Supplementary material

Isomerisation free allylic alkylation of terminal π -allyl palladium complexes

Katja Krämer and Uli Kazmaier*

Universität des Saarlandes, Institut für Organische Chemie

Im Stadtwald, Geb. C 4.2

D-66123 Saarbrücken, Germany

u.kazmaier@mx.uni-saarland.de

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Analytical data

General Remarks. All reactions were carried out in oven-dried glassware (60°C) under argon. All solvents were dried before use. THF was distilled from LiAlH₄ and stored over molecular sieves. The products were purified by flash chromatography on silica gel. Mixtures of EtOAc and hexanes were generally used as eluents. TLC: commercially precoated Polygram[®] SIL-G/UV 254 plates. Visualization was accomplished with UV-light and KMnO₄ solution. NMR-spectra were recorded in CDCl₃ using Bruker DRX 500 with MestRe-C NMR software. Selected signals in the NMR spectra for the minor isomers are extracted from the spectra of the isomeric mixture. CI-MS analyses were performed using a Finnigan MAT 95. Elemental analysis were carried out at the department of chemistry. The (*Z*)/(*E*) ratios were determined with a LC-10 AT high pressure liquid chromatograph using a Lichrosorb silica capillary column. The diastereomeric ratios were determined with a Varian 800 gas chromatograph using Chiralsil-*L*-Val capillary column. This column has the specification that (*R*)- before (*S*)-amino acid esters are eluted. (*E*)-reference substances are synthesized of the corresponding (*E*)-starting material by palladium catalyzed allylic alkylation.

6-(*tert*-Butyldimethylsilyloxy)-2-trifluoroacetylamino-4-hexenoic acid *tert*-butyl ester (**2d**)

According to the general procedure for palladium catalyzed allylation, **2d** was obtained from **1d** after purification by column chromatography (hexane/EtOAc = 9:1) as a colourless oil (95 mg, 81 %) with a ratio of (*Z*)/(*E*) = 94:6. *R_F* (hexane/EtOAc = 9:1) = 0.27. (*Z*)-isomer: ¹H NMR (500 MHz, CDCl₃): δ 0.06 (s, 6H), 0.88 (s, 9H), 1.46 (s, 9H), 2.66 (m, 2H), 4.15 (dd, *J* = 13.5 Hz, 5.6 Hz, 1H), 4.21 (dd, *J* = 13.5 Hz, 5.9 Hz, 1H), 4.46 (dq, *J* = 6.7 Hz, 5.3 Hz, 1H), 5.32 (m, 1H), 5.70 (ddd, *J* = 11.1 Hz, 5.9 Hz, 5.6 Hz, 1H), 7.12 (d, *J* = 5.3 Hz, 1H). ¹³C NMR (125 MHz, CDCl₃): δ -5.30, 18.4, 25.9, 27.9, 29.5, 52.6, 59.5, 83.4, 115.7 (q, *J* = 287.7 Hz), 123.1, 134.0, 156.7 (q, *J* = 37.4 Hz), 169.2. (*E*)-isomer: ¹H NMR (500 MHz, CDCl₃): δ 0.03 (s, 6H), 0.88 (s, 9H), 1.46 (s, 9H), 2.55 (m, 1H), 2.65 (m, 1H), 4.09 (d, *J* = 4.6 Hz, 2H), 4.50 (m, 1H), 5.48 (m, 1H), 5.64 (dd, *J* = 15.2 Hz, 4.6 Hz, 1H), 6.85 (d, *J* = 6.4 Hz, 1H). ¹³C NMR

(125 MHz, CDCl₃): δ -5.38, -5.36, 18.3, 25.9, 28.0, 29.5, 52.46, 63.0, 83.40, 115.6 (q, J = 287.8 Hz), 122.1, 135.0, 156.5 (q, J = 37.4 Hz), 169.2. HPLC (silica, hexane/THF = 99.5:0.5, 2 ml/min): $t_R(Z)$ = 18.82', $t_R(E)$ = 24.97'. Anal. Calcd for C₁₈H₃₂F₃NO₄Si (411.54): C, 52.53; H, 7.84; N, 3.40. Found: C, 52.53; H, 7.63, N, 3.58. HRMS (CI): m/z [M]⁺ calcd. for C₁₈H₃₂F₃NO₄Si: 411.2053; found: 411.2013.

6-Tetrahydropyranyloxy-2-trifluoroacetyl-amino-4-hexenoic acid *tert*-butyl ester (2e).

