Supplementary Information

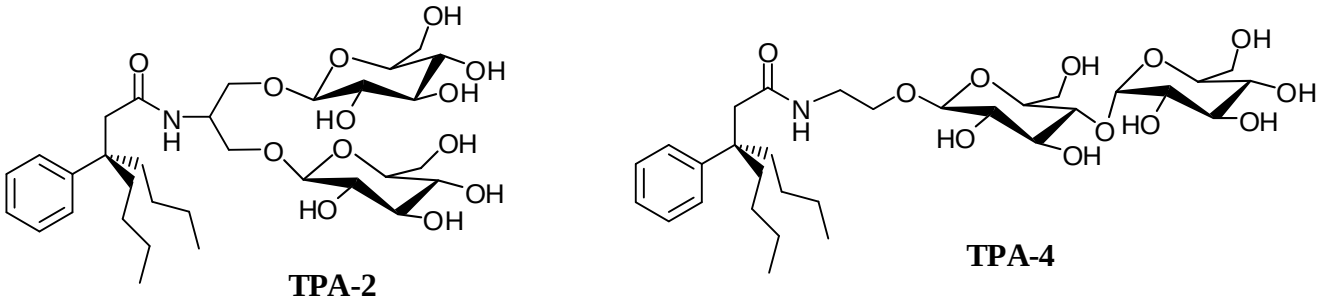


Figure S1. Chemical structures of the previously described TPAs, TPA-2 and TPA-4.

