Supplementary Information

Hierarchical Chirality Transfer of Perylene Diimide-tethered Pillar[5]arenes for Configuration and Type Differentiation of Amino Acid Derivatives

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Materials and Instruments

L- and D-amino acid alkyl ester hydrochlorides enantiomers (99%) were purchased from Sigma Aldrich. All chemicals and solvents were used as received without further purification. ^{1}H NMR spectra were recorded at room temperature on Bruker AMX-400 (operating at 400 MHz for ^{1}H NMR) and all chemical shifts are reported in ppm with TMS as the internal standard. UV-vis spectra were obtained on a JASCO V650 spectrometer at room temperature. Fluorescence spectra were taken on Fluoromax-4 spectrofluorometer. Circular dichroism (CD) spectra were recorded on a JASCO J-1500 spectrometer using a quartz cuvette of 1 cm path length.

S1, **C8** and amino acid derivatives were synthesized according to the previously reported methods.[1]

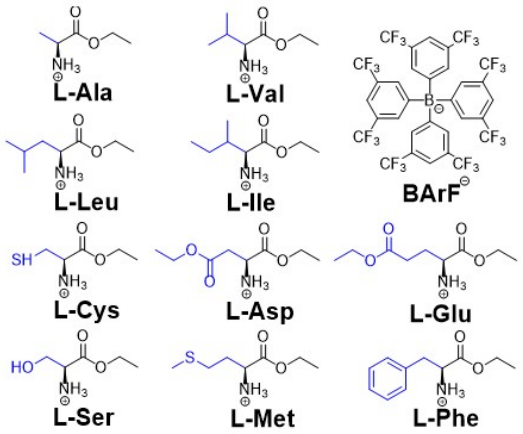

Fig. S1. Chemical structures of amino acid derivatives.

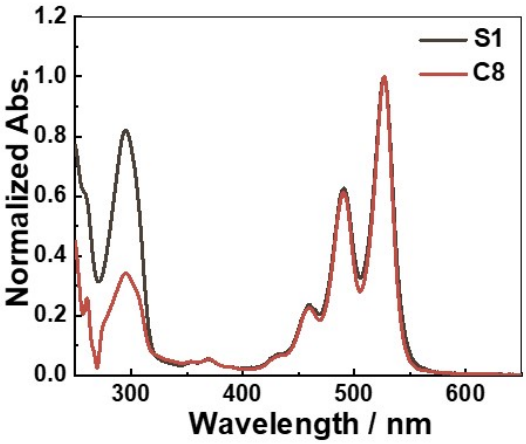

Fig. S2. Normalized UV-Vis absorption spectra of **S1** and **C8** in $CHCl_3$.

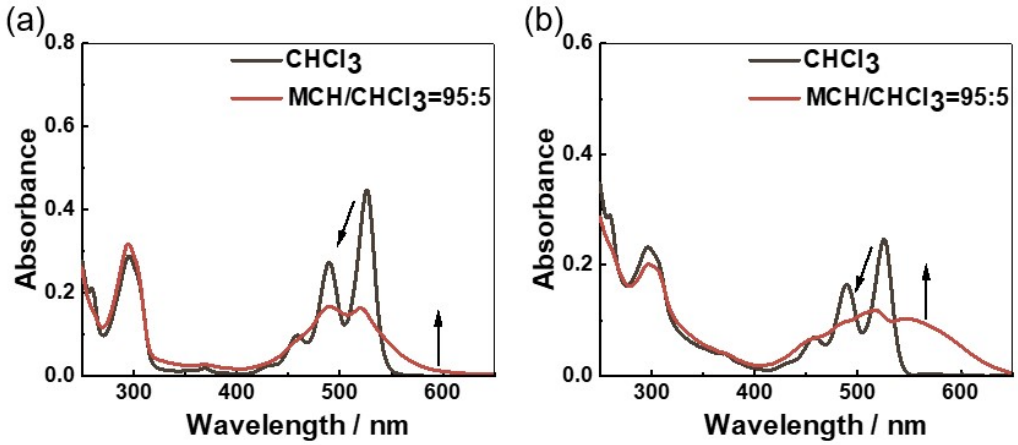

Fig. S3. Solvent-dependent UV-Vis absorption spectra of (a) **S1** (0.01 mM), (b) **C8** (0.01 mM) from pure $CHCl_3$ to 95% MCH.

