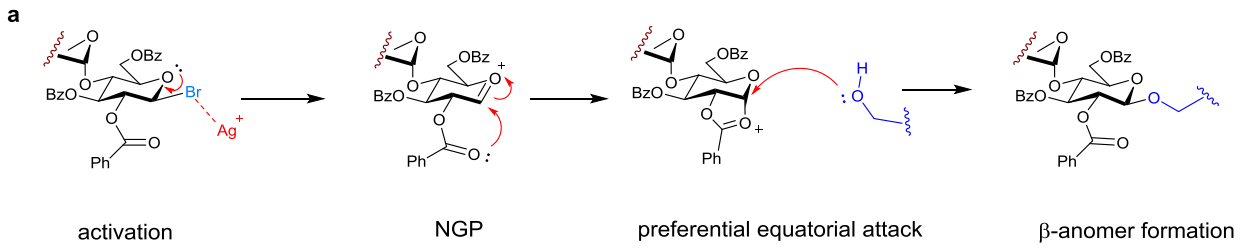
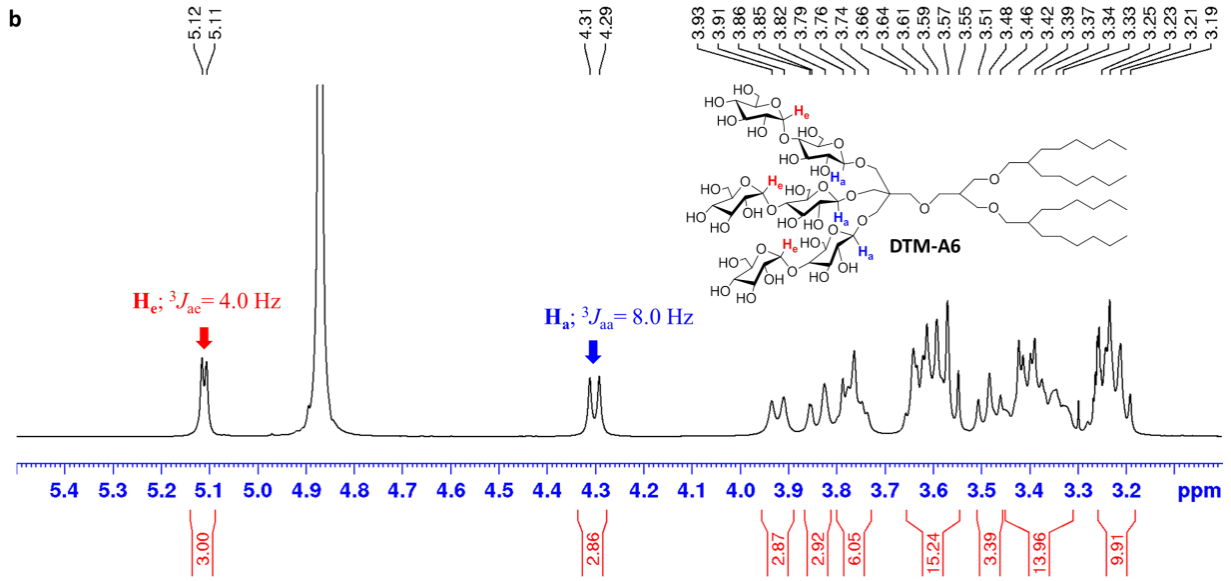
Supporting Information





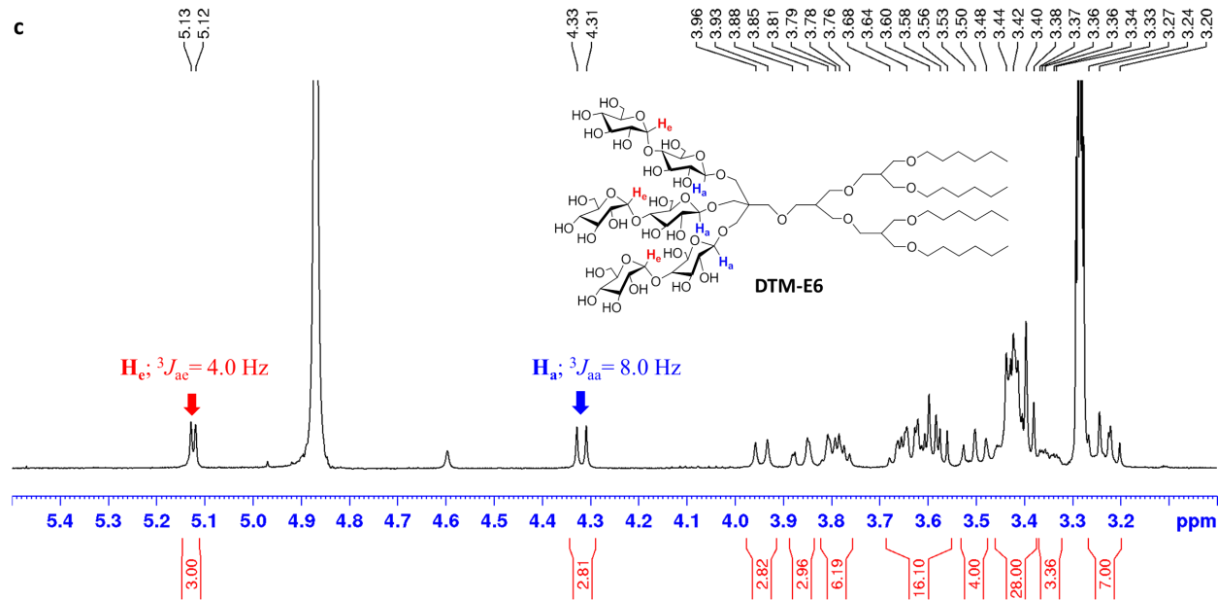


Figure S1. (a) Mechanism of neighboring group participation (NGP), leading to the preferential formation of β-glycosidic bond and ^{1}H NMR spectra of DTM-A6 (b) and DTM-E6 (c). The two sets of anomeric protons in the maltoside head group, labeled H_a and H_e in the chemical structures, are different in terms of their chemical shifts (δ) and coupling constants (^{3}J). Assignments for anomeric protons along with the coupling constants ($^{3}J_{aa}$ and $^{3}J_{ae}$) are given above the peaks in the NMR spectra. The peaks for the anomeric protons (H_a and H_e) appeared at 4.34 and 5.15 ppm for DTM-A6 while at 4.35 and 5.17 ppm for DTM-E6, as respective doublets with vicinal coupling constants ($^{3}J_{aa}$ and $^{3}J_{ae}$) of 8.0 and 4.0 Hz, respectively. The chemical shifts and coupling constants observed for newly formed H_a are typical for anomeric protons with β-glycosidic bond while the correponding values observed for H_e are typical for anomeric protons with α-glycosidic bond.

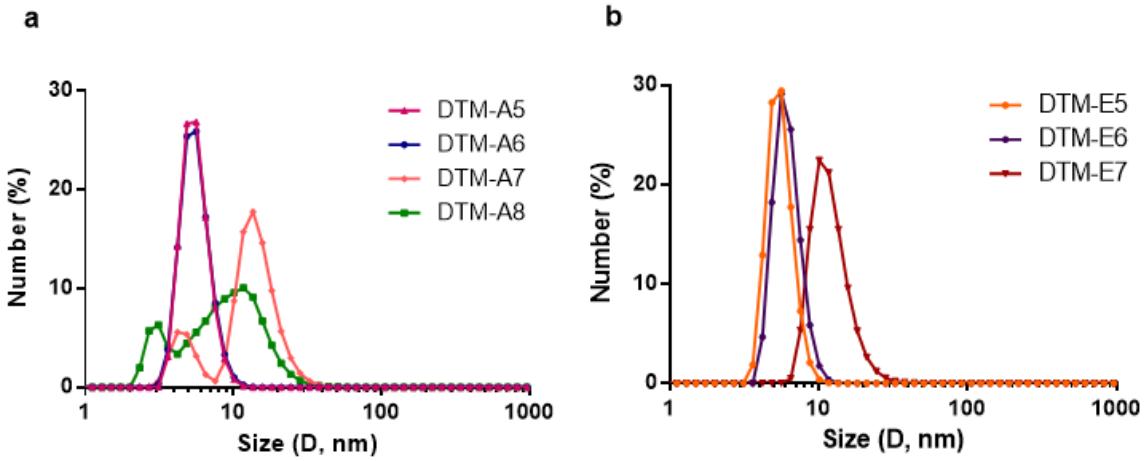


Figure S2. Dynamic light scattering profile of micelles formed by DTM-As and DTM-Es. Each DTM-A (DTM-A5, DTM-A6, DTM-A7, or DTM-A8) or DTM-E (DTM-E5, DTM-E6, or DTM-E7) was used at 1.0 wt%. Autocorrelation analysis of scattered light intensity as a function of time produces the translational diffusion coefficient and hydrodynamic radius (R_h) of detergent micelles.

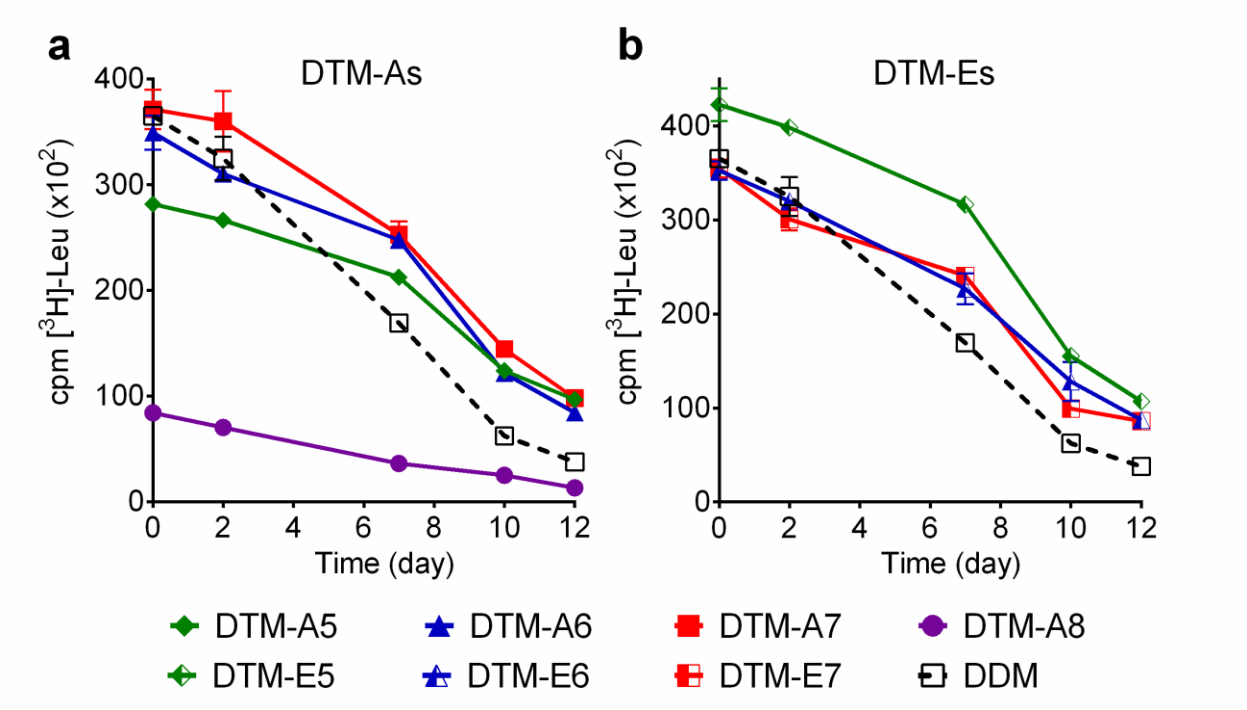


Figure S3. Long-term stability of LeuT solubilized in (a) DTM-As (DTM-A5/A6/A7/A8) or (b) DTM-Es (DTM-E5/E6/E7). Detergents were evaluated at CMC+0.02 wt%. DDM-purified transporter was diluted into the solutions containing individual DTMs and the resulting solutions were incubated over 12 days at room temperature. During the incubation, transporter stability was assessed by measuring the ability to bind the radiolabeled substrate ([^{3}H]-Leu) at regular intervals *via* scintillation proximity assay (SPA).

