Supplementary Information (25 pages)

Aggregation-Induced Emission of GFP-like Chromophores via Exclusion of Solvent-Solute Hydrogen Bonding

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Contents:

General Methods.

Electronic spectra were recorded at room temperature (23 ± 1°C). UV-visible spectra were measured on a Cary300 double beam spectrophotometer. Fluorescence spectra were recorded on a PTI QuantaMaster C-60 spectrometer and corrected for the response of the detector. The optical density (OD) of all solutions was about 0.1 at the wavelength of excitation. A N_2-bubbled (15 min) solution of anthracene (Φ_f = 0.27 in n-hexane)[1] was used as a standard for the fluorescence quantum yield determinations of compounds under N_2-bubbled solutions with solvent refractive index correction. An error of 10% is estimated for the fluorescence quantum yields. The fluorescence quantum yield of powder was determined using an integrating sphere (150 mm diameter, $BaSO_4$ coating) of Edinburgh Instruments by the Edinburgh FLS920 spectrometer. Fluorescence decays were measured at room temperature by the Edinburgh FLS920 spectrometer with a gated hydrogen arc lamp using a scatter solution to profile the instrument response function. The goodness of the nonlinear least-squares fit was judged by the reduced χ^2 value (<1.2 in all cases), the randomness of the residuals, and the autocorrelation function. The average size of the aggregates of *p*-ABDIs and *m*-ABDIs was measured on Zetasizer Nano ZS Particle Size, Malvern. Quantum yields of photoisomerization were measured by using optically dense degassed solutions (0.5 x 10^{-3} M, containing 3% THF for pre-dissolution of the *m*-D8A1 and *p*-D8A1) at λ = 350 nm by using a 75-W Xe arc lamp and monochromator. *N*-phenyl-4-aminostilbenes was used as a reference standard (Φ_{tc} = 0.34 in CH_2Cl_2).[2] The extent of photoisomerization (<10%) was determined by

using HPLC analysis (Waters 600 Controller and 2998 photodiode array detector, Thermo APS-2 Hypersil, hexane and ethyl acetate mixed solvent) without back-reaction corrections.

Cell incubation and imaging

MCF-10A cell was obtained from American Type Culture Collection (ATCC, Manassas, VA, USA). The normal human mammary epithelial MCF-10A cells were maintained in α-MEM supplemented with FBS (10%) and antibiotic-antimycotic (1%) in 5% CO_2 at 37 °C. Prior to measurements, cells were seeded on 12-well plates and cultured on 15 mm glass coverslips at an initial cell density of 1×10^4 cells per mL for 1 day. The cell number and viability of the cells in each well were then determined by applying the Trypan Blue exclusion method and the Alamar Blue method, respectively. The precipitated cells were washed three times with PBS to remove excess chromophores before being used bright field and PL imaging measurements by using an Olympus IX71 (Tokyo, Japan) fluorescence microscope with a DP70 digital camera. Owing to the limit of the microscopic system, the excitation wavelengths were set in a range 460-480 nm.

Cytotoxicity assays

Cell viability was determined using the Alamar Blue method.[3] Following the incubation of MCF-10A cells ($<10^4$ cells/mL/well) in a culture medium containing 5% CO_2 for 24 h at 37 °C, the culture medium was replaced with different concentration of chromophores (50 nM – 500 μM) and then the cells were incubated for another 24 h. The cells were carefully rinsed with PBS three times followed by treatment with the Alamar Blue reagent (1 ×, 100 μL/well, BioSource International Inc., Camarillo, CA, USA) for 4 h. Fluorescence due to the reduction of the dye by live cells was measured by a microplate fluorometer (Synergy™ 4 Multi-Mode Microplate Reader, Biotek Instruments, Winooski, VT) with an excitation wavelength at 545 nm and an emission wavelength at 590 nm. Because the optical intensity is directly correlated with cell quantity, cell viability was calculated by assuming 100% viability in the control set (media containing no *m*-D1Aa or *p*-D1Aa).

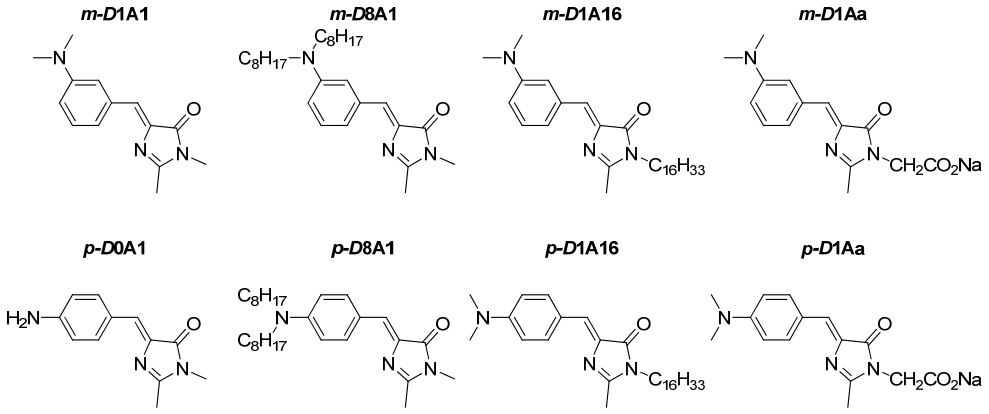
Materials.

Solvents for spectra and quantum yield measurements all were HPLC grade and used as received. Anhydrous THF and acetonitrile were obtained from the solvent purifier SPBT-103 of LC Technology Solutions Inc. equipped with SP-505 column. Anhydrous DMF and DMSO were prepared by drying overnight over 4A molecular sieve (8 to 12 mesh, ACROS) and then distilled under reduced pressure. The synthesis of *m*-D1A1,[4] *p*-D0A1,[5] compound **4,**[6] compound **8,**[7] and compound **10**[8] have been reported. All the new compounds were identified by ^{1}H NMR, ^{13}C NMR, Mass, and elemental analysis.

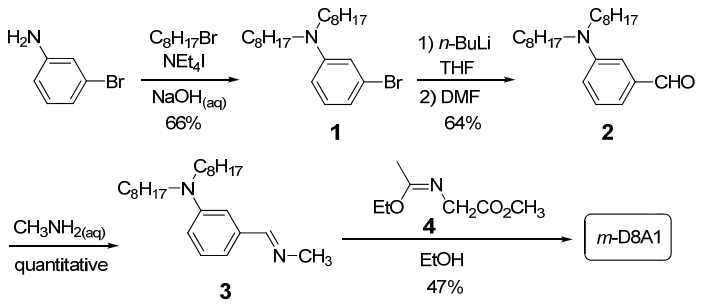
Calculation method

Density functional theory (DFT) calculations were performed using the Gaussian 09 program[9] package with B3LYP functional and 6-31G** basis set.[10-12] Singlet excitation energies for states S_1–S_6 were calculated with the time-dependent DFT (TDDFT) method on the optimized geometries at the same level. In the TDDFT calculation, the polarizable continuum model (PCM) was employed to consider the bulk water solvent effect.[13,14]

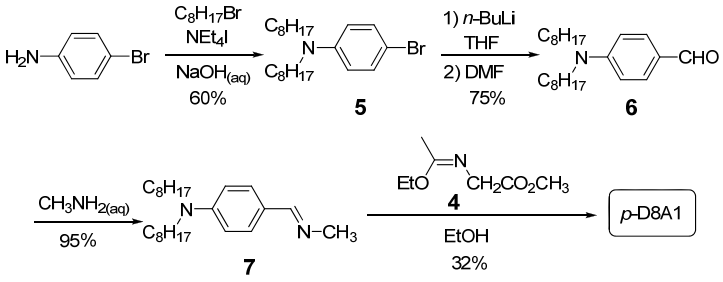
Chart S1 Structures of *m*-D1A1, *m*-D8A1, *m*-D1A16, *m*-D1Aa, *p*-D0A1, *p*-D8A1, *p*-D1A16, and *p*-D1A1.



