Synthesis and modification of pore-filled membranes for efficient all-vanadium redox flow batteries

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Redox flow batteries (RFBs) are one of the promising energy storage devices that utilizing the oxidation and reduction of electroactive species for charging and discharging, respectively [1,2]. All-vanadium redox flow batteries (VRFBs) can be used for large-scale intermittent storage systems such as wind turbines and solar cells as well as applications which requires high capacity and high power output such as an electric vehicle. The VRFBs consists of electrolytes with redox couples of V^{2+}/V^{3+} and VO^{2+}/VO^{2+} for both compartments, a battery cell, circularatory pumps, and an ion-exchange membrane for separation and ion transport [3]. Ion exchange membranes have significant roles for the reliability of of the VRFBs. Conventional VRFBs with commercial Nafion membranes has been widely studied in terms of the ion selelctivity and permeation of metal species. Anion-exchange membranes are also advantageous for lower metal permeations with high proton transport [4]. In addition, pore-filled membranes with ion-exchange resins and polyelectrolytes have been reported, showing better chemical stabilities based on the inert substrate [3,4].

In this work, we have developed pore-filled polymer membranes (PFPMs) for the VRFB applications. In order to improve physical and electrochemical properties of the pore-filled membranes, surface modifications with brominated poly(phenylene oxide) as well as polypyrrole coating were conducted. Futhermore, the membranes were systematically investigated in terms of the ion mobility and crossover of the metal species through the membranes to optimize the VRFB performances. As a result, the PFPMs exhibited excellent electrochemical and mechanical properties and the vanadium crossover was effectively prohibited by the surface modification.

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