Electronic Supplementary Material (ESI) for RSC Advances

Supporting Information

Tuning of photoluminescence on different surface functionalized carbon quantum dots

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Materials and Methods:

Chitosan, alginic acid, γ-butyrolactone were purchased from Sigma Aldrich, whereas starch, polyethylene glycol, cadmium acetate, copper acetate, stannous chloride, zinc acetate, diethylene glycol, triethanol amine, N-methylpyrollidone were received from Merck India. All the chemicals were of analytical grade and used without further purification.

In our typical experiment, 10 mg of chitosan, starch and alginic acid was separately dissolved in 100 mL of milli-Q water with constant stirring. Acidic medium was maintained during the preparation of chitosan solution by adding 1 mL of acetic acid. The solutions were then filtered to remove undissolved substances to obtain a clear solution. In a typical synthesis of quantum dots; 5 mL of the above solutions were taken individually in three different beakers and 30 mL of polyethylene glycol (Mol. Wt. 200; PEG-200) was mixed in each of the above solutions. Finally those mixtures were heated in a microwave oven operating at 450 watt for 5-6 minutes till the colour of the solutions turned to deep brown. Influence of divalent metal ions were verified by introducing 5 mL 1×10^{-3} M solutions of $Cd^{2+,}$ Cu^{2+}, Sn^{2+} and Zn^{2+} in each set separately prior to the commencement of reaction for quantum dots. Similarly the influence of organic solvents were investigated by adding 5 mL of N-methylpyrollidone, γ-butyrolactone, diethylene glycol, triethanol amine and aniline separately into each and every sets of reactions starting from the same precursors.

Characterizations:

Fourier Transform Infrared Spectroscopy (FTIR) was conducted by Perkin-Elmer spectrum RX-1 IR spectrophotometer, whereas absorption and fluorescence measurements were done by Shimadzu absorption spectrophotometer (model no: UV-1700) and Hitachi spectrofluorimeter

(model no: F-7000) respectively. Very diluted dispersion of unmodified and modified CQDs in PEG-200 were tested directly for PL measurements. Prior to PL analysis UV-Vis absorbances of all the CQDs were adjusted to same. High-resolution transmission electron microscopy (HRTEM) and EDAX were carried out by using JEOL JEM 2010 electron microscope, operating at an acceleration voltage of 200 kV. For HR-TEM analysis a very dilute aqueous suspension was prepared, which was then deposited on a copper grid and finally dried in air. Fluorescent microscopic analyses along with their corresponding optical images were carried out by using a Carl Zeiss-Axiolab fluorescent microscope. Time Correlated Single Photon Counting (TCSPC) lifetime measurement was carried out by using a picosecond diode laser at 370 nm (IBH, Nanoled) as a light source and the signal was taken at magic angle (54.7^{o}) polarization using an Hamamatsu MCP PMT (3809U). The data analysis was evaluated by using IBH DAS, version 6, and decay analysis software.

