Supporting Information

Stereoselective Synthesis of a Protected Side Chain of Meliponamycin A

Oliver Andler and Uli Kazmaier

a Saarland University, Organic Chemistry I, Campus, Building C4.2, D-66123 Saarbrücken, Germany
b Helmholtz Institute for Pharmaceutical Research Saarland (HIPS), Saarland University Campus, Building C8.1, 66123 Saarbrücken, Germany

Email: u.kazmaier@mx.uni-saarland.de

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Experimental Section

**General remarks:** All air- or moisture-sensitive reactions were carried out in oven-dried glassware (75 °C) under an atmosphere of nitrogen. Dried solvents were distilled before use: THF was distilled from sodium/benzophenone, diisopropylamine was dried with CaH₂ and acetone with B₂O₃ before distillation. Anhydrous dichloromethane (DCM), DMSO, DMF, toluene and 1,2-dichloroethane were purchased from Acros Organics and stored under nitrogen. Petroleum ether (40-60 °C), pentane and ethyl acetate were distilled prior to use. The products were purified by flash chromatography on silica gel (Macherey-Nagel 60, 0.063-0.2 mm or 0.04-0.063 mm) or automated flash chromatography using a Büchi Pure C-185 Chromatography System and Teledyne Isco RediSep® Rf Silver Normal-phase Silica Flash (30-70 µm) columns. For reversed-phase flash chromatography, a Büchi Reveleris® Prep Chromatography System and Büchi FlashPure Select C18 (30 µm spherical) columns were used. Preparative HPLC was performed on a Büchi Reveleris® Prep Chromatography System using a Phenomenex Luna® C18(2) 100 Å column (250 x 21.1 mm, 5 µm). Analytical TLC was performed on pre-coated silica gel plates (Macherey-Nagel, Polygram® SIL G/UV254). Visualization was accomplished with UV-light, KMnO₄ solution or cerium(IV)/ammonium molybdate solution. Melting points were determined with a MEL-TEMP II apparatus and are uncorrected. ¹H and ¹³C spectra were recorded with Bruker AV 400 Ultra Shield [400 MHz (¹H), 100 MHz (¹³C)], Bruker AV 500 [500 MHz (¹H) and 125 MHz (¹³C)] or Bruker Avance Neo 500 [500 MHz (¹H) and 125 MHz (¹³C)] spectrometers in CDCl₃ or DMSO-d₆. Chemical shifts are reported in ppm (δ) with respect to TMS, and CHCl₃ or DMSO-d₅ was used as the internal standard. Selected signals for the minor diastereomers are extracted from the spectra of the isomeric mixture. Peaks were assigned using ¹H,¹H COSY, multiplicity edited ¹H,¹³C HSQC, ¹H,¹³C HMBC and NOESY spectra. Diastereomeric ratios were determined by HPLC on a Shimadzu LC-2030C Liquid chromatograph [column: Phenomenex Onyx® Monolithic C18 130 Å (50 x 4.6 mm)] or by ¹H NMR. Optical rotations were measured with a Jasco P-2000 polarimeter at the sodium D line (589 nm). αD values are given in 10⁻¹ deg cm² g⁻¹. Mass spectra were recorded with a Finnigan MAT 95 sector field spectrometer (HRMS, CI), a Bruker Daltonics maXis 4G hr-ToF spectrometer (HRMS, ESI) or a Shimadzu LCMS-2020 single quadrupole spectrometer (LRMS, ESI).

**General procedure for the drying of zinc chloride:** In a Schlenk flask, ZnCl₂ was heated to approximately 250 °C in vacuo (0.1 mbar) with stirring over 5–10 min using a heat gun. After cooling to room temperature with stirring, the flask was refilled with nitrogen and the drying procedure was repeated for a second time. The dried ZnCl₂ was dissolved in anhydrous THF as stated in the experimental procedures.
Synthesis of the carbon skeleton via Matteson homologation

(4S,5S)-4,5-Dicyclohexyl-2-ethyl-1,3,2-dioxaborolane (1)

(S,S)-1,2-Dicyclohexylethane-1,2-diol [(S,S)-DICHED] was prepared as described previously.\(^1\)\(^2\)

7.66 g (33.8 mmol, 1.0 eq.) (S,S)-DICHED followed by 3.00 g (40.6 mmol, 1.2 eq.) ethylboronic acid were dissolved in 177 ml diethyl ether at room temperature. After the addition of 11.0 g anhydrous MgSO\(_4\), the suspension was stirred for 19 h, filtered and concentrated in vacuo. The residue was passed through a short plug of silica (pentane, diethyl ether 95:5) to obtain 1 in 99 % yield (8.85 g, 33.5 mmol) as a colorless oil, R\(_f\) = 0.54 (pentane, diethyl ether 95:5); \(\alpha^2_D = -67.9 \) (c = 1.0, CHCl\(_3\)).

\(^1\)H NMR (400 MHz, CDCl\(_3\)): \(\delta = 3.83 \) (m, 2 H, 5-H), 1.83–1.71 (m, 6 H, 1-H\(^\dagger\), 2-H\(^\dagger\), 3-H\(^\dagger\)), 1.68 (m, 2 H, 1-H), 1.59 (m, 2 H, 3-H\(^\dagger\)), 1.32 (m, 2 H, 4-H), 1.28–1.11 (m, 6 H, 2-H\(^\dagger\), 3-H\(^\dagger\)), 1.06 (m, 2 H, 3-H), 1.01–0.89 (m, 5 H, 2-H, 7-H), 0.79 (q, \(J_{6,7} = 8.1 \) Hz, 2 H, 6-H).

\(^13\)C NMR (100 MHz, CDCl\(_3\)): \(\delta = 83.2 \) (d, C-5), 43.0 (d, C-4), 28.3 (t, C-3\(^\dagger\)), 27.3 (t, C-2\(^\dagger\)), 26.5 (t, C-1), 26.0 (t, C-3), 25.9 (t, C-2), 7.9 (q, C-7), 2.5 (bs, C-6).

HRMS (Cl) m/z calcd for C\(_{16}\)H\(_{30}\)O\(_2\)B [M+H]\(^+\): 265.2333, found: 265.2339.

(4S,5S)-4,5-Dicyclohexyl-2-\{(S)-1-\{(4-methoxybenzyl)oxy\}propyl\}-1,3,2-dioxaborolane (3)

Nucleophile solution: 5.82 ml (\(\rho = 1.11 \) g/ml, 46.7 mmol, 1.4 eq.) 4-methoxybenzyl alcohol were added to a suspension of 1.74 g (43.4 mmol, 1.3 eq.) sodium hydride (60 % in mineral oil) in 21 ml anhydrous THF and 62 ml anhydrous DMSO. The mixture was stirred at room temperature for 9 h.

LDA solution: 26.1 ml (41.7 mmol, 1.25 eq.) n-butyllithium (1.6 M in hexanes) were added dropwise to a solution of 6.42 ml (\(\rho = 0.71 \) g/ml, 45.1 mmol, 1.35 eq.) diisopropylamine in 6.7 ml anhydrous THF at −40 °C. After stirring at the same temperature for 10 min, the LDA solution was allowed to warm to room temperature and stirred for another 20 min.

Homologation: The freshly prepared LDA solution was slowly added to a solution of 8.82 g (33.4 mmol, 1.0 eq.) 1 and 6.44 ml (\(\rho = 1.32 \) g/ml, 100 mmol, 3.0 eq.) anhydrous DCM in 47 ml anhydrous THF at −40 °C. After stirring at the same temperature for 10 min, a solution of 9.10 g (66.8 mmol, 2.0 eq.) zinc chloride in 40 ml anhydrous THF was added. The mixture was allowed to warm to room temperature and stirred for 2 h. The resulting red solution of α-chloroboronic ester 2 was directly used in the substitution step.

Substitution: The α-chloroboronic ester solution was cooled to 0 °C and the nucleophile solution was added dropwise. After completion of the addition, the mixture was stirred for 14 h at room temperature.

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S3
After quenching with saturated NH₄Cl solution, the layers were separated and the aqueous layer was extracted twice with pentane. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. The crude product was purified by flash chromatography (petroleum ether, ethyl acetate 95:5) to obtain 3 in 93% yield (12.8 g, 30.9 mmol) as a pale yellow oil, Rₐ = 0.23 (petroleum ether, ethyl acetate 95:5); αᵢ̂D₀ = −23.6 (c = 0.5, CHCl₃).

\[ \text{\( ^{1}H\ NMR\ (400\ MHz,\ CDCl_3)\): } \delta = 7.29 (d, J_{11,12} = 8.7\ Hz, 2\ H, 11-H), 6.86 (d, J_{12,11} = 8.7\ Hz, 2\ H, 12-H), 4.51 (d, J_{9,9a} = 11.6\ Hz, 1\ H, 9-H\)), 4.43 (d, J_{9a,9b} = 11.6\ Hz, 1\ H, 9-H\), 3.91 (m, 2\ H, 5-H), 3.80 (s, 3\ H, 14-H), 3.27 (t, J_{6,7} = 6.7\ Hz, 1\ H, 6-H), 1.83–1.73 (m, 6\ H, 2-H′′′, 3-H′′′), 1.73–1.64 (m, 4\ H, 1-H′, 7-H), 1.60 (m, 2\ H, 3-H′′), 1.34 (m, 2\ H, 4-H), 1.28–1.14 (m, 6\ H, 1-H, 2-H′, 3-H′), 1.08 (m, 2\ H, 3-H), 1.03–0.91 (m, J_{8,7} = 7.5\ Hz, 5\ H, 2-H, 8-H).

\[ \text{\( ^{13}C\ NMR\ (100\ MHz,\ CDCl_3)\): } \delta = 159.0 (s, C-13), 131.4 (s, C-10), 129.4 (d, C-11), 113.6 (d, C-12), 83.6 (d, C-5), 71.6 (t, C-9), 68.6 (b, C-6), 55.2 (q, C-14), 42.9 (d, C-4), 28.3 (t, C-3′), 27.4 (t, C-2′), 26.4 (t, C-1), 26.0 (t, C-3), 25.9 (t, C-2), 24.4 (t, C-7), 11.0 (q, C-8).

HRMS (ESI) m/z calcld for C_{25}H_{40}O_4B [M+H]^+: 415.3014, found: 415.3019.

\( (4S,5S)-4,5\)-Dicyclohexyl-2-[(4R,5R)-5-[(4-methoxybenzyl)oxy]-2-methylheptan-4-yl]-1,3,2-dioxaborolane (4)

\( (4S,5S)-4,5\)-Dicyclohexyl-2-isobutyl-1,3,2-dioxaborolane (4′)

LDA solution: 14.8 ml (23.7 mmol, 1.25 eq.) n-butyllithium (1.6 M in hexanes) were added dropwise to a solution of 3.64 ml (ρ = 0.71 g/ml, 25.5 mmol, 1.35 eq.) disopropylamine in 3.8 ml anhydrous THF at −40 °C. After stirring at the same temperature for 10 min, the LDA solution was allowed to warm to room temperature and stirred for another 20 min.

Homologation: The LDA solution was slowly added to a solution of 7.84 g (18.9 mmol, 1.0 eq.) freshly prepared 3 and 3.65 ml (ρ = 1.32 g/ml, 56.8 mmol, 3.0 eq.) anhydrous DCM in 26 ml anhydrous THF at −40 °C. After stirring at the same temperature for 10 min, a solution of 7.73 g (56.8 mmol, 3.0 eq.) zinc chloride in 35 ml anhydrous THF was added. The mixture was allowed to warm to room temperature and stirred for 2 h. After quenching with saturated NH₄Cl solution, the layers were separated and the aqueous layer was extracted twice with pentane. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. The crude α-chloroboronic ester was directly used in the substitution step.

Substitution: The α-chloroboronic ester was dissolved in 60 ml anhydrous THF, cooled to −40 °C and 10.9 ml (21.7 mmol, 1.15 eq.) isobutylmagnesium chloride (2 M in THF) were added dropwise. After completion of the addition, the mixture was allowed to slowly warm to room temperature overnight.

After stirring for 18 h, the reaction was quenched with saturated NH₄Cl solution. The layers were separated and the aqueous layer was extracted twice with pentane. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. The crude product was purified by
flash chromatography (petroleum ether, ethyl acetate 98:2, 95:5) to obtain 4 in 72% yield (6.63 g, 13.7 mmol) as a colorless solid, Rf = 0.35 (petroleum ether, ethyl acetate 95:5); m.p. 52–53 °C (from petroleum ether, ethyl acetate); \( \alpha_D^{20} = -27.0 \) (c = 1.0, CHCl3); and 4* in 16% yield (874 mg, 2.99 mmol) as a colorless oil, Rf = 0.68 (petroleum ether, ethyl acetate 95:5); \( \alpha_D^{20} = -52.8 \) (c = 0.5, CHCl3).

