Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting information

Achieving colour-tuneable afterglow through pH-responsive exciton transfer channels in a carbon dot matrix system

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Materials.

Pteric acid was purchased from McLean Company (Shanghai, China). Hydrochloric acid (HCl) and sodium hydroxide (NaOH) were supplied by Sinopharm Chemical Reagent Corporation (Shanghai, China). Cyanuric acid (CA) was provided by Aladdin (Shanghai, China). All chemicals were not further purified.

Characterizations.

All photoluminescence and afterglow spectra and afterglow lifetime mentioned in the article were measured by a fluorescence spectrometer (Edinburgh FS5, UK). Absolute quantum yield was recorded by a C9920-02G system (Hamamatsu, Japan). The morphologies of the samples were obtained by transmission electron microscopy (TEM, JEOL JEM-2100, Japan). X-ray photoelectron spectroscopy (XPS) measurements were performed on an ESCALAB 250 XPS system (Thermo Electron Corporation, USA). The FTIR spectra were measured using a Bruker Tensor 27 spectrophotometer (Germany).

Experiments.

Synthesis of CDs solution

The CDs were synthesized by a simple hydrothermal method. Typically, Pteric acid (0.1 g) 、HCl (0.2 mL) and deionized water (30 mL) were added to a Teflon-lined autoclave (100 mL) and heated at 200 °C for 2 h. After cooling down to room temperature naturally, the CDs solution was centrifuged at high speed (10000 rad per min) for 5 min by 3 times to remove the large particles and then a light-yellow CDs solution was obtained.

Synthesis of CD@CA

The CDs solution (0.5 mL) and CA (1.0 g) were dissolved in 4 mL aqueous solution and added into a beaker. Place the beaker on a stirring table and stir at room temperature for 12 hours, and subsequently to form CD@CA.

Synthesis of CD@CANa

The CDs solution (0.5 mL), CA (1.0 g) and NaOH (0.93 g) were dissolved in 4 mL aqueous solution and added into a beaker. Place the beaker on a stirring table and stir at room temperature for 12 hours, and subsequently cooled down naturally to room temperature to form CD@CANa.

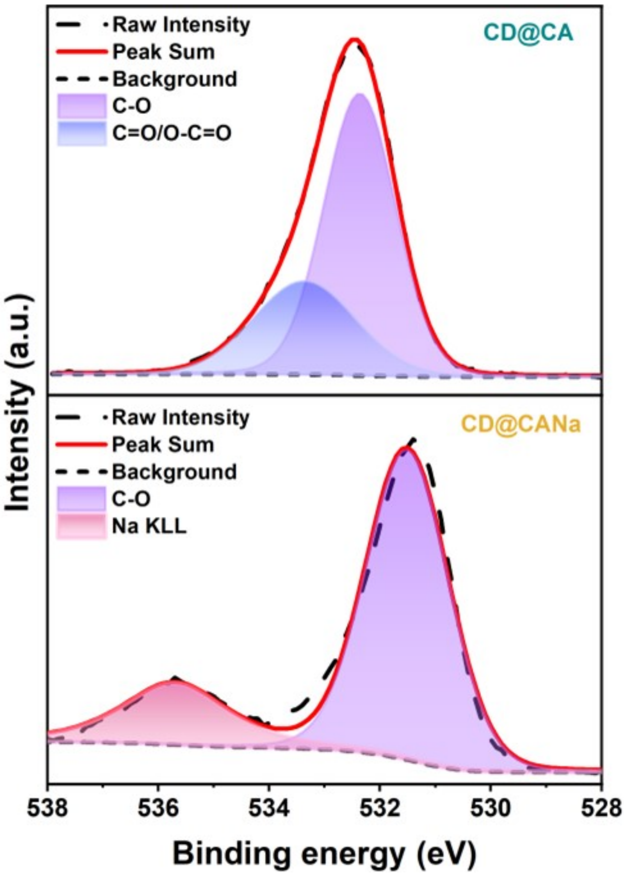

Figure S1 High-resolution XPS spectra and fitting results of O 1s of CD@CA and CD@CANa powders.

