Electronic Supplementary Material (ESI) for Polymer Chemistry.

Electronic Supplementary Information

Easily Readable Palindromic Sequence-Defined Polymers Built by Cascade Thiol-Maleimide Michael Couplings

Qiunan Shi,[a] Xiaohuan Cao,[a] Yajie Zhang,[a] Suhua Duan,[a] Lihua Hu,[c] Yuxuan Xu,[d] Jingqiu Lu,[a] Zhihao Huang,*[a] Zhengbiao Zhang*[a,b] and Xiulin Zhu[a,e]

[a] College of Chemistry, Chemical Engineering and Materials Science, Soochow University, 215123, Suzhou, China.

[b] Collaborative Innovation Center of Suzhou Nano Science and Technology, Soochow University, 215123, Suzhou, China.

[c] Analysis and Testing Center, Soochow University, 215123, Suzhou, China.

[d] Applied Technology College of Soochow University, Soochow University, 215325, Suzhou, China.

[e] Global Institute of Software Technology, No. 5 Qingshan Road, Suzhou National Hi-Tech District, 215163, Suzhou, China.

Correspondence:

E-mail: zhhuang@suda.edu.cn; zhangzhengbiao@suda.edu.cn

SECTION A. Experimental Section

1. Materials

Unless stated otherwise, commercially available reagents were purchased from Sigma-Aldrich, Acros Organic, Alfa Aesar, TCI, Energy chemical, Adams and Sinopharm Chem. Dry tetrahydrofuran (THF), dichloromethane (DCM), toluene and *N*, *N*-dimethylformamide (DMF) were collected fresh from an Innovative Technology PS-MD-5 solvent purification system. All other dry solvents used were dried over 4 Å molecular sieves and stored under argon.

2. Analysis Techniques

Nuclear magnetic resonance (NMR). All ^{1}H NMR, ^{13}C NMR spectra were collected using a Bruker nuclear magnetic resonance instrument (300 MHz) using tetramethylsilane (TMS) as the internal standard at room temperature. The ^{1}H NMR spectra were referenced to 7.26 ppm in $CDCl_3$, and ^{13}C NMR spectra were referenced to 77.00 ppm in $CDCl_3$.

Size exclusion chromatography (SEC). The number-average molecular weight (M_n) and polydispersity ($Đ = M_w/M_n$) of the polymers were determined using a size exclusion column TOSOH HLC-8320 equipped with refractive index and UV detectors using two TSKgel Super Multipore HZ-N (4.6 × 150 mm, 3 μm beads size) columns arranged in series. THF was used as the eluent at a flow rate of 0.35 mL/min at 40 °C. Data acquisition was performed using EcoSEC software, and molecular weights were calculated with polystyrene (PS) standards.

Matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF). MALDI-TOF mass spectroscopy (MS) were acquired on an UltrafleXtreme III MALDI-TOF mass spectrometer (Bruker Daltonics, Germany) equipped with an Nd:YAG smart beam-II laser with 355-nm wavelength and 200 Hz firing rate. The

MALDI sample spots were prepared onto the MTP 384 target plate. The compound trans-2-[3-(4-tert-butyl-phenyl)-2-methyl- 2-propenylidene]-malononitrile (DCTB, Aldrich, >98%) served as the matrix and was prepared in $CHCl_3$ at a concentration of 20 mg/mL. The cationizing agent sodium trifluoroacetate was prepared in ethanol at a concentration of 10 mg/mL. The matrix and cationizing salt solutions were mixed in a ratio of 10/1 (v/v). The instrument was calibrated prior to each measurement with external PMMA at the molecular weight under consideration. All samples were dissolved in $CHCl_3$ at a concentration of 10 mg/mL. After sample preparation and solvent evaporation, the target plate was inserted into the MALDI-TOF mass spectrometer. For high resolution mass analysis the instrument was operated in the reflector mode.

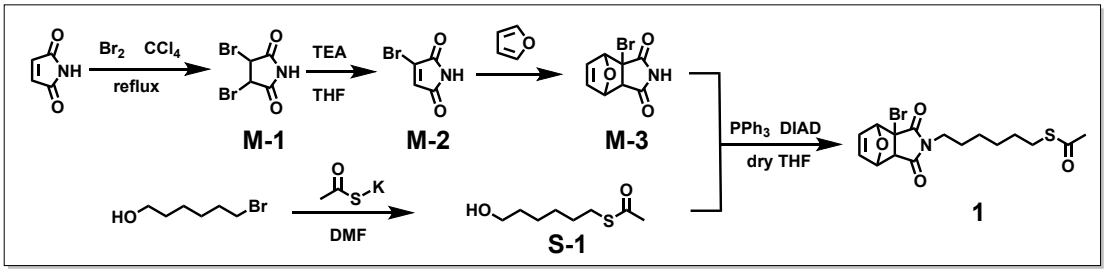
MALDI-TOF MS/MS. Tandem MALDI-TOF MS analysis was recorded by using the laser induced dissociation (LID)-LIFT mode on the same instrument controlled by the Flexcontrol 1.4 software package. For MS/MS, ions generated by the MALDI process were accelerated at 7.50 kV through a grid at 6.85 kV. Fragmentation was performed in the simple metastable decomposition mode, and the fragments have the same velocity with the precursors. The precursors and fragments then passed into a precursor ion selector (PCIS). In this region, a parent ion is able to be picked with the associated fragments out of a mixture, and the selected ions travel side by side into the LIFT cell. The fragments were further accelerated by 19 kV in the LIFT cell to reduce the difference of kinetic energy, and then passed through a post lift metastable suppressor (PLMS) to filter the residual metastable parent ions. The fragments with similar kinetic energy then passed into the reflector, and finally to the detector. MS and MS/MS data were further processed using FlexAnalysis 1.3 software package.

Recycling Preparative Size exclusion chromatography (prep-SEC). Prep-SEC separation using a LC-9260 NEXT recycling preparative HPLC system (Japan Analytical Industry) equipped with two tandem 20Φ (i.d. 20 mm × 600 mmL) columns, an IR detector and a 254 nm UV detector. THF was used as an eluent with a flow rate

of 6 mL/min. The samples were dissolved in THF at a concentration of 100 mg/mL, and the maximum capacity of the column is 300 mg. Before injection, the solution was filtered through a 0.2 μm pore PTFE syringe filter The SEC was performed under a cycling mode until the coinciding peaks were separated.

3. Monomer design and synthesis

3.1 Synthetic route of monomer **1**



Scheme S1. Synthesis of monomer **1**.

M-1:[1] To a 1.0 L three-neck round-bottom flask equipped with a condenser were added with maleimide (30.0 g, 0.31 mol) and 500 mL of CCl_4. The mixture was stirred at room temperature under argon atmosphere. Bromine (18.0 mL, 0.35 mol) was added subsequently and then the mixture was refluxed at 78 ºC for about 1 h. Crude products were crystallized and filtered after cooling to room temperature. The filter cake was washed with 2×100 mL petrol ether (PE) and dried under vacuum at 25 ºC overnight to afford crude **M-1** (73.1 g, yield 92.1%) as a yellow crystal without any further purification.

M-2:[1] **M-1** (73.0 g, 0.28 mol) was dissolved to anhydrous THF (700 mL) in a 1.0 L three-neck round-bottom flask equipped with a 250.0 mL slow-addition apparatus and cooled to 0 ºC under argon atmosphere. Triethylamine (TEA, 43.4 mL, 0.31 mol) was dissolved in anhydrous THF (200 mL) and dropped in the stirred reaction system slowly at 0 ºC and maintained for 15 minutes more. After that, the mixture was moved to room temperature and stirred for about 2 h. The insoluble substance was filtered and the filter cake was washed with 3×200 mL ethyl acetate (EA) and the combined filtrate was concentrated. The residue was redissolved in 500 mL EA and then washed with 3×250 mL brine. The organic phase was dried with anhydrous Na_2SO_4 and the solvent was evaporated, and the crystal was dried under vacuum to afford **M-2** (41.8 g, yield 83.6%) as a yellow powder. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.51 (s, 1H), 6.89 (s, 1H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 167.88, 164.85, 132.85, 132.18.

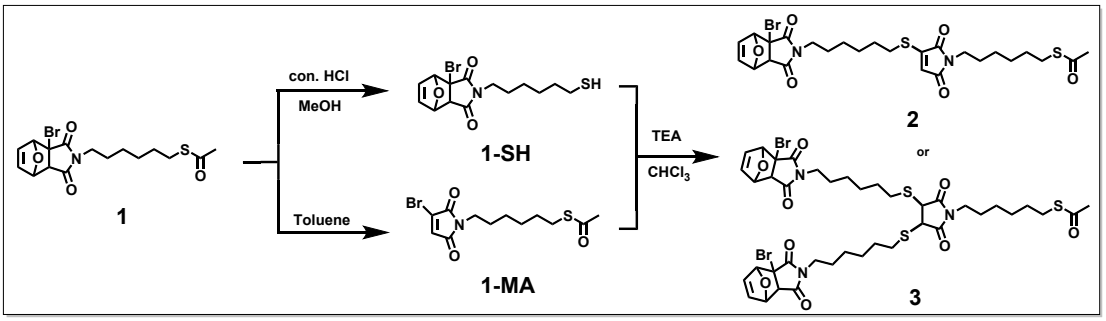
M-3: To a 350 mL thick-wall pressure flask were added with **M-2** (12.0 g, 68.2 mmol),

furan (46.4 g, 0.68 mol) and anhydrous diethyl ether (18.0 mL). The flask was sealed and the mixture was stirred at 78 ºC for 4 days. After cooling to room temperature, the mixture was filtered. The filter cake was washed with 3×50 mL PE and the products were dried under vacuum at 25 ºC overnight to afford **M-3** (14.2 g, yield 85.3%) as a light gray powder. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 8.00 (s, 1H), 6.82 – 6.57 (m, 2H), 5.31 (d, *J* = 5.9 Hz, 2H), 2.88 (s, 1H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 172.88, 136.56, 136.51, 83.18, 82.63, 56.92, 55.92.

S-1:[2] 6-bromo-1-hexaneol (26.0 g, 0.14 mol) was dissolved in 500 mL of DMF in a 1.0 L round-bottom flask. Then potassium thioacetate (32.8 g, 0.29 mol) was added and the mixture was stirred at room temperature overnight. The reaction mixture was diluted by 500 mL EA and washed with 3×500 mL saturated NH_4Cl (aq.) to remove DMF. The upper phase was collected and dried with anhydrous Na_2SO_4. The solvent was evaporated to afford **S-1** (25.0 g, yield 98.8%) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 3.64 (t, *J* = 8.7 Hz, 2H), 2.86 (d, *J* = 9.8 Hz, 2H), 2.32 (s, 3H), 1.67 – 1.53 (m, 4H), 1.39 (dd, *J* = 9.7, 4.8 Hz, 4H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 196.18, 62.66, 32.48, 30.61, 29.43, 28.98, 28.48, 25.21.

Monomer (1):[3] To a 1.0 L three-neck round-bottom flask were added with **S-1** (25.0 g, 0.14 mol), triphenylphosphine (55.8 g, 0.21 mol) and 800 mL anhydrous THF. Then **M-3** (45.0 g, 0.18 mol) was added subsequently to the stirred system at -10 ºC. Diisopropyl azodiformate (DIAD, 43.0 g, 0.21 mol) was then added dropwise to the mixture slowly at -10 ºC under argon atmosphere. The mixture was stirred at room temperature for another 2 h and the solvent was then evaporated. The residue was then purified by silica gel column chromatography eluting with PE/EA (v/v = 6/1 to 3/1) and recrystallized to afford monomer **1** (40.8 g, yield 71.5%) as a white solid. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 2H), 5.38 – 5.18 (m, 2H), 3.53 (t, *J* = 9.7 Hz, 2H), 2.92 – 2.77 (m, 2H), 2.32 (s, 3H), 1.56 (dt, *J* = 19.6, 8.9 Hz, 4H), 1.33 (s, 4H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.90, 173.29, 173.21, 136.53, 136.49, 83.09, 82.52, 55.73, 55.22, 39.58, 30.64, 29.26, 28.90, 28.12, 27.15, 25.96.

3.2 Orthogonal deprotection of monomer **1** and characterization of **2** and **3**[4]



Scheme S2. Orthogonal deprotection and thiol-maleimide coupling of deprotected **1**.

1-MA: Monomer **1** (19.4 g, 48.2 mmol) was dissolved in 300 mL of toluene in a 500 mL round-bottom flask. The mixture was stirred at 110 ºC for about 8 h. TLC showed the reaction was complete. Toluene was evaporated under vacuum after the mixture was cooled to room temperature to afford the product **1-MA** (16.0 g, yield 99.3%) as a dark yellow solid. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.87 (s, 1H), 3.55 (t, J = 7.2 Hz, 2H), 2.85 (t, J = 7.2 Hz, 2H), 2.32 (s, 3H), 1.68 – 1.47 (m, 4H), 1.34 (ddd, J = 22.7, 12.2, 6.2 Hz, 4H).

1-SH: Monomer **1** (23.3 g, 57.9 mmol) was dissolved in 700 mL methanol (MeOH) in a 1.0 L three-neck round-bottom flask equipped with a condenser under argon atmosphere. The mixture was heated to 55 ºC and then concentrated hydrochloric acid (34.5 mL, 0.41 mol) was added subsequently to the reaction system. The mixture was stirred and refluxed at 55 ºC for about 6 h and monitored by TLC. After cooling to room temperature, the reaction was quenched with 500 mL water and extracted with dichloromethane (DCM, 2×300 mL). The organic layer was collected and washed with 300 mL water and then dried with anhydrous Na_2SO_4. The solvent was evaporated under vacuum to afford **1-SH** (20.7 g, yield 99.6%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 2H), 5.26 (d, J = 2.8 Hz, 2H), 3.54 (t, J = 7.2 Hz, 2H), 2.85 (s, 1H), 2.50 (dd, J= 14.7, 7.4 Hz, 2H), 1.70 – 1.52 (m, 4H), 1.50 – 1.22 (m, 4H).

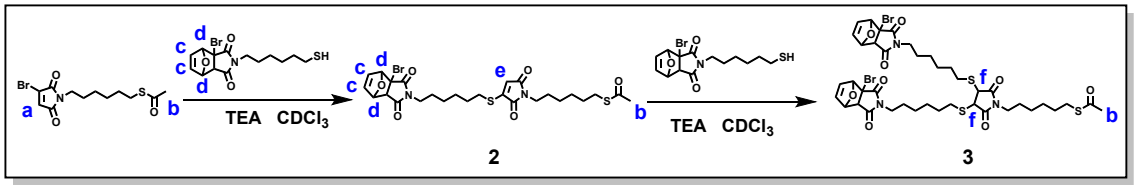
Thiol-bromomaleimide Michael coupling:

1-MA (160 mg, 0.48 mmol) was dissolved in 5.0 mL $CHCl_3$, TEA (0.2 mL, 1.4 mmol) was added subsequently at 25 ºC. **1-SH** (173 mg, 0.48 mmol) was dissolved in 5.0 mL

$CHCl_3$ and added dropwise to the stirred solution under argon atmosphere. The mixture was washed successively with saturated $NaHCO_3$ (10.0 mL), water (10.0 mL) and brine (10.0 mL). The organic layer was dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 5/1 to 5/2) to afford **2** (250 mg, yield 85.1%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.66 (s, 2H), 6.02 (s, 1H), 5.37 – 5.09 (m, 2H), 3.52 (dt, *J*= 19.1, 7.2 Hz, 4H), 2.86 (dt, *J* = 11.2, 7.3 Hz, 5H), 2.32 (s, 3H), 1.83 – 1.14 (m, 16H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.94, 173.34, 173.24, 169.74, 168.00, 151.30, 136.54, 136.46, 117.21, 83.11, 82.55, 55.72, 55.18, 39.39, 38.01, 31.50, 30.64, 29.31, 28.98, 28.37, 28.22, 28.14, 27.44, 27.03, 26.20, 25.77.

1-MA (160 mg, 0.48 mmol) was dissolved in 5.0 mL $CHCl_3$, TEA (0.6 mL, 4.2 mmol) was added subsequently at 25 ºC. **1-SH** (505 mg, 1.4 mmol) was dissolved in 10.0 mL $CHCl_3$ and added to the stirred solution under argon atmosphere. The reaction was stirred and monitored by TLC, and then washed successively with saturated $NaHCO_3$ (15.0 mL), water (15.0 mL) and brine (15.0 mL). The organic layer was dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 6/1 to 3/1) to afford **3** (330 mg, 70.8%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 4H), 5.26 (d, *J* = 2.3 Hz, 4H), 3.52 (m, 6H), 3.42 (s, 2H), 2.73 (dt, *J* = 12.5, 7.4 Hz, 8H), 2.32 (s, 3H), 1.61 (m, 12H), 1.35 (m, 12H).

4. Kinetics experiment of cascade thiol-maleimide Michael couplings (CTMMC)



Scheme S3. CTMMC using deprotected monomer **1**.

The feed ratio of thiols and bromomaleimides was considered to influence the content of the products in CTMMC. ^{1}H NMR of **1-MA** in $CDCl_3$ was recorded and taken as the zero point. A solution of **1-MA** (56.0 mg, 0.17 mmol) in $CDCl_3$ (500 μL) was aliquoted as 50 μL in each NMR tube. A mixture of **1-SH** (from 0.5 to 2.2 equivalent of 1-MA, sampled from the predetermined solution of 74.9 mg **1-SH** dissolved in 1000 μL $CDCl_3$) and TEA (3.0 equivalent of **1-SH**) was respectively added to the same solution. Each solution was diluted to 500 μL with $CDCl_3$ for appropriate testing concentration (about 5 - 20 mg/mL solution in $CDCl_3$ for ^{1}H NMR) and mixed quickly. The content of each product at different starting ratio was recorded after 1 hour. With the acetyl proton signal b at 2.32 ppm as interior label, the instant content of **2** was monitored by the thiomaleimide proton signal e at 6.01 ppm. The instant content of **3** after a whole cascade process was calculated from the ratio of **2** and the remaining **1-MA** (monitored by the bromomaleimide proton signal a at 6.89 ppm).

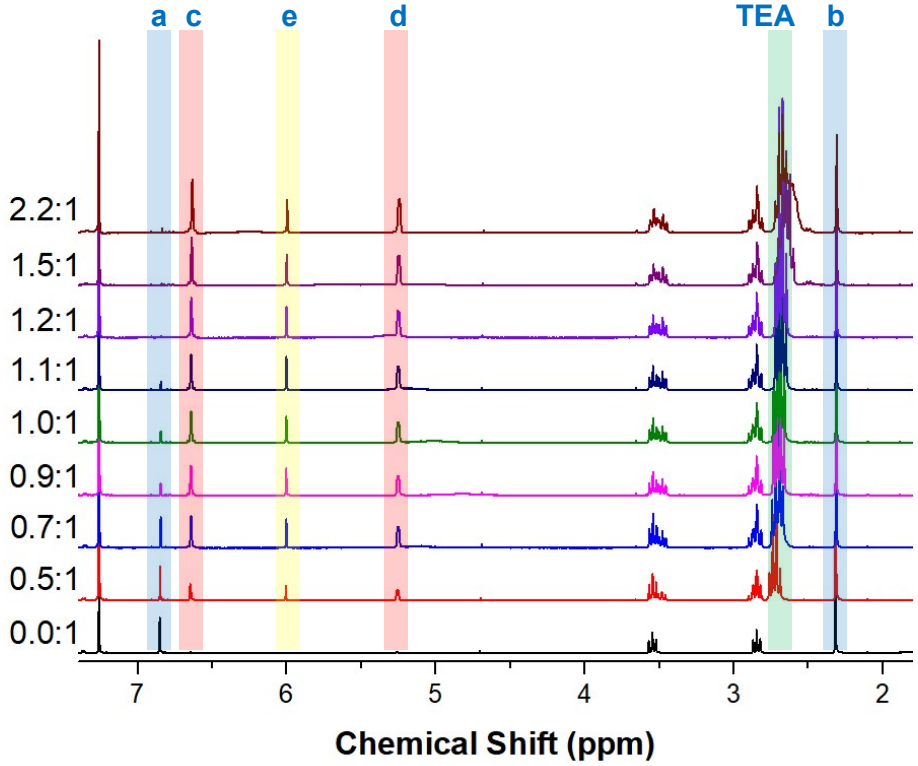


Figure S1. ^{1}H NMR spectra of CTMMC in 1 hour at different feeding ratios.

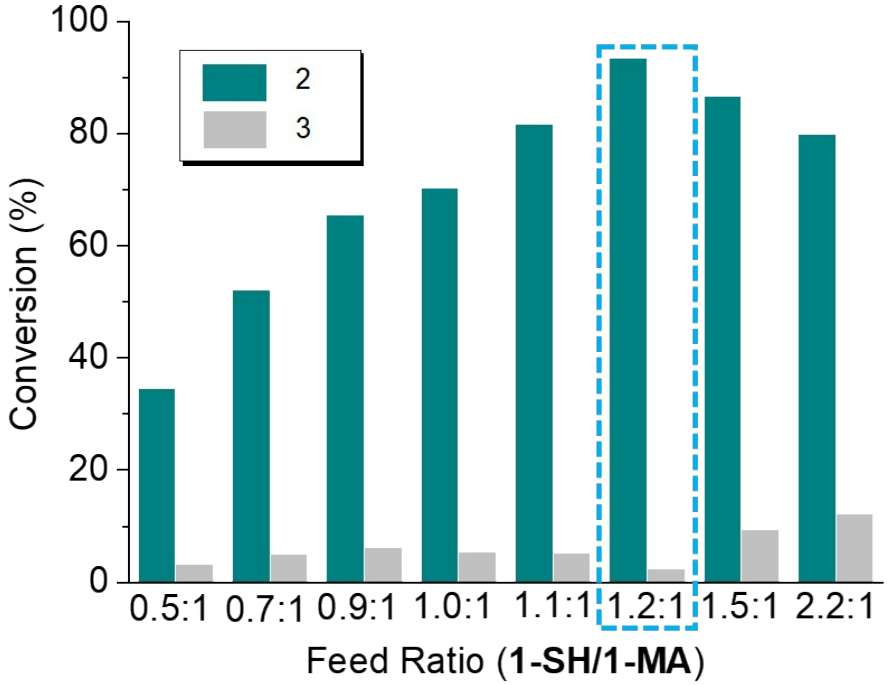


Figure S2. Instant content of the products in 1 hour at different feed ratios.

^{1}H NMR of **1-MA** in $CDCl_3$ was recorded and taken as the zero-time point. A solution of **1-MA** (14.0 mg, 0.041 mmol) in $CDCl_3$ (500 μL) was aliquoted as 250 μL in each NMR tube. A mixture of **1-SH** (9.1 mg, 0.025 mmol, 1.2 equivalent of 1-MA for highest yield of **2** and 16.6 mg, 0.046 mmol, 2.2 equivalent of **1-MA** for excessive 1-SH) and TEA (3.0 equivalent of **1-SH**) in 250 μL $CDCl_3$ was respectively added to the same solution and mixed quickly. The recording of the first ^{1}H NMR spectrum was complete within one minute. The progress of cascade Michael additions was monitored by the integral changes of bromomaleimide proton signal a in 6.89 ppm and thiomaleimide proton signal e in 6.01 ppm.

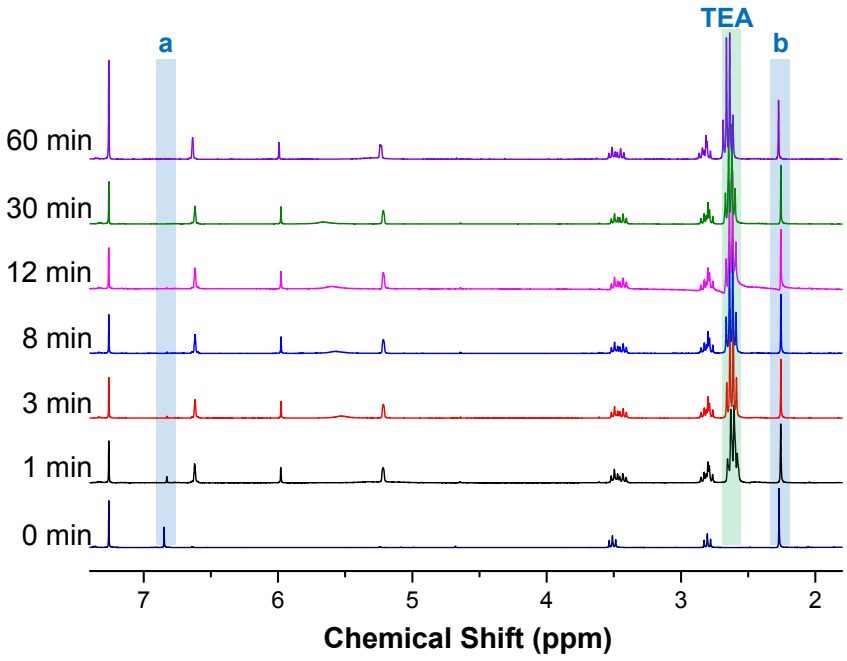
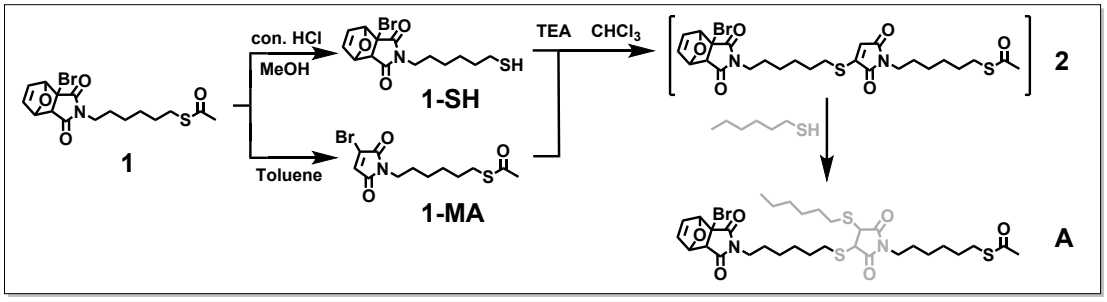


Figure S3. ^{1}H NMR spectra of cascade Michael couplings at a feed ratio of **1-SH/1-MA** = 1.2: 1.

5. Synthetic protocols

5.1 Synthesis of dimers via CTMMC-integrated IEG

5.1.1 Synthetic route of dimer **A**



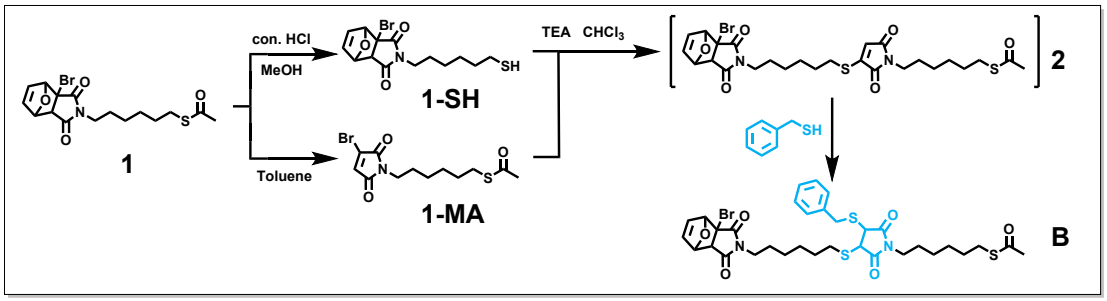
Scheme S4. Synthetic route of **A** via CTMMC-integrated IEG.

A: **1-MA** and **1-SH** precursors to **A** were prepared using the procedures described in section

1-MA (16.0 g, 47.9 mmol) was dissolved in 160 mL $CHCl_3$ in a 500 mL three-neck round-bottom flask equipped with a 250 mL slow-addition apparatus. TEA (24.0 mL, 0.17 mol) was added subsequently at 25 ºC. After that, a solution of **1-SH** (20.7 g, 57.6 mmol) in 180 mL $CHCl_3$ was added dropwise to the stirred mixture under argon atmosphere (TLC indicated the 1st coupling was completed). A mixture of TEA (31.4 mL, 225.9 mmol) and hexyl mercaptan (Side Chain **A**, 10.6 mL, 75.2 mmol) dissolved in 20.0 mL $CHCl_3$ was then added. The mixture was stirred at 25ºC for 12 h and quenched with 300 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (300 mL) and brine (300 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by flash column on silica gel eluting with PE/EA (v/v = 6/1 to 4/1) to give **A** (26.3 g, overall yield 75.2% of CTMMC) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 2H), 5.27 (d, J = 2.3 Hz, 2H), 3.60 – 3.44 (m, 4H), 3.43 (s, 2H), 2.93 – 2.66 (m, 7H), 2.32 (s, 3H), 1.73 – 1.23 (m, 24H), 0.89 (t, J = 6.8 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.87, 174.66, 174.63, 173.29, 173.21, 136.53, 136.48, 83.10, 82.53, 55.73, 55.22, 46.77, 46.73, 39.53, 39.05, 32.17, 31.97, 31.29, 30.64, 29.29, 28.97, 28.92, 28.74, 28.40, 28.17, 28.06, 27.25, 27.14, 26.07, 25.95, 22.49, 14.02.

Intermediate **2** was also rigorous characterized by sampling (~ 20 mg) before adding hexyl mercaptan, which was purified by flash column on silica gel eluting with PE/EA (v/v = 5/1 to 5/2): ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.66 (s, 2H), 6.02 (s, 1H), 5.37 – 5.09 (m, 2H), 3.52 (dt, *J*= 19.1, 7.2 Hz, 4H), 2.86 (dt, *J* = 11.2, 7.3 Hz, 5H), 2.32 (s, 3H), 1.83 – 1.14 (m, 16H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.94, 173.34, 173.24, 169.74, 168.00, 151.30, 136.54, 136.46, 117.21, 83.11, 82.55, 55.72, 55.18, 39.39, 38.01, 31.50, 30.64, 29.31, 28.98, 28.37, 28.22, 28.14, 27.44, 27.03, 26.20, 25.77.

5.1.2 Synthetic route of dimer **B**



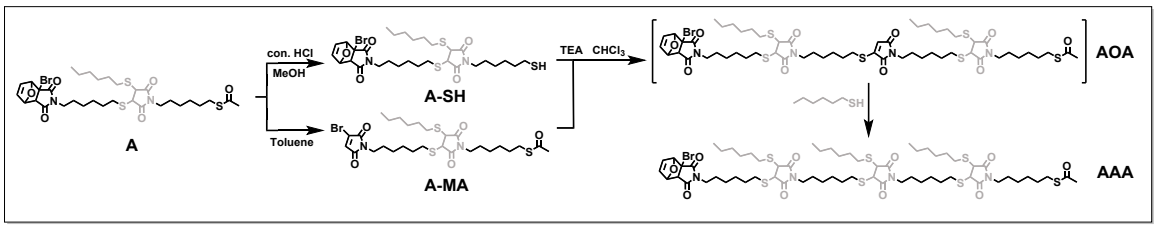
Scheme S5. Synthetic route of **B** via CTMMC-integrated IEG.

B: **1-MA** and **1-SH** precursors to **B** were prepared using the procedures described in section 3.2.

1-MA (2.8 g, 8.3 mmol) was dissolved in 28 mL $CHCl_3$ in a 100 mL three-neck round-bottom flask equipped with a 50 mL slow-addition apparatus. TEA (4.2 mL, 30.0 mmol) was added subsequently at 25 ºC. After that, a solution of **1-SH** (3.6 g, 10.0 mmol) in 36 mL $CHCl_3$ was added dropwise to the stirred mixture under argon atmosphere (TLC indicated the 1st coupling was completed). A mixture of TEA (6.8 mL, 48.9 mmol) and benzyl mercaptan (Side Chain **B**, 1.9 mL, 16.3 mmol) dissolved in 5.0 mL $CHCl_3$ was then added. The mixture was stirred at 25ºC for 12 h and quenched with 80 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (80 mL) and brine (80 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by flash column on silica gel eluting with PE/EA (v/v = 6/1 to 4/1) to give **B** (4.9 g, overall yield 80.2% of CTMMC) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.34 (m, 5H), 6.65 (s, 2H), 5.26 (d, J = 2.7 Hz, 2H), 4.14 (d, J = 13.5 Hz, 1H), 3.91 (d, J = 13.5 Hz, 1H), 3.61 – 3.43 (m, 4H), 3.32 (dd, J = 21.1, 3.0 Hz, 2H), 2.85 (t, J = 7.2 Hz, 3H), 2.76 – 2.48 (m, 2H), 2.32 (s, 3H), 1.69 – 1.26 (m, 16H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.94, 174.81, 174.43, 173.32, 173.23, 136.53, 136.50, 136.43, 129.24, 128.74, 127.69, 83.11, 82.54, 55.76, 55.22, 46.29, 45.41, 39.56, 39.10, 36.33, 29.31, 28.94, 28.68, 28.19, 28.03, 27.26, 27.15, 26.11, 25.94.

5.2 Synthesis of palindromic tetramers via CTMMC-integrated IEG

5.2.1 Synthetic route of palindromic tetramer **AAA**



Scheme S6. Synthetic route of **AAA** via CTMMC-integrated IEG.

A-MA: A (11.6 g, 15.8 mmol) was dissolved in 300 mL of toluene in a 500 mL round-bottom flask. The mixture was stirred at 110 ºC for about 8 h. TLC showed the reaction was complete. Toluene was evaporated under vacuum after the mixture was cooled to room temperature to afford the product **A-MA** (10.5 g, yield 99.8%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.87 (s, 1H), 3.62 – 3.46 (m, 4H), 3.44 (s, 2H), 2.94 – 2.65 (m, 6H), 2.32 (s, 3H), 1.74 – 1.48 (m, 12H), 1.49 – 1.20 (m, 12H), 0.89 (d, J = 6.7 Hz, 3H).

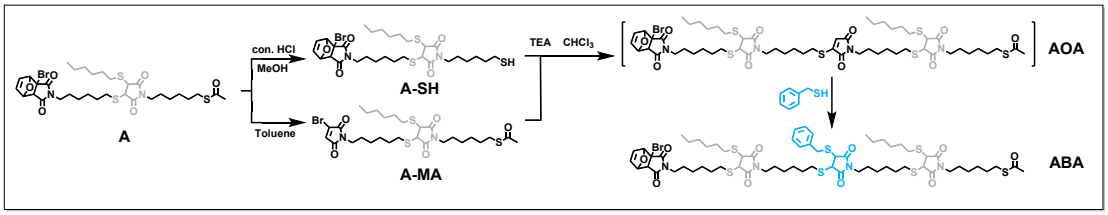
A-SH: A (15.0 g, 20.5 mmol) was dissolved in 20.0 mL $CHCl_3$ and diluted with 250 mL MeOH in a 500 mL three-neck round-bottom flask equipped with a condenser under argon atmosphere. The mixture was heated to 55 ºC and then concentrated hydrochloric acid (22.2 mL, 0.27 mol) was added dropwise to the reaction system. The mixture was stirred and refluxed at 55 ºC for about 6 h and monitored by TLC. After cooling to room temperature, the reaction was quenched with 300 mL water and extracted with DCM (2×150 mL). The organic layer was collected and washed with 300 mL water and then dried with anhydrous Na_2SO_4. The solvent was evaporated under vacuum to afford **A-SH** (14.4 g, yield 99.7%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 2H), 5.27 (d, J = 2.3 Hz, 2H), 3.53 (dd, J = 14.7, 7.4 Hz, 4H), 3.44 (s, 2H), 2.94 – 2.67 (m, 3H), 2.51 (dd, J = 14.6, 7.4 Hz, 1H), 1.79 – 1.16 (m, 24H), 0.89 (t, J = 6.8 Hz, 3H).

