

Electronic Supplementary Information for
Formation of highly luminescent nearly monodisperse carbon quantum
dots via emulsion-templated carbonization of carbohydrates

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Experimental details

Synthesis of carbon quantum dots (CQDs). All chemicals were purchased from Sigma-Aldrich and used as received unless otherwise specified. 1-octanol (oil phase, 10 mL) was degassed in a reaction flask under argon for 1 h. To form emulsions, a 10 wt% aqueous solution of glucose (water phase, 1 mL) was injected into the flask containing degassed 1-octanol and the mixture was aged at 80 °C under vigorous stirring for 1 h. To the mixture was then added hexadecylamine (800 mg) and the temperature was elevated to 160 °C under argon to initiate the carbonization. The temperature was kept for 2 h to complete the formation of CQDs capped with hexadecylamine. The resulting colloidal CQDs were washed with methanol three times and finally re-dispersed in octane (5 mg mL⁻¹).

Synthesis of acid-treated CQDs. 0.1 M inorganic acid solutions (H₂NO₃, H₂SO₄, H₃PO₄) were prepared by diluting the commercially available acids. The acid solution (1 mL) was injected into the reaction flask immediately following to the addition of the glucose solution. The subsequent procedures were the same as described above for the synthesis of CQDs.

Characterization. Fourier transform infrared (FT-IR) spectroscopy was performed using a spectrometer (Nicolet 6700, Thermo) Absorbance spectra were recorded using a spectrophotometer (Optizen POP, Mecasys). Photoluminescence spectra were measured using a fluorometer (FP-6500, Jasco). Transmission electron microscope (TEM) images were obtained using Jeol JEM-2200FS with the image Cs-corrector at an accelerating voltage of 200 kV. Quantum yield measurements were referred to Lakowicz, J. R. "Principles of Fluorescence Spectroscopy", 2nd Ed., 1999, Kluwer Academic/Plenum Publishers, New York. Quinine sulphate in 0.1 M H₂SO₄ (the literature quantum yield of 54% at 360 nm) and Coumarin 6 in ethanol (the literature quantum yield of 78% at 420 nm) were used as a standard. Quantum yields were estimated by the following equation:

$$Q = Q_s \left(\frac{I}{I_s} \right) \left(\frac{F_s}{F} \right) \left(\frac{n}{n_s} \right)^2$$

where Q is the quantum yield, I is the integrated area under the emission spectrum, F is the absorbance (optical density, D) at the excitation wavelength ($F = 1 - 10^{-D}$), and n is the refractive index of the solvent. In all cases, the subscript “S” stands for the standard. For all measurements, the 10 mm cuvettes were pre-stored under the excitation wavelength in order to minimize re-absorption.

