Chapter 11

Cost-Effective Chalcogenide-Based Nanocomposite Electrodes for High-Performance Electrochemical and Photoelectrochemical Water Splitting

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ABSTRACT

Water splitting, also known process with immense potential in the global shift toward sustainable energy systems. This process involves breaking down water (H_2O) into its, wind, or hydropower. As the world seeks alternatives to fossil fuels to mitigate climate change and reduce greenhouse gas emissions, hydrogen has emerged as a promising energy carrier due to its high energy content and environmentally friendly combustion, which produces only water as a by-product.demonstrating the decomposition of water using direct current electricity. Since then, the field has evolved significantly, driven by advancements in electrochemical systems, materials science, and catalysis. materials science, and catalysis. Modern water splitting can be broadly categorized into three primary methods: electrolysis, photoelectrochemical (PEC) water splitting, and thermochemical water splitting. Among these, electrolysis is the most mature and widely researched technique, involving the application of electrical energy to drive the non-spontaneous reaction.

INTRODUCTION TO WATER SPLITTING AND HYDROGEN PRODUCTION

Water splitting, also known process with immense potential in the global shift toward sustainable energy systems. This process involves breaking down water (H_2O) into its wind or hydropower. As the world seeks alternatives to fossil fuels to mitigate climate change and reduce greenhouse gas emissions, hydrogen has emerged as a promising energy carrier due to its high energy content and environmentally friendly combustion, which produces only water as a by-product, (Tari, 2015a; Tari, 2015b). demonstrates the decomposition of water using direct current electricity. Since then, the field has evolved significantly, driven by advancements in electrochemical systems, materials science, and catalysis. materials science, and catalysis, (Tari et al., 2022). Modern water splitting can be broadly categorized into three primary methods: electrolysis, photoelectrochemical (PEC) water splitting, and thermochemical water splitting, (Abbas& Bang, 2015). Among these, electrolysis is the most mature and widely researched technique, involving the application of electrical energy to drive the non-spontaneous reaction, (Kannan & Tari, 2025). In a typical electrolyzer, water molecules at the anode are oxidized to form oxygen gas and protons, while at the cathode, these protons are reduced to form hydrogen gas. This process is facilitated by catalysts that lower the activation energy and improve overall efficiency. Photoelectrochemical water splitting, on the other the redox reactions required for splitting water. This method holds promise for direct solar-to-hydrogen conversion, but challenges remain in terms of material stability,

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