CH$_2$), 19.3 (CH$_2$), 17.7/17.6 (CH$_2$), 14.2 (CH$_3$); **HRMS-ESI (m/z):** calcd for C$_{16}$H$_{22}$NO$_2$ [M+H]$^+$ 260.1645; found 260.1654 (Δ = 0.1 ppm).

**benzyl 2-(pyridin-3-yl)-3,4-dihydropyridine-1(2H)-carboxylate (10)**

A solution of Rh(CO)$_2$acac (0.5 mol %, 0.7 mg, 0.002 mmol) and biphephos (1 mol%, 4.2 mg, 0.005 mmol) in anhydrous degassed THF (3 mL), prepared in a Schlenk glassware under inert atmosphere, was introduced under inert atmosphere into a stainless steel autoclave containing 7 (150 mg, 0.53 mmol) and pyridinium p-toluenesulfonate (3.4 mg, 0.015 mmol), in anhydrous degassed THF to reach a final concentration of 0.04 M. The autoclave was flushed with H$_2$/CO (1:1) three times. Then, the autoclave was filled with 5 bar of H$_2$/CO (1:1) and heated to 70 °C with stirring for 12 h. Then, the autoclave was cooled to room temperature and gases were slowly and carefully released. The solvent was evaporated under reduced pressure. The residue was purified by flash chromatography (98:2 CH$_2$Cl$_2$/MeOH) to give 10 as colorless oil (126 mg, 81%). **RF** = 0.45 (97:3 CH$_2$Cl$_2$/MeOH); **IR (film)** 2952, 1701, 1652, 1407, 1321, 1311, 1106, 1061, 696 cm$^{-1}$; **H NMR** (CDCl$_3$, 400 MHz) δ 8.46 (br s, 2H), 7.42 (m, 1H), 7.33-7.29 (m, 5H), 7.19 (m, 1H), 7.02 (m, 1H), 5.16-5.01 (m, 3H), 4.77 (m, 1H), 2.08-1.88 (m, 3H), 1.72-1.63 (m, 1H); **C NMR** (CDCl$_3$, 100 MHz) δ 156.8 (C), 148.5 (CH), 147.6 (CH), 136.4 (C), 136.0 (C), 133.5/133.3 (CH), 128.7 (2*CH), 128.3 (CH), 128.2 (2*CH), 127.8/127.7 (CH), 123.4 (CH), 106.8/106.6 (CH), 67.0 (CH$_2$), 52.9/52.5 (CH), 27.4/27.2 (CH$_2$), 17.1/16.9 (CH$_3$); **HRMS-ESI (m/z):** calcd for C$_{18}$H$_{19}$N$_2$O$_2$ [M+H]$^+$ 295.1441; found 295.1442 (Δ = 1.1 ppm).
benzyl 2-methoxy-6-propylpiperidine-1-carboxylate (11)

A solution of Rh(CO)$_2$acac (0.25 mol %, 2.6 mg, 0.010 mmol) and biphephos (0.5 mol%, 15.9 mg, 0.020 mmol) in anhydrous degassed THF (0.5 mL), prepared in a Schlenk glassware under inert atmosphere, was introduced under inert atmosphere into a stainless steel autoclave containing 6 (1000 mg, 4.04 mmol) in anhydrous degassed MeOH to reach a final concentration of 0.2 M. The autoclave was flushed with H$_2$/CO (1:1) three times. Then, the autoclave was filled with 5 bar of H$_2$/CO (1:1) and heated to 60 °C with stirring for 12 h. Then, the autoclave was cooled to room temperature and gases were slowly and carefully released. The solvent was evaporated under reduced pressure. The residue was purified by flash chromatography (95:5 pentane/Et$_2$O) to give 11 as colorless oil (990 mg, 84%). Rf = 0.50 (90:10 pentane/Et$_2$O); IR (film) 2954, 2871, 1694, 1411, 1306, 1069, 696 cm$^{-1}$; $^1$H NMR (CDCl$_3$ filtered on basic Al$_2$O$_3$, 400 MHz) δ 7.37-7.32 (m, 5H), 5.51 (br s, 0.5H), 5.38 (br s, 0.5H), 5.18-5.15 (m, 2H), 4.25 (br s, 0.5H), 4.17 (br s, 0.5H), 3.31 (br s, 1.5H), 3.23 (br s, 1.5H), 1.93-1.81 (m, 2H), 1.75-1.68 (m, 3H), 1.62-1.52 (m, 2H), 1.43-1.24 (m, 3H), 0.95-0.89 (m, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz) δ 156.9/156.1 (C), 136.8 (C), 128.6 (CH), 128.2 (2*CH), 128.1 (2*CH), 82.4 (CH), 67.4/67.3 (CH$_2$), 55.7/55.2 (CH), 51.0 (CH$_3$), 36.0/35.5 (CH$_2$), 30.8 (CH$_2$), 27.7/27.3 (CH$_2$), 20.6 (CH$_2$), 14.1 (CH$_3$), 13.8 (CH$_2$); HRMS-ESI (m/z): calcd for C$_{17}$H$_{25}$NO$_3$Na [M+Na]$^+$ 314.1727; found 314.1729 ($\Delta$ = 1.8 ppm).

benzyl 2-methoxy-6-methylpiperidine-1-carboxylate (12)