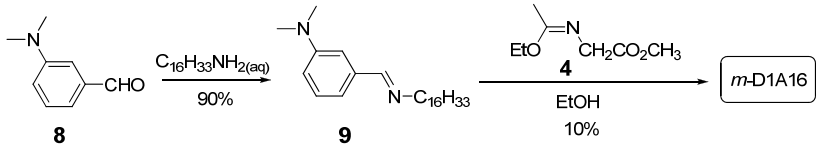
Scheme S1 Synthesis of *m*-D8A1



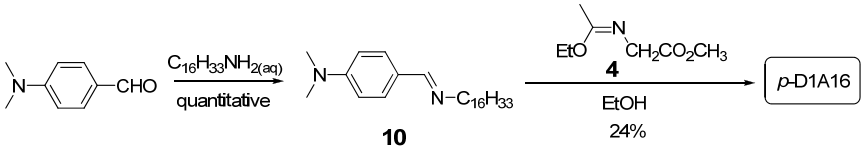
Scheme S2 Synthesis of *p*-D8A1



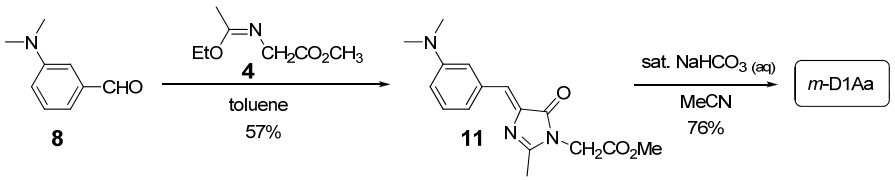
Scheme S3 Synthesis of *m*-D1A16



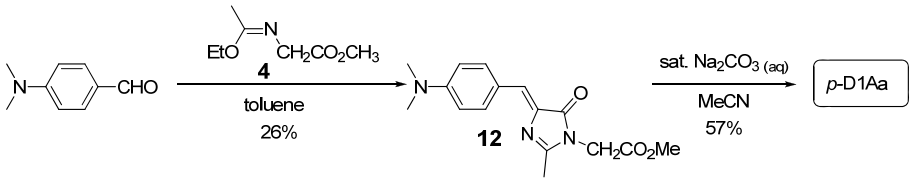
Scheme S4 Synthesis of *p*-D1A16



Scheme S5 Synthesis of *m*-D1Aa



Scheme S6 Synthesis of *p*-D1Aa



Synthesis of Compound 1:

A mixture of 3-bromoaniline (5.2 g, 30.0 mmol) and 1-bromooctane (11.5 g, 66.0 mmol), tetraethylammonium iodide (1.1 g, 3.0 mmol), and 8 N $NaOH_{(aq)}$ (30 mL) was heated at 100 ºC with stirring for 48 h. The solvent was removed under reduced pressure, and the residue was dissolved in CH_2Cl_2 and washed with brine. The organic layer was dried over anhydrous $MgSO_4$ and the filtrate was concentrated under reduced pressure. The crude product was purified by silica gel column chromatography with hexane to afford yellow liquid product, **1** (7.9 g, 66 %). ^{1}H-NMR (400 MHz, $CDCl_3$): 7.00 (t, J = 8.0 Hz, 1H), 6.72 (s, 1H), 6.70 (d, J = 8.0 Hz, 1H), 6.50 (d, J = 8.0 Hz, 1H), 3.21 (t, J = 8.0 Hz, 4H), 1.50-1.58 (m, 4H), 1.27-1.30 (m, 20H), 0.86-0.89 (m, 6H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 149.2, 130.2, 123.4, 117.6, 114.1, 110.1, 51.0, 31.9, 29.6, 29.4, 27.2, 27.2, 22.8, 14.2 ppm; HRMS (ESI^+) calcd for $C_{22}H_{39}BrN^+$ ($M+H^+$): 396.2266, found: 396.2260.

Synthesis of Compound 2:

To a solution of **1** (1.9 g, 5.0 mmol) in dry THF (5.0 mL) was added *n*-BuLi (3.4 mL of 1.6 M solution in hexane, 5.4 mmol) at -78 °C over a period of 5 min. The solution was stirred for 30 min at -78 °C, and DMF (10 mL) was added slowly. The solution was stirred for further 30 min at -78 °C. The reaction mixture was warmed to room temperature and stirred at room temperature over 12

h, before quenching with large excess of H_2O. The heterogeneous mixture was stirred for 20 min and extracted with dichloromethane. The organic layer was dried with $MgSO_4$, filtered and concentrated by rotary-evaporation. The crude product was purified by silica gel column chromatography with hexane/dichloromethane (9/5) to afford yellow liquid, **2** (1.1 g, 64 %). ^{1}H-NMR (400 MHz, $CDCl_3$): 9.90 (s, 1H), 7.32 (t, J = 8.0 Hz, 1H), 7.08 (s, 1H),7.08 (t, J = 8.0 Hz, 1H), 6.86 (dd, J = 8.0 Hz and 4.8 Hz,1H), 3.29 (t, J = 8.0 Hz, 4H), 1.58-1.68 (m, 4H), 1.28-1.32 (m, 20H), 0.89 (t, J = 6.0 Hz, 6H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 193.3, 148.6, 137.4, 129.7, 117.6, 117.6, 111.0, 51.0, 31.8, 29.5, 29.3, 27.1, 27.1, 22.6, 14.1 ppm; HRMS (ESI^+) calcd for $C_{23}H_{40}NO^+$ ($M+H^+$): 346.3104, found: 346.3092.

Synthesis of Compound 3:

Compound **2** (1.7 g, 5.0 mmol) was added 40% aqueous methylamine (0.9 mL, 10.0 mmol) at room temperature, and stirred for 12 h. Then, water was removed in vacuo to give yellow liquid compound, **3** (quantitative, by NMR analysis). ^{1}H-NMR (400 MHz, $CDCl_3$): 8.21 (s,1H), 7.22 (t, J = 8.0 Hz, 1H), 6.99 (s, 1H), 6.93 (d, J = 8.0 Hz, 1H), 6.69 (dd, J = 8.0 Hz and 2.4 Hz, 1H), 3.50 (s, 3H), 3.28 (t, J = 7.6 Hz, 4H), 1.56-1.59 (m, 4H), 1.29-1.32 (m, 20H), 0.87-0.93 (m, 6H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 163.2, 148.1, 136.9, 129.1, 115.2, 113.9, 110.5, 50.9, 48.2, 31.9, 29.5, 29.4, 27.2, 27.2, 22.7, 14.2 ppm; HRMS (ESI^+) calcd. for $C_{24}H_{43}N_2^+$ ($M+H^+$): 359.3421, found: 359.3430.

Synthesis of Compound *m*-D8A1:

Compound **3** (1.8 g, 5.0 mmol) was combined with the imidate **4** (0.9 g, 5.5 mmol) in absolute EtOH (5.0 mL), and then stirred for 12 h. The solvent was removed under reduced pressure, and the residue was dissolved in CH_2Cl_2 and washed with brine. The organic layer was dried over anhydrous $MgSO_4$ and the filtrate was concentrated under reduced pressure. The crude product was purified by silica gel column chromatography with hexane/ethyl acetate/CH_2Cl_2 (7/1/2) to afford yellow solid, *m*-D8A1 (1.0 g, 47 %, mp: 71-72°C). ^{1}H-NMR (400 MHz, $CDCl_3$): 7.54 (s, 1H), 7.31

(d, J = 8.0 Hz, 1H), 7.20 (t, J = 8.0 Hz, 1H), 7.04 (s, 1H), 6.64 (dd, J = 8.0 Hz and 2.0 Hz, 1H), 3.26 (t, J = 8.0 Hz, 4H), 3.17 (s, 3H), 2.35 (s, 3H), 1.51-1.60 (m, 8H), 1.24-1.33 (m, 20H), 0.85-0.89 (m, 6H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 170.7, 161.4, 148.0, 138.0, 134.6, 129.2, 128.7, 119.4, 115.0, 113.6, 51.3, 31.9, 29.5, 29.4, 27.3, 26.5, 22.7, 15.7, 14.2 ppm; HRMS (EI) calcd. for $C_{28}H_{45}N_3O^+$: 439.3557, found: 439.3559; Anal. calcd. for $C_{24}H_{21}N_3O$: C, 76.49; H, 10.32; N, 9.56; found: C, 76.42; H, 10.33; N, 9.49.

Synthesis of Compound 5:

A mixture of 4-bromoaniline (5.2 g, 30.0 mmol) and 1-bromooctane (11.5 g, 66.0 mmol), tetraethylammonium iodide (1.1 g, 3.0 mmol), and 8 N $NaOH_{(aq)}$ (30.0 mL) was heated at 100 ºC with stirring for 48 h. The solvent was removed under reduced pressure, and the residue was dissolved in CH_2Cl_2 and washed with brine. The organic layer was dried over anhydrous $MgSO_4$ and the filtrate was concentrated under reduced pressure. The crude product was purified by silica gel column chromatography with hexane to afford yellow liquid product, **5** (7.1 g, 60 %). ^{1}H-NMR (400 MHz, $CDCl_3$): 7.22 (d, J = 9.2 Hz, 2H), 6.46 (d, J = 9.2 Hz, 2H), 3.19 (t, J = 8.0 Hz, 4H), 1.45-1.61 (m, 4H), 1.20-1.39 (m, 20H), 0.83-0.90 (m, 6H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 146.5, 131.3, 113.0, 106.5, 51.3, 32.2, 29.8, 29.7, 27.5, 27.4, 23.0, 14.6 ppm.

