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Entitled

CALCIUM PHOSPHATE/IONIC LIQUID PTFE COMPOSITE MEMBRANE FOR PROTON EXCHANGE MEMBRANE FUEL CELL APPLICATIONS

by

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Abstract

The dependence on fossil fuels can be possibly reduced by the utilization of renewable energy sources. Fuel cells offer a promising alternative for renewable power generation. Among the various types of fuel cells, Proton Exchange Membrane Fuel Cell (PEMFC) is recently attracting the attention due to its several advantages of high-power density, all solid structure and silent operation. The diverse types of materials used in this type of fuel cells raised drawbacks related to fuel cell cost and durability. By far, Nafion of DuPont is still the current state of the art membrane for PEMFCs. It is known for its high ionic conductivity and stability at low temperatures (i.e. ≤ 80°C) and fully humidified conditions. However, the membrane loses its conductivity and stability at higher temperatures. Higher temperature operation is preferred in PEMFCs as it enhances reaction kinetics, eliminates water accumulation at the cathode and improves the catalysts' tolerance for less pure fuels. Hence, intensive research efforts are triggered to search for Nafion alternatives that can provide an effective and comparable performance to that of Nafion's at high temperature operations and anhydrous conditions.

This work aims at synthesizing Nafion-free composite membranes based on a combination of Calcium Phosphate (CP), Ionic Liquids (ILs) and Glycerol (GLY) supported on polytetrafluoroethylene (PTFE) and have relatively high proton conductivity and good characteristics compared to literature. The membranes were synthesized by the spin coating technique and involved the formation of CP/IL particles within the pores of PTFE. The synthesized membranes were evaluated for their proton conductivities, morphology, structure, and thermal stability using different characterization techniques. Four ILs were investigated in this work. Among the four ionic liquids incorporated in the synthesis of the membranes, the "1-Hexyl-3-methylimidazolium tricyanomethanide [HMIM][$C_4N_3^-$]," and the "Diethylmethylammonium Methanesulfonate [DMEA][OMS]" ionic liquids showed an improved proton conductivity at room temperature (i.e. 10^{-1} and 10^{-2} S cm^{-1}, respectively) as well as a high proton conductivity at 200°C and under completely anhydrous conditions in the order of 10^{-3} and 10^{-4} S cm^{-1}, respectively. The improvement in proton conductivity of the current Nafion-free synthesized membranes can be possibly explained by the ability of CP, ILs and GLY to form proton conduction paths within the membrane structure. The XRD and FTIR results explained the enhancement in proton conductivity by the presence of water molecules and intercalation of IL. Also, SEM and EDS results confirmed the change in membranes structure as well as the formation of CP within the membranes pores, which are consistent with the conductivity enhancement. The findings in this thesis work are promising for potential high temperature and reasonable performing membranes in PEMFC. They also provide a lower cost membrane that would potentially decrease the cost of membranes, hence, decrease the capital cost of fuel cells stacks in general.

Keywords: Composite membranes, PEM fuel cells, High temperature membranes, Nafion, Calcium phosphate, Ionic liquids, Proton conductivity, Spin coating.