Supporting Information

Efficient Synthetic Supramolecular Channels and Their Light-deactivated Ion Transport in Bilayer Lipid Membrane

Chunyan Bao,* Meixin Ma, Funa Meng, Qiuning Lin, and Linyong Zhu*

Shanghai Key Laboratory for Function Materials Chemistry, Institute of Fine Chemicals, East China University of Science and Technology, Shanghai, 200237, P. R. China

Corresponding author email: baochunyan@ecust.edu.cn; linyongzhu@ecust.edu.cn

1. Synthesis of compounds

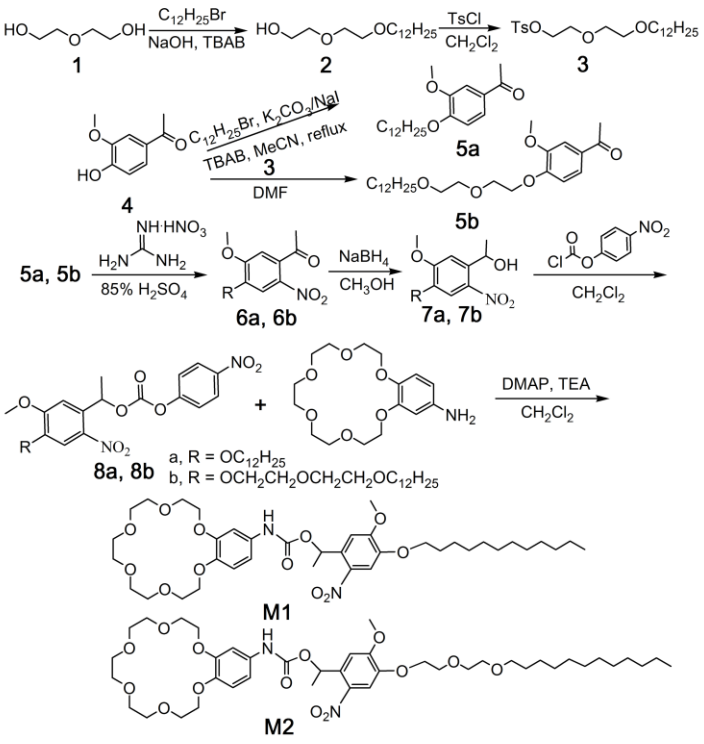


Figure S1. Synthetic routes of compounds **M1** and **M2**.

Compound 2: NaOH (2. 0 g, 0.05 mol) and tetrabutyl ammonium bromide (0.81 g, 2.5 mmol) were dissolved in Di-ethylene glycol (1, 53.0 g, 0.5 mol) at 80 ℃, then

1-bromododecane (12.5 g, 0.05 mol) was dropwise added to the solution, and the reaction was kept 100 ℃ for 24 h. After cooling to room temperature, 150 mL of water was added, the product was extracted with diethyl ether for twice (2 × 20 mL). The separated organic layer was dried over $MgSO_4$ and concentrated in vacuum. The obtained crude oil was purified by reduced pressure distillation, the compound **2** (10.0 g, 73.0%) was collected as colourless oil. ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 3.76~3.71 (m, 2H), 3.68 (dd, J = 5.8, 3.5 Hz, 2H), 3.63~3.58 (m, 4H), 3.46 (t, J = 6.8 Hz, 2H), 1.68~1.52 (m, 2H), 1.37~1.27 (m, 16H), 0.87(t, J = 6.5 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 72.5, 71.6, 70.5, 70.2, 61.9, 31.9, 29.7, 29.6, 29.5, 29.4, 26.1, 22.7, 14.1. MS(ESI): m/z: Calcd. For $C_{16}H_{34}O_3Na^+$ $[M+Na]^+$: 297.2. Found: 297.2.

Compound 3: A solution of 4-toluene sulfonyl chloride (2.1 g, 11.0 mmol) in dry dichloromethane (20 mL) was added dropwise to the stirred solution of compound 2 (2.0 g, 7.3 mmol) and N, N-diisopropylethylamine (3 mL, 18.2 mmol) in dry dichloromethane (48 mL) at 0 ℃ over 30 min. After addition, the reaction was stirred for 12 hours at RT. The reaction liquid was washed several times with saline solution and water, dried over $MgSO_4$ and concentrated in vacuum. The product was purified by column chromatography (SiO_2) eluting with ethyl acetate/petroleum ether (1/6) to obtain compound 3 as a faint yellow oil (2.1g, 67.0%). ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.80 (d, J = 8.3 Hz, 2H), 7.34 (d, J = 8.1 Hz, 2H), 4.17 (t, J = 6.8 Hz, 2H), 3.69 (t, J = 6.8 Hz, 2H), 3.60~3.55 (m, 2H), 3.53~3.49 (m, 2H), 3.41 (t, J = 6.8 Hz, 2H), 1.60~1.51 (m, 2H), 1.36~1.20 (m, 16H), 0.88 (t, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 144.8, 133.1, 129.8, 128.0, 71.6, 70.8, 70.0, 69.3, 68.7, 31.9, 29.7,

29.6, 29.5, 29.4, 26.1, 22.7, 21.7, 14.1. MS(ESI): m/z: Calcd. For $C_{23}H_{40}O_5SNa^+$[M+Na]$^+$: 451.2. Found: 451.2.

