Supporting Information

for

Total Synthesis of Mosin B, an Antitumor Acetogenin: Desymmetrization Approach to Stereodivergent Synthesis of \textit{threo/trans/erythro}-Type Acetogenins

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\((R)-1,2-O$-$Isopropylidene$-$6$-(trimethylsilyl)$-5$-hexyne$-1,2$-diol (23).\) \(\text{nBuLi (1.54 M in } \text{n-hexane, 3.03 mL, 4.66 mmol} \) was added to a solution of trimethylsilylacetylene (0.645 mL, 4.66 mmol) in THF (39 mL) with stirring at \(-78 \degree C\). After 10 min, a solution of 10 (995 mg, 3.88 mmol) in HMPA (2.7 ml) was added to the mixture, and the whole was stirred for 20 min at 0 \degree C. The reaction was quenched with saturated NH\(_4\)Cl, and the solvent was concentrated under reduced pressure. The residue was extracted with EtOAc, and the extract was washed with saturated NH\(_4\)Cl, water, and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (10:1) to give 23 (590 mg, 67\%) as a colorless oil. \(\alpha D^{2}9=+6.3 \) (c=1.03, CHCl\(_3\)); \(\text{H NMR (500 MHz, CDCl}\(_3\)): \(\delta=0.14 \) (s, 9H), 1.35 (s, 3H), 1.40 (s, 3H), 1.69–1.76 (m, 1H), 1.80–1.87 (m, 1H), 2.31 (dt, 1H, \(J=17.1, 7.6 \text{ Hz}\)), 2.37 (ddd, 1H, \(J=17.1, 7.6, 6.1 \text{ Hz}\)), 3.59 (dd, 1H, \(J=7.9, 6.7 \text{ Hz}\)), 4.08 (dd, 1H, \(J=7.9, 6.1 \text{ Hz}\)), 4.15–4.20 (m, 1H); \(\text{C NMR (67.8 MHz, CDCl}\(_3\)): \(\delta=0.06 \) (3C), 16.4, 25.6, 26.9, 32.7, 69.2, 75.0, 85.1, 106.2, 108.7; \(\text{IR (KBr): } \nu=\text{2175 cm}^{-1};\ \text{MS (El): } m/z \%) = 226 (5.9) [M]\(^+\), 211 (100); \text{elemental analysis calcd (\%): } \text{C}{12H}_{22O}_{2Si}: \text{C} 63.66, \text{H} 9.80; \text{found: } \text{C} 63.49, \text{H} 9.51.\)

\((R)-6$-(trimethylsilyl)$-5$-hexyne$-1,2$-diol (24).\) A solution of 23 (590 mg, 2.61 mmol) in AcOH–water (16:9, 25 mL) was stirred at rt for 10 h. The reaction was quenched with NaHCO\(_3\), and the mixture was extracted with CHCl\(_3\). The extract was washed with brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (1:1) to give 24 (423 mg, 87\%) as a
colorless powder. m.p. 54.0–54.5 °C (n-hexane); [α]D = +16.1 (c=1.00, CHCl3); 1H NMR (500 MHz, CDCl3): δ=0.15 (s, 9H), 1.67 (q, 2H, J=6.9 Hz), 1.90 (t, 1H, J=5.8 Hz), 2.37 (d, 1H, J=4.9 Hz), 2.40 (t, 2H, J=7.0 Hz), 3.51 (ddd, 1H, J=11.0, 6.9, 5.0 Hz), 3.68 (ddd, 1H, J=11.0, 6.4, 3.4 Hz), 3.85–3.91 (m, 1H); 13C NMR (67.8 MHz, CDCl3): δ=0.04 (3C), 16.3, 31.7, 66.4, 71.3, 85.5, 106.6; IR (KBr): ν=3358, 2175 cm–1; MS (FAB): m/z: 187 [M+H]+; elemental analysis calcd (%) for C9H18O2Si: C 58.02, H 9.74; found: C 58.16, H 9.48.

