Approach to 3-(cyclo)alkylpiperidines through “sp$^3$–sp$^3$ via sp$^2$–sp$^3$” coupling (Supporting information)

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Experimental part.

General. The solvents were purified according to the standard procedures. All the starting materials were purchased from commercial sources. Analytical TLC was performed using Polychrom SI F254 plates. Column chromatography was performed using Kieselgel Merck 60 (230–400 mesh) as the stationary phase. $^1$H and $^{13}$C NMR spectra were recorded on a Varian 400 Gemini 2000 spectrometer (at 400 MHz for Protons and 101 MHz for Carbon-13). Chemical shifts are reported in ppm downfield from TMS ($^1$H, $^{13}$C) as an internal standard. Mass spectra were recorded on Agilent 1100 LC/MSD SL instrument or Agilent 1260 LC/MS instrument (electrospray ionisation (ESI)).

Representative procedure for the preparation of 2: 1-(2-bromopyridin-3-yl)cyclopentanol (2a). To a cooled (−78°C) solution of diisopropylamine (18.3 g, 25.4 mL, 0.181 mol) in absolute THF (700 mL), n-BuLi (69 mL, 23% in hexane, 2.5 M, 0.172 mol) was added dropwise under argon atmosphere. The mixture was stirred at −78°C for 1 h, and a solution of 2-bromopyridine (23.1 g, 14.3 mL, 0.146 mmol) in dry THF (150 mL) was added dropwise over 20 min. The reaction mixture was kept at −78°C for 90 min, and pre-cooled (−78°C) solution of cyclopentanone (26.6 g, 28 mL, 0.316 mol) in dry THF (70 mL) was added in one portion. The mixture was stirred at −78°C for additional 80 min and quenched with saturated aq NaHCO$_3$ (140 mL) at −78°C, then warmed to rt and diluted with EtOAc (1 L). The organic phase was separated, washed with saturated aq NaHCO$_3$ (2×150 mL) and brine (200 mL), dried over Na$_2$SO$_4$, and concentrated in vacuo to give 22.5 g of residue. The product was purified by flash chromatography (gradient hexane–EtOAc as an eluent), followed by recrystallization from pentane. The sample of 2a of analytical purity was obtained by additional recrystallization from hexanes. Yield 14.2 g (40%). White needles. Mp 80–82 °C (hexanes). MS (m/z, ESI): 242/244 (MH$^+$). Anal. calc. for C$_{10}$H$_{12}$BrNO C 49.61 H 5.00 Br 33.00 N 5.79. Found C 49.37 H 5.27 Br 32.74 N 5.70. $^1$H NMR (400 MHz, CDCl$_3$) δ 8.22 (d, $J=$
3.6 Hz, 1H), 7.94 (d, \(J = 7.8\) Hz, 1H), 7.31 – 7.19 (m, 1H), 2.65 (br s, 1H), 2.39 – 2.25 (m, 2H), 2.18 – 2.05 (m, 2H), 2.05 – 1.93 (m, 2H), 1.91 – 1.80 (m, 2H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 147.5 (CH), 141.6 (C), 140.9 (C), 135.8 (CH), 122.18 (CH), 82.2 (C), 39.3 (CH\(_2\)), 23.7 (CH\(_2\)).

2-(2-Bromopyridin-3-yl)propan-2-ol (2b). Purified by column chromatography (gradient hexanes – hexanes/MeOtBu (5 : 1) – benzene/MeOtBu (5 : 1) as eluent). Yield 4.09 g (41%). Yellowish oil. MS (\(m/z\), ESI): 216/218 (MH\(^+\)). Anal. calc. for C\(_8\)H\(_{10}\)BrNO C 44.47 H 4.66 Br 36.98 N 6.48. Found C 44.10 H 4.38 Br 37.25 N 6.29. \(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.23 (dd, \(J = 4.6, 1.9\) Hz, 1H), 8.04 (dd, \(J = 7.8, 1.9\) Hz, 1H), 7.30 – 7.22 (m, 1H), 2.75 (br s, 1H), 1.77 (s, 6H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 147.6 (CH), 143.4 (C), 139.7 (C), 135.6 (CH), 122.4 (CH), 71.9 (C), 28.86 (CH\(_3\)).

