

SPECTRAL PROPERTIES OF YTTERBIUM SPECIES IN DOPED CESIUM LEAD HALIDE PEROVSKITES

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Perovskites have been shown to be a promising material in photovoltaics, where single junction perovskite solar cells have reached efficiencies of 26.1% [1]. CsPbCl₃ perovskites doped with Yb³⁺ ions are capable of quantum cutting (QC), where one perovskite exciton is converted into two ytterbium excitations [2]. This phenomenon can be used in luminescent solar converters to efficiently turn ultraviolet light into near infrared light, which has been shown to increase commercial solar cell efficiency [3]. The main problem holding back commercial use of these materials is the toxic and hard to scale methods of synthesis, primarily hot injection methods [4]. We used a modified facile mechanosynthesis method [5], where only simple grinding and annealing are required to synthesize perovskite powders. We are exploring energy transfer mechanisms between the perovskite and Yb³⁺ ions by applying steady state and time resolved spectroscopy methods.

We investigate low temperature photoluminescence (PL) spectra of CsPb_{1-1.5x}Yb_xCl₃ doped with different Yb³⁺ concentrations, where two ytterbium species with different optical properties should form: dimers and monomers [6]. Dimers are two adjacent Yb³⁺ ions in the perovskite that can undergo QC, while monomers are solitary Yb³⁺ ions that cannot undergo QC and probably are not incorporated into the perovskite lattice. By mathematically manipulating Yb doped perovskite PL spectra excited at two different wavelengths, 375 and 940 nm, we derived PL spectrum for each of the Yb species (fig. 1A). Mathematical methods were used to approximate perovskite doped with different Yb³⁺ concentrations PL upon 375 nm excitation from the obtained dimer and monomer spectra (fig. 1B). The proportion of monomers increases with Yb³⁺ concentration (fig. 1B), which suggests that at higher concentrations Yb³⁺ ions are not as efficiently incorporated into the lattice or energy is being transferred from the dimers to monomers. At low concentrations we observe more Yb³⁺ dimers due to optimal ion concentration for the incorporation into the lattice and low migration limited quenching. The differences in intensities of 976 nm peak (fig. 1B), are attributed to reabsorption by the monomers. Further experiments are being conducted using perovskite quantum dots, which should create different ratios of species. This would allow more precise identification of their characteristics.

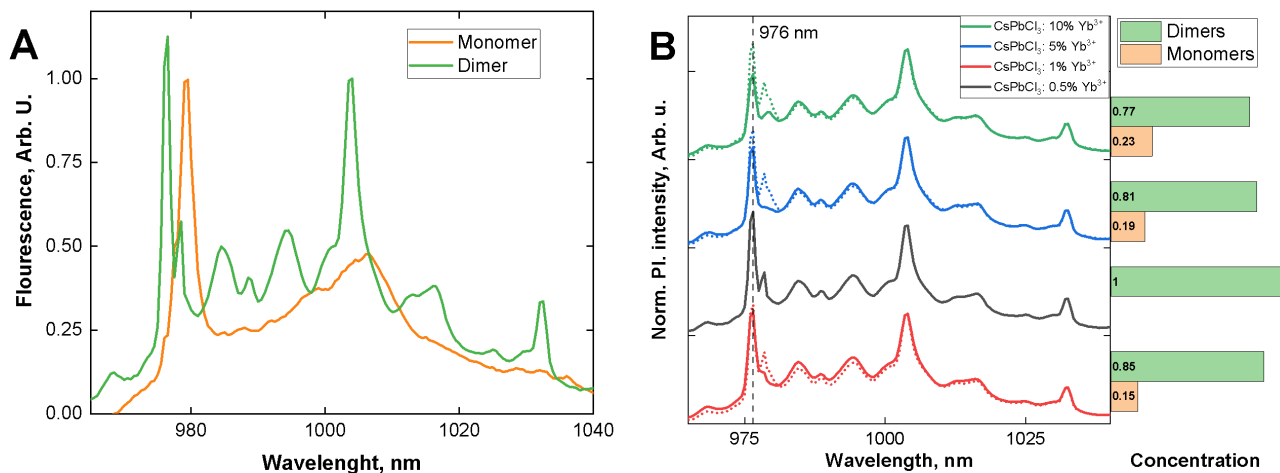


Fig. 1. (A) PL spectra of dimeric and monomeric Yb species in the perovskite powders mathematically obtained from the experimental data measured at 80 K, upon 375 nm excitation. (B) Perovskite PL at 80 K, upon 375 nm excitation (solid) and approximation made from mathematically obtained monomer and dimer spectra (dotted). Bar graphs show at what proportions dimer and monomer spectra were added.

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