Supporting Information

SYNTHESIS OF 1,5-DIOXASPIRO[3.4]OCTANE THROUGH BROMOCATION-INDUCED CASCADE CYCLIZATION

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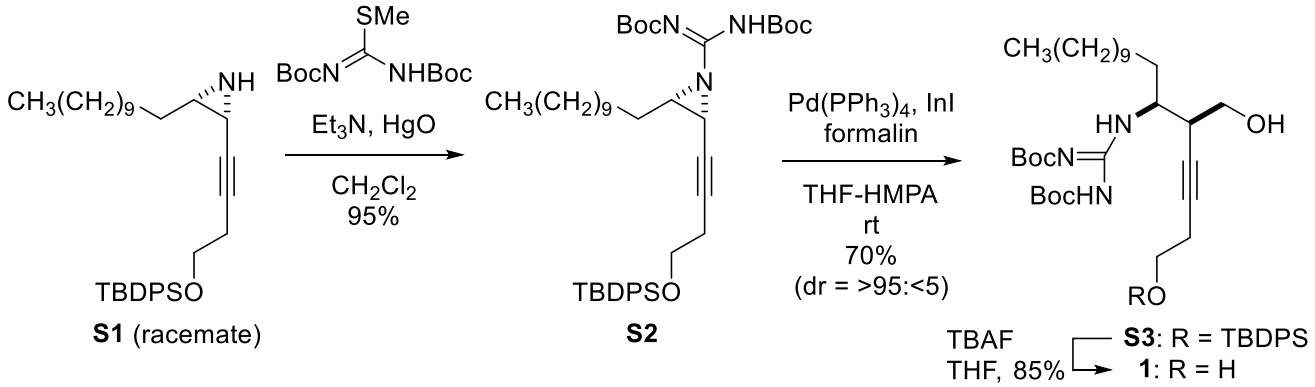
GENERAL

Infrared spectra (IR) were recorded on a JASCO FT/IR-8300 spectrophotometer and are reported in wave number (cm^{-1}). Proton nuclear magnetic resonance (^1H NMR) spectra were recorded on a Bruker Avance-400 (400 MHz) or a Varian Gemini-2000 (300 MHz) spectrometer. Chemical shifts of all compounds are reported in ppm relative to the residual undeuterated solvent (chloroform-*d* as $\delta = 7.26$ or benzene-d_4 as $\delta = 7.15$). Data were reported as follows: Chemical shift, integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, or br = broadened), coupling constant, and assignment. Carbon nuclear magnetic resonance (^{13}C NMR) spectra were recorded on a Bruker Avance-400 (400 MHz) or a Varian Gemini-2000 (300 MHz) spectrometer. Chemical shifts of all compounds are reported in ppm relative to the residual solvent (chloroform-*d* as $\delta = 77.0$ or benzene-d_4 as $\delta = 128.0$). All NMR were measured at 300 K. High-resolution mass spectra (HRMS) were recorded on an Applied Biosystems Mariner ESI-TOF spectrometer and reported in *m*/*z*.

Reactions were monitored by thin layer chromatography (TLC) on 0.25 mm silica gel coated glass plates $60F_{254}$ (Merck, #1.05715.0001). Visualization was achieved by using UV light (254 nm) and appropriate reagent (ethanolic phosphomolybdic acid or *p*-anisaldehyde solution in H_2SO_4/AcOH/EtOH), followed by heating. Silica gel 60 (particle size 0.063-0.200 mm, Merck, #1.07734.9025) was used for open-column chromatography. Silica gel 60N (spherical, neutral, particle size 0.04-0.05 mm, Kanto, #37563-79) was used for flash column chromatography. Aluminum oxide 90 (Merck, #1.01097.1000) was used for alumina column chromatography. Dry THF and CH_2Cl_2 were purchased from Kanto Chemical Co., Inc. HMPA, toluene and Et_3N were distilled from CaH_2. Celite® (Hyflo Super-Cel Celite®) was purchased from Nacalai tesque Co., Inc. InI (anhydrous, powder, 99.999%) was purchased from sigma-Aldrich. All other commercially available reagents were as received.



