Low-cost Ultrathin Proton Exchange Membranes for Next Generation E-fuels

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Abstract:

Perfluorosulfonic acid (PFSA) ionomers have been used extensively in proton exchange membranes due to their high proton conductivity and strong electrochemical stability. However, their high-cost and poor ion selectivity have been the limiting facts in their applications for mixed liquid electrolyte systems as well as in fuel cells. We have developed a novel multilayer ionomer membrane consists of hydrophobic nanoporous ultra-high molecular weight polyethylene laminated with ultrathin PFSA membranes to address the high-cost and poor ion selectivity issues in conventional PFSA ionomer membranes. The new ultrathin membrane with overall thickness as low as 2 micron meter exhibits tensile yield strengths more than 10 times higher than that of Nafion membranes and exhibits high proton conductivity up to 10 mS/cm. In addition, the membrane also exhibits extremely high ion-selectivity by blocking all ions that do not form strong hydrogen bonding with water molecules. Application of the new membrane in all vanadium flow batteries has demonstrated that the membrane shows both strong ion selectivity and higher discharge capacity than Nafion membranes, particularly at large cycle numbers. The newly developed membranes are also applicable in low temperature hydrogen fuel cells as well as for use in anionic exchange membranes.