

Electronic Supplementary Information

Efficient full-color emitting carbon-dot-based composite phosphors by chemical dispersion

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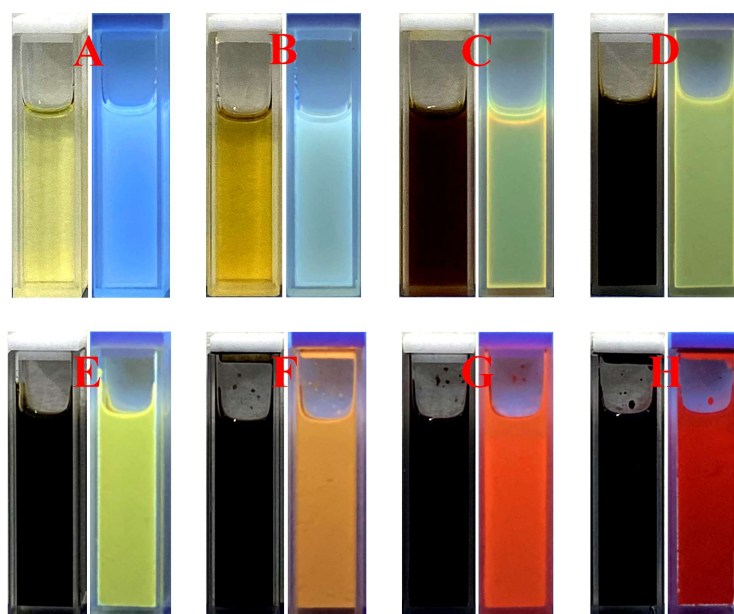


Fig. S1 Optical images of CDots A–H original solutions in DMF under room light and ultraviolet light of 365 nm.

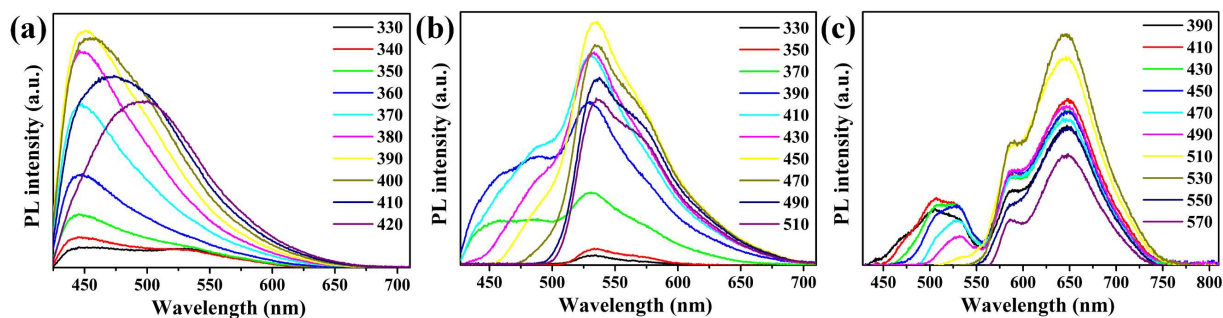


Fig. S2 PL spectra of CDots (a) A, (b) D, and (c) H in DMF at different excitation wavelengths.

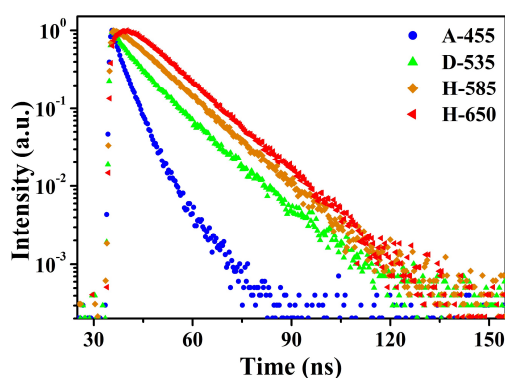


Fig. S3 Time-resolved PL spectra of CDots A at 455 nm, CDots D at 535 nm, and CDots H at 585 and 650 nm in DMF (405 nm excitation).

