Supporting information

for

The selective deprotonation of carbon quantum dots for fluorescent detection of phosphate and visualization of latent fingerprints

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Quantum yield measurement

The quantum yield (QY) of the CQDs was determined according to the established method using quinine sulfate (QY is 0.54 in 0.1 M H_2SO_4) as a reference.[1] In order to minimize the reabsorption effects, the absorbencies of solution in the 10 mm fluorescence cuvette were kept between 0.02 to 0.1. The QY of the QDs was calculated according to the below equation:

$$\varphi_x = \varphi_{re} \times (I_x/I_{re}) \times (A_{re}/A_x) \times (n_x/n_{re})^2$$

Where φ is the QY, I is the integrated area of emission spectrum, A is the absorbance and n is the refractive index of the solvent. The subscript "x" and "re" refer to the sample and the reference, respectively.

Fluorescence life time test

Fluorescence life time was determined using time correlated single photon counting technique.[2] Decays were recorded for CQDs with emission and excitation wavelengths at 448 nm and 375 nm respectively. Decay curves were fitted using multi

exponential model as the following Eq1:

$$R(t)=B_1e^{(-t/\tau 1)}+B_2e^{(-t/\tau 2)}+B_3e^{(-t/\tau 3)} \quad (1)$$

where $R(t)$ is the intensity usually as summed to decay as the sum of individual single exponential decays, B_1, B_2 and B_3 are the pre-exponential factors, τ_1, τ_2 and τ_3 are the decay times. The average life time (τ_{ave}) of CQDs in the presence of different concentration of Pi in water (pH=7.4) solution was determined by Eq2.

$$\tau_{ave}=\Sigma_i B_i \tau_i^2/\Sigma_i B_i \tau_1 \quad (2)$$

Cytotoxicity test

The cytotoxicity of CQDs was tested according to the standard MTT assays. HL7702 cells were seeded in 96-well plates (NEST) with the intensity of 8×10^4 cells mL^{-1}. The HL7702 cells were cultured by using CQDs solution with different concentration (0, 25, 50, 100, 200, and 300 μg/mL) for 24 h. The absorbance of each well at 490 nm was measured with a microplate reader, and the relative survival rate of the cells after 24 h was calculated.

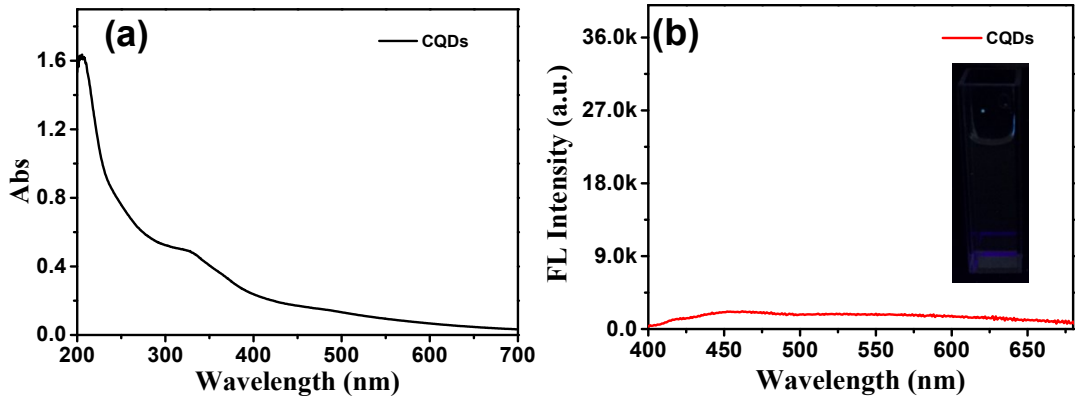

Fig. S1 (a) The UV-Vis absorption spectra of CQDs (20 μg/mL) in water solution (pH=7.4). (b) The fluorescence spectra of CQDs (Ex=365 nm, 20 μg/mL) in water solution (pH=7.4). Inset: Photographs of CQDs in water solution (pH=7.4) under UV irradiation of 365 nm.

