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Multimodal bioimaging using RE^{3+}-doped Gd_3TaO_7 nanoparticles prepared by a modified sol-gel route

Fernanda H. Borges [1,2], York E. Serge-Correales[1], Robert Mauricot[2], Marc Verelest[2], and Rogéria R. Gonçalves[1]

[1]Laboratório de Materiais Luminescentes Micro e Nanoestruturados – Mater Lumen, Chemistry Department, FFCLRP, University of São Paulo, Ribeirão Preto, Brazil
[2] Centre d'Élaboration des Matériaux et d'Études Structurales, CNRS, University of Toulouse – UPS, Toulouse, France
E-mail: rrgoncalves@ffclrp.usp.br

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Nanoparticles doped with rare earth (RE) ions have great potential for biomedical applications, as optical markers imaging and diagnostics, as well as multifunctional probes for Theranostics [1,2]. Besides the fact that they exhibit emission in the region of biological transparency windows in the near infrared (NIR), among other great advantages, these RE^{3+}-based materials can also be prepared on a nanometric scale and are highly biocompatible [3]. However, the optical imaging technique, as promising as it is, still has spatial resolution limitations when compared to other techniques [4] and the combination of two or more imaging techniques (multimodal imaging) becomes very interesting. Multimodal imaging is an emerging field and, nowadays, the goal is to obtain good contrasting capacities in different techniques in one single probe [5]. For this, RE tantalates are suitable candidates and can be explored for this application. The obtention of these materials in a nanoscale form with controlled shape is still a challenge. In this sense, in order to design RE_3TaO_7 with size and shape control, the use of the polyol method, also considered as a high-temperature sol-gel process [6], has been proved effective. Spherical RE^{3+}-doped Gd_3TaO_7 nanoparticles were synthesized by refluxing the precursors in ethyleneglycol (EG), followed by annealing at 1000 °C. Transmission electron microscopy (TEM) exhibited particles with approximately 170 nm of diameter for the annealed samples. Even for high annealing temperature, the spherical form was retained, and no formation of agglomerates was observed. Phase purity and stabilization were observed by X-ray diffraction (XRD) analysis, affording the cubic Gd_3TaO_7 crystalline phase. Raman spectroscopy was used to confirm the formation of the cubic phase, as well as luminescent spectroscopy using Eu^{3+} as a structural probe. Upconversion luminescence with intense red and NIR emission bands were observed for the samples Er^{3+}/Yb^{3+} and Tm^{3+}/Yb^{3+} co-doped Gd_3TaO_7, respectively, under 980 nm excitation. We also investigated the performance of these UC nanoparticles samples as an optical temperature sensor, along with their possible application as a multimodal imaging probe was also studied, where MR and CT studies were also conducted. These results shows that these materials present interesting luminescent features and suitable properties for application as multimodal imaging probes.

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