SUPPORTING INFORMATION

Towards Solution-Phase Automated Iterative Synthesis: Fluorous-tag Assisted Solution-Phase Synthesis of Mannose Oligosaccharides

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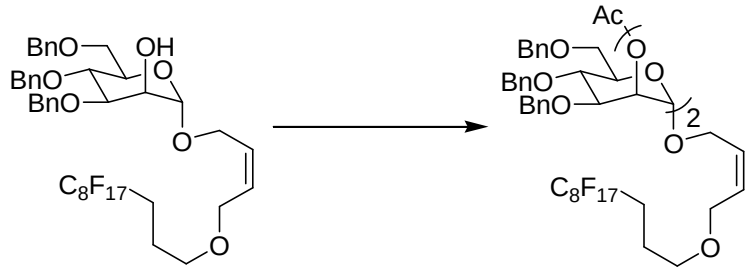
Experimental

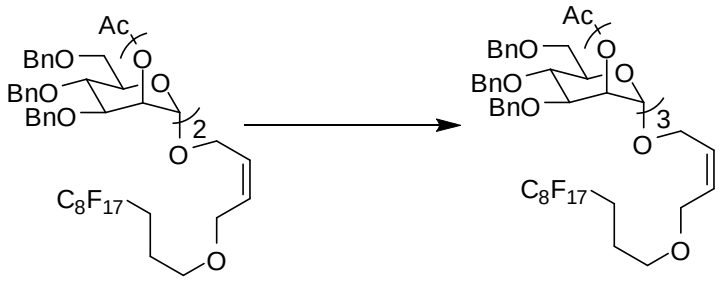
All reagents were purchased from Aldrich. Dichloromethane, THF and toluene were used from solvent purification towers. All other commercial reagents and solvents were used as received without further purification. The reactions were monitored and the R_f values determined using analytical thin layer chromatography (tlc) with 0.25 mm EM Science silica gel plates (60F-254). The developed TLC plates were visualized by immersion in *p*-anisaldehyde solution followed by heating on a hot plate. Flash chromatography was performed with Selecto Scientific silica gel, 32-63 μm particle sizes. Fluorous phase chromatography was performed using fluorous solid-phase extraction cartridges containing silica gel bonded with perfluorooctylethylsilyl chains (Fluorous Technologies Inc.; Pittsburgh, PA). All other Fluorous reagents were also obtained from Fluorous Technologies, Inc. All moisture-sensitive reactions were performed in flame- or oven-dried glassware under a nitrogen atmosphere. All reactions were stirred magnetically at ambient temperature unless otherwise indicated. ^{1}H NMR and ^{13}C NMR spectra were obtained with a Bruker DRX400 and Varian VXR300. ^{1}H NMR spectra were reported in parts per million (δ) relative to $CDCl_3$ (7.27 ppm) or CD_3OD (4.80) as an internal reference. ^{13}C NMR spectra were reported in parts per million (δ) relative to $CDCl_3$ (77.23 ppm) or CD_3OD (49.15 ppm). The coupling constants *J* are measured in Hz. A Shimadzu LCMS 2010 quadrupole mass spectrometer (Shimadzu Scientific Instruments, Columbia, MD) equipped with and electronspray ionization (ESI) source was used in positive ion mode. MALDI analysis was performed on Finnigan MAT using 2,5-dihydroxybenzoic acid matrix.



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-(2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-α-D-mannopyranoside (15)

A solution of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranoside[1] (150 mg, 0.153 mmol) and 2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α/β-D-mannopyranosyl trichloroacetimidate (146 mg, 0.229 mmol) in dichloromethane (3 mL) was cooled to 5 ºC and TMSOTf (6 μL, 0.031 mmol) was added. The reaction mixture was stirred for 30 min. The reaction mixture was quenched with triethylamine (30 μL) and then concentrated under reduced pressure. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain mannose disaccharide (214 mg, 0.147 mmol, 96%) as a yellow gel.
R_f: 0.77 (EtOAc/hexane, 1:1)

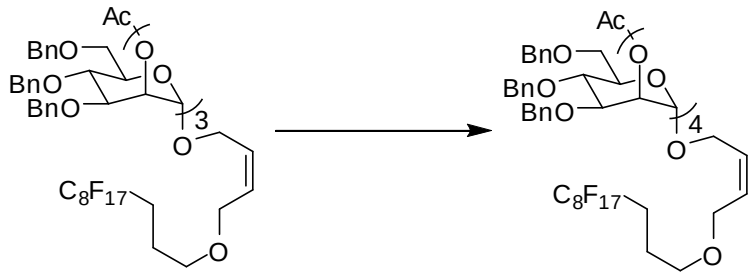
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.79-1.86 (2H, m), 2.09-2.21 (2H, m), 2.16 (3H, s), 3.38 (2H, t, *J* = 6 Hz), 3.71-4.21 (14H, m), 4.43-4.70 (12H, m), 4.88 (1H, dd, *J* = 3.6, 10.8 Hz), 4.94 (1H, s), 5.11 (1H, s), 5.57 (1H, s), 5.62-5.69 (2H, m), 7.16-7.36 (30H, m).
^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 20.87, 21.27, 28.06, 62.77, 66.54, 68.72, 68.79, 62.84, 69.49, 69.57, 71.95, 71.97, 72.01, 72.19, 72.31, 73.32, 73.40, 73.44, 73.54, 74.31, 74.81, 74.91, 74.99, 75.04, 75.15, 75.22, 75.27, 77.35, 78.21, 79.62, 98.21, 100.74, 127.53, 127.55, 127.58, 127.61, 127.64, 127.68, 127.71, 127.77, 127.85, 127.93, 128.02, 128.06, 128.14, 128.17, 128.26, 128.30, 128.32, 128.34, 128.39, 128.42, 128.43, 128.51, 129.77, 138.11, 138.25, 138.34, 138.41, 138.44, 138.45, 138.52, 138.59, 138.62, 170.25.
MS (ESI): 1477 $(M+Na)^+$



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-[2-*O*-(2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl]-α-D-mannopyranoside (16)

To a solution of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-(2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-α-D-mannopyranoside (214 mg, 0.147 mmol) in methanol (5 mL) was added NaOH (0.5 M, 0.59 mL, 0.294 mmol) in methanol. The reaction mixture was stirred at room temperature for 30 min and concentrated. The crude product was dissolved in minimum amount of MeOH and loaded onto FSPE column. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain deacetylated mannose disaccharide (202 mg, 0.143 mmol, 97%) as a yellow gel. This was taken for the next coupling cycle. A solution of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-(3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-α-D-mannopyranoside (202 mg, 0.143 mmol) and 2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α/β-D-mannopyranosyl trichloroacetimidate (137 mg, 0.215 mmol) in dichloromethane (3 mL) was cooled to 5 ºC and TMSOTf (5 μL, 0.028 mmol) was added. The reaction mixture was stirred for 30 min. The reaction mixture was quenched with triethylamine (30 μL) and then concentrated under reduced pressure. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain mannose trisaccharide (253 mg, 0.134 mmol, 94%) as a yellow gel.
R_f: 0.79 (EtOAc/hexane, 1/1)
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.79-1.86 (2H, m), 2.05-2.21 (2H, m), 2.15 (3H, s), 3.37 (2H, t, *J* = 6 Hz), 3.55 (1H, d, *J* = 10.8 Hz), 3.65-4.02 (17H, m), 4.13-4.17 (2H,

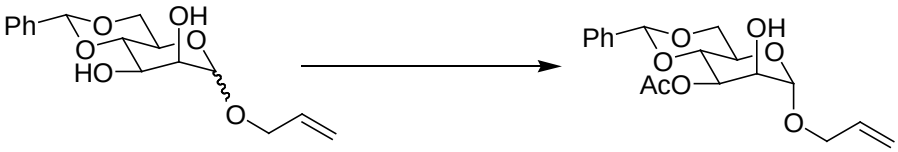
m), 4.33 (1H, d, *J* = 12 Hz), 4.43-4.72 (14H, m), 4.83-4.90 (3H, m), 4.97 (1H, s), 5.08 (1H, s), 5.23 (1H, s), 5.26 (1H, s), 5.57 (1H, s), 5.62-5.65 (2H, m), 7.17-7.35 (45H, m).
^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 20.87, 21.27, 28.06, 62.77, 66.54, 68.72, 68.79, 62.84, 69.49, 69.57, 71.95, 71.97, 72.01, 72.19, 72.31, 73.32, 73.40, 73.44, 73.54, 74.31, 74.81, 74.91, 74.99, 75.04, 75.15, 75.22, 75.27, 77.35, 78.21, 79.62, 98.21, 100.74, 127.53, 127.55, 127.58, 127.61, 127.64, 127.68, 127.71, 127.77, 127.85, 127.93, 128.02, 128.06, 128.14, 128.17, 128.26, 128.30, 128.32, 128.34, 128.39, 128.42, 128.43, 128.51, 129.77, 138.11, 138.25, 138.34, 138.41, 138.44, 138.45, 138.52, 138.59, 138.62, 170.25.
MS (ESI): 1909 $(M+Na)^+$



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-[2-*O*-(2-*O*-(2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl]-α-D-mannopyranoside (17)

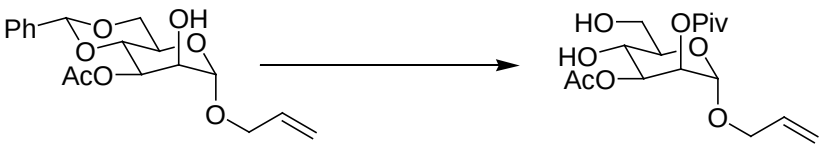
To a solution of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-[2-*O*-(2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl]-α-D-mannopyranoside (253 mg, 0.134 mmol) in methanol (5 mL) was added NaOH (0.5 M, 0.54 mL, 0.268 mmol) in methanol. The reaction mixture was stirred at room temperature for 30 min and concentrated. The crude product was dissolved in minimum amount of MeOH and loaded onto FSPE column. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain deacetylated mannose disaccharide (242 mg, 0.131 mmol, 98%) as a yellow gel. This was taken for the next coupling cycle. A solution of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-[2-*O*-(3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl]-α-D-mannopyranoside (242 mg, 0.131 mmol) and 2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α/β-D-mannopyranosyl trichloroacetimidate (125 mg, 0.197 mmol) in dichloromethane (3 mL) was cooled to 5 ºC and TMSOTf (5 μL, 0.026 mmol) was added. The reaction mixture was stirred for 30 min. The reaction mixture was quenched with triethylamine (30 μL) and then concentrated under reduced pressure. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain mannose trisaccharide (280 mg, 0.121 mmol, 92%) as a yellow gel.
R_f: 0.80 (EtOAc/hexane, 1:1)
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.78-1.86 (2H, m), 2.05-2.21 (2H, m), 2.15 (3H, s), 3.36 (2H, t, *J* = 5.6 Hz), 3.49-3.79 (11H, m), 3.85-4.02 (14H, m), 4.12-4.19 (4H, m),

4.35 (1H, d, *J* = 2.4 Hz), 4.37 (1H, d, *J* = 3.2 Hz), 4.39-4.89 (22H, m), 4.99 (1H, s), 5.07 (1H, s), 5.20 (1H, s), 5.26 (1H, d, *J* = 3.6 Hz), 5.57-5.66 (3H, m), 7.17-7.38 (60H, m).
^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 20.81, 21.28, 29.79, 62.77, 66.54, 68.70, 68.75, 69.52, 69.56, 69.65, 71.62, 71.80, 71.87, 71.96, 71.99, 72.22, 72.34, 73.33, 73.43, 73.55, 74.35, 74.75, 74.91, 75.04, 75.15, 75.23, 75.30, 75.58, 77.34, 78.24, 79.48, 98.21, 99.49, 100.85, 101.27, 127.27, 127.52, 127.54, 127.60, 127.64, 127.67, 127.73, 127.77, 127.82, 127.93, 128.03, 128.12, 128.22, 128.26, 128.31, 128.37, 128.38, 128.41, 128.51, 128.64, 128.70, 129.69, 138.13, 138.21, 138.37, 138.41, 138.44, 138.48, 138.50, 138.56, 138.61, 138.68, 170.22.
MS (MALDI-TOF): 2319 $(M+H)^+$



Synthesis of Allyl-3-*O*-acetyl-4,6-*O*-benzylidene-2-hydroxy-α-D-mannopyranoside (19)

Allyl-4,6-*O*-benzylidene-2,3-di-*O*-hydroxy-α/β-D-mannopyranoside[2] (5.18 g, 16.8 mmol) was dissolved in dichloromethane (60 mL) and cooled to –15 ºC and pyridine (2.0 mL, 25.2 mmol) was added followed by acetyl chloride (1.32 mL, 18.5 mmol). The reaction mixture was stirred at –15 ºC for 1 h and quenched with water. The aqueous layer was extracted with dichloromethane (2 x 100 mL). The combined organic layer was washed with HCl (2N, 50 mL), brine (50 mL) and dried over sodium sulfate. The solvent was removed under reduced pressure and the crude product was purified by flash column chromatography on silica gel using 38% ethyl acetate/hexane to give the desired product as α-anomer (3.21 g, 9.17 mmol, 55%).
R_f: 0.37 (EtOAc/hexane, 1:1)
^{1}H NMR (400 MHz, CD_3OD): δ (ppm) 2.08 (3H, s), 2.76 (1H, br s), 3.79-3.84 (1H, m), 3.91-4.00 (2H, m,), 4.05-4.11 (2H, m), 4.15-4.4.20 (1H, m), 4.24 (1H, dd, *J* = 4.4, 10 Hz), 4.84 (1H, s), 5.20 (1H, d, *J* = 10.4 Hz), 5.26-5.33 (2H, m), 5.52 (1H, s), 5.82-5.91 (1H, m), 7.33-7.46 (5H, m).
^{13}C NMR (100 MHz, CD_3OD): δ (ppm) 21.14, 63.94, 68.34, 68.82, 69.74, 70.83, 76.17, 99.57, 101.93, 118.03, 126.24, 128.30, 129.13, 133.40, 137.27, 170.18.
MS (ESI): 373 $(M+Na)^+$



Synthesis of Allyl-3-*O*-acetyl-4,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside (20)

Allyl-3-*O*-acetyl-4,6-*O*-benzylidene-2-hydroxy-α-D-mannopyranoside (2.24 g, 6.40 mmol) was dissolved in dichloromethane (40 mL) at room temperature. DMAP (1.56 g, 12.8 mmol) was added followed by pivaloyl chloride (0.95 mL, 7.68 mmol) and it was

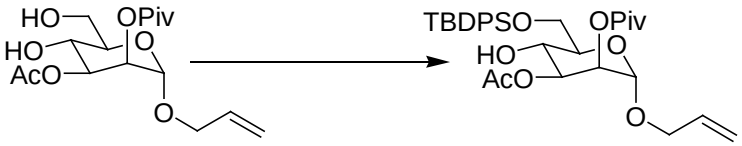
then stirred for 1 h. After the reaction was complete, ethyl acetate/hexane (1:3) (60 mL) was added. The white solid was filtered over celite and the filtrate was concentrated. A solution of crude Allyl-3-*O*-acetyl-4,6-*O*-benzylidene-2-*O*-pivaloyl-α-D-mannopyranoside in 60% aq. AcOH (50 mL) was heated at 70 ºC for 3 h. It was then cooled down to room temperature and poured into water (50 mL). The water layer was extracted with ethyl acetate (2 x 200 mL). The combined organic layer was washed with sodium bicarbonate (3 x 80 mL) followed by brine (80 mL) and dried over sodium sulfate. The solvent was removed under reduced pressure and the crude product was purified by flash column chromatography on silica gel using 45% ethyl acetate/hexane to yield of the desired product (1.81 g, 5.22 mmol, 91%) as white oil.