A solution of Rh(CO)$_2$acac (0.25 mol %, 2.9 mg, 0.011 mmol) and biphephos (0.5 mol%, 17.9 mg, 0.023 mmol) in anhydrous degassed THF (0.5 mL), prepared in a Schlenk glassware under inert atmosphere, was introduced under inert atmosphere into a stainless steel autoclave containing 8 (1000 mg, 4.56 mmol) in anhydrous degassed MeOH to reach a final concentration of 0.2 M. The autoclave was flushed with H$_2$/CO (1:1) three times. Then, the autoclave was filled with 5 bar of H$_2$/CO (1:1) and heated to 60 °C with stirring for 12 h. Then, the autoclave was cooled to room temperature and gases were slowly and carefully released. The solvent was evaporated under reduced pressure. The residue was purified by flash chromatography (90:10 pentane/Et$_2$O) to give 12 as colorless oil (990 mg, 84%). Rf = 0.60 (90:10 pentane/Et$_2$O); IR (film) 2963, 2885, 1697, 1408 cm$^{-1}$; $^1$H NMR (CDCl$_3$ filtered on basic Al$_2$O$_3$, 400 MHz) δ 7.38-7.31 (m, 5H), 5.44 (br s, 1H), 5.17 (br s, 2H), 4.39 (br s, 1H), 3.24 (br s, 1H), 2.00-1.89 (m, 2H), 1.73-1.49 (m, 3H), 1.46-1.40 (m, 1H), 1.31 (d, J = 7 Hz, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz) δ 136.8 (C), 128.6 (CH), 128.2 (2*CH), 128.1 (2*CH), 82.3 (CH), 67.4/67.3 (CH$_2$), 55.1 (CH), 46.7 (CH$_3$), 30.5 (CH$_2$), 30.1 (CH$_2$), 26.5 (CH$_2$), 13.6 (CH$_3$), some pics are missing due to the presence of rotamers and diastereomers; HRMS-ESI (m/z): calcd for C$_{15}$H$_{21}$NO$_3$Na [M+Na]$^+$ 286.1414; found 286.1416 ($\Delta$ = 0.9 ppm).
General Procedure A for Hydrogenation

In a high pressure reactor under inert atmosphere, to a solution of substrate in MeOH (10 mL) was added Pearlman’s catalyst (Pd(OH)$_2$/C 20%, 10% w/w). The mixture was set under 5 bar of hydrogen and was shacked overnight. The residue was filtrated over a Celite® pad and concentrated HCl was added (1 mL). The solvent was removed under reduced pressure. Et$_2$O and NaOH 15% were added and the aqueous layer was extracted with Et$_2$O (3 times). The organic layer was dried over Na$_2$SO$_4$, filtered, and carefully concentrated under reduced pressure to give the desired alkaloid.

(±)-coniine (13)

(±)-coniine 13 was prepared following the general procedure A as described above from 9 (123 mg, 0.47 mmol) to yield the titled compound (51 mg, 85%) as colorless oil. IR (film) 3270, 2955, 2925, 2855, 1461, 1262, 1120, 743 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 400 MHz) δ 3.07 (dddd, $J$ = 11.7, 4.0, 2.2, 1.8 Hz, 1H), 2.62 (ddd, $J$ = 11.7, 11.6, 2.6 Hz, 1H), 2.48-2.43 (m, 1H), 1.80-1.74 (m, 1H), 1.68-1.56 (m, 2H), 1.42-1.28 (m, 7H), 1.11-1.01 (m, 1H), 0.91 (dd, $J$ = 7.0, 7.0 Hz, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz) δ 56.8 (CH), 47.3 (CH$_2$), 39.7 (CH$_2$), 33.0 (CH$_2$), 26.7 (CH$_2$), 19.1 (CH$_2$), 14.4 (CH$_3$); LRMS-ESI (m/z) 128.2 (M+1); HRMS-ESI (m/z): calcd for C$_8$H$_{18}$N $[M+H]^+$ 128.1434; found 128.1436 ($\Delta$ 2.1 ppm).

(±)-anabasine (14)

(±)-anabasine 14 was prepared following the general procedure A as described above from 10 (126 mg, 0.43 mmol) to yield the titled compound (57 mg, 83%) as colorless oil. Rf = 0.1 (90:10 CH$_2$Cl$_2$/MeOH); IR (film) 3276, 2928, 2851, 1576, 1440, 1422, 1317, 1108, 714 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 400 MHz) δ 8.56 (d, $J$ = 2.3 Hz, 1H), 8.46 (dd, $J$ = 4.8, 1.6 Hz, 1H), 7.69 (dt, $J$ = 7.9, 2.0 Hz, 1H), 3.61 (dd, $J$ = 10.3, 2.9 Hz, 1H), 3.19-3.15 (m, 1H), 2.80-2.74 (m, 1H), 1.89-1.86 (m, 1H), 1.77-1.73 (m, 1H), 1.67-1.63 (m, 1H), 1.52-1.44 (m, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz) δ 148.75 (CH), 148.67 (CH), 140.7 (C), 134.2 (CH), 123.5 (CH), 59.9 (CH), 47.7 (CH$_2$), 34.9 (CH$_2$), 25.8 (CH$_2$), 25.3 (CH$_2$); LRMS-ESI (m/z) 163.1 (M+1); HRMS-ESI (m/z): calcd for C$_{10}$H$_{15}$N$_2$ [M+H]$^+$ 163.1230; found 163.1232 ($\Delta$ = 1.6 ppm).

