Supporting Information

pH-Controlled Chirality Inversion in Enantiodifferentiating Photocyclodimerization of 2-Antharacenecarboxylic Acid mediated by γ-Cyclodextrin Derivatives

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TABLE OF CONTENTS

1. General information……..…....S1

2. Synthesis and characterization of CDx derivatives……...……...S3

3. Conformation analysis of host **7** ……..…..……..….S13

4. Binding constant of hosts **5**, **6** and **7** with AC…….....….S17

5. Photocyclodimerization of AC and mediated by native and modified CDxs…...S21

6. Calculation of pK_a values……..……..S25

7. UV-vis., fluorescence and CD spectral studies ……....S27

8. References……..……..……S32

1. General Information

1.1 Experimental

Materials

γ-Cyclodextrin (CDx, **5**) (Junsei, Japan), and 8-bromomethylquinoline (Adamas, China) were purchased and used as received without further purification. 2-Antharacenecarboxylic acid (AC) has purchased from Aladdin (China) and used as received without further purification. Double distilled water (which was free from ions) and HPLC grade solvents have used for all spectral measurements. All other chemicals and solvents were purchased from Adamas-beta, Amethyst, Oceanpak and used as received without further purification.

1.2 Methods

Reverse-phase chromatography was used to separate the CDx derivatives and water-soluble compounds through ODS-SM-50C column and water - 90% EtOH/MeOH (v/v) (linear elution) in water as eluent.

Nuclear magnetic resonance spectroscopy (NMR) was acquired on a Bruker Ascend 400 (400 MHz) instrument using TMS as an internal standard at 298 K. Coupling constants were reported in Hz and chemical shifts (δ) in ppm [relative to TMS or residual solvent peaks [for ^{1}H ($CDCl_3$: 7.26, DMSO-d_6: 2.50, D_2O: 4.79, CD_3CN: 1.94, CD_3OD: 3.31) and ^{13}C ($CDCl_3$: 77.16, DMSO-d_6: 39.52, CD_3CN: 1.32, 118.26, CD_3OD: 49.00)].[S1] Multiplicities were assigned as *s* (singlet), *d* (doublet), *t* (triplet), *q* (quartet), *m* (multiplet) and *brs* (broad singlet).

Ultraviolet-visible absorption spectroscopy (UV-Vis.) measurements have recorded using a JASCO V-650 double beam spectrophotometer with a PMT detector. UV-Vis. Analyses have done using JASCO-Spectral manager, and the calculations have done in Microsoft Origin software. Fluorescence spectroscopy was recorded using JASCO FP-8500 or Fluoromax-4 (attached with TCSPC) spectrofluorometer (HORIBA JOBIN YVON) with excitation slit set at 5.0 nm bandpass and emission at 5.0 nm bandpass in 1 x 1 cm quartz cell (or otherwise mentioned). Emission calculations have done using Microsoft Origin software. Circular dichroism spectroscopy (CD) has measured using JASCO J-1500 spectropolarimeter with PMT detector in the wavelength range of 190-900 nm. For these studies, solutions were of

less or higher concentration than those for spectrophotometric studies. The sample cell temperature was controllable in the range from -90 ^{o}C to 100 ^{o}C.

Mass spectral data were obtained using Electrospray Ionization Mass Spectrometry (ESI-MS) and Matrix-Assisted Laser Desorption Ionization-Time of Flight (MALDI-TOF) mass spectrometry. Isothermal titration calorimetry (ITC) data has recorded by using VP-ITC MicroCalorimeter.

1.3 Preparation of stock solutions

Preparation of PBS buffer solution: The pH 4-9 buffer solutions were prepared by mixing the different volumes of separately-made 66.7 mM NaH_2PO_4 and 66.7 mM Na_2HPO_4 solution. PH 1, 2, and 3 buffer solutions were made by the addition of 1 M HCl solution to 66.7 mM NaH_2PO_4 solution. The pH 10-buffer solution was prepared by the addition of 66.7 mM NaOH solution to 66.7 mM Na_2HPO_4 solution.

Preparation of AC solution: 0.004 M AC solution was prepared by dissolving the 88.89 mg of AC in 0.01 M NaOH solution and sonicated for 2 hrs at room temperature. The diluted AC solutions of different pH have prepared by dilution of the above stock using respective PBS buffers' and used for measurements.

Preparation of host solution: Host solutions of different pH were prepared by dissolving the respective quantity of solid hosts **5**, **6**, **7,** and **8** in PBS buffers and used for measurements.

1.4 Photoreaction

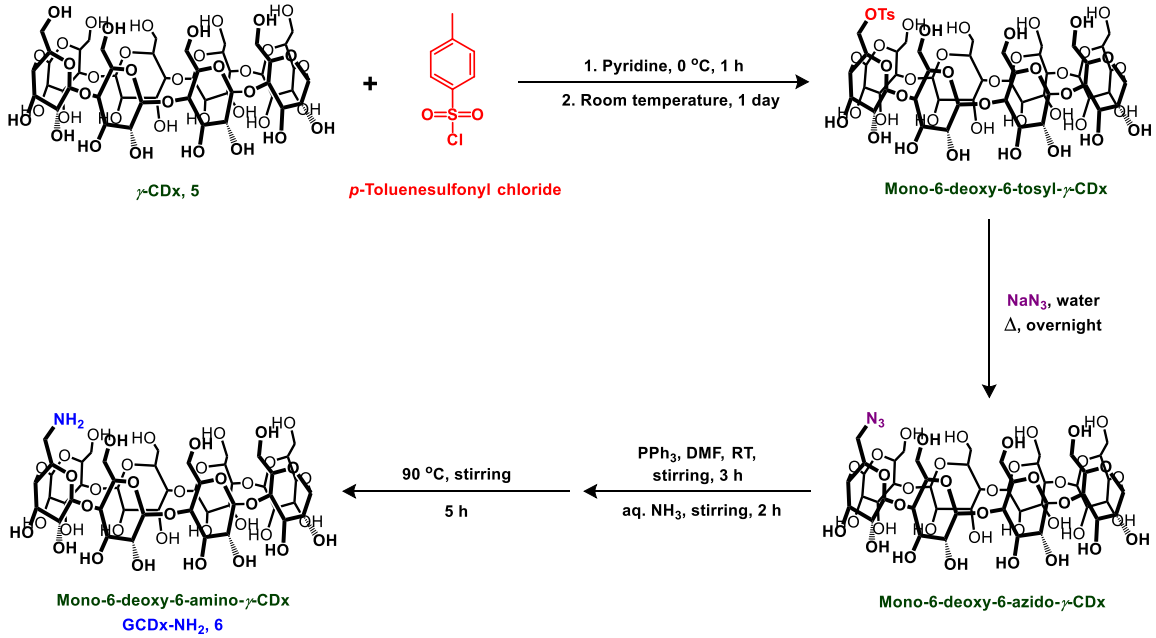
Photoirradiation has performed in a temperature-controlled water/ethylene glycol bath. Solutions containing 0.2 mM AC and 2.0 mM CDx host derivatives **5**, **6, 7**, and **8** have directly irradiated at 365 nm in a borosilicate glass tube under an N_2 atmosphere with an LED lamp (Manufacturer: Zhuhai haoyun optoelectronic technology co. LTD, and model: HY-UV0003; diameter of 1 cm and an intensity of 200 mW/cm^2, distance: ~2-3 cm) for an appropriate time.

The resulting photolyzed solution was filtered using membrane and analyzed by analytical chiral HPLC, performed on a tandem column of Inertsil ODS-2 (GL Sciences Inc.) and CHIRALCEL® OJ-RH (Daicel), and operated at 35 ºC using 0.1% trifluoroacetic acid (TFA) dissolved in water and acetonitrile (62:38, volume ratio), at a

flow rate of 0.5 mL/min. The relative chemical yield and *ee* value of photoproducts were determined from the peak area of HPLC chromatogram.

2. Synthesis and characterization of CDx derivatives

2.1 Synthesis and characterization of mono-6-deoxy-6-NH_2-γ-CDx ($GCDx\text{-}NH_2$, **6**)



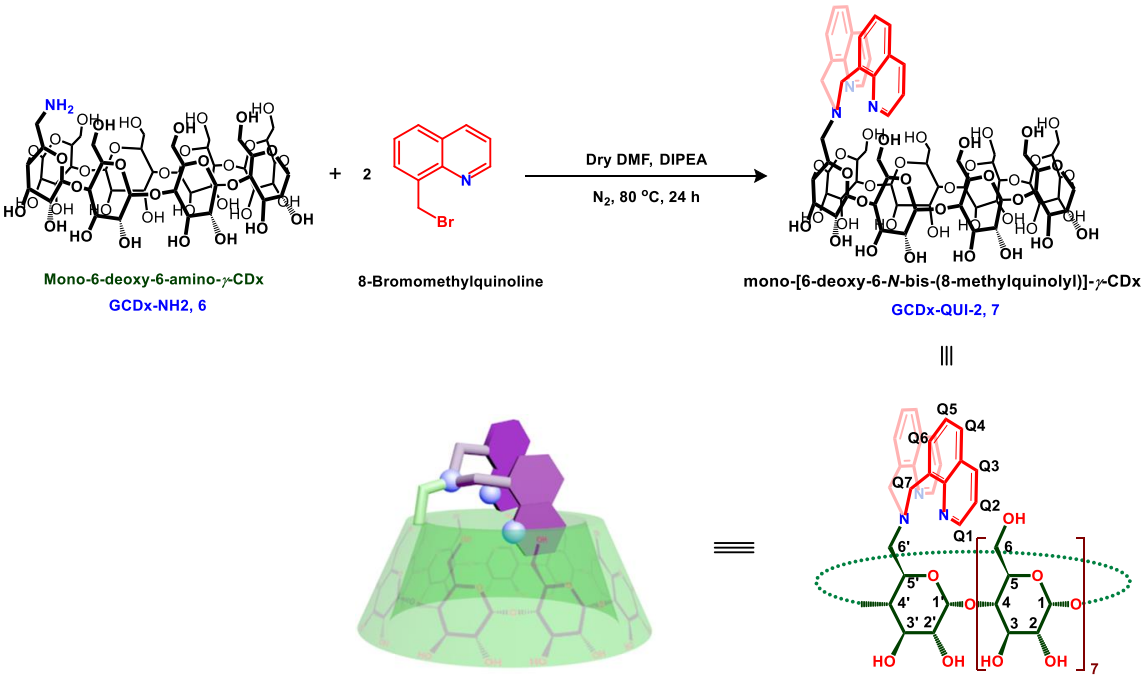
Scheme S1. Synthesis of mono-6-deoxy-6-amino-*γ*-CDx derivative ($GCDx\text{-}NH_2$, **6**).

Commercially available *γ*-cyclodextrin (CDx, **5**) has purchased and used as received without further purification. Mono-6-amino-γ-CDX ($GCDx\text{-}NH_2$, **6**) was synthesized and purified according to the procedure described in the literature with slight modification in the last step (Scheme S1).[S2]

A DMF (10 mL) solution containing mono-6-deoxy-azido-γ-CDx (1.8 g, 1.3 mmol) and triphenylphophine (PPh_3, 0.5 g, 1.9 mmol) stirred at room temperature for 3 hours, then aqueous NH_3 (3 mL) has added dropwised onto this mixture and continued the stirring at room temperature for another 2 hours. ThenFurther, the solution was stirred at 90 °C in oil bath for 5 hours, after the reaction completed, the whole mixture poured dropwise onto acetone (500 mL) to afforded white crystalline precipitates (1.63 g, 97%). The product was dried for 24 h under vacuum at 60 °C and then stored in a vacuum desiccator and are characterized by ^1H and ^{13}C NMR, and ESI-MS analysis, which were in accordance with literature reports.[S2] **Mono-6-deoxy-**

6-amino-*γ*-cyclodextrin (GCDx-NH_2, **6**), **^{1}H NMR (400 MHz, D_2O, δ ppm):** 5.13 - 5.05 (*m*, 8H), 3.90 (*m*, 11H), 3.82 (*d*, *J* = 9.5 Hz, 20H), 3.65 - 3.59 (*m*, 9H), 3.56 (*t*, *J* = 9.3 Hz, 6H), 3.46 (*t*, *J* = 9.5 Hz, 1H), 3.29 - 3.19 (*m*, 1H), 3.05 - 2.95 (*m*, 1H). **^{13}C NMR (101 MHz, D_2O, δ ppm):** 101.6, 101.0, 80.3, 79.6, 72.8, 72.2, 71.7, 60.1, 40.7. **HRMS (ESI)** *m/z* calcd. for $C_{48}H_{82}NO_{39}$ $[M+H]^+$ 1296.4464, found 1296.4474; *m/z* calcd. for $C_{48}H_{81}NO_{39}Na$ $[M+Na]^+$ 1318.4283, found 1318.4275.

2.2 Synthesis and characterization of mono-*N*-bis-(8-methylquinolyl) tethered γ-CDx derivatives (GCDx-QUI-2, **7**)



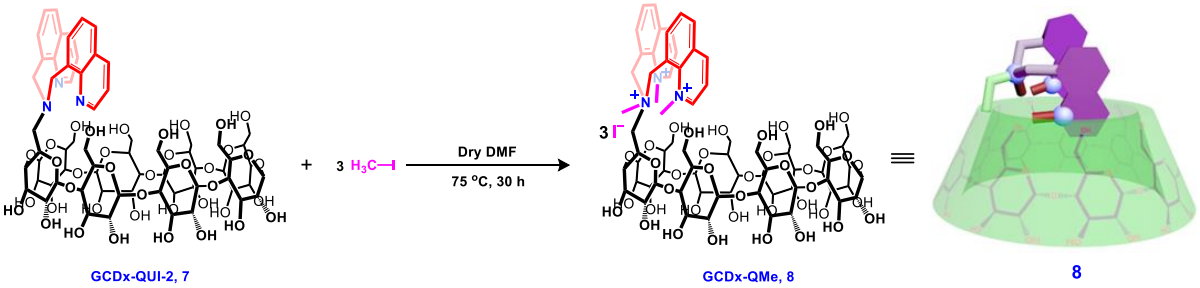
Scheme S2. Synthesis of γ-CDx appended mono-*N*-bis-(8-aminomethylquinoline) derivative (GCDx-QUI-2, **7**).

To a dry DMF solution (10 mL) of GCDx-NH_2 (**6**) (1.296 g, 1 mmol), 8-bromomethylquinoline (0.489 g, 2.2 mmol) and DIPEA (0.2 mL) were added drop-wise. The reaction mixture was stirred at 80 °C in oil bath for 24 h under a nitrogen atmosphere, and then the solvent was removed under vacuum. The residue was dissolved in a small amount of DMF and then added drop-wise to acetone (300 mL). The resulting white precipitate was filtered and washed successively with acetone (20 mL x 4) to gave the crude product. The crude product was loaded onto the preparative reverse phase column (ODS-SM-50C) and eluted with a linear gradient ranging from

water to 40% (v/v) methanol-water. The desired fraction was collected, and the eluent was evaporated and lyophilized to yield the desired products as white crystalline solid.

Mono-[6-deoxy-6-*N*-bis(8-methylquinolyl)]-*γ*-cyclodextrin (GCDx-QUI-2, 7) (1.29 g, yield 82%) **^{1}H NMR (400 MHz, D_2O, δ ppm) :** 8.76 (*s*, 1H), 8.33 (*s*, 1H), 7.86 (*dd*, *J* = 8.2, 1.0 Hz, 1H), 7.47 (*d*, *J* = 34.3 Hz, 1H), 7.30 (*d*, *J* = 43.4 Hz, 2H), 7.02 (*s*, 1H), 5.97 (*dd*, *J* = 10.3, 4.6 Hz, 1H), 5.42 (*d*, *J* = 4.1 Hz, 1H), 5.31 (*d*, *J* = 3.9 Hz, 1H), 5.16 (*d*, *J* = 3.2 Hz, 1H), 5.05 (*d*, *J* = 3.6 Hz, 1H), 4.89 (*d*, *J* = 4.0 Hz, 1H), 4.72 (*d*, *J* = 3.6 Hz, 1H), 4.57 (*d*, *J* = 3.9 Hz, 1H), 4.52 - 4.41 (*m*, 1H), 4.29 - 4.07 (*m*, 3H), 4.03 (*dd*, *J* = 14.2, 4.8 Hz, 1H), 3.97 (*s*, 1H), 3.91 (*dt*, *J* = 8.2, 3.2 Hz, 2H), 3.86 - 3.68 (*m*, 5H), 3.67 - 3.54 (*m*, 2H), 3.54 - 3.46 (*m*, 1H), 3.46 - 3.33 (*m*, 3H), 3.33 - 3.25 (*m*, 1H), 3.21 (*td*, *J* = 9.5, 3.7 Hz, 1H), 3.03 (*dd*, *J* = ss18.4, 9.2 Hz, 1H), 2.87 - 2.78 (*m*, 1H), 2.61 (*dd*, *J* = 12.6, 3.1 Hz, 1H), 2.50 - 2.39 (*m*, 1H), 2.34 (*d*, *J* = 8.1 Hz, 1H), 2.20 (*d*, *J* = 9.8 Hz, 1H), 1.46 (*d*, *J* = 9.9 Hz, 1H). **^{13}C NMR (101 MHz, D_2O, δ ppm):** 149.4, 144.9, 137.4, 132.2, 130.1, 127.4, 126.4, 126.2, 122.0, 101.4, 100.8, 82.4, 81.0, 73.2, 72.7, 72.0, 71.7, 71.4, 67.5, 60.3, 58.7, 56.3. **HRMS (ESI)** *m/z* calcd. for $C_{68}H_{96}N_3O_{39}$ $[M+H]^+$ 1578.5621, found 1578.5620.