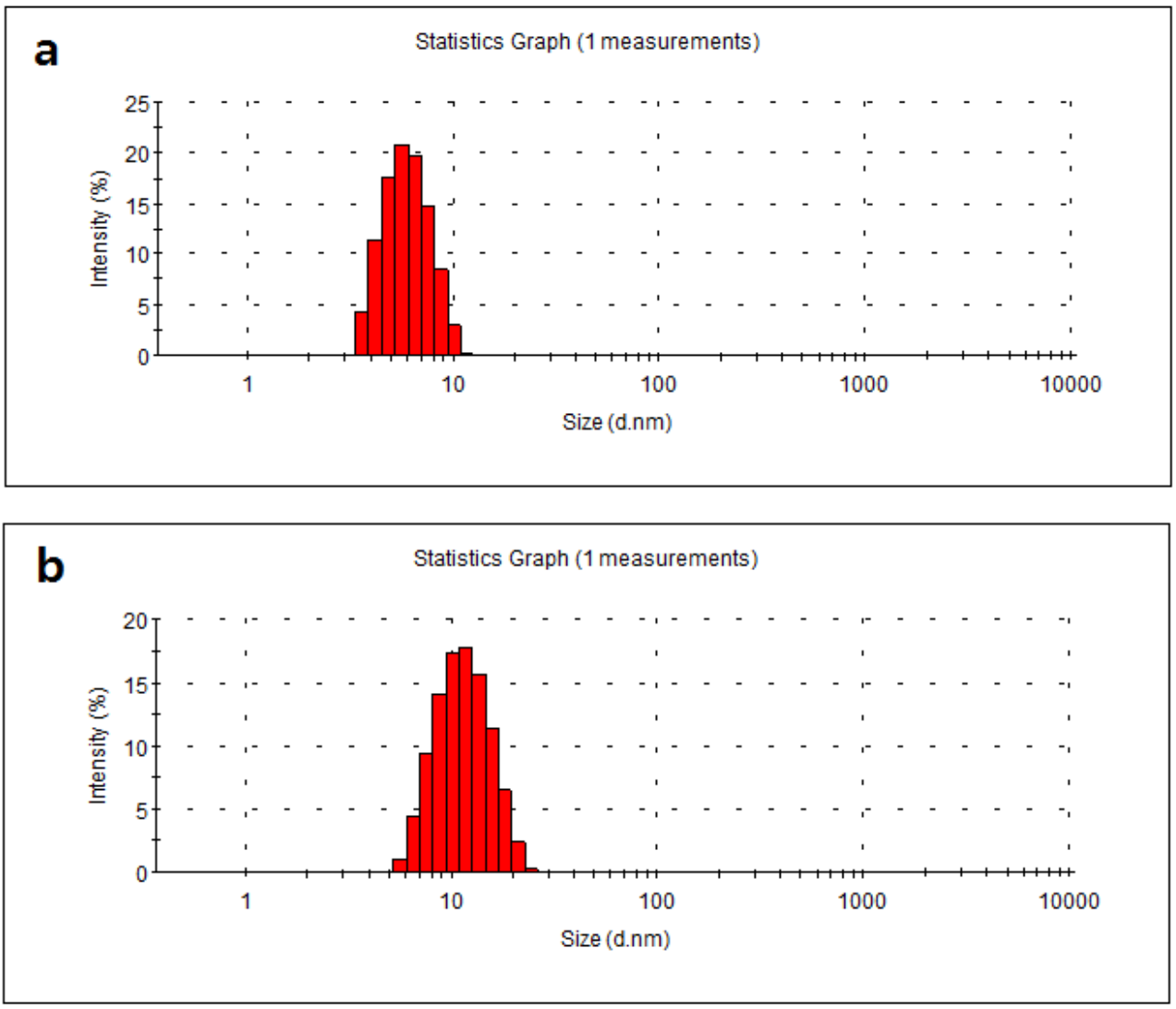


Figure S2 Size distribution of micelles formed by (a) CGT-2 and (b) CGT-3 at 1.0 wt % obtained by dynamic light scattering (DLS).

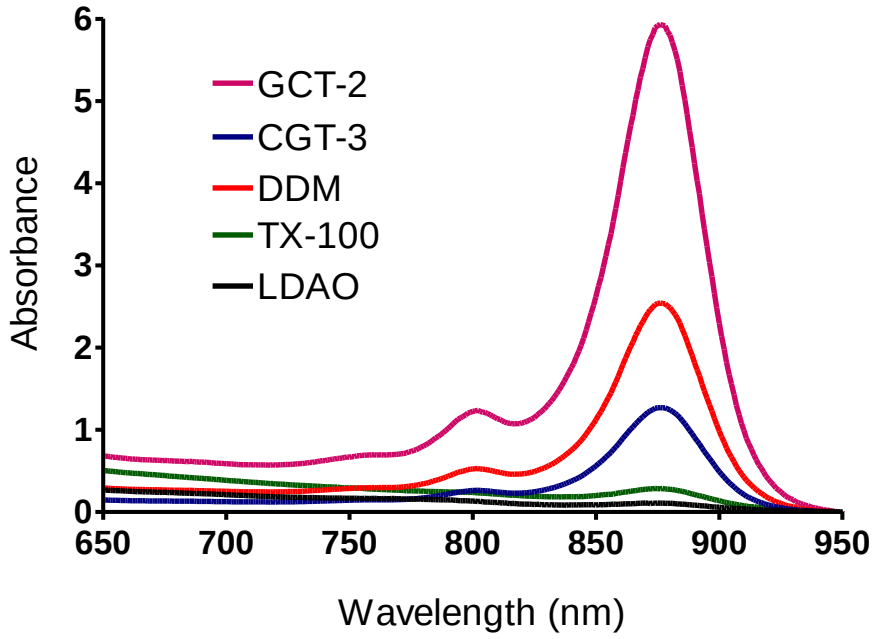


Figure S3 The spectra of resuspended membrane debris containing LHI-RC material following collection in the form of a pellet using ultracentrifugation. These signals are from complexes that remain embedded in the membrane and provide data complementary to that from complexes suspended by detergent micelles in the supernatant. Protein solubilization efficiencies in individual detergents were estimated based on the total amount of photosynthetic supperassembly added to the solubilization reaction minus the amount still remaining in the homogenized pellets. The pellets were obtained via ultracentrifugation of detergent-treated samples and homogenized prior to measurement.