According to the general procedure for palladium catalyzed allylation, **2e** was obtained from **1e** after purification by column chromatography (hexane/EtOAc = 85:15) as a colourless oil (83 mg, 87%) with a ratio of (Z)/(E) = 98:2. R_F (hexane/EtOAc = 85:15) = 0.22. (Z)-Isomer: major diastereomer (55% ds): ¹H NMR (500 MHz, CDCl₃): δ = 1.46 (s, 9H), 1.47-1.57 (m, 4H), 1.68 (m, 1H), 1.78 (m, 1H), 2.67 (m, 2H), 3.55 (m, 1H), 3.81 (m, 1H), 4.11 (m, 2H), 4.44 (m, 1H), 4.67 (m, 1-H), 5.48 (m, 1H), 5.76 (m, 1H), 7.52 (d, J = 6.9 Hz, 1H); ¹³C NMR (125 MHz, CDCl₃): δ 18.9, 25.3, 27.9, 29.4, 30.2, 52.6, 61.9, 62.6, 83.0, 98.7, 115.6 (q, J = 286.0 Hz), 127.7, 129.7, 156.4 (q, J = 37.6 Hz), 169.4. Minor diastereomer (selected signals): ¹H NMR (500 MHz, CDCl₃): δ 1.46 (s, 9H), 3.50 (m, 1H), 3.96 (dd, J = 12.4 Hz, 7.1 Hz, 1H), 4.27 (dd, J = 12.4 Hz, 6.1 Hz, 1H), 4.59 (m, 1-H), 7.27 (d, J = 5.6 Hz, 1H). ¹³C NMR (125 MHz, CDCl₃): δ 19.6, 28., 29.5, 30.4, 52.5, 61.5, 62.6, 83.2, 96.4, 126.4, 130.3, 169.2. (E)-isomer: major diastereomer (55% ds): ¹H NMR (500 MHz, CDCl₃): δ 1.46 (s, 9H), 1.47-1.57 (m, 4H), 1.68 (m, 1H), 1.78 (m, 1H), 2.55 (m, 1H), 2.65 (m, 1H), 3.48 (m, 1H), 3.82 (m, 1H), 3.91 (dd, J = 12.8 Hz, 6.2 Hz, 1H), 4.15 (dd, J = 12.8 Hz, 5.4 Hz, 1H), 4.52 (m, 1H), 4.58 (m, 1-H), 5.54 (m, 1H), 5.63 (ddd, J = 15.4 Hz, 6.2 Hz, 5.4 Hz, 1H, 5-H), 6.88 (bs, 1H); ¹³C NMR (125 MHz, CDCl₃): δ 19.4, 25.4, 28. 0, 30.6, 34.6, 52.6, 62.2, 67.0, 83.5, 97.9, 115.6 (q, J = 286.0 Hz), 125.3, 132.1, 156.4 (q, J = 37.6 Hz), 169.2. minor diastereomer (selected signals): ¹³C NMR (125 MHz, CDCl₃): δ 19.4, 62.2, 66.9, 83.5, 97.9, 132.1; HPLC (silica, hexane/THF = 97:3, 2 ml/min): $t_R(Z)$ = 9.47', 10.28', $t_R(E)$ = 14.21'; Anal. Calcd for C₁₇H₂₆F₃NO₅ (381.39): C, 53.54; H, 6.87; N, 3.67. Found: C, 53.18; H, 6.74; N, 3.58; HRMS (CI): m/z [M]⁺ calcd. for C₁₇H₂₆F₃NO₅: 381.1763; found: 381.1727.

6-Benzyloxy-2-trifluoroacetyl-amino-4-hexenoic acid *tert*-butyl ester (**2f**)

According to the general procedure for palladium catalyzed allylation, **2f** was obtained from **1f** after purification by column chromatography (hexane/EtOAc = 9:1) as a colourless oil (96 mg, 99%) with a ratio of (*Z*)/(*E*) = 99:1. R_F (hexane/EtOAc = 8:2) = 0.36. (*Z*)-isomer: ^1H NMR (500 MHz, CDCl_3): δ 1.46 (s, 9H), 2.57 (m, 1H), 2.65 (m, 1H), 3.91 (dd, J = 11.7 Hz, 6.6 Hz, 1H), 3.98 (dd, J = 11.7 Hz, 6.2 Hz, 1H), 4.38 (m, 1H), 4.51 (dd, J = 12.0 Hz, 2H), 5.50 (m, 1H), 5.84 (dt, J = 10.9 Hz, 6.5 Hz, 1H), 7.24-7.35 (m, 5H), 7.55 (d, J = 4.5 Hz, 1H). ^{13}C NMR (125 MHz, CDCl_3): δ 27.9, 29.6, 52.5, 64.7, 72.9, 83.1, 115.7 (q, J = 288.1 Hz), 127.3, 127.9, 128.1, 128.5, 130.3, 137.4, 157.0 (q, J = 37.0 Hz), 169.1. (*E*)-isomer: ^1H NMR (500 MHz, CDCl_3): δ 1.46 (s, 9H), 2.55 (m, 1H), 2.68 (m, 1H), 3.96 (d, J = 5.1 Hz, 2H), 4.47 (s, 2H), 4.52 (m, 1H), 5.55 (m, 1H), 5.70 (dt, J = 15.4 Hz, 5.7 Hz, 1H), 6.89 (d, J = 6.4 Hz, 1H), 7.26-7.34 (m, 5H). ^{13}C NMR (125 MHz, CDCl_3): δ 28.0, 34.6, 52.6, 69.9, 72.1, 83.6, 115.6 (q, J = 287.8 Hz), 125.6, 127.6, 127.6, 128.3, 132.0, 138.1, 156.4 (q, J = 37.4 Hz), 169.2. HPLC (silica, hexane/ EtOAc = 97:3, 2 ml/min): $t_R(\text{Z})$ = 6.04', $t_R(\text{E})$ = 7.96'. HRMS (CI): m/z $[\text{M}+\text{H}]^+$ calcd. for $\text{C}_{19}\text{H}_{24}\text{F}_3\text{NO}_4$: 388.1691; found: 388.1754.