2.3 Synthesis and characterization of GCDx-QMe derivative, (8)



Scheme S3. Synthesis of GCDx-QMe derivative (**8**).

The oven-dried round-bottom flask were charged with dry DMF (5 mL), GCDx-QUI-2, (**7**) (1 mmol, 1.579 g), CH_3I (3.5 mmol, 0.497 g). The reaction mixture was stirred at 75 °C in oil bath for 24 h under a nitrogen atmosphere, and then the solvent was removed under vacuum. The residue was dissolved in a small amount of DMF and then added drop-wise to acetone (300 mL). The resulting white precipitate was filtered and washed successively with acetone (20 mL x 4) to gave the crude product. The crude product was loaded onto the preparative reverse phase column (ODS-SM-

50C) and eluted with a linear gradient ranging from water to 35% (v/v) methanol-water. The desired fraction was collected, and the eluent was evaporated/lyophilized to yield the desired products as white crystalline solid.

GCDx-QMe, 8 (1.93 g, yield 96%) **^{1}H NMR (400 MHz, D_2O, δ ppm) :** 8.93 - 8.73 (*m*, 1H), 8.45 - 8.32 (*m*, 1H), 7.95 - 7.90 (*m*, 1H), 7.55 (*ddd*, *J* = 11.1, 6.6, 1.9 Hz, 1H), 7.42 (*d*, *J* = 7.9 Hz, 1H), 7.29 (*d*, *J* = 8.9 Hz, 1H), 7.07 (*t*, *J* = 7.4 Hz, 1H), 6.04 (*dd*, *J* = 10.4, 4.5 Hz, 1H), 5.52 - 5.45 (*m*, 1H), 5.38 (*d*, *J* = 3.7 Hz, 1H), 5.22 (*d*, *J* = 2.9 Hz, 1H), 5.11 (*d*, *J* = 3.4 Hz, 1H), 4.95 (*d*, *J* = 3.7 Hz, 1H), 4.90 (*d*, *J* = 13.9 Hz, 1H), 4.63 (*d*, *J* = 3.5 Hz, 1H), 4.56 - 4.48 (*m*, 1H), 4.34 – 4.13 (*m*, 3H), 4.09 (*dd*, *J* = 14.4, 4.5 Hz, 1H), 4.03 (*s*, 2H), 4.02 - 3.92 (*m*, 2H), 3.92 - 3.74 (*m*, 6H), 3.73 - 3.60 (*m*, 2H), 3.60 - 3.52 (*m*, 1H), 3.53 - 3.49 (*m*, 1H), 3.47 (*s*, 1H), 3.45 - 3.39 (*m*, 1H), 3.34 (*t*, *J* = 9.1 Hz, 1H), 3.27 (*t*, *J* = 9.4 Hz, 1H), 3.14 - 3.02 (*m*, 1H), 2.88 (*d*, *J* = 11.8 Hz, 1H), 2.71 - 2.62 (*m*, 1H), 2.55 - 2.44 (*m*, 1H), 2.40 (*d*, *J* = 8.5 Hz, 1H), 2.26 (*d*, *J* = 9.8 Hz, 1H), 1.51 (*d*, *J* = 10.0 Hz, 1H). **^{13}C NMR (101 MHz, D_2O, δ ppm):** 150.0, 136.5, 132.6, 128.8, 128.4, 126.5, 122.3, 102.0, 100.8, 82.2, 80.6, 78.0, 75.2, 73.1, 72.0, 71.2, 70.7, 69.0, 60.3, 59.2, 58.6, 43.1. **HRMS (MALDI-TOF)** *m/z* calcd. for $C_{71}H_{104}N_3O_{39}FBr$ $[M+F+Br]^+$ 1720.5414, found 1720.5419.

2.4. ^{1}H and ^{13}C NMR and HRMS spectra

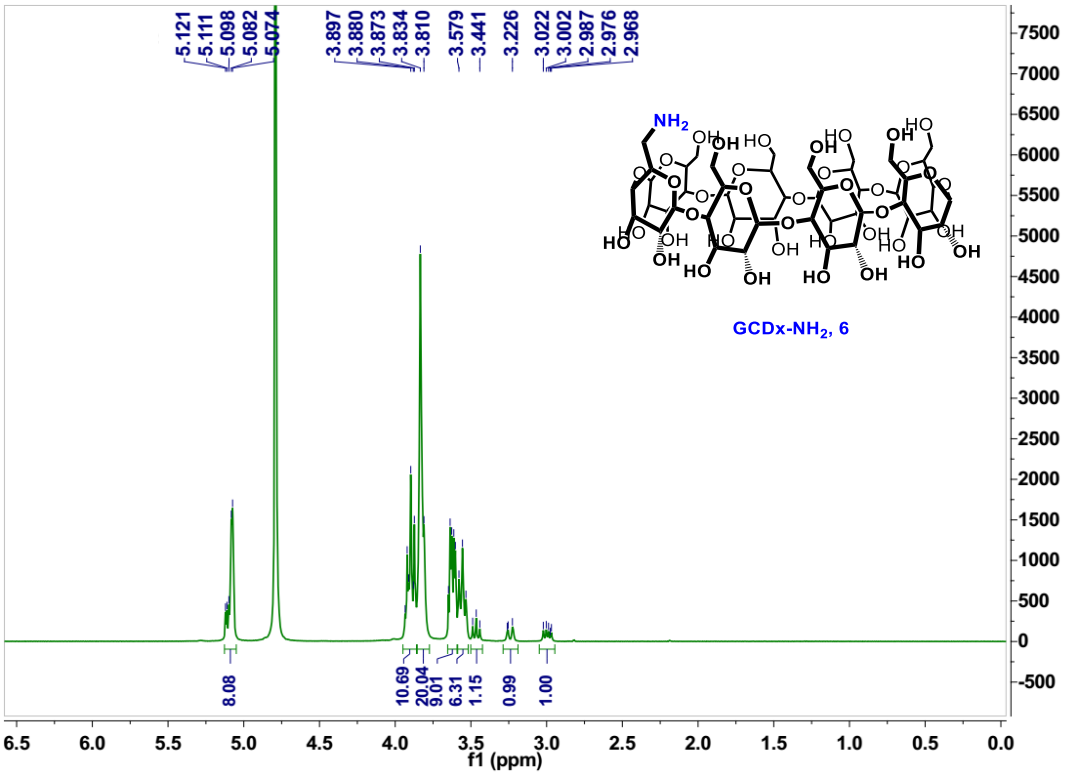


Figure S1. ^{1}H NMR Spectrum of mono-6-deoxy-6-amino-*γ*-CDx (GCDx-NH2, **6**) (D_2O, 400 MHz, 25 °C).

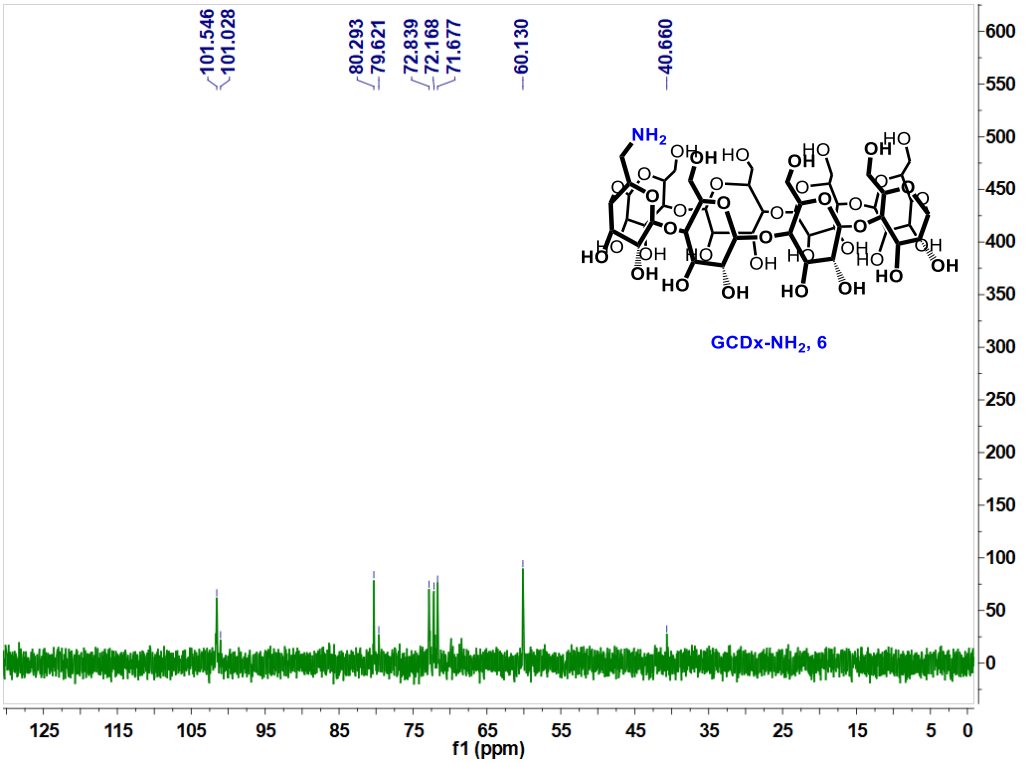
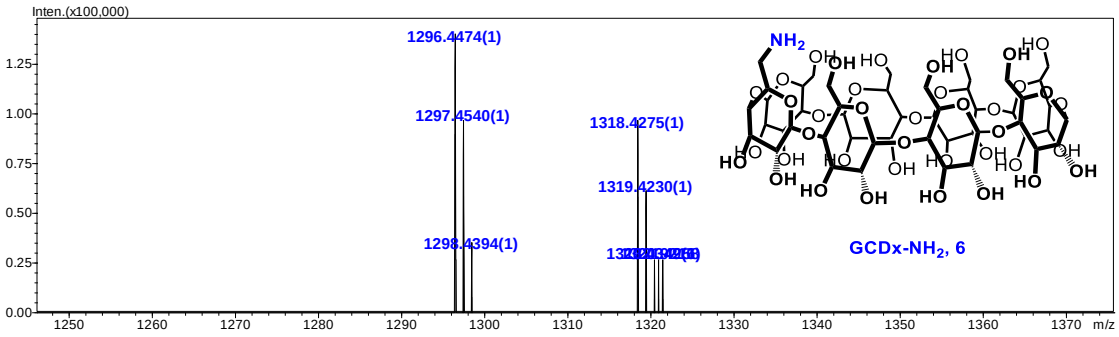


Figure S2. ^{13}C NMR Spectrum of mono-6-deoxy-6-amino-*γ*-CDx (GCDx-NH2, **6**) (D_2O, 101 MHz, 25 °C).

GCDx-NH2, **6** ESI+



ESI-

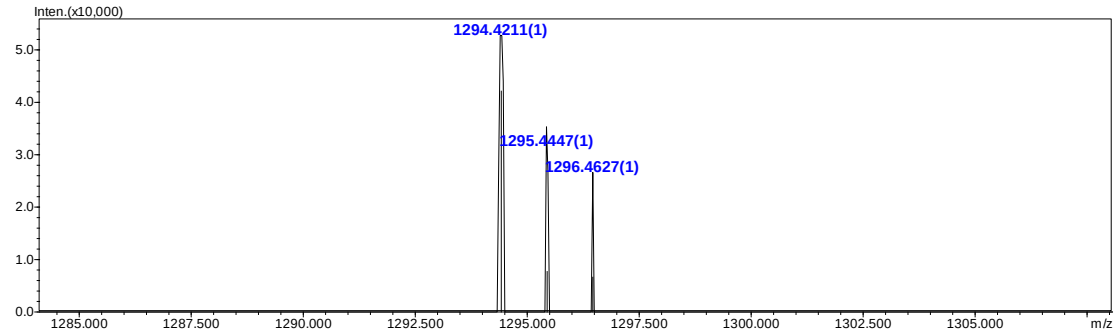


Figure S3. HRMS (ESI) Spectrum of GCDx-NH2, **6**.

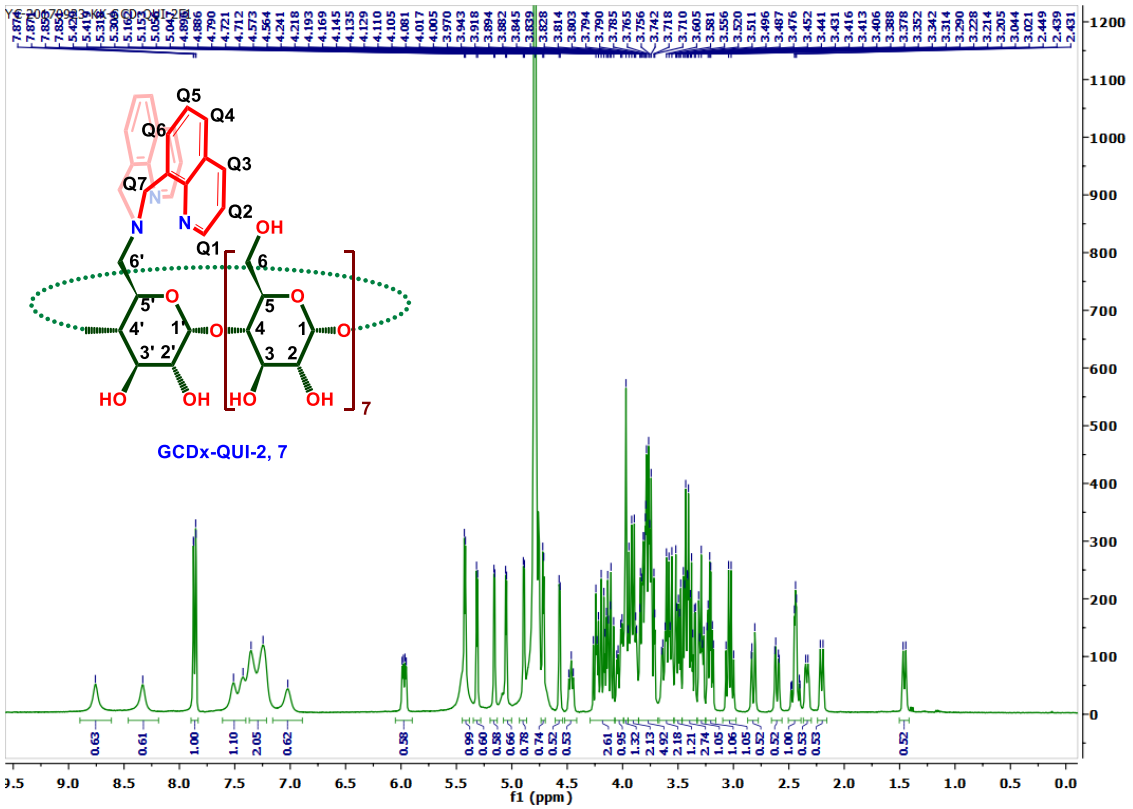


Figure S4. ^{1}H NMR Spectrum of **7** (D_2O, 400 MHz, 25 ^{o}C).

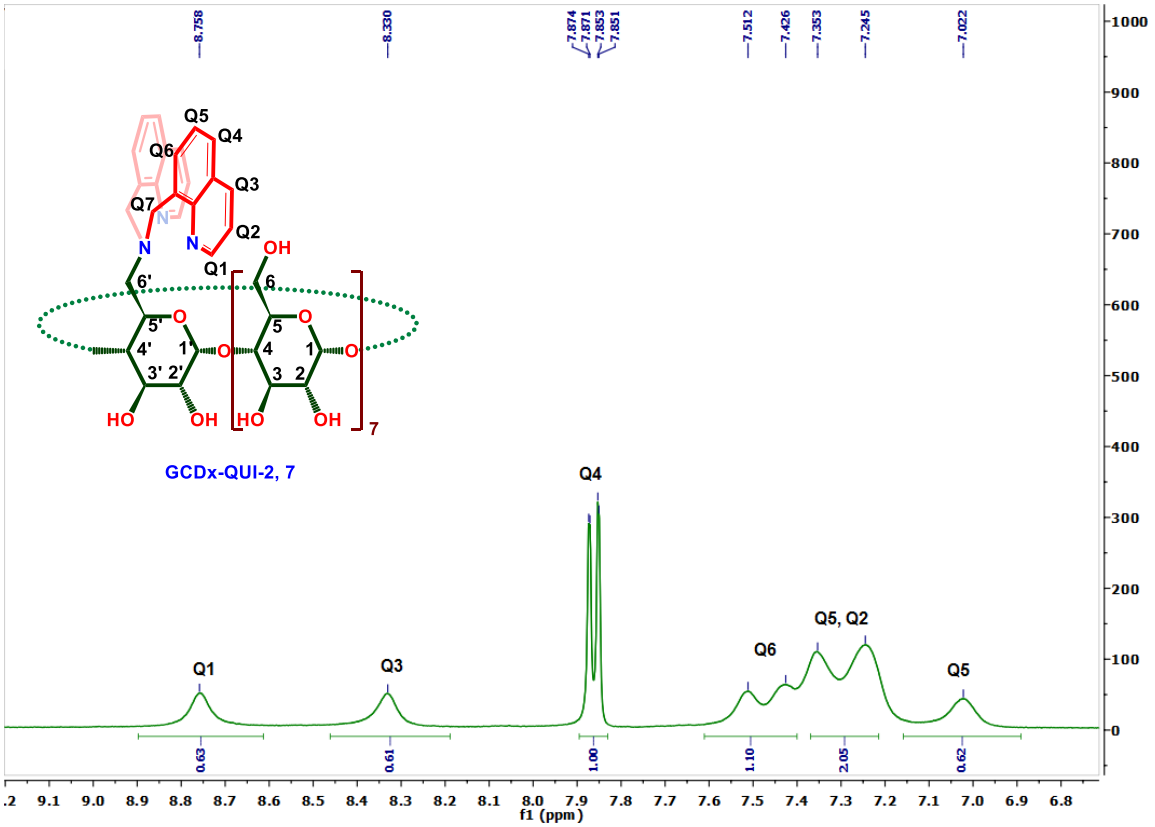


Figure S5. Expanded ^{1}H NMR spectrum of **7** (D_2O, 400 MHz, 25 °C).