Compound 5a: A stirred solution of acetovanillone (4, 5.0 g, 30.1 mmol), potassium carbonate (16.6 g, 120 mmol), 1-bromododecane (9.3 mL, 39.1 mmol) , a trace of potassium iodide and TBAB in 80 mL dry CH_3CN was refluxed for 12 h. After the reaction was completed and the system was cooled to room temperature, the remained and insoluble catalyst was filtered off and the solvent was concentrated in vacuum. Column chromatography (silica gel, 25% EtOAc/hexanes) afforded compound 5a (9.5 g, 95%) as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.61~7.53 (m, 2H), 6.90 (d, *J* = 8.3 Hz, 1H), 4.10 (t, *J* = 6.9 Hz, 2H), 3.94 (s, 3H), 2.59 (s, 3H), 1.95~1.84 (m, 2H), 1.53~1.24 (m, 18H), 0.90 (t, *J* = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 196.9, 153.0, 149.2, 130.2, 123.3, 111.0, 110.4, 69.1, 56.1, 31.9, 29.7, 29.60, 29.4, 27.0, 26.2, 25.9, 22.7, 14.2. MS(EI): m/z: Calcd. For $C_{21}H_{34}O_3^+$ [M] $^+$: 334.2508. Found: 334.2506.

Compound 5b: A solution of compound 3 (0.5 g, 1.17 mmol), acetovanillone (4, 0.21 g, 1.28 mmol) and Cs_2CO_3 (0.46 g, 1.4 mmol) in dry DMF (12 mL) was heated to 110 ℃, stirred for 12 h. The reaction was cooled and poured into 100 mL ice water to generate solid precipitation, filtered and dried the filter cake. The obtained crude solid was purified by column chromatography (SiO_2) eluting with ethyl acetate/petroleum ether (1 / 5) to obtain compound 5b as a white solid (0.44 g, 44.0%).^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.60~7.53 (m, 2H), 6.95 (d, J = 8.3 Hz, 1H), 4.28 (t, J = 5.1 Hz, 2H), 3.99~3.91 (m, 5H), 3.75 (dd, J = 5.6, 3.9 Hz, 2H), 3.62 (dd, J = 5.7, 3.8 Hz, 2H), 3.47 (t,

J = 6.8 Hz, 2H), 2.59 (s, 3H), 1.65~1.54 (m, 2H), 1.41~1.20 (m, 18H), 0.90 (t, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 196.8, 152.7, 149.3, 130.7, 123.2, 111.6, 110.5, 71.60, 71.0, 70.1, 69.4, 68.4, 56.0, 31.9, 29.7, 26.1, 22.7, 14.1. MS(EI): m/z: Calcd. For $C_{25}H_{42}O_5^+[M]^+$: 422.3032. Found: 422.3031.

Compound 6a: A solution of 85% sulfuric acid (17 mL) was slowly added to a stirred system of compound 5a (2.0 g, 6.0 mmol, powder) in 100 mL roundflask at 0 ℃. After compound 5a was all dissolved in sulfuric acid, guanidine nitrate (0.74 g，6.0 mmol) was slowly added to the above mixture, the temperature of the reaction was kept at -5-0 ℃, stirred for 15 min. After the reaction was completed, the mixture was neutralized with aqueous $NaHCO_3$, then the product was extracted with EtOAc. The separated organic layer was washed with saturated sodium chloride solution for three times, dried (Na_2SO_4) and concentrated in vacuum. Column chromatography (silica gel, 17% EtOAc/hexanes) afforded compound 6a (1.3 g, 60.0%) as a faint yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.62 (s, 1H), 6.77 (s, 1H), 4.12 (t, J = 6.8 Hz, 2H), 3.99 (s, 3H), 2.52 (s, 3H), 1.97~1.84 (m, 2H), 1.54~1.26 (m, 18H), 0.90 (t, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 200.2, 154.2, 149.2, 138.4, 132.5, 108.7, 107.7, 69.7, 56.7, 31.9, 30.4, 29.7, 29.6, 29.5, 29.4, 29.3, 28.8, 25.9, 22.7, 14.1. MS(EI): m/z: Calcd. For $C_{21}H_{33}NO_5^+$ [M] $^+$: 379.2359. Found: 379.2360.

Compound 6b: Compound 6b was synthesized by the same method as for compound 6a. ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.70 (s, 1H), 6.75 (s, 1H), 4.32~4.26 (m, 2H), 3.98~3.90 (m, 5H), 3.76~3.69 (m, 2H), 3.63~3.58 (m, 2H), 3.45 (t, J = 6.8 Hz, 2H), 2.50 (s, 3H), 1.65~1.54 (m, 2H), 1.36~1.19 (m, 18H), 0.88 (t, J = 6.8

Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 200.2, 154.4, 149.0, 138.3, 108.8, 108.6, 71.6, 71.0, 70.1, 69.4, 69.2, 56.6, 31.9, 30.4, 29.7, 29.6, 29.6, 29.5, 29.4, 26.1, 22.7, 14.1. MS(EI): m/z: Calcd. For $C_{25}H_{41}NO_7^+[M]^+$: 467.2883. Found: 467.2884.

Compound 7a: $NaBH_4$ (64.0 mg, 1.68 mmol) was slowly added to a stirred solution of compound 6a (0.32 g, 0.84 mmol) in CH_3OH (30 mL). After addition, the reaction was stirred at room temperature for 30 min. Then the mixture was neutralized with diluted hydrochloric acid solution, concentrated in vacuo. The residue was dissolved in EtOAc and consecutively washed with saturated sodium chloride solution for three times. The organic phase was dried (Na_2SO_4) and concentrated in vacuum. Column chromatography (silica gel, 25% EtOAc/hexanes) afforded compound 7a (0.3 g, 96.0%) as a light yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.58 (s, 1H), 7.31 (s, 1H), 5.58 (q, J = 6.3 Hz, 1H), 4.08 (td, J = 6.9, 1.3 Hz, 2H), 4.01 (s, 3H), 1.93~1.84 (m, 2H), 1.58 (d, J = 6.3 Hz, 3H), 1.53~1.26 (m, 18H), 0.90 (t, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 154.1, 147.3, 139.6, 136.5, 108.7, 108.6, 69.5, 65.8, 56.4, 31.9, 29.7, 29.6, 29.4, 28.9, 25.9, 24.2, 22.7, 14.2. MS(EI): m/z: Calcd. For $C_{21}H_{33}NO_5^+$ $[M]^+$: 381.2515. Found: 381.2429.