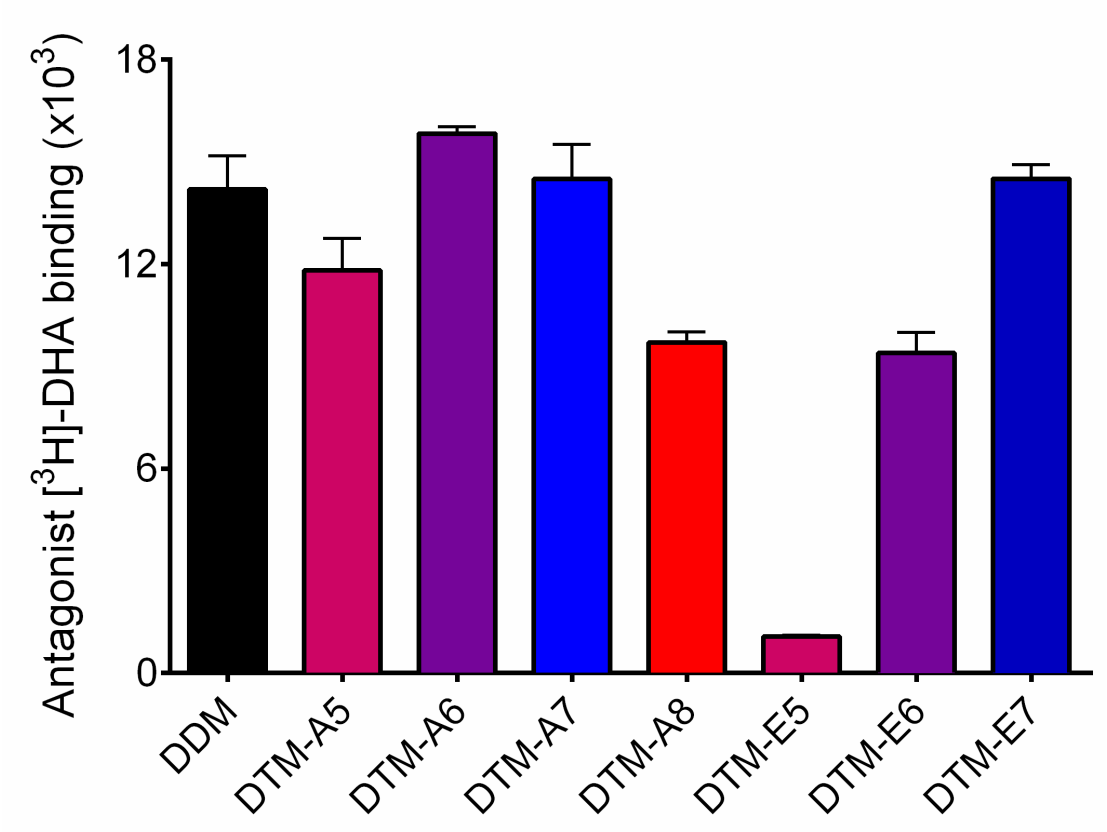


Figure S4. Stability of β_2AR solubilized in DDM, a DTM-A (DTM-A5/A6/A7/A8) or a DTM-E (DTM-E5/E6/E7). DDM-purified receptor was diluted into solutions containing the respective DTMs to give a final detergent concentration of CMC+0.2 wt%. Receptor stability was assessed by measuring the ability of the receptor to bind the radiolabeled ligand ([^{3}H]-dihydroalprenolol; [^{3}H]-DHA) following dilution and 30-min incubation.

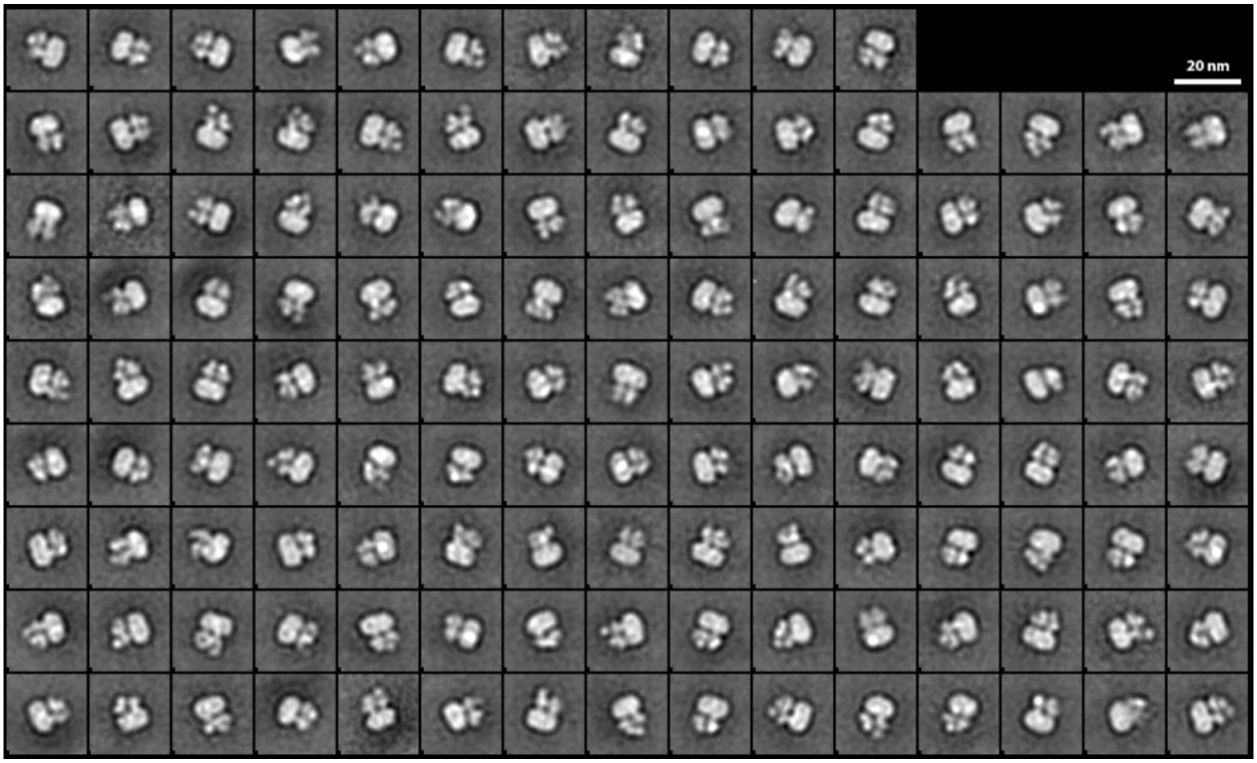


Figure S5. 2D classification of particle projections with 131 class averages obtained from EM analysis of negatively stained β_2AR-G_s complex solubilized in DTM-A6.

Detergent CMC determination by diphenylhexatriene (DPH) encapsulation

5.0 mM stock solutions of DTM-As and DTM-Es were prepared in distilled, deionized water. A series of detergent solutions with a range of concentrations were prepared from the stock solution. 200 µL of each detergent sample was placed into 96-well plate in duplicate. A DPH stock solution was made by dissolving 3.0 mg DPH in 5.0 mL THF. A DPH working solution was prepared by adding 50 µL of the stock solution into 950 µL of distilled water. For dye encapsulation, 2.0 µL DPH work solution was added into each well containing a detergent solution. Following 15 ~ 20 min incubation at room temperature, fluorescence intensities were measured at 430 nm upon excitation at 358 nm by using Synergy Mx Monochromator-Based Multi-Mode Microplate reader. Detergent CMC values were determined by plotting florescence intensities as a function of detergent concentrations.

Detergent micelle size measurement by dynamic light scattering (DLS) experiment

The DTM-As and DTM-Es were dissolved in distilled, deionized water to give a detergent concentration of 1.0 wt%. DTMs solutions were filtered using a syringe filter with a pore size of 0.22 µm. Hydrodynamic radii of the micelles produced by the DTM-As and DTM-Es were measured using a Malvern Zeta Sizer Nano ZS90 particle analyzer. A He-Ne laser at 633 nm with a maximum power of 5mW was used as a light source and scattered light was collected at the angle of 90°. Temperature was maintained at 25 ℃ throughout all measurements. The translational diffusion coefficient and hydrodynamic radius (R_h) of detergent micelles was calculated by autocorrelation analysis of scattered light intensity as a function of time. R_h values were expressed as mean ± SD (n = 5).

Protein stability evaluation

R. capsulatus superassembly stability assay

The superassembly was solubilized and purified according to the reported protocol.[1] Specialized photosynthetic membranes obtained from an engineered strain of *Rhodobacter capsulatus* were used for protein extraction. A 10 mL aliquot of the frozen membranes was completely thawed and then homogenized using a glass tissue homogenizer. The homogenate was incubated with mild agitation at 32 ℃ for 30 mins. The resulting homogenate was mixed with 1.0 wt% DDM and incubated at 32 ℃ for an additional 30 mins to allow the complex solubilization. Following ultracentrifugation, the supernatant containing the solubilized LHI-RC complexes was incubated with Ni^{2+}-NTA resins at 4 ℃ for one hour. The resin-containing solution was filtered using 10 HisSpinTrap columns and the individual columns were washed two times with 500 µL binding buffer containing 10 mM Tris (pH 7.8), 100 mL NaCl and

1×CMC DDM. Buffer containing 1M imidazole (2×300 μL) was used to elute the DDM-purified LHI-RC complexes. 80 μL of the protein sample was diluted into 920 μL of individual detergent solutions (DTM-As, DTM-Es, DDM and OG) so that the final detergent concentration was CMC+0.04 wt% or CMC+0.2 wt%. The resulting LHI-RC complex in each detergent was incubated at 25 ℃ for 15 days. Protein stability was measured at regular intervals during the incubation by measuring the UV-Visible spectra of the samples in the range of 650 nm to 950 nm. Protein integrity was assessed by monitoring 875 nm absorbance (A_{875}).