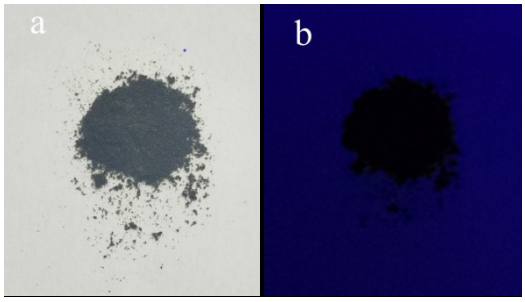

Fig. S2 The photographs of CQDs power under daylight (a) or excitation with UV 365 nm light (b).

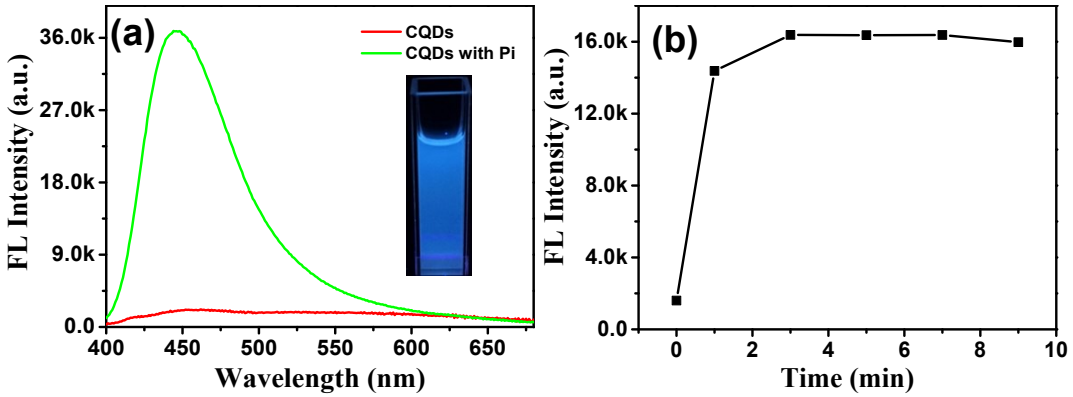

Fig. S3 (a) The fluorescence spectra of CQDs (20 μg/mL) in the absence and presence of Pi (216.67 μM) in water solution (pH=7.4), Ex=365 nm. Inset: Photographs of CQDs in the presence of Pi (216.67 μM) in water solution (pH=7.4) under UV irradiation of 365 nm. (b) Optimization of reaction time between Pi and CQDs.

Table S1 CQD (20 μg/mL) for the detection of Pi in soda drinks.

Sample	Added Pi (μM)	Measured Pi (μM)	Recovery (%)	RSD% (n=3)
Pepsi Cola	10.0	10.1	101	3.79
		10.7	107	
		10.0	100	
	50.0	51.7	103.4	2.66
		50.9	101.8	
		49.1	98.2	
Sprite	10.0	10.4	104	4.36
		11.1	111	
		10.3	103	
	50.0	49.3	98.6	2.31
		49.8	99.6	
		51.5	103	
Fanta	10.0	10.3	103	2.65
		10.8	108	
		10.4	104	
	50.0	50.2	100.4	1.83
		49.6	99.2	
		51.4	102.8	

Table S2 Comparison of different fluorescence sensors comprising heavy metal ions for the detection of Pi.

Sensing system	Linear range (μM)	LOD (μM)	Ref.
CDs@ZIF-90	1-50	0.23	3
s-GQDs-Al^{3+}	0.25-7.5	0.1	4
Carbon dots (C-dots)-Fe^{3+}	0.4-22	0.25	5
$Mo_7O_{24}^{6-}$-mediated N-GQDs	7.0-30	0.05	6
Carbon Quantum Dots−Europium(III)	1-13.5	0.06	7
CDs/QDs@ZIF-8-Pb^{2+}	0.25-50, 0.8-50	0.0094, 0.0567	8
CQDs	0-100	0.34	This work

