Supporting information

Zeolite-Confined Carbon Dots: Tuning Thermally Activated Delayed Florescence Emission via Energy Transfer

Hongyue Zhang,[a,b] Jiancong Liu,[c] Bolun Wang,[a] Kaikai Liu,[a] Guangrui Chen,[a] Xiaowei Yu,[a] Jiyang Li,*[a] and Jihong Yu,*[a,b]

[a] *State Key Laboratory of Inorganic Synthesis and Preparative Chemistry, College of Chemistry, Jilin University, Changchun 130012, P. R. China.*

[b] *International Center of Future Science, Jilin University, 2699 Qianjin Street, Changchun 130012, P. R. China.*

[c] *Key Laboratory of Functional Inorganic Material Chemistry, Ministry of Education of the People's Republic of China, Heilongjiang University, Harbin 150080, China.*

Emails: jihong@jlu.edu.cn; lijiyang@jlu.edu.cn

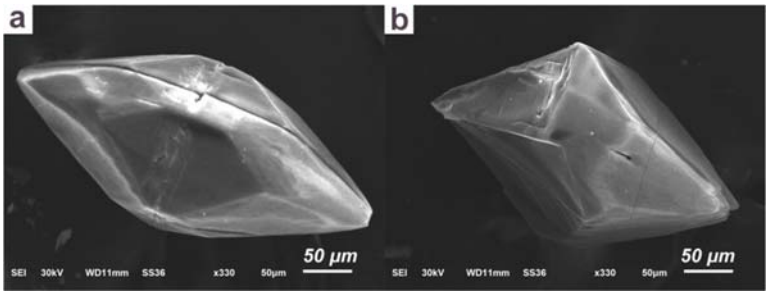

Figure S1. SEM images of (a) CD_1 CD_2@MgAPO-5-a and (b) CD_1CD_2@MgAPO-5-b.

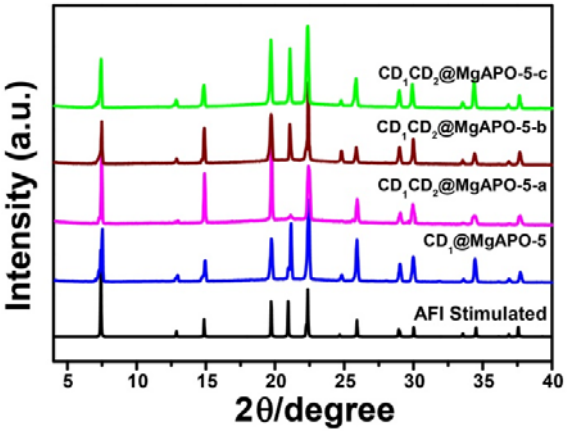

Figure S2. Powder X-ray diffraction (PXRD) patterns of experimental CDs@MgAPO-5 composites and simulated AFI topology.

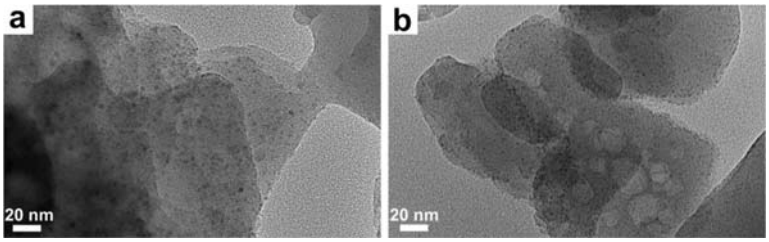

Figure S3. TEM images of (a) CD_1 CD_2@MgAPO-5-a and (b) CD_1CD_2@MgAPO-5-b.

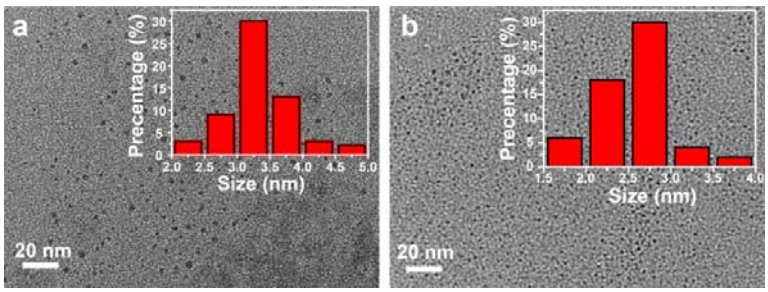

Figure S4. TEM images and particle diameter distributions of the mother liquids of (a) CD_1@MgAPO-5 and (b) CD_1CD_2@MgAPO-5-c.

