



Università
Ca' Foscari
Venezia

Department of Environmental Sciences, Informatics and Statistics

Department of Molecular Sciences and Nanosystems

**Conjunct Seminar of the PhD Programme in Environmental Science
and Chemistry**

Fuel Cells and the Sustainable Production of Energy

Prof. Howard M. Colquhoun

Department of Chemistry, University of Reading, UK

July 05th, 2018 at 12:00

Room Delta 1B

Organizer of the seminar
prof. Fabio Aricò

Directors of Ph.D. courses
prof. Alessandro Scarso and Prof. Bruno Pavoni

Fuel Cells and the Sustainable Production of Energy

Howard M. Colquhoun

Department of Chemistry
University of Reading, UK

Current energy-generation technologies across the world are not sustainable because they depend heavily on fossil fuels such as coal, oil and natural gas. Not only are reserves of such carbon-based fuels limited (peak oil production may well be reached within the next decade) but their combustion generates vast quantities of carbon dioxide and so is a major factor in driving climate change. Developing a sustainable strategy for energy production is thus one of the most important problems in the whole of science and technology. Many potential options are available but no single, best technology has yet emerged because all current options have disadvantages.

- One problem is intermittent output: solar cells do not work when it is dark; wind turbines generate energy only when the wind blows; tidal energy peaks and falls twice a day.
- Hydroelectric power is entirely dependent on geography (high mountains) and climate (heavy rainfall), and most suitable locations have been used. Hydroelectricity currently provides about 20% of the world's energy-supply, and 80% of its sustainable energy.
- Uranium fission produces continuous energy without generating CO₂, but the problems of radioactive waste disposal and the potential for nuclear accidents seem too great for this established technology to be a realistic long-term solution.
- Fusion of hydrogen isotopes to form helium (as occurs in the sun and in the H-bomb) is a possible long-term solution, as the fuels are abundant and no radioactive waste is produced. The only problem is that temperatures of about 100,000,000 °C must be reached for fusion reactions to be self-sustaining. Such temperatures can be reached in current experimental fusion reactors, but it may be 2030 before a next-generation fusion reactor ("ITER", being built in southern France) generates more energy than it consumes.

As well as energy-generation there are also issues of energy-storage and energy-distribution. Storage is needed to smooth out the intermittent production of energy from renewable sources, and distribution is required to provide energy in situations where the use of conventional transmission-lines is not feasible (e.g. automotive transport). A possible answer to both issues is the hydrogen fuel cell. This is an electrochemical device in which hydrogen reacts with oxygen to generate electrical energy directly (Fig. 1).

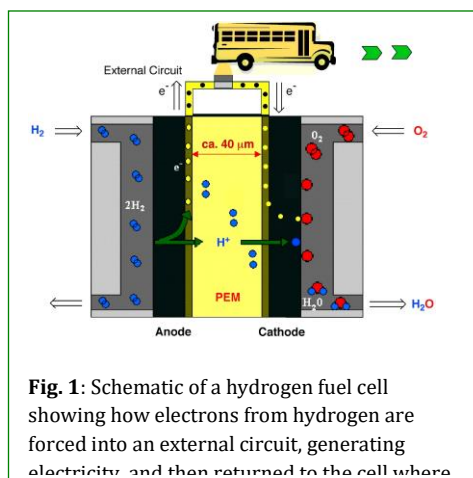


Fig. 1: Schematic of a hydrogen fuel cell showing how electrons from hydrogen are forced into an external circuit, generating electricity and then returned to the cell where

The only other reaction product is water, with no waste heat and no CO₂ production. A fuel cell is ideally suited to smoothing out the peaks and valleys of sustainable electricity production, because it is essentially an electrolysis cell running in reverse. Surplus electricity can thus be stored by electrolysing water to make hydrogen, and the energy then recovered by oxidising the hydrogen in a fuel cell.

The present lecture will discuss both the environmental aspects of sustainable energy production and the chemistry, especially materials chemistry, of the hydrogen fuel cell.