Supplementary Information for

Long, Self-Assembled Molecular Ladders by Cooperative Dynamic Covalent Reactions

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General Experimental Procedures

All chemicals and reagents, unless specified, were purchased from commercial sources and used as received without any further purification. Matrix-assisted laser desorption/ionization (MALDI) mass spectra were recorded using a Bruker Autoflex mass spectrometer, whereas electrospray ionization (ESI) mass spectra were recorded using an Agilent Q-TOF 1200 series spectrometer. All MALDI analyses, excluding Im_***16***, were performed in reflectron positive ion mode using 2-(4-hydroxyphenylazo)benzoic acid (HABA) as the matrix, where 3 μL of a solution of the sample in chloroform (1.5 mM) was mixed with 10 μL of a mixture of 6 mg matrix in 300 μL acetonitrile, spotted on a MALDI sample plate (Bruker), and allowed to air dry. MALDI analysis for Im_***16*** was performed in linear positive ion mode. Reverse phase high performance liquid chromatography (RP-HPLC) was performed using a Shimadzu LC-6AD HPLC pump, equipped with a Shimadzu FRC 70A fraction collector, using analytical and preparative reversed phase Phenomenex Luna C18(2) columns with a linear gradient of water and acetonitrile as the eluent at 30°C, and monitored with a Shimadzu Prominence UV/vis detector at 214 nm. Analytical gel permeation chromatography (GPC) was similarly performed using a Shimadzu LC-6AD HPLC pump, equipped with a series of three Phenogel GPC/SEC columns (length 300 mm × diameter 7.8 mm, pore sizes of 500, 100, and 50 Å) with 94:4:2 (v/v/v) $CHCl_3$:MeOH:Et_3N as the eluent at 30°C, and monitored with a Shimadzu Prominence UV/vis detector at 313 nm. The analytical GPC was calibrated utilizing low dispersity polystyrene standards (low molecular weight Readycal Set, Fluka). UV-vis measurements were recorded on an Agilent Cary 60 spectrophotometer in anhydrous chloroform in quartz cuvettes with a 1 cm path length. Scans were taken over the range of 300 to 650 nm, and a background spectrum of pure solvent was subtracted from each scan. Sample concentrations were on the order of 100 μM for each of the peptoids studied. Spectra were then normalized for comparison.

Abbreviations

DABCYL-NHS: 4-(4-dimethylaminophenylazo)benzoic acid, succinimidyl ester

DABCYL-EN: DABCYL ethylene diamine

DCM: dichloromethane

DIC: *N*,*N*′-diisopropylcarbodiimide

DMF: *N*,*N*-dimethylformamide

EDANS: (5-(2-aminoethyl)amino)naphthalene-1-sulfonic acid

Et_3N: triethylamine

MeCN: acetonitrile

NMP: *N*-methyl-2-pyrrolidone

TFA: trifluoroacetic acid

THF: tetrahydrofuran

Section 1: Dynamic Covalent Assembly of Molecular Ladders with *n* Rungs

Solid-Phase Synthesis of Oligopeptoids

Oligopeptoid synthesis was carried out on 133 mg of Rink Amide Resin SS (0.1 mmol scale, 100-200 mesh, 1% DVB, Advanced ChemTech) using an automated microwave peptide synthesizer (Liberty Blue, CEM Corporation). Three primary amine monomers, 4-(2-aminoethyl)-*N*-(*tert*-butoxycarbonyl) phenylamine (Am), 4-(1,3-dioxacyclopent-2-yl)benzylamine (Al), and 2-(2-ethoxyethoxy)ethylamine (E^3A) were synthesized as reported from a published approach.[1] All other monomers, reagents, and solvents were purchased from commercial sources and directly used without further purification. Aldehyde and amine-functionalized oligopeptoids were synthesized according to a published submonomer approach to solid-phase peptoid synthesis.[1] The resin was swelled for 5 min at room temperature and subsequently deprotected with 20% 4-methylpiperidine in DMF (v/v) for 30 s at 75°C and 90 s at 90°C, followed by bromoacetylation for 5 min at 75°C with simultaneous addition of 1.5 mL of 1.0 M bromoacetic acid in DMF and 1.5 mL of 1.0 M DIC in DMF. Halide displacement was then carried out by adding 2.5 mL of 0.5 M primary amine monomer in NMP followed by an incubation of 5 min at 75°C. These bromoacetylation and displacement reactions were alternated until the desired peptoid sequence was achieved. All synthesized peptoids were acetylated by treatment with acetic anhydride to cap the secondary amine end groups.

Cleavage and Side-chain Deprotection

After solid-phase synthesis, the resultant dried Rink-amide resin was transferred to a 25 mL solid-phase peptide synthesis vessel (CG-1866, Chemglass) and treated with 4 mL of TFA cleavage cocktail for 10 – 25 min while bubbling with nitrogen at room temperature. The TFA cleavage solution was collected by filtering through the fritted glass into a 25 mL round bottom flask. The remaining resin was further rinsed twice with 2mL of fresh TFA cleavage cocktail to collect any residual peptoid. The cleavage solution was combined and evaporated by blowing a gentle stream of nitrogen to yield crude peptoid, the structures of which are illustrated in Figure S1. The crude product was reconstituted in HPLC grade MeCN/water (v/v, the least amount of MeCN to dissolve the crude peptoid oil) and further purified by preparative HPLC.

To note, TFA cleavage cocktail and cleavage time are dependent on the number and variety of protecting groups used. 95% aq.[2] TFA was used to deprotect acetal-protected aldehyde-functionalized peptoids, whereas 95% TFA in DCM was used to deprotect Boc-protected amine-functionalized peptoids. Additionally, the crude amine-functionalized peptoids were subjected to 1 M $NaHCO_3$ to adjust the pH to ~7.6 prior to HPLC purification.[1]

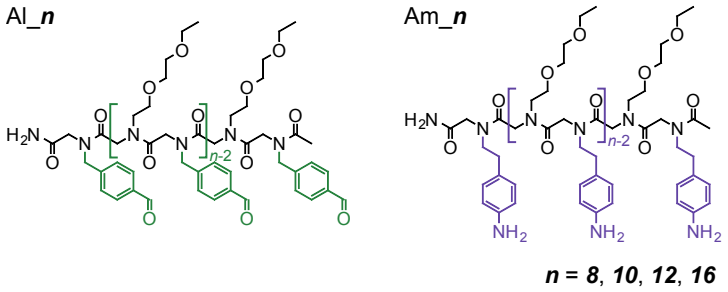


Figure **S1**. Chemical structures of aldehyde- and amine-functionalized oligopeptoids: Al_***n*** (left) and Am_***n*** (right).

Purification of Oligopeptoids by Preparative RP-HPLC

All deprotected peptoids were purified by preparative RP-HPLC using a linear gradient of H_2O (A) and MeCN (B) at a flow rate of 12 mL/min. The purified fractions were combined, concentrated, reconstituted in 50% MeCN/H_2O (v/v), frozen with liquid nitrogen, and lyophilized to afford fluffy white powder. The purity of the collected, aldehyde- and amine-functionalized peptoids was further examined by analytical RP-HPLC.

Preparative HPLC method:

(1) Al_***8***: (1) 30% B, 0.1 – 4.1 min; (2) 30% – 80% B, 4.1 – 24.1 min; (3) 80% – 30% B, 24.1 – 27.1 min;

(2) Al_***10***: (1) 30% B, 0.1 – 4.1 min; (2) 30% – 85% B, 4.1 – 26.1 min; (3) 85% – 30% B, 26.1 – 29.1 min;

(3) Al_***12***: (1) 30% B, 0.1 – 4.1 min; (2) 30% – 85% B, 4.1 – 26.1 min; (3) 85% B, 26.1 – 27.1 min; (4) 85% – 30% B, 27.1 – 30.1 min;

(4) Al_***16***: (1) 30% B, 0.1 – 4.1 min; (2) 30% – 60% B, 4.1 – 12.1 min; (3) 60% – 80% B, 12.1 – 28.1 min; (4) 80% – 30% B, 28.1 – 31.1 min;

(5) Am_***8*** & Am_***10***: (1) 20% B, 0.1 – 4.1 min; (2) 20% – 65% B, 4.1 – 30.1 min; (3) 65% – 20% B, 30.1 – 32.1 min;

(6) Al_***12***: (1) 25% B, 0.1 – 4.1 min; (2) 25% – 65% B, 4.1 – 36.1 min; (3) 65% – 25% B, 36.1 – 38.1 min;

(7) Al_***16***: (1) 35% B, 0.1 – 4.1 min; (2) 35% – 55% B, 4.1 – 12.1 min; (3) 55% – 70% B, 12.1 – 25.1 min; (4) 70% – 35% B, 25.1 – 28.1 min;

Table **S1**. Structural information of aldehyde-functionalized oligopeptoid sequences subjected to MALDI mass spectrometry, HPLC and GPC analysis.

