Fetal Bovine Serum-Mediated Enhancement of Cerium Oxide-Based Luminescent Sensors for Hydrogen Peroxide Detection

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Reactive oxygen species (ROS) such as hydrogen peroxide (HP), hydroxyl radicals and superoxide anions play a significant role in biological processes utilized by living cells as signaling molecules and immune agents. At the same time, an increase of the level of ROS within cells can trigger inflammation, DNA and protein damage, and even cell death. Therefore, controlling the level of ROS in biological systems is a challenging task.

For luminescent HP sensing both organic molecules (such as dichlorodihydrofluorescein diacetate, dihydrorhodamine and Amplex Red (Invitrogen)) and inorganic NPs are used. Inorganic HP sensors have an advantage of higher stability and reversibility compared to organic molecules. Another advantage of HP sensors based on doped NPs compared to organic sensors is the ability for time-resolved measurements providing the change of HP concentration in dynamics, while the organic sensors are non-reversible and therefore can detect the total amount of HP generated, but not the instantaneous HP concentration. In this study Ce^{3+} luminescence intensity of cerium oxide NPs is used for monitoring the HP concentration.

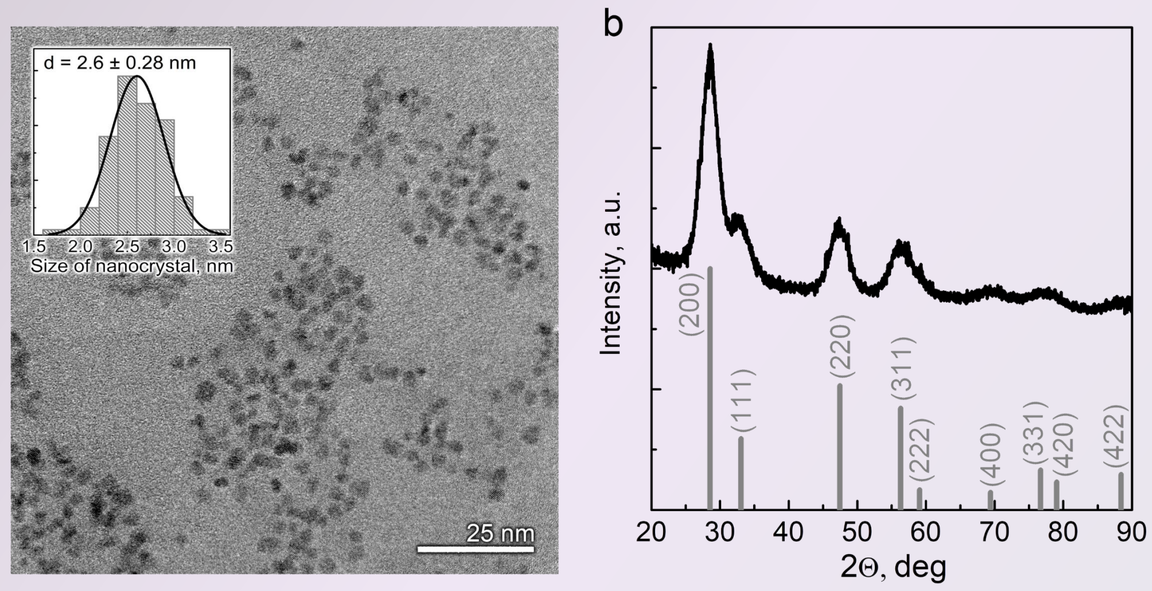

Fig1. TEM image with size distribution shown in the inset (a) and XRD (b) of CeO_{2-x} NPs

