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Supporting Material

3,6-Di-*O*-benzyl-D-glucal (14)

Tri-*O*-acetyl-D-glucal (from Aldrich) (9.31 g, 34.2 mmol) dissolved in anhydrous methanol (100 mL) was treated with NaOMe (0.5 mL, 25 wt % in MeOH) at 0°C and stirred overnight at room temperature under nitrogen atmosphere. Evaporation of the solvent *in vacuo* followed by flash column chromatography using 20:1-10:1 EtOAc/MeOH gave white crystalline, hygroscopic solid which was directly subjected for the next reaction after azeotropically dried using toluene and MeOH and put under vacuum for 2h.

The D-glucal thus obtained and bis(tributyltin) oxide (19.1 mL, 1.05 mol eq) in dry benzene (150 mL) were refluxed for 20h under Dean-Stark trap. The reaction was cooled to room temperature, treated with benzyl bromide (14.0 mL, 3.4 mol eq) and TBABr (25 g, 2.3 mol eq), and refluxed for 24h. The reaction was cooled, concentrated *in vacuo*, dissolved in water (200 mL) and extracted with EtOAc (3×200 mL). The collected organic washings were dried over Na_2SO_4 and concentrated. Flash chromatography using hexane (to remove tin residue) and 10%-15% EtOAc in hexane gave **14**(9.54 g, 86%) as colorless oil.

$[\alpha]^{23}_D$ -25.0° (c 5.7, $CHCl_3$); FTIR ($CHCl_3$ film) 3432, 1646, 1453, 1234, 1096 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.34-7.25 (10H, m), 6.37 (1H, dd, J=6.1, 1.4 Hz), 4.82 (1H, dd, J=6.2, 2.3 Hz), 4.67 (1H, d, J=11.8 Hz), 4.61-4.53 (3H, m), 4.08-4.05 (1H, m), 3.98-3.94 (2H, m), 3.81-3.75 (2H, m), 2.63 (1H, d, J=3.1 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 138.3, 137.7, 128.4 (two peaks), 127.7 (two peaks), 100.0, 76.9, 76.2, 73.6, 70.7, 69.1, 68.8; HRMS calcd for $C_{20}H_{26}NO_4$ ($M+NH_4^+$) 344.1862, found 344.1841.

Synthesis of lactal carbonate 16

To a solution of the lactal carbonate **15**[9] (3.82 g, 5.70 mmol) and BnBr (1.02 mL, 8.55 mmol) at 0°C was added NaH (340 mg, 60% dispersion in oil, 8.55 mmol). The resulting mixture was stirred at 0°C for 2h, slowly warmed to room temperature and stirred overnight. It was diluted with EtOAc (100 mL), poured into ice water (100 mL), and neutralized with NH_4Cl. The aqueous layer was extracted with 1:1 hexane/EtOAc (2×100 mL). The combined organic phases were washed with brine, dried over $MgSO_4$, and concentrated under reduced pressure. Flash column chromatography using 9:1-7:1 hexane/EtOAc provided **16** (3.91 g, 90%) as a colorless oil.

$[\alpha]^{25}_D$ -17.1° (c 0.36, $CHCl_3$); FTIR (neat) 2942, 2866, 1810, 1651, 1454, 1371, 1240, 1100, 882, 737, 697 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.35-7.25 (15H, m), 6.41 (1H, d, J=6.0 Hz), 4.88 (1H, d, J=5.5 Hz), 4.86-4.84 (1H, m), 4.65-4.58 (4H, m), 4.57 (1H, d, J=12.2 Hz), 4.46 (1H, d, J=11.4 Hz), 4.17-4.13 (2H, m), 4.11-4.09 (1H, m), 3.89 (1H, dd, J=11.0, 4.7 Hz), 3.84 (1H, d, J=5.1 Hz), 3.82 (1H, d, J=1.6 Hz), 3.74 (1H, dd, J=5.5, 1.7 Hz), 3.68 (1H, dd, J=11.0, 2.8 Hz), 3.58 (1H, dd, J=5.5, 4.7 Hz), 1.08-1.00 (21H, m); ^{13}C NMR (100 MHz, $CDCl_3$) δ 154.06, 144.56, 138.55, 138.04, 137.01, 128.51, 128.37, 128.25, 128.13, 127.97, 127.77, 127.69, 127.52, 127.44, 100.28, 99.32, 77.06, 76.52, 75.91, 73.81, 73.73, 73.60, 73.49, 73.37, 71.23, 70.62, 67.93, 61.31, 17.89, 17.85, 11.96; HRMS (FAB) calcd for $C_{43}H_{56}O_{10}SiNa$ ($M+Na^+$) 783.3541, found 783.3545.