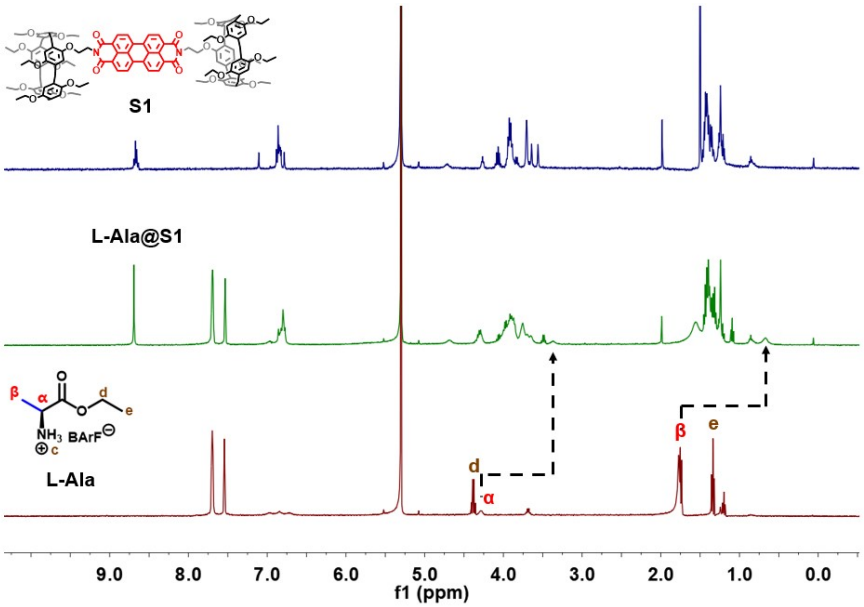

Fig. S4. ^1H NMR spectra (400 MHz, CD_2Cl_2, 298 K) of **S1** (1 mM) (blue), L-Ala@**S1** ([L-Ala] = 2 mM, [L-Ala]/[**S1**] = 2) (green) and L-Ala (1 mM) (red).

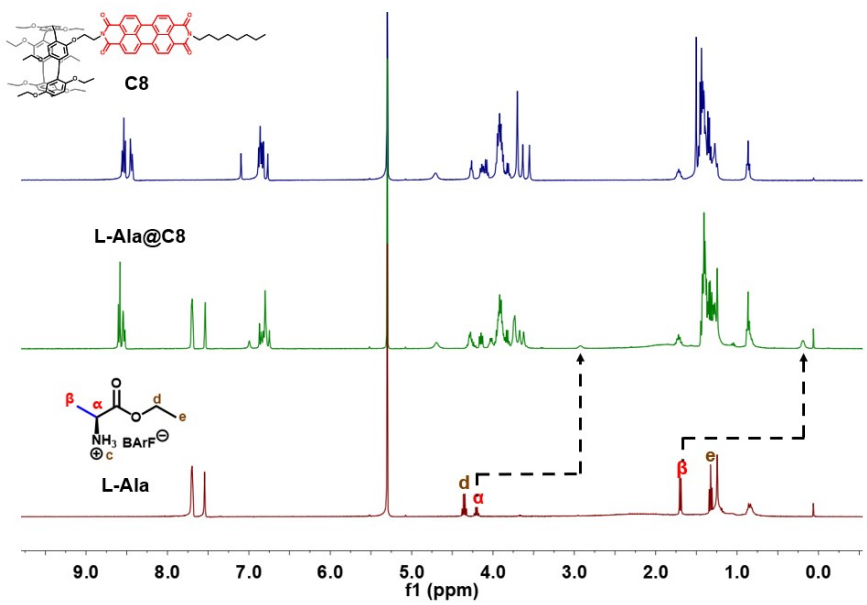

Fig. S5. ^{1}H NMR spectra (400 MHz, CD_2Cl_2, 298 K) of **C8** (1 mM) (blue), L-Ala@**C8** ([L-Ala] = [**C8**] = 1 mM) (green) and L-Ala (1 mM) (red).

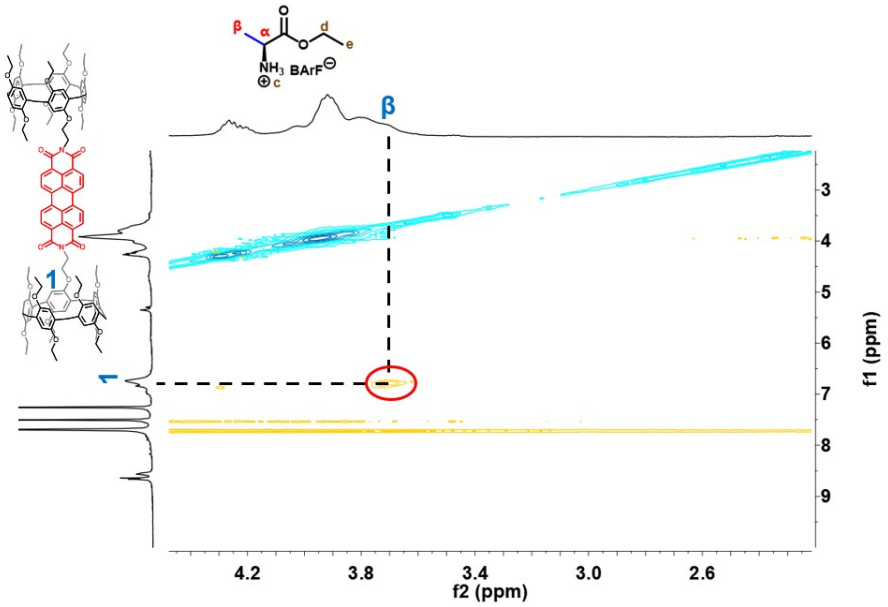

Fig. S6. ^{1}H-^{1}H ROESY NMR (400 MHz, $CDCl_3$, 298 K) spectra of L-Ala@**S1** ([L-Ala] = 2 mM, [L-Ala]/[**S1**] = 2).

