

Advancing Mullite-Based Ceramics for Solid Oxide Fuel Cells and Electrolysis Cells

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Mullite-based ceramics have garnered significant attention as promising materials for Solid Oxide Fuel Cells (SOFCs) and Solid Oxide Electrolysis Cells (SOECs), owing to their exceptional structural versatility, high ionic and electronic conductivity, and chemical stability under high-temperature conditions. This study delves into the potential of tailored oxides with the general formula RM_2O_5 , where R is a rare earth element and M is a transition metal, as key materials for electrodes and electrolytes in SOFC and SOEC applications.

The influence of strategic dopants, including Sr and Ce, is systematically investigated to optimize oxygen vacancy concentrations and enhance catalytic activity at the electrode-electrolyte interface. Employing a combination of solid-state synthesis and advanced characterization techniques, we fine-tune the phase stability, electrical conductivity, and microstructural properties of these ceramics. The electrochemical performance of RM_2O_5 materials is evaluated in both fuel cell and electrolysis modes, demonstrating improved ionic conductivity, reduced polarization losses, and enhanced operational efficiency.

In addition to material design, innovative approaches such as interface engineering and composite material strategies are explored to mitigate degradation mechanisms and ensure long-term stability in dual-mode operation. Preliminary results highlight the exceptional potential of RM_2O_5 -based ceramics for efficient hydrogen production and sustainable electricity generation, with a focus on scalability, cost-effectiveness, and compatibility with existing SOFC and SOEC systems.

This work advances the understanding of Mullite-based ceramics as multifunctional materials tailored for high-temperature electrochemical applications and underscores their critical role in the transition toward sustainable energy solutions.

Keywords: Mullite ceramics, Solid Oxide Fuel Cells (SOFCs), Solid Oxide Electrolysis Cells (SOECs), RM_2O_5 oxides