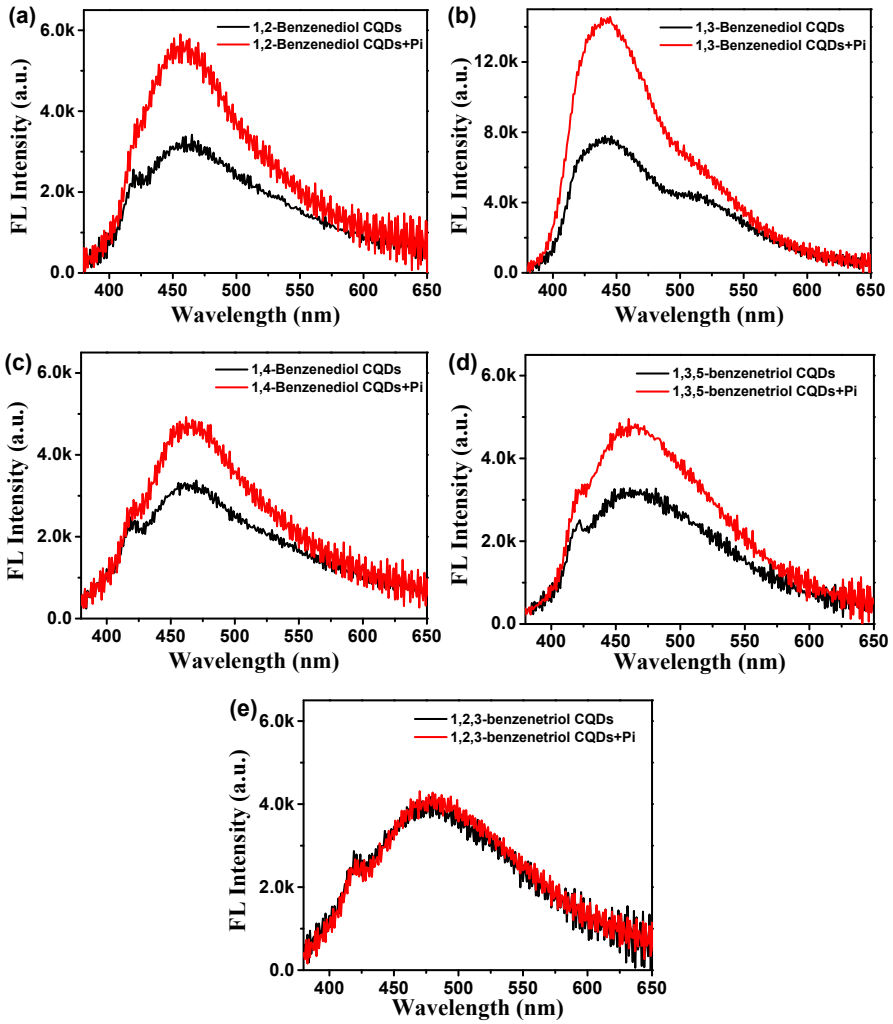

Fig. S4 The fluorescence spectra change of CQDs (20 μg/mL) that were prepared from different precursors (*i.e.*, benzenediol and benzenetriol) before and after addition of Pi (100 μM) in water solution (pH=7.4). The starting materials are 1,2-benzenediol (a), 1,3-benzenediol (b), 1,4-benzenediol (c), 1,3,5-benzenetriol (d), and 1,2,3-benzenetriol CQDs (e), respectively. Excitation wavelength is at 365 nm.