R_f 0.15 (silica, 50% EtOAc/hexane)

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) 1.19 (9H, s), 2.01 (3H, s), 2.18 (1H, br s), 2.74 (1H, br s), 3.69-3.73 (1H, m), 3.82-3.88 (2H, m), 3.94-4.00 (2H, m), 4.16 (1H, dd, *J* = 5 Hz, 13 Hz), 4.77 (1H, s), 5.16-5.30 (4H, m), 5.82-5.92 (1H, m).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) 20.88, 27.11, 39.04, 62.28, 66.42, 68.45, 69.47, 72.26, 72.39, 96.73, 118.12, 133.26, 171.01, 177.44.

MS (ESI): 348 $(M+H)^+$



Synthesis of Allyl-3-*O*-acetyl-6-*O*-*t*-butyldiphenylsilyl-4-hydroxy-2-*O*-pivaloyl-α-D-mannopyranoside (21)

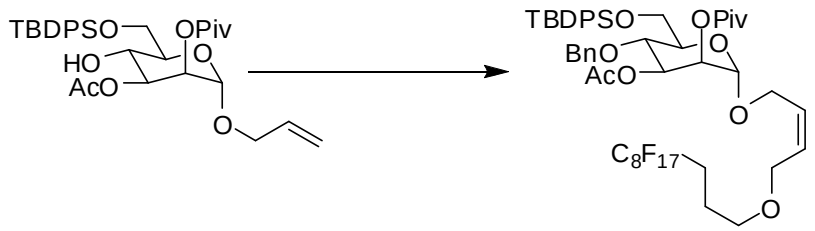
Allyl-3-*O*-acetyl-4,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside (1.47 g, 4.24 mmol) was dissolved in dichloromethane (30 mL) and cooled to 0 ºC. Imidazole (433 mg, 6.36 mmol) was added followed by TBDPSCl (1.10 mL, 4.24 mmol) and the reaction mixture was stirred at 0 ºC for 1 h. It was then diluted with ethyl acetate (200 mL) and the organic layer washed with water (30 mL), HCl (2N, 30 mL), and brine (30 mL). The solvent was removed under reduced pressure and the crude product was purified by flash column chromatography on silica gel using 6% ethyl acetate/dichloromethane to give the desired product (2.14 g, 3.66 mmol, 86%) as white oil.

R_f: 0.55 (EtOAc/DCM, 1:9)

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) 1.16 (9H, s), 2.05 (3H, s), 2.95 (1H, br s), 3.84-4.17 (4H, m), 4.28 (1H, d, *J* = 12 Hz), 4.45 (1H, dd, *J* = 3.6 Hz, 12 Hz), 4.81 (1H, s), 5.02-5.28 (6H, m), 5.79-5.88 (1H, m), 7.23-7.30 (5H, m).

^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) 20.72, 27.01, 38.99, 63.09, 65.52, 68.54, 69.12, 70.03, 70.68, 75.78, 96.67, 118.11, 128.28, 128.33, 128.57, 128.59, 133.18, 135.00, 154.52, 171.40, 177.34.

MS (ESI): 587 $(M+H)^+$

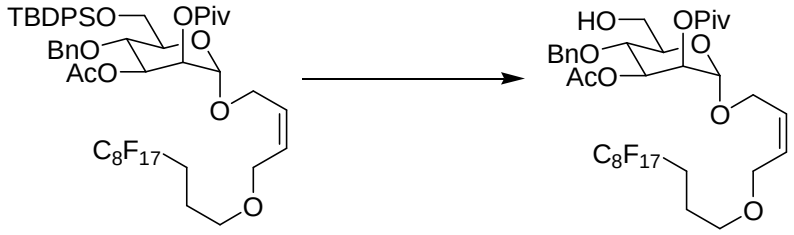


Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-3-*O*-acetyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-2-*O*-pivaloyl-α-D-mannopyranoside (24)

To a solution of allyl-3-*O*-acetyl-6-*O*-*t*-butyldiphenylsilyl-4-hydroxy-2-*O*-pivaloyl-α-D-mannopyranoside (1.67 g, 2.85 mmol) in dichloromethane (20 mL) and cyclohexane (10 mL) was added benzyltrichloroacetimidate (2.88 g, 11.4 mmol). The reaction mixture was cooled to 0 ºC and trfilic acid (0.13 mL, 1.43 mmol) was added. It was then stirred at the same temperature for 8 h and filtered over celite. The filtrate was washed with saturated sodium bicarbonate (30 mL), water (30 mL), and brine (30 mL), and dried over sodium sulfate. The solvent was removed under reduced pressure and the crude product was subjected to the next step without further purification. The crude allyl-3-*O*-acetyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-2-*O*-pivaloyl-α-D-mannopyranoside (1.06 g, 1.57 mmol) was dissolved in a mixture of acetic acid (5 mL) and water (1 mL) (5:1). Sodium acetate (386 mg, 4.71 mmol) was added followed by palladium chloride (416 mg, 2.35 mmol) and the reaction mixture was heated in a commercial microwave oven at 100 W power and 80 ºC for 5 min. It was then filtered over celite and extracted with ethyl acetate (2 x 50 mL). The combined organic layer was washed with sodium bicarbonate (3 x 30 mL) followed by brine (50 mL) and dried over sodium sulfate. The solvent was removed under reduced pressure and the crude product was purified by flash column chromatography on silica gel using 8% ethyl acetate/dichloromethane to give the desired lactol as a mixture of anomers. To a solution of 3-*O*-acetyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-2-*O*-pivaloyl-α-D-mannopyranoside (229 mg, 0.360 mmol) in dichloromethane (4 mL) was added powdered 4 Å molecular sieves (100 mg) and trichloroacetonitrile (0.18 mL, 1.80 mmol) at room temperature. The reaction mixture was stirred for 10 min and cesium carbonate (129 mg, 0.396 mmol) was added and stirred further for 45 min. It was then filtered over celite and solvent was removed under reduced pressure. The crude product was directly used for glycosylation. A solution of 3-*O*-acetyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-2-*O*-pivaloyl-α/β-D-mannopyranosyl trichloroacetimidate (165 mg, 0.212 mmol) and 3-(perfluorooctyl)propanyloxybutenyl alcohol (77 mg, 0.141 mmol) in dichloromethane (3 mL) was cooled to 5 ºC and TMSOTf (13 μL, 0.071 mmol) was added. The reaction mixture was stirred for 15 min. The reaction mixture was quenched with triethylamine (40 μL) and then concentrated under reduced pressure. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain Fluorous-tagged mannose (151 mg, 0.130 mmol, 2% over 4 steps) as a yellow gel.

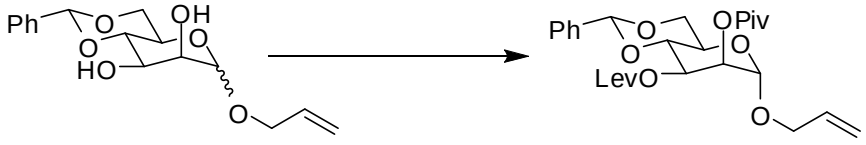
R_f: 0.68 (EtOAc/DCM, 1:9)

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) 1.12 (9H, s), 1.26 (9H, s), 1.81-1.88 (2H, m), 1.93 (3H, s), 2.09-2.20 (2H, m), 3.40 (2H, t, *J* = 6 Hz), 3.78-4.18 (7H, m), 4.62-4.68 (2H, m), 4.81 (1H, s), 5.29 (1H, d, *J* = 1.6 Hz), 5.31-5.37 (1H, m), 5.68-5.72 (2H, m), 7.16-7.43 (11H, m), 7.73 (2H, d, *J* = 6.8 Hz), 7.77 (2H, d, *J* = 6.4 Hz).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) 19.40, 20.86, 26.91, 27.16, 39.06, 62.66, 62.81, 66.56, 68.74, 69.86, 72.26, 72.52, 72.90, 74.96, 77.31, 96.76, 127.67, 127.78, 127.89, 128.45, 129.73, 129.80, 130.43, 133.13, 133.53, 135.67, 135.94, 138.10, 169.79, 177.60.
MS (ESI): 1189 $(M+Na)^+$



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-3-*O*-acetyl-4-*O*-benzyl-6-hydroxy-2-*O*-pivaloyl-α-D-mannopyranoside (25)

To a solution of 3-(perfluorooctyl)propanyloxybutenyl-3-*O*-acetyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-2-*O*-pivaloyl-α-D-mannopyranoside (137 mg, 0.118 mmol) in THF (3 mL) was added acetic acid (30 μL) followed by tetrabutylammonium fluoride (1.0 M in THF, 0.24 mL, 0.236 mmol). The reaction mixture was stirred for 10 h and then concentrated. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain the desilylated product (72 mg, 0.083 mmol, 70%) as a white gel.
R_f: 0.47 (EtOAc/DCM, 1:9)
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.21 (9H, s), 1.81-1.89 (2H, m), 1.56 (1H, br s), 1.90 (3H, s), 2.06-2.22 (2H, m,), 3.46 (2H, t, *J* = 6 Hz), 3.73-3.90 (4H, m), 4.02 (1H, d, *J* = 4.8 Hz), 4.08 (1H, dd, *J* = 6, 13.8 Hz), 4.18 (1H, dd, *J* = 4.4, 12.4 Hz), 4.63 (2H, s), 4.74 (1H, d, *J* = 1.6 Hz), 5.19-5.20 (1H, m), 5.31 (1H, dd, *J* = 3.2, 9.6 Hz), 5.62-5.71 (2H, m), 7.23-7.31 (5H, m).



Synthesis of Allyl-4,6-*O*-benzylidene-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside (27)

Allyl-4,6-*O*-benzylidene-2,3-di-*O*-hydroxy-α/β-D-mannopyranoside (1.06 g, 3.44 mmol) was dissolved in dichloromethane (20 mL) and cooled to –15 ºC and DCC (779 mg, 3.78

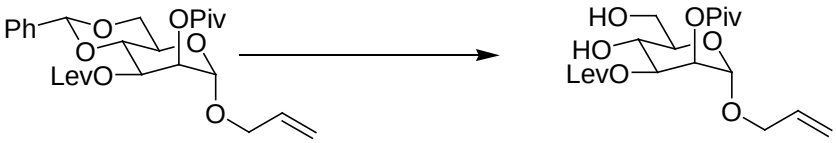
mmol) was added followed by DMAP (84 mg, 0.688 mmol). Levulinic acid (0.39 mL, 3.78 mmol) was then added dropwise. The reaction mixture was stirred at –15 ºC for 1 h and filtered through celite. The filtrate was concentrated and the crude product was taken directly to the next step without further purification. Allyl-4,6-*O*-benzylidene-2-*O*-hydroxy-3-*O*-levunilyl-α/β-D-mannopyranoside (1.0 g, 2.46 mmol) was dissolved in dichloromethane (20 mL) at room temperature. DMAP (600 mg, 4.92 mmol) was added followed by pivaloyl chloride (0.36 mL, 2.95 mmol) and it was then stirred for 1 h. After the reaction was complete, ethyl acetate/hexane (1:3) (60 mL) was added. The white solid was filtered over celite and the filtrate was concentrated. The crude product was purified by flash column chromatography on silica gel using 26% ethyl acetate/hexane to give the desired product as α-anomer (635 mg, 1.29 mmol, 53% over two steps).

R_f: 0.72 (EtOAc/hexane, 1:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) 1.24 (9H, s), 2.06 (3H, s), 2.38-2.66 (4H, m), 3.73-3.81 (1H, m), 3.93-3.98 (3H, m), 4.12-4.25 (2H, m), 4.75 (1H, d, *J* = 1.2 Hz), 5.16 (1H, dd, *J* = 1.2 Hz, 10 Hz), 5.24-5.40 (3H, m), 5.54 (1H, s), 5.81-5.88 (1H, m), 7.23-7.44 (5H, m).

^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 27.19, 27.85, 29.82, 37.87, 39.03, 63.85, 68.49, 68.83, 68.88, 69.80, 76.58, 97.66, 101.87, 118.12, 126.24, 128.25, 129.10, 133.17, 137.13, 171.70, 177.34, 206.24.

MS (ESI): 513 $(M+Na)^+$



Synthesis of Allyl-4,6-dihydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside (28)

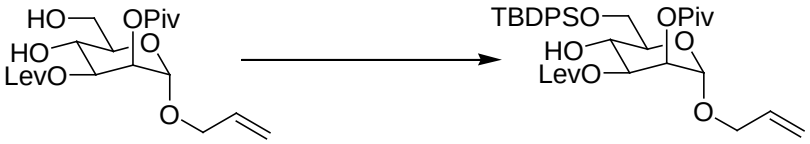
A solution of allyl-4,6-*O*-benzylidene-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside (635 mg, 1.29 mmol) in 60% aq. AcOH (20 mL) was heated at 70 ºC for 2 h. It was then cooled down to room temperature and poured into water (20 mL). The water layer was extracted with ethyl acetate (2 x 100 mL). The combined organic layer was washed with sodium bicarbonate (3 x 50 mL) followed by brine (50 mL) and dried over sodium sulfate. The solvent was removed under reduced pressure and the crude product was purified by flash column chromatography on silica gel using 45% ethyl acetate/hexane to yield of the desired product (505 mg, 1.25 mmol, 97%) as white oil.

R_f: 0.22 (EtOAc/hexane, 1:1)

^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) 1.14 (9H, s), 2.07 (3H, s), 2.30-2.73 (4H, m), 3.62-3.92 (5H, m), 4.10 (1H, dd, *J* = 4.4 Hz, 13 Hz), 4.69 (1H, s), 5.06-5.21 (4H, m), 5.71-5.80 (1H, m).

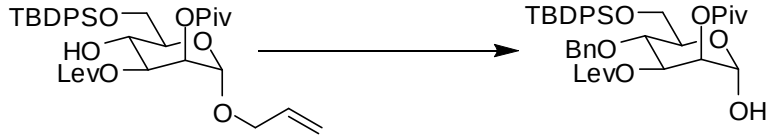
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) 27.05, 27.87, 29.79, 37.99, 38.94, 62.14, 66.00, 68.18, 69.49, 72.28, 72.41, 96.64, 117.83, 133.30, 172.30, 177.43, 207.72.