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**1H NMR** (400 MHz, CDCl3): \( \delta = 7.26 \) (m, 2 H, 15-H), 6.85 (m, 2 H, 16-H), 4.43 (s, 2 H, 13-H), 3.82–3.76 (m, 5 H, 5-H, 18-H), 3.45 (dt, \( ^3J_{7,6} \approx ^3J_{7,8} = 5.8 \) Hz, 1 H, 7-H), 1.80 (m, 2 H, 2-H’’’), 1.76–1.68 (m, 4 H, 2-H’’, 3-H’’’), 1.64 (m, 2 H, 1-H’), 1.62–1.48 (m, 6 H, 3-H’’, 6-H, 11-H, 8-H), 1.41 (ddd, \( ^2J_{10b,10a} = 12.8 \) Hz, \( ^3J_{10a,10b} = 10.9 \) Hz, \( ^3J_{10b,11} = 5.0 \) Hz, 1 H, 10-Hb), 1.32–1.08 (m, 9 H, 1-H, 2-H’, 3-H’, 4-H, 10-Ha), 1.05–0.92 (m, 4 H, 2-H, 3-H), 0.92–0.85 (m, 9 H, 9-H, 12-H, 12-H’).

**13C NMR** (100 MHz, CDCl3): \( \delta = 158.7 \) (s, C-17), 131.7 (s, C-14), 128.8 (d, C-15), 113.5 (d, C-16), 83.4 (d, C-5), 82.3 (d, C-7), 70.3 (t, C-13), 55.3 (q, C-18), 43.1 (d, C-4), 36.0 (t, C-10), 28.5 (t, C-3’), 27.8 (t, C-2’), 27.7 (t, C-11), 26.5 (t, C-1), 26.0 (t, C-3), 25.9 (t, C-2), 24.8 (t, C-8), 23.7 (q, C-12’), 22.0 (q, C-12), 9.6 (q, C-9).

The signal of C-6 could not be detected.

**HRMS** (Cl) m/z calcd for \( \text{C}_{30}\text{H}_{40}\text{O}_{18}\text{B} [M]^+: 484.3718, \) found: 484.3708.

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**1H NMR** (400 MHz, CDCl3): \( \delta = 3.82 \) (m, 2 H, 5-H), 1.85 (tqq, \( ^3J_{7,6} \approx ^3J_{7,8} \approx ^3J_{7,8} = 6.8 \) Hz, 1 H, 7-H), 1.81–1.71 (m, 6 H, 1-H’, 2-H’’, 3-H’’’), 1.67 (m, 2 H, 1-H), 1.59 (m, 2 H, 3-H’’), 1.31 (m, 2 H, 4-H), 1.26–1.11 (m, 6 H, 2-H’, 3-H’), 1.06 (m, 2 H, 3-H), 0.98 (m, 2 H, 2-H), 0.94 (d, \( ^3J_{8,7} = 6.6 \) Hz, 3 H, 8-H’), 0.93 (d, \( ^3J_{8,7} = 6.6 \) Hz, 3 H, 8-H), 0.77 (d, \( ^3J_{6,7} = 7.1 \) Hz, 2 H, 6-H).

**13C NMR** (100 MHz, CDCl3): \( \delta = 83.2 \) (d, C-5), 43.1 (d, C-4), 28.4 (t, C-3’), 27.4 (t, C-2’), 26.5 (t, C-1), 26.0 (t, C-3), 25.9 (t, C-2), 25.3 (q, C-8’), 25.2 (q, C-8), 24.8 (d, C-7), 21.0 (bs, C-6).

**HRMS** (Cl) m/z calcd for \( \text{C}_{18}\text{H}_{32}\text{O}_{18}\text{B} [M]^+: 292.2568, \) found: 292.2566.

Ethyl \( (5R,6S,7R,9E)-5\{[(4S,5S)-4,5-dicyclohexyl-1,1,2-dioxaborol-2-yl]-6-isobutyl-7\{[4-methoxybenzyl]oxy\}-2-methylnon-2-enoate (5a) \)

LDA solution; 4.03 ml (6.45 mmol, 1.25 eq.) n-butyllithium (1.6 M in hexanes) were added dropwise to a solution of 993 µl (\( p = 0.71 \) g/ml, 6.97 mmol, 1.35 eq.) diisopropylamine in 1.2 ml
anhydrous THF at −40 °C. The LDA solution was allowed to warm to room temperature and stirred for 20 min.

Homologation: The LDA solution was slowly added to a solution of 2.50 g (5.16 mmol, 1.0 eq.) 4 and 1.08 ml (ρ = 2.49 g/ml, 15.5 mmol, 3.0 eq.) dibromomethane in 7.6 ml anhydrous THF at −78 °C. After stirring at the same temperature for 1 h, a solution of 2.11 g (15.5 mmol, 3.0 eq.) zinc chloride in 10.6 ml anhydrous THF was added. The mixture was allowed to slowly warm to room temperature and stirred for 17 h. After quenching with saturated NH₄Cl solution, the layers were separated and the aqueous layer was extracted twice with pentane. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. The crude α-bromoboronic ester was directly used in the substitution step.

Substitution: 3.55 ml (5.68 mmol, 1.10 eq.) n-butyllithium (1.6 M in hexanes) were added dropwise to a solution of 846 μl (ρ = 0.71 g/ml, 5.93 mmol, 1.15 eq.) diisopropylamine in 12.7 ml anhydrous THF at −40 °C. The LDA solution was allowed to warm to room temperature, stirred for 20 min and cooled to −78 °C. 933 μl (ρ = 1.063 g/ml, 7.74 mmol, 1.5 eq.) anhydrous DMPU was added dropwise and the mixture was stirred at −78 °C for 30 min. After the addition of 896 μl (ρ = 0.923 g/ml, 6.45 mmol, 1.25 eq.) ethyl tiglate, the resulting yellow dienolate solution was stirred at −78 °C for another 30 min followed by the dropwise addition of a solution of the crude α-bromoboronic ester in 12.7 ml anhydrous THF. The mixture was allowed to slowly warm to room temperature.

After stirring for 21 h, the reaction was quenched with saturated NH₄Cl solution. The layers were separated and the aqueous layer was extracted twice with pentane. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. The crude product was purified by flash chromatography (pentane, ethyl acetate 95:5) to obtain 5a in 61 % yield (1.96 g, 3.14 mmol) as a colorless oil, Rₜ = 0.16 (pentane, ethyl acetate 95:5); αᵣD = −30.2 (c = 0.5, CHCl₃).

1H NMR (400 MHz, CDCl₃): δ = 7.26 (d, 3J₂₁,₂₂ = 8.7 Hz, 2 H, 21-H), 6.85 (d, 3J₂₂,₂₁ = 8.7 Hz, 2 H, 22-H), 6.77 (tq, 3J₃₄,₈ = 7.5 Hz, 4J₁₀,₁₁ = 1.2 Hz, 1 H, 3-H), 4.44 (s, 2 H, 19-H), 4.16 (q, 3J₂₅,₂₆ = 7.1 Hz, 2 H, 25-H), 3.79 (s, 3 H, 24-H), 3.65 (m, 2 H, 11-H), 3.23 (td, 3J₇,₈ = 6.2 Hz, 3J₉,₆ = 3.7 Hz, 1 H, 7-H), 2.33 (ddd, 2J₉₄a,₄b = 14.7 Hz, 3J₄b₃ ≈ 3J₄b₅ = 8.4 Hz, 1 H, 4-H₉), 2.14 (ddd, 2J₉₄a,₄b = 14.4 Hz, 3J₄a₅ ≈ 3J₄a₅ = 6.6 Hz, 1 H, 4-H₉), 1.86–1.74 (m, 6 H, 6-H, 10-H, 14-H‘‘), 1.74–1.21 (m, 3J₂₆,₂₅ = 7.2 Hz, 18 H, 5-H, 8-H, 12-H, 13-H‘, 14-H‘‘, 15-H, 16-Hb, 17-H, 26-H), 1.20–1.06 (m, 9 H, 13-H, 14-H‘, 16-Hb), 0.93 (m, 2 H, 14-H), 0.89–0.79 (m, 9 H, 9-H, 18-H, 18-H‘).

13C NMR (100 MHz, CDCl₃): δ = 168.2 (s, C-1), 158.9 (s, C-23), 143.1 (d, C-3), 131.5 (s, C-20), 129.1 (d, C-21), 127.5 (s, C-2), 113.5 (d, C-22), 83.5 (d, C-11), 81.4 (d, C-7), 70.8 (t, C-19), 60.2 (t, C-25), 55.3 (q, C-24), 42.9 (d, C-12), 39.8 (d, C-6), 38.3 (t, C-16), 29.0 (t, C-4), 28.7 (t, C-13‘), 28.0 (t, C-14‘), 26.5 (t, C-15), 25.9 (t, C-13), 25.8 (t, C-14), 25.6 (d, C-17), 23.6 (q, C-18‘), 23.1 (t, C-8), 22.8 (bs, C-5), 22.1 (q, C-18), 14.3 (q, C-26), 12.5 (q, C-10), 10.3 (q, C-9).

tert-Butyl (5R,6S,7R,E)-5-[(4S,5S)-4,5-dicyclohexyl-1,3,2-dioxaborolan-2-yl]-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnon-2-enoate (5b)

LDA solution: 6.03 ml (9.65 mmol, 1.4 eq.) n-butyllithium (1.6 M in hexanes) were added dropwise to a solution of 1.49 ml (ρ = 0.71 g/ml, 10.5 mmol, 1.5 eq.) diisopropylamine in 1.8 ml anhydrous THF at −40 °C. The LDA solution was allowed to warm to room temperature and stirred for 20 min.

Homologation: The LDA solution was slowly added to a solution of 3.44 g (7.10 mmol, 1.0 eq.) 4 and 1.62 ml (ρ = 2.49 g/ml, 23.2 mmol, 3.3 eq.) dibromomethane in 11.4 ml anhydrous THF at −78 °C. After stirring at the same temperature for 1 h, a solution of 3.16 g (23.2 mmol, 3.3 eq.) zinc chloride in 15.8 ml anhydrous THF was added. The mixture was allowed to slowly warm to room temperature and stirred for 21 h. After quenching with saturated NH₄Cl solution, the layers were separated and the aqueous layer was extracted twice with pentane. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. The crude α-bromoboronic ester was directly used in the substitution step.

Substitution: 5.31 ml (5.68 mmol, 1.2 eq.) n-butyllithium (1.6 M in hexanes) were added dropwise to a solution of 1.27 ml (ρ = 0.71 g/ml, 8.88 mmol, 1.3 eq.) diisopropylamine in 19 ml anhydrous THF at −40 °C. The LDA solution was allowed to warm to room temperature, stirred for 20 min and cooled to −78 °C. 1.40 ml (ρ = 1.063 g/ml, 11.5 mmol, 1.6 eq.) anhydrous DMPU were added dropwise and the mixture was stirred at −78 °C for 30 min. After the addition of 1.51 g (9.65 mmol, 1.4 eq.) tert-butyl tiglate to the resulting yellow dienolate solution was stirred at −78 °C for another 30 min followed by the dropwise addition of a solution of the crude α-bromoboronic ester in 19 ml anhydrous THF. The mixture was allowed to slowly warm to room temperature.

