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Optimal Concentration of Fluorescent Nanodiamonds in Aqueous Media for Bioimaging and Thermometry Applications

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Abstract : Nanodiamonds have been widely studied for their physical properties, including chemical inertness, biocompatibility, optical transparency from the ultraviolet to the infrared region, high thermal conductivity, and mechanical strength. In this work, we studied how the fluorescence spectrum of nanodiamonds quenches concerning the concentration in aqueous solutions systematically ranging from 0.1 to 10 mg/mL. Our results demonstrated a non-linear fluorescence quenching as the concentration increases for both of the NV zero-phonon lines; the 5 mg/mL concentration shows the maximum fluorescence emission. Furthermore, this behaviour is theoretically explained as an electronic recombination process that modulates the intensity in the NV centres. Finally, to gain more insight, the FRET methodology is used to determine the fluorescence efficiency in terms of the fluorophores' separation distance. Thus, the concentration level is simulated as follows, a small distance between nanodiamonds would be considered a highly concentrated system, whereas a large distance would mean a low concentrated one. Although the 5 mg/mL concentration shows the maximum intensity, our main interest is focused on the concentration of 0.5 mg/mL, which our studies demonstrate the optimal human cell viability (99%). In this respect, this concentration has the feature of being as biocompatible as water giving the possibility to internalize it in cells without harming the living media. To this end, not only can we track nanodiamonds on the surface or inside the cell with excellent precision due to their fluorescent intensity, but also, we can perform thermometry tests transforming a fluorescence contrast image into a temperature contrast image.

Keywords : nanodiamonds, fluorescence spectroscopy, concentration, bioimaging, thermometry
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