Supporting information

Calculation methods for luminescent quantum efficiency

For europium based materials, the emission quantum efficiency (η) of the emitting $^5D_0$ level can be determined on the basis of emission spectra together with the lifetimes and can be calculated using the following equation[1]:

$$\eta = \frac{A_r}{A_r + A_{nr}}$$

Here, A_r and A_{nr} represent the radiative and non-radiative transition rates, respectively. Among which, the A_r can be obtained by adding up the radiative rates for each $^5D_0 \rightarrow {}^7F_J$ (J = 0, 1, 2, 3, 4) transition.

$$A_r = \sum A_{0J} = A_{00} + A_{01} + A_{02} + A_{03} + A_{04}$$

Here, A_{0J} is the experimental coefficients of spontaneous emission. The branching ratio for $^5D_0 \rightarrow {}^7F_J$ (J = 5, 6) have been neglected since they are not detected in experiments, and can be ignored in the depopulation of $^5D_0$ excited state. Meanwhile, because of the independence to chemical environments, the magnetic dipole transition $^5D_0 \rightarrow {}^7F_1$ can be used as an internal reference to the whole spectra. Thus, the A_{0J} can be obtained using the following equation:

$$A_{0J} = A_{01} \times \frac{I_{0J}}{I_{01}} \times \frac{\nu_{01}}{\nu_{0J}}$$

Here, I_{01} and I_{0J} the integrated intensities of the $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_J$ (J=0—4) transitions, while the ν_{01} and ν_{0J} the corresponding energy barycenters. According to the reports of references, A_{01} in this equation can be calculated by the expression $A_{01} = 0.31 \times 10^{-11} n^3 (\nu_{01})^3$, and it's value can be determine to be 50 s^{-1} approximately[2]. Furthermore, the luminescent lifetime, radiative and non-radiative transition rates can be related through the following equation[3]:

$$\frac{1}{\tau} = A_r + A_{nr}$$

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1 E. E. S. Teotonio, J. G. P. Espinola, H. F. Brito, O. L. Malta, S. F. Oliveira, D. L. A. de Faria and C. M. S. Izumi, *Polyhedron*, 2002, 21, 1837.

2 W. T. Carnall, H. Crosswhite, H. M. Crosswhite, *Argonne National laboratory Report*, 1978, unnumbered.

3 H. J. Zhang, W. Q. Fan, J. Feng, S. Y. Song, Y. Q. Lei and S. Dang, *Opt. Mater.*, 2011, 33, 582.