After stirring for 21 h, the reaction was quenched with saturated NH₄Cl solution. The layers were separated and the aqueous layer was extracted twice with pentane. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. The crude product was purified by flash chromatography (petroleum ether, ethyl acetate 95:5) to obtain 5b in 72 % yield (3.33 g, 5.10 mmol) as a colorless oil, Rf = 0.18 (petroleum ether, ethyl acetate 95:5); α_D = −28.7 (c = 1.0, CHCl₃).

\[ ^1H \text{NMR} (400 \text{ MHz, CDCl}_3): \delta = 7.25 \text{ (d, } J_{21,22} = 8.6 \text{ Hz, } 2 \text{ H, 21-H}), 6.85 \text{ (d, } J_{22,21} = 8.6 \text{ Hz, } 2 \text{ H, 22-H}), 6.67 \text{ (t, } J_{3,4} = 6.9 \text{ Hz, } 1 \text{ H, 3-H}), 4.44 \text{ (s, } 2 \text{ H, 19-H}), 3.79 \text{ (s, } 3 \text{ H, 24-H}), 3.65 \text{ (m, } 2 \text{ H, 11-H}), 3.22 \text{ (m, } 1 \text{ H, 7-H}), 2.29 \text{ (dd, } J_{4b,4a} = 14.8 \text{ Hz, } J_{4b,3} \approx J_{4a,5} = 7.6 \text{ Hz, } 1 \text{ H, 4-H}), 2.13 \text{ (ddd, } J_{4a,4b} = 14.6 \text{ Hz, } J_{4a,3} \approx J_{4a,5} = 7.3 \text{ Hz, } 1 \text{ H, 4-H}), 1.85−1.75 \text{ (m, } 6 \text{ H, 6-H, 10-H, 14-H'''), 1.75−1.29 \text{ (m, } 24 \text{ H, 5-H, 8-H, 12-H, 13-H', 14-H''}, 15-\text{H}, 16-\text{H}, 17-\text{H}, 26-\text{H}), 1.21−1.05 \text{ (m, } 9 \text{ H, 13-H, 14-H'}, 16-\text{H}), 0.94 \text{ (m, } 2 \text{ H, 14-H}), 0.88−0.77 \text{ (m, } 9 \text{ H, 9-H, 18-H, 18-H')} \].

\[ ^13C \text{NMR} (100 \text{ MHz, CDCl}_3): \delta = 167.5 \text{ (s, } C-1), 158.8 \text{ (s, } C-23), 142.2 \text{ (d, } C-3), 131.5 \text{ (s, } C-20), 129.1 \text{ (d, } C-21), 128.9 \text{ (s, } C-2), 113.5 \text{ (d, } C-22), 83.4 \text{ (d, } C-11), 81.3 \text{ (d, } C-7), 79.6 \text{ (s, } C-18) \].

Synthesis of the tetrahydropyran ring system

Ethyl (5R,6S,7R,E)-5-hydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnon-2-enoate (6a)

To a solution of 2.12 g (3.40 mmol, 1.0 eq.) boronic ester 5a in 6.8 ml THF were added 1.58 ml (ρ = 1.11 g/ml, 17.0 mmol, 5.0 eq.) hydrogen peroxide (33 % in water) followed by a solution of 1.80 g (17.0 mmol, 5.0 eq.) sodium carbonate in 6.8 ml water at 0 °C. After stirring at room temperature for 4.5 h, brine was added and the mixture was extracted three times with diethyl ether. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. Purification of the residue by flash chromatography (pentane, ethyl acetate 9:1, 85:15) gave 6a in 71 % yield (982 mg, 2.42 mmol) as a colorless oil, R₆ = 0.35 (pentane, ethyl acetate 8:2); α⁺ = −30.9 (c = 1.0, CHCl₃).

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\text{HRMS (CI) m/z calcd for C}_{40}H_{60}O_{8}B [M+H]^+: 653.4947, \text{found: 653.4925.}
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\begin{align*}
\text{1H NMR (500 MHz, CDCl₃): } & \delta = 7.22 (m, 2 H, 16-H), 6.86 (m, 2 H, 17-H), 6.79 (ddq, ^1J_{3,4a} = 7.9 Hz, ^3J_{3,4b} = 6.6 Hz, ^4J_{3,10} = 1.4 Hz, 1 H, 3-H), 4.61 (d, ^2J_{14b,14a} = 11.0 Hz, 1 H, 14-Hb), 4.31 (d, ^2J_{14a,14b} = 11.0 Hz, 1 H, 14-Ha), 4.20–4.11 (m, ^3J_{20,21} = 7.3 Hz, 3 H, 5-H, 20-H), 3.79 (s, 3 H, 19-H), 3.63 (d, ^2J_{OH,5} = 2.0 Hz, 1 H, OH), 3.49 (ddd, ^3J_{7,8a} = 8.1 Hz, ^3J_{7,8b} = 4.9 Hz, ^3J_{7,6} = 2.8 Hz, 1 H, 7-H), 2.40 (ddddd, ^2J_{4b,4a} = 15.3 Hz, ^3J_{4b,3} = 3^3J_{4b,5} = 6.7 Hz, ^5J_{4b,10} = 4^4J_{4b,6} = 0.9 Hz, 1 H, 4-Hb), 2.22 (ddd, ^2J_{4a,4b} = 14.5 Hz, ^3J_{4a,3} = 3^4J_{4a,5} = 6.9 Hz, 1 H, 4-Ha), 2.19–1.79 (m, 4 H, 8-Hb, 10-H), 1.63 (m, 1 H, 8-Ha), 1.56–1.36 (m, 3 H, 6-H, 11-Hb, 12-H), 1.27 (t, ^3J_{21,20} = 7.1 Hz, 3 H, 21-H), 1.16 (ddd, ^2J_{11b,11b} = 13.9 Hz, ^3J_{11a,12} = 9.3 Hz, ^3J_{11a,6} = 3.7 Hz, 1 H, 11-Ha), 0.91–0.86 (m, 6 H, 9-H, 13-H'), 0.81 (d, ^2J_{13,12} = 6.4 Hz, 3 H, 13-H).
\end{align*}
\]

\[
\text{13C NMR (125 MHz, CDCl₃): } \delta = 168.0 (s, C-1), 159.4 (s, C-18), 138.9 (d, C-3), 130.1 (s, C-15), 129.5 (d, C-16), 129.1 (s, C-2), 113.9 (d, C-17), 82.6 (d, C-7), 71.9 (t, C-14), 69.9 (d, C-5), 60.4 (t, C-20), 55.3 (q, C-19), 40.8 (d, C-6), 34.0 (t, C-11), 33.5 (t, C-4), 25.5 (d, C-12), 23.7 (q, C-13'), 23.5 (t, C-8), 21.8 (q, C-13), 14.2 (q, C-21), 12.7 (q, C-10), 9.9 (q, C-9).
\]

\[
\text{HRMS (ESI) m/z calcd for C}_{29}H_{39}O_{5} [M+H]^+: 407.2792, \text{found: 407.2800.}
\]
**tert-Butyl (5R,6S,7R,E)-5-hydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnon-2-enoate (6b)**

To a solution of 3.58 g (5.48 mmol, 1.0 eq.) boronic ester 5b in 11.0 ml THF were added 2.55 ml (ρ = 1.11 g/ml, 27.4 mmol, 5.0 eq.) hydrogen peroxide (33 % in water) followed by a solution of 1.10 g (27.4 mmol, 5.0 eq.) sodium hydroxide in 11.0 ml water at 0 °C. After stirring at room temperature for 1 h, brine was added. The mixture was filtered and the filtrate was extracted three times with diethyl ether. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. Purification of the residue by flash chromatography (petroleum ether, ethyl acetate 85:15, 3:1) gave 6b in 79 % yield (1.89 g, 4.35 mmol) as a colorless oil, Rₐ = 0.39 (petroleum ether, ethyl acetate 8:2); αᵦ²⁰ = −51.2 (c = 0.5, CHCl₃).

![Chemical Structure](image)

**¹H NMR** (400 MHz, CDCl₃): δ = 7.22 (m, 2 H, 16-H), 6.86 (m, 2 H, 17-H), 6.66 (ddq, 3J₃,₄a = 7.8 Hz, 3J₃,₄b = 6.5 Hz, 3J₄,₅a = 1.3 Hz, 1 H, 3-H), 4.60 (d, 2J₄b,₁₄a = 11.1 Hz, 1 H, 14-Hb), 4.31 (d, 2J₄a,₁₄b = 11.0 Hz, 1 H, 14-Ha), 4.12 (m, 1 H, 5-H), 3.79 (s, 3 H, 19-H), 3.62 (d, 3J₉H₅ = 1.8 Hz, 1 H, OH), 3.49 (ddd, 3J₇,₈a = 8.4 Hz, 3J₇,₈b = 4.6 Hz, 3J₇,₆ = 2.7 Hz, 1 H, 7-H), 2.39 (ddd, 3J₄b,₄a = 14.9 Hz, 3J₄b,₅ = 7.3 Hz, 1 H, 4-Hb), 2.20 (ddd, 3J₄a,₄b = 14.8 Hz, 3J₄a,₅ = 7.2 Hz, 1 H, 4-Ha), 1.85 (m, 1 H, 8-Hb), 1.80 (m, 3 H, 10-H), 1.63 (m, 1 H, 8-Ha), 1.55–1.45 (m, 11 H, 6-H, 12-H, 21-H), 1.41 (ddd, 2J₁₁b₁₁a = 14.2 Hz, 3J₁₁b₁₁b = 9.4 Hz, 3J₁₁b₁₁c = 4.6 Hz, 1 H, 11-Hb), 1.15 (ddd, 2J₁₁a₁₁b = 13.7 Hz, 3J₁₁a₁₁c = 9.4 Hz, 3J₁₁a₁₁d = 3.2 Hz, 1 H, 11-Ha), 0.90–0.85 (m, 6 H, 9-H, 13-H), 0.80 (d, 3J₁₃,₁₂ = 6.5 Hz, 3 H, 13-H).

**¹³C NMR** (100 MHz, CDCl₃): δ = 167.3 (s, C-1), 159.3 (s, C-18), 137.7 (d, C-3), 130.5 (s, C-2), 130.1 (s, C-15), 129.5 (d, C-16), 113.9 (d, C-17), 82.5 (d, C-7), 79.9 (s, C-20), 71.8 (t, C-14), 69.8 (d, C-5), 55.3 (q, C-19), 40.5 (d, C-6), 33.9 (t, C-11), 33.4 (t, C-4), 28.1 (q, C-21), 25.5 (d, C-12), 23.7 (q, C-13), 23.5 (t, C-8), 21.7 (q, C-13), 12.7 (q, C-10), 9.8 (q, C-9).

**HRMS** (Cl) m/z calcd for C₂₆H₃₅O₅ [M+H]+: 435.3105, found: 435.3121.

**Ethyl (5R,6R,7R,E)-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-5-[(methylthio)carbonothioyl]oxy]non-2-enoate (7a)**

153 mg (3.83 mmol, 2.0 eq.) sodium hydride (60 % in mineral oil) were added to a solution of 778 mg (1.91 mmol, 1.0 eq.) alcohol 6a and 1.3 mg (19 µmol, 1 mol-%) imidazole in 19 ml anhydrous THF at room temperature. After stirring for 20 min, 577 µl (ρ = 1.263 g/ml, 9.57 mmol, 5.0 eq.) carbon disulfide were added dropwise. The resulting yellow solution was stirred for another 20 min and 598 µl (ρ = 2.27 g/ml, 9.57 mmol, 5.0 eq.) methyl iodide were added dropwise. After stirring for 4 h at room temperature, saturated NH₄Cl solution was added. The layers were separated and the aqueous layer was extracted three times with diethyl ether. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. Purification of the residue by flash chromatography (pentane, ethyl acetate 95:5) gave 7a in 90 % yield (855 mg, 1.72 mmol) as a pale yellow oil, Rₐ = 0.33 (pentane, ethyl acetate 9:1); αᵦ²⁰ = +22.4 (c = 0.5, CHCl₃).
**1H NMR** (400 MHz, CDCl₃): δ = 7.25 (m, 2 H, 18-H), 6.85 (m, 2 H, 19-H), 6.72 (tq, 3J₃,₄ = 7.4 Hz, 4J₃,₁₀ = 1.3 Hz, 1 H, 3-H), 5.98 (td, 3J₅,₄ = 6.6 Hz, 3J₅,₆ = 3.7 Hz, 1 H, 5-H), 4.41 (d, 2J₁₆b,₁₆a = 11.0 Hz, 1 H, 16-Hb), 4.37 (d, 2J₁₆a,₁₆b = 11.0 Hz, 1 H, 16-Ha), 4.18 (q, 3J₂₂,₂₃ = 7.2 Hz, 2 H, 22-H), 3.80 (s, 3 H, 21-H), 3.29 (ddd, 3J₇,₈ₐ = 6.7 Hz, 3J₇,₆ = 14.2 Hz, 1 H, 7-H), 2.73 (ddd, 2J₆₉,a₄ = 14.2 Hz, 3J₄₉,b₃ = 7.8 Hz, 1 H, 4-Hb), 2.56 (ddd, 2J₆₈,a₄ = 15.0 Hz, 3J₄₈,a₃ = 7J₄₈,a₅ = 7.0 Hz, 1 H, 4-Ha), 2.49 (s, 3 H, 12-H), 2.06 (m, 1 H, 6-H), 1.84 (m, 3 H, 10-H), 1.73–1.50 (m, 3 H, 8-H, 14-H), 1.40 (ddd, 2J₃₉,b₁₃ = 14.2 Hz, 3J₃₉,b₆ = 13J₃₉,b₁₄ = 6.6 Hz, 1 H, 13-Hb), 1.34–1.24 (m, 3J₂₃,₂₂ = 7.2 Hz, 4 H, 13-Ha, 23-H), 0.95–0.84 (m, 9 H, 9-H, 15-H, 15-H').