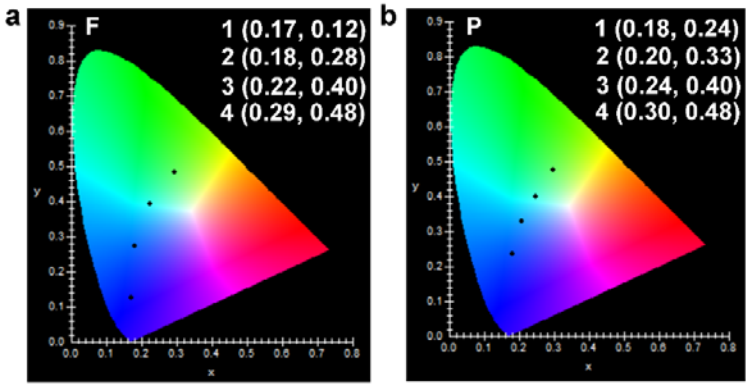

Figure S5. The CIE color coordinates for fluorescence emission (a) and delayed fluorescence emission (b) of CDs-based composites: 1 (CD_1@MgAPO-5), 2 (CD_1CD_2@MgAPO-5-a), 3 (CD_1CD_2@MgAPO-5-b), 4 (CD_1CD_2@MgAPO-5-c).

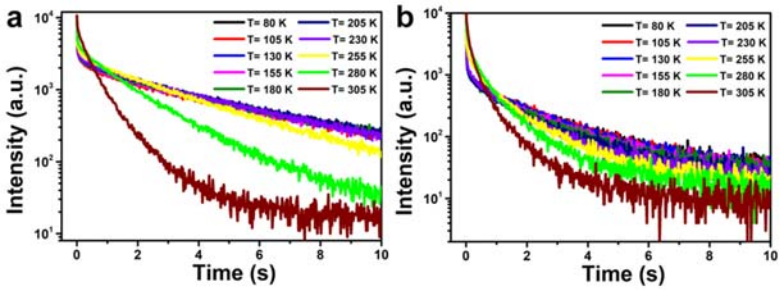

Figure S6. Temperature-dependent time-resolved decay spectra of CD_1CD_2@MgAPO-5-a monitored at 497nm emission: a; and CD_1CD_2@MgAPO-5-b monitored at 505nm emission: b**.**

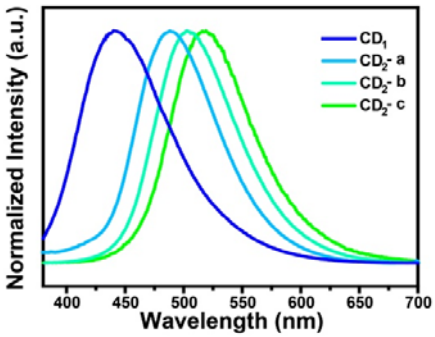

Figure S7. The normalized steady-state photoluminescence spectra of CDs seperated from the mother liquid of CD_1CD_2@MgAPO-5-c excited by 360 nm UV light.

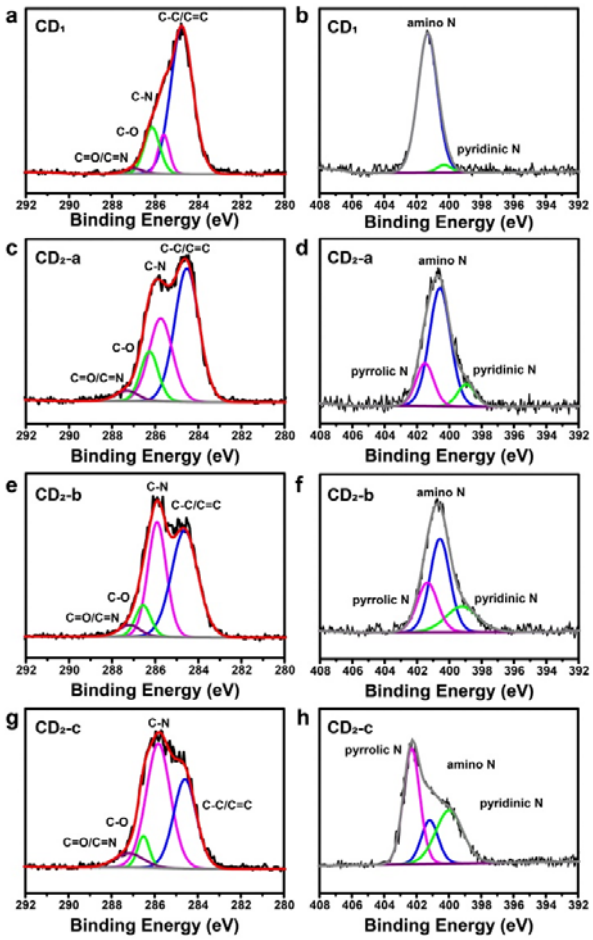

Figure S8. High-resolution C 1s and N 1s XPS spectra of separated CD_1, CD_2-a, CD_2-b and CD_2-c.

