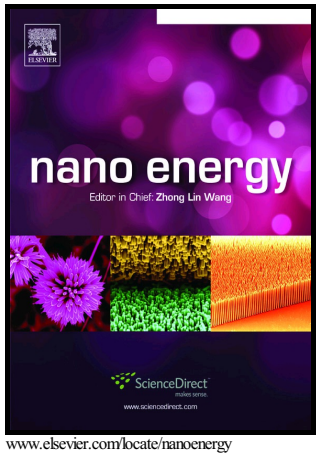

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Recent Progress and Perspectives of Bifunctional Oxygen Reduction/Evolution Catalyst Development for Unitized Regenerative Anion Exchange Membrane Fuel Cells

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Abstract

Unitized regenerative anion exchange membranes fuel cells (UR-AEMFCs) have been widely considered as energy conversion and storage devices due to their low cost and high-energy storage capacity, especially when integrated with renewable resources. However, the oxygen electrode reactions have long been one of the primary limiting factors of UR-AEMFCs due to their sluggish kinetics and resulting high overpotentials. To date, nanoparticles of platinum-group metals (PGMs) have been primary applied as catalysts because they are widely believed to simultaneously lower the thermodynamic and kinetic barriers of the oxygen reduction and evolution reactions (ORR and OER), which occur at a single electrode in unitized regenerative fuel cells (URFCs). However, the high-cost and scarcity of PGMs have recently shifted more researchers' attention to nanostructured transition metal oxide-based non-PGM catalysts as alternatives for UR-AEMFCs. Based on a theoretical analysis of the ORR/OER mechanism, the rate limiting steps of this reversible reaction pair has differing catalytic requirements, which make it challenging to develop effective bifunctional electrocatalysts with single active sites. Therefore, this review focuses on the development of ORR/OER dual active site nanostructured catalysts using transition metals or metal oxides that have been developed in recent years. Experimental evidence is critically collected from the literature to provide the perspectives of morphology, valence, electronic structure, energy band, etc. The second part of this review summarizes different methods to synthesize hybrid structures with advanced carbon materials, which compensates for the poor electrical conductivity that most pure transition metal oxides lack. Different mechanisms for improved activity at hetero-atomic interfaces are compared and analyzed. Furthermore, reversible ORR/OER electrocatalyst durability requirements are discussed for industrial implementation of UR-AEMFCs, and promising pathways for future catalyst design are proposed.

Keywords

Oxygen reduction reaction; oxygen evolution reaction; nanostructured catalysts; regenerative; anion exchange membrane fuel cells; non-platinum group metal