Supporting Information

Stereochemical Diversity Through Cyclodimerization: Synthesis of Natural Product-like Macrodilolides

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General Information: ¹H- and ¹³C-NMR were recorded in CDCl₃ at 400 MHz and 75.0 MHz respectively unless specified otherwise. Chemical shifts are reported in parts per million using the solvent resonance internal standard chloroform (7.24 and 77.0 ppm, unless specified otherwise). Data are reported as follows: chemical shift, integration, multiplicity (app = apparent, par obsc = partially obscured, ovrlp = overlapping, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad, abq = ab quartet) and coupling constant. Ratios of diastereomers (dr) were determined by ¹H-NMR (400 MHz) operating at a signal/noise ratio of >200:1. Infrared Resonance (IR) spectra were recorded on a Nicolet Impact 400 FT-IR spectrometer. Optical rotations were recorded on an AUTOPOL III digital polarimeter at 589 nm, and are reported as [α]_D (concentration in grams/100 mL solvent). High resolution mass spectra (HRMS) were obtained on a Finnegan MAT-90 spectrometer in the Boston University Mass Spectrometry Laboratory. Tetrahydrofuran (THF), ethyl ether (Et₂O), methylene chloride (CH₂Cl₂), benzene and toluene were dried using a solvent drying system (Al₂O₃). All other reagents were used as supplied from commercial sources. All reactions were carried out in oven-dried glassware under argon or N₂ atmosphere unless otherwise noted. Analytical thin layer chromatography was performed using Whatman Reagent silica gel 60-A plates. Flash chromatography was performed using E. Merck silica gel (230-400 mesh). High performance liquid chromatography (HPLC) was performed on an Agilent 1100 using a diode array detector (DAD) and a quadropole mass spectrometer. Ratios of cyclodimerization products were determined by evaporative light scattering (ELS) detection using a Waters 600 HPLC using a Waters DAD, Micromass ZQ quadropole mass spectrometer, and a Sedere ELS detector. All HPLC separations were done using HPLC grade solvents using a Waters Xterra MS C₁₈ 2.1 x 100 mm column. Preparative high performance liquid chromatography was performed using a Waters 600 E pump with Fraction Lynx collection system and the separations were done using a terra RP18 19 x 150 mm column. A CEM Discover–Explorer microwave system (www.cem.com) was employed for microwave promoted dimerizations.

(5R)-Methyl-(6S)-methoxy-7-hydroxy-3-heptenoate (6a): $[\alpha]_D^{20} +28.8^\circ$ (c 0.96, CH₂Cl₂); IR $\nu_{\max}$ 3436, 2955, 2881, 1734, 1437, 1169, 975 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 5.54-5.41 (2H, m), 3.60 (3H, s), 3.57 (1H, dd, J = 3.3 Hz, ovrlp), 3.45 (1H, dd, J = 6.3 Hz, 11.9 Hz), 3.36 (3H, s), 3.00-2.96 (3H, m), 2.45-2.37 (2H, br), 0.98 (3H, d, J = 6.9 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 172.5, 136.1, 122.0, 85.3, 61.6, 57.9, 51.6, 37.7, 37.4, 15.8; HRMS (CI/NH₃) m/z calculated for C₁₀H₁₈O₄ 202.1205, found 202.1198.

(5R)-Methyl-6-hydroxy-3-hexenoate (6b): $[\alpha]_D^{20} +14.2^\circ$ (c 0.4, CH₂Cl₂); IR $\nu_{\max}$ 3419, 2956, 1734, 1437, 1170, 1034 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 5.57 (1H, m), 5.41 (1H, m), 3.63 (3H, s), 3.43 (1H, dd, J = 5.6 Hz, 10.8 Hz), 3.35 (1H, dd, J = 7.5 Hz, 10.8 Hz), 3.01 (2H, m), 2.32 (1H, m), 2.05 (1H, br), 0.95 (3H, d, J = 6.7 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 172.6, 136.9, 122.9, 66.9, 51.7, 39.4, 37.6, 16.0; HRMS (CI/NH₃) m/z calculated for C₈H₁₄O₃ 158.0943, found 158.0932.

(2S)-Benzoxy-(5S)-methyl-(6S)-methoxy-7-hydroxy-3-heptenoate (6d): $[\alpha]_D^{20} +0.9^\circ$ (c 0.75, CH₂Cl₂); IR $\nu_{\max}$ 3446, 2955, 1748, 1455, 1099 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.31-7.23 (5H, m), 5.79 (1H, dd, J = 7.6 Hz, 15.5 Hz), 5.54 (1H, dd, J = 7 Hz, 15.5 Hz), 4.54 (2H, abq, J = 4.2 Hz), 3.72 (3H, s), 3.60 (1H, dd, J = 2.6 Hz, 13.2 Hz), 3.48 (1H, dd, J = 7.3 Hz, 13.2 Hz), 3.40 (3H, s), 2.49 (1H, m), 2.00 (1H, br), 1.05 (3H, d, J = 6.9 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 171.5, 137.8, 137.2, 128.4, 128.0, 125.0, 85.1, 78.4, 71.1, 61.8, 58.2, 52.1, 37.7, 15.7; HRMS (CI/NH₃) m/z calculated for C₁₇H₂₄O₅ 308.1624, found 309.1678 (M + 1).

(5R)-Methyl-(6R)-methoxy-7-hydroxy-3-heptenoate (6e): $[\alpha]_D^{20} +3.56^\circ$ (c 0.92, CH₂Cl₂); IR $\nu_{\max}$ 3448, 2953, 2880, 1738, 1437, 1169, 974 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 5.53 (2H, m), 3.63 (3H, s), 3.58 (1H, dd, J = 3.9 Hz, 11.8 Hz), 3.50 (1H, dd, J = 6.6 Hz, 11.8 Hz), 3.38 (3H, s), 3.10 (1H, m), 3.01 (2H, d, J = 5.3 Hz), 2.48 (1H, m), 2.19 (1H, m), 0.97 (3H, d, J = 7.0 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 172.5, 136.1, 122.2, 85.2, 61.8, 58.2, 51.7, 37.7, 37.4, 15.2; HRMS (CI/NH₃) m/z calculated for C₁₀H₁₈O₄ 202.1205, found 203.1258 (M + 1).

(5R)-Methyl-(6S)-N-tosylsulfonamide-7-hydroxy-3-heptenoate (6f): $[\alpha]_D^{20} +28.4^\circ$ (c 0.8, CH₂Cl₂); IR $\nu_{\max}$ 3510, 3288, 2955, 1733, 1437, 1326, 1158, 736 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.71 (2H, d, J = 7.9 Hz), 7.23 (2H, d, J = 7.9 Hz), 5.49 (1H, d, J = 8.9 Hz), 5.46-5.37 (1H, m), 5.28-5.22 (1H, m), 3.62 (3H, s), 3.52 (1H, br), 3.41 (1H, br), 3.07 (1H, m), 2.90 (3H, m), 2.36 (3H, s), 2.69 (1H, m), 0.68 (3H, d, J = 6.9 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 172.7, 143.3, 137.8, 135.9, 129.6, 127.0, 123.1, 62.0, 59.2, 51.8, 38.6, 37.2, 21.2, 16.3; HRMS (CI/NH₃) m/z calculated for C₁₆H₂₃NO₅S 341.1297, found 342.1336 (M + 1).

(5S)-Methyl-(6R)-methoxy-7-hydroxy-3-heptenoate (6g): $[\alpha]_D^{20} +28.3^\circ$ (c 1.7, CH₂Cl₂); IR $\nu_{\max}$ 3445, 2953, 1739, 1437, 1165, 1078, 1014 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 5.38 (1H, dd, J = 6.9 Hz, 0.4 Hz), 3.64 (3H, s),

3.59 (1H, dd, $J = 4.3$ Hz, 11.9 Hz), 3.46 (1H, dd, $J = 4.9$ Hz, 11.9 Hz), 3.41 (3H, s), 3.09-2.95 (3H, m), 2.32 (2H, m), 1.56 (3H, s), 1.07 (3H, d, $J = 6.9$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 172.8, 141.1, 117.3, 84.3, 62.3, 58.4, 51.8, 45.0, 32.8, 15.6, 13.4; HRMS (CI/ NH_3) m/z calculated for $\text{C}_{11}\text{H}_{20}\text{O}_4$ 216.1362, found 217.1428 ($M + 1$).