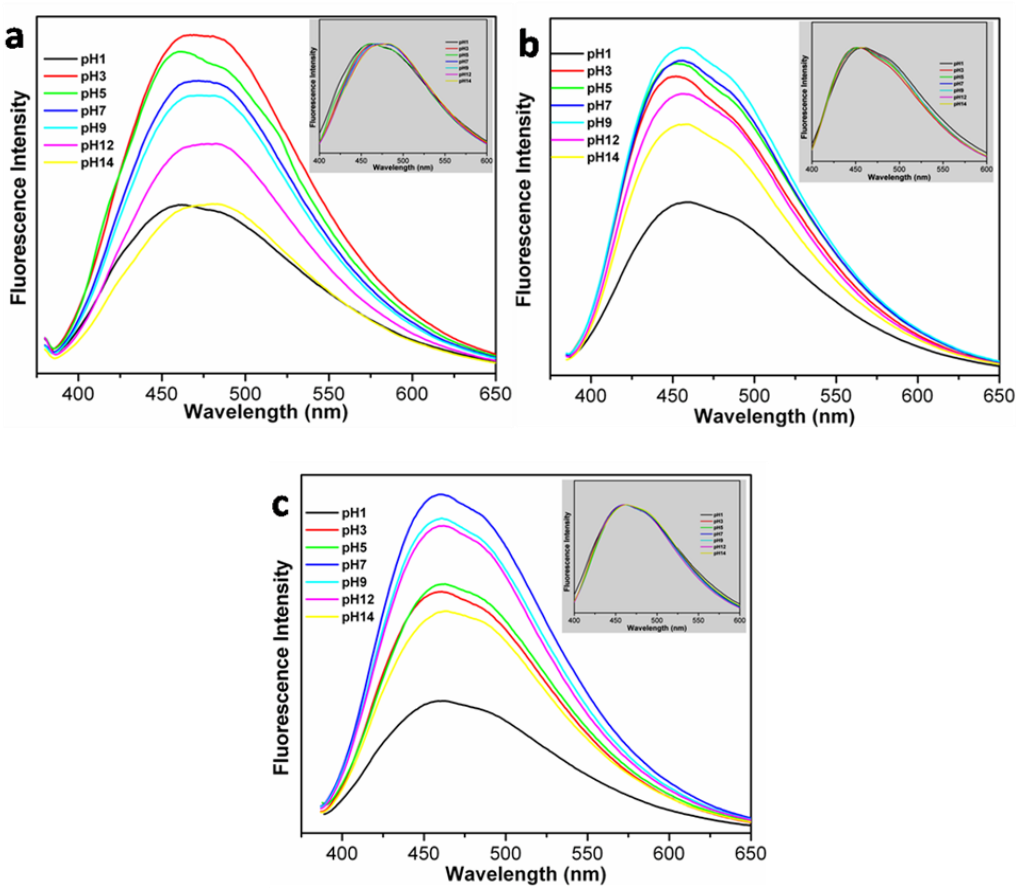

Figure S1. Fluorescence spectra of (a) CCQD, (b) ACQD and (c) SCQD against the variation of pH. The inset images in each figure represent the corresponding normalized florescence intensity.

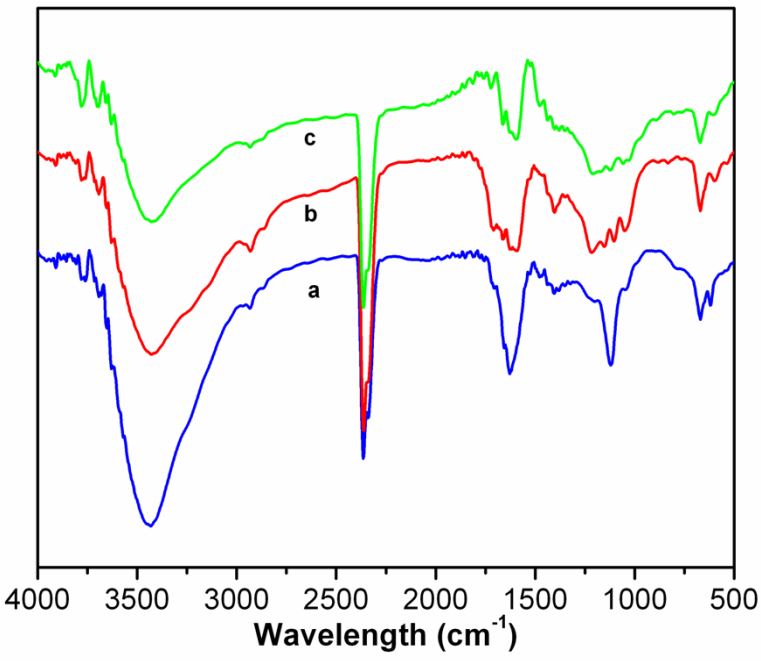

Figure S2. FTIR spectra of the carbons made from (a) alginic acid, (b) chitosan and (c) starch.