Synthesis of Compound 6:

To a solution of **5** (1.9 g, 5.0 mmol) in dry THF (5.0 mL) was added n-BuLi (3.2 mL of 1.6 M solution in hexane, 5.1 mmol) at -78 °C over a period of 5 min. The solution was stirred for 30 min at -78 °C, and DMF (10 mL) was added slowly. The solution was stirred for further 30 min at -78 °C. The reaction mixture was warmed to room temperature and stirred at room temperature over 12 h, before quenching with large excess of H_2O. The heterogeneous mixture was stirred for 20 min and extracted with dichloromethane. The organic layer was dried with $MgSO_4$, filtered and concentrated by rotary-evaporation. The crude product was purified by silica gel column chromatography with hexane/dichloromethane (2/3) to afford yellow liquid, **6** (1.3 g, 75 %).

^{1}H-NMR (400 MHz, $CDCl_3$): 9.66 (s, 1H), 7.67 (d, J = 8.8 Hz, 2H), 6.51 (d, J = 8.8 Hz, 2H), 3.32 (t, J = 8.0 Hz, 4H), 1.58-1.61 (m, 4H), 1.27-1.32 (m, 20H), 0.83-0.90 (m, 6H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 189.7, 152.4, 132.0, 124.3, 110.5, 51.2, 31.9, 29.5, 29.4, 27.2, 27.2, 22.8, 14.2 ppm.

Synthesis of Compound 7:

Compound **6** (1.1 g, 3.3 mmol) was added 40% aqueous methylamine (0.6 mL, 6.6 mmol) at room temperature, and stirred for 12 h. Then, water was removed in vacuo to give yellow liquid compound, **7** (95%, by NMR analysis). ^{1}H-NMR (400 MHz, $CDCl_3$): 8.09 (s, 1H), 7.51 (d, J = 8.8 Hz, 2H), 6.58 (d, J = 8.8 Hz, 2H), 3.43 (s, 3H), 3.27 (t, J = 7.2 Hz, 4H), 1.57 (t, J = 7.2 Hz, 4H), 1.27-1.31(m, 20H), 0.86-0.90 (m, 6H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 162.0, 149.6, 129.2, 123.3, 110.8, 51.0, 48.1, 31.9, 29.5, 29.4, 27.3, 27.2, 22.7, 14.2 ppm; HRMS (ESI^+) calcd. for $C_{24}H_{43}N_2^+$ ($M+H^+$): 359.3421, found: 359.3408.

Synthesis of Compound *p*-D8A1:

Compound **7** (1.8 g, 5.0 mmol) was combined with the imidate **4** (0.9 g, 5.5 mmol) in absolute EtOH (5.0 mL), and stirred for 12 h. The solvent was removed under reduced pressure, and the residue was dissolved in CH_2Cl_2 and washed with brine. The organic layer was dried over anhydrous $MgSO_4$ and the filtrate was concentrated under reduced pressure. The crude product was purified by silica gel column chromatography with hexane/ethyl acetate/CH_2Cl_2 (5/1/4) to afford yellow solid, *p*-D8A1 (0.7 g, 32 %, mp: 64-65°C). ^{1}H-NMR (400 MHz, $CDCl_3$): 7.99 (d, J = 9.2 Hz, 2H), 7.05 (s, 1H), 6.61 (d, J = 9.2 Hz, 2H), 3.30 (t, J = 7.8 Hz, 4H), 3.17 (s, 3H), 2.34 (s, 3H), 1.57 (m, 4H), 1.28-1.31(m, 20H), 0.87-0.90 (m, 6H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 170.4, 158.2, 149.3, 134.2, 134.0, 128.8, 121.2, 111.2, 51.1, 31.9, 29.5, 29.4, 27.4, 27.2, 26.6, 26.6, 22.7, 14.2 ppm; HRMS (EI) calcd. for $C_{28}H_{45}N_3O^+$: 439.3557, found: 439.3562; Anal. calcd. for $C_{24}H_{21}N_3O$: C, 76.49; H, 10.32; N, 9.56; found: C, 76.53; H, 9.88; N, 9.55.

Synthesis of Compound 8:[6]

To a solution of 3-bromo-*N,N*-dimethylaniline (8.0 g, 40.0 mmol) in dry THF (30.0 mL) was added n-BuLi (25.0 mL of 1.6 M solution in hexane, 40.0 mmol) at -78 °C over a period of 5 min. The solution was stirred for 30 min at -78 ^{o}C, and DMF (12 mL) was added slowly. The solution was stirred for further 30 min at -78 °C. The reaction mixture was warmed to room temperature and stirred at room temperature over 16 h, before quenching with large excess of H_2O. The heterogeneous mixture was stirred for 20 min and extracted with ethyl acetate. The organic layers were dried with $MgSO_4$, filtered and concentrated by rotary-evaporation. The crude product was purified by silica gel column chromatography with hexane/dichloromethane (1.7/1) to afford yellow liquid, **8** (3.4 g, 57 %). ^{1}H-NMR (400 MHz, $CDCl_3$): 3.00 (s, 6H), 6.96 (d, J = 8.4 Hz, 1H), 7.15-7.20 (m, 2H), 7.37 (t, J = 8.4 Hz, 1H), 9.93 (s, 1H) ppm.

Synthesis of Compound 9:

Compound **8** (0.30 g, 2 mmol) was dissolved in anhydrous EtOH (4 mL) and the solution was added *n*-hexadecylamine (0.48 g, 2 mmol) at room temperature, and stirred for 12 h. Then, water was removed in vacuum to give yellow liquid compound, **9** (90%, by NMR analysis).^{1}H-NMR ($CDCl_3$): 8.20 (s, 1H), 7.25 (t, J = 8.0 Hz, 1H), 7.13 (s, 1H), 7.00 (d, J = 8.0 Hz, 1H), 6.78 (dd, J = 8.0 Hz and 2.0 Hz, 1H), 3.58 (t, J = 6.8 Hz, 2H), 2.97 (s, 6H), 1.63-1.80 (m, 2H), 1.25-1.40 (m, 26H), 0.86 (t, J = 6.8 Hz, 3H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 161.6, 150.8, 137.1, 129.2, 117.2, 114.9, 111.1, 61.9, 40.6, 31.9, 31.0, 29.7, 29.7, 29.7, 29.6, 29.5, 29.4, 27.4, 22.7, 14.1 ppm; HRMS (ESI^+) calcd. for $C_{25}H_{45}N_2^+$ ($M+H^+$): 373.3577, found: 373.3568.

Synthesis of Compound *m*-D1A16:

Compound **9** (0.8 g, 2.0 mmol) was combined with the imidate **4** (0.3 g, 2.0 mmol) in absolute EtOH (4.0 mL), and stirred for 12 h. The solvent was removed under reduced pressure, and the residue was dissolved in CH_2Cl_2 and washed with brine. The organic layer was dried over anhydrous $MgSO_4$ and the filtrate was concentrated under reduced pressure. The crude product was purified by silica gel column chromatography with ethyl acetate/ CH_2Cl_2 (2/8) to afford yellow

solid, *m*-D1A16 (0.1 g, 10 %, mp: 66-67°C). ^{1}H-NMR (400 MHz, $CDCl_3$): 7.48-7.51 (m, 2H), 7.26 (t, J = 8.0 Hz, 1H), 7.05 (s, 1H), 6.75 (dd, J = 8.0 Hz and 2.4 Hz, 1H), 3.56 (t, J = 7.6 Hz, 2H), 2.97 (s, 6H), 2.36 (s, 3H), 1.58-1.62 (m, 2H), 1.24-1.31 (m, 26H), 0.86 (t, J = 7.6 Hz, 3H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 170.1, 161.4, 150.1, 137.8, 134.3, 128.9, 128.1, 120.5, 115.7, 114.4, 40.9, 40.8, 32.2, 30.0, 30.0, 29.9, 29.9, 29.8, 29.7, 29.7, 29.6, 27.1, 23.1, 16.3, 14.6 ppm; HRMS (ESI^+) calcd for $C_{29}H_{48}N_3O^+$ ($M+H^+$): 454.3792, found: 454.3799; Anal. calcd. for $C_{29}H_{47}N_3O$: C, 76.77; H, 10.44; N, 9.26; found: C, 77.12; H, 10.06; N, 9.08.