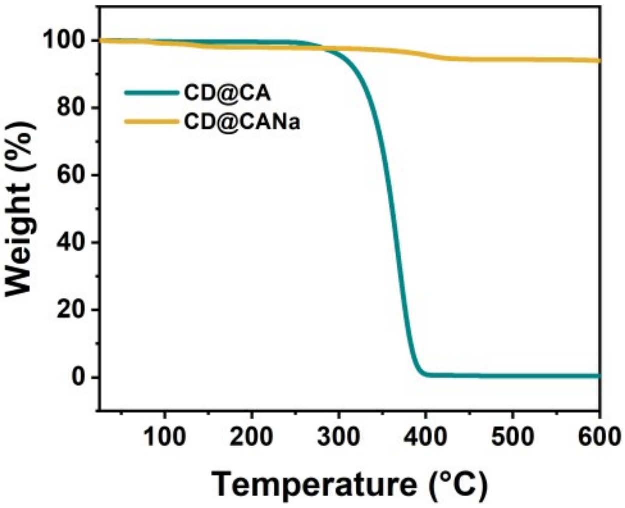

Figure S2 TGA of CD@CA and CD@CANa powders.

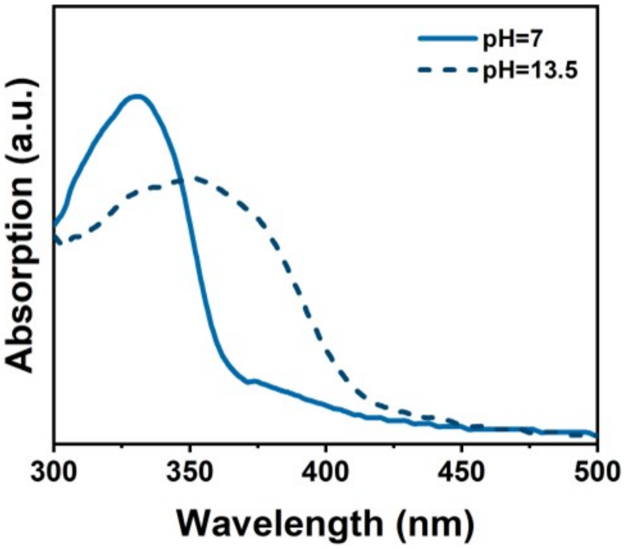

Figure S3 Absorption spectra of CD aqueous solution at pH 7 and 13.5.

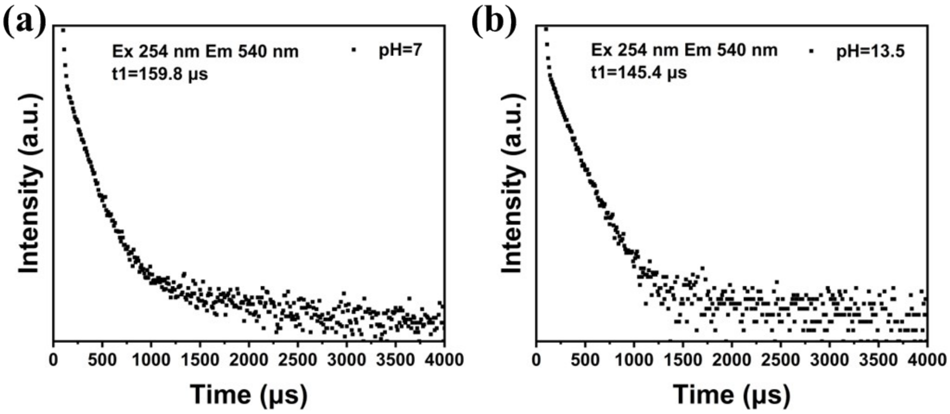

Figure S4 Time-resolved phosphorescence decay spectra of CDs at (a) pH 7 and (b) pH 13.5.

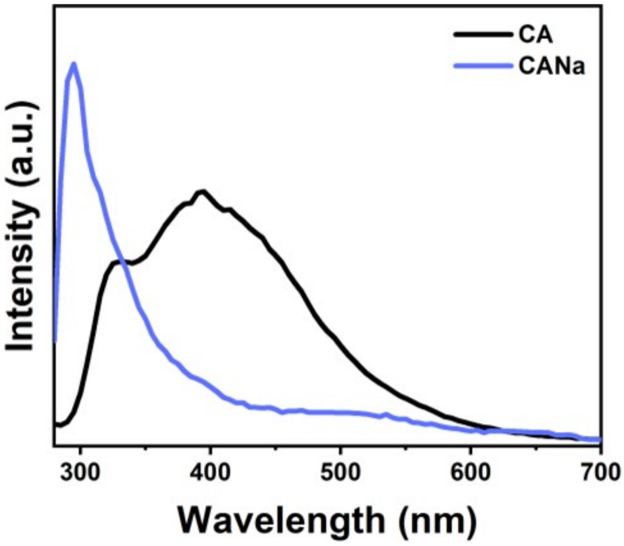

Figure S5 Phosphorescence spectra of CA and CANa.