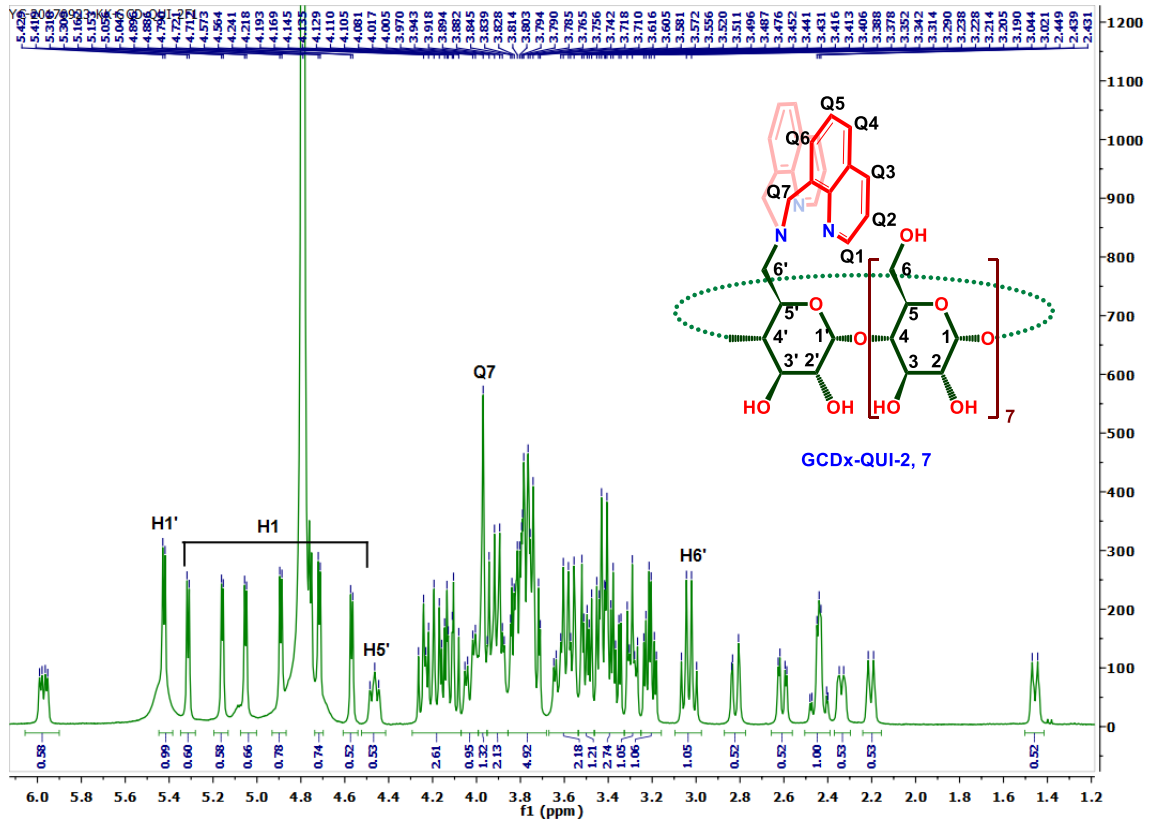


Figure S6. Expanded ^{1}H NMR spectrum of **7** (D_2O, 400 MHz, 25 °C).

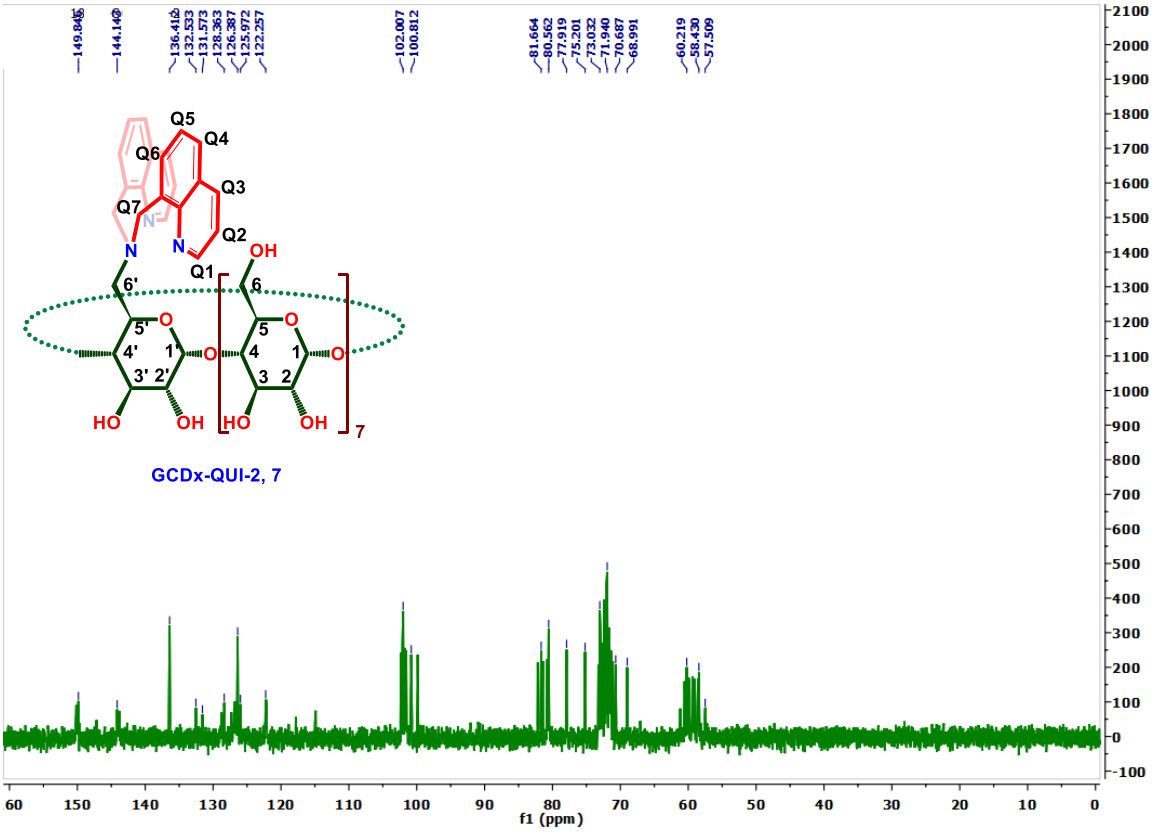


Figure S7. ^{13}C NMR Spectrum of **7** (D_2O, 101 MHz, 25 ^{o}C).

GCDx-QUI-2, **7** ESI+

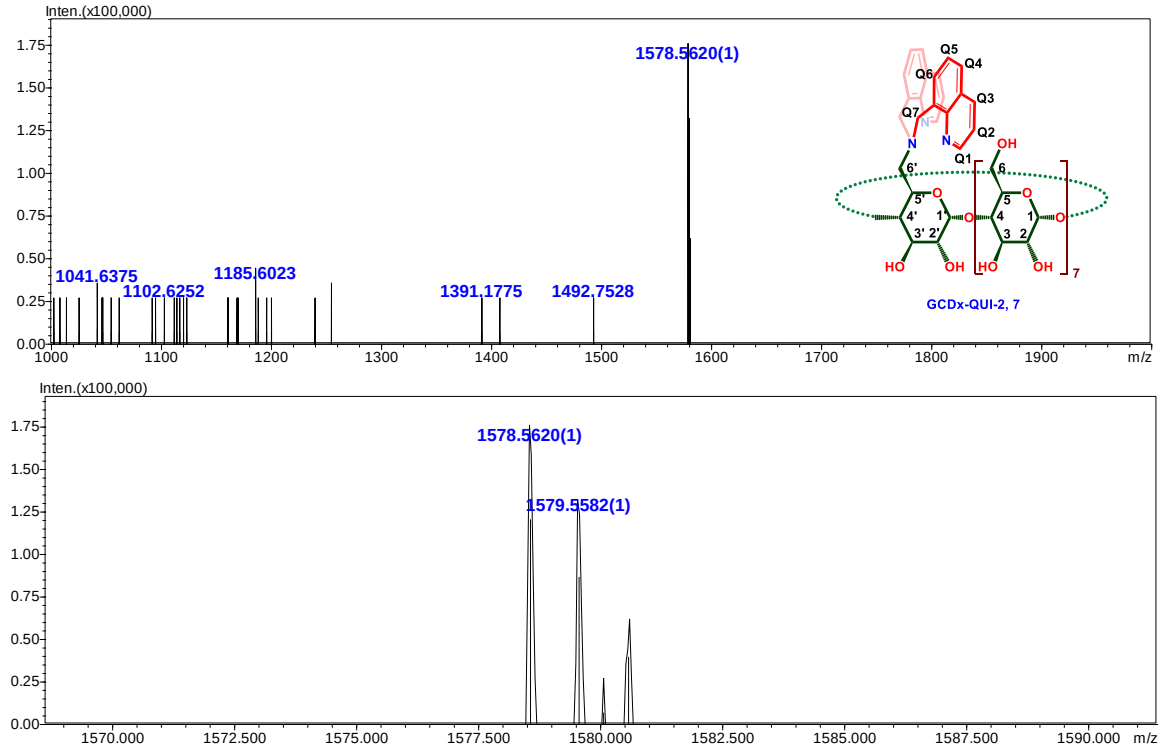


Figure S8. HRMS (ESI) Spectrum of **7**.

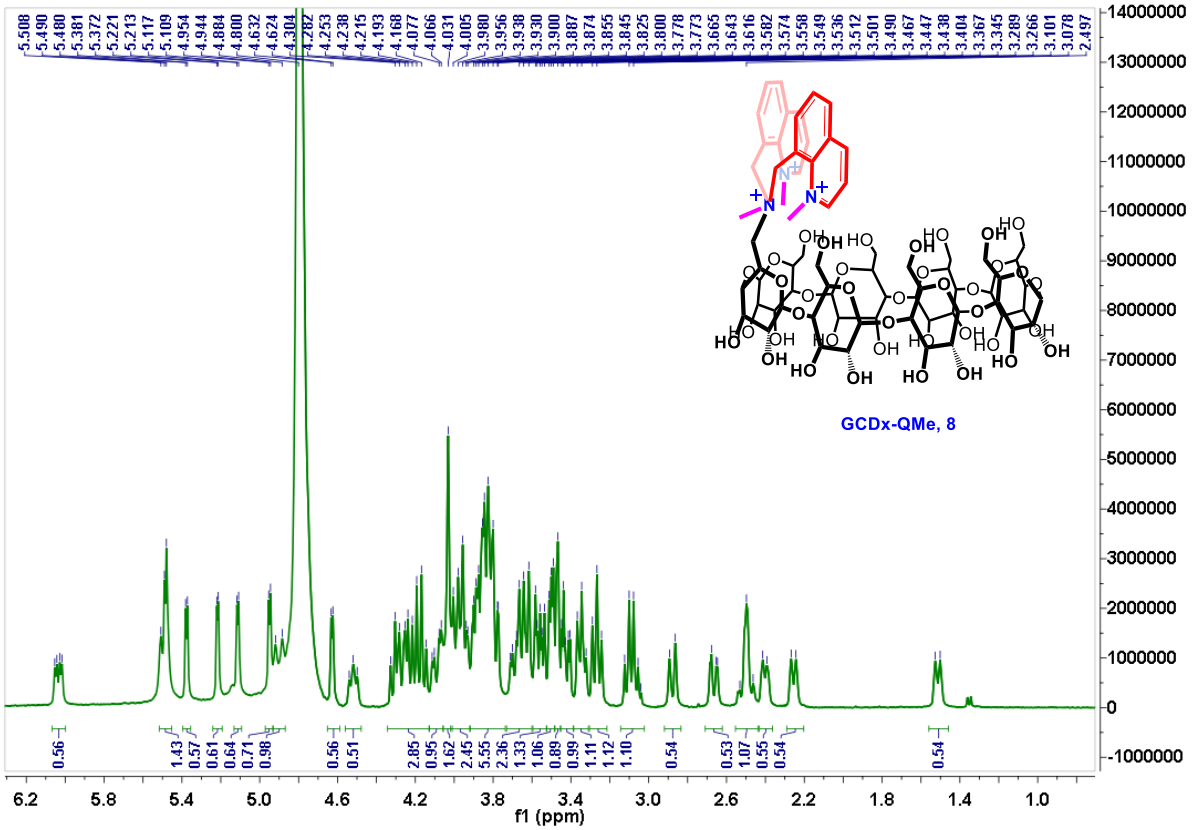


Figure S9. ^{1}H NMR Spectrum of **8** (D_2O, 400 MHz, 25 ^{o}C).

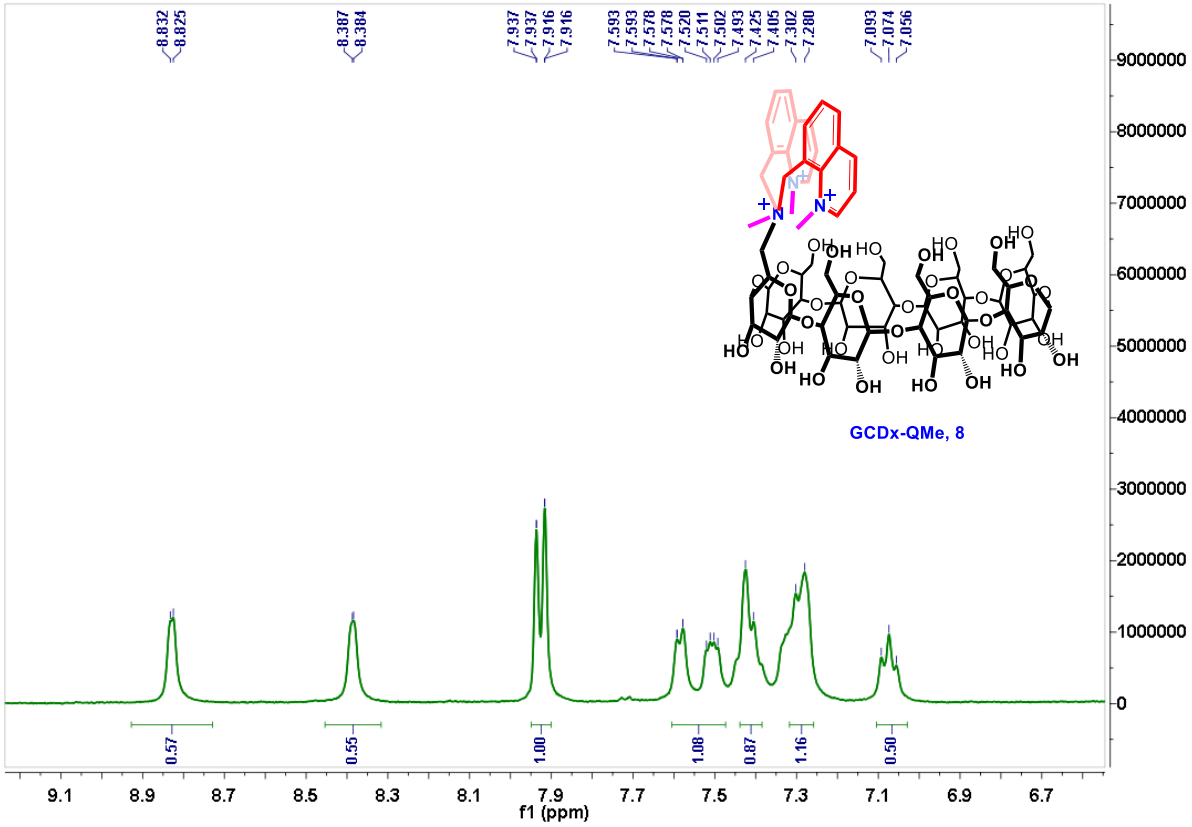


Figure S10. Expanded ^{1}H NMR spectrum of **8** (D_2O, 400 MHz, 25 ^{o}C).