LeuT stability assay

Wild type of the leucine transporter (LeuT) from *Aquifex aeolicus* was purified according to the protocol described previously.[2] At first, LeuT was expressed in *E. coli* C41(DE3) transformed with pET16b encoding C-terminally 8xHis-tagged transporter (expression plasmid was kindly provided by Dr E. Gouaux, Vollum Institute, Portland, Oregon, USA). Briefly, after isolation of bacterial membranes and solubilization in 1% DDM, protein was bound to Ni^{2+}-NTA resin (Life Technologies, Denmark) and eluted in 20 mM Tris-HCl (pH 8.0), 1 mM NaCl, 199 mM KCl, 0.05% DDM and 300 mM imidazole. Subsequently, approx. 1.5 mg/ml protein stock was diluted 10 times into an identical buffer without DDM and imidazole, but supplemented with a DTM-A, a DTM-E, or DDM (a positive control) at the final concentration of CMC + 0.04 wt% or CMC + 0.2 wt%, respectively. Protein samples were stored at room temperature for 12 days and the samples were centrifuged at regular intervals during the incubation, prior to protein activity measurement. Protein activity was determined by measuring [^{3}H]-Leu binding using scintillation proximity assay (SPA).[3] Assay was performed with 5 μL of the respective protein samples in the buffer containing 200 mM NaCl and the respective test compounds at the concentrations indicated above. SPA reaction was carried out in the presence of 20 nM [^{3}H]-Leu and copper chelate (His-Tag) YSi beads (both from PerkinElmer, Denmark). Total [^{3}H]-Leu binding fort the respective samples was measured using MicroBeta liquid scintillation counter (PerkinElmer).

MelB solubilization and thermal stability assay

E. coli DW2 strain (Δ*melB* and Δ*lacZY*) harboring pK95ΔAHB/WT $MelB_{St}$/CH10 plasmid were used to produce the protein.[4] The plasmid contains the gene encoding the wild-type melibiose permease of *Salmonella typhimurium* ($MelB_{St}$) with a 10-His tag at the C-terminus. Cell growth and membrane preparation were carried out as described.[5] Protein assay was carried out with a Micro BCA kit (Thermo Scientific). The membrane samples containing $MelB_{St}$ (the final total membrane protein concentration was 10 mg/mL) in a solubilization buffer (20 mM sodium phosphate, pH 7.5, 200 mM NaCl, 10% glycerol and 20 mM melibiose) were mixed with individual detergents (DDM, DTM-As, and DTM-Es) at

1.5% (w/v). The extractions were incubated at four different temperatures (0, 45, 55, and 65 ℃) for 90 min. Insoluble fractions were removed by ultracentrifugation at 355,590 *g* in a Beckman OptimaTM MAX Ultracentrifuge using a TLA-100 rotor for 45 min at 4 ℃. 20 μg membrane proteins without ultracentrifugation were applied for the untreated membrane or same and equal volume of detergent extracts after the ultracentrifugation step, were loaded for analysis by SDS-15% PAGE, and $MelB_{St}$ was visualized by immunoblotting with a Penta-His-HRP antibody (Qiagen).

Preparation of RSO vesicles and Trp→D^2G FRET assay. RSO membrane vesicles were prepared via osmotic lysis from *E. coli* DW2 cells containing $MelB_{St}$ or $MelB_{Ec}$.[6-8] The RSO membrane vesicles in a buffer (pH 7.5) containing 100 mM KP_i and 100 mM NaCl at a protein concentration of 1 mg/ml were treated with 1.0 % individual detergents (DDM, DTM-A5, and DTM-A6) at 23 ℃ for 60 min and subjected to ultracentrifugation using TLA 120.2 rotor at >300,000 g for 45 min at 4 ℃. The supernatants were applied for FRET (Trp→D^2G) experiments using an Amico-Bowman Series 2 (AB2) Spectrofluorometer. The 2'-(*N*-Dansyl)aminoalkyl-1-thio-β-D-galactopyranoside (D^2G, dansyl-galactoside) was obtained from Drs. Gerard Leblanc and H. Ronald Kaback. D^2G FRET signal was collected at 490 and 465 nm for $MelB_{St}$ and $MelB_{Ec}$, respectively, upon excitation of Trp residues at 290 nm.[8] 10 μM D^2G and excess melibiose or equal volume of water (control) were added into the MelB solutions at 1-min and 2-min time points, respectively.

β_2AR stability assay

Long-term stability measurement

The β_2AR was purified using 0.1% DDM as previously described.[9] Briefly, the receptor was expressed in Sf9 insect cells infected with baculovirus and solubilized in 1% DDM. The DDM-solubilized receptor was purified by alprenolol sepharose in the presence of 0.01% cholesteryl succinate (CHS). The DDM-purified β_2AR was diluted into buffer solutions containing DDM or a DTM (DTM-A6, DTM-A7, or DTM-E7) to reach a detergent concentration of CMC + 0.2 wt%. β_2AR in each detergent was stored for 4 days at room temperature and its ligand binding capacity was measured at regular intervals by incubating the receptor with 10 nM of radioactive [^{3}H]-dihydroalprenolol (DHA) for 30 min at room temperature. The mixture was loaded onto a G-50 column and the flow-through with certain amount of binding buffer (20 mM HEPES pH 7.5, 100 mM NaCl, supplemented with 0.5 mg/mL BSA) was collected. A further 15 mL scintillation fluid was added. Receptor-bound [^{3}H]-DHA was measured with a scintillation counter (Beckman). Receptor stability was assessed by ligand binding ability, measured at regular intervals during a 4-day incubation period at room temperature.

Purification and stability measurement of β_2AR-Gs complex solubilized in DTM-A6

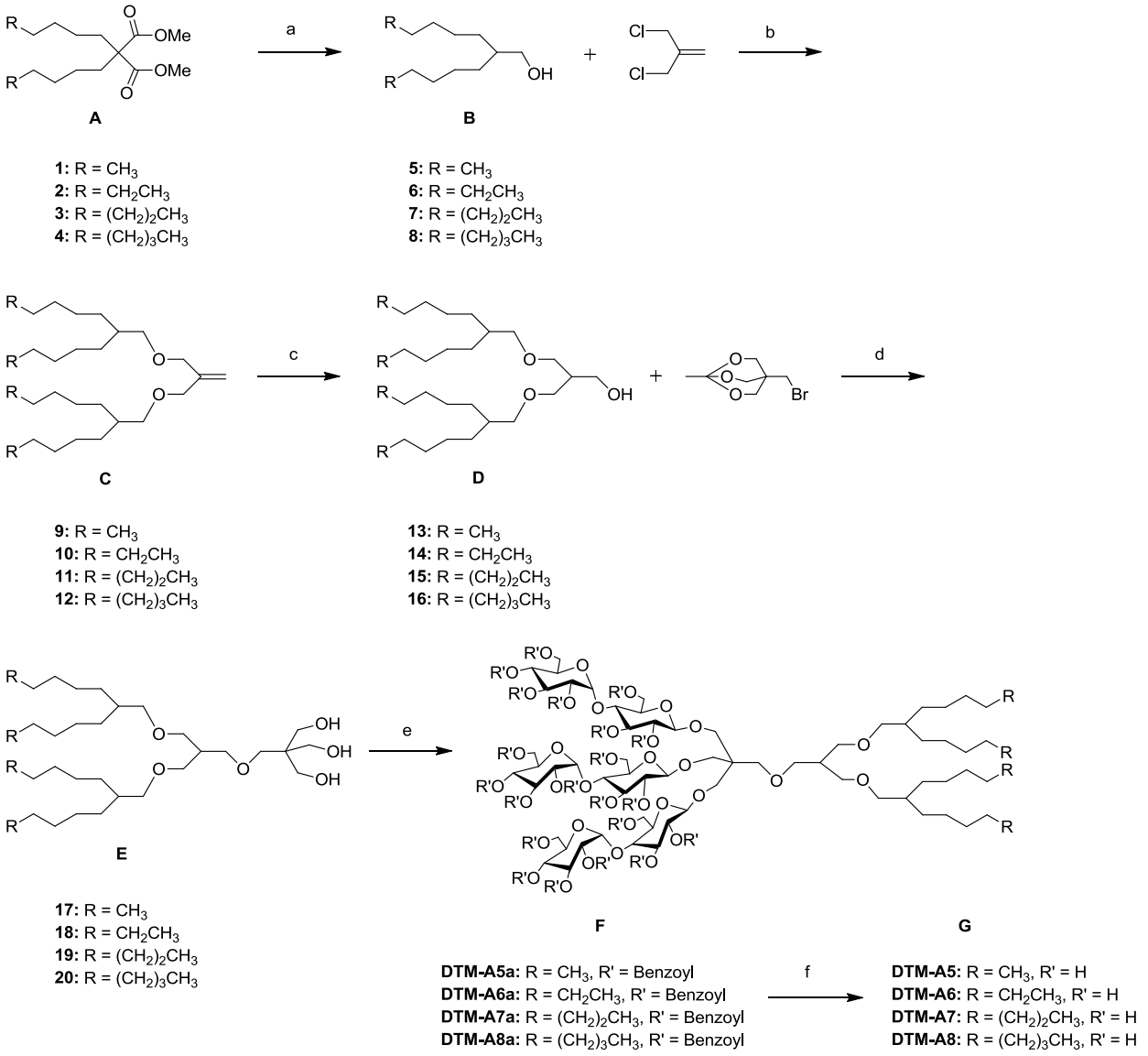
100 μM β_2AR in 0.1% DDM was mixed with 120 μM G_s heterotrimer for 30 min at room temperature. 0.5 unit apyrase (NEB) and 2 mM $MgCl_2$ was added to facilitate complex formation followed by incubation for a further 1 hr. 1% DTM-A6 was then added to give a final concentration of 0.8% and the sample incubated for a further 30 min to initiate detergent exchange from DDM to DTM-A6. The protein solution was loaded onto an M1 Flag column, washed with a series of buffers with different molar ratios of 0.1% DDM buffer to 0.5% DTM-A6 buffer to allow complete detergent exchange from DDM to DTM-A6, and the protein finally eluted with 0.05% (70xCMC) DTM-A6 buffer. A preparative gel filtration was carried out to purify the β_2AR-Gs complex with running buffer (20mM HEPES pH 7.5, 100 mM NaCl, 0.005% DTM-A6, 1 μM BI, 100 μM TCEP). To measure the stability of the β_2AR-Gs complex in DTM-A6, analytical gel filtrations were performed using the running buffer as above, but without DTM-A6 (detergent-free condition) following 3 and 15-day incubation.

Negative stain EM analysis of β_2AR-Gs solubilized in DTM-A6

β_2AR-G_s complex was prepared for electron microscopy using the conventional negative staining protocol using 0.75% uranyl formate for complex staining,[10] and imaged at room temperature with a Tecnai T12 electron microscope operated at 120 kV using low-dose procedures.. Images were recorded at a magnification of 71,138x and a defocus value of ~ -1.1 μm on a Gatan US4000 CCD camera. All images were binned (2x2 pixels) to obtain a pixel size of 4.16 Å at the specimen level. Particles were manually excised using e2boxer (part of the EMAN2 software suite).[11] 2D reference-free alignment and classification of particle projections was performed using ISAC.[12] 12,279 projections of β_2AR-Gs were subjected to ISAC, producing ~131 classes consistent over two-way matching and accounting for 11,926 particle projections.