MS (ESI): 403 $(M+H)^+$



Synthesis of Allyl-6-*O*-*t*-butyldiphenylsilyl-4-hydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside (29)

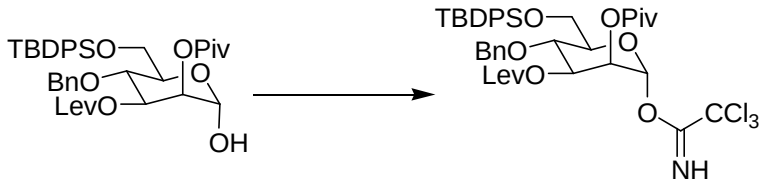
Allyl-4,6-dihydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside (505 mg, 1.25 mmol) was dissolved in dichloromethane (8 mL) and cooled to 0 ºC. Imidazole (128 mg, 1.88 mmol) was added followed by TBDPSCl (0.35 mL, 1.38 mmol) and the reaction mixture was stirred at 0 ºC for 1 h. It was then diluted with ethyl acetate (100 mL) and the organic layer washed with water (30 mL), HCl (2N, 30 mL), and brine (30 mL). The solvent was removed under reduced pressure and the crude product was purified by flash column chromatography on silica gel using 6% ethyl acetate/dichloromethane to give the desired product (700 mg, 1.09 mmol, 87%) as white oil.
R_f: 0.52 (EtOAc/DCM, 1:9)
^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) 1.07 (9H, s), 1.21 (9H, s), 2.11 (3H, s), 2.40-2.84 (4H, m), 3.16 (1H, d, *J* = 4 Hz), 3.75-3.77 (1H, m), 3.93-4.13 (5H, m), 4.81 (1H, s), 5.13 (1H, d, *J* = 10 Hz), 5.21-5.26 (3H, m), 5.79-5.85 (1H, m), 7.33-7.38 (6H, m), 7.72 (4H, d, *J* = 7 Hz).
^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) 19.38, 26.91, 27.18, 28.04, 29.81, 38.11, 39.02, 63.72, 66.34, 67.98, 69.61, 72.57, 72.83, 96.65, 117.76, 127.76, 129.80, 133.29, 133.35, 133.53, 135.71, 135.76, 172.38, 177.56, 207.36.
MS (ESI): 643 $(M+H)^+$



Synthesis of 4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α/β-D-mannopyranoside (30)

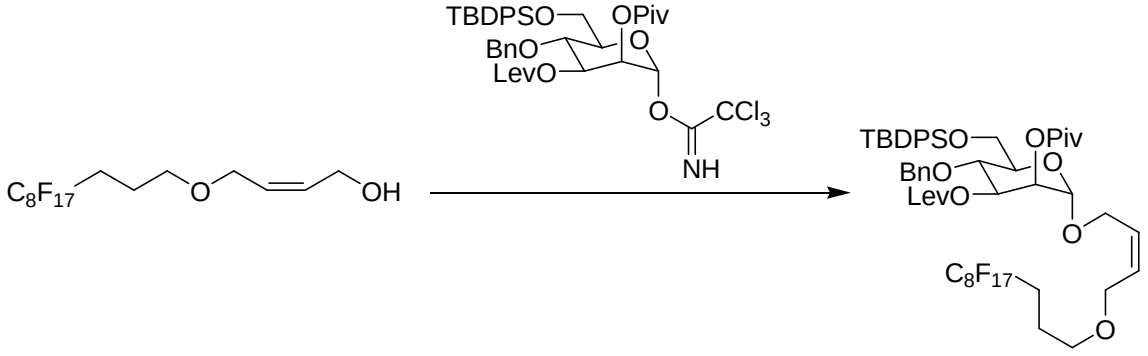
To a solution of allyl-6-*O*-*t*-butyldiphenylsilyl-4-hydroxy-3-*O*-levunilyl-2-*O*-pivaloyl-α-D-mannopyranoside (1.69 g, 2.63 mmol) in dichloromethane (20 mL) and cyclohexane (10 mL) was added benzyltrichloroacetimidate (2.0 g, 7.89 mmol). The reaction mixture was cooled to 0 ºC and trfilic acid (0.12 mL, 1.32 mmol) was added. It was then stirred at the same temperature for 6 h and filtered over celite. The filtrate was washed with saturated sodium bicarbonate (30 mL), water (30 mL), and brine (30 mL), and dried over sodium sulfate. The solvent was removed under reduced pressure and the crude product was subjected to the next step without further purification. To crude allyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levunilyl-2-*O*-pivaloyl-α-D-mannopyranoside (2.50 g, 3.42 mmol) in methanol (30 mL) was added palladium chloride (303 mg, 1.71 mmol). The reaction mixture was stirred for 2 h at room temperature and filtered over celite. The solvent was removed under reduced pressure and the crude product was purified by flash

column chromatography on silica gel using 8% ethyl acetate/dichloromethane providing the title compound as yellow gel (1.28 g, 2.24 mmol, 85% over two steps).
R_f: 0.32 (EtOAc/DCM, 1:9)
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.09 (9H, s), 1.26 (9H, s), 2.13 (3H, s), 2.32-2.49 (2H, m), 2.61-2.78 (2H, m), 3.05 (1H, d, *J* = 4 Hz), 3.81-4.19 (4H, m), 4.60-4.73 (2H, m), 5.12 (1H, s), 5.24 (1H, s), 5.36-5.41 (1H, m), 7.16-7.38 (11H, m), 7.67-7.74 (4H, m).



Synthesis of 4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α/β-D-mannopyranosyl trichloroacetimidate (31)

To a solution of 4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levunilyl-2-*O*-pivaloyl-α/β-D-mannopyranoside (735 mg, 1.06 mmol) in dichloromethane (8 mL) was added powdered 4 Å molecular sieves (200 mg) and trichloroacetonitrile (0.53 mL, 5.30 mmol) at room temperature. The reaction mixture was stirred for 10 min followed by the addition of cesium carbonate (380 mg, 1.17 mmol) and stirring was continued for another 45 min. It was then filtered over celite and solvent was removed under reduced pressure. The crude product was purified by flash column chromatography on silica gel using 3% ethyl acetate/dichloromethane affording the title compound (851 mg, 1.02 mmol, 96%).
R_f: 0.75 (EtOAc/hexane, 1:1)
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.14 (9H, s), 1.30 (9H, s), 2.17 (3H, s), 2.40-2.46 (1H, m), 2.51-2.58 (1H, m), 2.64-2.72 (1H, m), 2.76-2.83 (1H, m), 3.96-4.06 (3H, m), 4.30 (1H, t, *J* = 10 Hz), 4.69 (1H, d, *J* = 10.8 Hz), 4.79 (1H, d, *J* = 11.2 Hz), 5.47 (1H, dd, *J* = 3.6, 10 Hz), 5.50-5.52 (1H, m), 6.32 (1H, s), 7.23-7.45 (11H, m), 7.72-7.76 (4H, m), 8.71 (1H, s).
^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 19.45, 27.02, 27.24, 27.82, 29.89, 37.87, 39.13, 62.35, 68.13, 72.07, 72.30, 75.04, 75.18, 90.89, 95.41, 127.77, 127.85, 127.96, 128.14, 128.52, 129.81, 129.87, 132.95, 133.51, 135.73, 135.97, 137.88, 160.11, 171.80, 177.34, 206.19.
MS (ESI): 837 $(M+H)^+$



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside (32)

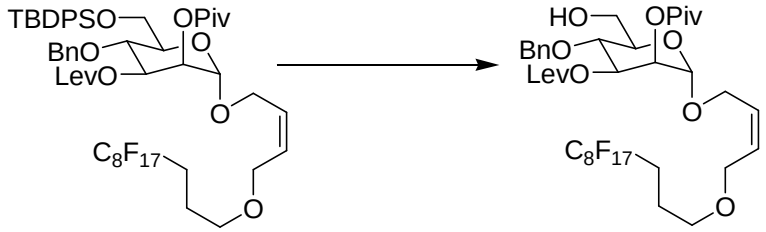
A solution of 4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levunilyl-2-*O*-pivaloyl-α/β-D-mannopyranosyl trichloroacetimidate (200 mg, 0.239 mmol) and 3-(perfluorooctyl)propanyloxybutenyl alcohol (87 mg, 0.159 mmol) in dichloromethane (3 mL) was cooled to 5 ºC and TMSOTf (15 μL, 0.80 mmol) was added. The reaction mixture was stirred for 15 min. The reaction mixture was quenched with triethylamine (30 μL) and then concentrated under reduced pressure. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain Fluorous-tagged mannose (183 mg, 0.150 mmol, 95%) as a yellow gel.

R_f: 0.71 (EtOAc/DCM, 1:9)

^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.10 (9H, s), 1.24 (9H, s), 1.77-1.86 (2H, m), 2.05-2.21 (2H, m), 2.15 (3H, s), 2.32-2.49 (2H, m), 2.61-2.78 (2H, m), 3.38 (2H, t, *J* = 6 Hz), 3.77 (1H, d, *J* = 9.6 Hz), 3.88-4.17 (7H, m), 4.61 (1H, d, *J* = 11.2 Hz), 4.70 (1H, d, *J* = 11.2 Hz), 4.79 (1H, s), 5.24 (1H, s), 5.35 (1H, dd, *J* = 3.2, 9.6 Hz), 5.61-5.71 (2H, m), 7.17-7.43 (11H, m), 7.73 (4H, dd, *J* = 6.8, 14.8 Hz).

^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 19.37, 20.84, 26.90, 27.15, 27.89, 29.82, 37.86, 39.04, 62.65, 62.82, 66.53, 68.72, 69.81, 72.54, 72.65, 72.76, 74.93, 96.74, 127.64, 127.76, 127.87, 127.92, 128.41, 129.70, 129.77, 130.40, 133.15, 133.52, 135.66, 135.91, 138.05, 171.76, 177.65, 206.32.

MS (ESI): 1223 $(M+H)^+$



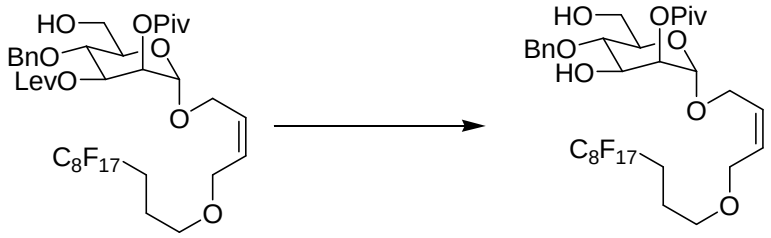
Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-6-hydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside (33)

To a solution of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levunilyl-2-*O*-pivaloyl-α-D-mannopyranoside (102 mg, 0.084 mmol) in THF (3 mL) was added acetic acid (30 μL) followed by tetrabutylammonium fluoride (1.0 M in THF, 0.17 mL, 0.168 mmol). The reaction mixture was stirred for 8 h and then concentrated. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain the desilylated product (57 mg, 0.058 mmol, 70%) as a yellow gel.

R_f: 0.54 (EtOAc/DCM, 1:9)

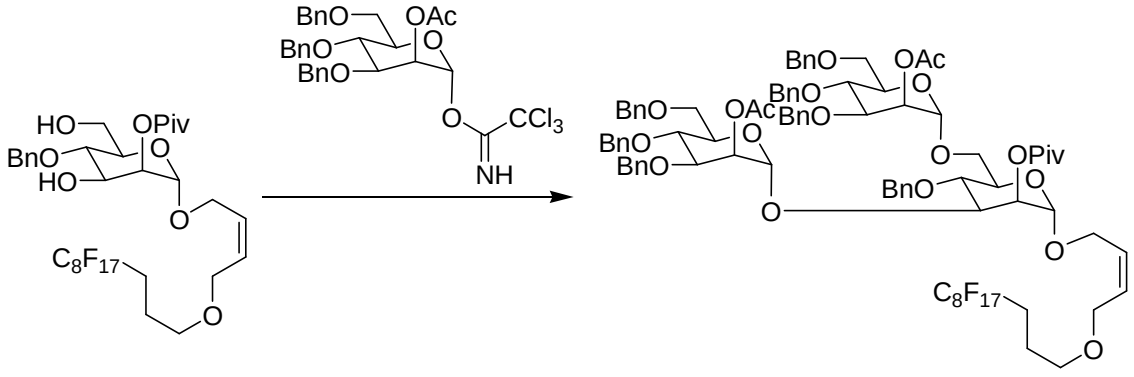
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.20 (9H, s), 1.80-1.88 (2H, m), 2.07-2.21 (2H, m), 2.13 (3H, s), 2.32-2.49 (2H, m), 2.61-2.78 (2H, m), 3.45 (2H, t, *J* = 6 Hz), 3.72-3.83 (3H, m), 3.90 (1H, t, 9.6 Hz), 4.01 (2H, d, *J* = 5.2 Hz), 4.07 (1H, dd, *J* = 6.4, 12.8 Hz),

4.17 (1H, dd, *J* = 5.6, 13.2 Hz), 5.17 (1H, dd, *J* = 2, 3.2 Hz), 5.33 (1H, dd, *J* = 3.2, 10 Hz), 5.63-5.71 (2H, m), 7.23-7.34 (5H, m).
^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 20.82, 27.11, 27.85, 29.84, 37.81, 39.02, 61.78, 63.16, 66.51, 68.86, 69.62, 71.95, 72.24, 72.35, 74.91, 96.90, 127.89, 128.02, 128.22, 128.51, 130.19, 137.76, 171.73, 177.42, 206.31.
MS (ESI): 983 $(M+H)^+$



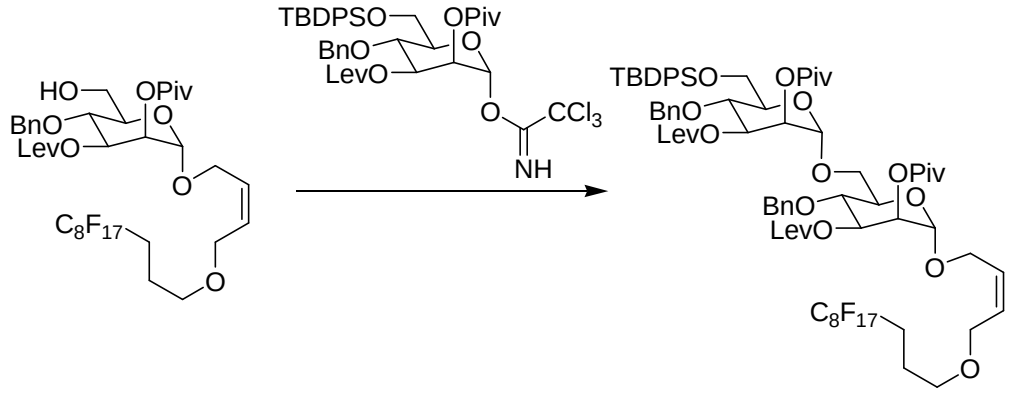
Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside (34)

To a solution of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-6-hydroxy-3-*O*-levunilyl-2-*O*-pivaloyl-α-D-mannopyranoside (42 mg, 0.043 mmol) in pyridine (3 mL) was added 1 M solution of $NH_2NH_2.H_2O$ in pyridine/acetic acid (3:2) (0.215 mmol, 0.22 mL). The reaction mixture was stirred for 30 min and then concentrated. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain the desired product (36 mg, 0.041 mmol, 95%) as a yellow gel.
R_f: 0.38 (EtOAc/hexane, 1:1)
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.21 (9H, s), 1.62 (1H, br s), 1.81-1.88 (4H, m), 2.09-2.18 (2H, m), 3.39 (1H, br s,), 3.45 (2H, t, *J* = 6 Hz), 3.64-3.72 (2H, m), 3.76 (1H dd, *J* = 3.6, 12 Hz), 3.84 (1H, dd, *J* = 2.4, 12 Hz), 4.00 (1H, d, *J* = 5.6 Hz), 4.05 (1H, dd, *J* = 6, 12.8 Hz), 4.11-4.19 (2H, m), 4.70 (1H, d, *J* = 11.2 Hz), 4.75 (1H, d, *J* = 1.2 Hz), 4.77 (1H, d, *J* = 11.2 Hz), 5.02-5.04 (1H, m), 5.62-5.73 (2H, m), 7.23-7.33 (5H, m).
^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 27.15, 39.11, 62.01, 63.15, 66.49, 68.88, 70.46, 71.77, 72.08, 74.99, 75.15, 96.96, 128.03, 128.18, 128.31, 128.34, 128.68, 130.08, 137.98, 178.11.
MS (ESI): 884 $(M+H)^+$



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3,6-di-*O*-(2-*O*-acetyl-3,4,6-*O*-tribenzyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside (35)