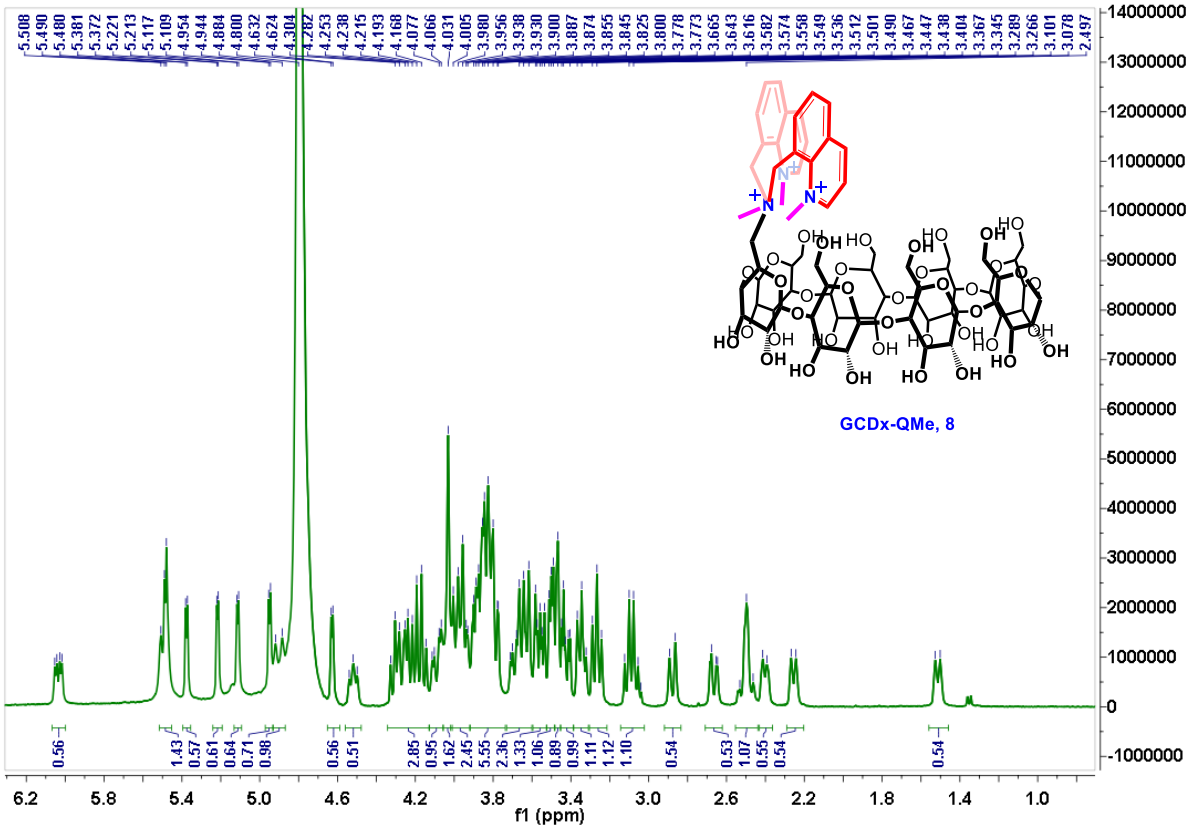


Figure S11. Expanded ^{1}H NMR spectrum of **8** (D_2O, 400 MHz, 25 °C).

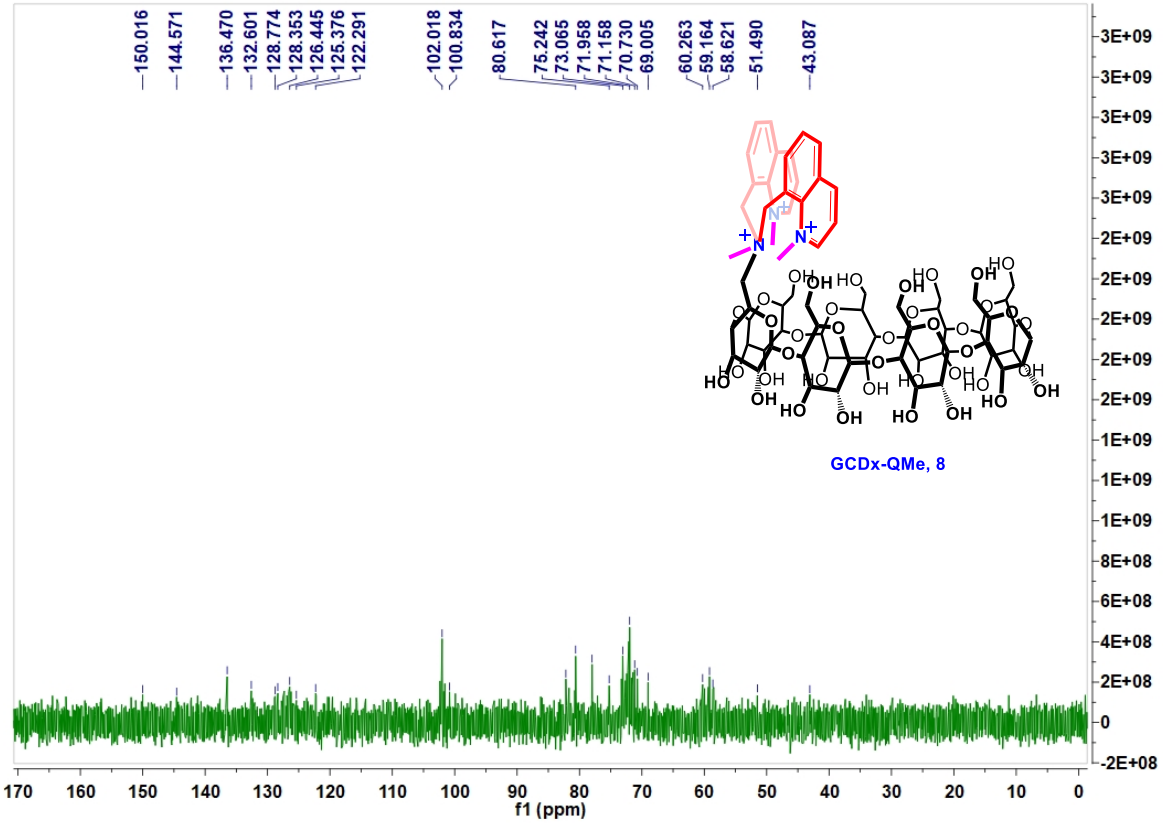


Figure S12. ^{13}C NMR Spectrum of **8** (D_2O, 101 MHz, 25 °C).

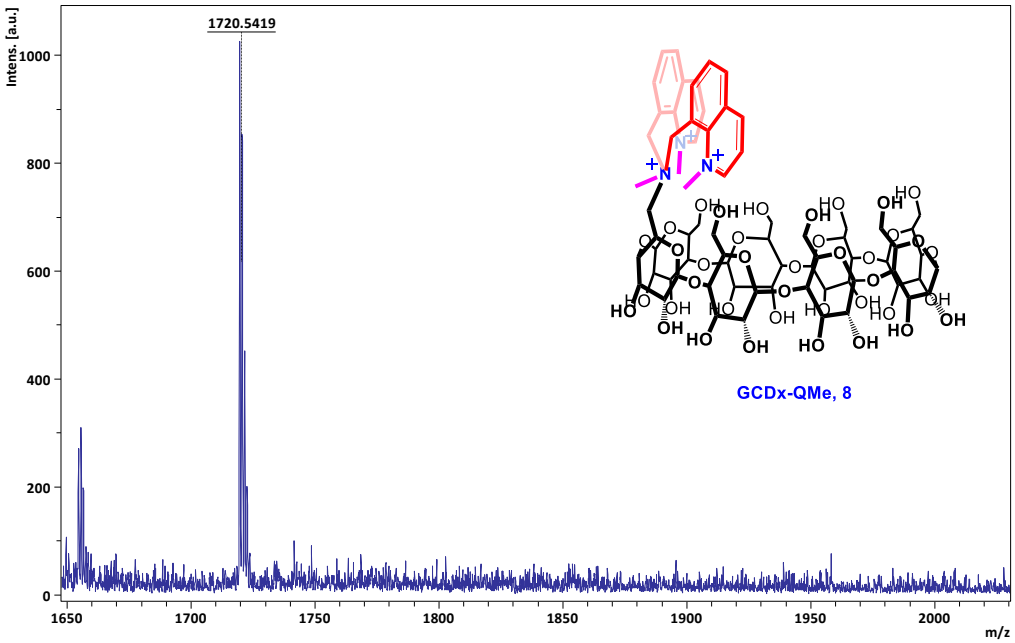


Figure S13. HRMS (MALDI-TOF) Spectrum of **8**.

3. Conformation analysis of host 7

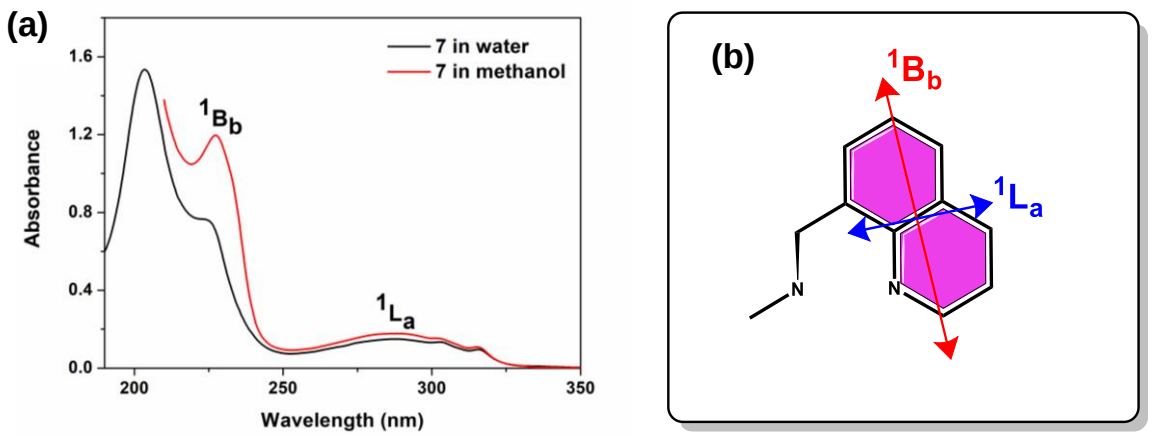


Figure S14. (a) The absorption spectrum of **7** (37 μM) in water and methanol. (b) The orientations of the absorption transition moments for both ^1B_b and ^1L_a absorption bands are shown in the box.

The absorption bands at 226, 284, and 315 nm are attributed to the long (^1B_b) and short ($^1L_{a,b}$)-axis polarized π-π* transitions of the quinoline chromophore. The ICD signals of the two quinoline chromophores appeared at ~230 and 290 nm and are attributed to the corresponding ^1B_b and $^1L_{a,b}$ electronic transitions.[S4] The CD spectra of **7** in water consist of a negative couplet appearing around 233 nm. According to the

empirical rule on the ICD phenomena of CDx complexes, the observed CD signals of **7** indicate that the anchored quinoline chromophores locate inside the CDx cavities with the long ^1B_b transition band being parallel to the CDx axis and the short $^1L_{a,b}$ transition band being almost vertical to the CDx axis. Both the quinoline chromophores in **7**, accommodated inside the CDx cavity resulted in the counter clockwise orientation of its electronic transitions that correspond to the negative exciton chirality ECCD signals according to the exciton chirality method. The weak positive CE peak at around 239 nm observed for **7** in methanol indicates that both of the quinoline chromophores are not completely excluded from the CDx cavity.[S4] This confirmations was confirmed by the fact that a much wider and upfield shifted distribution for the proton signals were observed in D_2O than in methanol-d_4, suggesting the quinoline moiety was more self-included in D_2O to thus exert strong shielding or deshielding effects on different glucose units.

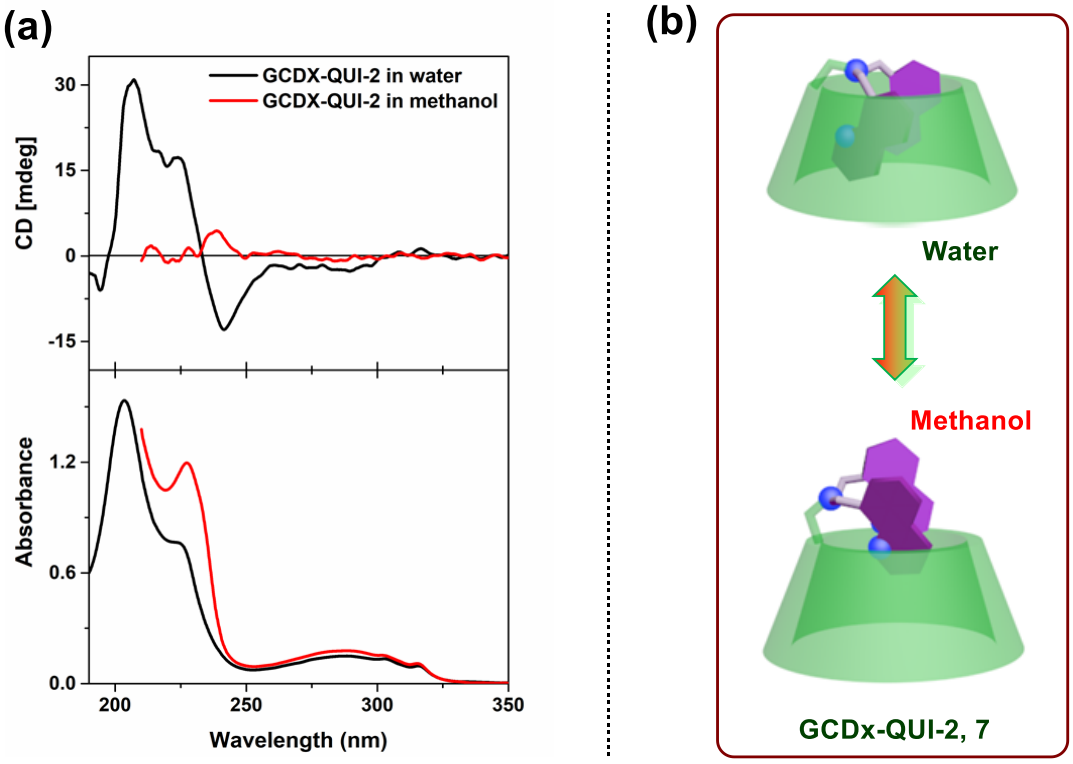


Figure S15. (a) Circular dichroism (upper panel) and UV-vis. absorption spectra (lower panel) of **7** (3.17×10^{-5} M) in water and methanol at 25 °C, and (b) Proposed quinoline chromophore conformations obtained by applying exciton chirality theory to the CD spectra of **7**.[S4]

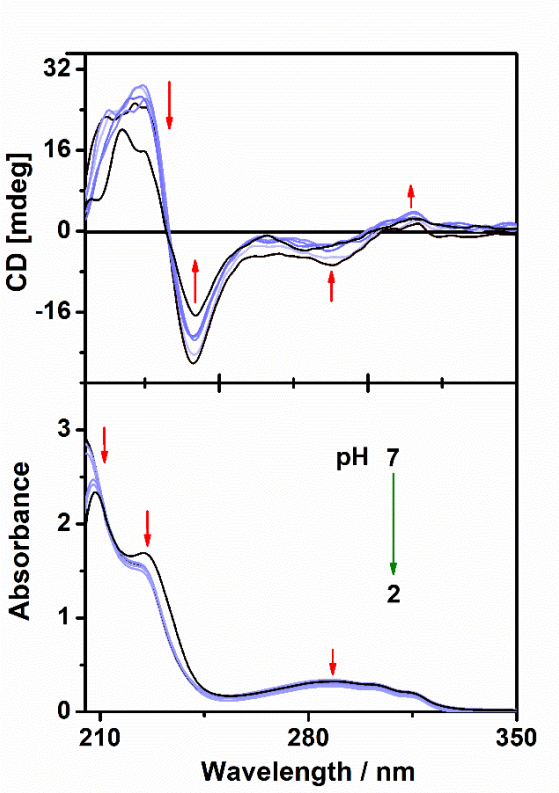


Figure S16. Circular dichroism (CD) and UV-vis. absorption spectral changes of **7** (63.4 μM) in PBS buffers (pH 2-7), at 25 °C.

