**Supporting Information**

**Morphology evolution, energy transfer and multicolor luminescence of lanthanide-doped Ba\textsubscript{2}LaF\textsubscript{7} nanocrystals by one-step hydrothermal synthesis**

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Fig 8a shows the excitation and emission spectra of Ba\textsubscript{2}LaF\textsubscript{7}:3\%Tm\textsuperscript{3+}, only one emission peak at 455 nm in the blue region is obtained, which is derived from the \textsuperscript{3}D\textsubscript{2} \rightarrow \textsuperscript{3}F\textsubscript{4} transition of Tm\textsuperscript{3+} ions. And the strongest peak at 355 nm of the excitation spectrum is attributed to the \textsuperscript{3}H\textsubscript{6} \rightarrow \textsuperscript{1}D\textsubscript{2} transition.\textsuperscript{1,2} The excitation and emission spectra of Ba\textsubscript{2}LaF\textsubscript{7}:1\%Er\textsuperscript{3+} is shown in Fig 8b, at a wavelength of 378 nm, the emission peaks at 525 nm and 552 nm are originated from the \textsuperscript{2}H\textsubscript{11/2}/\textsuperscript{4}S\textsubscript{3/2} \rightarrow \textsuperscript{4}I\textsubscript{15/2} transition of Er\textsuperscript{3+}, respectively. And when using 552 nm as a monitoring wavelength, the excitation peaks are mainly located at 363nm (\textsuperscript{4}I\textsubscript{15/2} \rightarrow \textsuperscript{4}G\textsubscript{9/2}), 378nm (\textsuperscript{4}I\textsubscript{15/2} \rightarrow \textsuperscript{4}G\textsubscript{11/2}) and 406nm (\textsuperscript{4}I\textsubscript{15/2} \rightarrow \textsuperscript{2}H\textsubscript{9/2}).\textsuperscript{3} As for Ba\textsubscript{2}LaF\textsubscript{7}:1\%Ho\textsuperscript{3+} (Fig 8c), when excited with a wavelength of 451 nm, a single peak at 546 nm in the green region which derived from the \textsuperscript{5}S\textsubscript{2} \rightarrow \textsuperscript{5}I\textsubscript{8} transition of Ho\textsuperscript{3+} ions is obtained, and the peaks of the excitation spectrum at 360 nm, 384 nm, 416 nm, 451 nm and 484 nm are due to the transitions from the ground state \textsuperscript{5}I\textsubscript{8} to the excited state \textsuperscript{3}H\textsubscript{6}, \textsuperscript{5}G\textsubscript{4}, \textsuperscript{5}G\textsubscript{5}, \textsuperscript{6}G\textsubscript{6} and \textsuperscript{5}F\textsubscript{3} of Ho\textsuperscript{3+}, respectively.\textsuperscript{1-3} And the Ba\textsubscript{2}LaF\textsubscript{7}:2\%Dy\textsuperscript{3+} sample, there are two main emission peaks including the strongest emission peak at 480 nm (\textsuperscript{4}F\textsubscript{9/2} \rightarrow \textsuperscript{6}H\textsubscript{15/2}) in the blue region and a weaker emission peak at 575 nm (\textsuperscript{4}F\textsubscript{9/2} \rightarrow \textsuperscript{6}H\textsubscript{13/2}) in the yellow region. At the monitoring wavelength of 480 nm, the excitation spectrum of Dy\textsuperscript{3+} ions consists
of many peaks at 295, 324, 350, 364, 387 nm, which are assigned to ground level $^6H_{15/2}$ to the excited levels $^4K_{13/2} + ^5H_{15/2}$, $^4K_{15/2}$, $^6M_{15/2} + ^5P_{7/2}$, $^4I_{11/2}$ and $^4M_{21/2}^4I_{13/2} + ^4K_{17/2} + ^4F_{7/2}$, respectively. Fig 8g shows the excitation and emission spectra of $\text{Ba}_2\text{LaF}_7:2\%\text{Sm}^{3+}$, when using 599 nm as a monitoring wavelength, the excitation spectrum of $\text{Sm}^{3+}$ mainly consists of three peaks at 360, 372 and 400 nm, which are attributed to the transitions of $^6H_{5/2} \rightarrow ^4D_{5/2}$, $^6H_{5/2} \rightarrow ^6P_{7/2}$ and $^6H_{5/2} \rightarrow ^4K_{11/2}$, respectively. When using 400 nm as the excitation wavelength, the three emission peaks in the visible region near 561, 599, and 645 nm, which are assigned to the intra-4f-shell transitions from the excited level $^6G_{5/2}$ to ground levels $^6H_{5/2}$, $^6H_{7/2}$, $^6H_{9/2}$, respectively. The spectrum of $\text{Ba}_2\text{LaF}_7:10\%\text{Ce}^{3+}$ phosphor is shown in Figure 8h, at 351 nm, the doublet (263 nm and 285 nm) of $\text{Ce}^{3+}$ ions can be assigned to the transitions of $^2F_{5/2}$ and $^2F_{7/2}$ to 5d level respectively, which appears due to the strong coupling of the 5d electron with host lattice. Upon excitation at 285 nm, the emission spectrum of $\text{Ba}_2\text{LaF}_7:10\%\text{Ce}^{3+}$ phosphors display a palpable peak at 365 nm, which corresponds to the transitions from 5d to 4f state.