Guanidino-aziridine S2: Aziridine **S1** was synthesized according to our procedure.[1] To a solution of aziridine **S1** (101 mg, 0.199 mmol), di-Boc-methylisothiourea (63.5 mg, 0.219 mmol) and Et_3N (277 μL, 1.99 mmol) in CH_2Cl_2 (2.8 mL) was added HgO (47.4 mg, 0.219 mmol) at room temperature. After being stirred at room temperature for 12 h, the reaction mixture was filtered through a pad of Celite® (eluted with CH_2Cl_2), and then concentrated under reduced pressure. The residue was purified by flash column chromatography (hexane/EtOAc = 20/1 with 1% *i*-Pr_2NH) to afford guanidino-aziridine **S2** (141 mg, 95%) as a colorless oil.

IR (film): ν_{max} (cm^{-1}) 2927, 2855, 1764, 1649, 1598, 1111. ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 0.88 (3H, t, J = 6.5 Hz, -CH_2CH_3), 1.05 (9H, s, -Si-^{t}Bu), 1.18-1.43 (19H, m, -$CH_aH_b(CH_2)_9CH_3$), 1.48 (18H, s, -O-^{t}Bu), 2.12 (1H, m, -$CH_aH_b(CH_2)_9CH_3$), 2.48 (2H, td, J = 7, 1.5 Hz, -CHC≡CCH_2-), 2.65 (1H, ddd, J = 8.5, 6, 4 Hz, -C*H*CHC≡CCH_2-), 3.21 (1H, dt, J = 6, 1.5 Hz, -C*H*C≡CCH_2-), 3.76 (2H, t, J = 7 Hz, -CH_2OTBDPS), 7.35-7.45 (6H, m, -Si-Ph), 7.63-7.69 (4H, m, -Si-Ph), 10.96 (1H, br s, -N*H*Boc). ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 14.1, 19.1, 22.7, 23.0, 26.0, 26.8, 28.0, 28.3, 28.7, 29.3, 29.4, 29.50, 29.54, 29.6, 29.7, 31.9, 34.3, 46.7, 62.5, 75.8, 80.5, 81.1, 82.2, 127.7, 129.6, 133.5, 135.5, 148.7, 162.9. HR-MS (ESI, positive): calcd. For $C_{44}H_{68}N_3O_5Si$ $[M+H]^+$, 746.4923; found, 746.4949.

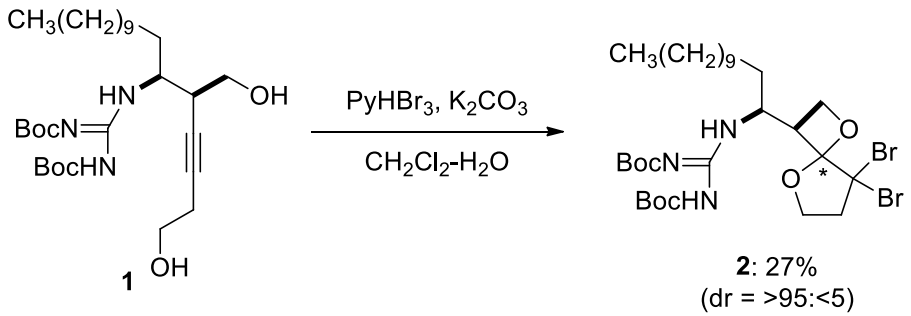
Alcohol S3: To a mixture of guanidino-aziridine **S2** (179 mg, 0.240 mmol), $Pd(PPh_3)_4$ (27.8 mg, 0.024 mmol) and InI (87.0 mg, 0.360 mmol) were added a degassed solution of THF/HMPA (2.5 mL, 4/1) and formalin (13 μl, 0.48 mmol, 30% solution in water) at room temperature under the argon atmosphere. After being stirred at room temperature for 4 h, the reaction mixture was passed through a short pad of flash silica gel (eluted with EtOAc with 1% *i*-Pr_2NH), and the resulting mixture was washed with water (20 mL x 3) and brine (20 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash column chromatography (hexane/EtOAc = 10/1 with 1% *i*-Pr_2NH) to afford alcohol **S3** (131 mg, 70%, dr = >95:<5 determined by ^1H NMR analysis) as a colorless oil.

