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Review

Cation engineering on lead iodide perovskites for stable and high-performance photovoltaic applications

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Abstract

Perovskite solar cells (PSCs) based on methylammonium lead iodide ($\text{CH}_3\text{NH}_3\text{PbI}_3$) have showed unprecedentedly outstanding performance in the recent years. Nevertheless, due to the weak interaction between polar CH_3NH_3^+ (MA^+) and inorganic PbI_3^- sublattices, $\text{CH}_3\text{NH}_3\text{PbI}_3$ dramatically suffers from poor moisture stability, thermal decomposition and device hysteresis. As such, strong electrostatic interactions between cations and anionic frameworks are desired for synergistic improvements of the abovementioned issues. While replacements of I⁻ with Br⁻ and/or Cl⁻ evidently widen optical bandgaps of perovskite materials, compositional modifications can solely be applied on cation components in order to preserve the broad absorption of solar spectrum. Herein, we review the current successful practices in achieving efficient, stable and minimally hysteretic PSCs with lead iodide perovskite systems that employ photoactive cesium lead iodide (CsPbI_3), formamidinium lead iodide ($\text{HC}(\text{NH}_2)_2\text{PbI}_3$, or FAPbI_3), $\text{MA}_{1-x-y-z}\text{FA}_x\text{Cs}_y\text{Rb}_z\text{PbI}_3$ mixed-cation settings as well as two-dimensional butylammonium ($\text{C}_4\text{H}_9\text{NH}_3^+$, or BA^+)/ MA^+ , polymeric ammonium (PEI^+)/ MA^+ co-cation layered structures. Fundamental aspects behind the stabilization of perovskite phases α - CsPbI_3 , α - FAPbI_3 , mixed-cation $\text{MA}_{1-x-y-z}\text{FA}_x\text{Cs}_y\text{Rb}_z\text{PbI}_3$ and crystallographic alignment of $(\text{BA})_2(\text{MA})_3\text{Pb}_4\text{I}_{13}$ for effective light absorption and charge transport will be discussed. This review will contribute to the continuous development of photovoltaic technology based on PSCs.

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