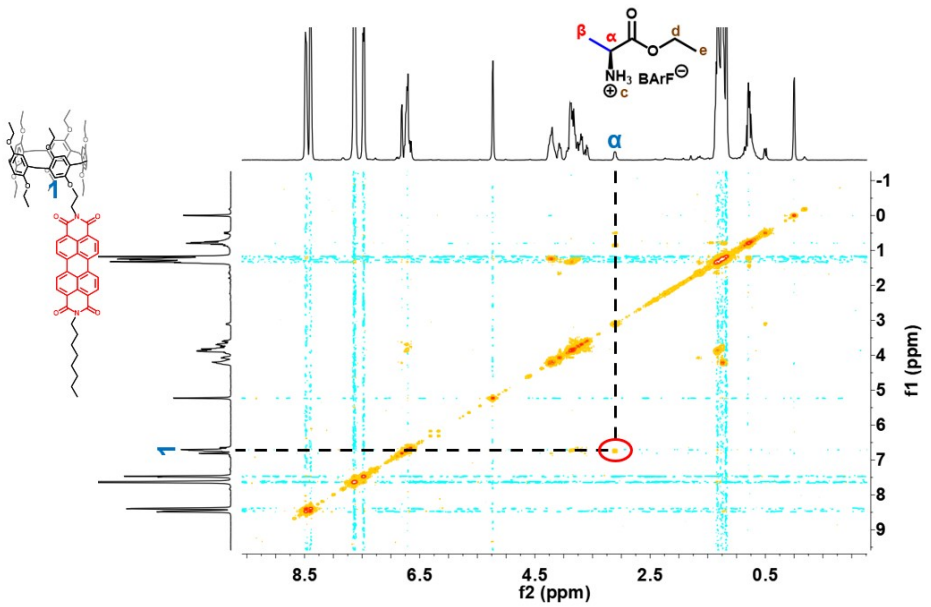

Fig. S7. ^{1}H-^{1}H ROESY NMR (400 MHz, CD_2Cl_2, 298 K) spectra of L-Ala@**C8** ([L-Ala] = [**C8**] = 1 mM).

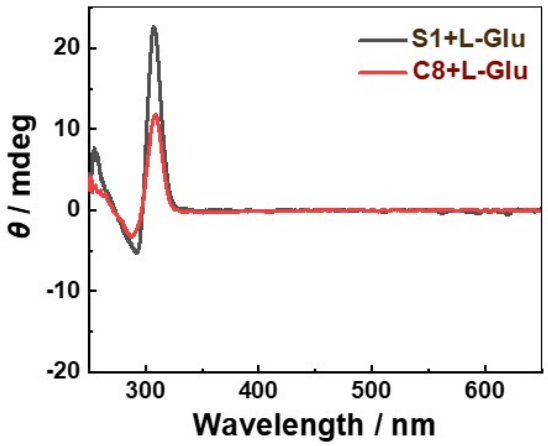

Fig. S8. CD spectra of **S1** (0.05 mM) and **C8** (0.05 mM) with L-Glu (100 μM) in $CHCl_3$ at 25 °C.

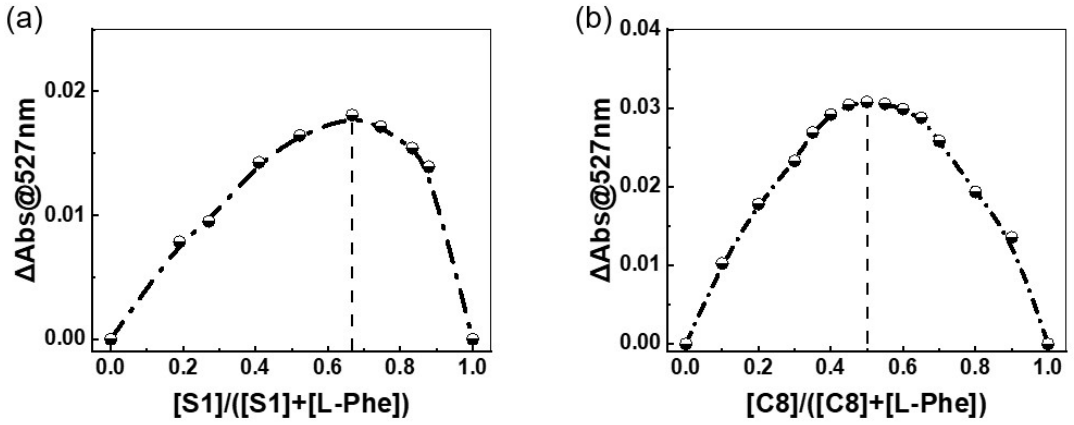

Fig. S9. Job's plot based on the intensity changes at 527 nm in the UV–vis absorption spectra in $CHCl_3$ (25 °C) for the complexation of L-Phe with (a) **S1** and (b) **C8**. [G] + [H] = 0.05 mM.

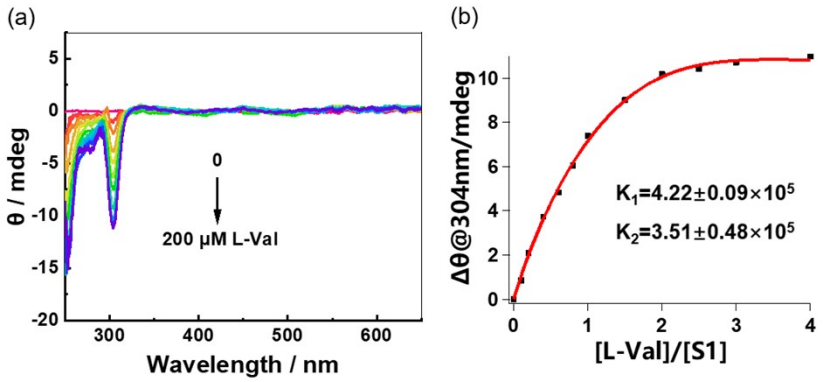

Fig. S10. (a) CD spectra of **S1** (0.05 mM) upon titration with L-Val (0-200 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the CD intensity changes at 304 nm, from which the association constants (*K*) for the formation of the 1:2 complexes were estimated to be K_1 = 4.22 ± 0.09 × 10^5 M^{-1} and K_2 = 3.51 ± 0.48 × 10^5 M^{-1}, respectively.

