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Supporting Information

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Highly stereoselective synthesis of β-lactams utilizing α-chloroimines as new and powerful chiral inductors

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cis-3-Benzyloxy-1-_tert_-butyl-4-(1-chloroethyl)-4-methylazetidin-2-one 9b

80% yield, yellow oil, TLC Rf 0.28 (hexane/EtOAc 3/1). ^{1}H NMR (270 MHz, $CDCl_3$): δ 1.43 (9H,s), 1.66 (3H, s), 1.76 (3H, d, J= 6.6 Hz), 4.19 (1H, s), 4.37 (1H, q, J= 6.6 Hz), 4.78 (1H, d, J= 11.9 Hz), 4.84 (1H, d, J= 11.9 Hz), 7.24-7.41 (5H, m). ^{13}C NMR (68 MHz, $CDCl_3$): δ 20.7, 23.4, 28.4, 55.1, 60.8, 70.0, 73.6, 87.6, 127.4, 127.5, 128.1, 137.2, 166.9. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1740. MS (70 eV) m/z (%): 309/11 (0.2, M^+), 91 (100), 85 (16). Anal. Calcd for $C_{17}H_{24}ClNO_2$: C 65.90; H 7.81; N 4.52. Found: C 66.11; H 8.04; N 4.39.

cis-3-Benzyloxy-4-(1-chloroethyl)-1-cyclohexyl-4-methylazetidin-2-one 9c

70% yield, yellow oil, TLC Rf 0.62 (hexane/EtOAc 3/2). ^{1}H NMR (270 MHz, $CDCl_3$): δ 1.19-2.06 (10H, m), 1.43 (3H, s), 1.53 (3H, d, J= 6.9 Hz), 3.09-3.21 (1H, m), 4.23 (1H, s), 4.45 (1H, q, J= 6.9 Hz), 4.69 (1H, d, J= 11.9 Hz), 4.93 (1H, d, J= 11.9 Hz), 7.29-7.36 (5H, m). ^{13}C NMR (68 MHz, $CDCl_3$): δ 15.9, 18.3, 21.7, 25.1, 25.9, 31.4, 31.7, 53.6, 63.1, 66.4, 72.9, 86.9, 127.7, 127.9, 128.4, 137.1, 166.3. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1742. MS (70 eV) m/z (%): 335/7 (0.5, M^+), 209/11 (34), 175 (26), 91 (100), 85 (35). Anal. Calcd for $C_{19}H_{26}ClNO_2$: C 67.94; H 7.80; N 4.17. Found: C 67.81; H 7.96; N 4.04.

cis-3-Benzyloxy-4-(1-chloroethyl)-1-ethyl-4-methylazetidin-2-one 9d

72% yield, white crystals, Mp. 85.6-86.0 °C, TLC Rf 0.25 (hexane/EtOAc 3/1). ^{1}H NMR (270 MHz, $CDCl_3$): δ 1.27 (3H, t, J= 7.3 Hz), 1.45 (3H, s), 1.54 (3H, d, J= 6.6 Hz), 3.31-3.40 (2H, m), 4.28 (1H, s), 4.48 (1H, q, J=6.6 Hz), 4.69 (1H, d, J= 11.9 Hz), 4.95 (1H, d, J= 11.9 Hz), 7.30-7.36 (5H, m). ^{13}C NMR (68 MHz, $CDCl_3$): δ 14.4, 16.3, 21.6, 35.7, 62.7, 66.9, 72.8, 87.3, 127.7, 127.9, 128.4, 137.0, 166.9. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1744. MS (70 eV) m/z (%): 282/4 (100, M^++1). Anal. Calcd for $C_{15}H_{20}ClNO_2$: C 63.94; H 7.15; N 4.97. Found: C 64.35; H 7.37; N 4.79.