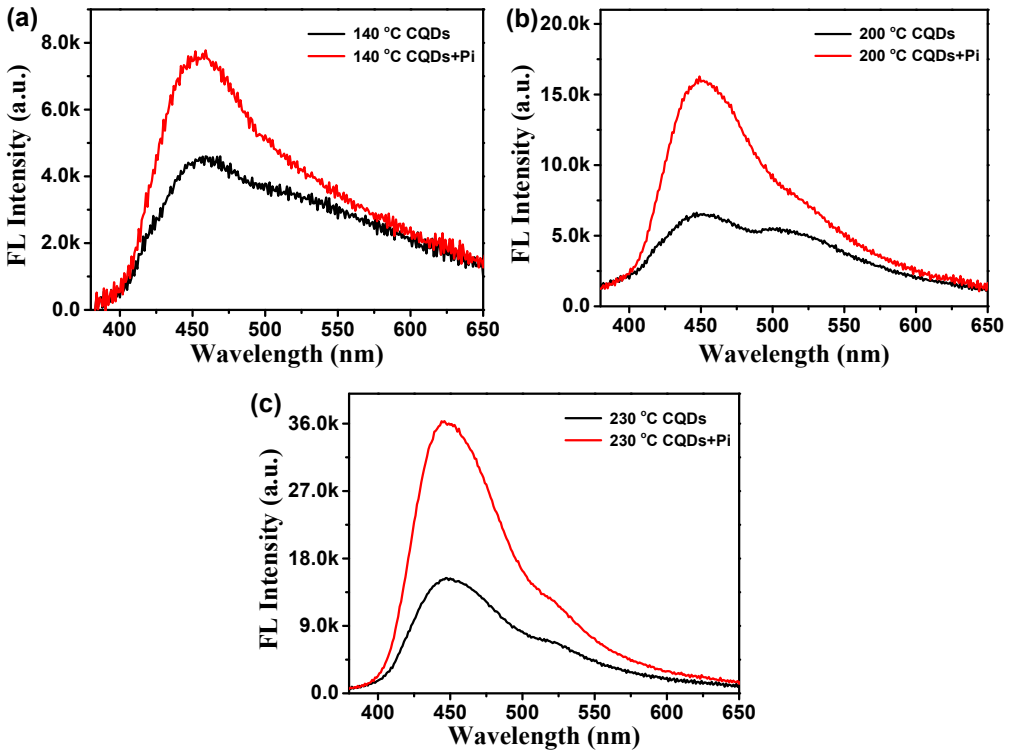

Fig. S5 The fluorescence spectra change of CQDs (20 μg/mL) that were prepared with different temperature (the precursor is 1,2,4-benzenetriol) before and after addition of Pi (100 μM) in water solution (pH=7.4). The temperatures are at 140 ^{0}C (a), 200 ^{0}C (b) and 230 ^{0}C (c), respectively. Ex=365 nm.

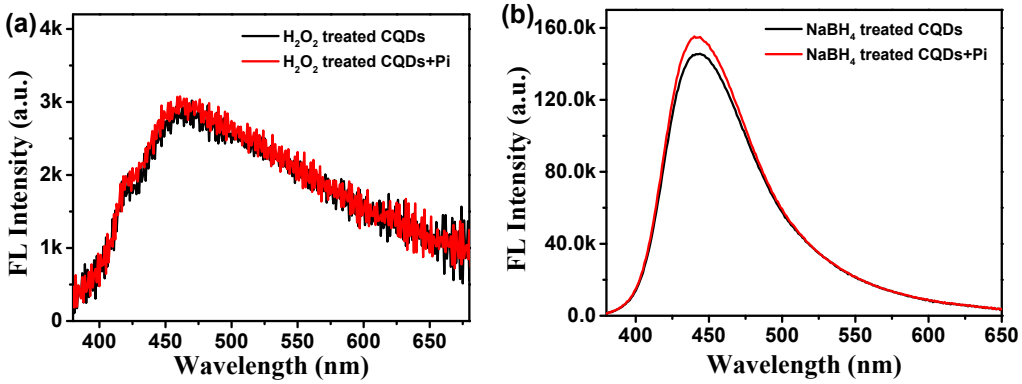

Fig. S6 The fluorescence spectra change of CQDs (20 μg/mL) that were pre-treated with H_2O_2 (1M) (a) or $NaBH_4$ (0.1M) (b) before and after addition of Pi (100 μM) in water solution (pH=7.4). Ex=365 nm.