Synthesis of lactal carbonate 18

To a solution of **16** (3.91 g, 5.14 mmol) in THF (25 mL) were added glacial AcOH (1.77 mL, 30.9 mmol) and TBAF (46 mL, 1 M in THF). After stirred overnight, the reaction mixture was diluted with EtOAc, poured into ice, neutralized with $NaHCO_3$ solution

(100 mL), and extracted with 1:1 hexane/EtOAc solution (3×100 mL). Collected extracts were washed with brine, dried over $MgSO_4$, and evaporated solvent *in vacuo*. Flash column chromatography on silica gel using 60:40:1 hexane/EtOAc/MeOH gave **17** (2.79 g, 90%).

^1H NMR (400 MHz, $CDCl_3$) δ 7.37-7.25 (15H, m), 6.41 (1H, d, J=5.9 Hz), 4.86 (1H, dd, J=6.1, 1.6 Hz), 4.79 (1H, d, J=6.2 Hz), 4.68-4.60 (5H, m), 4.50 (2H, AB, J=12.1 Hz, Δν=55.3 Hz, OCH_2Ar), 4.22-4.20 (1H, bum), 4.16-4.12 (2H, m), 4.02-4.00 (1H, bum), 3.86 (1H, dd, J=11.0, 4.0 Hz), 3.72-3.62 (4H, m), 3.56 (1H, t, J=4.9 Hz), 2.12 (1H, app d, J=6.4 Hz); LRMS (CI) calcd for $C_{34}H_{40}NO_{10}$ ($M+NH_4^+$) 622, found 622.

A solution of **17** (2.79 g, 4.61 mmol) and BnBr (710 μL, 5.99 mmol) at 0°C was treated with NaH (239 mg, 60% dispersion in oil, 5.99 mmol) and slowly warmed to room temperature to be stirred overnight. The reaction mixture was poured into ice after diluted with EtOAc, neutralized with NH_4Cl solution (100 mL), and extracted with 1:1 hexane/EtOAc (3×100 mL). The combined organic phases were washed with brine, dried over $MgSO_4$, and concentrated under reduced pressure. Flash chromatography using 4:1 hexane/EtOAc afforded **18** (2.59 g, 81%).

$[\alpha]^{25}_D$ -19.4° (c 3.02, $CHCl_3$); FTIR (neat) 3064, 3031, 2871, 1809, 1650, 1497, 1454, 1368, 1247, 1209, 1170, 1098, 1039, 738, 698 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.34-7.26 (20H, m), 6.41 (1H, d, J=5.9 Hz, H1), 4.91 (1H, d, J=5.2 Hz, H1'), 4.87 (1H, br d, J=3.7 Hz, H2), 4.78 (1H, dd, J=7.8, 1.5 Hz, H4'), 4.67-4.55 (6H, m), 4.48-4.44 (3H, m), 4.16-4.15 (2H, m, H3, H5), 4.11-4.10 (1H, m, H4), 3.90 (1H, td, J=7.8, 1.3 Hz, H5'), 3.86 (1H, dd, J=10.9, 4.7 Hz, H6), 3.69 (1H, dd, J=10.9, 2.6 Hz, H6), 3.62-3.58 (3H, m, 2H6', H2'); ^{13}C NMR (125 MHz, $CDCl_3$) δ 154.36, 144.97, 139.07, 138.46, 137.97, 137.34, 128.94, 128.87, 128.81, 128.69, 128.59, 128.36, 128.30, 128.18, 128.08,

127.88 (two unresolved aromatic carbons), 100.56, 99.77, 76.76, 76.40, 74.48, 74.27, 74.06, 73.91, 73.82, 70.90, 70.10, 68.52, 68.37 (two unresolved carbons); HRMS (FAB) calcd for $C_{41}H_{42}O_{10}Na$ ($M+Na^+$) 717.2676, found 717.2706.

3,6,2',6'-Tetra-*O*-benzyl-D-lactal (19)

The lactal carbonate **18** (2.59 g, 3.72 mmol) was dissolved in MeOH (20 mL) and treated with K_2CO_3 (257 mg, 1.86 mmol) to be stirred overnight. After evaporation of the solvent the mixture was partioned between EtOAc (100 mL) and NH_4Cl solution (100 mL). The aqueous layer was extracted with 1:1 hexane/EtOAc (2×100 mL). The combined organic phases were washed with brine, dried over $MgSO_4$, and concentrated under rotary evaporator. Flash column chromatography using 60:30:1 hexane/EtOAc/MeOH provided **19** (2.21 g, 89%).

$[\alpha]^{25}_D$ -0.67° (c 4.30, $CHCl_3$); FTIR (neat) 3443, 2867, 1651, 1497, 1453, 1247, 1070, 737, 697 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.42-7.31 (20H, m), 6.52 (1H, d, J=6.2 Hz), 4.97-4.93 (2H, m), 4.70-4.55 (8H, m), 4.40-4.39 (1H, m), 4.29 (1H, t, J=4.5 Hz), 4.22 (1H, t, J=3.9 Hz), 3.95-3.92 (2H, m), 3,77-3.74 (2H, m), 3.70 (1H, dd, J=10.4, 5.8 Hz), 3.55-3.54 (3H, m), 3.02 (1H, d, J=3.2 Hz), 2.95 (1H, s); ^{13}C NMR (125 MHz, $CDCl_3$) δ 145.06, 139.16, 138.84, 138.47, 138.33, 128.98, 128.95, 128.89, 128.80, 128.77, 128.34, 128.28, 128.22, 128.17, 128.05, 127.95 (one unresolved aromatic carbon), 102.99, 100.04, 79.48, 77.94, 77.69, 77.44, 76.20, 75.13, 74.06, 73.78, 73.73, 73.70, 73.50, 72.21, 70.42, 69.74, 69.39, 68.36; HRMS (FAB) calcd for $C_{40}H_{44}O_9Na$ ($M+Na^+$) 691.2883, found 691.2910.