Compound 7b: Compound 7b was synthesized by the same method as for compound 7a. ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.65 (s, 1H), 7.29 (s, 1H), 5.57 (q, J = 6.5 Hz, 1H), δ 5.57 (q, J = 6.5 Hz, 1H), 4.24 (t, J = 4.5 Hz, 2H), 3.98 (s, 3H), 3.92 (t, J = 4.8 Hz, 2H), 3.76~3.69 (m, 2H), 3.64~3.58 (m, 2H), 3.45 (t, J = 6.6 Hz, 2H), 2.05 (s, 1H), 1.65~1.54 (m, 2H), 1.56 (d, J = 6.3 Hz, 3H), 1.35~1.21 (m, 18H), 0.88 (t, J = 6.7 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 154.2, 147.0, 139.5, 137.1, 109.6,

108.7, 71.7, 71.0, 70.1, 69.5, 69.0, 65.8, 56.4, 31.9, 29.7, 29.6, 29.5, 29.4, 26.1, 24.3, 22.7, 14.2. MS(EI): m/z: Calcd. For $C_{25}H_{43}NO_7^+[M]^+$: 469.3. Found: 469.3.

Compound 8a: A solution of compound 7a (0.9 g, 2.36 mmol), 4-dimethylaminopyridine (DMAP, 0.14 g, 1.18 mmol) and triethylamine (0.66 mL, 4.72 mmol) in dry dichloromethane (10 mL) was slowly added to a stirred solution of 4-nitrophenyl chloroformate (0.62 g, 3.07 mmol) in dry dichloromethane (10 mL). The temperature of the reaction was kept at -5-0 ℃, stirred for 4 h. After the reaction was completed, the mixture was concentrated in vacuum at low temperature and column chromatography (silica gel, 20% EtOAc/hexanes) afforded compound 8a (1.0 g, 78%) as a light yellow solid. As for the active intermediate product, compound 8a was easy to be decomposed. So after completely dried under oil pump, compound 8a will be used directly to the next step.

Compound **M1**: A solution of compound 8a (0.1 g, 0.18 mmol) in dry dichloromethane (6 mL) was slowly added to a stirred solution of compound 9 (60.0 mg, 0.18 mmol), DMAP (44.0 mg, 0.36 mmol) and triethylamine (0.1 mL, 0.7 mmol) in dry dichloromethane (7 mL). The reaction was kept at room temperature, stirred for 6 h. After the reaction was completed, the mixture was concentrated in vacuum and column chromatography(silica gel, DCM/CH_3OH/TEA=100/4/0.05, v/v/v) afforded compound M1 (0.11 g, 81%) as a light yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.59 (s, 1H), 7.07 (d, J = 40.9 Hz, 2H), 6.79 (d, J = 8.6 Hz, 1H), 6.72 (dd, J = 8.6, 2.0 Hz, 1H), 6.60 (s, 1H), 6.49 (q, J = 6.3 Hz, 1H), 4.12 (m, J = 9.2, 4.9 Hz, 4H), 4.05 (t, J = 6.8 Hz, 2H), 3.94 (s, 3H), 3.91~3.87 (m, 4H), 3.77~3.66 (m, 12H), 1.90~1.81 (m, 2H), 1.65 (d,

J = 6.4 Hz, 3H), 1.50~1.24 (m, 18H), 0.88 (t, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$), δ (ppm): 154.0, 149.4, 147.5, 139.6, 133.3, 114.8, 108.8, 108.0, 70.7, 69.7, 69.5, 68.9, 56.5, 31.9, 29.7, 29.6, 29.5, 29.4, 29.3, 28.9, 25.9, 22.7, 22.3, 14.1. MS(ESI): m/z: Calcd. For $C_{38}H_{58}N_2O_{12}$ K^+ $[M+K]^+$: 773.3990. Found: 773.3606.

Compound 8b: Compound 8b was synthesized by the same method as for compound 8a.

Compound **M2**: Compound **M2** was synthesized by the same method as for compound **M1**. ^{1}H NMR (400 MHz, $CDCl_3$), δ (ppm): 7.69 (s, 1H), 7.10 (d, J = 44.5 Hz, 2H), 6.81 (d, J = 8.6 Hz, 1H), 6.74 (d, J = 8.3 Hz, 1H), 6.66 (s, 1H), 6.51 (q, J = 6.2 Hz, 1H), 4.25 (t, J = 4.9 Hz, 2H), 4.14 (dd, J = 9.1, 5.0 Hz, 4H), 3.99~3.88 (m, 9H), 3.80~3.69 (m, 14H), 3.62 (dd, J = 5.8, 3.8 Hz, 2H), 3.47 (t, J = 6.8 Hz, 2H), 1.66 (d, J = 6.4 Hz, 3H), δ 1.58 (dd, J = 13.9, 6.9 Hz, 2H), 1.28 (d, J = 12.9 Hz, 18H), 0.90 (t, J = 6.8 Hz, 3H). ^{13}C NMR (100 MHz, CDCl3), δ (ppm): 154.1, 149.4, 147.3, 139.5, 133.8, 115.0，109.7, 108.2, 77.4, 77.1, 76.7, 71.6, 71.0, 70.8, 70.7, 70.1, 69.7, 69.6, 69.5, 69.4, 69.0, 56.4, 31.9, 29.7, 29.6, 29.5, 29.4, 26.1, 22.7, 22.3, 14.1. MS(ESI): m/z: Calcd. For $C_{42}H_{66}N_2O_{14}$ $K^+$$[M+K]^+$: 861.4514. Found: 861.4231.