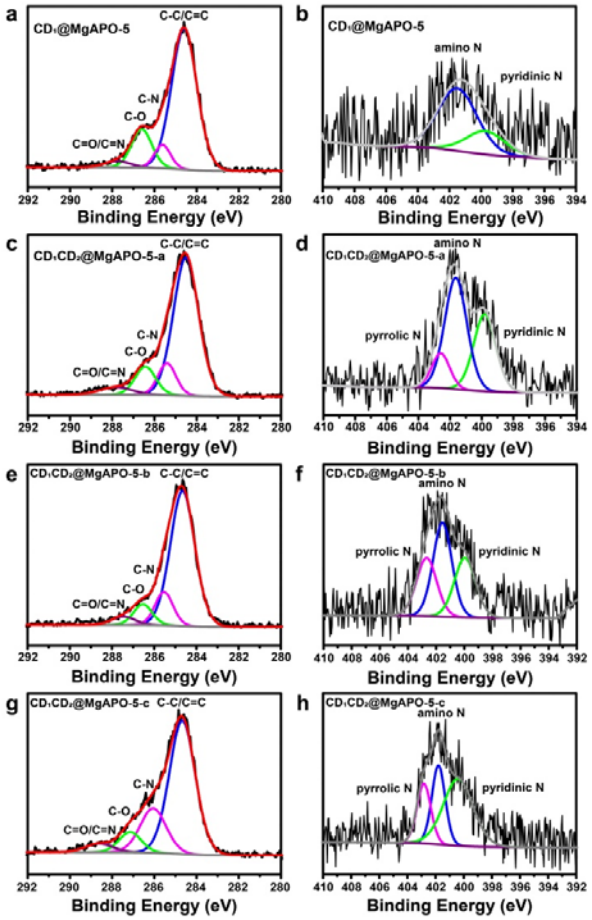

Figure S9. High-resolution C 1s and N 1s XPS spectra of CD_1@MgAPO-5, CD_1CD_2@MgAPO-5-a, CD_1CD_2@MgAPO-5-b and CD_1CD_2@MgAPO-5-c composites.

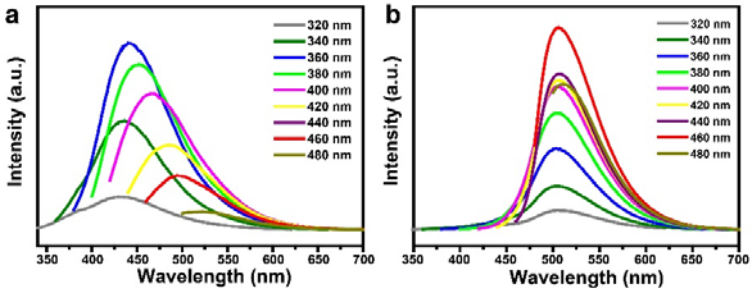

Figure S10. Photoluminescence spectra of CDs aqueous solution excited by the wavelengths from 320 nm to 480 nm (a) CD_1 and (b) CD_2-c.

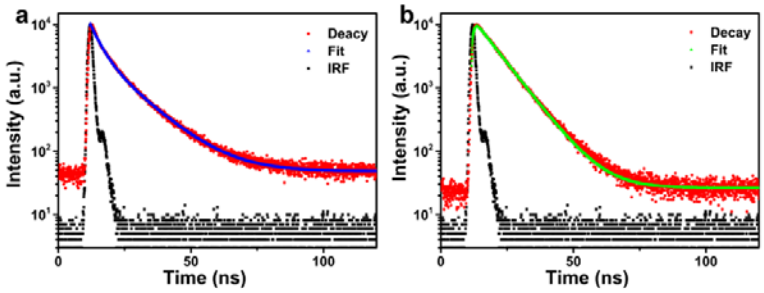

Figure S11. Time-resolved decay of the CDs aqueous solution. (a) CD_1 monitored at 435nm emission. (b) CD_2-c monitored at 515nm.