1-(2-Bromopyridin-3-yl)cyclobutanol (2c). Yield 5.84 g (56%). White needles. Mp 66–68 °C (heptane). MS (\(m/z\), ESI): 228/230 (MH\(^+\)). Anal. calc. for C\(_9\)H\(_{10}\)BrNO C 47.39 H 4.42 Br 35.03 N 6.14. Found C 47.03 H 4.38 Br 34.82 N 6.08. \(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.27 (dd, \(J = 4.7, 1.9\) Hz, 1H), 7.68 (dd, \(J = 7.6, 1.9\) Hz, 1H), 7.28 (dd, \(J = 7.6, 4.7\) Hz, 1H), 2.71 – 2.61 (m, 2H), 2.59 – 2.33 (m, 3H), 2.51 (br s, 1H), 2.29 – 2.15 (m, 1H), 1.77 – 1.65 (m, 1H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 148.2 (CH), 141.1 (C), 140.3 (C), 135.2 (CH), 122.3 (CH), 77.2 (C), 34.6 (CH\(_2\)), 14.0 (CH\(_2\)).

1-(2-Bromopyridin-3-yl)cyclohexanol (2d). Yield 6.31 g (54%). White powder. Mp 112–114 °C (hexanes). MS (\(m/z\), ESI): 256/258 (MH\(^+\)). Anal. calc. for C\(_{11}\)H\(_{14}\)BrNO C 51.58 H 5.51 Br 31.19 N 5.47. Found C 51.73 H 5.87 Br 31.01 N 5.66. \(^{1}\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 8.23 (dd, \(J = 4.6, 1.9\) Hz, 1H), 7.99 (dd, \(J = 7.8, 1.9\) Hz, 1H), 7.26 (dd, \(J = 7.8, 4.6\) Hz, 1H), 2.62 (br s, 1H), 2.26 (td, \(J = 13.3, 4.4\) Hz, 2H), 1.96 – 1.87 (m, 2H), 1.85 – 1.63 (m, 5H), 1.38 – 1.25 (m, 1H). \(^{13}\)C
NMR (101 MHz, CDCl₃) δ 147.5 (CH), 143.3 (C), 139.9 (C), 135.8 (CH), 122.44 (CH), 72.7 (C), 34.8 (CH₂), 24.7 (CH₂), 21.4 (CH₂).

1-(2-Bromopyridin-3-yl)cycloheptanol (2e). Yield 6.73 g (55%). White plates. Mp 89–91 °C (hexanes). MS (m/z, ESI): 270/272 (MH⁺). Anal. calc. for C₁₂H₁₆BrNO C 53.35 H 5.97 Br 29.58 N 5.18. Found C 52.99 H 5.84 Br 29.20 N 4.85. ¹H NMR (400 MHz, CDCl₃) δ 8.23 (dd, J = 4.6, 1.9 Hz, 1H), 8.02 (dd, J = 7.8, 1.9 Hz, 1H), 7.26 (dd, J = 7.8, 4.6 Hz, 1H), 2.55 (br s, 1H), 2.55 (ddd, J = 14.8, 10.8, 2.0 Hz, 2H), 1.96 – 1.80 (m, 4H), 1.78 – 1.69 (m, 2H), 1.69 – 1.57 (m, 4H). ¹³C NMR (101 MHz, CDCl₃) δ 147.3 (CH), 147.1 (C), 139.9 (C), 135.8 (CH), 122.3 (CH), 76.4 (C), 39.13 (CH), 27.8 (CH), 22.0 (CH).