(2$S$*,6$S$*)-benzyl 2-allyl-6-propylpiperidine-1-carboxylate (15)

In a dry flask under argon was introduced 11 (678 mg, 2.33 mmol) in CH$_2$Cl$_2$ (10 mL) at 0°C. Allyltrimethylsilane 4 (1.85 mL, 11.6 mmol) and BF$_3$·Et$_2$O (0.59 mL, 4.65 mmol) were added dropwise and the solution was stirred for 1h at 0°C. Na$_2$CO$_3$ solution was added and the organic layer was extracted with CH$_2$Cl$_2$ (3 times). The organic layer was dried over Na$_2$SO$_4$, filtered, and concentrated under reduced pressure. The residue was purified by flash chromatography (90:10 pentane/Et$_2$O) to give 15 (393 mg, 56%) as colorless oil. Rf = 0.36 (85:15 pentane/Et$_2$O); IR (film) 2934, 2870, 1687, 1408, 1314, 1267, 1075, 910, 696 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 400 MHz) δ 7.37-7.29 (m, 5H), 5.75 (ddt, $J$ = 17.3, 10.0, 7.5 Hz, 1H), 5.15 (s, 2H), 5.05-4.00 (m, 2H), 4.28-4.23 (m, 1H), 4.21-4.16 (m, 1H), 2.38-2.29 (m, 2H), 1.73-1.61 (m, 3H), 1.60-1.49 (m, 5H), 1.47-1.40 (m, 1H), 1.36-1.27 (m, 1H), 0.90 (t, $J$ = 7 Hz, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz)
δ 156.1 (C), 137.2 (C), 136.4 (CH), 128.5 (2*CH), 127.9 (3*CH), 116.9 (CH2), 66.9 (CH2), 50.7 (CH), 50.4 (CH), 39.2 (2*CH2), 37.2 (CH2), 27.6 (CH2), 27.2 (CH2), 20.7 (CH2), 14.2 (CH3); HRMS-ESI (m/z): calcd for C19H28NO2 [M+H]+ 302.2115; found 302.2117 (Δ = 0.7 ppm).

(2S*,6S*)-benzyl 2-allyl-6-methylpiperidine-1-carboxylate (16)

In a dry flask under argon was introduced 12 (1000 mg, 3.80 mmol) in CH2Cl2 (10 mL) at 0°C. Allytrimethylsilane 4 (2.41 mL, 15.19 mmol) and BF3·Et2O (0.96 mL, 7.59 mmol) were added dropwise and the solution was stirred for 1h at 0°C. Na2CO3 solution was added and the organic layer was extracted with CH2Cl2 (3 times). The organic layer was dried over Na2SO4, filtered, and concentrated under reduced pressure. The residue was purified by flash chromatography (90:10 pentane/Et2O) to give 16 (602 mg, 58%) as colorless oil. Rf = 0.51 (90:10 pentane/Et2O); IR (film) 2934, 2869, 1723, 1683, 1411, 1311, 1269, 1075, 697 cm⁻¹; 1H NMR (CDCl3, 400 MHz) δ 7.37-7.29 (m, 5H), 5.75 (ddt, J = 17.1, 10.1, 7.1 Hz, 1H), 5.15 (s, 2H), 5.06-4.99 (m, 2H), 4.44-4.36 (m, 1H), 4.27-4.22 (m, 1H), 2.39-2.29 (m, 2H), 1.73-1.61 (m, 3H), 1.57-1.45 (m, 3H), 1.22 (d, J = 7 Hz, 3H); 13C NMR (CDCl3, 100 MHz) δ 155.9 (C), 137.2 (C), 136.3 (CH), 128.5 (2*CH), 127.9 (CH), 127.8 (2*CH), 116.9 (CH2), 66.9 (CH2), 50.4 (CH), 46.1 (CH), 39.5 (CH2), 30.2 (CH2), 26.8 (CH2), 20.7 (CH2), 13.9 (CH2); LRMS-ESI (m/z) 274.1 (M+1); HRMS-ESI (m/z): calcd for C17H24NO2 [M+H]+ 274.1802; found 274.1803 (Δ = 0.6 ppm).

(±)-dihydropinidine (17)

(±)-dihydropinidine 17 was prepared following the general procedure A as described above from 15 (250 mg, 0.91 mmol) to yield the titled compound (92 mg, 71%) as colorless oil. IR (film) 2956, 2926, 2855, 1460, 1367, 1154 cm⁻¹; 1H NMR (CDCl3, 400 MHz) δ 7.33-7.27 (m, 5H), 7.57 (ddt, J = 17.1, 10.1, 7.1 Hz, 1H), 5.10 (s, 2H), 5.06-4.99 (m, 2H), 4.44-4.36 (m, 1H), 4.27-4.22 (m, 1H), 2.39-2.29 (m, 2H), 1.73-1.61 (m, 3H), 1.57-1.45 (m, 3H), 1.22 (d, J = 7 Hz, 3H); 13C NMR (CDCl3, 100 MHz) δ 155.9 (C), 137.2 (C), 136.3 (CH), 128.5 (2*CH), 127.9 (CH), 127.8 (2*CH), 116.9 (CH2), 66.9 (CH2), 50.4 (CH), 46.1 (CH), 39.5 (CH2), 30.2 (CH2), 26.8 (CH2), 20.7 (CH2), 13.9 (CH2); HRMS-ESI (m/z) 274.1 (M+1); HRMS-ESI (m/z): calcd for C9H20N [M+H]+ 142.1591; found 142.1598 (Δ = 0.6 ppm).

