

University of Wisconsin  
Chemistry 116  
Electrochemistry-Construction of Solar Cells and Fuel Cells\*

Redox reactions, reactions involving electron transfer, are fundamentally important to chemistry and have been studied by chemists for many years. Technological innovations based on redox reactions date back to prehistoric times when humans first learned to reduce copper and iron metals from their naturally occurring oxidized forms to make tools and weapons<sup>i</sup>. In more recent times, chemical entrepreneurs have used electrochemical methods to make themselves extremely wealthy. Working in the wood shed of his family home, a young chemist named Charles Hall invented the process of reducing aluminum from bauxite ore in 1886 when he was 20 years old and had just graduated from Oberlein College. In 1888, he helped found a company, The Pittsburgh Reduction Company, that is currently known as Alcoa and has annual revenues of over 2 billion dollars from the sale of aluminum products (including Reynolds Wrap)<sup>ii</sup>. Thomas Edison used the electrochemical reduction of Zinc as a way to quantify, and charge for, the amount of electricity that his customers were using. Since their invention in the early 1800s, batteries have made a significant impact in our need to store energy but significant innovation in battery technology has been fairly slow over the past 200 years.<sup>iii</sup> Unfortunately, fundamental research in electrochemistry seems to have also been slow since the publications of some highly cited papers in the 1960s by Rudolph Marcus at the University of Illinois, and Irvin Shain at the University of Wisconsin.<sup>iv</sup> (Yes, the Shain Wing of our chemistry building is named after an electrochemist.) As a result of the decline in faculty research interests in electrochemistry, electrochemical topics have also been receiving less and less coverage in university chemistry courses.

So why are we doing an electrochemistry experiment in Chemistry 116? Within the last five years, the field of electrochemistry has been reinvigorated because of its potential to solve the problem of global climate change. Many researchers believe that electrochemical cells can be used to harness the power of the sun to meet society's ever increasing demand for energy without producing the billions of tons of carbon dioxide associated with the world wide burning of fossil fuels.

In this experiment, you are going to build two devices that are important for the practical use of solar energy. You will construct a solar cell that will convert light energy into electrical current. The solar cell that you will construct is a type of Gratzel Cell. The web page:

<http://www.rsc.org/Education/EiC/issues/2007Sept/HarnessingSolarEnergyGratzelCells.asp>

has a good description of the layers used in a Gratzel Cell. You will also construct a hydrogen based fuel cell, and if all goes well, you will use your solar cell to generate the hydrogen for the fuel cell. Detailed directions for the construction of these cells will be provided at the beginning of your lab period. The construction methods that you will be using are based on techniques from the following web sites:

<http://www.mrsec.wisc.edu/Edetc/nanolab/fuelcell/index.html>

<http://www.mrsec.wisc.edu/Edetc/nanolab/TiO2/index.html>

<http://www.nd.edu/~pkamat/>

**Make sure you look at these web sites before coming to the lab!!!**

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\* The construction of the fuel cells and solar cells in this experiment are adaptations from the methods available from the "Exploring the Nanoworld" website at the University of Wisconsin-Madison Materials Research Science and Engineering Center. <http://www.mrsec.wisc.edu/Edetc/index.html> The adaptations were made by R. McClain, April 2010.

<sup>i</sup> <http://neon.mems.cmu.edu/cramb/Processing/history.html>

<sup>ii</sup> <http://www.fundinguniverse.com/company-histories/Alcoa-Inc-Company-History.html>

<sup>iii</sup> [http://en.wikipedia.org/wiki/History\\_of\\_the\\_battery](http://en.wikipedia.org/wiki/History_of_the_battery)

<sup>iv</sup> <http://electrochem.cwru.edu/estir/history.htm>