Carbon Ionic Conductors for use in Novel Carbon-Ion Fuel Cells

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ABSTRACT

Solid ionic electrolytes are a major concern in fuel cell development, but only a few compounds are known to be superionic. The fluorite structure, in particular, has been the basis for several superionic conductors of F^-, I^-, and O^{2-} ions. A number of ionic carbides exist at high temperature in the cubic fluoride structure. The stabilization of these cubic ionic carbides at room temperature or the discovery of high ionic conductivity in other ionic carbides would open the possibility of developing novel fuel cells based on carbon-ion mobility, rather than the oxygen-ion mobility that is the basis for current solid-oxide fuel cells. Ionic dicarbides are being synthesized by reacting mixtures of the appropriate rare earth oxide and amorphous ^{13}C under vacuum at high temperatures (>1600 °C), using a newly developed synthesis technique. Powder x-ray diffraction is used to confirm the crystal structure of all synthesized compounds. The coated samples are heated at 850 °C, 950 °C, and 1150 °C in a custom-built high vacuum furnace to allow the ^{12}C to diffuse into the bulk ^{13}C sample. This procedure, preparation of the potential ionic carbide material using C13 rather than normal carbon is necessary because ^{13}C sputtering targets or ^{13}C rods for arc evaporation are unavailable and could be fabricated. Using a secondary ion mass spectrometers (SIMS), the concentration of ^{12}C and ^{13}C profiles in the bulk material is measured by determining the distribution profile of ^{13}C with depth as a function of time and temperature of heating. These measurements are then used to determine a diffusion coefficient for carbon in the carbides as a function of temperature.