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Cellular imaging by green luminescence of Tb(III)-doped aminomodified silica nanoparticles

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ABSTRACT

The work introduces Tb(III)-centered luminescence of amino-modified silica nanoparticles doped with Tb(III) complexes for cellular imaging. For these purposes water-in-oil procedure was optimized for synthesis of 20 and 35 nm luminescent nanoparticles with amino-groups embedded on the surface. The obtained results indicate an impact of the nanoparticle size in decoration, aggregation behavior and luminescent properties of the nanoparticles in protein-based buffer solutions. Formation of a protein-based corona on the nanoparticles surface was revealed through the effect of the nanoparticles on helical superstructure of BSA. This effect is evident from CD spectral data, while no any size impact on the adsorption of BSA onto aminomodified silica surface was observed. Cellular uptake of the nanoparticles studied by confocal and TEM microscopy methods indicates greater cellular uptake for the smaller nanoparticles. Cytotoxicity of the nanoparticles was found to agree well with their cellular uptake behavior, which in turn was found to be greater for the smaller nanoparticles.

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1. Introduction

Rapid development of fluorescent cell imaging techniques is a reason for increasing interest in sensitive and versatile imaging agents [1–7]. The latter are well represented in literature [1–7] by metal complexes, quantum dots and fluorescent organic molecules, which can be applied either itself or as fluorescent labels of biomolecules. Molecular beacons, which are oligonucleotides modified by fluorescent and quenching dye moieties at opposite ends of the oligonucleotide chain, are worth noting as selective imaging agents for living cancer cells [7]. Imaging agents with lanthanide-centered luminescence [8–11] has gained great attention during recent decades as promising alternative to the abovementioned fluorophores. Unique photophysical properties of the lanthanide ions such as emission in the UV, visible or NIR regions depending on the Ln(III) ions, large Stokes shift, sharp line-like emission bands, a long luminescence lifetimes, typically in the millisecond range and low propensity to photobleaching [8] are worth noting as reasons for this attention. Development of lanthanide-based imaging agents is represented by both molecular and nanoparticulate routes. The advantage of molecular complexes for bioimaging arises from well-known antennae-effect of ligand environment [8,9,12] which enables to gain in luminescence efficiency. Nevertheless, kinetic and thermodynamic stability of lanthanide complexes still opens room for further improvement for application in bioimaging [8].

Nanoparticulate route in developing cell imaging agents provides great advantages due to restricted degradation of nanoparticles in bio-environment. The use of inorganic lanthanide-doped nanoparticles as imaging agents is well documented in literature [10,13–15], albeit an encapsulation of lanthanide complexes into polymeric nanoparticles represents promising alternative to the inorganic nanoparticles [10,13]. Silica nanoparticles due to their transparency and low hazardous effect are of particular importance [16–18]. Moreover, protective encapsulation of silica matrix around dye molecules prevents photobleaching and photodegradation phenomena common for dyes itself [19,20]. The doping of lanthanide complexes into silica nanoparticles enables to gain in luminescence efficiency resulted from antennae-effect of ligand environment, while silica

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