Nano-scale Modified Inorganic/Organic Hybrid Materials as Proton Conductors

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Proton exchange membranes are a key component in fuel cell systems. Various proton conducting polymers have been used to achieve high proton conductivity, including perfluorosulfonic acids such as Nafion® and Dow membranes as well as a wide range of sulfonated aromatic polymers. For automotive applications, high operation temperature can help fuel cell release the heat and reduce the size of the cooling system. High temperature also increases the anode CO tolerant, and lower humidification is needed. Most polymers studied to date, however, only exhibit acceptable proton conductivity when fully hydrated, limiting the operating temperature to roughly than 80^{o}C. Therefore, developing new materials for high temperature fuel cells (120~180^{o}C) operating with modest humidification is challenging but necessary work.

In this work, surface modified silica particles are bound with polymers to form proton-exchange membranes. Polymers such as Poly (vinylidene fluoride) and sulfonated poly (arylene ether sulfone) copolymers are used to bind all the ceramic particles together. Membranes with different amounts and different sizes, 10, 50, and 100 μm of particles have been tested.

To introduce acid functionality, different sultone or silane are attached to ceramic particles and converted to sulfonic groups, creating a proton network structure. The silica surface modification is characterized by XPS and membrane's morphology is also studied by using AFM. Proton conductivity is measured at different temperatures and humidity to understand the proton transfer phenomena.

In initial studies, sulfonic acid terminated alkyl chains were added to the surface of silica particles. Substantially lower conductivity per mole of acid were observed. In this talk, we will discuss our understanding of the role of several possible limiting factors in determining the conductivity of such composite networks. The roles of the density of proton carriers, the intrinsic proton acidity, inter-particle hopping and the intrinsic proton mobility near the particle will be assessed.

Acknowledgement
We gratefully acknowledge the financial support of the US DOE for this research.