AAA: **A-MA** (3.9 g, 5.9 mmol) was dissolved in 40 mL $CHCl_3$ in a 250 mL three-neck round-bottom flask equipped with a 250 mL slow-addition apparatus. TEA (3.1 mL, 22.5 mmol) was added subsequently at 25 ºC. After that, a solution of **A-SH** (4.9 g, 7.1

mmol) in 60 mL $CHCl_3$ was added dropwise to the stirred mixture under argon atmosphere (TLC indicated the 1st coupling was completed). A mixture of TEA (4.3 mL, 30.6 mmol) and hexyl mercaptan (1.4 mL, 10.2 mmol) dissolved in 10.0 mL $CHCl_3$ was then added. The mixture was stirred at 25ºC for 12 h and quenched with 100 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (100 mL) and brine (100 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by flash column on silica gel eluting with PE/EA (v/v = 6/1 to 3/1) to give **AAA** (4.9 g, overall yield 60.0% of CTMMC) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+$ = 1343.438, found: *m/z* = 1343.856. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (d, *J* = 0.4 Hz, 2H), 5.29 – 5.24 (m, 2H), 3.52 (dd, *J* = 16.0, 7.5 Hz, 8H), 3.44 (s, 6H), 2.94 – 2.80 (m, 8H), 2.74 (ddd, *J* = 16.5, 10.0, 4.0 Hz, 7H), 2.32 (s, 3H), 1.76 – 1.49 (m, 28H), 1.42 – 1.15 (m, 28H), 0.82 (t, *J* = 6.8 Hz, 9H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 194.85, 173.63, 172.26, 172.18, 135.50, 135.45, 82.07, 81.50, 54.71, 54.18, 45.71, 38.50, 37.98, 31.17, 31.01, 30.98, 30.26, 29.61, 28.27, 27.95, 27.90, 27.76, 27.71, 27.38, 27.12, 27.03, 26.21, 26.11, 25.08, 25.05, 24.93, 21.46, 12.99.

Intermediate **AOA** was also rigorous characterized by sampling (~ 20 mg) before adding hexyl mercaptan, which was purified by flash column on silica gel eluting with PE/EA (v/v = 5/1 to 5/2): MALDI-TOF MS calculated: $[M - Furan + Na]^+$ = 1225.357, found: *m/z* = 1225.517. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 2H), 6.03 (s, 1H), 5.26 (s, 2H), 3.59 – 3.45 (m, 8H), 3.44 (s, 4H), 2.94 – 2.63 (m, 13H), 2.32 (s, 3H), 1.84 – 1.15 (m, 48H), 0.89 (t, *J* = 6.8 Hz, 6H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.90, 174.72, 174.68, 174.66, 173.31, 173.22, 169.72, 168.00, 151.34, 136.54, 136.48, 117.21, 110.00, 83.10, 82.54, 55.74, 55.21, 46.75, 39.53, 39.06, 38.85, 37.98, 32.26, 32.18, 32.06, 32.04, 31.59, 31.29, 30.64, 29.30, 28.98, 28.93, 28.84, 28.74, 28.40, 28.18, 28.05, 27.50, 27.26, 27.14, 26.25, 26.08, 25.95, 22.50, 14.02.

5.2.2 Synthetic route of palindromic tetramer **ABA**

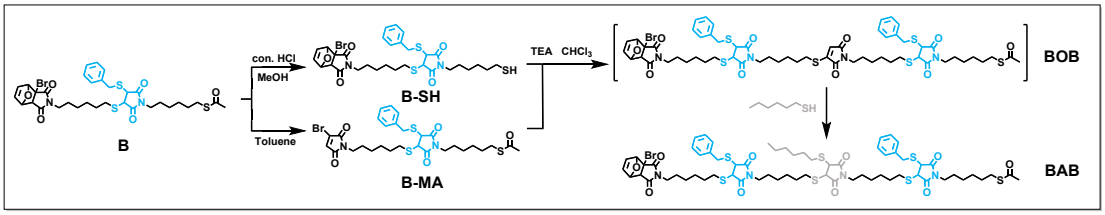


Scheme S7. Synthetic route of **ABA** via CTMMC-integrated IEG.

ABA: **A-MA** and **A-SH** precursors to **ABA** were prepared using the procedures described in section 5.2.1.

A-MA (5.9 g, 8.9 mmol) was dissolved in 60 mL $CHCl_3$ in a 250 mL three-neck round-bottom flask equipped with a 250 mL slow-addition apparatus. TEA (4.5 mL, 32.1 mmol) was added subsequently at 25 ºC. After that, a solution of **A-SH** (7.4 g, 10.7 mmol) in 75 mL $CHCl_3$ was added dropwise to the stirred mixture under argon atmosphere (TLC indicated the 1st coupling was completed). A mixture of TEA (4.9 mL, 35.4 mmol) and benzyl mercaptan (1.4 mL, 11.8 mmol) dissolved in 10.0 mL $CHCl_3$ was then added. The mixture was stirred at 25ºC for 12 h and quenched with 100 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (100 mL) and brine (100 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by flash column on silica gel eluting with PE/EA (v/v = 6/1 to 3/1) to give **ABA** (6.8 g, overall yield 54.8% of CTMMC) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+$ = 1349.391, found: *m/z* = 1349.499. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.35 (dt, *J*=18.6, 5.8, 5H), 6.65 (s, 2H), 5.26 (d, *J* = 2.5 Hz, 2H), 4.15 (d, *J* = 13.5 Hz, 1H), 3.91 (d, *J* = 13.5 Hz, 1H), 3.52 (dd, *J* = 16.0, 8.3 Hz, 8H), 3.44 (s, 2H), 3.33 (dd, *J* = 21.1, 2.9 Hz, 2H), 2.95 – 2.47 (m, 13H), 2.32 (s, 3H), 1.74 – 1.47 (m, 24H), 1.34 (ddd, *J* = 18.3, 14.3, 7.8 Hz, 24H), 0.89 (t, *J* = 6.7 Hz, 6H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.92, 174.81, 174.68, 174.42, 173.31, 173.23, 136.53, 136.49, 136.42, 129.23, 128.75, 127.70, 83.11, 82.54, 55.75, 55.21, 46.78, 46.30, 45.41, 39.54, 39.06, 36.34, 32.20, 32.03, 31.86, 31.30, 30.64, 29.69, 29.31, 28.99, 28.74, 28.42, 28.18, 28.09, 27.26, 27.15, 26.09, 25.96, 22.50, 14.02.

5.2.3 Synthetic route of palindromic tetramer **BAB**



Scheme S8. Synthetic route of **BAB** via CTMMC-integrated IEG.

B-MA: **B** (1.1 g, 1.5 mmol) was dissolved in 33.0 mL of toluene in a 50.0 mL round-bottom flask. The mixture was stirred at 110 ºC for about 8 h. TLC showed the reaction was complete. Toluene was evaporated under vacuum after the mixture was cooled to room temperature to afford the product **B-MA** (1.0 g, yield 99.5%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.46 – 7.29 (m, 5H), 6.86 (s, 1H), 4.15 (d, J = 13.5 Hz, 1H), 3.91 (d, J = 13.5 Hz, 1H), 3.52 (dt, J = 17.3, 7.1 Hz, 4H), 3.32 (dd, J = 20.8, 2.9 Hz, 2H), 2.85 (t, J = 7.2 Hz, 2H), 2.63 (dtd, J = 20.3, 12.6, 7.4 Hz, 2H), 2.32 (s, 3H), 1.67 – 1.15 (m, 16H).

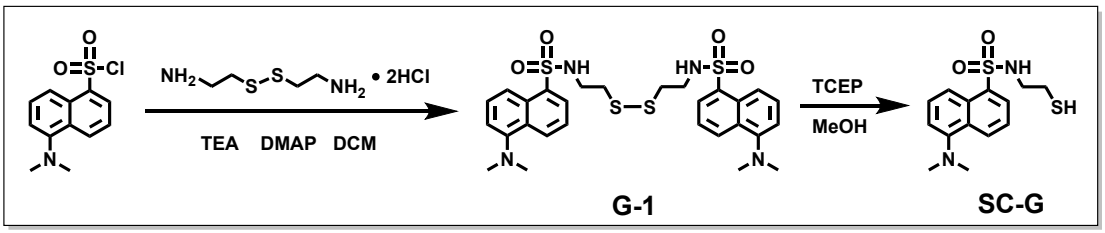
B-SH: **B** (1.3 g, 1.8 mmol) was dissolved in 5.0 mL $CHCl_3$ and diluted with 40.0 mL MeOH in a 100 mL three-neck round-bottom flask equipped with a condenser under argon atmosphere. The mixture was heated to 55 ºC and then concentrated hydrochloric acid (1.9 mL, 23.1 mmol) was added dropwise to the reaction system. The mixture was stirred and refluxed at 55 ºC for about 6 h and monitored by TLC. After cooling to room temperature, the reaction was quenched with 50.0 mL water and extracted with DCM (2×50.0 mL). The organic layer was collected and washed with 50.0 mL water and then dried with anhydrous Na_2SO_4. The solvent was evaporated under vacuum to afford **B-SH** (1.2 g, yield 97.9%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.45 – 7.28 (m, 5H), 6.65 (s, 2H), 5.26 (d, J = 2.7 Hz, 2H), 4.14 (d, J = 13.5 Hz, 1H), 3.91 (d, J = 13.5 Hz, 1H), 3.59 – 3.44 (m, 4H), 3.33 (dd, J = 20.8, 2.9 Hz, 2H), 2.85 (s, 1H), 2.74 – 2.44 (m, 4H), 1.70 – 1.17 (m, 16H).

BAB: **B-MA** (1.0 g, 1.5 mmol) was dissolved in 10 mL $CHCl_3$ in a 50 mL three-neck round-bottom flask equipped with a 25 mL slow-addition apparatus. TEA (0.72 mL, 5.2 mmol) was added subsequently at 25 ºC. After that, a solution of **B-SH** (1.2 g, 1.7 mmol) in 12 mL $CHCl_3$ was added dropwise to the stirred mixture under argon

atmosphere (TLC indicated the 1st Michael coupling was completed). A mixture of TEA (0.34 mL, 2.5 mmol) and hexyl mercaptan (0.12 mL, 0.82 mmol) dissolved in 5.0 mL $CHCl_3$ was then added. The mixture was stirred at 25ºC for 12 h and quenched with 30 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (30 mL) and brine (30 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by flash column on silica gel eluting with PE/EA (v/v = 6/1 to 3/1) to give **BAB** (1.1 g, overall yield 52.5% of cascade coupling) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 1355.344$, found: *m/z* = 1355.690. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.46 – 7.27 (m, 10H), 6.65 (s, 2H), 5.26 (d, *J* = 2.8 Hz, 2H), 4.15 (d, *J* = 13.5 Hz, 2H), 3.91 (d, *J* = 13.5 Hz, 2H), 3.62 – 3.40 (m, 10H), 3.33 (dd, *J* = 20.9, 3.0 Hz, 4H), 2.98 – 2.47 (m, 11H), 2.32 (s, 3H), 1.74 – 1.18 (m, 40H), 0.89 (t, *J* = 6.8 Hz, 3H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.83, 174.78, 174.65, 174.39, 173.28, 173.20, 136.54, 136.46, 136.43, 129.23, 128.73, 127.68, 83.10, 82.53, 55.72, 55.24, 46.75, 46.28, 45.40, 39.52, 39.02, 36.31, 32.21, 32.05, 31.79, 31.51, 31.29, 30.64, 29.68, 29.31, 28.92, 28.67, 28.40, 28.16, 28.00, 27.24, 27.13, 26.09, 25.91, 22.50, 14.04.

Intermediate **BOB** was also rigorous characterized by sampling (~ 20 mg) before adding hexyl mercaptan, which was purified by flash column on silica gel eluting with PE/EA (v/v = 5/1 to 2/1): MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 1237.263$, found: *m/z* = 1237.567. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.53 – 7.27 (m, 10H), 6.65 (d, *J* = 0.4 Hz, 2H), 6.02 (s, 1H), 5.26 (d, *J* = 2.8 Hz, 1H), 4.14 (d, *J* = 13.5 Hz, 1H), 3.91 (d, *J* = 13.5 Hz, 1H), 3.51 (dt, *J* = 11.7, 7.2 Hz, 8H), 3.33 (dd, *J* = 21.0, 2.9 Hz, 4H), 2.95 – 2.78 (m, 5H), 2.73 – 2.50 (m, 4H), 2.32 (s, 3H), 1.68 – 1.19 (m, 32H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.92, 174.85, 174.81, 174.46, 174.43, 173.31, 173.23, 169.73, 168.01, 151.35, 136.54, 136.49, 136.43, 136.37, 139.23, 128.75, 127.72, 127.69, 83.11, 82.54, 55.74, 55.23, 46.29, 45.42, 39.54, 39.10, 38.89, 37.98, 36.37, 36.33, 31.85, 31.59, 30.66, 29.31, 28..94, 28.67, 28.18, 28.15, 28.02, 27.51, 27.26, 27.14, 26.22, 26.11, 25.98, 25.93.

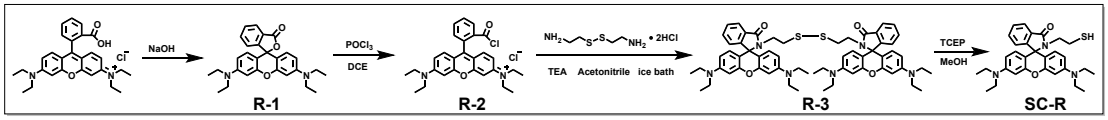
5.2.4 Synthetic route of fluorescent palindromic tetramers for anti-counterfeiting ink



Scheme S9. Synthetic route of side chain **SC-G**.[5]

G-1: To a solution of cystamine hydrochloride (1.5 g, 6.7 mmol) in 30 mL DCM at room temperature was added TEA (5.0 mL, 37.0 mmol) followed by 4-dimethylaminopyridine (DMAP, 3.7 g, 37 mmol). The reaction mixture was stirred for 30 minutes. Dansyl chloride (2.0 g, 7.4 mmol) was then added to the reaction mixture which was stirred for a further 16 hours. Then H_2O (50 mL) was added. The mixture was extracted with 3 x 40 mL DCM and the combined organic layers washed with 40 mL brine, dried with anhydrous Na_2SO_4 and concentrated in vacuo. The residue was purified by silica gel flash column eluting with PE/DCM/EA (v/v = 6/9/1) to afford **G-1** (2.15 g, 93.7%) as a green gum. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 8.55 (d, J = 8.5 Hz, 2H), 8.24 (m, 4H), 7.53 (m, 4H), 7.18 (d, J = 7.5 Hz, 2H), 5.30 (t, J = 6.2 Hz, 2H), 3.10 (q, J = 6.3 Hz, 4H), 2.89 (s, 12H), 2.49 (t, J = 6.4 Hz, 4H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 151.86, 134.51, 130.65, 129.85, 129.67, 129.51, 128.60, 123.26, 118.76, 115.38, 45.46, 41.64, 37.77.

SC-G: To a solution of dansyldisulfide **G-1** (1.0 g, 1.6 mmol) in 10 mL methanol at room temperature was added tris(2-carboxyethyl) phosphine hydrochloride (TCEP, 0.56 g, 1.9 mmol) under argon atmosphere. The reaction mixture was stirred and monitored by TLC. The mixture was then concentrated for the next reaction immediately.



Scheme S10. Synthetic route of side chain **SC-R**.[6]

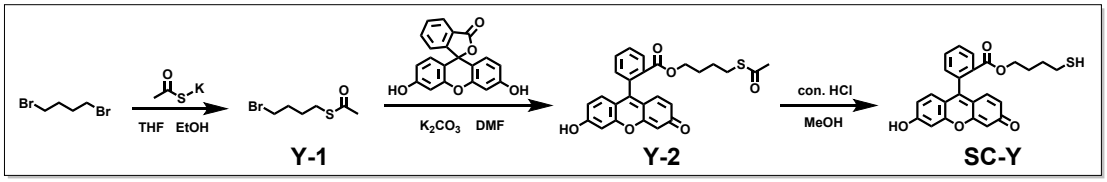
R-1: Rhodamine B salt (6.0 g, 12.5 mmol) was dissolved in 1 mol/L aqueous NaOH solution (400 mL) and stirred at room temperature for 2h. The mixture was then

extracted by 3 x 200 mL EA and the combined organic layers were washed once with 1 mol/L aqueous NaOH solution (400 mL) and then brine (400 mL). The organic solution was dried with Na_2SO_4, filtered and concentrated under reduce pressure to afford rhodamine B lactone **R-1** which is used as is in the next reaction.

R-2: To a solution of R-1 (12.5 mmol) mentioned above in anhydrous 1,2-dichloroethane (DCE, 45 mL) was added $POCl_3$ (4.5 mL, 49.5 mmol) dropwise over 5 min under stirring. The mixture solution was then heated at reflux for 4 h. After cooled to room temperature, the solvent was evaporated under reduced pressure to yield rhodamine B acyl chloride **R-2** which is used as is in the next reaction.

R-3: The crude rhodamine B acyl chloride **R-2** (12.5 mmol) was dissolved in acetonitrile (160 mL) and added dropwise to a solution of cystamine dihydrochloride (1.6 g, 7.0 mmol) in dry acetonitrile (80 mL) containing 11 mL of TEA over 1-1.5 h in an ice bath. After stirred for another 8 h, the solvent was removed under reduce pressure and the residue was redissolved in 100 mL DCM then washed with 2 x 100 mL water and 100 mL brine. The purple residue was dried in a vacuum oven and purified by column chromatography eluting with DCM/MeOH (v/v = 100/1 to 20/1), the first pink band was collected to afford **R-3** (4.14 g, overall yield 66.0%). ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.88 (m, 2H), 7.44 (dd, J = 5.2, 3.0 Hz, 4H), 7.08 (m, 2H), 6.34 (d, J = 8.6 Hz, 8H), 6.17 (d, J = 7.7 Hz, 4H), 3.24 (m, 20H), 2.25 (m, 4H), 1.12 (t, J = 6.7 Hz, 24H).

SC-R: To a solution of rhodamine B disulfide **R-3** (500 mg, 0.5 mmol) in 10 mL methanol at room temperature was added TCEP (180 mg, 0.6 mmol) under argon atmosphere. The reaction mixture was stirred and monitored by TLC. The mixture was then concentrated for the next reaction immediately.



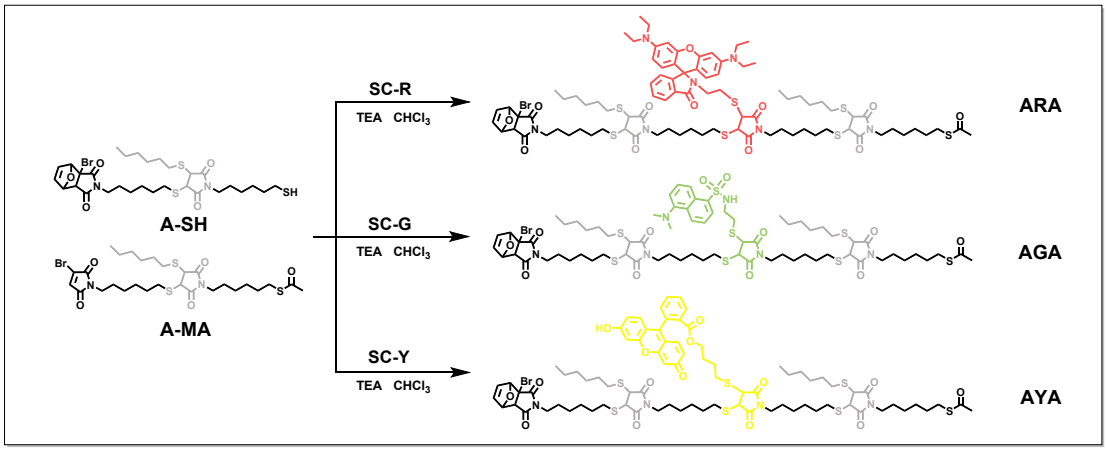
Scheme S11. Synthetic route of side chain **SC-Y**.

Y-1:[7] Potassium thioacetate (1.0 g, 8.8 mmol) was dissolved in ethanol (10 mL) and

the mixture was dropwise added into the solution of 1,4-dibromobutane (3.8 g, 17.5 mmol) in 20 mL THF under argon atmosphere. After stirred for 12 h, H_2O (50 mL) was added and the mixture was extracted with 3 x 30 mL EA, the combined organic layers were washed with brine and dried with Na_2SO_4, the solvent was evaporated under reduce pressure. The residue was purified by silica gel flash column eluting with PE/EA (v/v = 10/1 to 5/1) to afford **Y-1** (1.1 g, 59.5%). ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 3.41 (t, *J* = 6.6 Hz, 2H), 2.90 (t, *J* = 7.1 Hz, 2H), 2.33 (s, 3H), 1.93 (m, 2H), 1.74 (m, 2H).

Y-2:[8] To a 100 mL round-bottom flask equipped with a condenser was added **Y-1** (1.1 g, 5.2 mmol), fluorescein (2.6 g, 7.8 mmol) and potassium carbonate (1.4 g, 10.2 mmol) in 50 mL DMF under argon atmosphere. The mixture was diluted by 100 mL EA and washed with 3×50 mL saturated NH_4Cl (aq.) to remove DMF. The upper phase was collected and dried with anhydrous Na_2SO_4. The solvent was evaporated and the residue was purified by silica gel flash column eluting with DCM/MeOH (v/v = 80/1 to 15/1) to afford **Y-2** (1.4 g, 58.1%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 8.05 (d, *J* = 7.2 Hz, 1H), 7.65 (m, 2H), 7.16 (d, *J* = 6.5 Hz, 1H), 6.86 (s, 1H), 6.70 (ddd, *J* = 21.9, 10.0, 4.9 Hz, 5H), 4.00 (t, *J* = 4.9 Hz, 2H), 2.94 (t, *J* = 7.0 Hz, 2H), 2.34 (s, 3H), 1.81 (dd, *J* = 24.3, 6.2 Hz, 4H).

SC-Y: **Y-2** (460 mg, 1.0 mmol) was dissolved in 3 mL $CHCl_3$ and added to 15 mL in a 25 mL three-neck round-bottom flask equipped with a condenser under argon atmosphere. The mixture was heated to 55 ºC and then concentrated hydrochloric acid (0.68 mL, 0.82 mol) was added subsequently to the reaction system. The mixture was then turned red and stirred and refluxed at 55 ºC for about 10 h and monitored by ^{1}H NMR. After cooling to room temperature, the reaction was quenched with 20 mL water and extracted with DCM (2×20 mL). The organic layer was collected and washed with 200 mL water and then dried with anhydrous Na_2SO_4. The solvent was evaporated under vacuum to afford **SC-Y** (380 mg, 90.0%) as a dark yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 8.01 (d, *J* = 6.9 Hz, 1H), 7.64 (m, 2H), 7.15 (d, *J* = 7.3 Hz, 1H), 6.80 (s, 1H), 6.65 (m, 5H), 4.00 (t, *J* = 5.9 Hz, 2H), 2.62 (dt, *J* = 14.5, 7.4 Hz, 2H), 1.89 (m, 4H).



Scheme S12. Synthetic route of fluorescent palindromic tetramers (**ARA**, **AGA** and **AYA**) via CTMMC-integrated IEG.

General procedure: **A-MA** (330 mg, 0.5 mmol) was dissolved in 5 mL $CHCl_3$ with TEA (250 μL, 1.8 mmol) in a three-neck round-bottom flask. A solution of **A-SH** (410 mg, 0.6 mmol) in 5 mL $CHCl_3$ was added dropwise to the stirred mixture using syringe under argon atmosphere (TLC indicated the 1st Michael coupling was completed). A mixture of TEA (420 μL, 3.0 mmol) and thiol-containing fluorescent side chain (1.0 mmol of **SC-R**, **SC-G** or **SC-Y**, respectively) dissolved in 3.0 mL MeOH and diluted with 5.0 mL $CHCl_3$ was then added. The mixture was stirred at 25ºC for 18 h and quenched with 20.0 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (20.0 mL) and brine (20.0 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by prep-SEC to afford pure fluorescent palindromic tetramers.

ARA (spirocyclic form): 460 mg (overall yield 51.9% of CTMMC) after separated by prep-SEC. MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 1726.602$, found: $m/z = 1726.796$. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.90 (s, 1H), 7.44 (s, 2H), 7.08 (s, 1H), 6.65 (s, 2H), 6.40 (dd, $J = 38.5, 14.8$ Hz, 6H), 5.26 (s, 2H), 3.40 (dd, $J = 37.6, 12.4$ Hz, 24H), 2.79 (m, 13H), 2.60 (s, 2H), 2.31 (s, 3H), 1.44 (m, 48H), 1.22 (s, 12H), 0.89 (s, 6H).^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.89, 174.63, 174.39, 173.30, 173.21, 168.06, 153.45, 153.22, 148.85, 136.53, 132.52, 130.91, 128.87, 128.09, 123.77, 122.92, 108.19, 105.32, 97.69, 83.09, 82.53, 64.66, 55.73, 55.21, 46.95, 46.77, 46.34, 44.36, 39.53, 39.05, 32.18, 32.06, 31.98, 31.29, 31.07, 30.63, 30.31, 29.29, 28.97,

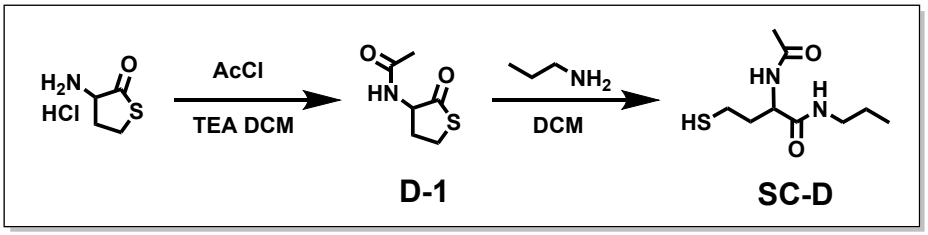
28.93, 28.86, 28.79, 28.74, 28.51, 28.40, 28.25, 28.17, 28.06, 27.25, 27.14, 26.18, 26.08, 25.96, 22.49, 14.02, 12.61.

ARA (ring-open form): Treated with TFA in MeOH or DMF. MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 1704.619$, found: $m/z = 1704.759$.

AGA: 450 mg (overall yield 56.9% of CTMMC) after separated by prep-SEC. MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 1535.438$, found: $m/z = 1535.711$. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 8.60 (d, J = 7.6 Hz, 1H), 8.30 (dd, J = 22.7, 7.6 Hz, 2H), 7.57 (q, J = 8.4 Hz, 2H), 7.23 (d, J = 7.3 Hz, 1H), 6.65 (s, 2H), 5.81 (s, 1H), 5.26 (s, 2H), 3.49 (m, 12H), 3.33 (d, J = 15.2 Hz, 2H), 3.24 (m, 2H), 2.78 (m, 19H), 2.31 (s, 3H), 1.49 (m,47H), 0.89 (t, J = 6.8 Hz, 6H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.91, 1174.94, 174.66, 174.06, 173.30, 173.23, 136.54, 136.46, 134.91, 130.44, 129.67, 129.60, 129.55, 128.37, 123.46, 115.49, 83.09, 82.53, 55.72, 55.22, 46.97, 46.77, 45.55, 42.75, 39.52, 39.21, 39.05, 39.01, 38.85, 37.07, 33.30, 32.72, 32.20, 32.17, 32.10, 31.99, 31.92, 31.29, 30.63, 30.02, 29.68, 29.29, 28.97, 28.92, 28.74, 28.40, 28.16, 28.06, 27.25, 27.20, 27.13, 26.07, 25.95, 24.44, 22.68, 22.49, 14.02.

AYA: 370 mg (overall yield 43.7% of CTMMC) after separated by prep-SEC. MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 1645.460$, found: $m/z = 1645.365$. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 8.02 (d, J = 7.3 Hz, 1H), 7.64 (m, 2H), 7.17 (d, J = 7.3 Hz, 1H), 6.78 (d, J = 9.6 Hz, 2H), 6.62 (m, 6H), 5.26 (s, 2H), 4.03 (d, J = 4.2 Hz, 2H), 3.50 (m, 14H), 2.76 (m, 15H), 2.32 (s, 3H), 1.91 (s, 2H), 1.47 (m, 50H), 0.88 (t, J = 6.2 Hz, 6H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 196.15, 174.80, 174.77, 174.74, 174.72, 174.61, 174.54, 173.38, 173.30, 173.23, 169.58, 160.62, 158.30, 152.49, 136.53, 136.46, 134.98, 129.66, 129.36, 129.10, 126.84, 125.50, 125.04, 124.00, 112.45, 111.94, 111.28, 111.05, 103.02, 101.42, 101.40, 83.09, 82.53, 67.50, 55.73, 55.19, 46.79, 39.56, 39.07, 32.23, 32.18, 32.01, 31.29, 30.65, 30.32, 29.28, 28.98, 28.94, 28.79, 28.74, 28.40, 28.17, 28.13, 28.05, 27.25, 27.14, 26.13, 26.07, 25.95, 22.49, 14.03.

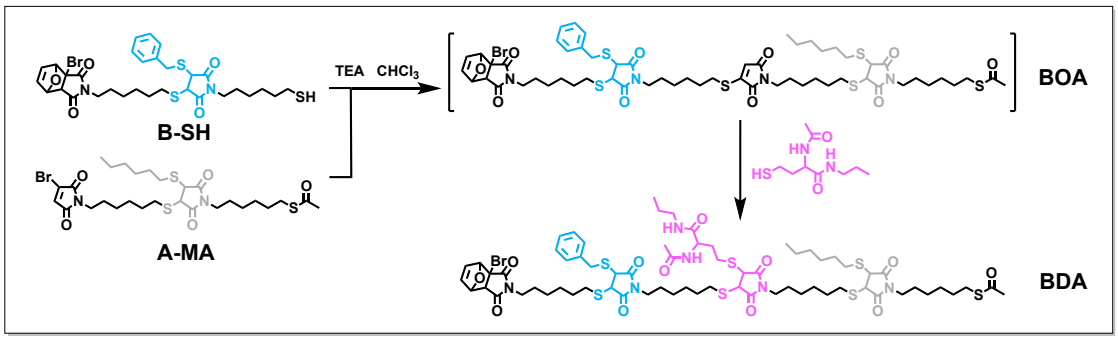
5.3 Synthetic route of tetramer **BDA** using cross IEG



Scheme S13. Synthetic route of side chain **SC-D**.

D-1: To a 500 mL two-neck round-bottom flask equipped with a 50 mL slow-addition apparatus were added DL-Homocysteinethiolactone hydrochloride (15.3 g, 0.10 mol), TEA (66.6 mL, 0.48 mol) and 250 mL DCM. Acetyl chloride (14.1 mL, 0.20 mol) was dropped into tie stirred mixture at 0 ºC in 30 minutes. Then the reaction was moved to room temperature and stirred for 4h. The insoluble substance was filtered and the filtrate was washed with 2×250 mL brine. The organic phase was dried with anhydrous Na_2SO_4 and the solvent was evaporated, and the crude product was purified by silica gel flash column eluting with EA to afford **D-1** (7.7 g, yield: 48.6%) as a white solid. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.04 (s, 1H), 4.53 (dt, *J* = 12.9, 6.5 Hz, 1H), 3.32 (dtd, *J* = 17.6, 11.4, 6.0 Hz, 2H), 3.03 – 2.85 (m, 1H), 2.05 (s, 3H), 1.92 (dd, *J* = 12.5, 7.0 Hz, 1H).

SC-D: **D-1** (7.7 g, 48.4 mmol) was dissolved in 40.0 mL DCM in a 50.0 mL round-bottom flask and stirred at room temperature until TLC monitored the reaction was complete. The solvent was evaporated and the residue was purified by silica gel flash column eluting with DCM/MeOH (v/v = 30/1) to afford **SC-D** (8.7 g, yield: 82.4%) as a white powder. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.47 (d, *J* = 6.9 Hz, 2H), 4.62 (dd, *J* = 14.2, 7.9 Hz, 1H), 3.30 – 3.12 (m, 2H), 2.69 – 2.44 (m, 2H), 2.12 – 1.87 (m, 5H), 1.64 – 1.46 (m, 3H), 0.93 (t, *J* = 7.4 Hz, 3H).



Scheme S14. Synthetic route of **BDA** via CTMMC-integrated cross IEG.

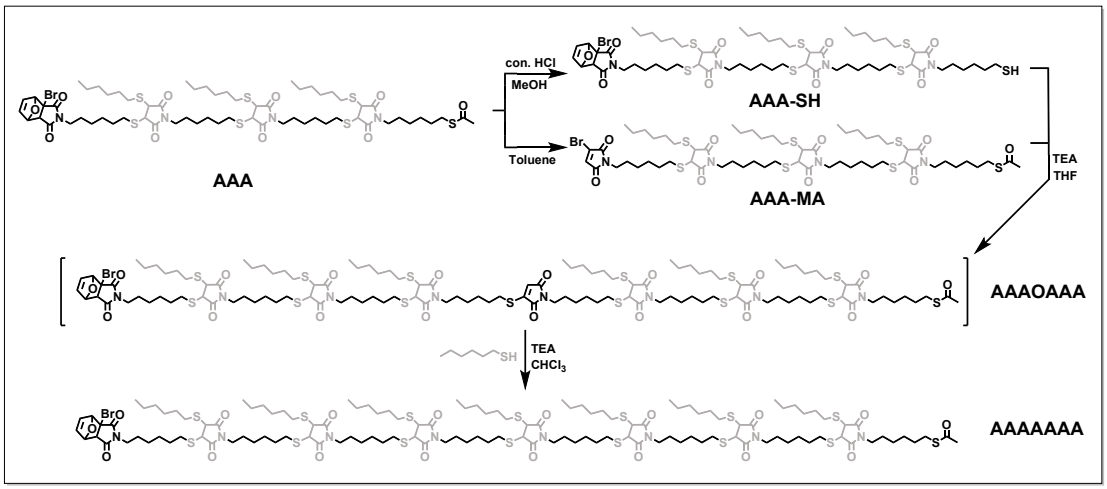
BDA: **A-MA** and **B-SH** precursors to **BDA** were prepared using the procedures described in section 5.2.1 and 5.2.3.