Preparation of alkyl-based dendritic trimaltosides (DTM-As)

Supplementary scheme 1



(a) (i) LiCl, H_2O, DMSO, 160 ˚C; (ii) $LiAlH_4$, THF, RT; (b) NaH, DMF, 70 ˚C; (c) THF, 1M BH_3-THF, NaOH, H_2O_2; (d) (i) NaH, DMF:THF (1:1), 100 ˚C, (ii) CH_2Cl_2:MeOH (1:1), HCl, NaOH; (e) perbenzoylated maltosylbromide, AgOTf, 2,4,6-collidine, CH_2Cl_2, -45 ˚C→ room temperature; (f) NaOMe, MeOH, RT.

*General procedure for the synthesis of dialkylated dimethylmalonate (**A**)*

Dimethylmalonate (1.0 equiv.) was added dropwise to a cold solution of NaH (3.0 equiv.) in DMSO under N_2 atmosphere. Alkyl iodide (2.5 equiv.) was added portionwise after the cessation of gas evolution. The resulting

mixture was allowed to stir at room temperature until the completion of reaction. Reaction was quenched by the addition of an ice cold 10% NH_4Cl solution followed by washing with ethylacetate twice. Combined ethylacetate fraction was washed with brine and dried over anhydrous Na_2SO_4. Rotary evaporation of organic solvent resulted in an oily residue which upon column chromatographic purification (EtOAc/hexane) afforded the desired product (**A**) as colorless oil.

General procedure for Krapcho's decarboxylation and reduction of dialkylated monoesters (step a; A→B)

LiCl (2.2 equiv.) and H_2O (1.1 equiv.) were added to the solution of dialkylated dimethylmalonate (**A**; 1.0 equiv.) in DMSO. The mixture was heated to reflux for 12 hrs followed by dilution with water. The diluted reaction mixture was washed with ethylacetate twice. Combined organic fractions were washed with brine and dried over anhydrous Na_2SO_4. The oily residue obtained after the removal of organic solvent was subjected to reduction without further purification. To an ice cold solution of dialkylated monomethylester in THF was added $LiAlH_4$ (2.2 equiv.). The resulting greyish slurry was allowed to stir for 6 hours at room temperature under N_2 atmosphere. The reaction was quenched by the addition of MeOH, water, 1 M HCl solution successively at 0 ℃ and then extracted with diethyl ether twice. Combined ether fractions were washed with brine and dried over anhydrous Na_2SO_4. Column chromatographic purification (EtOAc/hexane) of the oily residue obtained after the removal of organic solvent afforded the desired product (**B**) as colorless oil.

General procedure for the synthesis of tetra alkylated methallyl diether (step b; B→C)

NaH (3.0 equiv.) was added to the well stirred solution of dialkylated mono-ol (**B**; 2.5 equiv.) in DMF. The mixture was heated to 50 ℃ for 30 min under inert atmosphere followed by dropwise addition of methallyl dichloride (1.0 equiv.) and 15-crown-5-ether (0.25 equiv.) at room temperature. The resulting mixture was stirred at 50 ℃ for 24 hours. Reaction was quenched by the addition of methanol followed by dilution with ethylacetate. The organic fraction was washed with water, brine and dried over anhydrous Na_2SO_4. The oily residue was obtained after removal of solvent under reduced pressure was purified by column chromatography (EtOAc/hexane) to afford the desired product (**C**).

General procedure for hydroboration (step c; C→D)

A solution of tetraalkylated methallyldiether (**C**; 1.0 equiv.) and BH_3-THF (1 M, 1.1 equiv.) in THF was stirred at 0˚C under N_2 atmosphere for 2 hours. The Reaction was quenched with 3 M NaOH solution (2.2 equiv.) followed by the addition of 30 wt% H_2O_2. The reaction mixture was allowed to stir for another 2 hours at room temperature and diluted with diethyl ether. The diluted reaction mixture was washed with water and brine, and dried over anhydrous Na_2SO_4. The oily residue obtained after removal of solvent was subjected to column chromatographic purification to obtain the target product (**D**).

General procedure for the synthesis of tetraalkylated tri-ol (step d; D→E)

To a solution of tetraalkylated mono-ol (**D**; 1.0 equiv.) in DMF was added NaH (3.0 equiv.). The mixture was heated to 50 ℃ for 30 min. After cooling the mixture to room temperature, 4-(bromomethyl)-methyl-2,6,7-trioxabicyclo[2.2.2]-octane (3.0 equiv.) dissolved in THF was added dropwise, followed by the addition of 15-crown-5-ether (0.5 equiv.). The resulting mixture was heated at 100 ℃ for 24 hours. After quenching with methanol, organic solvents were removed under reduced pressure. The resulting solid residue dissolved in diethyl ether was washed with brine and dried over anhydrous Na_2SO_4. After concentration of the organic solvent, the resulting oily residue was dissolved in DCM/MeOH mixture. To this solution was added a few drops of conc. HCl and the resulting mixture was heated at 50 ℃ for 4 hours. After neutralization with NaOH and concentration of the reaction mixture, the residue was purified by column chromatography (EtOAc/hexane) to afford the desired product (**E**).

General procedure for maltosylation reaction (step e; E→F)[13]

Under N_2 atmosphere, a mixture of compound **E** (1.0 equiv.), AgOTf (3.6 equiv.), 2,4,6-collidine (1.0 equiv.) in anhydrous CH_2Cl_2 was stirred at -45 ℃. A solution of perbenzoylated maltosylbromide (3.6 equiv.) in CH_2Cl_2 was added dropwise to this suspension. Stirring was continued for 30 min at -45 ℃, and then the reaction mixture was allowed to warm to 0 ℃ and left stirring for 30 min. After completion of reaction (as indicated by TLC), pyridine was added to the reaction mixture followed by dilution with CH_2Cl_2 before being filtered over celite. The filtrate was washed successively with 1 M aqueous $Na_2S_2O_3$ solution, 0.1 M aqueous HCl solution, and brine. The organic layer was dried with anhydrous Na_2SO_4 and the solvents were removed by rotary evaporation. The residue was purified by silica gel column chromatography (EtOAc/hexane) providing desired product (**F**) as a glassy solid.

General Procedure for the de-O-benzoylations under Zemplén's condition (step f; F→G)[10]

The O-benzoylated compound (**F**) was dissolved in MeOH and then treated with the required amount of a methanolic solution of 0.5 M NaOMe such that the final concentration of NaOMe was 0.05 M. The reaction mixture was left stirring for 6 hours at room temperature, and then neutralized with Amberlite IR-120 (H^+ form) resin. The resin was removed by filtration and washed with MeOH and solvent was removed from the combined filtrate *in vacuo*. 50 mL of diethyl ether was added to the residue dissolved in 2 mL MeOH:CH_2Cl_2 (1:1) mixture to afford the desired product (G) as a white solid.

Dimethyl 2-pentylmalonate (1) was prepared in 90% yield according to the general procedure for preparation of dialkylated dimethylmalonate. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.69 (s, 6H), 1.34-1.05 (m, 16H), 0.87 (t, J = 7.2 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 172.7, 57.8, 52.4, 32.5, 32.2, 23.9, 22.6, 14.2.

Dimethyl 2-hexylmalonate (2) was prepared in 92% yield according to the general procedure for preparation of dialkylated dimethylmalonate. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.70 (s, 6H), 1.88-1.84 (m, 4H), 1.35-1.10 (m, 12H),

1.09-1.05 (m, 4H), 0.87 (t, *J* = 6.8 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 172.6, 57.8, 52.4, 32.5, 31.7, 29.6, 24.1, 22.7, 14.2.

Dimethyl 2-heptylmalonate (3) was prepared in 92% yield according to the general procedure for preparation of dialkylated dimethylmalonate. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.69 (s, 6H), 1.34-1.15 (m, 24H), 0.88 (t, *J* = 6.8 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 172.7, 57.8, 52.4, 32.5, 32.0, 30.0, 29.2, 24.2, 22.9, 14.3.

Dimethyl 2-octylmalonate (4) was prepared in 93% yield according to the general procedure for preparation of dialkylated dimethylmalonate. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.70 (s, 6H), 1.88-1.84 (m, 4H), 1.34-1.15 (m, 20H), 1.12-1.03 (m, 4H), 0.87 (t, *J* = 6.4 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 172.6, 57.8, 52.4, 32.5, 32.0, 30.0, 29.4, 29.3, 24.1, 22.8, 14.2.

2-pentylheptan-1-ol (5) was prepared in 89% yield according to the general procedure for Krapcho's decarboxylation and reduction of dialkylated monoesters. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.53 (d, *J* = 5.6 Hz, 2H), 1.48-1.40 (m, 1H), 1.36-1.18 (m, 16H), 0.87 (t, *J* = 6.4 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 65.8, 40.7, 32.5, 31.1, 26.7, 22.9, 14.3.

2-hexyloctan-1-ol (6) was prepared in 87% yield according to the general procedure for Krapcho's decarboxylation and reduction of dialkylated monoesters. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.53 (d, *J* = 5.2 Hz, 2H), 1.47-1.43 (m, 1H), 1.38-1.18 (m, 20H), 0.88 (t, *J* = 6.4 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 65.2, 40.5, 32.0, 30.6, 26.9, 25.9, 22.7, 14.3.

2-heptylnonan-1-ol (7) was prepared in 85% yield according to the general procedure for Krapcho's decarboxylation and reduction of dialkylated monoesters. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.53 (d, *J* = 4.0 Hz, 2H), 1.47-1.43 (m, 1H), 1.35-1.19 (m, 24H), 0.87 (t, *J* = 7.2 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 65.9, 40.7, 32.1, 31.1, 30.2, 29.5, 27.1, 22.9, 14.3.

2-octyldecan-1-ol (8) was prepared in 87% yield according to the general procedure for Krapcho's decarboxylation and reduction of dialkylated monoesters. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.53 (d, *J* = 4.0 Hz, 2H), 1.47-1.43 (m, 1H), 1.32-1.18 (m, 28H), 0.88 (t, *J* = 8.0 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 65.9, 40.7, 32.1, 31.1, 30.3, 29.8, 29.5, 27.1, 22.9, 14.3.

6-(((2-(((2-pentylheptyl)oxy)methyl)allyl)oxy)methyl)undecane (9) was prepared in 72% yield according to the general procedure for the synthesis of tetraalkylated methallyl diether. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.14 (s, 2H), 3.94 (s, 4H), 3.28 (d, *J* = 6.0 Hz, 4H), 1.60-1.53 (m, 2H), 1.32-1.18 (m, 32H), 0.88 (t, *J* = 8.0 Hz, 12H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 143.5, 113.0, 73.7, 71.7, 38.3, 31.9, 29.8, 26.8, 22.7, 14.1.

7-(((2-(((2-hexyloctyl)oxy)methyl)allyl)oxy)methyl)tridecane (10) was prepared in 98% yield according to the general procedure for the synthesis of tetra alkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 5.15 (s, 2H), 3.94 (s, 4H), 3.28 (d, *J* = 6.0 Hz, 2H), 1.60-1.53 (m, 2H), 1.32-1.18 (m, 40H), 0.88 (t, *J* = 8.0 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 143.5, 113.0, 73.7, 71.7, 38.3, 31.9, 31.5, 29.8, 26.8, 22.7, 14.1.