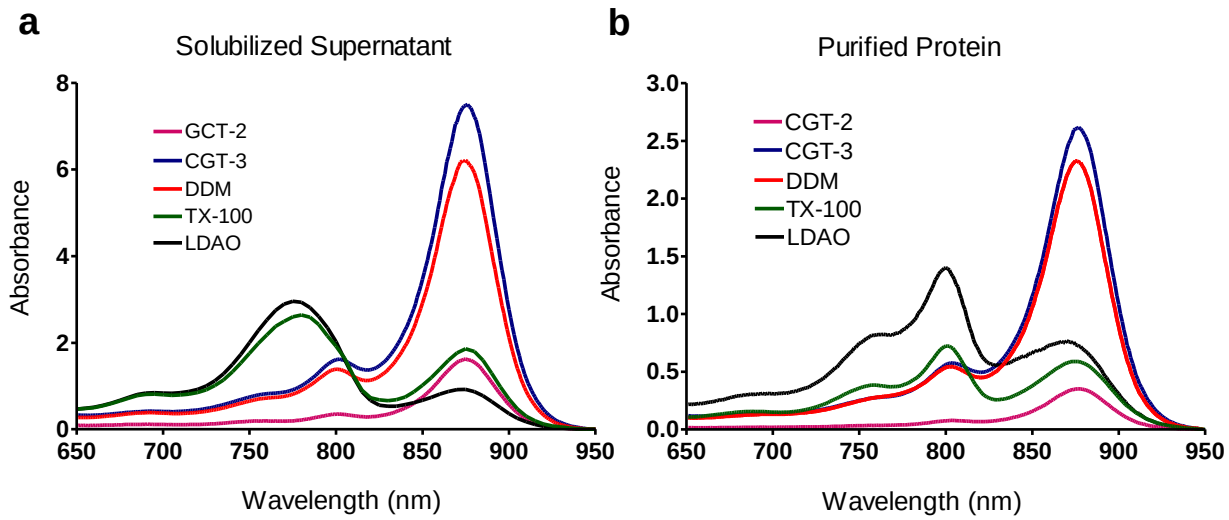


Figure S4. The spectra of solubilized supernatant and purified protein of *R. capsulatus* superassembly in CGT amphiphiles and three conventional detergents (DDM, TX-100 and LDAO). The solubilized supernatant was obtained by taking the soluble portion after ultracentrifugation of detergent-treated membrane samples. The purified protein was obtained via Ni-NTA affinity column utilizing an engineered seven-membered histidine tag that resides on the C-terminus of the M-subunit of the reaction center and collected in the elution buffer containing 1M imidazole