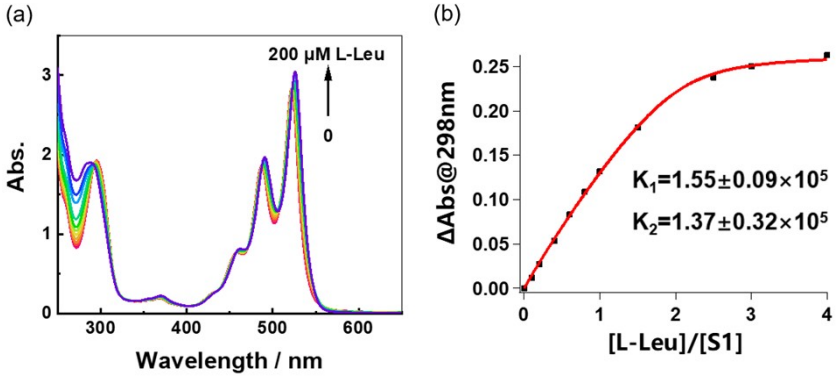

Fig. S11. (a) UV-Vis spectra of **S1** (0.05 mM) upon titration with L-Leu (0-200 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the UV-Vis intensity changes at 298 nm, from which the association constants (*K*) for the formation of the 1:2 complexes were estimated to be K_1 = 1.55 ± 0.09 × 10^5 M^{-1} and K_2 = 1.37 ± 0.32 × 10^5 M^{-1}, respectively.

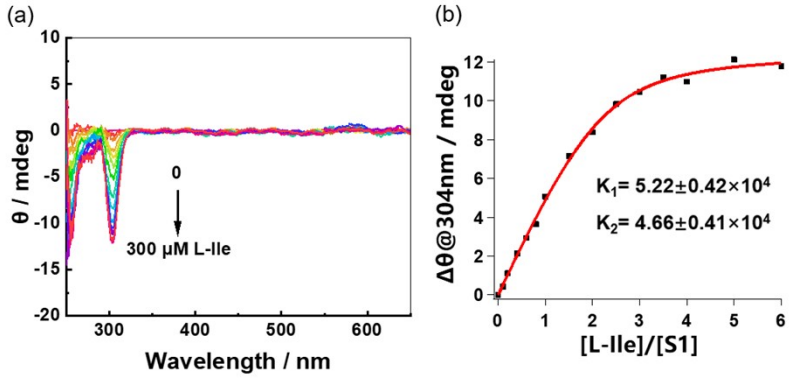

Fig. S12. (a) CD spectra of **S1** (0.05 mM) upon titration with L-Ile (0-300 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the CD intensity changes at 304 nm, from which the association constants (*K*) for the formation of the 1:2 complexes were estimated to be K_1 = 5.22 ± 0.42 × 10^4 M^{-1} and K_2 = 4.66 ± 0.41 × 10^4 M^{-1},

respectively.

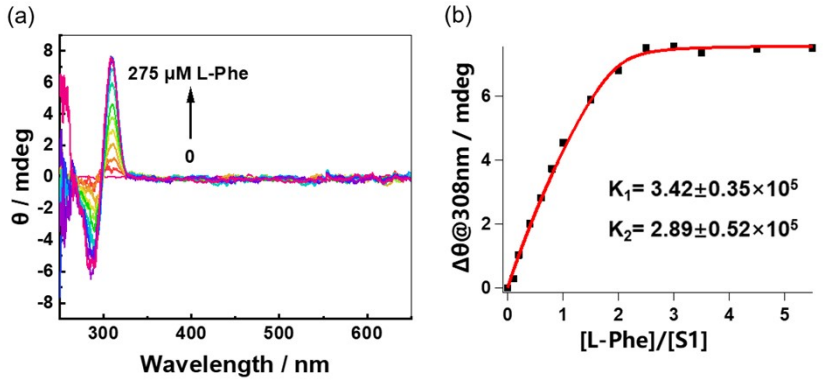

Fig. S13. (a) CD spectra of **S1** (0.05 mM) upon titration with L-Phe (0-275 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the CD intensity changes at 308 nm, from which the association constants (*K*) for the formation of the 1:2 complexes were estimated to be K_1 = 3.42 ± 0.35 × 10^5 M^{-1} and K_2 = 2.89 ± 0.52 × 10^5 M^{-1}, respectively.