(5R)-Methyl-(6R)-methoxy-7-hydroxy-3-heptenoate (6h): $[\alpha]_{\text{D}}^{20} +4.3^\circ$ (c 0.53, CH_2Cl_2); IR ν_{max} 3445, 2935, 1739, 1437, 1165, 1078, 1014 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3) δ 5.37 (1H, dd, $J = 7.2$ Hz, 2.7 Hz), 3.65 (1H, dd, ovrlp), 3.63 (3H, s), 3.47 (1H, dd, $J = 5.6$ Hz, 11.6 Hz), 3.34 (3H, s), 3.19 (1H, m), 3.02 (2H, d, $J = 7.2$ Hz), 2.46 (1H, m), 2.33 (1H, br), 1.60 (3H, s), 0.95 (3H, d, $J = 7$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 172.8, 140.7, 117.0, 83.5, 61.3, 57.8, 51.7, 42.9, 33.2, 14.5, 14.4; HRMS (CI/ NH_3) m/z calculated for $\text{C}_{11}\text{H}_{20}\text{O}_4$ 216.1362, found 216.1388.

6i $[\alpha]_{\text{D}}^{20} -4.44^\circ$ (c 0.45, CHCl_3); IR ν_{max} 3297, 2926, 1741, 1652, 1558, 1540 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3) δ 6.40 (1H, d, $J = 7.2$ Hz), 5.60 (2H, m), 4.57 (1H, m, $J = 7.2$ Hz), 3.70 (4H, ovlp), 3.54 (1H, m), 3.42 (3H, s), 3.07 (1H, dt, $J = 4.0$ Hz, 1.6 Hz), 2.95 (2H, d, $J = 5.2$ Hz), 2.53 (1H, m), 2.21 (1H, t, $J = 6$ Hz), 1.58 (1H, s), 1.36 (3H, d, $J = 7.2$ Hz), 1.06 (3H, d, $J = 6.4$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 173.8, 170.8, 138.0, 122.9, 85.2, 61.4, 57.8, 52.4, 47.9, 39.9, 38.4, 18.3, 16.3; HRMS (CI/ NH_3) m/z calculated for $\text{C}_{20}\text{H}_{32}\text{O}_6$ 273.1576, found ($M+1$) 274.1650.

General experimental procedure for the distannoxane-catalyzed cyclodimerization of hydroxyesters illustrated for **6a** (90 mg, 0.44 mmol): **(6R, 14R)-Dimethyl-(7S, 15S)-dimethoxy-1, 9-dioxacyclohexadeca-(4E, 12E)-diene-2, 10-dione (7a).** To hydroxyester **6a** (90 mg, 0.44 mmol) in chlorobenzene (44 mL, 0.01 M) was added distannoxane catalyst **A**¹ (24.5 mg, 0.044 mmol). The resulting solution was refluxed until starting material was consumed (monitored by TLC, typically 24 – 96 h). After cooling to rt. the reaction mixture was concentrated *in vacuo*. The crude product was purified by flash chromatography (silica, 40:60 EtOAc/hexanes) to yield 56 mg (0.164 mmol, 75%) of macrodiolide **7a** as a white solid. m.p. = 110-112 °C $[\alpha]_{\text{D}}^{20} -44.9^\circ$ (c 0.8, CH_2Cl_2); IR ν_{max} 1689, 1652, 1540, 1102, 1457, 1050 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3) δ 5.60-5.68 (2H, m), 5.26-5.32 (2H, m), 4.40 (2H, d, $J = 12.2$ Hz), 3.74 (2H, d, $J = 12.2$ Hz), 3.36 (6H, s), 3.18 (2H, dd, $J = 16$ Hz, 4 Hz), 2.94 (2H, d, $J = 9.9$ Hz), 2.84 (2H, dd, $J = 11$ Hz, 14 Hz), 2.53-2.59 (2H, m), 1.09 (3H, d, $J = 6.6$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 170.9, 135.0, 123.5, 82.6, 61.4, 57.4, 39.7, 39.1, 18.0; HRMS (CI/ NH_3) m/z calculated for $\text{C}_{18}\text{H}_{28}\text{O}_6$ 340.1886, found 340.1885.

Microwave assisted reactions were carried out with hydroxyester **6a** (10 mg, 0.048 mmol) and 2.7 mg catalyst **B** (0.0048 mmol) in 2.4 mL chlorobenzene (0.02 M) using a standard microwave reaction vessel (CEM Corp.). The mixture was irradiated for 7 minutes at 200°C (300W). The cooled reaction was concentrated *in vacuo* and the crude product was purified by flash chromatography (silica, 40:60 EtOAc/Hexanes) to give 4.8 mg (0.014 mmol 60%) of macrodiolide **7a**.

¹ Otera, J.; Dan-oh, N.; Nozaki, H. *J. Org. Chem.* **1991**, *56*, 5307.

7b

(6*S*, 13*S*)-Dimethyl-1, 8-dioxacyclotetradeca-(4*E*, 11*E*)-2, 9-dione (7b) was prepared according to the general procedure from hydroxyl ester **6b** (30 mg, 0.19 mmol) and distannoxane catalyst A (10.55 mg, 0.019 mmol) in chlorobenzene (19 mL). Flash chromatography (silica, 45:55 EtOAc/hexanes) yielded 19 mg (0.075 mmol, 80%) of macrodiolide **7b** as a colorless solid. m.p. = 63-65 ° C; $[\alpha]_D^{20}$ -49.2° (c 0.13, CH₂Cl₂); IR ν_{max} 3853.1, 1730.9, 1652.8, 1558.7, 1457.1, 1258.6 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 5.53-5.45 (2H, m), 5.30-5.24 (2H, m), 4.02 (2H, dd, *J* = 4 Hz, 11 Hz), 3.837 (2H, dd, *J* = 11 Hz, 10 Hz), 3.30-2.91 (4H, m), 2.52-2.49 (2H, m), 0.95 (6H, d, *J* = 7 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 171.4, 136.2, 123.5, 67.7, 39.6, 36.9, 16.8; HRMS (CI/NH₃) *m/z* calculated for C₁₄H₂₀O₄ 252.1362, found (M+1) 253.1417.

7c

(6*S*, 14*S*)-Dimethyl-(7*R*, 15*R*)-dibenzoxy-1, 9-dioxacyclohexadeca-(4*E*, 12*E*)-diene-2, 10-dione (7c) was prepared according to the general procedure from hydroxyester **6c**² (20 mg, 0.068 mmol) and distannoxane catalyst A (4 mg 0.0068 mmol) in chlorobenzene (6.8 mL). Flash chromatography (silica, 50:50 EtOAc/hexanes) yielded 11.3 mg (0.022 mmol, 68%) of macrodiolide **7c** as a yellow oil. $[\alpha]_D^{20}$ +69.0° (c 0.375, CH₂Cl₂); IR ν_{max} 3468.1, 1736.2, 1651.7, 1558.6, 1455.3, 1258.1, 1102.5, 1051.7, 977.36 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.32-7.25 (10H, m), 5.69-5.62 (2H, m), 5.32-5.25 (2H, m), 4.64 (2H, d, *J* = 12 Hz), 4.47 (2H, d, *J* = 12.2Hz), 4.39 (2H, d, *J* = 12.2 Hz), 3.75 (2H, dd, *J* = 11 Hz, 14 Hz), 3.18 (4H, d, *J* = 11 Hz), 2.83 (2H, dd, *J* = 11 Hz, 14 Hz), 2.68-2.62 (2H, m), 1.08 (6H, d, *J* = 6.6 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 171.4, 137.9, 135.4, 128.6, 128.3, 128.0, 123.9, 80.6, 71.9, 62.3, 40.2, 39.5, 18.6; HRMS (CI/NH₃) *m/z* calculated for C₃₀H₃₆O₆ 492.2512, found 493.2591 (M+1).