**13C NMR** (100 MHz, CDCl₃): δ = 215.3 (s, C-11), 167.7 (s, C-1), 159.1 (s, C-20), 136.1 (d, C-3), 130.8 (s, C-17), 130.5 (s, C-2), 129.5 (d, C-18), 113.6 (d, C-19), 83.5 (d, C-5), 80.8 (d, C-7), 71.5 (t, C-16), 60.5 (t, C-22), 55.3 (q, C-21), 40.7 (d, C-6), 36.1 (t, C-13), 31.2 (t, C-4), 26.2 (d, C-14), 24.0 (t, C-8), 23.2 (q, C-15'), 22.6 (q, C-15), 18.7 (q, C-12), 14.2 (q, C-23), 12.8 (q, C-10), 10.2 (q, C-9).

**HRMS** (ESI) m/z calcd for C₂₈H₄₁O₅S₂ [M+H]⁺: 497.2390, found: 497.2383.

tert-Butyl (5R,6R,7R,E)-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-5-[(methylthio)carbonothioyl]oxy]non-2-enoate (7b)

114 mg (2.85 mmol, 2.0 eq.) sodium hydride (60 % in mineral oil) were added to a solution of 620 mg (1.43 mmol, 1.0 eq.) alcohol 7a and 1.0 mg (14 µmol, 1 mol-%) imidazole in 14 ml anhydrous THF at room temperature. After stirring for 20 min, 430 µl (ρ = 1.263 g/ml, 7.13 mmol, 5.0 eq.) carbon disulfide were added dropwise. The resulting yellow solution was stirred for another 20 min and 446 µl (ρ = 2.27 g/ml, 7.13 mmol, 5.0 eq.) methyl iodide were added dropwise. After stirring for 3 h at room temperature, saturated NH₄Cl solution was added. The layers were separated and the aqueous layer was extracted three times with diethyl ether. The combined organic layers were dried over Na₂SO₄ and concentrated in vacuo. Purification of the residue by flash chromatography (pentane, ethyl acetate 95:5) gave 7b in 90 % yield (673 mg, 1.28 mmol) as a pale yellow oil, R₉ = 0.32 (pentane, ethyl acetate 95:5); αD²₀ = +23.8 (c = 1.0, CHCl₃).
$^1$H NMR (400 MHz, CDCl$_3$): $\delta = 7.25$ (m, 2 H, 18-H), 6.85 (m, 2 H, 19-H), 6.63 (tq, $^3J_{3,4} = 7.3$ Hz, $^4J_{3,10} = 1.3$ Hz, 1 H, 3-H), 5.98 (td, $^3J_{5,4} = 6.6$ Hz, $^3J_{5,6} = 3.8$ Hz, 1 H, 5-H), 4.39 (s, 2 H, 16-H), 3.80 (s, 3 H, 21-H), 3.28 (ddd, $^3J_{7,8a} = 6.7$ Hz, $^3J_{7,8b} = 5.0$ Hz, 1 H, 7-H), 2.73 (ddd, $^2J_{4b,4a} = 15.2$ Hz, $^3J_{4b,3} = 7.6$ Hz, $^3J_{4b,5} = 6.7$ Hz, 1 H, 4-H$_b$), 2.53 (ddd, $^2J_{4a,4b} = 15.4$ Hz, $^3J_{4a,3} = 7.0$ Hz, 1 H, 4-H$_a$), 2.49 (s, 3 H, 12-H), 2.06 (m, 1 H, 6-H), 1.80 (bs, 3 H, 10-H), 1.73–1.50 (m, 3 H, 8-H, 14-H), 1.47 (s, 9 H, 23-H), 1.41 (ddd, $^2J_{13b,13} = 14.3$ Hz, $^3J_{13b,6} = 3J_{13b,14} = 6.4$ Hz, 1 H, 13-H$_b$), 1.29 (ddd, $^2J_{13,13b} = 14.2$ Hz, $^3J_{13,6} = 7.7$ Hz, $^3J_{13,14} = 5.5$ Hz, 1 H, 13-H$_a$), 0.94–0.84 (m, 9 H, 9-H, 15-H, 15'-H).

$^{13}$C NMR (100 MHz, CDCl$_3$): $\delta = 215.3$ (s, C-11), 166.9 (s, C-1), 159.0 (s, C-20), 135.0 (d, C-3), 131.8 (s, C-2), 130.8 (s, C-17), 129.4 (d, C-18), 113.6 (d, C-19), 83.4 (d, C-5), 80.8 (d, C-7), 80.1 (s, C-22), 71.5 (t, C-16), 55.3 (q, C-21), 40.6 (d, C-6), 36.0 (t, C-13), 31.2 (t, C-4), 28.1 (q, C-23), 26.2 (d, C-14), 23.9 (t, C-8), 23.2 (q, C-15’), 22.6 (q, C-15), 18.7 (q, C-12), 12.7 (q, C-10), 10.2 (q, C-9).

HRMS (Cl) m/z calced for C$_{28}$H$_{45}$O$_5$S$_2$ [M+H]$^+$: 525.2703, found: 525.2709.

tert-Butyl (5$R$,6$R$,7$R$,E)-5-[(1H-imidazole-1-carbonothioyl)oxy]-6-isobutyl-7-[(4-methoxybenzoyl)oxy]-2-methylnon-2-enoate (8)

122 µl (ρ = 1.5 g/ml, 1.59 mmol, 1.75 eq.) thioisopropene were added dropwise to a vigorously stirred suspension of 432 mg (6.35 mmol, 7.0 eq.) imidazole in 2 ml anhydrous 1,2-dichloroethane at room temperature. After stirring for 30 min, a solution of 394 mg (906 µmol, 1.0 eq.) alcohol 6b in 1.6 ml anhydrous 1,2-dichloroethane was added and the mixture was heated to reflux for 3 h. 22 mg (181 mmol, 0.2 eq.) DMAP were added and refluxing was continued for another 26 h. The mixture was diluted with DCM, washed with water and saturated NaHCO$_3$ solution, dried over Na$_2$SO$_4$ and concentrated in vacuo. Purification of the residue by flash chromatography (petroleum ether, ethyl acetate 9:1, 85:15, 7:3) gave 8 in 80 % yield (393 mg, 722 µmol) as a pale yellow oil, R$_f = 0.34$ (petroleum ether, ethyl acetate 7:3); $\alpha^D_{20} = +44.1$ (c = 1.0, CHCl$_3$).

$^1$H NMR (500 MHz, CDCl$_3$): $\delta = 8.21$ (m, 1 H, 12-H), 7.46 (dd, $^4J_{14,12} \approx 3J_{14,13} = 1.4$ Hz, 1 H, 14-H), 7.08 (d, $^3J_{20,21} = 8.5$ Hz, 2 H, 20-H), 6.94 (m, 1 H, 13-H), 6.75 (d, $^3J_{21,20} = 8.8$ Hz, 2 H, 21-H), 6.61 (tq, $^3J_{3,4} = 7.4$ Hz, $^4J_{3,10} = 1.3$ Hz, 1 H, 3-H), 5.92 (ddd, $^3J_{5,4a} = 8.2$ Hz, $^3J_{5,4b} = 6.0$ Hz, $^3J_{5,6} = 1.9$ Hz, 1 H, 5-H), 4.42 (d, $^2J_{18b,18a} = 10.7$ Hz, 1 H, 18-H$_b$), 4.22 (d, $^2J_{18a,18b} =$
11.0 Hz, 1 H, 18-H\(_2\)), 3.78 (s, 3 H, 23-H), 3.31 (m, 1 H, 7-H), 2.77 (ddd, \(^3J_{1b,4a} = 14.5\) Hz, \(^3J_{4b,3} \approx \) \(^3J_{4b,5} = 6.9\) Hz, 1 H, 4-H\(_b\)), 2.56 (ddd, \(^2J_{1a,4b} = 15.2\) Hz, \(^3J_{4a,3} \approx \) \(^3J_{4a,5} = 7.7\) Hz, 1 H, 4-H\(_a\)), 1.94 (m, 1 H, 6-H), 1.81 (bs, 3 H, 10-H), 1.75 (m, 1 H, 8-H\(_b\)), 1.65–1.54 (m, 2 H, 8-H\(_a\), 16-H), 1.50 (ddd, \(^2J_{1b,15a} = 13.9\) Hz, \(^3J_{15b,16} = 8.2\) Hz, \(^3J_{15b,6} = 5.0\) Hz, 1 H, 15-H\(_b\)), 1.46 (s, 9 H, 25-H), 1.31 (ddd, \(^2J_{15a,15b} = 13.8\) Hz, \(^3J_{15a,6} = 9.2\) Hz, \(^2J_{15a,16} = 4.1\) Hz, 1 H, 15-H\(_a\)), 0.93 (d, \(^3J_{17^\prime,16} = 6.6\) Hz, 3 H, 17-H\(^\prime\)), 0.91–0.85 (m, 6 H, 9-H, 17-H).

**\(^{13}\)C NMR** (125 MHz, CDCl\(_3\)): \(\delta = 183.7\) (s, C-11), 166.7 (s, C-1), 159.0 (s, C-22), 136.8 (d, C-12), 134.0 (d, C-3), 132.4 (s, C-2), 130.4 (s, C-19), 130.4 (d, C-13), 129.2 (d, C-20), 117.9 (d, C-14), 113.6 (d, C-21), 82.5 (d, C-5), 80.4 (s, C-24), 80.0 (d, C-7), 71.4 (t, C-18), 55.2 (q, C-23), 40.1 (d, C-6), 35.7 (t, C-15), 30.9 (t, C-4), 28.0 (q, C-25), 25.9 (d, C-16), 23.6 (t, C-8), 23.5 (q, C-17'), 22.0 (q, C-17), 12.8 (q, C-10), 9.8 (q, C-9).

**HRMS** (CI) m/z calced for C\(_{30}\)H\(_{45}\)O\(_3\)N\(_2\)Si [M+H]\(^+\): 545.3044, found: 545.3059.

tert-Butyl 2-\{\(R\)-2-[(1,1,1,3,3,3-hexamethyl-2-[trimethylsilyl]trisilan-2-yl)thio]-5-\[(4R,5R)-5-[(4-methoxybenzyl)oxy]-2-methylheptan-4-yl]-4,5-dihydrofuran-3-yl\}propanoate (9)

To a solution of 384 mg (670 µmol, 1.0 eq.) 8 in 6.7 ml anhydrous toluene were added 28 mg (167 µmol, 0.25 eq.) AIBN and 413 µl (ρ = 0.806 g/ml, 1.34 mmol, 2.0 eq.) tris(trimethylsilyl)silane at room temperature. The solution was degassed by bubbling through nitrogen over 5 min and stirred at 85 °C (oil bath) for 6 h. 14 mg (84 µmol, 0.125 eq.) AIBN and 207 µl (ρ = 0.806 g/ml, 670 µmol, 1.0 eq.) tris(trimethylsilyl)silane were added and stirring at 85 °C was continued for another 1 h. After removal of the solvent in vacuo, the residue was purified by flash chromatography (petroleum ether, ethyl acetate 95:5) to give 9 (d.r. = 67:33 according to HPLC) in 53 % yield (259 mg, 357 µmol) as a colorless oil, R\(_f\) = 0.27 (petroleum ether, ethyl acetate 95:5).

![diagram](image.png)

**major diastereomer:**

\(^1\)H NMR (500 MHz, CDCl\(_3\)): \(\delta = 7.26\) (d, \(^3J_{18,19} = 8.8\) Hz, 2 H, 18-H), 6.86 (d, \(^3J_{19,18} = 8.8\) Hz, 2 H, 19-H), 4.56–4.42 (m, 2 H, 5-H, 16-H), 4.35 (m, 1 H, 16-H\(_a\)), 3.80 (s, 3 H, 21-H), 3.59 (q, \(^3J_{21,10} = 7.3\) Hz, 1 H, 2-H), 3.34 (m, 1 H, 7-H), 2.71 (dd, \(^2J_{1b,4a} = 14.8\) Hz, \(^3J_{4b,5} = 10.1\) Hz, 1 H, 4-H\(_a\)), 2.42 (dd, \(^2J_{4a,4b} = 15.1\) Hz, \(^3J_{4a,5} = 9.5\) Hz, 1 H, 4-H\(_b\)), 2.03 (m, 1 H, 6-H), 1.77 (m, 1 H, 14-H), 1.51 (m, 2 H, 8-H), 1.43 (s, 9 H, 23-H), 1.31 (m, 2 H, 13-H), 1.18 (d, \(^3J_{10,2} = 7.3\) Hz, 3 H, 10-H), 0.92 (t, \(^3J_{9,8} = 7.4\) Hz, 3 H, 9-H), 0.87 (m, 6 H, 15-H, 15-H\(^\prime\)), 0.24 (s, 27 H, 12-H).

