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# Supplementary Information

# Synthesis of amphiphilic carbon quantum dots with phosphorescence properties and their multifunctional applications

Jing Tan,[a] Jie Zhang,[a] Wang Li,[a] Liqun Zhang,[ab] Dongmei Yue*[ab]

[a] State Key Laboratory of Organic-Inorganic Composites, Beijing University of Chemical Technology, Beijing 100029, China.

[b] Key Laboratory of Beijing City on Preparation and Processing of Novel Polymer Materials, Beijing 100029, China.

E-mail: yuedm@mail.buct.edu.cn

# Experimental section

## Materials

Isophorone diisocyanate (IPDI), polytetramethylene ether glycol (PTMEG, Mn ~ 1,000), 1,4-butanediol (1,4-BDO), dibutyltindilaurate (DBTDL), and PVA (1788) were purchased from Aladdin Chemistry Co. Ltd, China. 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) was purchased from Sigma-Aldrich Co. LLC. DMEM high glucose medium and fetal bovine serum (FBS) were achieved from Solarbio Science &Technology Co., Ltd (Beijing, China). Other reagents were purchased from the Beijing Chemical Company, China. All the reagents and solvents of analytical reagent grade were used as received and without further purification. Deionized (DI) water (18.2 MΩ.cm at 25 °C) prepared by a Milli-Q (MQ) water system was used throughout all experiments

## Synthesis of N-doped CQDs

IPDI (8 g, 36 mmol) was put into a polytetrafluoroethylene vessel that was sealed by an explosion-proof enclosure. Then, raw N-doped CQDs were prepared under 700 W microwave irradiation (CEM MARS6 microwave system, USA) at 250 $^{o}$C for 10 min. During the irradiation, the colorless liquid became a dark brown solid, indicating the formation of raw CQDs. The obtained raw CQDs were dissolved in ethanol, centrifuged to remove the large particles, and then dialyzed with ethanol through a dialysis membrane (1000 Da) for 72 hours. The final product, over 6.66 g of CQDs, was obtained under reduced pressure.

