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Water Transport and Phase Change Phenomena in Polymer Electrolyte Fuel Cells Using Temperature Dependent Phase Separation Model

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Extended Abstract

A comprehensive multiphysics model has been developed to predict the internal transport phenomena and performance of polymer electrolyte fuel cells (PEMFCs). This model is based on the temperature-independent phase separation model (TIPSM) framework introduced in our previous research [1,2]. Specifically, the model visualizes and quantifies the evaporation and condensation processes throughout the computational domain, offering valuable insights into phase change dynamics. The primary objectives of this study are to accurately determine the actual heating value of PEFCs, investigate heat removal mechanisms, and assess the impact of phase changes on both cell performance and the cooling system load. The results reveal that increasing stoichiometry and coolant temperature enhances evaporative cooling, leading to a more LHV-like operation, which minimizes the cooling load. Conversely, while higher current density improves cell performance under pressurization, it also increases internal heat generation, resulting in an HHV-like operation that decreases overall cell efficiency.

References

[1] Park, Sungjea, Myong-Hwan Kim, and Sukkee Um. "Phase separation modeling of water transport in polymer electrolyte membrane fuel cells using the Multiple-Relaxation-Time lattice Boltzmann method." *Chemical Engineering Journal* (2024): 153629. https://doi.org/10.1016/j.cej.2024.153629

[2] Um, S., Wang, C.-Y., and Chen, K.S. “Computational fluid dynamics modeling of proton exchange membrane fuel cells.” *Journal of the Electrochemical society* 147.12 (2000): 4485. https://doi.org/10.1149/1.1394090