Code	**Formula**	**Exact mass M (g/mol)**	**Molecular weight (g/mol)**
Al_***8***	$C_{138}H_{182}N_{16}O_{38}$	2671.280	2673.048
Al_***10***	$C_{174}H_{230}N_{20}O_{48}$	3367.617	3369.846
Al_***12***	$C_{210}H_{278}N_{24}O_{58}$	4063.954	4066.644
Al_***16***	$C_{282}H_{374}N_{32}O_{78}$	5456.628	5460.240

Table **S2**. Structural information of aldehyde-functionalized oligopeptoid sequences subjected to MALDI mass spectrometry, HPLC and GPC analysis.

Code	**Formula**	**Exact mass M (g/mol)**	**Molecular weight (g/mol)**
Am_***8***	$C_{138}H_{206}N_{24}O_{30}$	2679.533	2681.304
Am_***10***	$C_{174}H_{260}N_{30}O_{38}$	3377.934	3380.166
Am_***12***	$C_{210}H_{314}N_{36}O_{46}$	4076.334	4079.028
Am_***16***	$C_{282}H_{422}N_{48}O_{62}$	5473.134	5476.142

MALDI Mass Spectra of Purified, Aldehyde- and Amine-Functionalized Oligopeptoids

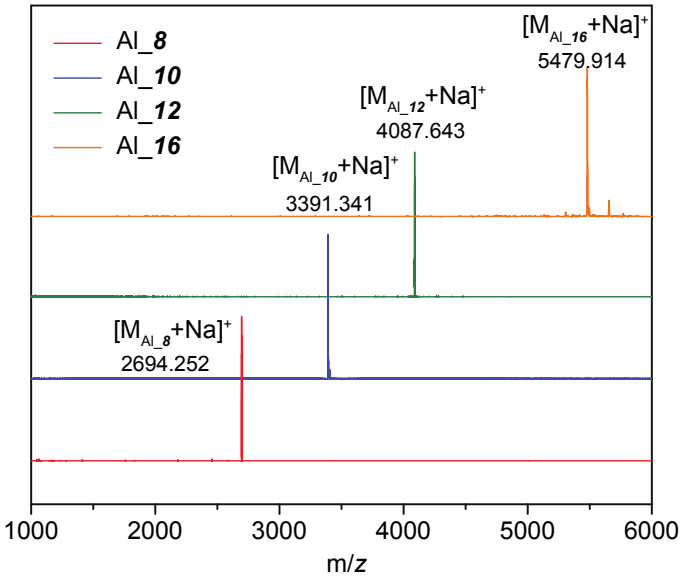


Figure **S2**. MALDI mass spectra of aldehyde-functionalized oligopeptoids purified by preparative RP-HPLC. Expected molecular weights: $[M_{Al\_8}+Na]^+$ = 2694.269; $[M_{Al\_10}+Na]^+$ = 3390.606; $[M_{Al\_12}+Na]^+$ = 4086.943; $[M_{Al\_16}+Na]^+$ = 5479.618.

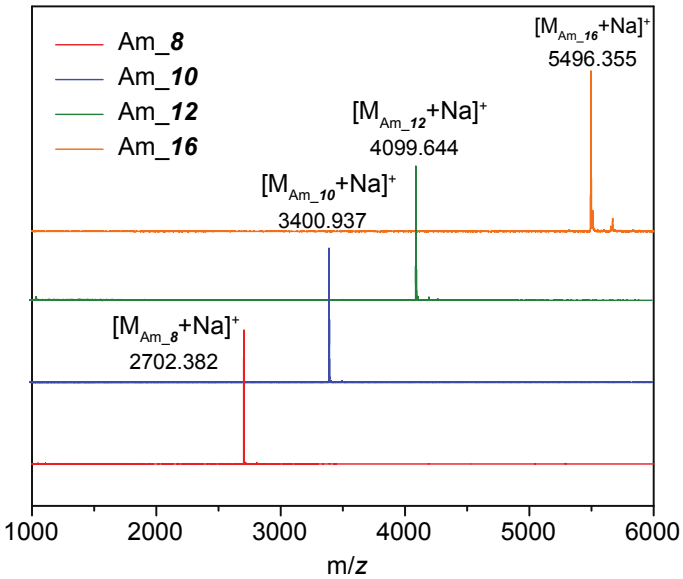


Figure **S3**. MALDI mass spectra of amine-functionalized oligopeptoids purified by preparative RP-HPLC. Expected molecular weights: $[M_{Am\_8}+Na]^+$ = 2702.522; $[M_{Am\_10}+Na]^+$ = 3400.923; $[M_{Am\_12}+Na]^+$ = 4099.323; $[M_{Am\_16}+Na]^+$ = 5496.124.

Analytical HPLC Traces of Purified, Aldehyde- and Amine-Functionalized Oligopeptoids

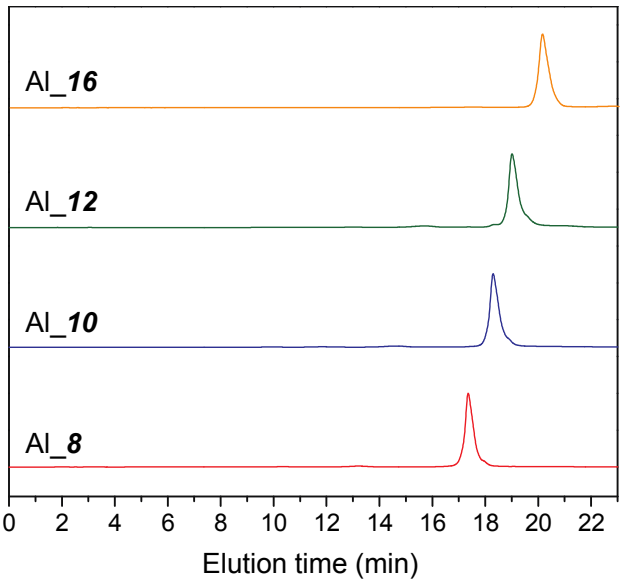


Figure **S4**. Analytical HPLC traces of aldehyde-functionalized oligopeptoids. Purity: Al_***8***, 97.5%; Al_***10***, 96.1%; Al_***12***, 95.4%; Al_***16***, 99.3%. Analytical HPLC method: flow rate at 1 mL/min; A: H_2O, B: MeCN; 20% – 90% B 0 – 20 min, 90% – 20% B 20 – 23 min.

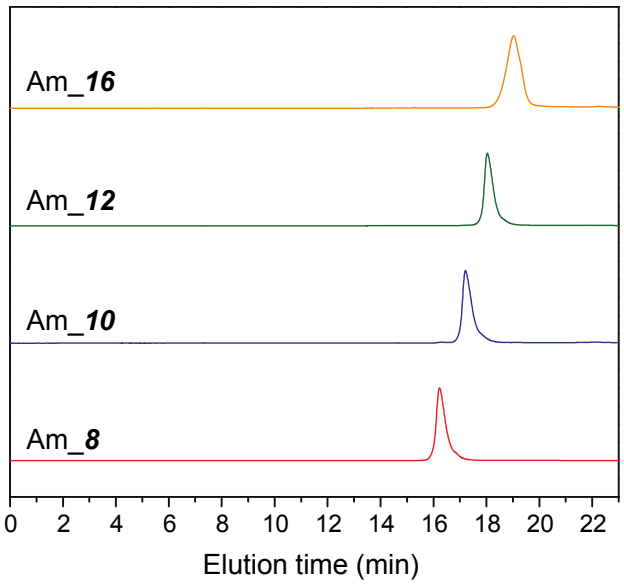


Figure **S5**. Analytical HPLC traces of amine-functionalized oligopeptoids. Purity: Am_***8***, 99.8%; Am_***10***, 96.9%; Am_***12***, 98.8%; Am_***16***, 98.9%. Analytical HPLC method: flow rate at 1 mL/min; A: H_2O, B: MeCN; 20% – 80% B 0 – 20 min, 80% – 20% B 20 – 23 min.

Analytical GPC Traces of Purified, Aldehyde- and Amine-Functionalized Oligopeptoids

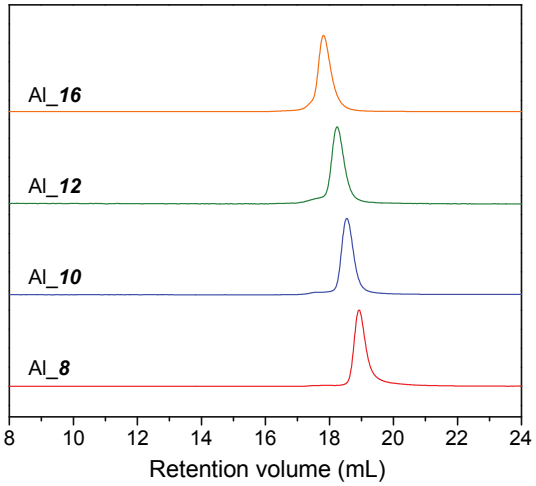


Figure **S6**. Analytical GPC of aldehyde-functionalized oligopeptoids. Analytical GPC method: isocratic flow rate at 1 mL/min; eluent: $CHCl_3/CH_3OH/Et_3N$ (94/4/2, v/v/v). Al_***8***, V_r = 18.92 mL, M_n = 3667 g/mol; Al_***10***, V_r = 18.54 mL, M_n = 4571 g/mol; Al_***12***, V_r = 18.24 mL, M_n = 5502 g/mol; Al_***16***, V_r = 17.81 mL, M_n = 7245 g/mol.

