Electronic Supplementary Information

High-Quality Water-Soluble Luminescent Carbon Dots for Multicolor Patterning, Sensors, and Bioimaging

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Measurement of quantum yield (Φ_s):

The Φ_s of the CDs were determined by a comparative method as follows:

$$\Phi_s = \Phi_R(\mathrm{Grad_S}/\mathrm{Grad_R})\ (\eta^2_S/\eta^2_R) \qquad (1)$$

where Grad is the gradient from the plot of integrated fluorescence intensity against absorbance and η(1.33) is the refractive index of the solvent. The subscripts S and R represent CDs and the reference (quinine sulfate in 0.10 M H_2SO_4). To prevent the re-absorption effect, the absorbances of CDs and quinine sulfate solutions in the 10-mm fluorescence cuvette were adjusted to less than 0.10 at the excitation wavelength (λ_{ex}) of 352 nm (*i.e.*, the absorption maximum of CDs). The integrated fluorescence intensity was the area under the PL curve in the wavelength range 380–680 nm. The Φ_R was taken as 0.54 since it is almost independent (within 5%) with λ_{ex} at 200–400 nm.[1]

References

1 X. Wang, K. Qu, B. Xu, J. Ren, X. Qu, *J. Mater. Chem.*, 2011, **21**, 2445-2450.

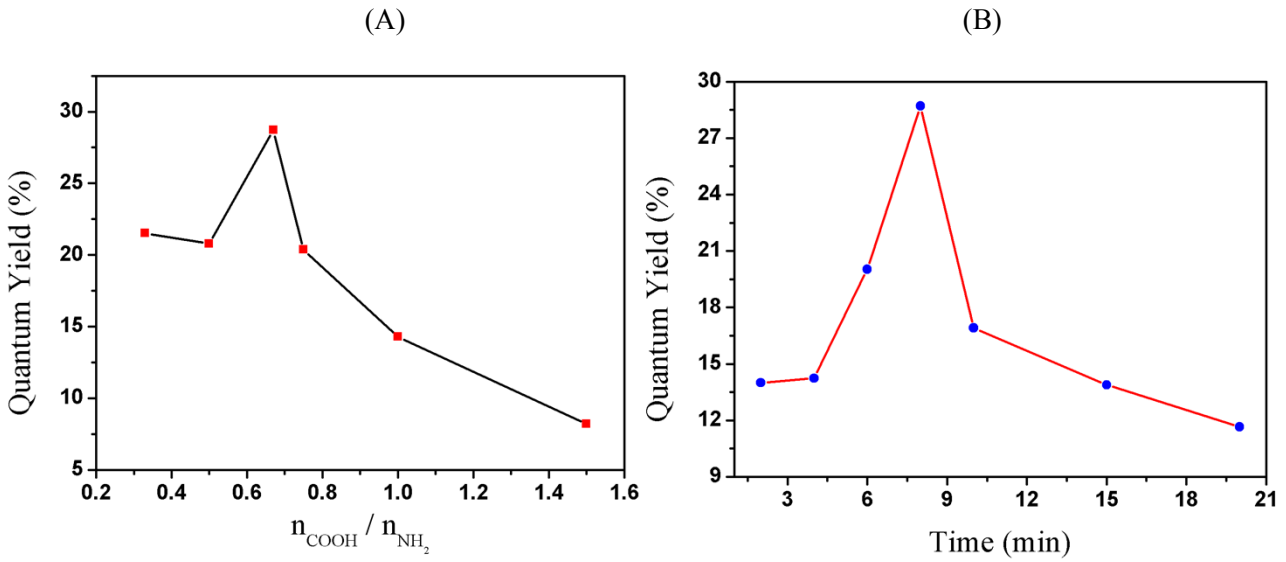


Fig. S1. Effect of (A) mole ratio of COOH/NH_2 functionalities (n_{COOH}/n_{NH_2}) of the precursors and (B) reaction time on the quantum yield of CDs.

