Resolve deep-rooted challenges of halide perovskite for sustainable energy development and environmental remediation

ABSTRACT

Metal halide perovskite (ABX3) has become a new class of fascinating nanomaterial that has attracted extensive interdisciplinary attention as a low-cost and easy to manufacture photocatalyst in the platform of solar energy conversion and environmental remediation. This is due to its appealing optimal band gaps, long carrier diffusion length, high carrier mobility, defect tolerance, unique chemical and optoelectronic properties. Nevertheless, their ionic crystal structures are unstable, therefore hindering practical application. In this review, we first introduce the unique structural and physical properties of metal halide perovskites. Subsequently, we examine the critical challenges faced by present halide perovskites, including (1) material instability, (2) Pb-toxicity, and (3) material defective structures. Next, we highlight the practical approaches being taken to resolve the bottlenecks of metal halide perovskites, particularly the adoption of (1) protonic solvents (i.e., HX; X = I or Br) for water splitting reaction, (2) mild protonic solvents for CO2 photoreduction, (3) functionalizing and encapsulation of perovskites, (4) engineering Pb-less/Pb-free material, and (5) defect remediation, followed by several methods to evaluate and quantify defect states. Then, we summarize a panorama of the latest progression of halide perovskites either in its pristine formed or hybridized formed used in photocatalysis, photoelectrochemical, and photovoltaicphotoelectrochemical systems. Lastly, this review is ended with a summary and some revitalized perspectives on the future directions for stable and efficient metal halide perovskite-based photocatalysis research. It is anticipated that this review provides a new research direction for future metal halide perovskite-based photocatalysis development.