

# LINKING MULTISCALE RHEOLOGY TO PERFORMANCE OF HIERARCHICALLY STRUCTURED PEM FUEL CELL CATALYST LAYER

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## ABSTRACT

Fuel cell technology is a rapidly evolving field as alternate energy sources become more crucial for the transition towards sustainable energy. However, the widespread adoption of fuel cells has been hindered by various issues, including the usage of expensive noble metals. Currently, the catalyst layers in a polymer electrolyte membrane (PEM) fuel cell are created from colloidal inks containing platinum-doped carbon nanoparticles (Pt/C) and ionomers suspended in an alcohol/water solvent. Unfortunately, the rapid solvent evaporation during this process results in catalyst layers with little control over their structure, which affects their performance. To improve the efficiency of fuel cells, we focused on hierarchically structuring the catalyst layer using spinodal decomposition of a water and 2,6-lutidine system. Our preliminary results show significant improvements in cell performance, with a 47% higher power density compared to conventional methods. While examining such improvements, rheology tests have demonstrated a significant increase in the storage modulus during spinodal decomposition, indicating a continuous network formation with jammed particles<sup>1</sup>. EDX analysis has further supported the jamming of Pt/C and ionomer chains in the lutidine-rich phase. Microrheology tests have shown that Pt/C and ionomers have a stronger affinity in the lutidine-rich phase, resulting in higher viscosity near the aggregate of Pt/C. This indicates ionomer chains' wrapping around Pt/C aggregates, leading to a higher rate of chemical reaction as it only occurs at boundaries between Pt/C, ionomer, and reactants. In summary, our proposed method for producing catalyst layers represents a significant advancement in fuel cell technology, as it enables greater control over the structure of the catalyst layer, and thereby enhancing the overall performance of cells. Additionally, our multiscale approach enabled gaining fundamental insights into the improved performance, including the formation of bicontinuous channels for better mass transport and the facilitation of ionomer coverage over Pt/C aggregates.

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