4-(2-Bromopyridin-3-yl)-1-methylpiperidin-4-ol (2f). Yield 6.59 g (54%). Yellowish needles. Mp 129–131 °C (heptane). MS (m/z, ESI): 271/273 (MH⁺). Anal. calc. for C₁₁H₁₅BrN₂O C 48.73 H 5.58 Br 29.47 N 10.33. Found C 48.48 H 5.37 Br 29.40 N 10.72. ¹H NMR (400 MHz, CDCl₃) δ 8.25 (dd, J = 4.6, 1.9 Hz, 1H), 7.88 (dd, J = 7.8, 1.9 Hz, 1H), 7.28 (dd, J = 7.8, 4.6 Hz, 1H), 2.81 – 2.74 (m, 2H), 2.55 – 2.46 (m, 2H), 2.43 – 2.34 (m, 2H), 2.33 (s, 3H), 2.10 – 2.02 (m, 2H). ¹³C NMR (101 MHz, CDCl₃) δ 147.8 (CH), 141.8 (C), 140.1 (C), 135.6 (CH), 122.5 (CH), 70.2 (C), 50.7 (CH₂), 45.88 (CH₃), 34.9 (CH₂).

1-(2-Bromopyridin-3-yl)-1-phenylethanol (2g). Yield 4.89 g (49%). White powder. Mp 112–113 °C (pentane). MS (m/z, ESI): 278/280 (MH⁺). Anal. calc. for C₁₃H₁₂BrNO C 56.14 H 4.35 Br 28.73 N 5.04. Found C 56.17 H 4.03 Br 28.47 N 4.79. ¹H NMR (400 MHz, CDCl₃) δ 8.27 (dd, J = 4.7, 1.7 Hz, 1H), 8.18 (dd, J = 7.8, 1.7 Hz, 1H), 7.36 (dd, J = 7.8, 4.7 Hz, 1H), 7.34 – 7.24 (m, 5H), 3.47 (br s, 1H), 2.00 (s, 3H). ¹³C NMR (101 MHz, CDCl₃) δ 148.1 (CH), 145.6 (C), 142.4 (C), 141.4 (C), 136.3 (CH), 128.0 (CH), 127.0 (CH), 125.4 (CH), 122.2 (CH), 75.8 (C), 28.9 (CH₃).
1-(2-Bromopyridin-3-yl)-2-methylpropan-1-ol (2h). Yield 6.23 g (60%). White powder. Mp 57–59 °C (hexanes). MS (m/z, ESI): 230/232 (MH⁺). Anal. calc. for C₉H₁₂BrNO C 46.98 H 5.26 Br 34.72 N 6.09. Found C 46.72 H 5.04 Br 34.54 N 6.36. \(^1\)H NMR (400 MHz, CDCl₃) δ 8.18 (dd, J = 4.7, 2.0 Hz, 1H), 7.80 (dd, J = 7.7, 2.0 Hz, 1H), 7.25 (dd, J = 7.7, 4.7 Hz, 1H), 4.81 (d, J = 5.1 Hz, 1H), 2.78 (br s, 1H), 2.10 – 1.97 (m, 1H), 0.97 (d, J = 6.9 Hz, 3H), 0.88 (d, J = 6.7 Hz, 3H). \(^1\)H NMR (101 MHz, CDCl₃) δ 148.1 (CH), 141.5 (C), 140.2 (C), 136.6 (CH), 122.5 (CH), 75.8 (CH), 33.2 (CH), 19.2 (CH₃), 15.9 (CH₃).

(2-Bromopyridin-3-yl)(phenyl)methanol (2i). Prepared following representative procedure, but using 1.11-fold excess of benzaldehyde to 2-bromopyridine. Yield 8.05 g (67%). White powder. Mp 123–125 °C (EtOH). MS (m/z, ESI): 264/266 (MH⁺). Anal. calc. for C₁₂H₁₀BrNO C 54.57 H 3.82 Br 30.25 N 5.30. Found C 54.36 H 4.15 Br 30.14 N 5.62. \(^1\)H NMR (400 MHz, CDCl₃) δ 8.15 (dd, J = 4.7, 1.9 Hz, 1H), 7.94 (dd, J = 7.7, 1.8 Hz, 1H), 7.39 – 7.24 (m, 6H), 6.09 (s, 1H), 3.40 (s, 1H). \(^1\)C NMR (101 MHz, CDCl₃) δ 148.4 (CH), 141.7 (C), 141.0 (C), 139.9 (C), 136.6 (CH), 128.2 (CH), 127.7 (CH), 126.7 (CH), 122.8 (CH), 73.4 (CH).

