Electronic Supplementary Material

A novel permanganate–morin–CdS quantum dots flow injection chemiluminescence system for sensitive determination of vancomycin

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1. Optical characteristics of synthesized CdS QDs

Investigation of the optical properties of four types of CdS QDs which were prepared in different heating times (3, 4, 5, and 6 h) was performed by implementation the room temperature UV-Vis absorption and PL spectra represented in Figures S1a and S1b, respectively. As it can be verified in the spectra indicated in figures, with the increase of colloidal preparation time, the first exciton peak (1_{sh}-1_{se}) in the absorption (Figure S1a) and the PL peaks (Figure S1b) of CdS QDs is red shifted to longer wavelengths that corresponds to the crystal growth during synthesis of QDs.
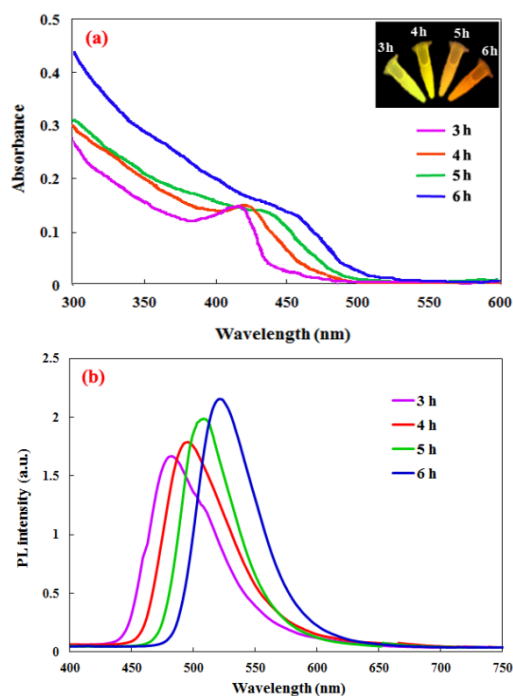

Figure S1. *(a): UV-Vis absorption and (b): PL spectra of CdS QDs after different synthesis times (3, 4, 5, and 6 h) at 150 °C. CdS QDs concentration: 1.0 mmol L^{-1}; excitation wavelength: 375 nm.*

These obtained outcomes are in a good agreement with preceding reported investigations confirming quantum confinement in the synthesized CdS QDs.[1, 2] The particle diameter determination of the as-prepared CdS QDs was performed by implementation the Peng's equation as follows:[3]

$$D = (-6.6521 \times 10^{-8})\lambda^3 + (1.9557 \times 10^{-4})\lambda^2 - (9.2352 \times 10^{-2})\lambda + 13.29 \qquad \text{(S-1)}$$

In the above expression, D (nm) and λ (nm) are representative of the determined diameter size and the wavelength of the first excitonic absorption peak of the CdS QDs, respectively. The achieved size for QDs treated with 3, 4, 5, and 6 h hydrothermal process times were 3.58, 4.07, 4.85 and 5.32 nm, respectively.

Considering the noteworthy function of the QDs in the involved CL reaction resulted in assessing band gap energy of the QDs by applying the optical absorption spectra, are represented in Figure S1a and Tauc's equation as follow expression:[4]

$$(A h\nu)^2 = K(h\nu - E_g) \qquad \text{(S-2)}$$

In the above expression, A, hν, K and E_g symbolize the absorption coefficient, the photon energy (eV), a constant and the optical direct band gap, respectively. The band gap energy for synthesized CdS QDs with 3, 4, 5, and 6 h heating times achieved by exploiting the plot of $(A h\nu)^2$ versus hν and extrapolating the linear region were 3.11, 2.96, 2.83, and 2.62 eV, respectively. Complementary information reveals that acquired values for the E_g of the prepared QDs are higher than the reported value for bulk CdS with absorption onset at 515 nm (E_g = 2.42 eV),[3] verifying quantum confinement in all synthesized CdS QDs samples.[5] Moreover, reduction in the E_g of QDs occurs with increase of particle size which ascribes to the above mentioned quantum confinement.[6]

2. FT-IR analysis of L-cysteine capped CdS QDs

To prove the existence of L-cysteine molecules to the CdS QDs surface, FT-IR spectroscopy was accomplished. Figure S2 represents the FT-IR spectra of free L-cysteine and L-cysteine capped CdS QDs samples. As is displayed in the figure, the peaks about 1550 to 1600 cm^{-1}, 1400

cm^{-1}, and 3000 to 3500 cm^{-1} (OH, COOH) can be ascribed to the stretching vibration of a carboxyl group. The peaks around 2900 to 3420 cm^{-1}, 600 to 800 cm^{-1}, and 2550 to 2750 cm^{-1} can be attributed to absorption peaks of –NH$_2$, C–S, and –S–H groups, respectively.[7, 8] Comparing two spectra in the figure revels that the stretching band of the thiol group (2550 to 2670 cm^{-1}) is not clearly observable in the FT-IR spectrum of L-cysteine capped CdS QDs which is in the consequence of capping of L-cysteine on the surface of the CdS QDs.
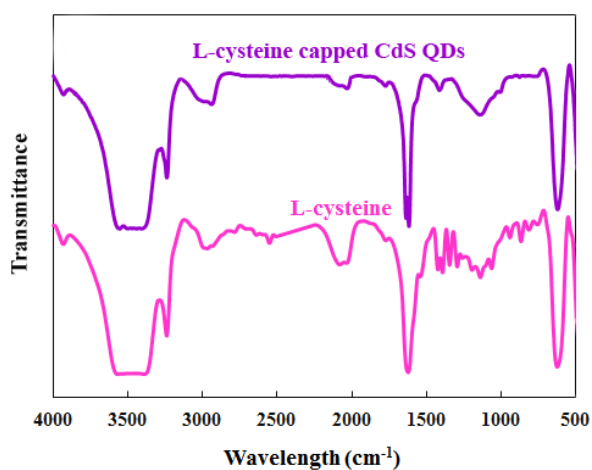

Figure S2. *FT-IR spectra of L-cysteine and the synthesized CdS QDs.*

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