3,6,2',3',6'-Penta-*O*-benzyl-D-lactal (20)

A mixture of **19** (1.20 g, 1.80 mmol) and bis (tributyltin) oxide (0.50 mL, 0.90 mmol) in anhydrous toluene (18 mL) under argon atmosphere was refluxed under a Dean-Stark trap for 5h. Cooling of the solution to room temperature was followed by addition of BnBr (320 μL, 2.69 mmol) and catalytic TBAI and the mixture was refluxed overnight. After concentration under rotary evaporator the residue was subjected to flash chromatography using 9:1-4:1 hexane/EtOAc to afford **20** (1.36 g, quant.) as a clear oil.

$[\alpha]^{25}_D$ -1.22° (c 3.20, $CHCl_3$); FTIR (neat) 3471, 3029, 2867, 1651, 1497, 1453, 1365, 1247, 1098, 1028, 737, 698 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.35-7.21 (25H, m), 6.45 (1H, d, J=6.2 Hz), 4.88 (1H, dd, J=6.2, 3.9 Hz), 4.83 (1H, d, J=10.9 Hz), 4.69 (2H, app s), 4.68 (1H, d, J=10.9 Hz), 4.59 (2H, app s), 4.55 (1H, d, J=7.8 Hz), 4.49 (2H, app s), 4.47 (2H, app s), 4.29 (1H, dd, J=9.6, 5.8 Hz), 4.18 (1H, t, J=4.4 Hz), 4.13 (1H, m), 3.99 (1H, br s), 3.85 (1H, dd, J=10.6, 6.4 Hz), 3.75-3.60 (4H, m), 3.47-3.41 (2H, m); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.43, 138.64, 138.42, 137.99, 137.84, 137.80, 128.40, 128.34, 128.26, 128.23, 128.18, 128.15, 127.82, 127.75, 127.69, 127.67, 127.65, 127.55, 127.51, 127.46, 127.31, 102.56, 99.56, 80.57, 78.69, 75.72, 75.10, 73.57, 73.32, 73.13, 72.94, 72.28, 71.94, 70.12, 68.90, 67.85, 66.62; HRMS (FAB) calcd for $C_{47}H_{50}O_9Na$ ($M+Na^+$) 781.3352, found 781.3374.

Synthesis of the disaccharide glycal 30

A solution of **10** (297 mg, 0.458 mmol) and benzyl bromide (165 μL, 1.37 mmol) in anhydrous DMF (4.0 mL) at 0°C was treated with sodium hydride (55 mg, 1.37 mmol), slowly warmed to room temperature and stirred for 18h. The mixture was poured into icy NH_4Cl solution (40 mL) and extracted with 2:1 hexane/EtOAc (3x40 mL). The extract was washed with brine, dried over $MgSO_4$, and concentrated. Flash

chromatography using 9:1 hexane/EtOAc gave **30** (309 mg, 82%).

$[\alpha]^{20}_D$ +34.2° (c 0.21, $CHCl_3$); FTIR (neat) 3029, 2942, 2866, 1804, 1648, 1460, 1383, 1347, 1235, 1165, 1107, 1036, 882, 778, 734, 693, 655 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.37-7.20 (10H, m), 6.39 (1H, dd, J=6.3, 1.6 Hz), 4.85 (1H, dd, J=7.6, 1.5 Hz), 4.82 (2H, AB, J=12.1 Hz, Δν=104 Hz, OCH_2Ar), 4.80-4.74 (4H, m), 4.62-4.59 (2H. m), 4.03-4.02 (1H, bum), 3.98-3.94 (3H, m), 3.88-3.77 (3H, m), 3.56 (1H, t, J=5.3 Hz), 1.08-1.03 (42H, m); ^{13}C NMR (75 MHz, $CDCl_3$) δ 153.95, 144.95, 138.91, 137.12, 128.50, 128.14, 128.09, 127.91, 127.98, 127.34, 99.84, 98.79, 77.87, 77.77, 77.20, 74.26, 74.04, 74.00, 72.13, 71.78, 71.35, 61.92, 61.55, 17.95, 17.90, 17.88, 11.88, 11.85; HRMS (FAB) calcd for $C_{45}H_{70}O_{10}Si_2K$ ($M+K^+$) 865.4144, found 865.4173.