A-MA (98 mg, 0.15 mmol) was dissolved in 2 mL $CHCl_3$, TEA (75 μL, 0.54 mmol) was added subsequently at 25 ºC. After that, a solution of **B-SH** (122 mg, 0.18 mmol) in 3 mL $CHCl_3$ was added dropwise to the stirred mixture under argon atmosphere (TLC indicated the 1st Michael coupling was completed). A mixture of TEA (125 μL, 0.9 mmol) and **SC-D** (66 mg, 0.3 mmol) dissolved in 3.0 mL $CHCl_3$ was then added. The mixture was stirred at 25ºC for 12 h and quenched with 5 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (5 mL) and brine (5 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by flash column on silica gel eluting with PE/EA (v/v = 1/1 to 1/3) to give **BDA** (113 mg, overall yield 51.2% of cascade coupling) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+$ = 1449.418, found: *m/z* = 1449.640. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.35 (m, 5H), 6.65 (m, 4H), 5.26 (d, *J* = 2.6 Hz, 2H), 4.68 (d, *J* = 29.0 Hz, 1H), 4.13 (dd, *J* = 12.0, 7.8 Hz, 1H), 3.92 (dd, *J* = 13.3, 6.8 Hz, 1H), 3.49 (m, 12H), 3.37 (t, *J* = 2.5 Hz, 1H), 3.30 (t, *J* = 2.5 Hz, 1H), 3.25 (m, 2H), 2.71 (m, 13H), 2.32 (s, 3H), 2.13 (d, *J* = 13.2 Hz, 2H), 2.08 (s, 3H), 1.45 (m, 22H), 0.91 (m, 6H).

5.3 Synthesis of palindromic octamers via CTMMC-integrated IEG

Due to the lowered reactivity of Br group (chain end) or maleimide (O) group (in the middle of the chain) during the elongation of the main chain, CTMMC for octamers shown less efficient than the tetramer. To improve the yield and alleviate the purification process, we applied THF instead of $CHCl_3$ in the 1st TMMC, and the intermediates were purified.

5.3.1 Synthetic route of palindromic octamer **AAAAAAA**



Scheme S15. Synthetic route of **AAAAAAA** via CTMMC-integrated IEG.

AAA-MA: AAA (2.1 g, 1.5 mmol) was dissolved in 100 mL of toluene in a 250 mL round-bottom flask. The mixture was stirred at 110 ºC for about 14 h. ^{1}H NMR and TLC showed the reaction was complete. Toluene was evaporated under vacuum after the mixture was cooled to room temperature to afford the product **AAA-MA** (1.7 g, yield 85.1%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.86 (s, 1H), 3.63 – 3.46 (m, 8H), 3.44 (s, 6H), 2.96 – 2.64 (m, 15H), 2.32 (s, 3H), 1.80 – 1.13 (m, 56H), 0.89 (t, J = 6.7 Hz, 9H).

AAA-SH: AAA (2.5 g, 1.8 mmol) was dissolved in 30.0 mL $CHCl_3$ and diluted with 90.0 mL MeOH in a 250 mL three-neck round-bottom flask equipped with a condenser under argon atmosphere. The mixture was heated to 55 ºC and then concentrated hydrochloric acid (3.7 mL, 44.4 mmol) was added dropwise to the reaction system. The mixture was stirred and refluxed at 55 ºC for about 16 h and monitored by TLC and ^{1}H

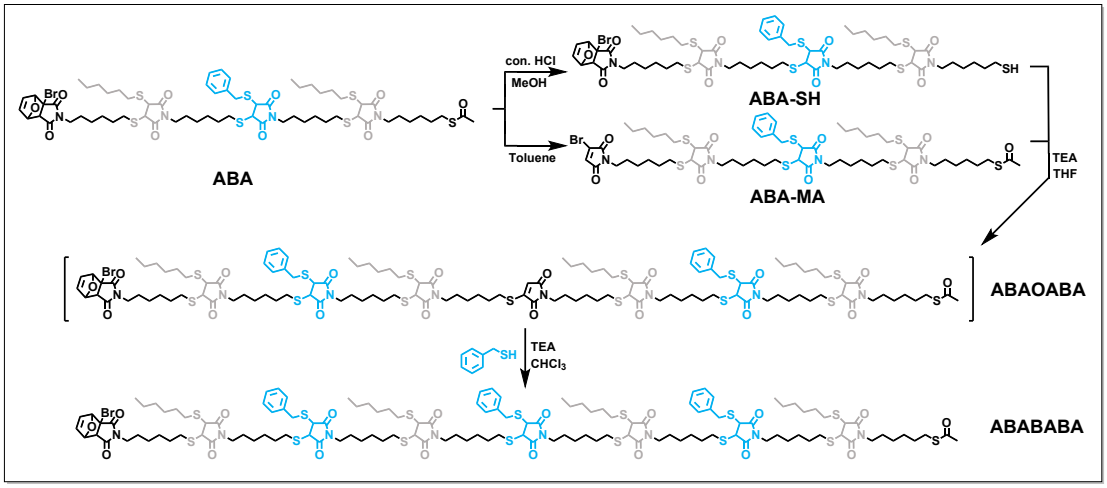
NMR. After cooling to room temperature, the reaction was quenched with 100 mL water and extracted with DCM (2×50.0 mL). The organic layer was combined and washed with 50.0 mL water and then dried with anhydrous Na_2SO_4. The solvent was evaporated under vacuum to afford **AAA-SH** (2.3 g, yield 95.0%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 2H), 5.26 (d, *J* = 2.3 Hz, 2H), 3.52 (dd, *J* = 15.0, 7.6 Hz, 8H), 3.44 (s, 6H), 2.94 – 2.67 (m, 13H), 2.51 (dd, *J* = 14.6, 7.4 Hz, 2H), 1.79 – 1.16 (m, 56H), 0.89 (t, *J* = 6.7 Hz, 9H).

AAAOAAA: AAA-MA (1.7 g, 1.3 mmol) was dissolved in 25.0 mL anhydrous THF in a 100 mL three-neck round-bottom flask equipped with a 100 mL slow-addition apparatus. TEA (0.71 mL, 5.1 mmol) was added subsequently at 25 ºC. **AAA-SH** (2.3 g, 1.7 mmol) was dissolved in 50.0 mL anhydrous THF and added dropwise to the stirred solution under argon atmosphere. The mixture was filtered to remove the insoluble substance and the filter cake was washed with 2×20.0 mL anhydrous THF. The filtrate was concentrated and redissolved in 30.0 mL $CHCl_3$, then washed successively with saturated $NaHCO_3$ (30.0 mL), water (30.0 mL) and brine (30.0 mL). The organic layer was dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 5/1 to 3/2) to afford **AAAOAAA** (2.1 g, yield 63.1%) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+$ = 2541.950, found: *m/z* = 2542.200. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 2H), 6.02 (s, 1H), 5.26 (d, *J* = 2.1 Hz, 2H), 3.52 (dd, *J* = 15.3, 7.6 Hz, 16H), 3.44 (s, 12H), 2.94 – 2.63 (m, 29H), 2.32 (s, 3H), 1.63 (tt, *J* = 12.5, 6.1 Hz, 56H), 1.49 – 1.21 (m, 56H), 0.89 (t, *J* = 6.8 Hz, 18H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.88, 174.67, 173.29, 173.21, 169.71, 167.99, 151.35, 136.53, 136.49, 117.21, 83.10, 82.53, 55.75, 55.22, 46.75, 39.54, 39.02, 38.86, 37.98, 31.30, 28.99, 28.15, 27.15, 25.97, 22.50, 14.03.

AAAAAAA: To a 50.0 mL three-neck round-bottom flask were added **AAAOAAA** (2.1 g, 0.81 mmol), TEA (3.4 mL, 24.3 mmol) and $CHCl_3$ (30.0 mL) under argon atmosphere. Hexyl mercaptan (1.2 mL, 8.1 mmol) was diluted by 4.0 mL $CHCl_3$ and added dropwise to the solution. The mixture was stirred at 25 ºC for 12 h and quenched with 50.0 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (50.0

mL) and brine (50.0 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 5/1 to 2/1) to afford the product **AAAAAAA** (1.3 g, yield 59.2%) as a yellow oil. MALDI-TOF MS calculated: [M – Furan + Na] $^+$ = 2660.031, found: *m/z* = 2660.401. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 6.65 (s, 2H), 5.26 (d, *J* = 2.2 Hz, 2H), 3.51 (t, *J* = 7.4 Hz, 16H), 3.44 (s, 14H), 2.94 – 2.63 (m, 31H), 2.32 (s, 3H), 1.75 – 1.50 (m, 60H), 1.35 (ddt, *J* = 10.7, 7.8, 5.2 Hz, 60H), 0.89 (t, *J* = 6.8 Hz, 21H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.88, 174.67, 173.29, 173.21, 169.71, 167.99, 151.35, 136.49, 117.21, 83.10, 82.53, 55.75, 55.22, 46.75, 39.54, 39.02, 38.86, 37.98, 32.22, 32.08, 31.60, 31.30, 30.64, 28.99, 28.80, 28.41, 28.15, 27.15, 26.26, 26.13, 25.97, 22.50, 14.03.

5.3.2 Synthetic route of palindromic octamer **ABABABA**



Scheme S16. Synthetic route of **ABABABA** via CTMMC-integrated IEG.

ABA-MA: ABA (2.8 g, 2.0 mmol) was dissolved in 80 mL of toluene in a 250 mL round-bottom flask. The mixture was stirred at 110 ºC for about 14 h. ^{1}H NMR and TLC showed the reaction was complete. Toluene was evaporated under vacuum after the mixture was cooled to room temperature to afford the product **ABA-MA** (2.3 g, yield 86.4%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.44 – 7.27 (m, 5H), 6.86 (s, 1H), 4.15 (d, J = 13.5 Hz, 1H), 3.91 (d, J = 13.5 Hz, 1H), 3.62 – 3.46 (m, 8H), 3.44 (s, 4H), 3.36 (d, J = 3.0 Hz, 1H), 3.29 (d, J = 2.9 Hz, 1H), 2.93 – 2.52 (m, 12H), 2.32 (s, 3H), 1.75 – 1.17 (m, 48H), 0.89 (t, J = 6.8 Hz, 6H).

ABA-SH: ABA (3.6 g, 2.6 mmol) was dissolved in 25.0 mL $CHCl_3$ and diluted with 110 mL MeOH in a 250 mL three-neck round-bottom flask equipped with a condenser under argon atmosphere. The mixture was heated to 60 ºC and then concentrated hydrochloric acid (5.4 mL, 64.8 mmol) was added dropwise to the reaction system. The mixture was stirred and refluxed at 60 ºC for about 16 h and monitored by TLC and ^{1}H NMR. After cooling to room temperature, the reaction was quenched with 100 mL water and extracted with DCM (2×50.0 mL). The organic layer was combined and washed with 50.0 mL water and then dried with anhydrous Na_2SO_4. The solvent was evaporated under vacuum to afford **ABA-SH** (3.2 g, yield 91.6%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.49 – 7.27 (m, 5H), 6.65 (s, 2H), 5.26 (d, J = 2.6 Hz, 2H), 4.15 (d, J = 13.5 Hz, 1H), 3.91 (d, J = 13.5 Hz, 1H), 3.52 (dt, J = 10.4, 7.1 Hz, 8H), 3.44 (s, 4H), 3.33 (dd, J = 21.1, 2.9 Hz, 2H), 2.95 – 2.67 (m, 13H), 2.51 (dd, J =

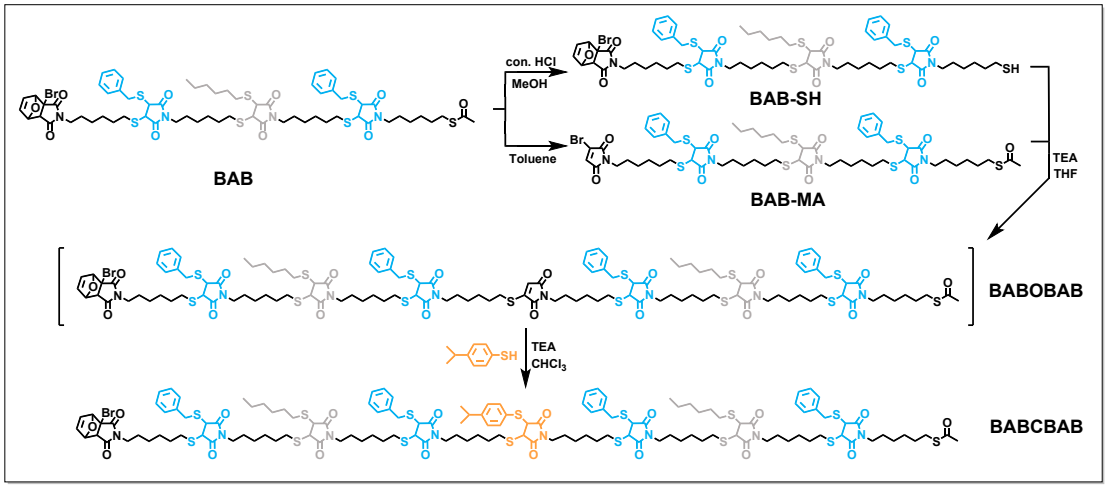
14.6, 7.4 Hz, 2H), 1.73 – 1.16 (m, 48H), 0.89 (t, *J* = 6.8 Hz, 6H).

ABAOABA: ABA-MA (2.3 g, 1.7 mmol) was dissolved in 25.0 mL anhydrous THF in a 100 mL three-neck round-bottom flask equipped with a 100 mL slow-addition apparatus. TEA (0.71 mL, 5.1 mmol) was added subsequently at 25 ºC. **ABA-SH** (3.2 g, 2.4 mmol) was dissolved in 50.0 mL anhydrous THF and added dropwise to the stirred solution under argon atmosphere. The mixture was filtered to remove the insoluble substance and the filter cake was washed with 2×30.0 mL anhydrous THF. The filtrate was concentrated and redissolved in 50.0 mL $CHCl_3$, then washed successively with saturated $NaHCO_3$ (30.0 mL), water (30.0 mL) and brine (30.0 mL). The organic layer was dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 5/1 to 3/2) to afford **ABAOABA** (2.2 g, yield 49.0%) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 2553.856$, found: *m/z* = 2554.507. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.34 (dq, *J* = 8.7, 7.2 Hz, 10H), 6.65 (s, 2H), 6.02 (s, 1H), 5.26 (d, *J* = 2.5 Hz, 2H), 4.15 (d, *J* = 13.5 Hz, 2H), 3.91 (d, *J* = 13.5 Hz, 2H), 3.51 (t, *J* = 12.1 Hz, 16H), 3.44 (s, 8H), 3.33 (dd, *J* = 21.1, 2.9 Hz, 4H), 2.96 – 2.48 (m, 25H), 2.32 (s, 3H), 1.78 – 1.22 (m, 96H), 0.89 (t, *J* = 6.7 Hz, 12H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.90, 174.80, 174.67, 174.40, 173.30, 173.22, 169.71, 167.99, 151.35, 136.53, 136.48, 136.41, 129.22, 128.74, 127.69, 117.20, 83.10, 82.53, 55.74, 55.21, 46.75, 46.29, 45.39, 39.53, 39.04, 37.97, 36.33, 32.22, 32.10, 32.03, 31.85, 31.59, 31.29, 30.64, 29.68, 29.29, 28.73, 28.40, 28.17, 28.15, 28.09, 27.25, 27.15, 26.25, 26.09, 25.96, 22.49, 14.02.

ABABABA: To a 50.0 mL three-neck round-bottom flask were added **ABAOABA** (0.67 g, 0.26 mmol), TEA (0.6 mL, 4.3 mmol) and $CHCl_3$ (25.0 mL) under argon atmosphere. Benzyl mercaptan (0.1 mL, 0.85 mmol) was diluted by 5.0 mL $CHCl_3$ and added dropwise to the solution. The mixture was stirred at 25 ºC for 18 h and quenched with 30.0 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (20.0 mL) and brine (20.0 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 3/1) to afford the product **ABABABA** (0.38 g, yield 54.1%) as a yellow oil.

MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 2677.891$, found: $m/z = 2678.046$. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.45 – 7.28 (m, 15H), 6.65 (s, 2H), 5.26 (d, J = 2.6 Hz, 2H), 4.15 (d, J = 13.5 Hz, 3H), 3.91 (d, J = 13.5 Hz, 3H), 3.50 (t, J = 7.1 Hz, 16H), 3.44 (s, 8H), 3.36 (d, J = 3.0 Hz, 3H), 3.29 (d, J = 2.9 Hz, 3H), 2.73 (m, 25H), 2.31 (s, 3H), 1.76 – 1.19 (m, 96H), 0.89 (t, J = 6.8 Hz, 12H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.91, 174.81, 174.68, 174.42, 173.31, 173.23, 136.53, 136.49, 136.42, 129.23, 128.75, 127.70, 83.11, 82.54, 55.75, 55.22, 46.77, 46.75, 46.29, 45.40, 39.54, 39.05, 36.34, 32.23, 32.08, 32.04, 31.92, 31.87, 31.51, 31.31, 30.64, 30.31, 30.19, 30.14, 29.69, 29.36, 29.31, 29.00, 28.80, 28.73, 28.42, 28.15, 28.10, 27.26, 26.14, 26.10, 25.96, 22.69, 22.51, 14.44, 14.13, 14.04.

5.3.3 Synthetic route of palindromic octamer **BABCBAB**



Scheme S17. Synthetic route of **BABCBAB** via CTMMC-integrated IEG.

BAB-MA: BAB (0.17 g, 0.12 mmol) was dissolved in 25 mL of toluene in a 50 mL round-bottom flask. The mixture was stirred at 110 ºC for about 14 h. ^{1}H NMR and TLC showed the reaction was complete. Toluene was evaporated under vacuum after the mixture was cooled to room temperature to afford the product **BAB-MA** (0.15 g, yield 95.0%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.53 – 7.27 (m, 10H), 6.86 (s, 1H), 4.15 (d, J = 13.5 Hz, 2H), 3.91 (d, J = 13.5 Hz, 2H), 3.53 (dt, J = 14.4, 7.0 Hz, 8H), 3.44 (s, 2H), 3.36 (d, J = 2.9 Hz, 2H), 3.29 (d, J = 2.9 Hz, 2H), 2.91 – 2.51 (m, 10H), 2.32 (s, 3H), 1.74 – 1.18 (m, 40H), 0.89 (t, J = 6.8 Hz, 3H).

BAB-SH: BAB (0.21 g, 0.14 mmol) was dissolved in 5.0 mL $CHCl_3$ and diluted with 30 mL MeOH in a 50 mL three-neck round-bottom flask equipped with a condenser under argon atmosphere. The mixture was heated to 60 ºC and then concentrated hydrochloric acid (0.40 mL, 4.8 mmol) was added dropwise to the reaction system. The mixture was stirred and refluxed at 60 ºC for about 16 h and monitored by TLC and ^{1}H NMR. After cooling to room temperature, the reaction was quenched with 50 mL water and extracted with DCM (2×30.0 mL). The organic layer was combined and washed with 30.0 mL water and then dried with anhydrous Na_2SO_4. The solvent was evaporated under vacuum to afford **BAB-SH** (0.19 g, yield 92.3%) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$, ppm): δ 7.34 (dq, J = 8.7, 7.1 Hz, 10H), 6.64 (s, 2H), 5.26 (d, J = 2.9 Hz, 2H), 4.14 (d, J = 13.5 Hz, 2H), 3.91 (d, J = 13.5 Hz, 2H), 3.51 (dd, J = 15.5, 7.5 Hz, 8H), 3.44 (s, 2H), 3.36 (d, J = 2.9 Hz, 2H), 3.29 (d, J = 2.9 Hz, 2H), 2.93 – 2.56 (m,

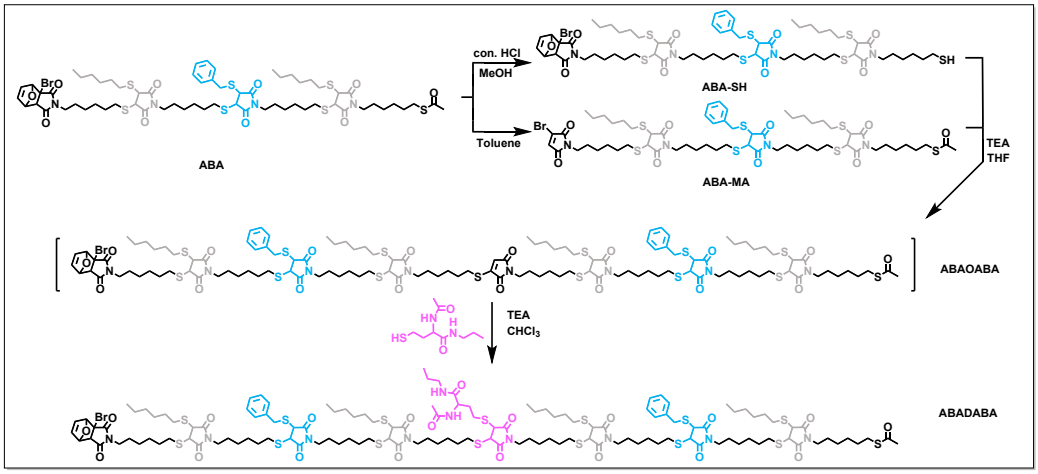
9H), 2.51 (dd, *J* = 14.7, 7.4 Hz, 2H), 1.74 – 1.18 (m, 40H) , 0.89 (t, *J* = 6.8 Hz, 3H).

BABOBAB: BAB-MA (0.15 g, 0.11 mmol) was dissolved in 10.0 mL anhydrous THF in a 100 mL three-neck round-bottom flask. TEA (0.6 mL, 4.3 mmol) was added subsequently at 25 ºC. **BAB-SH** (0.18 g, 2.4 mmol) was dissolved in 20.0 mL anhydrous THF and added dropwise to the stirred solution under argon atmosphere. The mixture was concentrated and redissolved in 10.0 mL $CHCl_3$, then washed successively with saturated $NaHCO_3$ (10.0 mL), water (10.0 mL) and brine (10.0 mL). The organic layer was dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 5/1 to 3/2) to afford **BABOBAB** (0.15 g, yield 52.0%) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+$ = 2565.762, found: *m/z* = 2565.774. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.46 – 7.27 (m, 20H), 6.64 (s, 2H), 6.02 (s, 1H), 5.26 (d, *J* = 2.9 Hz, 2H), 4.15 (d, *J* = 13.5 Hz, 4H), 3.91 (d, *J* = 13.5 Hz, 4H), 3.58 – 3.46 (m, 16H), 3.44 (s, 4H), 3.33 (dd, *J* = 20.8, 2.9 Hz, 8H), 2.96 – 2.51 (m, 21H), 2.32 (s, 3H), 1.71 – 1.21 (m, 80H), 0.89 (t, *J* = 7.0 Hz, 6H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.93, 174.81, 174.68, 174.42, 173.31, 173.23, 169.72, 169.66, 168.00, 151.35, 136.53, 136.48, 136.41, 129.22, 128.74, 127.69, 83.10, 82.53, 55.74, 55.21, 46.76, 46.29, 45.40, 39.54, 39.04, 37.98, 36.33, 32.22, 32.07, 31.90, 31.61, 31.42, 31.30, 30.64, 30.30, 30.18, 29.68, 29.30, 28.98, 28.71, 28.41, 28.14, 28.02, 27.51, 27.25, 27.14, 26.10, 25.93, 22.68, 22.50, 14.43, 14.12, 14.03.

BABCBAB: To a 25.0 mL three-neck round-bottom flask were added **BABOBAB** (0.07 g, 0.027 mmol), TEA (0.3 mL, 2.2 mmol) and $CHCl_3$ (6.0 mL) under argon atmosphere. Then p-isopropyl thiophenol (Side chain **C**, 0.1 mL, 0.64 mmol) was diluted by 0.50 mL $CHCl_3$ and added dropwise to the solution. The mixture was stirred at 25 ºC for 18 h and quenched with 10.0 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (10.0 mL) and brine (10.0 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 4/1 to 2/1) to afford the product **BABCBAB** (0.04 g, yield 54.0%) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+$ = 2717.828, found: *m/z* = 2718.203. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.48 – 7.27

(m, 22H), 7.20 (d, J = 8.1 Hz, 2H), 6.64 (s, 2H), 5.26 (d, J = 2.8 Hz, 2H), 4.15 (d, J = 13.5 Hz, 4H), 3.91 (d, J = 13.5 Hz, 4H), 3.67 (dd, J = 26.7, 2.9 Hz, 2H), 3.50 (dd, J = 11.5, 4.8 Hz, 16H), 3.44 (s, 4H), 3.33 (dd, J = 20.4, 2.2 Hz, 8H), 2.95 – 2.51 (m, 22H), 2.32 (s, 3H), 1.71 – 1.15 (m, 86H), 0.89 (t, J = 6.9 Hz, 6H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.93, 174.81, 174.67, 174.42, 173.48, 173.23, 150.92, 136.48, 136.41, 135.11, 129.23, 128.74, 127.69, 83.10, 82.53, 55.74, 55.21, 51.92, 46.91, 46.76, 46.29, 45.40, 39.54, 39.05, 36.33, 34.86, 34.52, 33.86, 32.23, 32.08, 31.86, 31.43, 31.30, 30.64, 30.30, 30.18, 29.69, 29.31, 28.99, 28.80, 28.72, 28.41, 28.11, 27.26, 27.15, 26.11, 25.93, 23.81, 22.68, 22.50, 14.03.

5.3.4 Synthetic route of palindromic octamer **ABADABA**



Scheme S18. Synthetic route of **ABADABA** via CTMMC-integrated IEG.

The intermediate **ABAOABA** were prepared using the procedures described in section 5.3.2.

ABADABA: To a 25.0 mL three-neck round-bottom flask were added **ABAOABA** (0.24 g, 0.092 mmol), TEA (0.1 mL, 0.72 mmol) and $CHCl_3$ (10.0 mL) under argon atmosphere. Then **SC-D** (0.04 mg, 0.18 mmol) was dissolved in 3.0 mL $CHCl_3$ and added dropwise to the solution. The mixture was stirred at 25 ºC for 12 h and quenched with 10.0 mL saturated $NaHCO_3$ (aq.). The organic layer was washed with water (10.0 mL) and brine (10.0 mL), then dried with anhydrous Na_2SO_4 and concentrated under vacuum. The crude product was purified by silica gel flash column eluting with PE/EA (v/v = 1/3) to afford the product **ABADABA** (0.11 g, yield 42.3%) as a yellow oil. MALDI-TOF MS calculated: $[M - Furan + Na]^+ = 2771.965$, found: $m/z = 2772.322$. ^1H NMR (300 MHz, $CDCl_3$, ppm): δ 7.44 – 7.27 (m, 10H), 6.86 – 6.60 (m, 4H), 5.26 (d, J = 2.4 Hz, 2H), 4.63 (d, J = 32.3 Hz, 1H), 4.15 (d, J = 13.5 Hz, 4H), 3.91 (d, J = 13.4 Hz, 4H), 3.50 (t, J = 7.2, 16H), 3.46 – 3.43 (m, 10H), 3.33 (dd, J = 21.2, 2.9 Hz, 4H), 3.24 (s, 2H), 2.96 – 2.48 (m, 27H), 2.32 (s, 3H), 2.15 (s, 2H), 2.05 (s, 3H), 1.77 – 1.20 (m, 98H), 0.97 – 0.86 (m, 15H). ^{13}C NMR (75 MHz, $CDCl_3$, ppm): δ 195.91, 174.81, 174.68, 174.42, 173.31, 173.23, 136.54, 136.42, 129.23, 128.75, 127.70, 83.11, 82.54, 55.75, 55.22, 46.78, 46.31, 45.42, 39.54, 39.06, 36.34, 32.23, 32.08, 31.87, 31.30, 30.65, 29.69, 29.30, 28.99, 28.80, 28.75, 28.42, 28.15, 27.26, 27.15, 26.11, 25.97, 22.64, 22.50, 14.03, 11.41.

SECTION B. Supplementary Figures

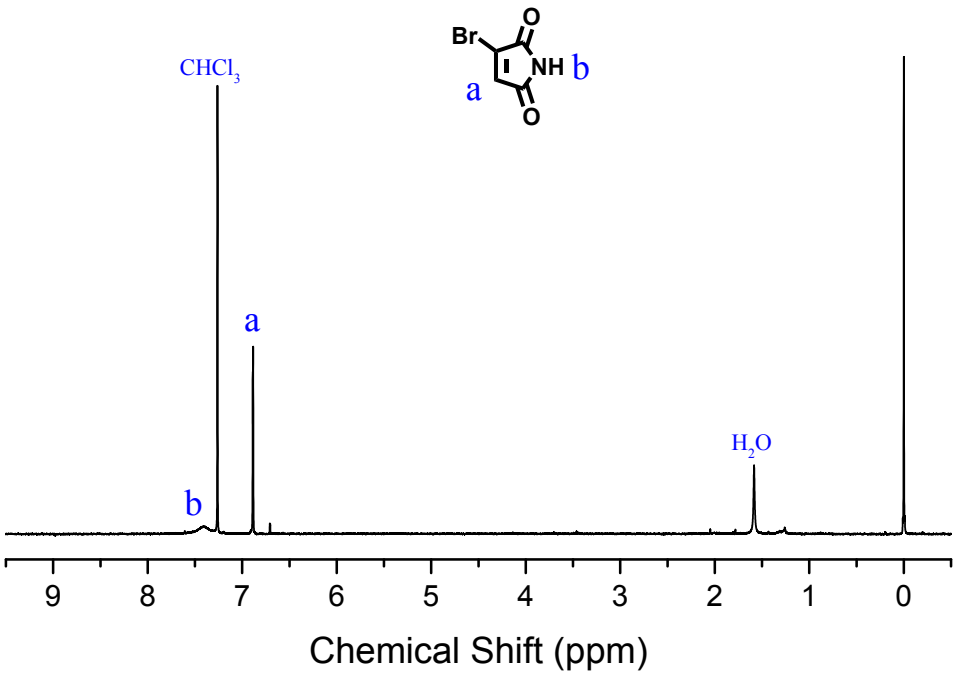


Figure S4. ^{1}H NMR spectrum of compound **M-2** in $CDCl_3$ (Bruker, 300 MHz, TMS)

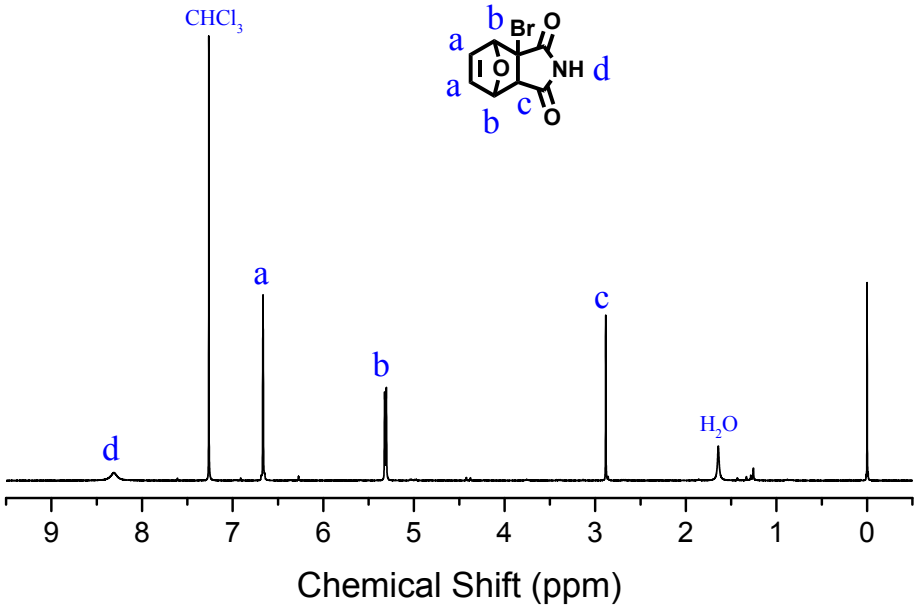


Figure S5. ^{1}H NMR spectrum of compound **M-3** in $CDCl_3$ (Bruker, 300 MHz, TMS)

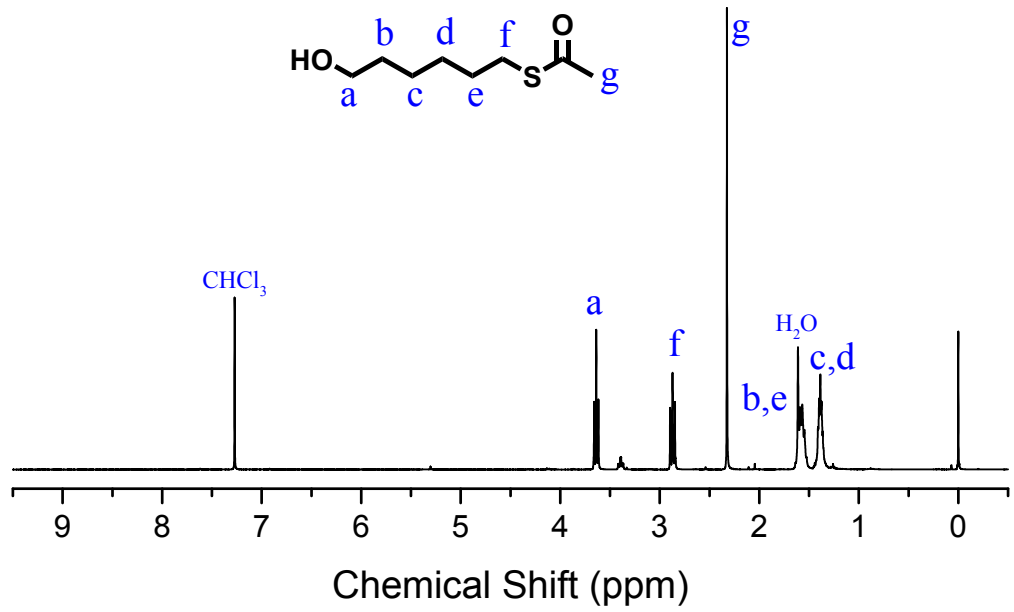


Figure S6. ^{1}H NMR spectrum of compound **S-1** in $CDCl_3$ (Bruker, 300 MHz, TMS)