***cis*-4-(1-Chloroethyl)-1-isopropyl-4-methyl-3-phenoxyazetidin-2-one 9e**

76% yield, yellow oil, TLC Rf 0.42 (hexane/EtOAc 3/1). ^{1}H NMR (270 MHz, $CDCl_3$): δ 1.40 and 1.47 (2×3H, 2×d, J=6.6 Hz), 1.55 (3H, s), 1.57 (3H, d, J= 6.6 Hz), 3.66 (1H, septet, J= 6.6 Hz), 4.56 (1H, q, J= 6.6 Hz), 4.84 (1H, s), 6.90-7.38 (5H, m). ^{13}C NMR (68 MHz, $CDCl_3$): δ 15.7, 21.4, 21.65, 21.74, 46.1, 62.7, 66.7, 86.6, 115.9, 122.4, 129.6, 157.6, 164.6. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1746. MS (70 eV) m/z (%): 281/3 (0.5, M^+), 196/8 (37), 161 (100), 103 (21), 94 (81), 91 (26), 77 (20). Anal. Calcd for $C_{15}H_{20}ClNO_2$: C 63.94; H 7.15; N 4.97. Found: C 64.17; H 7.28; N 4.74.

***cis*-1-Allyl-3-benzyloxy-4-(1-chloroethyl)-4-methyl-2-azetidinone 9f**

72% yield, colourless oil, TLC Rf 0.3 (hexane/EtOAc 3/1) ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.45 (3H, s), 1.54 (3H, d, *J*= 6.6 Hz), 3.91 (1H, d×d×t, *J*= 15.4 Hz, *J*= 6.9 Hz, *J*= 1.2 Hz), 4.00 (1H, d×d×t, *J*= 15.4 Hz, *J*= 5.5 Hz, *J*= 1.5 Hz), 4.31 (1H, s), 4.50 (1H, quadr, *J*= 6.6 Hz), 4.70 (1H, d, *J*= 11.7 Hz), 4.95 (1H, d, *J*= 11.7 Hz), 5.15-5.29 (2H, m), 5.80-5.93 (1H, m), 7.26-7.39 (5H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 16.5, 21.6, 43.4, 62.6, 67.2, 72.8, 87.4, 118.0, 127.7, 128.0, 128.5, 132.8, 136.9, 166.6. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1760, ν_{max}= 2983, 1644, 1498, 1455. MS (70 eV) m/z (%): 294/6(M^++1, 100). Anal. Calcd for $C_{16}H_{20}ClNO_2$: C 56.41; H 6.86; N 4.77. Found: C 65.74; H 6.98; N 4.53.

Synthesis of pyrrolidines 10 and aziridine 11

General procedure: To an ice-cooled mixture of azetidin-2-one **9** (5 mmol) in dry diethyl ether (15 mL) was added lithium aluminium hydride (10 – 25 mmol) in small portions. The resulting mixture was stirred for 2 hours at 0 °C or 4 hours at room temperature. Afterwards, water was added to neutralize the residual $LiAlH_4$ and the resulting suspension was filtered over potassium carbonate. Evaporation of the solvent afforded the crude product, which was purified by means of column chromatography on silica gel.

4-Benzyloxy-3-chloro-1-isopropyl-2,3-dimethylpyrrolidine 10a

55% yield, yellow oil, TLC Rf 0.32 (CH_2Cl_2/MeOH 19/1). ^{1}H NMR (270 MHz, $CDCl_3$): δ 0.84 and 1.08 (2×3H, 2×d, J= 6.6 Hz), 1.14 (3H, d, J= 5.9 Hz), 1.54 (3H, s), 2.77 (1H, q, J=5.9 Hz), 2.89 (2H, m), 2.98 (1H, septet, J= 6.6 Hz), 3.59 (1H, t, J= 8.0 Hz), 4.62 (1H, d, J= 12.0 Hz), 4.67 (1H, d, J=12.0 Hz), 7.26-7.37 (5H, m). ^{13}C NMR (68 MHz, $CDCl_3$): δ 13.4, 22.2, 14.1, 25.9, 47.0, 47.3, 62.8, 72.3, 78.0, 82.4, 127.7, 127.8, 128.4, 138.0. IR (NaCl, cm^{-1}): ν= 2961, 1493, 1450, 1361, 1351, 1327, 1234, 1164, 1143, 1097. MS (70 eV) m/z (%): 281/3 (2, M^+), 266/8 (45), 140 (37), 99 (18), 91 (100), 57 (26), 56 (23). Anal. Calcd for $C_{16}H_{24}ClNO$: C 68.19; H 8.58; N 4.97. Found: C 68.03; H 8.76; N 5.11.

