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Side chain hydrolysis method to prepare nanoporous membranes for vanadium flow battery application

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Abstract

A side-chain hydrolysis method is proposed for fabricating high performance nanoporous membranes that can be used in vanadium flow batteries (VFBs). The membranes were fabricated facilely by hydrolyzing the bulky ester groups at the side chain of a cross-linked copolymer. Such hydrolysis creates pores that function as the pathway for proton transport while the cross-links can minimize membrane swelling induced by the hydrolysis derived carboxylic acid groups. The cross-links also contain cations so that vanadium permeation can be suppressed via Donnan repulsion effect. Therefore, the fabricated membrane combines the benefits of ionic and porous membranes, and thus can balance proton conduction and the vanadium ion restriction, giving rise to a good performance in a VFB. The optimized VFB showed a coulombic efficiency of 97.3 % and an energy efficiency of 82.7 % at 80 mA cm^{-2} for 100 cycles. Our work provides a facile, novel and cost-effective method to fabricate high-performance membranes for VFB applications.

Keywords: vanadium redox flow battery, hydrolysis, porous membrane

1. Introduction

With the excessive consumption of fossil resources, there is an urgent need to develop renewable energies such as solar- and wind energy [1]. However, these energies are intermittent and need large scale energy storage technology to ensure a smooth power output [2, 3]. The vanadium flow battery (VFB) is one of such technologies. It is advantageous over other technologies due to its long cycle life, high safety, environmental friendliness, and decoupled energy and power design [4].