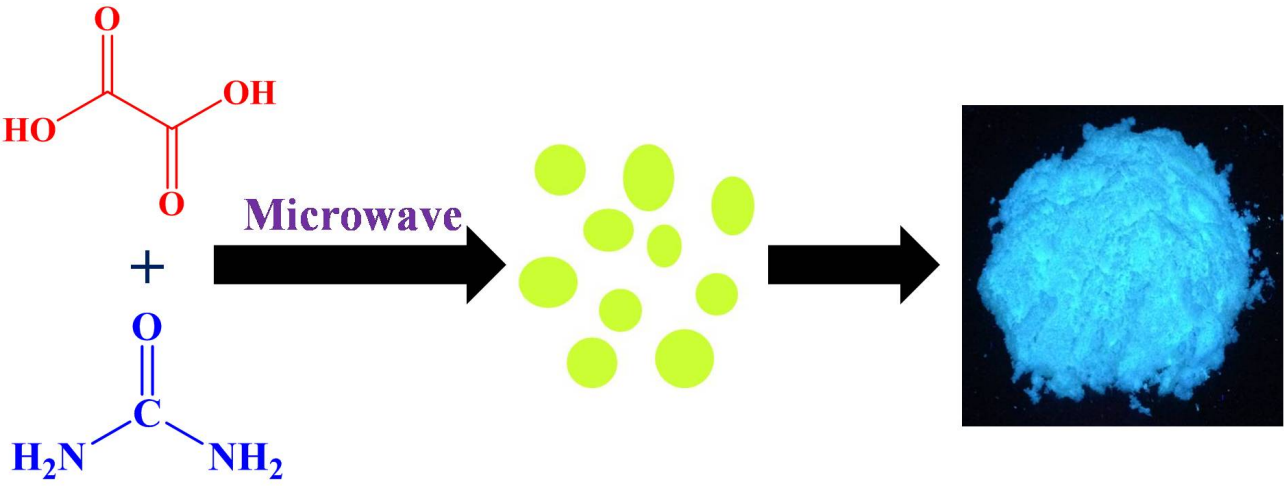


Fig. S2. The proposed microwave synthesis of CDs from oxalic acid and urea. This method can be applied to produce large amounts of CDs shown at the left panel. The solid CDs powder displays blue fluorescence under UV light.