6-Allyloxy-2-trifluoroacetyl-amino-4-hexenoic acid *tert*-butyl ester (**2g**)

According to the general procedure for palladium catalyzed allylation, **2g** was obtained from **1g** after purification by column chromatography (hexane/EtOAc = 9:1) as a colourless oil (86 mg, 81%) with a ratio of (*Z*)/(*E*) = 98:2. R_F (hexane/EtOAc = 8:2) = 0.28. (*Z*)-isomer: ^1H NMR (500 MHz, CDCl_3): δ 1.46 (s, 9H), 2.64 (m, 2H), 3.91 (dd, J = 11.8 Hz, 6.5 Hz, 1H), 3.98 (m, 3H), 4.38 (m, 1H), 5.20 (dd, J = 10.3 Hz, 1.4 Hz, 1H), 5.26 (dd, J = 17.2 Hz, 1.4 Hz, 1H), 5.49 (m, 1H), 5.82 (ddd, J = 11.0 Hz, 6.5 Hz, 6.0 Hz, 1H), 5.88 (m, 1H), 7.55 (bs, 1H). ^{13}C NMR (125 MHz, CDCl_3): δ 27.9, 29.6, 52.5, 64.9, 71.8, 83.1, 115.6 (q, J = 287.0 Hz), 118.0, 127.1, 130.4, 134.1, 157.0 (q, J = 37.6 Hz), 169.2. (*E*)-isomer: ^1H NMR (500 MHz,

CDCl₃): δ 1.46 (s, 9H), 2.54 (m, 1H), 2.67 (m, 1H) 3.91 (dd, J = 11.8 Hz, 6.5 Hz, 1H), 3.91 (m, 4H), 4.51 (m, 1H), 5.15 (dd, J = 10.4 Hz, 1.6 Hz, 1H). 5.26 (dd, J = 17.3 Hz, 1.6 Hz, 1H), 5.52 (m, 1H), 5.66 (dt, J = 15.4 Hz, 5.7 Hz, 1H), 5.87 (m, 1H), 6.88 (d, J = 6.1 Hz, 1H). ¹³C NMR (125 MHz, CDCl₃): δ 28.0, 34.6, 52.5, 69.9, 71.0, 83.6, 115.6 (q, J = 287.7 Hz), 117.0, 125.5, 132.0, 134.5, 156.5 (q, J = 37.6 Hz), 169.2. HPLC (silica, hexane/THF = 99.5:0.5, 2 ml/min): $t_R(Z)$ = 10.06', $t_R(E)$ = 13.87'. HRMS (CI): m/z [M+H]⁺ calcd. for C₁₅H₂F₃NO₄H: 338.1534; found: 338.1553.

6-Methoxy-2-trifluoroacetylamino-4-hexenoic acid *tert*-butyl ester (**2h**)