**\(^{13}\)C NMR** (125 MHz, CDCl\(_3\)): \(\delta = 173.9\) (s, C-1), 159.0 (s, C-20), 143.7 (s, C-11), 131.0 (s, C-17), 129.4 (d, C-18), 114.0 (s, C-3), 113.7 (d, C-19), 81.8 (d, C-5), 81.5 (d, C-7), 80.2 (s, C-22), 71.2 (t, C-16), 55.3 (q, C-21), 43.2 (d, C-6), 39.4 (d, C-2), 35.6 (t, C-13), 34.8 (t, C-4), 28.1 (q, C-23), 25.9 (d, C-14), 23.6 (t, C-8), 23.4 (q, C-15'), 22.7 (q, C-15), 16.5 (q, C-10), 10.6 (q, C-9), 0.5 (q, C-12).
minor diastereomer (selected signals):

$^1$H NMR (500 MHz, CDCl$_3$): $\delta = 3.57$ (q, $^3J_{\text{H},10} = 7.3$ Hz, 1 H, 2-H), 2.62 (dd, $^3J_{\text{H},4a} = 15.0$ Hz, $^3J_{\text{H},5} = 9.9$ Hz, 1 H, 4-H$_b$), 2.45 (dd, $^3J_{\text{H},4b} = 15.4$ Hz, $^3J_{\text{H},5} = 9.8$ Hz, 1 H, 4-H$_a$), 1.43 (s, 9 H, 23-H), 0.91 (t, $^3J_{\text{H},9} = 7.3$ Hz, 3 H, 9-H), 0.23 (s, 27 H, 12-H).

$^{13}$C NMR (125 MHz, CDCl$_3$): $\delta = 82.1$ (d, C-5), 81.6 (d, C-7), 28.1 (q, C-23), 25.9 (d, C-14), 23.7 (t, C-8), 23.3 (q, C-15*), 22.6 (q, C-15), 15.6 (q, C-10).

HRMS (CI) m/z calcd for C$_{27}$H$_{43}$Os[S $+$ 2H $-$ Si(TMS)$_3$]$: 479.2826, found: 479.2806.

LRMS (ESI) m/z calcd for C$_{36}$H$_{69}$O$_5$S$i_4$ [M+H]$^+$: 725, found: 725.

HPLC (Phenomenex Onyx $^\circledR$ Monolithic C18, H$_2$O + 0.1 % HCOOH, MeCN 90:10 $\rightarrow$ 1:99 [4 min], 1:99 [1.5 min], 90:10 [1 min], 4 ml/min, 40 °C): $t_R$(9b) = 5.039 min, $t_R$(epi-9b) = 5.157 min.

Ethyl (2S,3R,5R,6R,7R)-2,3-dihydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-5-[[methylthio]carbonothioyl]oxy)nonanoate (10a)

1.66 g (5.04 mmol, 3.0 eq.) potassium hexacyanoferrate(III), 697 mg (5.04 mmol, 3.0 eq.) potassium carbonate, 26.2 mg (34 μmol, 2 mol-%) (DHQD)$_2$Phal and 6.2 mg (17 μmol, 1 mol-%) potassium osmate dihydrate were dissolved in 8.4 ml water at room temperature. 160 mg (1.68 mmol, 1.0 eq.) methanesulfonamide were added and the mixture was cooled to 0 °C followed by the addition of a solution of 835 mg (1.68 mmol, 1.0 eq.) xanthate 7a in 8.4 ml tert-butanol. The resulting orange suspension was stirred at 0 °C for 2 d. Saturated Na$_2$SO$_3$ solution was added and the mixture was extracted three times with ethyl acetate. The combined organic layers were washed with brine, dried over Na$_2$SO$_4$ and concentrated in vacuo. Purification of the residue by flash chromatography (pentane, ethyl acetate 8:2) gave 10a (d.r. = 85:15 according to $^1$H NMR) in 94 % yield (834 mg, 1.57 mmol) as a pale yellow oil, $R_f$ = 0.21 (pentane, ethyl acetate 8:2).

major diastereomer:

$^1$H NMR (500 MHz, CDCl$_3$): $\delta = 7.25$ (m, 2 H, 18-H), 6.85 (m, 2 H, 19-H), 6.15 (ddd, $^3J_{\text{H},5} = 10.3$ Hz, $^3J_{\text{H},5} = 2.8$ Hz, 1 H, 5-H), 4.42 (d, $^2J_{\text{H},10a,16a} = 11.1$ Hz, 1 H, 16-H$_a$), 4.35 (d, $^2J_{\text{H},16a,16b} = 11.0$ Hz, 1 H, 16-H$_b$), 4.24 (q, $^3J_{\text{H},22,23} = 7.1$ Hz, 2 H, 22-H), 3.80 (s, 3 H, 21-H), 3.75 (ddd, $^3J_{\text{H},4a} = 11.0$ Hz, $^3J_{\text{H},5} = 6.4$ Hz, $^3J_{\text{H},4b} = 1.7$ Hz, 1 H, 3-H), 3.36–3.30 (m, 2 H, 2-OH, 7-H), 2.91 (d, $^3J_{\text{H},13} = 6.4$ Hz, 1 H, 3-OH), 2.48 (s, 3 H, 12-H), 2.14–1.97 (m, 2 H, 4-H$_b$, 6-H), 1.80 (ddd, $^3J_{\text{H},4a} = 14.5$ Hz, $^3J_{\text{H},4a} = 11.2$ Hz, $^3J_{\text{H},4a} = 5$ Hz, 1 H, 4-H$_a$), 1.73–1.56 (m, 3 H, 8-H, 14-H), 1.39 (ddd, $^3J_{\text{H},13} = 13.9$ Hz, $^3J_{\text{H},13} = 6.7$ Hz, 1 H, 13-H$_b$), 1.31 (s, 3 H, 10-H), 1.30–1.22 (m, $^3J_{\text{H},22} = 7.1$ Hz, 4 H, 13-H$_a$, 23-H), 0.95–0.86 (m, 9 H, 9-H, 15-H, 15-H').

$^{13}$C NMR (125 MHz, CDCl$_3$): $\delta = 217.7$ (s, C-11), 175.6 (s, C-1), 159.0 (s, C-20), 130.9 (s, C-17), 129.5 (d, C-18), 113.6 (d, C-19), 82.6 (d, C-5), 81.0 (d, C-7), 77.1 (s, C-2), 71.4 (t, C-16), 71.3 (d, C-3), 62.0 (t, C-22), 55.3 (q, C-21), 42.2 (d, C-6), 36.1 (t, C-13), 33.8 (t, C-4), 26.1 (d,
C-14), 23.7 (t, C-8), 23.1 (q, C-15*), 22.6 (q, C-15), 21.6 (q, C-10), 18.8 (q, C-12), 14.1 (q, C-23), 10.1 (q, C-9).

**minor diastereomer (selected signals):**

**1H NMR** (500 MHz, CDCl₃): δ = 3.79 (s, 3 H, 21-H), 3.37 (s, 1 H, 2-OH), 2.52 (d, 3JCH₃ = 8.2 Hz, 1 H, 3-OH), 2.47 (s, 3 H, 12-H).

**13C NMR** (125 MHz, CDCl₃): δ = 129.6 (d, C-18), 113.7 (d, C-19), 82.6 (d, C-5), 81.0 (d, C-7), 73.3 (d, C-3), 71.7 (t, C-16), 62.2 (t, C-22), 40.9 (d, C-6), 35.9 (t, C-13), 32.8 (t, C-4), 26.3 (d, C-14), 23.9 (t, C-8), 23.4 (q, C-15*), 22.6 (q, C-15), 21.6 (q, C-10), 21.6 (q, C-10), 18.6 (q, C-12), 9.9 (q, C-9).

**HRMS** (ESI) m/z calcd for C₂₅H₄₃O₇S₂ [M+H]+: 531.2445, found: 531.2439.

tert-Butyl (2S,3R,5R,6R,7R)-2,3-dihydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-5-[[[(methylthio)carbonothioyl]oxy]nonanoate (10b)

1.25 g (3.80 mmol, 3.0 eq.) potassium hexacyanoferrate(III), 525 mg (3.80 mmol, 3.0 eq.) potassium carbonate, 19.7 mg (25 µmol, 2 mol-%) (DHQD)Phal and 4.7 mg (13 µmol, 1 mol-%) potassium osmate dihydrate were dissolved in 6.3 ml water at room temperature. 120 mg (1.27 mmol, 1.0 eq.) methanesulfonamide were added and the mixture was cooled to 0 °C followed by the addition of a solution of 664 mg (1.27 mmol, 1.0 eq.) xanthate 7b in 6.3 ml tert-butanol. The resulting orange suspension was stirred at 0 °C for 4 d. Saturated Na₂SO₄ solution was added and the mixture was extracted three times with ethyl acetate. The combined organic layers were washed with brine, dried over Na₂SO₄ and concentrated in vacuo. Purification of the residue by flash chromatography (pentane, ethyl acetate 8:2) gave 10b (d.r. = 81:19 according to 1H NMR) in 91 % yield (704 mg, 1.15 mmol) as a pale yellow resin, Rₜ = 0.30 (pentane, ethyl acetate 8:2).

**major diastereomer:**

**1H NMR** (400 MHz, CDCl₃): δ = 7.25 (m, 2 H, 18-H), 6.85 (m, 2 H, 19-H), 6.14 (ddd, 3J5a,b = 10.3 Hz, 3J5a,J3d ≈ 2.8 Hz, 1 H, 5-H), 4.41 (d, 2J1b,H₁a = 10.8 Hz, 1 H, 16-H₁b), 4.36 (d, 2J1b,H₁b = 10.9 Hz, 1 H, 16-H₁b), 3.80 (s, 3 H, 21-H), 3.70 (m, 1 H, 3-H), 3.37 (s, 1 H, 2-OH), 3.33 (m, 1 H, 7-H), 2.80 (d, 3JH₃,J8 ≈ 6.5 Hz, 1 H, 3-OH), 2.48 (s, 3 H, 12-H), 2.13 (m, 1 H, 6-H), 2.05 (m, 1 H, 4-H₁b), 1.76 (ddd, 2J4a,J4b = 14.5 Hz, 3J4a,J3d = 11.0 Hz, 3J4a,J5a ≈ 2.2 Hz, 1 H, 4-H₁a), 1.72–1.60 (m, 3 H, 8-H, 14-H), 1.46 (s, 9 H, 23-H), 1.40 (ddd, 2J1b,J13d ≈ 14.0 Hz, 3J1b,J13d ≈ 6.8 Hz, 1 H, 13-H₁b), 1.33–1.20 (m, 4 H, 10-H, 13-H₁b), 0.97–0.85 (m, 9 H, 9-H, 15-H, 15-H*).

**13C NMR** (100 MHz, CDCl₃): δ = 217.5 (s, C-11), 174.8 (s, C-1), 159.0 (s, C-20), 130.9 (s, C-17), 129.5 (d, C-18), 113.6 (d, C-19), 82.8 (d, C-5), 82.7 (s, C-22), 81.0 (d, C-7), 76.9 (s, C-2), 71.5 (t, C-16), 71.4 (d, C-3), 55.3 (q, C-21), 42.1 (d, C-6), 36.1 (t, C-13), 34.0 (t, C-4), 27.9 (q, C-23), 26.0 (d, C-14), 23.8 (t, C-8), 23.1 (q, C-15*), 22.7 (q, C-15), 21.5 (q, C-10), 18.8 (q, C-12), 10.2 (q, C-9).
minor diastereomer (selected signals):

\(^1\text{H NMR}\) (400 MHz, CDCl\(_3\)): \(\delta = 3.79\) (s, 3 H, 21-H), 3.42 (s, 1 H, 2-OH), 2.47 (s, 3 H, 12-H), 2.40 (d, \(^3J_{\text{OH},3} = 8.9\) Hz, 1 H, 3-OH), 1.48 (s, 9 H, 23-H).

\(^13\text{C NMR}\) (100 MHz, CDCl\(_3\)): \(\delta = 129.6\) (d, C-18), 113.7 (d, C-19).

HRMS (ESI) m/z calcld for C\(_{25}\)H\(_{47}\)O\(_7\)S\(_2\) [M+H]\(^+\): 559.2758, found: 559.2743.