IR (film): ν_{max} (cm^{-1}) 3318, 2927, 2856, 1721, 1648, 1613, 1131. ^1H NMR (400 MHz, $CDCl_3$): δ (ppm)

0.88 (3H, t, *J* = 6.5 Hz, -CH_2CH_3), 1.05 (9H, s, -Si-^{t}Bu), 1.19-1.34 (19H, m, -$CH_aH_b(CH_2)_9CH_3$), 1.46 (9H, s, -O-^{t}Bu), 1.49 (9H, s, -O-^{t}Bu), 2.04 (1H, m, -$CH_aCH_b(CH_2)_9CH_3$), 2.30 (1H, dq, *J* = 12, 2.5 Hz, -$CHCH_2OH$), 2.50 (2H, td, *J* = 7, 2.5 Hz, -$CH_2CH_2OTBDPS$), 3.53-3.68 (2H, m, -CH_2OH), 3.78 (2H, t, *J* = 7 Hz, -$CH_2OTBDPS$), 4.06 (1H, tdd, *J* = 11, 8.5, 7.5 Hz, -NHC*H*-), 5.24 (1H, br s, -O*H*), 7.35-7.44 (6H, m, -Si-Ph), 7.65-7.71 (4H, m, -Si-Ph), 8.22 (1H, d, *J* = 8.5 Hz, -N*H*(=NBoc)NHBoc), 11.45 (1H, br s, -N*H*Boc). ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 14.1, 19.1, 22.6, 23.0, 25.6, 26.7, 28.0, 28.1, 28.2, 29.2, 29.3, 29.3, 29.4, 29.6, 29.6, 31.9, 33.2, 41.1, 51.1, 61.7, 62.7, 79.5, 80.0, 80.5, 83.5, 127.6, 129.5, 133.6, 133.6, 135.5, 135.5, 153.1, 156.9, 162.7. HR-MS (ESI, positive): calcd. For $C_{45}H_{72}N_3O_6Si$ $[M+H]^+$, 778.5185; found, 778.5172.

Diol 1: To a solution of alcohol **S3** (143 mg, 0.184 mmol) in THF (1.8 mL) was added TBAF (275 μL, 0.276 mmol, 1.0 M solution in THF) at room temperature. After being stirred at room temperature for 1 h, the reaction was quenched with brine (10 mL). The resulting mixture was extracted with EtOAc (10 mL x 3). The combined organic layer was dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash column chromatography (hexane/EtOAc = 3/1 with 1% *i*-Pr_2NH) to afford diol **1** (84.0 mg, 85%) as a colorless oil.