Synthesis of Compound 10:[7]

4-Dimethylaminobenzaldehyde (0.5 g, 3.0 mmol) was dissolved in anhydrous EtOH (6.0 mL) and the solution was added *n*-hexadecylamine (0.7 g, 3.0 mmol) at room temperature, and stirred for 12 h. Then, water was removed in vacuo to give yellow liquid compound, **10** (quantitative, by NMR analysis). ^{1}H-NMR ($CDCl_3$): 8.11 (s, 1H), 7.57 (d, J = 8.8 Hz, 2H), 6.68 (d, J = 8.8 Hz, 2H), 3.52 (t, J = 7.2 Hz, 2H), 2.99 (s, 6H), 1.64-1.67 (m, 2H), 1.24-1.30 (m, 26H), 0.87 (t, J = 7.2 Hz, 3H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 160.6, 151.9, 129.3, 124.6, 111.6, 61.8, 40.2, 31.9, 31.2, 29.7, 29.6, 29.5, 29.4, 27.4, 22.7, 14.1 ppm.

Synthesis of Compound *p*-D1A16:

Compound **10** (1.1 g, 3.0 mmol) was combined with the imidate **4** (0.5 g, 3.0 mmol) in absolute EtOH (4.0 mL), and stirred for 12 h. The solvent was removed under reduced pressure, and the residue was dissolved in CH_2Cl_2 and washed with brine. The organic layer was dried over anhydrous $MgSO_4$ and the filtrate was concentrated under reduced pressure. The crude product was purified by silica gel column chromatography with ethyl acetate/ CH_2Cl_2 (2/8) to afford yellow solid, *p*-D1A16 (0.3 g, 24 %, mp: 66-68°C). ^{1}H-NMR (400 MHz, $CDCl_3$): 8.03 (d, J = 8.8 Hz, 2H), 7.04 (s, 1H), 6.68 (d, J = 8.8 Hz, 2H), 3.56 (t, J = 7.2 Hz, 2H), 3.03 (s, 6H), 2.35 (s, 3H), 1.55-1.65 (m, 2H), 1.24-1.30 (m, 26H), 0.87 (t, J = 7.2 Hz, 3H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 170.5, 158.8, 151.2, 134.6, 133.9, 128.5, 122.2, 111.6, 40.6, 40.1, 32.0, 29.8, 29.7, 29.7, 29.7, 29.6, 29.6,

29.5, 29.4, 26.9, 22.8, 15.8, 14.3 ppm; HRMS (ESI^+) calcd for $C_{29}H_{48}N_3O^+$ ($M+H^+$): 454.3792, found: 454.3795; Anal. calcd. for $C_{29}H_{47}N_3O$: C, 76.77; H, 10.44; N, 9.26; found: C, 77.08; H, 10.03; N, 9.22.

Synthesis of Compound 11:

Compound **8** (0.5 g, 3.2 mmol), imidate **4** (1.1 g, 6.9 mmol), and toluene (3.0 mL) was heated at 70 ºC with stirring for 12 h. The solvent was removed under reduced pressure, and the residue was dissolved in CH_2Cl_2 and washed with brine. The organic layer was dried over anhydrous $MgSO_4$ and the filtrate was concentrated under reduced pressure. The crude product was purified by silica gel column chromatography with *n*-hexane/ CH_2Cl_2 (1/1) to afford yellow product, **11** (0.5 g, 57 %, mp: 144-146 °C). ^{1}H-NMR (400 MHz, $CDCl_3$): 7.53 (s, 1H) , 7.50 (d, J = 8.0 Hz, 1H), 7.27 (t, J = 8.0 Hz, 1H), 7.11 (s, 1H), 6.77 (dd, J = 8.0 Hz and 2.8 Hz, 1H), 4.38 (s, 2H), 3.77 (s, 3H), 2.98 (s, 6H), 2.32 (s, 3H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 169.9, 167.8, 160.4, 150.5, 137.5, 134.3, 129.4, 129.1, 120.8, 116.0, 114.8, 52.8, 41.3, 40.6, 15.70 ppm; HRMS (EI) calcd. for $C_{16}H_{19}N_3O_3^+$: 301.1421, found: 301.1422; Anal. calcd. for $C_{16}H_{19}N_3O_3$: C, 63.77; H, 6.36; N, 13.94; found: C, 63.43; H, 6.07; N, 13.61.

Synthesis of Compound *m*-D1Aa:

A mixture of **12** (0.2 g, 0.5 mmol), saturated $NaHCO_{3(aq)}$ (2.7 mL), and acetonitrile (2.7 mL) was heated at 80 ºC with stirring for 12 h. The reaction progress was monitored by thin-layer chromatography (TLC) with IPA/H_2O/NH_4OH (10/3/2). The solvent was removed under reduced pressure, and the residue was dissolved in water and washed with dichloromethane. The aqueous layer was concentrated under reduced pressure. The crude product was separated on a reversed phase silica gel (RP-18/ 40-63 mm) column (2 × 10 cm) eluted with MeOH/H_2O (20 : 80, v : v) to afford pure compound, *m*-D1Aa (0.1 g, 76 %, m.p. >200 °C). ^{1}H-NMR (400 MHz, D_2O): 7.55 (s, 1H), 7.49 (d, J = 8.0 Hz, 1H), 7.42 (t, J = 8.0 Hz, 1H), 7.15 (s, 1H), 7.10 (dd, J = 8.0 Hz and 2.4 Hz, 1H), 4.20 (s, 2H), 2.92 (s, 6H), 2.34 (s, 3H) ppm; ^{13}C-NMR (100 MHz, D_2O/CD_3OD): 174.6, 171.8,

165.3, 151.8, 137.6, 134.5, 130.3, 130.1, 123.1, 118.1, 118.0, 44.2, 41.3, 13.0 ppm; HRMS (ESI^+) calcd for $C_{15}H_{17}N_3NaO_3^+$ ($M+H^+$): 310.1162, found: 310.1152.

Synthesis of Compound 12:

4-Dimethylaminobenzaldehyde (0.3 g, 2.0 mmol), imidate **4** (0.4 g, 4.4 mmol), and toluene (2.0 mL) was heated at 70 ºC with stirring for 12 h. The solvent was removed under reduced pressure, and the residue was dissolved in CH_2Cl_2 and washed with brine. The organic layer was dried over anhydrous $MgSO_4$ and the filtrate was concentrated under reduced pressure. The crude product was purified by silica gel column chromatography with ethyl acetate/ CH_2Cl_2 (1/9) to afford yellow product, **12** (0.2 g, 26 %, mp: 168-170°C). ^{1}H-NMR (400 MHz, $CDCl_3$): 8.04 (d, J = 8.8 Hz, 2H), 7.09 (s, 1H), 6.68 (d, J = 8.8 Hz, 2H), 4.38 (s, 2H), 3.75 (s, 3H), 3.03 (s, 6H), 2.30 (s, 3H) ppm; ^{13}C-NMR (100 MHz, $CDCl_3$): 169.3, 167.6, 157.0, 151.1, 133.9, 133.5, 129.4, 121.7, 111.5, 52.8, 41.5, 40.3, 15.8 ppm. HRMS (EI) calcd. for $C_{16}H_{19}N_3O_3^+$: 301.1421, found: 301.1434; Anal. calcd. for $C_{16}H_{19}N_3O_3$: C, 63.77; H, 6.36; N, 13.94; found: C, 63.69; H, 6.29; N, 13.93.

Synthesis of Compound *p*-D1Aa:

A mixture of **12** (0.6 g, 2.0 mmol), saturated $Na_2CO_{3(aq)}$ (20 mL), and acetonitrile (20 mL) was heated at 80 ºC with stirring for 12 h. The reaction progress was monitored by thin-layer chromatography (TLC) with IPA/H_2O/NH_4OH (10/3/2). The solvent was removed under reduced pressure, and the residue was dissolved in water and washed with dichloromethane. The aqueous layer was concentrated under reduced pressure. The crude product was separated on a reversed phase silica gel (RP-18/ 40-63 mm) column (2 × 10 cm) eluted with a gradient solvent of MeOH/H_2O (2 : 8, 20 mL; 4 : 6, 20 mL; 6 : 4, 20 mL; 8 : 2, 20 mL; 10 : 0, 20 mL) to afford pure compound, *p*-D1Aa (0.4 g, 57 %, m.p. >200 °C). ^{1}H-NMR (400 MHz, D_2O): 7.66 (d, J = 8.8 Hz, 2H), 6.80 (s, 1H), 6.60 (d, J = 8.8 Hz, 2H), 4.06 (s, 2H), 2.92 (s, 6H), 2.22 (s, 3H) ppm; ^{13}C-NMR (100 MHz, D_2O/CD_3OD): 174.9, 171.4, 160.7, 152.8, 135.1, 132.5, 131.8, 121.2, 112.4, 44.2, 39.9, 14.7 ppm. HRMS (ESI^+) calcd for $C_{15}H_{17}N_3NaO_3^+$ ($M+H^+$): 310.1162, found: 310.1150.