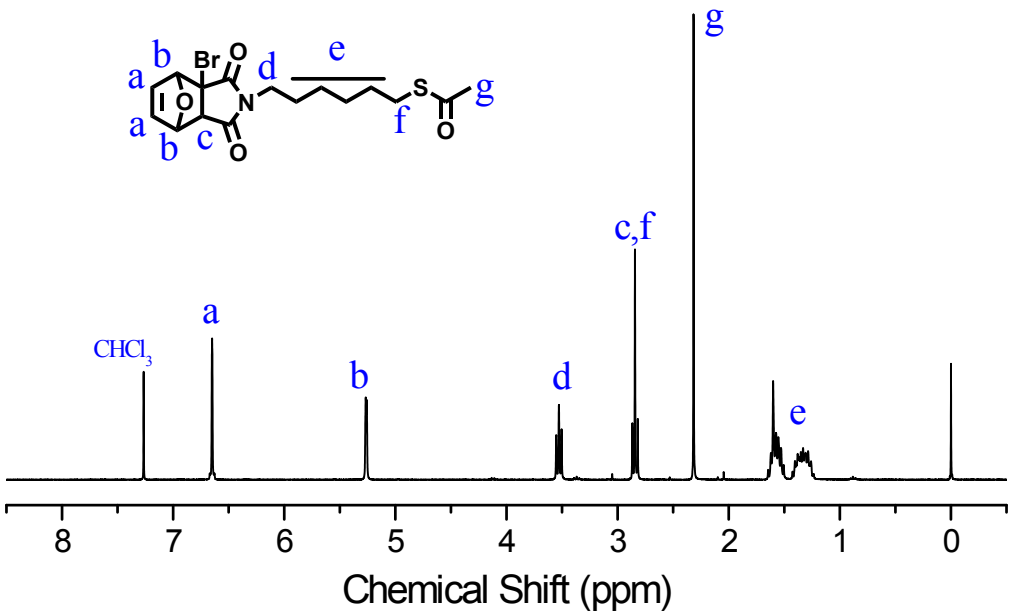


Figure S7. ^{1}H NMR spectrum of **monomer 1** in $CDCl_3$ (Bruker, 300 MHz, TMS)

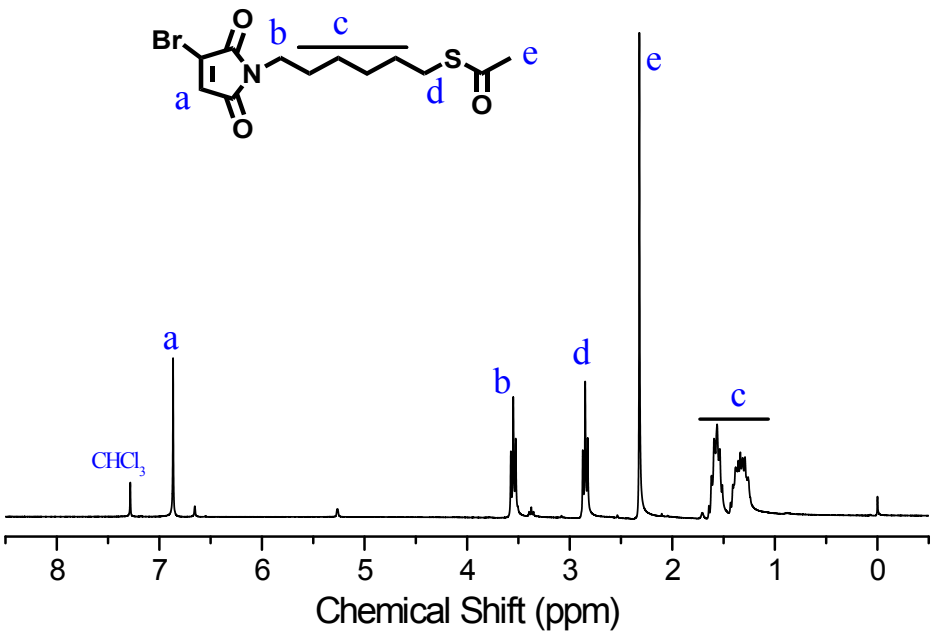


Figure S8. ^{1}H NMR spectrum of compound **1-MA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

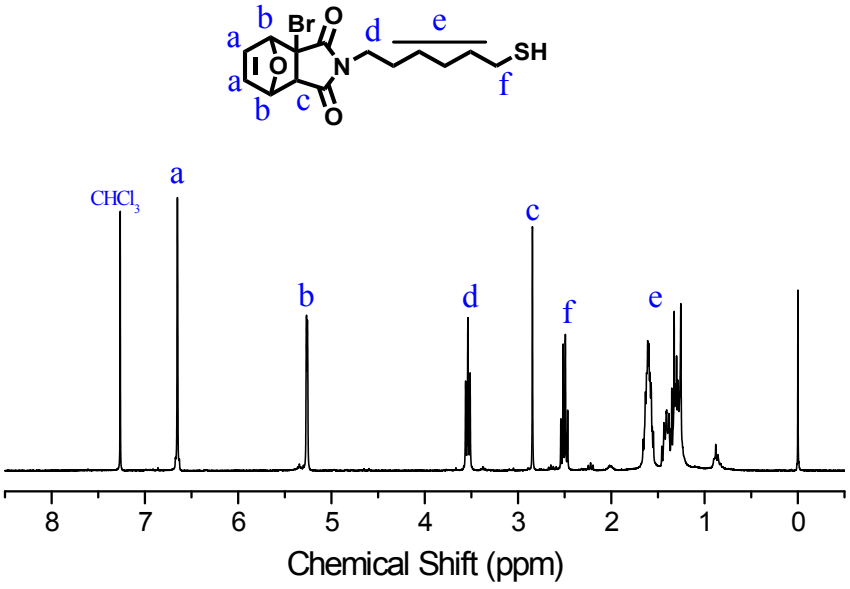


Figure S9. ^{1}H NMR spectrum of compound **1-SH** in $CDCl_3$ (Bruker, 300 MHz, TMS)

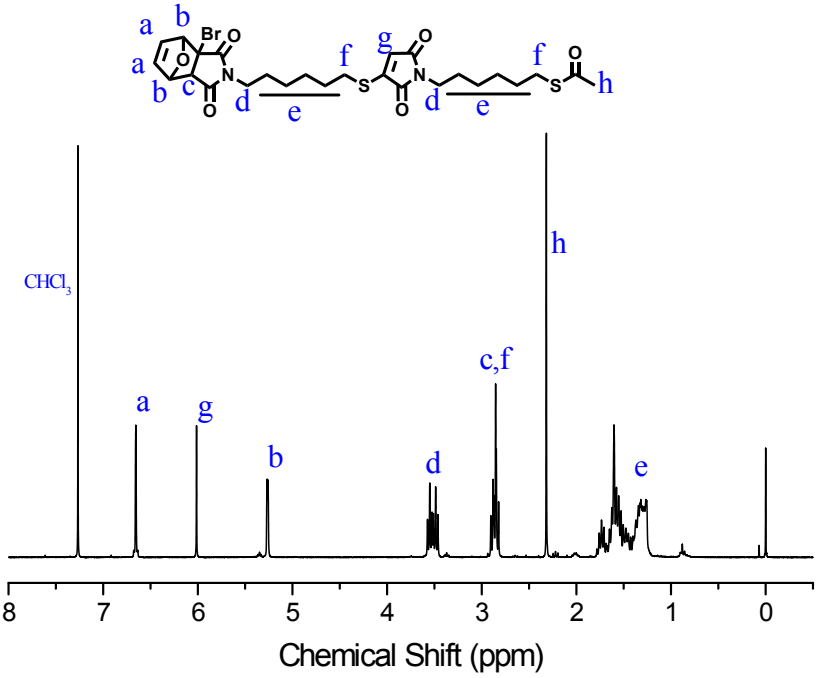


Figure S10. ^{1}H NMR spectrum of compound **2** in $CDCl_3$ (Bruker, 300 MHz, TMS)

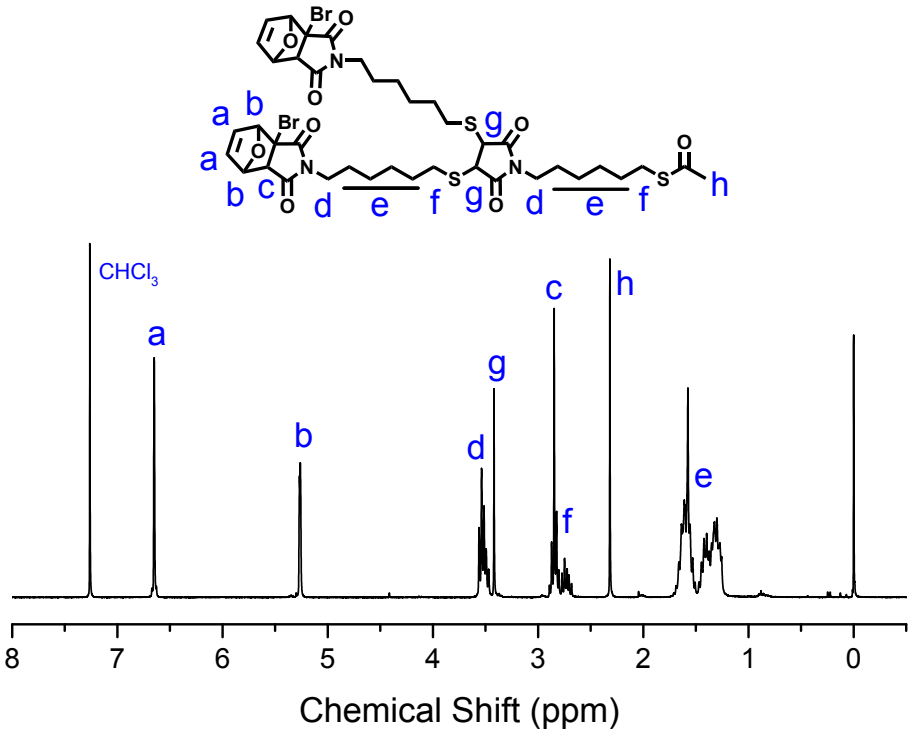


Figure S11. ^{1}H NMR spectrum of compound **3** in $CDCl_3$ (Bruker, 300 MHz, TMS)

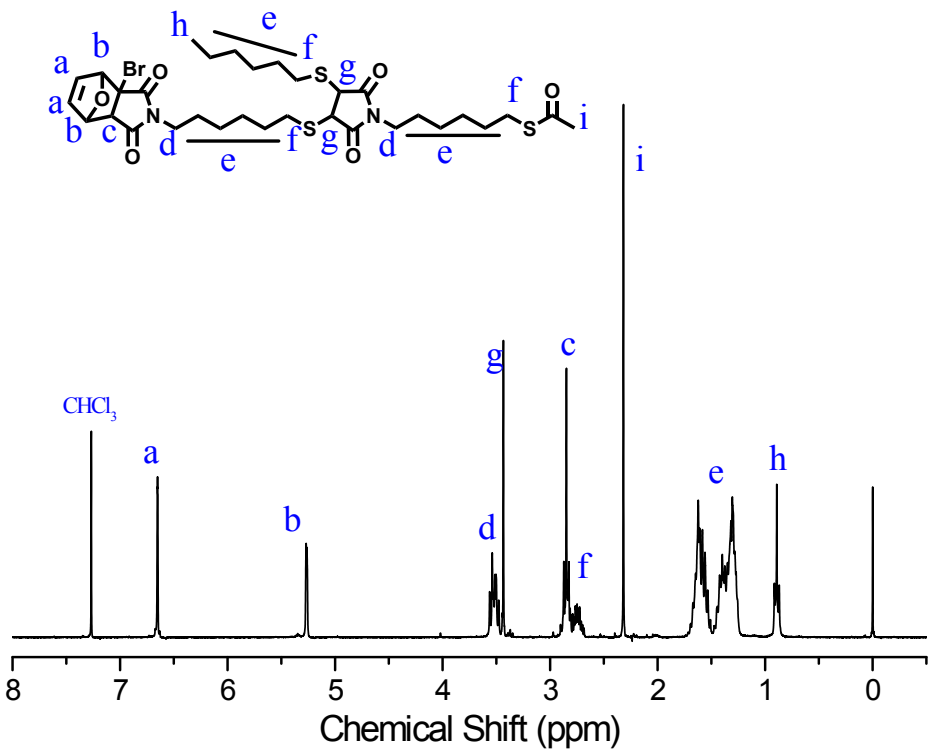


Figure S12. ^{1}H NMR spectrum of dimer **A** in $CDCl_3$ (Bruker, 300 MHz, TMS)

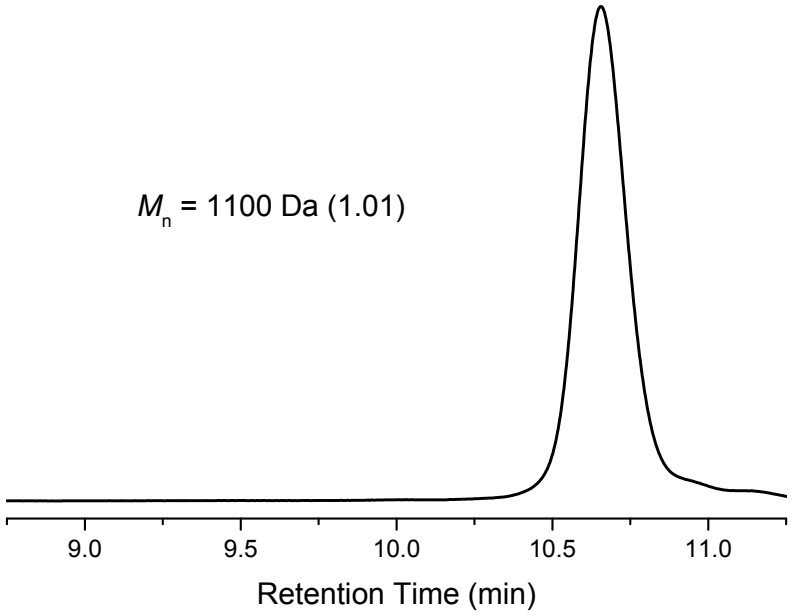


Figure S13. SEC trace of **A**.

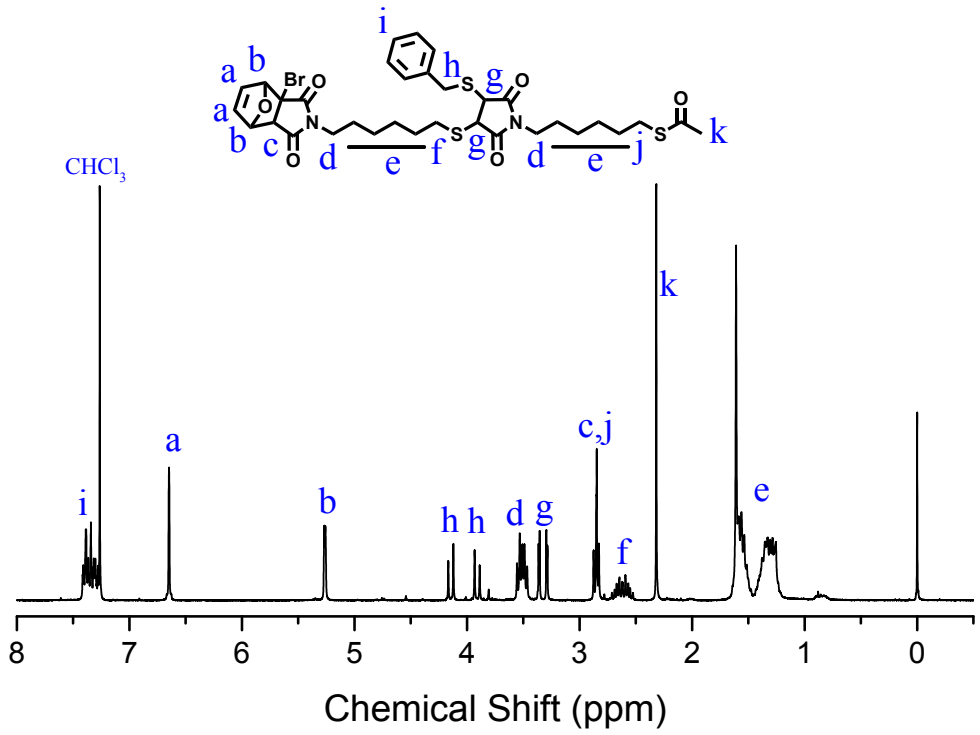


Figure S14. ^{1}H NMR spectrum of dimer **B** in $CDCl_3$ (Bruker, 300 MHz, TMS)

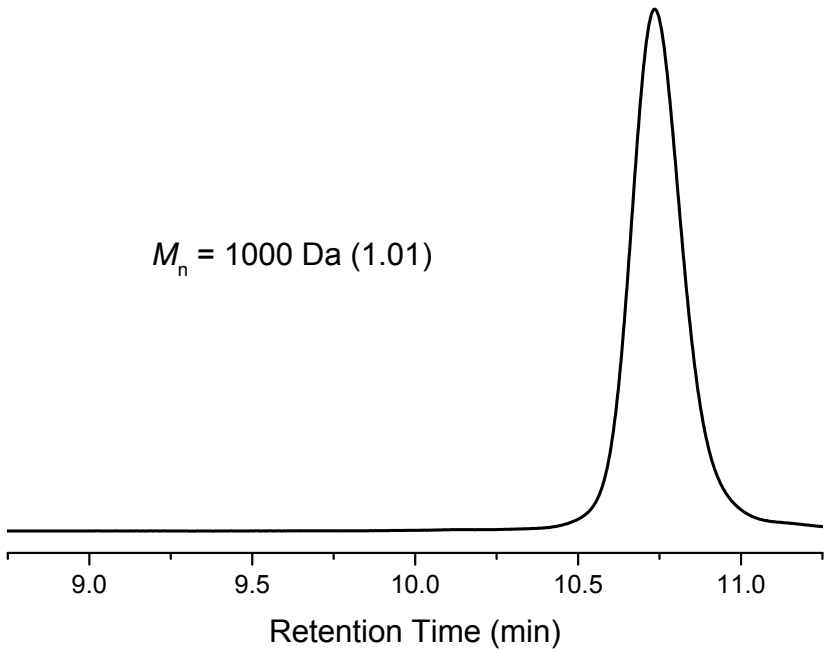


Figure S15. SEC trace of **B**.

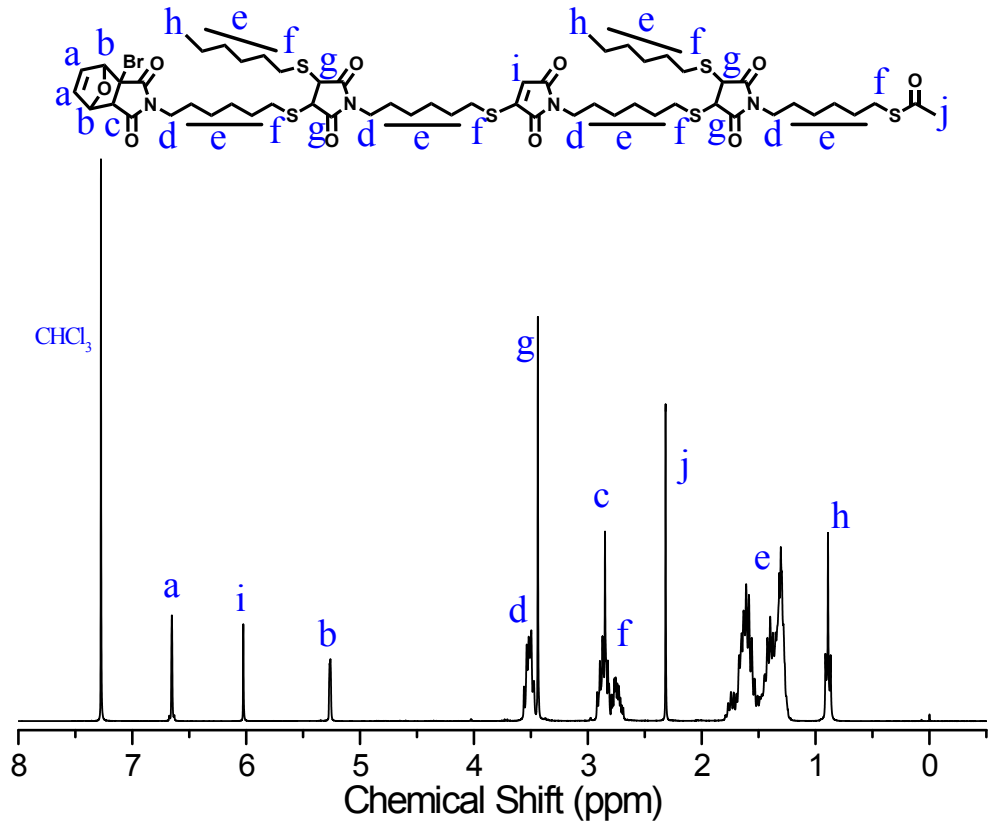


Figure S16. ^{1}H NMR spectrum of tetramer **AOA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

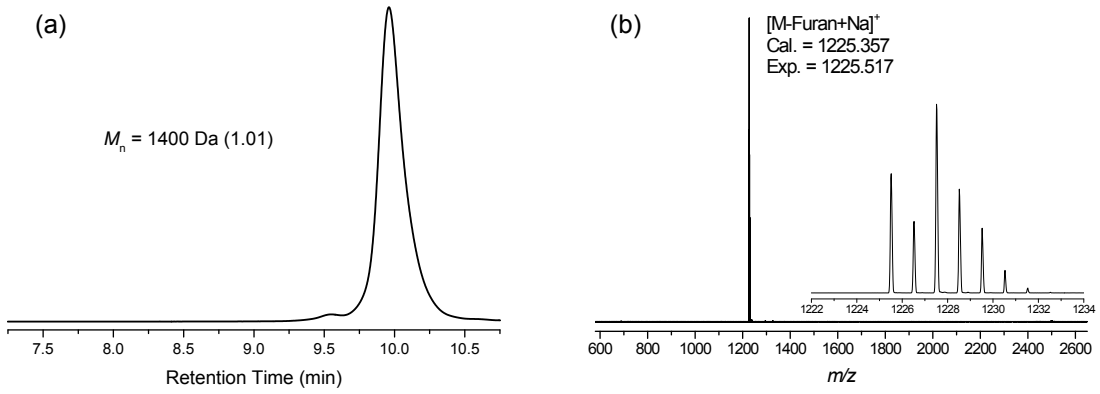


Figure S17. (a) SEC trace of **AOA**; (b) MALDI-TOF mass spectrum of **AOA**.

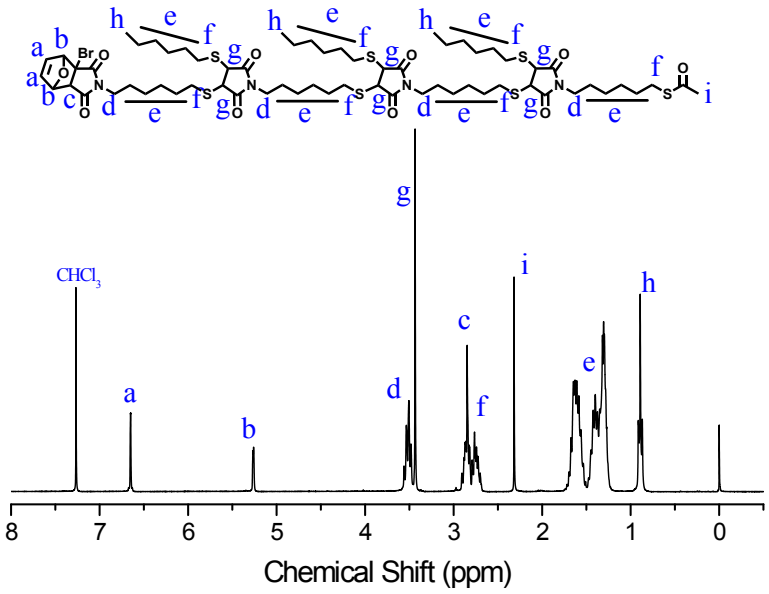


Figure S18. ^{1}H NMR spectrum of tetramer **AAA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

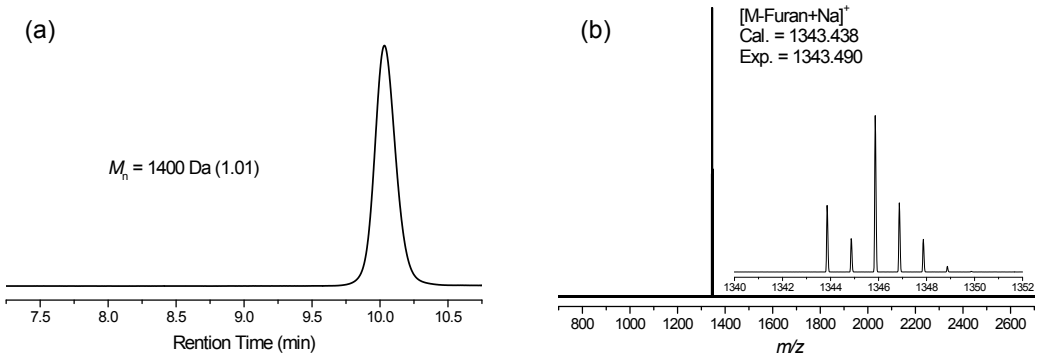


Figure S19. (a) SEC trace of **AAA**; (b) MALDI-TOF mass spectrum of **AAA**.

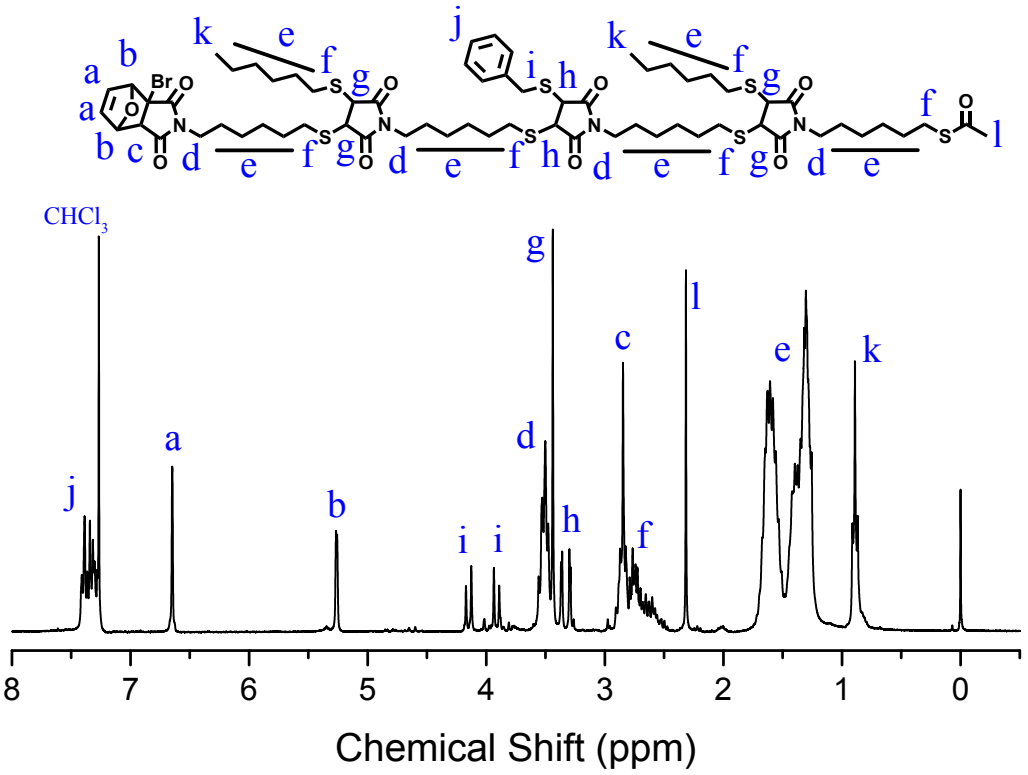


Figure S20. ^{1}H NMR spectrum of tetramer **ABA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

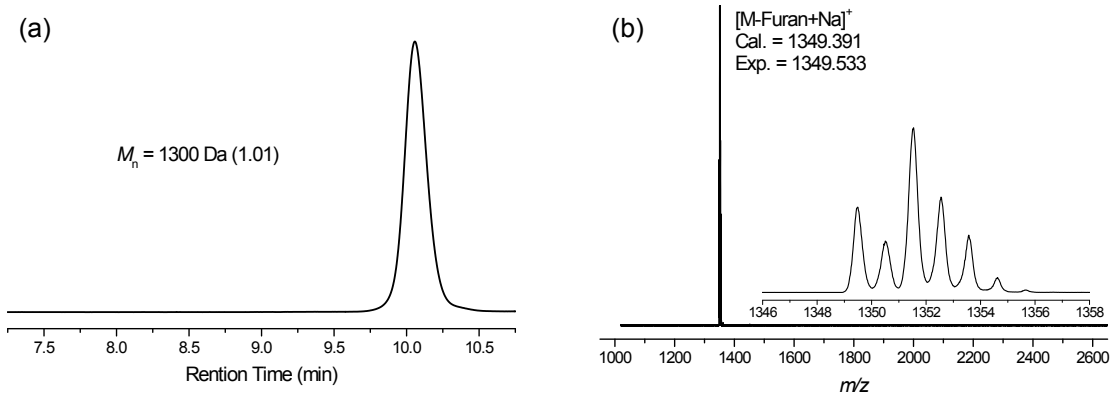


Figure S21. (a) SEC trace of **ABA**; (b) MALDI-TOF mass spectrum of **ABA**.

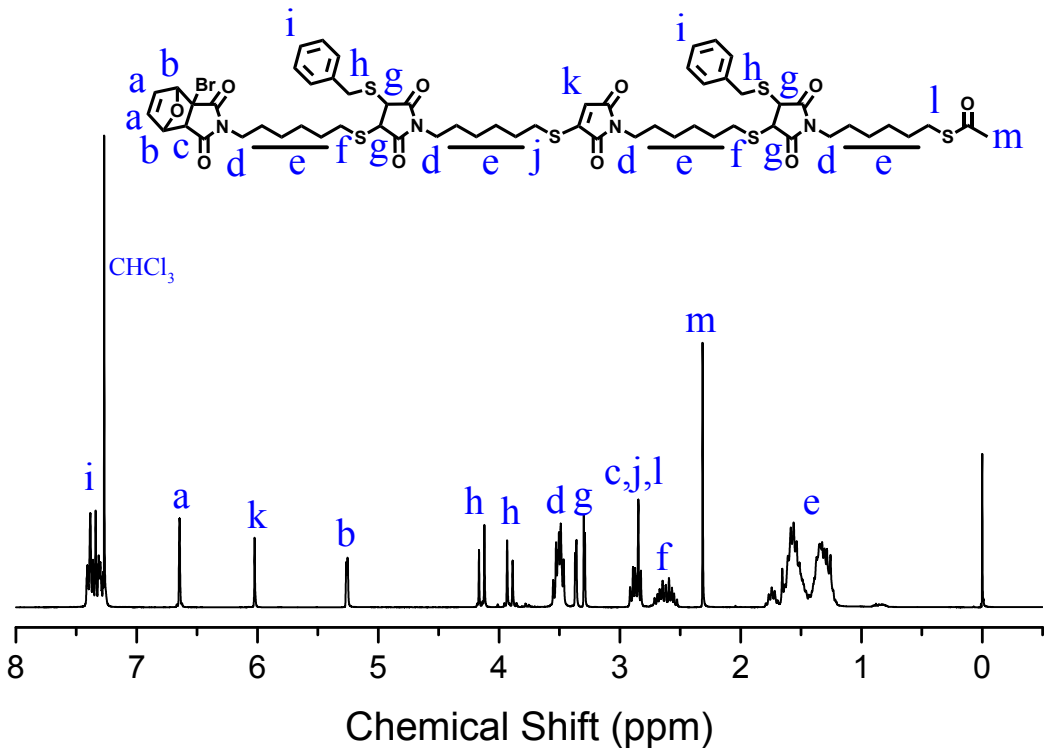


Figure S22. ^{1}H NMR spectrum of tetramer **BOB** in $CDCl_3$ (Bruker, 300 MHz, TMS)

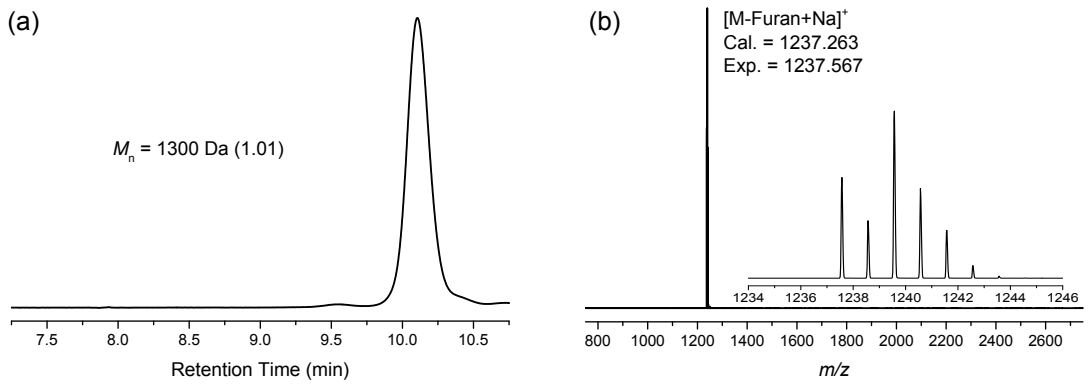


Figure S23. (a) SEC trace of **BOB**; (b) MALDI-TOF mass spectrum of **BOB**.

