

CHEMICAL AND BIOLOGICAL ENGINEERING DEPARTMENT SEMINAR SERIES

Developing a new Fuel Cell Ionomer from Scratch

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Time: Wednesday, October 1; 3:15 – 4:30 pm

Location: Perlstein Hall Auditorium

Abstract

Currently the proton exchange membrane (PEM) is fabricated from a perfluorosulfonic acid (PFSA) polymer such as Nafion[®]. Unfortunately PFSA ionomers must be fully hydrated to achieve practical levels of proton conductivity limiting their practical use to temperatures <100 °C. This necessitates humidifying the inlet fuel cell gases, which results in unacceptable parasitic power losses and system complexity. To achieve the goal of a PEM that can operate at >100°C using dry inlet gases it will be necessary to develop new PEMs that are not necessarily based on pure PFSA ionomers.

The heteropoly acids (HPAs) are a class of inorganic oxides that have some of the highest solid state proton conductivities known at room temperature. In order to develop new PEMs based on the HPAs for elevated temperature, dry operation, it will be necessary to both immobilize the HPA and ensure that all of the protons are mobile all of the time. If both these objectives can be obtained a new class of PEMs will be developed that could facilitate the use of PEM fuel cells in automotive applications. We have created this new class of PEM by polymerizing HPA monomers with appropriate co-monomers to produce films with unique proton conducting properties.

In conjunction with 3M we have fabricated vinyl, styrenyl, ethylstyrenyl and methylmethacrylate HPA monomers. Of these the methylmethacrylate system appears to be too intrinsically unstable to be readily studied. The ethylstyrenyl precursor is not available as a pure isomer and the styrenyl isomer is difficult to synthesize. We have, therefore, devoted much of our effort to the vinyl functionalized HPA systems. By dissolving the HPA vinyl monomer in other suitable co-monomers we have been able to achieve films with up to 75wt% HPA. This is important as films with less than 50wt% HPA do not show practical proton conductivities. A 75wt% inorganic fraction is probably a 40vol% fraction. The films obtained are initially very dark due to the reaction of the free radical initiator with the HPA, but lighten up on exposure to air. The films are also initially quite flexible but become more brittle on ageing. This is because the polymerization reaction takes some time to go to completion and solid state NMR shows that it takes several days for the residual olefins to react. However, at 80°C we achieved impressive conductivities with this new ionomer. The only other materials that show similar conductivities under these conditions are sulfonic acids and sulfonamides. In initial films the material behaves similarly to hydrocarbon based sulfonic acids in terms of its response to humidity. SAXS and AFM measurements indicate that the material forms HPA clusters on the order of 100s of nm. NMR measurements indicate that lambda values may be as high as 40. In order to improve the properties of the ionomer, we are currently working to improve the ionomer by varying its chemistry and morphology by the use of differing co-monomers.

Biography

Dr. Herring has a BSc and PhD in chemistry from the University of Leeds. After postdoctoral appointments at the California Institute of Technology and the National Renewable Energy Laboratory, he joined the Colorado School of Mines in January of 1995 where he is currently an Associate Professor of Chemical Engineering. Dr Herring's current research interests are in fundamental studies and the development of advanced fuel cell components for PEM fuel cells, and in the use of biomass and hydrocarbon thermo-chemical conversion processes for analysis or to produce fuels and chemicals. He has been awarded the Glenn award of the Fuel divisions of the ACS and a 3M untenured faculty award.