Electrocatalysis in Solid Oxide Fuel Cells

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The promise of direct and efficient conversion of chemical to electrical energy makes fuel cell development an area of great technological interest. Solid Oxide Fuel Cells (SOFCs) are unique in that they operate via ionic transport of oxidant (oxygen anions) from the air electrode (cathode) to the fuel electrode (anode). As such, SOFC can theoretically utilize a wide range of fuels, promising efficient power generation from high energy density fuels that are easily stored and transported; however, state-of-the-art Ni-based SOFC anodes are limited to hydrogen fuel due to carbon fouling on Ni in the presence of dry hydrocarbons.

Perovskite structured mixed metal oxides are a key class of functional materials utilized as catalysts and electrocatalysts in SOFCs. We have developed a unique pulse reactor system to study the catalytic activity of these materials towards hydrocarbon oxidation under SOFC anode conditions. This information is then utilized to interpret the dynamic electrocatalytic activity of direct hydrocarbon SOFC anodes. This is complemented by thin-film electrode studies that enable more detailed electrochemical characterization. Although commercial SOFC development is underway, these efforts are hindered by the required operating temperature of >700^{o}C. As the SOFC operating temperature is reduced, the cathode rapidly becomes the performance-limiting component in the cell. We have utilized a thin-film SOFC cathode system to probe the operating mechanism of these cathode materials with a goal to enhance performance at lower operating temperatures. Finally, I will present recent efforts that seek to lower the SOFC operating temperature through utilization of proton conducting oxide electrolytes and nanostructuring of the electrodes.

Biographical Sketch

Steven McIntosh is currently and Assistant Professor of Chemical Engineering at the University of Virginia. He received his Batchelor of Engineering with 1st class honors from the University of Edinburgh, Scotland, in 1999 and his MS and PhD in Chemical Engineering from the University of Pennsylvania in 2001 and 2004, respectively. His graduate work was conducted under the supervision of Prof. Raymond Gorte and his PhD was entitled 'Development of Direct Hydrocarbon Solid Oxide Fuel Cells'. Following a postdoctoral period in the Inorganic Materials Science group of Prof. Henny Bouwmeester at the University of Twente, NL, Dr. McIntosh joined the University of Virginia in 2006.

Dr. McIntosh has authored or co-authored 16 archival journal publications, and was awarded a Marie Curie Intra-European Postdoctoral Fellowship from the European Union in 2004 and received a National Science Foundation CAREER award in 2007. His research interests are in electrochemistry, catalysis and solid-state ionics with a particular focus on solid oxide fuel cell development.