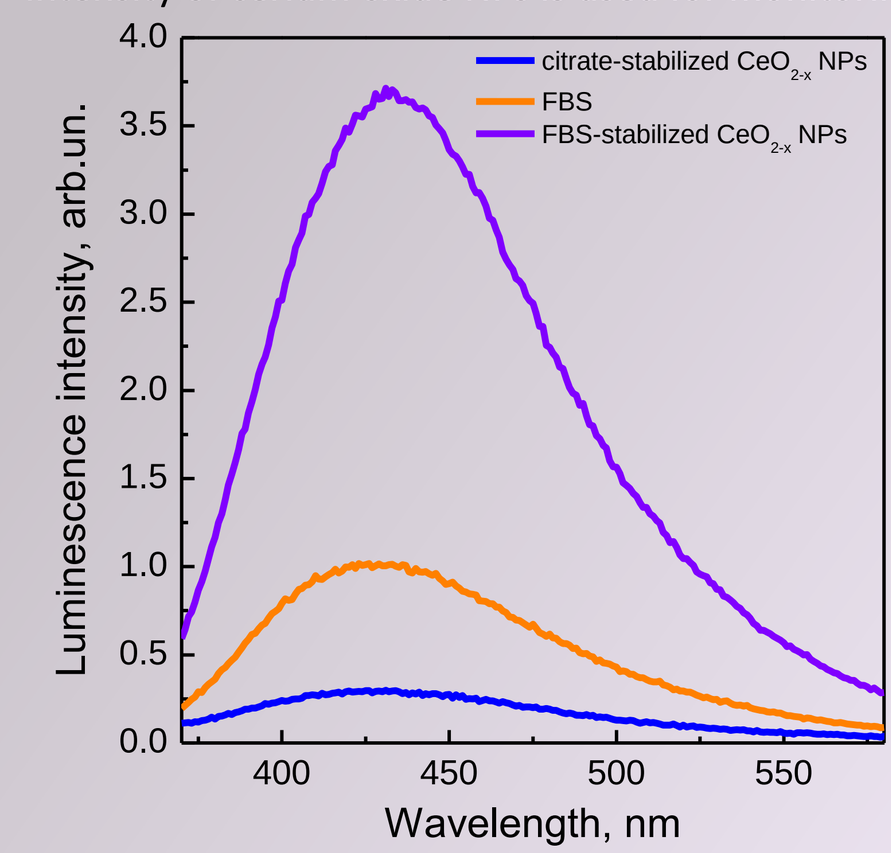

Fig2. Luminescence of water solutions of citrate-stabilized CeO_{2-x}, FBS, and FBS-stabilized CeO_{2-x}

	CeO_{2-x}	CeO_{2-x} DMEM	CeO_{2-x} Hanks	CeO_{2-x} C199
Mean hydrodynamic diameter (nm), without FBS	8.1	599.7	859.2	793.5
Mean hydrodynamic diameter (nm), with FBS (10 %)	195.0	217.5	195.8	202.1

Tab1. Mean hydrodynamic diameters of CeO_{2-x} NPs in biological media (DMEM, Hanks, C199) with and without FBS measured by DLS techniques