Table S1. DFT-derived molecular orbitals and TDDFT-calculated electronic transition energy (ΔE), oscillator strength (*f*), description and percentage of configuration interaction of *m*-D1A1, *m*-D8A1, and *m*-D1Aa in water.

compound	Excited state	ΔE (nm)	*f*	Description [a]	Percentage
m-D1A1	S_1	465	0.0662	H→L	97%
	S_2	355	0.6041	H−1→L	95%
m-D8A1	S_1	468	0.0613	H→L	97%
	S_2	356	0.6328	H−1→L	95%
m-D1Aa	S_1	491	0.0610	H→L	98%
	S_2	358	0.6257	H−1→L	94%

[a] H denotes HOMO and L denotes LUMO

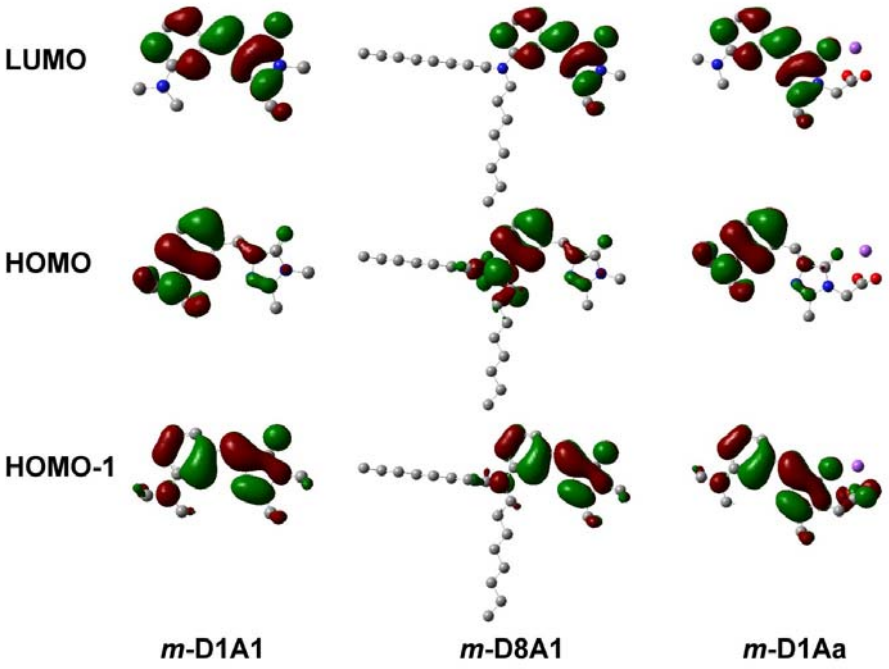


Table S2. A full table of photophysical data for the *m*-ABDIs.

compd	solvent	λ_{abs} (nm)	λ_f [a] (nm)	Φ_f (%)	τ_f (ns)[a,b]	k_f (10^8 s^{-1})[g]	k_{nr} (10^8 s^{-1})[h]
m-D1A1	Hex	349	492	46	22.5	0.20	0.24
	THF	354	584	14	15.3	0.09	0.56
	MeCN	352	643	5	8.6	0.06	1.10
	DMF	357	624	4			
	DMSO	360	642	3			
	MeOH	353	701	< 0.1	na		
	H_2O[c]	351	na	< 0.01	na		
m-D8A1	Hex	352	504	48	19.7	0.24	0.26
	THF	357	555	19	14.8	0.13	0.55
	MeCN	355	621	7	9.4	0.07	0.99
	DMF	357	611	7			
	DMSO	362	626	7			
	MeOH	354	697	< 0.1	na		
	H_2O[c]	361	578	14	7.1[a,e]	0.20	1.21
m-D1A16	Hex	352	491	53	17.3	0.31	0.27
	THF	357	563	21	12.3	0.17	0.64
	MeCN	357	625	7	5.3	0.13	1.75
	DMF	359	620	5			
	DMSO	359	636	3			
	MeOH	355	701	< 0.1	na		
	H_2O[c]	367	582	9	7.0[a,f]	0.13	1.30
m-D1Aa	H_2O	349	na	< 0.01	na		

[a] na: not available, because fluorescence is too weak and the lifetime is too short to be determined. [b] The τ_f was determined with excitation and emission wavelengths at the spectral maxima. [c] Containing 3% THF for pre-dissolution of the substrate. [d] τ_f is fitted with biexponential functions and reported as a mean value: $\tau_f = (A_1 \times \tau_1^2 + A_2 \times \tau_2^2)/(A_1 \times \tau_1 + A_2 \times \tau_2)$. [e] $A_1 = 10\%$, $\tau_1 = 1.9$ ns, $A_2 = 90\%$, $\tau_2 = 7.3$ ns. [f] $A_1 = 18\%$, $\tau_1 = 2.4$ ns, $A_2 = 82\%$, $\tau_2 = 7.3$ ns.

Table S3. Photophysical data for the *p*-ABDIs.

compd	solvent	λ_{abs} (nm)	λ_f [a] (nm)	Φ_f (%)	τ_f [a,b,c] (ns)	k_f (10^8 s^{-1})[d]	k_{nr} (10^8 s^{-1})[e]
p-D0A1	Hex	399	434	< 0.1	< 0.1	< 0.1	> 99.9
	MeCN	419	493	< 0.1	< 0.1	< 0.1	> 99.9
p-D8A1	Hex	410	465	< 0.1	< 0.1	< 0.1	> 99.9
	THF	426	478	< 0.1	< 0.1	< 0.1	> 99.9
	MeCN	430	499	< 0.1	< 0.1	< 0.1	> 99.9
	MeOH	444	505	< 0.1	< 0.1	< 0.1	> 99.9
	H_2O	431	467	< 0.1	< 0.1	< 0.1	> 99.9
p-D1A16	Hex	399	453	< 0.1	< 0.1	< 0.1	> 99.9
	THF	417	475	< 0.1	< 0.1	< 0.1	> 99.9
	MeCN	420	491	< 0.1	< 0.1	< 0.1	> 99.9
	MeOH	433	500	< 0.1	< 0.1	< 0.1	> 99.9
	H_2O	435	504	< 0.1	< 0.1	< 0.1	> 99.9
p-D1Aa	H_2O	441	528	< 0.1	< 0.1	< 0.1	> 99.9

[a] the lifetime is shorter than the detection limit of the instrument. [b] The τ_f was determined with excitation and emission wavelengths at the spectral maxima.
[c] Containing 3% THF for pre-dissolution of the substrate. [d] $k_f = 1/\tau_f$. [e] $k_{nr} = (1-\Phi_f)/\tau_f$.

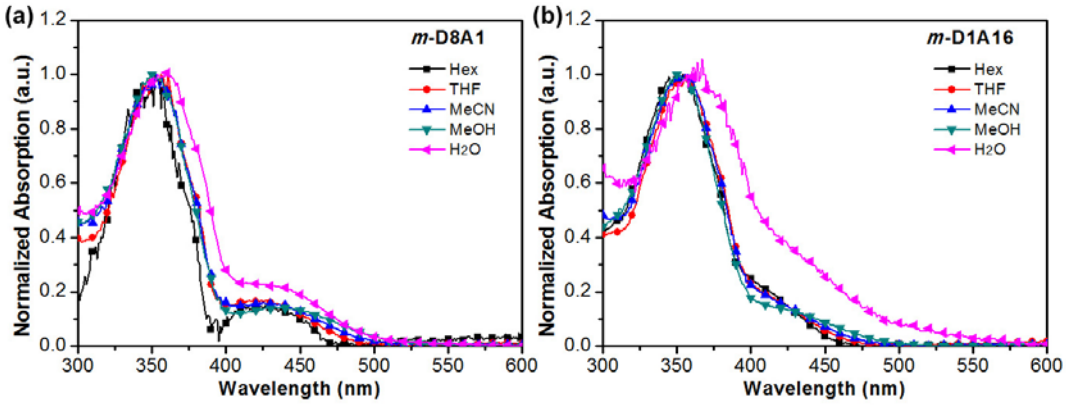


Figure S1. Normalized absorption spectra of *m*-D8A1 and *m*-D1A16 in hexane, THF, MeCN, MeOH, and H_2O.