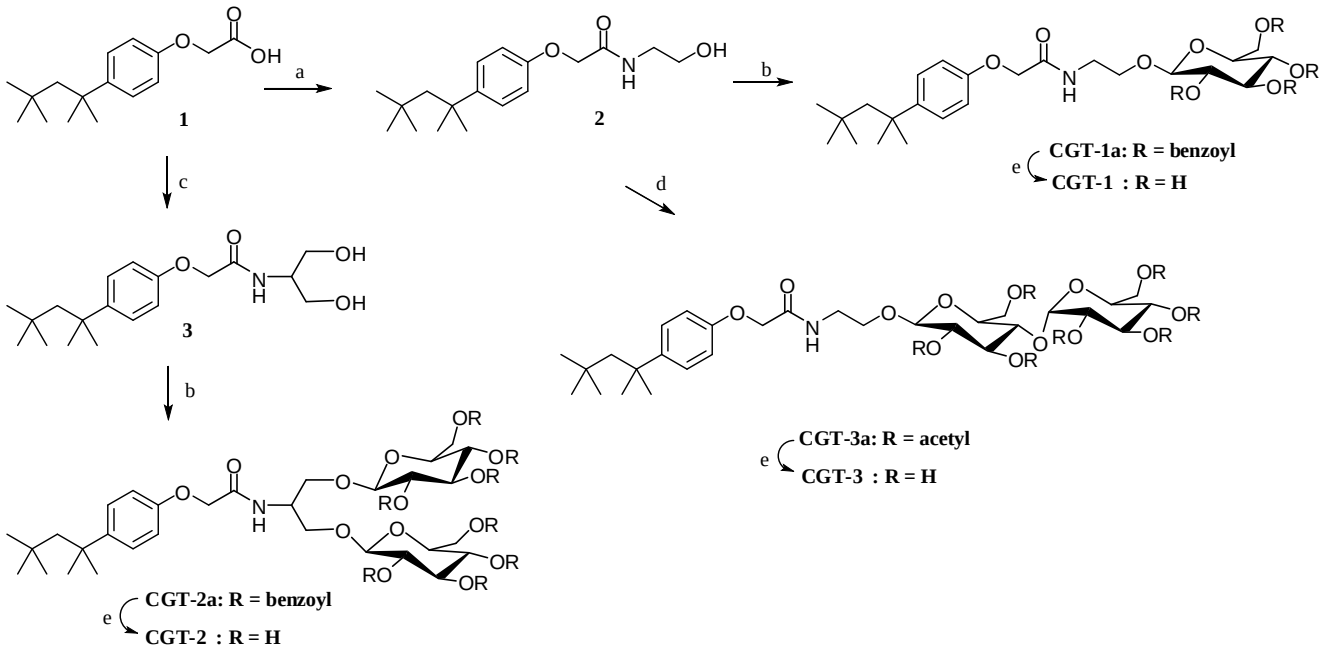
Protein stability evaluation

Stability assay for *R. capsulatus* superassembly

The solubilization and purification of the *R. capsulatus* superassembly were conducted according to the published protocol.[1] First, we obtained specialized photosynthetic membranes called intracytoplasmic membranes from an engineered strain of *Rhodobacter (R.) capsulatus*, U43[pUHTM86Bgl], lacking the light-harvesting complex II (LHII) and sporting a histidine tag appended to the C-terminus of the M-subunit of the RC. We began the solubilization experiment by thawing and homogenizing frozen aliquots of *R. capsulatus* membranes at room temperature. The solution was then incubated with mild agitation at 32˚C for 30 min. Subsequently, the solution was further incubated for 30 min after adding individual detergents at 1.0 wt % to 1.0 mL solutions of *R. capsulatus* superassembly. This slurry was then subjected to ultracentrifugation at 310,000 *g* at 4℃ for 30 min to remove membrane debris. The spectra of solubilized supernatant and resuspended membrane pellet (after being homogenized) were taken in a range from 650 nm to 950 nm. For the purification of the protein, detergent-solubilized samples were transferred into a new 1.7 mL microcentrifuge tube containing Ni-NTA resin (Qiagen, Inc.; Valencia, CA; pre-equilibriated and stored in an equal volume of buffer containing 10 mM Tris, pH 7.8, and 100 mM NaCl). Following an one-hour incubation at 4℃ for protein binding, the resin was collected and washed twice with 0.5 mL of binding buffer (a pH 7.8 Tris solution containing DDM at 1xCMC). Purified protein solution were eluted three times with 0.20 mL elution buffer solutions containing 1 M imidazole (otherwise, this buffer was identical to binding buffer; the pH of each solution was readjusted to pH = 7.8) and diluted with 0.4 mL of the binding buffer to reach 1.0 mL solution. Then UV-Vis spectra of the superassembly purified in individual detergents were taken to assess the stability of the protein.

Amphiphile Synthesis

Supplementary scheme



(a) 2-ethanolamine, EDC • HCl, HOBt, DMF, room temperature; (b) perbenzoylated glucosylbromide 1.2 equiv., AgOTf, CH_2Cl_2, -45°C → room temperature; (c) serinol, EDC • HCl, HOBt, DMF, room temperature; (d) 1,2-trans peracetylated maltose (1.2 equiv.), $BF_3.Et_2O$, CH_2Cl_2, room temperature; (e) NaOMe, MeOH, room temperature.

***N*-(2-hydroxyethyl)-2-(4-(2,4,4-trimethylpentan-2-yl)phenoxy)acetamide (2) & *N*-(1,3-dihydroxypropan-2yl)-2-(2,4,4-trimethylpentan-2-yl)phenoxy)acetamide (3)**

These compounds were synthesized according to **supplementary scheme**. Commercially available 2-(4-(2,4,4-trimethylpentan-2-yl)phenoxy)acetic acid (**1**) (1.0 g, 3.8 mmol), 2-ethanolamine or serinol (0.28g or 0.41g, 4.5 mmol), 1-hydroxybenzotriazole monohydrate (HOBt) (0.60 g, 4.5 mmol) was dissolved in anhydrous DMF (30 mL). 1-(3-(dimethylamino)propyl)-3-ethylcarbodiimide hydrochoride (EDC • HC1) (0.85 g, 4.5 mmol) was added in small portions at 0°C and the resulting solution left stirring at room temperature for 20 h. The solution was taken up with EtOAc (100 mL) and was washed successively with a 1 M aqueous $NaHCO_3$ solution (100 mL), a 0.1 M aqueous HCl solution (100 mL) and brine (2 x 100 mL). Then the organic layer was dried with anhydrous Na_2SO_4 and the solvent was removed by rotary evaporation. The reaction mixture was precipitated with ether (100 mL) and the resulting solid was collected and dried *in vacuo* to afford the respective products as white solids (94% for **2** and 92% for **3**).