8-(((2-(((2-heptylnonyl)oxy)methyl)allyl)oxy)methyl)pentadecane (11) was prepared in 74% yield according to the general procedure for the synthesis of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 5.15 (s, 2H), 3.94 (s, 4H), 3.28 (d, *J* = 6.0 Hz, 4H), 1.60-1.53 (m, 2H), 1.36-1.18 (m, 48H), 0.88 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 143.7, 113.2, 74.0, 71.9, 38.5, 32.1, 31.7, 30.3, 29.6, 27.1, 22.9, 14.3.

9-(((2-(((2-octyldecyl)oxy)methyl)allyl)oxy)methyl)heptadecane (12) was prepared in 70% yield according to the general procedure for the synthesis of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 5.15 (s, 2H), 3.94 (s, 4H), 3.28 (d, *J* = 6.0 Hz, 4H), 1.59-1.51 (m, 2H), 1.36-1.18 (m, 56H), 0.88 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 143.7, 113.2, 74.0, 71.9, 38.5, 32.1, 31.7, 30.3, 29.8, 29.6, 27.1, 22.9, 14.3.

3-((2-pentylheptyl)oxy)-2-(((2-pentylheptyl)oxy)methyl)propan-1-ol (13) was prepared in 88% yield according to the general procedure for the hydroboration of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.76 (t, *J* = 4.0 Hz, 2H), 3.53-3.48 (m, 4H), 3.29 (d, *J* = 8.0 Hz, 4H), 2.12-2.05 (m, 1H), 1.56-1.50 (m, 2H), 1.32-1.18 (m, 32H), 0.88 (t, *J* = 4.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 74.9, 71.6, 65.4, 41.4, 38.4, 32.1, 30.0, 27.0, 22.9, 14.3.

3-((2-hexyloctyl)oxy)-2-(((2-hexyloctyl)oxy)methyl)propan-1-ol (14) was prepared in 86% yield according to the general procedure for the hydroboration of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.76 (t, *J* = 5.2 Hz, 2H), 3.55-3.46 (m, 4H), 3.28 (d, *J* = 6.0 Hz, 4H), 2.93 (t, *J* = 5.6 Hz, 1H), 2.14-2.07 (m, 1H), 1.58-1.50 (m, 2H), 1.32-1.18 (m, 40H), 0.88 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 74.9, 71.6, 65.3, 41.4, 38.5, 32.1, 31.6, 29.9, 27.0, 22.9, 14.3.

3-((2-heptylnonyl)oxy)-2-(((2-heptylnonyl)oxy)methyl)propan-1-ol (15) was prepared in 86% yield according to the general procedure for the hydroboration of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.76 (t, *J* = 5.2 Hz, 2H), 3.55-3.46 (m, 4H), 3.28 (d, *J* = 6.0 Hz, 4H), 2.92 (t, *J* = 5.6 Hz, 1H), 2.12-2.07 (m, 1H), 1.58-1.50 (m, 2H), 1.32-1.18 (m, 48H), 0.88 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 75.0, 71.8, 63.3, 41.4, 38.5, 32.1, 30.2, 29.9, 29.5, 27.0, 22.8, 14.2.

3-((2-octyldecyl)oxy)-2-(((2-octyldecyl)oxy)methyl)propan-1-ol (16) was prepared in 89% yield according to the general procedure for the hydroboration of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.76 (t, *J* = 5.2 Hz, 2H), 3.54-3.46 (m, 4H), 3.28 (d, *J* = 6.0 Hz, 4H), 2.96 (t, *J* = 5.6 Hz, 1H), 2.13-2.07 (m, 1H), 1.58-1.50 (m, 2H), 1.32-1.18 (m, 56H), 0.88 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 75.0, 71.8, 63.3, 41.4, 38.5, 32.1, 31.7, 30.2, 29.9, 29.5, 27.0, 22.8, 14.2.

2-(hydroxymethyl)-2-((3-((2-pentylheptyl)oxy)-2-(((2-pentylheptyl)oxy)methyl)propoxy)methyl)propane-1,3-diol (17) was prepared in 42% yield according to the general procedure for the synthesis of tetraalkylated triol. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.62 (s, 6H), 3.41 (d, *J* = 4.0 Hz, 2H), 3.38 (s, 2H), 3.32 (d, *J* = 4.0 Hz, 4H) 3.18 (d, *J* = 4.0 Hz, 4H), 2.97 (br s, 3H), 2.10-2.07 (m, 1H), 1.50-1.41 (m, 2H), 1.36-1.18 (m, 32H), 0.88 (t, *J* = 6.4 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 74.8, 73.6, 71.0, 69.7, 64.9, 45.2, 40.2, 38.3, 32.5, 31.6, 26.7, 22.9, 14.3.

2-((3-((2-hexyloctyl)oxy)-2-(((2-hexyloctyl)oxy)methyl)propoxy)methyl)-2-(hydroxymethyl)propane-1,3-diol (18) was prepared in 60% yield according to the general procedure for the synthesis of tetraalkylated triol. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.66 (s, 6H), 3.51 (br s, 3H) 3.46 (d, *J* = 6.0 Hz, 2H), 3.39 (d, *J* = 6.0 Hz, 4H), 3.25 (d, *J* = 4.2 Hz, 4H), 2.17-2.11 (m, 1H), 1.54-1.41 (m, 2H), 1.36-1.18 (m, 40H), 0.88 (t, *J* = 6.4 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 74.8, 73.4, 70.8, 69.6, 64.2, 45.2, 40.2, 38.2, 32.0, 31.6, 29.9, 26.9, 22.8, 14.3.

2-((3-((2-heptylnonyl)oxy)-2-(((2-heptylnonyl)oxy)methyl)propoxy)methyl)-2-(hydroxymethyl)propane-1,3-diol (19) was prepared in 44% yield according to the general procedure for the synthesis of tetraalkylated triol. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.69 (s, 6H), 3.48 (d, *J* = 6.0 Hz, 2H), 3.44 (s, 2H), 3.39 (d, *J* = 4.0 Hz, 4H), 3.25 (d, *J* = 8.0 Hz, 4H), 3.03 (br s, 3H) 2.17-2.14 (m, 1H), 1.58-1.51 (m, 2H), 1.36-1.18 (m, 48H), 0.88 (t, *J* = 6.4 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 74.9, 73.6, 70.9, 69.7, 65.0, 45.2, 40.2, 38.3, 32.1, 31.6, 30.3, 29.6, 27.0, 22.9, 14.3.

2-(hydroxymethyl)-2-((3-((2-octyldecyl)oxy)-2-(((2-octyldecyl)oxy)methyl)propoxy)methyl)propane-1,3-diol (20) was prepared in 44% yield according to the general procedure for the synthesis of tetraalkylated triol. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.71 (s, 6H), 3.48 (s, 2H), 3.39 (d, *J* = 4.0 Hz, 4H), 3.25 (d, *J* = 8.0 Hz, 4H), 2.60 (br s, 3H) 2.17-2.14 (m, 1H), 1.53-1.51 (m, 2H), 1.36-1.18 (m, 56H), 0.88 (t, *J* = 6.4 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 74.7, 73.5, 70.8, 69.6, 64.5, 53.3, 45.2, 40.2, 38.2, 32.1, 31.5, 30.3, 29.8, 27.0, 22.8, 14.2.

DTM-A5a was prepared in 65% yield according to the general procedure for maltosylation reaction. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.06 (d, *J* = 8.0 Hz, 6H), 7.96 (d, *J* = 8.0 Hz, 6H), 7.87-7.84 (m, 18H), 7.78 (d, *J* = 8.0 Hz, 6H), 7.66 (d, *J* = 8.0 Hz, 6H), 7.55-7.45 (m, 18H), 7.43-7.31 (m, 36H), 7.27-7.21 (m, 9H), 6.08 (t, *J* = 8.0 Hz, 3H), 5.65 (d, *J* = 8.0 Hz, 3H), 5.62 (d, *J* = 8.0 Hz, 3H), 5.44 (t, *J* = 8.0 Hz, 3H), 5.18-5.08 (m, 6H), 4.55 (q, *J* = 12.0 Hz, 6H), 4.30-4.22 (m, 9H), 4.16-4.10 (m, 3H), 3.68 (t, *J* = 10.0 Hz, 6H), 3.17-3.04 (m, 15H), 2.97 (d, *J* = 12.0 Hz, 3H), 1.96-1.87 (m, 1H), 1.48-42 (m, 2H), 1.28-1.08 (m, 32H), 0.85 (t, *J* = 7.0 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.0, 165.7, 165.4, 164.9, 164.7, 133.4, 133.1, 129.8, 129.6, 129.5, 129.4, 129.3, 128.8, 128.7, 128.6, 128.3, 128.2, 100.9, 95.8, 74.7, 74.3, 72.3, 71.2, 70.2, 69.8, 69.1, 68.9, 68.8, 67.7, 63.4, 62.4, 60.3, 53.5, 44.8, 40.1, 38.2, 31.9, 31.4, 29.8, 26.8, 22.7, 20.9, 14.2.

DTM-A6a was prepared in 70% yield according to the general procedure for maltosylation reaction. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.13 (d, *J* = 8.0 Hz, 6H), 8.05 (d, *J* = 8.0 Hz, 6H), 7.94-7.87 (m, 18H), 7.81 (d, *J* = 8.0 Hz, 6H), 7.70 (d, *J* = 8.0 Hz, 6H), 7.56-7.53 (m, 6H), 7.48-7.40 (m, 18H), 7.38-7.33 (m, 12H), 7.31-7.27 (m, 15H), 7.24 (t, *J* = 8.0 Hz, 6H), 7.16 (t, *J* = 8.0 Hz, 6H), 6.18 (t, *J* = 8.0 Hz, 3H), 5.73 (t, *J* = 12.0 Hz, 6H), 5.51 (t, *J* = 8.0 Hz, 3H), 5.26-5.20 (m, 6H), 4.64 (q, *J* = 12.0 Hz, 6H), 4.42-4.34 (m, 9H), 4.24 (d, *J* = 12.0 Hz, 3H), 3.80 (d, *J* = 8.0 Hz, 3H), 3.75 (d, *J* = 4.0 Hz, 3H), 3.31-3.06 (m, 18H), 2.05-1.97 (m, 1H), 1.56-1.48 (m, 2H), 1.34-1.20 (m, 40H), 0.88 (t, *J* = 6.0 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.0, 165.7, 165.4, 164.9, 164.7, 133.4, 133.1, 129.8, 129.6, 129.5, 129.4, 129.3, 128.8, 128.7, 128.6, 128.3, 128.2, 100.9, 95.8, 74.7, 74.3, 72.3, 71.2, 70.2, 69.8, 69.1, 68.9, 68.8, 67.7, 63.4, 62.4, 60.3, 53.5, 44.8, 40.1, 38.2, 31.9, 31.4, 31.3, 29.8, 26.8, 22.7, 20.9, 14.2.

