

# Fuel cells: not an easy solution for transportation

The biggest difficulty of weaning us from our present heavy dependence on fossil fuels has been finding a replacement for gasoline as a transportation fuel. One such touted replacement has been the fuel cell.

Paul Stonehart has been working on fuel cells for a long time – since 1959, in fact, the year he entered graduate school at King's College, Cambridge, where his 1962 doctoral dissertation was titled "Electrode Reactions of Oxygen and Hydrogen Peroxide." In the early years of his career he was involved with fuel cell development for key phases of our human space flight programs -- projects Gemini and Apollo and later the Space Shuttle. In the years since he has obtained patents for many technological improvements to phosphoric acid fuel cells (PAFCs) and polymer membrane fuel cells (PEMFCs). Indeed, the story of these developments has been documented in the patent literature as well as in the scientific literature, where Stonehart has written about 200 papers on fuel cell science and technology and has been described as one of the pioneers and a recognized international authority for the development of fuel cells. He is also the Francis Bacon medalist and prizewinner from The Royal Society of Chemistry for 2004 based on his fuel cell contributions.

As Stonehart recounted in his talk on "Fuel Cells -- Science, Technology, and Economics for Ultra Clean Electric Power Production" to the Physics and Chemistry Teachers Clubs of New York at New York University on 16 March 2007, a fuel cell is basically a long life gas battery that uses only oxygen and hydrogen as reactants to make water.

Early fuel cells, such as those for Gemini and Apollo, used hydrogen and oxygen carried onboard and were based on largely empirical understandings, Stonehart said. It was the need to develop a fuel cell capable of using hydrocarbon fuels (as a source for the hydrogen fuel) that led to the phosphoric acid fuel cell. This required a deep scientific basis for the successful production of this fuel cell operating on natural gas. One key to dealing with this has been nanochemistry, developing electrocatalyst particles with diameters not greater than 10 nm.

Fuel cells have to be tailored to their uses, Stonehart said, and there have been many of them. He cited 200 kW phosphoric acid fuel cell units which fit on the back of flatbed trucks. When connected to a natural gas source, they run 40,000 hours without maintenance. A cluster of five of them have been set up to generate a megawatt of electric power for the Post Office in Alaska.

Just as NASA found promise in fuel cells for its human space flight programs, so also has Germany seen a future for them in submarines. Stonehart feels that there are many other attractive uses for fuel cells, but he adds that they are not easily a solution for transportation. For one reason, air pollutants (particularly sulfur) affect fuel cell catalysts -- this is not a problem in fuel cells operating at high temperatures but becomes serious in fuel cells operating at lower temperatures like 100°C as in PEMFCs. Another problem is that of freezing temperatures on the water by-product of fuel cells. Moreover, Stonehart pointed out, since fuel cells run on natural

gas, they are not an answer to our current dependence on fossil fuels.

*(Editor's Note: The role of water in hydrogen fuel cells and the need for what Stonehart calls a "deep scientific basis" for their successful production are considered in considerable detail in Recommended Resource #5 of this issue.)*