Plasmonic hot-electron assisted phase transformation in 2D-MoS_2 for the hydrogen evolution reaction: current status and future prospects

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ABSTRACT

Layered two-dimensional (2D) transition metal dichalcogenides (TMDs) offer unique opportunities as sustainable energy materials owing to their high surface area per unit volume arising from the atomically thin architectures, chemically tunable in-plane electrical conductivity, electrocatalytic activities, absorption coefficient, and high stability. Physicochemical modifications of these layered TMDs with plasmonic nanostructures further enhance their optoelectronic and photoelectrochemical properties to saturation limits. This article provides a comprehensive overview of the structural and electrocatalytic properties of layered 2D molybdenum disulfides (MoS_2) with and without plasmonic nanostructure modification for their application as an electrode for electrocatalytic hydrogen production *via* the hydrogen evolution reaction (HER). The 2H-phase of 2D-MoS_2 has limited active electrocatalytic sites and low electron conductivity; however, it can be phase transformed into a 1T phase with a larger number of surface catalytic sites and higher metallic conductivity. The structure and properties of the two phases of 2D-MoS_2, their synthesis, mechanisms, and characteristics of phase transitions with or without plasmonic nanostructures are thoroughly discussed for their application as an electrocatalyst for the HER. Plasmonic hot electron-assisted 2H to 1T phase transformation in 2D-MoS_2 provides enormous opportunities in producing hydrogen efficiently *via* water splitting. This article also discusses further initiatives required to develop 2D-MoS_2 as a large-scale electrocatalyst for hydrogen production.

KEYWORDS

Electrocatalysis; Electrocatalysts; Energy harvesting; Hot electrons; Hydrogen production; Layered semiconductors; Nanostructures; Phase transitions; Physicochemical properties; Plasmonics; Sulfur compounds; Transition metals

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