According to the general procedure for palladium catalyzed allylation, **2h** was obtained from **1g** after purification by column chromatography (hexane/EtOAc = 8:2) as a colourless oil (65 mg, 84%) with a ratio of (*Z*)/(*E*) = 97:3. R_F (hexane/EtOAc = 8:2) = 0.21. (*Z*)-isomer: ¹H NMR (500 MHz, CDCl₃): δ 1.46 (s, 9H), 2.62 (m, 2H), 3.34 (s, 3H), 3.86 (dd, J = 11.5 Hz, 6.8 Hz, 1H), 3.92 (J = 11.5 Hz, 6.4 Hz, 1H), 4.34 (m, 1H), 5.52 (m, 1H), 5.83 (ddd, J = 11.0 Hz, 6.8 Hz, 6.4 Hz, 1H), 7.70 (bs, 1H). ¹³C NMR (125 MHz, CDCl₃): δ 27.9, 29.4, 52.5, 58.3, 67.4, 83.0, 115.7 (q, J = 288.0 Hz), 127.8, 130.2, 157.0 (q, J = 37.2 Hz), 169.1. (*E*)-isomer: ¹H NMR (500 MHz, CDCl₃): δ 1.46 (s, 9H), 2.58 (m, 1H), 2.67 (m, 1H), 3.28 (s, 3H), 3.86 (d, J = 5.7 Hz, 1H), 4.51 (m, 1H), 5.51 (m, 1H), 5.63 (dt, J = 15.4 Hz, 5.7 Hz, 1H), 6.90 (d, J = 5.7 Hz, 1H). ¹³C NMR (125 MHz, CDCl₃): δ 27.9, 34.6, 52.6, 57.8, 72.3, 83.5, 115.7 (q, J = 287.9 Hz), 125.6, 131.9, 156.5 (q, J = 37.8 Hz), 169.2. HPLC (silica, hexane/THF = 97:3, 2 ml/min): $t_R(Z)$ = 9.88', $t_R(E)$ = 14.39'. HRMS (CI): m/z [M+H]⁺ calcd. for C₁₃H₂₀F₃NO₄H: 312.1378; found: 312.1389.

6-Benzoyloxy-2-trifluoroacetylamino-4-hexenoic acid *tert*-butyl ester (**2i**)

The reaction was carried out under argon using standard Schlenk techniques. 654 mg (4.80 mmol) ZnCl₂ which had been dried by heating *in vacuo* and 991 mg (4.36 mmol) Tfa-Gly-*OrBu* were dissolved in 10 ml dry THF and cooled to -78°C. A LHMDS-solution which was freshly prepared from 1.94 g HMDS (12.0 mmol) and 6.8 ml (10.9 mmol) of a 1.6 M solution of *n*-BuLi (1.25 mmol) in hexane in 15 ml of dry THF was added dropwise at this temperature. The solution was stirred for 15 min. Then a solution of 17 mg (0.0436 mmol) allyl palladium chloride dimer and 52 mg (0.197 mmol) triphenylphosphine in 15 ml of dry THF was added and stirring was continued for 10 min. 1.43 g (4.36 mmol) of **1i** which was dissolved in 10 ml of dry THF was added dropwise and the reaction mixture was stirred overnight at -78°C. Then the solution was diluted with diethyl ether and 1 M KHSO₄ was added. The layers were separated and the aqueous layer was extracted with diethyl ether. The combined organic layers were dried over MgSO₄ and the solvent was removed under reduced pressure. **2i** was obtained after purification by column chromatography (hexane/EtOAc = 9:1) as a colourless oil (1.11 g, 63%) with a ratio of (*Z*)/(*E*) = 94:6. *R_F* (hexane/EtOAc = 8:2) = 0.27. (*Z*)-isomer: ¹H NMR (500 MHz, CDCl₃): δ 1.47 (s, 9H), 2.81 (m, 2H), 4.52 (m, 1H), 4.69 (dd, *J* = 12.6 Hz, 6.4 Hz, 1H), 4.94 (dd, *J* = 12.6 Hz, 8.0 Hz, 1H), 5.56 (m, 1H), 5.79 (ddd, *J* = 10.6 Hz, 8.0 Hz, 6.4 Hz, 1H), 7.36 (d, *J* = 5.3 Hz, 1H), 7.42 (dd, *J* = 7.8 Hz, 7.0 Hz, 2H), 7.55 (t, *J* = 7.0 Hz, 1H), 8.00 (d, *J* = 7.8 Hz, 2H). ¹³C NMR (125 MHz, CDCl₃): δ 27.9, 29.5, 52.7, 60.4, 83.4, 115.7 (q, *J* = 287.9 Hz), 127.7, 128.2, 128.4, 129.6, 129.8, 133.2, 157.1 (q, *J* = 37.4 Hz), 166.7, 169.1. (*E*)-isomer: ¹H NMR (500 MHz, CDCl₃): δ 1.47 (s, 9H), 2.59 (m, 1H), 2.71 (m, 1H), 4.53 (m, 1H), 4.75 (d, *J* = 5.9 Hz, 1H), 5.48 (m, 1H), 5.68 (dt, *J* = 15.3 Hz, 6.0 Hz, 1H), 6.93 (d, *J* = 5.9 Hz, 1H), 7.41 (dd, *J* = 7.8 Hz, 7.0 Hz, 2H), 7.53 (t, *J* = 7.0 Hz, 1H), 8.00 (d, *J* = 7.8 Hz, 2H). ¹³C NMR (125 MHz, CDCl₃): δ 28.0, 34.6, 52.5, 64.6, 83.6, 115.7 (q, *J* = 287.9 Hz), 127.6, 128.3, 129.4, 129.6, 129.8, 133.0, 157.1 (q, *J* = 37.4 Hz), 166.2, 169.1. GC (Chira-Si-*L*-Val, 180°C isothermal, injector 250°C, detector 300°C): *t_R*((*Z*)-(2*R*)) = 53.90', *t_R*((*Z*)-(2*S*)) = 54.34', *t_R*((*E*)-(2*R*)) = 55.84', *t_R*((*E*)-(2*S*)) = 56.32' (the enantiomers could not be completely separated). Anal. Calcd for C₁₉H₂₂F₃NO₅ (401.38): C, 56.86; H, 5.52; N, 3.49. Found: C, 56.28; H, 5.63; N, 3.68. HRMS (CI): *m/z* [M+H]⁺ calcd. for C₁₉H₂₂F₃NO₅H: 402.1484; found: 402.1478.