Synthesis of ehtanethiosulfonamide 32

To a stirred mixture of glycal **30** (893 mg, 1.08 mmol), benzenesulfonamide (509 mg, 3.24 mmol), and flame-dried powdered 4Å MS (900 mg) in dry CH_2Cl_2 (10 mL) at 0°C was added I(*sym*-coll)$_2ClO_4$ (1.77 g, 3.78 mmol) in one portion. The resulting reaction was stirred in the dark for 30 min before quenched with saturated $Na_2S_2O_3$ solution (10 mL). The mixture was filtered through a celite pad, washed with saturated $Na_2S_2O_3$ solution and $CuSO_4$ solution, dried over $MgSO_4$, and concentrated. Flash chromatography using 6:1 hexane/EtOAc provided **31** (896 mg, 80%).

^1H NMR (400 MHz, $CDCl_3$) δ 7.92 (2H, d, J=8.2 Hz), 7.58 (1H, t, J=8.2 Hz), 7.49 (2H, t, J=8.2 Hz), 7.38-7.20 (10H, m), 5.69 (1H, dd, J=7.4, 2.7 Hz), 5.50 (1H, d, J=7.9 Hz), 5.00 (1H, d, J=4.1 Hz), 4.96-4.87 (3H, m), 4.79 (1H, dd, J=7.8, 4.0 Hz), 4.72 (1H, d, J=11.4 Hz), 4.44 (1H, d, J=12.1 Hz), 4.29 (1H, t, J=3.9 Hz), 3.99-3.77 (6H, m), 3.74 (1H, t, J=4.2 Hz), 3.66-3.63 (1H, m), 3.28 (1H, dd, J=9.0, 5.7 Hz), 1.13-0.98 (42H, m); LRMS

(CI) calcd for $C_{51}H_{80}O_{12}N_2SSi_2I$ ($M+NH_4^+$) 1128, found 1128.

To a solution of ehtanethiol (202 μL, 2.73 mmol) in anhydrous DMF (2.5 mL) at -40°C were added LHMDS (1.09 mL, 1.0 M in THF) and a solution of iodosulfonamide **31** (606 mg, 0.546 mmol) in DMF (3.0 mL). The reaction was stirred for 1h at -40°C and for 2h at room temperature. After diluted with EtOAc (100 mL), it was washed with saturated NH_4Cl solution (50 mL) and brine, dried over $MgSO_4$, and concentrated. Purification by flash column chromatography yielded **32** (476 mg, 84%).

$[\alpha]^{23}_D$ -25.0° (c 1.26, $CHCl_3$); FTIR (neat) 3286, 2943, 2866, 1809, 1784, 1464, 1382, 1328, 1257, 1163, 1094, 1030, 998, 915, 882, 796, 733, 690, 656, 596 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.89 (2H, d, J=7.7 Hz), 7.56-7.23 (13H, m), 5.27 (1H, d, J=3.4 Hz), 5.00 (1H, d, J=11.8 Hz), 4.89-4.81 (3H, m), 4.76-4.73 (2H, m), 4.61 (1H, d, J=11.8 Hz), 4.47 (1H, d, J=10.3 Hz), 4.06 (1H, dd, J=10.2, 2.4 Hz), 4.01-3.97 (2H, m), 3.94-3.89 (3H, m), 3.76-3.62 (3H, m), 3.46 (1H, t, J=6.4 Hz), 2.38-2.27 (2H, m), 1.16-1.07 (21H, m), 1.05-0.99 (21H, m); ^{13}C NMR (125 MHz, $CDCl_3$) δ 153.99, 141.22, 139.27, 137.54, 132.56, 128.69, 128.48, 127.98, 127.96, 127.75, 127.44, 127.08, 103.46, 83.14, 82.21, 79.29, 76.28, 76.08, 75.81, 74.62, 73.64, 73.49, 71.57, 61.97, 61.17, 56.41, 23.80, 17.92, 17.91, 17.89, 14.30, 11.84, 11.82 (one unresolved aromatic resonance); HRMS (FAB) calcd for $C_{58}H_{81}O_{12}NS_2Si_2K$ ($M+K^+$) 1066.4640, found 1066.4620.

Synthesis of the tetrasaccharides 37 and 41

To a solution of **35** (54 mg, 0.030 mmol) in dry THF (0.3 mL) was added glacial AcOH (24 μL, 0.42 mmol) and TBAF (635 μL, 1.0 M in THF). The resulting solution was stirred overnight and worked up as above. Flash column chromatography using 20:10:1 hexane/EtOAc/MeOH gave the desilylated methylglycoside **36** (45 mg, quant.).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80-7.78 (2H, m), 7.38-7.14 (37H, m), 6.95 (1H, app t, J=7.2 Hz), 5.80 (1H, d, J=4.2 Hz), 5.08 (1H, s), 5.02-4.78 (6H, m), 4.65-4.57 (4H, m), 4.44 (1H, d, J=11.6 Hz), 4.36 (1H, d, J=12.1 Hz), 4.27-4.24 (4H, m), 4.15 (1H, d, J=8.1 Hz), 4.10-4.07 (2H, m), 3.94-3.80 (5H, m), 3.77-3.63 (6H, m), 3.59-3.55 (1H, m), 3.56 (3H, s), 3.50-3.33 (6H, m), 3.31 (1H, dd, J=9.5, 3.4 Hz), 3.14-3.09 (2H, m), 2.53-2.49 (3H, m); LRMS (FAB) calcd for $C_{81}H_{89}O_{23}NSNa$ ($M+Na^+$)1498, found1498.

