Supporting information

Efficient and stable fluorescence sensor based on APTES-functionalized $CsPbBr_3$ perovskite quantum dots for ultrasensitive tetracycline detection in ethanol

Tong Wang, [a, b, 1] Xiao Wei, [a, b, 1*] Yuhan Zong, [a, b] Shen Zhang, [a, b] Weisheng Guan, [a, b]

[a]Key Laboratory of Subsurface Hydrology and Ecological Effects in Arid Region, Ministry of Education, Chang'an University, Xi'an 710054, China

[b]School of Water and Environment, Chang'an University, Xi'an 710054, China

*Corresponding author: Tel: +86 029 82339956; Fax: +86 029 82339281; E-mail address: chdwx@chd.edu.cn (X. Wei).

[1]These authors contributed equally to this work

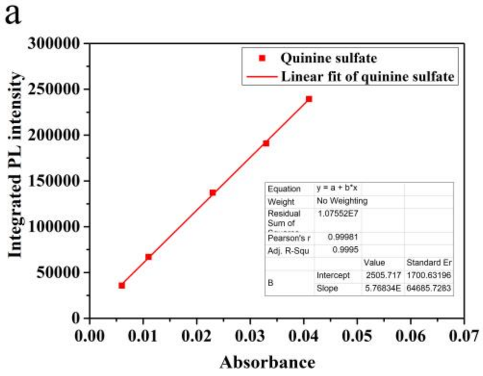

Fig. S1. The fitting diagrams of the absorbance value at the excitation wavelength and the integral of the emission wavelength spectrum of the standard solution (a) and APTES@IPQDs (b) respectively.

The fluorescence quantum yield of APTES@IPQDs was calculated by the following formula:

$$\Phi_{sample} = \Phi_{standard} \cdot \frac{K_{sample}}{K_{standard}} \cdot \frac{n_{sample}^2}{n_{standard}^2}$$

Herein, Φ is the fluorescence quantum yield, K is the slope from Fig. S1, and n is the refractive index of the solvent used. The quinine sulfate in 0.1 M H_2SO_4 excited at 360 nm was selected as the standard solution for APTES@IPQDs, and its ΦF was 0.56. Based on this method, the calculated quantum yield of APTES@IPQDs was 46.86%.

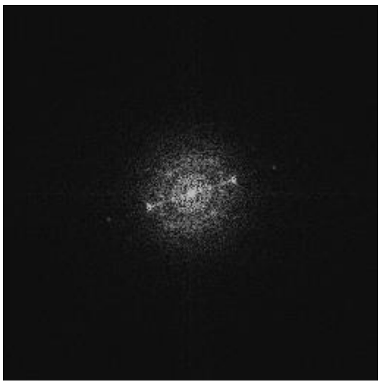

Fig. S2. The corresponding FFT pattern of APTES@IPQDs

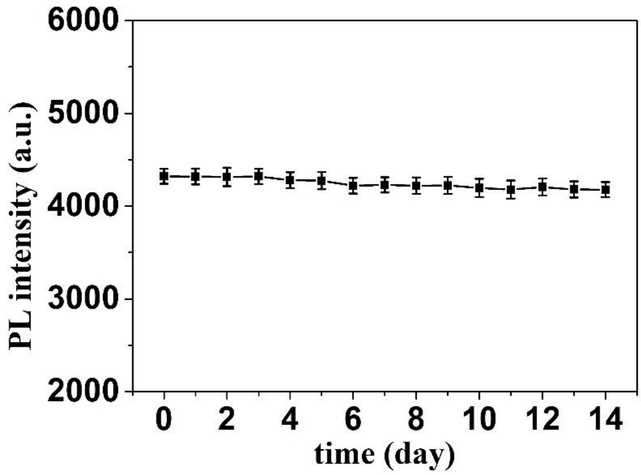

Fig. S3. The stability of APTES@IPQDs in two weeks

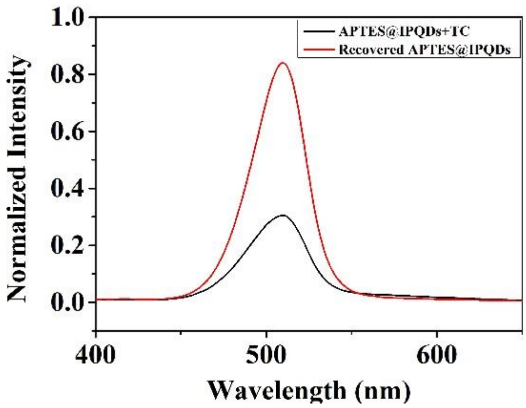

Fig. S4. Fluorescence spectra of APTES@IPQDs with TC (8.0 μM) and the recovered APTES@IPQDs