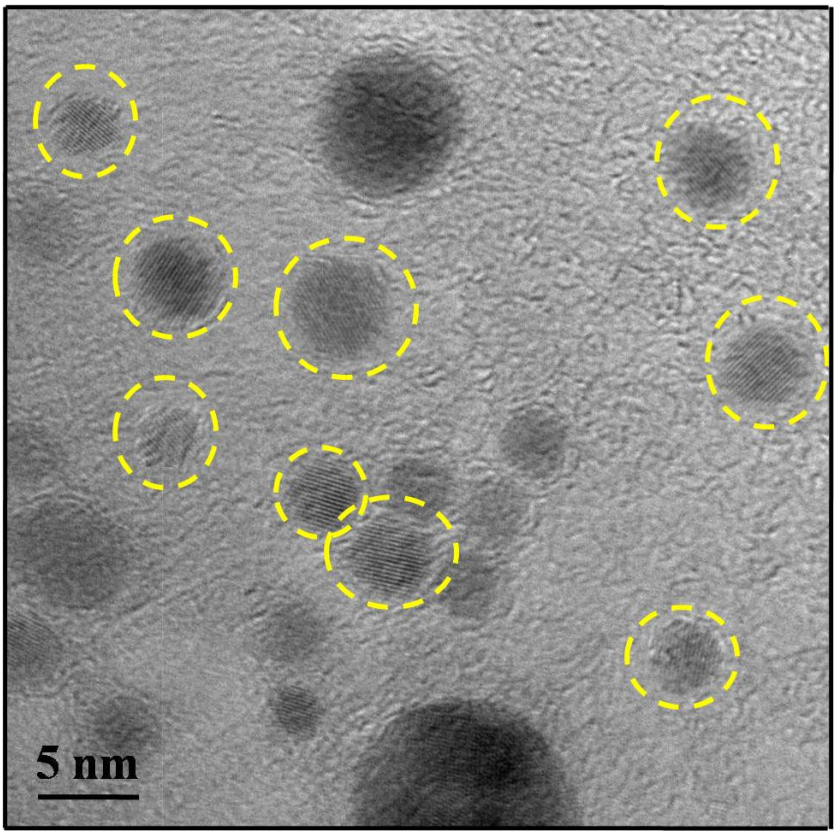


Fig. S3. HRTEM image of CDs. The yellow circles highlight examples of CDs with obvious lattice spacings.

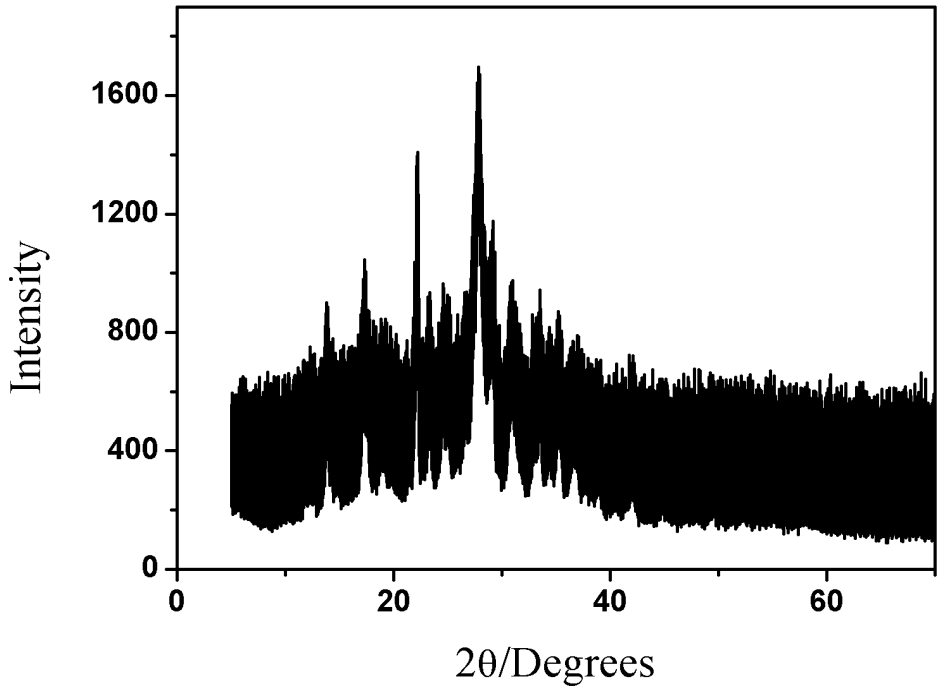


Fig. S4. XRD pattern of CDs.

Table S1. Elemental analysis of the as-synthesized CDs: (A) elemental content and (B) relative number of atom in CDs.

(A)

Sample name	Elemental content (%)			
	C	H	O (Calculated)	N
CDs	21.35	5.19	43.60	29.86

(B)

Sample name	Relative number of atom				Empirical formula
	C	H	O	N	
CDs	6	17	9	7	$C_6H_{17}N_7O_9$