To liquid ammonia (~5mL) at -78°C was added Na (80 mg) and a solution of the above desilylated methylglycoside (37 mg, 0.023 mmol) in dry THF (0.5 mL). The resulting dark blue solution was allowed to reflux at -33°C for 30 min. Cooled to -78°C, added MeOH (2 mL) and stirred overnight at room temperature. The reaction was neutralized by adding Dowex 50×8-200 ion exchange resin (from Aldrich), filtered, and washed with ammonia solution in MeOH. Filtrate was concentrated, put under vacuum for a while, and treated with anhydrous pyridine (1.5 mL) and Ac_2O (0.5 mL) at 0°C to be stirred overnight at room temperature. The reaction was poured into ice water (10 mL) and extracted with EtOAc (3×10 mL). Collected organics were washed with saturated $CuSO_4$ solution, dried over $MgSO_4$, and concentrated *in vacuo*. Flash column chromatography using 10:20:1 hexane/EtOAc/MeOH gave peracetylated β-methylglycoside of asialo GM_1 **37** (24 mg, 80% overall) as a white solid.

$[\alpha]^{18}_D$ +1.65° (c 0.48, $CHCl_3$); FTIR (neat) 3369, 1746, 1673, 1555, 1434, 1372, 1232, 1170, 1131, 1049, 956, 904, 756, 602 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.80 (1H, d, J=6.6 Hz, NH), 5.40 (1H, d, J=3.2 Hz, H4''), 5.36 (1H, d, J=3.3 Hz, H4'''), 5.21-5.17 (2H, m, H2', H3), 5.05 (1H, dd, J=10.4, 7.9 Hz, H2'''), 5.05 (1H, d, J=8.3 Hz, H1''), 4.99 (1H, dd, J=11.0, 3.4 Hz, H3''), 4.98 (1H, dd, J=10.5, 3.5 Hz, H3'''), 4.94 (1H, dd, J=9.6, 8.0 Hz, H2), 4.83 (1H, dd, J=10.5, 2.6 Hz, H3'), 4.59 (1H, d, J=7.8 Hz, H1'''), 4.49 (1H, dd,

J=11.9, 1.8 Hz, H6), 4.43 (1H, d, J=7.8 Hz, H1'), 4.39 (1H, d, J=7.9 Hz, H1), 4.25 (1H, dd, J=11.7, 5.5 Hz, H6'), 4.16-4.10 (6H, m, H6, H4', H6', H6", 2H6'"), 3.90 (1H, dd, J=11.5, 6.8 Hz, H6"), 3.83 (1H, t, J=6.8 HZ, H5'"), 3.80-3.73 (2H, m, H4, H5"), 3.68 (1H, t, J=6.0 Hz, H5'), 3.59 (1H, ddd, J=7.0, 5.2, 1.9 Hz, H5), 3.47 (3H, s, CH_3O), 3.04 (1H, ddd, J=10.9, 8.0, 6.7 Hz, H2"), 2.14 (3H, s, CH_3CO), 2.11 (3H, s, CH_3CO), 2.11 (3H, s, CH_3CO), 2.09 (3H, s, CH_3CO), 2.08 (3H, s, CH_3CO), 2.07 (3H, s, CH_3CO), 2.06 (3H, s, CH_3CO), 2.06 (3H, s, CH_3CO), 2.05 (3H, s, CH_3CO), 2.01 (3H, s, CH_3CO), 1.96 (3H, s, CH_3CO), 1.92 (3H, s, CH_3CO); ^{13}C NMR (75 MHz, $CDCl_3$) δ 172.13, 172.11, 170.77, 170.56, 170.49, 170.47, 170.33, 170.06, 169.71, 169.52, 169.32, 169.30, 169.28, 101.52, 100.95, 100.21, 98.15, 77.21, 75.60, 73.52, 72.83, 72.67, 72.38, 72.03, 71.32, 71.11, 70.88, 70.63, 69.68, 69.03, 68.95, 66.86, 62.76, 62.48, 62.02, 61.02, 56.97, 55.63, 23.58, 20.82, 20.78, 20.74, 20.72, 20.68, 20.66, 20.63, 20.54, 20.50 (two unresolved carbons); HRMS (FAB) calcd for $C_{51}H_{71}O_{33}NNa$ ($M+Na^+$) 1248.3810, found 1248.3840.

Compound **41** was prepared in an identical fashion from **39**.