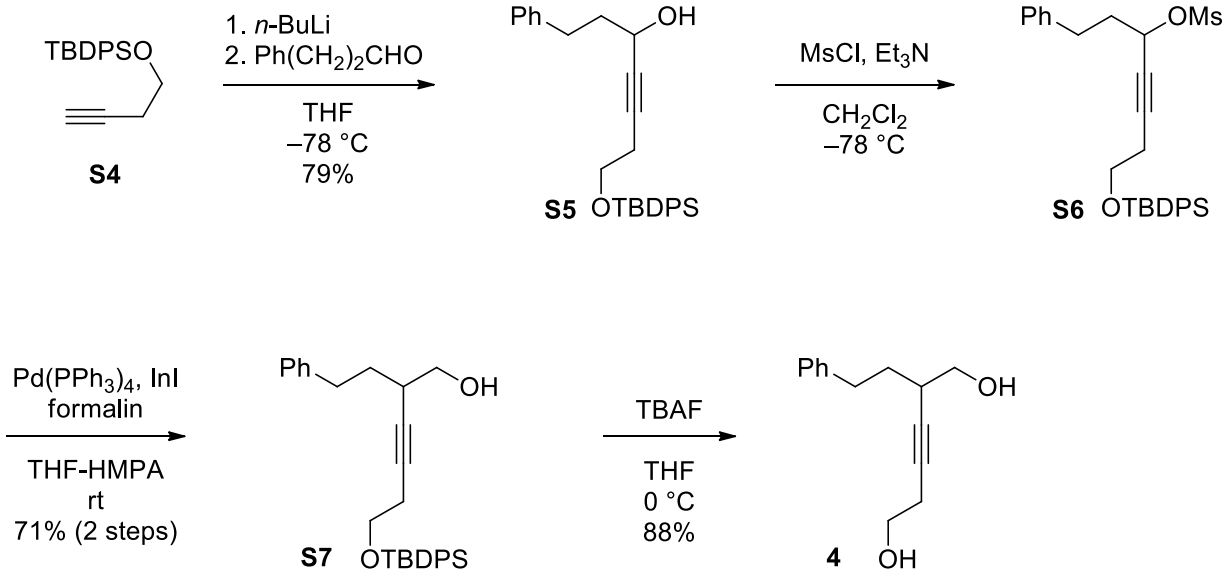
IR (film): ν_{max} (cm^{-1}) 3315, 2926, 2855, 1723, 1650, 1614, 1131. ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 0.87 (3H, t, *J* = 6.5 Hz, -CH_2CH_3), 1.20-1.37 (19H, m, -$CH_aH_b(CH_2)_9CH_3$), 1.45 (9H, s, -O-^{t}Bu), 1.50 (9H, s, -O-^{t}Bu), 1.96-2.07 (1H, m, -$CH_aCH_b(CH_2)_9CH_3$), 2.35 (1H, m, -$CHCH_2OH$), 2.47 (2H, td, *J* = 6, 2 Hz, -$CH_2CH_2OTBDPS$), 3.60 (1H, dd, *J* = 11.5, 2.5 Hz, -CH_aH_bOH), 3.66 (1H, dd, *J* = 11.5, 2.5 Hz, -CH_aH_bOH), 3.70 (2H, t, *J* = 6 Hz, -CH_2OH), 4.08 (1H, qd, *J* = 8.5, 2.5 Hz, -NHC*H*-), 8.27 (1H, d, *J* = 8.5 Hz, -N*H*(=NBoc)NHBoc), 11.44 (1H, br s, -N*H*Boc). ^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 14.1, 22.6, 23.3, 25.7, 28.0, 28.1, 29.3, 29.3, 29.3, 29.4, 29.6, 31.9, 33.0, 41.0, 51.2, 61.0, 61.8, 79.7, 80.8, 80.9, 83.7, 153.11, 156.9, 162.6. HR-MS (ESI, positive): calcd. For $C_{29}H_{54}N_3O_6$ $[M+H]^+$, 540.4007; found, 540.4003.



Spirocyclic oxetane 2: To a vigorously stirred mixture of diol **1** (20.6 mg, 0.0382 mmol) and K_2CO_3

(31.7 mg, 0.229 mmol) in CH_2Cl_2/H_2O (2 mL, 1/1) was added $PyHBr_3$ (36.6 mg, 0.114 mmol). After being stirred at room temperature for 30 min, to the reaction mixture were added K_2CO_3 (571 mg, 4.12 mmol) and $PyHBr_3$ (329 mg, 1.03 mmol). After being stirred at room temperature for 30 min, the reaction was quenched with sat. Na_2SO_3 solution (5 mL). The resulting mixture was partitioned, and the aqueous layer was extracted with EtOAc (10 mL x 2). The combined organic layer was washed with water (30 mL) and brine (30 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash column chromatography (hexane/EtOAc = 5/1 with 1% *i*-Pr_2NH) to afford oxetane **2** (7.1 mg, 27%) as a colorless oil.

IR (film): ν_{max} (cm^{-1}) 2925, 2854, 1719, 1636, 1613, 1154, 1124, 947. ^1H NMR (400 MHz, $CDCl_3$): δ (ppm) 0.88 (3H, t, J = 6.5 Hz, -CH_2CH_3), 1.20-1.37 (18H, m, -$CH_2(CH_2)_9CH_3$), 1.49 (9H, s, -O-^{t}Bu), 1.51 (9H, s, -O-^{t}Bu), 1.66 (1H, m, -$CH_aH_b(CH_2)_9CH_3$), 1.90 (1H, m, -$CH_aH_b(CH_2)_9CH_3$), 2.78 (1H, ddd, J = 14, 5, 2 Hz, -$CH_aH_bCBr_2$-), 2.91 (1H, dt, J = 14, 9.5 Hz, -$CH_aH_bCBr_2$-), 3.51 (1H, ddd, J = 9, 7.5, 5.5 Hz, -$CHCH_2O$-), 4.05-4.13 (3H, m, -$CHCH_2O$-, -$OCH_aH_bCH_2$-), 4.32 (1H, dd, J = 7.5, 5.5 Hz, -$OCH_aH_bCH_2$-), 4.81 (1H, m, -NHC*H*-), 8.33 (1H, br, -N*H*(=NBoc)NHBoc), 11.56 (1H, br s, -N*H*Boc). ^{13}C NMR (100 MHz, $CDCl_3$): δ(ppm) 1.01, 14.1, 22.7, 25.5, 27.2, 27.7, 27.9, 28.1, 28.2, 28.3, 28.4, 29.3, 29.5, 29.6, 29.6, 29.6, 29.7, 31.9, 32.1, 43.4, 44.3, 49.1, 65.0, 66.7, 66.9, 79.0, 82.9 113.1 153.2, 156.4, 164.0. HRMS (ESI, positive): calcd. For $C_{29}H_{52}N_3O_6Br_2$ $[M+H]^+$, 696.2217; found, 696.2249.



