Introduction to Hydrogen Production, Distribution, and Use

Due to its high gravimetric energy density and carbon-free nature, hydrogen has the potential to act as an energy carrier in a low GHG-emissions future. Despite these fundamental advantages over carbon-based carriers, hydrogen still must overcome several technological barriers before it can be widely adopted.

Large-scale production of hydrogen is neither efficient nor carbon-free at the present time. Transportation and storage of hydrogen is difficult because of its low volumetric energy density. And hydrogen may offer pathways to higher conversion efficiencies than are available to traditional fuels, although those pathways are not currently cost effective.

GCEP is continuing to investigate the basic science and technology solutions to all three of hydrogen's main challenges. In addition to the work that has been completed on monitoring of bio-hydrogen conversion processes (2006), micro- and nano-scale fuel cells (2006), climate effects of hydrogen (2007), and cyanobacteria-based hydrogen production (2007), there are four ongoing projects in the area of hydrogen.

Professors Hongjie Dai, Bruce Clemens, and Anders Nilsson form an interdisciplinary team of faculty that is conducting research into reversible hydrogen storage on carbon nanotubes. They have recently resolved a long-standing debate in the literature over how much hydrogen can be adsorbed onto high surface-area, nanostructured carbon substrates.

Professor Jonathan Stebbins is leading a team investigating the fundamental dynamics of ion transport within fuel cells. Using high-temperature nuclear magnetic resonance spectroscopy, he has developed a model for the motion of electrical carriers in solid electrolytes based on his observations of changes in the crystal lattice. These data may be used to formulate better devices for the efficient use of hydrogen.

Scanning Electron Microsocopy (SEM) has become an important tool for analyzing the surface dynamics of fuel cells. Professors Peter Pinsky and David Barnett are attempting to reduce the uncertainty in SEM measurements by modeling precisely the interaction effects between the probe-tip and the sample surface. Their work will lead to diagnostics that can pinpoint the most and least efficient parts of the critical interfaces inside the devices which turn hydrogen into useful electricity.

Professor James Swartz is designing an oxygen-tolerant hydrogenase protein. When this protein is incorporated into a living cell, it may enable the efficient production of hydrogen from sunlight and water, using biological agents as catalysts.