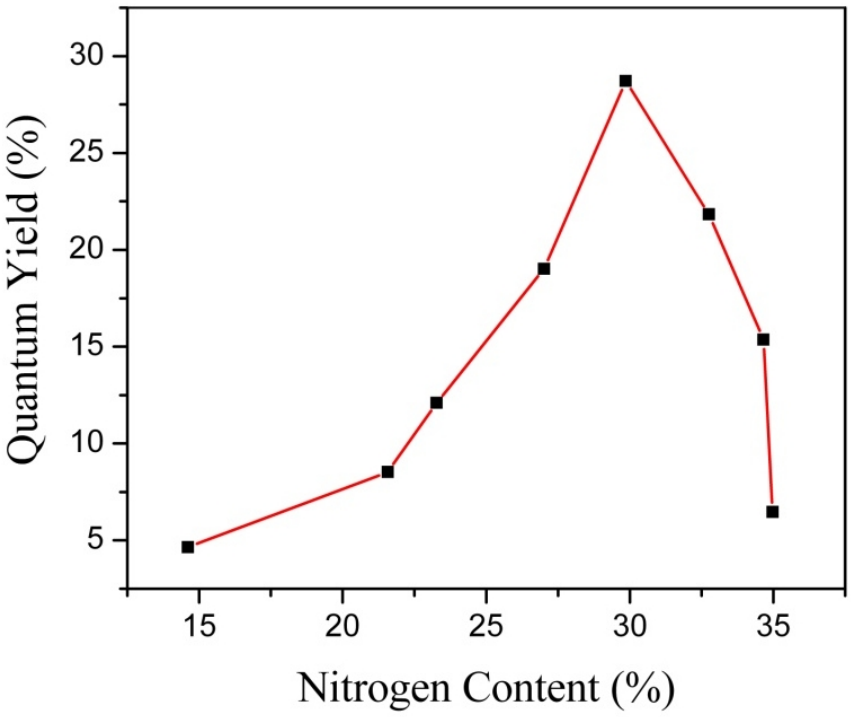


Fig. S5. Effect of the nitrogen's content in CDs on the quantum yield of CDs.

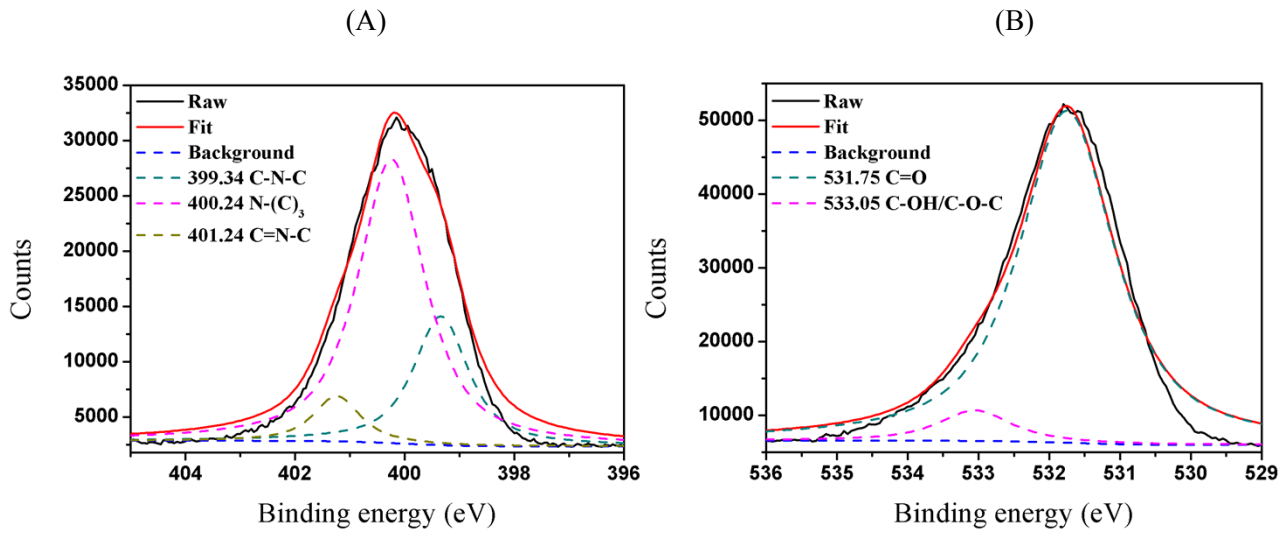


Fig. S6. (A) N1s XPS and (B) O1s XPS of CDs.