2. The studies of self-assembled properties of M2 in solution

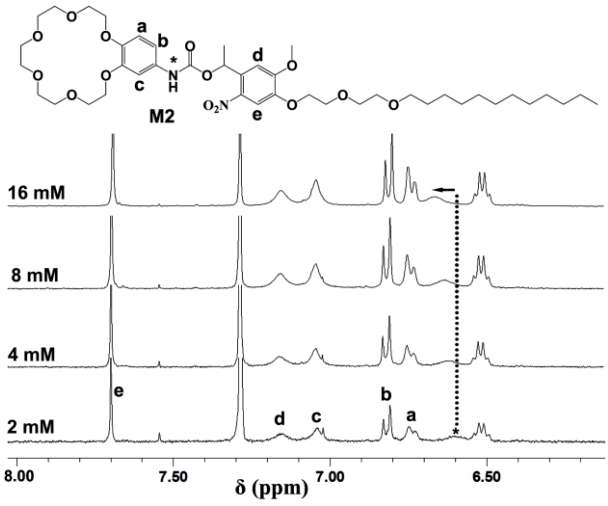


Figure S2. Partial ^{1}H NMR spectra for compound **M2** at different concentrations in $CDCl_3$ at 25 ^{o}C.

3. Patch-clamp measurements.

3.1. General process. DPhPC lipids at 50 mg/mL in chloroform were dried under a stream of nitrogen for 4 h and then dispersed in decane at 20 mg/mL. This solution was used to precoat a 150 μm hole in the side of a Delrin® cup (Warner Instruments, Hamden, CT) upon which a planar lipid bilayer membrane was formed across within a chamber having 1 mL of 1 M KCl (10 mM HEPES, pH 7.0) on both sides. All the operation temperature was kept at 25 ˚C (room temperature) by a temperature controller. Formation of membrane was monitored by monitoring membrane resistance and capacitance. The potential was applied at 100 mV from cis side by an Ag/AgCl electrode and the channel responses were recorded. The transporter in DMSO (0.5 mM) 5μL was added to both the *cis/trans* side of the chamber and the solution was stirred for 2 minutes, channel activity was measured with respect to the *trans* (ground) side. The Axon patch clamp workstation was used for all experiments. Data were amplified (Chem-Clamp; Dagan Corp. USA), digitized (DigiData 1322A; Axon Instruments,

Foster City, CA), and stored on a Celeron PC using the Clamplex program (version 9.2; Axon Instruments, Foster City, CA). The sampling rate was recorded at 10 kHz and all data was low pass filtered at 5 kHz. Unitary current of single channel was evaluated by observing quite a lot of events with long recording time (more than 1 h). Data Analysis was performed using the Clampfit suite software (version 9.2; Axon Instruments, Foster City, CA) and the data were reduced with reduction factor 50 and output for further analysis with OriginLab 8.0 (OriginLab Corporation, North-ampton, MA, USA).

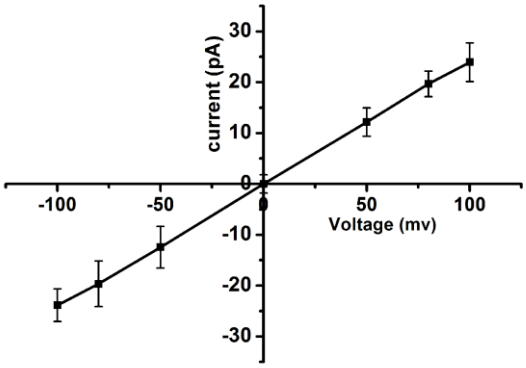


Figure S3. The I-U plot using a voltage ramp from -100 mV to 100 mV for M2 in 500 mM KCl (10.0 mM HEPES, pH 7.0).

3.2. Estimation of Pore Size Using Hille's Equation.[1-5]

The pore size formed by compound **M2** could be estimated based on the Hille's equation as following:

$$g^{-1} = 4L\rho/(\pi D^2) \quad (S1)$$

where g is the measured channel conductance, L is the pore length, D is the pore diameter and ρ is the bulk resistivity of the ionic solution. For our case, ρ is estimated to be 0.08 Ω•m at 1 M for KCl, L would be around 2.55 nm for the thickness of

DPhPC bilayer membrane.[6] Then, the above equation would predict a pore diameter of about ~ 3.2 Å for compound **M2**.

3.3. Photo-regulated Current Recording of Compound M1 on Planar Bilayers by Patch-clamp Technology. The in situ photo-regulated experiments were carried out by introducing a 365 nm LED lamp (30 $mWcm^{-2}$) in the oblique upper direction of *cis* side of the chamber for irradiating the pore.

4. HPTS assay

4.1. General preparation of large unilamellar vesicles (LUVs). A chloroform solution of EYPC (400 μL, 10 mg) and cholesterol (100 μL, 1 mg) was first evaporated with Ar-flux to form a thin film and then dried under high vacuum overnight. The lipid cake was hydrated in 0.5 mL of HEPES buffer (HEPES 10 mM, 100 mM NaCl or KCl , pH 7.0) containing 1 mM HPTS for 2 h at 40 ℃. The lipid suspension was submitted to 6 freeze-thaw cycles (-196 ℃/40 ℃) using liquid nitrogen and a thermostatic bath, and then 21 times extruded through a 0.1 μm polycarbonate membrane at room temperature. The LUV suspension was separated from extravesicular dye by size exclusion chromatography (SEC) (stationary phase: pre-packed column Sephadex™ G-25, mobile phase: HEPES buffer) and diluted with HEPES buffer to give a stock solution with a lipid concentration of 1 mM (assuming 100% of lipids were incorporated into liposomes). The size of the vesicles was determined by DLS experiments with mean diameter of 150 nm, and P. I. value of 0.071.