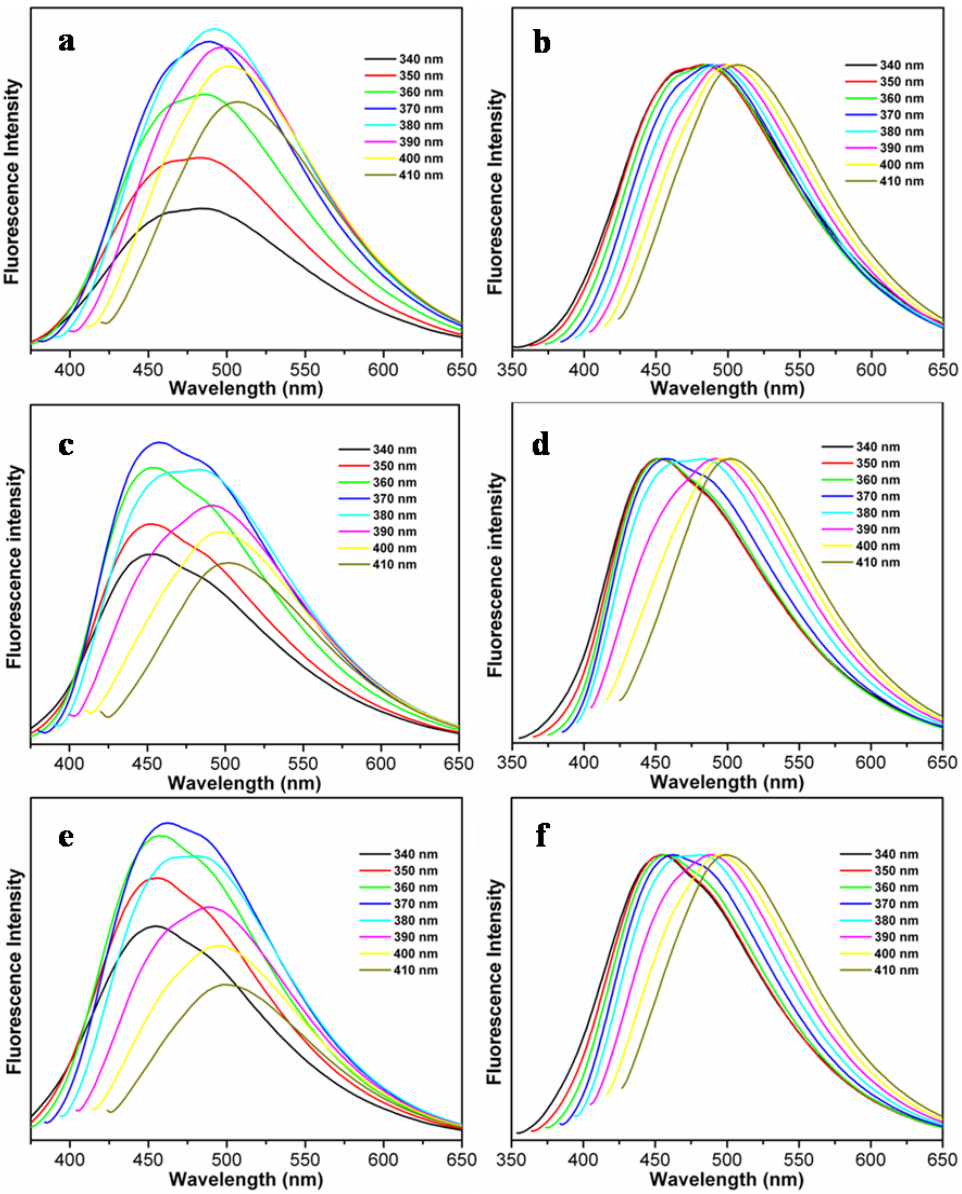

Figure S3. Fluorescence emission spectra of (a) CCQD, (c) ACQD and (e) SCQD with variation of wavelength from 340 to 410 nm. The corresponding normalized fluorescence intensity for CCQD, ACQD and SCQD are shown in figure (b), (d) and (f) respectively.