4-Benzyloxy-1-*tert*-butyl-3-chloro-2,3-dimethylpyrrolidine 10b

41% yield, yellow oil, TLC Rf 0.24 (CH_2Cl_2/MeOH 19/1). ^{1}H NMR (270 MHz, $CDCl_3$): δ 1.03 (9H, s), 1.34 (3H, d, J= 6.6 Hz), 1.54 (3H, s), 2.82-3.07 (3H, m), 3.40-3.46 (1H, m), 4.63 (2H, s), 7.22-7.38

(5H, m). ^{13}C NMR (68 MHz, $CDCl_3$): δ 20.2, 27.0, 27.1, 49.5, 54.8, 61.7, 72.5, 79.2, 82.4, 127.7, 127.8, 128.3, 138.0. IR (NaCl, cm^{-1}): ν= 2974, 1497, 1480, 1455, 1365, 1195, 1149, 1120, 1092, 1056, 1028. MS (70 eV) m/z (%): no M^+, 280/2 (28, M^+-Me), 154 (6), 91 (34), 77 (5), 57 (9). Anal. Calcd for $C_{17}H_{26}ClNO$: C 69.02; H 8.86; N 4.73. Found: C 68.81; H 8.97; N 4.77.

2-(1-Allyl-2,3-dimethyl-2-aziridinyl)-2-(benzyloxy)ethanol 11

47% yield, colourless oil, TLC Rf 0.3 (CH_2Cl_2/MeOH 19/1). ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.21 (3H, d, *J*= 5.8 Hz), 1.22 (3H, s), 1.34 (1H, quadr, *J*= 5.8 Hz), 2.98 (1H, d×d×t, *J*= 13.8 Hz, *J*= 5.7 Hz, *J*= 1.1 Hz), 3.30 (1H, d×d, *J*= 13.8 Hz, *J*= 6.1 Hz), 3.36 (1H, d×d, *J*= 9.3 Hz, *J*= 3.6 Hz), 3.54 (1H, d×d, *J*= 11.3 Hz, *J*= 3.6 Hz), 3.71 (1H, d×d, *J*= 11.3 Hz, *J*= 9.3 Hz), 4.55 (1H, d, *J*= 11.4 Hz), 4.87 (1H, d, *J*= 11.4 Hz), 5.11-5.30 (2H, m), 5.96-6.09 (1H, m), 7.27-7.39 (5H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 11.6, 14.7, 42.6, 43.2, 55.0, 63.1, 71.7, 84.7, 116.4, 127.6, 127.8, 128.4, 136.3, 138.7. IR (NaCl, cm^{-1}): ν_{max}= 2932, 1644, 1455. MS (70 eV) m/z (%): 262 (M^++1, 100). Rf: 0.3 (MeOH-CH_2Cl_2: 5-95). Anal. Calcd for $C_{16}H_{23}ClNO_2$: C 73.53; H 8.87; N 5.36. Found: C 73.45; H 9.05; N 5.24.

* To obtain spectral data of imines **14**, the solvent was removed completely. Because of the instability of these imines, no elemental analysis of these compounds could be obtained.

***N*-((2*S*)-2-Chloropropylidene)benzylamine 14a**

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.66 (3H, d, *J* = 6.6 Hz), 4.55 (1H, d×q, *J* = 6.6, *J* = 5.5 Hz), 4.62 (2H, d, *J* = 1.4 Hz), 7.24-7.37 (5H, m), 7.71 (1H, d×t, *J* = 5.5 Hz, *J* = 1.4 Hz). ^{13}C NMR (75 MHz, $CDCl_3$): δ 21.9, 56.9, 64.1, 127.2, 128.1, 128.7, 138.3, 163.6. IR (NaCl, cm^{-1}): $\nu_{C=N}$= 1667. MS (70 eV) m/z (%): 182/4 (M^++1, 20), 108 (100).