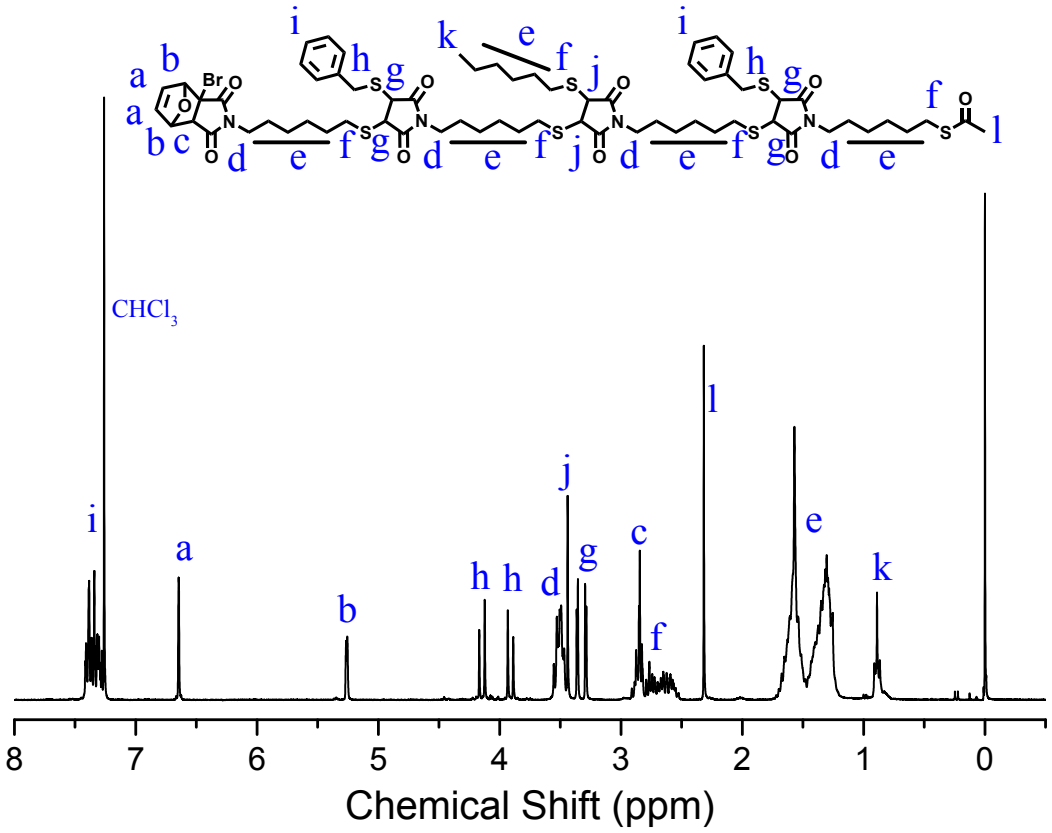


Figure S24. ^{1}H NMR spectrum of tetramer **BAB** in $CDCl_3$ (Bruker, 300 MHz, TMS)

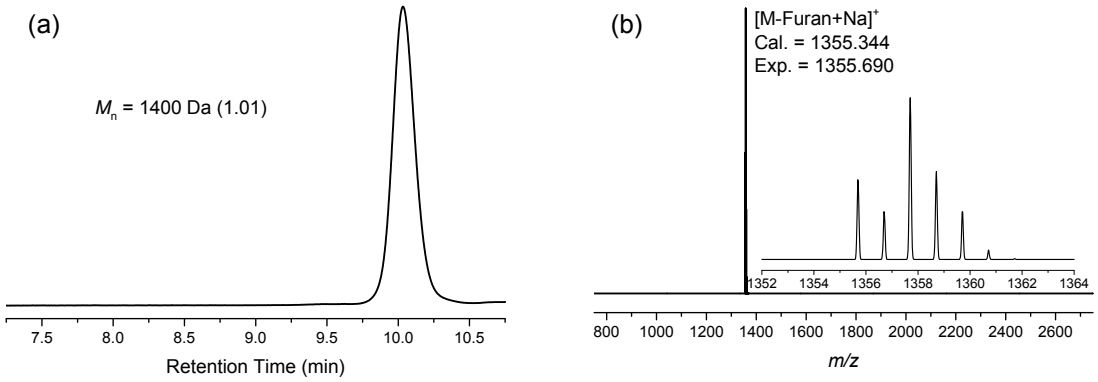


Figure S25. (a) SEC trace of **BAB**; (b) MALDI-TOF mass spectrum of **BAB**.

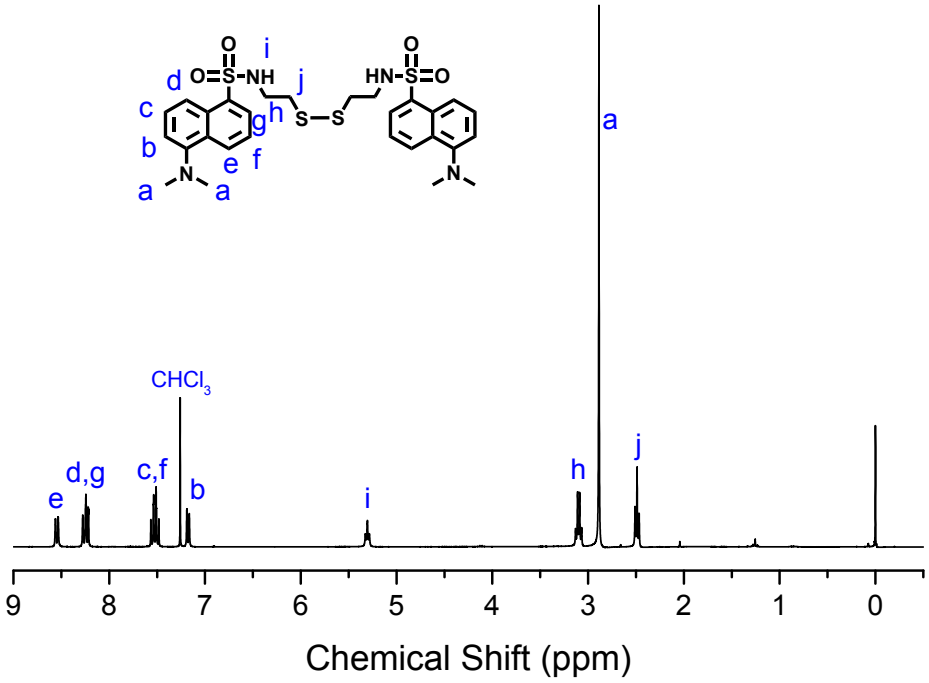


Figure S26. ^{1}H NMR spectrum of compound **G-1** in $CDCl_3$ (Bruker, 300 MHz, TMS)

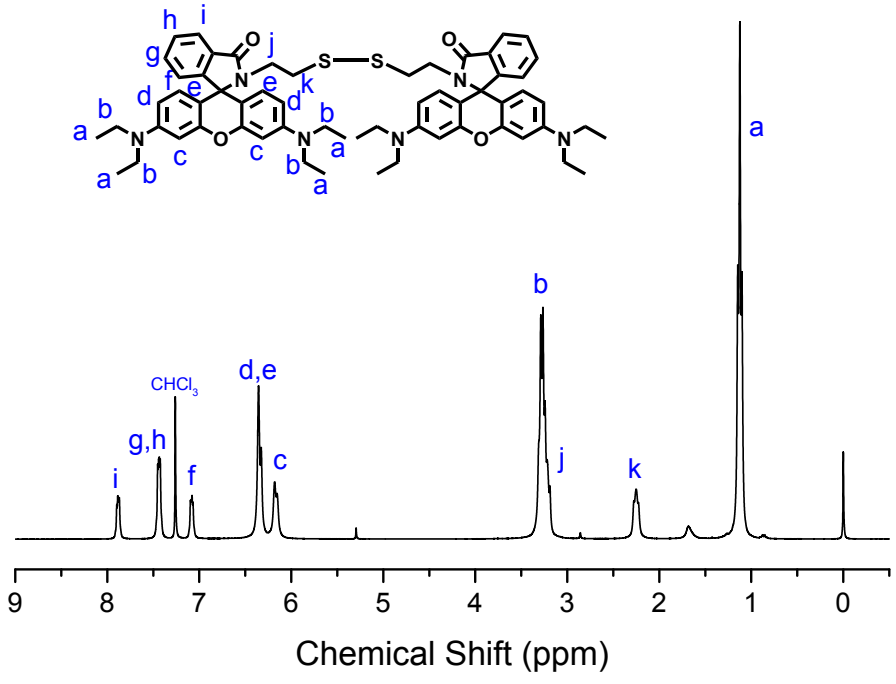


Figure S27. ^{1}H NMR spectrum of compound **R-3** in $CDCl_3$ (Bruker, 300 MHz, TMS)

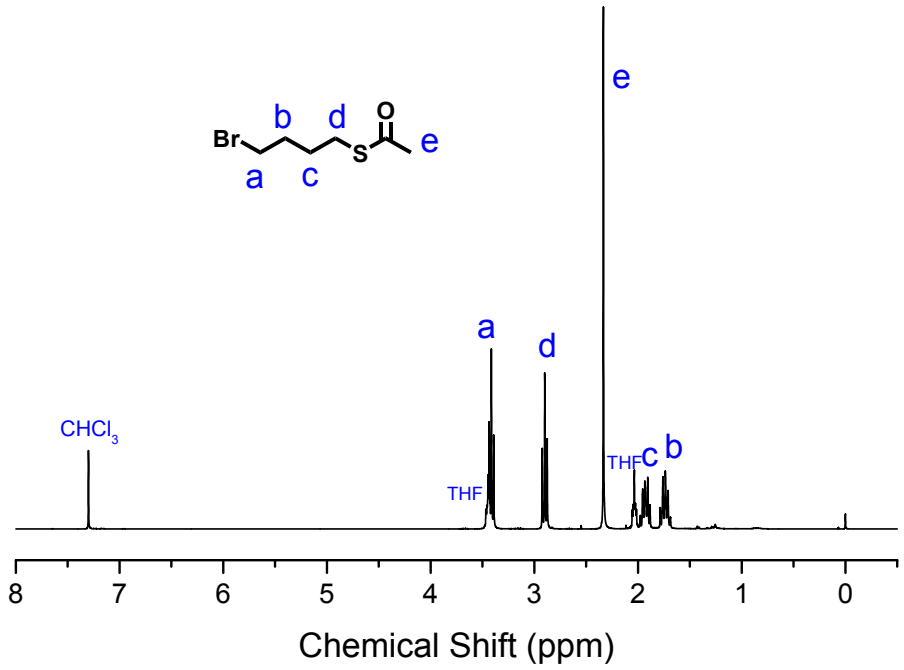


Figure S28. ^{1}H NMR spectrum of compound **Y-1** in $CDCl_3$ (Bruker, 300 MHz, TMS)

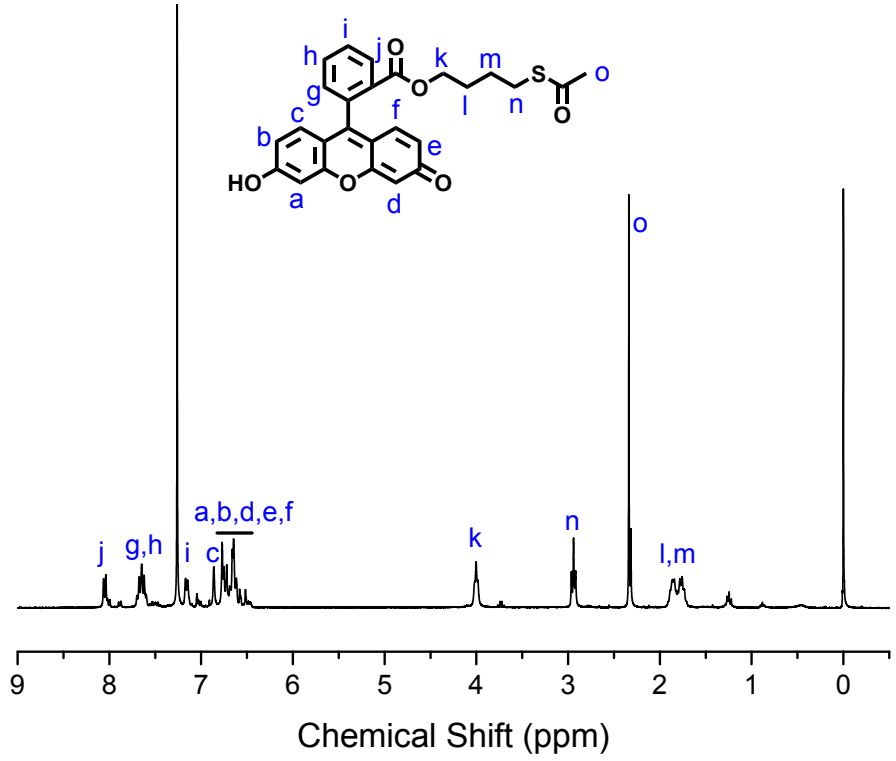


Figure S29. ^{1}H NMR spectrum of compound **Y-2** in $CDCl_3$ (Bruker, 300 MHz, TMS)

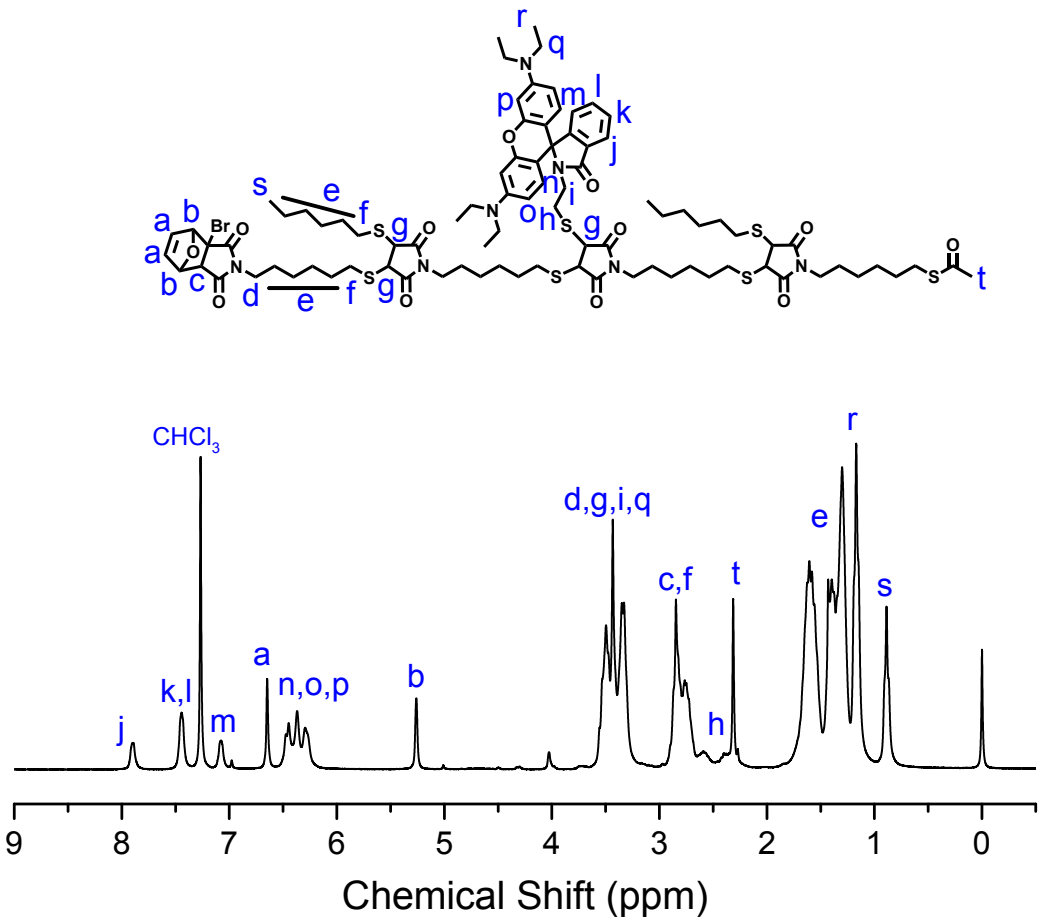


Figure S30. ^{1}H NMR spectrum of tetramer **ARA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

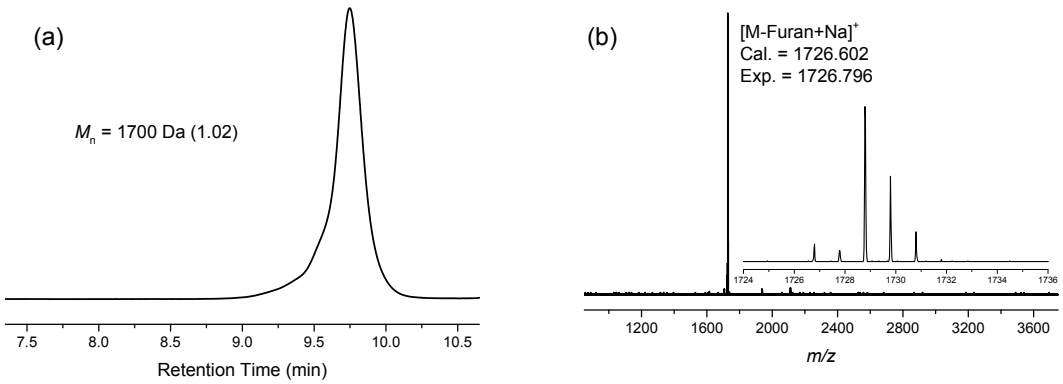


Figure S31. (a) SEC trace of **ARA**; (b) MALDI-TOF mass spectrum of **ARA**.

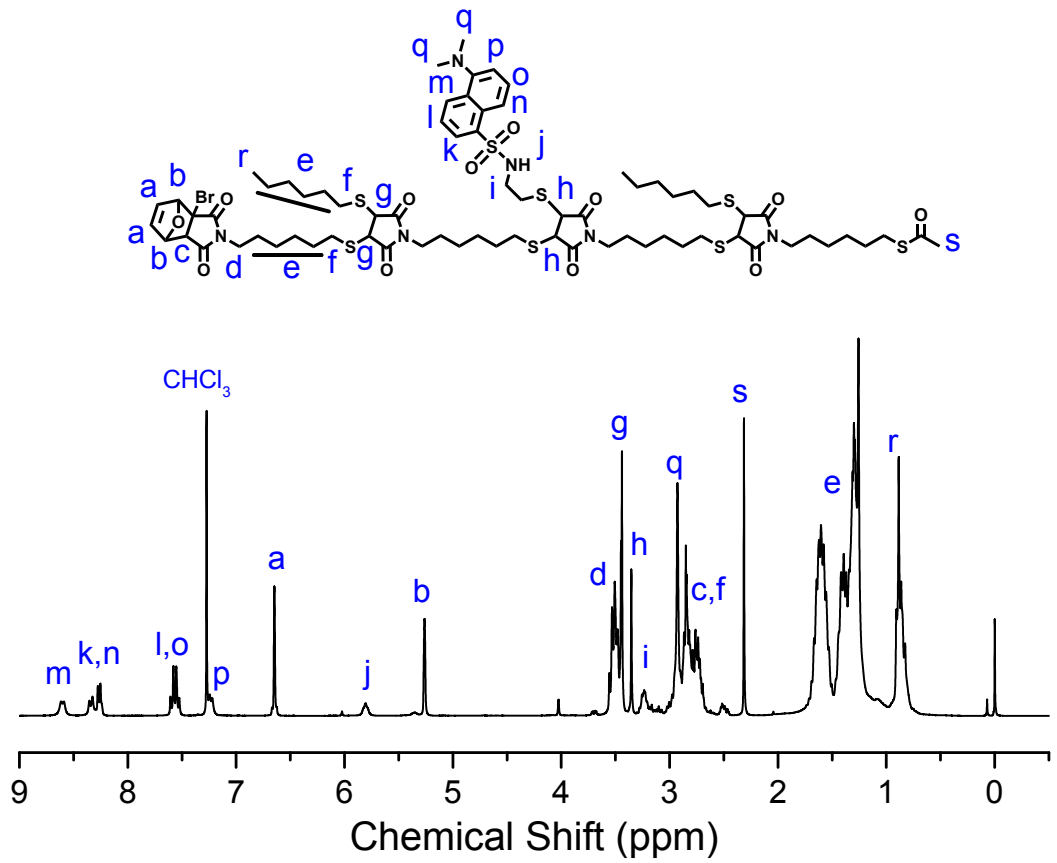


Figure S32. ^{1}H NMR spectrum of tetramer **AGA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

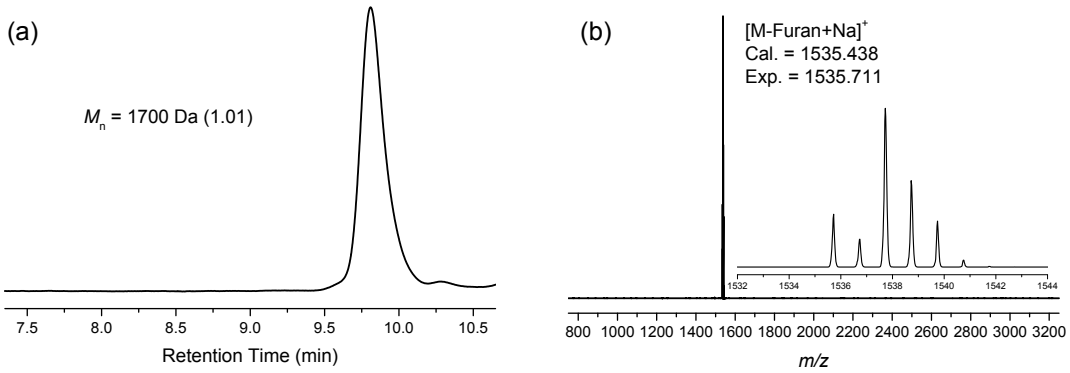


Figure S33. (a) SEC trace of **AGA**; (b) MALDI-TOF mass spectrum of **AGA**.

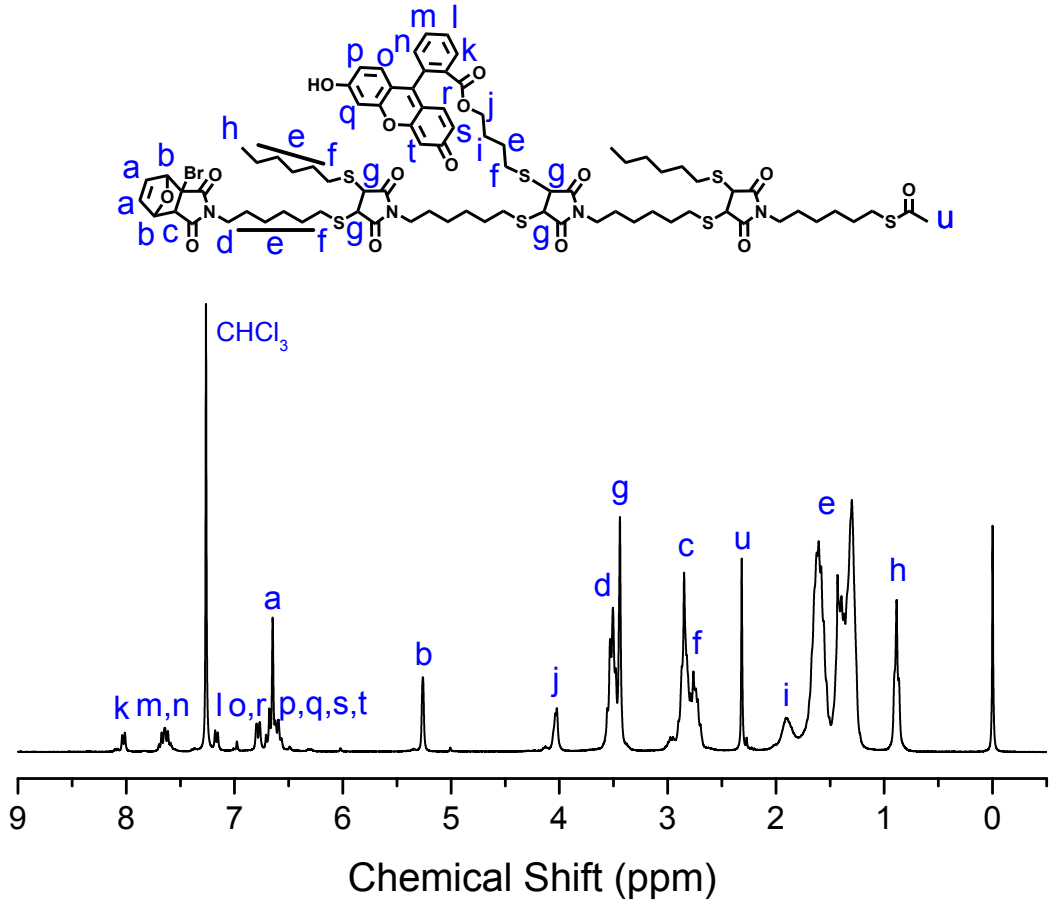


Figure S34. ^{1}H NMR spectrum of tetramer **AYA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

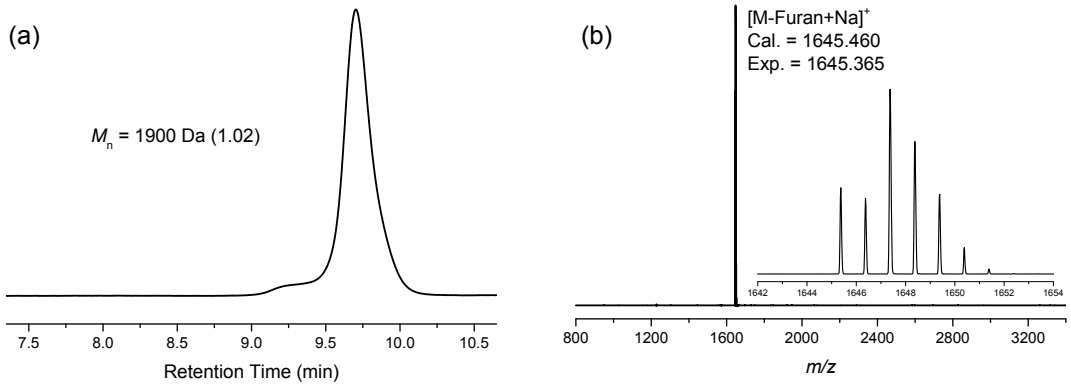


Figure S35. (a) SEC trace of **AYA**; (b) MALDI-TOF mass spectrum of **AYA**.

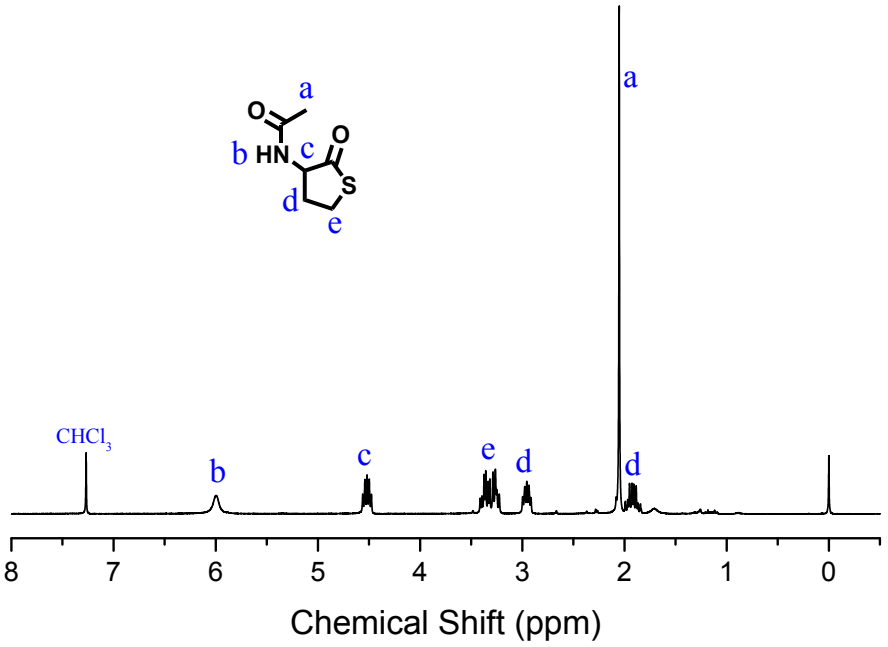


Figure S36. ^{1}H NMR spectrum of compound **D-1** in $CDCl_3$ (Bruker, 300 MHz, TMS)

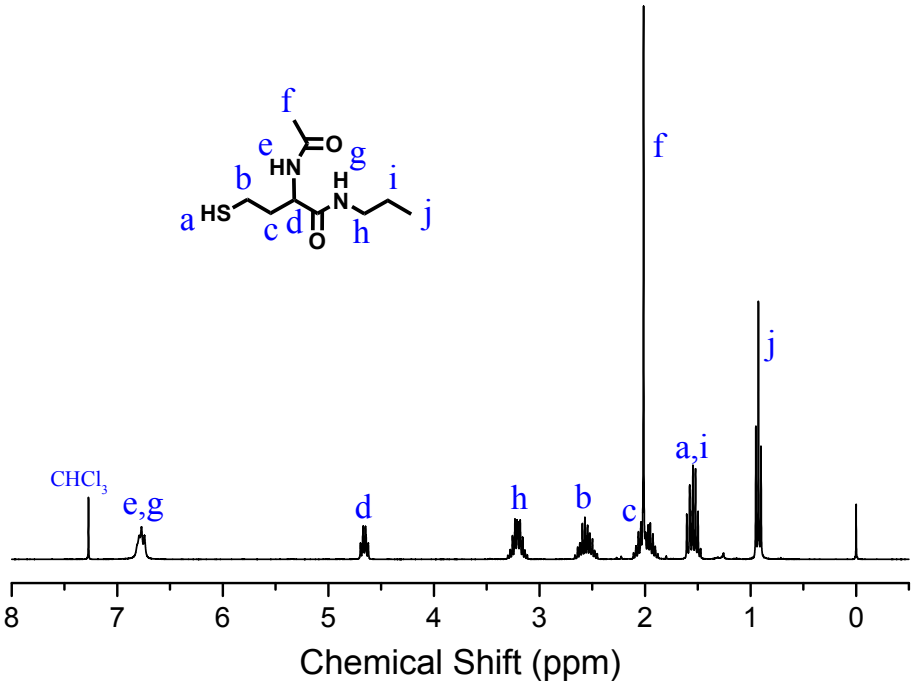


Figure S37. ^{1}H NMR spectrum of compound **SC-D** in $CDCl_3$ (Bruker, 300 MHz, TMS)

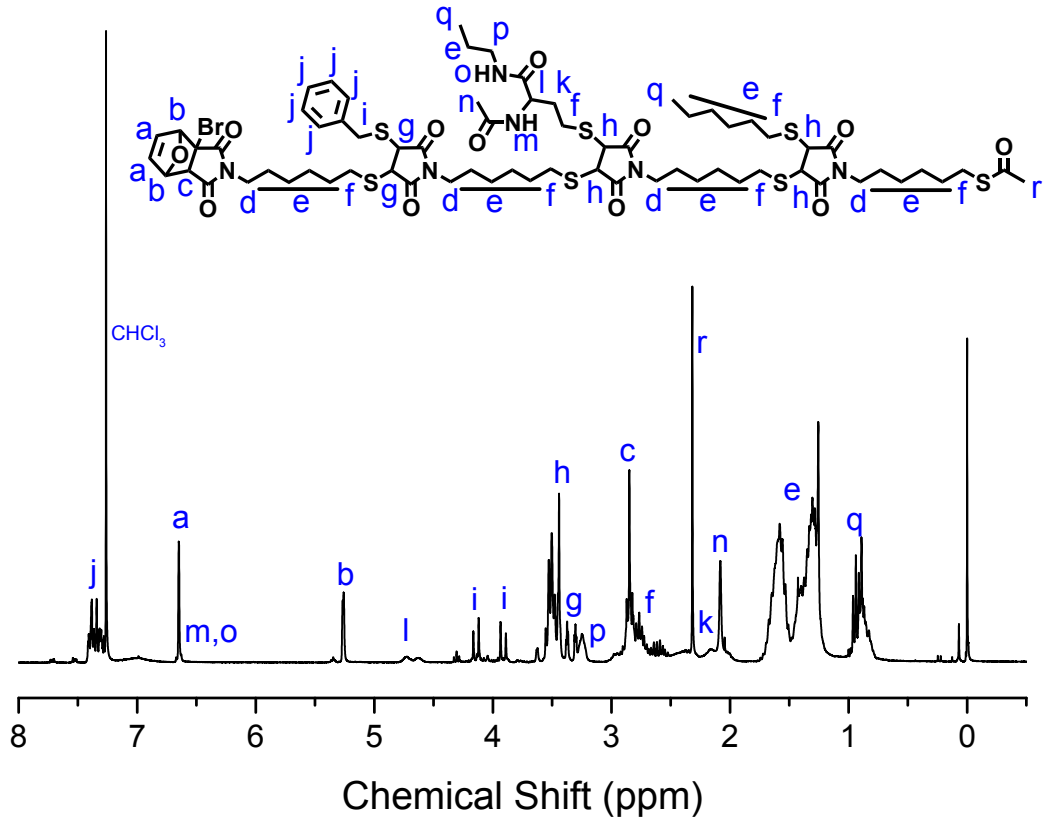


Figure S38. ^{1}H NMR spectrum of tetramer **BDA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

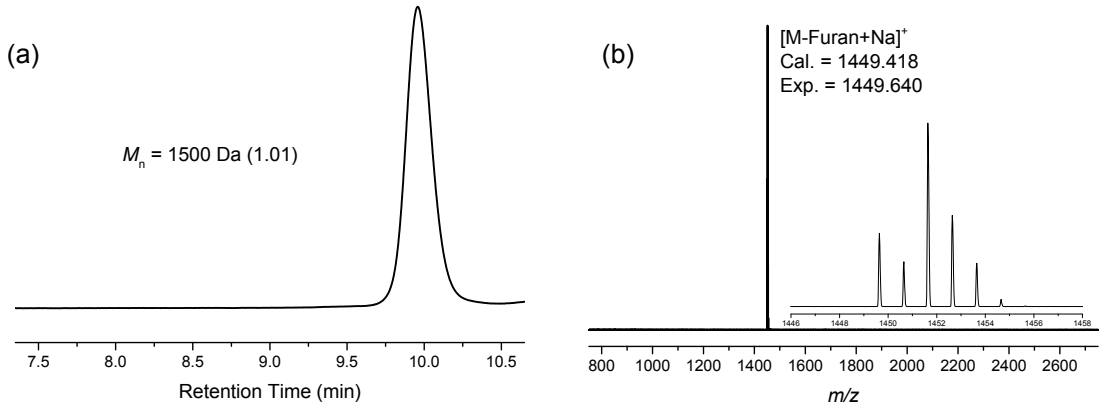


Figure S39. (a) SEC trace of **BDA**; (b) MALDI-TOF mass spectrum of **BDA**.