4.2. Determination of transport activity with the HPTS assays. Generally, 100 μL of the lipid suspension were added to 2900 μL gently stirred, thermostatic buffer in a

fluorimetric cell. The total lipid concentration in the fluorimetric cell was about 33 μM. The time-dependent change in fluorescence intensity (λ_{em} = 510 nm) was monitored at two excitation wavelengths simultaneously ($I_{t,\ 450}$: λ_{ex} = 450 nm, $I_{t,405}$: λ_{ex} = 405 nm) during the addition of base (30 μL, 0.5 M KOH) at t = 50 s, then 30 μL transporter in DMSO with different concentrations (presented as mol% relative to lipid) was added at t = 100 s, and 60 μL of 5% Triton X-100 aqueous solution was added at t = 350 s for final completed balance. Time courses of fluorescence intensity I_t were obtained by first, ratiometric analysis ($R = I_{t,450} / I_{t,405}$) and second, normalization according to equation S1,

$$I_t = (R - R_{100})/(R_\infty - R_{100}) \quad \text{(S1)}$$

where R_{100} = R before addition of transporter and R_∞ = R after addition of Triton X-100. I_t at 350 s just before addition of Triton X-100 was defined as transmembrane activity Y.

The obtained transmembrane activities Y in different concentrations were analyzed with the Hill equation S2 to give effective concentration EC_{50} and the Hill coefficient n,

$$Y = Y_\infty + (Y_0 - Y_\infty)/(1 + (c/EC_{50})^n) \quad \text{(S2)},$$

where Y_0 is Y in absence of transporter, Y_∞ is Y with excess transporter, and c is the transporter concentration.

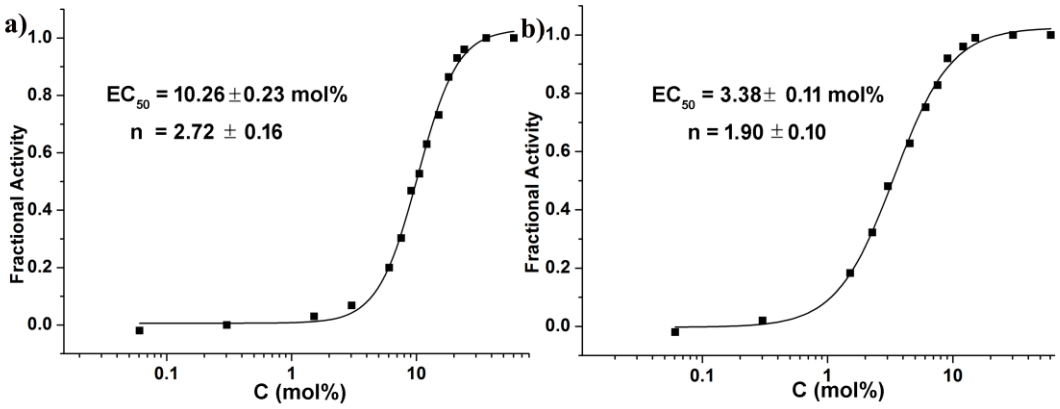


Figure S4. The representative Hill plots of transmembrane activities of a) **M1** and b) **M2**.

4.3. Determination of ion selectivity with HPTS assay. 100 μL of EYPC-LUVs as prepared above was added to 2900 μL of gently stirred, thermostatic buffer (10 mM HEPES, 100 mM M^+Cl^-, pH 7.0, where $M^+ = Li^+$, Na^+, K^+, Rb^+, Cs^+) in a fluorimetric cell. The time-dependent change in fluorescence intensity was monitored and analyzed as described above (final concentration of **M1** is 18.0 mol%) to obtain the fractional transmembrane activities Y dependent on the externally added ions.

4.4. Determination of transmembrane activity of amphotericin B with the HPTS assays.

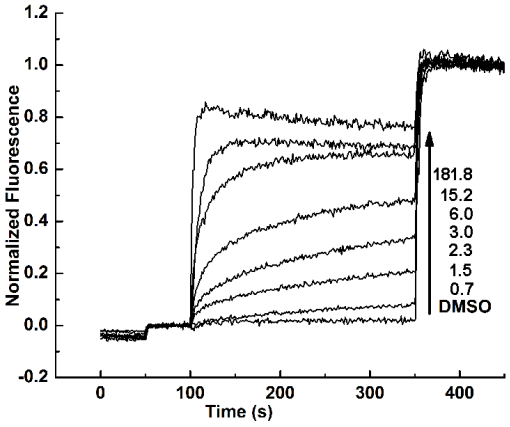


Figure S5. HPTS assays of amphotericin B for K^+ transport with increasing concentrations (final concentrations, mol%).

5. The solubility and doping amounts of M1 and M2 in BLMs.

The solubility of the compounds in buffer was determined as follows: To a series of centrifuge tubes containing 3 mL of HEPES buffer (10 mM HEPES, 100 mM KCl, pH 7.0) were respectively added 50 μL THF solutions of compounds **M1** or **M2** (final concentrations: 2.5 μM、5 μM、10 μM、20 μM、30 μM、40 μM、50 μM、60 μM、70 μM、and 80 μM). The obtained mixture was shaking at 40 ℃ overnight to remove THF solvent, and then analyzed by the detection of absorption.