(R)-5-Hexyne-1,2-diol (25). TBAF (1.0 M in THF, 4.46 mL, 4.46 mmol) was added to a solution of 24 (415 mg, 2.23 mmol) in THF (22 mL) with stirring at rt. After 5 min, water was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed with water and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with EtOAc to give 25 (232 mg, 91%) as a colorless waxy solid. [α]D = +44.0 (c=0.48, MeOH); 1H NMR (500 MHz, CD3OD): δ=1.51–1.59 (m, 1H), 1.71 (dtd, 1H, J=13.7, 7.9, 4.0 Hz), 2.18 (m, 1H), 2.24–2.36 (m, 2H), 3.42–3.49 (m, 2H), 3.68–3.72 (m, 1H); 13C NMR (67.8 MHz, CD 3OD): δ=15.4, 33.4, 67.1, 69.6, 71.8, 84.7; IR (KBr): ν=3296, 2116 cm –1; MS (FAB): m/z: 137 [M+Na] +; HRMS-FAB: [M+Na] + calcd for C 6H10O2Na 137.0578; found 137.0582.

(R)-2-(tert-Butyldimethylsilyloxy)-5-hexynyl p-Toluenesulfonate (26). p-TsCl (387 mg, 2.03 mmol) was added to a solution of 25 (232 mg, 2.03 mmol) in pyridine (2 mL) with stirring at rt. After 1h, saturated NH4Cl was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed with saturated NH 4Cl, water and brine prior to drying and solvent evaporation. The residue was dissoleved in DMF (2 mL), and imidazole (276 mg, 4.06 mmol) and TBSCl (612 mg, 4.06 mmol) was added to the mixture with stirring at rt. After 14 h, water was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed with water and brine prior to drying and solvent evaporation. The residue was chromatogaraphed on silica gel with hexane–EtOAc (10:1) to give 26 (536 mg, 69% in two steps) as a colorless oil. [α]D = +18.2 (c=1.21, CHCl3); 1H NMR (500 MHz, CDCl3): δ=0.02 (s, 3H), 0.05 (s, 3H), 0.84 (s, 9H), 1.57–1.62 (m, 1H), 1.65–1.71 (m, 1H), 1.93 (t, 1H, J=2.7 Hz), 2.21 (td, 2H, J=7.3, 2.4 Hz), 2.45 (s, 3H), 3.87 (dd, 1H, J=9.8, 4.9 Hz), 3.89 (dd, 1H, J=9.8, 5.5 Hz), 3.96–4.01 (m, 1H); 13C NMR (CDCl 3, 67.8 MHz): δ=–5.0, –4.6, 14.1, 17.9, 21.6, 25.7 (3C), 32.6, 68.4, 69.0, 72.7, 83.4, 127.9 (2C), 129.7 (2C), 132.8, 144.8; IR (KBr): ν=3296, 2116 cm –1; MS (FAB): m/z: 383 [M+H]+; elemental analysis calcd (%) for C19H30O4SSi: C 59.65, H 7.90, S 8.38; found: C 59.50, H 7.79, S 8.28.

(R)-5-(tert-Butyldimethylsilyloxy)-6-iodo-1-hexyne (27). A mixture of 26 (510 mg, 1.33 mmol), NaHCO3 (894 mg, 10.6 mmol), and NaI (598 mg, 3.99 mol) in acetone (13 mL) was refluxed for 41 h. Water was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed with brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (20:1) to give 27 (398 mg, 88%) as a colorless oil. [α]D = +28.0 (c=1.16, CHCl3); 1H NMR (500 MHz, CDCl3): δ=0.10 (s, 3H), 0.11 (s, 3H), 0.91 (s, 9H), 1.75 (m, 1H), 1.82–1.88 (m, 1H), 1.96 (t, 1H, J=2.7 Hz), 2.25 (td, 2H, J=7.3, 2.6 Hz), 3.19 (dd, 1H, J=10.4, 6.1 Hz), 3.23 (dd, 1H, J=10.4, 3.7 Hz), 3.66–3.70 (m, 1H); 13C NMR (CDCl3, 67.8 MHz): δ=–4.7, –4.4, 13.5, 14.3, 18.0, 25.8 (3C), 35.6, 66.9, 69.5, 83.7; IR (KBr): ν=3309, 2116 cm –1; MS (FAB): m/z: 383 [M+Na]+; elemental analysis calcd (%) for C19H23S2Os: C 59.65, H 6.85, O 137.51; found: C 59.50, H 6.55, O 137.23.