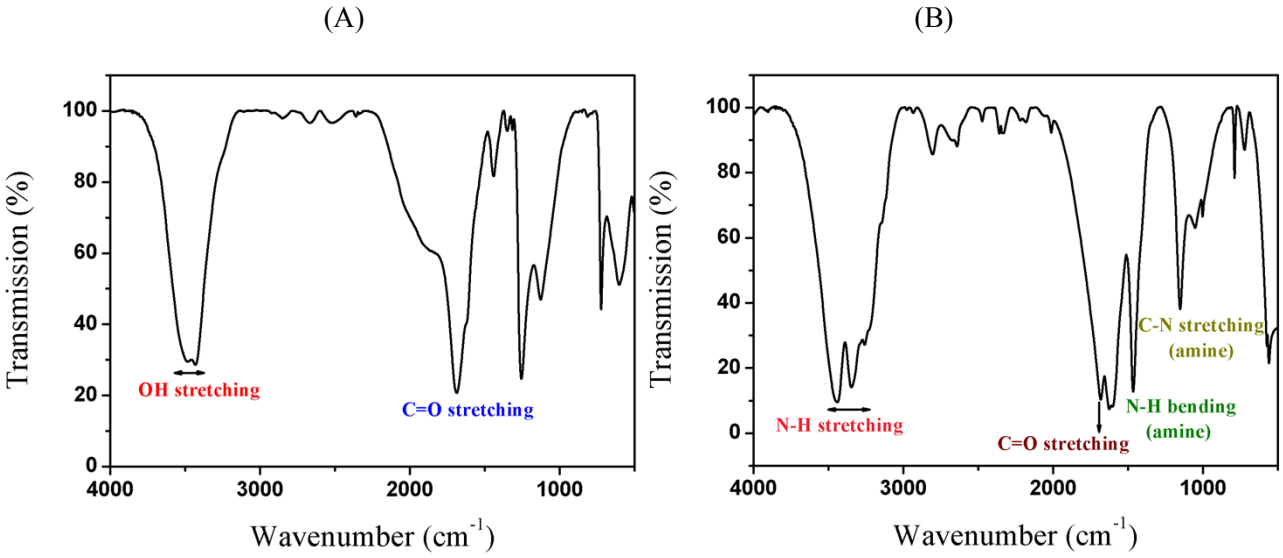


Fig. S7. FTIR spectra of (A) oxalic acid and (B) urea.