Compound **2**; **^{1}H NMR** (300 MHz, $CDCl_3$): δ 7.34-7.25 (m, 2H), 7.10 (s, 1H), 6.87-6.78 (m, 2H), 4.49 (s, 2H), 3.80-3.70 (br m, 2H), 3.56-3.47 (m, 2H), 2.90 (br s, 1H), 1.70 (s, 2H), 1.34 (s, 6H), 0.71 (s, 9H); **^{13}C NMR** (75 MHz, $CDCl_3$): δ 169.8, 155.0, 144.1, 127.6, 114.1, 67.5, 62.2, 57.1, 42.1, 38.2, 32.5, 31.9, 31.8; **HRMS (ESI)**: calcd. for $C_{18}H_{29}NO3Na$ $[M+Na]^+$ 330.204, found 330.2024.

Compound **3**; **^{1}H NMR** (300 MHz, $CDCl_3$): δ 7.34-7.20 (m, 2H), 6.89-6.74 (m, 2H), 4.51 (s, 2H), 4.09-3.95 (m, 1H), 3.93-3.69 (m, 4H), 2.87 (br s, 2H), 1.70 (s, 2H), 1.34 (s, 6H), 0.70 (s, 9H); **^{13}C NMR** (75 MHz, $CDCl_3$): δ 169.6, 154.9, 144.2, 127.6, 114.2, 67.6, 63.1, 57.2, 52.4, 38.3, 32.5, 31.9, 31.8; **HRMS (ESI)**: calcd. for $C_{19}H_{316}F_{12}NO_4Na$ $[M+Na]^+$ 360.2146, found 360.2137.

CGT-1a and CGT-2a was synthesized according to a literature method[2] with slight modification. A mixture of alcohol derivative (**2** or **3**), AgOTf (1.2 or 2.4 equiv.) and 2,4,6-collidine (0.9 or 1.8 equiv.) in anhydrous CH_2Cl_2 (40 mL) was stirred at -45°C. A solution of perbenzoylated glucosylbromide (1.2 or 2.4 equiv.) in CH_2Cl_2 (40 mL) was added dropwise over 0.5 h to this suspension. Stirring was continued for 0.5 h at -45°C, and then the reaction mixture was allowed to warm to 0 °C and left stirring for 1.5 h. After completion of the reaction (as detected by TLC), pyridine was added to the reaction mixture, and it was diluted with CH_2Cl_2 (40 mL) before being filtered through celite. The filtrate was washed successively with a 1 M aqueous $Na_2S_2O_3$ solution (40 mL), a 0.1 M aqueous HCl solution (40 mL), and brine (2 x 40 mL). Then the organic layer was dried with anhydrous Na_2SO_4, and the solvent was removed by rotary evaporation. The residue was purified by silica gel column chromatography (EtOAc/hexane), which provided the desired product as a glassy solid (95% for **CGT-1a** and 92% for **CGT-2a**).

CGT-3a was prepared according to the literature method[3] with slight modification. $BF_3.Et_2O$ (3 equiv with respect to protected maltose) was added to the 1,2-trans peracetylated maltose (1.2 equiv) and the alcohol derivatives (**2**) (1.0 equiv) in dry CH_2Cl_2 under a nitrogen atmosphere at room temperature. The reaction was monitored by TLC. When the reaction did not progress further (usually 48 h), the mixture was diluted with CH_2Cl_2, and washed with saturated aqueous $NaHCO_3$ and then water. The organic layer was dried with Na_2SO_4, and concentrated by rotary evaporation. The residue was purified by silica gel column chromatography (EtOAc/ hexane 1:1) providing desired product as a glassy solid.

