

## Transporting and transferring electrons across perovskite-acceptor interfaces

(<sup>1</sup>Graduate School of Environmental Science, Hokkaido University, <sup>2</sup>University of Rostock, <sup>3</sup>University of Hyogo, <sup>4</sup>Kyoto University) ○ Sachith Bhagyashree Mahesha,<sup>1</sup> Takuya Okamoto,<sup>1</sup> Ghimire Sushant,<sup>2</sup> Tomokazu Umeyama,<sup>3</sup> Yuta Takano,<sup>1</sup> Hiroshi Imahori,<sup>4</sup> Vasudevanpillai Biju<sup>1\*</sup>

**Keywords:** halide perovskite; nanocrystals; interfacial electron transfer; fullerene

Halide perovskite nanocrystals (PNCs) become attractive due to their high photoluminescence (PL) quantum yields, tunable bandgap, and straightforward synthesis.<sup>1</sup> As a result, these materials become superior light absorbers in perovskite solar cells (PSCs) and the certified power conversion efficiency of a PSC exceeds 25%. Recently, photoinduced electron transfer (PET) studies in PNC-based electron donor-acceptor (D-A) systems receive great momentum, which is owing to the general interest to optimize the perovskite solar cell technology.<sup>2</sup> Radiative and nonradiative carrier losses adversely affect the energy conversion efficiency in thick perovskite films.<sup>3</sup> Both the PL lifetime and transient absorption measurements in the presence of electron- and hole-accepting materials reveal the high charge mobility in perovskite films. However, the distance- or thickness-dependent recombination dynamics of photogenerated excitons/charge carriers at the perovskite-electron acceptor interfaces are yet to be completely understood.

We reveal the extent of diffusion, the degree of radiative loss, and the rate of diffusion-controlled interfacial electron transfer in heterojunction films of cesium or formamidinium lead bromide (Cs/FAPbBr<sub>3</sub>) PNCs and C<sub>60</sub> or TiO<sub>2</sub>. Self-assembled PNC films prepared from FAPbBr<sub>3</sub> show a longer PL lifetime than a solution, showing a long-range carrier migration or efficient carrier-trapping de-trapping cycles. To examine the nature of PET from PNCs, we perform PL studies of PNC solutions in the absence or presence of C<sub>60</sub>. The acceptor quenches the PL intensity but not the lifetime in a solution, revealing a static electron transfer. Conversely, the distance-dependent electron transfer in films changes from dynamic to static by moving the pump-probe towards the donor-acceptor interface.<sup>4</sup> While radiative recombination dominates the electron transfer at 800 μm or farther, the acceptors quantitatively scavenge the photogenerated carriers within 100 μm.

In summary, the adsorption of C<sub>60</sub> molecules onto the hydrophobic-caped surface of a PNC leads to static and quantitative PL quenching by electron transfer. Also, the electron transfer efficiency is appreciably high for excitons generated within 800 μm of a D-A interface. The migrating or trapped photogenerated charge carriers in the D-A films enable diffusion-controlled interfacial electron transfer.

1) S. Ghimire, et al. *ACS Energy Lett.* 4 (2019) 133. 2) L. Chouhan, et al. *Chem. Soc. Rev.* 49 (2020) 2869. 3) V. C. Nair, et al. *Angew. Chem. Int. Ed.* 56 (2017) 1214. 4) B. M. Sachith et al. *J. Phys. Chem. Lett.* 12 (2021), 8644.