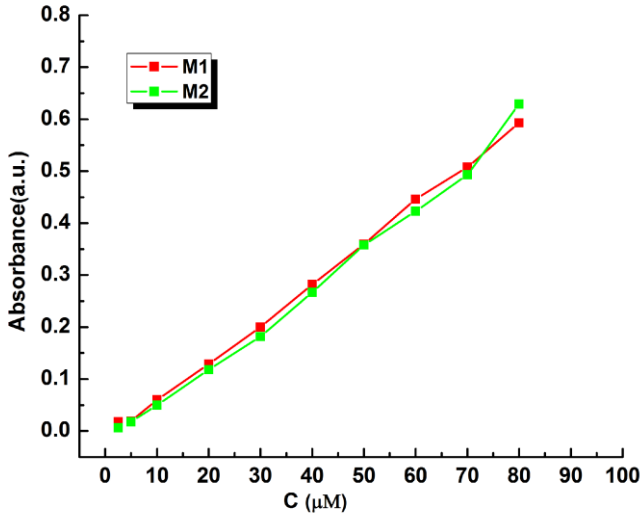


Figure S6. Assays of solubility of compounds **M1** and **M2** in HEPES solution (10.0 mM HEPES, 100 mM KCl, pH 7.0).

The general process for doping amounts experiments were described as below: To 1 mL of EYPC-LUVs without HPTS (with a lipid concentration of 1 mM) prepared as described above was added into a DMSO solution of compounds **M1** or **M2** (2 mM, 50 μL) and stirred for 10 mins. Then, an aliquot of the obtained composite LUVs was

taken out and purified by minicolumn centrifugation with pre-packed Sephadex™ G-25. The compound contained vesicle solution was collected, and the doping amount was quantified by the UV analysis.

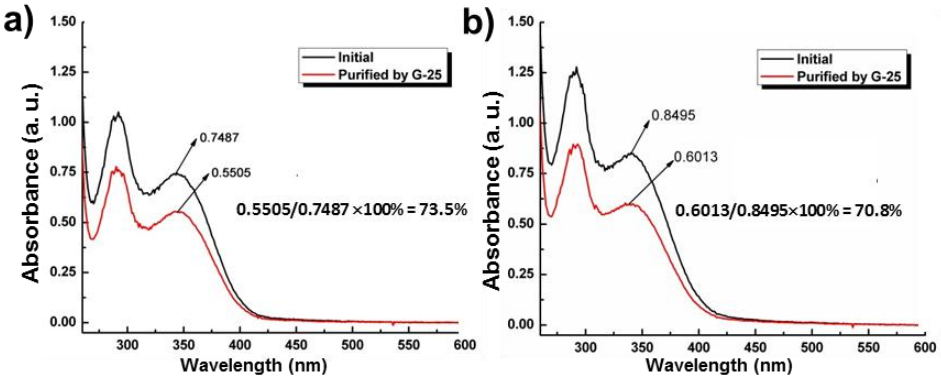


Figure S7. Optical absorption determines the amount of compounds a) **M1** and b) **M2** embedded in the membrane of LUVs. Black curve represented the original absorption spectra of the mixed LUV solution containing compounds, and red curve represented the absorption spectra of the purified LUV solution by minicolumn centrifugation.

6. Determination of association constants K_a between the K^+ ions and compounds.

The K_a values between the compounds and K^+ ion were determined by the picrate salt extraction technique from H_2O into $CHCl_3$ described by Cram et. al.[7] The detailed experimental process was detailed as follows: An aqueous of 15 mM potassium picrate solution was extracted with a 15 mM solution of **M1** or **M2** in chloroform. The picrate concentrations of the organic and of the aqueous layer were measured by UV-vis spectrometer. The amounts of picrate ion in both aqueous and $CHC1_3$ layers were determined from their absorbance at 440 nm after appropriate dilution in CH_3CN. After calculation with equations, the resulted K_a was listed in Table S1.

Table S1 Association constants (M^{-1}) of **M1** and **M2** complex.

	M1, K_a (M^{-1})	M2, K_a (M^{-1})
K^+	8.40×10^7	7.28×10^7

7. Substitution dipole effect in M1 and M2.

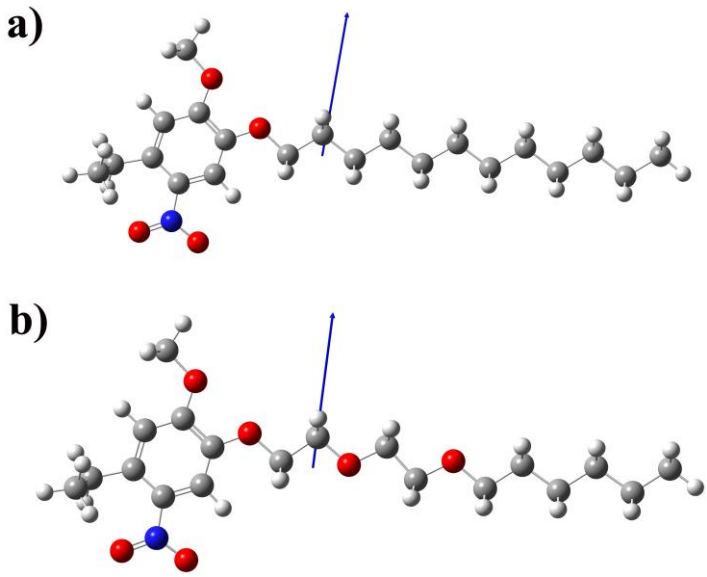


Figure S8. Dipole moment calculations were performed on the substitutions of **M1** and **M2** by density functional theory calculations at the B3LYP/6-31G(d) level. Each arrow indicates the approximate direction and magnitude of dipole moment, 5.5 D for **M1** and 5.4 D for **M2**.

