

Comparing Limits of Performance in Aqueous and Non-aqueous Redox Flow Batteries

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Among the available energy storage technologies for large-scale applications, redox flow batteries (RFBs) are promising candidates to meet the requirements. Unlike the conventional batteries, RFBs are capable of decoupling the energy and the power allowing the relatively easy and inexpensive scale-up as well as improved safety features. In RFB systems, the volume and concentration of the solution determine the amount of energy can be stored. On the other hand, the adopted chemistry and the intrinsic performance of the cell affect the power density of the system. RFBs, in general, can be categorized in terms of the type of electrolyte used into aqueous systems, non-aqueous systems, and hybrid systems. Several distinct characteristics among the proposed systems are the operating voltage window, the range of working temperature, the cost and, last but not least, the safety.

Since the cell performance is strongly related to the cost of the entire system, significant efforts have been made to enhance performance of the aqueous systems. In this work, we show our present state of optimization of components of the all-vanadium redox flow battery (VRFB) to achieve peak power density of 1340 mW/cm². The polarization curve of this cell is a straight line, suggesting that ohmic processes dominate the voltage loss during operation. Non-aqueous redox flow batteries (NARFB) have been proposed by several researchers. These electrolytes possess a wider electrochemical window for high voltage chemistries. Nevertheless, the voltage loss due to ohmic effects is likely to be more significant, given that the conductivity of the non-aqueous electrolyte is usually much lower than that of the aqueous acidic media. This motivates us to compare the performance limit for the aqueous and the non-aqueous RFBs by estimating the ohmic loss of the systems.

Here we report the achieved high performance for the VRFB and, based on that, develop a comparison of performance limits of the aqueous and non-aqueous systems using a simple ohmic model. Note that additional factors which can be unfavorable for the NARFBs are not considered here, including cost of the electrolyte and safety concern. Additionally, any specific kinetic

limitations at electrodes are not considered and a comparison based on ohmic losses is given. This motivates a discussion of design aspects for favorable applications of the NARFB.

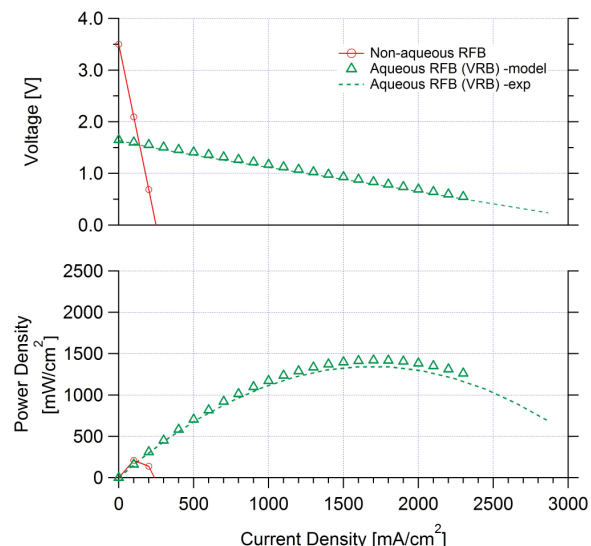


Figure 1. Polarization and power density curves were illustrated by considering the loss due to the electrolyte and the ionic conduction in the electrode. VRFB calculated (triangles), VRFB experimental (dash line) and NARFB calculated (circles). In the NARFB case, electrolyte conductivity of 10⁻² S/cm was used.

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