7d

(6*S*, 14*S*)-Dimethyl-(7*R*, 15*R*)-dimethoxy-(3*S*, 11*S*)-benzoxy-1, 9-dioxacyclohexadeca-4*E*, 12*E*-diene-2, 10-dione (7d) was prepared according to the general procedure from hydroxyester **6d** (80 mg, 0.259 mmol) and distannoxane catalyst A (14 mg, 0.0259 mmol) in chlorobenzene (25.9 mL). Flash chromatography (silica, 60:40 EtOAc/hexanes) afforded 60 mg (0.11 mmol, 84%) of macrodiolide **7d** as a colorless oil. $[\alpha]_D^{20}$ +48.3 (c 0.6 CH₂Cl₂); IR ν_{max} 1496.9, 1456.3, 1251.0, 1111.3, 1027.6, 975.8 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ 7.34-7.27 (8H, m), 5.64-5.52 (4H, m), 4.46 (4H, abq, *J* = 12 Hz), 4.33 (2H, d, *J* = 7.6 Hz), 4.27 (2H, dd, 2.6 Hz, *J* = 12.2 Hz), 3.85 (2H, dd, *J* = 1.7 Hz, 12.2 Hz), 3.36 (6H, s), 2.98 (2H, m), 2.70-2.64 (2H, m), 1.12 (6H, d, *J* = 6.6 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 171.3, 138.3, 137.3, 128.6, 128.1, 127.0, 82.4, 81.0, 71.5, 62.1, 57.5, 39.7, 17.7; HRMS (CI/NH₃) *m/z* calculated for C₃₂H₄₀O₈ 552.2797, found 553.2807 (M+1).

² Zhu, B; Panek, J. S. *Org. Lett.* **2000**, 2, 2575.

(6*R*, 14*R*)-Dimethyl-(7*R*, 15*R*)-dimethoxy-1, 9-dioxacyclohexadeca-(4*E*, 12*E*)-diene-2, 10-dione (7e**)** was prepared according to the general procedure from hydroxyester **6e** (20 mg, 0.099 mmol) and distannoxane catalyst **A** (5.5 mg 0.0099 mmol) in chlorobenzene (9.9 mL). Flash chromatography (silica, 45:55 EtOAc/hexanes) yielded 7.6 mg (0.022 mmol, 45%) of macrodiolide **7e** as a colorless solid. m.p. = 111-114 °C; $[\alpha]_D^{20}$ -28.0° (c 0.5, CH₂Cl₂); IR ν_{max} 3853.1, 1733.7, 1652, 1506, 1269, 1103 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 5.55-5.51 (4H, m), 4.33 (2H, dd, *J* = 5 Hz, 11 Hz), 3.56 (2H, dd, *J* = 10 Hz, 10 Hz), 3.39 (6H, s), 3.30-3.34 (2H, m), 3.05 (2H, dd, *J* = 3 Hz, 13 Hz), 2.91 (2H, dd, *J* = 2 Hz, 6 Hz), 2.56-2.52 (2H, m), 1.07 (6H, d, *J* = 8 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 171.1, 134.3, 123.9, 362.8, 59.1, 39.5, 39.2, 16.9; HRMS(CI/NH₃) *m/z* calculated for C₁₈H₂₈O₆ 340.1886, Found 340.1889.

(6*S*, 14*S*)-Dimethyl-(7*R*, 15*R*)-di(N-tosylsulfonamide)-1, 9-dioxacyclohexadeca-(4*E*, 12*E*)-diene-2, 10-dione (7f**)** was prepared according to the general procedure from hydroxyester **6f** (30 mg, 0.088 mmol) and distannoxane catalyst **A** (4.8 mg, 0.0088 mmol) in chlorobenzene (8.8 mL). Flash chromatography (silica, 60:40 EtOAc/hexanes) yielded 15.5 mg (0.025 mmol, 58%) of macrodiolide **7f** as a yellow solid. m.p. = 115-117° C; $[\alpha]_D^{20}$ +61.6° (c 0.125, CH₂Cl₂); IR ν_{max} 3853.1, 3277.9, 2923.6, 1740.5, 1684.1, 1652.8, 1456.8, 1327.9, 1259.5, 1159.4, 1092.1 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 7.70 (4H, d, *J* = 8 Hz), 7.26 (4H, d, *J* = 8 Hz), 5.42-5.49 (2H, m), 5.22-5.29 (2H, m), 4.85 (2H, d, *J* = 9 Hz), 3.78 (2H, dd, *J* = 12 Hz, 1.4 Hz), 3.66 (2H, *J* = 2 Hz, 12 Hz), 3.13 (2H, dd, *J* = 10 Hz, 9 Hz), 3.01 (2H, dd, *J* = 3 Hz, 13 Hz), 2.77 (2H, dd, *J* = 10 Hz, 13 Hz), 2.395 (6H, s), 2.35-2.29 (2H, m), 0.98 (6H, d, *J* = 6.6 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 170.4, 143.9, 137.9, 135.6, 130.0, 127.1, 123.9, 65.3, 57.0, 40.6, 39.2, 21.7, 18.5; HRMS (CI/NH₃) *m/z* calculated for C₃₀H₃₈O₈N₂S₂ 618.2070, found 618.2104.

(6*S*, 14*S*)-Dimethyl-(7*R*, 15*R*)-dimethoxy-(5, 13)-dimethyl-1, 9-dioxacyclohexadeca-(4*E*, 12*E*)-diene-(2, 10)-dione (7g**)** was prepared according to the general procedure from hydroxy ester **6g** (20 mg 0.092 mmol) and distannoxane catalyst **A** (5.2 mg, 0.0092 mmol) in chlorobenzene (9.3 mL). Flash chromatography (silica, 45:55 EtOAc/hexanes) yielded 11 mg (0.030 mmol, 65%) of macrodiolide **7g** as a colorless solid. m.p. = 103-105 °C; $[\alpha]_D^{20}$ +106.6° (c 0.75, CH₂Cl₂); IR ν_{max} 2963.15, 1727.6, 1460.7, 1307.5, 1251.7, 1217.1, 1142.9, 1109.6, 1073.1 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 5.49 (2H, dd, *J* = 5 Hz, 11 Hz), 4.40 (2H, dd, *J* = 3 Hz, 12 Hz), 3.60 (2H, d, *J* = 13 Hz), 3.37 (6H, s), 3.07 (4H, dd, *J* = 10 Hz, 14 Hz), 2.99 (2H, dd, *J* = 5 Hz, 14 Hz), 2.665-2.623 (2H, m), 1.572 (6H, s); 1.11 (3H, d, *J* = 7.2 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 171.5, 139.4, 119.3, 81.6, 61.2, 57.9, 45.3, 34.8, 16.1, 11.7; HRMS(CI/NH₃) *m/z* calculated for C₂₀H₃₂O₆ 368.2199, found 369.2297.

(6*S*, 14*S*)-Dimethyl-(7*S*, 15*S*)-dimethoxy-(5, 13)-dimethyl-1,9-dioxacyclohexadeca-(4*E*, 12*E*)-diene-(2, 10)-dione (7h**)** was prepared according to the general procedure from the hydroxyl ester **6h** (10 mg, 0.046 mmol) and distannoxane catalyst A (2.6 mg, 0.0046 mmol) in chlorobenzene (4.6 mL). Flash chromatography (silica, 45:55 EtOAc/hexanes) yielded 4 mg (0.01 mmol, 48%) of macrodiolide **7h** as a colorless oil. $[\alpha]_D^{20}$ -12° (c 0.2, CH₂Cl₂); IR $\nu_{\max}$ 2931.4, 2823.9, 1739.7, 1458.4, 1260.5, 1122.1, 1081.9, 1046.2, 1012.9 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ 5.34 (2H, m), 4.27 (2H, dd, J = 4.3 Hz, 10.9 Hz), 3.52 (2H, dd, J = 10.5 Hz, 1 Hz), 3.37 (6H, s), 3.31 (2H, m), 3.09 (2H, dd, J = 9.6 Hz, 14.8 Hz), 2.92 (2H, J = 5.3 Hz, 14.8 Hz), 2.54 (2H, m), 1.64 (6H, s), 1.10 (6H, d, J = 7.3 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 171.4, 139.5, 118.6, 81.6, 62.2, 58.9, 43.9, 34.4, 14.2, 14.0; HRMS (CI/NH₃) m/z calculated for C₂₀H₃₂O₆ 368.2199, found 368.2225.