(2S*,6S*)-benzyl 2-(4-oxobutyl)-6-propylpiperidine-1-carboxylate (18)

A solution of Rh(CO)2acac (1 mol %, 0.6 mg, 0.002 mmol) and biphephos (2 mol%, 3.9 mg, 0.005 mmol) in anhydrous degassed THF (3 mL), prepared in a Schlenk glassware under inert atmosphere, was introduced under inert atmosphere into a stainless steel autoclave containing 15 (75 mg, 0.25 mmol) in anhydrous degassed THF to reach a final concentration of 0.04 M. The autoclave was flushed with H2/CO (1:1) three times. Then, the autoclave was filled with 5 bar of H2/CO (1:1) and heated to 60 °C with stirring for 12 h. Then, the autoclave was cooled to room temperature and gases were slowly and carefully released. The solvent was evaporated under reduced pressure. The residue was purified by flash chromatography (85:15 pentane/EtOAc) to give 18 as slightly yellow oil (70 mg, 85%). Rf = 0.35 (80:20 pentane/EtOAc); IR (film) 2934, 2869, 1723, 1683, 1411, 1311, 1269, 1075, 697 cm⁻¹; 1H NMR (CDCl3, 400 MHz) δ 9.69 (br s, 1H), 7.36-7.30 (m, 5H), 5.12 (s, 2H), 4.18 (br s, 2H), 2.42 (br s, 2H), 1.65-1.26 (m, 14H), 0.89 (t, J = 7.2 Hz, 3H); 13C NMR (CDCl3, 100 MHz) δ 202.4 (C), 156.2 (C), 137.1 (CH), 128.5 (2*CH), 128.1 (CH), 128.0 (2*CH), 67.1 (CH2), 50.7 (CH), 50.3 (CH), 43.7 (CH2), 37.0 (CH2), 34.2 (CH2), 27.7 (CH2), 27.6
(2S*,6S*)-benzyl 2-methyl-6-(4-oxobutyl)piperidine-1-carboxylate (19)

A solution of Rh(CO)$_2$acac (0.8 mol%, 2.6 mg, 0.010 mmol) and biphephos (1.6 mol%, 16.1 mg, 0.020 mmol) in anhydrous degassed THF (3 mL), prepared in a Schlenk glassware under inert atmosphere, was introduced under inert atmosphere into a stainless steel autoclave containing 16 (350 mg, 1.28 mmol) in anhydrous degassed THF to reach a final concentration of 0.1 M. The autoclave was flushed with H$_2$/CO (1:1) three times. Then, the autoclave was filled with 5 bar of H$_2$/CO (1:1) and heated to 60 °C with stirring for 12 h. Then, the autoclave was cooled to room temperature and gases were slowly and carefully released. The solvent was evaporated under reduced pressure. The residue was purified by flash chromatography (80:20 pentane/EtOAc) to give 19 as slightly yellow oil (308 mg, 79%).

Rf = 0.49 (80:20 pentane/EtOAc); IR (film) 2942, 2852, 1715, 1673, 1419 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$ 9.68 (br s, 1H), 7.37-7.30 (m, 5H), 5.17-5.10 (m, 2H), 4.41 (qdd, $J$ = 7.0, 5.2, 2.2 Hz, 1H), 4.17 (td, $J$ = 6.9, 5.2 Hz, 1H), 2.42 (br t, $J$ = 6.7 Hz, 2H), 1.72-1.51 (m, 9H), 1.49-1.44 (m, 1H), 1.19 (d, $J$ = 7.1 Hz, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz) $\delta$ 202.4 (CH), 156.0 (C), 137.2 (C), 128.6 (2*CH), 128.1 (3*CH), 67.1 (CH$_2$), 50.2 (CH), 46.2 (CH), 43.7 (CH$_2$), 34.5 (CH$_2$), 30.3 (CH$_2$), 27.7 (CH$_2$), 20.7 (CH$_3$), 19.8 (CH$_2$), 14.1 (CH$_2$); HRMS-ESI (m/z): calcd for C$_{18}$H$_{26}$NO$_3$ [M+H]$^+$ 304.1907; found 304.1909 ($\Delta$ = 0.6 ppm).

Compound 20 was prepared following the general procedure A as described above from 18 (62 mg, 0.19 mmol) to yield the titled compound (30 mg, 88%) as colorless oil. Rf = 0.05 (90:10 CH$_2$Cl$_2$/MeOH); IR (film) 2929, 2871, 2784, 1444, 1092 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$ 3.34 (br d, $J$ = 10.5 Hz, 1H), 1.96 (br s, 2H), 1.79 (br s, 1H), 1.73-1.65 (m, 6H), 1.54-1.20 (m, 10H), 0.88 (t, $J$ = 7.1 Hz, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz) $\delta$ 64.3 (CH), 63.9 (CH), 51.3 (CH$_2$), 35.4 (CH$_2$), 33.3 (CH$_2$), 33.1 (CH$_2$), 31.3 (CH$_2$), 25.8 (CH$_2$), 24.3 (CH$_2$), 24.2 (CH$_2$), 19.4 (CH$_2$), 14.5 (CH$_3$); LRMS-ESI (m/z) 182.2 (M+1). HRMS-ESI (m/z): calcd for C$_{12}$H$_{24}$N [M+H]$^+$ 182.1903; found 182.1904 ($\Delta$ = 1.1 ppm).