Propargyl alcohol S5: To a solution of alkyne **S4** (3.52 g, 11.4 mmol) in dry THF (60 mL) was added *n*-BuLi (1.60 M in hexane, 6.7 mL, 10.7 mmol) at –78 °C under N_2 atmosphere. After being stirred at –78 °C for 0.5 h, to the reaction mixture was added freshly distilled 3-phenylpropanal (1.0 mL, 7.6 mmol). After being stirred at –78 °C for 0.5 h, the reaction was quenched with sat. NH_4Cl solution (60 mL) and allowed to warm to room temperature. The resulting mixture was partitioned, and the aqueous layer was

extracted with EtOAc (60 mL x 2). The combined organic layer was washed with brine (120 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (hexane/CH_2Cl_2 = 1/1 to hexane/EtOAc = 4/1 to 1/4) to afford propargyl alcohol **S5** (2.66 g, 79%) as a colorless oil.

IR (film): ν_{max} (cm^{-1}) 3348, 2361, 1111. ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 1.08 (9H, s, -C(C*H*$_3$)$_3$), 1.94-2.03 (2H, m, PhCH$_2$C*H*$_2$-), 2.51 (2H, td, J = 7, 2 Hz, -C≡CC*H*$_2$-), 2.78 (2H, t, J = 8 Hz, PhC*H*$_2$-), 3.80 (2H, t, J = 7 Hz, -C*H*$_2$O-), 4.33 (1H, tt, J = 6.5, 2 Hz, -C*H*(OH)-), 7.16-7.23 (3H, m, Ph), 7.25-7.32 (2H, m, Ph), 7.36-7.48 (6H, m, Ph), 7.68-7.74 (4H, m, Ph). ^{13}C NMR (75 MHz, $CDCl_3$): δ (ppm) 19.1, 22.8, 26.7, 31.3, 39.4, 61.9, 62.4, 82.1, 82.9, 125.9, 127.7, 128.4, 128.5, 129.8, 133.6, 135.6, 141.5. HRMS (ESI, positive): calcd. For $C_{29}H_{34}O_2NaSi$ $[M+Na]^+$, 465.2220; found, 465.2231.

Alcohol S7: This reaction was performed according to the reported procedure.[2] To a solution of propargyl alcohol **S5** (1.32 g, 2.98 mmol) in dry CH_2Cl_2 (15 mL) were added dry Et_3N (0.85 mL, 6.10 mmol) and then MsCl (0.35 mL, 4.5 mmol) at –78 °C under N_2 atmosphere. After being stirred at –78 °C for 1.0 h, the reaction was quenched with sat. $NaHCO_3$ solution (15 mL) and allowed to warm to room temperature. The resulting mixture was partitioned, and the aqueous layer was extracted with CH_2Cl_2 (15 mL x 2). The combined organic layer was washed with brine (30 mL), and concentrated under reduced pressure. The residue was diluted with Et_2O (15 mL) and the resulting mixture was washed with H_2O (15 mL) and brine (15 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure to afford the crude mesylate **S6** (1.53 g) as a pale yellow oil, which was used in the next reaction without further purification.