Ethyl (25,3R,6R,7R)-2,3-dihydroxy-6-isobuty1-7-[(4-methoxybenzy1)oxy]-2-methylnonanoate (11a)

A solution of 528 µl (\(\rho = 1.082\) g/ml, 1.96 mmol, 1.3 eq.) tributyltin hydride in 15 ml anhydrous toluene was degassed by bubbling through with nitrogen for 5 min and heated to 85 °C (oil bath). 802 mg (1.51 mmol, 1.0 eq.) 10a and 62.0 mg (378 µmol, 0.25 eq.) AIBN were dissolved in 15 ml anhydrous toluene and the solution was degassed by bubbling through with nitrogen for 5 min. The xanthate / AIBN solution was added dropwise to the hot Bu\(_3\)SnH solution over 30 min. After completion of the addition, stirring at 85 °C was continued for another 4.5 h. After removal of the solvent in vacuo, the residue was purified by flash chromatography (pentane, ethyl acetate 9:1, 7:3) to give 11a (d.r. = 85:15 according to \(^1\text{H NMR}\)) in 70 % yield (449 mg, 1.06 mmol) as a colorless oil, \(R_f = 0.26\) (pentane, ethyl acetate 7:3).

major diastereomer:

\(^1\text{H NMR}\) (400 MHz, CDCl\(_3\)): \(\delta = 7.26\) (m, 2 H, 16-H), 6.86 (m, 2 H, 18-H), 4.42 (s, 2 H, 14-H), 4.27 (q, \(^3J_{21,20} = 7.2\) Hz, 3 H, 21-H), 3.80 (s, 3 H, 19-H), 3.60 (m, 1 H, 3-H), 3.40 (s, 1 H, 2-OH), 3.24 (ddd, \(^3J_{7,6} = 6.0\) Hz, \(^3J_{7,8a} = 4.2\) Hz, 1 H, 7-H), 1.94 (d, \(^3J_{\text{OH},3} = 9.0\) Hz, 1 H, 3-OH), 1.71 (m, 1 H, 6-H), 1.67–1.56 (m, 3 H, 4-H\(_a\), 5-H\(_b\), 12-H), 1.51 (m, 2 H, 8-H), 1.40–1.21 (m, 9 H, 4-H\(_a\), 5-H\(_a\), 10-H, 11-H\(_b\), 21-H), 1.04 (ddd, \(^2J_{11a,11b} = 13.7\) Hz, \(^3J_{11a,6} = 7.8\) Hz, \(^3J_{11a,12} = 6.1\) Hz, 1 H, 11-H\(_a\)), 0.91 (t, \(^3J_{9,8} = 7.3\) Hz, 3 H, 9-H), 0.87 (d, \(^3J_{13,12} = 6.7\) Hz, 3 H, 13-H\(_3\)), 0.86 (d, \(^3J_{13,12} = 6.5\) Hz, 3 H, 13-H).

\(^13\text{C NMR}\) (100 MHz, CDCl\(_3\)): \(\delta = 176.3\) (s, C-1), 159.0 (s, C-18), 131.2 (s, C-15), 129.3 (d, C-16), 113.7 (d, C-17), 82.2 (d, C-7), 77.2 (s, C-2), 76.1 (d, C-3), 71.1 (t, C-14), 62.2 (t, C-20), 55.3 (q, C-19), 39.4 (t, C-11), 37.3 (d, C-6), 28.3 (t, C-4), 26.7 (t, C-5), 25.5 (d, C-12), 23.4 (q, C-13), 22.7 (t, C-8), 22.5 (q, C-13), 21.8 (q, C-10), 14.1 (q, C-21), 10.5 (q, C-9).

minor diastereomer (selected signals):

\(^1\text{H NMR}\) (400 MHz, CDCl\(_3\)): \(\delta = 3.36\) (s, 1 H, 2-OH), 2.00 (d, \(^3J_{\text{OH},3} = 8.9\) Hz, 1 H, 3-OH).

\(^13\text{C NMR}\) (100 MHz, CDCl\(_3\)): \(\delta = 129.4\) (d, C-16), 113.9 (d, C-17), 82.4 (d, C-7), 75.8 (d, C-3), 71.2 (t, C-14), 62.2 (t, C-20), 14.1 (q, C-21), 10.4 (q, C-9).

HRMS (ESI) m/z calcld for C\(_{25}\)H\(_{41}\)O\(_6\) [M+H]\(^+\): 425.2898, found: 425.2900.
**tert-Butyl (2S,3R,6R,7R)-2,3-dihydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnonanoate (11b)**

A solution of 414 mg (741 µmol, 1.0 eq.) 10b, 30.4 mg (185 µmol, 0.25 eq.) AIBN and 259 µl (ρ = 1.082 g/ml, 963 µmol, 1.3 eq.) tributyltin hydride in 7.4 ml anhydrous toluene was degassed by bubbling through with nitrogen for 5 min and heated to 85 °C (oil bath) for 2 h. After removal of the solvent in vacuo, the residue was purified by flash chromatography (pentane, ethyl acetate 9:1, 85:15, 8:2, 7:3) to give 11b (d.r. = 81:19 according to 1H NMR) in 64 % yield (214 mg, 473 µmol) as a colorless oil, Rf = 0.42 (pentane, ethyl acetate 8:2); and 11c (d.r. = 56:44 according to 1H NMR) in 14 % yield (46 mg, 102 µmol) as a colorless oil, Rf = 0.37 (pentane, ethyl acetate 8:2).

![Chemical Structure](image)

**major diastereomer:**

1H NMR (400 MHz, CDCl3): δ = 7.26 (m, 2 H, 16-H), 6.86 (m, 2 H, 17-H), 4.44 (d, 3J14b,14a = 11.1 Hz, 1 H, 14-Hb), 4.40 (d, 3J14a,14b = 11.1 Hz, 1 H, 14-Ha), 3.80 (s, 3 H, 19-H), 3.60 (m, 1 H, 3-H), 3.47 (s, 1 H, 2-OH), 3.24 (dd, 3J7,6 ≈ 3J7,8a = 6.0 Hz, 3J7,8b = 4.0 Hz, 1 H, 7-H), 1.88 (d, 3J9,8b = 9.7 Hz, 1 H, 3-OH), 1.71 (m, 1 H, 6-H), 1.67–1.57 (m, 3 H, 4-Hb, 5-Hb, 12-H), 1.55–1.43 (m, 11 H, 8-H, 21-H), 1.37–1.24 (m, 6 H, 4-Ha, 5-Ha, 10-H, 11-Hb), 1.04 (ddd, 3J11a,11b = 13.7 Hz, 3J11a,6 = 7.8 Hz, 3J11a,12 = 6.2 Hz, 1 H, 11-Ha), 0.95–0.82 (m, 9 H, 9-H, 13-H, 13’-H).

13C NMR (100 MHz, CDCl3): δ = 175.5 (s, C-1), 159.0 (s, C-18), 131.3 (s, C-15), 129.3 (d, C-16), 113.7 (d, C-17), 82.9 (s, C-20), 82.3 (d, C-7), 77.0 (s, C-2), 76.2 (d, C-3), 71.1 (t, C-14), 55.3 (q, C-19), 39.3 (t, C-11), 37.3 (d, C-6), 28.6 (t, C-4), 27.9 (q, C-21), 26.8 (t, C-5), 25.5 (d, C-12), 23.4 (q, C-13’), 22.7 (t, C-8), 22.5 (q, C-13), 21.9 (q, C-10), 10.6 (q, C-9).

**minor diastereomer (selected signals):**

1H NMR (400 MHz, CDCl3): δ = 3.45 (s, 1 H, 2-OH), 1.91 (d, 3J9,8b = 9.5 Hz, 1 H, 3-OH).

13C NMR (100 MHz, CDCl3): δ = 129.4 (d, C-16).

HRMS (ESI) m/z calcd for C26H45O6 [M+H]+: 453.3211, found: 453.3212.
major diastereomer:

\(^1\)H NMR (400 MHz, CDCl\(_3\)): δ = 7.21 (m, 2 H, 16-H), 6.85 (m, 2 H, 17-H), 4.58 (d, \(^2\)J\(_{14b,14a}\) = 11.0 Hz, 1 H, 14-H\(_b\)), 4.46–4.24 (m, \(^2\)J\(_{14a,14b}\) = 10.9 Hz, 2 H, 5-H, 14-H\(_a\)), 3.88 (m, 1 H, 3-H), 3.78 (s, 3 H, 19-H), 3.64 (d, \(^3\)J\(_{OH,5}\) = 1.8 Hz, 1 H, 5-OH), 3.47 (m, 1 H, 7-H), 3.07 (d, \(^3\)J\(_{OH,3}\) = 7.2 Hz, 1 H, 3-OH), 2.43 (dq, \(^3\)J\(_{2,3}\) ≈ \(^3\)J\(_{2,10}\) = 7.0 Hz, 1 H, 2-H), 1.87–1.56 (m, 3 H, 4-H\(_b\), 8-H), 1.54–1.39 (m, 11 H, 6-H, 12-H, 21-H), 1.39–1.26 (m, 2 H, 4-H\(_a\), 11-H\(_b\)), 1.22–1.09 (m, \(^2\)J\(_{10,2}\) = 7.1 Hz, 4 H, 10-H, 11-H\(_a\)), 0.96–0.77 (m, 9 H, 9-H, 13-H, 13-H').

\(^1\)C NMR (100 MHz, CDCl\(_3\)): δ = 175.4 (s, C-1), 159.3 (s, C-18), 130.1 (s, C-15), 129.5 (d, C-16), 113.8 (d, C-17), 82.9 (d, C-7), 80.7 (s, C-20), 71.7 (t, C-14), 71.0 (d, C-3), 67.2 (d, C-5), 55.2 (q, C-19), 46.4 (d, C-2), 42.0 (d, C-6), 38.6 (t, C-4), 34.7 (t, C-11), 28.0 (q, C-21), 25.6 (d, C-12), 23.5 (t, C-8), 23.5 (q, C-13').

minor diastereomer (selected signals):

\(^1\)H NMR (400 MHz, CDCl\(_3\)): δ = 4.02 (m, 1 H, 3-H), 3.71 (d, \(^3\)J\(_{OH,5}\) = 1.0 Hz, 1 H, 5-OH), 3.18 (d, \(^3\)J\(_{OH,3}\) = 5.6 Hz, 1 H, 3-OH), 2.49 (qd, \(^3\)J\(_{2,10}\) = 7.0 Hz, \(^2\)J\(_{2,3}\) = 5.3 Hz, 1 H, 2-H), 1.43 (s, 9 H, 21-H), 1.17 (d, \(^3\)J\(_{10,2}\) = 7.1 Hz, 3 H, 10-H).

\(^1\)C NMR (100 MHz, CDCl\(_3\)): δ = 175.6 (s, C-1), 159.3 (s, C-18), 130.1 (s, C-15), 129.5 (d, C-16), 83.0 (d, C-7), 80.5 (s, C-20), 71.8 (t, C-14), 69.9 (d, C-3), 67.5 (d, C-5), 45.5 (d, C-2), 37.6 (t, C-4), 34.6 (t, C-11), 28.0 (q, C-21), 21.9 (q, C-13), 12.1 (q, C-10), 9.8 (q, C-9).

HRMS (ESI) m/z calc'd for C\(_{26}\)H\(_{45}\)O\(_6\) [M+H]\(^+\): 453.3211, found: 453.3220.

**Ethyl (2S,6R,7R)-2-hydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-3-oxononanoate (12a)**

1.77 g (11.1 mmol, 12.0 eq.) pyridine sulfur trioxide complex were added to 3.1 ml anhydrous DMSO. After stirring at room temperature for 15 min, the resulting brown suspension was added dropwise to a solution of 394 mg (928 µmol, 1.0 eq.) \(\text{11a}\) and 2.98 ml (\(\rho = 0.726 \text{ g/ml}\), 21.3 mmol, 23.0 eq.) triethylamine in 3.1 ml anhydrous DMSO and 3.1 ml anhydrous DCM at 0 °C. The mixture was warmed to room temperature and stirred for 7 h. Diethyl ether was added and the mixture was washed with saturated NH\(_4\)Cl solution (1x), water (3x) and brine (1x). The organic layer was dried over Na\(_2\)SO\(_4\) and concentrated in vacuo. Purification of the residue by flash chromatography (pentane, ethyl acetate 85:15) gave \(\text{12a}\) (d.r. = 85:15 according to \(^1\)H NMR) in 76 % yield (297 mg, 703 µmol) as a pale yellow oil, \(R_t = 0.32\) (pentane, ethyl acetate 8:2).
According acetone, a concentrated aqueous DMSO solution of tert-butyl peroxodisulfate was added dropwise to a solution of 17 mg (0.040 µmol) of 11 (98% eq.) in acetonitrile and stirred at room temperature for 15 min. The resulting brown solution was added dropwise to a solution of 18 mg (0.040 µmol) of diethyl ether. The mixture was warmed to room temperature and stirred for 1.5 h. The mixture was washed three times with water. The organic layer was dried over Na2SO4 and concentrated in vacuo. Purification of the residue by flash chromatography (pentane, ethyl acetate 9:1, 8:2) gave tert-Butyl (2S,6R,7R)-2-hydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-3-oxononanoate (12b) as a colorless oil with an HPLC purity of 98% eq. Yield: 27 µmol (12 mg).
Alternatively, preparative chromatography of the mixture (H₂O/MeCN 9:1→MeCN) gave 13 (d.r. = 87:13 according to ¹H NMR) in 91% yield (135 mg, 446 µmol) as a colorless solid, R₇ = 0.49 (pentane, ethyl acetate 8:2).