A solution of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside (30 mg, 0.034 mmol) and 2-*O*-acetyl-3,4,6-*O*-tribenzyl-α/β-D-mannopyranosyl trichloroacetimidate (65 mg, 0.102 mmol) in dichloromethane (3 mL) was cooled to 5 ºC and TMSOTf (15 μL, 0.80 mmol) was added. The reaction mixture was stirred for 30 min. The reaction mixture was quenched with triethylamine (30 μL) and then concentrated under reduced pressure. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain mannose trisaccharide (58 mg, 0.032 mmol, 94%) as a yellow gel.
R_f: 0.78 (EtOAc/DCM, 1:9)
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.17 (9H, s), 1.78-1.85 (2H, m), 2.09 (3H, s), 2.13 (3H, s), 2.08-2.18 (2H, m), 3.41 (2H, t, *J* = 6 Hz), 3.57-4.18 (18H, m), 4.40-4.49 (7H, m), 4.59-4.73 (7H, m), 4.83 (2H, d, *J* = 10.8 Hz), 4.96 (1H, s), 5.04 (1H, s), 5.13 (1H, s), 5.35 (1H, s), 5.44 (1H, d, *J* = 2 Hz), 5.56-5.68 (2H, m), 7.10-7.38 (35H, m).
^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 20.86, 21.10, 21.15, 27.20, 39.01, 63.18, 65.88, 66.52, 68.21, 68.40, 68.61, 68.79, 70.84, 71.69, 71.77, 71.82, 71.95, 72.12, 73.41, 73.47, 73.95, 74.16, 74.50, 74.62, 77.29, 77.59, 78.06, 78.57, 96.37, 98.29, 100.22, 127.27, 127.29, 127.32, 127.51, 127.60, 127.68, 127.72, 127.79, 127.87, 127.90, 127.96, 128.07, 128.13, 128.17, 128.27, 128.35, 128.36, 128.39, 128.51, 128.57, 130.11, 137.59, 137.75, 137.83, 138.11, 138.36, 138.38, 138.84, 170.27, 170.30, 177.57.
MS (ESI): 1835 $(M+H)^+$



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-*O*-levulinyl-6-*O*-(4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside (36)

A solution of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-6-hydroxy-3-*O*-levunilyl-2-*O*-pivaloyl-α-D-mannopyranoside (78 mg, 0.079 mmol) and 4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levunilyl-2-*O*-pivaloyl-α/β-D-mannopyranosyl trichloroacetimidate (86 mg, 0.103 mmol) in dichloromethane (3 mL) was cooled to 5 ºC and TMSOTf (7 μL, 0.40 mmol) was added. The reaction mixture was stirred for 15 min.

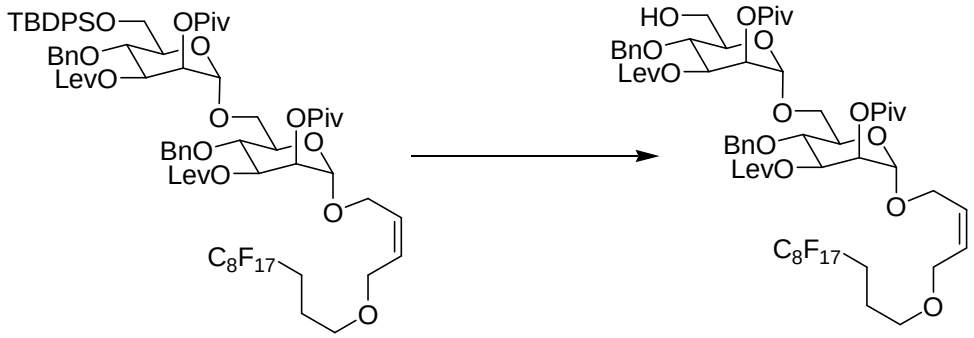
The reaction mixture was quenched with triethylamine (20 μL) and then concentrated under reduced pressure. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain mannose disaccharide (118 mg, 0.071 mmol, 90%) as a yellow gel.

R_f: 0.75 (EtOAc/DCM, 1:9)

^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.09 (9H, s), 1.19 (9H, s), 1,24 (9H, s), 1.79-1.86 (2H, m), 2.14 (3H, s), 2.16 (3H, s), 2.08-2.21 (2H, m), 2.37-2.50 (4H, m), 2.63-2.76 (2H, m), 3.44 (2H, t, *J* = 6 Hz), 3.70 (2H, d, *J* = 9.6 Hz), 3.81-3.91 (5H, m), 4.03-4.21 (5H, m), 4.56 (1H, d, *J* = 11.2 Hz), 4.61 (1H, d, *J* = 11.2 Hz), 4.69 (1H, d, *J* = 2.8 Hz), 4.71 (2H, s), 4.91 (1H, s), 5.16 (1H, s), 5.31-5.33 (2H, m), 5.37 (1H, dd, *J* = 3.6, 10 Hz), 5.56-5.68 (2H, m), 7.10-7.43 (16H, m), 7.70 (2H, d, *J* = 6.8 Hz), 7.75 (2H, d, *J* = 6.8 Hz).

^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 19.37, 26.91, 27.12, 27.17, 27.89, 29.83, 29.86, 37.83, 37.88, 39.00, 62.60, 63.10, 66.59, 68.76, 69.44, 69.57, 71.09, 72.47, 72.61, 72.67, 74.76, 74.96, 77.30, 96.68, 98.04, 127.63, 127.75, 127.86, 127.87, 128.38, 128.41, 129.68, 129.76, 130.53, 133.13, 133.50, 135.69, 135.94, 137.75, 138.14, 171.40, 171.71, 177.38, 177.65, 206.27.

MS (ESI): 1679 $(M+Na)^+$



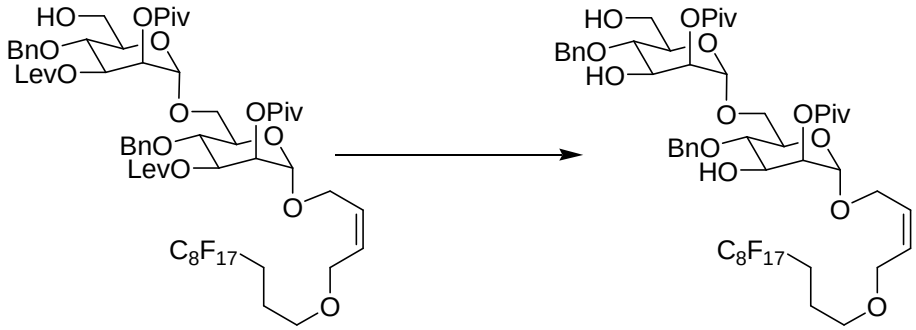
Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-*O*-levulinyl-6-*O*-(4-*O*-benzyl-6-hydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside (37)

To a solution of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-*O*-levulinyl-6-*O*-(4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside (96 mg, 0.058 mmol) in THF (3 mL) was added acetic acid (30 μL) followed by tetrabutylammonium fluoride (1.0 M in THF, 0.17 mL, 0.168 mmol). The reaction mixture was stirred for 10 h and then concentrated. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain the desilylated product (65 mg, 0.046 mmol, 79%) as a yellow gel.

R_f: 0.54 (EtOAc/DCM, 1:9)

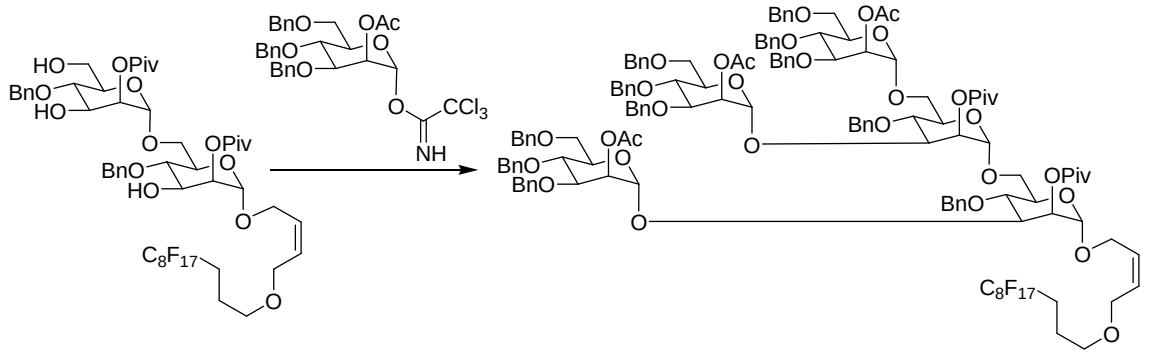
^{1}H NMR (300 MHz, $CDCl_3$): δ (ppm) 1.20 (9H, s), 1,22 (9H, s), 1.79-1.86 (3H, m), 2.14 (3H, s), 2.16 (3H, s), 2.08-2.21 (2H, m), 2.36-2.49 (4H, m), 2.63-2.74 (2H, m), 3.45 (2H, t, *J* = 6 Hz), 3.68-4.16 (14H, m), 4.58 (1H, d, *J* = 11.2 Hz), 4.62 (1H, d, *J* = 11.2 Hz),

4.69-4.75 (3H, m), 4.89 (1H, d, *J* = 2 Hz), 5.15-5.17 (1H, m), 5.27-5.38 (3H, m), 5.61-5.72 (2H, m), 7.16-7.38 (10H, m).
^{13}C NMR (75 MHz, $CDCl_3$): δ (ppm) 20.85, 27.12, 27.15, 27.83, 27.88, 29.84, 37.82, 39.00, 61.61, 63.17, 65.51, 66.56, 68.75, 69.25, 69.53, 71.07, 71.99, 72.07, 72.40, 72.43, 72.53, 74.81, 74.94, 96.71, 97.89, 127.66, 127.87, 127.98, 128.22, 128.47, 128.49, 130.47, 137.77, 137.82, 171.39, 171.72, 177.12, 177.61, 206.26, 206.28.
MS (ESI): 1419 $(M+H)^+$



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-hydroxy-6-*O*-(4-*O*-benzyl-3,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside (42)

To a solution of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-*O*-levulinyl-6-*O*-(4-*O*-benzyl-6-hydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside (65 mg, 0.046 mmol) in pyridine (3 mL) was added 1 M solution of $NH_2NH_2.H_2O$ in pyridine/acetic acid (3:2) (0.460 mmol, 0.46 mL). The reaction mixture was stirred for 30 min and then concentrated. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain the desired product (53 mg, 0.043 mmol, 94%) as a yellow gel.
R_f: 0.38 (EtOAc/DCM, 1:9)
^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.19 (9H, s), 1.21 (9H, s), 1.79-2.21 (7H, m), 3.44 (2H, t, *J* = 6 Hz), 3.58-3.86 (9H, m), 4.01-4.16 (5H, m), 4.62 (1H, d, *J* = 11.2 Hz), 4.69 (1H, d, *J* = 11.2 Hz), 4.73 (1H, d, *J* = 1.2 Hz), 4.76 (1H, d, *J* = 11.2 Hz), 4.82-4.85 (2H, m), 5.00-5.01 (1H, m), 5.08-5.09 (1H, m), 5.60-5.69 (2H, m), 7.23-7.33 (10H, m).
^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 27.13, 27.15, 39.08, 39.13, 61.80, 63.12, 66.11, 66.52, 68.82, 70.57, 70.72, 70.79, 71.79, 71.85, 72.17, 74.89, 74.91, 74.94, 75.62, 77.28, 96.68, 97.72, 127.90, 127.95, 128.04, 128.17, 128.29, 128.61, 128.66, 130.18, 138.00, 138.03, 177.95, 178.27.
MS (ESI): 1222 $(M+H)^+$



Synthesis of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-*O*-(2-*O*-acetyl-3,4,6-*O*-tribenzyl-α-D-mannopyranoside)-6-*O*-[4-*O*-benzyl-3,6-di-*O*-(2-*O*-acetyl-3,4,6-*O*-tribenzyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside]-2-*O*-pivaloyl-α-D-mannopyranoside (43)

A solution of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-hydroxy-6-*O*-(4-*O*-benzyl-3,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside (50 mg, 0.041 mmol) and 2-*O*-acetyl-3,4,6-*O*-tribenzyl-α/β-D-mannopyranosyl trichloroacetimidate (117 mg, 0.185 mmol) in dichloromethane (3 mL) was cooled to 5 ºC and TMSOTf (4 μL, 0.021 mmol) was added. The reaction mixture was stirred for 30 min. The reaction mixture was quenched with triethylamine (30 μL) and then concentrated under reduced pressure. The crude product was purified by solid-phase extraction by using a Fluorous solid-phase extraction (FSPE) cartridge. Non-fluorous compounds were eluted with 80% MeOH/water and the desired product was eluted by 100% MeOH. The solvent was removed under reduced pressure to obtain mannose pentasaccharide (58 mg, 0.032 mmol, 92%) as a yellow gel.

R_f: 0.82 (EtOAc/DCM, 1:9)

^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 1.14 (9H, s), 1.18 (9H, s), 1.79-1.86 (2H, m), 2.06 (3H, s), 2.08 (3H, s), 2.12 (3H, s), 2.03-2.21 (2H, m), 3.36 (2H, t, *J* = 6 Hz), 3.53-3.58 (3H, m), 3.59-3.78 (12H, m), 3.81-3.88 (4H, m), 3.90-4.00 (6H, m), 4.05-4.12 (2H, m), 4.14 (1H, dd, *J* =3.2, 8.8 Hz), 4.31-4.49 (11H, m), 4.52-4.76 (11H, m), 4.81-4.86 (3H, m), 4.96 (1H, s), 5.03 (1H, s), 5.09-5.14 (3H, m), 5.34-5.36 (2H, m), 5.46 (1H, s), 5.58-5.64 (2H, m), 7.09-7.28 (55H, m).

^{13}C NMR (100 MHz, $CDCl_3$): δ (ppm) 20.85, 21.03, 21.07, 21.15, 27.16, 27.23, 29.76, 38.98, 63.13, 66.53, 68.13, 68.40, 68.55, 68.68, 68.98, 69.02, 70.72, 70.84, 71.24, 71.79, 71.85, 71.96, 72.13, 72.27, 73.41, 73.48, 73.84, 73.94, 74.11, 74.42, 74.59, 74.82, 75.20, 75.31, 75.45, 75.52, 77.28, 77.66, 78.19, 78.34, 78.60, 96.24, 97.01, 98.45, 100.17, 100.29, 127.26, 127.29, 127.49, 127.53, 127.62, 127.65, 127.68, 127.71, 127.75, 127.78, 127.81, 127.83, 127.86, 127.88, 127.96, 128.01, 128.04, 128.06, 128.09, 128.15, 128.26, 128.33, 128.36, 128.44, 128.46, 128.50, 128.53, 128.65, 130.49, 137.48, 137.73, 137.76, 137.82, 138.10, 138.30, 138.39, 138.89, 138.91, 170.18, 170.24, 177.18, 177.64.

MS (MALDI-TOF): 2645 $(M+H)^+$

References

1. Mamidyala, S. K.; Ko, K.-S.; Jaipuri, F. A.; Park, G.; Pohl, N. L. *J. Fluorine Chem.* **2006**, *127*, 571-579.
2. Perron-Sierra, F. M.; Burbridge, M.; Pean, C.; Tucker, G. C.; Casara, P. *Tetrahedron Lett*. **2004**, *45*, 4163-4166.