10,21-Dimethoxy-3,9,14,20-tetramethyl-1,12-dioxa-4,15-diazacyclodocosa-7,18-diene-2,5,13,16-tetraone (7i**)** was prepared according to the general procedure using 15 mg (0.05 mmol) hydroxyester **6i** and 3 mg (0.005 mmol) of distannoxane catalyst A. The reaction was maintained for 24 h at reflux in chlorobenzene. Flash chromatography (silica, 95:5 EtOAc/MeOH) yielded 8 mg (0.016 mmol, 66%) of macrodiolide **7i** as a white amorphous solid. m.p. = 179-182°C; $[\alpha]_D^{20}$ $+57.8^\circ$ (c 0.13, CH₂Cl₂); IR $\nu_{\max}$ 3312, 2932, 1734, 1683, 1652, 1558, 1540, 1456 1161 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 6.34 (2H, d, J = 7.2 Hz), 5.55 (4H, m), 4.57 (2H, m), 4.35 (2H, dd, J = 2.8 Hz, 9.2 Hz), 4.01 (2H, dd, J = 6.4 Hz, 5.6 Hz), 3.42 (6H, s), 3.13 (2H, dt, J = 2.8 Hz, 5.6 Hz), 3.01-2.88 (8H, m), 2.44 (2H, q, J = 7.6 Hz), 1.39 (6H, d, J = 7.2 Hz), 1.07 (6H, d, J = 6.8 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 174.9, 139.3, 126.0, 84.6, 67.4, 60.3, 50.0, 42.4, 41.1, 20.1, 18.5; HRMS (CI/NH₃) m/z calculated for C₂₀H₃₂O₆ 482.2628, found 483.2672 (M+1).

(6*R*, 14*S*)-Dimethyl-7*S*-methoxy-1,9-dioxacyclopentadeca-(4*E*, 12*E*)-diene-2, 10-dione (8a**)** was prepared according to the general procedure from hydroxyester **6b** (8.7 mg, 0.055 mmol), hydroxy ester **6a** (11 mg, 0.055 mmol) and distannoxane catalyst A (6.1 mg, 0.011 mmol) in chlorobenzene (5.5 mL). Preparative HPLC (gradient 75:25 H₂O/CH₃CN to 40/60 H₂O/CH₃CN in 10 minutes) yielded 5.4 mg (0.018 mmol, 33%, retention time: 13.22 minutes) of macrodiolide **8a** as a colorless oil, 2.3 mg (0.007 mmol, 25%, retention time: 11.72 minutes) of dimer **7a** and 1.4 mg (0.005 mmol, 20%, retention time: 14.12 minutes) of dimer **7b**. $[\alpha]_D^{20}$ $+61.66^\circ$ (c 0.6, CH₂Cl₂); IR $\nu_{\max}$ 2960.4 1735.3, 1459.6, 1370.3, 1256.7, 1153.8, 1106.9, 1052.6, 1016.7 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 5.69-5.56 (2H, m), 5.41-5.35 (1H, dd, J = 15.4 Hz, 8.4 Hz), 5.28-5.22 (1H, dd, J = 9 Hz, 15.0 Hz), 5.39 (1H, dd, J = 1.8 Hz, 12.1 Hz), 3.90-3.81 (3H, m), 3.37 (3H, s), 3.10-3.05 (2H, m), 2.97-2.86 (3H, m), 2.51 (1H, m), 1.08 (3H, d, J = 6.6 Hz), 0.98 (H, d, J = 7 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 171.9, 171.0, 137.0, 134.0, 124.3, 123.1, 83.0, 68.1, 62.2, 57.8, 40.2, 38.9, 38.3, 36.6, 18.7, 16.8; HRMS (CI/NH₃) calculated m/z for C₁₆H₂₄O₅ 296.1624, found 296.1636.

9a

(*6S*, *14S*)-Dimethyl-(*7R*, *15S*)-dimethoxy-(*5*, *13*)-dimethyl-1, 9-dioxacyclohexadeca-(*4E*, *12E*)-diene-(*2*, *10*)-dione (**9a**) was prepared according to the general procedure from hydroxyester **6g** : **6h** (1 ; 1) (18 mg, 0.083 mmol) and distannoxane catalyst A (5.1 mg 0.0083 mmol) in chlorobenzene (8.3 mL). Flash chromatography (silica, 40:60 EtOAc/hexanes) yielded 3.8 mg (0.01 mmol, 25%) of macrodiolide **9a** as a colorless oil, 2 mg (0.005 mmol, 25%) of dimer **7g** and 1.5 mg (0.004 mmol, 20%) of dimer **7h**. $[\alpha]_D^{20} +50.9^\circ$ (c 0.65, CH_2Cl_2); IR ν_{max} 2962.5, 1732.7, 1651.9, 1458.64, 1256.6, 1107.4, 1078.8, 1044.9, 1018.5 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3): δ 5.45 (1H, dd, $J = 1.3$ Hz, 5 Hz), 5.35 (1H, dd, $J = 4$ Hz, 5 Hz), 4.40 (1H, $J = 3$ Hz, 8 Hz), 4.25 (1H, dd, $J = 4$ Hz, 11 Hz), 3.61 (1H, dd, $J = 1.3$ Hz, 12.2 Hz), 3.48 (1H, dd, $J = 10.2$ Hz, 10.2 Hz), 3.37 (3H, s), 3.36 (3H, s), 3.33-3.29 (1H, m), 3.14-3.07 (2H, m), 3.03 (1H, dd, $J = 2$ Hz, 6 Hz), 2.89 (1H, dd, $J = 1$ Hz, 5 Hz), 2.65-2.60 (1H, m), 2.55-2.15 (1H, m), 1.63 (3H, s), 1.572 (3H, s), 1.12 (3H, d, $J = 3$ Hz), 1.10 (3H, d, $J = 2.6$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 171.8, 171.0, 139.6, 139.3, 119.18, 119.13, 82.03, 81.7, 62.39, 60.9, 59.4, 57.8, 45.4, 57.8, 45.4, 44.5, 34.8, 16.1, 15.0, 13.9, 11.8; HRMS (CI/ NH_3) m/z calculated for $\text{C}_{20}\text{H}_{32}\text{O}_6$ 368.2199, found 368.2216.

10a

10b

Bisepoxides 10a and 10b. To a solution of macrodiolide **7a** (30 mg, 0.0867 mmol) in CCl_4 (1 mL) was added 131.6 mg (4.4 equiv, 50%) *m*-CPBA and the reaction was stirred for 4 h. The reaction was quenched by addition of solution of saturated sodium bicarbonate and sodium thiosulfate. The solution was extracted with CH_2Cl_2 (3 x 10 mL), dried over MgSO_4 , filtered, concentrated *in vacuo*. The crude product was purified using silica gel chromatography (45:55 EtOAc: hexanes) to afford 20 mg (0.053 mmol, 62%) of bisepoxide **10a** as a white solid and 7.8 mg (0.021 mmol, 24%) of heterodimer **10b** as colorless oil. Bisepoxide **10a**: m.p. = 168-171 $^\circ\text{C}$; $[\alpha]_D^{20} -14.6^\circ$ (c 0.35, CH_2Cl_2); IR ν_{max} 3458.2, 2966.3, 1734.5, 1558.9, 1461.4, 1257.1, 1182.0, 1151.1, 1097.1, 1052.6, 1034.3 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3) δ 4.68 (2H, dd, $J = 3$ Hz, 13 Hz), 3.82 (2H, d, $J = 12$ Hz), 3.37 (6H, s), 3.16-3.02 (6H, m), 2.60 (2H, d, $J = 9.2$ Hz), 1.98 (2H, dd, $J = 10$ Hz, 13 Hz), 1.58-1.53 (2H, m), 1.16 (6H, d, $J = 6.9$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 169.7, 81.2, 61.5, 60.6, 58.0, 55.6, 38.8, 38.5, 14.2. HRMS (CI/ NH_3) m/z calculated for $\text{C}_{18}\text{H}_{28}\text{O}_8$ 372.1784, found 373.1853. Bisepoxide **10b**: $[\alpha]_D^{20} -33.1^\circ$ (c 0.35, CH_2Cl_2); IR ν_{max} 2930.6, 1737.8, 1463.4, 1259.0, 1182.5, 1098.5 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3) δ 4.47 (1H, dd, $J = 2.8$ Hz, 11.6 Hz), 4.32 (1H, dd, $J = 2$ Hz, 12 Hz), 4.23 (1H, dd, $J = 4.8$ Hz, 12 Hz), 3.93 (1H, dd, $J = 11.6$ Hz, 11.6 Hz), 3.42 (3H, s), 3.41 (3H, s), 3.19-3.13 (3H, m), 2.97 (1H, m), 2.79-2.67 (4H, m), 2.57 (1H, dd, $J = 5.2$ Hz, 14.4 Hz), 2.31 (1H, dd, $J = 6.4$ Hz, 13.6 Hz), 1.67-1.57 (2H, m), 1.07 (3H, d, $J = 6.8$ Hz), 1.04 (3H, d, $J = 7.2$ Hz); ^{13}C NMR (75 MHz, CDCl_3) δ 170.1, 169.7, 82.0, 80.3, 62.9, 61.1, 60.3, 60.1, 59.5, 58.1, 57.8, 55.1, 52.2, 39.1, 38.5, 37.5, 36.7, 13.4, 11.1; HRMS (CI/ NH_3) m/z calculated for $\text{C}_{18}\text{H}_{28}\text{O}_8$ 372.1854, found 373.1873 ($M + 1$).

