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Pore-network modeling of the two-phase flow and transport in the MPL-GDL double layer: model validation and exploration of optimal pore structures

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Proton exchange membrane fuel cells are promising energy devices that involve complex two-phase flow and transport in multiple porous layers. During fuel cell operation, oxygen in the flow channel diffuses through a porous cathode gas diffusion layer (GDL) and a microporous layer (MPL) to the catalyst layer, where the oxygen reduction reaction takes place. The water generated via oxygen reduction reaction is then drained out through the MPL-GDL in the other direction. Water flooding—a problem that commonly occurs in fuel cells—impedes oxygen transport and limits the cell's current density. Therefore, how to better manage water in the MPL-GDL double layer to achieve a greater oxygen diffusivity becomes a critical issue. However, the primary factors controlling the two-phase flow and transport dynamics in the MPL-GDL especially regarding the main features of an optimal pore structure of MPL remain not understood.

To address this knowledge gap, we develop a pore-network modeling framework to represent the two-phase flow and transport—including both liquid water percolation and oxygen diffusion—in the MPL-GDL double layer. We employ water percolation and flow-through experiments conducted on multiple MPL-GDL products to validate our numerical simulations covering a wide range of pore structures and experimental conditions. Using the validated pore-network model, we then conduct a set of comprehensive numerical experiments to evaluate performance of different pore structures of the MPL with a focus on improving water management and oxygen transport in the MPL-GDL double layer.

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Participation

Online

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