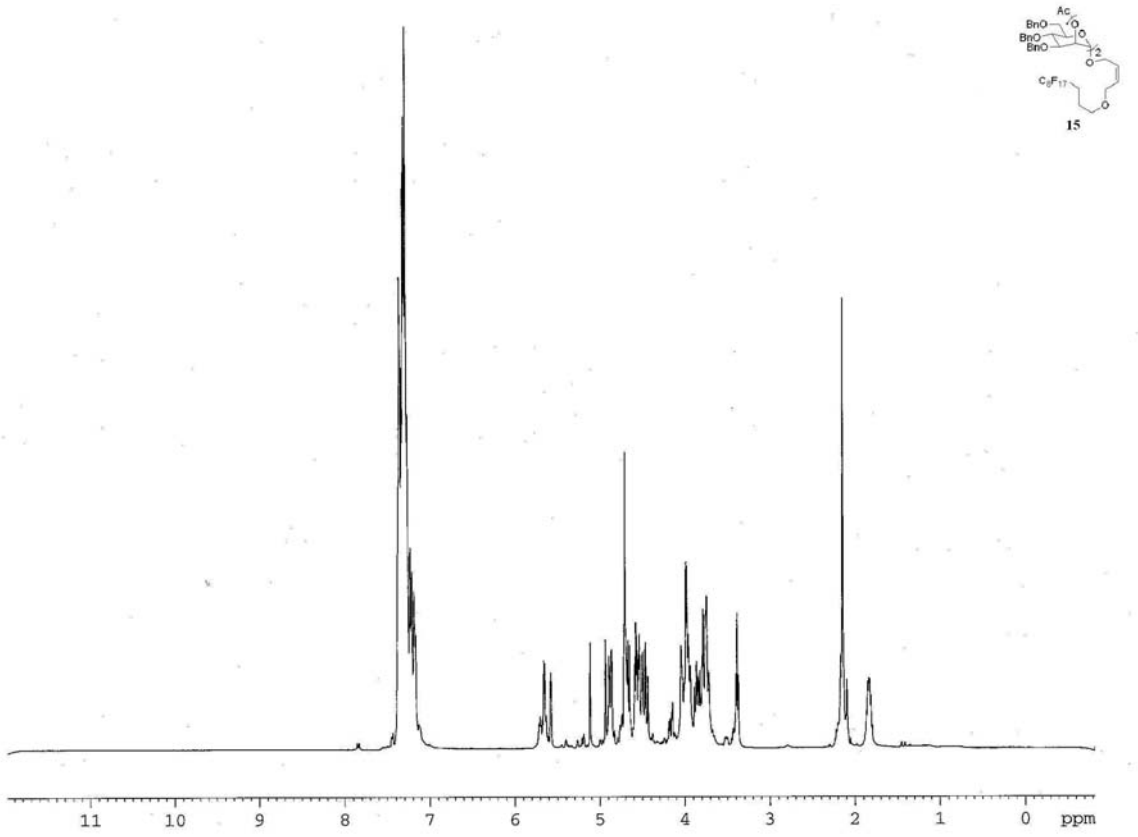


Figure S1: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-(2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-α-D-mannopyranoside.

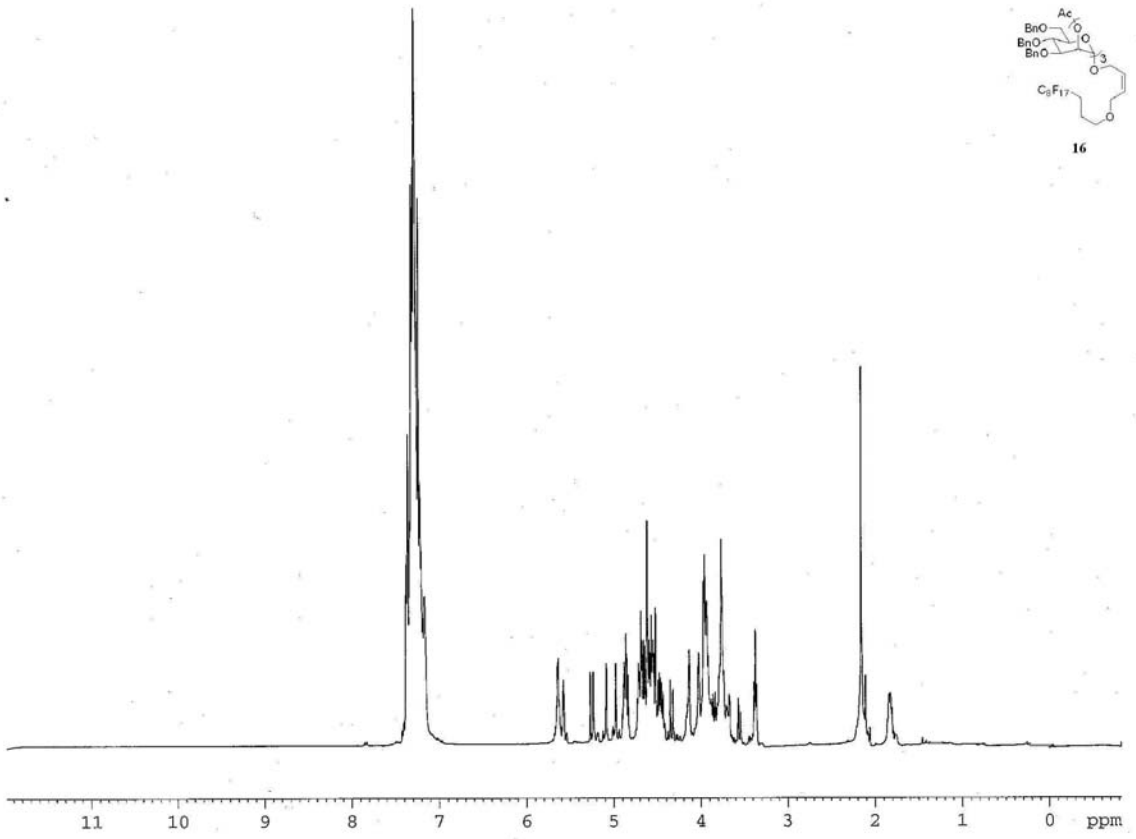


Figure S2: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-[2-*O*-(2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl]-α-D-mannopyranoside.

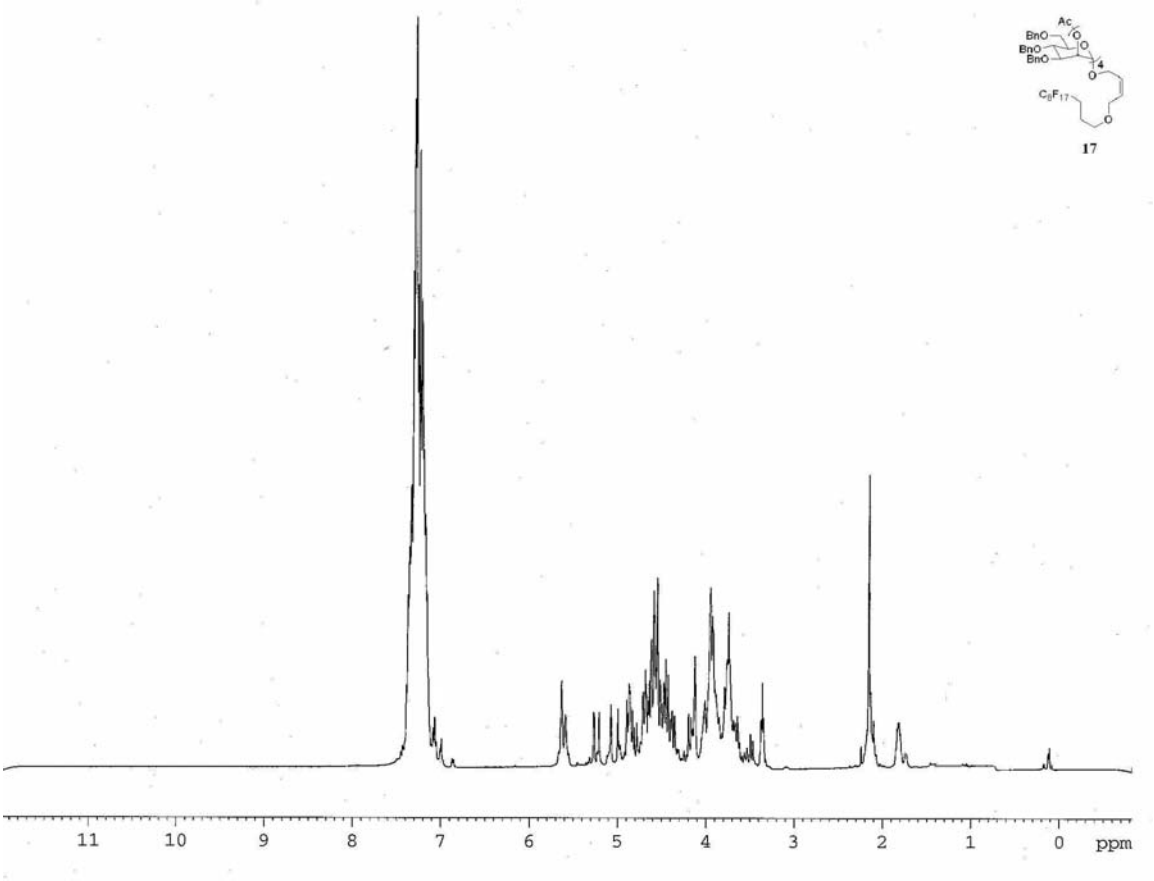


Figure S3: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-3,4,6-tri-*O*-benzyl-2-*O*-[2-*O*-(2-*O*-(2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl]-α-D-mannopyranoside.

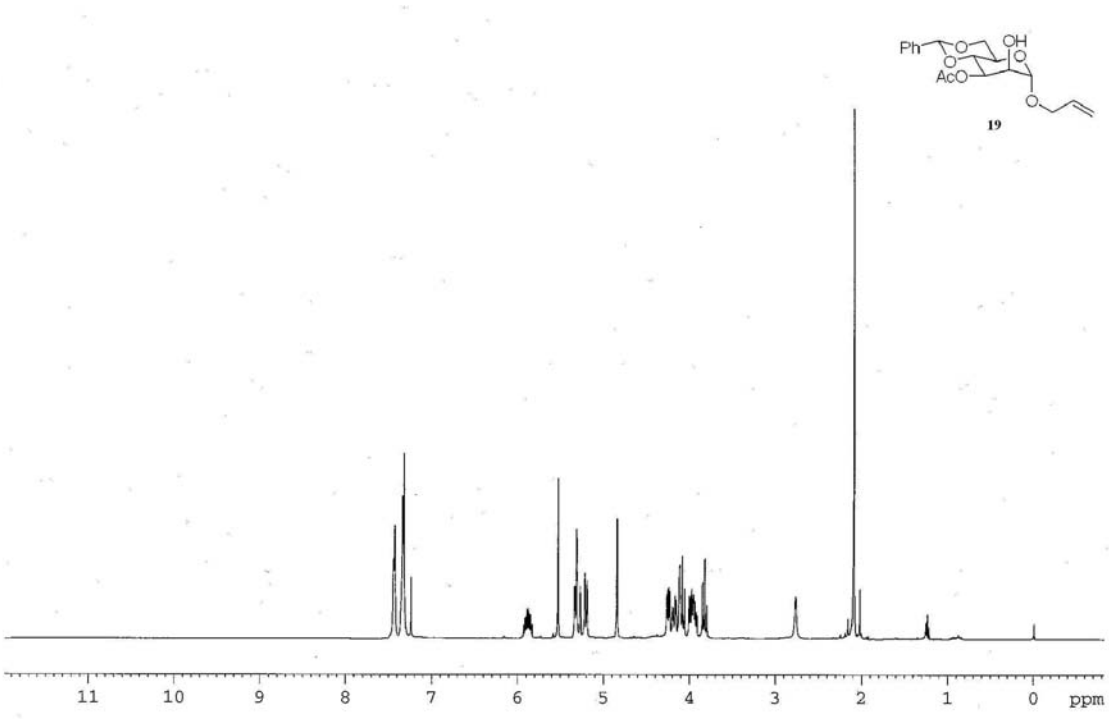


Figure S4: ^{1}H NMR of allyl-3-*O*-acetyl-4,6-*O*-benzylidene-2-hydroxy-α-D-mannopyranoside.

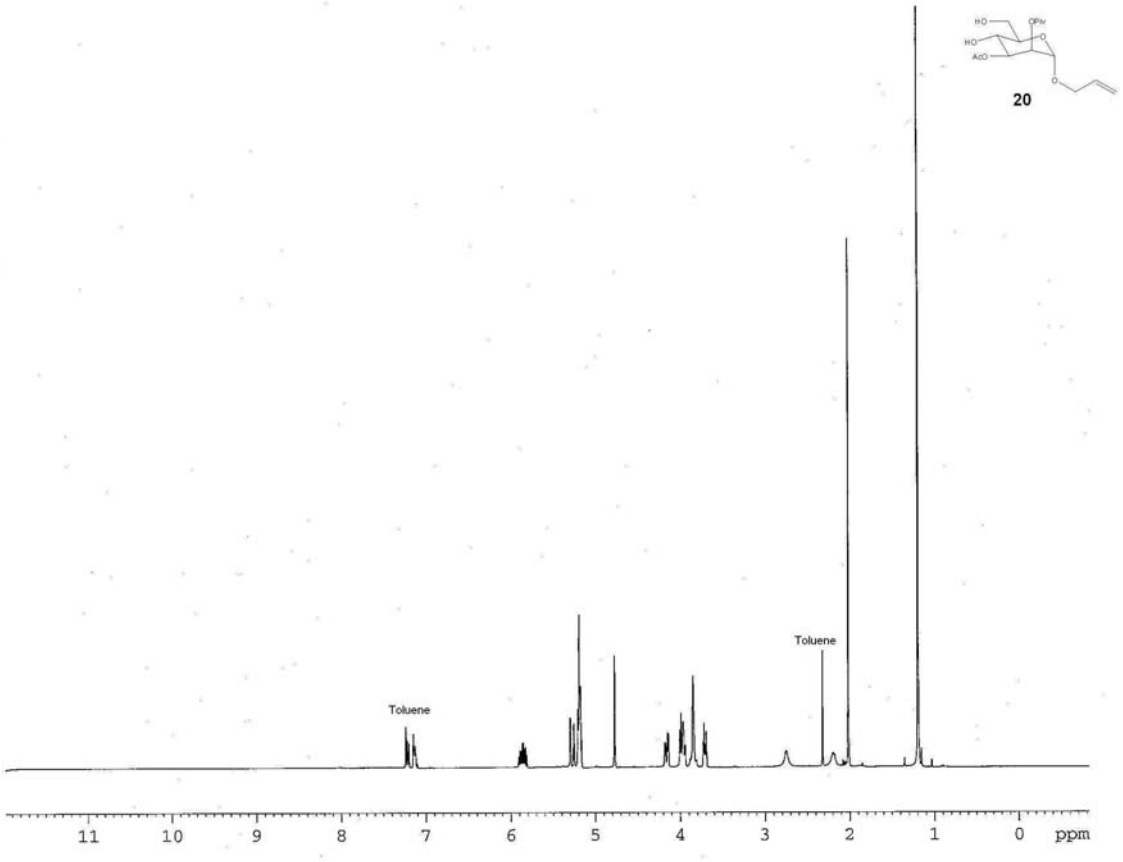


Figure S5: ^{1}H NMR of allyl-3-*O*-acetyl-4,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside.