11

Bisepoxide (11). To a solution of macrodiolide **7g** (10 mg 0.027 mmol) in CH_2Cl_2 (1 mL) was added 40.8 mg (4.4 eq, 50%) *m*-CPBA, and the reaction was stirred at rt for 4 h. The reaction was quenched by addition of a mixture of saturated sodium bicarbonate and sodium thiosulfate. The solution was extracted with CH_2Cl_2 (3 x 10 mL), dried over MgSO_4 filtered

and concentrated in vacuo. The crude product was purified using silica gel chromatography (50:50 EtOAc: hexanes) to afford 10 mg (0.025 mmol, 92%) of bisepoxide **11** as a white solid. mp= 162-165 ° C; $[\alpha]_D^{20} +34.3^\circ$ (c 0.65, CH₂Cl₂); IR v_{max} 3448.5, 1733.5, 1689.2, 1651.5, 1558.4, 1458.4, 1237.8, 1168.6, 1110.6 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ 4.68 (2H, dd, *J* = 2.7 Hz, 12.2 Hz), 3.74 (2H, d, *J* = 12.2 Hz), 3.36 (6H, s), 3.09- 3.02 (6H, m), 2.22-2.17 (2H, m), 1.56-1.51 (4H, m), 1.25 (6H, s), 1.16 (6H, d, *J* = 6.6 Hz); ¹³C NMR (75MHz, CDCl₃) δ 169.4, 80.6, 61.5, 60.5, 60.2, 57.4, 42.9, 35.1, 12.0, 11.8; HRMS (CI/NH₃) *m/z* calculated for C₂₀H₃₂O₈ 400.2097, found 401.2181 (M+1).

(6R, 14R)-Dimethyl-(7S, 15S)-dimethoxy-(5R, 13R)-dihydroxy-1, 9-dioxacyclohexadeca-(3E, 11E)-diene-2, 10-dione (12). To a solution of bisepoxide **10a** (20 mg, 0.053 mmol) dissolved in 2 mL THF was added DBU (16 μL, 0.11 mmol) at rt and the reaction was monitored by TLC until reaction reached completion (approximately 1.5 h). The reaction was diluted by addition of distilled water and was extracted with CH₂Cl₂ (3 x 10 mL), dried over MgSO₄, filtered and concentrated *in vacuo*. The crude product was purified using silica gel chromatography (60:40 EtOAc:hexanes) to afford 18 mg (0.0477 mmol, 90%) of **12** as a yellow oil. $[\alpha]_D^{20} -9.7^\circ$ (c 0.7, CH₂Cl₂); IR v_{max} 3428.8, 2993.0, 1646.6, 1462.1, 1386.8, 1342.4, 1278.8, 1168.9, 1147.4, 1105.4, 1068.9, 1017.9 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ 7.00 (2H, dd, *J* = 5 Hz, 15 Hz), 6.05 (2H, dd, *J* = 1.3 Hz, 15 Hz), 4.64 (2H, dd, *J* = 2 Hz, 11 Hz), 4.021 (2H, b), 3.76 (2H, dd, *J* = 2 Hz, 11 Hz), 3.428 (6H, s), 3.09-3.06 (2H, m), 2.45 (2H, b), 1.96-1.95 (2H, m), 1.07 (6H, d, *J* = 6.9 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 165.4, 149.7, 121.8, 78.9, 73.2, 61.5, 58.5, 43.4, 10.9, HRMS (CI/NH₃) *m/z* calculated for C₁₈H₂₈O₈ 372.1784, found 373.1830.

(6R, 14R)-Dimethyl-(7S, 15S)-methoxy-(5R, 13R)-hydroxyl-(5R, 13R)-methyl-1, 9-dioxacyclohexadeca-(3E, 11E)-diene-2, 10-dione (13). To a solution of bisepoxide **11** (15 mg, 0.037 mmol) dissolved in THF (1.5 mL) was added DBU (19 μL, 0.12 mmol) at rt., and the reaction was monitored by TLC until reaction went to completion (approximate 1.5 h). The reaction was quenched by addition of distilled water and was extracted with CH₂Cl₂ (3 x 10 mL), dried over MgSO₄, filtered and concentrated *in vacuo*. The crude product was purified using silica gel chromatography (50:50 hexanes:EtOAc) to afford 14 mg (0.032 mmol, 91%) of **13** as yellow oil. $[\alpha]_D^{20} +7.7^\circ$ (c 0.4, CH₂Cl₂); IR v_{max} 3449.6, 2980.7, 1718.1, 1650.9, 1558.7, 1457.0, 1380.8, 1279.4, 1132.1, 1061.0, 1025.3 cm⁻¹; ¹H NMR (400 MHz, CDCl₃): δ 6.97 (2H, d, *J* = 15.8 Hz), 6.03 (2H, d, *J* = 10 Hz), 4.57 (2H, d, *J* = 11 Hz), 3.65 (2H, dd, *J* = 11 Hz, 10 Hz), 3.39 (6H, s), 3.13 (2H, d, *J* = 9.5 Hz), 1.92-1.89 (2H, m), 1.27 (6H, s), 1.03 (6H, d, *J* = 7 Hz); ¹³C NMR (75 MHz, CDCl₃) δ 165.9, 154.8, 122.2, 78.1, 74.5, 60.6, 57.8, 45.4, 22.7, 7.1; HRMS (CI/NH₃) *m/z* calculated for C₂₀H₃₂O₈ 400.2097, found 401.2158.

Selected NMR spectra

^1H NMR (400 MHz, CDCl_3)

Crude mixture of reaction:

^1H NMR (400 MHz, CDCl_3)

1

1

¹H NMR (400 MHz, CDCl₃)

¹³C NMR (75MHz, CDCl₃)

¹H NMR (400 MHz, CDCl₃)

Chemical structure of **12** is shown above the spectrum. The structure is a 10-membered ring with two methoxy groups (OMe) and two methyl groups (Me). The ring is substituted with a carbonyl group (C=O) and a methoxy group (OMe) at the 1-position, and a carbonyl group (C=O) and a methoxy group (OMe) at the 4-position. The methyl groups are at the 2 and 5 positions.

Peak (ppm)	Integration
7.260	1.00
6.078	0.36
4.659	1.32
4.210	1.02
3.782	1.11
3.014	0.97
2.022	0.03
1.583	1.06
1.227	8.32
1.004	
0.868

12

LC/MS/ELS data for Table 2 (entry 1)

LC/MS/ELS data for Table 2 (entry 3)

LC/MS/ELS data for Table 2 (entry 5)

LC/MS/ELS data for Table 2 (entry 6)

LC/MS/ELS data for Table 2 (entry 7)

X-ray Crystal Structure of Compound **7a**

Crystals of **7a** suitable for x-ray analysis were obtained by slow evaporation from hexanes / methylene chloride. The structure was solved and refined (R-factor = 3.65%). Crystallographic data have been deposited with the Cambridge Crystallographic Data Centre (CCDC 202599).

