Non-aqueous redox flow batteries using pore-filled anion-exchange membranes prepared by direct-polymerization of imidazolium monomers

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Redox flow battery (RFB) is an electrochemical system that enables conversion of electrical energy to chemical energy and vice versa through surface redox reactions on positive and negative electrodes and being developed especially for large-scale electrictity storage applications. Recently, RFBs employing non-aqueous electrolytes have receiving great interests due to the higher electrochemical window, resulting in higher energy and power densities [1,2]. On the other hand, a number of non-aqueous RFB researches have been focused on redox-active species, solvent, and electrode materials. Although separating materials play significant roles for the inhibition of self-discharge due to the active species crossover and energy and power efficiencies, almost no profound research was conducted on separating materials, *i.e.* ion-exchange membranes, for non-aqueous RFBs.

A pore-filled membrane (PFM) firstly proposed by Yamaguchi et al. is known to possess extraordinary properties such as high dimensional and chemical stabilities [3,4]. The PFMs composed of a completely inert and tough porous substrate and a polymer with functional groups that fills the pores can provide both high ion conductivity and excellent mechanical properties. Moreover, undesirable excessive swelling of filling polymer can be sufficiently restricted by the inert porous substrate.

In this work, pore-filled anion-exchange membranes (PFAEMs) with a thin film thickness below 25 μm were prepared via a direct-polymerization of allyl-imidazolium monomers with various counter ions to achieve high performance non-aqueous RFBs by reducing the high mass transport resistance through a membrane in non-aqueous medium. The ion transport characteristics through the membranes in non-aqueous electrolyte system been systematically investigated. In addition, the performance characteristics of novel non-aqueous RFB system employing metal-complex redox shuttles and lab-made PFAEMs have been evaluated. As a resulf, non-aqueous RFB utilizing metal complex redox electrolyte and PFAEMs showed the promising energy efficiencies (> 85%).

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