6-(4-Methoxybenzoyl)-2-trifluoroacetylamino-4-hexenoic acid *tert*-butyl ester (2j)

According to the general procedure for palladium catalyzed allylation, **2j** was obtained from **1j** after purification by column chromatography (hexane/EtOAc = 8:2) as a colourless oil (106 mg, 98%) with a ratio of (*Z*)/(*E*) = 96:4. R_F (hexane/EtOAc = 8:2) = 0.24. (*Z*)-isomer: ^1H NMR (500 MHz, CDCl_3): δ 1.47 (s, 9H), 2.82 (m, 2H), 3.84 (s, 3H), 4.51 (m, 1H), 4.64 (dd, J = 12.6 Hz, 6.4 Hz, 1H), 4.92 (dd, J = 12.6 Hz, 8.1 Hz, 1H), 5.54 (m, 1H), 5.77 (ddd, J = 10.8 Hz, 8.1 Hz, 6.4 Hz, 1H), 6.90 (d, J = 8.8 Hz, 2H), 7.40 (d, J = 5.3 Hz, 1H), 7.96 (d, J = 8.8 Hz, 2H). ^{13}C NMR (125 MHz, CDCl_3): δ 27.9, 29.4, 52.7, 55.4, 60.1, 83.3, 113.7, 115.6 (q, J = 287.9 Hz), 122.2, 127.9, 128.1, 131.7, 156.5 (q, J = 37.4 Hz), 163.6, 166.6, 169.1. (*E*)-isomer: ^1H NMR (500 MHz, CDCl_3): δ 1.45 (s, 9H), 2.58 (m, 1H), 2.70 (m, 1H), 3.84 (s, 3H), 4.54 (m, 1H), 4.71 (d, J = 5.9 Hz, 2H), 5.66 (m, 1H), 5.78 (dt, J = 15.4 Hz, 5.9 Hz, 1H), 6.89 (d, J = 8.9 Hz, 2H), 6.93 (d, J = 6.7 Hz, 1H), 7.96 (d, J = 8.9 Hz, 2H). ^{13}C NMR (125 MHz, CDCl_3): δ 27.9, 34.6, 52.5, 55.4, 64.3, 83.7, 113.6, 115.6 (q, J = 287.9 Hz), 122.4, 127.3, 129.7, 131.6, 156.5 (q, J = 37.4 Hz), 163.6, 166.0, 169.1. HPLC (silica, hexane/ EtOAc = 97:3, 2 ml/min): $t_R(\textit{Z})$ = 11.92', $t_R(\textit{E})$ = 15.92'. HRMS (CI): m/z $[\text{M}]^+$ calcd. for $\text{C}_{20}\text{H}_{24}\text{F}_3\text{NO}_6$: 431.1556; found: 431.1563.