Table 1. Crystal data and structure refinement for **7a**

Identification code	7a	
Empirical formula	C ₁₈ H ₂₈ O ₆	
Formula weight	340.40	
Temperature	173(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P2 (1)	
Unit cell dimensions	a = 9.3989(9) Å	α = 90°.
	b = 10.2639(10) Å	β = 102.618(2)°.
	c = 10.2739(10) Å	γ = 90°.
Volume	967.18(16) Å ³	
Z	2	
Density (calculated)	1.169 Mg/m ³	
Absorption coefficient	0.087 mm ⁻¹	
F(000)	368	
Crystal size	0.60 x 0.20 x 0.10 mm ³	
Theta range for data collection	2.66 to 28.28°.	
Index ranges	-12 ≤ h ≤ 12, -13 ≤ k ≤ 11, -13 ≤ l ≤ 13	
Reflections collected	8515	
Independent reflections	4182 [R(int) = 0.0281]	
Completeness to theta = 28.28°	99.3 %	
Absorption correction	SADABS	
Max. and min. transmission	0.9914 and 0.8496	
Refinement method	Full-matrix least-squares on F ²	
Data / restraints / parameters	4182 / 1 / 329	
Goodness-of-fit on F ²	0.986	
Final R indices [I > 2σ(I)]	R ₁ = 0.0365, wR ₂ = 0.0807	
R indices (all data)	R ₁ = 0.0509, wR ₂ = 0.0869	
Absolute structure parameter	-1.5(7)	
Largest diff. peak and hole	0.129 and -0.165 e.Å ⁻³	

Table 2. Atomic coordinates ($\times 10^4$) and equivalent isotropic displacement parameters ($\text{\AA}^2 \times 10^3$)

for **7a**. $U(\text{eq})$ is defined as one third of the trace of the orthogonalized U_{ij} tensor.

	x	y	z	$U(\text{eq})$
O(1)	5874(1)	8818(2)	11579(2)	52(1)
O(2)	7436(1)	9192(1)	6088(1)	44(1)
O(3)	3721(1)	9851(1)	6368(1)	39(1)
O(4)	2586(2)	8066(2)	6878(1)	54(1)
O(5)	995(1)	10272(1)	11855(1)	37(1)
O(6)	4650(1)	10703(1)	11341(1)	36(1)
C(1)	5809(2)	9954(2)	11289(2)	33(1)
C(2)	6960(2)	10710(2)	10803(2)	35(1)
C(3)	6427(2)	11121(2)	9371(2)	33(1)
C(4)	7017(2)	10719(2)	8392(2)	32(1)
C(5)	6543(2)	11126(2)	6960(2)	35(1)
C(6)	6154(2)	9968(2)	6028(2)	37(1)
C(7)	5015(2)	9067(2)	6380(2)	40(1)
C(8)	2598(2)	9217(2)	6711(1)	36(1)
C(9)	1419(2)	10150(2)	6882(2)	37(1)
C(10)	1911(2)	11005(2)	8089(2)	31(1)
C(11)	1352(2)	10942(2)	9158(2)	29(1)
C(12)	1775(2)	11802(2)	10361(2)	29(1)
C(13)	2220(2)	11013(2)	11646(2)	30(1)
C(14)	3412(2)	10022(2)	11648(2)	34(1)
C(15)	7722(2)	11968(2)	6549(2)	46(1)
C(16)	7585(3)	8655(4)	4868(2)	71(1)
C(17)	520(2)	12717(2)	10461(2)	39(1)
C(18)	700(2)	10401(3)	13137(2)	50(1)

X-ray Crystal Structure of Compound **10a**

Crystals of **10a** suitable for x-ray analysis were obtained by slow evaporation from Hexanes / methylene chloride. The structure was solved and refined (R-factor = 4.66%). Crystallographic data have been deposited with the Cambridge Crystallographic Data Centre (CCDC 202600).

Table 1. Crystal data and structure refinement for **10a**.

Identification code	10a	
Empirical formula	C18 H28 O8	
Formula weight	372.40	
Temperature	173(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P2	
Unit cell dimensions	a = 11.4095(8) Å	$\alpha = 90^\circ$.
	b = 5.3468(4) Å	$\beta = 98.1870(10)^\circ$.
	c = 15.4399(11) Å	$\gamma = 90^\circ$.
Volume	932.30(12) Å ³	
Z	2	
Density (calculated)	1.327 Mg/m ³	
Absorption coefficient	0.104 mm ⁻¹	
F(000)	400	
Crystal size	0.40 x 0.20 x 0.05 mm ³	
Theta range for data collection	1.33 to 32.46°.	
Index ranges	-17 ≤ h ≤ 16, -7 ≤ k ≤ 8, -22 ≤ l ≤ 23	
Reflections collected	9211	
Independent reflections	5673 [R(int) = 0.0256]	
Completeness to theta = 32.46°	92.6 %	
Absorption correction	SADABS	
Max. and min. transmission	0.9948 and 0.831397	
Refinement method	Full-matrix least-squares on F ²	
Data / restraints / parameters	5673 / 1 / 336	
Goodness-of-fit on F ²	1.034	
Final R indices [I > 2σ(I)]	R1 = 0.0461, wR2 = 0.1094	
R indices (all data)	R1 = 0.0572, wR2 = 0.1198	
Absolute structure parameter	0.8(7)	
Largest diff. peak and hole	0.577 and -0.312 e.Å ⁻³	

Table 2. Atomic coordinates ($\times 10^4$) and equivalent isotropic displacement parameters ($\text{\AA}^2 \times 10^3$)

for **10a**. $U(\text{eq})$ is defined as one third of the trace of the orthogonalized U_{ij} tensor.

	x	y	z	$U(\text{eq})$
O(1)	-1733(1)	8655(2)	2321(1)	23(1)
O(2)	-2154(1)	4121(2)	-430(1)	26(1)
O(3)	-4346(1)	10349(2)	-962(1)	28(1)
O(4)	-5874(1)	7739(2)	-1331(1)	19(1)
C(1)	-2074(1)	8974(3)	1400(1)	19(1)
C(2)	-1792(1)	6508(3)	967(1)	20(1)
C(3)	-2210(1)	6537(3)	-10(1)	20(1)
C(4)	-3290(1)	5296(3)	-421(1)	18(1)
C(5)	-3932(1)	6089(3)	-1304(1)	20(1)
C(6)	-4716(1)	8302(3)	-1190(1)	18(1)
C(7)	-6647(1)	9813(3)	-1181(1)	21(1)
C(8)	-1536(2)	10947(4)	2784(1)	34(1)
C(9)	-462(2)	5981(4)	1134(1)	29(1)
O(1')	2206(1)	18743(3)	2836(1)	34(1)
O(2')	2281(1)	14096(3)	5525(1)	31(1)
O(3')	4642(2)	20407(3)	6892(1)	48(1)
O(4')	5545(1)	17984(3)	6015(1)	37(1)
C(1')	2364(1)	19065(3)	3759(1)	23(1)
C(2')	2028(1)	16571(3)	4144(1)	22(1)
C(3')	2311(1)	16554(3)	5129(1)	22(1)
C(4')	3389(1)	15435(3)	5610(1)	21(1)
C(5')	3874(2)	16282(3)	6526(1)	23(1)
C(6')	4701(1)	18473(3)	6512(1)	22(1)
C(7')	6386(2)	19929(3)	5900(1)	28(1)
C(8')	2062(2)	21009(4)	2353(1)	42(1)
C(9')	708(2)	16017(5)	3881(1)	33(1)

X-ray Crystal Structure of Compound **11**

Crystals of **11** suitable for x-ray analysis were obtained by slow evaporation from hexanes / methylene chloride. The structure was solved and refined (R-factor = 8.14%). Crystallographic data have been deposited with the Cambridge Crystallographic Data Centre (CCDC 202601).