Representative procedure for the preparation of 1: 3-cyclopenylpiperidine (1a). A mixture of 10% Pd/C (5.0 g, 50% wet with H₂O for safety, unreduced), MeOH (400 mL), pyridine 2a (25.1 g, 0.103 mol), and concentrated aq HCl (2.5 mL, 0.03 mol), was placed in an autoclave and hydrogenated at 40 bar of H₂ and 85 °C for 64 h. The catalyst was filtered off, and the filtrate was evaporated under reduced pressure to give 24.6 g of the residue. It was dissolved in H₂O (150 mL), 20% aq NaOH (50 mL) was added, and the mixture was extracted with hexanes (2×80 mL). The combined organic phases were dried over NaOH and evaporated in vacuo. The crude product was distilled in vacuo to give the product 1a. Yield 13.8 g (87%). Colorless liquid. Bp 94–96 °C / 10 mbar. MS (m/z, ESI): 154 (MH⁺). Anal. calc. for C₁₀H₁₉N C 78.37 H 12.50 N 9.14. Found C 78.03 H 12.71 N 8.96. \(^1\)H NMR (400 MHz, CDCl₃) δ 3.07 – 2.99 (m, 1H), 2.97 – 2.89 (m, 1H), 2.46 (td, J
= 11.9, 2.9 Hz, 1H), 2.21 (dd, J = 11.9, 10.4 Hz, 1H), 2.04 (br s, 1H), 1.85 – 1.77 (m, 1H), 1.75 – 1.63 (m, 2H), 1.63 – 1.48 (m, 3H), 1.48 – 1.31 (m, 4H), 1.20 – 1.10 (m, 1H), 1.10 – 0.93 (m, 3H). 13C NMR (101 MHz, CDCl3) δ 51.9 (CH2), 46.7 (CH2), 44.0 (CH), 42.9 (CH), 30.2 (CH2), 30.1 (CH2), 30.0 (CH2), 26.5 (CH2), 24.9 (CH2), 24.7 (CH2).

3-Isopropylpiperidine (1b). Yield 10.2 g (83%). Colorless liquid. Bp 164–166 °C. MS (m/z, ESI): 128 (MH+). Anal. calc. for C8H17N C 75.52 H 13.47 N 11.01. Found C 75.78 H 13.69 N 10.71. 1H NMR (400 MHz, CDCl3) δ 3.05 – 2.98 (m, 1H), 2.97 – 2.91 (m, 1H), 2.44 (td, J = 11.9, 2.9 Hz, 1H), 2.24 (dd, J = 11.9, 10.6 Hz, 1H), 1.80 – 1.73 (m, 1H), 1.61 (br s, 1H), 1.66 – 1.58 (m, 1H), 1.43 – 1.29 (m, 2H), 1.17 – 1.07 (m, 1H), 1.06 – 0.94 (m, 1H), 0.82 (d, J = 6.8 Hz, 6H). 13C NMR (101 MHz, CDCl3) δ 50.4 (CH2), 46.8 (CH2), 43.4 (CH), 30.9 (CH), 28.2 (CH2), 26.8 (CH2), 19.7 (CH3), 19.5 (CH3).

3-Cyclobutylpiperidine (1c). Yield 11.0 g (80%). Colorless liquid. Bp 74–75 °C / 10 mbar. MS (m/z, ESI): 141 (MH+). Anal. calc. for C9H17N C 77.63 H 12.31 N 10.06. Found C 77.34 H 12.58 N 10.38. 1H NMR (400 MHz, CDCl3) δ 2.92 (d, J = 12.0 Hz, 2H), 2.45 (td, J = 11.9, 2.9 Hz, 1H), 2.06 (dd, J = 11.9, 10.4 Hz, 1H), 1.98 – 1.86 (m, 3H), 1.84 – 1.51 (m, 7H), 1.41 – 1.23 (m, 2H), 0.82 (ddd, J = 23.8, 12.5, 3.9 Hz, 1H). 13C NMR (101 MHz, CDCl3) δ 49.9 (CH2), 46.7 (CH2), 43.7 (CH), 39.3 (CH), 28.0 (CH2), 26.4 (CH2), 26.2 (CH2), 26.1 (CH2), 18.0 (CH2).