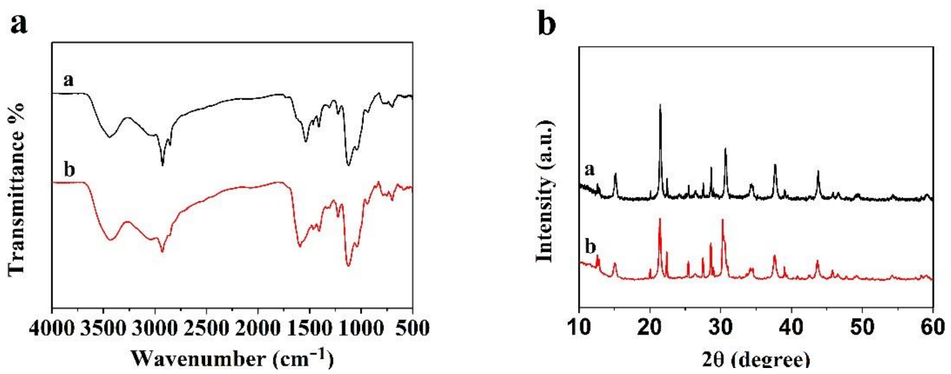

Fig. S5. The FT-IR spectra (a) and XRD patterns (b) of APTES@IPQDs and recovered APTES@IPQDs (the black line (a) represents the APTES@IPQDs, the red line (b) represents the recovered APTES@IPQDs).

Table S1. Specific statistics of the XPS survey for APTES@IPQDs.

Name	Peak BE	Hight CPS	FWHM eV	Area (P) CPS.eV	Area (N) TPP-2M	Atomic %
Cs3d	723.84	76651.16	1.23	208065.09	0.11	5.81
Pb4f	138.19	70520.81	1	145531.41	0.1	5.08
Br3d	68.26	27176.73	1.18	47929.39	0.38	20.31

Table S2. Comparison of LOD with other reported methods for the detection of TC.

method	LOD (μM)	Solvent	References
silver nanoparticles	29	water	[S1]
CdTe quantum dots	2.1	water	[S2]
ZnO nanorods	1.27	water	[S3]
Carbon dots	0.165	water	[S4]
Eu-Carbon dots	0.3	water	[S5]
MoS_2 quantum dots	0.1	water	[S6]
Red/Green CdTe QDs	0.35	water	[S7]
APTES@IPQDs	0.076	ethanol	This work

Table S3. Fitting parameters of the PL decay curves.

	τ_1 (ns)	τ_2 (ns)	A_1	A_2	τ_{ave} (ns)	χ^2 (%)
APTES@IPQDs with 0 μM TC	19.76	115.92	2693.99	1449.52	92.78	1.284
APTES@IPQDs with 10 μM TC	19.47	100.55	2859.73	1144.83	74.12	1.267
APTES@IPQDs with 15 μM TC	18.38	90.52	2133.82	639.37	61.38	1.256

The measurements of time-resolved decay

In order to determine the fluorescence quenching mechanism, the fluorescence decay curves of APTES@IPQDs with different concentrations of TC were recorded separately. The pulsed excitation light was 375 nm, and emission wavelength was 512 nm. All the decay curves were fitted by biexponential fit model:

$$I(t) = A_1 e^{(-t/\tau_1)} + A_2 e^{(-t/\tau_2)}$$

The average lifetimes of APTES@IPQDs were evaluated by the following formula:

$$\tau_{ave} = \frac{(A_1\tau_1^2 + A_2\tau_2^2)}{(A_1\tau_1 + A_2\tau_2)}$$

Table S4. Recovery of TC in the spiked soil samples at different concentrations (n=4).

sample	Concentration taken (μM)	Found (μM)	Recovery (%)	RSD (%)
1	0.5	0.466	93.2	5.4
2	1.0	1.077	107.7	3.3
3	4.0	3.788	94.7	2.7
4	7.0	7.331	104.7	4.1
5	10.0	9.818	98.18	3.5

supplementary material references:

[S1] M. Amjadi, J. L. Manzoori, F. Pakpoor, *J. Anal. Chem.*, 2016, **71,** 253-258.
[S2] M. Chao, C. Hu, J. Chen, *Anal. Chim. Acta*, 2016, **925,** 61-69.
[S3] Z. Zhou, K. Lu, X. Wei, T. Hao, Y. Xu, X. Lv, Y. Zhang, *RSC Adv.*, 2016, **6,** 10-1039.
[S4] D. Uriarte, C. Domini, M. Garrido, *Talanta*, 2019, **201,** 143-148.
[S5] M. L. Liu, B. B. Chen, T. Yang, J. Wang, X. D. Liu, C. Z. Huang, *Methods Appl. Fluores.*, 2017, **5,** 15003.

[S6] H. Huang, C. Du, H. Shi, X. Feng, J. Li, Y. Tan, W. Song, *Part. Part. Syst. Char.*, 2015, **32,** 72-79.

[S7] X. Wei and H. Chen, *Anal. Bioanal. Chem.*, 2019, **411,** 5809-5816.