Latest fuel cell material advance overcomes low humidity conductivity problem

September 11 2006

Fuel cells have been a workable technology for decades – but expensive and lacking in infrastructure. In recent years, researchers have addressed durability, manufacturability, and conductivity challenges in alternative proton exchange membrane (PEM) materials for fuel cells – bringing the hydrogen-based energy source closer to reality.

James McGrath, University Distinguished Professor of Chemistry with the Macromolecules and Interfaces Institute at Virginia Tech, announced his research group's latest development, a PEM material that retains conductivity during low humidity, during his plenary lecture at the Challenges for the Hydrogen Economy symposium during the 232nd National Meeting of the American Chemical Society.

Fuel cells convert chemical energy, usually from hydrogen, to electrical energy. In a PEM fuel cell, the critical exchange takes place through a thin water-swollen copolymer film that contains sulfonic acid (SO3H) groups. Electrons are peeled off by oxidation of the hydrogen atoms and hydrated protons pass through the film to combine with oxygen on the other side to form water as a byproduct.

The efficiency of the exchange process depends upon water, so efficiency – measured as proton conductivity – goes down as humidity goes down. "Up to now, a lot of water has been needed to assist the proton transfer process," said McGrath. "But, in the desert, that is pretty inefficient." McGrath, chemical engineering Professor Don Baird, and their students demonstrated a method for creating a material with improved conductivity even at lower humidity. The U.S. Department of Energy awarded McGrath and Baird's groups $1.5 million over five years to advance the research.

Instead of stirring two kinds of reactive monomers, or small molecules, together to form a new random copolymer, the new material links blocks of two different short polymers in sequences. For example, he would link polymer W (loves water) and polymer d (dry but strong) into a chain this way: WWWWWdddddddWWWWWddddddd.

The researchers can link a 10- to 50-unit block of a polymer containing acidic groups (SO3H) that like water (hydrophilic) to an equally long block of a polymer that has mechanical strength, thermal stability, and endurance, but hates water (hydrophobic). The chains self-assemble into flexible thin films. Under an atomic force microscope, the film's swirling surface looks like a fingerprint, with light ridges and dark channels. It turns out that the soft hydrophilic polymer forms the dark channels where water is easily absorbed so that the entire film – or proton exchange membrane (PEM) – has an affinity for water transport that is two to three times higher than the present commercially available PEM.

In addition to making PEM materials with better qualities, another goal of the research is to make PEM materials that can be easily manufactured. The self-assembling nature of the block copolymer material into a nanocomposite film is an important attribute. In addition, Baird is working on processing the film from powders using a reverse roll coater, equipment commonly available in the coatings industry but not yet being used to produce PEM material.

Source: Virginia Tech