***N*-((2*S*)-2-Chloropropylidene)allylamine 14b**

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.65 (3H, d, *J* = 6.6 Hz), 4.07 (2H, d, *J* = 5.8 Hz), 4.44-4.54 (1H, m), 5.13-5.20 (2H, m), 5.80-6.03 (1H, m), 7.62 (1H, d×t, *J* = 5.2 Hz, *J* = 1.4 Hz). ^{13}C NMR (75 MHz, $CDCl_3$): δ 21.8, 56.8, 62.3, 116.5, 135.0, 163.5. IR (NaCl, cm^{-1}): ν_{max}= 2972. MS (70 eV) m/z (%): 132/4 (M^++1, 100).

***N*-((2*S*)-2-Chloropropylidene)butylamine 14c**

^{1}H NMR (300 MHz, $CDCl_3$): δ 0.93 (3H, t, *J* = 7.4 Hz), 1.32 (2H, sext, *J* = 7.43 Hz), 1.53-1.64 (2H, m), 1.63 (3H, d, *J* = 6.6 Hz), 3.43 (2H, t, *J* = 6.9 Hz), 4.48 (1H, d×q, *J* = 6.6, *J* = 5.5 Hz), 7.71 (1H, d×t, *J* = 5.5 Hz, *J* = 1.4 Hz). ^{13}C NMR (75 MHz, $CDCl_3$): δ 14.0, 20.3, 22.0, 32.6, 57.0, 60.3, 162.4. IR (NaCl, cm^{-1}): $\nu_{C=N}$= 1646. MS (70 eV) m/z (%): 113 (M^++1-Cl, 100).

***N*-((2*S*)-2-Chloropropylidene)isobutylamine 14d**

^{1}H NMR (300 MHz, $CDCl_3$): δ 0.91 (6H, d, *J* = 6.6 Hz), 1.63 (3H, d, *J* = 6.6 Hz), 1.91 (1H, sept, *J* = 6.6 Hz), 3.23 (2H, d, *J* = 6.6 Hz), 4.44-4.53 (1H, m), 7.55 (1H, d, *J* = 5.8 Hz). ^{13}C NMR (75 MHz, $CDCl_3$): δ 20.5, 21.9, 29.2, 56.8, 58.5, 162.5. IR (NaCl, cm^{-1}): $\nu_{C=N}$= 1667. MS (70 eV) m/z (%): 148/50 (M^++1, 100).

***N*-((2*S*)-2-Chloropropylidene)isopropylamine 14e**

^{1}H NMR (300 MHz, $CDCl_3$): δ 1.16 and 1.17 (6H, 2×d, *J* = 6.3 Hz), 1.62 (3H, d, *J* = 6.6 Hz), 3.38 (1H, sept, *J* = 6.3 Hz), 3.23 (2H, d, *J* = 6.6 Hz), 4.41-4.50 (1H, m), 7.58 (1H, d, *J* = 5.8 Hz). ^{13}C NMR (75 MHz, $CDCl_3$): δ 22.0, 23.7, 23.8, 57.0, 60.5, 160.0. IR (NaCl, cm^{-1}): ν_{max}= 2984. MS (70 eV) m/z (%): 134/6 (M^++1, 100).