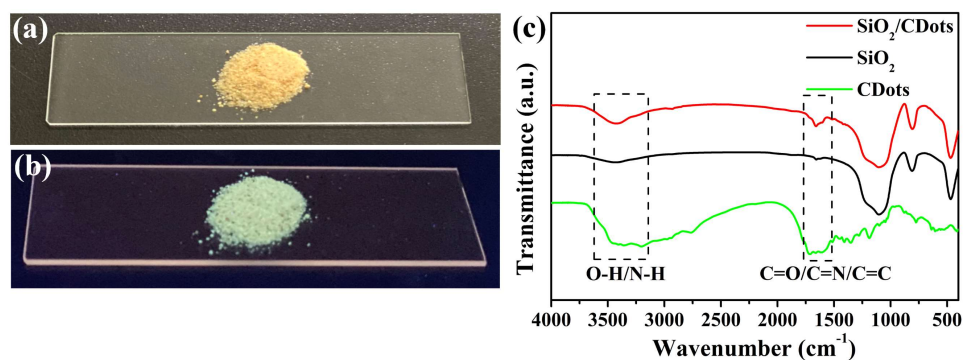


Fig. S4 Optical images of SiO₂/CDot powders without APTMS under (a) room light and (b) ultraviolet light of 365 nm. (c) FT-IR spectra of SiO₂/CDot powders without APTMS, SiO₂ nanoparticles, and CDots D.

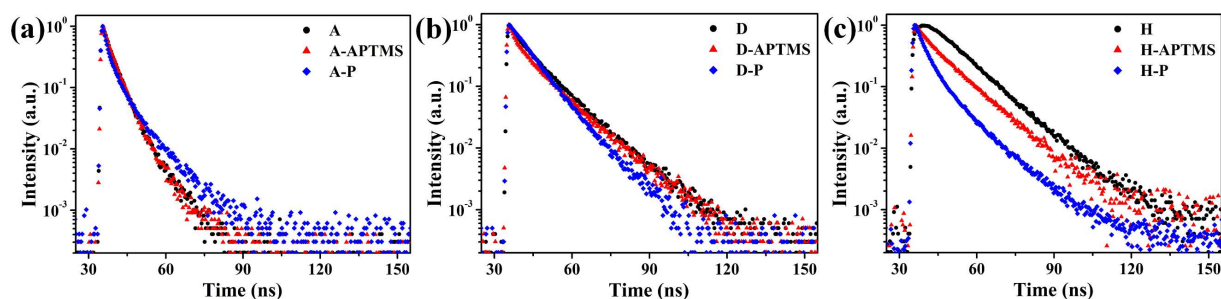


Fig. S5 Time-resolved PL spectra of CDots (a) A at 455 nm, (b) D at 535 nm, and (c) H at 650 nm in DMF, DMF mixed with APTMS, and SiO₂/CDot composite phosphors (405 nm excitation).

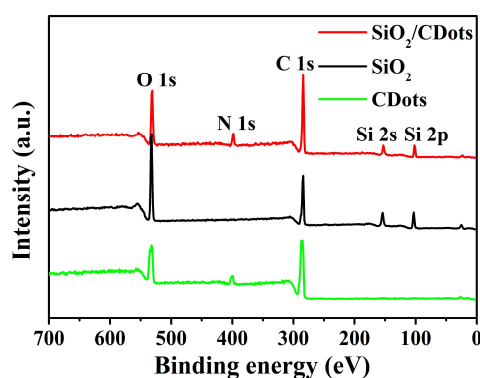


Fig. S6 XPS spectra of SiO₂/CDot composite phosphors D-P, SiO₂ nanoparticles, and CDots D.

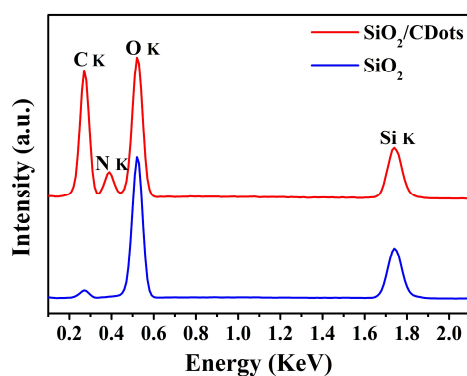


Fig. S7 EDX spectra of SiO₂/CDots composite phosphors D-P and SiO₂ nanoparticles.