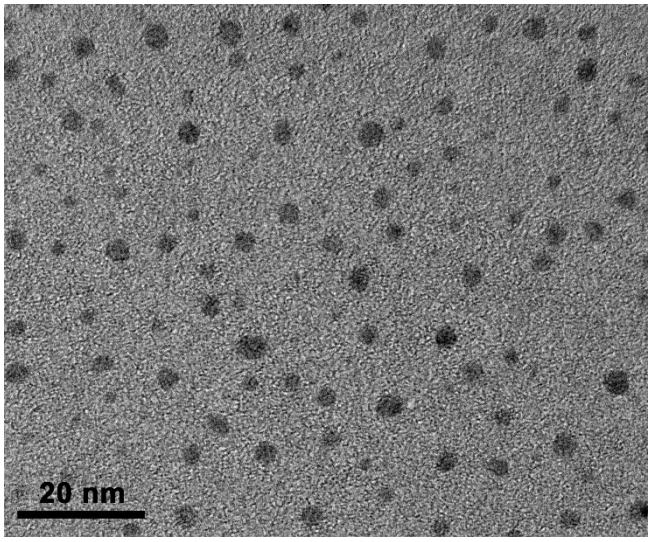


**Fig. S1** HRTEM images of the ACDs.

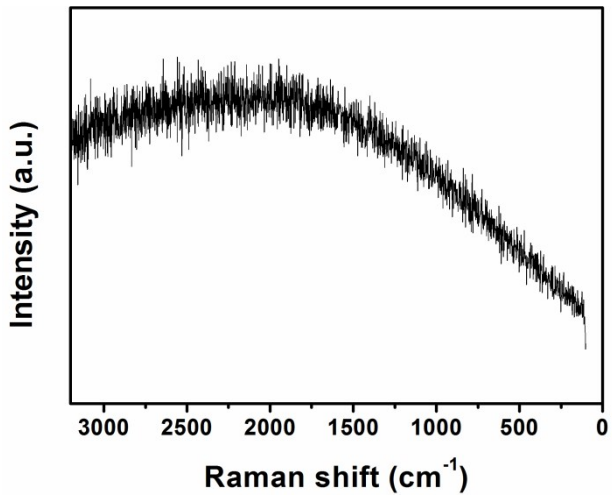


**Fig. S2** Raman spectrum of ACDs.

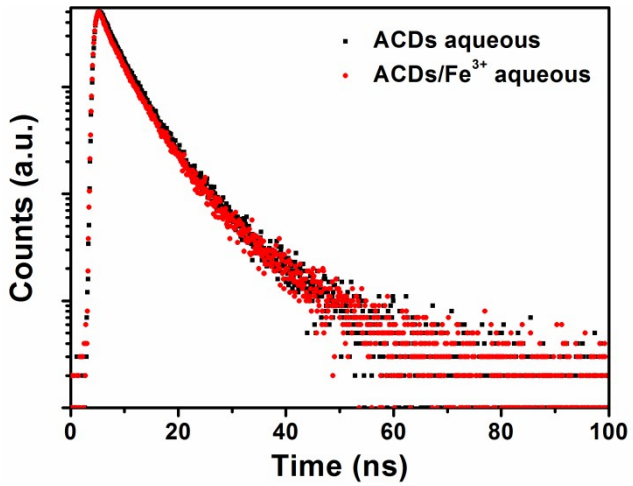


**Fig. S3** Fluorescence decay curves of ACDs in the absence and presence of $Fe^{3+}$ measured with excitation and emission wavelengths of 320 and 375 nm, respectively.

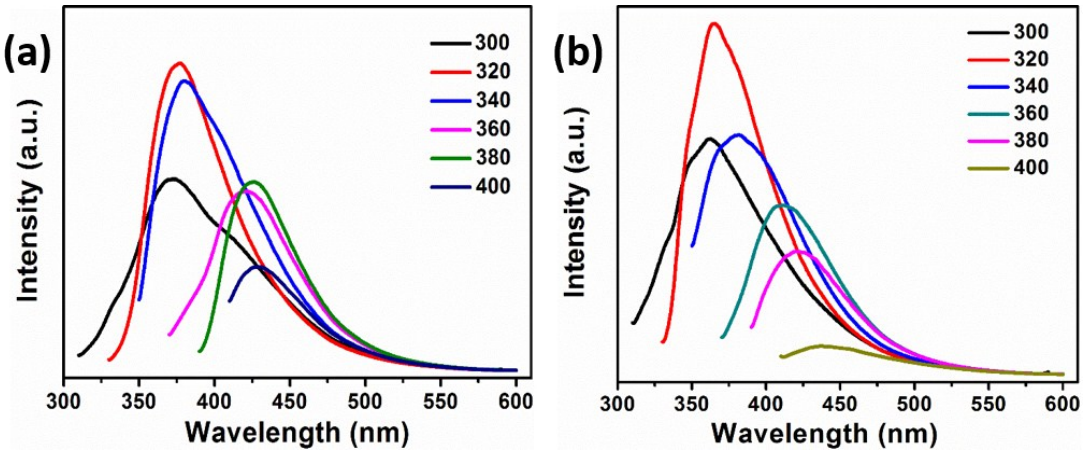


**Fig. S4** Fluorescence emission spectra of ACDs dispersed in (a) ethanol and (b) toluene recorded from 300 to 400 nm in 20 nm increments

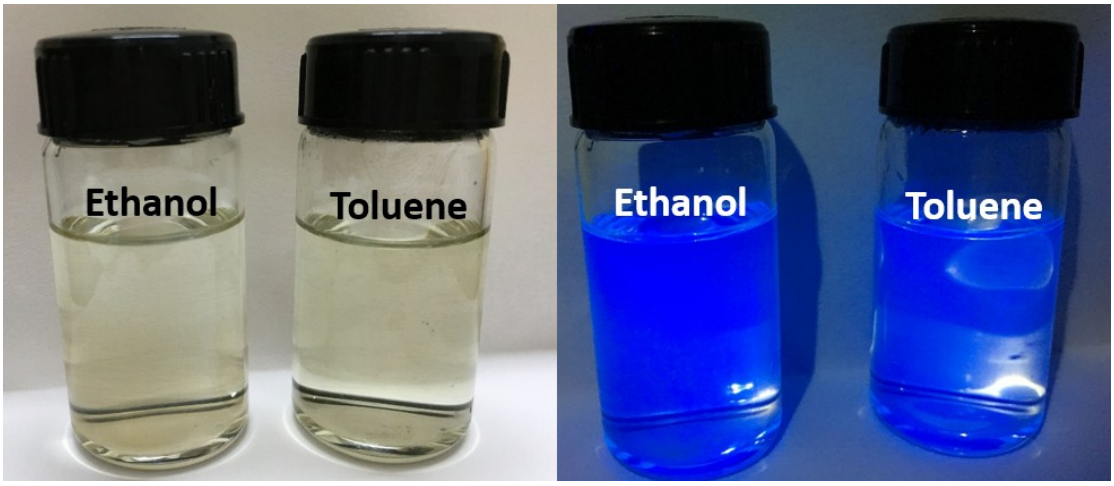


**Fig. S5** Digital images of 0.2 mg/mL ACDs dispersed in ethanol and toluene (left) and their fluorescent images (right) under UV light excitation (365 nm).

