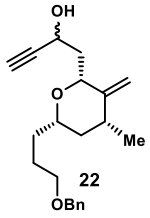
solution (10 mL), dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The obtained residue was purified by flash column chromatography (SiO_2, 10→30% EtOAc in hexanes) to afford pure aldehyde **21** (179 mg, 0.591 mmol, 90% yield) as a colorless foam. **21**: R_f = 0.80 (SiO_2, hexanes/EtOAc 3:2, *v*/*v*); $[\alpha]_D^{23}$ = +17.0 (*c* = 2.0, CH_2Cl_2); FT-IR (film) ν_{max} = 3004, 2848, 2725, 1725, 1650, 1454, 1363, 1087, 1028, 904, 735 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ = 9.81 (dd, *J* = 2.7, 2.0 Hz, 1 H), 7.36–7.32 (m, 4 H), 7.30–7.26 (m, 1 H), 4.84 (dd, *J* = 1.9, 0.6 Hz, 1 H), 4.75 (d, *J* = 1.9 Hz, 1 H), 4.49 (s, 2 H), 4.29–4.22 (m, 1 H), 3.62–3.54 (m, 1 H), 3.47 (ddt, *J* = 26.7, 9.3, 6.5 Hz, 2 H), 2.79–2.65 (m, 2 H), 2.36–2.28 (m, 1 H), 1.84–1.68 (m, 2 H), 1.67–1.59 (m, 1 H), 1.57–1.47 (m, 2 H), 1.14–1.07 (m, 4 H) ppm; ^{13}C NMR (151 MHz, $CDCl_3$) δ = 201.9, 150.2, 138.7, 128.4, 127.8, 127.6, 105.4, 77.7, 74.4, 72.9, 70.3, 45.7, 42.6, 35.6, 32.5, 26.0, 18.0 ppm; HRMS (ESI-TOF) calcd for $C_{19}H_{26}O_3Na^+$ $[M+Na]^+$ 325.1774; Found 325.1771.

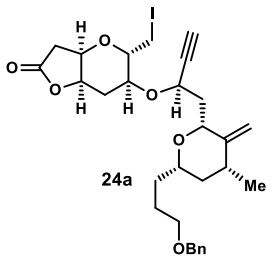
1-{(2*R*,4*R*,6*S*)-6-[3-(Benzyloxy)propyl]-4-methyl-3-methylidenetetrahydro-2*H*-pyran-2-yl}but-3-yn-2-ol (22): To a stirred solution of aldehyde **21** (600 mg, 1.98 mmol, 1.0 equiv) in THF (15 mL) at −78 °C

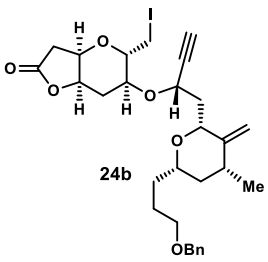


was added ethynylmagnesium bromide (0.5 M in THF, 9.92 mL, 4.96 mmol, 2.5 equiv), and the reaction mixture was warmed to −10 °C. After 15 min, the reaction mixture was quenched by the addition of saturated aqueous NH_4Cl solution (30 mL). The aqueous layer was extracted with EtOAc (3 × 20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The obtained residue was purified by flash column chromatography (SiO_2, 5→20% EtOAc in hexanes) to afford alcohol **22** (mixture of diastereomers, 1.5:1 *dr*, 520 mg, 1.58 mmol, 80% yield) as a colorless foam. **22**: R_f = 0.35 (SiO_2, hexanes/EtOAc 5:1, *v*/*v*); $[\alpha]_D^{23}$ = +21.3 (*c* = 3.0, CH_2Cl_2); FT-IR (film) ν_{max} = 3415, 3297, 2956, 2850, 1650, 1454, 1365, 1312, 1206, 1089, 1062, 903, 697 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ = 7.36–7.31 (m, 4 H), 7.29–7.26 (m, 1 H), 4.87 (d, *J* = 1.5 Hz, 0.6 H), 4.84 (d, *J* = 1.6 Hz, 0.4 H), 4.83 (d, *J* = 1.6 Hz, 1 H), 4.67 (tdt, *J* = 7.3, 5.2, 2.4 Hz, 1 H), 4.51–4.47 (m, 2 H), 4.34–4.28 (m, 0.4 H), 3.98–3.93 (m, 0.6 H), 3.66 (dddd, *J* = 11.2, 7.3, 5.5, 2.1 Hz, 0.4 H), 3.62–3.57 (m, 0.6 H), 3.54–3.43 (m, 2 H), 2.46 (d, *J* = 2.1 Hz, 1 H), 2.45 (d, *J* = 2.1 Hz, 1 H), 2.35–2.23 (m, 1 H), 2.21–2.09 (m, 1.6 H), 2.05 (ddd, *J* = 14.4, 5.9, 2.7 Hz, 0.4 H), 1.83–1.61 (m, 3 H), 1.59–1.50 (m, 2 H), 1.15–1.08 (m, 4 H) ppm; ^{13}C NMR (151 MHz, $CDCl_3$) δ = 150.5, 150.3, 138.7, 138.6,