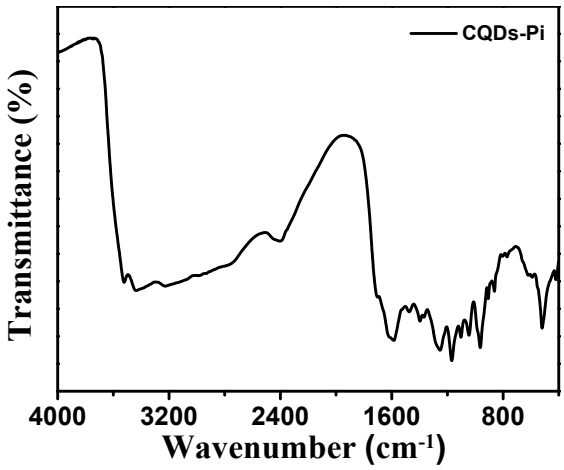

Fig. S7 FTIR spectra of CQDs in the presence of Pi.

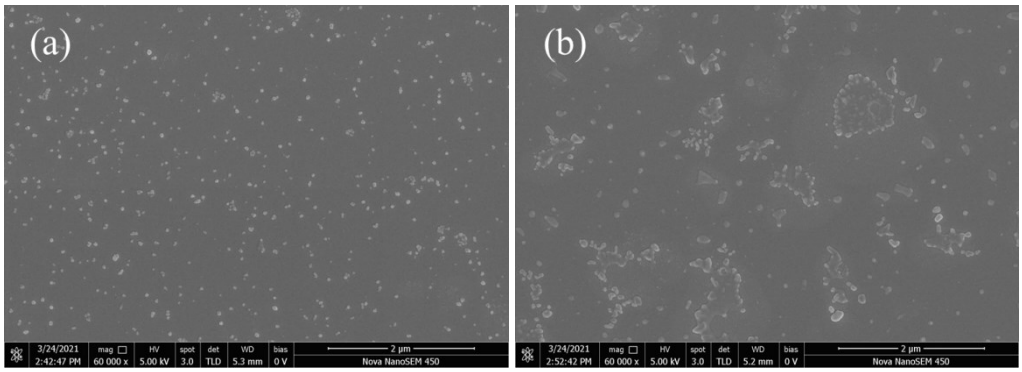

Fig. S8 SEM images of CQDs (20 μg/mL) in the absence (a) and presence (b) of 60 μM Pi in water solution (pH=7.4).

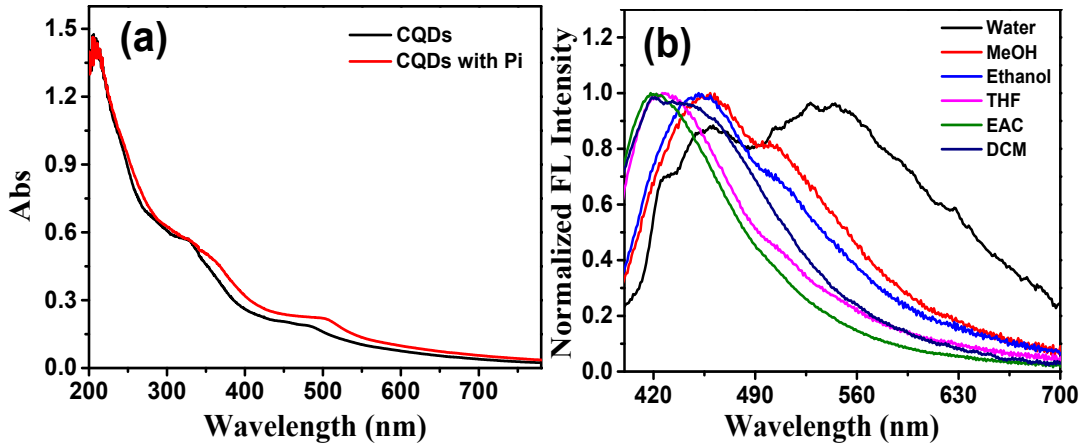

Fig. S9 (a) The UV-Vis absorption spectra of CQDs (20 μg/mL) in the absence and presence of Pi (180 μM) in water solution (pH=7.4). (b) Normalized fluorescence spectra of CQDs (20 μg/mL) in various solutions. Ex=365 nm.