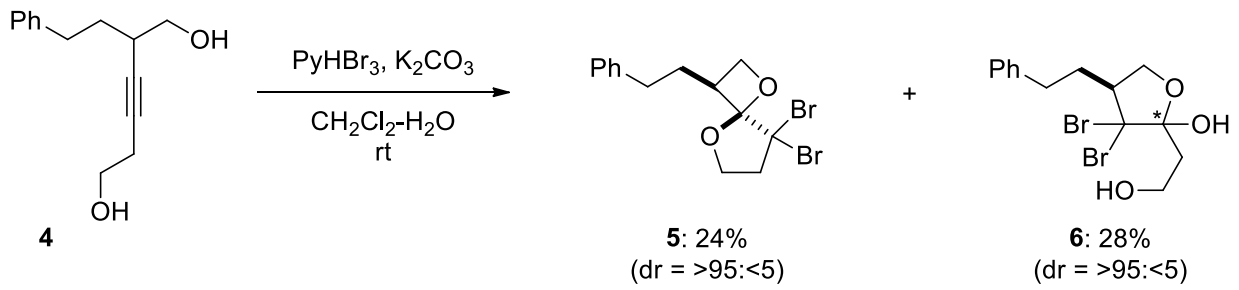
To a solution of the crude mesylate **S6** (1.53 g) in dry THF (9.6 mL) and dry HMPA (2.4 mL) were added $Pd(PPh_3)_4$ (155 mg, 0.134 mmol) and then InI (780 mg 3.23 mmol) at room temperature under Ar atmosphere. The resulting mixture was degassed by three freezed-thraw cycles, the flask was filled with Ar. After being stirred at room temperature for 3 h, the reaction was quenched with H_2O (15 mL). The resulting mixture was partitioned, and the aqueous layer was extracted with Et_2O (15 mL x 2). The combined organic layer was washed with brine (30 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (hexane/EtOAc = 9/1 to 4/1) to afford alcohol **S7** (971 mg, 71% in 2 steps) as a dark yellow oil.

IR (film): ν_{max} (cm^{-1}) 3420, 1112. ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 1.08 (9H, s, -C(C*H*$_3$)$_3$), 1.68-1.82 (3H, m, PhCH$_2$C*H*$_2$-, -O*H*), 2.46-2.60 (3H, m, -C*H*(CH$_2$OH)-, -C≡CC*H*$_2$-), 2.71 (1H, m, PhC*H*$_a$H$_b$-), 2.84 (1H, m, PhCH$_a$*H*$_b$-), 3.48-3.63 (2H, m, -C*H*$_2$OH), 3.80 (2H, t, J = 7 Hz, -C*H*$_2$O-), 7.15-7.23 (3H, m, Ph), 7.24-7.32 (2H, m, Ph), 7.36-7.49 (6H, m, Ph), 7.68-7.76 (4H, m, Ph). ^{13}C NMR

(75 MHz, $CDCl_3$): δ (ppm) 19.1, 22.9, 26.7, 33.0, 33.3, 34.9, 62.8, 65.6, 81.06, 81.12, 125.9, 127.7, 128.4, 128.5, 129.7, 133.7, 135.6, 141.8. HRMS (ESI, positive): calcd. For $C_{30}H_{36}O_2NaSi$ $[M+Na]^+$, 479.2377; found, 479.2364.

Diol 4: To a solution alcohol **S7** (946 mg, 2.07 mmol) in THF (20 mL) was added TBAF (1.0 M solution in THF, 3.2 mL, 3.20 mmol) at 0 °C under N_2 atmosphere. After being stirred at 0 °C for 2 h, the reaction was quenched with H_2O (20 mL) and allowed to warm to room temperature. The resulting mixture was partitioned, and the aqueous layer was extracted with Et_2O (20 mL x 2). The combined organic layer was washed with brine (40 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by silica gel column chromatography (hexane/EtOAc = 1/1 to 1/4) to afford diol **4** (398 mg, 88%) as a yellow oil.

IR (film): ν_{max} (cm^{-1}) 3348, 1041. ^1H NMR (300 MHz, $CDCl_3$): δ (ppm) 1.72-1.82 (2H, m, $PhCH_2CH_2$-), 1.82-1.92 (2H, br, -$CHCH_2OH$, -CH_2CH_2OH), 2.50 (2H, td, J = 6.5, 2 Hz, -$C{\equiv}CCH_2$-), 2.57 (1H, m, -$CH(CH_2OH)$-), 2.71 (1H, m, $PhCH_aH_b$-), 2.85 (1H, m, $PhCH_aH_b$-), 3.50-3.67 (2H, m, -$CH(CH_2OH)$-), 3.69-3.77 (2H, br, -CH_2CH_2OH), 7.16-7.22 (3H, m, Ph), 7.25-7.32 (2H, m, Ph). ^{13}C NMR (75 MHz, $CDCl_3$): δ (ppm) 23.0, 32.9, 33.3, 34.7, 61.2, 65.5, 80.3, 82.5, 125.9, 128.4, 128.5, 141.7. HRMS (ESI, positive): calcd. For $C_{14}H_{18}O_2Na$ $[M+Na]^+$, 241.1199; found, 241.1197.