(3*S*,4*S*)-1-Allyl-3-benzyloxy-4-((1*S*)-1-chloroethyl)-2-azetidinone 15b

31% overall yield, colourless oil, TLC Rf 0.05 (hexane/EtOAc 9/1), $[\alpha]_D$ = -22° (*c* 1, CH_2Cl_2), d.e.: 85%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.55 (3H, d, *J* = 6.6 Hz), 3.79 (1H, d×d, *J* = 9.9 Hz, *J* = 5.0 Hz), 3.91 (1H, d×d, *J* = 15.2 Hz, *J* = 7.2 Hz), 4.20 (1H, d×d×t, *J* = 15.2 Hz, *J* = 5.2 Hz, *J* = 1.6 Hz), 4.29 (1H, d×q, *J* = 9.9 Hz, *J* = 6.6 Hz), 4.65 (1H, d, *J* = 5.0 Hz), 4.71 (1H, d, *J* = 11.8 Hz), 4.95 (1H, d, *J* = 11.8 Hz), 5.21-5.30 (2H, m), 5.71-5.84 (1H, m), 7.28-7.39 (5H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 22.0, 43.9, 58.3, 62.8, 72.9, 80.8, 119.0, 127.9, 128.1, 128.5, 131.4, 136.8, 167.6. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1760. MS (70 eV) m/z (%): 280/2 (M^++1, 100). Anal. Calcd for $C_{15}H_{18}ClNO_2$: C 64.40; H 6.49; N 5.01. Found: C 64.76; H 6.57; N 4.85.

(3*S*,4*S*)-3-Benzyloxy-1-butyl-4-((1*S*)-1-chloroethyl)-2-azetidinone 15c

30% overall yield, colourless oil, TLC Rf 0.3 (hexane/EtOAc 5/1), $[\alpha]_D$ = -46° (*c* 1, CH_2Cl_2), d.e.: 88%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.86 and 0.92 (6H, 2×d, *J* = 6.6 Hz), 1.55 (3H, d, *J* = 6.3 Hz), 2.00-2.15 (1H, m), 3.20 (1H, d×d, *J* = 13.8 Hz, *J* = 5.8 Hz), 3.28 (1H, d×d, *J* = 13.8 Hz, *J* = 8.8 Hz), 3.77 (1H, d×d, *J* = 9.9 Hz, *J* = 5.0 Hz), 4.29 (1H, d×q, *J* = 9.9 Hz, *J* = 6.3 Hz), 4.65 (1H, d, *J* = 5.0 Hz), 4.71 (1H, d, *J* = 11.9 Hz), 4.95 (1H, d, *J* = 11.9 Hz), 7.26-7.37 (5H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 19.9, 20.4, 22.1, 26.6, 48.8, 58.4, 63.4, 72.8, 80.5, 127.8, 128.0, 128.5, 136.9, 168.0. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1753. MS (70 eV) m/z (%): 296/8 (M^++1, 100). Anal. Calcd for $C_{16}H_{22}ClNO_2$: C 64.97; H 7.50; N 4.74. Found: C 64.78; H 7.58; N 4.67.

(3*S*,4*S*)-3-Benzyloxy-4-((1*S*)-1-chloroethyl)-1-isobutyl-2-azetidinone 15d

43% overall yield, colourless oil, TLC Rf 0.3 (hexane/EtOAc 5/1), $[\alpha]_D$ = -50° (*c* 1, CH_2Cl_2), d.e.: 84%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.86 and 0.92 (6H, 2×d, *J* = 6.6 Hz), 1.55 (3H, d, *J* = 6.3 Hz), 2.00-2.15 (1H, m), 3.20 (1H, d×d, *J* = 13.8 Hz, *J* = 5.8 Hz), 3.28 (1H, d×d, *J* = 13.8 Hz, *J* = 8.8 Hz), 3.77 (1H, d×d, *J* = 9.9 Hz, *J* = 5.0 Hz), 4.29 (1H, d×q, *J* = 9.9 Hz, *J* = 6.3 Hz), 4.65 (1H, d, *J* = 5.0

Hz), 4.71 (1H, d, *J* = 11.9 Hz), 4.95 (1H, d, *J* = 11.9 Hz), 7.26-7.37 (5H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 19.9, 20.4, 22.1, 26.6, 48.8, 58.4, 63.4, 72.8, 80.5, 127.8, 128.0, 128.5, 136.9, 168.0. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1753. MS (70 eV) m/z (%): 296/8 (M^++1, 100). Anal. Calcd for $C_{16}H_{22}ClNO_2$: C 64.97; H 7.50; N 4.74. Found: C 64.91; H 7.69; N 4.57.