(3RS,5S)-3-[(2R)-2-(tert-Butyldimethylsilyloxy)-5-hexynyl]-5-methyl-3-(phenylsulfenyl)tetrahydrofuran-2-one (28). KHMDS (0.5 M in toluene, 0.358 mL, 0.179 mmol) was added to a solution
of 9 (37.3 mg, 0.179 mmol) in THF (0.6 mL) with stirring at 0 °C. After 10 min, a solution of 27 (40.4 mg, 0.119 mmol) in HMPA (0.3 mL) was added to the mixture, and the whole was stirred at the same temperature. After the mixture was refluxed for 5 h, the reaction was quenched with saturated NH₄Cl, and the mixture was extracted with EtOAc. The extract was washed with saturated NH₄Cl, water, and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (10:1) to give 28 (7.9 mg, 16%) as a colorless oil. [α]²₅<sup>D</sup> = −41.9 (c 0.58, CHCl₃); ¹H NMR (500 MHz, CDCl₃): δ = 0.03 (s, 3/4H), 0.07 (s, 3/4H), 0.15 (s, 9/4H), 0.17 (s, 9/4H), 0.87 (s, 9/4H), 1.27 (d, 9/4H, J = 6.1 Hz), 1.39 (d, 3/4H, J = 6.1 Hz), 1.59–1.64 (m, 1/4H), 1.68–1.78 (m, 7/4H), 1.86–1.94 (m, 2H), 1.96 (t, 3/4H, J = 2.7 Hz), 2.00 (dd, 3/4H, J = 15.0, 2.7 Hz), 2.04–2.11 (m, 3/4H), 2.15–2.26 (m, 3/2H), 2.32 (dd, 1/4H, J = 14.0, 9.8 Hz), 2.37 (dd, 1/4H, J = 14.0, 5.5 Hz), 3.00 (dd, 3/4H, J = 14.0, 7.9 Hz), 4.02 (tt, 1/4H, J = 6.1, 5.5 Hz), 4.35–4.40 (m, 3/4H), 4.55 (dq, 3/4H, J = 14.0, 6.1 Hz), 4.61 (dq, 1/4H, J = 2.7, 6.1 Hz), 7.33–7.43 (m, 3H), 7.54–7.59 (m, 2H); ¹³C NMR (67.8 MHz, CDCl₃): (major) δ = −4.1, −3.9, 13.8, 17.9, 21.4, 25.9, 36.7, 39.5, 41.1, 54.6, 68.2, 68.8, 73.2, 83.7, 129.0 (2C), 130.1, 136.8, 177.0; (minor) δ = −4.3, −4.2, 14.0, 17.9, 20.4, 25.8 (3C), 36.0, 41.7, 42.4, 54.4, 68.5, 73.6, 84.1, 129.0 (2C), 129.3, 130.0, 136.9 (2C), 175.0; IR (KBr): ν = 3309, 2119, 1767 cm⁻¹; MS (FAB) m/z: 419 [M+H]+; elemental analysis calcd (%) for C₂₃H₃₄O₃SSi: C 65.98, H 8.19, S 7.66; found: C 65.97, H 8.15, S 7.46.

(R)-2-(Methoxymethoxy)-5-hexynyl p-Toluenesulfonate (29). p-TsCl (167 mg, 0.876 mmol) was added to a solution of 25 (100 mg, 0.876 mmol) in pyridine (0.9 mL) with stirring at rt. After 1.5h, saturated NH₄Cl was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed saturated NH₄Cl, water and brine prior to drying and solvent evaporation. The residue was dissolved in CH₂Cl₂ (9 mL) and iPr₂NEt (0.759 mL, 4.38 mmol) was added at rt. After stirred at rt for 20 h, saturated NH₄Cl was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed with saturated NaHCO₃, water and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (5:1) to give 29 (184 mg, 67% in two steps) as a colorless oil. [α]²₃<sup>D</sup> = +27.6 (c = 1.38, CHCl₃); ¹H NMR (500 MHz, CDCl₃): δ = 1.67–1.77 (m, 2H), 2.25–2.29 (m, 2H), 2.45 (s, 3H), 3.32 (s, 3H), 3.86–3.91 (m, 1H), 4.05 (dd, 1H, J = 10.4, 4.9 Hz), 4.09 (dd, 1H, J = 10.4, 4.3 Hz), 4.61 (d, 1H, J = 6.7 Hz), 4.63 (dd, 1H, J = 7.9 Hz), 7.35 (d, 2H, J = 7.9 Hz), 7.80 (d, 2H, J = 7.9 Hz); ¹³C NMR (75 MHz, CDCl₃): δ = 14.2, 21.5, 30.2, 55.6, 69.1, 71.0, 73.5, 83.0, 96.3, 127.9 (2C), 129.8 (2C), 132.7, 144.9; IR (KBr): ν = 3309, 2119, 1767 cm⁻¹; MS (FAB) m/z: 335 [M+Na]+; HRMS-FAB: [M+Na]+ calcd for C₁₅H₂₀NaO₅S 335.0929; found: 335.0927.