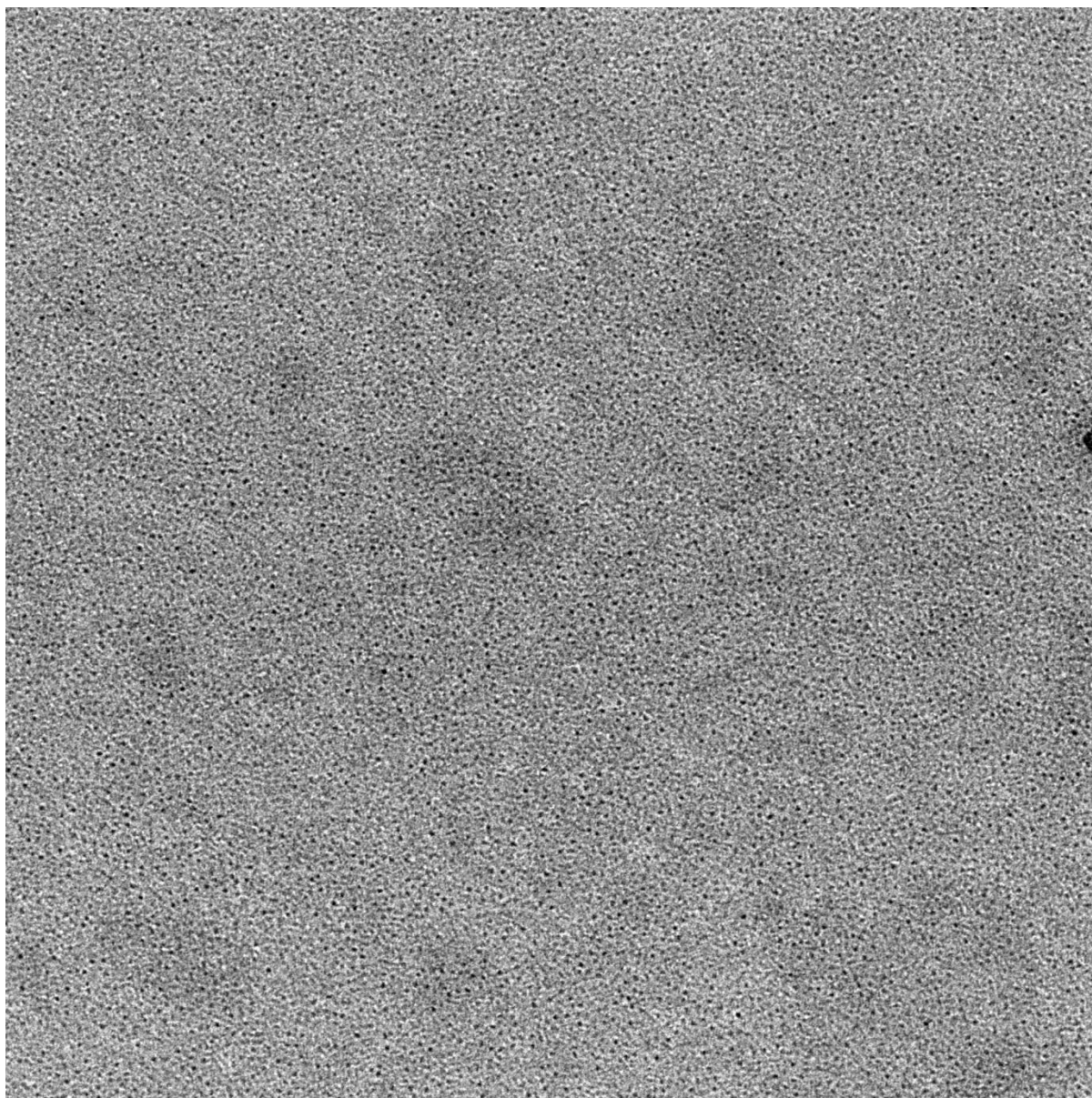


Fig. S1 A low magnification TEM image of nearly monodisperse ultrasemiconductor quantum dots for the population statistics ($N \sim 500$).