3-Cyclohexylpiperidine (1d). Yield 9.86 g (74%). Colorless liquid. Bp 110–112 °C / 10 mbar. MS (m/z, ESI): 168 (MH+). Anal. calc. for C11H21N C 78.98 H 12.65 N 8.37. Found 79.28 H 12.47 N 8.38. 1H NMR (400 MHz, CDCl3) δ 3.01 – 2.93 (m, 1H), 2.93 – 2.85 (m, 1H), 2.40 (td, J = 11.9, 2.9 Hz, 1H), 2.21 (dd, J = 11.9, 10.7 Hz, 1H), 1.77 – 1.69 (m, 1H), 1.67 – 1.48 (m, 7H), 1.39 – 1.25 (m, 1H), 1.21 – 1.03 (m, 4H), 1.03 – 0.92 (m, 2H), 0.92 – 0.79 (m, 2H). 13C NMR (101
MHz, CDCl\textsubscript{3}) $\delta$ 50.4 (CH\textsubscript{2}), 46.8 (CH\textsubscript{2}), 42.4 (CH), 41.0 (CH), 29.9 (CH\textsubscript{2}), 29.8 (CH\textsubscript{2}), 28.3 (CH\textsubscript{2}), 26.8 (CH\textsubscript{2}), 26.34 (CH\textsubscript{2}), 26.29 (2×CH\textsubscript{2}).

3-Cycloheptylpirperidine (1e). Yield 12.4 g (90%). Colorless liquid. Bp 127–128 °C / 12 mbar. MS ($m/z$, ESI): 182 (MH\textsuperscript{+}). Anal. calc. for C\textsubscript{12}H\textsubscript{23}N C 79.49 H 12.79 N 7.72. Found C\textsubscript{12}H\textsubscript{23}N C 79.28 H 12.97 N 8.01. $^1$H NMR (400 MHz, CDCl\textsubscript{3}) $\delta$ 2.99 – 2.91 (m, 2H), 2.44 (td, $J = 12.2$, 2.9 Hz, 1H), 2.30 (dd, $J = 11.9$, 10.6 Hz, 1H), 1.74 – 1.17 (m, 18H), 1.16 – 1.04 (m, 1H). $^{13}$C NMR (101 MHz, CDCl\textsubscript{3}) $\delta$ 50.2 (CH\textsubscript{2}), 46.9 (CH\textsubscript{2}), 43.6 (CH), 42.4 (CH), 31.1 (CH\textsubscript{2}), 31.0 (CH\textsubscript{2}), 28.08 (CH\textsubscript{2}), 28.07 (CH\textsubscript{2}), 28.06 (CH\textsubscript{2}), 27.1 (CH\textsubscript{2}), 26.71 (CH\textsubscript{2}), 26.68 (CH\textsubscript{2}).