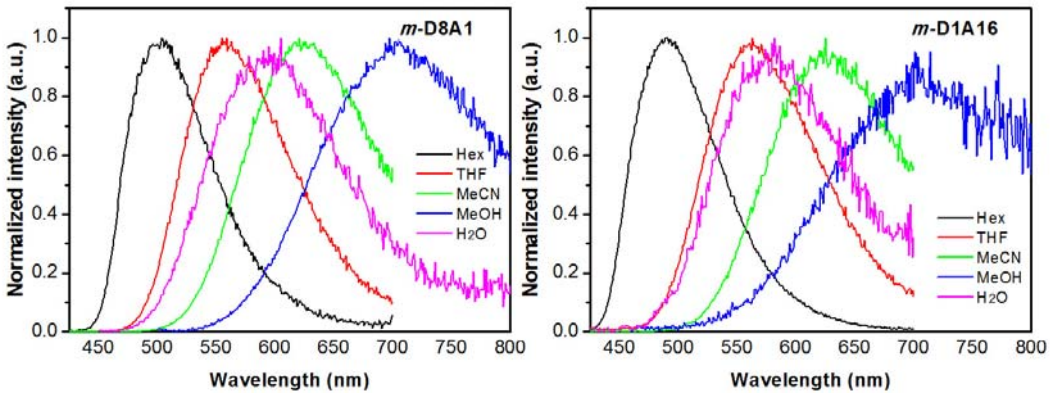


Figure S2. Normalized fluorescence spectra of *m*-D8A1 and *m*-D1A16 in hexane, THF, MeCN, MeOH, and H_2O.

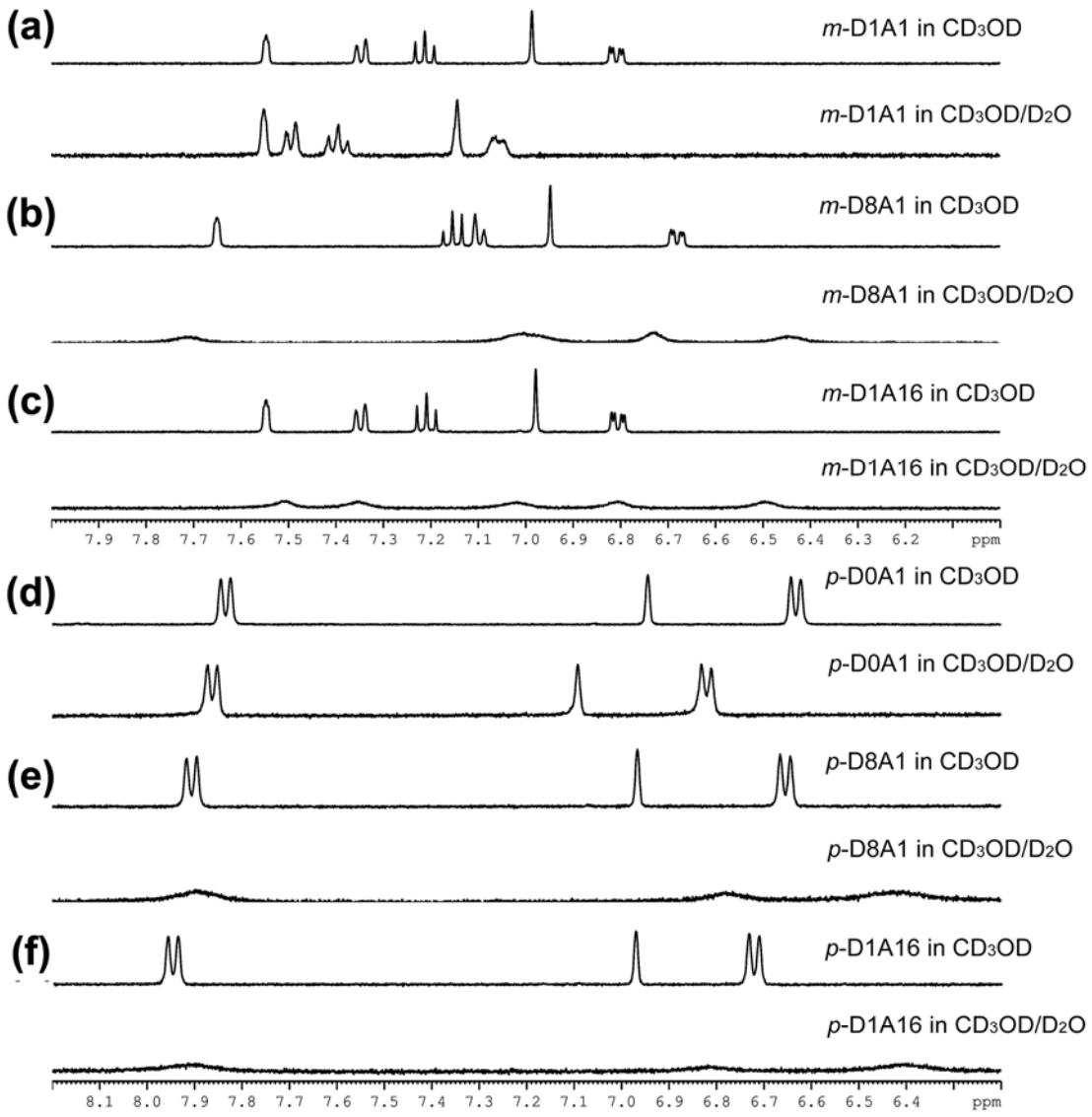


Figure S3. The ^{1}H NMR spectra for (a) *m*-D1A1, (b) *m*-D8A1, (c) *m*-D1A16 in (d) *p*-D0A1, (e) *p*-D8A1, and (f) *p*-D1A16, in CD_3OD (upper) and CD_3OD/D_2O (v/v=1/1) (lower)

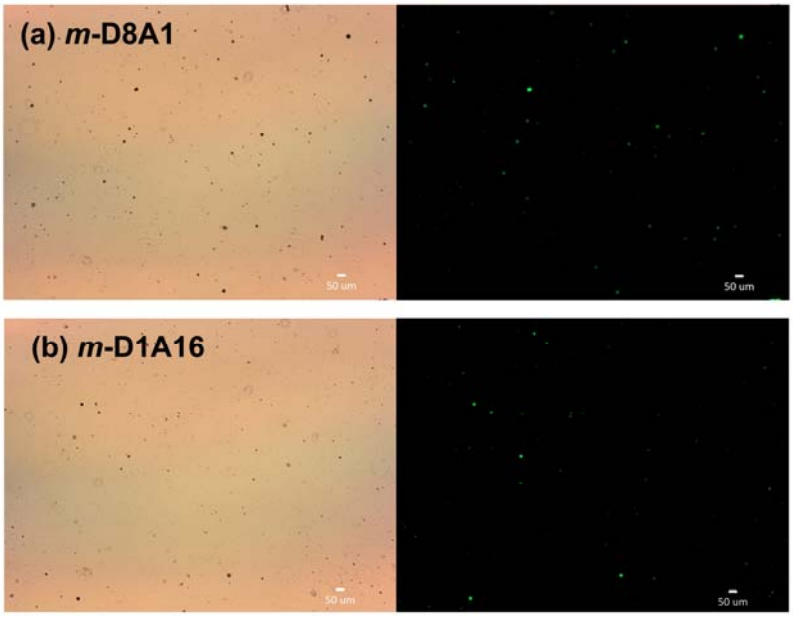


Figure S4. Microscopic images of (a) *m*-D8A1 and (b) *m*-D1A16 in H_2O. (Left) Optical images. (Right) Fluorescence images.

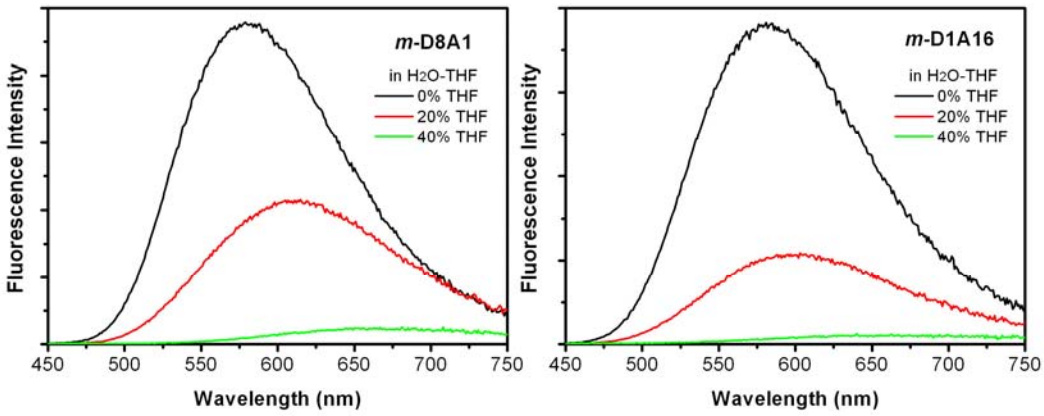


Figure S5. Fluorescence spectra of the aggregates of *m*-D8A1 and *m*-D1A16 before and after adding THF solvent. Substrate concentration: 0.05 mM. Excitation wavelength: 350 nm.

