Research of Morphology and Luminescence of Particles Based on Yttrium Fluorides for Medical Usage

[1] Shizuoka University, Japan
[2] Saint Petersburg State Institute of Technology, Russia
[3] ANSeeN Inc., Japan
Dorokhina Anastasia Mikhailovna [1,2], Kominami Hiroko [1], Bakhmetyev Vadim Vladimirovich [2], Toru Aoki [3], Hisashi Morii [3]

Abstract

The purpose of this experiment was to synthesize nanophosphor for use in medicine, namely, in photodynamic therapy. And also the study of the effect of duration, environment and stabilizers of solvothermal synthesis on the microstructure and luminescent properties of YF_3:Ce nanophosphor. Solvothermal synthesis was carried out in three different media: water, ethanol, and ethylene glycol. The optimal duration of the synthesis was also determined (the synthesis was carried out at a temperature of 200° C for 4...20 hours). Using SEM, the morphology and particle size of YF_3:Ce phosphors were studied depending on various stabilizers (polyethylene glycol, polyethyleneimine, polyvinylpyrrolidone).

Introduction

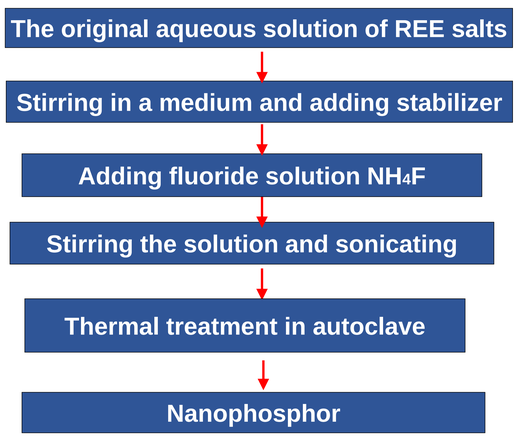
Photodynamic therapy (PDT) is a modern effective method of cancer treatment. **The main problem** limiting the use **of PDT** is the difficulty of supplying the light required to activate the photosensitizer, since body tissues absorb visible light.

A possible solution to the problem is the creation of a pharmacological preparation containing a photosensitizer and a nanophosphor that converts radiation that penetrates through the tissues of the body (X-ray or infrared) into light with a wavelength necessary for the operation of a photosensitizer.

Thus, we have now set the task to create a phosphor that meets the following requirements:

- excitation by radiation penetrating the body tissues (X-ray or γ-rays)
- emitting light in the region with the wavelength required to activate the photosensitizer
- non-toxic and harmless to the body
- particle size (no more than 100 nm)
- hydrolytic stability

Experiment



Results

The first part of the experiment: determining the optimal synthesis environment.

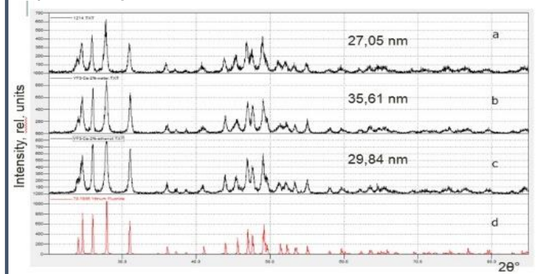


Fig. 1. Diffraction patterns of YF_3:Ce^{3+} samples synthesized in different media: a - ethylene glycol, b - water, c - ethanol, d – orthorhombic YF_3 (PDF card 70-1935).

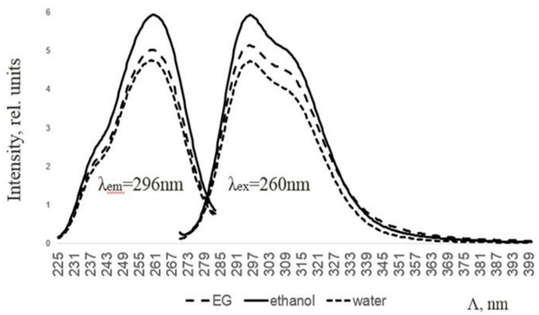


Fig. 2. Photoluminescence spectra (excitation and emission) of YF_3:Ce 2%mol. samples synthesized in various media.

The second part of the experiment: determining the optimal concentration of cerium.

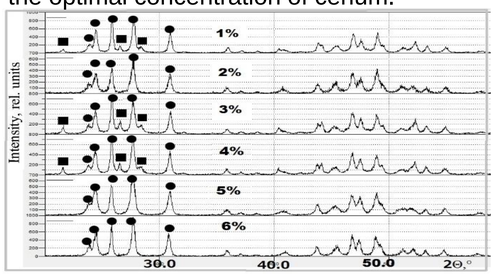


Fig. 3. X-Ray diffraction patterns with different concentrations of cerium. The circles indicate the peaks related to the orthorhombic phase, the squares - the cubic phase.

