**The influence of concentrations of sensitizers and activators
on luminescence kinetics parameters of upconversion nanocomplexes NaYF4:Yb3+/Tm3+**

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Table S1. Rise times of the luminescence signal of nanoparticles β-NaYF4:Yb3+/Tm3+ for all samples.

|  |  |  |  |
| --- | --- | --- | --- |
| sample number | 450 nm | 475 nm | 800 nm |
| 1 | 144 | 193 | 312 |
| 2 | 100 | 138 | 244 |
| 3 | 80 | 116 | 218 |
| 4 | 61 | 109 | 216 |
| 5 | 224 | 276 | 420 |
| 6 | 176 | 222 | 384 |
| 7 | 85 | 120 | 216 |
| 8 | 67 | 107 | 160 |

Table S2. Decay times of the luminescence signal of nanoparticles β-NaYF4:Yb3+/Tm3+ for all samples.

|  |  |  |  |
| --- | --- | --- | --- |
| sample number | 450 nm | 475 nm | 800 nm |
| 1 | 186 | 245 | 362 |
| 2 | 155 | 207 | 306 |
| 3 | 142 | 214 | 332 |
| 4 | 165 | 220 | 332 |
| 5 | 250 | 416 | 572 |
| 6 | 178 | 296 | 496 |
| 7 | 149 | 220 | 318 |
| 8 | 120 | 145 | 264 |

Calculation of the average distance between ions.

The calculation of the average distances between ions was based on the following considerations:

1. Nanoparticles consist of cells of a hexagonal crystalline phase.

Such cell is described by two parameters ***a*** and ***c*** (Table S3).

Table S3. Unit cells parameters of nanoparticles β-NaYF4:Yb3+/Tm3+ for all samples.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| sample number | thulium, % | ytterbium, % | a, nm | c, nm |
| 1 | 4 | 10 | 0.59745 | 0.35196 |
| 2 | 4 | 14 | 0.59734 | 0.35166 |
| 3 | 4 | 18 | 0.59723 | 0.35134 |
| 4 | 4 | 22 | 0.59717 | 0.35135 |
| 5 | 1 | 18 | 0.59728 | 0.35153 |
| 6 | 2 | 18 | 0.59731 | 0.3514 |
| 7 | 4 | 18 | 0.59723 | 0.35134 |
| 8 | 6 | 18 | 0.59707 | 0.35113 |

The volume of such a cell is equal to:

$v=\frac{\sqrt{3}}{2}a^{2}c$ (1)

1. In such a cell, sodium is located in one node of the lattice, in the other – either sodium, yttrium, ytterbium, or thulium. There is one rare earth (RE) ion per cell.
2. All rare earth ions are evenly distributed.
3. The concentration of rare earth ions (in %) is calculated based on the fact that the number of sodium ions + the number of yttrium ions + the number of ytterbium ions + the number of ytterbium ions + the number of thulium ions = 100%. So, for NaYF4:Yb/Tm (18%Yb, 2%Tm) total ytterbium+thulium ions=20%, thulium=2%, ytterbium=18%.

With such assumptions, the distances were estimated according to the following scheme:

1. The volume of one cell is found according to the formula (1).
2. The volume of nanoparticles is found (It is assumed that all of them have a spherical shape with a diameter of about 21.5 nm, according to the data of electron microscopy).
3. It is determined how many cells fit in the volume of one nanoparticle.
4. It is determined the number of cells with ytterbium and thulium ions in accordance with the concentration for a specific nanoparticle. Three numbers are found – the number of cells with ytterbium, the number of cells with thulium, the number of cells with either thulium or ytterbium (the sum of the first two).
5. Calculate the volume of the cell with the ion of interest. It is assumed that ion is situated in the center of this volume.
6. The distance between neighboring ions is determined, assuming that the volumes corresponding to the type of ions of interest are the volumes of the corresponding cubes. The distance between the ions in this case is the length of the side of the cube. The calculated distances are presented in Table S4.

Table S4. The calculated distances between rare earth ions.

|  |  |  |  |
| --- | --- | --- | --- |
| sample number | Distance between Tm3+ ions, nm | Distance between Yb3+ ions, nm | Distance between RE ions, nm |
| 1 | 1.4 | 1.03 | 0.92 |
| 2 | 1.4 | 0.92 | 0.85 |
| 3 | 1.39 | 0.84 | 0.79 |
| 4 | 1.39 | 0.79 | 0.75 |
| 5 | 2.21 | 0.85 | 0.83 |
| 6 | 1.76 | 0.84 | 0.82 |
| 7 | 1.39 | 0.84 | 0.79 |
| 8 | 1.22 | 0.84 | 0.77 |