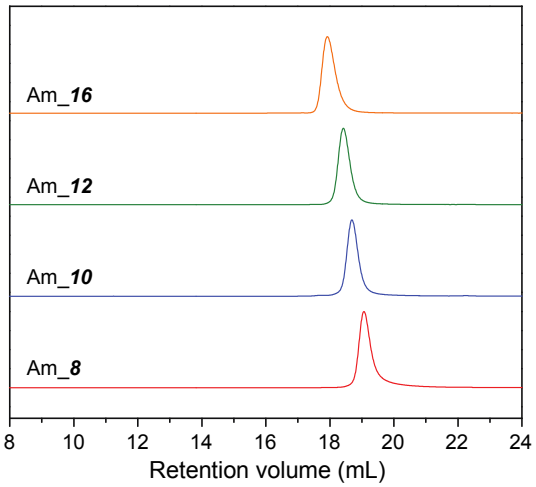
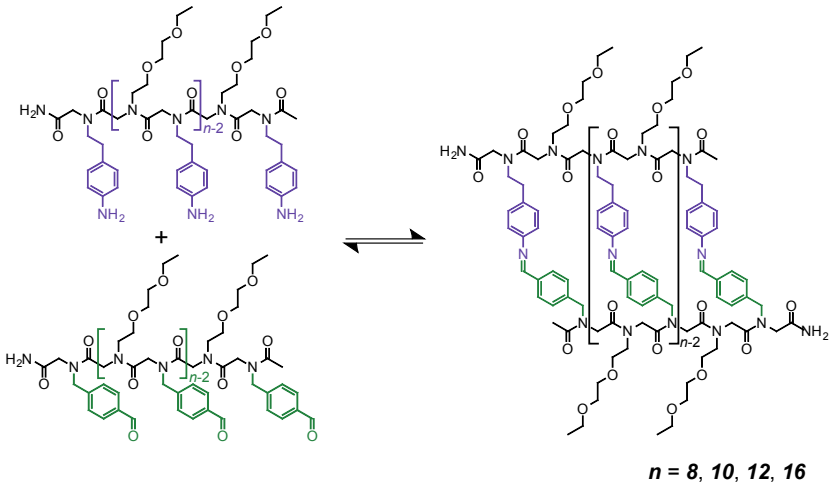


Figure **S7**. Analytical GPC of amine-functionalized oligopeptoids. Analytical GPC method: isocratic flow rate at 1 mL/min; eluent: $CHCl_3/CH_3OH/Et_3N$ (94/4/2, v/v/v). Am_***8***, V_r = 19.10 mL, M_n = 3390 g/mol; Am_***10***, V_r = 18.68 mL, M_n = 4194 g/mol; Am_***12***, V_r = 18.42 mL, M_n = 4923 g/mol; Am_***16***, V_r = 17.92 mL, M_n = 6750 g/mol.

General Procedure for Self-Assembly of Molecular Ladders of Length *n*



n* = *8*, *10*, *12*, *16

Scheme **S1**. Dimerization of peptoid-based molecular ladders *via* imine metathesis.

The approach used to dimerize aldehyde- and amine-functionalized peptoid oligomers to form molecular ladders followed a previously published method.[1] Briefly, 1 μmol of the peptoid oligomer Al_***n*** was mixed with 1 μmol of its complementary strand Am_***n***, in anhydrous $CHCl_3$ with a total reaction volume of 1 mL. To the reaction mixture, $Sc(OTf)_3$ (0.04 eq. per imine bond, 10 mM stock solution dissolved in MeCN) was added to catalyze the transimination and imine metathesis reactions (see Figure S8) and the mixture allowed to stir for a week. The reaction mixture was then directly analyzed by MALDI mass spectrometry and analytical GPC.

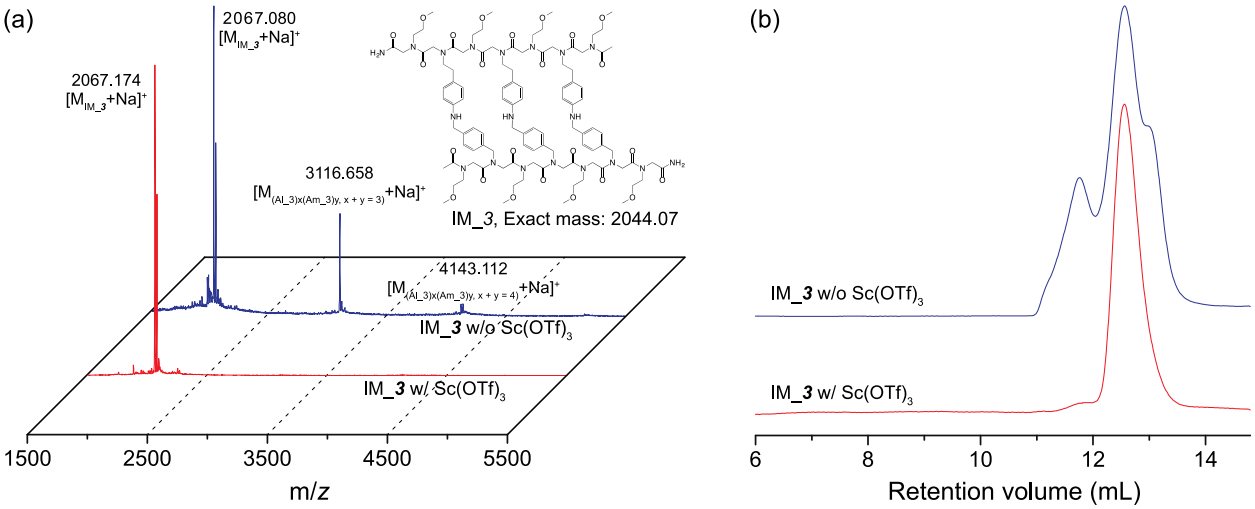


Figure **S8**. Influence of $Sc(OTf)_3$ on the rate of molecular ladder formation. Here, peptoid sequences Al_***3*** and Am_***3***, mixed in 1:1 stoichiometric ratios (1 mM) in chloroform, were allowed to react for 1 hour either with or without the addition of 4 mol% $Sc(OTf)_3$, followed by reduction with sodium cyanoborohydride. (a) MALDI-TOF mass spectra of the crude reaction mixtures demonstrate the rapid and exclusive generation of the desired Im_***3*** molecular ladder in the presence of $Sc(OTf)_3$, whereas the assembly reaction performed in the absence of the Sc(III) catalyst did not proceed to completion, yielding additional, out-of-registry species composed of three and four peptoid strands. (b) GPC traces for the crude reaction mixtures confirm the presence of high molecular weight, out-of-registry species for the assembly reaction performed in the absence of Sc(III).

Table **S3**. Structural information of peptoid-based ladder oligomers subjected to MALDI mass spectrometry and GPC analysis.

Code	Formula	Exact mass (g/mol)
Im_***8***	$C_{276}H_{372}N_{40}O_{60}$	5206.729
Im_***10***	$C_{348}H_{470}N_{50}O_{76}$	6565.445
Im_***12***	$C_{420}H_{568}N_{60}O_{92}$	7924.161
Im_***16***	$C_{564}H_{764}N_{80}O_{124}$	10641.594

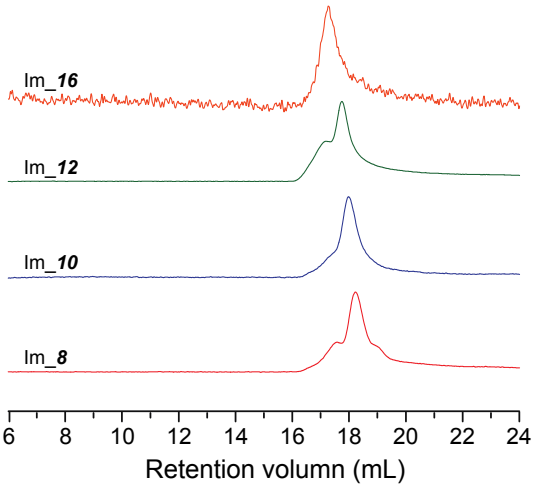


Figure **S9**. GPC traces for crude reaction mixtures. The traces are normalized to the height of the largest peak. Im_***8***, V_r = 18.23 mL, M_n = 5494 g/mol; Im_***10***, V_r = 18.00 mL, M_n = 6332 g/mol; Im_***12***, V_r = 17.75 mL, M_n = 7503 g/mol; Im_***16***, V_r = 17.27 mL, M_n = 10570 g/mol.

Deconvolution of GPC Traces

GPC traces of peptoid-based ladder oligomers were deconvoluted by fitting Gaussian functions to simulate the peaks using a script written in-house with Matlab R2012a (Mathworks Inc.). In each case, the baseline was subtracted and then 2-3 simulated peaks were utilized to fit the spectra.

