Absorption and fluorescence spectroscopy of functionalized magnetic nanodiamonds

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Exceptional mechanical, thermal and optical properties of nanodiamonds (NDs) are attracting attention in various fields. In particular their low toxicity and biocompatibility combined with ability to easily penetrate into living cells [1] open a way to use them in biomedicine in capacity of fluorescent labels for bioimaging or optical sensors of the biochemical reactions [2]. However, it is worth noting that essential dependence of the NDs' properties on the fabrication methods is an important drawback in the extensive and diverse research activity addressing the NDs applications.

In this work, we employed steady-state absorption and fluorescence spectroscopy, fluorescence microscopy and time-resolved fluorescence spectroscopy to study magnetic nanodiamonds (RayND-M) produced by pulsed laser ablation [3]. These NDs have a cubic diamond lattice in the core and chemically active graphitic shell at the average diameter of about 5.0 nm and possess ferromagnetic properties.

Two resonances dominate the extinction spectrum of the prepared suspensions. The first peak, at 276 nm, is probably due to π–π^* transition of sp_2-hybridized carbon atoms of the graphitic shell and enhanced by the quantum confinement effect [4]. The second one, around 390 nm, is less pronounced and is probably associated with a presence of oxygen functional groups (C=O/COOH) attached to the shell surface or with lattice defects and impurities in the single crystal diamond core [5].

At high concentrations of NDs (0.01% – 0.05%) in an aqueous solution the Rayleigh scattering dominates extinction spectra because the extinction coefficient shows λ^{-4} dependence on the wavelength. At lower concentrations, the optical losses decrease according to the λ^{-2} law, which corresponds to the absorption of light by sp2-hybridized carbon layer on the surface of NDs [6].

Fluorescence in nanodiamonds is more often caused by the presence of impurities, defects and etc. either the lattice or the surface. The NDs are characterized by excitation-dependent fluorescence in the visible region. The dependence of fluorescence maxima position on the excitation wavelength is due to the different contribution of oxygen-containing groups (such as OH, ketone C═O, and ester C═O) on the surface of NDs in absorption.

Thus, investigated NDs are unique multifunctional nanoobjects, which combine magnetic and specific fluorescent properties and can be successfully employed for image-guided magnetic separation of living cells [6].

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