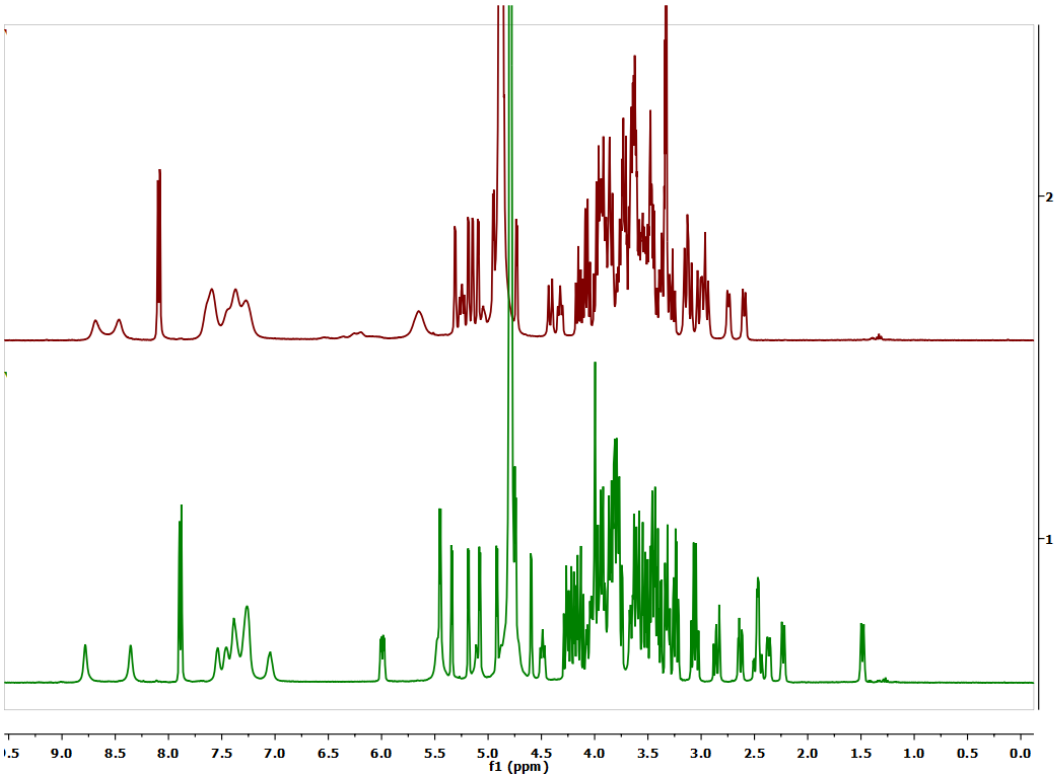


Figure S17. Comparison of ^{1}H NMR spectrum (400 MHz) of **7** in CD_3OD (top) and D_2O (bottom).

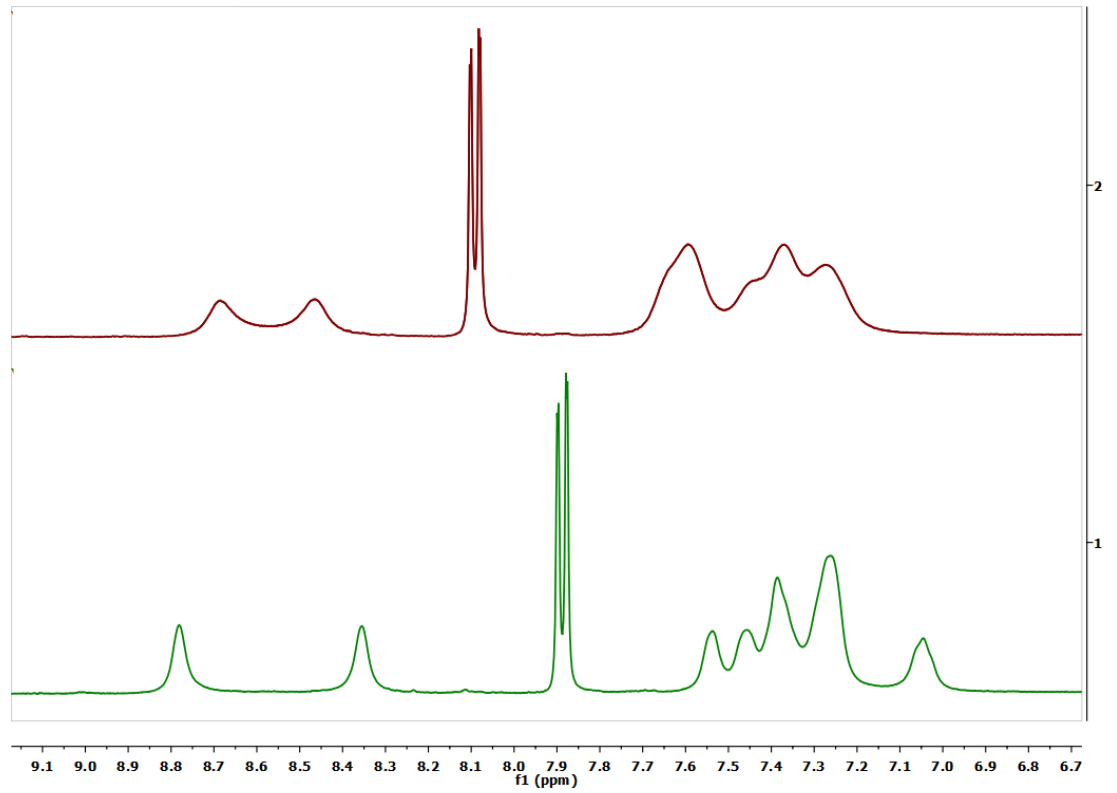


Figure S18. Expansion of Figure **S17** in the aromatic proton region.

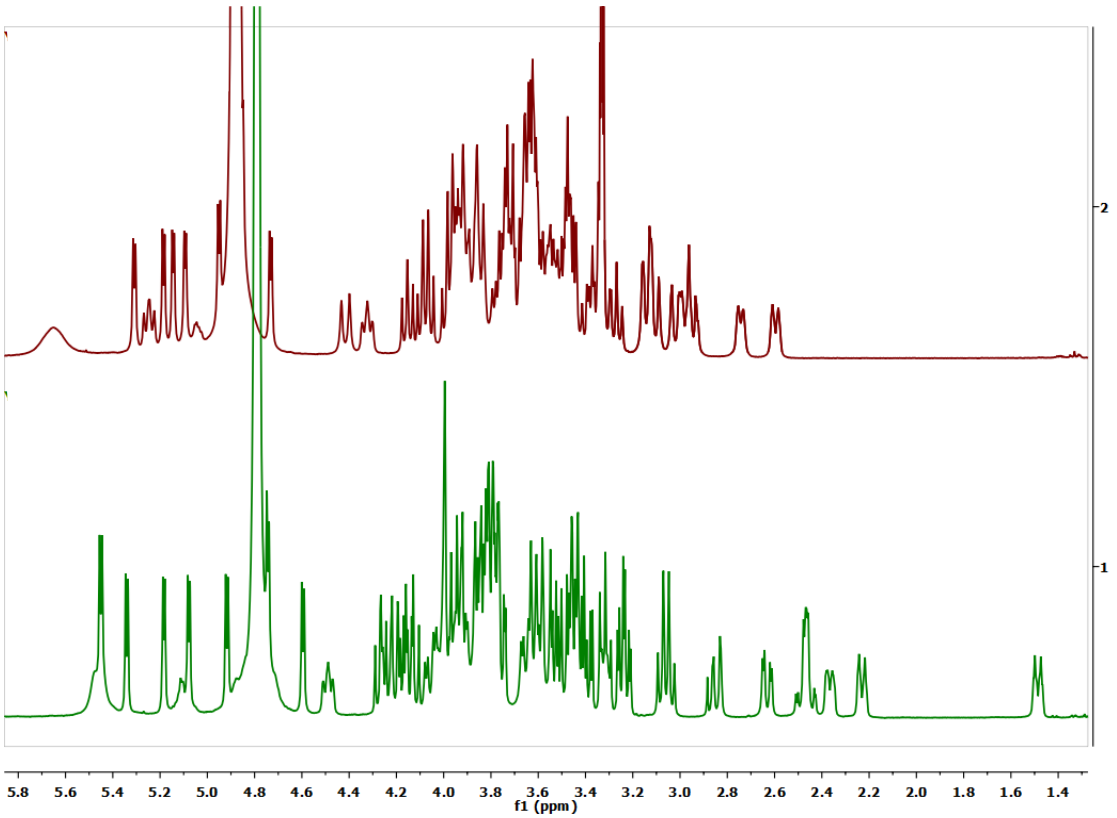


Figure S19. Expansion of Figure **S17** in the CDx proton region.

4. The binding constants of hosts 5, 6 and 7 with AC

Table S1. The calculated binding constant of **5** with AC at pH 9 at 25 ºC.[a]

pH	Binding constant / M^{-1}		$K_1 K_2$ / x 10^7 M^{-2}	K_2 / K_1
	K_1	K_2		
9	161 ± 25	38500 ± 3300	6.20	239.1

[a] Reported in ref. S3, and binding constants were calculated in 25 mM borate buffer using fluorescence and UV-vis titrations at 25 ºC.

Table S2. Calculated binding constant of **6** with AC at different pH at 25 ºC.[a]

pH	Binding constant / M^{-1}		$K_1 K_2$ / x 10^7 M^{-2}	K_2 / K_1
	K_1	K_2		
7	3970 ± 1100	6350 ± 1200	2.52	1.6
8	3810 ± 450	6290 ± 680	2.40	1.7
9	3540 ± 340	7630 ± 630	2.70	2.2
10	4490 ± 1600	7780 ± 1400	3.49	1.7

[a] calculated using ITC measurements, [AC] = 0.2 mM, [**6**] = 4 mM in PBS buffer.

Table S3. Calculated binding constant upon complexation of **7** with AC at different pH at 25 ºC.[a]

pH	Binding constant / M^{-1}		$K_1 K_2$ / x 10^7 M^{-2}	K_2 / K_1
	K_1	K_2		
6 [b]	1410 ± 290	15800 ± 2300	2.23	11.2
7	3370 ± 200	11700 ± 780	3.94	3.5
8	4340 ± 240	10900 ± 650	4.73	2.5
9	3680 ± 350	8650 ± 840	3.18	2.4
10	734 ± 19	1150 ± 90	0.08	1.6

[a] calculated using ITC measurements, [AC] = 0.2 mM, and [**7**] = 4 mM in PBS buffer. [b] estimated [AC] = 0.02 mM by UV-vis. absorption spectra and [**7**] = 4 mM.

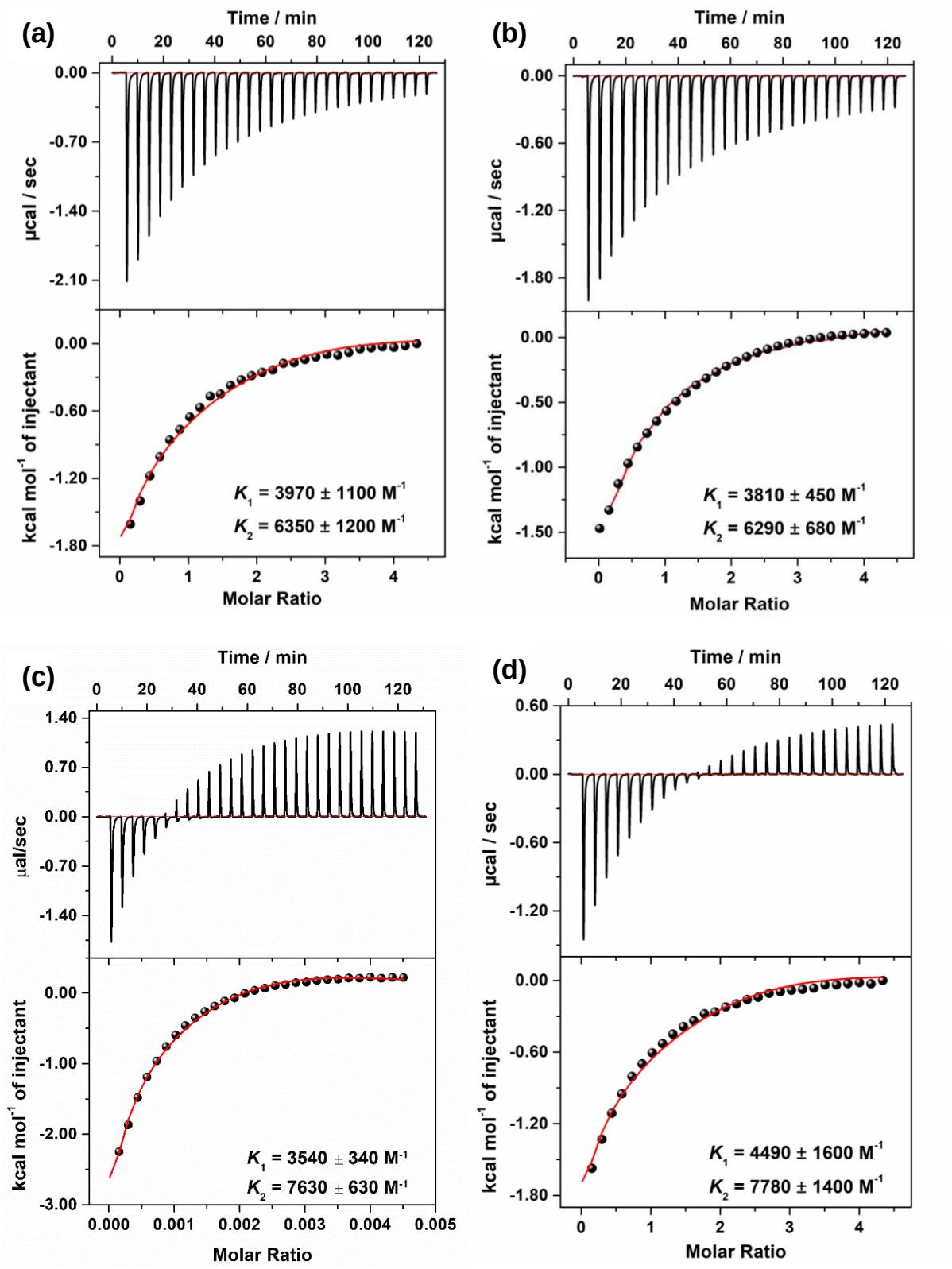


Figure S20. ITC titration data for the complexation of host **6** with AC in aqueous PBS buffer solution (a) pH7, (b) pH8, (c) pH9, and (d) pH10 at 25 °C, which gave the 1:1 association constant (K_1) and the 1:2 association constant (K_2).

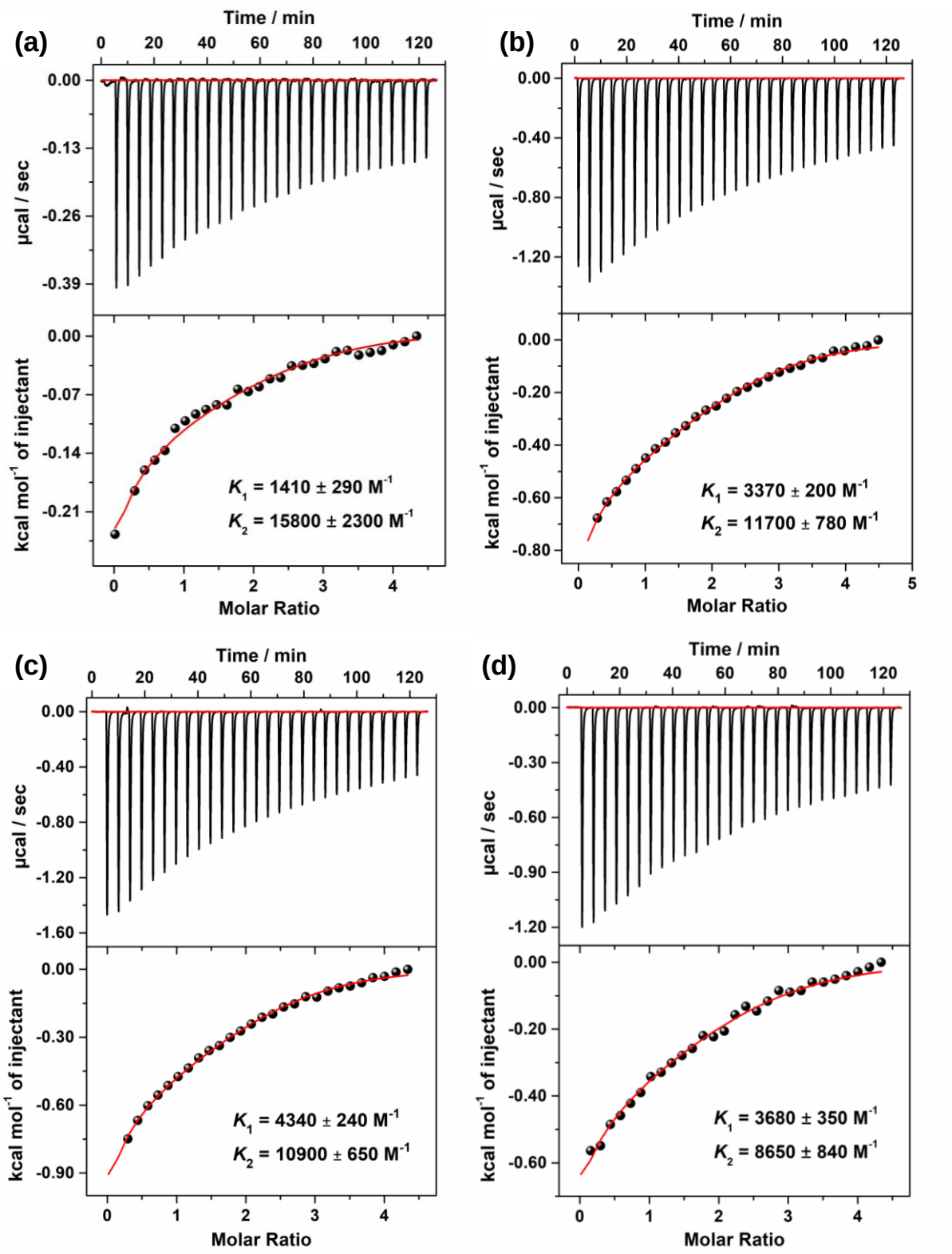


Figure S21. ITC titration data for the complexation of host **7** with AC in aqueous PBS buffer solution (a) pH6, (b) pH7, (c) pH8, and (d) pH9 at 25 °C, which gave the 1:1 association constant (K_1) and the 1:2 association constant (K_2).