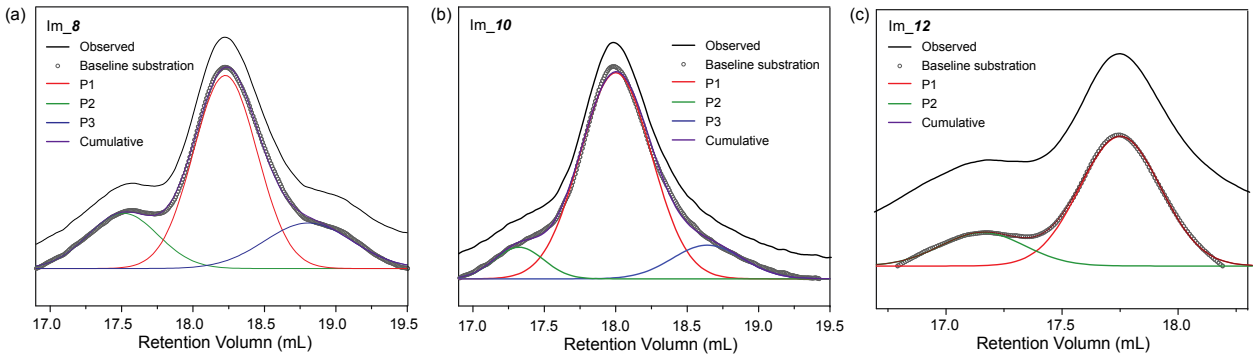


Figure **S10**. Deconvoluted GPC traces of peptoid-based, dimerized molecular ladders (a) Im_***8***, (b) Im_***10***, and (c) Im_***12*** (straight reaction mixtures). The target product peak is labeled in red.

Table **S4**. GPC analysis of peptoid-based, dimerized molecular ladders.

Code	M_n by GPC (g/mol)	Expected M_n (g/mol)	Area (%)
Im_***8***	5494	5210	61%
Im_***10***	6332	6570	79%
Im_***12***	7503	7930	79%
Im_***16***	10570	10649	-*

* unable to be determined due to the low signal-to-noise ratio of GPC trace for Im_***16***

Section 2: Kinetics Study of Molecular Ladder Formation

Hybridization kinetics experiments were performed for peptoid-based molecular ladders with 4, 8, 10, and 12 rungs. An inert peptoid sequence comprised of E^3A spacer, denoted as E^3A-21, was used at a known concentration as an internal standard for this kinetics study. E^3A-21 was synthesized by a submonomer approach to solid-phase synthesis as reported previously using an automated synthesizer,[1] further purified by preparative RP-HPLC, and characterized by MALDI mass spectrometry and analytical RP-HPLC (see Figure S11). Samples were prepared by adding $Sc(OTf)_3$ (0.04 eq. per imine bond, 10 mM stock solution dissolved in MeCN) and between 4 and 20 nmol E^3A_***21*** into anhydrous chloroform, followed by the addition of 1 μmol of the peptoid oligomer Al_***n*** and 1 μmol of Am_***n*** into the mixture, making a total reaction volume of 1 mL. Aliquots of the reaction mixture were taken at increasing time intervals, and examined by MALDI mass spectrometry with a Bruker Autoflex mass spectrometer. Multiple regions of interest were ionized in each sample to obtain an average ratio of target peak areas, and concentrations of target molecular ladders and out of registry molecular ladders were calculated by comparing to the peak area of the internal standard.

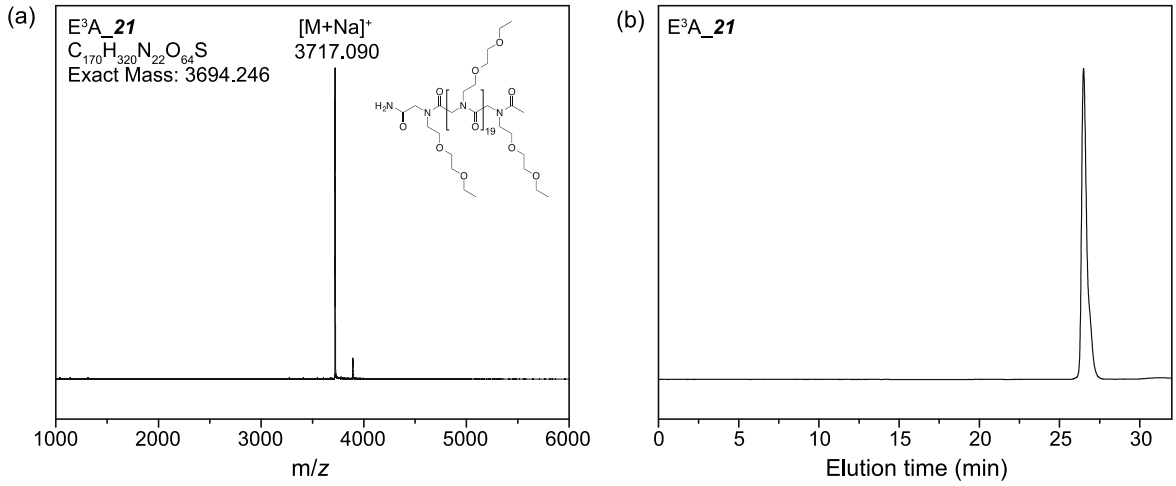


Figure **S11**. Characterizations of the E^3A_***21*** internal standard employed in kinetics experiments: (a) MALDI mass spectrum of E^3A_***21*** purified by preparative RP-HPLC. Expected molecular weights: $[M+Na]^+$ = 3717.235; (b) analytical HPLC trace of E^3A_***21***. Purity: 98.8%. Analytical HPLC method: flow rate at 1 mL/min; A: H_2O, B: MeCN; 20% B 0 – 4 min, 20% – 80% B 4 – 28 min, 80% – 20% B 28 – 32 min.

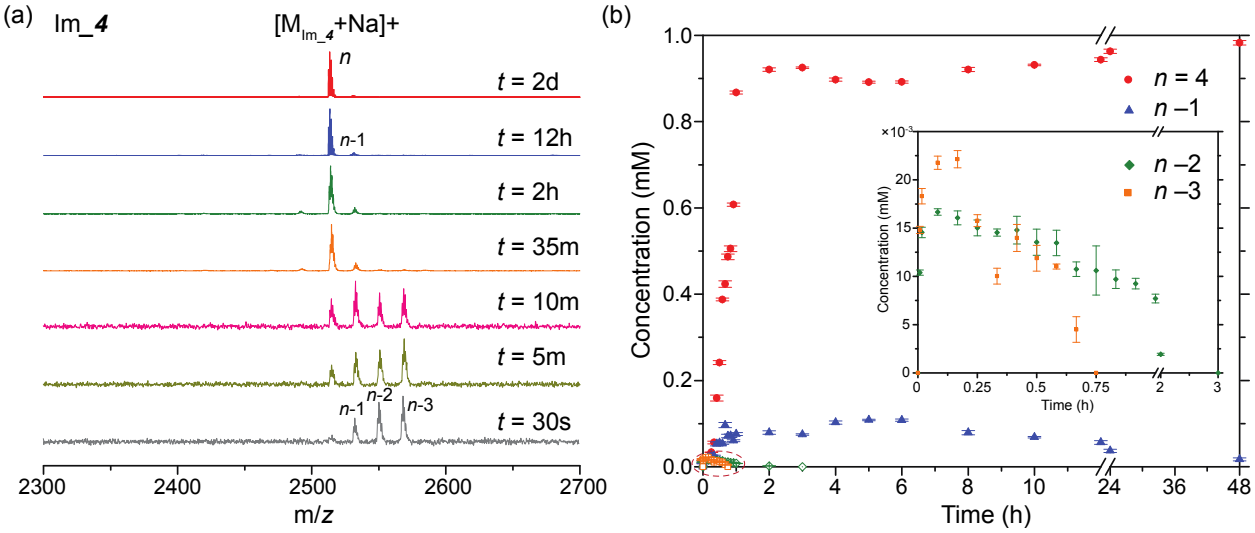


Figure **S12**. Kinetics of the formation of molecular ladder with n = 4 rungs over the course of 2 days. (a) MALDI-TOF mass spectra of the crude reaction mixture at increasing time intervals; (b) Concentration of the desired molecular ladder Im_***4*** and its out of registry molecular ladders versus time during the molecular ladder assembly process.

Table S5. Molecular weight of the desired molecular ladder with n = 4 rungs and its out of registry ladders subjected to MALDI analysis.