Compound 21 was prepared following the general procedure A as described above from 19 (287 mg, 0.95 mmol) to yield the titled compound (131 mg, 90%) as colorless oil. IR (film) 2936, 2869, 2791, 1438, 1085 cm$^{-1}$; $^1$H NMR (CDCl$_3$, 400 MHz) $\delta$ 3.22 (br d, $J$ = 10.6 Hz, 1H), 2.58-2.38 (m, 1H), 1.96-1.89 (m, 1H), 1.76-1.61 (m, 4H), 1.58-1.48 (m, 4H), 1.37-1.20 (m, 5H), 1.06 (br d, $J$ = 6.3 Hz, 3H); $^{13}$C NMR (CDCl$_3$, 100 MHz) $\delta$ 63.1 (CH), 59.1 (CH), 51.8 (CH$_2$), 35.4 (CH$_2$), 34.1 (CH$_2$), 33.9 (CH$_2$), 26.4 (CH$_2$), 24.8 (CH$_2$), 24.6 (CH$_2$), 20.8 (CH$_3$); HRMS-ESI (m/z): calcd for C$_{10}$H$_{20}$N [M+H]$^+$ 154.1590; found 154.1588 ($\Delta$ = 1.4 ppm).
(2S*,6S*)-benzyl 2-((E)-4-oxopent-2-enyl)-6-propylpiperidine-1-carboxylate (22)

In a dry flask under argon, 15 (330 mg, 1.09 mmol) and methylvinylketone (914 µL, 10.9 mmol) were introduced in CH₂Cl₂ (15 mL). Grubbs II catalyst (27.9 mg, 0.03 mmol) was added and the solution was stirred at reflux for 12 h. The solvent was evaporated under reduced pressure and the residue was purified by flash chromatography (85:15 to 80:20 pentane/EtOAc) to yield 22 (301 mg, 80%) as colorless oil. Rf = 0.51 (80:20 pentane/EtOAc); IR (film) 2941, 1678, 1412 cm⁻¹; ¹H NMR (CDCl₃, 400 MHz) δ 7.36-7.30 (m, 5H), 6.77-6.70 (m, 1H), 6.04 (dt, J = 16.0, 1.4 Hz, 1H), 5.18-5.09 (m, 2H), 4.40 (br s, 1H), 4.20 (br s, 1H), 2.58-2.41 (m, 2H), 2.18 (s, 3H), 1.69-1.46 (m, 8H), 1.39-1.23 (m, 2H), 0.9 (t, J = 7.3 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 198.6 (C), 156.1 (C), 145.5 (CH), 137.0 (C), 133.2 (CH), 128.6 (2*CH), 128.1 (CH), 127.9 (2*CH), 67.2 (CH₂), 50.6 (CH), 49.9 (CH), 38.2 (CH₂), 37.2 (CH₂), 27.8 (CH₂), 27.4 (CH₂), 26.8 (CH₃), 20.7 (CH₃), 14.2 (CH₂), 14.1 (CH₂); HRMS-ESI (m/z): calcd for C₂₁H₂₉NO₃ [M+H]+ 344.2220; found 344.2224 (Δ = 1.2 ppm).

(2S*,6S*)-benzyl 2-methyl-6-((E)-4-oxopent-2-enyl)piperidine-1-carboxylate (23)

In a dry flask under argon, 16 (250 mg, 0.95 mmol) and methylvinylketone (792 µL, 9.5 mmol) were introduced in CH₂Cl₂ (12 mL). Grubbs II catalyst (24.2 mg, 0.03 mmol) was added and the solution was stirred at reflux for 12 h. The solvent was evaporated under reduced pressure and the residue was purified by flash chromatography (80:20 pentane/EtOAc) to yield 23 (257 mg, 86%) as colorless oil. Rf = 0.36 (80:20 pentane/EtOAc); IR (film) 2938, 1674, 1408 cm⁻¹; ¹H NMR (CDCl₃, 400 MHz) δ 7.39-7.31 (m, 5H), 6.73 (dt, J = 16.1, 7.4 Hz, 1H), 6.03 (dt, J = 16.1, 1.5 Hz, 1H), 5.18-5.09 (m, 2H), 4.44-4.35 (m, 2H), 2.16 (s, 3H), 1.73-1.48 (m, 6H), 1.21 (d, J = 7.1 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 198.6 (C), 155.9 (C), 145.5 (CH), 137.0 (C), 133.2 (CH), 128.6 (2*CH), 128.1 (CH), 127.9 (2*CH), 67.2 (CH₂), 49.8 (CH), 46.1 (CH), 38.4 (CH₂), 37.2 (CH₂), 27.8 (CH₂), 27.4 (CH₂), 26.8 (CH₃), 20.7 (CH₃), 14.2 (CH₂), 14.1 (CH₂); HRMS-ESI (m/z): calcd for C₁₉H₂₆NO₃ [M+H]+ 316.1907; found 316.1910 (Δ = 1.0 ppm).

