Modification of Polyolefin Membrane Using Supercritical Carbon Dioxide for Redox Flow Batteries

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Abstract : This work presents a novel method for treating porous hydrophobic polyolefin membranes using supercritical carbon dioxide that allows usage of the modified membrane in redox flow batteries with an aqueous electrolyte. Polyolefin membranes are well known and widely used, however, they cannot be used as separators in redox flow batteries with an aqueous electrolyte since they have insufficient wettability, and therefore do not provide sufficient proton conductivity. The main aim of the presented work was the development of hydrophilic composites based on cheap membranes and precursors. Supercritical fluid was used as a medium for the deposition of the hydrophilic phase on the hydrophobic surface of the membrane. Due to the absence of negative capillary effects in a supercritical medium, a homogeneous composite is obtained as a result of synthesis. The in-situ synthesized silicon oxide nanoparticles and the chitosan polymer layer act as the hydrophilic phase and not only increase the affinity of the membrane towards the electrolyte, but also reduce the pore size of the polymer matrix, which positively affects the ion selectivity of the membrane. The composite material obtained as a result of synthesis has enhanced hydrophilic properties and is capable of providing proton conductivity in redox flow batteries. The morphology of the obtained composites was characterized by electron microscopy. To analyze the phase composition, infrared spectroscopy was used. The hydrophilic properties were studied by water contact angle measurements. In addition, the proton conductivity and ion selectivity of the obtained samples were studied, and tests in real redox flow batteries were performed. As a result, modified membrane was characterised in detail and moreover it was shown that modified cheap polyolefin membranes have pronounced proton conductivity and high ion selectivity, so their performance in a real redox flow battery approaches expensive commercial analogues, reaching 70% of energy efficiency.

Keywords : carbon dioxide, chitosan, polymer membrane, redox flow batteries, silica nanoparticles, supercritical fluid
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