Im_*4*	**Expected Exact Mass M (g/mol)**	**Expected [M+Na]$^+$**	**Observed [M+Na]$^+$ by MALDI**
n = 4	2489.296	2512.285	2512.661
n-1	2507.307	2530.296	2530.625
n-2	2525.317	2548.306	2548.609
n-3	2543.328	2566.317	2566.586

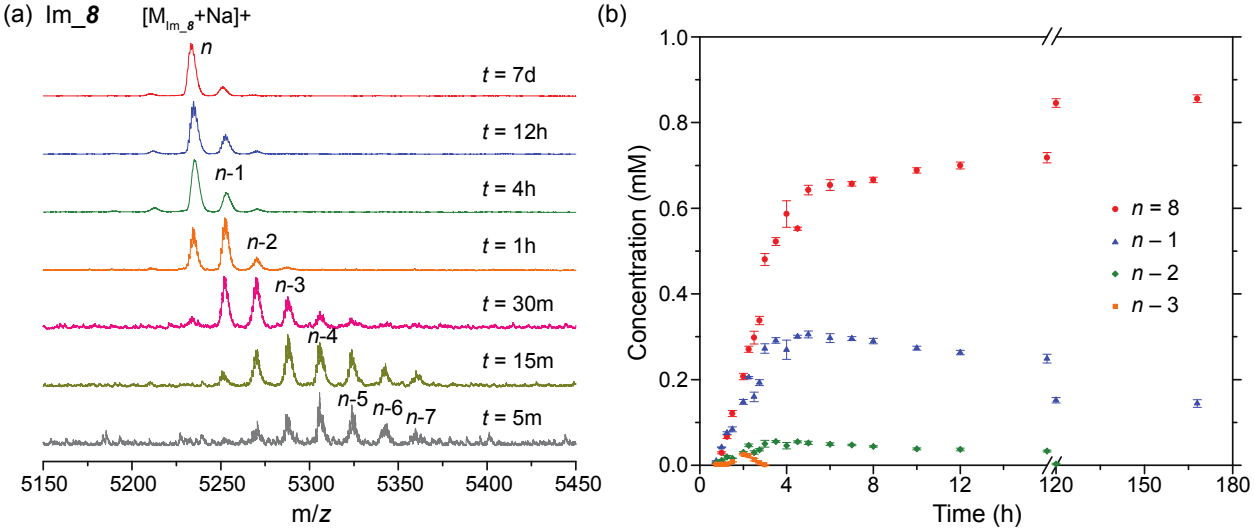


Figure **S13**. Kinetics of the formation of molecular ladder with n = 8 rungs over the course of 7 days. (a) MALDI-TOF mass spectra of the crude reaction mixture at increasing time intervals; (b) Concentration of the desired molecular ladder Im_***8*** and its out of registry molecular ladders versus time during the molecular ladder assembly process.

Table S6. Molecular weight of the desired molecular ladder with n = 8 rungs and its out of registry ladders subjected to MALDI analysis.

Im_*8*	**Expected Exact Mass M (g/mol)**	**Expected $[M+Na]^+$**	**Observed $[M+Na]^+$ by MALDI**
n = 8	5206.729	5229.718	5229.993
n-1	5224.739	5247.728	5248.767
n-2	5242.75	5265.739	5266.512
n-3	5260.76	5283.749	5284.495
n-4	5278.771	5301.760	5302.477
n-5	5296.782	5319.771	5320.580
n-6	5314.792	5337.781	5338.778
n-7	5332.803	5355.792	5356.677

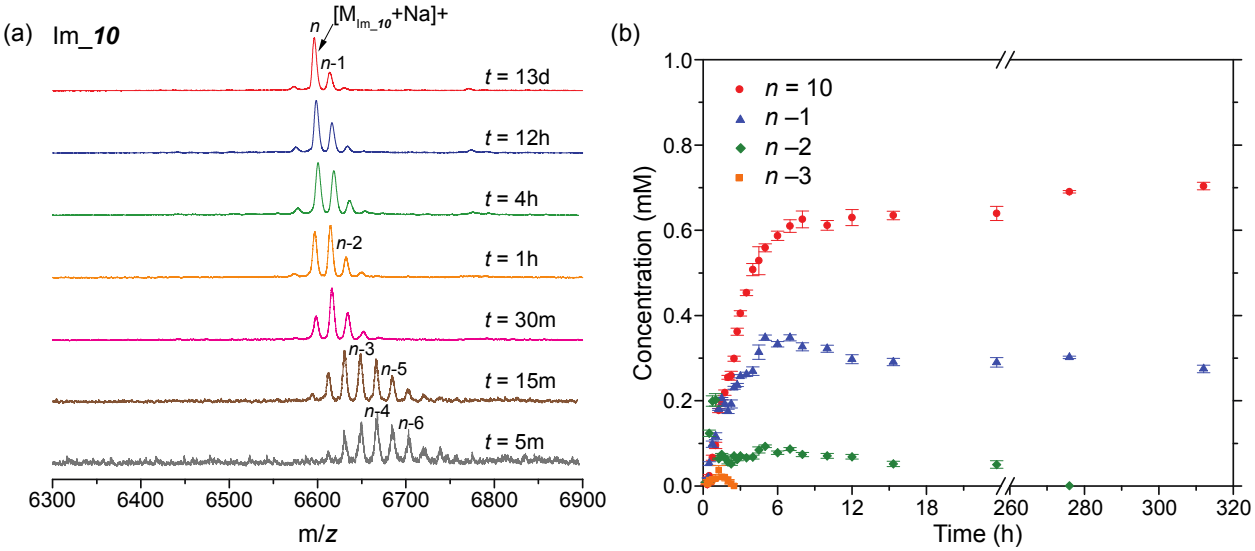


Figure **S14**. Kinetics of the formation of molecular ladder with n = 10 rungs over the course of 13 days. (a) MALDI-TOF mass spectra of the crude reaction mixture at increasing time intervals; (b) Concentration of the desired molecular ladder Im_***10*** and its out of registry molecular ladders versus time during the molecular ladder assembly process.

Table S7. Molecular weight of the desired molecular ladder with n = 10 rungs and its out of registry ladders subjected to MALDI analysis.

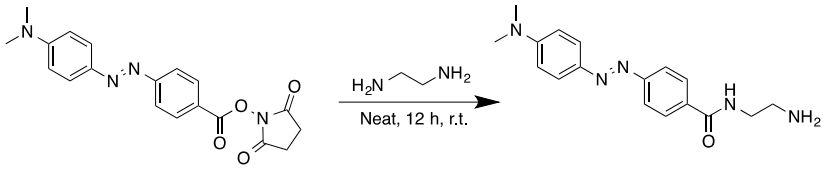
Im_*10*	**Expected Exact Mass M (g/mol)**	**Expected $[M+Na]^+$**	**Observed $[M+Na]^+$ by MALDI**
n = 10	6565.445	6588.434	6588.421
n-1	6583.456	6606.445	6606.459
n-2	6601.466	6624.455	6624.260
n-3	6619.477	6642.466	6642.578
n-4	6637.487	6660.476	6660.633
n-5	6655.45	6678.487	6679.984
n-6	6673.508	6696.500	6696.167
n-7	6691.519	6714.508	6715.235
n-8	6709.53	6732.519	6733.553

Table S8. Molecular weight of the desired molecular ladder with n = 12 rungs and its out of registry ladders subjected to MALDI analysis.

Im_*12*	**Expected Exact Mass M (g/mol)**	**Expected $[M+Na]^+$**	**Observed $[M+Na]^+$ by MALDI**
n = 12	7924.161	7947.150	7946.661
n-1	7942.172	7965.161	7964.742
n-2	7960.182	7983.171	7982.973
n-3	7978.193	8001.182	8000.485
n-4	7996.204	8019.193	8018.546
n-5	8014.214	8037.203	8036.782
n-6	8032.225	8055.214	8054.671
n-7	8050.235	8073.224	8027.702
n-8	8068.246	8091.235	8090.625
n-9	8086.256	8109.245	8108.447
n-10	8104.267	8127.256	8126.153
n-11	8122.277	8145.266	8143.880

Section 3: Forster Resonance Energy Transfer (FRET) for Registry Mechanism of Ladder Formation

Synthesis of DABCYL-EN for Solid-Phase Peptoid Synthesis



Scheme **S2**. Synthesis of DABCYL-EN for subsequent use as a primary amine-bearing submonomer in solid-phase peptoid synthesis.

To a 20 mL vial equipped with magnetic stirrer, 500 mg (1.36 mmol) of DABCYL succinimide ester and 10 mL (excess) of distilled ethylene diamine were added. The reaction was allowed to stir for 12 h and then excess ethylene diamine was removed by rotary evaporation. DCM (3 × 15 mL) was then added to the vial to extract the product and combined. The combined DCM solution was then washed with distilled water (2 × 10 mL) to remove excess amine and succinimide. The organic layer was dried over Na_2SO_4, filtered and solvent removed by rotary evaporation. The resulting red/orange solid was then dried for 3 h under high vacuum (398 mg, 91% yield).