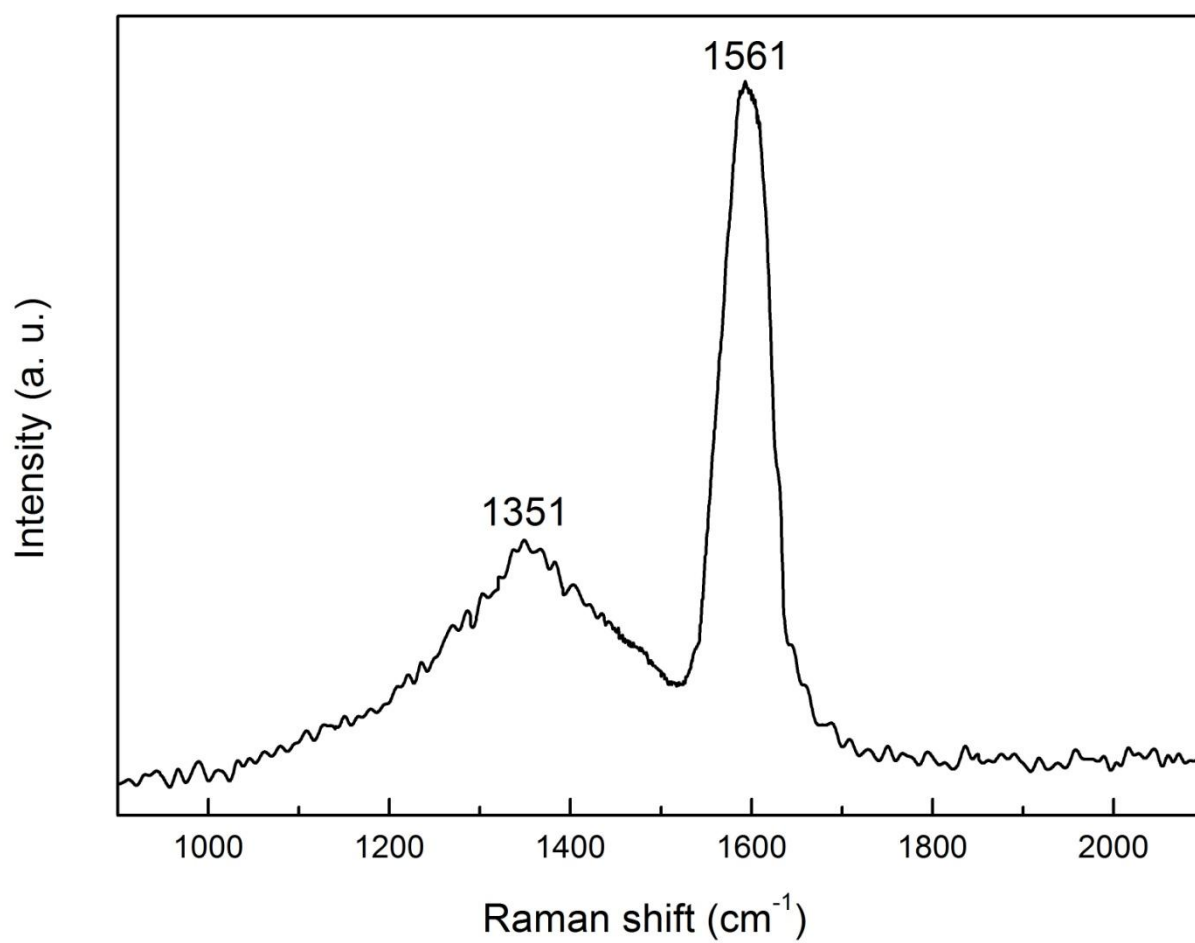


Fig. S2 Raman spectra of as-prepared GQDs. The G band at around 1561 cm⁻¹ is much more prominent than the D band at around 1351 cm⁻¹.

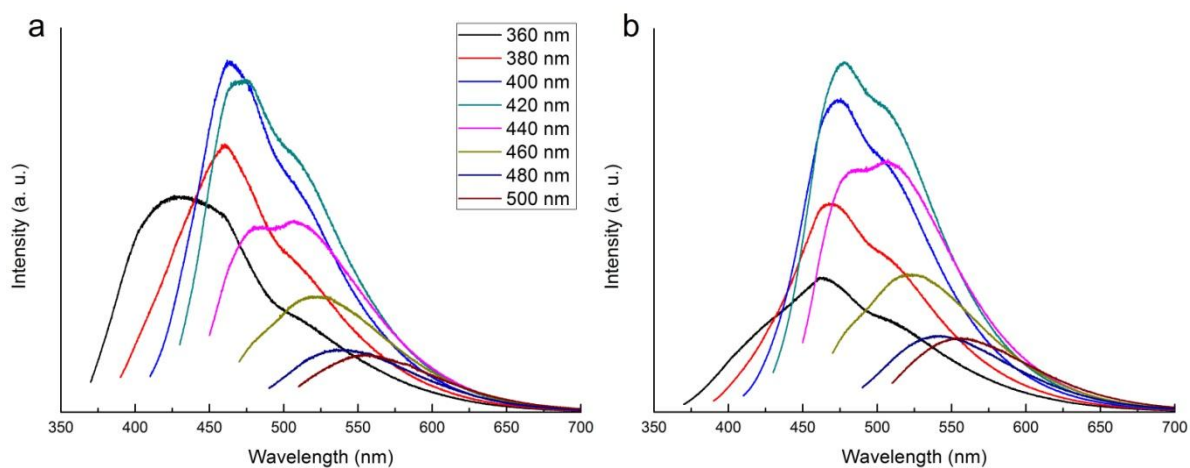


Fig. S3 Emission spectra of (a) original and (b) nitric acid-treated CQDs at various excitation wavelengths. The color coding represents the excitation wavelength and is the same for both graphs.