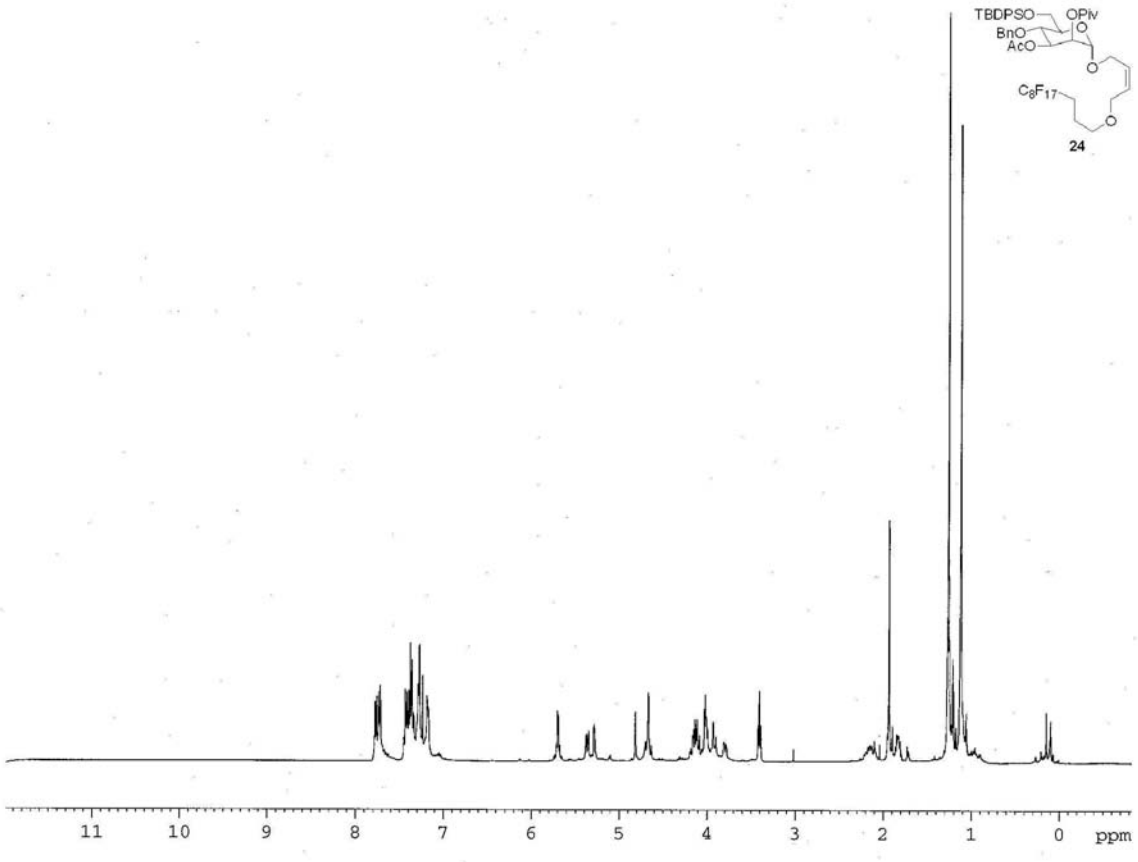


Figure S6: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-3-*O*-acetyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-2-*O*-pivaloyl-α-D-mannopyranoside.

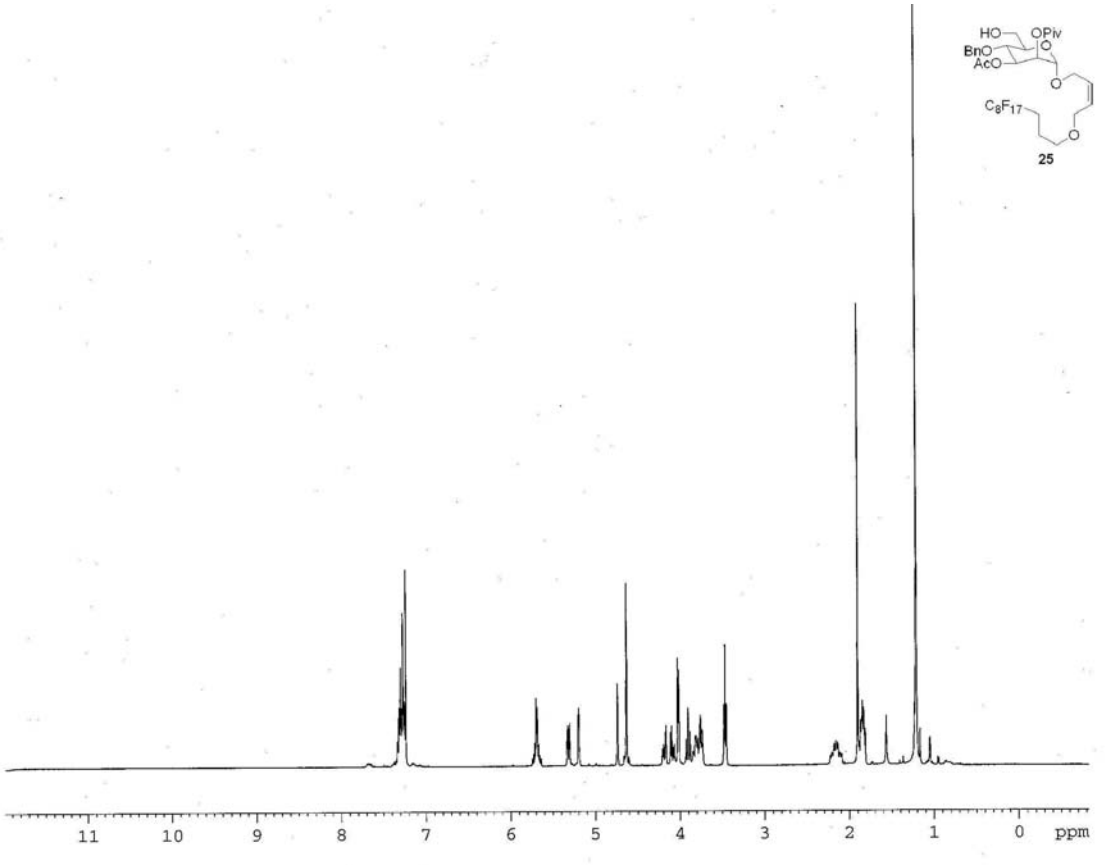


Figure S7: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-3-*O*-acetyl-4-*O*-benzyl-6-hydroxy-2-*O*-pivaloyl-α-D-mannopyranoside.

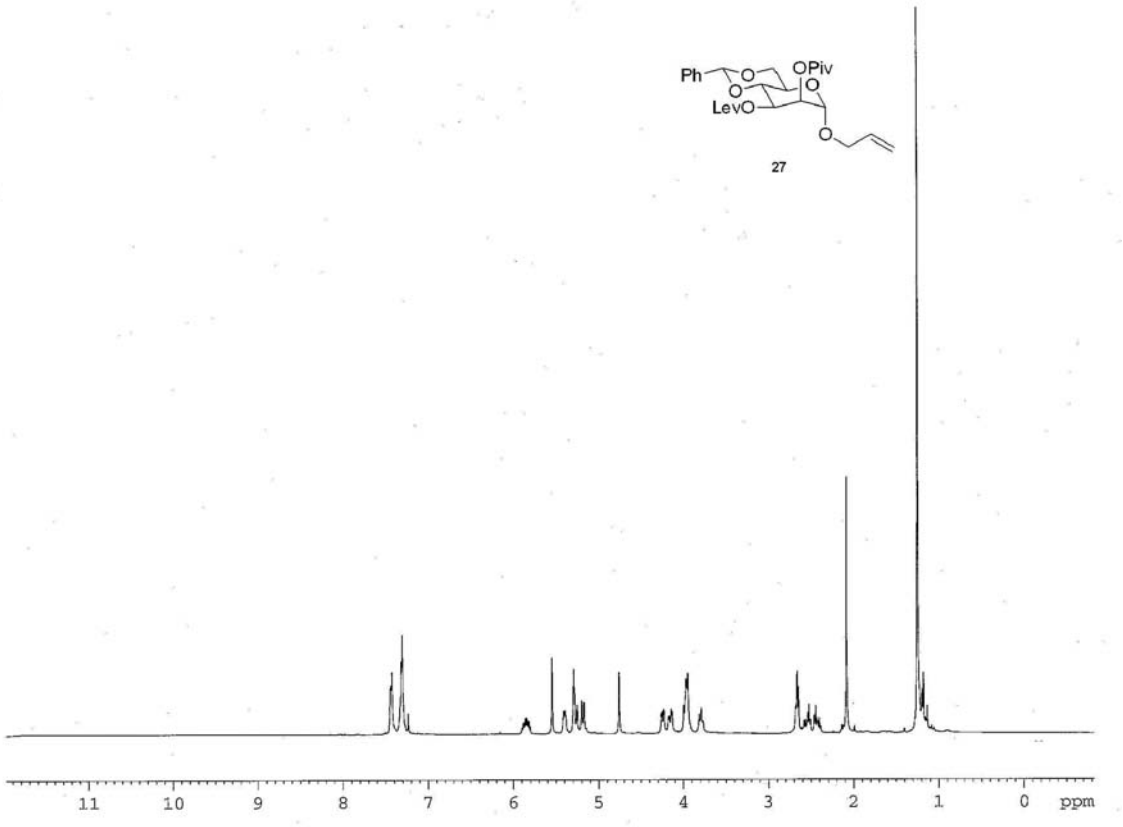


Figure S8: ^{1}H NMR of allyl-4,6-*O*-benzylidene-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside.

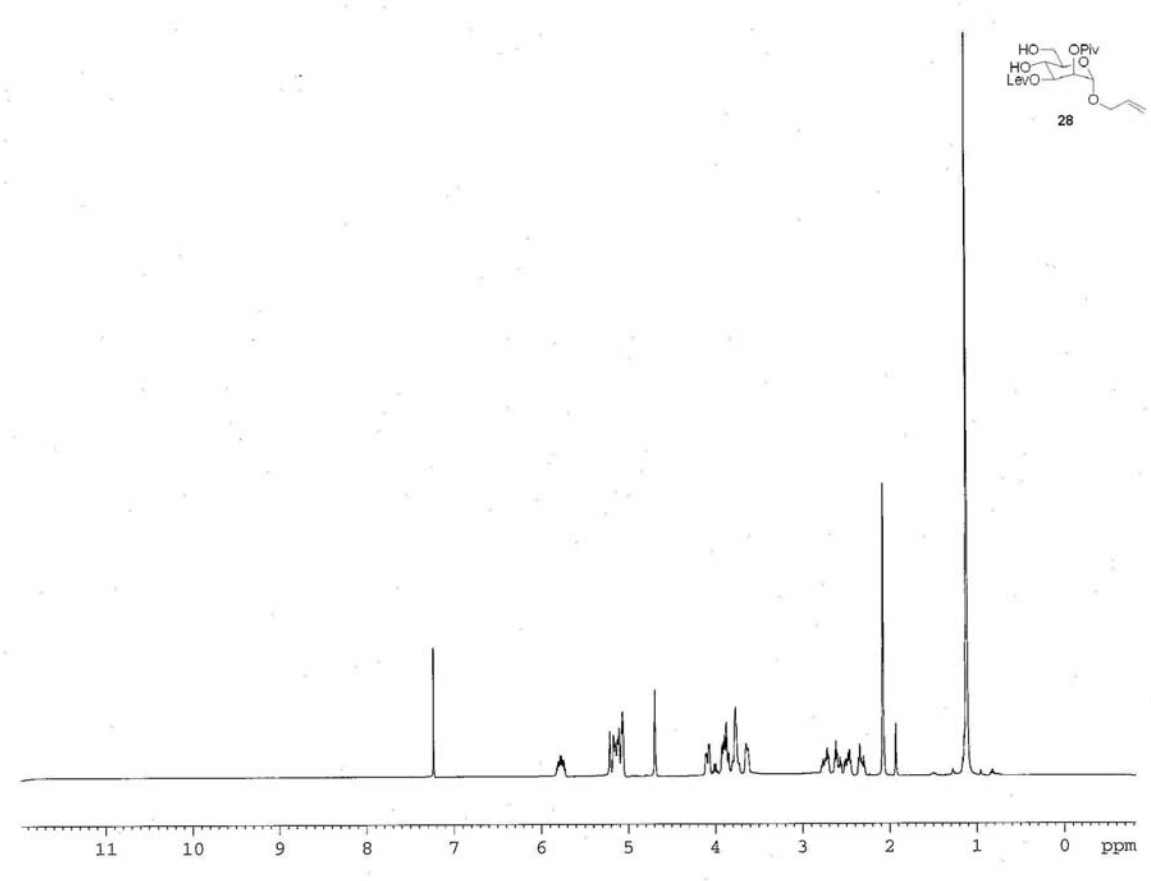


Figure S9: ^{1}H NMR of allyl-4,6-dihydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside.

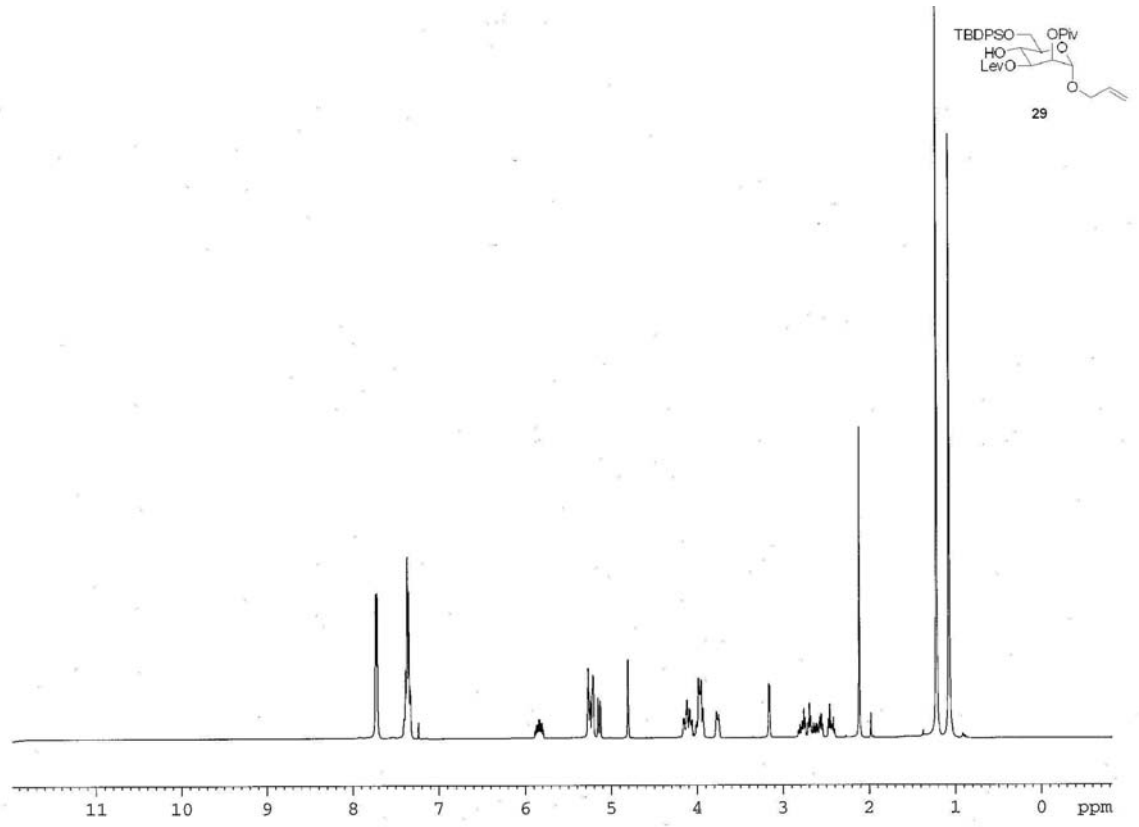


Figure S10: ^{1}H NMR of allyl-6-*O*-*t*-butyldiphenylsilyl-4-hydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside.