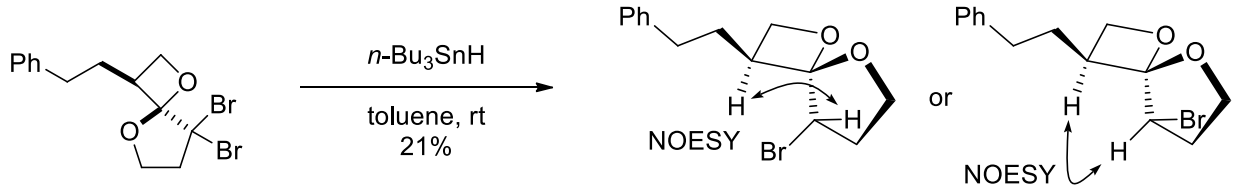


Cascade bromocyclization of diol 4: To a solution diol **4** (58.0 mg, 0.266 mmol) in CH_2Cl_2 (4 mL) and H_2O (4 mL) were added K_2CO_3 (258 mg, 1.87 mmol) and then $PyHBr_3$ (304 mg, 0.950 mmol) at room temperature. After being stirred at room temperature for 0.5 h, the reaction was quenched with sat. Na_2SO_3 solution (10 mL). The resulting mixture was partitioned, and the aqueous layer was extracted with CH_2Cl_2 (10 mL x 2). The combined organic layer was washed with H_2O (20 mL) and brine (20 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash column chromatography (hexane/CH_2Cl_2 = 2/1 with 1% pyridine to hexane/EtOAc = 2/1 with 1% pyridine) to afford spirocyclic oxetane **5** (36.9 mg, involving inseparable byproduct) and hemiketal **6** (29.2 mg, 28%, dr = >95:<5 determined by ^1H NMR analysis) as a yellow oil. To the mixture of spirocyclic oxetane **5** and byproduct were added CH_2Cl_2/$CHCl_3$ (10 mL, 1/1) at room temperature.

After being stirred at room temperature for 2.5 h, the solution was concentrated under reduced pressure. To the residue were added $CH_2Cl_2/CHCl_3$ (10 mL, 1/1) at room temperature again. After being stirred at room temperature for 2.5 h, the solution was concentrated under reduced pressure. The residue was purified by flash column chromatography (hexane/CH_2Cl_2 = 2/1 with 1% pyridine) to afford spirocyclic oxetane **5** (23.9 mg, 24%, dr = >95:<5 determined by ^{1}H NMR analysis) as a colorless oil.

Spirocyclic oxetane 5: IR(film): ν_{max} (cm^{-1}) 1018, 946. ^{1}H NMR (400 MHz, C_6D_6): δ (ppm) 1.97 (1H, m, $PhCH_2CH_aH_b$-), 2.15-2.26 (2H, m, $PhCH_2CH_aH_b$-, -$CBr_2CH_aH_b$-), 2.35 (1H, m, $PhCH_aH_b$-), 2.53 (1H, m, $PhCH_aH_b$-), 2.59 (1H, ddd, J = 14, 10, 9 Hz, -$CBr_2CH_aH_b$-), 3.26 (1H, m, -$CH_2CH(CH_2$-)-), 3.50 (1H, td, J = 8.5, 1.5 Hz, -$OCH_aH_bCH_2$-), 3.57-3.64 (2H, m, -$OCH_aH_bCH_2$-, -$OCH_aH_bCH(CH_2$-)-), 4.11 (1H, dd, J = 7.5, 5 Hz, -$OCH_aH_bCH(CH_2$-)-), 7.00-7.07 (3H, m, Ph), 7.10-7.15 (2H, m, Ph). ^{13}C NMR (100 MHz, C_6D_6): δ (ppm) 31.7, 34.2, 41.5, 44.3, 66.5, 68.5, 69.0, 115.1, 126.8, 129.2, 129.3, 142.7. HRMS (ESI, positive): calcd. For $C_{14}H_{16}O_2NaBr_2$ $[M+Na]^+$, 396.9409; found, 396.9420.