Table S3 Fluorescence decay time (τ_{ave}) and pre-exponential factor (B) of CQDs in the absence and presence of Pi (66.67 μM) in water (pH=7.4) solution.

Sample	τ_1 (ns)	τ_2 (ns)	B_1	B_2	χ^2	τ_{ave} (ns)
CQDs	1.09	5.10	2827.95	362.94	1.17	2.60
CQDs-66.67 μM Pi	1.40	4.35	2666.62	494.55	1.23	2.47

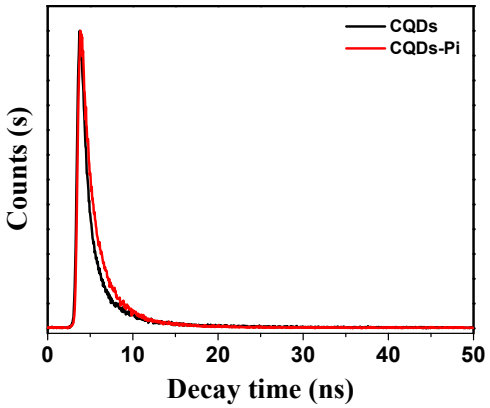

Fig. S10 Fluorescence decay of CQDs in the absence and presence of Pi (66.67 μM) in water solution (pH=7.4). The emission was monitored at 440 nm and excitation was at 375 nm.

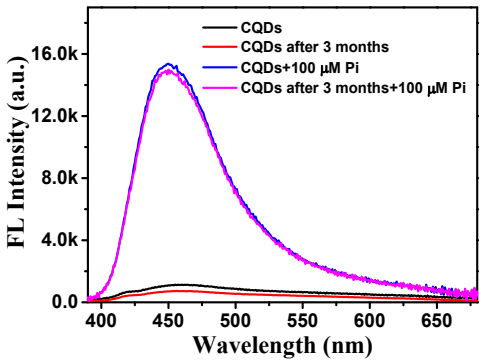

Fig. S11 The fluorescence spectra of the as-synthesized CQDs (20 μg/mL) solution in the absence and presence of Pi (100 μM), and the CQDs solution being stored for 3 months before and after addition of Pi in water solution (pH=7.4).

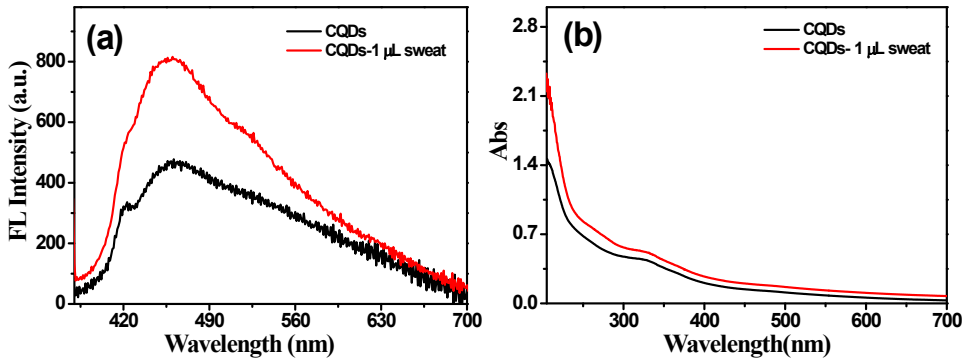

Fig. S12 The fluorescence spectra (a) and absorption spectra (b) of CQDs (20 μg/mL) solution without and with 1 μL sweat in water solution (pH=7.4). Ex=365 nm.

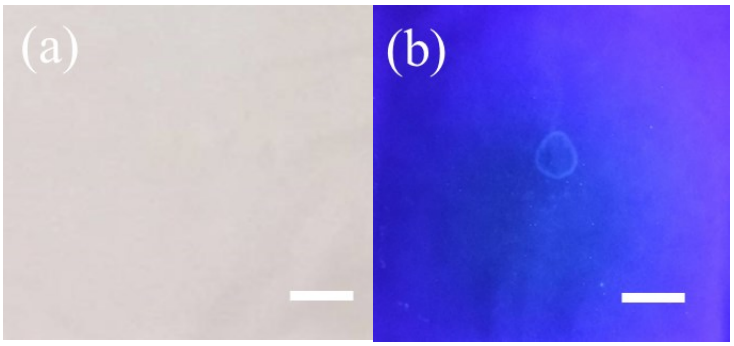

Fig. S13 The photographs of the paper that was sprayed with CQDs (20 μg/mL), followed with addition of 1 μL sweat under daylight (a) and UV 365 nm light (b). Scale bar: 1 cm.