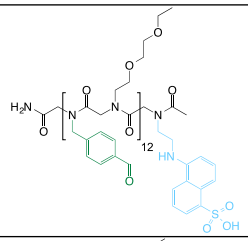
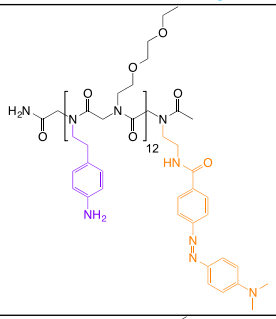
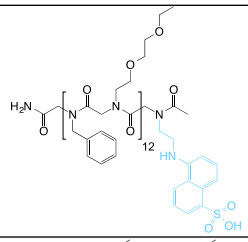
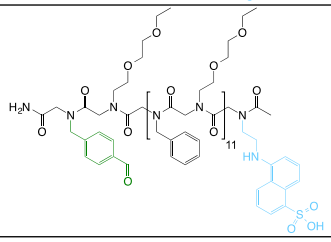
^{1}H NMR (700 MHz, DMSO-d6) δ: 8.52 (s, 1H, -N*H*-), 7.99 (d, 2H, Ar), 7.82 (m, 4H, Ar), 6.84 (d, 2H, Ar), 3.29 (t, 2H, -NH-CH_2-), 2.70 (t, 2H, -CH_2-NH_2), 2.08 (s, 6H, -N(CH_3)$_2$)
^{13}C NMR (175 MHz, DMSO-d6) δ: 165.73, 153.88, 152.81, 142.62, 134.94, 128.32, 125.07, 121.50, 111.57, 43.11, 41.30, 30.70
ESI+: 312.1 m/z $[M+H]^+$

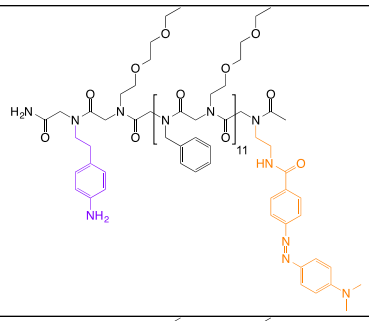
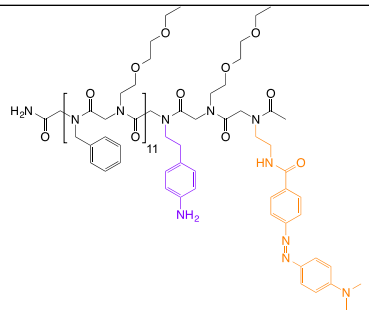
Preparation of oligopeptoids for FRET study

Six primary amine monomers, 4-(2-aminoethyl)-*N*-(*tert*-butixycarbonyl) phenylamine (Am), 4-(1,3-dioxacyclopent-2-yl)benzylamine (Al), 2-(2-ethoxyethoxy)ethylamine (E^3A), benzylamine (Bz), EDANS and DABCYL-EN were utilized for the synthesis of peptoids for FRET study. Peptoids containing EDANS and DABCYL were prepared according to the aforementioned submonomer approach to solid-phase synthesis. However, 0.2 M EDANS in DMF/DBU (4:1, v/v) and 0.2 M DABCYL-EN in NMP were used for halide displacement instead. Additionally, halide displacement with EDANS was proceeded twice to ensure the reaction completion. Subsequently, the resultant peptoids were cleaved from the resin beads by treatment with a TFA cleavage cocktail and purified by preparative HPLC. Peptoids containing DABCYL were purified by preparative RP-HPLC using a linear gradient of H_2O (A) and MeCN (B) at a

flow rate of 12 mL/min. The purified fractions were combined, concentrated, reconstituted in 50% MeCN/H_2O (v/v), frozen with liquid nitrogen and lyophilized to afford fluffy white powders. The purity of the collected peptoids with DABCYL was further examined by analytical RP-HPLC. Peptoids containing EDANS were purified using 0.1%TFA in both water (A) and MeCN (B) as eluent. The purified fractions were combined and evaporated to dryness. The resultant peptoids were dissolved in methanol and evaporated to dryness several times to remove the trace amount of TFA.

Table **S9**. Structural information of oligopeptoid sequences subjected to FRET study.

Code	**Structure**	**Formula**	**Exact mass M (g/mol)**	**Molecular weight (g/mol)**
Al_***12***-EDANS		$C_{232}H_{307}N_{27}O_{65}S$	4543.127	4546.192
Am_***12***-DABCYL		$C_{237}H_{350}N_{42}O_{51}$	4600.6085	4603.650
Bz_***12***-EDANS		$C_{220}H_{307}N_{27}O_{53}S$	4207.188	4210.072
Al-Bz_***11***-EDANS		$C_{221}H_{307}N_{27}O_{54}S$	4235.183	4238.082

Am-Bz_***11***-DABCYL		$C_{226}H_{317}N_{31}O_{51}$	4281.317	4284.188
Bz_***11***-Am-DABCYL		$C_{226}H_{317}N_{31}O_{51}$	4281.317	4284.188

Preparative HPLC method:

(1) Al_***12***-EDANS: (1) 40% B, 0.1 – 4.1 min; (2) 40% – 70% B, 4.1 – 31.7 min; (3) 70% – 40% B, 31.7 – 33.7 min;

(2) Am_***12***-DABCYL: (1) 30% B, 0.1 – 4.1 min; (2) 30% – 75% B, 4.1 – 34.1 min; (3) 75% – 30% B, 34.1 – 36.1 min;

(3) Bz_***12***-EDANS: (1) 50% B, 0.1 – 4.1 min; (2) 50% – 85% B, 4.1 – 32.9 min; (3) 85% – 50% B, 32.9 – 34.9 min;

(4) Al-Bz_***11***-EDANS: (1) 50% B, 0.1 – 4.1 min; (2) 50% – 85% B, 4.1 – 36.1 min; (3) 85% – 50% B, 36.1 – 38.1 min;

(5) Am-Bz_***11***-DABCYL & Bz_***11***-Am-DABCYL (1) 55% B, 0.1 – 4.1 min; (2) 55% – 95% B, 4.1 – 32.7 min; (3) 95% – 55% B, 32.7 – 4.7 min.

MS (ESI+):

ESI-MS spectra were acquired and deconvoluted by the Agilent Qualitative Analysis Program.

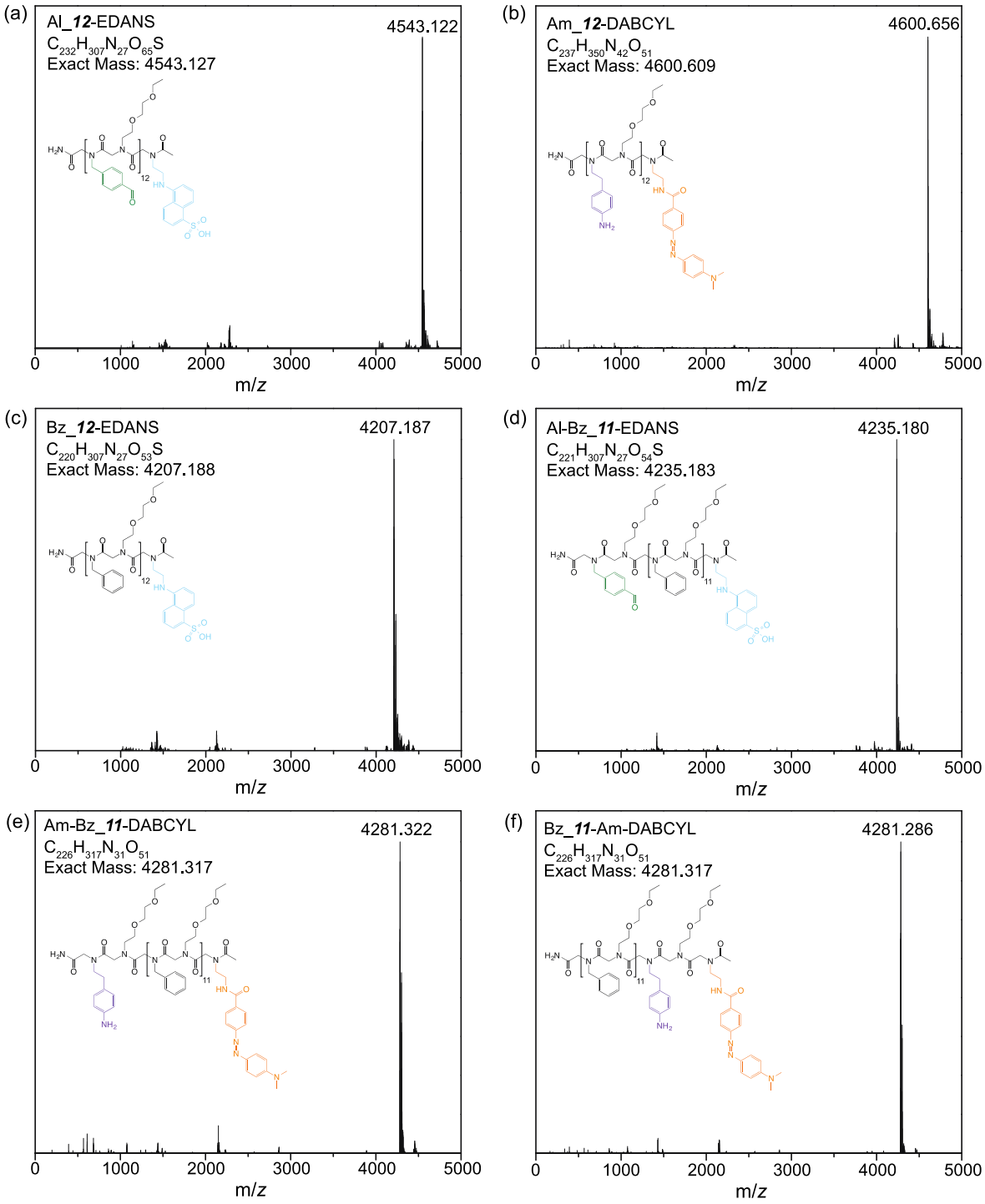


Figure **S15**. Deconvoluted ESI-MS spectra of oligopeptoids containing FRET pairs purified by preparative RP-HPLC: (a) Al_***12***-EDANS; (b) Am_***12***-DABCYL; (c) Bz_***12***-EDANS; (d) Al-Bz-***11***-EDANS; (e) Am-Bz-***11***-DABCYL; (f) Bz-***11***-Am-DABCYL.