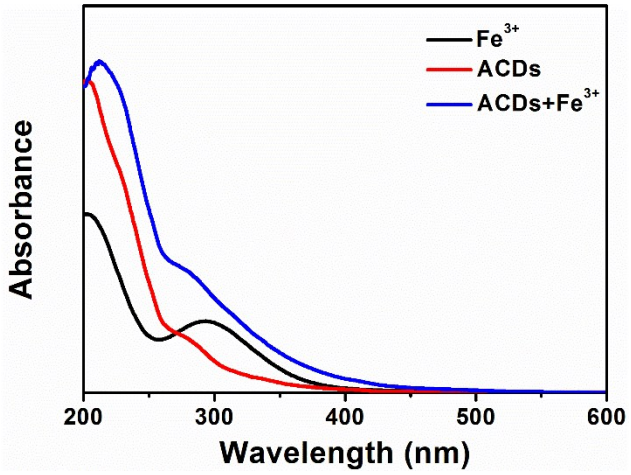


Fig. S6 UV−vis absorption spectra of $Fe^{3+}$ and ACDs in the absence and presence of $Fe^{3+}$.

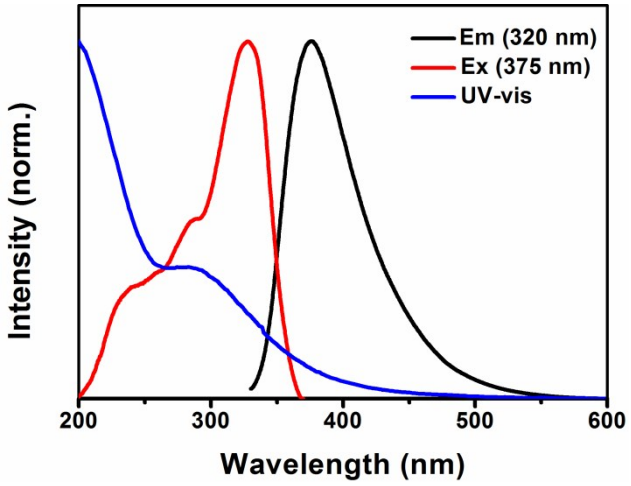


**Fig. S7** Fluorescence excitation and emission spectra of ACDs and UV−vis absorption spectrum of $Fe^{3+}$.

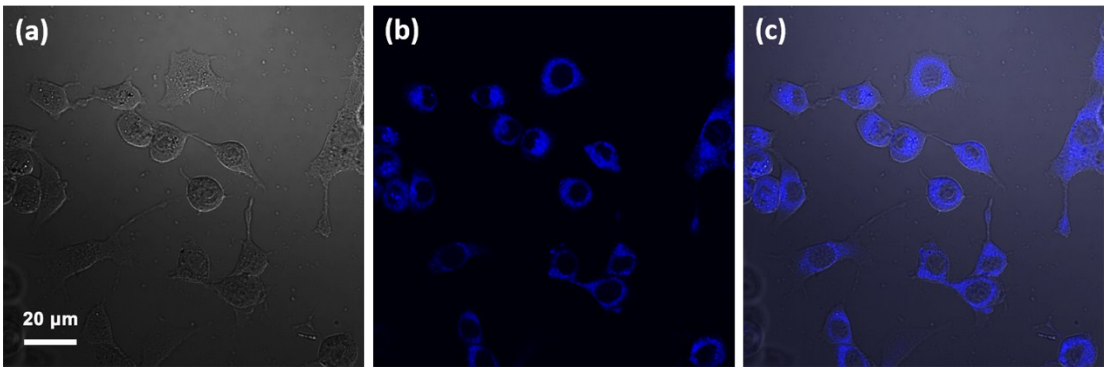


**Fig. S8** Cellular imaging of the ACDs. Washed cells imaged using (a) bright field, and (b) confocal photoluminescence microscopy, and (c) overlap of the corresponding bright field image and the fluorescence image at a single λ = 405 nm laser excitation.