128.5, 127.8, 127.7, 127.6, 127.5, 105.3, 105.1, 84.8, 84.6, 78.5, 77.8, 77.7, 76.7, 73.0, 72.9, 72.6, 70.2, 70.1, 62.0, 60.9, 42.5, 39.2, 37.3, 35.6, 35.5, 32.7, 32.6, 26.1, 26.0, 18.1, 18.0 ppm; HRMS (ESI-TOF) calcd for $C_{21}H_{28}O_3Na^+$ $[M+Na]^+$ 351.1931; Found 351.1935.

(3a*R*,5*S*,6*S*,7a*R*)-6-{[(2*R*)-1-{(2*R*,4*R*,6*S*)-6-[3-(Benzyloxy)propyl]-4-methyl-3-methylidenetetrahydro-2*H*-pyran-2-yl}but-3-yn-2-yl]oxy}-5-(iodomethyl)hexahydro-2*H*-furo[3,2-*b*]pyran-2-one (24a) and (3a*R*,5*S*,6*S*,7a*R*)-6-{[(2*S*)-1-{(2*R*,4*R*,6*S*)-6-[3-(benzyloxy)propyl]-4-methyl-3-methylidenetetrahydro-2*H*-pyran-2-yl}but-3-yn-2-yl]oxy}-5-(iodomethyl)hexahydro-2*H*-furo[3,2-*b*]pyran-2-one (24b):



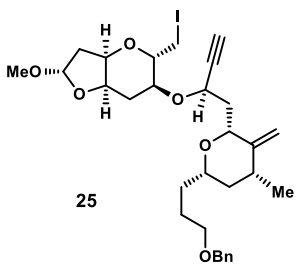


To a stirred solution of alkyne **22** (200 mg, 0.609 mmol, 1.0 equiv) in CH_2Cl_2 (5 mL) at 23 °C was added $Co_2(CO)_8$ (250 mg, 0.731 mmol, 1.2 equiv) in one portion. After 20 min, a solution of iodide **23**[5] (363 mg, 1.22 mmol, 2.0 equiv) in CH_2Cl_2 (8 mL) was added. The reaction mixture was cooled to 0 °C, and $BF_3{\cdot}Et_2O$ (151 µL, 1.22 mmol, 2.0 equiv) was added dropwise. After 0.5 h, the reaction mixture was carefully quenched by the addition of saturated aqueous $NaHCO_3$ solution (20 mL), and allowed to warm to 23 °C. The aqueous layer was extracted with CH_2Cl_2 (3 × 20 mL) and the combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure.

To a stirred solution of the so-obtained crude residue in acetone (20 mL) was added portion wise diammonium cerium(IV) nitrate (CAN) (1.67 g, 3.04 mmol, 5.0 equiv) at 0 °C. The resulting mixture was allowed to warm to 23 °C and stirred for 1 h before it was quenched by the addition of water (60 mL). The aqueous layer was extracted with EtOAc (3 × 30 mL) and the combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The obtained residue was purified by flash column chromatography (SiO_2, 10 → 40% ethyl acetate in hexanes) to afford pure *cis*-isomer **24a** (185 mg, 0.304 mmol, 50% yield overall) and *trans*-isomer **2b** (59.0 mg, 0.097 mmol, 16% yield overall) as colorless oils (3:1 *dr*). **24a** (*cis*-isomer): R_f = 0.50 (SiO_2, 40% EtOAc in hexanes); $[\alpha]_D^{23}$ = +108.3 (*c* = 0.6, CH_2Cl_2); FT-IR (film) ν_{max} = 3283, 3030, 2929, 2854, 1781, 1454, 1365, 1095, 1050, 904, 698 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ = 7.36–7.31 (m, 4H), 7.30–7.26 (m, 1H), 4.80 (d, *J* = 1.5 Hz, 1H), 4.77 (d,