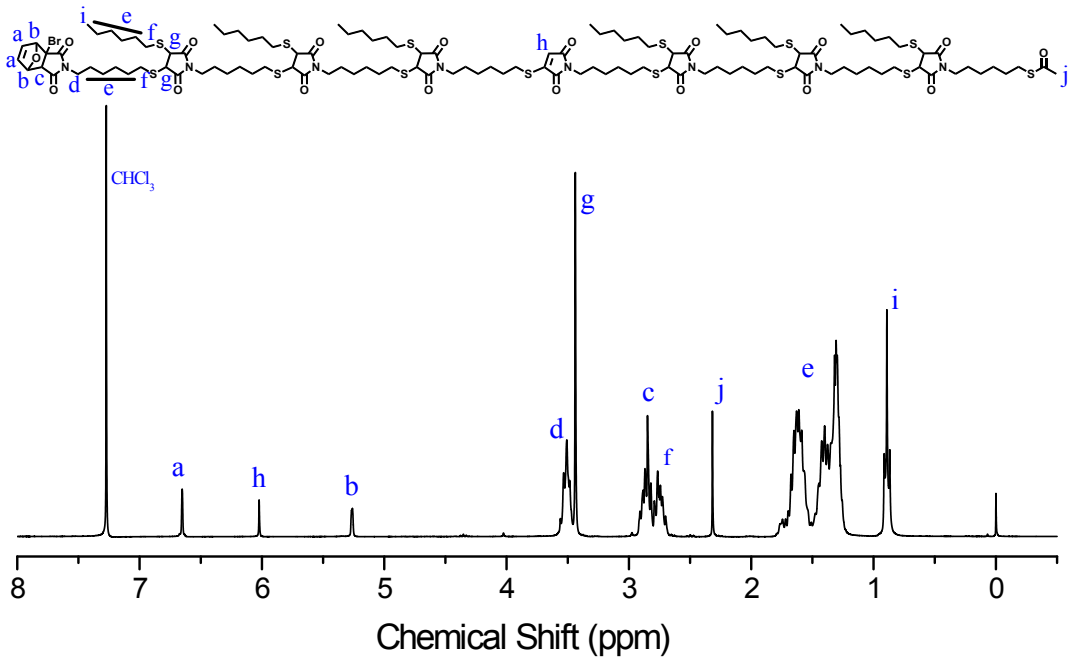


Figure S40. ^{1}H NMR spectrum of octamer **AAAOAAA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

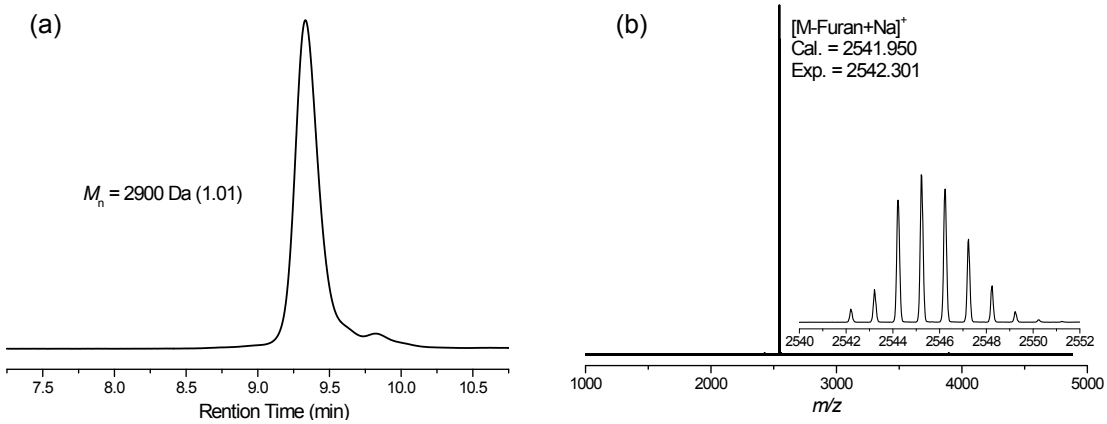


Figure S41. (a) SEC trace of **AAAOAAA**; (b) MALDI-TOF mass spectrum of **AAAOAAA**.

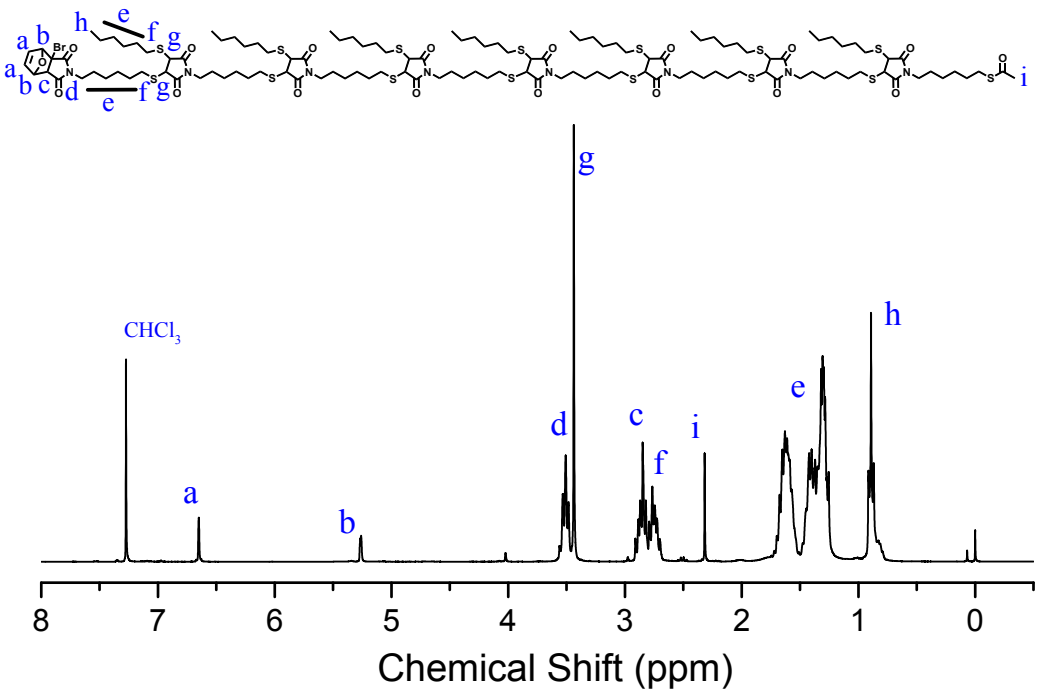


Figure S42. ^{1}H NMR spectrum of octamer **AAAAAAA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

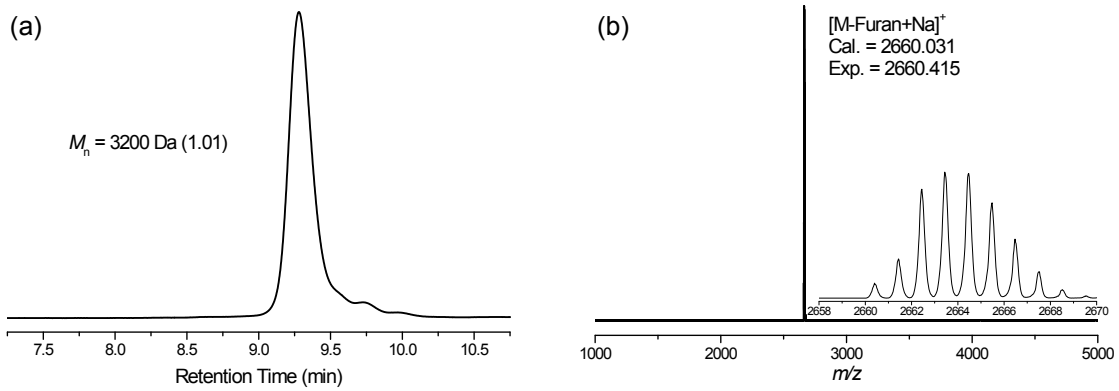


Figure S43. (a) SEC trace of **AAAAAAA**; (b) MALDI-TOF mass spectrum of **AAAAAAA**.

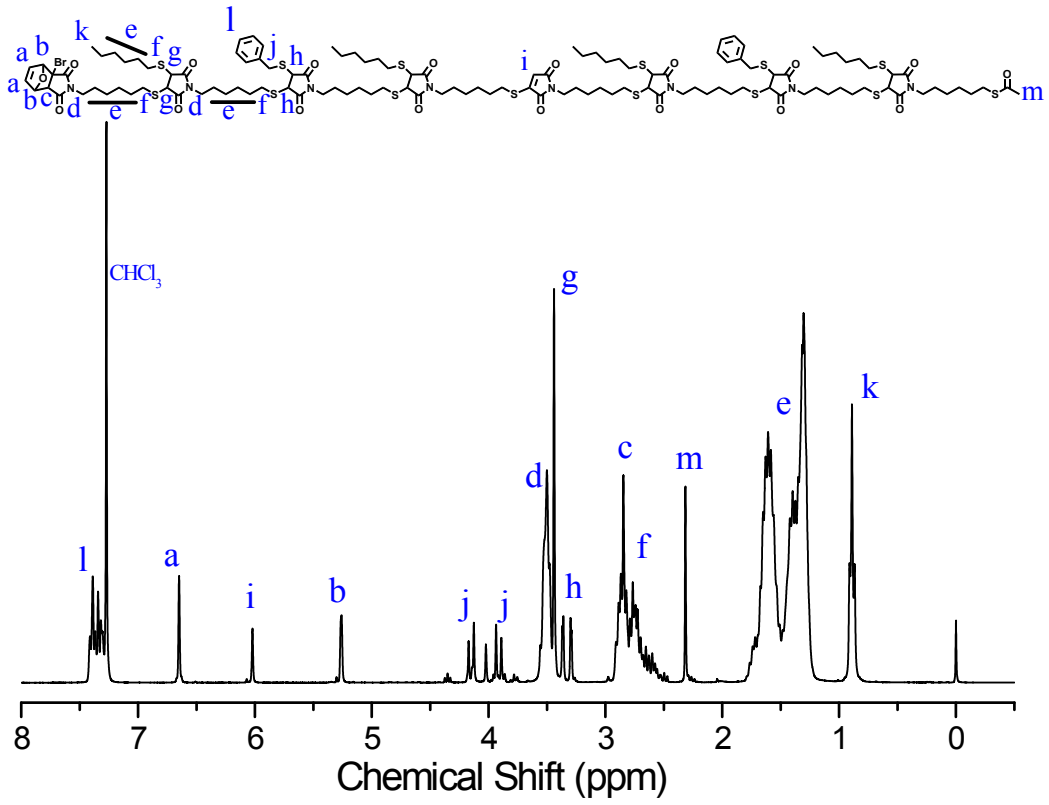


Figure S44. ^{1}H NMR spectrum of octamer **ABAOABA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

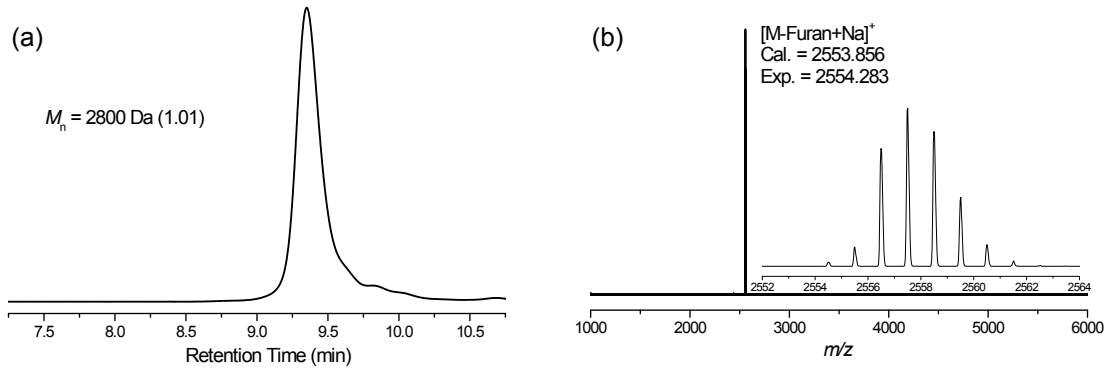


Figure S45. (a) SEC trace of **ABAOABA**; (b) MALDI-TOF mass spectrum of **ABAOABA**.

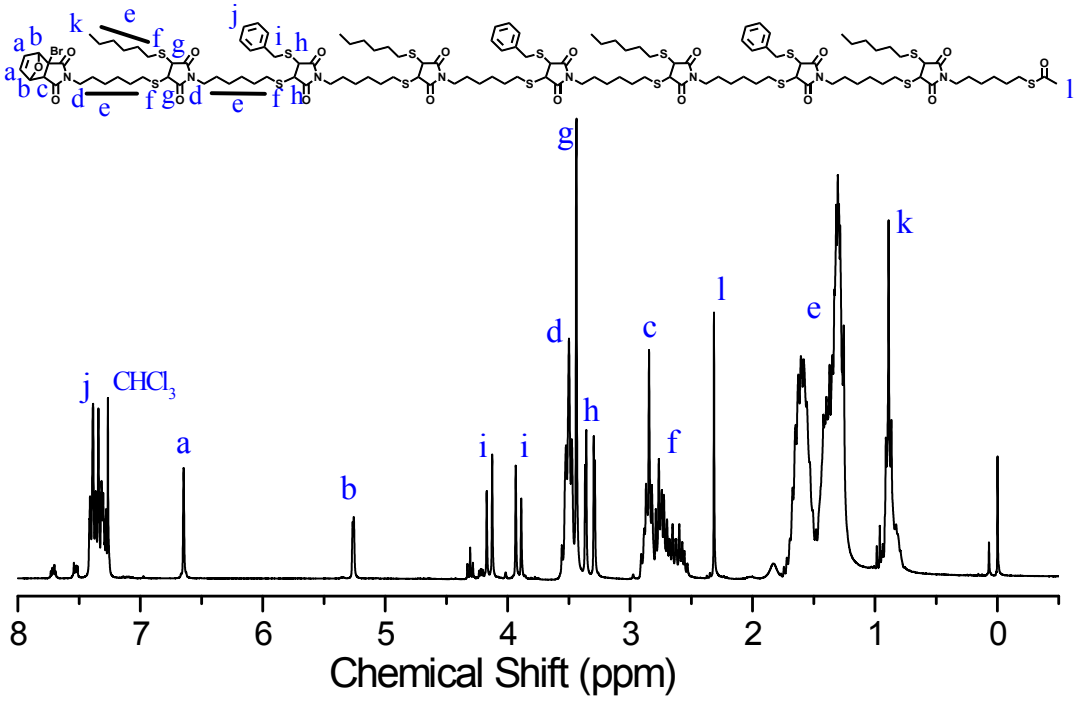


Figure S46. ^{1}H NMR spectrum of octamer **ABABABA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

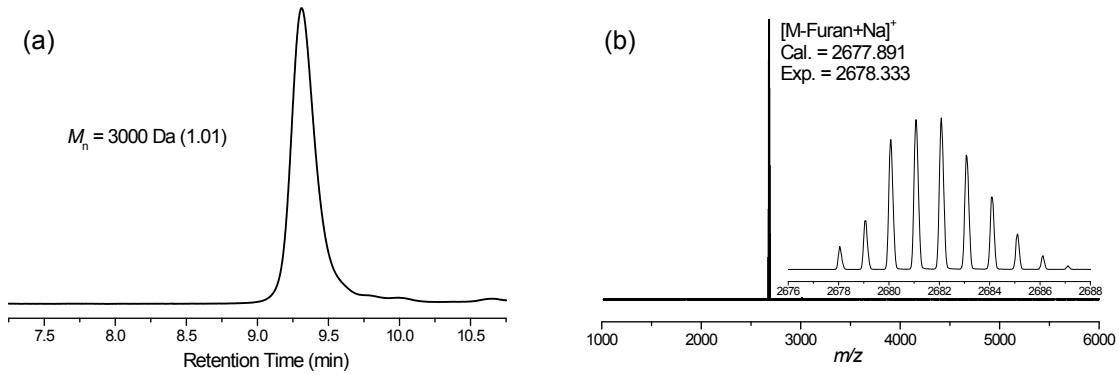


Figure S47. (a) SEC trace of **ABABABA**; (b) MALDI-TOF mass spectrum of **ABABABA**.

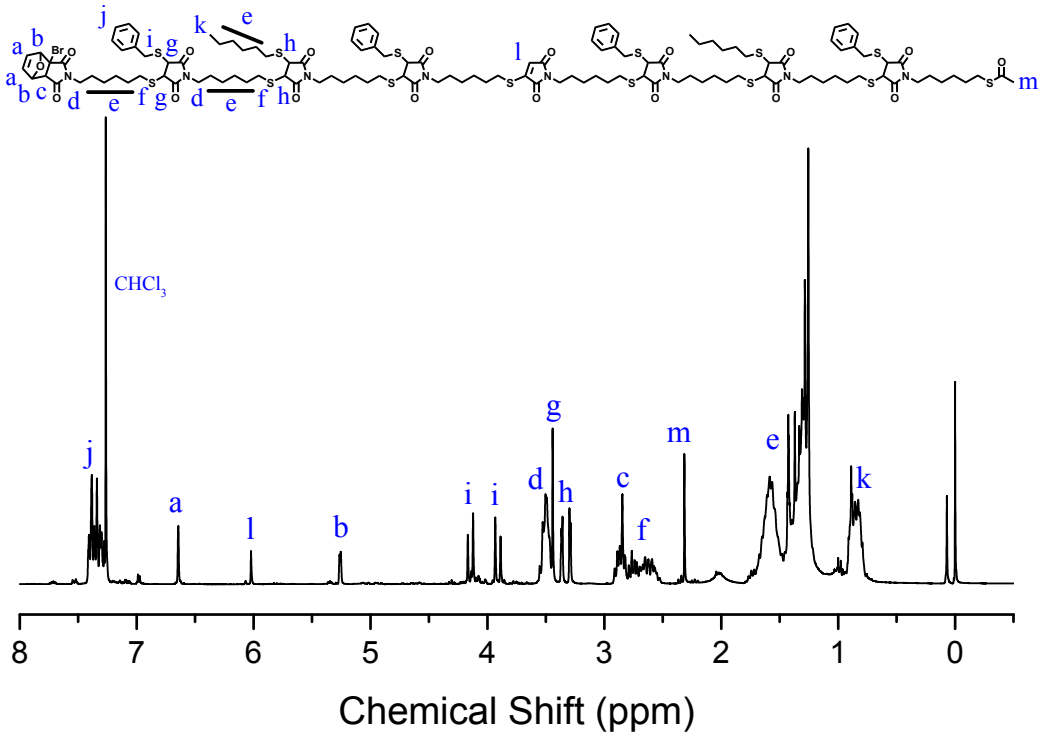


Figure S48. ^{1}H NMR spectrum of octamer **BABOBAB** in $CDCl_3$ (Bruker, 300 MHz, TMS)

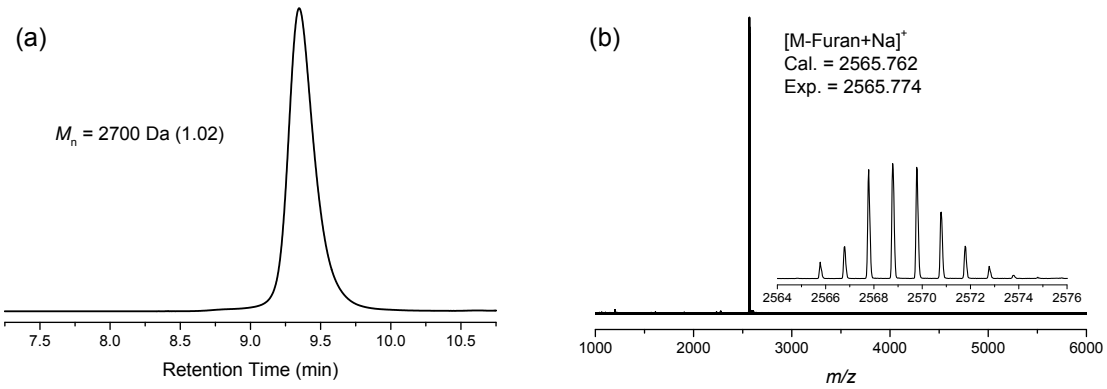


Figure S49. (a) SEC trace of **BABOBAB**; (b) MALDI-TOF mass spectrum of **BABOBAB**.

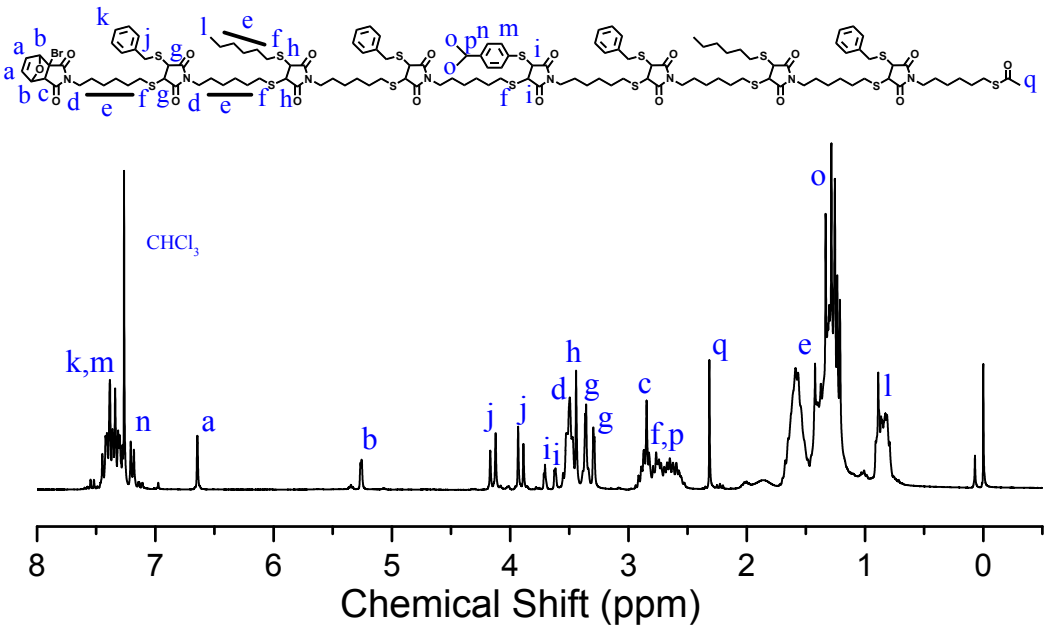


Figure S50. ^{1}H NMR spectrum of octamer **BABCBAB** in $CDCl_3$ (Bruker, 300 MHz, TMS)

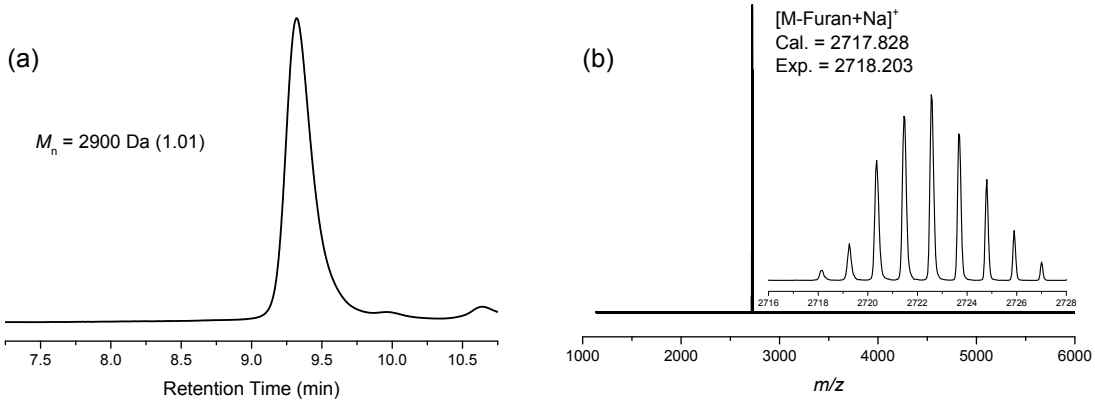


Figure S51. (a) SEC trace of **BABCBAB**; (b) MALDI-TOF mass spectrum of **BABCBAB**.

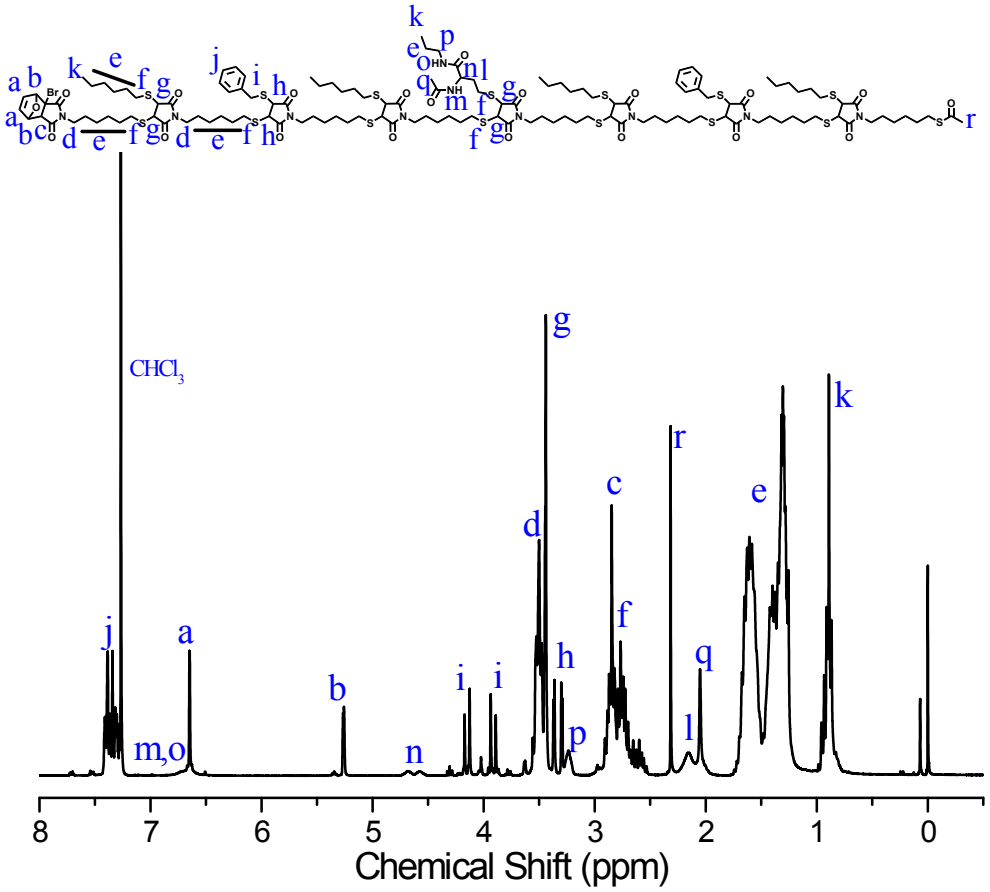


Figure S52. ^{1}H NMR spectrum of octamer **ABADABA** in $CDCl_3$ (Bruker, 300 MHz, TMS)

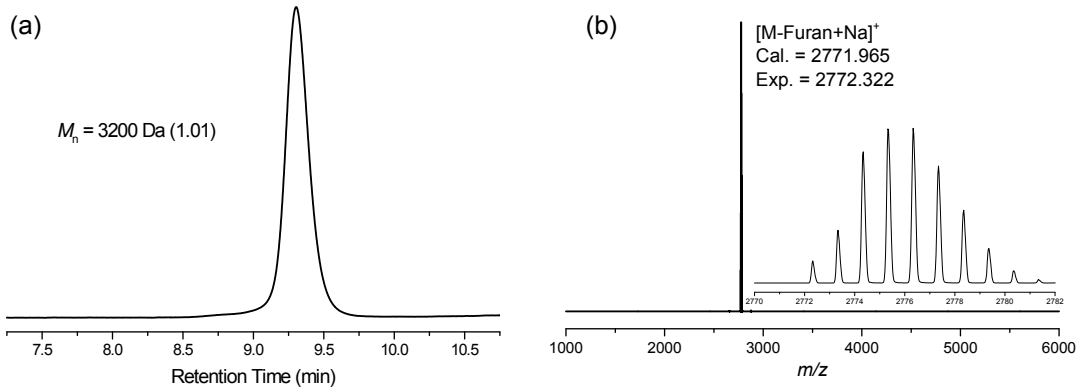


Figure S53. (a) SEC trace of **ABADABA**; (b) MALDI-TOF mass spectrum of **ABADABA**.

SECTION C. Computer Simulation of Bond Dissociation Energy (BDE) and proposed mechanism of MS/MS induced synergistic C-S bond cleavages

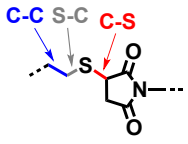
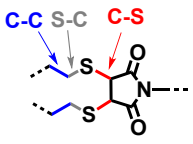
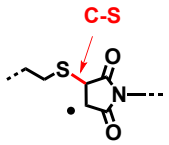
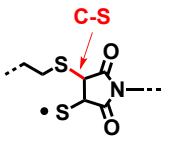
Model structure / BDE (kcal/mol)				
C-S	57.2	56.8	**7.9**	**14.3**
S-C	~ 69.2			
C-C	~ 79.9			

Table S1. Computer simulations of bond dissociation energy (BDE) of chemical bonds of succinimide thioether and its derivates; The molecular geometry optimized using the Density Functional Theory method of the three parameter Becke-style hybrid functional (B3LYP) with the basis set of 6-311+g(d,p). All calculations were performed using GAUSSIAN 2009 package.

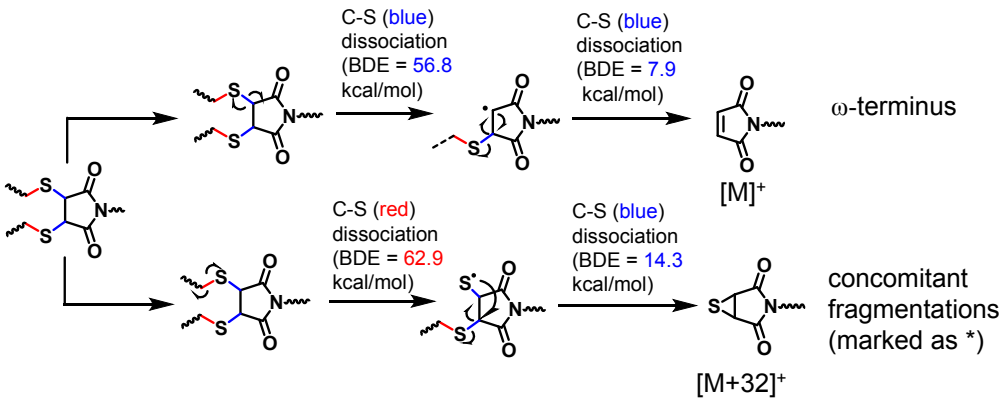


Figure S54. Proposed mechanism of the synergistic cleavages in MALDI-TOF MS/MS.

SECTION D. MALDI-TOF MS/MS analysis of oligomers

Precursor ions were all used furan-deprotected signals [M - Furan + Na] $^{+}$ due to the furan groups were cleaved from α-maleimide groups under high laser intensity in MALDI. Based on BDE calculation, the dissociation in tandem MS were mainly occurred at C-S or S-C bonds and the detected ions were mainly stable fragments. The nomenclature of fragments in backbone was adapted from the one proposed by Wesdemiotis et al.[9] while fragments in side chain were marked for a clear expression. The structure analysis of each fragment was less than 0.1% mass error.

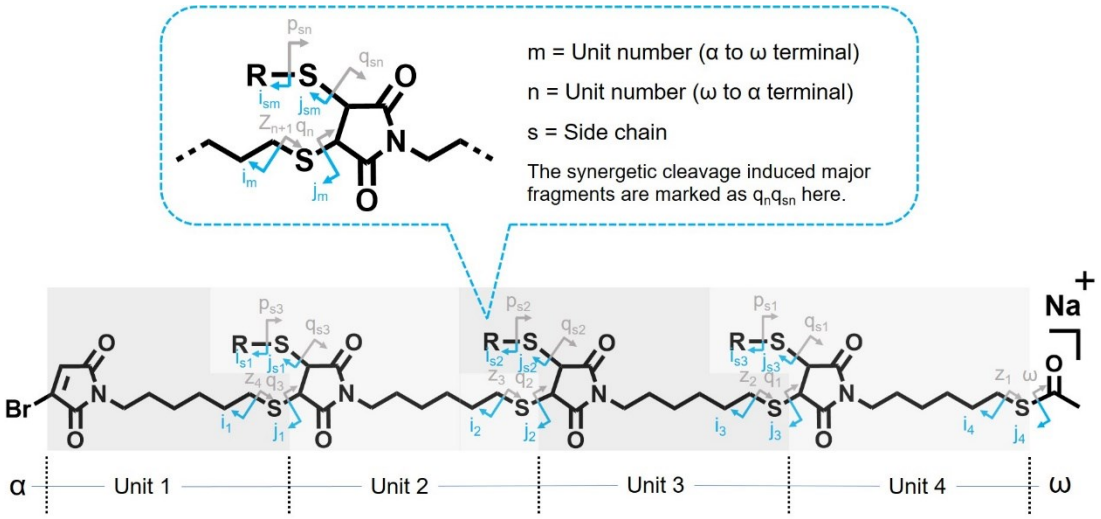


Figure S55. Illustration of the general nomenclature of fragments in tandem MS.

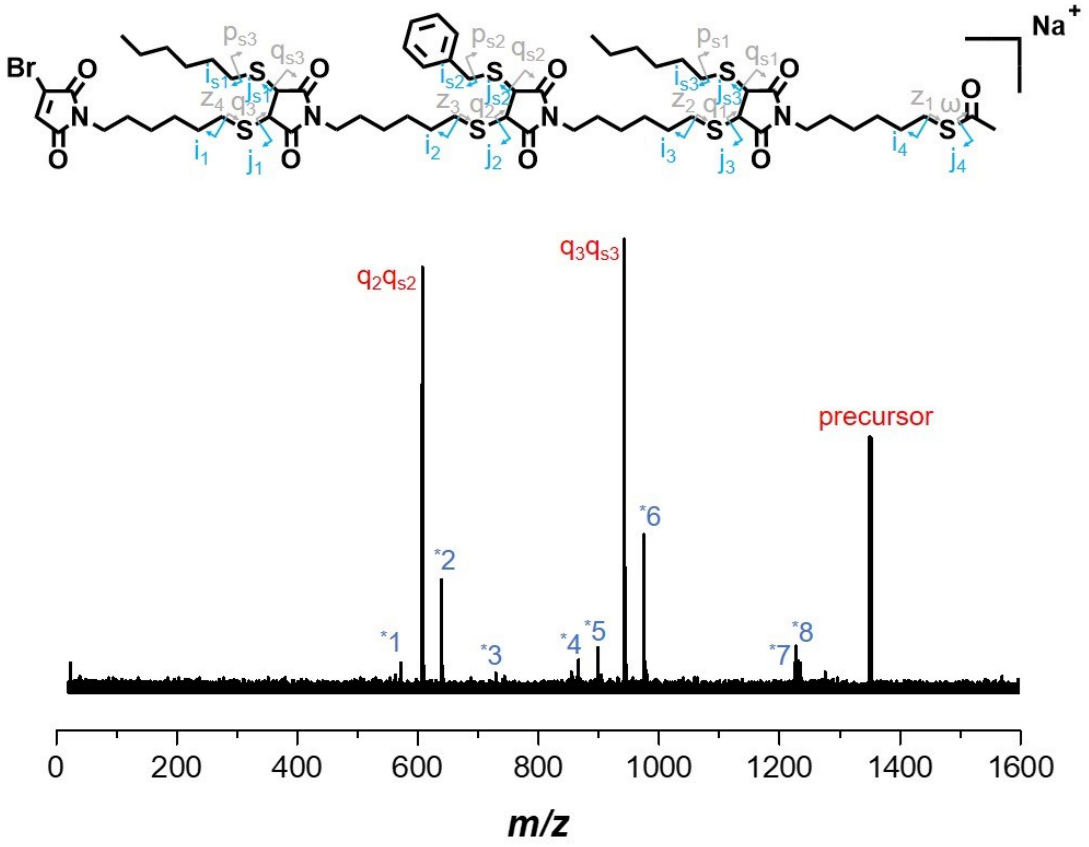
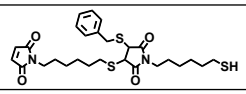
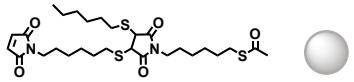
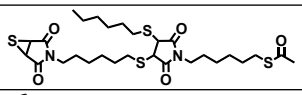
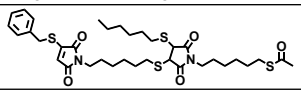
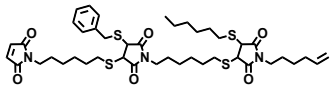
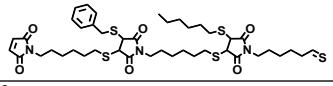
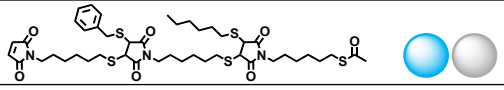
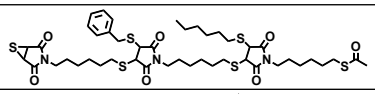
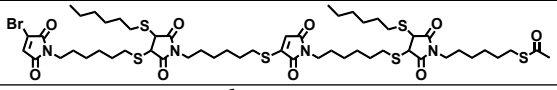
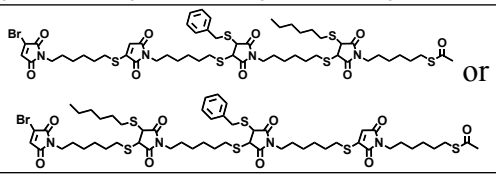


Figure S56. MALDI-TOF MS/MS spectrum of **ABA**.