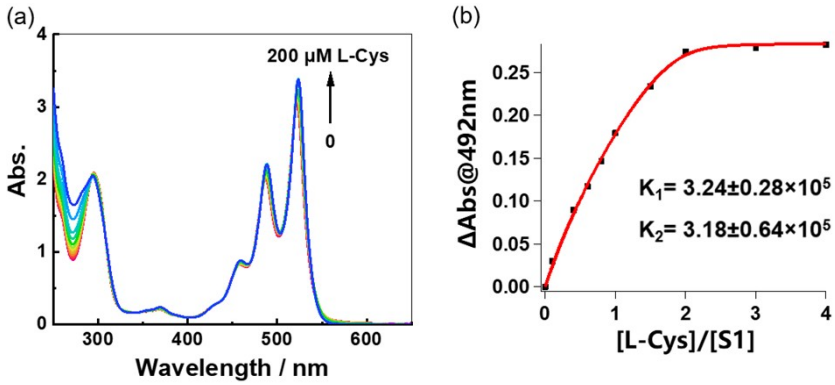

Fig. S14. (a) UV-Vis spectra of **S1** (0.05 mM) upon titration with L-Cys (0-200 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the UV-Vis intensity changes at 492 nm, from which the association constants (*K*) for the formation of the 1:2 complexes were estimated to be K_1 = 3.24 ± 0.28 × 10^5 M^{-1} and K_2 = 3.18 ± 0.64 × 10^5 M^{-1}, respectively.

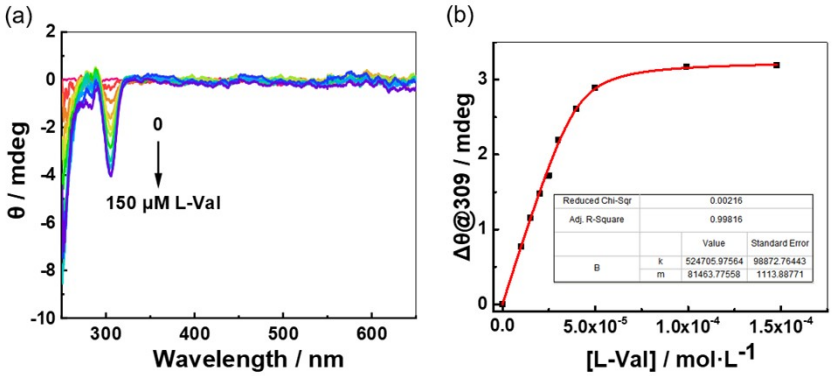

Fig. S15. (a) CD spectra of **C8** (0.05 mM) upon titration with L-Val (0-150 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the CD intensity changes at 309 nm, from which the association constants (*K*) for the formation of the 1:1 complexes were estimated to be *K* = 5.25 ± 0.99 × 10^5 M^{-1}.

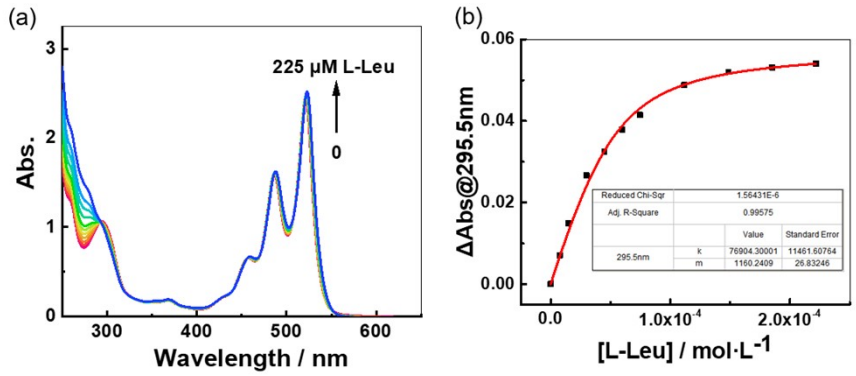

Fig. S16. (a) UV-Vis spectra of **C8** (0.05 mM) upon titration with L-Leu (0-225 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the UV-Vis intensity changes at 295.5 nm, from which the association constants (*K*) for the formation of the 1:1 complexes were estimated to be $K = 7.69 \pm 1.12 \times 10^4$ M^{-1}.

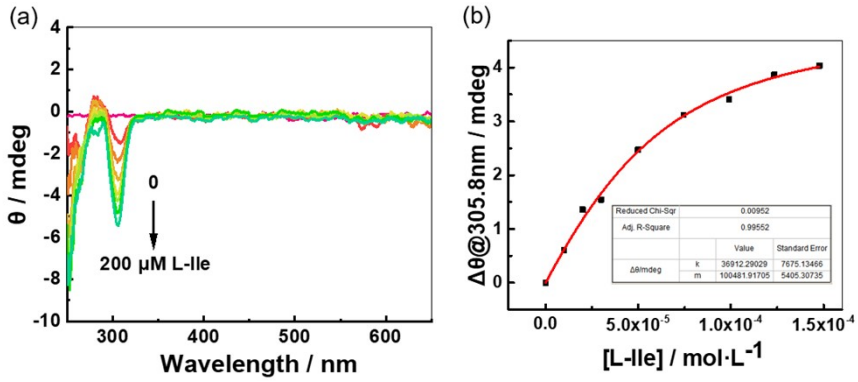

Fig. S17. (a) CD spectra of **C8** (0.05 mM) upon titration with L-Ile (0-200 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the CD intensity changes at 305.8 nm, from which the association constants (*K*) for the formation of the 1:1 complexes were estimated to be $K = 3.69 \pm 0.77 \times 10^4$ M^{-1}.