(4R*,6S*,9aR*)-4-methyl-6-propyloctahydro-1H-quinolizine, (±)-9-epi-195C (24)

(±)-9-epi-195C 24 was prepared following the general procedure A as described above from 22 (272 mg, 0.79 mmol) to yield the titled compound 24 (124 mg, 80%) as slightly yellow oil. IR (film) 2932, 1655, 1375 cm⁻¹; ¹H NMR (CDCl₃, 400 MHz) δ 2.64-2.59 (m, 1H), 2.56-2.51 (m, 1H), 2.46 (t app, J = 10.5 Hz, 1H), 1.83-1.75 (m, 1H), 1.67-1.61 (m, 3H), 1.52-1.44 (m, 5H), 1.40-1.20 (m, 7H), 1.12 (s, J = 6.4 Hz, 3H), 0.91 (t, J = 7.3 Hz, 3H); ¹³C NMR (CDCl₃, 100 MHz) δ 58.1 (CH), 57.1 (CH), 55.9 (CH), 39.7 (CH₂), 34.3 (CH₂), 33.4 (CH₂), 30.6 (CH₃), 23.7 (CH₂), 22.7 (CH₂), 22.4 (CH₃), 20.2 (CH₂), 17.7 (CH₂), 14.4 (CH₃); HRMS-ESI (m/z): calcd for C₁₆H₂₆N [M+H]+ 196.2060; found 196.2070 (Δ = 0.1 ppm).
(4R*,6S*,9αS*)-4,6-dimethyloctahydro-1H-quinolizine (25)

Compound 25 was prepared following the general procedure A as described above from 23 (220 mg, 0.70 mmol) to yield the titled compound (97 mg, 83%) as colorless oil. IR (film) 2924, 1458, 1376, 1313 cm\(^{-1}\); \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\) 2.57 (dd, \(J = 6.9, 3.6, 6.6\) Hz, 2H), 2.34 (tt, \(J = 10.8, 2.8\) Hz, 1H), 1.76-1.68 (m, 2H), 1.67-1.60 (m, 2H), 1.52-1.47 (m, 2H), 1.43-1.24 (m, 6H), 1.13 (d, \(J = 6.4\) Hz, 6H); \(^13\)C NMR (CDCl\(_3\), 100 MHz) \(\delta\) 57.2 (CH), 56.1 (2*CH), 32.5 (2*CH\(_2\)), 32.2 (2*CH\(_3\)), 24.0 (2*CH\(_3\)), 20.8 (2*CH\(_2\)); HRMS-ESI (m/z): calcd for C\(_{11}\)H\(_{23}\)NO \([M+H]^+\) 168.1747; found 168.1746 (\(\Delta = 0.4\) ppm).

(2R)- (1-(Benzylxoycarbonyl)piperidin-2-yl)acetic acid (27)

A freshly prepared solution of CrO\(_3\) (2 g, 0.02 M) and H\(_2\)SO\(_4\) (0.04 M, 2 ml) in 5 ml of H\(_2\)O was added dropwise to 2-(piperidin-2-yl)ethanol 26 (1.0 g, 8.0 mmol) dissolved in H\(_2\)O (20 ml) at 0 °C. The reaction mixture was stirred at 0 °C for 1 hour and stirred at rt for 3 hours. The solution was treated with a saturated solution of Ba(OH)\(_2\) until pH 8 and the residue was filtrated on celite. After evaporation of the solvent under reduced pressure the expected 2-(piperidin-2-yl)acetic acid (830 mg, 5.8 mmol) was obtained by precipitation from Et\(_2\)O as a white solid. \(^1\)H NMR (CDCl\(_3\), 200 MHz) \(\delta\) 3.49-3.40 (m, 1H), 3.32-3.18 (m, 2H), 2.52-2.49 (m, 2H), 1.92-1.65 (m, 6H).

2-(Piperidin-2-yl)acetic acid (300 mg, 2.1 mmol) was dissolved in THF (15 ml) and the solution cooled to 0 °C; a 10% solution of NaOH (5.67 ml, 2.1 mmol) in H\(_2\)O and benzyl chloroformate (329 µl, 2.31 mmol) were added. The reaction mixture was stirred at 0°C for 20 min. and 18 hours at room temperature. Then the mixture was treated with HCl 1N until pH 3. After extraction with EtOAc (3 x 20 ml) the organic layers were washed with brine and dried over dry Na\(_2\)SO\(_4\). The residue obtained after filtration and evaporation was purified by flash chromatography (Eluent: 98:2 CH\(_2\)Cl\(_2\)-MeOH) giving 27 (490 mg 80% yield) as a colourless oil. \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\) 9.71 (bs, 1H), 7.32-7.26 (m, 5H), 5.10 (s, 2H), 4.78 (m, 1H), 4.05 (m, 1H), 2.83 (m, 1H), 2.60-2.57 (m, 2H), 1.63-1.49 (m, 6H); \(^13\)C NMR (CDCl\(_3\), 50 MHz) \(\delta\) 176.3 (CO), 155.4 (CO), 136.5 (C), 128.3 (2*CH) 127.8 (CH), 127.6 (2*CH), 67.1 (CH\(_2\)), 47.9 (CH), 39.5 (CH\(_2\)), 34.9 (CH\(_3\)), 28.0 (CH\(_2\)), 25.0 (CH\(_2\)), 18.6 (CH\(_3\)); LRMS-ESI (m/z) 276.0 [M-H]; HRMS-ESI (m/z): calcd for C\(_{15}\)H\(_{18}\)NO\(_4\) [M-H] 276.1241; found 276.1238.