3-(1-Phenylethyl)piperidine (1g). Purified by column chromatography (hexanes/EtOAc/Et\textsubscript{3}N (50 : 50 : 1) as eluent). Mixture of diastereomers (ca. 70 : 30). Yield 6.36 g (71%). Yellowish oil. MS ($m/z$, ESI): 190 (MH\textsuperscript{+}). Anal. calc. for C\textsubscript{13}H\textsubscript{19}N C 82.48 H 10.12 N 7.40. Found C\textsubscript{13}H\textsubscript{19}N C 82.26 H 9.93 N 7.07. $^1$H NMR (400 MHz, CDCl\textsubscript{3}) $\delta$ 7.31 – 7.24 (m, 2H), 7.21 – 7.17 (m, 0.7H), 7.17 – 7.11 (m, 2.3H), 3.26 (d, $J = 11.8$ Hz, 0.7H), 2.96 (d, $J = 11.9$ Hz, 1H), 2.70 (d, $J = 12.0$ Hz, 0.3H), 2.52 – 2.39 (m, 2H), 2.37 – 2.27 (m, 0.7H), 2.17 – 2.10 (m, 0.3H), 2.07 – 1.99 (m, 0.3H), 1.78 – 1.41 (m, 4H), 1.39 – 1.26 (m, 0.7H), 1.24 (d, $J = 7.0$ Hz, 3H), 1.08 (ddd, $J = 24.1$, 12.6, 4.1 Hz, 0.3H), 0.91 (ddd, $J = 24.1$, 12.5, 3.8 Hz, 0.7H). $^{13}$C NMR (101 MHz, CDCl\textsubscript{3}) $\delta$, major isomer 145.9 (C), 127.8 (CH), 127.2 (CH), 125.5 (CH), 51.0 (CH\textsubscript{2}), 46.6 (CH\textsubscript{2}), 43.7 (CH), 43.2 (CH), 29.7 (CH\textsubscript{2}), 26.5 (CH\textsubscript{2}), 19.0 (CH\textsubscript{3}); minor isomer 146.0 (C), 127.8 (CH), 127.0 (CH), 125.5 (CH), 51.4 (CH\textsubscript{2}), 46.6 (CH\textsubscript{2}), 43.7 (CH), 43.2 (CH), 29.1 (CH\textsubscript{2}), 26.6 (CH\textsubscript{2}), 18.8 (CH\textsubscript{3}).

3-Isobutylpiperidine (1h). Yield 10.6 g (66%). Colorless liquid. Bp 72–75 °C / 30 mbar. MS ($m/z$, ESI): 142 (MH\textsuperscript{+}). Anal. calc. for C\textsubscript{9}H\textsubscript{19}N C 76.53 H 13.56 N 9.92. Found C\textsubscript{9}H\textsubscript{19}N C 76.31 H 13.84 N 9.59. $^1$H NMR (400 MHz, CDCl\textsubscript{3}) $\delta$ 2.98 – 2.93 (m, 1H), 2.93 – 2.89 (m, 1H), 2.46 (td, $J = 12.0$, 2.9 Hz, 1H), 2.13 (dd, $J = 11.9$, 10.5 Hz, 1H), 1.81 (s, 1H), 1.77 – 1.69 (m, 1H), 1.62 – 1.52 (m, 2H), 1.47 – 1.32 (m,
2H), 1.02 – 0.87 (m, 3H), 0.81 (d, J = 6.8 Hz, 3H), 0.80 (d, J = 6.8 Hz, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 53.0 (CH$_2$), 46.8 (CH$_2$), 43.7(CH$_2$), 34.5 (CH), 31.6 (CH), 26.4 (CH$_2$), 24.3 (CH), 22.6 (CH$_3$), 22.4 (CH$_3$).

3-Benzylpiperidine (1i). Yield 11.9 g (85%). Colorless liquid. Bp 35–137 °C / 10 mmHg. MS (m/z, ESI): 176 (MH$^+$). Anal. calc. for C$_{12}$H$_{17}$N C 82.23 H 9.78 N 7.99. Found C 81.95 H 10.01 N 7.74. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.30 – 7.23 (m, 2H), 7.21 – 7.16 (m, 1H), 7.16 – 7.11 (m, 2H), 3.03 – 2.92 (m, 2H), 2.57 – 2.40 (m, 3H), 2.28 (dd, J = 12.0, 10.3 Hz, 1H), 1.89 (br s, 1H), 1.82 – 1.74 (m, 1H), 1.74 – 1.67 (m, 1H), 1.67 – 1.59 (m, 1H), 1.47 – 1.33 (m, 1H), 1.13 – 1.02 (m, 1H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 140.0 (C), 128.6 (CH), 127.8 (CH), 125.4 (CH), 52.5 (CH$_2$), 46.7 (CH$_2$), 40.9 (CH$_2$), 38.9 (CH), 31.1 (CH$_2$), 26.4 (CH$_2$).