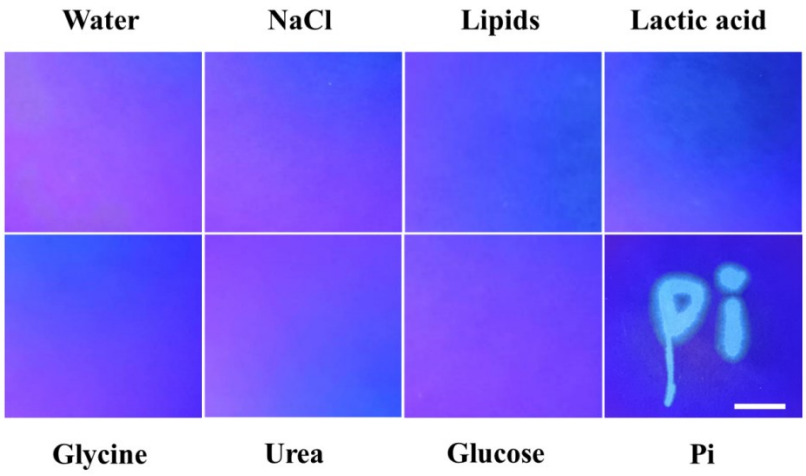

Fig. S14 Fluorescence images (under 365 nm irradiation) of characters "Pi" written with different substances common in LFPs and sprayed with a CQDs (20 μg/mL) aqueous solution. Scale bar: 2 cm.

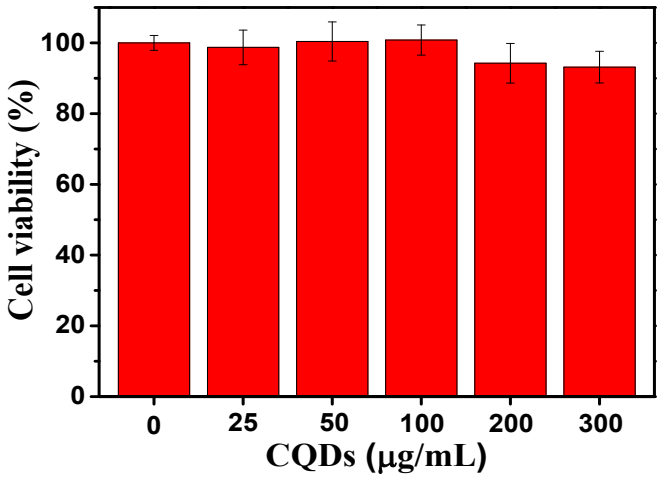

Fig. S15 The viability of HL7702 cells after incubation with different concentration of CQDs for 24 h.

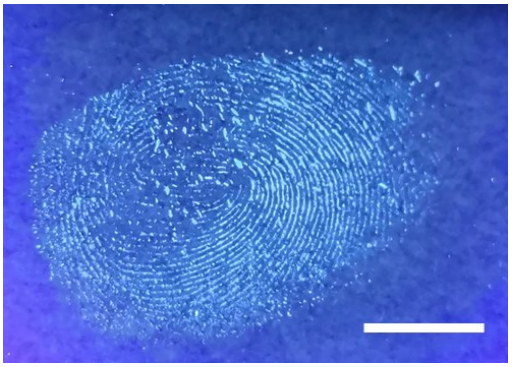

Fig. S16 Fluorescence image of paper that was sprayed with CQDs (20 μg/mL) and finger touched after being stored at room temperature for 30 days. Scale bar: 1 cm.

References

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