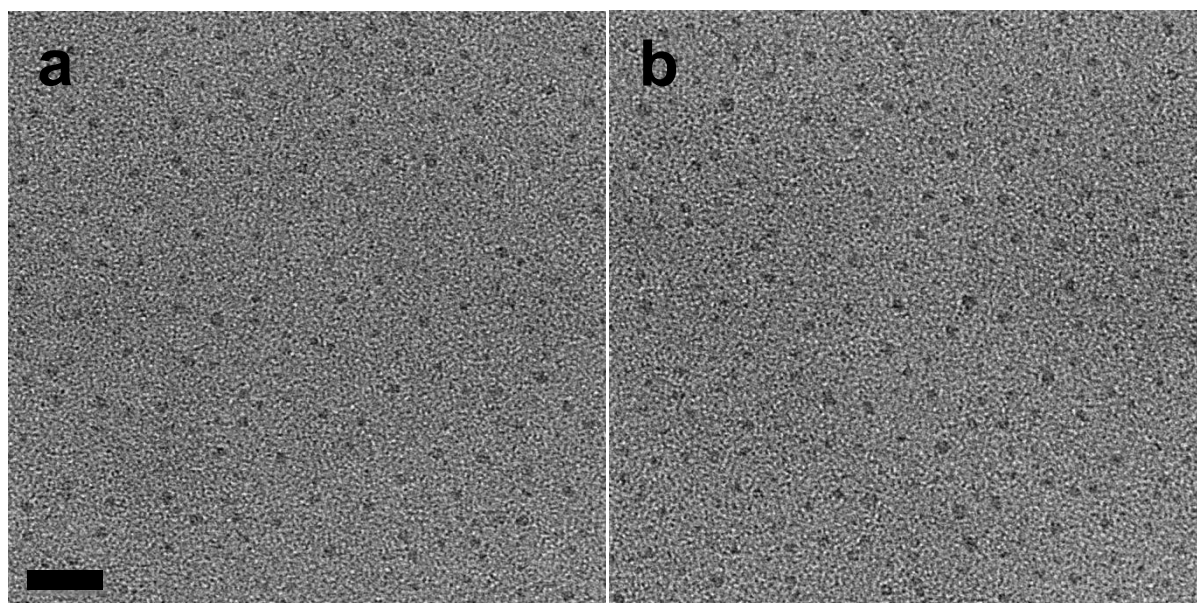


Fig. S4 The size of CQDs (a) without and (b) with the nitric acid treatment. The scale bar represents 10 nm for both images. No significant change is induced in their size irrespective of the acid treatment.