(R)-5-(Methoxymethoxy)-6-iodo-1-hexyne (30). A mixture of 29 (180 mg, 0.577 mmol), NaHCO₃ (388 mg, 4.62 mmol), and NaI (259 mg, 1.73 mmol) in acetone (6 mL) was refluxed for 26 h. Water was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed with saturated NaHCO₃, water and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (10:1) to give 30 (121 mg, 79%) as a colorless oil. [α]²₄<sup>D</sup> = +27.6 (c = 0.73, CHCl₃); ¹H NMR (500 MHz, CDCl₃): δ = 1.83–1.87 (m, 2H), 1.96 (t, 1H, J = 2.4 Hz), 2.25–2.29 (m, 2H), 2.45 (s, 3H), 3.32 (s, 3H), 3.86–3.91 (m, 1H), 4.05 (dd, 1H, J = 10.4, 4.9 Hz), 4.09 (dd, 1H, J = 10.4, 4.3 Hz), 4.61 (d, 1H, J = 6.7 Hz), 4.63 (dd, 1H, J = 7.9 Hz), 7.35 (d, 2H, J = 7.9 Hz), 7.80 (d, 2H, J = 7.9 Hz); ¹³C NMR (75 MHz, CDCl₃): δ = 14.2, 21.5, 30.2, 55.6, 69.1, 71.0, 73.5, 83.0, 96.3, 127.9 (2C), 129.8 (2C), 132.7, 144.9; IR (KBr): ν = 3309, 2119, 1767 cm⁻¹; MS (FAB) m/z: 335 [M+Na]+; HRMS-FAB: [M+Na]+ calcd for C₁₅H₂₀NaO₅S 335.0929; found: 335.0927.

(R)-2-Hydroxy-5-hexynyl Pivaloate (31). Pivaloyl chloride (0.214 mL, 1.75 mmol) was added to a solution of 25 (200 mg, 1.75 mmol) in pyridine (1.8 mL) and CH₂Cl₂ (1.8 mL) with stirring at 0 °C.
After 5 min, the whole was stirred at rt for 4 h. After solvent evaporation, azeotropic removal of pyridine with toluene was repeated three times. The residue was chromatographed on silica gel with hexane–EtOAc (5:1) to give 31 (288 mg, 83%) as a colorless oil. [α]$_D^{25}$ = +8.7 (c = 1.14, CHCl$_3$); 1H NMR (500 MHz, CDCl$_3$): δ = 1.23 (s, 9H), 1.68–1.72 (m, 2H), 1.98 (t, 1H, J = 2.7 Hz), 2.16 (d, 1H, J = 4.3 Hz), 2.38 (td, 2H, J = 7.0, 2.6 Hz), 4.01–4.05 (m, 2H), 4.15 (dd, 1H, J = 14.0, 6.1 Hz); 13C NMR (75 MHz, CDCl$_3$): δ = 14.5, 27.0 (3C), 31.9, 38.7, 68.0, 68.4, 68.9, 83.5, 178.6; IR (KBr): ν = 3485, 3300, 2118, 1728 cm$^{-1}$; MS (FAB): m/z: 199 [M+H]$^+$; HRMS-FAB: [M+H]$^+$ calcd for C$_{11}$H$_{19}$O$_3$ 199.1334; found 199.1380.