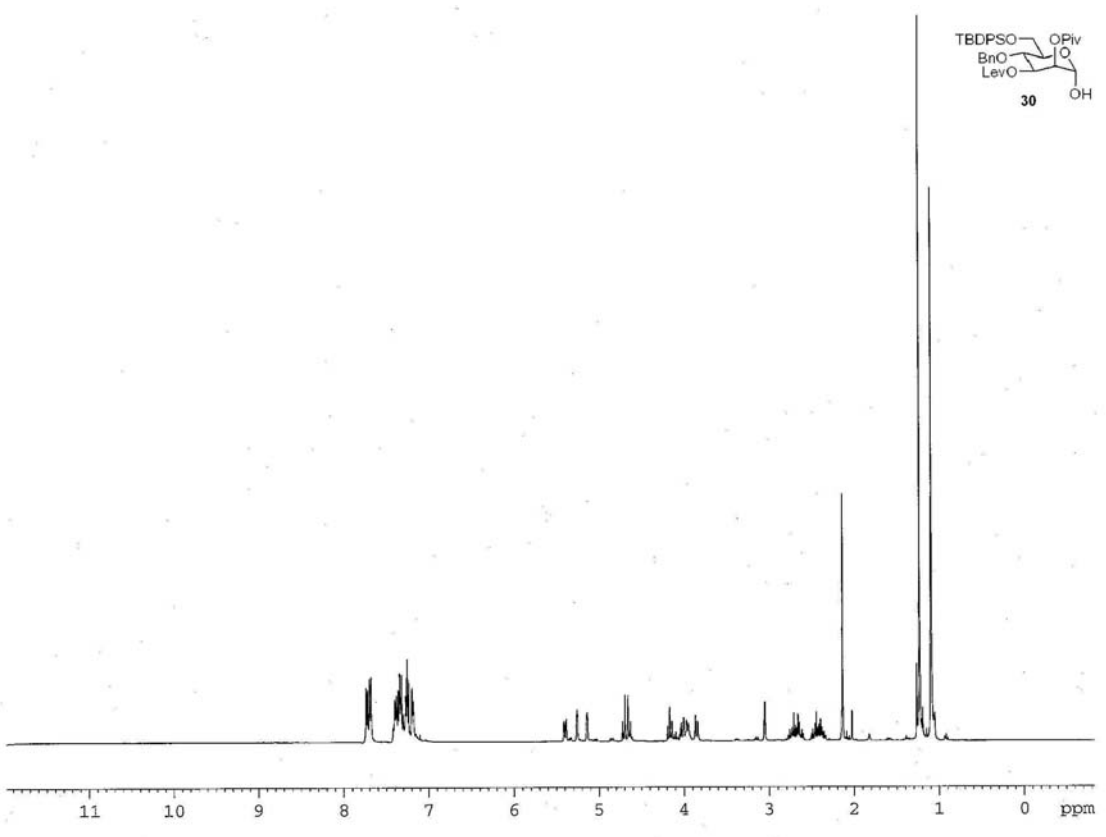


Figure S11: ^{1}H NMR of 4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside.

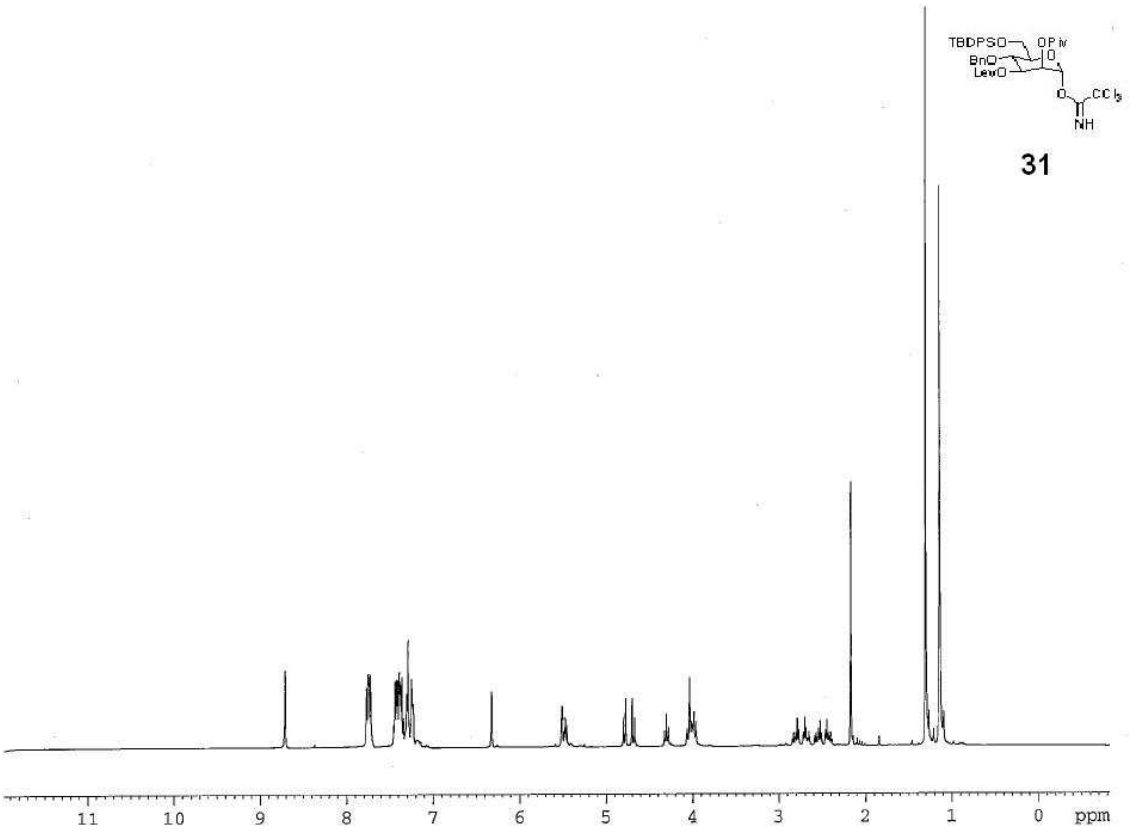


Figure S12: ^{1}H NMR of 4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranosyl trichloroacetimidate.

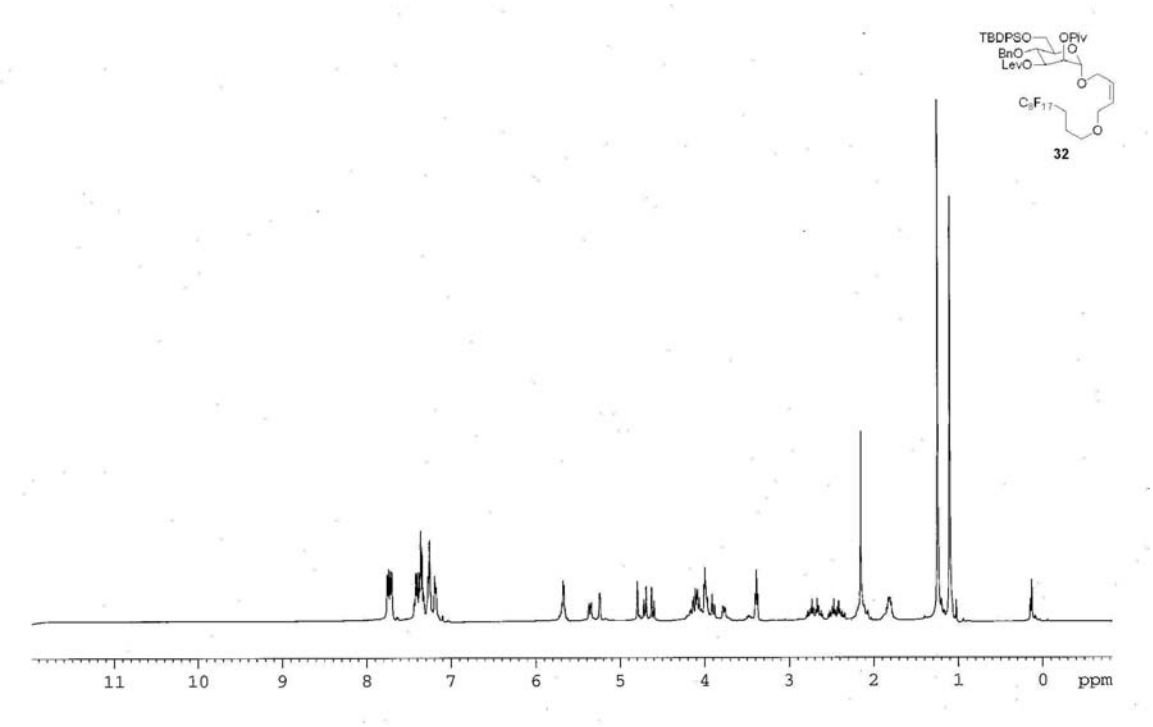


Figure S13: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside.

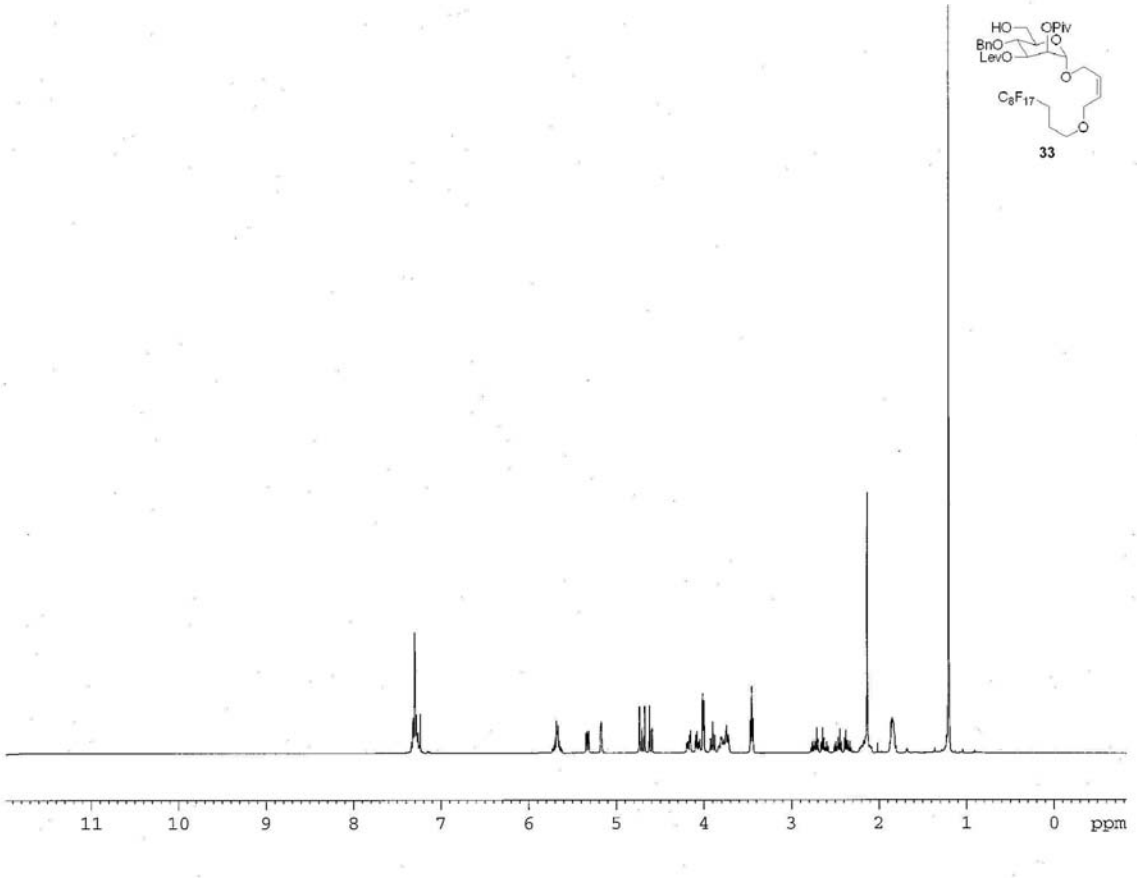


Figure S14: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-6-hydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside.

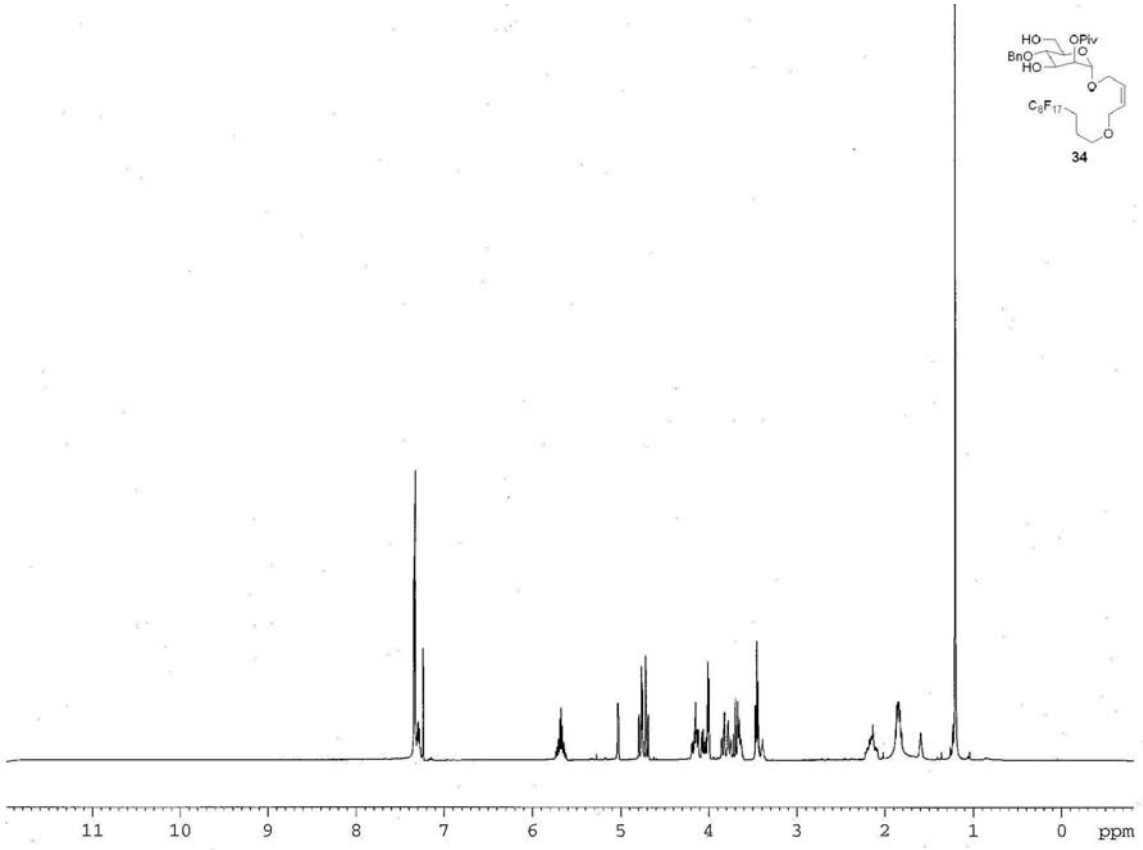


Figure S15: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside.