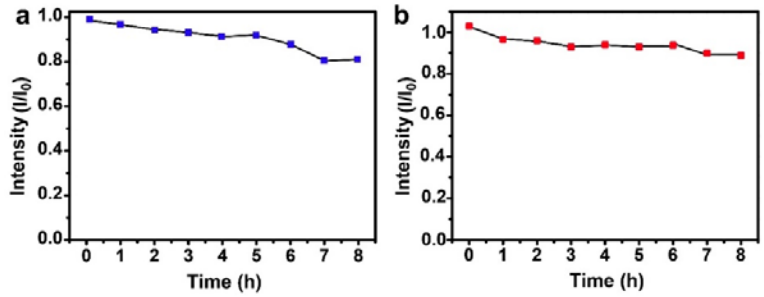

Figure S12. Photoluminescent stability of CD_1CD_2@MgAPO-5-c. (a) irradiated for 8 hours and (b) grinded for 8 hours.

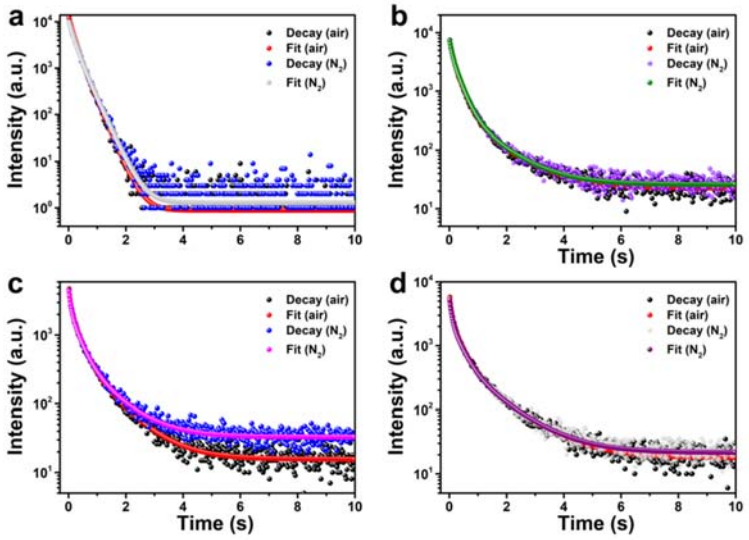

Figure S13. Time-resolved decay of the CDs@MgAlPO-5 composites under air and N_2 conditions: a. CD_1@MgAPO-5, b. CD_1CD_2@MgAPO-5-a, c. CD_1CD_2@MgAPO-5-b and d. CD_1CD_2@MgAPO-5-c.