For **41**: $[\alpha]^{19}_D$ +42.6° (c 1.04, $CHCl_3$); FTIR (neat) 3601, 2941, 1750, 1675, 1534, 1433, 1371, 1229, 1168, 1132, 1050, 908, 755, 602 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 6.34 (1H, d, J=7.2 Hz), 5.49 (1H, dd, J=2.9, 1.3 Hz), 5.38 (1H, dd, J=3.3, 0.9 Hz), 5.19-5.10 (3H, m, H2', H3), 5.07 (1H, d, J=3.4 Hz), 5.01 (1H, dd, J=10.4, 3.4 Hz), 4.89 (1H, dd, J=10.8, 2.8 Hz), 4.84 (1H, dd, J=9.3, 7.9 Hz), 4.73 (1H, d, J=7.8Hz), 4.53 (1H, d, J=7.8Hz, H3'), 4.48-4.35 (5H, m), 4.20-4.03 (6H, m), 3.98 (1H, dd, J=11.4, 6.0 Hz), 3.95 (1H, t, J=6.7 HZ), 3.89 (1H, dd, J=11.0, 7.6 Hz), 3.81-3.73 (2H, m), 3.60 (1H, ddd, J=7.2, 5.2, 1.9 Hz), 3.47 (3H, s, CH_3O), 2.14 (3H, s, CH_3CO), 2.11 (3H, s, CH_3CO), 2.10 (3H, s, CH_3CO), 2.10 (3H, s, CH_3CO), 2.08 (3H, s, CH_3CO), 2.06 (3H, s, CH_3CO),

2.04 (3H, s, CH_3CO), 2.04 (3H, s, CH_3CO), 2.04 (3H, s, CH_3CO), 2.03 (3H, s, CH_3CO), 1.97 (3H, s, CH_3CO); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.84, 170.56, 170.37, 170.34, 170.32, 170.28, 170.24, 170.05, 169.95, 169.91, 169.87, 169.59, 169.36, 101.16, 101.13, 99.57, 98.82, 73.14, 73.08, 72.49, 72.28, 71.94, 71.92, 71.90, 71.03, 70.74, 69.32, 69.16, 67.48, 67.44, 66.74, 62.16, 61.37, 60.92, 60.68, 56.95, 49.73, 23.00, 20.94, 20.83, 20.82, 20.68, 20.65, 20.64, 20.52 (six unresolved carbons); HRMS (FAB) calcd for $C_{51}H_{71}NO_{33}K$ ($M+K^+$) 1264.3550, found 1264.3590.

3,6-Di-*O*-triisopropylsilyl-D-galactal (43)

To a solution of 6-*O*-TIPS-D-galactal (**7**) (172 mg, 0.570 mmol) and imidazole (78 mg, 1.14 mmol) in anhydrous DMF (3.0 mL) at 0°C was added TIPSCl (122 μL, 0.570 mmol). The reaction was warmed to room temperature and stirred for 41h. It was poured into water (30 mL) and extracted with hexane/EtOAc solution (3×30 mL). The collected organic layers were washed with brine, dried over $MgSO_4$, and concentrated. Flash column chromatography using 60:1-20:1-3:1 hexane/EtOAc provided **43** (162 mg, 62%) with recovered starting material **7** (12 mg, 7%).

$[\alpha]^{23}_D$ -33.6° (c 2.04, $CHCl_3$); FTIR (neat) 3558, 2944, 2868, 2361, 1645, 1464, 1385, 1240, 1164, 1088, 1046, 1014, 996, 918, 883, 854, 808, 726, 683 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 6.35 (1H, dd, J=5.5, 1.5 Hz, H1), 4.59-4.57 (4H, m, H2, H3), 4.04 (1H, dd, J=9.6, 7.3 Hz), 4.01-4.00 (1H, m, H4), 3.92 (1H, dd, J=9.6, 5.9 Hz, H5), 3.87 (1H, dd, J=7.0, 6.2 Hz), 2.57 (1H, t, J=1.2 Hz, OH); ^{13}C NMR (125 MHz, $CDCl_3$) δ 144.14, 102.43, 76.85, 65.18, 64.50, 61.86, 17.88, 17.86, 12.14, 11.92; HRMS (FAB) calcd for $C_{24}H_{50}O_4Si_2K$ ($M+K^+$) 497.2885, found 497.2871.

4-*O*-Acetyl-3,6-di-*O*-triisopropylsilyl-D-galactal (44)

