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Studying the impact of electrode pore structure on redox flow battery performance with multiphysics pore network modeling

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The redox flow battery is a promising energy storage technology for mitigating the uncertainty of renewable energy sources and bringing us a step closer to integrating them with the current energy grid systems. However, they are a relatively new technology that are unproven and currently too expensive. Optimizing flow batteries is an active area of research since it can potentially reduce their cost by maximizing their performance. The optimization can be performed on multiple fronts namely new redox pairs with better kinetics, operating conditions such as temperature, the macroscopic geometry of the flow battery, flow configuration, and electrode microstructure. Optimizing the microstructure of flow battery electrodes is equally important but less studied compared to the other options. We provide a general modeling framework based on pore networks to study the multiphysics involved in a hydrogen-bromine flow battery. A numerical algorithm was developed to solve the coupled systems of equations, making this a multiphysics model. Because we used pore network modeling, the simulations are relatively cheap in computation cost compared to direct numerical simulations and therefore can be used for parametric sweeps of structural parameters in a reasonable time. As a case study, we use the proposed framework to investigate the effects of electrode microstructural features such as porosity, pore size distribution, and fiber alignment on the overall performance of the flow battery.

References

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