New perspective on leaky membrane extends fuel cell run time

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Direct methanol fuel cells -- which could potentially power portable wireless electronic devices from computers to cell phones to iPods -- could soon benefit from a new approach to membrane leakage and a new membrane-electrode assembly design developed by Penn State engineers.

Dr. Chao-Yang Wang, professor of mechanical engineering and materials science, directs the research, says, "A fuel cell based on our new approach and design could potentially run a notebook computer for 20 hours on straight methanol versus the two to three hours of power current fuel cells produce with six percent mixtures of methanol and water."

The new approach is detailed in a paper, "Low Crossover of Methanol and Water Through Thin Membranes in Direct Methanol Fuel Cells," published recently in the *Journal of The Electrochemical Society*. The authors are Fuquiang Liu, doctoral candidate in materials sciences; Dr. Guoqiang Lu, postdoctoral researcher, and Wang.

Direct methanol fuel cells produce electricity via a chemical reaction that takes place on the surface of a catalyst-coated membrane that is an anode on one side and a cathode on the other. On the anode side of the membrane, methanol is oxidized, generating carbon dioxide, hydrogen ions and electrons that travel through an external circuit as the electric output of the fuel cell. The hydrogen ions pass through the membrane and combine with oxygen from the air on the cathode side of the fuel

cell and form water.

However, in practice, the efficiency of direct methanol fuel cells is hampered by fuel crossover through the membrane. Not only hydrogen ions but also methanol and water can leak through the membrane. Crossover at the membrane of water and methanol reduces the cell voltage and wastes fuel.

Wang notes that researchers traditionally have tried to prevent the movement of methanol through the membrane by using a dilute methanol/water mixture as the fuel at the anode. However, he and his research team at Penn State's Electrochemical Engine Center have shown that looking at the problem in a different way results in a novel solution.

Wang and his team have been studying direct methanol fuel cells since 1998. Instead of looking at the problem as one of methanol leaking through the membrane, they view it as a case of too much water leaking through.

He says, "If you lose more water than methanol in the reaction area on the anode side of the membrane, the solution there becomes more concentrated in methanol, causing more methanol to cross over to the cathode side. Controlling the water leakage also can control the methanol leakage."

With this new view of the problem, the Penn State team designed a new membrane-electrode assembly that accomplishes low methanol crossover, low water crossover and high cell performance simultaneously.

The new design includes a barrier on the anode side of the membrane to reduce methanol crossover and a backing on the cathode side that builds

up counter pressure to the flow of water to allow less water through.

Wang notes that the new design allows the use of highly concentrated methanol solutions or even pure methanol in the fuel cell. He adds, "Highly concentrated methanol or pure methanol is preferred for portable power applications because very dilute methanol solutions require large amounts of water to be carried in the fuel tank which drastically reduces the energy density of the system."

Fuel cells based on the new approach promise not only to be more efficient but also smaller and lighter than those currently available.

Source: Penn State