J = 1.5 Hz, 1 H), 4.56–4.45 (m, 5 H), 3.97 (dt, J = 11.0, 1.6 Hz, 1 H), 3.83 (dt, J = 6.4, 4.8 Hz, 1 H), 3.74 (dddd, J = 11.2, 7.4, 5.3, 2.1 Hz, 1 H), 3.59 (ddd, J = 7.7, 6.3, 3.9 Hz, 1 H), 3.53–3.43 (m, 3 H), 3.28 (dd, J = 10.8, 7.8 Hz, 1 H), 2.76 (dd, J = 18.5, 6.3 Hz, 1 H), 2.67 (dd, J = 18.4, 1.6 Hz, 1 H), 2.42 (d, J = 2.0 Hz, 1 H), 2.39–2.30 (m, 1 H), 2.21–2.10 (m, 2 H), 2.06 (dt, J = 14.9, 4.9 Hz, 1 H), 1.96 (ddd, J = 14.2, 11.1, 2.2 Hz, 1 H), 1.86–1.74 (m, 2 H), 1.73–1.65 (m, 1 H), 1.59–1.49 (m, 2 H), 1.08–1.01 (m, 4 H) ppm; ^{13}C NMR (151 MHz, $CDCl_3$) δ = 175.0, 151.5, 138.8, 128.5, 127.8, 127.7, 104.2, 83.4, 76.7, 76.0, 74.5, 73.5, 73.1, 72.9, 70.6, 69.4, 63.3, 53.6, 43.3, 38.3, 35.7, 35.6, 32.8, 26.6, 26.4, 18.1, 5.5 ppm; HRMS (ESI-TOF) calcd for $C_{29}H_{37}O_6INa^+$ $[M+Na]^+$ 631.1527; Found 631.1528. **24b** (*trans*-isomer): R_f = 0.4 (SiO_2, hexanes/EtOAc 3:2, *v*/*v*); $[\alpha]_D^{23}$ = +22.6 (*c* = 0.50, CH_2Cl_2); FT-IR (film) ν_{max} = 3285, 2929, 2852, 1781, 1454, 1364, 1194, 1092, 1049, 904, 698 cm^{-1}; ^{1}H NMR (600 MHz, $CDCl_3$) δ = 7.36–7.31 (m, 4 H), 7.30–7.27 (m, 1 H), 4.85 (brs, 1 H), 4.81 (d, J = 1.9 Hz, 1 H), 4.63–4.55 (m, 2 H), 4.51 (AB quart, J = 11.5 Hz, 2 H), 4.46 (ddd, J = 10.3, 4.9, 2.1 Hz, 1 H), 3.90 (dd, J = 10.6, 3.0 Hz, 1 H), 3.73–3.64 (m, 1 H), 3.56 (td, J = 6.7, 4.0 Hz, 1 H), 3.49 (dddd, J = 15.8, 13.2, 9.0, 6.5 Hz, 3 H), 3.36 (dd, J = 10.9, 4.0 Hz, 1 H), 3.30 (dd, J = 10.9, 6.7 Hz, 1 H), 2.79–2.63 (m, 2 H), 2.56 (ddd, J = 14.4, 6.1, 4.7 Hz, 1 H), 2.48 (d, J = 2.0 Hz, 1 H), 2.35–2.23 (m, 1 H), 2.19–2.09 (m, 2 H), 2.04 (ddd, J = 13.2, 10.3, 3.1 Hz, 1 H), 1.79 (dddd, J = 17.2, 9.2, 6.8, 4.3 Hz, 2 H), 1.71–1.61 (m, 1 H), 1.55–1.48 (m, 2 H), 1.11–1.05 (m, 4 H) ppm; ^{13}C NMR (151 MHz, $CDCl_3$) δ = 174.7, 150.7, 138.7, 128.5, 127.8, 127.7, 104.8, 82.8, 77.5, 76.2, 75.2, 74.9, 74.0, 73.1, 73.0, 70.4, 69.2, 67.9, 43.2, 37.9, 35.8, 34.7, 32.5, 30.3, 26.2, 18.1, 6.0 ppm; HRMS (ESI-TOF) calcd for $C_{29}H_{37}O_6INa^+$ $[M+Na]^+$ 631.1527; Found 631.1528.