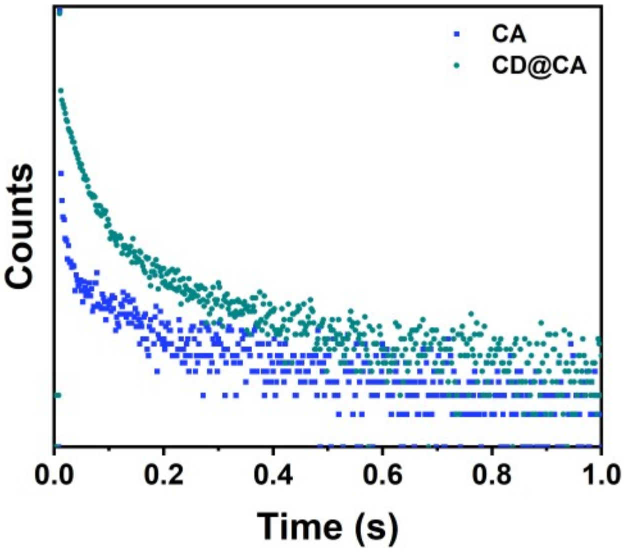

Figure S6 Time-resolved phosphorescence decay spectra of CA and CD@CA with an emission wavelength of 390 nm.

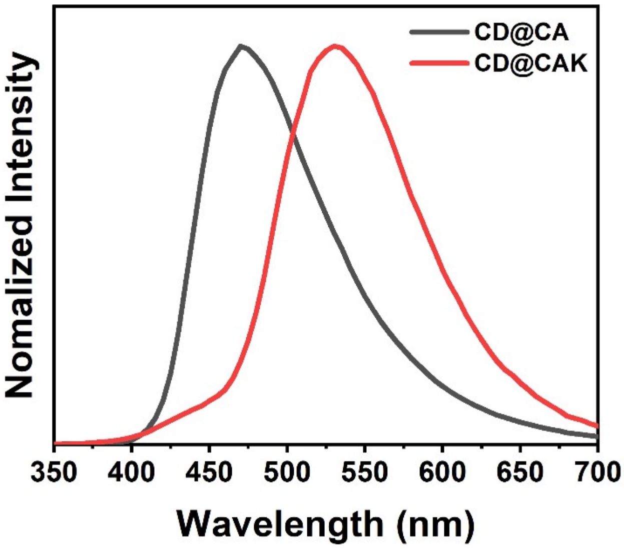

Figure S7 The afterglow spectra of CD@CA and CD@CAK excited with a 254 nm UV lamp.

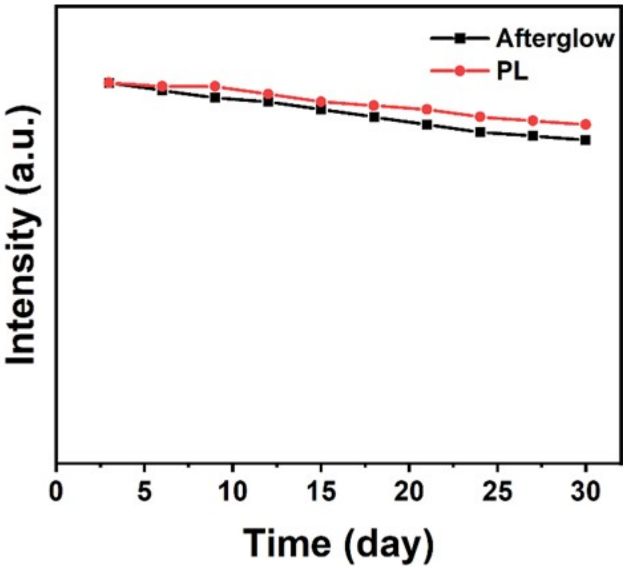

Figure S8 Afterglow and photoluminescence emission spectra of the CD@CANa after being placed in ambient environment more than 30 days.