6-Hydroxyl-2-trifluoroacetylamino-4-hexenoic acid *tert*-butyl ester (3). Alcohol **3** was obtained from **2e** by cleaving the protection group with cat. *p*-TsOH in methanol and was applied in the following reaction without further purification. R_F (hexane/EtOAc = 7:3) = 0.16. (*Z*)-Isomer: ^1H NMR (500 MHz, CDCl_3): δ 1.47 (s, 9H), 1.74 (bs, 1H), 2.36 (m, 1H), 2.72 (m, 1H), 4.14 (dd, J = 12.5 Hz, 7.6 Hz, 1H), 4.19 (dd, J = 12.5 Hz, 6.7 Hz, 1H), 4.43 (m, 1H), 5.47 (m, 1H), 5.86 (ddd, J = 11.0 Hz, 7.6 Hz, 6.7 Hz, 1H, 5-H), 7.53 (bs, 1H); ^{13}C NMR (125 MHz, CDCl_3): δ 27.9, 29.4, 52.5, 57.7, 83.4, 115.7 (q, J = 285.7 Hz), 126.3, 132.5, 156.9 (q, J = 37.4 Hz), 169.2. (*E*)-Isomer: ^1H NMR (500 MHz, CDCl_3): δ 1.46 (s, 9H), 1.85 (bs, 1H), 2.52 (m, 1H), 2.66 (m, 1H), 4.08 (d, J = 5.5 Hz, 1H), 4.52 (m, 1H), 5.53 (m, 1H), 5.63 (dd, J = 15.4 Hz, 5.5 Hz, 1H), 6.96 (d, J = 5.6 Hz, 1H); ^{13}C NMR (125 MHz, CDCl_3): δ 28.0, 34.6, 52.6, 62.9, 83.6, 115.6 (q, J = 285.8 Hz), 124.2, 134.5, 156.6 (q, J = 37.4 Hz), 169.2;

Anal. Calcd for C₁₂H₁₈F₃NO₄ (297.27): C, 48.48; H, 6.10; N, 4.71. Found: C, 48.66; H, 5.91; N, 4.90.

6-(*tert*-Butyldimethylsilyloxy)-2-trifluoroacetylamino-4-heptenoic acid-*tert*-butyl ester (6a)

According to the general procedure for palladium catalyzed allylation (the reaction mixture was allowed to warm up to r.t.), **6a** was obtained from **5a** after purification by column chromatography (hexane/EtOAc = 9:1) as a colourless oil (110 mg, 92%), only the (*E*)-isomer was obtained with 92% ds. %. R_F (hexane/EtOAc = 9:1) = 0.25. (*E*)-isomer: major diastereomer (92% ds): (2*S*,2*S*)-diastereomer: ¹H NMR (500 MHz, CDCl₃): δ 0.01, 0.02 (2s, 6H), 0.86 (s, 9H), 1.15 (d, *J* = 6.3 Hz, 3H), 1.47 (s, 9H), 2.53 (m, 1H), 2.64 (m, 1H), 4.24 (m, 1H), 4.48 (m, 1H), 5.39 (m, 1H), 5.57 (dd, *J* = 15.1 Hz, 4.7 Hz, 1H), 6.82 (d, *J* = 6.6 Hz, 1H). ¹³C NMR (125 MHz, CDCl₃): δ -5.0, -4.8, 18.2, 24.3, 25.8, 28.0, 34.0, 52.6, 68.3, 83.4, 115.7 (q, *J* = 287.9 Hz), 120.2, 140.6, 156.4 (q, *J* = 37.4 Hz), 169.3. minor diastereomer: (2*R*,6*S*)-diastereomer (selected signals): ¹³C NMR (125 MHz, CDCl₃): δ -4.9, 18.2, 24.4, 28.0, 34.2, 52.6, 68.5, 83.4, 120.4, 169.2. GC (Chira-Si-*L*-Val, 180°C isothermal, injector 250°C, detector 300°C): t_R (2*R*,6*S*) = 40.63', t_R (2*S*,6*S*) = 44.22'. Anal. Calcd for C₁₉H₃₄F₃NO₄Si (425.56): C, 53.62; H, 8.05; N, 3.29. Found: C, 53.86; H, 7.73; N, 3.60.

6-Benzyloxy-2-trifluoroacetylamino-4-heptenoic acid-*tert*-butylester (6b)

According to the general procedure for palladium catalyzed allylation, **6b** was obtained from **6a** after purification by column chromatography (hexane/EtOAc = 9:1) as a colourless oil (93 mg, 86%) as a colourless oil with a ratio of (*Z*)/(*E*) = 87:13. R_F (hexane/EtOAc = 9:1) = 0.16. (*Z*)-isomer: major diastereomer (54% ds): (2*R*,6*S*)-diastereomer: ¹H NMR (500 MHz, CDCl₃):