(3*S*,4*S*)-3-Benzyloxy-4-((1*S*)-1-chloroethyl)-1-isopropyl-2-azetidinone 15e

19% overall yield, colourless oil, TLC Rf 0.3 (hexane/EtOAc 5/1), $[\alpha]_D$ = -50° (*c* 1, CH_2Cl_2), d.e.: 89%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 1.30 and 1.42 (6H, 2×d, *J* = 6.9 Hz), 1.57 (3H, d, *J* = 6.3 Hz), 3.75 (1H, d×d, *J* = 9.1 Hz, *J* = 5.3 Hz), 3.88 (1H, sept, *J* = 6.9 Hz), 4.27 (1H, d×q, *J* = 9.1 Hz, *J* = 6.3 Hz), 4.56 (1H, d, *J* = 5.3 Hz), 4.71 (1H, d, *J* = 11.8 Hz), 4.92 (1H, d, *J* = 11.8 Hz), 7.26-7.37 (5H, m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 20.7, 20.9, 21.9, 46.6, 58.2, 63.0, 72.8, 80.3, 127.9, 128.0, 128.5, 137.0, 167.5. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1748. MS (70 eV) m/z (%): 282/4 (M^++1, 100). Anal. Calcd for $C_{15}H_{20}ClNO_2$: C 63.94; H 7.15; N 4.97. Found: C 63.71; H 7.22; N 5.09.

(3*S*,4*S*)-1-Butyl-4-((1*S*)-1-chloroethyl)-3-methoxy-2-azetidinone 15f

d.e.: 80%. ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.88 (3H, t, *J* = 7.4 Hz), 1.31 (2H, sext, *J* = 7.4 Hz), 1.52 (3H, d, *J* = 6.6 Hz), 1.47-1.65 (2H, m), 3.25-3.32 (1H, m), 3.44-3.56 (1H, m), 3.57 (3H, s), 3.75 (1H, d×d, *J* = 9.6 Hz, *J* = 5.0 Hz), 4.26 (1H, d×q, *J* = 9.6 Hz, *J* = 6.6 Hz), 4.44 (1H, d, *J* = 5.0 Hz). ^{13}C NMR (75 MHz, $CDCl_3$): δ 13.6, 20.1, 21.9, 29.4, 41.1, 58.5, 59.2, 63.1, 83.0, 167.8. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1759. MS (70 eV) m/z (%): 220/2 (M^++1, 100). Anal. Calcd for $C_{10}H_{18}ClNO_2$: C 54.67; H 8.26; N 6.38. Found: C 54.54; H 8.42; N 6.43.

Synthesis of (3*S*,4*S*)-1-Butyl-4-((1*S*)-1-chloroethyl)-3-hydroxy-2-azetidinone 16

(3*S*,4*S*)-3-Benzyloxy-1-butyl-4-((1*S*)-1-chloroethyl)-2-azetidinone **15c** (1 mmol) was dissolved in methanol (5 mL) and placed in a hydrogenator. Pd on carbon (10 mass %) was added and the resulting mixture was stirred overnight under 5 bar hydrogen. Pd was filtered off on Celite® and the solvent was evaporated under reduced pressure. Further purification was performed by column chromatography on silica gel (CH_2Cl_2/MeOH 95/5), yielding pure (3*S*,4*S*)-1-butyl-4-((1*S*)-1-chloroethyl)-3-hydroxy-2-azetidinone **16**.