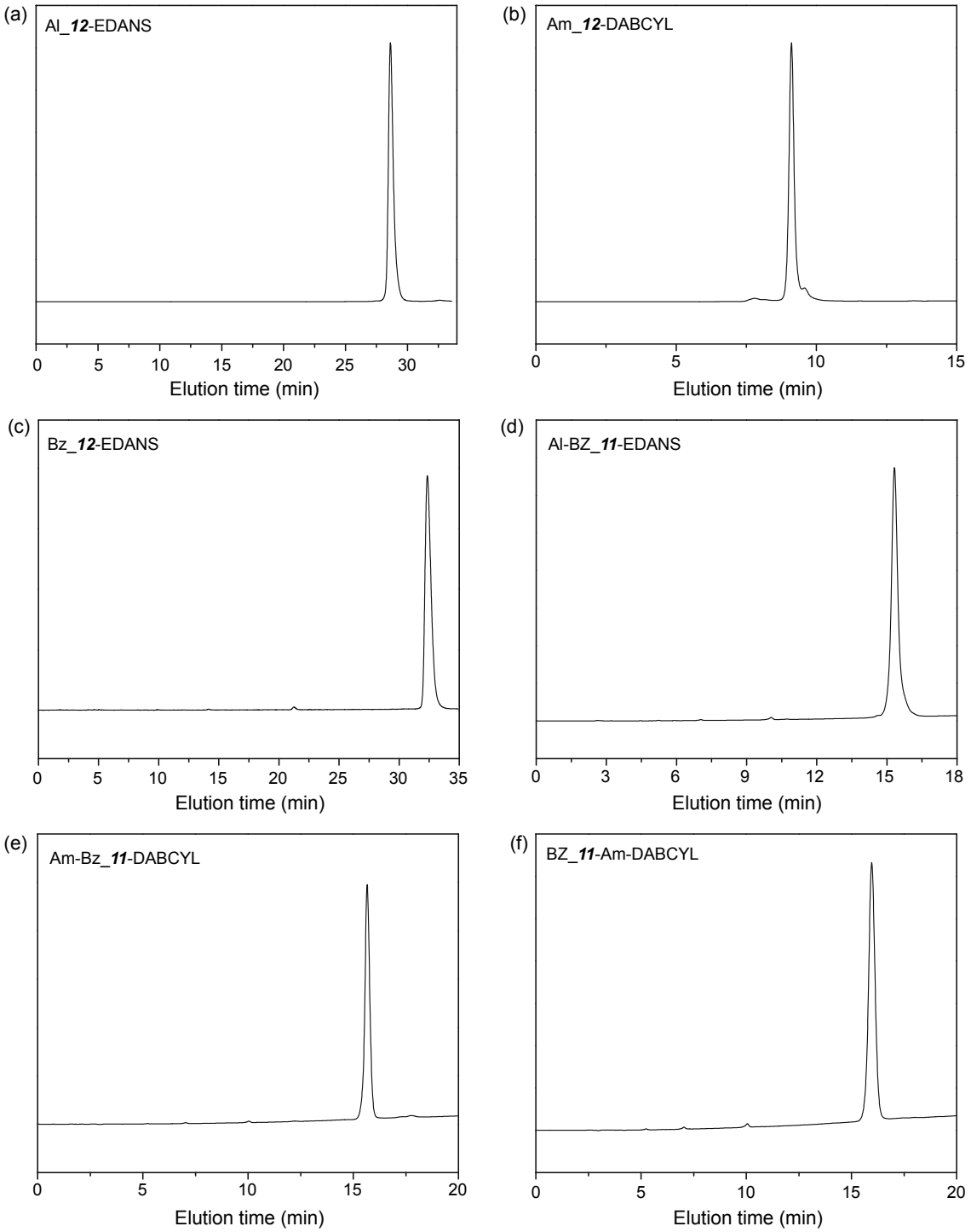


Figure **S16**. Analytical HPLC traces of oligopeptoids comprised of FRET pairs. Purity: Al_***12***-EDANS, 99.3%; Am_***12***-DABCYL, 95.8%; Bz_***12***-EDANS, 98.4%; Al-Bz-***11***-EDANS, 97.9%, Am-Bz-***11***-DABCYL, 96.1%; Bz-***11***-Am-DABCYL, 97.2%.

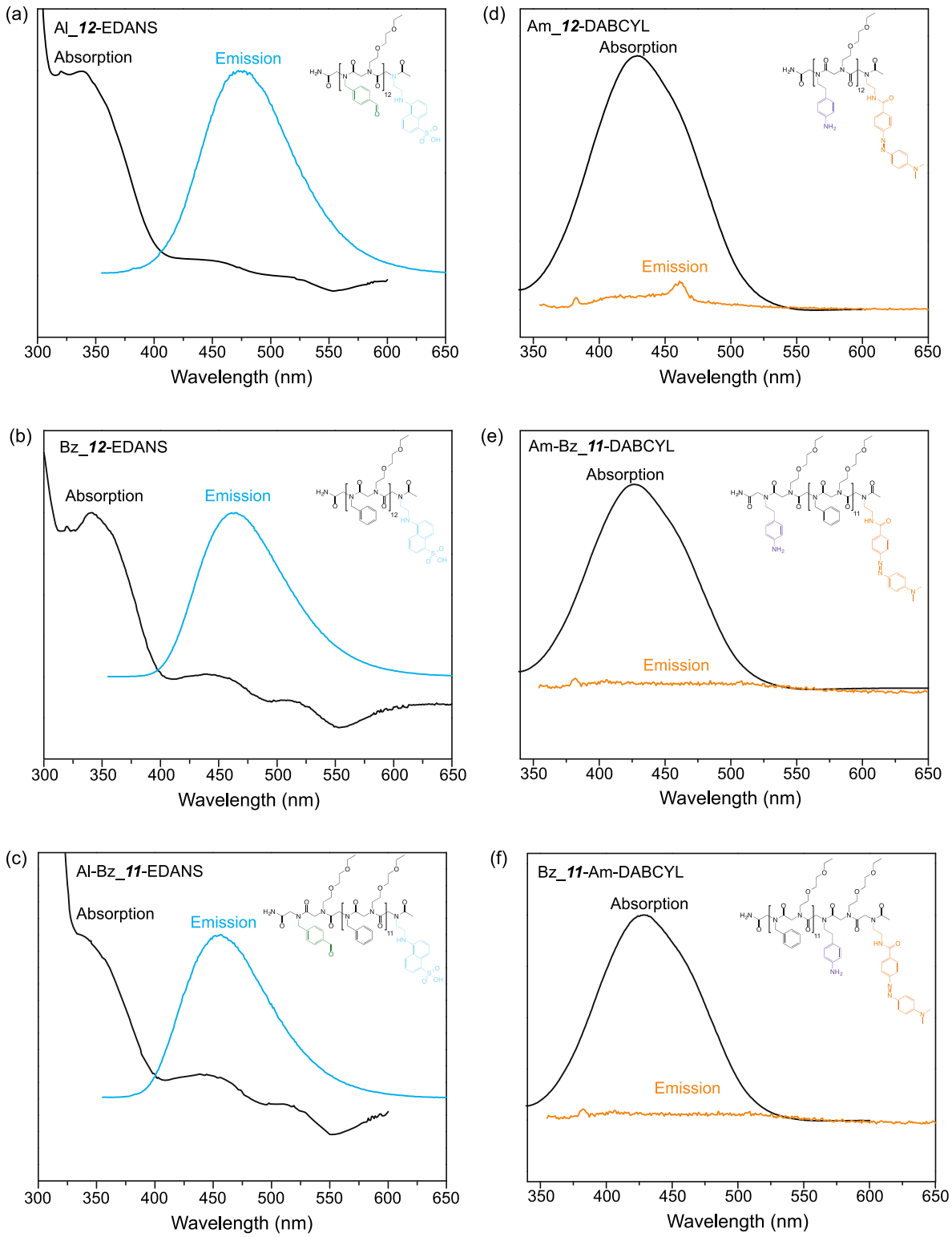


Figure **S17**. UV absorption and emission of peptoids containing either EDANS or DABCYL subjected to FRET study: (a) Al_***12***-EDANS, 99.3%; (b) Bz_***12***-EDANS; (c) Al-Bz-***11***-EDANS; (d) Am_***12***-DABCYL; (e) Am-Bz-***11***-DABCYL; (f) Bz-***11***-Am-DABCYL.

