Halide Perovskites: Exploring Applications Beyond Photovoltaics

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The efficiency of single-junction perovskite solar cells (PSCs) is reaching the practical limit with current certified record efficiency of 27%. While achieving long-term stability in such cells remains a challenge, many companies are testing large panels in outdoor applications. As the perovskite solar cells are commercialized it is time for researchers to look beyond photovoltaic properties. Perovskite quantum dots offer new opportunities to tailor light energy harvesting and photon management.[1-5]

Steering energy transfer pathways in semiconductor nanocrystal-dye assembly is important in designing semiconductor-multi chromophoric films for display devices. Such hybrid films can *down convert* or *up convert* incident photons and deliver emission at desired wavelengths. By selecting high energy donor (*e.g.*, $CsPbBr_3$) one can down convert the incident photons through an energy transfer cascade, as in the case of $CsPbBr_3$-rubrene-DBP system to populate singlet excited DBP (perylene derivative). On the other hand, when the donor energy is low as in the case of $CsPbI_3$-rubrene-DBP, one can populate singlet DBP via triplet-triplet annihilation. Thus, by steering energy transfer pathways, it is possible to manage the photon flow and obtain desired emission output.

Another application of semiconductor QDs is in photocatalysis. Bandgap engineering of perovskite nanocrystals provides a unique handle to modulate the charge transfer interactions with acceptor molecules. Aromatic amines are useful probes to extract photogenerated holes from perovskite nanocrystals of varying bandgap. The efficiency and rate of hole transfer is governed by energy level alignment of semiconductor donor-molecular acceptor. The rate constant of hole transfer ($0.15\text{-}2.2\times10^9$ s^{-1}) dependence on the thermodynamic driving force $-\Delta G$, follows Marcus electron transfer theory with a reorganization energy of ~1 eV. Spectroscopic and kinetics results that provide new insights into interfacial charge transfer process in semiconductor-acceptor systems will be discussed.

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