To isolate isomerically pure 13, 30 mg of the diastereomeric mixture were further purified by preparative HPLC (Phenomenex Luna® C18(2), H₂O/MeCN 9:1→MeCN) to give 24 mg 1a (d.r. = 96:4 according to ¹H NMR) as a colorless solid.

Alternatively, 135 mg of the diastereomeric mixture were recrystallized from 7 ml water/ethanol 4:3 to give 87 mg 13 (single isomer according to ¹H NMR) as colorless needles; m.p. 83–85 °C (from water, ethanol); α₀D = +82.4 (c = 0.5, CHCl₃). By concentration of the mother liquor followed by a second recrystallization from 3 ml water/ethanol 4:3, another 18 mg 13 (d.r. = 89:11 according to ¹H NMR) were obtained as colorless needles.
major diastereomer:

$^1$H NMR (500 MHz, CDCl$_3$, 0 °C): $\delta = 4.35$ (d, $^4$J$_{3\text{-OH},4b}$ = 2.4 Hz, 1 H, 3-0H), 4.26 (q, $^3$J$_{14b,15}$ = 7.2 Hz, 2 H, 14-H), 3.44 (ddd, $^3$J$_{7a,8a}$ $\approx$ $^3$J$_{7b}$ = 9.4 Hz, 1 H, 7-H), 3.08 (s, 1 H, 2-0H), 1.84 (ddd, $^3$J$_{4b,4a}$ $\approx$ $^3$J$_{4b,5a}$ = 13.3 Hz, $^3$J$_{4b,5b}$ = 4.1 Hz, $^3$J$_{4b,3\text{-OH}}$ = 2.4 Hz, 1 H, 4-Hb), 1.76 (m, 1 H, 5-Ha), 1.71–1.58 (m, 3 H, 4-Ha, 8-Hb, 12-H), 1.41 (s, 3 H, 10-H), 1.38–1.29 (m, $^3$J$_{15,14}$ = 7.2 Hz, 4 H, 5-Ha, 15-H), 1.29–1.16 (m, 2 H, 6-H, 8-Ha), 1.07 (ddd, $^2$J$_{11b,11a}$ = 13.4 Hz, $^3$J$_{11b,12}$ = 10.4 Hz, $^3$J$_{11b,6}$ = 3.2 Hz, 1 H, 11-Hb), 0.91 (ddd, $^2$J$_{11a,11b}$ = 13.9 Hz, $^3$J$_{11a,6}$ = 10.2 Hz, $^3$J$_{11a,12}$ = 4.1 Hz, 1 H, 13-Ha), 0.87 (d, $^3$J$_{13',12}$ = 6.6 Hz, 3 H, 13-H'), 0.80 (d, $^3$J$_{13,12}$ = 6.6 Hz, 3 H, 13-H), 0.77 (t, $^3$J$_{6,8}$ = 7.3 Hz, 3 H, 9-H).

$^{13}$C NMR (125 MHz, CDCl$_3$, 0 °C): $\delta$ = 176.2 (s, C-1), 98.5 (s, C-3), 78.5 (s, C-2), 76.1 (d, C-7), 62.2 (t, C-14), 40.4 (t, C-11), 36.8 (d, C-6), 26.4 (t, C-4), 25.2 (t, C-8), 24.5 (d, C-12), 24.2 (q, C-13'), 24.0 (t, C-5), 21.2 (q, C-13), 19.4 (q, C-10), 14.2 (q, C-15), 9.5 (q, C-9).

minor diastereomer (selected signals):

$^1$H NMR (500 MHz, CDCl$_3$, 0 °C): $\delta = 3.70$ (s, 1 H, 2-0H), 3.64 (d, $^4$J$_{3\text{-OH},4b}$ = 2.6 Hz, 1 H, 3-0H).

$^{13}$C NMR (125 MHz, CDCl$_3$, 0 °C): $\delta$ = 173.5 (s, C-1), 96.6 (s, C-3), 79.3 (s, C-2), 75.4 (d, C-7), 61.9 (t, C-14), 40.3 (t, C-11), 35.7 (d, C-6), 28.3 (t, C-4), 25.0 (t, C-8), 21.2 (q, C-13), 19.0 (q, C-10), 14.2 (q, C-15), 8.7 (q, C-9).

HRMS (ESI) m/z calcd for C$_{16}$H$_{30}$O$_5$ [M+H]$^+$: 303.2166, found: 303.2175.

Ethyl (4S,5S,7R,8R)-7-ethyl-8-isobutyl-2,2,4-trimethyl-1,3,6-trioxaspiro[4.5]decane-4-carboxylate (14)

33 mg (231 μmol, 1.0 eq.) phosphorus pentoxide were added to a solution of 70 mg (231 μmol, 1.0 eq.) 13 (single isomer) in 2.3 ml anhydrous acetone at room temperature. After stirring for 3 h, diethyl ether and saturated NaHCO$_3$ solution were added. The layers were separated and the aqueous layer was extracted twice with diethyl ether. The combined organic layers were dried over Na$_2$SO$_4$ and concentrated in vacuo. Purification of the residue by flash chromatography (pentane, ethyl acetate 97:3) gave 14 in 92 % yield (73 mg, 213 μmol) as a colorless oil, $R_f = 0.39$ (pentane, ethyl acetate 95:5); $\alpha_D^{20} = +114.6$ (c = 0.5, CHCl$_3$).

$^1$H NMR (500 MHz, CDCl$_3$): $\delta = 4.18$ (dq, $^2$J$_{14b,14a}$ = 10.8 Hz, $^3$J$_{14a,15}$ = 7.2 Hz, 1 H, 14-Hb), 4.14 (dq, $^2$J$_{14a,14b}$ = 10.8 Hz, $^3$J$_{14a,15}$ = 7.2 Hz, 1 H, 14-Ha), 3.47 (ddd, $^3$J$_{7a,8a}$ = 9.6 Hz, $^3$J$_{7,6}$ = 7.0 Hz, $^3$J$_{7b,8b}$ = 2.9 Hz, 1 H, 7-H), 1.79 (m, 1 H, 5-Hb), 1.72–1.60 (m, 3 H, 4-Ha, 8-Hb, 12-H), 1.58 (s, 3 H, 17-H'), 1.51 (s, 3 H, 17-H), 1.50 (s, 3 H, 10-H), 1.48–1.32 (m, 4 H, 4-Ha, 5-Ha, 6-H, 8-Ha), 1.29 (t, $^3$J$_{15,14}$ = 7.2 Hz, 3 H, 15-H), 1.10 (ddd, $^2$J$_{11b,11a}$ = 13.4 Hz, $^3$J$_{11b,12}$ = 10.3 Hz, $^3$J$_{11b,6}$ = 3.1 Hz, 1 H, 11-Hb), 0.94 (ddd, $^2$J$_{11a,11b}$ = 13.6 Hz, $^3$J$_{11a,6}$ = 9.8 Hz, $^3$J$_{11a,12}$ = 4.3 Hz,
Methyl [(4S,5S,7R,8R)-7-ethyl-8-isobutyl-2,2,4-trimethyl-1,3,6-trioxaspiro[4.5]decane-4-carbonyl]-L-leucinate (15)

Saponification: 31 mg (745 µmol, 5.0 eq.) lithium hydroxide monohydrate were added to a solution of 51 mg (149 µmol, 1.0 eq.) ethyl ester 14 in 990 µl ethanol, 250 µl water and 250 µl THF. After refluxing the mixture for 16 h, the solvent was removed in vacuo to yield the crude carboxylate which was used in the next step without further purification.

Note: Attempts to isolate the carboxylic acid by acidification with aqueous HCl led to decomposition.

Amide coupling: The crude carboxylate and 68 mg (372 µmol, 2.5 eq.) L-leucine methyl ester hydrochloride were dissolved in 3 ml DCM. 130 µl (ρ = 0.74 g/ml, 745 µmol, 5.0 eq.) DIPEA and 142 mg (372 µmol, 2.5 eq.) HATU were added and the mixture was stirred at room temperature for 22 h. Ethyl acetate was added and the mixture was washed with 1 M KHSO₄ solution, saturated NaHCO₃ solution and brine. The organic layer was dried over Na₂SO₄ and concentrated in vacuo. Purification of the residue by automated flash chromatography (hexane → hexane, ethyl acetate 8:2) gave 15 in 85 % yield (56 mg, 127 µmol) as a colorless oil, R₆ = 0.24 (pentane, ethyl acetate 9:1); α₂₀ = +69.3 (c = 1.0, CHCl₃).

**1H NMR** (500 MHz, DMSO-d₆): δ = 7.69 (d, 3J₁₄,₁₅b = 10.1 Hz, 3J₁₄,NH = 8.5 Hz, 3J₁₄,₁₅a = 4.3 Hz, 1 H, 14-H), 3.63 (s, 3 H, 19-H), 3.40 (ddd, 3J₁₄,₁₅b = 9.8 Hz, 3J₁₄,₁₅a = 7.2 Hz, 1 J₈,₉b = 2.6 Hz, 1 H, 1 H), 1.85–1.69 (m, 3 H, 4-H₆, 5-H₆, 15-Hb), 1.69–1.51 (m, 4 H, 8-H₆, 12-H, 15-Ha, 16-H), 1.48 (s, 3 H, 21-H'), 1.47 (s, 3 H, 21-H), 1.40 (m, 1 H, 8-H₆), 1.37–1.20 (m, 6 H, 4-H₆, 5-H₆, 6-H, 10-H), 1.08 (ddd, 3J₁₁b,₁₁a = 12.8 Hz, 3J₁₁b,₁₂ = 10.8 Hz, 3J₁₁b,₁₆ = 2.0 Hz, 1 H, 11-Hb), 0.95–0.85 (m, 10 H, 9-H, 11-Ha, 13-H', 17-H'), 0.83 (d, 3J₁₇,₁₆ = 6.1 Hz, 3 H, 17-H), 0.81 (d, 3J₁₃,₁₂ = 6.4 Hz, 3 H, 13-H).

**13C NMR** (125 MHz, DMSO-d₆): δ = 172.5 (s, C-18), 172.0 (s, C-1), 109.3 (s, C-20), 104.1 (s, C-3), 88.0 (s, C-2), 75.9 (d, C-7), 52.0 (q, C-19), 50.1 (d, C-14), 40.3 (t, C-11), 39.2 (t, C-15), 35.5 (d, C-6), 31.4 (t, C-4), 28.2 (q, C-21'), 28.1 (q, C-21), 25.3 (t, C-5), 25.2 (t, C-8), 24.4 (d, C-16), 24.2 (d, C-12), 24.1 (q, C-13'), 22.8 (q, C-17'), 21.2 (q, C-13), 21.1 (q, C-17), 21.0 (q, C-10), 9.3 (q, C-9).

The signal at 39.2 ppm overlapped with the solvent peak and was therefore estimated from HSQC and HMBC spectra.