8. Observation of photo-cleavage of M1 and M2 by NMR, HPLC and TEM morphology studies.

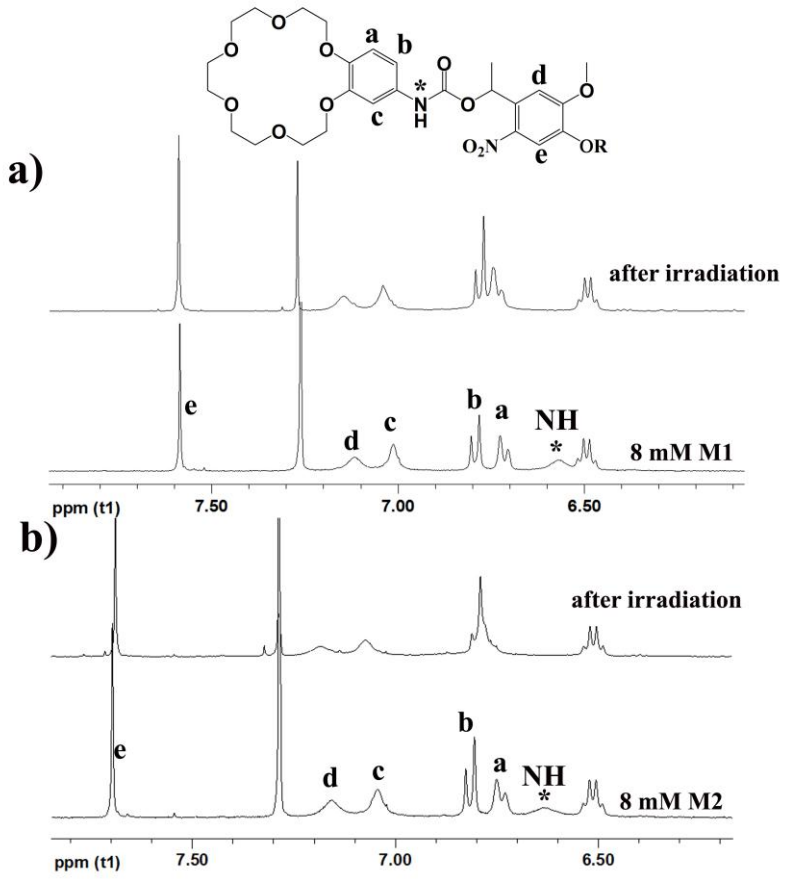
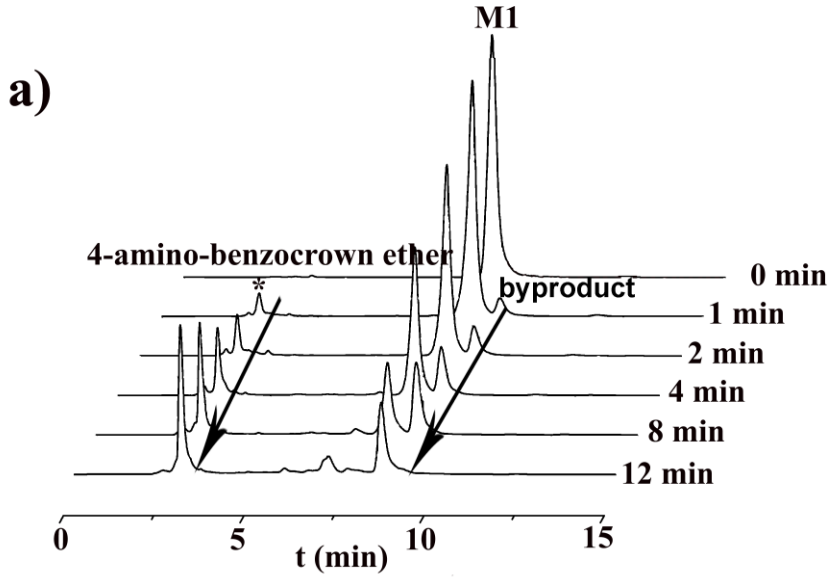
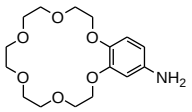
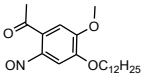
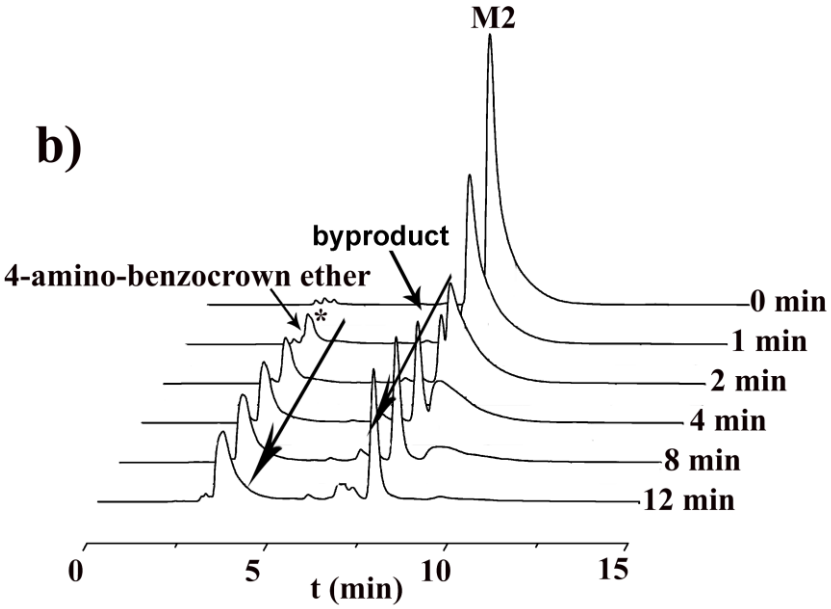


Figure S9. The NMR spectra for a) **M1** and b) **M2** in $CDCl_3$ solution (8.0 mM) before irradiation and after 10 min exposure to UV light (365 nm, 30 $mWcm^{-2}$).



