

New PEM Fuel Cell Membranes For Higher Temperature, Drier Operating Conditions Based On The Heteropolyacids.

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State of the art proton exchange membrane (PEM) fuel cells currently use perfluorosulfonic acid (PFSA) ionomers. PFSA PEMs are limited to operating temperatures of 80°C or less and require high relative humidity for adequate proton conduction. For automotive applications it is desirable to operate the fuel cell at a temperature of at least 120°C and low humidity to enable the use of existing radiator technology and to eliminate the parasitic loads and system complications associated with externally humidifying the gas streams. For stationary applications PEM fuel cells operating at elevated temperature would allow the use of cheaper H₂ containing larger amounts of CO and facilitate combined heat and power applications. At the same time new electrolytes must also display i) adequate proton conductivity at -20°C for cold start-up, ii) sufficient oxidative stability for long life, iii) impermeability of reactant gases for minimal crossover, and iv) suitable mechanical attributes. To date, there have been many attempts to develop a PEM for use under the conditions of elevated temperature and low RH, but none of these have sufficient proton conductivity and durability in a fuel cell environment to represent a practical solution.

The heteropoly acids (HPA) represent a synthetically versatile inorganic super acid functionality that has very high proton conductivity at room temperature, 0.2 S cm⁻¹, and can be readily incorporated into hybrid organic/inorganic composite materials. Whilst many reports have shown that proton conductivity in the commercially available HPA is dependant on water, research at CSM has demonstrated HPA as useful proton conductors in working fuel cells at temperatures as high as 215°C, offering high proton self diffusion coefficients that peak at temperatures as high as 130°C and activation energy values, E_a, as low as 6 KJ Mol⁻¹. We are the first group in the world to report a complete polarization curve for a membrane in which an HPA in the solid state is the only proton conductor. We are currently working on two approaches. In one we synthesize hybrid HPA monomers that can be co-polymerized into stand alone proton conducting materials. In the second immobilized HPA additives are added to PFSA ionomers synthesized by 3M to not only improve proton conduction under hot and dry conditions but allow the oxidative stability of the film.