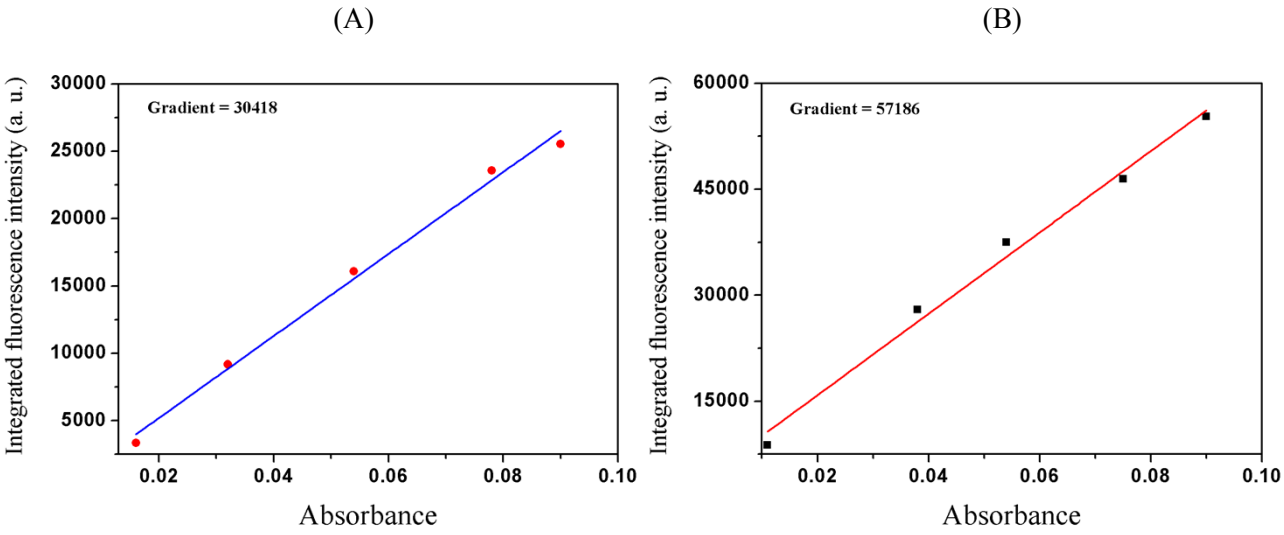
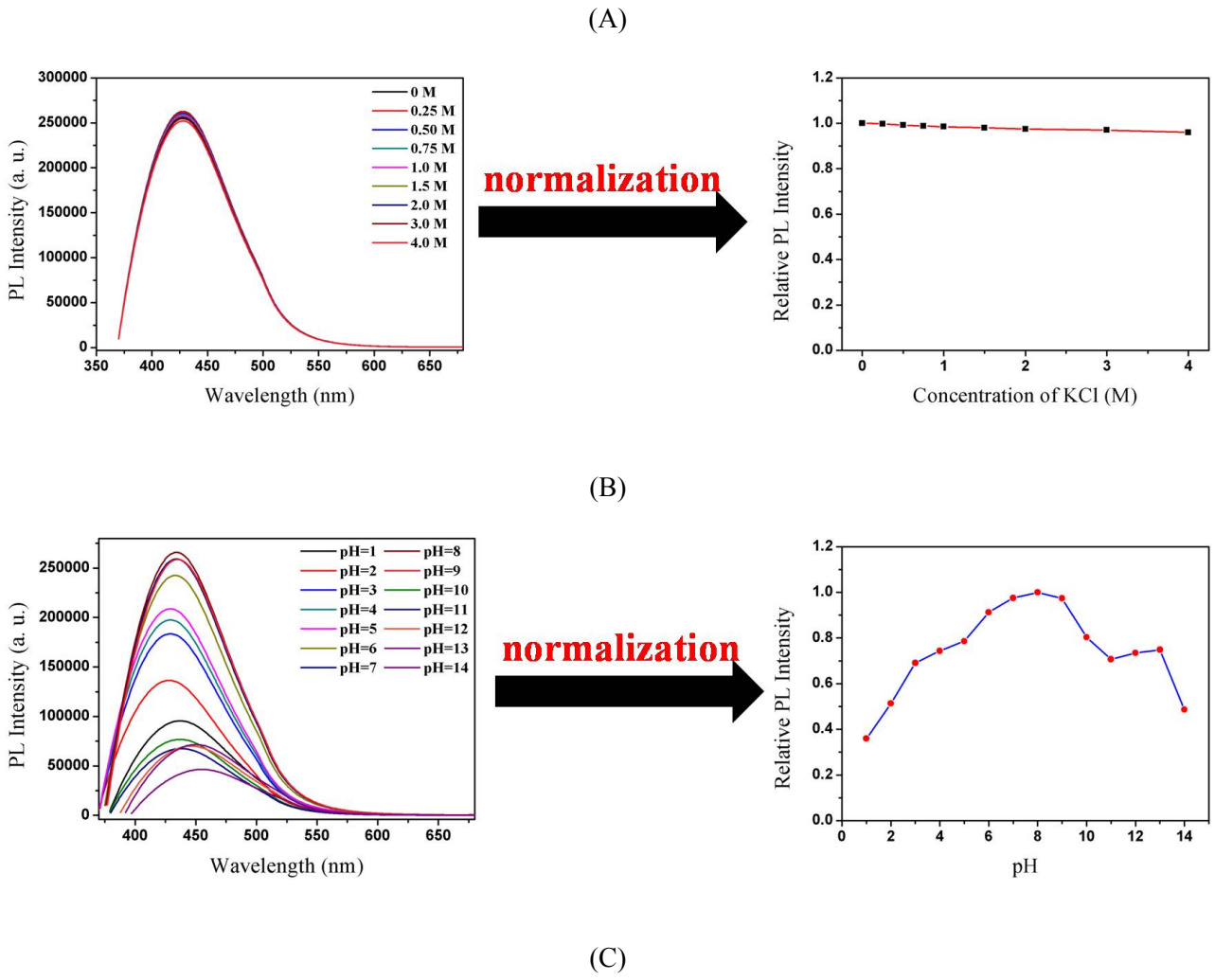


Fig. S8. Plots of integrated PL intensity against absorbance of (A) CDs and (B) quinine sulfate at excitation 352 nm.



