Dr. David Keffer—Forging the Future of Fuel Cell Technology

On the sixth floor of Dougherty Engineering Building, Dr. David Keffer, associate professor in the Department of Chemical Engineering, sits among piles of papers, books and files working on alternative ways of generating power. With drawings by his four-year-old daughter hanging on the walls of his office, Keffer is reminded of the need for alternative energy for the future generations.

"The idea here is that it doesn't matter if you're generating energy for power plants, your home or car, all these processes create CO_2 and contribute to the main cause of global warming," said Keffer. "We need to find alternative ways of generating power, and relevant to this theme of sustainable energy research being done in the college is the work we're doing with fuel cells."

Along with Dr. Brian Edwards, associate professor of chemical engineering, Keffer leads the Computation Materials Research Group, a group of students, professors and researchers who use computational tools to further understand the relationship between the molecular structure of a material and its effect on macroscopic properties and processability. One project Keffer is working on with seven other researchers is understanding the molecular structure of fuels cells.

"Fuel cells are the alternative for power generation," said Keffer. "We need to make them economically viable, which requires new material development."

In a fuel cell, hydrogen enters and is split into protons and electrons by a platinum catalyst. The electrons are carried off to do electrical work, but the protons have to complete the circuit by being transported through a membrane separating the electrodes. This is where Keffer comes in.

"Researchers do not fundamentally understand how the proton gets from this catalyst particle into the membrane, and if you don't understand that, you can't model it," said Keffer. "Our contract with the Department of Energy is to understand this question that has been out there for 40 years or more as to how the proton moves through the electrode-electrolyte interface."

In order to understand this process, Keffer and the research team have created a computer model membrane at the molecular level to look at the nanostructures that form.

"We want to see how the water wets the electrode, which gives us some idea of which of these catalyst particles can contribute to the overall power generation of the fuel cell," said Keffer. "We're in year two of the project and making good progress."

According to Keffer, the research team has a strong indication as to what is going on inside the membrane and published some results, but want to have things nailed down unambiguously before all results are published.

"If we can fully understand this procedure, it will lead to improved fuel cell membrane electrode assembly designs," said Keffer.

Dr. David Keffer is investigating the molecular structure of fuel cells in order to produce more efficient energy sources for the future.

Keffer has always had a natural affinity for chemistry, but was undecided on a major when he first went to school at the University of Florida, so he took courses in both chemical engineering and materials science.

"What appealed to me about chemical engineering is that it has a very mathematically rigorous foundation," said Keffer. "When you want to describe a system from a chemical engineering point of view, you don't have to rely on intuition. You can instead rely on a methodical procedure with well-established, physically rigorous rules. If you are faithful to it, it can lead to the solution you're looking for. This is the hallmark of chemical engineering."

After three summer internships in industry, Keffer decided to be a professor.

"It became clear that I wanted to use more of my engineering training than it appeared I was going to use with a bachelor's degree in engineering," said Keffer. "There are several universities that have a reputation for producing faculty in chemical engineering, and Minnesota is one of them."

After completing his Ph.D. work at the University of Minnesota in 1996, Keffer moved to Washington, D.C., where he did his post-doctorate work in the Theoretical Chemistry group at the Naval Research Lab. He moved to Knoxville, Tenn., in 1998 as an assistant professor at UT and is now in his tenth year in the Department of Chemical Engineering.

Although chemical engineering is his life's work, Keffer enjoys delving into the world of literature every once in a while.

"I was always interested in literature and took lots of courses in literature and creative writing at Florida," said Keffer. "I have pretty diverse literary interests, but mostly I'm interested in post-modernism."

Keffer's focus on authors with scientific training, the post-modern elements of their writing and how science played a role in their writing led Dean Edie Lawler from Drew University, a small liberal arts college in New Jersey, to invite him to speak to her freshman class.

"I published an article about Primo Levi on a post-modern literature website in 2001," said Keffer. "Someone from the university saw it and asked me to give a presentation on the role of chemistry in Levi's literature." (www.themodernword.com)

Keffer met his wife, Lynn, in 1993 when they were both students at the University of Minnesota. They were married in 2001 and have two children, Ruth, who is four, and Joseph, who is one-year-old. Keffer and his family live in South Knoxville, from where Keffer happily bikes into work on a regular basis.

Keffer's research through the Computation Materials Research Group contributes to a problem looked at by scientists and engineers for generations, which when solved, will improve energy consumption and sustainability for generations to come.

"Our research is a complimentary technique," said Keffer. "Through simulations, we can provide information alongside experiments, which enhance the understanding of fuel cells on the molecular level and mediate the effect humanity has on the environment."

–Story by Amanda Womac