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Novel Ion Exchange Membranes Synthesized by Radiation Grafting Technique for Application in Vanadium Redox Batteries

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Vanadium redox battery (VRB) has attracted more and more attention as energy storage system due to its long cycle life, deep discharge ability, high energy efficiency and low cost. Ion exchange membrane (IEM) is one of the key components of VRB to prevent the crossover of vanadium ions, and allow the transport of ions to complete the conducting circuit. The ideal IEM should possess low permeation rates of vanadium ions to minimize self-discharging, high conductivity, good chemical stability and cost-competitive. The current available commercial membranes cannot satisfy all of the above requirements. In this report, a series of amphoteric ion exchange membranes (AIEMs) were prepared by co-grafting of styrene/ N,N-dimethylaminoethyl methacrylate (DMAEMA), α-methylstyrene/DMAEMA or sodium styrene sulfonate/DMAEMA binary monomers into fluoropolymer films and sequent chemical reactions. The properties of the AIEM strongly depended on the composition and grafting yield of the membrane, i.e. higher content of DMAEMA brought lower permeability of vanadium ions, while higher grafting yield led to higher water uptake, IEC and conductivity. By changing the conditions of grafting reaction, The AIEM exhibited high ion exchange capacity (IEC) and conductivity, as well as significantly reduced permeability of vanadium ions. VRB assembled with the AIEM maintained an open circuit voltage (OCV) higher than 1.3V after placed for 300 h, and exhibited higher columbic efficiency and energy efficiency than that with Nafion 117 membrane. Furthermore, the AIEM grafted DMAEMA and α-methylstyrene has high chemical stability. The preparation of AIEM with grafting DMAEMA and sodium styrene sulfonate avoids the sulfonation, which is an environmental friendly process. In order to optimize the synthesis method, radiation grafting technique and solution casting method have been used to synthesize the AIEM by grafting styrene and DMAEMA into poly(vinylidene fluoride) (PVDF) powder. This AIEM with new process could get higher conductivity than traditional method using PVDF film as substrate, due to the uniform distribution of ion exchange group in the AIEM. Based on the above experiments, upscaling radiation grafting technique has been developing for the preparation of the AIEM with the area 850 mm x 750 mm.

Country/Organization invited to participate

China

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