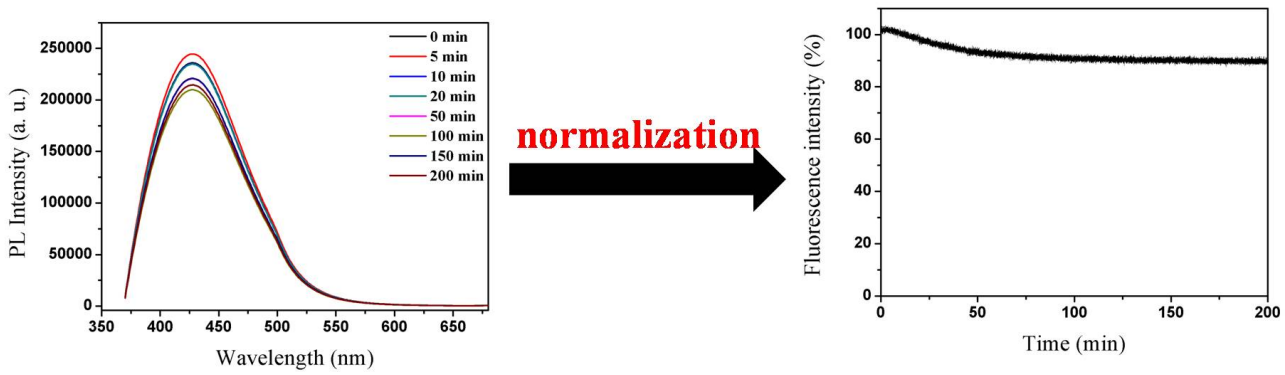


Fig. S9. (A) Effect of ionic strength on fluorescence intensity of CDs. The ionic strengths are controlled by various concentrations of KCl. (B) Effect of pH on fluorescence intensity of CDs. The pH is adjusted by the PBS buffers. The excitation/emission wavelengths ($\lambda_{ex}/\lambda_{em}$) are 352/426 nm. (C) The time-dependence of fluorescent intensity of CDs at $\lambda_{ex}/\lambda_{em}$ of 352/426 nm. The concentration of CDs is 0.50 mg/mL.

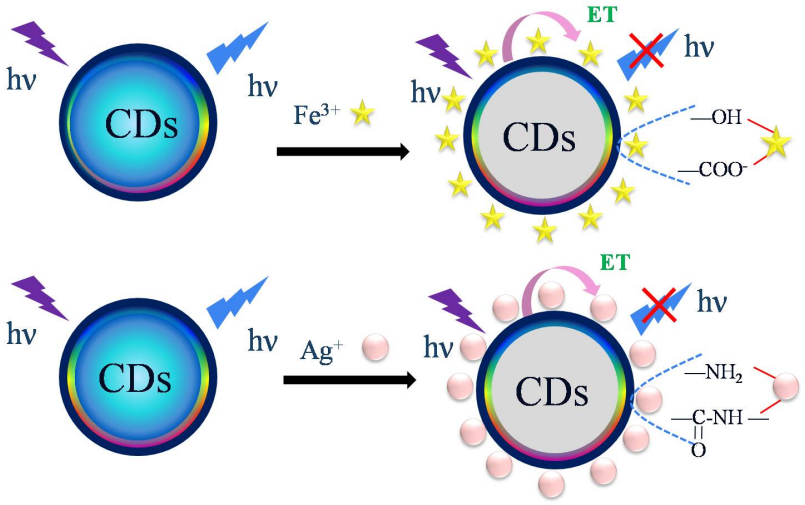


Fig. S10. Sensing principle of the CDs based probe for Fe^{3+} and Ag^{+}.