Data from LC-Mass

Number	Retention time (min)	Molecular mass (ESI)	products
1	2.81	328.5 $[M+H]^+$ 350.7 $[M+Na]^+$	4-aminobenzocrown ether 
2	8.10	757.8 $[M+Na]^+$	**M1**
3	8.86	364.6 $[M+H]^+$	byproduct 



Data from LC-Mass

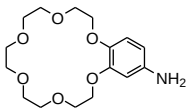
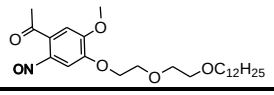
Number	Retention time (min)	Molecular mass (ESI)	products
1	3.39	328.5 $[M+H]^+$ 350.7 $[M+Na]^+$	4-aminobenzocrown ether 
2	7.66	452.6 $[M+H]^+$ 474.5 $[M+Na]^+$	byproduct 
3	8.60	845.9 $[M+Na]^+$	**M2**

Figure S10. The evolution of HPLC spectra and the corresponding LC-Mass data upon 365 nm irradiation (30 $mWcm^{-2}$) of a) **M1** and b) **M2** in CH_3CN solution (detected at 290 nm, eluent solvent: CH_3CN/MeOH = 9/1, speed: 0.5 mL/min).

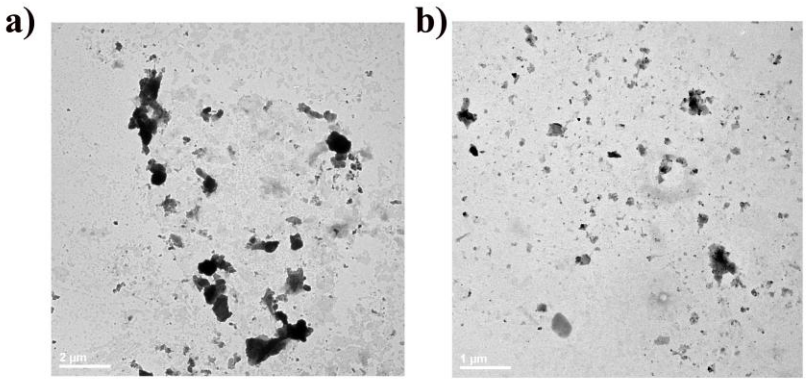


Figure S11. Direct TEM observation of the damaged self-assemblies of irradiated a) **M1** and b) **M2** in 10 mM HEPES solution.

9. Light-regulated transmembrane activity of M1 and M2 in different concentrations.

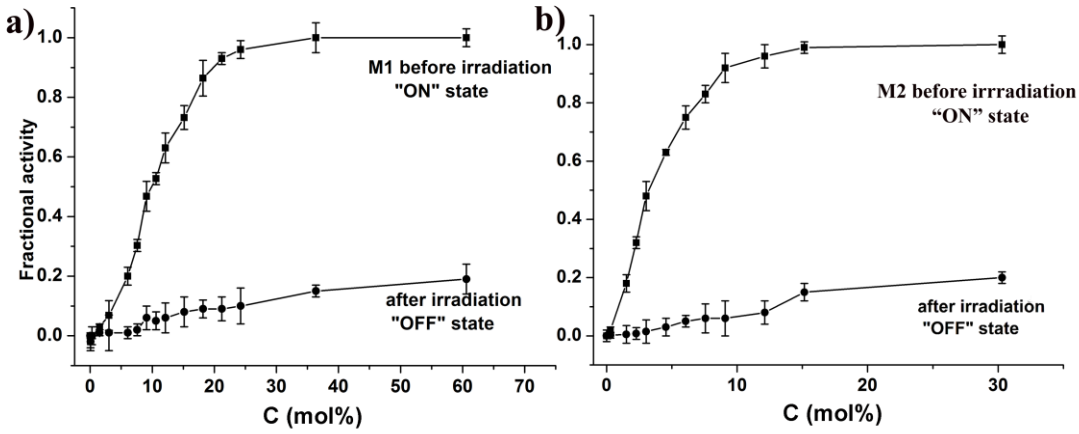


Figure S12. The comparison of transmembrane activities of a) **M1** and b) **M2** before and after 365 nm irradiation (30 $mWcm^{-2}$, 10 min) at different concentrations.

10. Determination of transmembrane activity of 4-amino-18-benzocrown-6 ether with the HPTS assays.

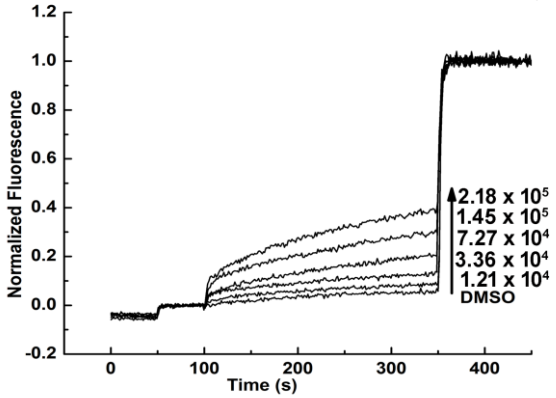


Figure S13. HPTS assays of 4-amino-18-benzocrown-6 ether, one of the photolysis product, for K^+ transport with increasing concentrations (final concentrations, mol%).

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