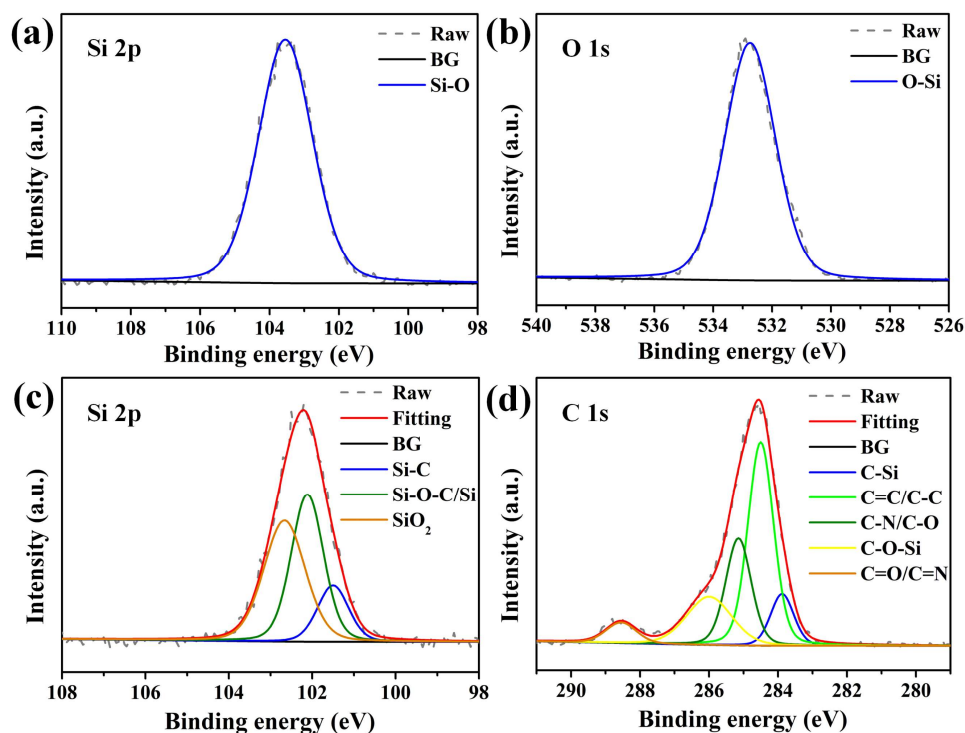


Fig. S8 High-resolution (a) Si 2p and (b) O 1s XPS spectra of SiO₂ nanoparticles. High-resolution (c) Si 2p and (d) C 1s XPS spectra of SiO₂/CDot composite phosphors D-P. "BG" for background line.

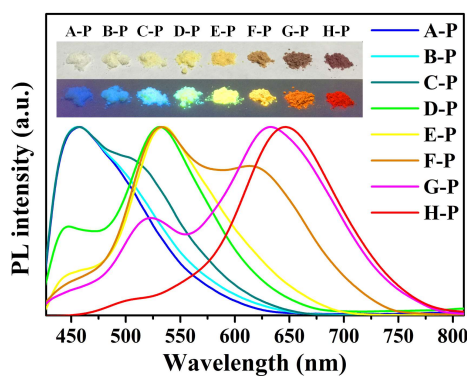


Fig. S9 PL spectra of full-color emitting starch/CDot phosphors at 400 nm excitation, inset: optical images under room light and ultraviolet light of 365 nm.

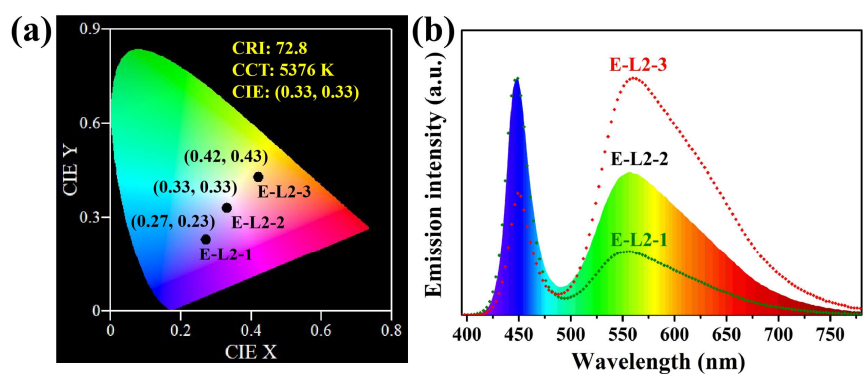


Fig. S10 (a) CIE chromaticity chart and (b) emission spectra (under 3.0 V) of the WLED device E-L2-2 and reference devices (E-L2-1 and E-L2-3) based on phosphors E-P.