δ 1.24 (d, J = 6.3 Hz, 3H), 1.48 (s, 9H), 2.54 (m, 1H), 2.69 (m, 1H), 4.20 (m, 1H), 4.33 (d, J = 11.7 Hz, 1H), 4.40 (d, J = 11.7 Hz, 1H), 4.48 (m, 1H), 5.40 (m, 1H), 5.53 (dd, J = 11.0 Hz, 8.1 Hz, 1H), 7.04 (d, J = 7.1 Hz, 1H), 7.23 – 7.32 (m, 5H). ^{13}C NMR (125 MHz, CDCl_3): δ 20.8, 27.9, 29.8, 52.6, 69.7, 70.0, 83.6, 115.6 (q, J = 285.9 Hz), 124.9, 127.7, 128.0, 128.4, 136.9, 138.0, 156.7 (q, J = 37.2 Hz), 169.2. minor diastereomer : (2*S*,6*S*)-diastereomer (selected signals): ^{13}C NMR (125 MHz, CDCl_3): δ 21.2, 29.8, 70.2, 70.1, 83.4, 124.1, 128.6, 127.6, 128.4, 136.9, 138.3. (*E*)-isomer: (2*S*,6*S*)-diastereomer: ^1H NMR (500 MHz, CDCl_3): δ 1.24 (d, J = 6.3 Hz, 3H), 1.47 (s, 9H), 2.55 (m, 1H), 2.70 (m, 1H), 3.87 (m, 1H), 4.33 (d, J = 12.0 Hz, 1H), 4.49 (d, J = 12.0 Hz, 1H), 4.53 (m, 1H), 5.45 (dt, J = 15.5 Hz, 6.9 Hz, 1H), 5.53 (dd, J = 15.5 Hz, 7.3 Hz, 1H), 6.89 (d, J = 6.3 Hz, 1H), 7.23 – 7.32 (m, 5H). ^{13}C NMR (125 MHz, CDCl_3): δ 21.5, 28.0, 34.4, 52.6, 69.9, 75.0, 83.6, 115.6 (q, J = 287.9 Hz), 124.3, 127.4, 127.5, 128.3, 137.7, 138.6, 156.5 (q, J = 37.4 Hz), 169.3. GC (Chira-Si-*L*-Val, 150°C isothermal, injector 250°C, detector 300°C): $t_R((Z)-(2R,6S))$ = 112.25', $t_R((Z)-(2S,6S))$ = 116.55.83', $t_R((E)-(2S,6S))$ = 123.95'. Anal. Calcd for $\text{C}_{20}\text{H}_{26}\text{F}_3\text{NO}_4$ (401.42): C, 59.84; H, 6.53; N, 3.49. Found: C, 59.53; H, 6.52; N, 3.39. HRMS (CI): m/z $[\text{M}+\text{H}]^+$ calcd. for $\text{C}_{20}\text{H}_{26}\text{F}_3\text{NO}_4\text{H}$: 402.1847; found: 402.1918.

6-Tetrahydropyranyloxy-2-trifluoroacetyl-amino-4-heptenoic acid-*tert*-butyl ester (**6c**)

According to the general procedure for palladium catalyzed allylation, **6c** was obtained from **5c** after purification by column chromatography (hexane/EtOAc = 8:2) as a colourless oil (85 mg, 84%) with a ratio of (*Z*)/(*E*) = 87:13 with a diastereometric ratio concerning C-12 of 75:25. R_F (hexane/EtOAc = 9:1) = 0.17. (*Z*)-isomer: major diastereomer (82% ds): (2*R*,6*S*)-diastereomer: ^1H NMR (500 MHz, CDCl_3): δ 1.23 (d, J = 6.3 Hz, 3H), 1.45 (s, 9H), 1.49 - 1.56 (m, 4H), 1.64 (m, 1H), 1.80 (m, 1H), 2.57 (m, 1H), 2.66 (m, 1H), 3.61 (m, 1H), 3.75 (m, 1H), 4.57 (m, 1H), 4.44 (m, 1H), 4.73 (m, 1H), 5.34 (dd, J = 10.5 Hz, 1H), 5.47 (dt, J = 10.5 Hz, 5.0 Hz, 1H), 8.06 (d, J = 5.7 Hz, 1H). ^{13}C NMR (125 MHz, CDCl_3): δ 18.2, 21.2, 25.3, 27.9, 29.3, 29.6, 53.1, 60.9, 64.4, 82.7, 92.7, 115.8 (q, J = 285.9 Hz), 128.0, 134.3, 157.6 (q, J = 37.8 Hz), 169.6. minor diastereomers (selected signals): ^1H NMR (500 MHz, CDCl_3): δ 1.19 (d, J = 6.2 Hz, 3H), 7.91 (d, 1H, J = 6.3 Hz). ^{13}C NMR (125 MHz, CDCl_3): δ 125.2,