Hemiketal 6: IR (film): ν_{max} (cm^{-1}) 3373, 1071. ^{1}H NMR (400 MHz, C_6D_6): δ (ppm) 1.82 (1H, m, $PhCH_2CH_aH_b$-), 2.23-2.47 (5H, m, $PhCH_2CH_aH_b$-, $PhCH_2$-, -CH_2CH_2OH), 3.17 (1H, qd, J = 9, 2.5 Hz, -$CH_2CH(CH_2$-)-), 3.44 (1H, t, J = 8 Hz, -OCH_aH_b-), 3.50 (1H, m, -CH_aH_bOH), 3.81 (1H, td, J = 9.5, 3.5 Hz, -CH_aH_bOH), 3.85 (1H, t, J = 8 Hz, -OCH_aH_b-), 6.04 (1H, br, -OH), 6.94-6.98 (2H, m, Ph), 7.01-7.15 (3H, m, Ph). ^{13}C NMR (100 MHz, C_6D_6): δ (ppm) 32.3, 33.9, 36.0, 51.1, 59.3, 70.1, 78.5, 108.1, 126.4, 128.5, 128.7, 141.6. HRMS (ESI, positive): calcd. For $C_{14}H_{18}O_3NaBr_2$ $[M+Na]^+$, 414.9515; found, 414.9514.



5 (dr = >95:<5) **8** (dr = >95:<5)

Monobromo compound 8: To a solution spirocyclic oxetane **5** (12.2 mg, 32.4 μmol) in dry toluene (1 mL) was added n-Bu_3SnH (45 μL, 0.167 mmol) at room temperature under Ar atmosphere. The resulting mixture was degassed by three freezed-thraw cycles, the flask was filled with Ar. After being stirred at room temperature for 3 h, the reaction was quenched with 10% KF solution (2 mL) and then the resulting mixture was filtered through a pad of Celite® (eluted with EtOAc). The aqueous layer was extracted with EtOAc (10 mL x 2). The combined organic layer was washed with H_2O (20 mL) and brine (20 mL), dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue

was purified by alumina column chromatography (hexane/Et_2O = 9/1) to afford monobromo compound **8** (2.0 mg, 21%, dr = >95:<5 determined by ^1H NMR analysis) as a colorless oil.

IR (film): ν_{max} (cm^{-1}) 1173, 940. ^1H NMR (400 MHz, C_6D_6): δ (ppm) 1.66 (1H, m, -CHBrC$H_a$$H_b$-), 1.78 (1H, m, $PhCH_2CH_aH_b$-), 1.98-2.08 (2H, m, -$CHBrCH_aH_b$-, $PhCH_2CH_aH_b$-), 2.20-2.35 (2H, m, PhCH_2-), 2.80 (1H, tt, J = 7.5, 6 Hz, -$CH_2CH(CH_2)$-), 3.19 (1H, ddd, J = 9, 8.5, 7 Hz, -$CHBrCH_2CH_aH_bO$-), 3.28 (1H, dd, J = 11, 7.5 Hz, -C*H*Br-), 3.68 (1H, td, J = 8.5, 2.5 Hz, -$CHBrCH_2CH_aH_bO$-), 3.80 (1H, dd, J = 6, 5 Hz, -$OCH_aH_bCH(CH_2)$-), 4.19 (1H, dd, J = 7.5, 5 Hz, -$OCH_aH_bCH(CH_2)$-), 6.98-7.02 (2H, m, Ph), 7.03-7.08 (1H, m, Ph), 7.11-7.15 (2H, m, Ph). ^{13}C NMR (100 MHz, C_6D_6): δ (ppm) 30.6, 32.3, 33.9, 40.5, 51.3, 65.8, 69.2, 111.7, 126.3, 128.6, 128.7, 142.1. HRMS (ESI, positive): calcd. For $C_{14}H_{17}O_2NaBr$ $[M+Na]^+$, 319.0304; found, 319.0319.

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