Design of Fuel Cells with Solid Acid Proton Conductors

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The compound CsH_2PO_4 has emerged as a viable electrolyte for intermediate temperature fuel cells. This material is a member of the general class of compounds known as solid acids or acid salts, in which polyanion groups are linked together via hydrogen bonds and monatomic cations provide overall charge balance. Within this class, several solid acids display a so-called superprotonic transition, at which the compound transforms to a structurally disordered phase of high conductivity. At the transition the conductivity jumps by 3-5 orders of magnitude and the activation energy for proton transport drops to a value of ~ 0.35 eV. The rapid proton transport in the superprotonic phase results from the high degree of polyanion rotational disorder. In the case of CsH_2PO_4 the transition occurs at 230 °C (with the conductivity rising to 2.2×10^{-2} S/cm at 240 °C), enabling fuel cell operation at temperatures between 230 and 260 °C.

Solid acids, and CsH_2PO_4 in particular, offer a number of realized and potential advantages for fuel cell operation relative to polymer, solid oxide, and liquid electrolyte alternatives. Fuel cell development based on this material, however, is still very much in its infancy. Fabrication methodologies have progressed to the stage that thin (~ 25 μm) electrolyte cells supported on porous gas diffusion electrodes, can be reproducibly prepared. In such cells, which yield peak power densities of over 400 mW/cm^2, oxygen electro-reduction is rate-limiting, much as it is in conventional polymer electrolyte membrane fuel cells. In this work we present recent results aimed at quantifying electrocatalytic activity of Pt in CsH_2PO_4 based fuel cells.

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