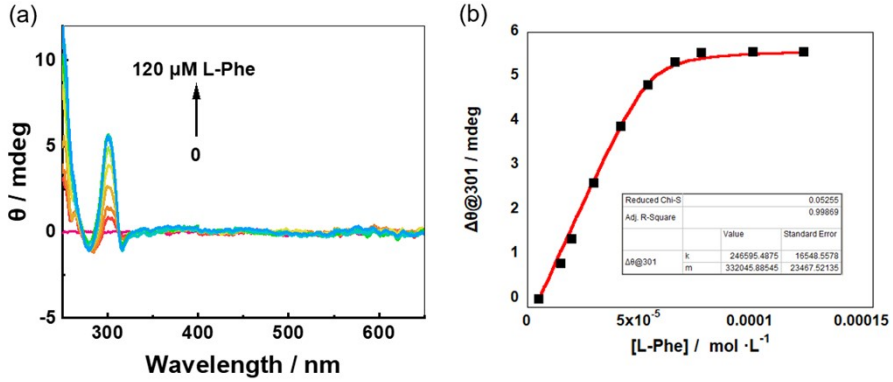

Fig. S18. (a) CD spectra of **C8** (0.05 mM) upon titration with L-Phe (0-120 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the CD intensity changes at 301 nm, from which the association constants (*K*) for the formation of the 1:1 complexes were estimated to be $K = 2.47 \pm 0.16 \times 10^5$ M^{-1}.

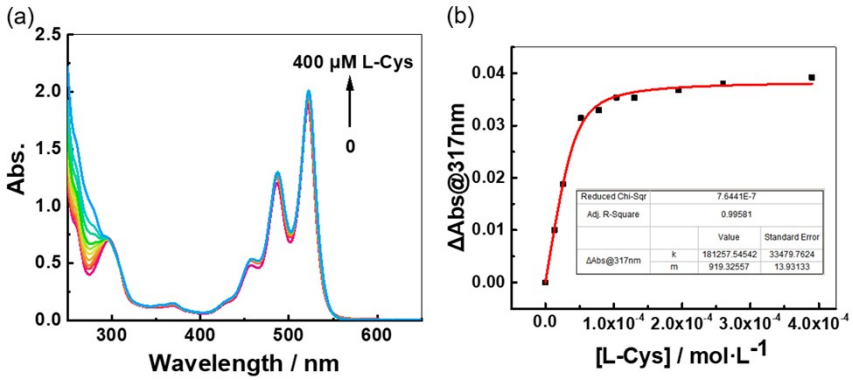

Fig. S19. (a) UV-Vis spectra of **C8** (0.05 mM) upon titration with L-Cys (0-400 μM) in $CHCl_3$ at 25 °C. (b) The non-linear curve-fitting based on the UV-Vis intensity changes at 317 nm, from which the association constants (*K*) for the formation of the 1:1 complexes were estimated to be $K = 1.81 \pm 0.33 \times 10^5$ M^{-1}.

Table S1. Binding constants (K, M^{-1}) for **S1** and **C8** with amino acid derivatives.

	S1		**C8**
	K_1 (M^{-1})	K_2 (M^{-1})	K (M^{-1})
L-Ala[a]	$2.73 \pm 0.33 \times 10^5$	$2.74 \pm 0.62 \times 10^5$	$2.07 \pm 0.33 \times 10^5$
L-Val	$4.22 \pm 0.09 \times 10^5$	$3.51 \pm 0.48 \times 10^5$	$5.25 \pm 0.99 \times 10^5$
L-Leu	$1.55 \pm 0.09 \times 10^5$	$1.37 \pm 0.32 \times 10^5$	$7.69 \pm 1.12 \times 10^4$
L-Ile	$5.22 \pm 0.42 \times 10^4$	$4.66 \pm 0.41 \times 10^4$	$3.69 \pm 0.77 \times 10^4$
L-Phe	$3.42 \pm 0.35 \times 10^5$	$2.89 \pm 0.52 \times 10^5$	$2.47 \pm 0.16 \times 10^5$
L-Asp	$7.57 \pm 0.25 \times 10^4$	$7.65 \pm 0.37 \times 10^4$	$8.89 \pm 1.60 \times 10^4$
L-Glu[a]	$7.00 \pm 0.61 \times 10^5$	$7.01 \pm 1.20 \times 10^5$	$3.23 \pm 0.28 \times 10^5$
L-Ser[a]	$7.67 \pm 0.11 \times 10^5$	$7.70 \pm 0.13 \times 10^5$	$6.41 \pm 0.91 \times 10^5$
L-Met[a]	$9.35 \pm 0.51 \times 10^3$	$6.06 \pm 0.72 \times 10^3$	$7.64 \pm 1.06 \times 10^3$
L-Cys	$3.24 \pm 0.28 \times 10^5$	$3.18 \pm 0.64 \times 10^5$	$1.81 \pm 0.33 \times 10^5$

The *K* (K_1 and K_2 where two values are listed) were obtained from CD or UV-vis spectroscopic titrations with [**S1**]=[**C8**]= 0.05 mM in $CHCl_3$ at 25 °C. [a] *K* value from previous work. [1a]