(R)-2-(tert-Butyldimethylsilyloxy)-5-hexynyl Pivaloate (32). Imidazole (196 mg, 2.88 mmol) and TBSCl (435 mg, 2.88 mmol) was added to a solution of 31 (286 mg, 1.44 mmol) in DMF (1.4 ml) with stirring at rt. After 12 h, water was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed with water and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (10:1) to give 32 (449 mg, 100%) as a colorless oil. [α]$_D^{26}$ = +19.3 (c = 0.52, CHCl$_3$); 1H NMR (500 MHz, CDCl$_3$): δ = 0.10 (s, 6H), 0.89 (s, 9H), 1.21 (s, 9H), 1.67–1.77 (m, 2H), 1.95 (t, 1H, J = 2.7 Hz), 2.27 (td, 1H, J = 3.4, 2.4 Hz), 2.29 (td, 1H, J = 4.9, 2.4 Hz), 3.94–4.04 (m, 3H); 13C NMR (67.8 MHz, CDCl$_3$): δ = –4.8, –4.6, 14.3, 18.0, 25.7 (3C), 27.2 (3C), 33.3, 38.8, 67.6, 68.5, 68.7, 84.0, 178.4; IR (KBr): ν = 3315, 2119, 1732 cm$^{-1}$; MS (FAB): m/z: 313 [M+H]$^+$; HRMS-FAB: [M+H]$^+$ calcd for C$_{17}$H$_{33}$O$_3$Si 313.2199; found 313.2208.

(R)-2-(Methoxymethoxy)-5-hexynyl Pivaloate (33). MOMCl (0.587 mL, 7.81 mmol) was added to a mixture of 31 (310 mg, 1.56 mmol) and iPr$_2$NEt (1.35 mL, 7.81 mmol) in CH$_2$Cl$_2$ (16 mL) with stirring at 0 °C. After 5 min, the whole was stirred at rt for 19 h. Saturated NH$_4$Cl was added to the mixture, and the mixture was extracted with EtOAc. The extract was washed with saturated NaHCO$_3$, water and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (5:1) to give 33 (351 mg, 93%) as a colorless oil. [α]$_D^{26}$ = +33.1 (c = 0.98, CHCl$_3$); 1H NMR (500 MHz, CDCl$_3$): δ = 1.22 (s, 9H), 1.72–1.83 (m, 2H), 1.97 (t, 1H, J = 2.7 Hz), 2.34 (td, 2H, J = 7.0, 2.4 Hz), 3.40 (s, 3H), 3.92 (tdd, 1H, J = 7.9, 4.9, 4.9 Hz), 4.09 (dd, 1H, J = 11.6, 5.5 Hz), 4.17 (dd, 1H, J = 11.6, 4.3 Hz), 4.68 (d, 1H, J = 6.7 Hz), 4.76 (d, 1H, J = 6.7 Hz); 13C NMR (75 MHz, CDCl$_3$): δ = 14.3, 26.9 (3C), 30.8, 38.5, 55.4, 65.6, 68.8, 73.8, 83.3, 96.0, 177.9; IR (KBr): ν = 3273, 3313, 2119 cm$^{-1}$; MS (FAB): m/z: 243 [M+H]$^+$; HRMS-FAB: [M+H]$^+$ calcd for C$_{13}$H$_{25}$O$_4$Si 243.1596; found 243.1586.

(R)-2-(tert-Butyldimethylsilyloxy)-5-hexyn-1-ol (34). DIBALH (1.0 M in toluene, 1.28 mL, 1.28 mmol) was added to a solution of 32 (200 mg, 0.641 mmol) in CH$_2$Cl$_2$ (6 mL) with stirring at –78 °C. After 5 min, the whole was stirred at rt for 1 h. The mixture was extracted with EtOAc, and the extract was washed with water and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (5:1) to give 34 (144 mg, 98%) as a colorless oil. [α]$_D^{26}$ = +19.3 (c = 0.97, CHCl$_3$); 1H NMR (500 MHz, CDCl$_3$): δ = 1.22 (s, 9H), 1.72–1.83 (m, 2H), 1.97 (t, 1H, J = 2.7 Hz), 2.34 (td, 2H, J = 7.0, 2.4 Hz), 3.40 (s, 3H), 3.92 (tdd, 1H, J = 7.9, 4.9, 4.9 Hz), 4.09 (dd, 1H, J = 11.6, 5.5 Hz), 4.17 (dd, 1H, J = 11.6, 4.3 Hz), 4.68 (d, 1H, J = 6.7 Hz), 4.76 (d, 1H, J = 6.7 Hz); 13C NMR (75 MHz, CDCl$_3$): δ = 14.3, 26.9 (3C), 30.8, 38.5, 55.4, 65.6, 68.8, 73.8, 83.3, 96.0, 177.9; IR (KBr): ν = 3273, 313, 2119 cm$^{-1}$; MS (FAB): m/z: 229 [M+H]$^+$; HRMS-FAB: [M+H]$^+$ calcd for C$_{12}$H$_{25}$O$_4$Si 229.1624; found 229.1621.