DTM-A7a was prepared in 66% yield according to the general procedure for maltosylation reaction. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.06 (d, *J* = 8.0 Hz, 6H), 7.96 (d, *J* = 8.0 Hz, 6H), 7.87-7.84 (m, 18H), 7.78 (d, *J* = 8.0 Hz, 6H),

7.66 (d, *J* = 8.0 Hz, 6H), 7.53-7.44 (m, 18H), 7.43-7.31 (m, 36H), 7.27-7.21 (m, 9H), 6.09 (t, *J* = 8.0 Hz, 3H), 5.65 (d, *J* = 8.0 Hz, 3H), 5.62 (d, *J* = 8.0 Hz, 3H), 5.42 (t, *J* = 8.0 Hz, 3H), 5.18-5.09 (m, 6H), 4.55 (q, *J* = 12.0 Hz, 6H), 4.34-4.23 (m, 9H), 4.17-4.11 (m, 3H), 3.68 (d, *J* = 8.0 Hz, 3H), 3.66 (d, *J* = 8.0 Hz, 3H) 3.25-3.06 (m, 15H), 2.97 (d, *J* = 12.0 Hz, 3H), 1.95-1.85 (m, 1H), 1.46-1.41 (m, 2H), 1.28-1.12 (m, 48H), 0.86 (t, *J* = 8.0 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.1, 165.8, 165.7, 165.5, 165.0, 164.7, 133.4, 133.2, 129.9, 129.8, 129.7, 129.5, 129.4, 128.9, 128.7, 128.6, 128.4, 128.2, 100.9, 95.9, 74.8, 74.4, 72.4, 72.3, 72.2, 71.2, 70.3, 69.9, 69.0, 65.8, 63.5, 62.4, 60.3, 53.5, 44.8, 40.2, 38.2, 31.9, 31.4, 29.4, 26.9, 22.7, 15.3, 14.2.

DTM-A8a was prepared in 62% yield according to the general procedure for maltosylation reaction. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.09 (d, *J* = 8.0 Hz, 6H), 7.98 (d, *J* = 8.0 Hz, 6H), 7.89-7.84 (m, 18H), 7.79 (d, *J* = 8.0 Hz, 6H), 7.68 (d, *J* = 8.0 Hz, 6H), 7.57-7.46 (m, 18H), 7.43-7.37 (m, 16H), 7.36-7.29 (m, 17H), 7.26-7.18 (m, 12H), 6.13 (t, *J* = 8.0 Hz, 3H), 5.67 (t, *J* = 8.0 Hz, 6H), 5.46 (t, *J* = 8.0 Hz, 3H), 5.22-5.13 (m, 6H), 4.59 (q, *J* = 10.0 Hz, 6H), 4.37-4.28 (m, 9H), 4.19 (d, *J* = 12.0 Hz, 3H), 3.75 (d, *J* = 8.0 Hz, 3H), 3.70 (d, *J* = 8.0 Hz, 3H) 3.30-3.04 (m, 15H), 3.02 (d, *J* = 12.0 Hz, 3H), 2.01-1.90 (m, 1H), 1.49-1.41 (m, 2H), 1.28-1.12 (m , 56H), 0.87 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ166.1, 165.8, 165.5, 165.1, 164.8, 133.6, 133.4, 133.2, 129.9, 129.7, 129.6, 129.5, 129.4, 128.9, 128.8, 128.7, 128.6, 128.4, 128.2, 100.9, 95.9, 74.8, 74.4, 72.3, 72.2, 71.3, 69.9, 69.0, 67.8, 63.5, 62.4, 53.5, 44.9, 40.2, 38.3, 31.9, 31.4, 30.2, 29.7, 29.5, 26.9, 22.8, 14.2.

DTM-A5 was prepared in 92% yield according to the general procedure for de-O-benzoylation. **^{1}H NMR** (400 MHz, CD_3OD): δ 5.14 (d, *J* = 4.0 Hz, 3H), 4.34 (d, *J* = 8.0 Hz, 3H), 3.97 (d, *J* = 8.0 Hz, 3H), 3.87 (m, 3H), 3.83-3.79 (m, 6H), 3.68-3.58 (m, 15H), 3.52 (t, *J* = 10.0 Hz, 3H), 3.47-3.42 (m, 9H), 3.31-3.30 (m, 3H), 3.30-3.28 (m, 3H), 3.27-3.21 (m, 9H), 2.15-2.07 (m, 1H), 1.61-1.52 (m, 2H), 1.39-1.21 (m, 32H), 0.91 (t, *J* = 7.0 Hz, 12H); **^{13}C NMR** (100 MHz, CD_3OD): 105.0, 102.9, 81.3, 77.8, 76.5, 75.5, 75.1, 74.8, 74.2, 71.5, 70.4, 70.1, 62.7, 62.3, 48.5, 46.6, 41.6, 39.5, 33.6, 32.7, 27.7, 23.8, 14.7. **HRMS (FAB^{+})**: calcd. for $C_{69}H_{128}O_{36}$ $[M+Na]^+$ 1555.8083, found 1555.8087.

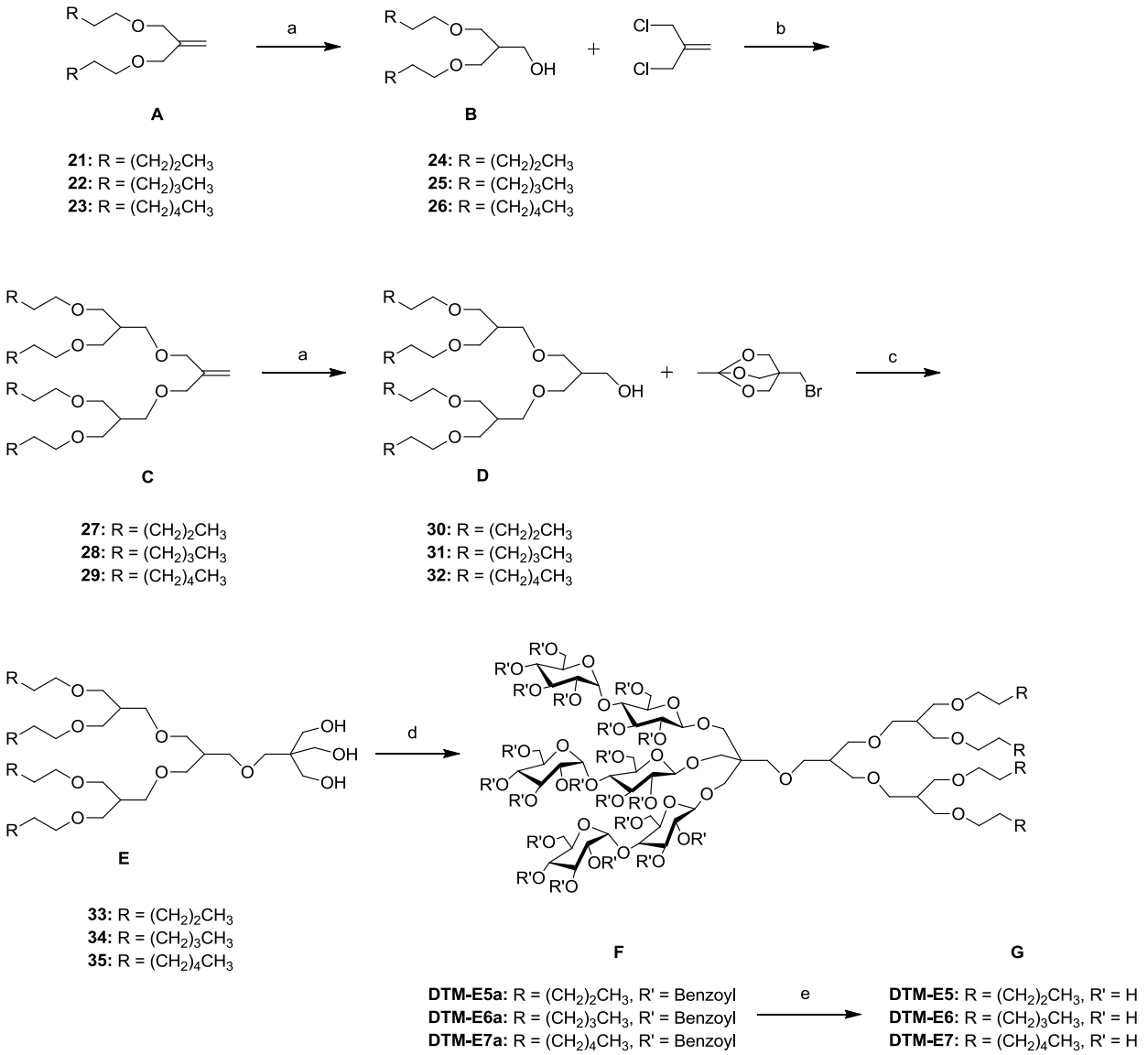
DTM-A6 was prepared in 90% yield according to the general procedure for de-O-benzoylation. **^{1}H NMR** (400 MHz, CD_3OD): δ 5.13 (d, *J* = 4.0 Hz, 3H), 4.34 (d, *J* = 8.0 Hz, 3H), 3.96 (d, *J* = 10.0 Hz, 3H), 3.84 (m, 3H), 3.81-3.79 (m, 7H), 3.67-3.60 (m, 15H), 3.54 (t, *J* = 11.6 Hz, 3H), 3.45-3.42 (m, 9H), 3.38-3.30 (m, 3H), 3.26-3.22 (m, 10H), 2.14-2.09 (m, 1H), 1.60-1.50 (m, 2H), 1.37-1.22 (m, 40H), 0.90 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, CD_3OD): δ 105.1, 102.9, 81.4, 77.8, 76.6, 75.6, 75.1, 74.8, 74.2, 71.5, 70.4, 70.1, 62.8, 62.3, 48.5, 46.6, 41.7, 39.5, 33.2, 32.8, 32.7, 31.0, 28.0, 23.9, 14.7. **HRMS (FAB^{+})**: calcd. for $C_{73}H_{136}O_{36}$ $[M+Na]^+$ 1611.8709, found 1611.8707.

DTM-A7 was prepared in 90% yield according to the general procedure for de-O-benzoylation. **^{1}H NMR** (400 MHz, CD_3OD): δ 5.14 (d, *J* = 4.0 Hz, 3H), 4.34 (d, *J* = 8.0 Hz, 3H), 3.97 (d, *J* = 8.0 Hz, 3H), 3.87 (m, 3H), 3.81-3.79 (m, 6H), 3.67-3.59 (m, 15H), 3.52 (t, *J* = 10.0 Hz, 3H), 3.45-3.42 (m, 9H), 3.38-3.30 (m, 6H), 3.27-3.21 (m, 9H), 2.13-2.08 (m, 1H), 1.59-1.51 (m, 2H), 1.37-1.25 (m, 48H), 0.90 (t, *J* = 6.4 Hz, 12H); **^{13}C NMR** (100 MHz, CD_3OD): δ 105.0, 102.9, 81.4, 77.8, 76.6, 75.6, 75.1, 74.8, 74.2, 71.5, 70.9, 70.4, 66.9, 62.7, 62.3, 46.6, 41.7, 39.5, 33.2, 32.7, 30.6, 28.1, 23.9, 15.6, 14.7. **HRMS (FAB^{+})**: calcd. for $C_{77}H_{144}O_{36}$ $[M+Na]^+$ 1667.9335, found 1667.9330.

