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Melt-Processed Anhydrous Proton Exchange Membranes for Fuel Cell Applications

A. Mokrini, A. Siu, G. Diaz, C. Crites and L. Robitaille.
*Industrial Materials Institute, National Research Council Canada,
75 de Mortagne, Boucherville, Québec, Canada. J4B 6Y4*
asmae.mokrini@cnrc-nrc.gc.ca

Perfluorosulfonic acid resins (PFSA) are today's benchmark materials for proton exchange membranes (PEMs) for fuel cells. These materials exhibit outstanding stability and a proton conductivity of 0.1 S/cm at 80°C when fully humidified. However their performance drops dramatically at higher temperatures and/or low humidification. This behaviour thus limits PEM fuel cells (PEMFCs) operation to temperatures below approximately 90°C. However, operation at higher temperature is highly desirable since it i) increases the kinetics of the electrochemical reactions, ii) simplifies water management, iii) improves tolerance towards CO when employing hydrogen from reformers and iv) simplifies the streamline design and engineering. Designing systems that can conduct protons with low or no humidity is perhaps the greatest challenge for the new generation of PEM materials.

In this paper, we present the properties of nanocomposite PEMs incorporating a series of anhydrous charge carriers. These charge carriers are excellent candidates for the fabrication of water-free membranes operating at temperatures above 120°C, however, their volatility or leaching could prevent them from being successfully used in open electrochemical systems.

In this work, anhydrous charge carriers were immobilized on inorganic nanoparticles and incorporated into PEMs formulations. Nanoparticles with diameters ranging from 50-200nm were synthesized via a sol-gel process and the desired anhydrous charge carriers immobilized on their surfaces. Nanocomposite PEMs were prepared using melt-processing technologies, by blending the grafted nanoparticles and fluorinated polymers such as poly(vinylidene fluoride) (PVDF) and ionomers such as Nafion®. The properties of PEMs developed as a function of nanoparticles size and content, as well as the proton conductivity at controlled temperature and RH will be presented.