Table 1. Crystal data and structure refinement for **11**

Identification code	11	
Empirical formula	C ₂₀ H ₃₂ O ₈	
Formula weight	400.46	
Temperature	173(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P2(1)	
Unit cell dimensions	a = 5.5780(6) Å	$\alpha = 90^\circ$.
	b = 17.6572(16) Å	$\beta = 90.614(4)^\circ$.
	c = 20.963(2) Å	$\gamma = 90^\circ$.
Volume	2064.6(4) Å ³	
Z	4	
Density (calculated)	1.288 Mg/m ³	
Absorption coefficient	0.099 mm ⁻¹	
F(000)	864	
Crystal size	0.60 x 0.10 x 0.04 mm ³	
Theta range for data collection	0.97 to 23.25°.	
Index ranges	-6 ≤ h ≤ 5, -19 ≤ k ≤ 15, -23 ≤ l ≤ 23	
Reflections collected	8047	
Independent reflections	4272 [R(int) = 0.0650]	
Completeness to theta = 23.25°	99.2 %	
Absorption correction	SADABS	
Max. and min. transmission	0.9961 and 0.269874	
Refinement method	Full-matrix least-squares on F ²	
Data / restraints / parameters	4272 / 1 / 517	
Goodness-of-fit on F ²	1.098	
Final R indices [I > 2σ(I)]	R1 = 0.0814, wR2 = 0.2038	
R indices (all data)	R1 = 0.0981, wR2 = 0.2125	
Absolute structure parameter	-2(2)	
Largest diff. peak and hole	0.371 and -0.367 e.Å ⁻³	

Table 2. Atomic coordinates ($\times 10^4$) and equivalent isotropic displacement parameters ($\text{\AA}^2 \times 10^3$)

for **11**. $U(\text{eq})$ is defined as one third of the trace of the orthogonalized U_{ij} tensor.

	x	y	z	$U(\text{eq})$
O(1)	13585(11)	4424(3)	13781(3)	28(1)
O(2)	8646(10)	5950(3)	15155(3)	31(2)
O(3)	14031(14)	7912(5)	14757(3)	61(2)
O(4)	11619(11)	7604(4)	13939(3)	33(2)
O(5)	11249(11)	9133(3)	13475(3)	34(2)
O(6)	7845(11)	7127(3)	12204(3)	33(2)
O(7)	14652(12)	5550(4)	12577(3)	38(2)
O(8)	12520(11)	5961(4)	13410(3)	34(2)
C(1)	13740(16)	5057(5)	14216(4)	27(2)
C(2)	11374(15)	5085(5)	14552(4)	26(2)
C(3)	11123(15)	5780(5)	14975(4)	27(2)
C(4)	9884(15)	6440(5)	14702(4)	25(2)
C(5)	10276(17)	7266(5)	14942(4)	30(2)
C(6)	12250(17)	7613(6)	14559(4)	34(2)
C(7)	13288(15)	7906(5)	13491(4)	24(2)
C(8)	11940(15)	8520(5)	13076(4)	25(2)
C(9)	9621(15)	8206(4)	12774(4)	22(2)
C(10)	10089(15)	7515(5)	12356(4)	24(2)
C(11)	9526(15)	6756(5)	12625(4)	22(2)
C(12)	10643(16)	6030(5)	12403(4)	32(2)
C(13)	12862(16)	5809(5)	12792(4)	24(2)
C(14)	14431(16)	5756(5)	13853(4)	30(2)
C(15)	15863(17)	4104(6)	13648(5)	40(2)
C(16)	10832(19)	4342(5)	14914(5)	41(3)
C(17)	12856(17)	5834(6)	15538(4)	33(2)
C(18)	13213(17)	9609(6)	13654(4)	37(2)
C(19)	8322(17)	8839(5)	12392(4)	29(2)
C(20)	11773(17)	7592(5)	11796(4)	29(2)
O(1')	11614(11)	589(3)	11710(3)	30(2)
O(2')	8086(10)	2681(3)	12838(2)	26(1)

O(3')	14477(12)	3617(4)	12082(3)	38(2)
O(4')	12088(10)	4415(3)	11532(2)	27(1)
O(5')	13217(11)	5866(3)	10896(3)	33(2)
O(6')	8277(10)	3978(3)	9847(2)	27(1)
O(7')	14158(12)	2607(5)	10490(3)	50(2)
O(8')	11456(10)	2090(3)	11128(3)	30(2)
C(1')	12225(16)	1281(5)	12011(4)	26(2)
C(2')	9982(16)	1576(5)	12343(4)	25(2)
C(3')	10374(16)	2331(5)	12668(4)	28(2)
C(4')	9520(15)	3011(5)	12352(4)	22(2)
C(5')	10485(16)	3799(5)	12447(4)	23(2)
C(6')	12539(16)	3925(5)	12032(4)	25(2)
C(7')	14067(15)	4522(5)	11106(4)	26(2)
C(8')	13284(16)	5104(5)	10618(4)	26(2)
C(9')	10880(16)	4958(5)	10293(4)	25(2)
C(10')	10727(15)	4170(5)	9971(4)	27(2)
C(11')	9570(16)	3558(5)	10336(4)	30(2)
C(12')	10076(17)	2737(5)	10203(4)	32(2)
C(13')	12134(16)	2481(5)	10598(4)	24(2)
C(14')	13346(16)	1828(5)	11575(4)	27(2)
C(15')	13550(20)	106(6)	11585(5)	49(3)
C(16')	8979(16)	986(5)	12812(4)	30(2)
C(17')	12268(16)	2367(5)	13191(4)	24(2)
C(18')	15413(19)	6218(6)	10953(6)	54(3)
C(19')	10288(19)	5606(5)	9805(4)	37(2)
C(20')	12392(16)	4010(5)	9458(4)	33(3)

X-ray Crystal Structure of Compound 7e

Crystals of **7e** suitable for x-ray analysis were obtained by slow evaporation from hexanes / methylene chloride. The structure was solved and refined (R-factor = 4.7%). Crystallographic data have been deposited with the Cambridge Crystallographic Data Centre (CCDC 202596).

Table 1. Crystal data and structure refinement for **7e**.

Identification code	7e	
Empirical formula	C ₁₈ H ₂₈ O ₆	
Formula weight	340.40	
Temperature	173(2) K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P1	
Unit cell dimensions	a = 8.2496(11) Å	α = 82.558(6)°.
	b = 10.1013(15) Å	β = 82.658(6)°.
	c = 11.6656(17) Å	γ = 82.064(6)°.
Volume	948.7(2) Å ³	
Z	2	
Density (calculated)	1.192 Mg/m ³	
Absorption coefficient	0.088 mm ⁻¹	
F(000)	368	
Crystal size	0.20 x 0.05 x 0.02 mm ³	
Theta range for data collection	2.05 to 20.81°.	
Index ranges	-8 ≤ h ≤ 8, -10 ≤ k ≤ 10, -11 ≤ l ≤ 11	
Reflections collected	4361	
Independent reflections	3114 [R(int) = 0.0327]	
Completeness to theta = 20.81°	99.5 %	
Absorption correction	SADABS	
Max. and min. transmission	0.9982 and 0.663464	
Refinement method	Full-matrix least-squares on F ²	
Data / restraints / parameters	3114 / 3 / 433	
Goodness-of-fit on F ²	0.984	
Final R indices [I > 2σ(I)]	R ₁ = 0.0470, wR ₂ = 0.0864	
R indices (all data)	R ₁ = 0.0693, wR ₂ = 0.0947	
Absolute structure parameter	1.4(14)	
Largest diff. peak and hole	0.160 and -0.168 e.Å ⁻³	

Table 2. Atomic coordinates ($\times 10^4$) and equivalent isotropic displacement parameters ($\text{\AA}^2 \times 10^3$)

for **7e**. $U(\text{eq})$ is defined as one third of the trace of the orthogonalized U_{ij} tensor.

	x	y	z	$U(\text{eq})$
O(1)	11592(6)	17848(5)	-2407(4)	59(2)
O(2)	5983(5)	13716(4)	666(3)	38(1)
O(3)	6917(4)	15414(4)	-1404(4)	30(1)
O(4)	6100(6)	17500(5)	-2196(4)	62(2)
O(5)	13964(5)	15149(4)	-5514(3)	36(1)
O(6)	12522(4)	15992(4)	-3282(4)	32(1)
C(1)	12168(7)	16690(8)	-2367(6)	34(2)
C(2)	12494(7)	15788(6)	-1253(5)	33(2)
C(3)	11188(7)	14856(6)	-933(6)	33(2)
C(4)	10142(7)	14869(6)	18(5)	33(2)
C(5)	8856(6)	13908(6)	324(5)	29(2)
C(6)	7148(7)	14661(6)	593(5)	35(2)
C(7)	6706(7)	15879(6)	-267(5)	36(2)
C(8)	6561(8)	16345(8)	-2294(6)	35(2)
C(9)	6810(6)	15732(6)	-3427(5)	35(2)
C(10)	8548(7)	15084(6)	-3708(5)	31(2)
C(11)	9446(7)	15348(6)	-4713(5)	31(2)
C(12)	11182(6)	14744(6)	-5045(5)	28(2)
C(13)	12333(7)	15826(6)	-5322(5)	36(2)
C(14)	12198(7)	16750(6)	-4384(5)	32(2)
C(15)	9319(8)	12865(6)	1336(6)	49(2)
C(16)	4513(7)	14032(6)	1405(5)	43(2)
C(17)	11221(7)	13952(7)	-6087(5)	49(2)
C(18)	15082(7)	15970(6)	-6221(5)	44(2)
O(1')	12745(6)	7796(5)	-8479(4)	57(1)
O(2')	18937(5)	10710(4)	-5618(4)	49(1)
O(3')	18526(4)	9372(4)	-7556(4)	32(1)
O(4')	18335(6)	7396(5)	-8155(5)	66(2)

