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Editor's choice collection on luminescent metal halides: here come halide perovskites and their derivatives

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As one of the giant families in metal halides, lead-based halide perovskites represented by $MPbX_3$ (M = CH_3NH_3 , Cs; X = Cl, Br, I) have appeared as fascinating luminescent materials in recent years, and show superior optoelectronic properties and versatile applications in solar cells, illumination, displays, lasers, detectors, sensors, etc. Generally, halide perovskites comprise ABX₃ (X = halogen) with six-coordinated metal halide octahedra connected with each other to form a three-dimensional (3D) structure, in which the A ion is usually an inorganic alkali cation, namely Cs⁺ and Rb⁺, or an organic ammonium cation such as $CH_3NH_3^+$ (MA⁺) and $(NH_2)_2CH^+$ (FA⁺), while the B site ion is a divalent metal ion such as Sn2+ and Pb2+. However, according to the connectivity character of the BX6 octahedra, such perovskitetype structures can be classified into dimensionalities including three-dimensional (3D), two-dimensional (2D), one-dimensional (1D), and zerodimensional (0D) at the molecular level, and thus we name those compounds with low-dimensional structural character (2D, 1D and 0D) as perovskite derivatives or metal halides. It is noteworthy that halide

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perovskites and their derivatives are a new generation of luminescent materials for emerging optoelectronic applications, as highlighted in this collection and summarized below.

Firstly, organic-inorganic hybrid halide perovskites have stunned the photovoltaic community in the past ten years. These materials have demonstrated unprecedented development in many aspects. Recently, the phase transition property in $FAPbX_3$ (X = Br, I) was theoretically investigated (DOI: https://doi.org/10. 1039/d2tc00559j). Additionally, doping Sr into FAPb_{1-x}Sr_xI₃ quantum dots can lead to an increase in photoluminescence quantum yields (PLQYs) (DOI: https://doi. org/10.1039/d0tc04625f). Beyond hybrid halide perovskites, the all-inorganic halide perovskite CsPbX3 has been widely studied at both the single-crystal and nanocrystal scales for different applications. For example, CsPbBr3 single-crystals grown by an additive assisted method are applied to gamma-ray detection (DOI: https://doi.org/ 10.1039/d0tc02706e). CsPbX₃ nanocrystals have received more attention for display applications, and tunable emission was realized by selecting different halogens and/or changing the shapes, doping with exotic ions, etc. For instance, nano-wires were obtained through noncatalytic chemical vapor deposition growth (DOI: https://doi.org/10.1039/ d1tc00077b). Lanthanide ion doping is reported to adjust the optical properties (DOI: https://doi.org/10.1039/d1tc05506b). Sodium doping can also lead to enhanced performance for CsPbBr3 quantum dotbased electroluminescent light-emitting (DOI: https://doi.org/10.1039/ d1tc05997a). Based on the doping strategy, not only can the desirable emission color be realized, but the PLOYs can be enhanced to meet more requirements and applications. Moreover, encapsulating CsPbX₃ nanocrystals into metal-organic frameworks can enhance the stability, which produces a novel method for the preparation of composite materials with highly efficient luminescence in practical applications (DOI: https://doi.org/10.1039/ d2tc00075i).

Secondly, low-dimensional perovskite derivatives, also called metal halides, have become state-of-the-art materials in terms of structural design, performance modification and different applications. For example, lead-free zero-dimensional hybrid or all-inorganic metal halides based on Cu⁺, Mn²⁺, Sb³⁺, Bi³⁺, In³⁺ and Te⁴⁺ have emerged as star materials with excellent luminescence for lighting applications (DOI: https://doi.org/10. 1039/d0tc00562b; https://doi.org/10.1039/ https://doi.org/10.1039/ d0tc05752e; d1tc05140g; https://doi.org/10.1039/ d1tc01037a; https://doi.org/10.1039/ d1tc05680h). The toxicity of lead halide perovskites can be avoided as well. Moreover, the applications of luminescent metal halides have also been extended

to solar cells, X-ray detection, and photocatalysis. Recent reports show that Cs₂SnI₆/ ZnO heterojunctions can be employed as high-performance UV-visible dual-band photodetectors (DOI: https://doi.org/ 10.1039/c9tc05940g). PEA2SnBr4 shows impressive water-stability and functions as a co-catalyst in hydrogen photogeneration and organic-dye degradation (DOI: https://doi.org/10.1039/d0tc02525a). Additionally, polycrystalline Cs3Bi2I9 was reported to exhibit ultralow-detectionlimit X-ray detection (DOI: https://doi. org/10.1039/d2tc00599a). 2D halide perovskites show good optoelectronic properties https://doi.org/10.1039/d0tc04250a), and Ruddlesden-Popper 2D perovskites are reported to function as Li-ion battery electrodes (DOI: https://doi.org/10.1039/ d1ma00020a).

Thirdly and finally, considering the multi-functional properties of metal halides, a large number of reviews have also been published to summarize the basic thermal properties and optical properties (DOI: https://doi.org/10.1039/ d0tc03754k). However, water-stability and thermal stability are still the key points for the future study of metal halides. In the future, searching for and exploring metal halides with excellent water and thermal stability as well as excellent optical properties remains challenging and significant. By carefully selecting published articles from Journal of Materials Chemistry C and Materials Advances into a themed collection, I hope that the charming and the rich performances of luminescent metal halides can be witnessed by chemists, physicists, and materials scientists. I would like to thank all the authors for their excellent research, the reviewers and the editorial staff for their careful and hard work during publication. I hope this collection could motivate novel research and promote positive developments to make more progress in luminescent metal halides for optoelectronic applications.



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