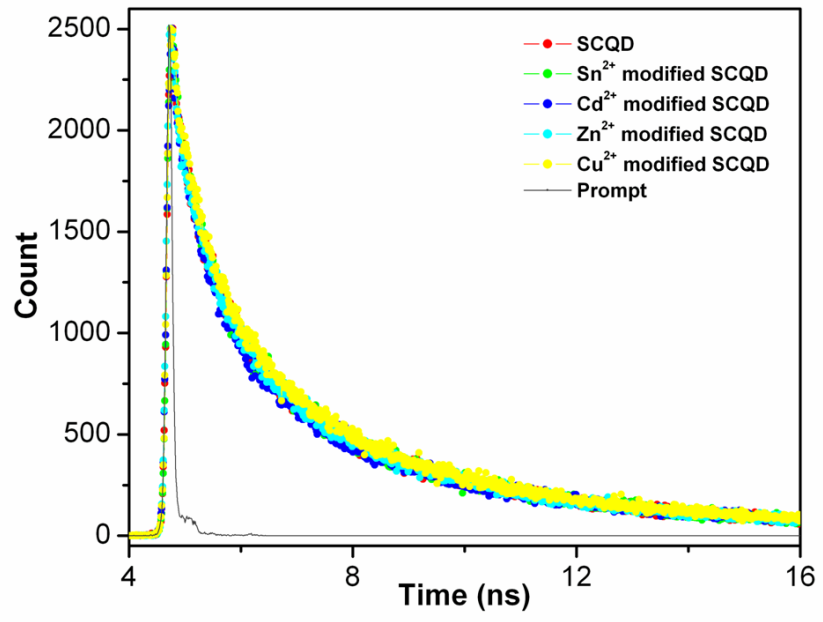

Figure S4. Fluorescence decay for unmodified and metal ions modified SCQD.

Table1 TCSPC data for SCQD and different metal ions modified SCQD.

Substance	a_1	τ_1 **(ns)**	a_2	τ_2 **(ns)**	a_3	τ_3 **(ns)**	$\langle\tau\rangle$ **(ns)**	χ^2
SCQD	0.3585	1.93	0.5255	0.27	0.1160	6.83	1.63	0.98
Sn^{2+} modified SCQD	0.3542	1.82	0.5258	0.236	0.1204	6.54	1.56	0.99
Cd^{2+} modified SCQD	0.3459	2.02	0.5436	0.30	0.1104	7.20	1.66	0.97
Zn^{2+} modified SCQD	0.3606	1.96	0.5271	0.25	0.1125	6.87	1.61	1.022
Cu^{2+} modified SCQD	0.3707	2.07	0.5094	0.31	0.1195	6.98	1.76	0.95

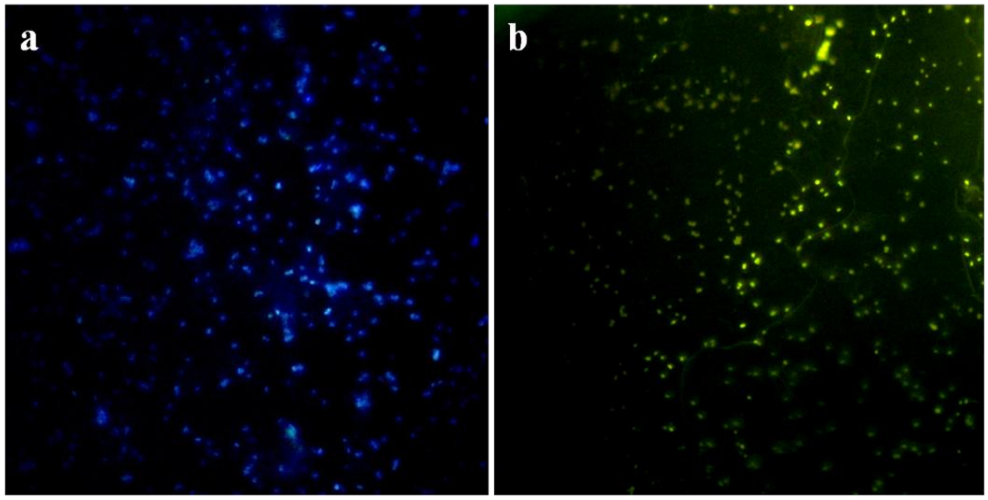

Figure S5. Fluorescence labeling of *S. aureus* after incubation with Sn^{2+} modified SCQD. All of those bacterial cells emit bright blue and green fluorescent light at (a) 410 and (b) 360nm excitation respectively under a fluorescent microscope.