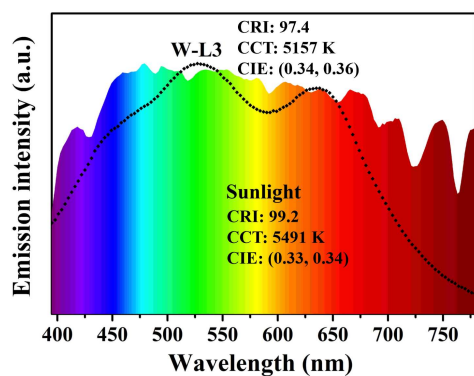


Fig. S11 Emission spectra of (color filling) sun at 16:00 in summer and (black symbol) W-L3.

Table S1 PL QYs of CDots A–H in DMF at optimized excitation wavelengths.

Sample	A	B	C	D	E	F	G	H
PL QYs (%)	33.0	34.6	33.2	38.3	48.1	45.9	38.1	35.7
Excitation (nm)	390	420	450	450	450	450	450	530

Table S2 Relative atomic concentrations of C, N, and O elemental components and their ratios to C content in CDots A, D, and H, resulted from XPS spectra.

Sample	C (mol%)	N (mol%)	O (mol%)	N/C (%)	O/C (%)
A	65.9	13.6	20.5	20.6	31.1
D	74.9	5.8	19.3	7.7	25.8
H	68.8	9.0	22.2	13.1	32.3

Table S3 Fitting parameters for the time-resolved PL spectra of CDots A, D, and H in DMF.

Sample	τ_1 (ns)	a_1 (%)	τ_2 (ns)	a_2 (%)	τ_{ave} (ns) ^a
A-455	5.03	44.4	2.46	55.6	4.05
D-535	10.23	75.2	2.98	24.8	9.59
H-585	12.47	100.0	—	—	12.47
H-650	12.88	100.0	—	—	12.88

^aThe average PL lifetimes were evaluated by the equation $\tau_{ave} = \sum \frac{a_i \tau_i^2}{a_i \tau_i}^{1,2}$

Table S4 PL QYs of full-color emitting SiO₂/CDot composite phosphors at optimized excitation wavelengths.

Sample	A-P	B-P	C-P	D-P	E-P	F-P	G-P	H-P
PL QYs (%)	38.1	37.8	40.5	54.0	64.3	50.8	43.3	32.7
Excitation (nm)	390	400	440	450	450	450	450	450

Table S5 Fitting parameters for the time-resolved PL spectra of CDots A at 455 nm, D at 535 nm, and H at 650 nm in DMF, DMF mixed with APTMS, and SiO₂/CDot composite phosphors.

Sample	τ_1 (ns)	a_1 (%)	τ_2 (ns)	a_2 (%)	τ_{ave} (ns)
A	5.03	44.4	2.46	55.6	4.05
A-APTMS	4.82	50.5	2.33	49.5	4.02
A-P	6.51	29.3	1.59	70.7	4.69
D	10.23	75.2	2.98	24.8	9.59
D-APTMS	10.56	53.4	2.22	46.6	9.27
D-P	7.91	100.0	—	—	7.91
H	12.88	100.0	—	—	12.88
H-APTMS	11.50	73.9	3.29	26.1	10.75
H-P	10.72	23.3	3.43	76.7	6.98

Table S6 Quantitative elemental analysis results of SiO₂/CDots composite phosphors D-P and SiO₂ nanoparticles from EDX.

Sample	C (mol%)	N (mol%)	O (mol%)	Si (mol%)
SiO ₂ /CDots	39.4	12.0	34.1	14.5
SiO ₂	—	—	66.9	33.1

References

- [1] K. Jiang, Y. Wang, C. Cai and H. Lin, *Adv. Mater.*, 2018, **30**, 1800783.
- [2] W. Li, S. Wu, X. Xu, J. Zhuang, H. Zhang, X. Zhang, C. Hu, B. Lei, C. F. Kaminski and Y. Liu, *Chem. Mater.*, 2019, **31**, 9887–9894.