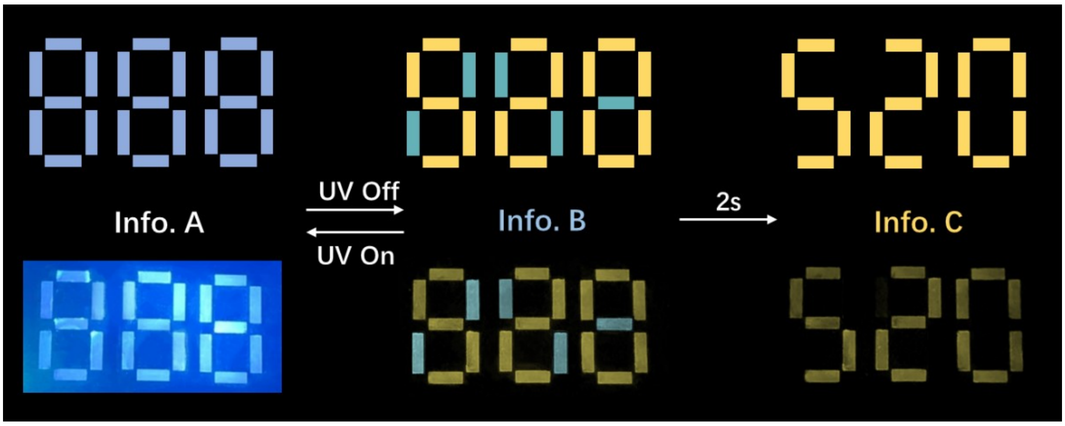

Figure S9 Photographs of "888" pattern model printed by CD@CA and CD@CANa powder in daylight and under 254 nm ultraviolet light (UV-on) and with the light off (UV-off).

Table S1 Time resolved phosphorescence decay components of CD@CA and CD@CANa powders.

Sample	τ_1 (s)	A_1 (%)	τ_2 (s)	A_2 (%)	τ_3 (s)	A_3 (%)	τ_{avg} (s)
CD@CA	0.00596	26.93	0.1271	57.33	0.4166	15.74	0.2430
CD@CANa	0.0849	4.36	0.3163	58.23	0.6961	37.41	0.5350

[a] The average lifetimes were calculated using the equation: $\tau_{ave} = \sum\alpha_i\tau_i^2/\sum\alpha_i\tau_i$

Table S2 Time resolved phosphorescence decay components of CA and CD@CA at 390 nm emission.

Sample	τ_1 (s)	A_1 (%)	τ_2 (s)	A_2 (%)	τ_3 (s)	A_3 (%)	τ_{avg} (s)
CA	0.00446	20.68	0.0576	24.11	0.321	55.21	0.3
CD@CA	0.017	44.43	0.0506	32.64	0.279	22.93	0.2134

[a] The average lifetimes were calculated using the equation: $\tau_{ave} = \sum \alpha_i {\tau_i}^2 / \sum \alpha_i \tau_i$

Table S3 Comparison of previous studies with this work on the phosphorescent quantum yield and lifetime.

Reference	Journal	material	PQY(%)	Lifetime(s)
[1]	Chem. Eng. J., 2023, 470, 144061	organic afterglow materials	5.5	1.33
[2]	Adv. Opt. Mater., 2023, 2302482	organic afterglow materials	13.6	1.02
[3]	J. Phys. Chem. Lett., 2022, 13, 9558-9563	CDs	11.2	1.30
[4]	Chem. Eng. J., 2023, 462, 142339.	CDs	20.8	1.18
[5]	Sens. Actuators, B, 2022, 351, 130976	CDs	24.4	0.55
This work		CDs	34.8	0.54

Reference

[1] Q. Wang, Q. Tan, S. Zhao, et al., Chem. Eng. J. 470 (2023) 144061.

[2] Y. Jiang, C, Zhang, R. Wang, et al., Adv. Opt. Mater. (2023) 2302482.

[3] T. Chao, J. Wang, X. Dong, et al., J. Phys. Chem. Lett. 13 (2022) 9558-9563.

[4] Q. Li, D. Cheng, H. Gu, et al., Chem. Eng. J. 462 (2023) 142339.

[5] Q. Feng, Z. Xie, M. Zheng, Sens. Actuators, B 351 (2022) 130976.