(3*S*,4*S*)-1-Butyl-4-((1*S*)-1-chloroethyl)-3-hydroxy-2-azetidinone 16

74% yield, white crystals, Mp: 90°C, TLC Rf 0.3 (CH_2Cl_2/MeOH 95/5), $[\alpha]_D$ = -30 (*c* 1, CH_2Cl_2) ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.93 (3H, t, *J* = 7.4 Hz), 1.30 (2H, sext, *J* = 7.4 Hz), 1.61 (3H, d, *J* = 6.6 Hz), 1.50-1.69 (2H, m), 3.27-3.37 (1H, m), 3.46-3.56 (1H, m), 3.75 (1H, d×d, *J* = 9.6 Hz, *J* = 5.0 Hz), 4.31 (1H, d×q, *J* = 9.6 Hz, *J* = 6.6 Hz), 4.85 (1H, d×d, *J* = 5.3 Hz, *J* = 5.0 Hz), 4.97 (1H, broad d, *J* = 5.3 Hz). ^{13}C NMR (75 MHz, $CDCl_3$): δ 13.6, 20.0, 22.1, 29.3, 41.4, 58.6, 64.5, 75.4, 170.4. IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1710, ν_{OH}= 3256. MS (70 eV) m/z (%): 206/8 (M^++1, 100). Anal. Calcd for $C_9H_{16}ClNO_2$: C 52.56; H 7.84; N 6.81. Found: C 52.38; H 7.88; N 6.65.

Synthesis of (3*S*,4*S*)-1-butyl-4-((1*S*)-1-chloroethyl)-3-((1*R*)-2,2,2-trifluoro-1-methoxy-1-phenylethyl)azetidin-2-one 17

To a solution of (3*S*,4*S*)-1-butyl-4-((1*S*)-1-chloroethyl)-3-hydroxy-2-azetidinone **16** (0.15 mmol) in CH_2Cl_2 (10 mL) was added (*R*)-α-methoxy-α-(trifluoromethyl)phenylacetic acid chloride (0.16 mmol). After addition of 4-dimethylaminopyridine (0.015 mmol) and triethylamine (0.29 mmol), the resulting mixture was stirred overnight (16 hours) at room temperature. Afterwards, the reaction mixture was poured in an aqueous solution of HCl (20 mL, 0.5 M) and extracted with CH_2Cl_2 (3×15 mL) The combined organic fractions were dried ($MgSO_4$) and the solvent was evaporated under vacuum, affording (3*S*,4*S*)-1-butyl-4-((1*S*)-1-chloroethyl)-3-((1*R*)-2,2,2-trifluoro-1-methoxy-1-phenylethyl)azetidin-2-one **17** in 83% yield.

(3*S*,4*S*)-1-Butyl-4-((1*S*)-1-chloroethyl)-3-((1*R*)-2,2,2-trifluoro-1-methoxy-1-phenylethyl)azetidin-2-one 17

83% yield, colourless oil, $[\alpha]_D$ = -56° (*c* 1, CH_2Cl_2). ^{1}H NMR (300 MHz, $CDCl_3$): δ 0.93 (3H, t, *J* = 7.4 Hz), 1.12 (3H, d, *J* = 6.6 Hz), 1.31 (2H, sext, *J* = 7.4 Hz), 1.51-1.74 (2H, m), 3.32 (1H, d×d×d, *J* = 13.8 Hz, *J* = 8.3 Hz, *J* = 5.5 Hz), 3.48-3.61 (1H, m), 3.59 (3H, q, *J* = 1.1 Hz), 3.90 (1H, d×d, *J* = 9.6 Hz, *J* = 4.7 Hz), 3.93-4.00 (1H, m), 6.10 (1H, d, *J* = 4.7 Hz), 7.40-7.44 and 7.54-7.57 (5H, 2×m). ^{13}C NMR (75 MHz, $CDCl_3$): δ 13.6, 20.0, 21.4, 29.2, 41.9, 55.8, 56.8, 62.3, 75.1, 84.6 (q, *J* = 27.7 Hz), 123.1 (q, *J* = 288.5 Hz), 127.2, 128.7, 130.0, 131.4, 163.4, 165.1. ^{19}F NMR (282 Hz, $CDCl_3$): δ -71,29 (3F, s). IR (NaCl, cm^{-1}): $\nu_{C=O}$= 1779. MS (70 eV) m/z (%): 422/4 (M^++1, 100). Anal. Calcd for $C_{19}H_{23}ClF_3NO_4$: C 54.10; H 5.50; N 3.32. Found: C 54.22; H 5.64; N 3.42.