Diffusion and conversion impedance in solid oxide fuel cells

In fuel cell electrodes where the thin, active electrode layer is supported by a porous layer the diffusion processes as well as the change in the gas phase composition due to the conversion of reactants will influence the cell impedance. Two models are developed for the description of these processes. The first is a CSTR model based on a well convected gas supply volume equipped with gas inlet and outlet. Since the current distribution on the electrode surface is uniform, the impedance is derived for perturbation from a steady state and contributions from kinetics are directly additive. In the other model the gas supply is considered as a plug flow along the electrode surface. It is assumed that the gas flow channel is sufficiently thin to eliminate any concentration gradients perpendicular to the flow direction. In this case the current density decreases in the flow direction due to consumption of reactants and accumulation of products. For simplicity this model is restricted to cases dominated by mass transfer and conversion of the gas supply. Qualitatively the predictions by both models are alike. At high frequencies a Warburg diffusion impedance is seen. Depending on the dimensions of the gas volume relative to the supporting layer this may turn towards the real axis as a nernstian diffusion impedance, or directly into the semicircle dominating the low frequency region.

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