Characterization of Oxygen Diffusion and Catalytic Behavior of Composite Materials in Solid Oxide Fuel Cells Using the Non-destructive Adler-Lane-Steele Method

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Solid oxide fuel cells (SOFCs) are technologically interesting because they provide high-efficiency energy conversion via an electrochemical reaction within the cells. To bring SOFC to market, researchers must develop highly electroactive, low-cost devices that are chemically stable in both high (800 – 1000 °C) and low (600 – 800 °C) temperatures, as well as optimize oxygen reduction in electrodes. The electrochemical performance of SOFC is highly dependent on the catalytic activity (or catalyst behavior) of the electrode materials involved in the oxygen reduction reaction due to the slower oxygen reduction kinetics at lower temperatures. Understanding the fundamental properties of oxygen self-diffusion in solid-state ionic systems is critical for developing next-generation electrolyte and electrode material compositions and microstructures that enable SOFCs to operate at lower temperatures more effectively, durably, and affordably. To date, the most common method for evaluating electrocatalytic performance is electrochemical impedance spectroscopy (EIS), which causes sample damage due to its set-up procedure. As a result, modeling approaches have been used to better understand the reaction mechanism, oxygen diffusion coefficient, and kinetics of SOFC electrode reactions, including the mixed ionic electronic conductor (MIEC)-based electrode. Several models have recently been developed to represent the reaction mechanisms of SOFCs, with Adler-Lane-Steele (ASL) mathematical theory believed to be suitable for predicting oxygen gas diffusion through the pores of the MIEC-based materials. Hence, the aim of this paper is to validate the area-specific resistance of composite electrodes using the ASL modeling technique rather than the standard EIS analysis. The findings are significant in contributing to the development of a new non-destructive method for analyzing the catalytic behavior of SOFC components.