A solution of 3,6-di-*O*-triisopropylsilyl-D-galactal (**43**) (1.11 g, 2.41 mmol) was treated with anhydrous pyridine (3.0 mL), Ac_2O (1.0 mL), in the presence of catalytic DMAP and stirred 16h at room temperature. The reaction was poured into water (50 mL) and extracted with 4:1 hexane/EtOAc. The combined organic phases were washed with saturated $CuSO_4$ solution and brine, dried over $MgSO_4$, and concentrated *in vacuo*. Flash column chromatography using 100:1 hexane/EtOAc afforded **44** (1.08 g, 89%). $[\alpha]^{18}_D$ -36.67° (c 3.92, $CHCl_3$); FTIR (neat) 2944, 2867, 1748, 1645, 1456, 1367, 1234, 1153, 1104, 1072, 1014, 883, 827, 789, 684, 659, 462 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 6.34(1H, dd, J=6.3, 1.5 Hz, H1), 5.48 (1H, t, J=2.2 Hz, H4), 4.71 (1H, ddd, J=6.3, 2.2, 1.8 Hz, H2), 4.64 (1H, br s, H3), 4.10 (1H, t, J=6.4 Hz, H5), 3.90 (1H, dd, J=10.3, 6.6 Hz, H6), 3.78 (1H, dd, J=10.3, 6.5 Hz, H6), 2.13 (3H, s, CH_3CO), 1.16-1.02 (42H, m); ^{13}C NMR (75 MHz, $CDCl_3$) δ 170.09, 143.36, 103.75, 76.45, 66.46, 63.70, 61.52, 20.93, 17.91, 17.87, 12.20, 11.91; HRMS (FAB) calcd for $C_{26}H_{52}O_5Si_2K$ ($M+K^+$) 539.2990, found 539.2972.

Synthesis of ethanethiosulfonamide 46

To a stirred mixture of glycal **43** (476 mg, 1.04 mmol), benzenesulfonamide (489 mg, 3.11 mmol), and freshly activated powdered 4Å MS (500 mg) in dry CH_2Cl_2 (10 mL) at 0°C was added I(*sym*-coll)$_2ClO_4$ (1.94 g, 4.14 mmol) in one portion. The resulting mixture was stirred in the dark for 30 min. Saturated $Na_2S_2O_3$ solution (10 mL) wasadded to it. The mixture was filtered through a pad of celite, washed with saturated $Na_2S_2O_3$ solution and $CuSO_4$ solution, dried over $MgSO_4$. The volatiles were evacuated and the residue was dried under vacuum for a few hours. Most of the

benzenesulfonamide was precipitated from **45** out by creating the crude product with a 7:1 hexane/EtOAc solution.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (2H, d, J=8.9 Hz), 7.60 (1H, t, J=8.9 Hz), 7.52 (2H, t, J=8.9 Hz), 6.86 (1H, d, J=8.1 Hz), 5.75 (1H, d, J=8.1 Hz), 4.22 (1H, d, J=5.1 Hz), 4.05 (1H, br s), 3.82 (1H, t, J=9.0 Hz), 3.43 (1H, dd, J=8.9, 4.9 Hz), 3.38 (1H, dd, J=9.0, 4.7 Hz), 2.91 (1H, dd, J=8.8, 4.8 Hz), 2.23 (1H, d, J=2.7 Hz), 1.07-0.93 (42H, m).

To a solution of ehtanethiol (329 μL, 4.45 mmol) in anhydrous DMF (4.0 mL) at -40°C were added LHMDS (1.78 mL, 1.0 M in THF) and a solution of iodosulfonamide **45** (from above) in DMF (5.0 mL). The reaction was stirred for 1h at -40°C, slowly warmed to -10°C for 30 min, and stirred for 1.5h at 10°C. Poured into ice, neutralized with NH_4Cl solution (50 mL), and extracted with 2:1 hexane/EtOAc (3×50 mL). Collected organics were washed with brine, dried over $MgSO_4$, and concentrated. Flash column chromatography using 15:1-10:1 hexane/EtOAc yielded **46** (363 mg, 52% for two steps).

$[\alpha]^{23}_D$ -62.02° (c 2.48, $CHCl_3$); FTIR (neat) 3489, 3276, 2943, 2866, 1460, 1383, 1322, 1253, 1157, 1106, 1014, 882, 791, 685, 594, 566 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.94 (2H, d, J=7.2 Hz), 7.59 (1H, t, J=7.5 Hz), 7.51 (2H, t, J=7.7 Hz), 5.20 (1H, bum, NH), 4.25 (1H, d, J=2.4 Hz, H4), 4.17 (1H, d, J=9.8 Hz, H1), 3.81 (1H, dd, J=12.1, 6.2 Hz, H6), 3.77 (1H, dd, J=12.1, 6.2 Hz, H6), 3.60 (1H, dd, J=9.6, 2.4 Hz, H3), 3.45 (1H, dt, J=9.7, 6.7 Hz, H2), 3.37 (1H, t, J=6.2 Hz, H5), 2.43 (1H, ddd, J=14.9, 12.2, 7.4 Hz, SCH_2Me), 2.06 (1H, ddd, J=14.9, 12.2, 7.4 Hz, SCH_2Me), 1.23-1.04 (3H, m), 1.13-1.00 (42H, m); ^{13}C NMR (125 MHz, $CDCl_3$) δ 139.13, 133.03, 128.88, 127.89, 83.25, 80.78, 75.51, 69.78, 62.52, 55.43, 22.66, 18.44, 18.37, 17.88, 17.86, 14.46, 13.26, 11.90; HRMS (FAB) calcd for $C_{32}H_{61}O_6NS_2Si_2Na$ ($M+Na^+$) 698.3376, found 698.3369.