(2R)-Benzy 2-(2-(methoxy(methyl)amino)-2-oxoethyl)piperidine-1-carboxylate (28)

To a solution of 27 (100 mg, 0.36 mmol) in dry THF (5 ml) DMTMM [4-(4,6-Dimethoxy-1,3,5-triazin-2-yl)-4-methylmorpholinum chloride] (130 mg, 0.47 mmol) and N-methyl morpholine (82 µl, 0.72 mmol) were added and the reaction mixture was stirred at room temperature 1 hour. N,O-Dimethyldoxylamine hydrochloride (35 mg, 0.36 mmol) was added and the reaction mixture was stirred at room temperature for 18 hours. The solution was treated with H\(_2\)O and after extraction with Et\(_2\)O (2 x 5 ml) the organic layers were washed with a saturated solution of Na\(_2\)CO\(_3\) (2 x 10 ml), a solution of HCl 1N (1 x 10 ml) and finally dried. The solvent was evaporated to give compound 29 (99 mg, 86%).[\(\alpha\)]\(_D\)^{25} -11.1 (c = 0.06 in CDCl\(_3\)); \(^1\)H NMR (CDCl\(_3\), 400 MHz) \(\delta\) 7.34-7.23 (m, 5H), 5.08 (s, 2H), 4.78 (m, 1H), 4.05 (m, 1H), 3.59 (s, 3H), 3.07 (m, 3H), 2.88 (m, 1H), 2.72-2.63 (m, 2H), 1.65-1.52 (m, 6H); \(^13\)C NMR (CDCl\(_3\), 50 MHz) \(\delta\) 173.0 (CO), 168.1747; found 168.1746 (\(\Delta = 0.4\) ppm).
155.2 (CO), 136.8 (C), 128.3 (2*CH), 127.8 (CH), 127.7 (2*CH), 66.9 (CH2), 61.2 (CH3), 47.9 (CH), 39.7 (CH2), 32.8 (CH2), 28.2 (CH2), 25.2 (CH2), 18.8 (CH2); **HRMS-ESI (m/z):** 343.0 [M+Na]+; **HRMS-ESI (m/z):** calcd for C17H25N2O4 [M+H]+ 321.1814; found 321.1823.

**(2R)-Benzyl 2-(2-oxopentyl)piperidine-1-carboxylate (29)**

To a stirred solution of 28 (99 mg, 0.31 mmol) in dry THF (7 ml) cooled to 0 °C, propyl magnesium chloride (1.25 mmol of a 2 M solution in ether) was added dropwise and the reaction mixture stirred at room temperature for 3 hours. A saturated solution of NH4Cl was added and after extraction with EtOAc (2x 10 ml) the organic layers were dried over dry Na2SO4. The crude obtained after filtration and evaporation was purified by flash chromatography (Eluent: hexane from 100 to 50 % - EtOAc from 0 to 50%) to give 29 (70 mg, 75% yield). **αααα [α]d**25 +13.0 (c = 0.06 in CDCl3); **1H NMR** (CDCl3, 400 MHz) δ 7.34-7.23 (m, 5H), 5.08 (s, 2H), 4.75 (m, 1H), 4.05 (m, 1H), 2.83 (m, 1H), 2.65-2.59 (m, 2H), 2.35 (m, 2H), 1.61-1.47 (m, 8H), 0.84 (t, J = 30.06 Hz, 3H); **13C NMR** (CDCl3, 100 MHz) δ 209.0 (CO), 155.2 (CO), 136.8 (C), 128.3 (CH), 127.9 (CH), 67.0 (CH2), 47.6 (CH), 44.8 (CH2), 43.2 (CH2), 39.8 (CH2), 28.2 (CH2), 25.2 (CH2), 18.8 (CH2), 17.1 (CH2), 13.5 (CH2); **LRMS-ESI (m/z):** 304.0 [M+H]+; **HRMS-ESI (m/z):** calcd for C18H26NO3 [M+H]+ 304.1913; found 304.1923.

**Benzyl (2R) 2-((R)-2-hydroxypentyl)piperidine-1-carboxylate (30)**

To a solution of 29 (100 mg, 0.32 mmol) in dry THF (7 ml), LiAl(O-tBu)3H (109 mg, 0.44 mmol) was added and the reaction mixture was stirred at room temperature for 1 hour. The reaction mixture was cooled down to 0 °C and H2O added dropwise. The suspension obtained was extracted with Et2O (3 x 10 ml) and organic layer dried over dry Na2SO4. After filtration and evaporation compound 30 was purified by flash chromatography (Eluent: CH2Cl2) to give 73 mg (73 % yield). **αααα [α]d**25 +21.6 (c = 0.09 in CDCl3); **1H NMR** (CDCl3, 400 MHz) δ 7.32-7.23 (m, 5H), 5.08 (s, 2H), 4.41 (m, 1H), 4.02 (m, 1H), 3.59 (m, 1H), 2.87 (m, 1H), 1.76-1.23 (m, 12H), 0.89 (m, 3H); **13C NMR** (CDCl3, 50 MHz) δ 155.3 (CO), 136.3 (C), 128.0 (2* CH2), 127.7 (CH2), 127.5 (CH2), 69.3 (CH), 66.9 (CH2), 48.4 (CH), 39.3 (CH2), 37.6 (CH2), 28.6 (CH2), 25.0 (CH2), 18.5 (CH2), 13.5 (CH3); **LRMS-ESI (m/z):** 328 [M+Na]+; **HRMS-ESI (m/z):** calcd for C18H27NO3Na [M+Na]+ 328.1889; found 328.1877.