DTM-A8 was prepared in 94% yield according to the general procedure for de-O-benzoylation. **^{1}H NMR** (400 MHz, CD_3OD): δ 5.15 (d, *J* = 4.0 Hz, 3H), 4.34 (d, *J* = 8.0 Hz, 3H), 3.96 (d, *J* = 10.0 Hz, 3H), 3.87 (m, 3H), 3.83-3.79 (m, 6H), 3.68-3.59 (m, 15H), 3.52 (t, *J* = 12.0 Hz, 4H), 3.45-3.42 (m, 10H), 3.38-3.30 (m, 4H), 3.27-3.22 (m, 9H), 2.12-2.08 (m, 1H), 1.58-1.51 (m, 2H), 1.38-1.27 (m, 56H), 0.90 (t, *J* = 6.8 Hz, 12H). **^{13}C NMR** (100 MHz, CD_3OD): δ 105.1, 103.0, 81.4, 77.9, 76.6, 75.6, 75.2, 74.8, 74.2, 71.5, 70.4, 70.1, 67.3, 62.8, 62.3, 46.7, 41.7, 39.5, 33.3, 32.7, 31.7, 30.9, 30.6, 28.1, 23.9, 15.6, 14.7. **HRMS (FAB^{+})**: calcd. for $C_{81}H_{152}O_{36}$ $[M+Na]^{+}$ 1723.9961, found 1723.9956.

Preparation of ether-based dendritic trimaltosides (DTM-Es)

Supplementary scheme 2



(a) THF, 1M BH_3-THF, NaOH, H_2O_2; (b) NaH, DMF, 70 ˚C; (c) (i) NaH, DMF:THF (1:1), 100 ˚C, (ii) CH_2Cl_2 : MeOH (1:1), HCl, NaOH; (d) perbenzoylated maltosylbromide, 2,4,6-collidine, AgOTf, CH_2Cl_2 , -45 ˚C→RT; (e) NaOMe, MeOH, RT.

*General procedure for the synthesis of dialkylated methallyl diether (**A**)*

To a well stirred solution of an aliphatic alcohol (2.5 equiv.) in THF was added NaH (3.0 equiv.) at 0 ℃ under N_2 atmosphere. After 30 min stirring methallyl dichloride (1.0 equiv.) was added dropwise. The resulting mixture was subjected to reflux for 24 hours subsequently quenched by methanol. The reaction mixture was diluted with

ethylacetate, followed by washing with water, brine and dried over anhydrous Na_2SO_4. The oily residue obtained after the removal of solvent was subjected to column chromatographic purification (Hex/EtOAc) to afford the pure desired product (**A**).

1-((2-((pentyloxy)methyl)allyl)oxy)pentane (21) was prepared in 90% yield according to the general procedure for synthesis of dialkylated methallyl diether. ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.16 (s, 2H), 3.97 (s, 4H), 3.41 (t, *J* = 6.6 Hz, 4H), 1.62-1.55 (m, 4H), 1.35-1.31 (m, 8H), 0.88 (t, *J* = 7.2 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 143.5, 113.4, 71.6, 70.6, 29.6, 28.5, 22.7, 14.2.

1-((2-((hexyloxy)methyl)allyl)oxy)hexane (22) was prepared in 92% yield according to the general procedure for synthesis of dialkylated methallyl diether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 5.01 (s, 2H), 3.82 (s, 4H), 3.27 (t, *J* = 9.6 Hz, 4H), 1.48-1.41 (m, 4H), 1.23-1.17 (m, 12H), 0.76 (t, *J* = 5.8 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 143.3, 112.9, 71.4, 70.4, 31.7, 29.7, 25.9, 22.6, 13.9.

1-((2-((heptyloxy)methyl)allyl)oxy)heptane (23) was prepared in 90% yield according to the general procedure for synthesis of dialkylated methallyl diether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 5.14 (s, 2H), 3.95 (s, 4H), 3.39 (t, *J* = 6.6 Hz, 4H), 1.57 (quin, *J* = 6.8 Hz, 4H), 1.30-1.28 (m, 16H), 0.88 (t, *J* = 6.8 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 143.4, 112.9, 71.4, 70.4, 31.9, 29.8, 29.2, 26.2, 22.6, 14.0.

3-(pentyloxy)-2-((pentyloxy)methyl)propan-1-ol (24) was prepared in 91% yield according to the general procedure for hydroboation. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.75 (d, *J* = 4.8 Hz, 2H), 3.52 (m, 4H), 3.41 (t, *J* = 6.6 Hz, 4H), 3.04 (br s, 1H), 2.09 (m, 1H), 1.60-1.53 (m, 4H), 1.33-1.28 (m, 8H), 0.88 (t, *J* = 6.8 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 71.7, 64.6, 62.6, 41.4, 29.4, 28.4, 22.6, 14.1.

3-(hexyloxy)-2-((hexyloxy)methyl)propan-1-ol (25) was prepared in 90% yield according to the general procedure for hydroboration. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.75 (d, *J* = 4.8 Hz, 2H), 3.52 (m, 4H), 3.41 (t, *J* = 6.6 Hz, 4H), 3.04 (br s, 1H), 2.09 (m, 1H), 1.60-1.53 (m, 4H), 1.33-1.28 (m, 12H), 0.88 (t, *J* = 6.8 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 71.1, 69.9, 62.6, 41.4, 31.4, 29.4, 25.6, 22.4, 13.7.

3-(heptyloxy)-2-((heptyloxy)methyl)propan-1-ol (26) was prepared in 90% yield according to the general procedure for hydroboation. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.70 (d, *J* = 2.8 Hz, 2H), 3.49 (d, *J* = 2.8 Hz, 4H), 3.39 (t, *J* = 7.2 Hz, 4H), 3.37 (br s, 1H), 2.07-1.98 (m, 1H), 1.61-1.55 (m, 4H), 1.41-1.28 (m, 16H), 0.88 (t, *J* = 4.8 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 71.3, 70.2, 63.3, 41.5, 31.7, 29.5, 29.0, 26.0, 22.5, 13.9.

12-methylene-8,16-bis((pentyloxy)methyl)-6,10,14,18-tetraoxatricosane (27) was prepared in 86% yield according to the general procedure for preparation of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 5.14 (s, 2H), 3.94 (s, 4H), 3.45 (d, *J* = 5.6 Hz, 12H), 3.37 (t, *J* = 2.8 Hz, 8H), 2.18-2.14 (m, 2H), 1.56-1.53 (m, 8H), 1.33-1.31 (m, 16H), 0.89 (t, *J* = 6.6 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 143.2, 113.2, 71.8, 71.3, 69.2, 68.9, 40.4, 29.5, 28.5, 22.6, 14.1.

9,17-bis((hexyloxy)methyl)-13-methylene-7,11,15,19-tetraoxapentacosane (28) was prepared in 85% yield according to the general procedure for preparation of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 5.13 (s, 2H), 3.94 (s, 4H), 3.44 (d, *J* = 3.6 Hz, 12H), 3.38 (t, *J* = 6.4 Hz, 8H), 2.18-2.12 (m, 2H), 1.62-1.43 (m, 8H), 1.38-1.21 (m, 24H), 0.89 (t, *J* = 6.6 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 143.2, 113.2, 71.8, 71.3, 69.2, 68.9, 40.5, 31.8, 29.8, 25.9, 22.8, 14.1.

10,18-bis((heptyloxy)methyl)-14-methylene-8,12,16,20-tetraoxaheptacosane (29) was prepared in 85% yield according to the general procedure for preparation of tetraalkylated methallyldiether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 5.13 (s, 2H), 3.94 (s, 4H), 3.45 (d, *J* = 3.6 Hz, 12H), 3.38 (t, *J* = 6.4 Hz, 8H), 2.18-2.12 (m, 2H), 1.57-1.51 (m, 8H), 1.30-1.28 (m, 32H), 0.88 (t, *J* = 6.6 Hz, 6H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 143.3, 113.2, 71.8, 71.3, 69.2, 68.9, 40.5, 31.9, 29.8, 29.3, 26.3, 22.8, 14.2.

3-(3-(pentyloxy)-2-((pentyloxy)methyl)propoxy)-2-((3-(pentyloxy)-2-((pentyloxy)methyl)propoxy)methyl) propan-1-ol (30) was prepared in 76% yield according to the general procedure for hydroboation of tetra alkylated methalyl diether. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.73 (d, *J* = 2.8 Hz, 2H), 3.55-3.49 (m, 4H), 3.46 (d, *J* = 5.6 Hz, 4H), 3.42 (d, *J* = 6.0 Hz, 8H), 3.38 (t, *J* = 2.8 Hz, 8H), 2.92 (br s, 1H) 2.17-2.09 (m, 3H), 1.58-1.52 (quin, *J* = 6.8 Hz, 8H), 1.33-1.30 (m, 16H), 0.89 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 71.4, 70.1, 69.3, 64.4, 41.4, 40.4, 29.4, 28.5, 22.6, 14.2.

3-(3-(hexyloxy)-2-((hexyloxy)methyl)propoxy)-2-((3-(hexyloxy)-2-((hexyloxy)methyl)propoxy)methyl) propan-1-ol (31) was prepared in 74% yield according to the general procedure for hydroboation. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.71 (d, *J* = 4.8 Hz, 2H), 3.55-3.45 (m, 8H), 3.42 (d, *J* = 6.4 Hz, 8H), 3.38 (t, *J* = 6.6 Hz, 8H), 3.07 (br s, 1H), 2.16-2.08 (m, 2H), 1.58-1.50 (quin, *J* = 6.8 Hz, 8H), 1.33-1.20 (m, 24H), 0.88 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 71.3, 71.0, 69.9, 69.2, 64.0, 41.4, 40.3, 31.7, 29.6, 25.8, 22.6, 14.1.

3-(3-(heptyloxy)-2-((heptyloxy)methyl)propoxy)-2-((3-(heptyloxy)-2-((heptyloxy)methyl)propoxy)methyl) propan-1-ol (32) was prepared in 74% yield according to the general procedure for hydroboation. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.72 (d, *J* = 4.8 Hz, 2H), 3.54-3.49 (m, 4H), 3.46 (d, *J* = 6.0 Hz, 4H), 3.41 (d, *J* = 6.0 Hz, 8H), 3.38 (t, *J* = 6.4 Hz, 8H), 2.93 (br s, 1H), 2.15-2.10 (quin, *J* = 6.0 Hz, 2H), 1.56-1.52 (m, 8H), 1.33-1.20 (m, 32H), 0.88 (t, *J* = 5.2 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 71.3, 70.8, 69.3, 64.3, 63.9, 41.4, 40.3, 31.9, 29.7, 29.2, 26.2, 22.7, 14.2.

2-(hydroxymethyl)-2-((3-(3-(pentyloxy)-2-((pentyloxy)methyl)propoxy)-2-((3-(pentyloxy)-2-((pentyloxy)methyl)propoxy)methyl)propoxy)methyl)propane-1,3-diol (33) was prepared in 44% yield according to the general procedure for the synthesis of tetraalkylated triol. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.65 (s, 6H), 3.48-3.37 (m, 28H), 2.16-2.10 (m, 3H), 1.59-1.52 (quin, *J* = 6.8 Hz, 8H), 1.35-1.30 (m, 16H), 0.90 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 72.8, 71.4, 70.3, 69.8, 69.6, 69.2, 64.4, 45.2, 40.3, 40.1, 29.4, 28.4, 22.6, 14.2.