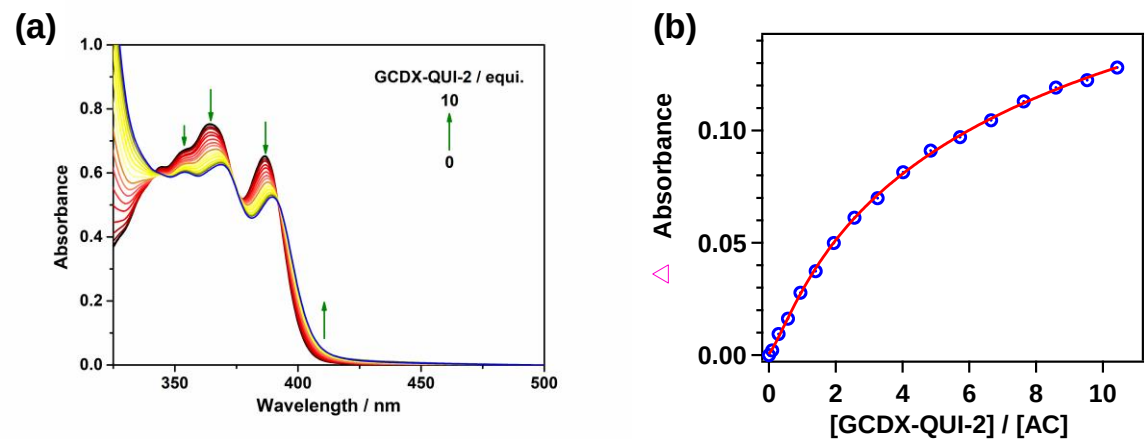


Figure S22. (a) UV-Vis absorption spectral changes of AC upon addition of **7** in pH 7 buffer, [AC] = 0.2 mM; [**7**] = 0 - 0.33 mM. (b) Calculated 1:1 association constant (K_1) is 2734.5 ± 103 M^{-1} and the 1:2 association constant (K_2) 10893 ± 760 M^{-1}.

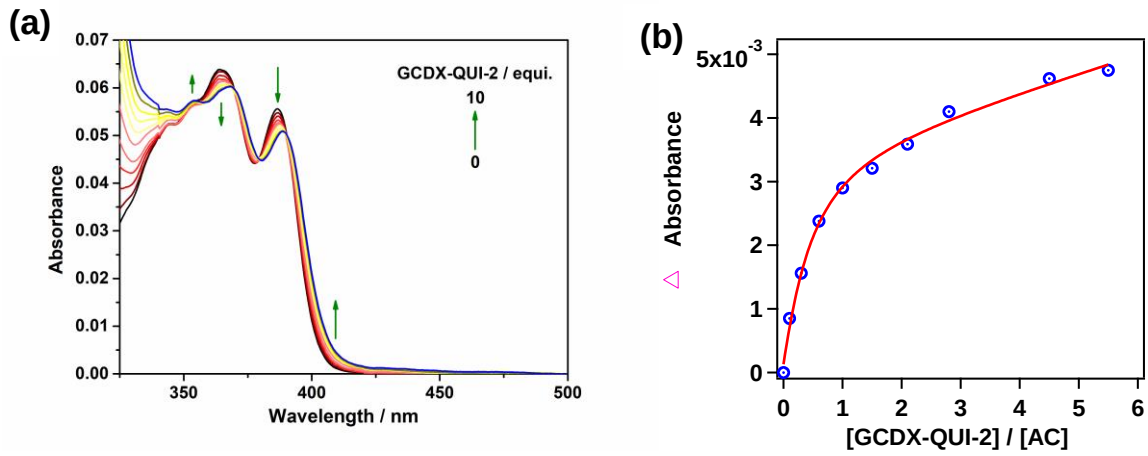


Figure S23. (a) UV-Vis absorption spectral changes of AC upon addition of **7** in pH 8 PBS buffer, [AC] = 0.2 mM; [**7**] = 0 - 5 mM (2 mM). (b) Calculated 1:1 association constant (K_1) is 4118.1 ± 740 M^{-1} and the 1:2 association constant (K_2) 12216 ± 3330 M^{-1}.

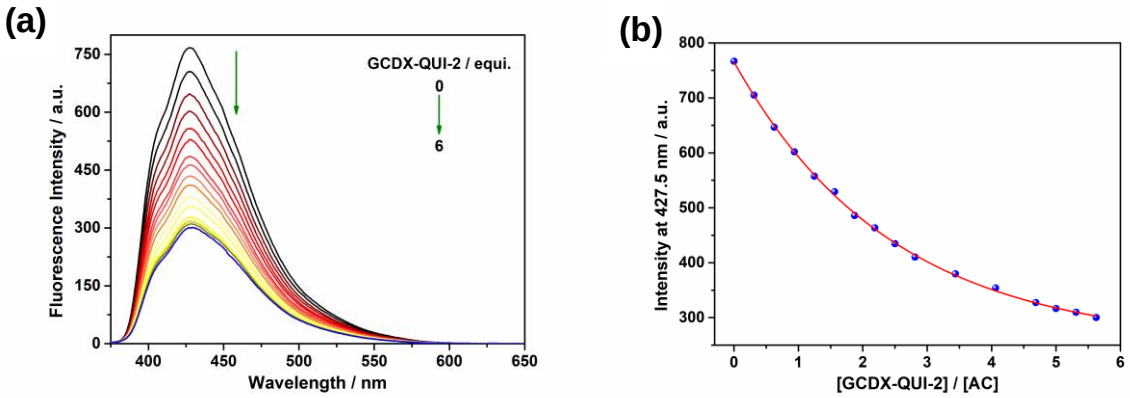


Figure S24. (a) Fluorescence emission spectral changes of AC upon addition of **7** in pH 7 PBS buffer, [AC] = 0.2 mM; [**7**] = 2 mM. (b) Plot of the fluorescence intensity at 427.5 nm versus the host [**7**].

Table S4. Estimated populations of the free AC and complex species (AC:**7**) in the solution used for the photoreaction.[a]

pH	[AC] /mM	[7] /mM	H/G ratio	Population of AC / %		
				free	1:1	1:2
6	0.2	0	0.0	100	0	0
	0.2	0.1	0.5	68	6	26
	0.2	0.2	1	53	11	36
	0.2	0.4	2	40	17	43
	0.2	1	5	24	30	46
	0.2	2	10	16	42	42
	0.2	4	20	10	56	34
	0.02	4	200	14.5	78.5	7
7	0.2	2	10	10	61	29
	0.2	4	20	6	74	20
8	0.2	2	10	8	67	25
	0.2	4	20	5	79	16
9	0.2	0.1	0.5	62	12	26
	0.2	0.2	1	46	21	33
	0.2	1	5	16	53	31
	0.2	2	10	10	67	23
	0.2	4	20	6	79	15
	0.02	4	200	6	92	2
10	0.2	2	10	38	53	9
	0.2	4	20	23	69	8

[a] calculated using binding constant data from ITC measurements, pH 6 (K_1 =1410 ± 290 and K_2 = 15800 ± 2300), pH 7 (K_1 = 3370 ± 200 and K_2 = 11700 ± 780) pH 8 (K_1 = 4340 ± 240 and K_2 = 10900 ± 650) pH 9 (K_1 = 3680 ± 350 and K_2= 8650 ± 840) and pH (K_1 = 734 ± 19 and K_2 = 1150 ± 90).

5. Photocyclodimerization of AC and mediated by native and modified CDxs

Table S5. Photocyclodimerization AC in PBS buffer. [a]

Buffer / pH	Conv. / %	Relative yield / %				*ee* /%		(3+4) /(1+2) [b]	1/2 [c]	3/4 [c]
		1	2	3	4	2	3			
1	*d*	32.7	10.7	35.1	18.9	*e*	*e*	1.2	3.1	1.9
2	*d*	33.1	12.4	34.7	19.1	*e*	*e*	1.2	2.7	1.8
3	*d*	32.3	13.5	34.4	19.8	*e*	*e*	1.2	2.4	1.7
4	*d*	33.6	16.7	31.5	18.3	*e*	*e*	1.0	2.0	1.7
5	*d*	35.6	19.2	30.0	20.1	*e*	*e*	0.9	1.9	1.5
6	*d*	34.5	29.4	20.1	10.1	*e*	*e*	0.5	1.2	2.0
7	48.6	36.9	28.5	18.1	13.7	-0.3	0.1	0.5	1.3	1.3
8	70.9	38.0	36.2	15.3	10.5	-0.2	0.4	0.4	1.1	1.5
9	73.2	36.9	36.2	15.0	11.9	-0.2	0.4	0.4	1.0	1.3
10	73.4	37.1	36.4	14.9	11.6	-0.4	0.3	0.4	1.0	1.3

[a] All the photocyclodimerization reactions were carried in [AC] = 0.2 mM, and PBS buffer using 365 nm LED light irradiation for 30 min. at 0.5 °C. [b] HH / HT ratio. [c] *Anti* / *Syn* ratio. [d] low yield <7% [e] Not determined because of the low yield.

Table S6. Photocyclodimerization AC in host **5** in PBS buffer. [a]

Buffer / pH	Conversion / %	Relative yield / %				*ee* /%		(3+4) /(1+2) [b]	1/2 [c]	3/4 [c]
		1	2	3	4	2	3			
1	53.7	47.7	13.1	26.1	4.2	11.3	0.7	0.5	3.6	6.2
1 [d]	64.7	54.6	19.7	21.2	4.6	11.5	1.8	0.4	2.8	4.6
2	58.7	50.5	21.2	23.6	4.7	8.3	0.3	0.4	2.4	5.0
2 [d]	60.9	52.8	22.9	19.3	5.0	11.6	1.7	0.3	2.3	3.9
3	59.6	52.1	25.3	17.9	4.7	8.2	0.9	0.3	2.1	3.9
3 [d]	70.5	51.2	22.7	20.6	5.5	11.5	3.1	0.4	2.3	3.7
4	49.6	52.9	25.5	17.0	4.6	7.9	1.9	0.3	2.1	3.7
4 [d]	46.4	48.3	27.3	17.4	7.1	14.1	4.4	0.3	1.8	2.5
5	48.4	45.2	30.5	16.5	7.9	21.2	4.0	0.3	1.5	2.1
5 [d]	55.8	43.1	35.0	14.6	7.2	28.9	6.9	0.3	1.2	2.0
6	49.2	39.5	40.9	11.7	7.9	36.3	4.5	0.2	1.0	1.5
6 [d]	52.2	39.7	43.0	10.1	7.2	38.2	7.6	0.2	0.9	1.4
7	99.6	39.0	46.5	8.0	6.5	40.6	2.9	0.2	0.8	1.2
8	99.0	39.0	46.7	7.8	6.4	41.5	2.4	0.2	0.8	1.2
9	99.6	39.0	46.9	7.6	6.5	42.7	2.9	0.2	0.8	1.2
10	99.8	39.1	46.6	7.8	6.5	41.8	2.9	0.2	0.8	1.2

[a] All the photocyclodimerization reactions were carried in [**5**] = 2.0 mM, [AC] = 0.2 mM, and PBS buffer using 365 nm LED light irradiation for 30 min. at 0.5 °C. [b] HH / HT ratio. [c] *Anti* / *Syn* ratio. [d] filtrate.

Table S7. Photocyclodimerization AC in host **6** in PBS buffer. [a]

Buffer / pH	Conv. / %	Relative yield / %				*ee* /%		(3+4) /(1+2) [b]	1/2 [c]	3/4 [c]
		1	2	3	4	2	3			
1	23.9	46.6	14.0	33.9	5.5	7.9	0.9	0.7	3.3	6.2
1 [d]	73.8	51.3	19.4	27.1	7.0	6.7	1.0	0.5	2.6	3.9
2	25.2	48.1	21.1	24.8	6.0	7.6	0.7	0.4	2.3	4.1
2 [d]	63.7	49.0	20.1	23.3	6.6	6.1	0.6	0.4	2.4	3.5
3	28.5	50.7	21.4	21.8	6.1	7.2	0.6	0.4	2.4	3.6
3 [d]	38.4	50.8	22.8	20.0	6.4	7.3	0.5	0.4	2.2	3.2
4	36.3	44.7	22.7	23.4	9.2	10.9	-0.4	0.5	2.0	2.6
4 [d]	55.1	39.4	34.2	16.0	8.4	18.0	-0.9	0.3	1.2	1.9
5	41.0	39.0	35.0	15.6	10.5	19.1	-0.6	0.4	1.1	1.5
5 [d]	61.0	38.2	37.1	14.4	9.1	20.0	-1.4	0.3	1.0	1.6
6	69.4	38.9	40.9	11.1	9.2	21.7	-1.5	0.3	1.0	1.2
6 [d]	98.6	39.7	41.3	10.3	8.7	21.5	-2.2	0.2	1.0	1.2
7	99.4	39.7	43.4	8.8	8.2	23.7	-2.5	0.2	0.9	1.1
8	99.6	39.4	43.8	8.7	8.2	25.2	-2.3	0.2	0.9	1.1
9	99.6	39.1	44.5	8.5	7.9	32.0	-2.2	0.2	0.9	1.1
10	99.3	38.8	45.0	8.4	7.9	36.2	-2.9	0.2	0.9	1.1

[a] All the photocyclodimerization reactions were carried in [**6**] = 2.0 mM, [AC] = 0.2 mM, and PBS buffer using 365 nm LED light irradiation for 30 min. at 0.5 °C. [b] HH / HT ratio. [c] *Anti* / *Syn* ratio. [d] filtrate, estimated [AC] = 0.02 μM (pH1), 0.17 μM (pH2), 0.86 μM (pH3), 1.33 μM (pH4) and 3.62 μM (pH5), by HPLC.

Table S8. Photocyclodimerization AC in host **7** in PBS buffer (pH 1-10) at different temperatures (°C). [a]

Solvent	Added salt	T /°C	Conv. / %	Relative yield / %				*ee* / %		(3+4) /(1+2)[b]	1/2[c]	3/4[c]
				1	2	3	4	2	3			
pH 1	none	25	76.4	30.1	5.7	50.3	13.9	30.7	17.9	1.8	5.2	3.6
		0.5	91.4	29.2	10.8	44.4	15.6	39.2	22.6	1.5	2.7	2.9
pH 1 [d]	none	25	66.2	36.2	10.1	42.5	12.8	14.8	5.4	1.2	3.6	3.3
		0.5	70.1	34.7	13.0	37.9	14.3	16.6	8.2	1.1	2.7	2.6
	LiCl [e]	0.5	12.1	41.9	11.8	30.9	15.3	39.4	22.4	0.9	3.5	2.0
		-20	7.5	48.9	13.0	29.1	9.0	21.0	25.2	0.6	3.8	3.2
	CsCl [f]	0.5	53.0	39.6	7.8	40.1	12.5	41.4	14.3	1.1	5.1	3.2
		-20	64.1	43.9	9.0	40.4	6.8	35.7	17.5	0.9	4.9	6.0
pH 1/ MeOH [g]	none	0.5	42.0	44.8	15.4	31.1	8.8	26.2	13.2	0.7	2.9	3.5
		-20	47.1	41.8	16.4	33.9	7.9	45.8	10.1	0.7	2.5	4.3
pH 2	none	0.5	54.3	38.3	18.1	32.3	11.4	25.5	4.2	0.8	2.1	2.9
pH 2 [d]	none	0.5	16.5	45.4	18.2	23.6	12.8	21.6	5.0	0.6	2.5	1.8
pH 3	none	0.5	58.1	43.8	23.3	24.1	8.8	24.8	11.1	0.5	1.9	2.7
pH 3 [d]	none	0.5	12.7	43.7	21.1	22.8	12.5	24.6	2.0	0.5	2.1	1.8
pH 4	none	0.5	12.0	39.1	24.5	24.5	11.9	18.6	-15.1	0.6	1.6	2.1
pH 4 [d]	none	0.5	25.0	39.1	26.8	19.8	14.4	26.6	-13.6	0.5	1.5	1.4
pH 5	none	0.5	17.3	38.9	37.1	12.9	11.1	17.8	-49.8	0.3	1.1	1.2
pH 5 [d]	none	0.5	27.5	37.1	33.7	15.4	13.7	28.0	-39.6	0.4	1.1	1.1
pH 6	none	25	27.9	38.8	38.0	12.9	10.4	22.5	-32.8	0.3	1.0	1.2
		0.5	36.0	38.5	43.9	9.8	7.9	15.7	-51.2	0.2	0.9	1.2
pH 6 [d]	none	25	21.5	37.9	36.2	11.6	13.1	12.3	-26.7	0.3	1.1	0.9
		0.5	32.6	38.6	39.3	12.1	10.0	27.8	-33.0	0.3	1.0	1.2
pH 6 [d]	LiCl [e]	0.5	13.8	31.8	24.4	26.9	16.8	28.4	-15.1	0.8	1.3	1.6
		-20	17.2	55.9	18.0	18.2	7.9	41.4	-19.8	0.4	3.1	2.3
	CsCl [f]	0.5	43.7	27.1	20.1	25.4	27.4	37.6	-48.3	1.1	1.4	0.9
		-20	59.7	33.4	21.2	26.1	19.3	41.0	-64.4	0.8	1.6	1.4
pH 6/ MeOH [g]	none	0.5	19.5	41.5	34.7	14.1	9.6	14.1	-44.6	0.3	1.2	1.5
		-20	22.6	43.2	30.8	15.8	10.2	22.6	-52.2	0.4	1.4	1.6
7	none	0.5	48.0	38.3	44.7	8.9	8.1	18.9	-47.0	0.2	0.9	1.1
8	none	0.5	55.0	38.4	43.6	9.3	8.8	19.8	-44.2	0.2	0.9	1.1
9	none	0.5	70.4	39.4	41.1	10.2	9.4	23.2	-44.8	0.2	1.0	1.1
10	none	0.5	73.6	36.4	41.5	11.7	10.4	28.0	-44.9	0.3	0.9	1.1

[a] All the photocyclodimerization reactions were carried in [**7**] = 2.0 mM, [AC] = 0.2 mM, and PBS buffer (pH 1-10) using 365 nm LED light irradiation for 30 min. at different temperatures. [b] HH / HT ratio. [c] *Anti* / *Syn* ratio. [d] filtrate, estimated [AC] = 0.016 μM (pH1), 0.032 μM (pH2), 1.07 μM (pH3), 2.53 μM (pH4) and 5.32 μM (pH5), by HPLC. [e] LiCl (1 M). [e] CsCl (6M). [f] ratio of solvent is 1:1 (V/V).

