A Multicomponent Transport Model for Proton Exchange Membrane Fuel Cells Using Ordered Membrane Electrode Assembly

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Abstract: Designing cost-effective electrodes is essential to the development of proton exchange membrane fuel cells (PEMFCs). Therein, the highly ordered electrode has been proved to be effective by reducing Pt loading. To insight into the enhancement mechanism of ordered membrane electrode assembly (OMEA), in this work, a two-dimensional steady-state multicomponent mass-transport model is developed, in which a cylindrical structure model is adapted to account for the diffusion characteristics of reactants in ordered catalyst layer. Moreover, the overpotential corresponding to mass and charge transport limitations are calculated in this model based on concentration distribution and Ohm's law, respectively. The numerical model result shows a good agreement with experimental data in literature. The simulation results indicate that the whole cell using OMEA yields a high power density due to the reduced mass transport resistance and the increased electrochemical active surface area, which is comparable to the conventional membrane electrode assembly (CMEA) with high Pt loading. Additionally, the effects of geometrical parameters in OMEA, such as contact angle and porosity on cell performance were systemically investigated. The results demonstrate that contact angles have an obvious effect on the cell performance owing to the variation of relative permeability and species diffusivity. The optimum porosity depended on a balance between the mass and charge transport resistance.

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