Table S2. Analysis of probable fragmented structures of **ABA** in MALDI-TOF MS/MS.

Number	$m/z_{cal.}$ $m/z_{exp.}$	Probable fragments	Probable structure (+ Na^+)
*1	571.173 571.351	$j_3q_3q_{s3}$	
★	607.230 607.425	q_2q_{s2}	
*2	639.203 639.386	q_2p_{s2} or z_3q_{s2}	
*3	729.249 729.437	q_2	
*4	866.334 866.541	$i_4q_3q_{s3}$	
*5	898.306 898.598	$j_4q_3q_{s3}$	
★	942.332 942.656	q_3q_{s3}	

*6	974.304 974.607	q_3p_{s3} or z_4q_{s3}	
*7	1225.356 1225.763	q_{s2}	
*8	1231.309 1231.730	q_{s3} or q_{s1}	
★	1349.391 1349.855	precursor	

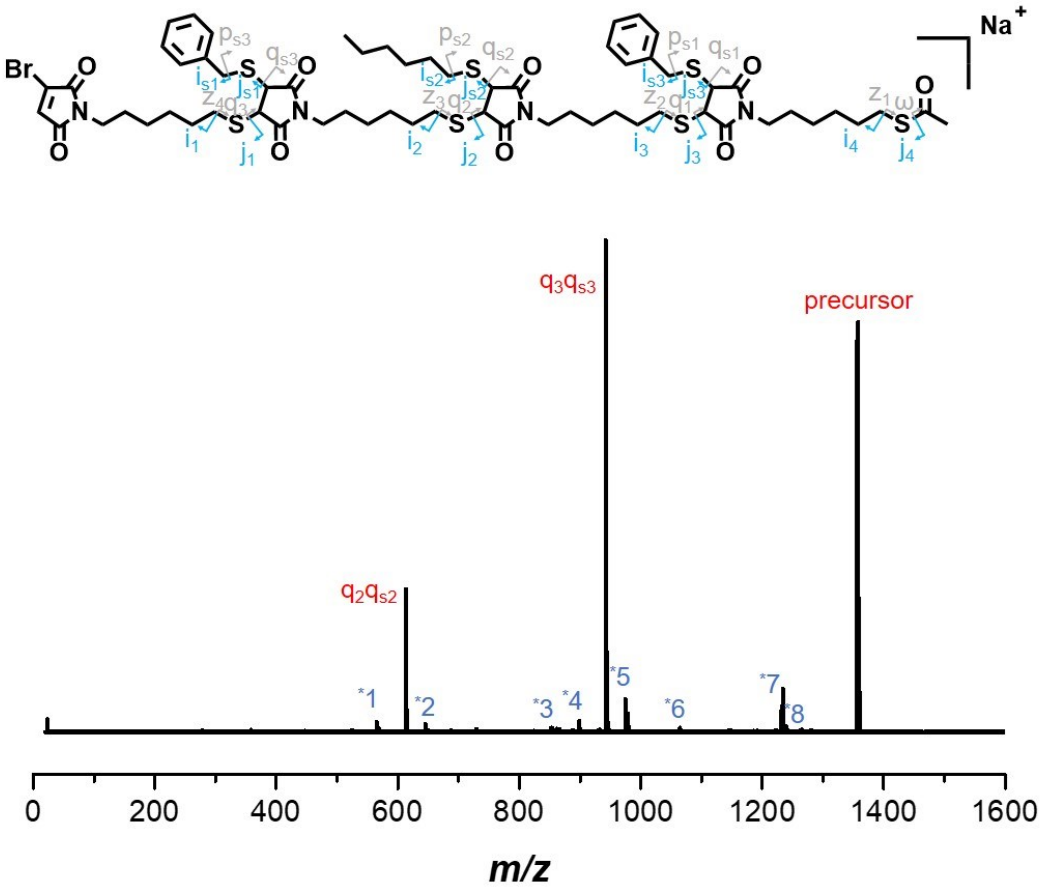
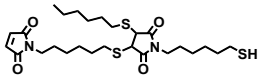
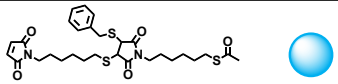
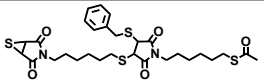
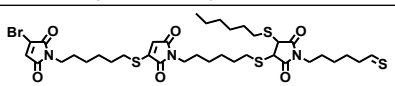
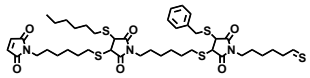
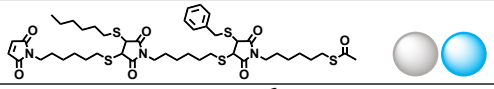
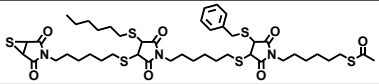
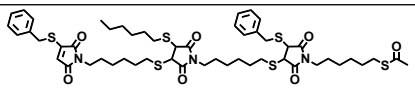
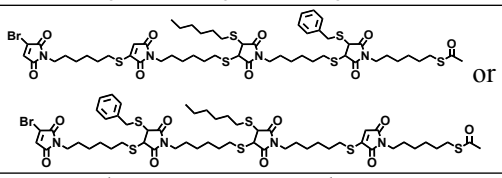
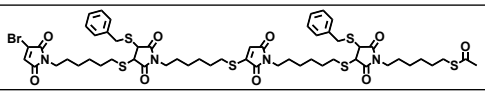


Figure S57. MALDI-TOF MS/MS spectrum of **BAB**.

Table S3. Analysis of probable fragmented structures of **BAB** in MALDI-TOF MS/MS.

Number	$m/z_{cal.}$ $m/z_{exp.}$	Probable fragments	Probable structure (+ Na^+)
*1	565.220 565.472	$j_3q_3q_{s3}$	
★	613.184 613.419	q_2q_{s2}	
*2	645.156 645.389	q_2p_{s2} or z_3q_{s2}	
*3	852.181 852.612	j_3q_{s3}	
*4	898.306 898.649	$j_4q_3q_{s3}$	
★	942.332 942.675	q_3q_{s3}	
*5	974.304 974.647	q_3p_{s3} or z_4q_{s3}	

*6	1064.351 1064.752	q_3	
*7	1231.310 1231.677	q_{s3} or q_{s1}	 or
*8	1237.263 1237.651	q_{s2}	
★	1355.344 1355.690	precursor	

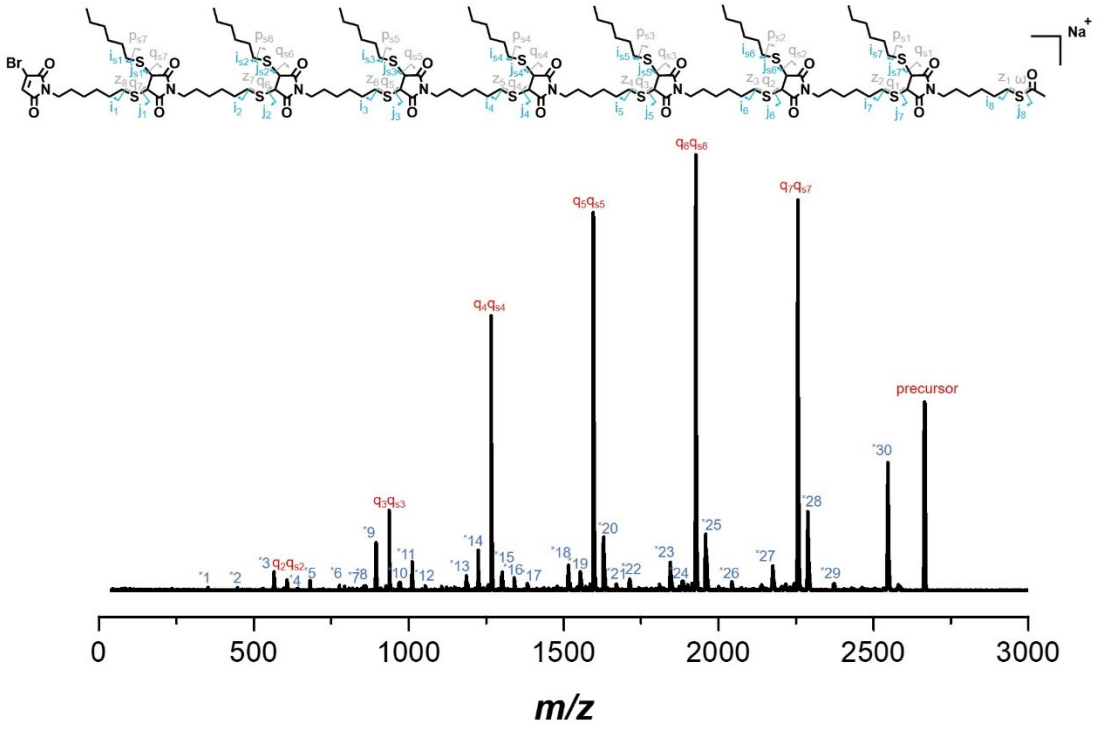
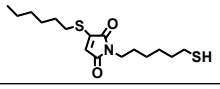
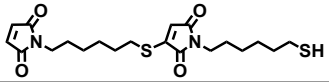
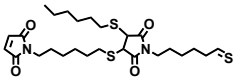
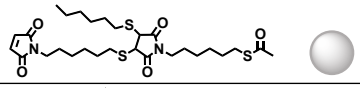
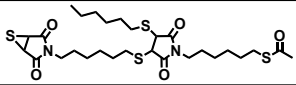
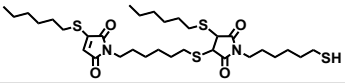
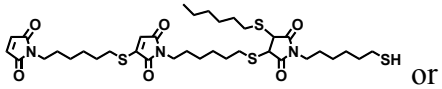
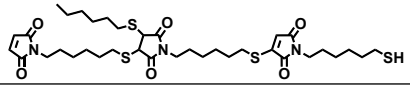
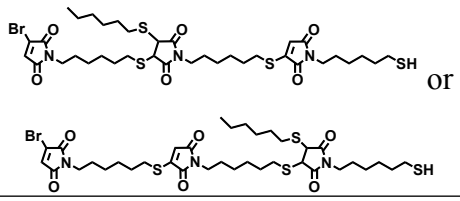
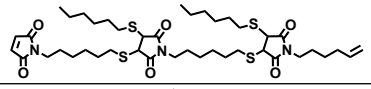
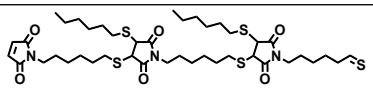
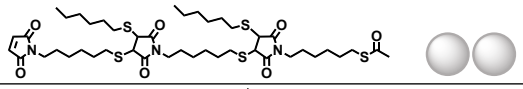
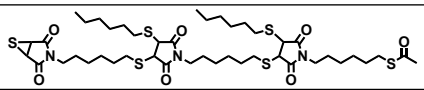
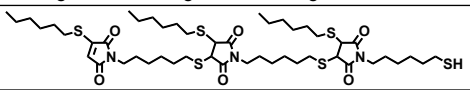
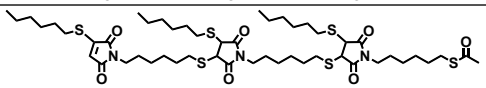
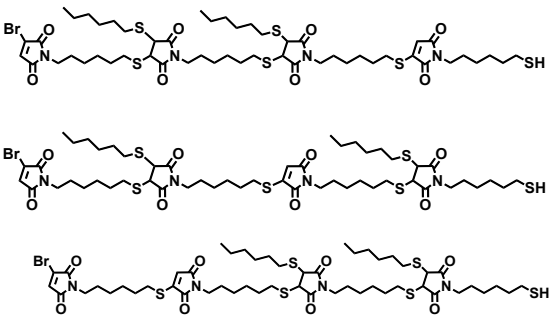
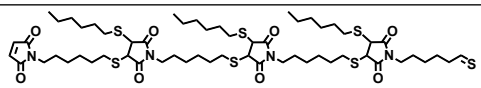
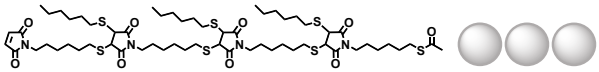
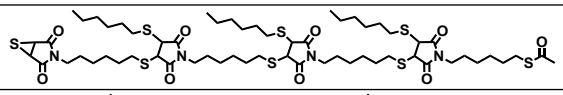
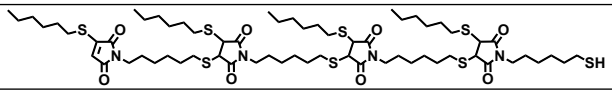
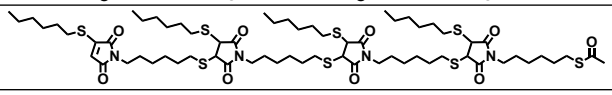
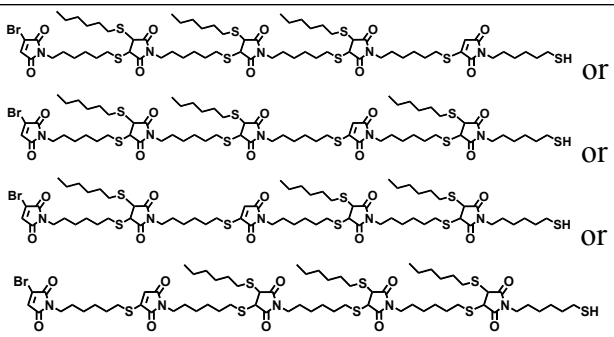
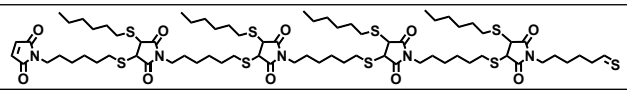
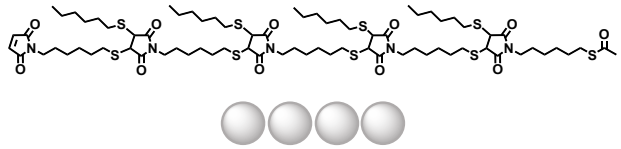
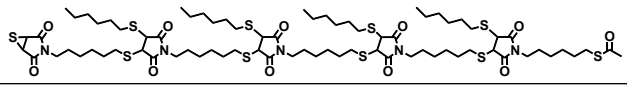
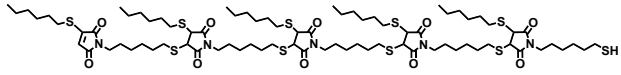
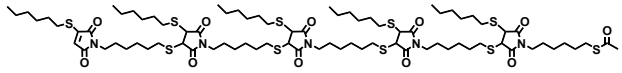
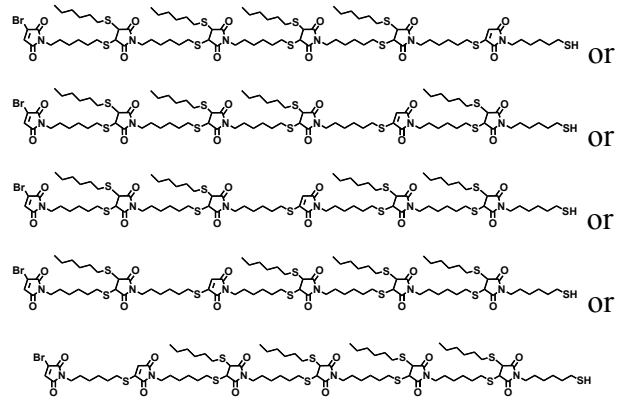
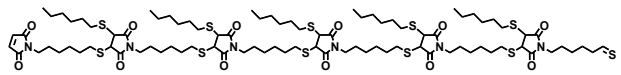
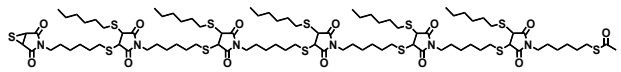
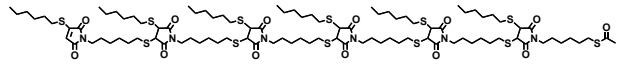
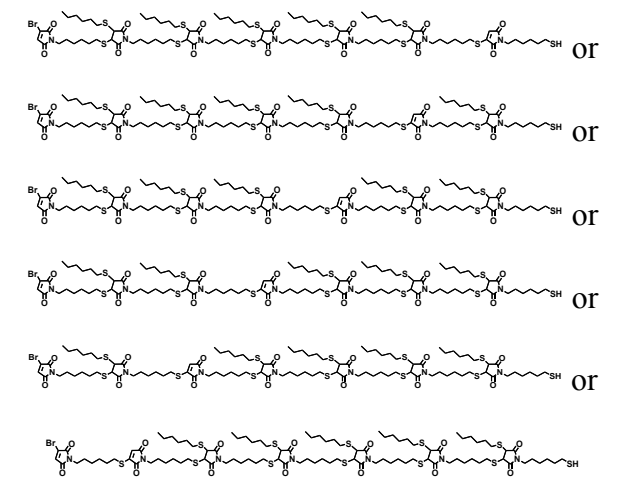


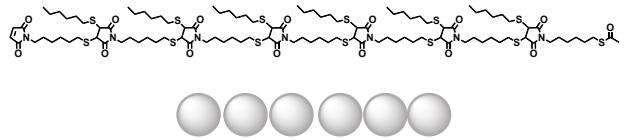
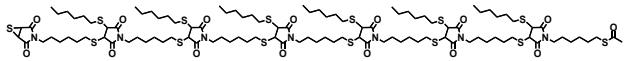
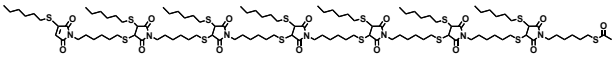
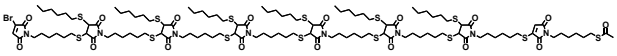
Figure S58. MALDI-TOF MS/MS spectrum of **AAAAAAA**.

Table S4. Analysis of probable fragmented structures of **AAAAAAA** in MALDI-TOF MS/MS.

Number	$m/z_{cal.}$ $m/z_{exp.}$	Probable fragments	Probable structure (+ Na^+)
*1	352.138 352.307	j_2q_7 etc.	
*2	447.138 447.502	$j_3q_{s6}q_7q_{s7}$ etc.	
*3	563.204 563.560	$j_3q_7q_{s7}$ etc.	
★	607.230 607.694	q_2q_{s2}	
*4	639.203 639.631	q_2p_{s2} or z_3q_{s2}	
*5	681.283 681.790	j_3q_7 etc.	
*6	776.287 776.777	$j_4q_{s6}q_7q_{s7}$ or $j_4q_{s5}q_7q_{s7}$ etc.	 or 

*7	854.197 854.903	j_3q_{s6} or j_3q_{s7}	 or
*8	860.380 860.969	$i_4q_7q_{s7}$ etc.	
*9	892.353 892.911	$j_4q_7q_{s7}$ etc.	
★	936.379 936.982	q_3q_{s3}	
*10	968.351 968.904	q_3p_{s3} or z_4q_{s3}	
*11	1010.434 1011.099	j_4q_7 etc.	
*12	1052.445 1053.056	q_3	
*13	1183.345 1184.105	j_4q_{s5} or j_4q_{s6} or j_4q_{s7}	 or
*14	1221.501 1222.195	$j_5q_7q_{s7}$ etc.	
★	1265.527 1266.296	q_4q_{s4}	
*15	1297.499 1298.162	q_4p_{s4} or z_5q_{s4}	
*16	1339.583 1340.340	j_5q_7 etc.	
*17	1381.593 1382.380	q_4	
*18	1512.494 1513.278	j_5q_{s4} or j_5q_{s5} or j_5q_{s6} or j_5q_{s7}	 or

*19	1550.649 1551.460	$j_6q_7q_{s7}$ etc.	
★	1594.675 1595.540	q_5q_{s5}	
*20	1626.647 1627.441	q_5p_{s5} or z_6q_{s5}	
*21	1668.731 1669.546	j_6q_7 etc.	
*22	1710.741 1711.591	q_5	
*23	1841.642 1842.616	j_6q_{s3} or j_6q_{s4} or j_6q_{s5} or j_6q_{s6} or j_6q_{s7}	
*24	1879.798 1880.735	$j_7q_7q_{s7}$ or $j_8q_6q_{s6}$	
★	1923.824 1924.807	q_6q_{s6}	
*25	1955.796 1956.738	q_6p_{s6} or z_7q_{s6}	
*26	2039.890 2040.833	q_6	
*27	2170.790 2171.865	j_7q_{s2} or j_7q_{s3} or j_7q_{s4} or j_7q_{s5} or j_7q_{s6} or j_7q_{s7}	

★	2252.972 2254.022	q_7q_{s7}	
*28	2284.944 2285.991	q_7p_{s7} or z_8q_{s7}	
*29	2369.038 2370.079	q_7	
*30	2541.949 2542.837	q_{s1} etc.	 etc.
★	2660.031 2661.170	precursor	

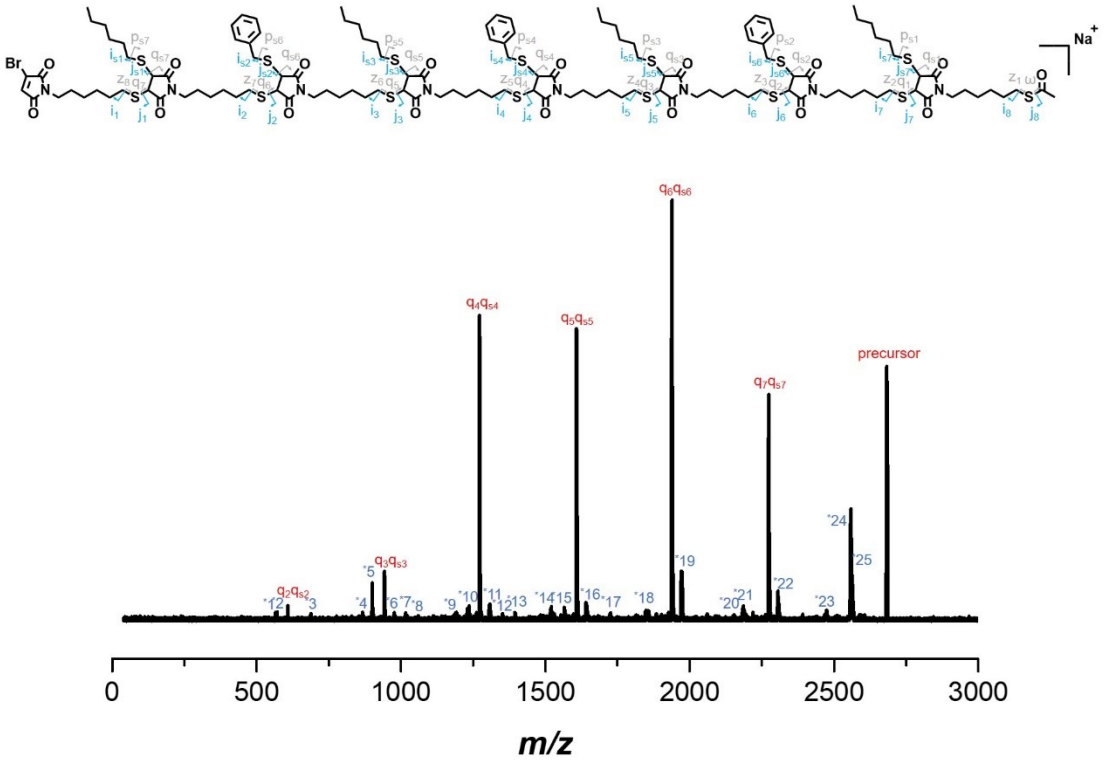
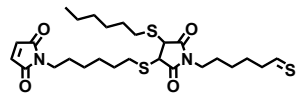
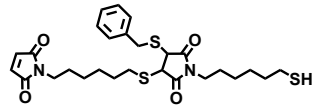
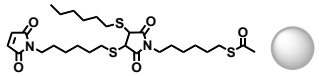
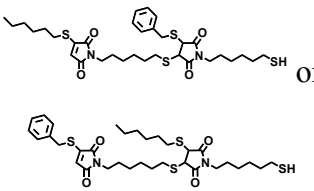
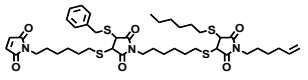
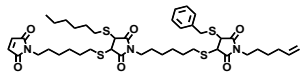
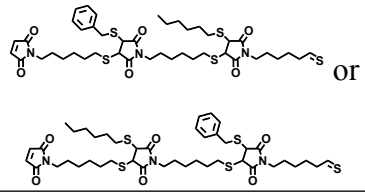
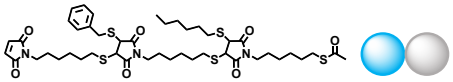
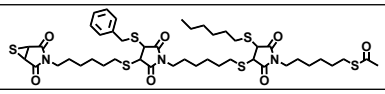
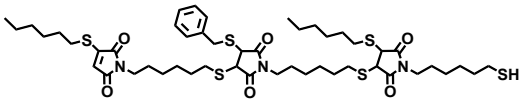
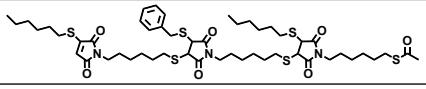
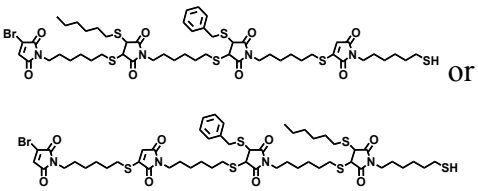
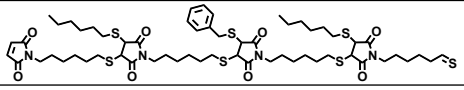
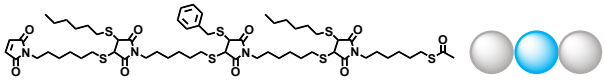
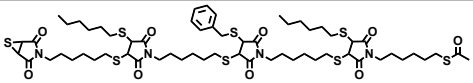
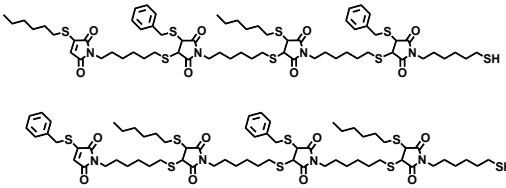
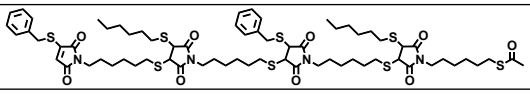
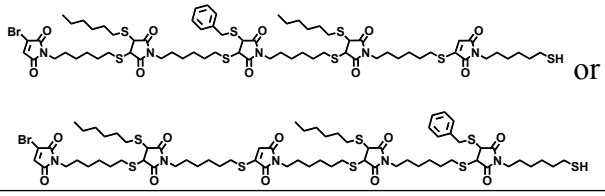
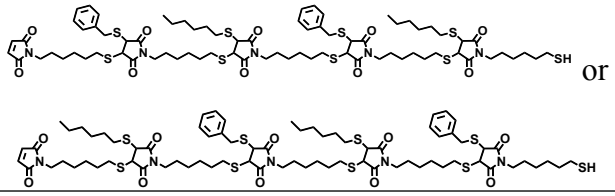
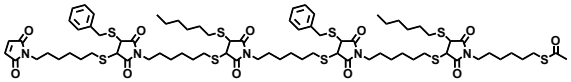
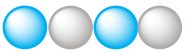
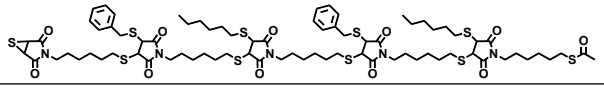
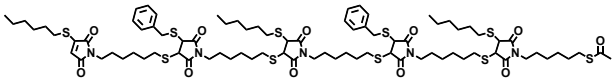
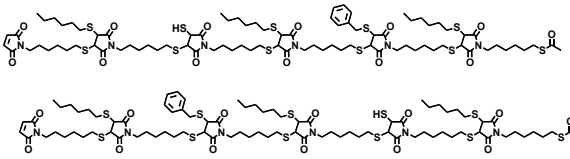
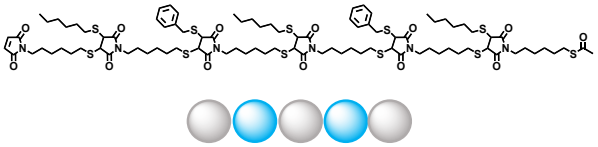
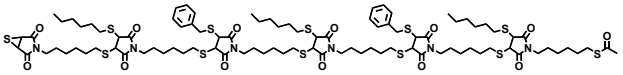
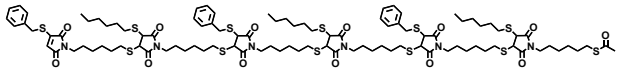
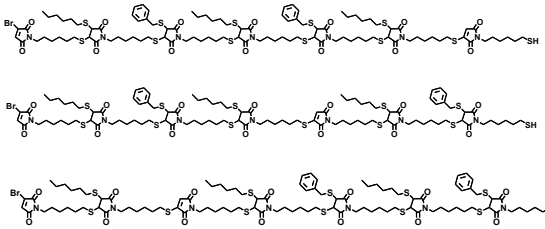
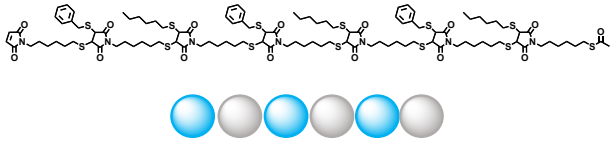
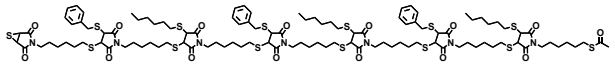
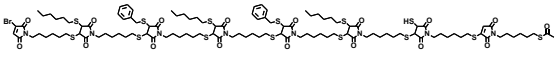
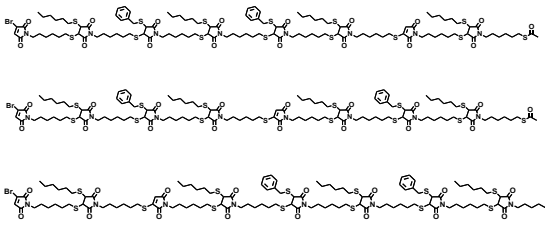
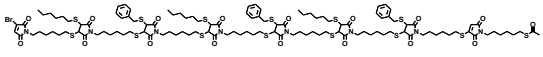


Figure S59. MALDI-TOF MS/MS spectrum of **ABABABA**.

Table S5. Analysis of probable fragmented structures of **ABABABA** in MALDI-TOF MS/MS.