125.6, 135.6, 135.8. (*E*)-isomer: major diastereomer: (2*S*,6*S*)-diastereomer: ^1H NMR (500 MHz, CDCl_3): δ 1.22 (d, $J = 6.7$ Hz, 3H), 1.46 (s, 9H), 1.49 - 1.56 (m, 4H), 1.64 (m, 1H), 1.80 (m, 1H), 2.51 (m, 1H), 2.64 (m, 1H), 3.45 (m, 1H), 3.84 (m, 1H), 4.21 (m, 1H), 4.48 - 4.51 (m, 2H), 5.41 - 5.42 (m, 2H), 6.87 (d, $J = 6.4$ Hz, 1H). ^{13}C NMR (125 MHz, CDCl_3): δ 19.6, 21.9, 25.5, 28.0, 30.7, 34.3, 52.6, 62.5, 71.3, 83.5, 95.6, 115.6 (q, $J = 288.0$ Hz), 124.4, 137.3, 156.4 (q, $J = 37.6$ Hz), 169.2. minor diastereomers (selected signals): ^1H NMR (500 MHz, CDCl_3): δ 1.16 (d, $J = 6.7$ Hz, 3H), 4.69 (m, 1H), 5.47 (m, 1H), 5.62 (dd, $J = 16.8$ Hz, 5.8 Hz, 1H), 6.90 (bs, 1H). ^{13}C NMR (125 MHz, CDCl_3): δ 19.3, 19.75, 19.81, 21.8, 25.2, 25.35, 25.43, 28.0, 30.7, 30.8, 34.3, 34.4, 34.5, 52.5, 62.1, 62.6, 71.2, 71.5, 83.3, 83.5, 83.6, 95.8, 96.0, 124.5, 169.1, 169.15, 169.3. HRMS (CI): m/z $[\text{M}+\text{H}]^+$ calcd. for $\text{C}_{18}\text{H}_{28}\text{F}_3\text{NO}_5\text{H}$: 396.1953; found: 396.1949.

6-Hydroxy-2-trifluoroacetyl-amino-heptenoic acid-*tert*-butylester

Determination of the (*Z*)/(*E*)-ratio of **6c** was carried out after cleavage of the THP protection group with cat. *p*-TsOH in methanol. **7** was obtained as a colorless oil (60 mg, 92%). R_F (hexane/EtOAc = 8:2) = 0.10. (*Z*)-isomer: major diastereomer (82% ds): (2*R*,6*S*)-diastereomer: ^1H NMR (500 MHz, CDCl_3): δ 1.26 (d, $J = 6.3$ Hz, 3H), 1.46 (s, 9H), 1.78 (bs, 1H), 2.66 (m, 2H), 4.34 (m, 1H), 4.55 (m, 1H), 5.37 (m, 1H), 5.62 (dd, $J = 11.0$ Hz, 7.6 Hz, 1H), 7.69 (bs, 1H). ^{13}C NMR (125 MHz, CDCl_3): δ 23.9, 27.9, 29.6, 52.7, 63.4, 83.2, 115.6 (q, $J = 287.9$ Hz), 125.3, 137.6, 156.5 (q, $J = 37.4$ Hz), 169.4. minor diastereomer: (2*S*,6*S*)-diastereomer (selected signals): ^1H NMR (500 MHz, CDCl_3): δ 1.21 (d, $J = 6.4$ Hz, 3H), 7.58 (bs, 1H). ^{13}C NMR (125 MHz, CDCl_3): δ 23.8, 29.4, 52.5, 63.6, 124.1, 138.0. (*E*)-isomer: (2*S*,6*S*)-diastereomer: ^1H NMR (500 MHz, CDCl_3): δ 1.22 (d, $J = 6.6$ Hz, 3H), 1.47 (s, 9H), 1.65 (bs, 1H), 2.48 (ddd, $J = 13.6$ Hz, 7.3 Hz, 6.3 Hz, 1H), 2.66 (ddd, $J = 13.6$ Hz, 7.3 Hz, 6.3 Hz, 1H), 4.25 (m, 1H), 4.51 (m, 1H), 5.48 (dt, $J = 15.5$ Hz, 7.3 Hz, 1H), 5.62 (dd, $J = 15.5$ Hz, 6.0 Hz, 1H), 6.91 (bs, 1H). ^{13}C NMR (125 MHz, CDCl_3): δ 23.2, 28.0, 34.5, 52.6, 68.1, 83.6, 115.6 (q, $J = 287.9$ Hz), 122.4, 139.7, 156.5 (q, $J = 37.4$ Hz), 169.2. GC (Chira-Si-*L*-Val, gradient: 120°C (3 min) to 180 °C (3 min), 2 °C/min, injector 250°C, detector 300°C): t_R (*E*) = 22.15', t_R (*Z*) = 23.54' (the diastereomers could not be separated whether by GC or HPLC).

analysis, ds is determined from NMR). Anal. Calcd for $C_{13}H_{20}F_3NO_4$ (311.30): C, 50.16; H, 6.48; N, 4.50. Found: C, 49.66; H, 6.33; N, 4.77.