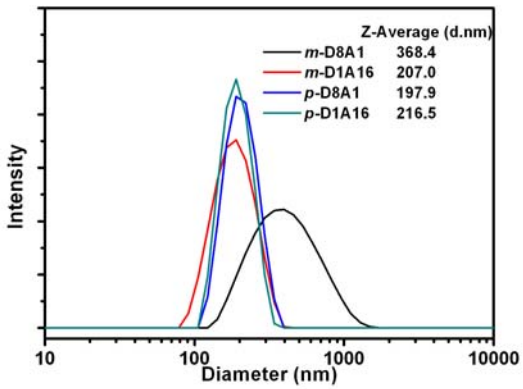


Figure S6. Dynamic light scattering (DLS) measurements of the *m*-ABDIs and *p*-ABDIs in H_2O (3mg/mL; containing 3% MeOH for pre-dissolution of the substrate)

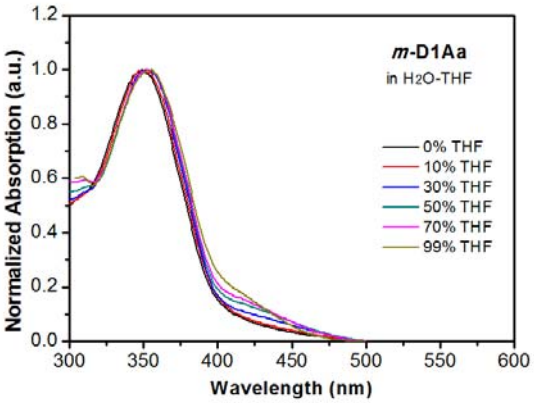


Figure S7. Normalized absorption spectra of *m*-D1Aa in the mixed solvent of THF-H_2O.

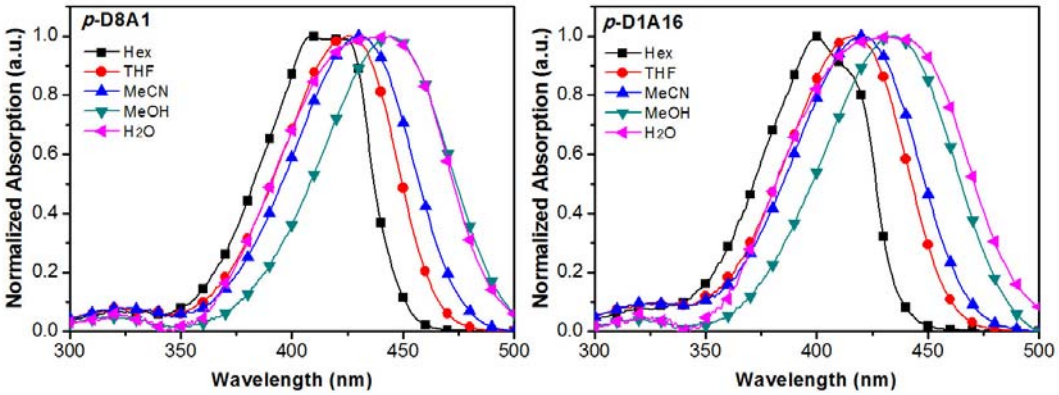


Figure S8. Normalized absorption spectra of *p*-D8A1 and *p*-D1A16 in hexane, THF, MeCN, MeOH, and H_2O.

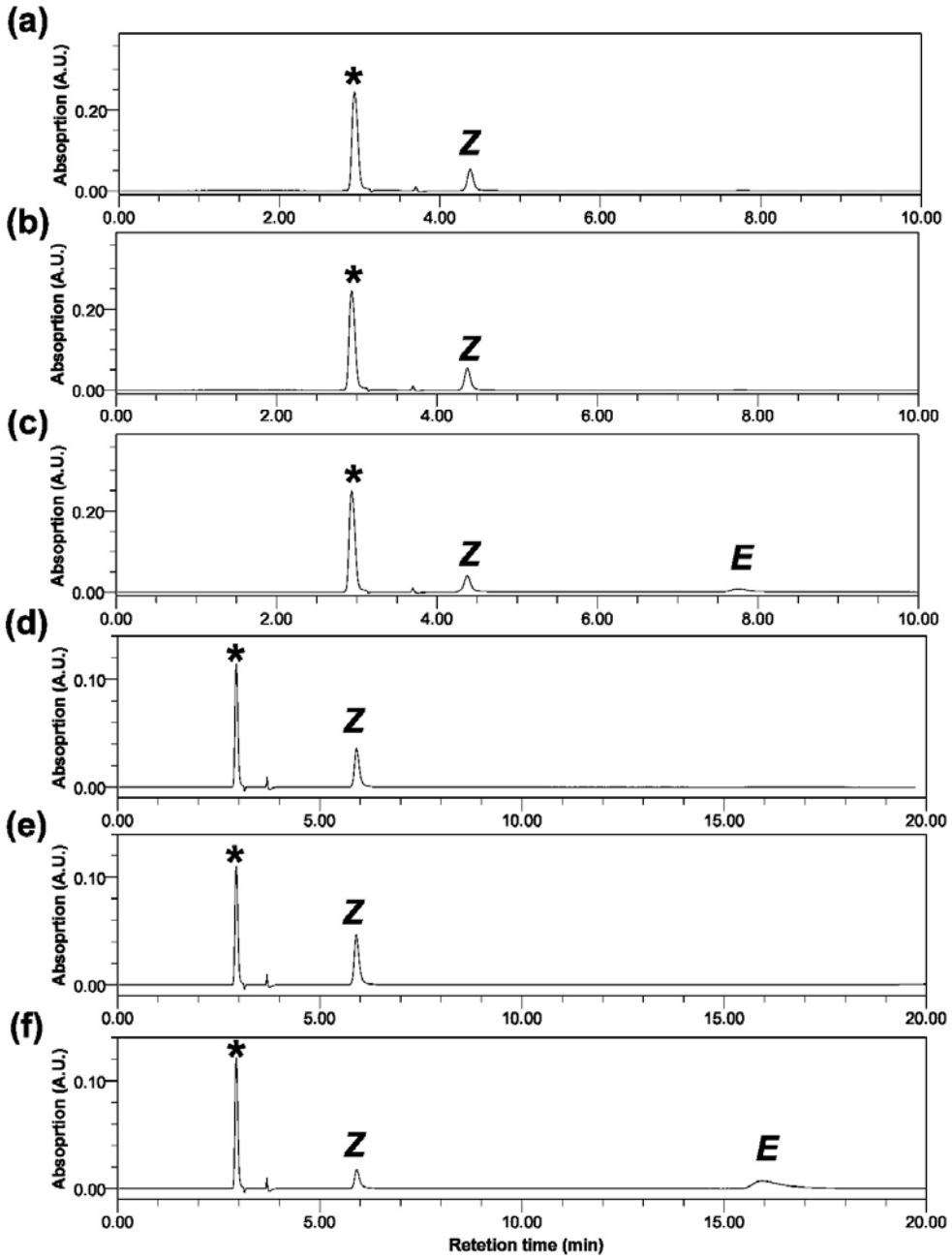


Figure S9. HPLC chromatograms of *m*-D8A1 powder (a) without irradiation and (b) under irradiation with 350 nm light for 60 min, and (c) dissolved in THF then irradiation with 350 nm light for 10 min; HPLC chromatograms of *p*-D8A1 powder (d) without irradiation and (e) under irradiation with 350 nm light for 60 min, and (f) dissolved in THF then irradiation with 350 nm light for 20 min. (eluent solvents: ethyl acetate/THF = 50/50; the flow rate: 1 mL/min; monitoring wavelength: 290 nm for *m*-D8A1 and 265 nm for *p*-D8A1). The peak denotes * is from the internal standard 1,4-dioctyloxybenzene.