**(3R,4aR)-3-Propylhexahydro-3H-pyrido[1,2-c][1,2,3]oxathiazine 1,1-dioxide (31)**

To a solution 30 (73 mg, 0.22 mmol) in dry MeOH, 10% Pd/C (20 mg) was added and, after 3 cycles of vacuum/N2, the solution was submitted to H2 (1 Atm). The reaction mixture was stirred at rt for 3 hours. The catalyst was filtrated on celite and the organic solvent removed under reduced pressure. The residue was dissolved in dry CH2Cl2 (5 mL) at 0 °C under N2 and imidazole (24 mg, 0.35 mmol) and TEA (0.26 ml, 1.92 mmol) were added. Freshly distilled SOCl2 (70 µl, 0.98 mmol) was added after 10 min and the reaction was stirred at 0°C for 1 hour and at rt for 24 hours. H2O (15 ml) was added. After extraction with CH2Cl2 (2 x 15 ml), the organic layers were
N-{(1R)-1-[(2S)-Piperidin-2-ylmethyl]butyl}prop-2-en-1-amine (32)

\[
\text{Chemical Formula: C}_{13}\text{H}_{26}\text{N}_2 \\
\text{Exact Mass: 210.2096} \\
\text{Molecular Weight: 210.3589}
\]

In a 10 ml microwave vial, a mixture of allylamine (0.68 ml, 9 mmol) and sulfonamide 31 (40 mg, 0.14 mmol) was submitted to microwave dielectric heating at 100 °C for 20 minutes (Power max 150 W). A 1:1 mixture of Et2O and 20% solution of H2SO4 was added and the suspension was stirred at room temperature for 12 hours. After separation, the water phase was treated with Na2CO3 until pH 9 and extracted with CHCl3 (3 x 5 ml). The organic layers were dried, the solvent evaporated at reduced pressure and purified by flash chromatography (Eluent: CHCl3-MeOH-NH3 99.5:0.5:0.1) giving 32 (20 mg, 63%) as a yellow oil. [\(\alpha\)l]D +9.7 (c = 0.03 in CDCl3); \[^1\text{H} \text{NMR}\] (CDCl3, 400 MHz) \(\delta\) 4.71 (m, 1H), 5.19 (d, J = 12 Hz, 1H), 5.08 (d, J = 6 Hz, 1H), 3.15 (m, 2H), 3.01 (m, 3H), 2.58 (m, 2H), 2.53 (bs, 1H), 2.35 (bs, 1H), 1.78-1.26 (m, 12H), 0.64 (t, \(J = 7\) Hz, 3H). \[^{13}\text{C} \text{NMR}\] (CDCl3, 50 MHz) \(\delta\) 139.6 (CH), 115.2 (CH2), 59.1 (CH), 54.3 (CH), 49.6 (CH2), 48.7 (CH2), 42.3 (CH2), 39.6 (CH2), 30.2 (CH2), 21.2 (CH2), 20.9 (CH2), 17.5 (CH3); \text{LRMS-ESI (m/z)} 233 [M+Na]⁺; \text{HRMS-ESI (m/z)}: calcd for C\text{13}H\text{26}N\text{2}Na [M+Na]⁺ 233.3488; found 233.3481.

(+)-Tetraponerine T-3 (33)

\[
\text{Chemical Formula: C}_{14}\text{H}_{27}\text{N}_2 \\
\text{Exact Mass: 222.2096} \\
\text{Molecular Weight: 222.3696}
\]

In a 10 ml microwave vessel RhCl(CO)(PPh\text{3})\text{2} (1.3 mg, 0.002 mmol) and xanthos (4.6 mg, 0.008 mmol) were added to a solution of 32 (20 mg, 0.1 mmol) in dry toluene (2 ml). The solution was pressurized with syngas at 110 psi and heated to 100 °C (2 x 30 min) by microwave irradiation at 150 W. The flask was cooled and the internal gas released. The residue was treated with 1N HCl (7 ml) and extracted with EtOAc (3 x 5 ml); the water layer was treated with 2N NaOH until pH 9 and extracted with EtOAc (3 x 5 ml). The organic layers were dried over dry Na2SO4 and the solvent evaporated at reduced pressure. The residue was purified by column chromatography on silica gel (Eluent: CHCl3 to CHCl3-EtOH 95:5) to give compound 33 (18 mg, 80% yield). [\(\alpha\)l]D +25 (c 0.07 in CDCl3); \(\text{li}t^{19}\) [\(\alpha\)l]D = +27 (0.07 CHCl3); \[^1\text{H} \text{NMR}\] (CDCl3, 400 MHz) \(\delta\) 3.59 (m, 1H), 2.95-2.78 (m, 2H), 2.43 (m, 2H), 2.12 (m, 3H), 1-85-1-36 (m, 14 H), 0.88 (t, \(J = 7\) Hz, 3H); \[^{13}\text{C} \text{NMR}\] (CDCl3, 50 MHz) \(\delta\) 80.1 (CH), 68.3 (CH), 58.2 (CH), 50.1 (CH2), 45.2 (CH2), 43.1 (CH2), 42.3 (CH2), 37.2 (CH2), 32.6 (CH2), 31.4 (CH2), 23.7 (CH2), 19.9 (CH2), 14.6 (CH2), 10.1(CH3); \text{LRMS-ESI (m/z)} 223 [M+H]⁺; \text{HRMS-ESI (m/z)}: calcd for C\text{14}H\text{27}N\text{2} [M+H]⁺ 223.2174; found 223.2177.
Supporting Information. Mann et al.

-N-cbz

30
Supporting Information. Mann et al.
-S64-
Supporting Information. Mann et al.