Number	**$m/z_{cal.}$** **$m/z_{exp.}$**	**Probable fragments**	**Probable structure (+ Na^+)**
*1	563.204 563.751	$j_4q_6q_{s6}$ or $j_6q_4q_{s4}$ or $j_8q_2q_{s2}$	
*2	571.173 571.537	$j_3q_7q_{s7}$ or $j_5q_5q_{s5}$ or $j_7q_3q_{s3}$	
★	607.230 607.041	q_2q_{s2}	
*3	687.239 687.506	j_3q_7 or j_4q_6 etc.	 or
*4	866.334 866.762	$i_4q_7q_{s7}$ or $i_5q_6q_{s6}$ etc.	 or 

*5	898.306 898.575	$j_4q_7q_{s7}$ or $j_5q_6q_{s6}$ etc.	 or
★	942.332 943.041	q_3q_{s3}	
*6	974.304 974.939	q_3p_{s3} or z_4q_{s3}	
*7	1016.387 1016.914	j_4q_7 or j_6q_5 or j_8q_3	
*8	1058.398 1058.796	q_3	
*9	1189.298 1189.921	j_4q_{s5} or j_4q_{s7}	 or
*10	1227.454 1228.228	$j_6q_6q_{s6}$ or $j_8q_4q_{s4}$	
★	1271.480 1272.405	q_4q_{s4}	
*11	1303.452 1304.316	q_4p_{s4} or z_5q_{s4}	
*12	1351.489 1352.297	j_5q_7 or j_7q_5 or j_6q_6 or j_8q_4	 or
*13	1393.499 1394.317	q_4	
*14	1518.447 1517.555	j_5q_{s4} or j_5q_{s6}	 or
*15	1564.571 1565.496	$j_6q_7q_{s7}$ or $j_7q_6q_{s6}$ or $j_8q_5q_{s5}$	 or
★	1606.582 1607.617	q_5q_{s5}	

			
*16	1638.554 1639.542	q_5p_{s5} or z_6q_{s5}	
*17	1722.647 1723.788	q_5	
*18	1845.683 1846.869	$p_{s4}q_6q_{s6}$ or $p_{s2}q_6q_{s6}$	 or
★	1935.730 1936.893	q_6q_{s6}	
*19	1967.702 1968.914	q_6p_{s6} or z_7q_{s6}	
*20	2057.749 2058.869	q_6	
*21	2182.696 2181.999	j_7q_{s2} or j_7q_{s4} or j_7q_{s6}	 or or
★	2070.831 2072.130	q_7q_{s7}	
*22	2302.803 2304.068	q_7p_{s7} or z_8q_{s7}	
*23	2469.761 2469.632	$q_{s1}p_{s2}$ or $q_{s2}p_{s1}$ etc.	 etc.
*24	2553.855 2555.242	q_{s2} or q_{s4} or q_{s6}	 or or
*25	2559.808 2560.503	q_{s1} or q_{s3} or q_{s5} or q_{s7}	 etc.
★	2677.890 2678.487	precursor	

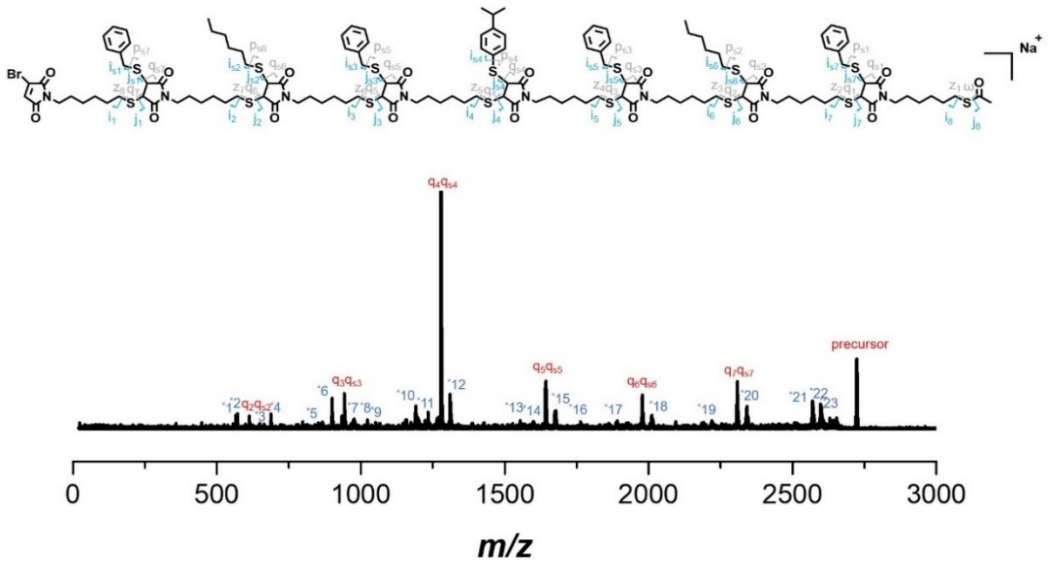
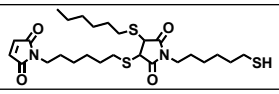
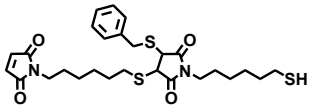
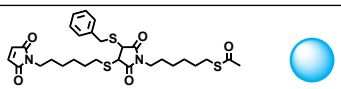
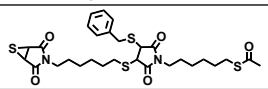
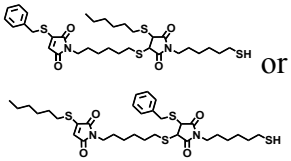
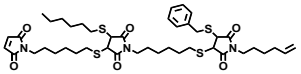
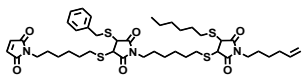
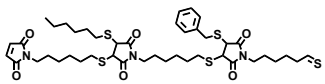
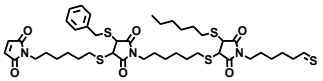
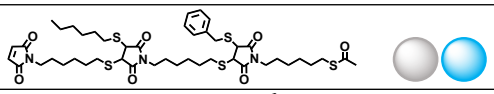
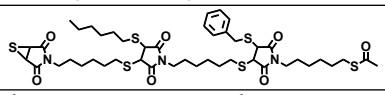
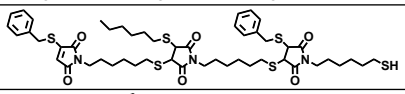
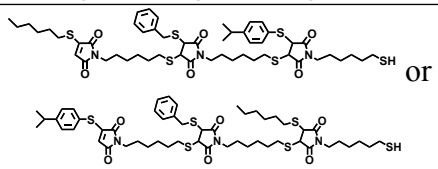
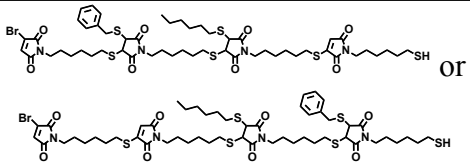
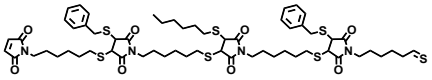
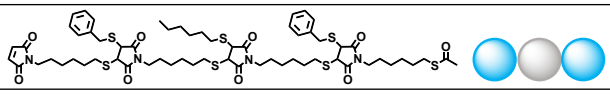
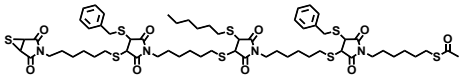
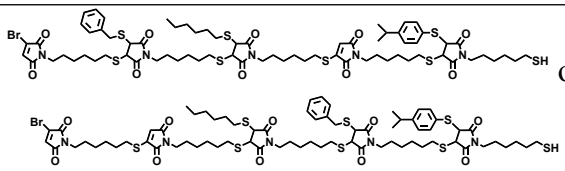
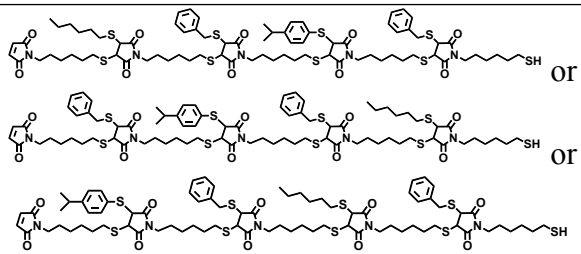
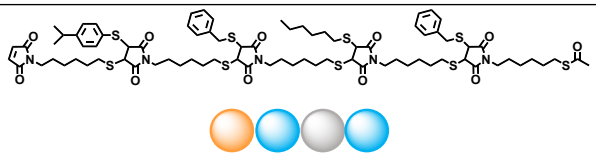
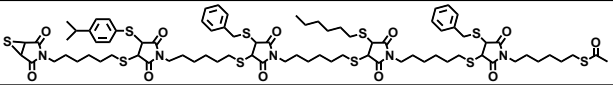
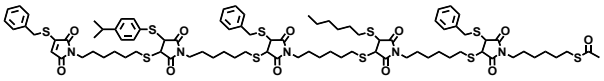
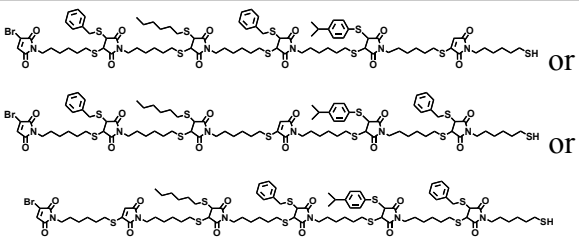
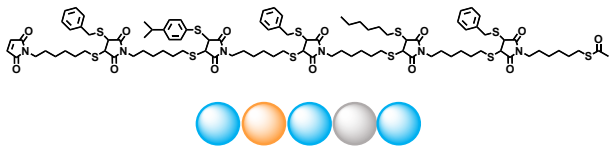
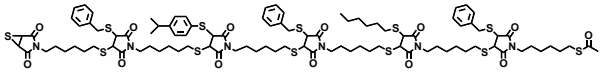
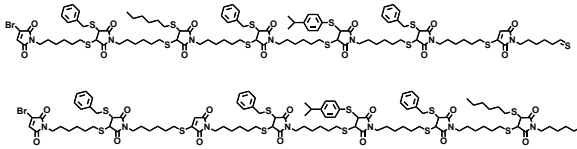
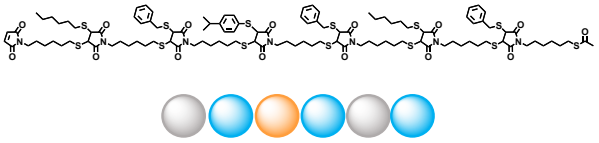
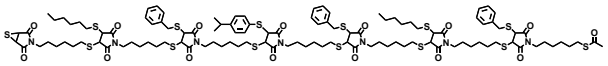
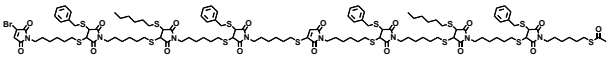
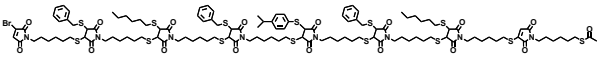
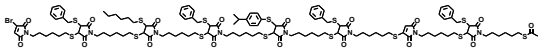
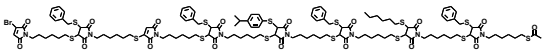


Figure S60. MALDI-TOF MS/MS spectrum of **BABCBAB**.

Table S6. Analysis of probable fragmented structures of **BABCBAB** in MALDI-TOF MS/MS.

Number	$m/z_{cal.}$ $m/z_{exp.}$	Probable fragments	Probable structure (+ Na^+)
*1	565.220 565.675	$j_3q_7q_{s7}$ or $j_7q_3q_{s3}$	
*2	571.173 571.564	$j_4q_6q_{s6}$ or $j_6q_4q_{s4}$ or $j_8q_2q_{s2}$	
★	613.184 613.544	q_2q_{s2}	
*3	645.156 645.916	q_2p_{s2} or z_3q_{s2}	
*4	687.239 687.578	j_3q_7 or j_4q_6 etc.	 or
*5	866.334 866.955	$i_4q_7q_{s7}$ or $i_8q_3q_{s3}$	 or 
*6	898.306 898.988	$j_4q_7q_{s7}$ or $j_8q_3q_{s3}$	 or 

★	942.332 942.992	q_3q_{s3}	
*7	974.304 974.991	q_3p_{s3} or z_4q_{s3}	
*8	1022.340 1022.807	j_4q_7 or j_8q_3	
*9	1050.372 1051.047	j_5q_6 or j_7q_4	
*10	1189.298 1190.018	j_4q_{s5} or j_4q_{s7}	
*11	1233.407 1234.197	$j_8q_4q_{s4}$	
★	1277.433 1278.264	q_4q_{s4}	
*12	1309.405 1310.088	q_4p_{s4} or z_5q_{s4}	
*13	1552.431 1551.848	j_5q_{s5} or j_5q_{s7}	
*14	1598.555 1597.604	$j_6q_7q_{s7}$ or $j_7q_6q_{s6}$ or $j_8q_5q_{s5}$	
★	1640.566 1641.526	q_5q_{s5}	
*15	1672.538 1673.477	q_5p_{s5} or z_6q_{s5}	
*16	1762.585 1763.461	q_5	
*17	1887.533 1886.894	j_6q_{s3} or j_6q_{s5} or j_6q_{s7}	

★	1975.667 1976.742	q_6q_{s6}	
*18	2007.639 2008.883	q_6p_{s6} or z_7q_{s6}	
*19	2220.618 2219.897	j_7q_{s2} or j_7q_{s6}	 or
★	2304.816 2306.064	q_7q_{s7}	
*20	2336.788 2338.058	q_7p_{s7} or z_8q_{s7}	
*21	2565.761 2527.008	q_{s4}	
*22	2593.793 2594.963	q_{s1} or q_{s3} or q_{s5} or q_{s7}	 etc.
*23	2599.746 2601.350	q_{s2} or q_{s6}	 or 
★	2717.827 2719.153	precursor	

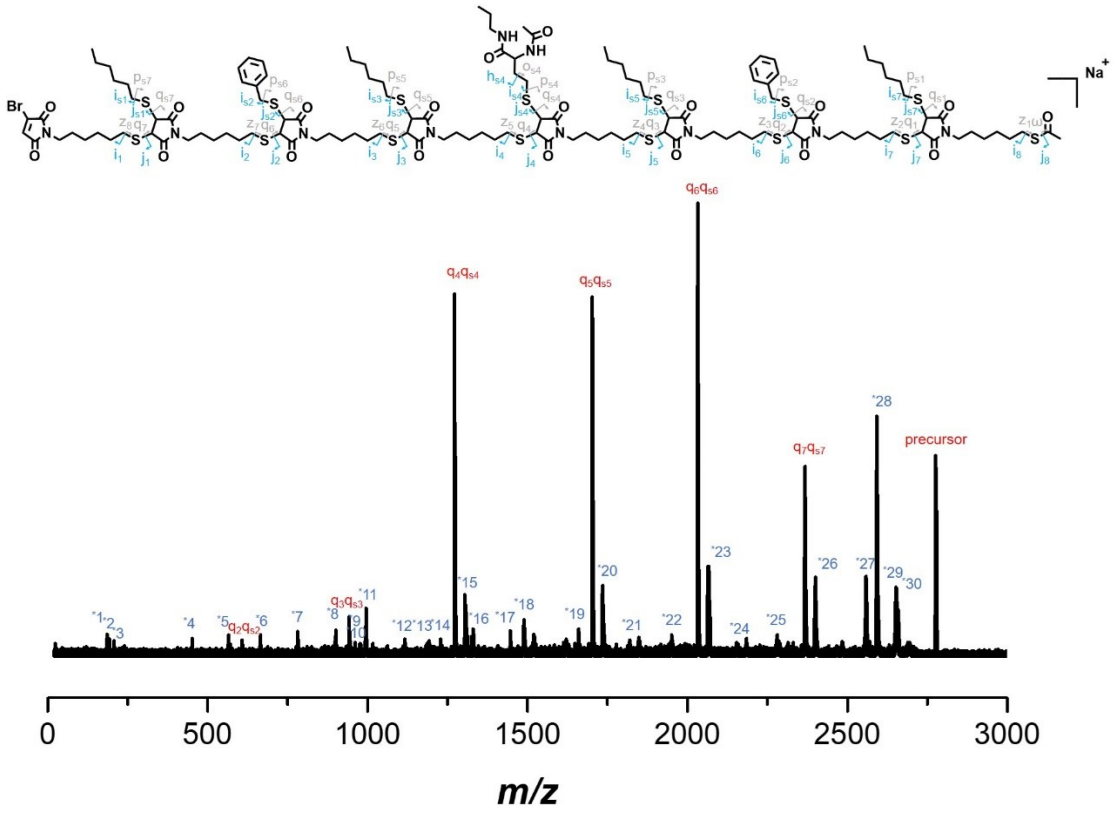
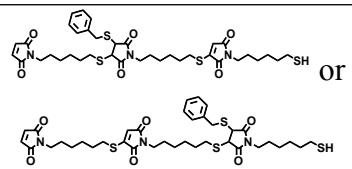
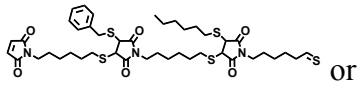
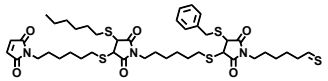
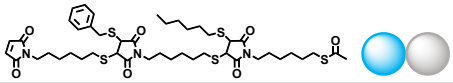
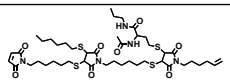
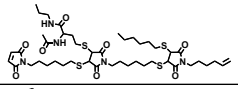
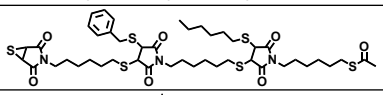
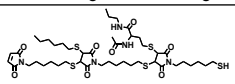
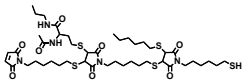
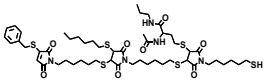
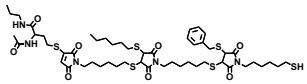
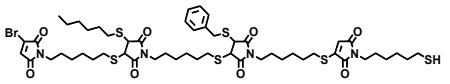
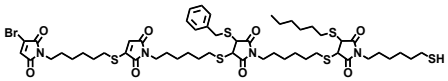
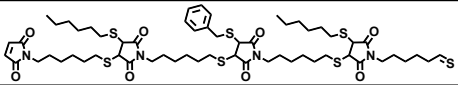
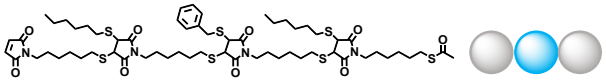
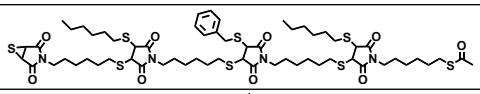
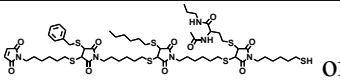
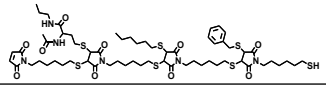
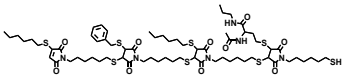
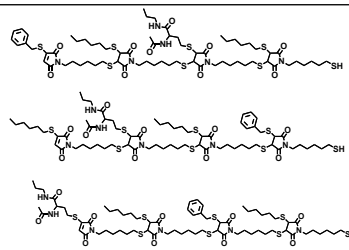
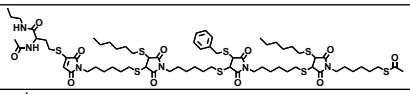
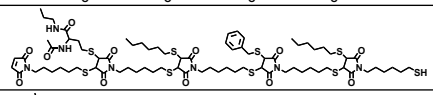
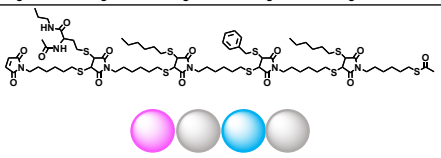
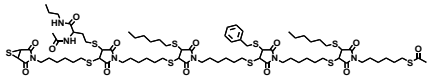
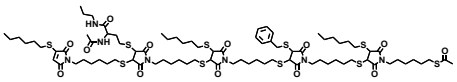
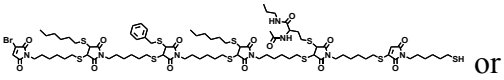
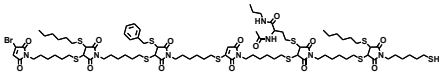
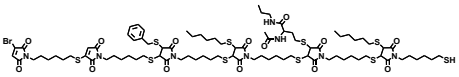
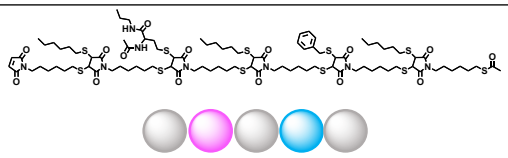
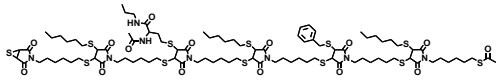
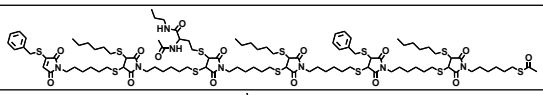
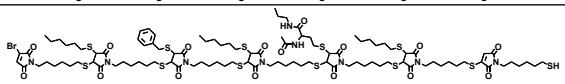
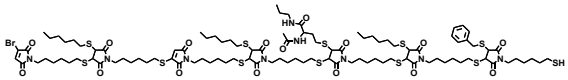
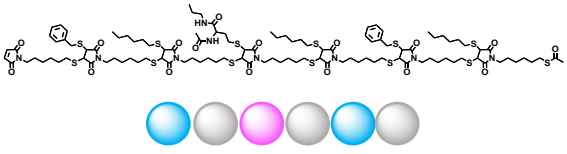
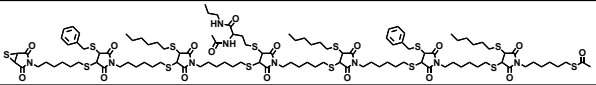
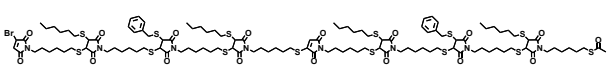


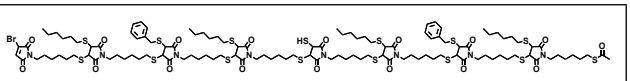
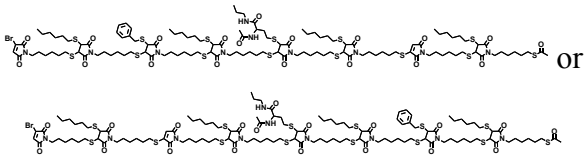
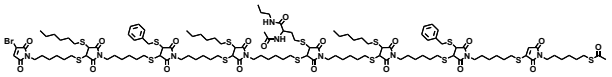
Figure S61. MALDI-TOF MS/MS spectrum of **ABADABA**.

Table S7. Analysis of probable fragmented structures of **ABADABA** in MALDI-TOF MS/MS.

Number	$m/z_{cal.}$ $m/z_{exp.}$	Probable fragments	Probable structure (+ Na^+)
*1	185.128 185.268	i_{s4}^+	(without Na^+)
*2	193.095 193.224	h_{s4}	
*3	207.110 207.247	i_{s4}	
*4	452.165 452.349	j_5q_4	
*5	565.220 565.237	$j_4q_6q_{s6}$ or $j_6q_4q_{s4}$ or $j_8q_2q_{s2}$	
★	607.230 607.475	q_2q_{s2}	
*6	665.247 665.635	$j_5q_5q_{s5}$	

*7	782.240 781.731	$j_4q_5q_7q_{s7}$ or $j_8q_1q_3q_{s3}$ or $j_7q_3q_4q_{s4}$	 or
*8	898.306 898.623	$j_4q_7q_{s7}$ or $j_8q_3q_{s7}$ or $j_7q_4q_{s4}$	 or 
★	942.332 942.816	q_3q_{s3}	
*9	960.408 961.064	$i_5q_6q_{s6}$ or $i_6q_5q_{s5}$	 or 
*10	974.304 974.779	q_3p_{s3} or z_4q_{s3}	
*11	994.395 994.864	$j_5q_6q_{s6}$ or $j_6q_5q_{s5}$	 or 
*12	1116.415 1116.933	j_5q_6 or j_7q_4	 or 
*13	1189.298 1189.870	j_4q_{s5} or j_4q_{s7}	 or 
*14	1227.454 1228.071	$j_8q_4q_{s4}$	
★	1271.480 1272.054	q_4q_{s4}	
*15	1303.452 1304.056	q_4p_{s4} or z_5q_{s4}	
*16	1329.497 1330.044	$j_5q_7q_{s7}$ or $j_7q_5q_{s5}$	 or 
*17	1445.563 1446.167	j_5q_7 or j_6q_6 or j_7q_5 or	 or

		j_8q_4	 or or
*18	1487.573 1488.123	q_4	
*19	1658.645 1659.264	$j_8q_5q_{s5}$	
★	1700.656 1701.374	q_5q_{s5}	
*20	1732.628 1733.328	q_5p_{s5} or z_6q_{s5}	
*21	1816.722 1817.400	q_5	
*22	1947.622 1949.522	j_6q_{s3} or j_6q_{s5} or j_6q_{s7}	 or  or 
★	2029.804 2030.645	q_6q_{s6}	
*23	2061.776 2062.631	q_6p_{s6} or z_7q_{s6}	
*24	2151.823 2153.426	q_6	
*25	2276.771 2277.746	j_7q_{s2} or j_7q_{s6}	 or 
★	2364.905 2365.825	q_7q_{s7}	
*26	2396.878 2397.773	q_7p_{s7} or z_8q_{s7}	
*27	2553.855 2554.555	q_{s4}	

*28	2587.843 2588.697	p_{s4}	
*29	2647.930 2648.746	q_{s2} or q_{s6}	 or
*30	2653.883 2654.147	q_{s1} or q_{s3} or q_{s5} or q_{s7}	 etc.
★	2771.964 2772.922	precursor	

SECTION E. A blind test of sequencing an “unknown” octamer

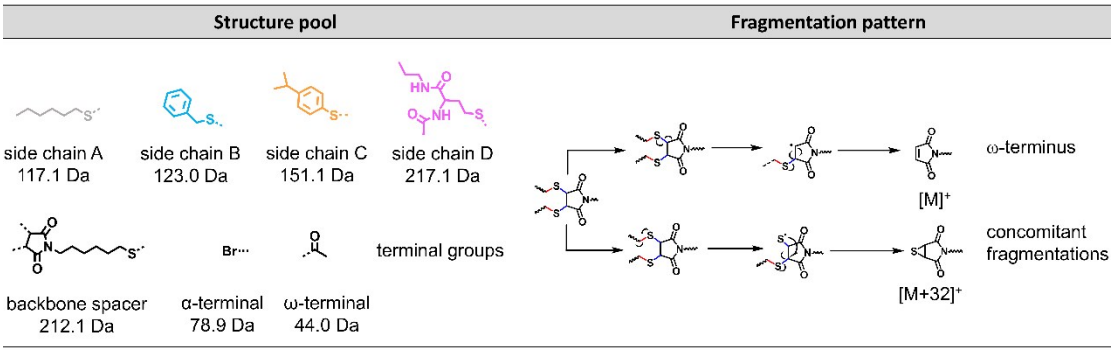


Table S8. The clues provided for the blind test, including a structure pool and fragmentation patterns.

Decipher procedure described by the undergraduate student in the blind test

1. Mark the main fragments with relatively high abundance or with a concomitant [M+32] signal, and then get the intervals;
2. From right to left, I can get the side chain information through the first and second intervals, that is 117.98 Da means hexyl mercaptan (side chain A) and 123.24 Da means benzyl mercaptan (side chain B). There is only two fragments in this area, which means the polymer may contain two side chains;
3. The third interval is 406.36 Da, probably means side chain A, backbone spacer and Br-terminal;
4. The five consecutive intervals present in a alternating mode. Additionally, 335 Da point to the benzyl mercaptan-containing unit (B) and 329 Da present the hexyl mercaptan-containing unit (A), which confirm the conclusion of procedure 2;
5. From the fragmentation pattern, the signal 607.043 Da could assign to a ion equiped with two backbone spacer, hexyl mercaptan-containing unit (A) and ω-terminal;
6. Overall, the sequcne should be ABABABA.

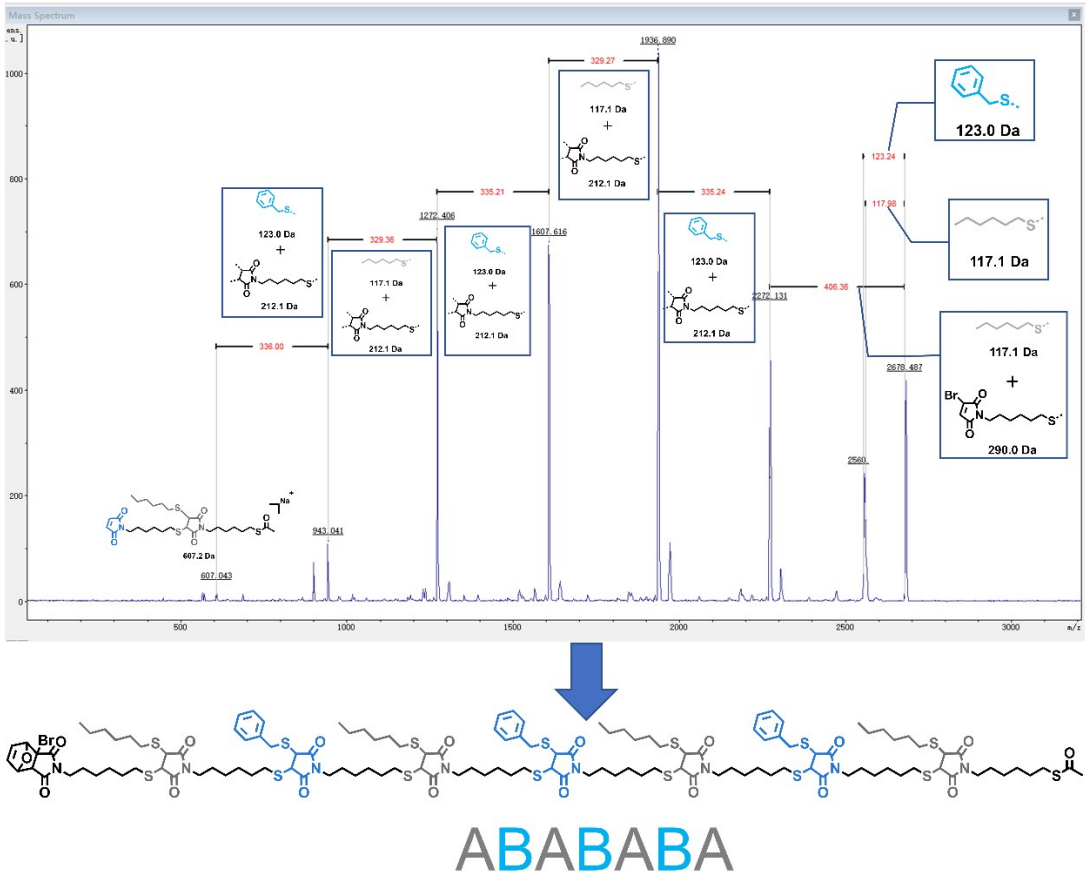


Figure S62. The marked MALDI-TOF MS/MS spectrum of the “unknown” octamer by the undergraduate student in blind test.

SECTION F. An anti-counterfeit system based on fluorescent tags in inkjet ink.

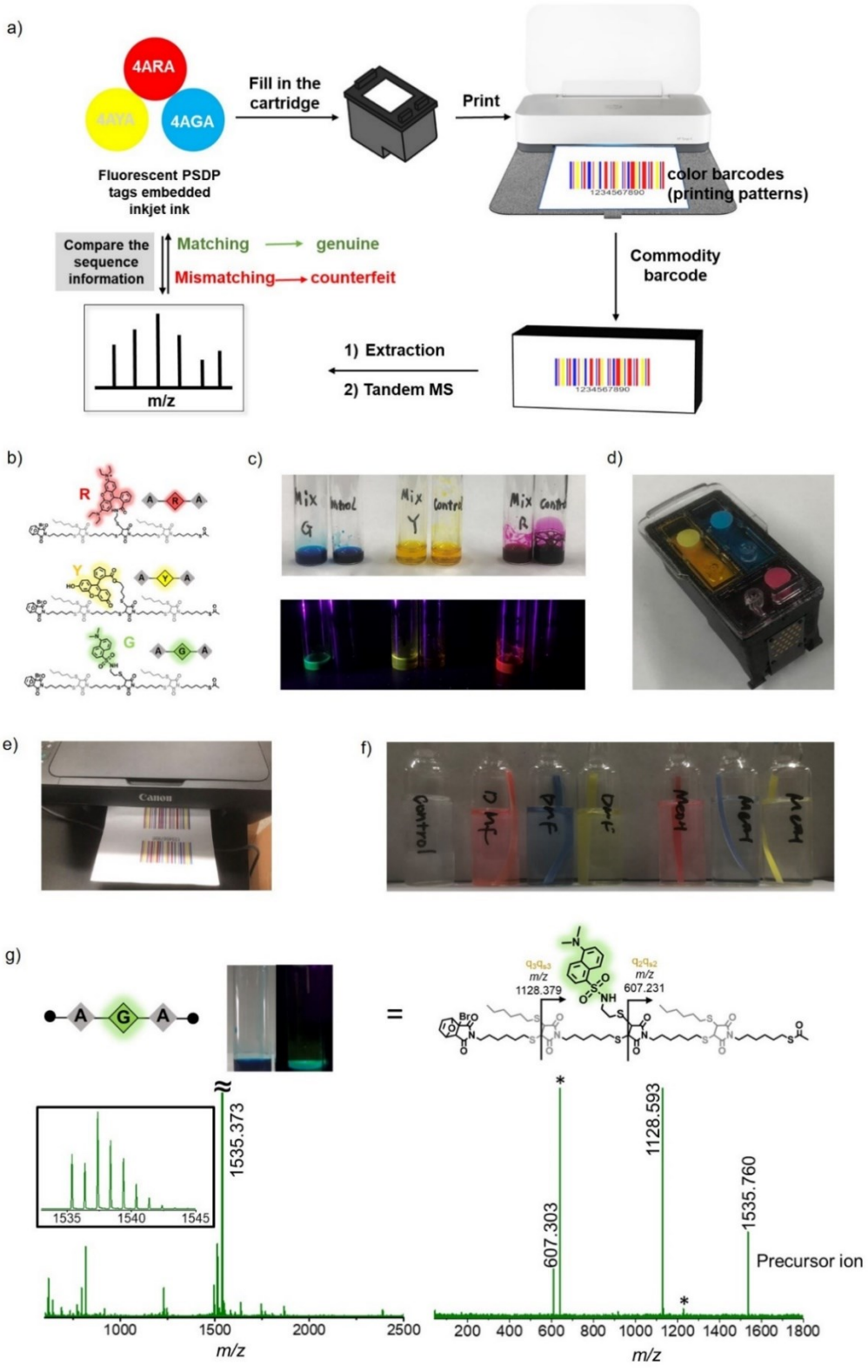


Figure S63. a) General illustration of the anti-counterfeit system based on fluorescent palindromic sequence-defined polymer tags in inkjet ink. b) The chemical structure of fluorescent palindromic sequence-defined polymer tags, containing dansylamine (green), rhodamine B (red) and fluorescein group (yellow) respectively. c) The anti-counterfeit inkjet ink was produced by commercial inkjet ink mixed with fluorescent palindromic sequence-defined polymer tags accordingly. d) A cartridge filled with anti-counterfeit inkjet ink. e) Printing patterns (color barcodes) using the inkjet printer. f) The anti-counterfeit inkjet ink can be extracted by immersing color strips, which cut from the color barcodes, into the solvent of DMF or MeOH. The solutions were concentrated to get the tandem MS samples. g) MALDI-TOF MS and MS/MS spectra of an extracted sample, which matched well with the anti-counterfeit sequence information **AGA**.

SECTION G. References.

1 D. Tuo, Q. He, Q. Wang, Y. Ao and D. Wang, *Chinese J. Chem.*, 2019, **37**, 684-688.

2 M. Witjmans, S. J. Rosenthal, B. Zwanenburg and N. A. Porter, *J. Am. Chem. Soc.*, 2006, **128**, 11720-11726.

3 E. C. Izgu and T. R. Hoye, *Chem. Sci.*, 2013, **4**, 2262-2266.

4 Z. Huang, J. Zhao, Z. Wang, F. Meng, K. Ding, X. Pan, N. Zhou, X. Li, Z. Zhang and X. Zhu, *Angew. Chem. Int. Ed.*, 2017, **56**, 13612-13617.

5 J. Youziel, A. R. Akhbar, Q. Aziz, M. E. Smith, S. Caddick, A. Tinker and J. R. Baker, *Org. Biomol. Chem.*, 2014, **12**, 557-560.

6 L. Wang, M. Sibrian-Vazquez, J. O. Escobedo, J. Wang, R. G. Moore and R. M. Strongin, *Chem. Commun.*, 2015, **51**, 1697-1700.

7 H. M. Osorio, S. Catarelli, P. Cea, J. B. Gluyas, F. Hartl, S. J. Higgins, E. Leary, P. J. Low, S. Martin, R. J. Nichols, J. Tory, J. Ulstrup, A. Vezzoli, D. C. Milan and Q. Zeng, *J. Am. Chem. Soc.*, 2015, **137**, 14319-14328.

8 B. Jing, D. Zhang and D. Zhu, *Tetrahedron Lett.*, 2000, **41**, 8559-8563.

9 C. Wesdemiotis, N. Solak, M. J. Polce, D. E. Dabney, K. Chaicharoen and B. C. Katzenmeyer, *Mass Spectrom. Rev.*, 2011, **30**, 523-559.