Methyl 3,7-anhydro-6-*O*-[(2*R*)-1-{(2*R*,4*R*,6*S*)-6-[3-(benzyloxy)propyl]-4-methyl-3-methylidenetetrahydro-2*H*-pyran-2-yl}but-3-yn-2-yl]-2,5,8-trideoxy-8-iodo-α-D-*altro*-octofuranoside (25): To a stirred solution of lactone **24b** (200 mg, 0.329 mmol, 1.0 equiv) in CH_2Cl_2 (10 mL) at −78 °C was added dropwise DIBAL-H (1.0 M in toluene, 395 µL, 0.395 mmol, 1.2 equiv). The resulting mixture was warmed to −20 °C and stirred for 1 h before it was diluted with ethyl acetate (20 mL) and quenched by the addition of saturated aqueous solution of Rochelle salt solution (40 mL), allowed to

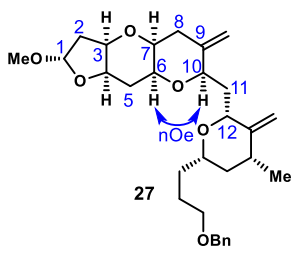


25

warm to 23 °C, and stirred for 2 h until the reaction mixture became a clear solution. The aqueous layer was extracted with EtOAc (3 × 10 mL), and the combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure.

The so-obtained crude residue was dissolved in MeOH (8 mL) and *p*-TsOH·H_2O (11.2 mg, 0.0658 mmol, 0.2 equiv) was added at 23 °C. After 0.5 h, the reaction mixture was quenched by the addition of saturated aqueous $NaHCO_3$ (6 mL) and diluted with water (6 mL). The aqueous layer was extracted with EtOAc (3 × 10 mL), and the combined organic layers were dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The obtained residue was purified by flash column chromatography (SiO_2, 5 → 20% EtOAc in hexanes) to afford pure acetal **25** (154 mg, 0.247 mmol, 75% yield overall) as a colorless oil. **25**: R_f = 0.60 (SiO_2, hexanes/EtOAc 2:1, *v*/*v*); $[\alpha]_D^{23}$ = +86.2 (*c* = 1.5, CH_2Cl_2); FT-IR (film) ν_{max} = 3286, 2927, 2853, 1454, 1366, 1211, 1114, 1093, 1057, 904, 698 cm^{-1}; ^1H NMR (600 MHz, $CDCl_3$) δ = 7.36–7.31 (m, 4 H), 7.30–7.27 (m, 1 H), 5.13 (dd, *J* = 4.3, 3.1 Hz, 1 H), 4.83 (d, *J* = 1.8 Hz, 1 H), 4.79 (d, *J* = 1.8 Hz, 1 H), 4.50 (s, 2 H), 4.48 (q, *J* = 5.2 Hz, 1 H), 4.44 (dt, *J* = 11.0, 2.2 Hz, 1 H), 4.13 (q, *J* = 4.5 Hz, 1 H), 4.02–3.96 (m, 1 H), 3.71–3.60 (m, 2 H), 3.55–3.42 (m, 4 H), 3.29 (s, 3 H), 3.22 (dd, *J* = 10.5, 8.1 Hz, 1 H), 2.39 (d, *J* = 2.0 Hz, 1 H), 2.30–2.21 (m, 3 H), 2.14 (ddd, *J* = 14.1, 11.1, 2.1 Hz, 1 H), 2.06–1.90 (m, 3 H), 1.87–1.79 (m, 1 H), 1.77 (ddd, *J* = 12.8, 4.6, 2.1 Hz, 1 H), 1.68 (ddq, *J* = 12.8, 9.5, 6.7 Hz, 1 H), 1.55 (ddd, *J* = 8.8, 7.3, 4.3 Hz, 2 H), 1.11–1.05 (m, 4 H) ppm; ^{13}C NMR (151 MHz, $CDCl_3$) δ = 151.1, 138.6, 128.5, 127.7, 127.6, 104.5, 104.1, 83.8, 74.4, 73.2, 73.1, 73.0, 72.9, 72.6, 63.1, 54.9, 43.3, 40.0, 38.3, 35.9, 33.0, 27.3, 26.4, 18.1, 7.9 ppm; HRMS (ESI-TOF) calcd for $C_{30}H_{41}O_6INa^+$ $[M+Na]^+$ 647.1840; Found 647.1842.

(2*S*,3a*R*,4a*S*,7*R*,8a*S*,9a*R*)-7-({(2*R*,4*R*,6*S*)-6-[3-(Benzyloxy)propyl]-4-methyl-3-methylidenetetrahydro-2*H*-pyran-2-yl}methyl)-2-methoxy-6-methylidenedecahydrofuro[3,2-*b*]pyrano[2,3-*e*]pyran (27):



To a stirred solution of **25** (108 mg, 0.173 mmol, 1.0 equiv) in THF (5 mL) at 0 °C was added KO*t*-Bu (38.8 mg, 0.346 mmol, 2.0 equiv). The resulting mixture was allowed to warm to 23 °C and stirred for 10 min before it was diluted with hexanes (30 mL) and EtOAc (15 mL) and filtered through a pad of SiO_2. The filtrate was concentrated under reduced pressure to give crude