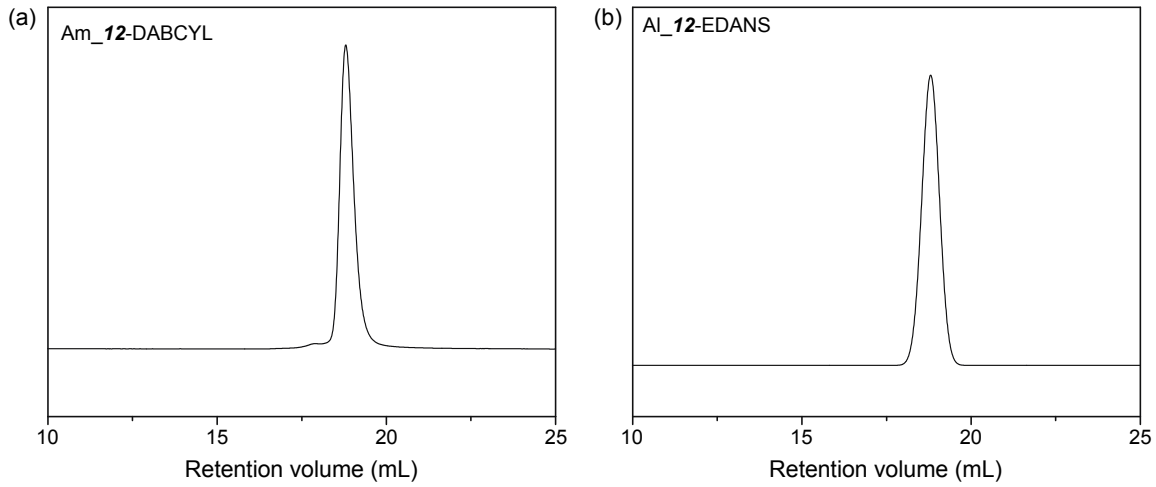


Figure **S18**. Analytical GPC of Am_***12***-DABCYL (a) and Al_***12***-EDANS (b). Analytical GPC method: isocratic flow rate at 1 mL/min; eluent: $CHCl_3/CH_3OH/Et_3N$ (94/4/2, v/v/v). Am_***12***-DABCYL, V_r = 18.41 mL, M_n = 4932 g/mol; Al_***12***-EDANS, V_r = 18.70 mL, M_n = 4155 g/mol.

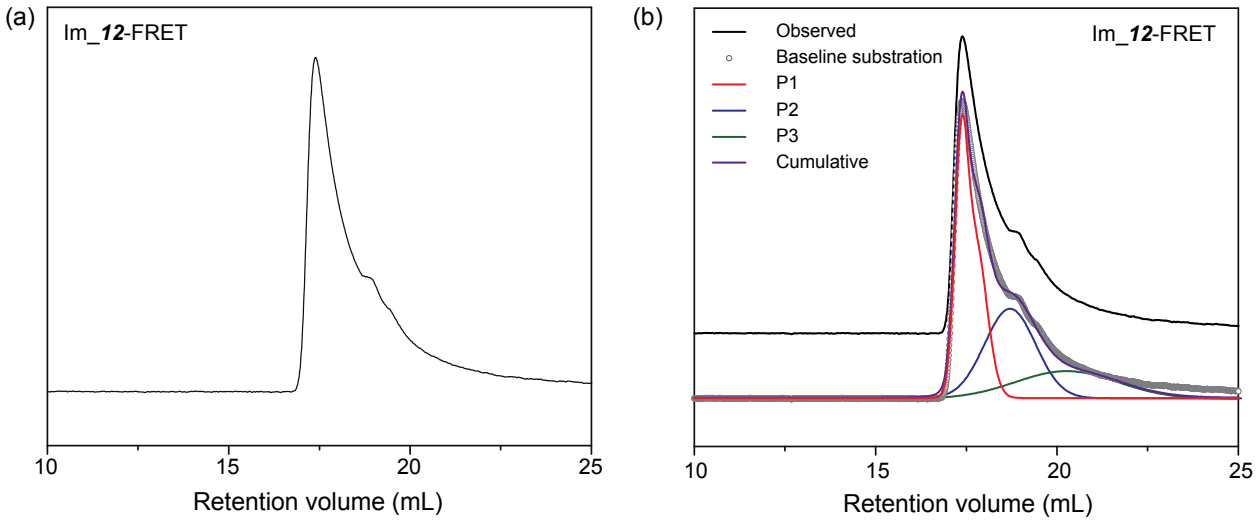


Figure **S19**. Analytical GPC of Im_***12***-FRET (a) and deconvoluted GPC traces of Im_***12***-FRET (b). Analytical GPC method: isocratic flow rate at 1 mL/min; eluent: $CHCl_3/CH_3OH/Et_3N$ (94/4/2, v/v/v). Im_***12***-FRET, V_r = 17.52 mL, M_n = 8846 g/mol.

Table **S10.** Deconvoluted peak analysis of Im_***12***-FRET.

Code	**M_n by GPC (g/mol)**	**Expected M_n (g/mol)**	**Area (%)**
Im_***12***-FRET	8799	8934	46

Photoluminescence spectroscopy:

Photoluminescence measurements were obtained on a Horiba Fluoromax-2 spectrofluorometer. Samples were prepared by adding 50 nmol EDANS peptoid solution and 2.4 μL of 10 mM $Sc(OTf)_3$ into 2 mL of

solvent (chloroform) in a 4 mL quartz cuvette (1 cm path length) with magnetic stir bar. Basic fluorescence measurements were then taken, excited at 343 nm and collected over the range 355 – 650 nm with slits set at 2.5 nm, and temperature controlled at 25°C. Then 50 nmol DABCYL peptoid were then added to the system for FRET type kinetics measurements. Kinetics experiments were taken in single wavelength collection mode at 464 nm over a course of 16 hours at increasing intervals (i.e., every 30 sec for 5 min, every 15 min for 1 hours, every 30 min for 2 hours, and then hourly for the remaining time points).

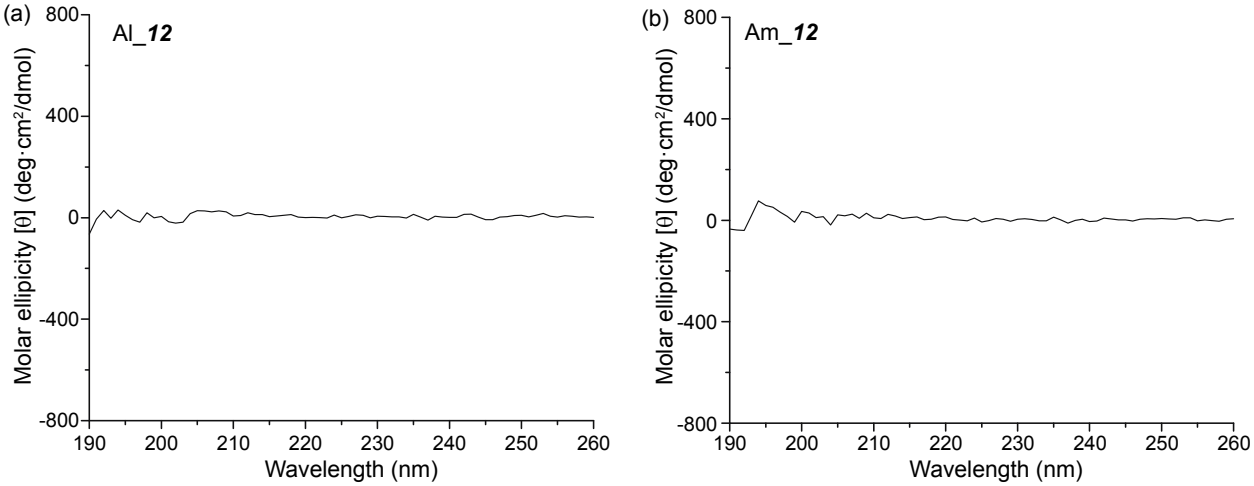


Figure **S20**. Circular dichroism (CD) spectra of Al_***12*** and Am_***12***. CD spectra were collected on a Jasco-815 CD spectrometer. Peptoids were dissolved in acetonitrile at concentrations of 25 mM. Blank scans containing only acetonitrile were collected and subtracted as background. Al_***12*** and Am_***12*** both exhibit spectra typical of random coil conformations, confirming non-ordered secondary structures for achiral peptoids.[3]

References:

1. T. Wei, J. H. Jung and T. F. Scott, *J. Am. Chem. Soc.*, 2015, **137**, 16196-16202.
2. H. Tran, S. L. Gael, M. D. Connolly and R. N. Zuckermann, *J. Vis. Exp.*, 2011, DOI: doi:10.3791/3373, e3373.
3. H.-M. Shin, C.-M. Kang, M.-H. Yoon and J. Seo, *Chem. Commun.*, 2014, **50**, 4465-4468.