CGT-1a; ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.05-7.97 (m, 2H), 7.94-7.86 (m, 4H), 7.86-7.78 (m, 2H), 7.58-7.20 (m, 12H), 6.95 (t, *J* = 5.6 Hz, 1H), 5.91 (t, *J* = 9.8 Hz, 1H), 5.67 (t, *J* = 9.5 Hz, 1H), 5.54 (tt, *J* = 9.9, 7.8 Hz, 1H), 4.86 (d, *J* = 8.2 Hz, 1H), 4.65 (dd, *J* = 12.3, 3.0 Hz, 1H), 4.56 (dd, *J* = 12.3, 5.2

Hz, 1H), 4.31 (d, *J* = 14.7 Hz, 1H), 4.22-4.11 (m, 2H), 4.02-3.92 (m, 1H), 3.83-3.72 (m, 1H), 3.66-3.54 (m, 1H), 3.54-3.39 (m, 1H), 1.70 (s, 2H), 1.34 (s, 6H), 0.71 (s, 9H) ; **^{13}C NMR** (75 MHz, $CDCl_3$): δ 168.8, 166.3, 166.0, 165.4, 165.3, 155.0, 143.8, 133.7, 133.4, 130.1, 130.0, 129.9, 129.7, 129.3, 129.0, 128.9, 128.6, 128.5, 127.5, 114.1, 101.4, 73.0, 72.6, 72.0, 69.8, 69.0, 67.3, 63.2, 57.1, 38.9, 38.2, 32.5, 32.0, 31.9.

CGT-2a ; **^{1}H NMR** (300 MHz, $CDCl_3$): δ 8.19-8.09 (m, 4H), 8.04-7.96 (m, 4H), 7.96-7.80 (m, 8H), 7.75-7.60 (m, 6H), 7.60-7.47 (m, 4H), 7.47-7.35 (m, 10H), 7.35-7.23 (m, 6H), 6.87 (t, *J* = 9.5 Hz, 4H), 5.61 (dt, *J* = 9.8, 1.8 Hz, 2H), 5.49 (dt, *J* = 9.0, 1.8 Hz, 2H), 5.46-5.33 (m, 2H), 4.53-4.43 (m, 2H), 4.43-4.25 (m, 5H), 3.93-3.74 (m, 4H), 3.52-3.44 (m, 1H), 3.39-3.24 (m, 2H), 3.06 (t, *J* = 9.5 Hz, 1H), 1.72 (s, 2H), 1.36 (s, 6H), 0.72 (s, 9H) ; **^{13}C NMR** (75 MHz, $CDCl_3$): δ 168.1, 166.2, 166.0, 165.3, 165.2, 165.0, 164.9, 155.0, 143.9, 133.9, 133.7, 133.5, 133.4, 133.3, 130.3, 129.9, 129.8, 129.7, 129.4, 129.3, 129.1, 129.0, 128.7, 128.6, 128.5, 127.6, 114.3, 101.7, 101.6, 72.6, 72.4, 72.2, 72.1, 71.9, 69.7, 67.8, 67.3, 66.8, 63.1, 63.0, 57.2, 47.1, 38.3, 32.5, 32.0, 31.9; **MS (MALDI-TOF)**: calcd. for $C_{87}H_{83}NO_{22}Na[M+Na]^+$ 1516.58, found 1516.6.

CGT-3a ; **^{1}H NMR** (300 MHz, $CDCl_3$): 7.37-7.24 (m, 2H), 7.00-6.90 (m, 1H), 6.90-6.79 (m, 2H), 5.45-5.30 (m, 2H), 5.26 (t, *J* = 9.0 Hz, 1H), 5.06 (t, *J* = 9.8 Hz, 1H), 4.91-4.79 (m, 2H), 4.56-4.44 (m, 4H), 4.30-4.16 (m, 2H), 4.08-3.86 (m, 4H), 3.74-3.57 (m, 3H), 3.56-3.38 (m, 1H), 2.11 (d, *J* = 5.8 Hz, 6H), 2.07-1.93 (m, 15H), 1.70 (s, 2H), 1.34 (s, 6H), 0.70 (s, 9H); **^{13}C NMR** (75 MHz, $CDCl_3$): δ 170.7, 170.6, 170.3, 170.1, 169.9, 169.6, 168.7, 155.0, 144.1, 127.6, 114.2, 100.5, 95.8, 75.5, 72.9, 72.5, 72.2, 70.2, 69.5, 68.8, 68.7, 68.2, 67.7, 62.9, 61.7, 57.1, 38.9, 38.2, 32.5, 31.9, 31.8, 21.1, 21.0, 20.9, 20.8, 20.7; **MS (ESI)**: calcd. for $C_{44}H_{63}F_{12}NO_{20}Na[M+Na]^+$ 948.3836, found 948.3833.