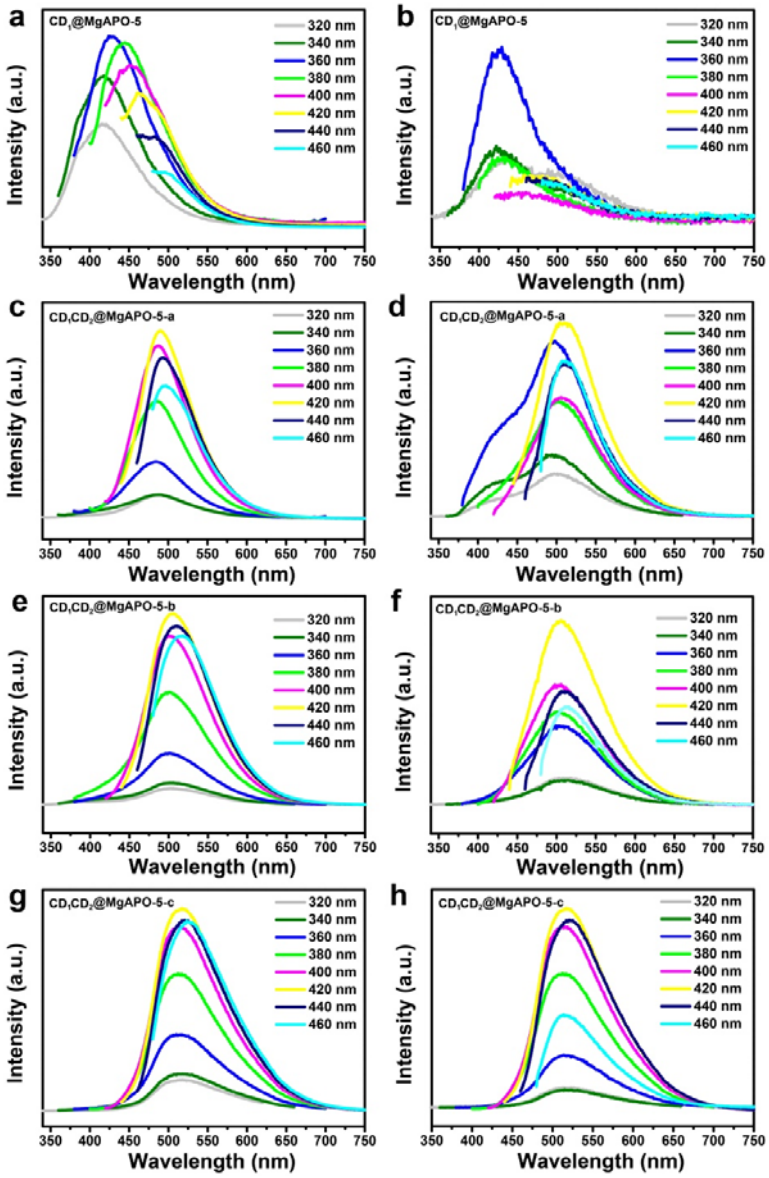

Figure S14. Photoluminescence spectra of CD-based composites excited by different excitation wavelength: (a), (c), (e) (g): fluorescence spectra; (b), (d), (d), (h): phosphorescence spectra.

Table S1. The ratio and lifetime of temperature-dependent delayed fluorescence of CD_1 CD_2@MgAPO-5-c.

Temperature (K)	Long-lifetime (s)/percentage (%)	Short-lifetime (s)/ Percentage (%)
80	1.61/9.45	$1.52E^{-4}$/90.55
105	1.52/9.46	0.0090/90.54
130	1.48/12.03	0.0087/87.97
155	1.45/23.17	0.044/76.83
180	1.32/35.16	0.036/64.84
205	1.38/33.40	0.033/66.60
230	1.19/41.46	0.050/58.54
255	1.02/41.79	0.095/58.21
280	0.97/50.47	0.072/49.53
305	0.89/67.81	0.064/32.19

Table S2. The ratio and lifetime of temperature-dependent delayed fluorescence of CD_1@MgAPO-5.

Temperature (K)	Long-lifetime (s)/ Percentage (%)	Short-lifetime (s)/ Percentage (%)
80	4.75/8.32	0.0078/91.68
105	2.73/22.45	0.010/77.55
130	4.60/8.45	0.0070/91.55
155	4.51/8.52	0.0074/91.48
180	4.33/8.53	0.0070/91.47
205	3.99/8.68	0.0072/91.32
230	3.66/12.38	0.0046/87.62
255	2.62/66.61	0.0082/33.39
280	0.99/78.16	0.017/21.84
305	0.52/86.67	0.26/13.33

Table S3. QYs of CD-based composites.

Composites	QYs
CD_1@MgAPO-5	20.86%
CD_1CD_2@MgAPO-5-a	25.09%
CD_1CD_2@MgAPO-5-b	37.06%
CD_1CD_2@MgAPO-5-c	42.0%

Table S4. TADF lifetimes of CD-based composites excited by 360 nm UV light.

Composites	Wavelength(nm)	τ_1(ms)	A_1(%)	τ_2(ms)	A_2(%)	τ_3(s)	A_3(%)	τ_{avg}	χ^2
CD_1@MgAPO-5	425	274.45	87.09	22.99	12.91	--	--	271.41	1.43
CD_1CD_2@MgAPO-5-a	497	200.40	48.04	793.50	36.51	38.32	15.45	578.0	1.29
CD_1CD_2@MgAPO-5-b	505	275.52	41.03	46.65	7.17	936.51	51.80	807.32	1.13
CD_1CD_2@MgAPO-5-c	515	238.59	53.65	61.91	14.33	1105.0	32.02	859.98	1.18

Table S5. Fluorescence lifetimes of CD_1 and CD_2-c aqueous solutions.

CDs	τ_1(ns)	A_1(%)	τ_2(ns)	A_2(%)	τ_{avg}	χ^2
CD_1 (λ_{em}=435 nm)	10.08	67.62	1.72	32.38	9.45	1.58
CD_2-c (λ_{em}=515 nm)	7.70	58.61	2.92	41.39	6.68	1.15

Table S6. Fluorescence lifetimes of CD-based composites excited by 360 nm UV light and emission at 425 nm.

Composites	Emission=425 nm					
	τ_1(ns)	A_1(%)	τ_2(ns)	A_2(%)	τ_{avg}	χ^2
CD_1@MgAPO-5	3.22	45.55	24.43	54.45	22.30	1.16
CD_1CD_2@MgAPO-5-a	5.13	62.46	16.52	37.54	12.55	1.28
CD_1CD_2@MgAPO-5-b	3.66	38.33	11.76	61.67	10.46	1.37
CD_1CD_2@MgAPO-5-c	2.93	41.39	7.70	58.61	6.02	1.15