Independent Nd^{3+} Excitation for Enhanced Upconversion Luminescence

Dohoon Kim[1], Dongkyu Kang[1], and Joonseok Lee[1]
[1]*Department of Chemistry, Hanyang University, Seoul 04763, Republic of Korea*
kdh44467@hanyang.ac.kr

Nd^{3+}-sensitized upconversion nanoparticles (UCNPs) offer improved compatibility with biological environments under 800 nm excitation. Compared to the 980 nm excitation, where significant water absorption induces undesirable thermal effects, 800 nm excitation presents a favorable alternative with minimal photothermal interference. However, 800 nm excitation can induce back energy transfer (BET) from the lanthanide emitters (e.g., Er^{3+}, Tm^{3+}) to the sensitizer Nd^{3+}, resulting in energy loss and compromised upconversion performance. In this study, Herein, we introduce a novel independent near-infrared (NIR) excitation wavelength at 860 nm, which is free from BET constraints and spectral overlap between Nd^{3+} and Er^{3+} observed at 800 nm. Further enhancement of upconversion luminescence was achieved by optimizing the Nd^{3+} concentration, yielding enhancement factors of 9.6 and 9.5 for Er^{3+} and Tm^{3+} emissions, respectively. Interestingly, an unexpected enhancement was also observed in Ho^{3+}-doped UCNPs, with an enhancement factor of 3.9 under 860 nm excitation. This occurred despite the absence of spectral overlap with Nd^{3+} in the 800 nm region, which would normally preclude BET, suggesting the involvement of additional mechanisms beyond BET suppression. These findings highlight the potential of selective excitation in suppressing BET and facilitating efficient energy transfer, which is expected to enhance upconversion performance in a wide range of Nd–Yb–based activator systems.

References

[1] Kang, D., Jeong, M., Lee, J. et al. *Nat. Commun.* 14, (2023), 2755.
[2] Yu, Z., Chan, W. K., Tan, T. T. Y. et al. *Small* 16, (2020), 1905265.

Figures

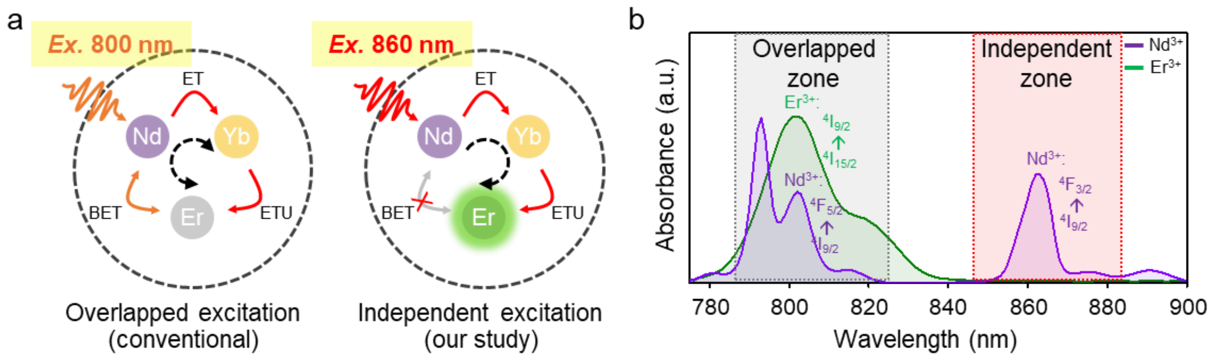

Figure 1: (a) Schematic illustration of independent 860 nm excitation compared to conventional 800 nm excitation. (b) The absorption spectra of sensitizer Nd^{3+} and activator Er^{3+}.