(R)-2-(Methoxymethoxy)-5-hexyn-1-ol (35). DIBALH (1.0 M in toluene, 1.91 mL, 1.91 mmol) was added to a solution of 33 (231 mg, 0.955 mmol) in CH$_2$Cl$_2$ (10 mL) with stirring at –78 °C. After 5
min, saturated Rochelle salt was gradually added to the mixture, and the whole was stirred at rt for 1h. The mixture was extracted with EtOAc, and the extract was washed with water and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (1:1) to give 35 (140 mg, 92%) as a colorless oil. [α]$_D^{25}$=+24.5 (c=0.65, MeOH); $^1$H NMR (500 MHz, CDCl$_3$): $\delta$=1.68 (dtd, 1H, $J$=9.8, 7.9, 6.1 Hz), 1.71–1.78 (m, 1H), 1.97 (t, 1H, $J$=2.7 Hz), 2.30–2.33 (m, 2H), 3.08–3.11 (m, 1H), 3.44 (s, 3H), 3.53 (ddd, 1H, $J$=12.2, 6.7, 4.3 Hz), 3.63 (ddd, 1H, $J$=11.6, 8.8, 2.4 Hz), 3.74 (dt, 1H, $J$=11.0, 4.3, 2.4 Hz), 4.72 (d, 1H, $J$=6.7 Hz), 4.76 (d, 1H, $J$=6.7 Hz); $^{13}$C NMR (67.8 MHz, CDCl$_3$): $\delta$=14.4, 30.1, 55.5, 65.1, 68.8, 80.0, 83.4, 96.9; IR (KBr): ν=3425, 3300, 2116 cm$^{-1}$.

(R)-2-(tert-Butyldimethylsilyloxy)-5-hexynyl Trifluoromethanesulfonate (36). Tf$_2$O (42.4 µL, 0.257 mmol) was added to a mixture of 34 (48.9 mg, 0.214 mmol) and 2,6-lutidine (29.8 µL, 0.257 mmol) in CH$_2$Cl$_2$ (2 mL) with stirring at 0 °C. The whole was stirred at the same temperature for 5 min. The reaction was quenched with saturated NH$_4$Cl, and the mixture was extracted with Et$_2$O. The extract was washed with saturated NH$_4$Cl, water, and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (20:1) to give 36 (70.1 mg, 91%) as a colorless oil. The triflate was unstable and was used immediately in the next step.

(R)-2-(tert-Butyldimethylsilyloxy)-5-hexynyl Chloromethanesulfonate (37). Chloromethanesulfonyl chloride (29.4 µL, 0.329 mmol) was added to a solution of 34 (50.0 mg, 0.219 mmol) and 2,6-lutidine (38.3 µL, 0.329 mmol in CH$_2$Cl$_2$ (2 mL) with stirring at 0 °C. The whole was stirred at the same temperature for 1h. The reaction was quenched with saturated NH$_4$Cl, and the mixture was extracted with Et$_2$O. The extract was washed with saturated NH$_4$Cl, water, and brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (20:1) to give 37 (67.5 mg, 90%) as a colorless oil. The chloromethanesulfonate was unstable and was used immediately in the next step.

