

Trapping Photogenerated Charge Carriers in Perovskite Nanocrystal Films by Doping with Electron Scavengers

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Keywords: Halide Perovskite; Nanocrystals; Fullerene; Electron Transfer; Photoluminescence

Perovskite nanocrystals (PNCs) become attractive due to their excellent photoluminescence (PL) and electronic properties. Thus, these perovskites show great promise to optical, electronic, and photovoltaic applications. Both PL lifetime and transient absorption measurements in the presence of electron- and hole-accepting materials reveal the high charge mobility in perovskite films.¹ We synthesize CsPbBr₃ and FAPbBr₃ PNCs by the hot injection² and ligand assisted reprecipitation³ methods, respectively, and subsequently investigate the PL properties of these PNCs in the presence and absence of electron scavengers such as fullerene (C₆₀). We evaluate the effect of C₆₀ on the PL of PNCs in solutions and thin films. Interestingly, the PL intensity of a PNC solution is continuously decreased with an increase in the concentration of C₆₀, indicating efficient electron transfer from PNC to C₆₀. However, the corresponding changes to the PL lifetime are not comparable to the decrease in PL intensity. Thus, the contribution of the static component to the PL quenching is considered. We record the transient absorption spectrum of a PNC solution supplemented with C₆₀, which shows electron transfer from PNCs to C₆₀ and the formation of C₆₀ radical anion.

To evaluate the diffusion of charge carriers in a PNC film, we dope one-half of the film with high-density C₆₀ and record the PL decays at every 100 μm distance from the interface region of PNC and C₆₀. As we move away from the interface region to the PNC only region, the PL lifetime is increased, showing long-range diffusion of photogenerated charge carriers in the PNC film, whereas the electrons near the interface region are efficiently captured by C₆₀. The corresponding plot of the distance and photocounts or the PL lifetime suggests that the contribution of the static component to the PL quenching is much lower than the dynamic component. PL spectra, PL decays, and the corresponding plot of the distance vs photocounts or the PL lifetime suggest the contributions by the dynamic and static electron transfer components to the PL quenching of PNCs. We hypothesize that the hydrophobic nature of C₆₀ enables it to closely interact with the PNCs capped with hydrophobic ligands. An interfacial electron transfer from PNC to C₆₀ can be rationalized with the detailed investigations of PNC films.

- 1) J. S. Manser, et al. *Nat. Photon*, **2014**, *9*, 737.
- 2) L. Protesescu, et al. *Nano Lett.*, **2015**, *15*, 3692.
- 3) V. C. Nair, et al. *Angew. Chem. Int. Ed*, **2017**, *56*, 1214.