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Structural-dependent Properties of Catalyst Layers for PEM Fuel Cells - A Comprehensive Review

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Abstract:

Catalyst layer (CL) is one of the most critical components in proton exchange membrane (PEM) fuel cells, and its multi-scale structure determines the functional properties, performance, and durability. However, fundamental understanding and experimental studies on the CLs' heterogeneous structure and structure-dependent functional properties are still not well documented in literature. The multi-scale, heterogeneous structure of CLs is formed during the manufacturing processes, and is affected by the corresponding materials, formulation, and manufacturing methods of CLs. The structure-dependent functional properties, including effective diffusivity, permeability, capillary pressure, contact angle, effective thermal conductivity, exchange current density, charge transfer coefficient, electrochemical surface area, effective electronic and protonic conductivity, are comprehensively reviewed in terms of fundamental concepts, theories, and recent experimental findings. These functional properties have a strong impact on the electrochemical behavior and transport phenomena in PEM fuel cells. The empirical correlations and recent progress on the experimental studies of these properties are discussed. An analytical model is developed to understand how the CL structure influences the functional properties, performance, degradation mechanisms, and durability of the PEM fuel cells.