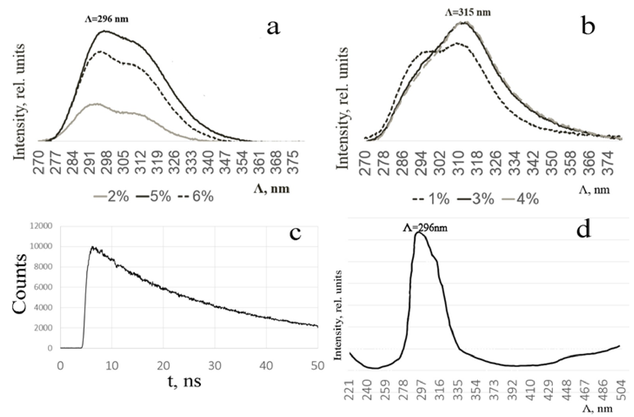


Fig. 4. Luminescence characteristics of samplesYF_3:Ce.
a - photoluminescence spectra of YF_3:Ce (orthorhombic phase);
b - photoluminescence spectra of YF_3:Ce samples (orthorhombic phase with an admixture of the cubic phase);
c - graph of decay time of YF_3:Ce 5%mol. sample;
d - X-ray luminescence spectrum YF_3:Ce 5%mol. sample).

The third part of the experiment: determining the optimal synthesis duration.

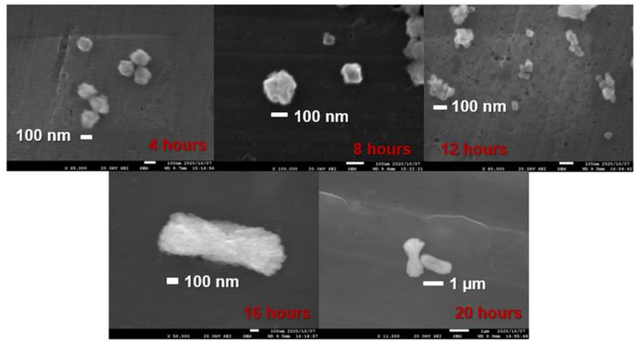


Fig.5. Micrographs of YF_3 samples synthesized for 4, 8, 12, 16 and 20 hours.

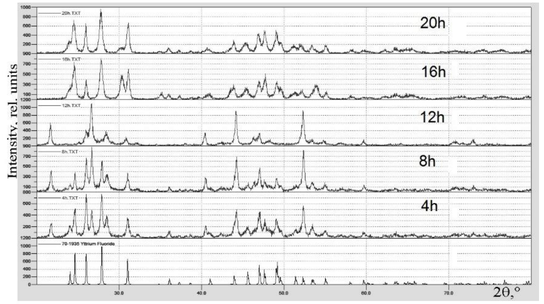


Fig. 6. X-ray diffraction patterns of YF_3 samples synthesized over different time periods.

The fifth part of the experiment: determining the optimal stabilizer (polyethylene glycol (PEG), polyethyleneimine (PEI), polyvinylpyrrolidone (PVP)).

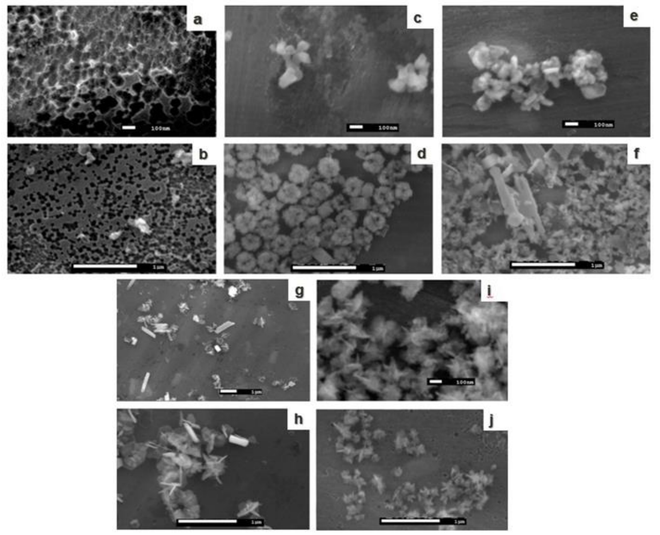


Fig. 6. Micrographs of YF_3:Ce^{3+} (5%) with various stabilizers: a, b – PEG-20000, c, d – PEG-2000, e, f – PEG-200, g, h – PEI, i, j - PVP.

Conclusions

- optimal phosphor for X-ray photodynamic therapy is yttrium fluoride with a cerium concentration of 5 mol%, since it has the highest luminescence intensity in the under UV and X-ray excitations.
- ethylene glycol medium was chosen, since it allows one to obtain particles less than 100 nm with good colloidal stability.
- as a stabilizer among PEG, PEI and PVP, PEG-20000 has proven itself in the best way. However, PVP also holds promise due to its shortened synthesis time