2-((3-(3-(hexyloxy)-2-((hexyloxy)methyl)propoxy)-2-((3-(hexyloxy)-2-((hexyloxy)methyl)propoxy)methyl)propoxy)methyl)-2-(hydroxymethyl)propane-1,3-diol (34) was prepared in 42% yield according to the general

procedure for the synthesis of tetraalkylated triol. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.66 (s, 6H), 3.50-3.48 (m, 4H), 3.43-3.37 (m, 24H), 3.08 (br s, 3H), 2.15-2.12 (m, 3H), 1.54-1.53 (m, 8H), 1.31-1.29 (m, 24H), 0.88 (t, *J* = 7.2 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 73.0, 71.5, 70.4, 69.9, 69.7, 69.3, 65.0, 45.1, 40.3, 31.9, 29.8, 26.0, 22.8, 14.3.

2-((3-(3-(heptyloxy)-2-((heptyloxy)methyl)propoxy)-2-((3-(heptyloxy)-2((heptyloxy)methyl)propoxy)methyl)-propoxy)methyl)-2-(hydroxymethyl)propane-1,3-diol (35) was prepared in 44% yield according to the general procedure for the synthesis of tetraalkylated triol. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 3.66 (s, 6H), 3.42-3.39 (m, 8H), 3.36-3.30 (m, 20 H), 3.08 (br s, 3H), 2.15-2.12 (m, 3H), 1.49-1.46 (m, 8H), 1.31-1.29 (m, 32H), 0.81 (t, *J* = 6.8 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 72.8, 71.4, 70.3, 69.8, 69.6, 69.2, 64.4, 45.1, 40.2, 40.1, 31.9, 29.7, 29.3, 26.2, 22.7, 14.2.

DTM-E5a was prepared in 62% yield according to the general procedure for maltosylation reaction. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.09 (d, *J* = 8.0 Hz, 6H), 7.98 (d, *J* = 8.0 Hz, 6H), 7.87 (t, *J* = 8.0 Hz, 20H), 7.79 (d, *J* = 8.0 Hz, 6H), 7.68 (d, *J* = 8.0 Hz, 6H), 7.54-7.18 (m, 61H), 6.12 (t, *J* = 10.0 Hz, 3H), 5.67 (t, *J* = 6.8 Hz, 6H), 5.45 (t, *J* = 9.6 Hz, 3H), 5.19 (dd, *J* = 10.4 Hz, *J* = 4 Hz, 3H), 5.14 (t, *J* = 8.0 Hz, 3H), 4.61 (t, *J* = 12.0 Hz, 6H), 4.36-4.28 (m, 10H), 4.18 (d, *J* = 8.0 Hz, 3H), 3.74 (d, *J* = 8.0 Hz, 3H), 3.68 (d, *J* = 12.0 Hz, 3H), 3.40-3.35 (m, 16H), 3.31-3.29 (m, 3H), 3.22-3.14 (m, 9H), 3.01 (d, *J* = 8.0 Hz, 3H), 2.15-2.12 (m, 2H), 1.95-1.89 (m, 1H), 1.54-1.53 (m, 8H), 1.31-1.29 (m, 16H), 0.88 (t, *J* = 7.2 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 165.6, 165.1, 165.0, 164.8, 133.7, 133.5, 133.2, 130.0, 129.9, 129.8, 129.7, 129.5, 129.4, 129.0, 128.9, 128.8, 128.7, 128.5, 128.3, 100.9, 95.9, 74.8, 72.3, 72.2, 71.3, 69.9, 69.7, 69.3, 69.0, 68.9, 63.5, 62.4, 60.5, 44.9, 40.4, 29.5, 28.5, 22.6, 22.1, 14.2.

DTM-E6a was prepared in 65% yield according to the general procedure for maltosylation reaction. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.10 (d, *J* = 8.0 Hz, 6H), 7.98 (d, *J* = 8.0 Hz, 6H), 7.88 (t, *J* = 8.0 Hz, 20H), 7.79 (d, *J* = 6.0 Hz, 6H), 7.68 (d, *J* = 8.0 Hz, 6H), 7.54-7.19 (m, 61H), 6.14 (t, *J* = 9.8 Hz, 3H), 5.68 (t, *J* = 9.6 Hz, 6H), 5.47 (t, *J* = 9.2 Hz, 3H), 5.21 (dd, *J* = 10.4 Hz, *J* = 3.2 Hz, 3H), 5.16 (t, *J* = 8.8 Hz, 3H), 4.59 (t, *J* = 12.0 Hz, 6H), 4.38-4.29 (m, 9H), 4.20 (d, *J* = 10.4 Hz, 3H), 3.75 (d, *J* = 7.2 Hz, 3H), 3.69 (d, *J* = 12.0 Hz, 3H), 3.39-3.30 (m, 17H), 3.21-3.19 (m, 9H), 3.13-3.05 (m, 3H), 3.02 (d, *J* = 8.4 Hz, 3H), 2.15-2.08 (m, 2H), 1.95-1.88 (m, 1H), 1.54-1.52 (m, 8H), 1.31-1.29 (m, 24H), 0.87 (t, *J* = 4.0 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.1, 165.8, 165.6, 165.1, 164.8, 133.7, 133.5, 133.2, 129.9, 129.8, 129.7, 129.5, 129.4, 129.0, 128.9, 128.8, 128.7, 128.5, 128.3, 100.9, 95.9, 74.8, 72.5, 72.3, 71.3, 70.2, 69.9, 69.8, 69.2, 69.0, 68.9, 63.5, 62.4, 44.9, 40.4, 31.8, 29.7, 25.9, 22.7, 14.2.

DTM-E7a was prepared in 66% yield according to the general procedure for maltosylation reaction. **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.10 (d, *J* = 8.0 Hz, 6H), 7.98 (d, *J* = 8.0 Hz, 6H), 7.88 (t, *J* = 8.0 Hz, 20H) 7.79 (d, *J* = 6.0 Hz, 6H), 7.68 (d, *J* = 8.0 Hz, 6H), 7.56-7.18 (m, 61H), 6.13 (t, *J* = 10.0 Hz, 3H), 5.68 (t, *J* = 10.0 Hz, 6H), 5.46 (t, *J* = 10.0 Hz, 3H), 5.20 (dd, *J* = 8 Hz, *J* = 4 Hz, 3H), 5.15 (t, *J* = 8.0 Hz, 3H), 4.59 (t, *J* = 10.0 Hz, 6H), 4.37-4.29 (m, 10H), 4.19 (d, *J* = 12.0 Hz, 3H), 3.75 (d, *J* = 8.0 Hz, 3H), 3.69 (d, *J* = 8.0 Hz, 3H), 3.39-3.30 (m, 16H), 3.30-3.27 (m, 3H), 3.21-3.15 (m, 6H), 3.12-3.06 (m, 3H), 3.02 (d, *J* = 12.0 Hz, 3H), 2.15-2.08 (m, 2H), 1.95-1.88 (m, 1H), 1.54-1.52 (m, 8H), 1.31-1.29 (m, 32H), 0.87 (t, *J* = 4.0 Hz, 12H); **^{13}C NMR** (100 MHz, $CDCl_3$): δ 166.1, 165.8, 165.6, 165.1, 164.8,

133.5, 133.2, 129.9, 129.8, 129.7, 129.5, 129.4, 129.0, 128.9, 128.8, 128.7, 128.5, 128.3, 100.9, 95.9, 74.8, 72.3, 72.2, 71.3, 69.9, 69.8, 69.3, 69.0, 67.8, 63.5, 62.4, 44.9, 40.4, 31.9, 29.8, 29.3, 26.3, 22.7, 14.2.

DTM-E5 was synthesized according to the general procedure for de-O-benzoylation. **^{1}H NMR** (400 MHz, CD_3OD): δ 5.15 (d, *J* = 4.0 Hz, 3H), 4.34 (d, *J* = 8.0 Hz, 3H), 3.96 (d, *J* = 12.0 Hz, 3H), 3.90-3.79 (m, 10H), 3.68-3.59 (m, 18H), 3.53 (t, *J* = 10.0 Hz, 6H), 3.45-3.40 (m, 27H), 3.27 (t, *J* = 8.0 Hz, 6H), 2.15-2.08 (m, 3H), 1.56 (quin, *J* = 6.8 Hz, 8H), 1.35-1.32 (m, 16H), 0.92 (t, *J* = 7.0 Hz, 12H); **^{13}C NMR** (100 MHz, CD_3OD): δ 105.1, 103.1, 81.5, 77.9, 76.6, 75.2, 74.9, 74.3, 72.4, 71.5, 71.2, 70.8, 70.3, 70.0, 62.8, 62.3, 46.7, 41.8, 30.6, 29.7, 23.7, 14.7. **HRMS (FAB$^+$)**: calcd. for $C_{73}H_{136}O_{40}$ $[M+Na]^+$ 1675.8506, found 1675.8510.

DTM-E6 was synthesized according to the general procedure for de-O-benzoylation. **^{1}H NMR** (400 MHz, CD_3OD): δ 5.17 (d, *J* = 4.0 Hz, 3H), 4.35 (d, *J* = 8.0 Hz, 3H), 3.96 (d, *J* = 9.6 Hz, 3H), 3.90-3.81 (m, 10H), 3.69-3.60 (m, 18H), 3.53 (t, *J* = 12.0 Hz, 6H), 3.45-3.41 (m, 27H), 3.35-3.24 (m, 6H), 2.05-1.99 (m, 3H), 1.56 (quin, *J* = 6.6 Hz, 8H), 1.35-1.32 (m, 24H), 0.92 (t, *J* = 7.0 Hz, 12H); **^{13}C NMR** (100 MHz, CD_3OD): δ 105.0, 102.9, 81.4, 77.8, 76.5, 75.1, 74.8, 74.1, 72.4, 71.5, 71.2, 70.7, 70.6, 70.2, 70.0, 62.8, 62.3, 46.7, 41.7, 41.6, 32.9, 30.8, 27.1, 23.8, 14.6. **HRMS (FAB$^+$)**: calcd. for $C_{77}H_{144}O_{40}$ $[M+Na]^+$ 1732.9132, found 1731.9124.

DTM-E7 was synthesized according to the general procedure for de-O-benzoylation. **^{1}H NMR** (400 MHz, CD_3OD): δ 5.15 (d, *J* = 4.0 Hz, 3H), 4.34 (d, *J* = 8.0 Hz, 3H), 3.97 (d, *J* = 12.0 Hz, 3H), 3.88 (d, *J* = 12.0 Hz, 4H), 3.83-3.78 (m, 6H), 3.68-3.61 (m, 18H), 3.55 (t, *J* = 16.0 Hz, 6H), 3.46-3.30 (m, 27H), 3.27 (m, 6H), 2.05-1.99 (m, 3H), 1.56 (quin, *J* = 6.6 Hz, 8H), 1.33-1.31 (m, 32H), 0.90 (t, *J* = 6.6 Hz, 12H); **^{13}C NMR** (100 MHz, CD_3OD): δ 105.1, 103.1, 81.5, 77.9, 76.6, 75.2, 74.9, 74.3, 72.4, 71.6, 70.8, 70.7, 70.3, 70.1, 62.8, 62.3, 41.8, 33.2, 30.9, 30.4, 27.5, 23.8, 14.7s. **HRMS (FAB$^+$)**: calcd. for $C_{81}H_{152}O_{40}$ $[M+Na]^+$ 1787.9758, found 1787.9763.

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