Cartesian coordinate of *m*-D1A1, *m*-D8A1, and *m*-D1Aa

***m*-D1A1** energy = -783.238878301 hartree

1	6	0.550976000	-1.523108000	0.009748000
2	6	-0.892140000	-1.344519000	-0.013314000
3	6	-1.698697000	-2.499827000	-0.005513000
4	6	-3.082058000	-2.367551000	-0.017737000
5	6	-3.683503000	-1.111701000	-0.042913000
6	6	-2.898380000	0.066110000	-0.067063000
7	6	-1.497814000	-0.075251000	-0.037202000
8	1	-1.236432000	-3.481952000	0.015821000
9	1	0.901459000	-2.553525000	0.035924000
10	6	1.549846000	-0.604585000	0.001502000
11	6	2.985108000	-1.003670000	0.028766000
12	7	3.650037000	0.234692000	0.008682000
13	6	2.684912000	1.235769000	-0.027093000
14	7	1.459608000	0.796050000	-0.032145000
15	6	3.061334000	2.678513000	-0.056685000
16	1	2.152277000	3.279531000	-0.082240000
17	1	3.647920000	2.954781000	0.827121000
18	1	3.669670000	2.912876000	-0.937877000
19	6	5.092627000	0.365144000	0.023898000
20	1	5.459960000	0.872086000	-0.874312000
21	1	5.437708000	0.911237000	0.907919000
22	1	5.496597000	-0.648895000	0.051326000
23	8	3.524975000	-2.098404000	0.061106000
24	1	-3.711471000	-3.252873000	-0.002654000
25	1	-0.847974000	0.787776000	-0.031183000
26	7	-3.490308000	1.324672000	-0.128594000
27	1	-4.764699000	-1.051816000	-0.043263000
28	6	-4.918711000	1.448629000	0.103398000
29	1	-5.205841000	2.496861000	0.006349000
30	1	-5.489913000	0.884268000	-0.642258000
31	1	-5.227643000	1.099471000	1.101823000
32	6	-2.665206000	2.503472000	0.078793000
33	1	-2.203714000	2.536986000	1.078309000
34	1	-1.860533000	2.552799000	-0.661914000
35	1	-3.282289000	3.395180000	-0.044849000

***m*-D8A1** energy = -1333.66964855 hartree

1	6	4.159652000	-2.891145000	-0.367550000

2	6	2.710943000	-3.014026000	-0.348669000
3	6	2.152266000	-4.269396000	-0.655212000
4	6	0.770504000	-4.423826000	-0.635458000
5	6	-0.064657000	-3.353773000	-0.328601000
6	6	0.465491000	-2.077954000	-0.016970000
7	6	1.864811000	-1.937030000	-0.020932000
8	1	2.800191000	-5.104013000	-0.905103000
9	1	4.710267000	-3.799058000	-0.607987000
10	6	4.952673000	-1.814720000	-0.134301000
11	6	6.438267000	-1.902481000	-0.204402000
12	7	6.839573000	-0.590170000	0.100707000
13	6	5.692803000	0.165771000	0.320077000
14	7	4.581830000	-0.501139000	0.194788000
15	6	5.769818000	1.614248000	0.666704000
16	1	4.758214000	2.001669000	0.788595000
17	1	6.327299000	1.771514000	1.597292000
18	1	6.279173000	2.184648000	-0.118610000
19	6	8.225701000	-0.173309000	0.156744000
20	1	8.441132000	0.607503000	-0.579923000
21	1	8.495536000	0.192077000	1.152927000
22	1	8.825718000	-1.055975000	-0.073695000
23	8	7.187748000	-2.833597000	-0.454058000
24	1	0.328529000	-5.387105000	-0.874070000
25	1	2.337785000	-1.004308000	0.248927000
26	7	-0.394741000	-1.010045000	0.269406000
27	1	-1.137201000	-3.504524000	-0.354688000
28	6	0.159495000	0.325264000	0.486568000
29	6	-0.782768000	1.469498000	0.089786000
30	1	1.059312000	0.419882000	-0.123950000
31	1	0.475281000	0.460354000	1.537079000
32	6	-0.115385000	2.840417000	0.262876000
33	1	-1.086034000	1.331494000	-0.955669000
34	1	-1.701168000	1.443454000	0.689383000
35	6	-1.023338000	4.015109000	-0.121176000
36	1	0.208231000	2.959222000	1.306767000
37	1	0.800321000	2.877536000	-0.343913000
38	1	-1.351705000	3.894189000	-1.163115000
39	1	-1.936939000	3.983674000	0.489485000
40	6	-0.351090000	5.383806000	0.042627000
41	6	-1.252019000	6.562522000	-0.344675000

42	1	0.564109000	5.412161000	-0.565969000
43	1	-0.023944000	5.504711000	1.085304000
44	6	-0.575268000	7.929702000	-0.186320000
45	1	-1.582154000	6.440907000	-1.386336000
46	1	-2.166069000	6.538350000	0.266027000
47	6	-1.480006000	9.102399000	-0.575765000
48	1	-0.245633000	8.051395000	0.854540000
49	1	0.337657000	7.953162000	-0.796959000
50	1	-0.967543000	10.062191000	-0.453748000
51	1	-1.798831000	9.026597000	-1.621571000
52	1	-2.384475000	9.127834000	0.042690000
53	6	-1.678162000	-1.298168000	0.919247000
54	6	-2.899584000	-1.283340000	-0.014288000
55	1	-1.831226000	-0.563600000	1.721006000
56	1	-1.614221000	-2.272660000	1.418366000
57	6	-4.203616000	-1.606657000	0.725244000
58	1	-2.978065000	-0.300676000	-0.493964000
59	1	-2.744426000	-2.003386000	-0.827320000
60	6	-5.437949000	-1.611878000	-0.185188000
61	1	-4.112486000	-2.586534000	1.215914000
62	1	-4.354270000	-0.878123000	1.535117000
63	1	-5.530255000	-0.633215000	-0.677090000
64	1	-5.288954000	-2.342610000	-0.992632000
65	6	-6.742591000	-1.932559000	0.554490000
66	6	-7.976682000	-1.947051000	-0.355585000
67	1	-6.893427000	-1.198299000	1.358743000
68	1	-6.647063000	-2.908688000	1.051227000
69	6	-9.281682000	-2.265213000	0.384722000
70	1	-8.072487000	-0.971936000	-0.854504000
71	1	-7.827466000	-2.683089000	-1.158592000
72	6	-10.508739000	-2.280926000	-0.531675000
73	1	-9.185311000	-3.238700000	0.884550000
74	1	-9.431547000	-1.528103000	1.185332000
75	1	-11.422850000	-2.510832000	0.025319000
76	1	-10.651873000	-1.309718000	-1.018929000
77	1	-10.403082000	-3.032829000	-1.321990000

***m*-D1Aa** energy = -1133.57215602 hartree

1	6	-0.417070000	-1.243391000	-0.282308000
2	6	-1.866327000	-1.273609000	-0.188581000

3	6	-2.500724000	-2.532006000	-0.213381000
4	6	-3.885164000	-2.599960000	-0.114832000
5	6	-4.654022000	-1.444825000	0.002474000
6	6	-4.045381000	-0.165989000	0.014415000
7	6	-2.640927000	-0.105533000	-0.069608000
8	1	-1.906613000	-3.436312000	-0.303294000
9	1	0.071657000	-2.212667000	-0.364436000
10	6	0.442052000	-0.191214000	-0.287826000
11	6	1.910202000	-0.374664000	-0.389732000
12	7	2.403434000	0.922862000	-0.366763000
13	6	1.304519000	1.782987000	-0.250943000
14	7	0.154940000	1.177510000	-0.206768000
15	6	1.469828000	3.262670000	-0.178917000
16	1	0.480785000	3.718710000	-0.134340000
17	1	2.035113000	3.554705000	0.713444000
18	1	2.006658000	3.651064000	-1.051175000
19	6	3.814930000	1.308923000	-0.449706000
20	1	4.135978000	1.351063000	-1.493673000
21	1	3.920489000	2.299015000	-0.001475000
22	8	2.562920000	-1.424134000	-0.479600000
23	1	-4.383018000	-3.565368000	-0.124222000
24	1	-2.118541000	0.839732000	-0.042995000
25	7	-4.808107000	0.992666000	0.097458000
26	1	-5.729440000	-1.541451000	0.084430000
27	6	-4.140360000	2.266355000	0.312548000
28	1	-3.591566000	2.308310000	1.266092000
29	1	-3.428152000	2.475835000	-0.492361000
30	1	-4.885716000	3.063300000	0.309703000
31	6	-6.219565000	0.895614000	0.426026000
32	1	-6.762831000	0.315222000	-0.328561000
33	1	-6.403684000	0.431154000	1.407813000
34	1	-6.652165000	1.897036000	0.438631000
35	6	4.692177000	0.288943000	0.323306000
36	8	4.320666000	0.011622000	1.495368000
37	8	5.608543000	-0.276337000	-0.331242000
38	11	4.494286000	-2.048695000	0.550465000

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