Table S9. Photocyclodimerization AC in host **8** in PBS buffer (pH 1-10) at 0.5 °C.[a]

Solvent	Added salt	T /°C	Conv. / %	Relative yield / %				*ee* / %		(3+4) /(1+2)[b]	1/2[c]	3/4[c]
				1	2	3	4	2	3			
pH 1	none	0.5	95.2	39.2	24.4	31.8	4.6	76.6	35.5	0.6	1.6	6.9
pH 1 [d]	none	0.5	81.6	41.2	13.7	34.9	7.5	63.4	31.1	0.6	1.6	6.9
	CsCl [e]	0.5	78.2	31.5	13.5	44.2	10.7	67.1	23.5	0.8	3.0	4.7
		-20	90.2	38.4	19.6	52.3	19.7	82.8	29.4	1.2	2.3	4.1
pH 1/ MeOH [f]	none	0.5	94.7	36.6	21.1	33.8	8.5	64.7	29.8	1.2	2.0	2.7
		-20	81.0	42.1	18.2	35.7	5.9	70.1	41.2	0.7	1.7	4.0
pH 2	none	0.5	90.2	39.3	24.1	29.9	6.7	65.4	13.9	0.6	1.6	4.4
pH 3	none	0.5	86.1	37.4	24.4	28.7	9.5	52.7	3.1	0.6	1.5	3.0
pH 4	none	0.5	45.9	38.4	30.9	19.9	10.7	30.9	-29.8	0.4	1.2	1.9
pH 5	none	0.5	74.7	40.4	36.5	13.8	9.2	25.5	-45.7	0.3	1.1	1.5
pH 6	none	0.5	74.6	40.3	39.6	11.9	8.3	25.2	-59.2	0.3	1.0	1.4
pH 7	none	0.5	75.9	40.1	42.4	11.1	6.4	24.8	-67.5	0.2	0.9	1.7
pH 7 [d]	none	0.5	76.2	39.7	40.3	12.6	7.3	23.4	-65.7	0.2	1.0	1.7
	CsCl [e]	0.5	42.4	24.0	21.6	20.4	34.0	25.6	-61.5	1.2	1.1	0.6
		-20	56.9	26.2	22.3	20.6	30.9	30.4	-76.2	1.1	1.2	0.7
pH 7/ MeOH [f]	none	0.5	40.5	48.8	30.4	11.5	9.3	65.7	-54.9	0.3	1.6	1.2
		-20	32.1	43.4	36.8	12.0	7.8	76.9	-63.1	0.2	1.2	1.5
pH 8	none	0.5	76.0	40.0	44.0	9.8	6.3	23.9	-67.5	0.2	0.9	1.6
pH 9	none	0.5	77.6	40.1	42.4	9.5	8.0	21.0	-66.9	0.2	0.9	1.2
pH 10	none	0.5	76.8	40.7	41.0	9.9	8.5	9.6	-66.3	0.2	1.0	1.2

[a] All the photocyclodimerization reactions were carried in [**8**] = 2.0 mM, [AC] = 0.2 mM, and PBS buffer (pH 1-10) using 365 nm LED light irradiation for 30 min. at different temperatures. [b] HH / HT ratio. [c] *Anti* / *Syn* ratio. [d] filtrate, estimated [AC] = 0.023 μM (pH1), 0.037 μM (pH2), 1.17 μM (pH3), 2.72 μM (pH4) and 5.77 μM (pH5), by HPLC. [e] CsCl (6M). [f] ratio of solvent is 1:1 (V/V).

6. Calculation of pK_a values

Table S10. pK_a values of free AC, native γ-CD (**5**), quinoline and quinoline attached host (**7**, its conjugated acid forms), and **5**/**6**/**7**:AC complexes at 25 ºC.[a]

	Calculated pK_a		Reported pK_a
	UV-vis.	Fluorescence	
AC (pK_a^{AC})	-	-	4.35 [S5]
γ-CDx, **5** (pK_a^{5}) [b]	-	-	12.081 [S6,S7]
Quinoline (p$K_a^{Qui.}$)	-	-	4.85 [S8]
7 (pK_a^{7}) [c]	-	4.49	-
5 : AC complex (p$K_a^{5:AC}$) [d]	5.8	-	-
6 : AC complex (p$K_a^{6:AC}$) [e]	5.28	5.41	-
7 : AC complex (p$K_a^{7:AC}$) [f]	4.93	4.98	-

[a] calculated using UV-vis and fluorescence spectral measurements, pH was adjusted using 66.7 mM, NaOH and 1 M HCl solution. [b] determined by potentiometry (25 °C). [c] [**7**] = 0.0317 mM. [d] Ref. S9. [e] [AC] = 0.004 mM, [**6**] = 0.2 mM. [f] [AC] = 0.02 mM, [**7**] = 0.2 mM.

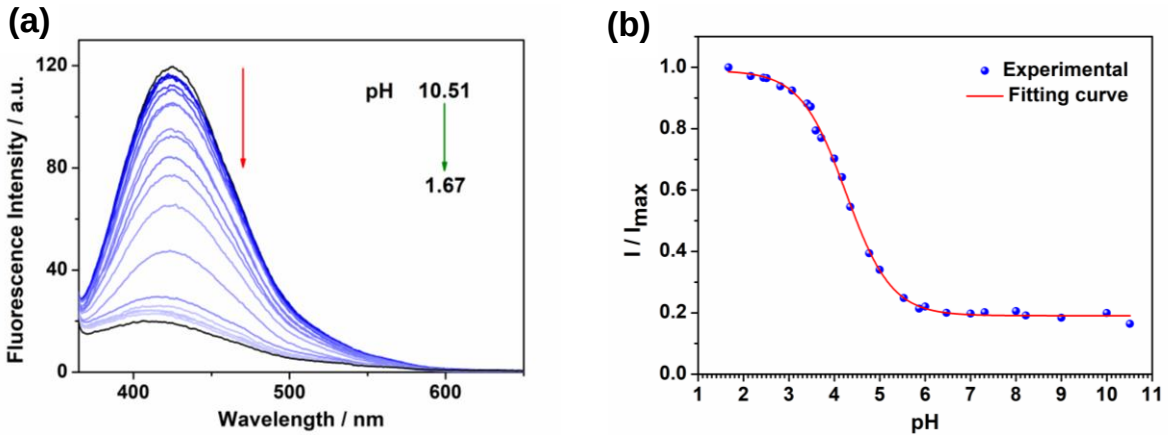


Figure S25. (a) Fluorescence spectral changes of **7** (0.063 mM) in different PBS buffers with pH ranging from 1.67 to 10.51, at 25 ºC, and (b) the relative fluorescence intensity changes with pH and the calculated pK_a of **7** is 4.49.

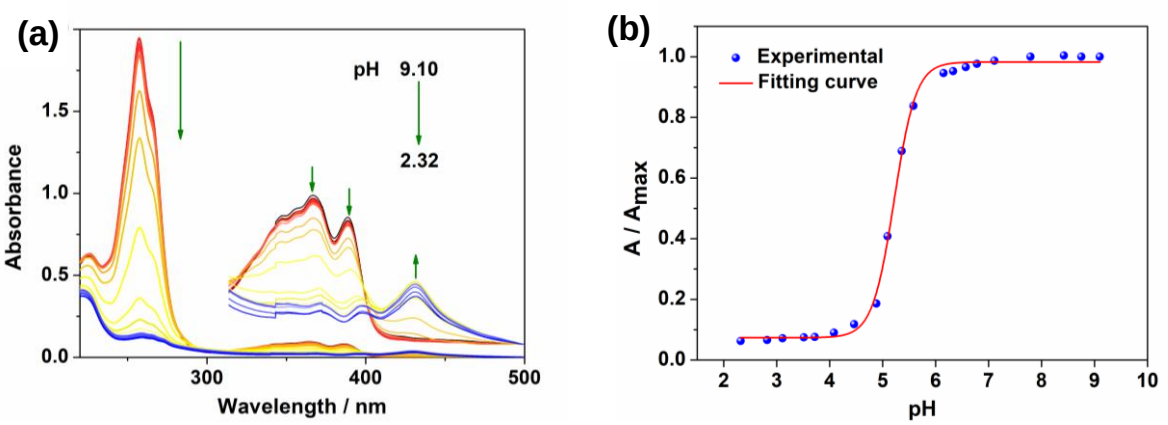


Figure S26. (a) Absorption spectral changes of **6** (0.2 mM) - AC (0.004 mM) complex in different PBS buffers with pH ranging from 2 to 9, at 25 ºC, and (b) the relative absorption changes with pH and the calculated pK_a of **6**:AC complex is 5.28.

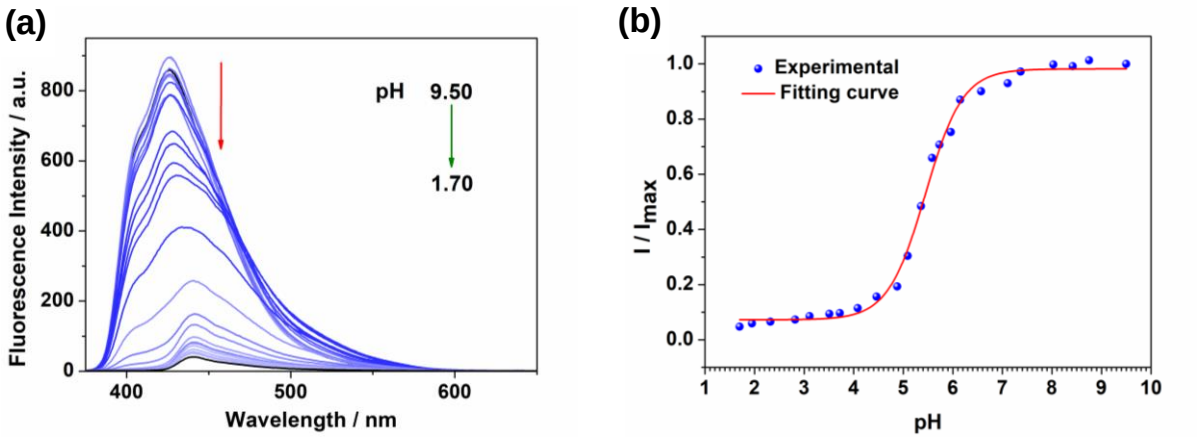


Figure S27. (a) Fluorescence spectral changes of **6** (0.2 mM) - AC (0.004 mM) complex in different PBS buffers with pH ranging from 1.70 to 9.50, at 25 °C, and (b) the relative fluorescence changes with pH and the calculated pK_a of **6**:AC complex is 5.41.

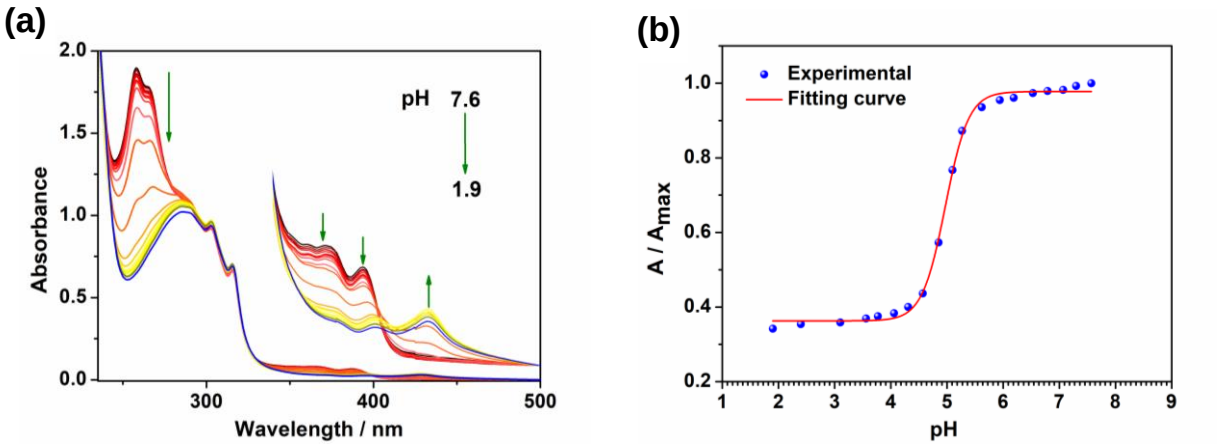


Figure S28. (a) Absorption spectral changes of **7** (0.2 mM) - AC (0.02 mM) complex in different PBS buffers with pH ranging from 1.9 to 7.6, at 25 °C, and (b) the relative absorption changes with pH and the calculated pK_a of **7**:AC complex is 4.93.

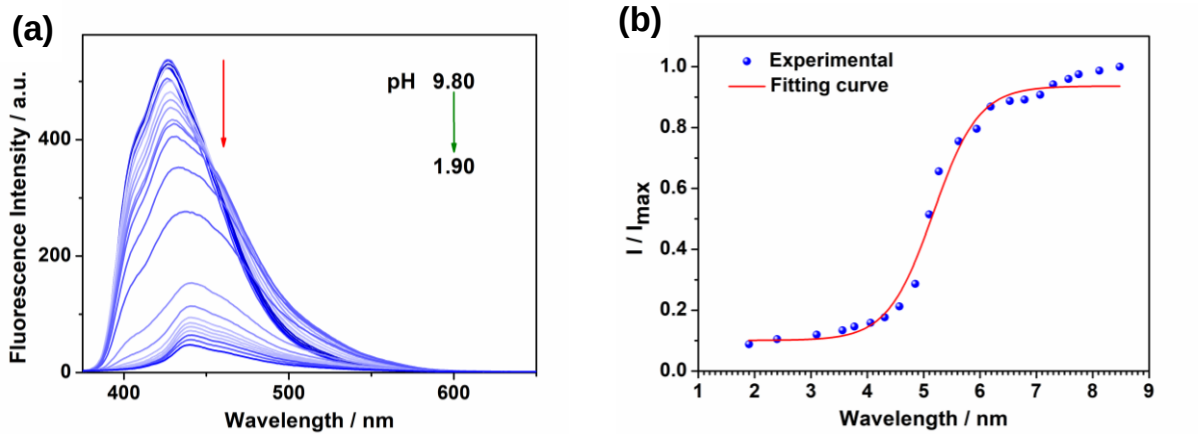


Figure S29. (a) Fluorescence spectral changes of **7** (0.2 mM) - AC (0.02 mM) complex in different PBS buffers with pH ranging from 1.90 to 9.80, at 25 °C, and (b) the relative fluorescence changes with pH and the calculated pK_a of **7**:AC complex is 4.98.