(R)-2-(Methoxymethoxy)-5-hexynyl Trifluoromethanesulfonate (38). Tf$_2$O (62.0 µL, 0.379 mmol) was added to a mixture of 35 (50.0 mg, 0.316 mmol) and 2,6-lutidine (44.0 µL, 0.379 mmol) in CH$_2$Cl$_2$ (3 mL). The whole was stirred at the same temperature for 15 min. The reaction was quenched with saturated NH$_4$Cl, and the mixture was extracted with Et$_2$O. The extract was washed with saturated NH$_4$Cl, water, and brine prior to drying and solvent evaporation. The triflate was unstable and used in the next step without further purification.

(R)-2-(Methoxymethoxy)-5-hexynyl Chloromethanesulfonate (39). Chloromethanesulfonyl chloride (56.4 µL, 0.632 mmol) was added to a mixture of 35 (50.0 mg, 0.316 mmol) and 2,6-lutidine (73.5 µL, 0.632 mmol) in CH$_2$Cl$_2$ (3 mL). The whole was stirred at the same temperature for 1 h. The reaction was quenched with saturated NH$_4$Cl, and the mixture was extracted with Et$_2$O. The extract was washed with saturated NH$_4$Cl, water, and brine prior to drying and solvent evaporation. The triflate was unstable and used in the next step without further purification.

General Procedure for Coupling Reaction of Lactone 9 and Alkylating Agent. (Table 2, Entry 3). KHMQS (0.5 M in toluene, 0.752 mL, 0.376 mmol) was added to a solution of 9 (78.3 mg, 0.376 mmol) in THF (0.6 mL) with stirring at 0 °C. After 10 min, a solution of 36 (135 mg, 0.376 mmol) in HMPA (0.327 mL, 1.88 mmol) was added to the mixture. The whole was stirred at the same temperature for 10 min. The reaction was quenched with saturated NH$_4$Cl, and the mixture was extracted with EtOAc. The extract was washed with saturated NH$_4$Cl, water, and brine prior to drying
and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (10:1) to give 28 (109 mg, 69%) as a colorless oil.

**General Procedure for Coupling Reaction of Alkyne 28 to 1-Pentanal. (Table 3, Entry 1).** nBuLi (1.5 M in hexane, 20.9 µL, 0.031 mmol) was added to a solution of 28 (13.1 mg, 0.031 mmol) in THF (0.3 mL) with stirring at −78 °C. After 5 min, 40 (3.3 µL, 0.031 mmol) was added to the mixture. The whole was stirred at the same temperature for 1h. The reaction was quenched with saturated NH₄Cl, and the mixture was extracted with EtOAc. The extract was washed with brine prior to drying and solvent evaporation. The residue was chromatographed on silica gel with hexane–EtOAc (10:1) to give 41 (3.2 mg, 20 %) as a colorless oil. ¹H NMR (300 MHz, CDCl₃): δ=0.03 (s, 3/4H), 0.07 (s, 3/4H), 0.15 (s, 9/4H H), 0.17 (s, 9/4H), 0.87–0.92 (m, 12H), 1.24 (d, 3H, J=6.7 Hz), 1.28–1.44 (m, 5H), 1.61–1.72 (m, 4H), 1.85–1.95 (m, 3/2H), 1.99–2.09 (m, 5/4H), 2.10–2.18 (m, 1H), 2.21–2.29 (m, 1H), 2.36 (dd, 1/2H, J=7.9, 4.3 Hz), 2.98 (dd, 5/4H, J=7.9, 4.9 Hz), 3.01 (dd, 5/4H, J=7.9, 4.9 Hz), 4.29 (m, 2H), 4.54 (dq, 3/4H, J=12.5, 6.1 Hz), 4.58–4.62 (m, 1/4H), 7.34–7.42 (m, 3H), 7.54–7.57 (m, 2H); ¹³C NMR (75 MHz, CDCl₃): (major) δ=−4.0, −3.9, 14.0, 14.3, 17.9, 21.3, 22.4, 25.9 (3C), 27.4, 36.9, 37.7, 39.6, 41.4, 55.0, 62.6, 68.4, 73.3, 82.3, 84.4, 129.0 (2C), 129.8, 130.2, 136.8 (2C), 177.3; IR (KBr): ν=3477, 1765 cm⁻¹; MS (FAB): m/z: 527 [M+Na]⁺. HRMS-FAB: [M+Na]⁺ calcd for C₂₈H₄₄NaO₄SSi 527.2627; found 527.2629.