FUEL CELLS: THE FINAL STEP IN A HYDROGEN ECONOMY

Francis J. DiSalvo

Department of Chemistry and Chemical Biology, Cornell University, 102 Baker Laboratories, Ithaca, NY 14853

Fuel Cells transform the chemical energy carried by a fuel into electrical energy. Hydrogen fuel cells are especially well suited for this task because they operate with high efficiency, they do not produce pollution, and they provide electrical power that can be tailored to a wide variety of applications – from large stationary power plants to transportation vehicles to consumer devices like cell phones and personal computers – all assuming that the challenges of hydrogen production and storage can be met.

The basic fuel cell types span a remarkable range of operating temperatures, construction materials, and performance specifications. Although fuel cells offer many advantages for a diverse set of applications, so far they have been introduced only on a limited scale and at high cost. There are serious and difficult obstacles to widespread implementation of fuel cell technology. Most of the challenges arise from the need for inexpensive, more durable materials that also have better operating characteristics, especially in the case of the electrocatalysts, membranes (ionic conductors) and reformer catalysts.

Reformers offer the potential for operating fuel cells by using a range of primary fuels based on gaseous or liquid hydrocarbons. Some current and proposed fuel cell power systems that are capable of using fuels other than hydrogen, either directly or through reformers, may serve as transitional technologies along the path to a full hydrogen economy. These hydrocarbon-based fuel cells may be important in increasing the efficiency of fuel use and in decreasing emissions or noise, a highly valued aspect in some military, commercial and consumer applications in the shorter term. However, some of the fundamental problems in fuel cell technology are independent of the fuel source, as we will discuss in this presentation.

In this presentation, we discuss primarily the challenges and problems associated with low-temperature fuel cells (operating from 40 to 150 or 200 ^{o}C) and, to a lesser extent, with high-temperature (650 to 1000 ^{o}C) fuel cells. Low temperature fuel cells, in particular, are the focus of current automotive fuel cell R&D activities that, when implemented, would be a major component of a hydrogen economy.

The development of efficient, durable and low cost fuel cells is a grand challenge that will take substantial and sustained efforts in chemical and materials research. These challenges can only be met by new materials with improved, or even revolutionary, properties and performance. A basic, exploratory research program of significant size and scope is needed to produce these enabling discoveries.

This presentation will outline many of the challenges and opportunities that need to be addressed with basic research in materials synthesis, analytical studies of the processes and kinetics of reaction as well as materials degradation, theoretical modeling, etc. It is hoped that by outlining the challenges, the scientific community can be energized to be engaged in the process of discovery and invention to produce the breakthroughs necessary to enable this vision of an energy future that promises less pollution and less reliance on energy imports.