



Synthesis and properties of nanodisperse scintillators for photodynamic therapy of tumors of the cranial cavity and bone tissue



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Introduction / Objectives / Aims

The direction of solving the problems of minimally invasive treatment of malignant tumors located in hard-to-reach areas of the body can be the synthesis of highly efficient nanodispersed scintillators, the study of their properties and prospects for use in photodynamic and optopharmacological therapy of tumors in conditions of excitation by "soft" X-rays.

The aim of this work is to develop a promising method for the synthesis of nanosized scintillators, active in a wide range of electromagnetic radiation - from X-ray to infrared. The development of a relatively simple, economical and well-reproducible method for the synthesis of nanosized scintillators based on lanthanum fluoride doped with terbium was chosen.

Methods

- Size and microstructure of the samples were determined by a high resolution transmission electron microscope (JEOL JSM-6060);
- the morphology of the particles were characterized by employing a field emission scanning electron microscope (FE-SEM Philips XL30 FEG);
- X-ray powder diffraction XRD was performed using a DRON-UM1 diffractometer using X-ray focusing according to Bragg-Brentano, anode radiation ($\lambda = 0.179021$ nm) and Fe-filter in the reflected rays;
- luminescence spectrum was measured by using a JASCO FP-6600 spectrometer.

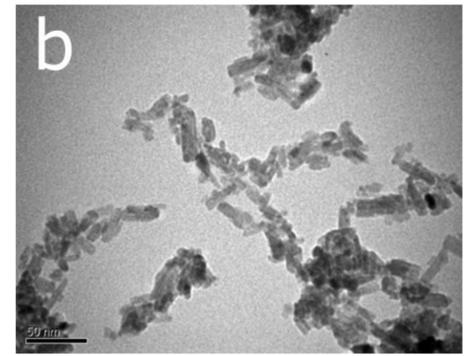
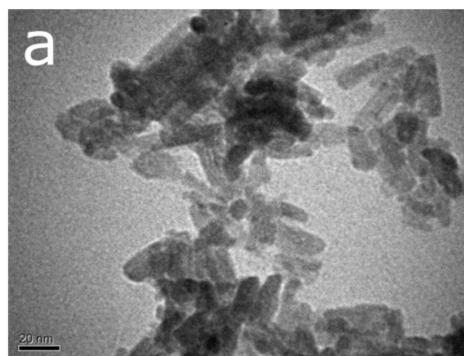
Synthesis

- Scintillation nanoparticles of $\text{LaF}_3:\text{Tb}$ up to 30 nm in size were synthesized by coprecipitation from an aqueous solution.
- As precursors used: $\text{La}(\text{NO}_3)_3 \times 6\text{H}_2\text{O}$, TbCl_3 , NH_4F ,
- All reagents meet the qualifications chemically pure. Distilled water was used as a solvent.
- Solutions of La^{3+} and Tb^{3+} salts in molar ratios of 4:1 were successively dissolved in a minimum volume of distilled water, after which a solution of NH_4F in the ratio $\text{La}^{3+}:\text{F}^- = 1:3$ was added dropwise to the mixture solution.
- The reaction mixture was stirred for 2 hours at room temperature. Finally centrifuged, washed three times with deionized water and dried at room temperature.
- The particles are well dispersed in aqueous solution and are characterized by high biocompatibility.

Low-temperature nitrogen adsorption-desorption isotherms pore distribution

Size and microstructure of the samples $\text{LaF}_3:\text{Tb}$

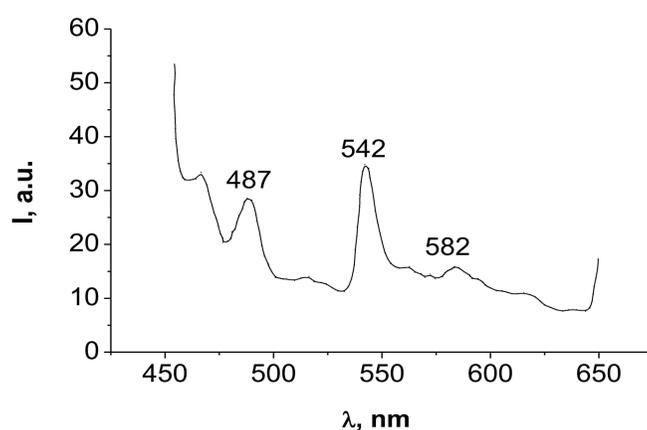
LaF_3 crystals doped with Tb^{3+} ($\text{LaF}_3:\text{Tb}$) were selected as scintillation nanoparticles. The conversion of X-rays to fluorescents is based on the mechanism by which Tb^{3+} electrons exhibit transitions in the "blue" (transitions $^5\text{D}_3 \rightarrow ^7\text{F}_j$) and "green" (transitions $^5\text{D}_4 \rightarrow ^7\text{F}_j$) regions of the spectrum, accompanied by photoluminescent effects at $\lambda = 487, 542, 582$ and 620 nm, and the mechanism of resonant fluorescence energy transfer (FRET) can lead to the activation of a photosensitizer, with an energy transfer efficiency of up to 56.7%, which induces agents for the treatment of cancer.



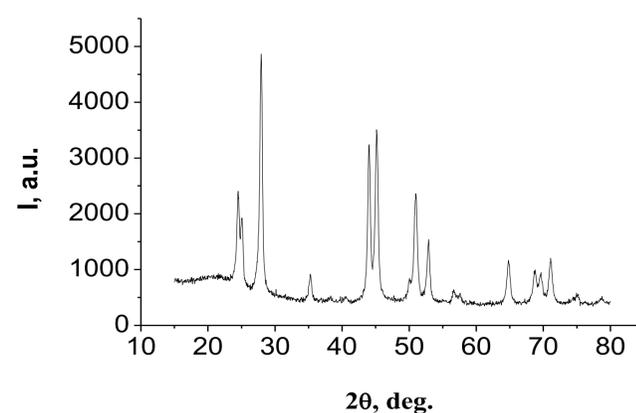
TEM images of nanoparticles $\text{LaF}_3:\text{Tb}$. Scale bar 20 nm (a); 50 nm (b)

Scintillation nanoparticles of $\text{LaF}_3:\text{Tb}$ up to 30 nm in size were synthesized by coprecipitation from an aqueous solution. The particles are well dispersed in aqueous solution and are characterized by high biocompatibility.

Luminescence spectrum and XRD study of the samples $\text{LaF}_3:\text{Tb}$



Luminescent spectrum of aqueous dispersion containing NPs $\text{LaF}_3:\text{Tb}$ under 254 nm UV excitation



XRD pattern of phases NPs $\text{LaF}_3:\text{Tb}$