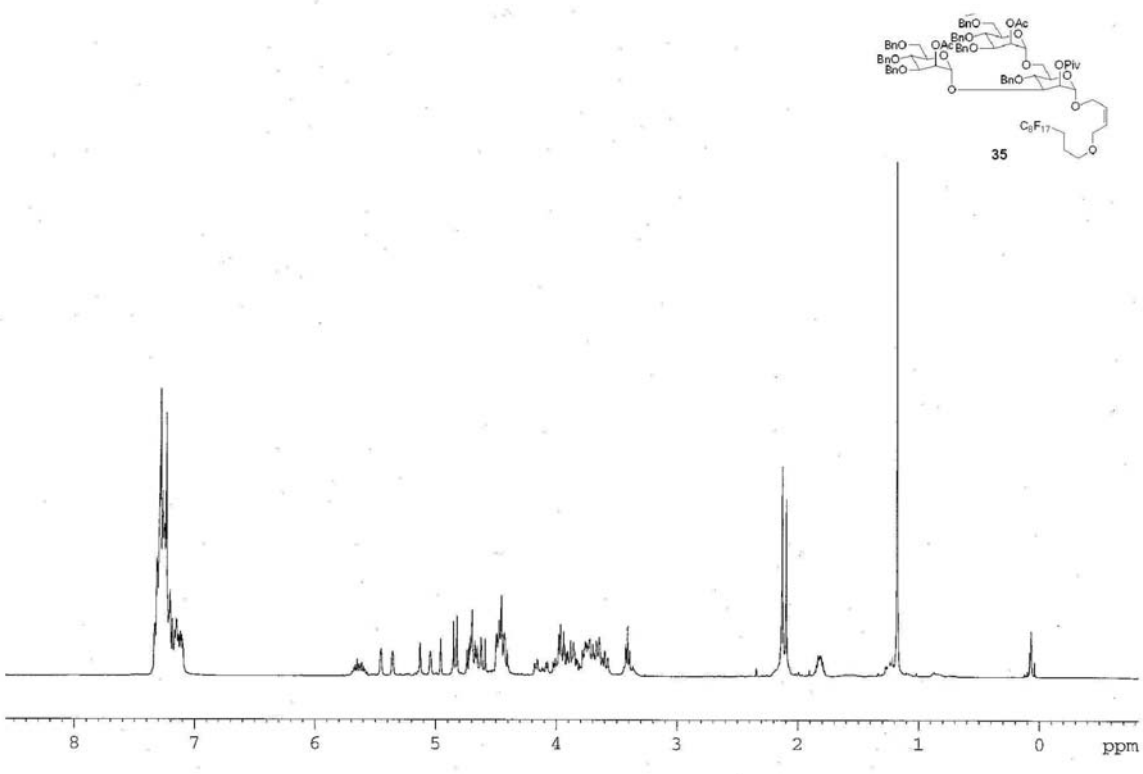


Figure S16: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3,6-di-*O*-(2-*O*-acetyl-3,4,6-*O*-tribenzyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside.

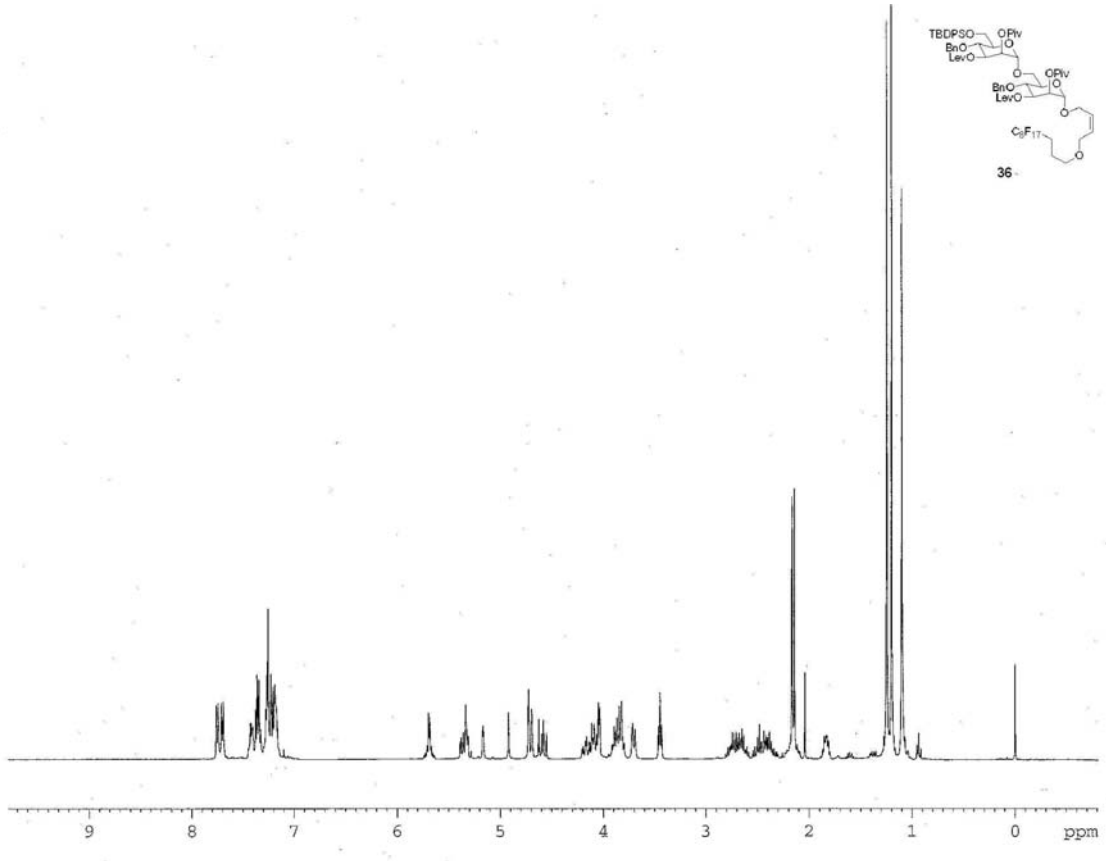


Figure S17: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-*O*-levulinyl-6-*O*-(4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside.

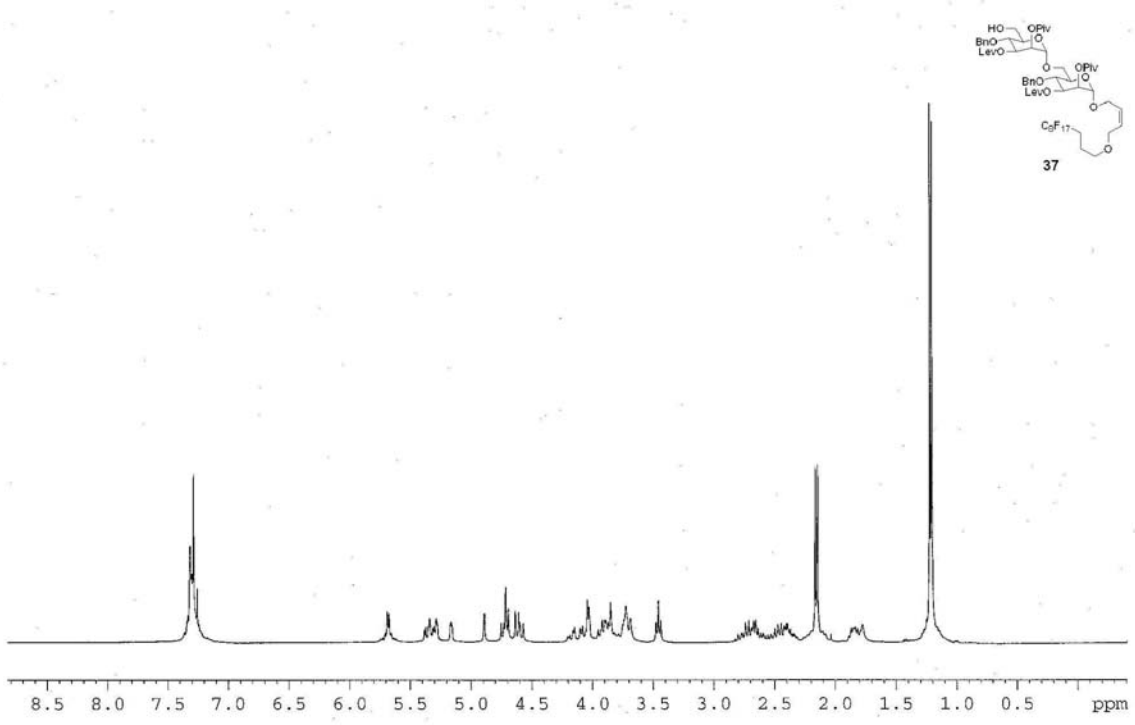


Figure S18: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-*O*-levulinyl-6-*O*-(4-*O*-benzyl-6-hydroxy-3-*O*-levulinyl-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside.

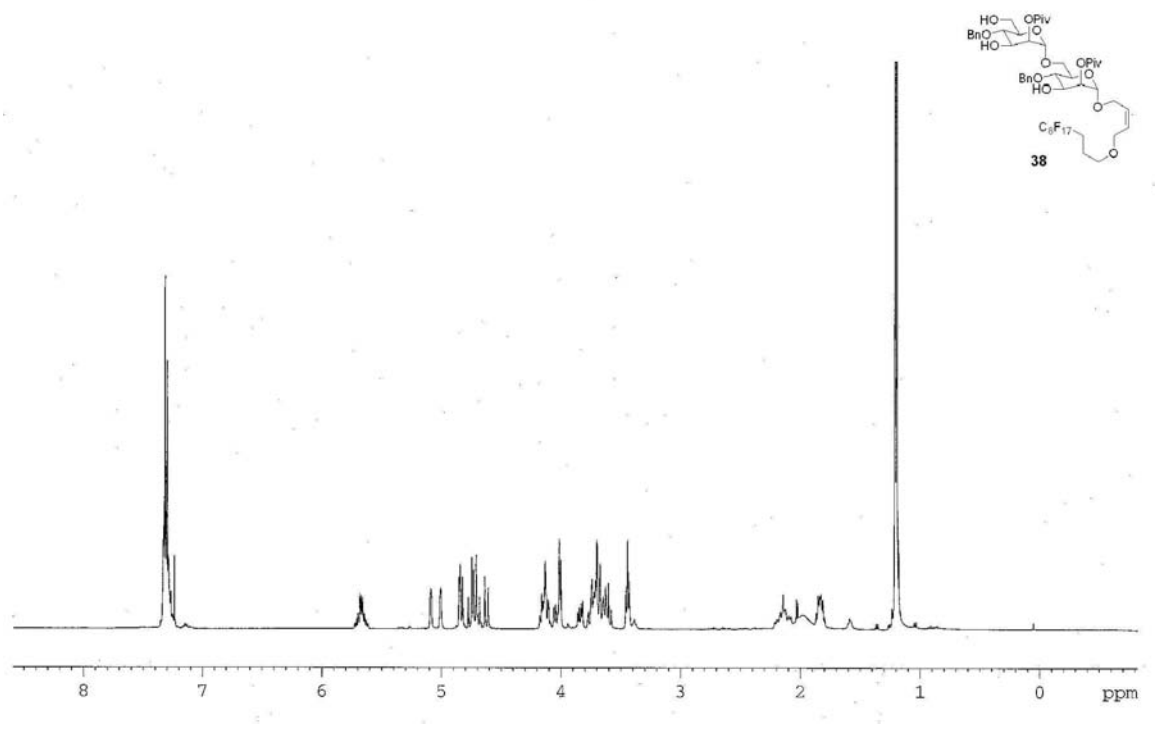


Figure S19: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-hydroxy-6-*O*-(4-*O*-benzyl-3,6-dihydroxy-2-*O*-pivaloyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside.

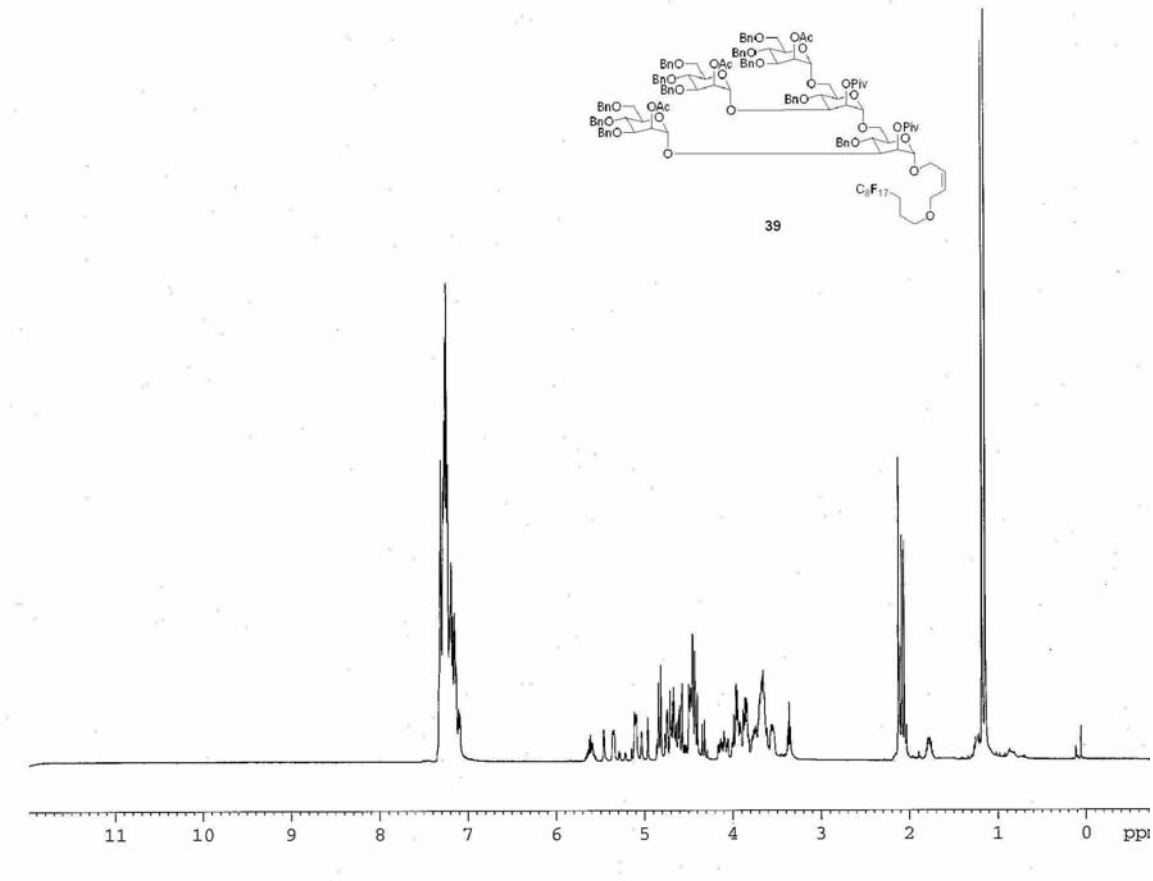


Figure S20: ^{1}H NMR of 3-(perfluorooctyl)propanyloxybutenyl-4-*O*-benzyl-3-*O*-(2-*O*-acetyl-3,4,6-*O*-tribenzyl-α-D-mannopyranoside)-6-*O*-[4-*O*-benzyl-3,6-di-*O*-(2-*O*-acetyl-3,4,6-*O*-tribenzyl-α-D-mannopyranoside)-2-*O*-pivaloyl-α-D-mannopyranoside]-2-*O*-pivaloyl-α-D-mannopyranoside.