7. UV-Vis., fluorescence, and CD spectral studies

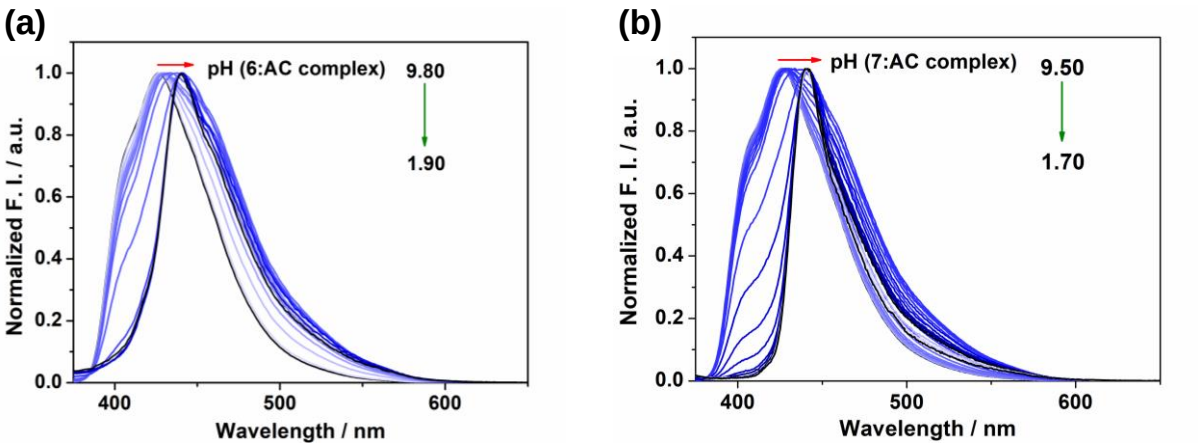


Figure S30. Normalized fluorescence spectra of (a) **6** (0.2 mM)-AC (0.004 mM), and (b) **7** (0.2 mM)-AC (0.02 mM) complex in different PBS buffers with pH range from ~1.70 – 9.80, at 25 °C.

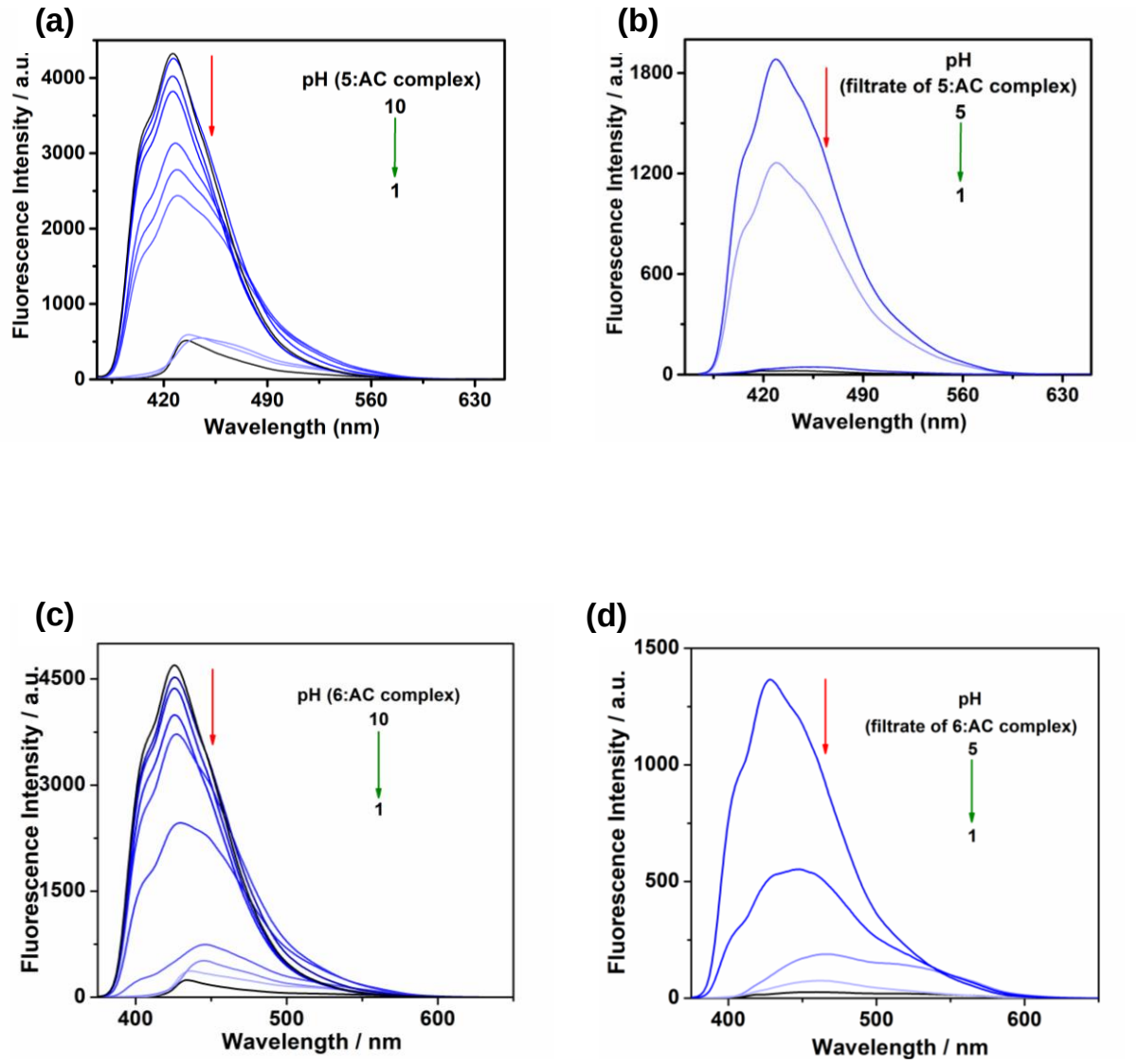


Figure S31. Fluorescence spectra of (a) **5** (0.2 mM)-AC (0.02 mM) complex (c) **6** (0.2 mM)-AC (0.02 mM) complex in different PBS buffer with the pH range from 1 - 10, and (b) & (d) its complex filtrate solution at 25 ^{o}C.

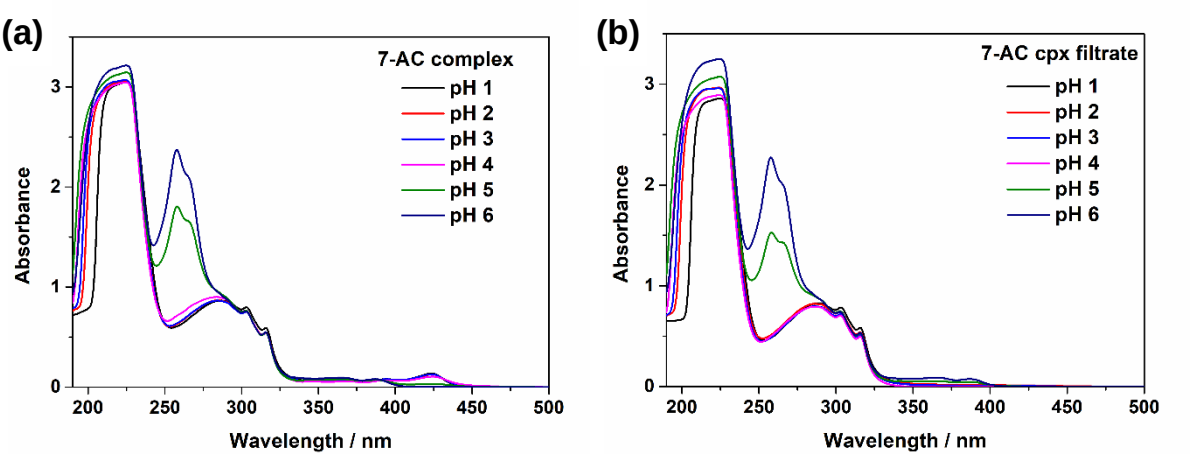


Figure S32. UV-vis spectra of (a) **7** (0.2 mM) - AC (0.02 mM) complex in different PBS buffers with the pH range from 1 to 6 and (b) its complex filtrate at 25 °C.

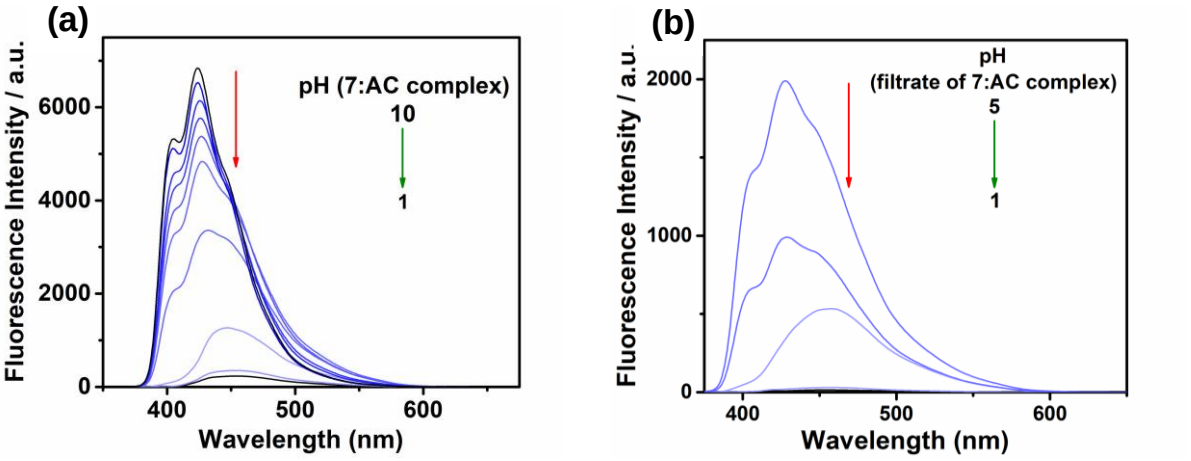


Figure S33. Fluorescence spectra of (a) **7** (0.3 mM) - AC (0.03 mM) complex in different PBS buffers with the pH range from 1-6 and (b) its complex filtrate at 25 °C.

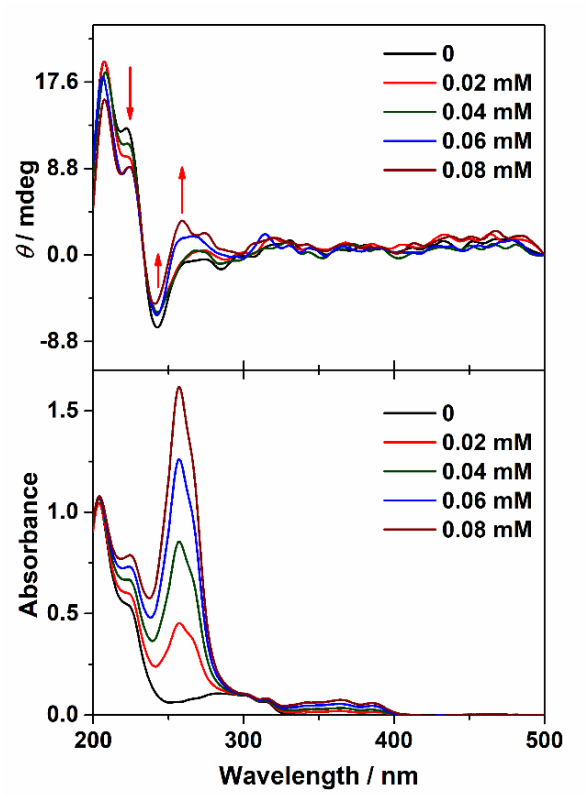


Figure S34. Circular dichroism spectra (upper panel) and UV-vis. (lower panel) of host **7** (0.19 mM) in a pH 7 (PBS, 66.7 mM) with increasing concentration of AC at 25 ºC.

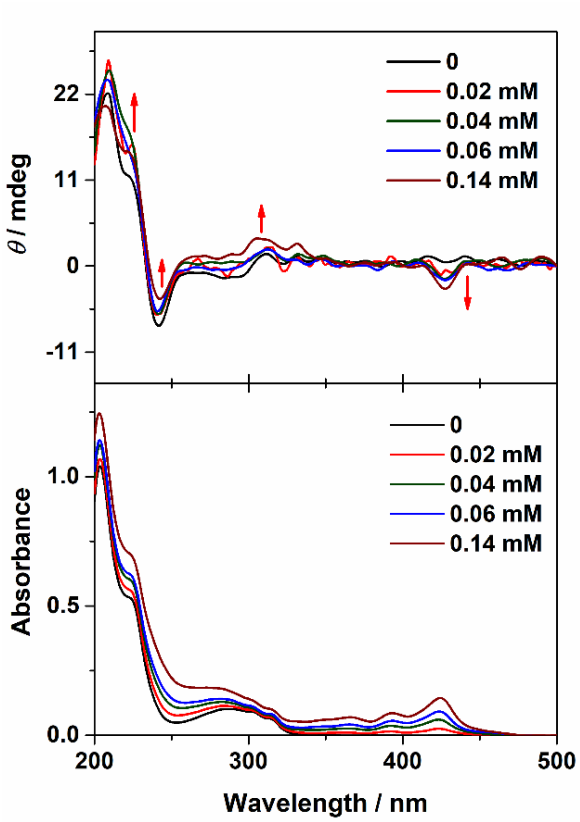


Figure S35. Circular dichroism spectra (upper panel) and UV-vis. (lower panel) of host **7** (0.19 mM) in a pH 2 (PBS, 66.7 mM) with increasing concentration of AC at 25 ºC.

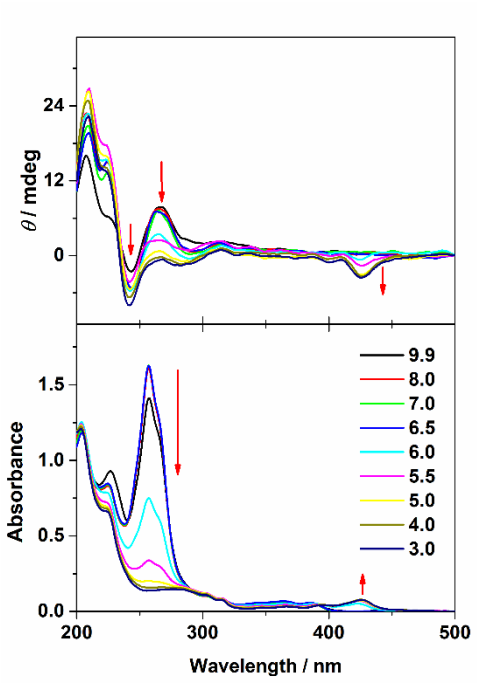


Figure S36. Circular dichroism spectra (upper panel) and UV-vis. (lower panel) of host **7** (0.2 mM) - AC (0.2 mM) complex in different PBS buffers with pH at 25 ºC.

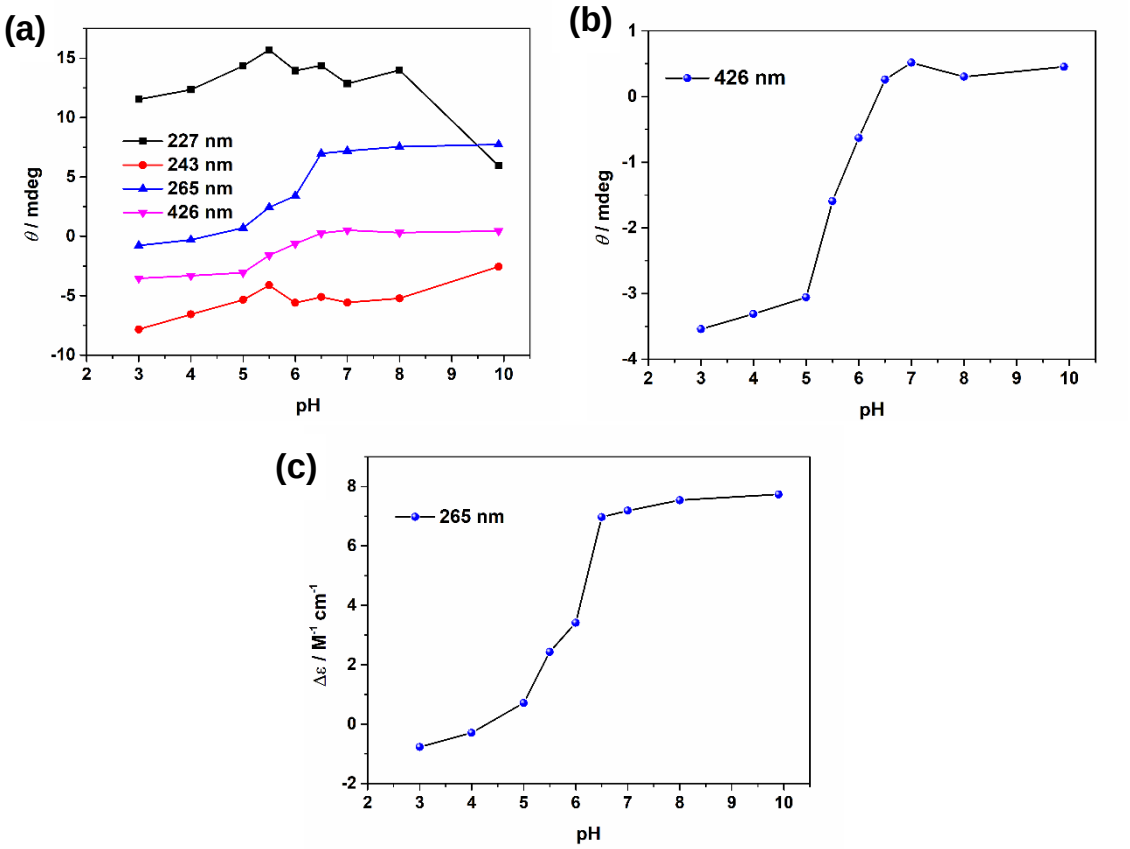


Figure S37. (a) and (b) Circular dichroism and (c) UV-vis. spectral changes of host **7** (0.2 mM) - AC (0.2 mM) complex in different PBS buffers with pH at different wavelengths (at 25 ºC).

8. References

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