CGT-1, CGT-2 and CGT-3 were synthesized according to the de-*O*-benzoylation or de-*O*-acetylation under Zemplén's conditions.[2] The *O*-protected compounds (**CGT-1a**, **CGT-2a** and **CGT-3a**) were dissolved in MeOH and then treated with the catalytic amount of NaOMe such that the final concentration of NaOMe was about 0.05 M. The reaction mixture was stirred for 6 h 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*. The residue was purified by silica gel column chromatography (MeOH/CH_2Cl_2). Further purification, by recrystallization using CH_2Cl_2/MeOH/diethyl ether, afforded fully deprotected product as a white solid (95% for **CGT-1** & **CGT-2** and 94% for **CGT-3**).

CGT-1; **^{1}H NMR** (300 MHz, CD_3OD): δ 7.31 (d, *J* = 8.5 Hz, 2H), 6.90 (d, *J* = 8.7 Hz, 2H), 4.48 (s, 2H), 4.28 (d, *J* = 7.7 Hz, 1H), 4.00-3.90 (m, 1H), 3.90-3.81 (m, 1H), 3.74-3.52 (m, 3H), 3.52-3.32 (m, 2H), 3.32-3.24 (m, 2H), 3.24-3.15 (m, 1H), 1.74 (s, 2H), 1.34 (s, 6H), 0.70 (s, 9H); **^{13}C NMR** (75 MHz, CD_3OD): δ 171.7, 157.2, 144.6, 128.5, 115.4, 104.7, 78.1, 75.2, 71.8, 69.6, 68.6, 62.9, 58.1, 40.4, 39.1, 33.3, 32.5, 32.4; **HRMS (ESI)**: calcd. for $C_{24}H_{39}F_4NO_8Na$ $[M+Na]^+$ 492.2573, found 492.2596.

CGT-2; **^{1}H NMR** (300 MHz, CD_3OD): δ 7.31 (d, *J* = 8.5 Hz, 2H), 6.90 (d, *J* = 8.7 Hz, 2H), 4.48 (s, 2H), 4.40-4.32 (m, 1H), 4.29 (t, *J* = 7.7 Hz, 2H), 3.97 (td, *J* = 11.0, 5.0 Hz, 2H), 3.89-3.77 (m, 3H), 3.73-3.53 (m, 3H), 3.40-3.21 (m, 5H), 3.18 (t, *J* = 8.4 Hz, 2H), 1.71 (s, 2H), 1.31 (s, 6H), 0.67 (s, 9H); **^{13}C NMR** (75 MHz, CD_3OD): δ 171.5, 157.1, 144.6, 128.5, 115.5, 105.0, 104.8, 78.1, 75.2, 71.8, 71.7, 69.6, 69.5, 68.6, 62.9, 58.1, 50.7, 39.1, 33.3, 32.4; **HRMS (ESI)**: calcd. for $C_{31}H_{51}NO_{14}Na$ $[M+Na]^+$ 684.3207, found 684.3218.

CGT-3; **^{1}H NMR** (300 MHz, CD_3OD): δ 7.32 (d, *J* = 9.0 Hz, 2H), 6.90 (d, *J* = 8.9 Hz, 2H), 5.14 (d, *J* = 3.8 Hz, 1H), 4.40 (s, 2H), 4.29 (d, *J* = 7.7 Hz, 1H), 4.01-3.88 (m, 1H), 3.88-3.73 (m, 3H), 3.73-3.32 (m, 10H), 3.32-3.18 (m, 2H), 1.73 (s, 2H), 1.33 (s, 6H), 0.70 (s, 9H); **^{13}C NMR** (75 MHz, CD_3OD): δ 171.7, 157.1, 144.6, 128.6, 115.4, 104.7, 103.1, 81.5, 77.8, 76.8, 75.2, 74.9, 74.8, 74.3, 71.6, 69.7, 68.6, 62.9, 62.3, 58.1, 40.4, , 39.1, 33.3, 32.5, 32.4; **HRMS (ESI)**: calcd. for $C_{30}H_{49}NO_{13}Na$ $[M+Na]^+$ 654.3102, found 654.31.

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