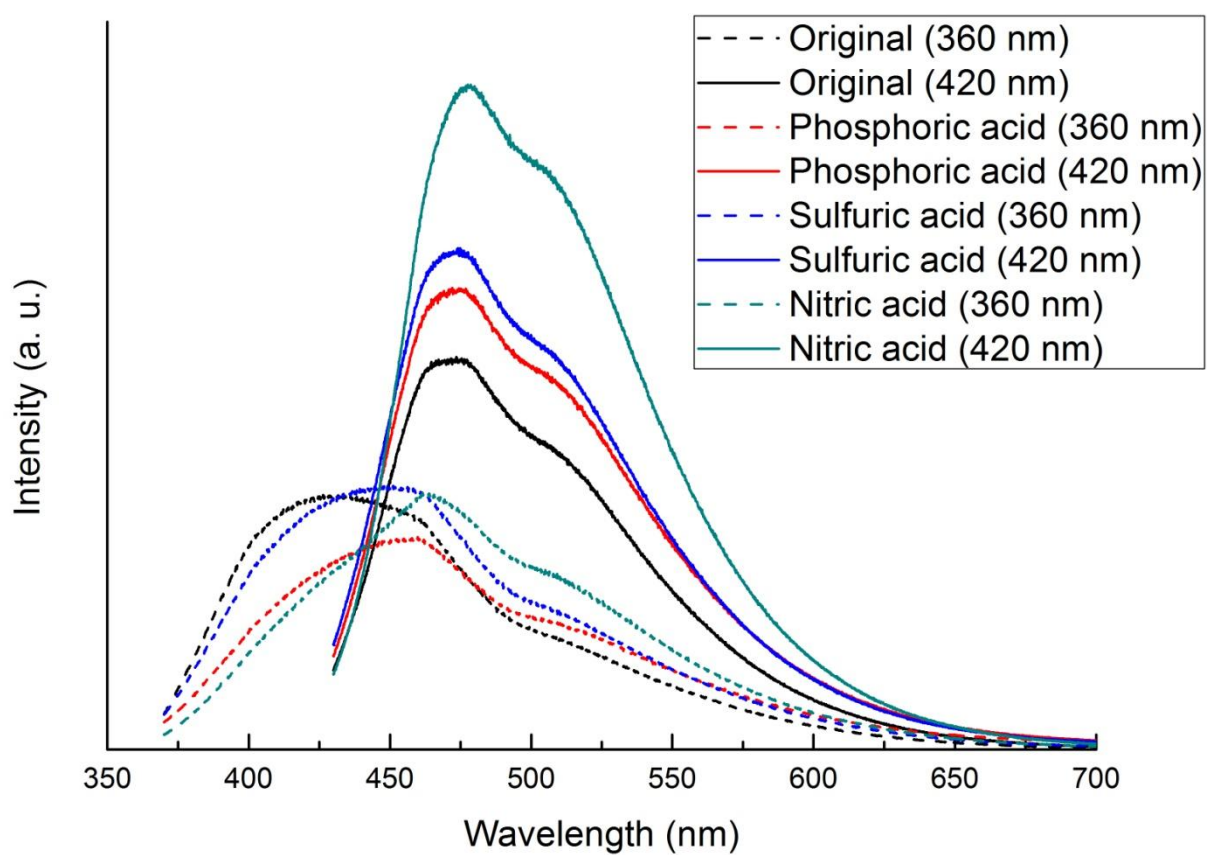


Fig. S5 Emission spectra (dashed and solid lines for 360 and 420 nm excitation, respectively) of original and acid (phosphoric, sulfuric, and nitric)-treated CQDs.

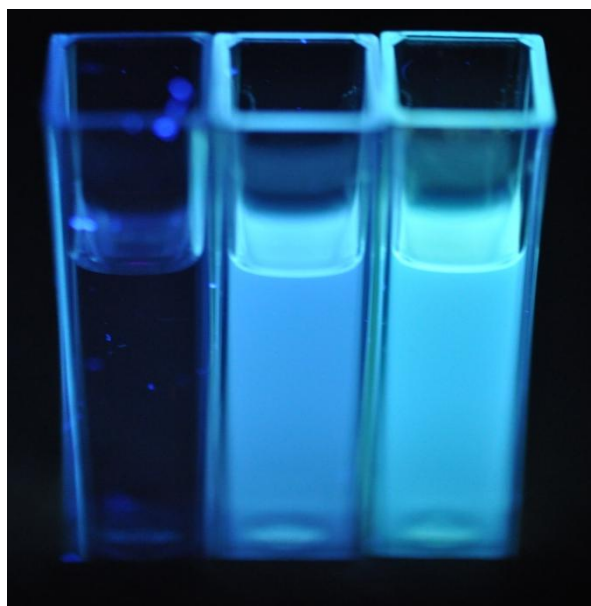


Fig. S6 Emission from original (middle) and nitric acid-treated (right) CQDs (dissolved in octane) under UV illumination (365 nm). The leftmost is pure octane for comparison. The nitric acid-treated CQDs exhibit more “green” emission due to the red shift of the emission peak near 360 nm excitation.