O(5')	12343(5)	11528(4)	-11425(3)	42(1)
O(6')	13027(4)	9873(4)	-9324(4)	31(1)
C(1')	12768(7)	8970(8)	-8391(6)	41(2)
C(2')	12561(7)	9629(6)	-7302(5)	40(2)
C(3')	14009(7)	10296(6)	-7129(5)	32(2)
C(4')	14741(7)	10166(6)	-6184(5)	36(2)
C(5')	16146(7)	10891(6)	-6014(5)	28(2)
C(6')	17603(7)	9933(6)	-5624(5)	34(2)
C(7')	18179(7)	8823(6)	-6378(5)	34(2)
C(8')	18577(7)	8533(8)	-8370(6)	40(2)
C(9')	18870(7)	9289(7)	-9565(6)	41(2)
C(10')	17391(7)	10260(6)	-9853(6)	35(2)
C(11')	16597(7)	10301(6)	-10773(6)	34(2)
C(12')	15144(7)	11278(6)	-11043(5)	29(2)
C(13')	13748(7)	10558(6)	-11336(5)	29(2)
C(14')	13370(7)	9381(6)	-10442(5)	33(2)
C(15')	15559(8)	11919(6)	-5152(6)	60(2)
C(16')	19734(8)	10457(7)	-4589(6)	60(2)
C(17')	15619(8)	12358(6)	-12038(5)	51(2)
C(18')	11276(7)	11278(7)	-12224(5)	53(2)

X-ray Crystal Structure of Compound **7g**

Crystals of **7g** suitable for x-ray analysis were obtained by slow evaporation from hexanes / methylene chloride. The structure was solved and refined (R-factor = 4.17%). Crystallographic data have been deposited with the Cambridge Crystallographic Data Centre (CCDC 202597).

Table 1. Crystal data and structure refinement for **7g**.

Identification code	7g	
Empirical formula	C ₁₀ H ₁₆ O ₃	
Formula weight	184.23	
Temperature	173(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	C2	
Unit cell dimensions	a = 18.327(6) Å	α = 90°.
	b = 5.4780(18) Å	β = 127.937(5)°.
	c = 13.272(4) Å	γ = 90°.
Volume	1050.9(6) Å ³	
Z	4	
Density (calculated)	1.164 Mg/m ³	
Absorption coefficient	0.085 mm ⁻¹	
F(000)	400	
Crystal size	0.40 x 0.20 x 0.20 mm ³	
Theta range for data collection	2.82 to 28.28°.	
Index ranges	-24 ≤ h ≤ 24, -6 ≤ k ≤ 7, -17 ≤ l ≤ 17	
Reflections collected	3664	
Independent reflections	2305 [R(int) = 0.0267]	
Completeness to theta = 28.28°	98.4 %	
Absorption correction	SADABS	
Max. and min. transmission	0.9833 and 0.78274	
Refinement method	Full-matrix least-squares on F ²	
Data / restraints / parameters	2305 / 1 / 171	
Goodness-of-fit on F ²	1.024	
Final R indices [I > 2σ(I)]	R ₁ = 0.0417, wR ₂ = 0.1041	
R indices (all data)	R ₁ = 0.0525, wR ₂ = 0.1102	
Absolute structure parameter	-0.3(12)	
Largest diff. peak and hole	0.167 and -0.137 e.Å ⁻³	

Table 2. Atomic coordinates ($\times 10^4$) and equivalent isotropic displacement parameters ($\text{\AA}^2 \times 10^3$)

for **7g**. $U(\text{eq})$ is defined as one third of the trace of the orthogonalized U_{ij} tensor.

	x	y	z	$U(\text{eq})$
O(1)	6377(2)	5690(3)	6285(2)	81(1)
O(2)	6232(1)	2754(2)	7295(1)	40(1)
O(3)	3667(1)	2114(3)	451(1)	50(1)
C(1)	6444(1)	3591(4)	6558(2)	41(1)
C(2)	6763(1)	1616(4)	6131(2)	40(1)
C(3)	6009(1)	931(4)	4756(2)	33(1)
C(4)	5913(1)	1802(3)	3749(2)	36(1)
C(5)	5102(1)	997(3)	2412(2)	36(1)
C(6)	4439(1)	3116(3)	1635(2)	39(1)
C(7)	5843(1)	4496(4)	7668(2)	42(1)
C(8)	6573(1)	3576(4)	3845(2)	56(1)
C(9)	5411(2)	-187(5)	1685(2)	53(1)
C(10)	3142(2)	3860(7)	-536(2)	72(1)

X-ray Crystal Structure of Compound **7b**

Crystals of **7b** suitable for x-ray analysis were obtained by slow evaporation from hexanes / methylene chloride. The structure was solved and refined (R-factor = 4.31%). Crystallographic data have been deposited with the Cambridge Crystallographic Data Centre (CCDC 202598).

Table 1. Crystal data and structure refinement for **7b**.

Identification code	7b	
Empirical formula	C ₁₄ H ₂₀ O ₄	
Formula weight	252.30	
Temperature	173(2) K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	P2(1)2(1)2(1)	
Unit cell dimensions	a = 4.7958(5) Å	α = 90°.
	b = 16.711(2) Å	β = 90°.
	c = 17.195(2) Å	γ = 90°.
Volume	1378.0(3) Å ³	
Z	4	
Density (calculated)	1.216 Mg/m ³	
Absorption coefficient	0.088 mm ⁻¹	
F(000)	544	
Crystal size	0.90 x 0.30 x 0.05 mm ³	
Theta range for data collection	2.44 to 28.28°.	
Index ranges	-5 ≤ h ≤ 5, -21 ≤ k ≤ 21, -22 ≤ l ≤ 3	
Reflections collected	4805	
Independent reflections	2567 [R(int) = 0.0303]	
Completeness to theta = 28.28°	92.5 %	
Absorption correction	SADABS	
Max. and min. transmission	0.9956 and 0.7409	
Refinement method	Full-matrix least-squares on F ²	
Data / restraints / parameters	2567 / 0 / 243	
Goodness-of-fit on F ²	1.015	
Final R indices [I > 2σ(I)]	R1 = 0.0431, wR2 = 0.0933	
R indices (all data)	R1 = 0.0624, wR2 = 0.1036	
Absolute structure parameter	1.1(15)	
Largest diff. peak and hole	0.166 and -0.134 e.Å ⁻³	

Table 2. Atomic coordinates ($\times 10^4$) and equivalent isotropic displacement parameters ($\text{\AA}^2 \times 10^3$)

for **7b**. $U(\text{eq})$ is defined as one third of the trace of the orthogonalized U_{ij} tensor.

	x	y	z	$U(\text{eq})$
O(1)	-2407(5)	1649(1)	8400(1)	71(1)
O(2)	-678(3)	2685(1)	7759(1)	37(1)
O(3)	-2869(4)	6168(1)	8527(1)	48(1)
O(4)	-60(3)	5104(1)	8435(1)	33(1)
C(1)	-872(5)	2207(1)	8370(1)	34(1)
C(2)	-2474(7)	2495(2)	7102(1)	38(1)
C(3)	-2368(6)	3188(1)	6544(1)	34(1)
C(4)	-3519(6)	3930(2)	6894(1)	34(1)
C(5)	-2126(6)	4585(2)	7062(1)	35(1)
C(6)	-3286(7)	5329(2)	7406(2)	41(1)
C(7)	-2077(5)	5591(1)	8176(1)	34(1)
C(8)	1034(6)	5303(1)	9197(1)	32(1)
C(9)	3054(5)	4650(1)	9449(1)	30(1)
C(10)	1751(5)	3834(1)	9463(1)	31(1)
C(11)	2342(5)	3249(1)	8981(1)	30(1)
C(12)	1069(7)	2433(2)	9020(1)	37(1)
C(13)	-3903(7)	2950(2)	5798(1)	42(1)
C(14)	4160(7)	4878(2)	10256(2)	41(1)