**HRMS** (ESI) m/z calcd for C₁₉H₃₄O₈N₆ [M+H]^+: 442.3163, found: 442.3175.

42.3 mg (248 µmol, 3.0 eq.) copper(II) chloride dihydrate were added to a solution of 36.5 mg (83 µmol, 1.0 eq.) acetonide 15 in 1.1 ml acetonitrile. The resulting suspension was stirred at room temperature for 29 h. The mixture was diluted with water and extracted three times with ethyl acetate. The combined organic layers were dried over Na2SO4 and concentrated in vacuo. Purification of the residue by automated flash chromatography (hexane → hexane, ethyl acetate 3:1) gave 16 in 99 % yield (33.0 mg, 82 µmol) as colorless needles, Rf = 0.31 (pentane, ethyl acetate 8:2); m.p. 117–118 °C (from hexane, ethyl acetate); αD²⁰ = +59.0 (c = 1.0, CHCl₃).

\[ \begin{align*}
\text{1H NMR} \ (500 \text{ MHz, CDCl}_3): & \text{ } \delta = 7.36 \ (d, \ 3_J_{\text{NH},14} = 8.5 \text{ Hz, } 1 \ H, \text{ NH}), 6.37 \ (bs, \ 1 \ H, \ 3-\text{OH}), \\
& 4.56 \ (ddd, \ 3_J_{14,15b} \approx 3_J_{14,\text{NH}} = 9.0 \text{ Hz, } 3_J_{14,15a} = 4.4 \text{ Hz, } 1 \ H, \ 14-\text{H}), 3.73 \ (s, \ 3 \ H, \ 19-\text{H}), 3.56 \ (dd, \ 3_J_{7,8a} = 10.1 \text{ Hz, } 3_J_{7,6} = 7.7 \text{ Hz, } 3_J_{7,8b} = 2.7 \text{ Hz, } 1 \ H, \ 7-\text{H}), 3.12 \ (bs, \ 1 \ H, \ 2-\text{OH}), 1.80–1.51 \ (m, \ 8 \ H, \ 4-\text{H}, \ 5-\text{Hb}, \ 8-\text{Hb}, \ 12-\text{H}, \ 15-\text{H}, \ 16-\text{H}), 1.50–1.37 \ (m, \ 4 \ H, \ 5-\text{Ha}, \ 10-\text{H}), 1.31 \ (m, \ 1 \ H, \ 8-\text{Hb}), 1.23 \ (m, \ 1 \ H, \ 6-\text{H}), 1.08 \ (ddd, \ 3_J_{11b,11a} = 13.4 \text{ Hz, } 3_J_{11b,12} = 10.1 \text{ Hz, } 3_J_{11b,6} = 3.3 \text{ Hz, } 1 \ H, \ 11-\text{Hb}), 1.01–0.90 \ (m, \ 7 \ H, \ 11-\text{Ha}, \ 17-\text{H}, \ 17-\text{H}'), 0.88 \ (d, \ 3_J_{13',12} = 6.6 \text{ Hz, } 3 \ H, \ 13-\text{H}'), 0.84–0.76 \ (m, \ 6 \ H, \ 9-\text{H}, \ 13-\text{H}).
\end{align*} \]

\[ \begin{align*}
\text{13C NMR} \ (125 \text{ MHz, CDCl}_3): & \text{ } \delta = 178.0 \ (s, \ C-1), 172.8 \ (s, \ C-18), 98.8 \ (s, \ C-3), 76.8 \ (s, \ C-2), \\
& 75.7 \ (d, \ C-7), 52.3 \ (q, \ C-19), 50.3 \ (d, \ C-14), 41.3 \ (t, \ C-15), 40.5 \ (t, \ C-11), 36.6 \ (d, \ C-6), 27.7 \ (t, \ C-4), 25.1 \ (t, \ C-8), 24.8 \ (d, \ C-16), 24.6 \ (d, \ C-12), 24.2 \ (q, \ C-13'), 24.1 \ (t, \ C-5), 22.8 \ (q, \ C-17'), 21.6 \ (q, \ C-17), 21.3 \ (q, \ C-13), 19.7 \ (q, \ C-10), 9.0 \ (q, \ C-9).
\end{align*} \]

The signal at 76.8 ppm overlapped with the solvent peak and was therefore estimated from HSQC and HMBC spectra.

Copies of the NMR spectra and HPLC chromatograms

(4S,5S)-4,5-Dicyclohexyl-2-ethyl-1,3,2-dioxaborolane (1)

$^1$H NMR (400 MHz, CDCl$_3$):

$^{13}$C NMR (100 MHz, CDCl$_3$):
(4S,5S)-4,5-Dicyclohexyl-2-\{(S)-1-[(4-methoxybenzyl)oxy]propyl\}-1,3,2-dioxaborolane (3)

\(^1\)H NMR (400 MHz, CDCl\(_3\)):

\(^1\)C NMR (100 MHz, CDCl\(_3\)):
(4S,5S)-4,5-Dicyclohexyl-2-[(4R,5R)-5-[(4-methoxybenzyl)oxy]-2-methylheptan-4-yl]-1,3,2-dioxaborolane (4)

$^1$H NMR (400 MHz, CDCl$_3$):

\[
\begin{array}{c}
\text{Chemical Shift (ppm)}
\end{array}
\]

\[
\begin{array}{c}
7.27 \\
6.86 \\
6.84 \\
5.06 \\
4.78 \\
2.00 \\
1.01 \\
0.89 \\
0.87 \\
0.86 \\
0.84 \\
0.82 \\
0.80
\end{array}
\]

$^{13}$C NMR (100 MHz, CDCl$_3$):

\[
\begin{array}{c}
\text{Chemical Shift (ppm)}
\end{array}
\]

\[
\begin{array}{c}
158.74 \\
131.68 \\
128.75 \\
128.75 \\
113.51 \\
83.40 \\
82.28 \\
77.32 \\
77.00 \\
76.69 \\
70.31 \\
55.27 \\
43.07 \\
28.51 \\
27.83 \\
27.74 \\
26.48 \\
25.98 \\
25.87 \\
24.84 \\
23.67 \\
22.02 \\
9.60
\end{array}
\]
(4S,5S)-4,5-Dicyclohexyl-2-isobutyl-1,3,2-dioxaborolane (4′)

$^1$H NMR (400 MHz, CDCl$_3$):

$^{13}$C NMR (100 MHz, CDCl$_3$):
Ethyl (5R,6S,7R,E)-5-[(4S,5S)-4,5-dicyclohexyl-1,3,2-dioxaborolan-2-yl]-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnon-2-enoate (5a)

$^1$H NMR (400 MHz, CDCl$_3$):

$^{13}$C NMR (100 MHz, CDCl$_3$):
**tert-Butyl (5R,6S,7R,E)-5-[(4S,5S)-4,5-dicyclohexyl-1,3,2-dioxaborolan-2-yl]-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnon-2-enoate (5b)**

$^1$H NMR (400 MHz, CDCl$_3$):

13C NMR (100 MHz, CDCl$_3$):
Ethyl (5R,6S,7R,E)-5-hydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnon-2-enoate (6a)

$^1$H NMR (500 MHz, CDCl$_3$):

$^{13}$C NMR (125 MHz, CDCl$_3$):
**tert-Butyl (5R,6S,7R,E)-5-hydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnon-2-enoate (6b)**

$^1$H NMR (400 MHz, CDCl$_3$):

$^{13}$C NMR (100 MHz, CDCl$_3$):
Ethyl (5R,6R,7R,E)-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-5-[(methylthio)carbonothioyl]oxy]non-2-enoate (7a)

\(^1\)H NMR (400 MHz, CDCl\(_3\)):

\[^{13}\text{C} \text{ NMR} \ (100 \text{ MHz, CDCl}_3)\):
tert-Butyl (5R,6R,7R,E)-6-isobutyl-7-{[(4-methoxybenzyl)oxy]-2-methyl-5-[(methylthio)carbonothioyl]oxy}non-2-enoate (7b)

$^1$H NMR (400 MHz, CDCl$_3$): 

$^{13}$C NMR (100 MHz, CDCl$_3$):
tert-Butyl (5\(R\),6\(R\),7\(R\), E)-5-[(1\(H\)-imidazole-1-carbonothioyl)oxy]-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnon-2-enoate (8)

\(^1\)H NMR (500 MHz, CDCl\(_3\)):

\[^{13}\text{C} \text{NMR} \ (125 \text{ MHz, CDCl}_3):\]

S33
**tert-Butyl 2-[(R)-2-[(1,1,1,3,3,3-hexamethyl-2-(trimethylsilyl)trisilan-2-ylthio]-5-[(4R,5R)-5-[(4-methoxybenzyl)oxy]-2-methylheptan-4-yl]-4,5-dihydrofuran-3-yl]propanoate (9)**

**1H NMR (500 MHz, CDCl₃):**

![NMR spectrum](image)

**13C NMR (125 MHz, CDCl₃):**

![NMR spectrum](image)
LC-MS (9 and epi-9)

Column: Phenomenex Onyx® Monolithic C18 130 Å (50 x 4.6 mm)

Eluent: H₂O + 0.1 % HCOOH, MeCN 90:10 → 1:99 [4 min], 1:99 [1.5 min], 90:10 [1 min], 4 ml/min, 40 °C

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MS Spectrum
Ethyl (25,3R,5R,6R,7R)-2,3-dihydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-5-[[[methylthio]carbonothioyl]oxy]nonanoate (10a, mixture of diastereomers)

$^1$H NMR (500 MHz, CDCl$_3$):

$^{13}$C NMR (125 MHz, CDCl$_3$):
**tert-Butyl (2S,3R,5R,6R,7R)-2,3-dihydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-5-[[[(methylthio)carbonothioyl]oxy]nonanoate (10b, mixture of diastereomers)**

**1H NMR (400 MHz, CDCl₃):**

![H NMR spectrum](image)

**13C NMR (100 MHz, CDCl₃):**

![C NMR spectrum](image)
Ethyl (25,3R,6R,7R)-2,3-dihydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnonanoate (11a, mixture of diastereomers)

$^1$H NMR (400 MHz, CDCl$_3$):

$^{13}$C NMR (100 MHz, CDCl$_3$):
**tert-Butyl (25,3R,6R,7R)-2,3-dihydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnonanoate (11b, mixture of diastereomers)**

\[^1\text{H}\text{ NMR} (400\text{ MHz, CDCl}_3):\]

\[^{13}\text{C}\text{ NMR} (100\text{ MHz, CDCl}_3):\]
**tert-Butyl (3R,5R,6S,7R)-3,5-dihydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methylnonanoate (11c, mixture of diastereomers)**

**$^1$H NMR (400 MHz, CDCl$_3$):**

![NMR spectrum](image)

**$^{13}$C NMR (100 MHz, CDCl$_3$):**

![NMR spectrum](image)
Ethyl (2S,6R,7R)-2-hydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-3-oxononanoate (12a, mixture of diastereomers)

$^1$H NMR (500 MHz, CDCl$_3$):

$^{13}$C NMR (125 MHz, CDCl$_3$):
**tert-Butyl (25R,6R,7R)-2-hydroxy-6-isobutyl-7-[(4-methoxybenzyl)oxy]-2-methyl-3-oxononanoate (12b, mixture of diastereomers)**

$^1$H NMR (400 MHz, CDCl$_3$):

$^{13}$C NMR (100 MHz, CDCl$_3$):
Ethyl (S)-2-[(2R,5R,6R)-6-ethyl-2-hydroxy-5-isobutyltetrahydro-2H-pyran-2-yl]-2-hydroxypropanoate (13, mixture of diastereomers, d.r. = 87:13)

$^1$H NMR (0 °C, 500 MHz, CDCl$_3$):

$^{13}$C NMR (0 °C, 125 MHz, CDCl$_3$):
Ethyl (S)-2-[(2R,5R,6R)-6-ethyl-2-hydroxy-5-isobutyltetrahydro-2H-pyran-2-yl]-2-hydroxypropanoate (13, purified by preparative HPLC, d.r. = 96:4)

$^1$H NMR (0 °C, 500 MHz, CDCl$_3$):

$^{13}$C NMR (0 °C, 125 MHz, CDCl$_3$):
Ethyl (S)-2-[(2R,5R,6R)-6-ethyl-2-hydroxy-5-isobutyltetrahydro-2H-pyran-2-yl]-2-hydroxypropanoate (13, purified by recrystallization, single diastereomer)

$^1$H NMR (0 °C, 500 MHz, CDCl$_3$):

$^{13}$C NMR (0 °C, 125 MHz, CDCl$_3$):
**Ethyl (4S,5S,7R,8R)-7-ethyl-8-isobutyl-2,2,4-trimethyl-1,3,6-trioxaspiro[4.5]decane-4-carboxylate (14)**

**$^1$H NMR (500 MHz, CDCl$_3$):**

![NMR spectrum](image)

**$^{13}$C NMR (125 MHz, CDCl$_3$):**

![NMR spectrum](image)
Methyl [(4S,5S,7R,8R)-7-ethyl-8-isobutyl-2,2,4-trimethyl-1,3,6-trioxaspiro[4.5]decane-4-carbonyl]-L-leucinate (15)

$^1$H NMR (500 MHz, DMSO-$d_6$):

$^{13}$C NMR (125 MHz, DMSO-$d_6$):
Methyl \{ (S) - 2-[(2R,5R,6R)-6-ethyl-2-hydroxy-5-isobutyrtetrahydro-2H-pyran-2-yl]-2-hydroxypropanoyl]-L-leucinate (16) \}

\( ^1H \) NMR (500 MHz, CDCl\(_3\)): 

\( ^{13}C \) NMR (125 MHz, CDCl\(_3\)): 

Chemical Shift (ppm)

0.97 0.90 1.00 3.01 1.01 0.93 8.35 4.04 8.35 0.93 1.01 3.01 1.00 0.90 0.97 ... 73

3.58
3.58
3.57
3.56
3.56
3.55
3.12
1.73
1.67
1.66
1.65
1.39
0.93
0.92
0.92
0.91
0.89
0.82
0.81
0.79