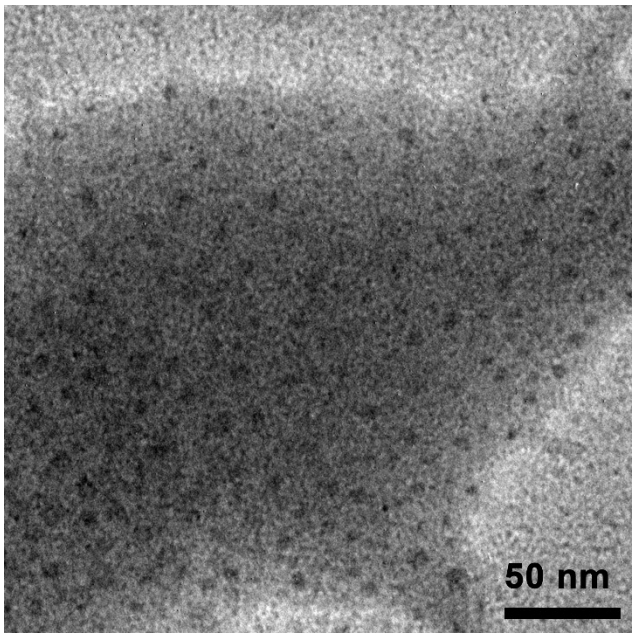


**Fig. S9** TEM image of ACDs/PU composites.

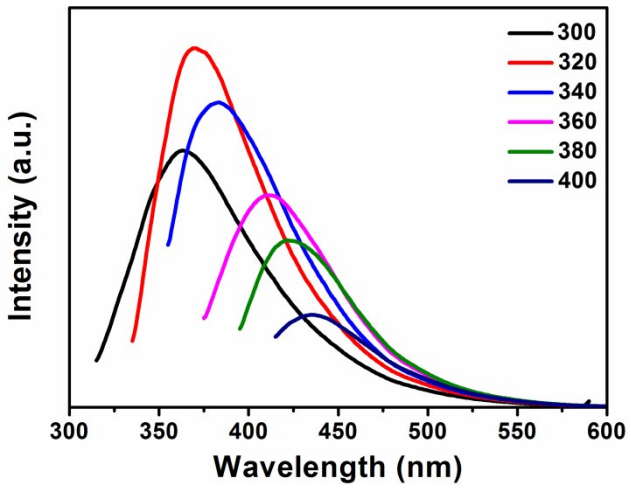


**Fig. S10** Fluorescence emission spectra of ACDs/PU composites.

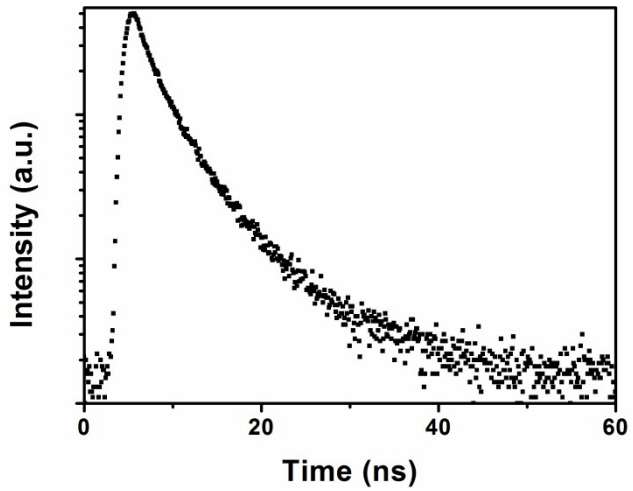


**Fig. S11** The time-resolved fluorescence decay trace of ACDs/PU composites.

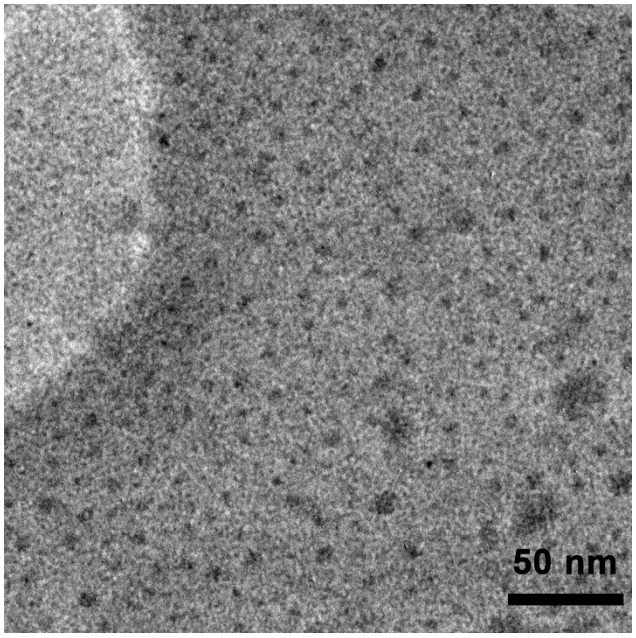


**Fig. S12** TEM image of ACDs/PVA composites.

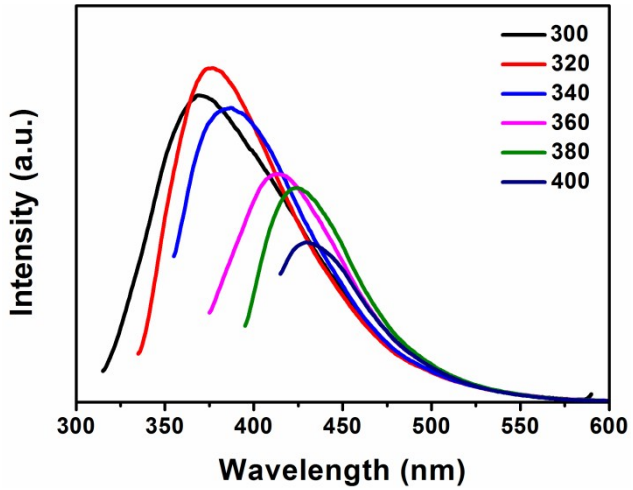


**Fig. S13** Fluorescence emission spectra of ACDs/PVA composites.

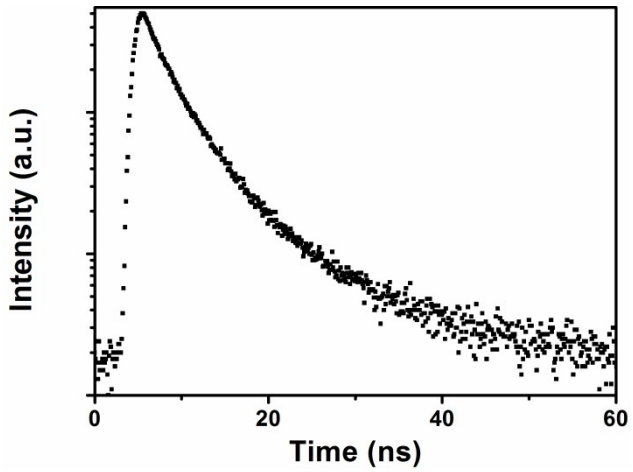


**Fig. S14** The time-resolved fluorescence decay trace of ACDs/PVA composites.

**Table S1** Atom percentages of ACDs and N-doped CQDs

| XPS | Composition percentage (%) | |
|---|---|---|
| | ACDs | N-doped CQDs |
| C | 76.57 | 81.83 |
| N | 13.71 | 11.47 |
| O | 9.37 | 6.7 |

**Table S2** The time resolved phosphorescence and delayed fluorescence decay components ($\lambda_{ex}$ = 320 nm and $\lambda_{em}$ = 375 and 450 nm) of ACDs/PU and ACDs/PVA composites. Where $\alpha_i$, $\tau_i$ are the amplitude and decay time (ms)[a].

| Sample | Em (nm) | $\alpha_1$ (%) | $\tau_1$ (ms) | $\alpha_2$ (%) | $\tau_2$ (ms) | $\alpha_3$ (%) | $\tau_3$ (ms) | $\tau_{ave}$ (ms) |
|---|---|---|---|---|---|---|---|---|
| ACDs/PU composite | 450 | 57.69 | 0.0114 | 18.01 | 0.1825 | 24.3 | 0.9273 | 0.81 |
| ACDs/PVA composites | 375 | 10.39 | 7.221 | 41.64 | 66.14 | 47.97 | 266.7 | 230 |
| ACDs/PVA composites | 450 | 11.69 | 13.6 | 29.34 | 97.7 | 85.97 | 475.9 | 450 |

[a] The average lifetimes were calculated using the equation