Asymmetric cell designs: a novel technique for passively retaining capacity in all-vanadium redox flow batteries

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Abstract

Several technologies, including solid-state and redox flow batteries, have been developed for medium and grid-scale energy storage [1-8]. Redox flow batteries (RFBs) are open batteries that can be scaled for output power or duration of service (energy storage capacity). Among various chemistries developed for RFBs, all-vanadium redox flow batteries (VRFBs) are unique due to utilization of the same element (vanadium) in four oxidation states for the negative and positive electrolytes. Many strategies have been explored for improving VRFB performance including improved cell design, superior material selection, and electrolyte engineering [9,10]. Although significant advances have yielded improved performance, reversible capacity decline during cycling is still a major issue yet to be addressed. Several parameters influence rapid capacity decay during cycling; the major contributor is unwanted transport of vanadium ions and water (crossover) through the ion-exchange membrane [11]. Some previous works have focused on measuring and mathematical modeling of crossover for various types of ion-exchange membranes [12,13,14]. Therefore, the major thrust within the literature has been focused on designing and fabricating high-performance ion-exchange membrane capable of mitigating crossover [15]. However, few efforts have considered other methods of mitigating crossover based on cell architecture. In this talk, we will introduce novel cell designs for crossover mitigation during VRFB cycling. We have designed, engineered and prototyped cell architectures with asymmetric configurations for the negative and positive sides that are capable of retaining discharge capacity over long-term cycling. We have utilized a unique setup equipped with UV/Vis spectroscopy for real-time measurement of crossover and consequently validated the asymmetric cell approach for retaining discharge capacity. The novel cell configurations we have engineered are under invention disclosures at University of Tennessee and provide an inexpensive solution for adopting VRFBs in industry as reliable and robust technology for grid-scale storage.

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