1'-Methyl-3,4'-bipiperidine (1f). 40% aq HBr (0.5 mL) was added to 2f (0.40 g, 2.08 mmol). The resulting solution was evaporated to dryness, and the residue was dried in vacuo (ca. 1 mmHg) at 40–45 °C for 9 h and at 75–80 °C for 2 h. A mixture of the resulting hydrobromide, dry MeOH (40 mL), 10% Pd-C (0.40 g, 50% wet with H$_2$O for safety, unreduced) was placed in an autoclave and hydrogenated at 40 bar of H$_2$ and 80 °C for 16 h. The catalyst was filtered and washed with MeOH (30 mL). The combined filtrates were evaporated to dryness to give 0.52 g of the residue, which was dissolved in dry THF (10 mL). K$_3$PO$_4$ (1.10 g, 5.20 mmol) was added, and the mixture was stirred overnight. The precipitate was filtered off, and the filtrates were evaporated in vacuo. The crude product was purified by preparative TLC (CHCl$_3$/MeOH/Et$_3$N (45:5:1) as eluent). Yield 172 mg (45%). Yellowish oil. MS (m/z, ESI): 183 (MH$^+$). Anal. calc. for C$_{11}$H$_{22}$N$_2$ C 72.47 H 12.16 N 15.37. Found C 72.25 H 12.47 N 15.10. $^1$H NMR (400 MHz, CDCl$_3$) δ 3.01 – 2.94 (m, 1H), 2.92 – 2.84 (m, 1H), 2.80 – 2.72 (m, 2H), 2.44 – 2.34 (m, 1H), 2.19 (dd, J = 14.6, 7.9 Hz, 1H), 2.13 (s, 3H), 2.08 (br s, 1H), 1.79 – 1.68 (m, 2H), 1.62 – 1.49 (m, 3H), 1.38 – 1.07 (m, 4H), 1.03 – 0.86 (m, 2H). $^{13}$C NMR (101
MHz, CDCl₃) δ 55.9 (CH₂), 55.8 (CH₂), 50.2 (CH₂), 46.7 (CH₂), 46.1 (CH₃), 41.6 (CH), 38.4 (CH), 29.2 (CH₂), 29.0 (CH₂), 28.2 (CH₂), 26.5 (CH₂).
$^1$H NMR spectrum of the compound 2a

![NMR spectrum of compound 2a](image)
$^{13}$C NMR spectrum of the compound 2a
$^1$H NMR spectrum of the compound 2b
$^{13}$C NMR spectrum of the compound 2b
$^1$H NMR spectrum of the compound 2c
$^{13}$C NMR spectrum of the compound $2c$
$^1$H NMR spectrum of the compound 2d
$^{13}$C NMR spectrum of the compound 2d
$^1$H NMR spectrum of the compound 2e
$^{13}$C NMR spectrum of the compound 2e
$^1$H NMR spectrum of the compound 2f
$^{13}$C NMR spectrum of the compound 2f
$^1$H NMR spectrum of the compound 2g
$^{13}$C NMR spectrum of the compound 2g
$^1$H NMR spectrum of the compound 2h
$^{13}$C NMR spectrum of the compound 2h
$^1$H NMR spectrum of the compound 2i
$^{13}$C NMR spectrum of the compound 2i

![Chemical Structure](image)
$^1$H NMR spectrum of the compound $1a$
$^{13}$C NMR spectrum of the compound 1a
$^1$H NMR spectrum of the compound 1b
$^{13}$C NMR spectrum of the compound 1b
$^1$H NMR spectrum of the compound 1c
$^{13}$C NMR spectrum of the compound 1c
\[ ^{1}\text{H NMR spectrum of the compound 1d} \]
$^{13}$C NMR spectrum of the compound 1d
$^1$H NMR spectrum of the compound 1e
$^{13}$C NMR spectrum of the compound 1e
$^1$H NMR spectrum of the compound 1f
$^{13}$C NMR spectrum of the compound 1f
$^1$H NMR spectrum of the compound $1g$
$^{13}$C NMR spectrum of the compound 1g
$^1$H NMR spectrum of the compound 1h
$^{13}$C NMR spectrum of the compound 1h
$^1$H NMR spectrum of the compound 1i
$^{13}$C NMR spectrum of the compound 1i