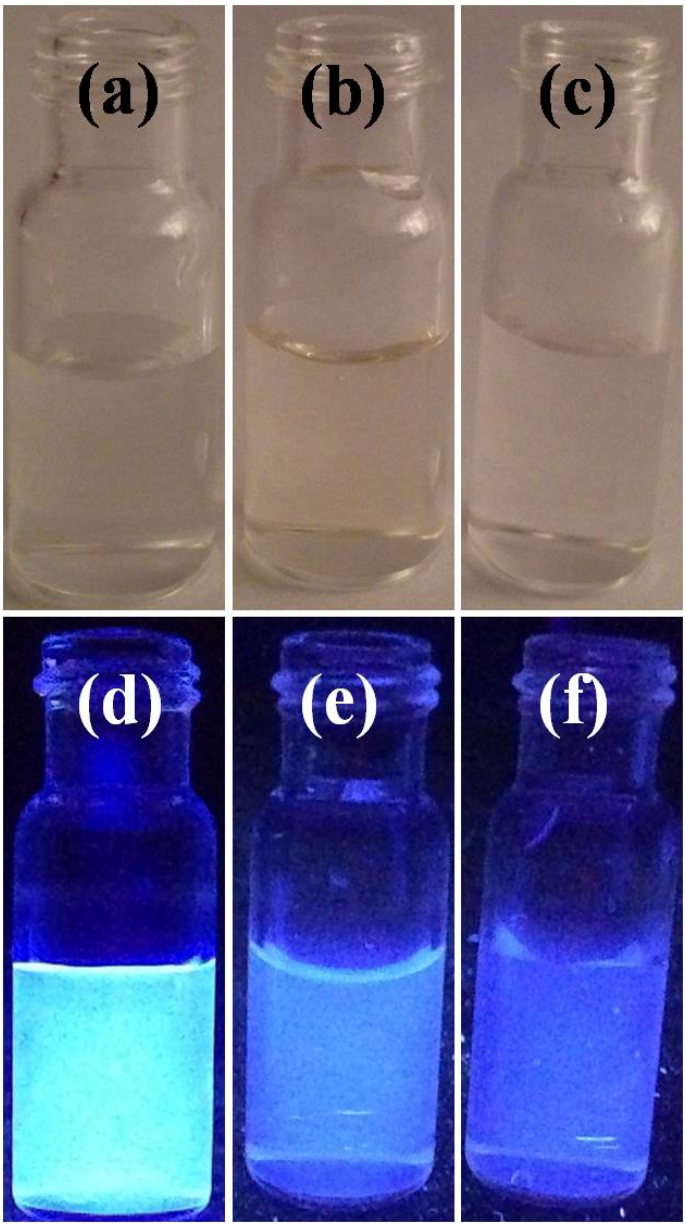


Fig. S11. Photographic images of CDs (0.50 mg/mL) before and after adding Fe^{3+} (0.20 mM) and Ag^{+} (0.20 mM) under daylight (a, b and c) and UV irradiation (d, e and f), respectively.

Table S2. Lifetime data obtained from the time-resolved decay curves of CDs (0.50 mg/mL), CDs (0.50 mg/mL)/Fe^{3+} (10 mM) and CDs (0.50 mg/mL)/Ag^{+} (3 mM) at $\lambda_{ex}/\lambda_{em}$ of 405/426 nm.

Sample	τ_1 (ns)	Percentage (%)	τ_2 (ns)	Percentage (%)	Average τ (ns)	χ^2
CDs	3.586	43.42	6.8058	56.58	5.41	1.028
CDs/Fe^{3+}	2.1471	31.93	5.0682	68.07	4.14	1.147
CDs/Ag^{+}	0.3091	55.65	4.4379	44.35	2.14	1.048

Fig. S12. Photograph of a bean sprout grown with water under daylight.