Synthesis of ehtanethiosulfonamide 48

A stirred mixture of glycal **44** (469 mg, 0.936 mmol), benzenesulfonamide (442 mg, 2.81 mmol), and flame-dried powdered 4Å MS (500 mg) in dry CH_2Cl_2 (9 mL) at 0°C was treated with I(*sym*-coll)$_2ClO_4$ (1.76 g, 3.74 mmol) and stirred in the dark for 30 min. Addition of saturated $Na_2S_2O_3$ solution (9 mL) was followed by vigrous shaking until there was no red color remained. The mixture was filtered through a pad of celite, washed with saturated $Na_2S_2O_3$ solution and $CuSO_4$ solution, dried over $MgSO_4$, and concentrated. Flash chromatography using 20:1-10:1 hexane/EtOAc gave **47** (684 mg, 93%).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93-7.50 (5H, m), 6.42(1H, br s), 5.75 (1H, d, J=7.7 Hz, H4), 5.45 (1H, s), 4.27 (1H, d, J=4.8 Hz), 3.67-3.64 (1H, m), 3.56-3.47 (2H, m), 3.02 (1H, dd, J=8.9, 5.4 Hz), 2.12(3H, s, CH_3CO), 1.13-0.96 (42H, m).

To a solution of ehtanethiol (323 μL, 4.36 mmol) in anhydrous DMF (4.0 mL) at -40°C were added LHMDS (1.74 mL, 1.0 M in THF) and a solution of iodosulfonamide **47** (684 mg, 0.872 mmol) in DMF (5.0 mL). The reaction mixture was stirred for 1h at -40°C, slowly warmed to -15°C for 1h, and stirred for 24h at -15°C. Poured into ice, neutralized with NH_4Cl solution (50 mL), and extracted with 2:1 hexane/EtOAc (3×50 mL). The combined organic extracts were washed with brine, dried over $MgSO_4$, and concentrated. Purification by flash column chromatography yielded **48** (548 mg, 88%). $[\alpha]^{22}_D$ -22.7° (c 4.02, $CHCl_3$); FTIR (neat) 3291, 2943, 2866, 1750, 1463, 1366, 1328, 1233, 1160, 1115, 1069, 1014, 883, 756, 685, 594 cm^{-1}; ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87-7.26 (5H, m), 5.46 (1H, d, J=2.5 Hz, H4), 4.46 (1H, d, J=7.7 Hz, NH), 4.36 (1H, d, J=10.1 Hz, H1), 4.04 (1H, dd, J=9.5, 2.8 Hz, H3), 3.72-3.62 (3H, m), 3.54 (1H, t, J=6.4

Hz, H5), 2.46-2.36 (2H, m, SCH_2), 2.11 (3H, s, CH_3CO), 1.19-1.12 (3H, m, $SCCH_3$), 1.09-1.00 (42H, m); ^{13}C NMR (125 MHz, $CDCl_3$) δ 169.85, 141.99, 132.20, 128.47, 127.35, 84.73, 78.30, 74.09, 70.13, 61.79, 57.73, 24.45, 20.90, 18.22, 18.20, 17.81, 17.78, 14.12, 12.90, 11.78; HRMS (FAB) calcd for $C_{34}H_{63}O_7NS_2Si_2K$ ($M+K^+$) 756.3221, found 756.3212.

3,6-Di-*O*-benzyl-D-galactal (50)

A mixture of D-galactal (4.4 g, 30 mmol) and bis(tributyltin) oxide (17 mL, 33 mmol) in anhydrous benzene (120 mL) was refluxed for 18h with azeotropic removal of water. It was cooled below boiling and BnBr (14 mL, 120 mmol) and TBABr (24 g) were added. 20 mL of benzene was distilled off and the reaction was refluxed for 22h. It was concentrated and subjected to flash column chromatography using hexane (3.0 L for the removal of tin residue) and 5%-10% EtOAc in hexane to give **50** (7.9 g, 80%). $[\alpha]^{24}_D$ -19.0° (c 0.33, $CHCl_3$); FTIR (neat) 3540, 3030, 2869, 1650, 1454, 1366, 1235, 1158, 1090, 1028, 910, 821, 736, 689 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 7.38-7.28 (10H, m), 6.43 (1H, dd, J=6.3, 1.7 Hz, H1), 4.71 (1H, dt, J=6.3, 2.0 Hz, H2), 4.67-4.57 (4H, m, $ArCH_2O$), 4.22-4.20 (1H, m, H3), 4.11-4.09(1H, m, H4), 4.03 (1H, t, J=6.2 Hz, H5), 3.79 (2H, m, 2H6), 2.54 (1H, dd, J=3.5, 0.7 Hz, OH); ^{13}C NMR (125 MHz, $CDCl_3$) δ 145.06, 137.83, 137.63, 128.54, 128.44, 127.97, 99.46, 75.36, 73.68, 70.69, 70.46, 69.27, 63.01 (one unresolved aromatic resonance); HRMS (FAB) calcd for $C_{20}H_{22}O_4K$ ($M+K^+$) 365.1155, found 365.1167.