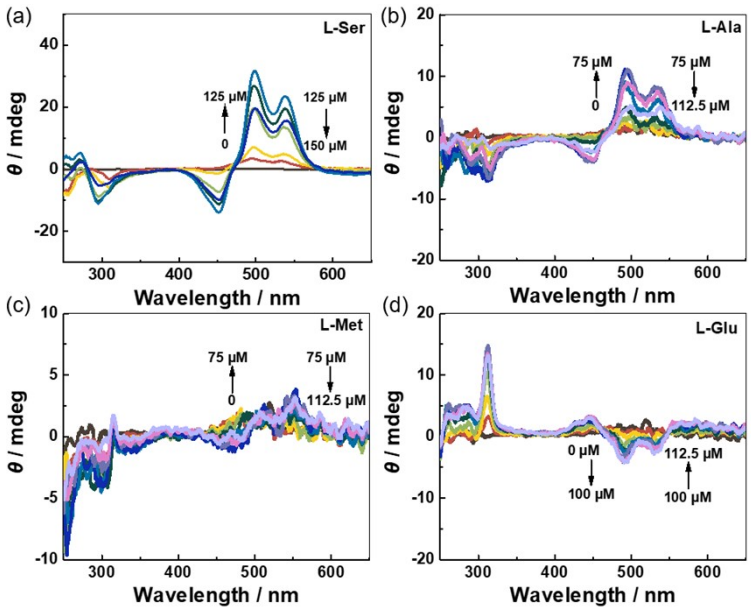

Fig. S20. CD spectra of **S1** (0.05 mM) upon titration with (a) L-Ser (0-150 μM), (b) L-Ala (0-112.5 μM), (c) L-Met (0-112.5 μM), (d) L-Glu (0-112.5 μM) in 95% MCH at 25 °C.

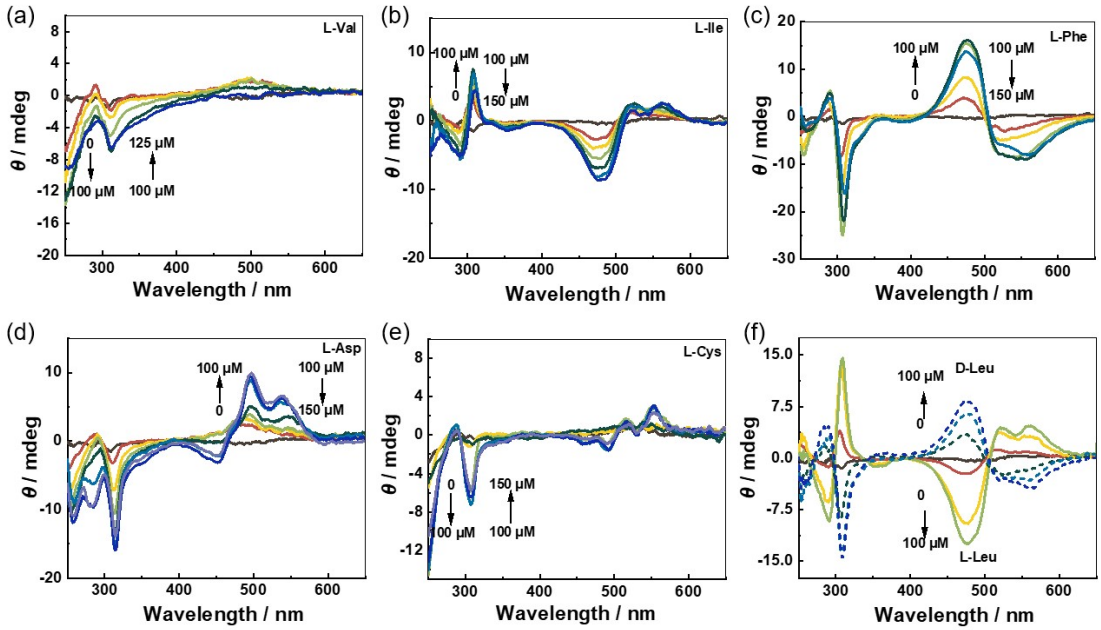

Fig. S21. CD spectra of **S1** (0.05 mM) upon titration with (a) L-Val (0-125 μM), (b) L-Ile (0-150 μM), (c) L-Phe (0-150 μM), (d) L-Asp (0-150 μM), (e) L-Cys (0-150 μM), (f) L/D-Leu (0-100 μM) in 95% MCH at 25 °C.

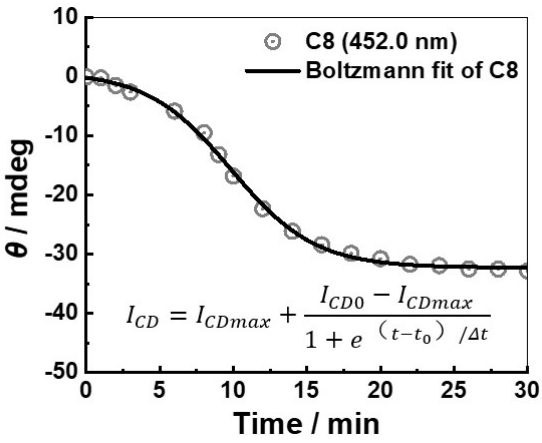

Fig. S22. Curve fitting for experimental points (gray circle) based on the Boltzmann equation of the formation kinetics of **Agg-C8** in 95% MCH at 25 °C. [**C8**] = 0.05 mM. I_{CDo} represent the CD intensities before aggregation and I_{CDmax} is the maximum CD intensities that aggregation reaching a stable state, t_0 is the time, in minutes, at which the inflection in CD intensity occurs, and Δt corresponds with the sigmoidal transition period as the CD intensity deviates from I_{CDo} in the semiloglinear regime, which is the reciprocal of the aggregation rate.