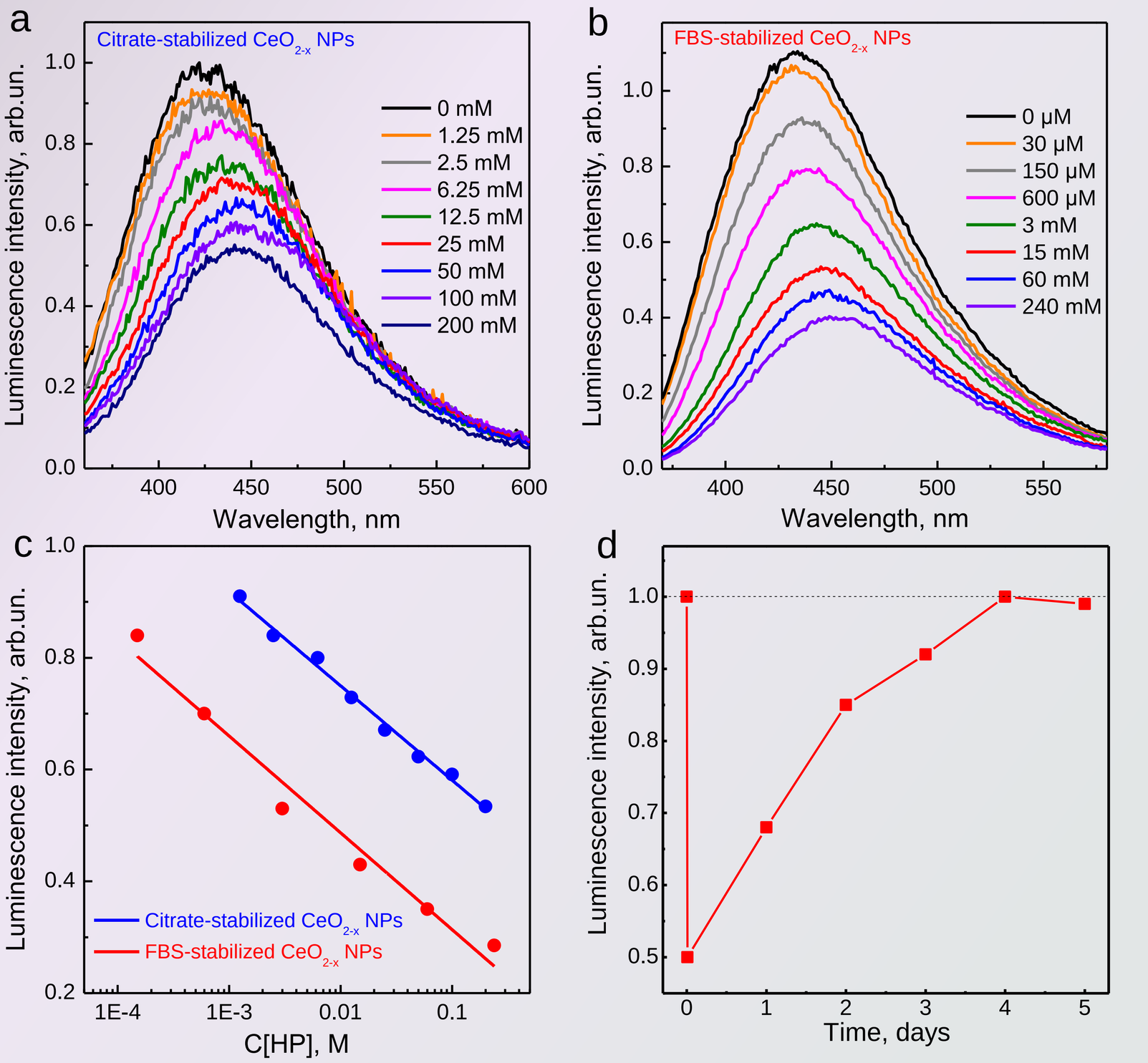

Fig3. Luminescence spectra of citrate-stabilized CeO_{2-x} NPs (a), and FBS-stabilized CeO_{2-x} NPs (b) after addition of HP. (c) Dependences of Ce^{3+} luminescence intensity on HP concentration in semi-log scale. (d) Recovery of Ce^{3+} luminescence intensity after HP addition of FBS-stabilized CeO_{2-x} NPs

Luminescent sensors based on the FBS-stabilized cerium oxide nanoparticles have a number of advantages when using for hydrogen peroxide sensing in biological media with high ionic strength. The fetal bovine serum both improves the colloidal stability of cerium oxide nanoparticles and stimulates $Ce^{4+} \rightarrow Ce^{3+}$ reduction leading to an increase in the intensity of Ce^{3+} luminescence of cerium oxide nanoparticles. FBS-stimulated increase in the luminescence intensity of NPs provides higher sensitivity to HP with linear concentration dependences from tens of μM to hundreds of mM. The luminescence sensors based on the FBS-stabilized cerium oxide nanoparticles are reversible due to $Ce^{3+} \leftrightarrow Ce^{4+}$ regeneration ability in nanoceria and able for multi-use in biological media.

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