Table S2. Kinetic parameters of **Agg-C8** with L-Ser.[a]

	t_0	Δt	R^2
C8	9.85 ± 0.141	2.85 ± 0.162	0.9985

[a] data from Fig. S21.

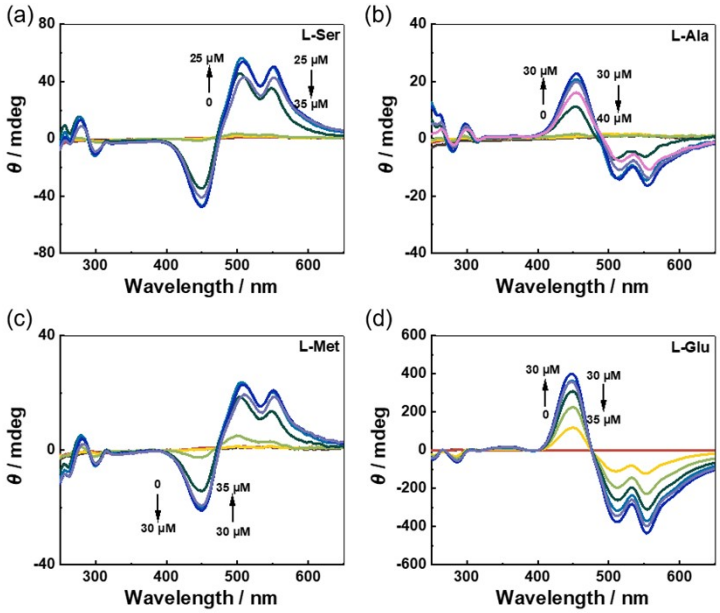

Fig. S23. CD spectra of **C8** (0.05 mM) upon titration with (a) L-Ser (0-35 μM), (b) L-Ala (0-40 μM), (c) L-Met (0-35 μM), (d) L-Glu (0-35 μM) in 95% MCH at 25 °C.

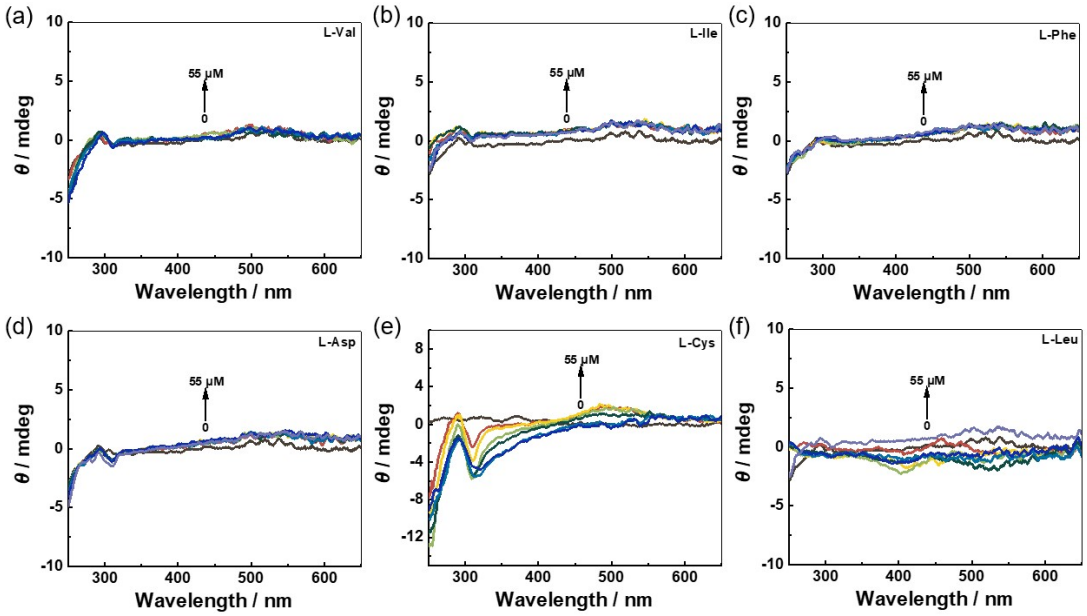

Fig. S24. CD spectra of **C8** (0.05 mM) upon titration with (a) L-Val (0-55 μM), (b) L-Ile (0-55 μM), (c) L-Phe (0-55 μM), (d) L-Asp (0-55 μM), (e) L-Cys (0-55 μM), (f) L-Leu (0-55 μM) in 95% MCH at 25 °C.

(1) (a) Zhao, T.; Yi, J.; Liu, C.; Liang, X.; Shen, Y.; Wei, L.; Xie, X.; Wu, W.; Yang, C., "First Come, First Served" and Threshold Effects in a Central-to-Planar-to-Helical Hierarchical Chiral Induction. *Angew. Chem. Int. Ed.* **2023,** *62*, e202302232; (b) Ji, J.; Li, Y.; Xiao, C.; Cheng, G.; Luo, K.; Gong, Q.; Zhou, D.; Chruma, J. J.; Wu, W.; Yang, C., Supramolecular enantiomeric and structural differentiation of amino acid derivatives with achiral pillar[5]arene homologs. *Chem. Commun.* **2020,** *56*, 161-164.