Title: Fuel Cell Characterization

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Appropriate Level: Regents Chemistry and/or AP Chemistry

Abstract: Sources of alternative energy continue to be a major area of research. An essential aspect of this research is fuel cell characterization, which gives a quantitative judgment of the fuel cell's performance. Such a measurement is conducted by measuring the current produced at a specified voltage. The greater the current, the better the performance.

Time requirement: Two 40-minute lab periods, or One 80 Minute Lab Period

NYS Standards: NYS Chemistry Core Curriculum 3.2d-h, i-l

Required Materials: **This lab is a supplement** to the lab activity produced by Per-Odd Eggen, Lise Kvittingen, and Truls Grønneberg, which can be found in the citation below*. This lab activity is available from the CCMR Educational Modules collection.

- distilled water.
- buffer solution of water.
- graphite for mechanical pencils
- thin rods of platinum (approximately the dimensions of the graphite)
- voltmeter


Safety: Safety goggle should be used during all portions of this lab activity.

Journal of Chemical Education **2004**, *81*, 1337.

Science Content for the Teacher

In recent years, the search for alternative energy sources has moved from an academic curiosity to an economic necessity. The twin pressures of rising oil prices and long-term climate change have necessitated a shift away from a carbon-based fuel economy. Scientists, engineers, and corporations are hard at work exploring various alternatives. One choice is to move toward a hydrogen-based economy where transportation no longer relies on the internal combustion engine, but on a hydrogen fuel cell.

A 150 year-old technology, hydrogen fuels cells are attractive alternatives for a number of reasons. One reason is efficiency. An internal combustion engine is limited by Carnot Efficiency, while a fuel cell converts chemical energy *directly* to electrical energy. Hydrogen fuel cells have the added benefit of producing nothing but water. This is a very appealing idea in our carbon-conscious age.

The purpose of this activity is to demonstrate the materials and conditions that make a good fuel cell. One major factor is the material used for the electrodes. Which cheap materials, such as graphite, may work for the electrolysis of water, performing the reverse reaction is much more difficult. This is because hydrogen gas (the substance most commonly used in fuel cells) is not readily absorbed onto graphite. In an effort to find a compromise between efficient, but expensive materials, like Platinum, and cheaper, less efficient materials, much materials research is being conducted in an effort to “dope” graphite. It is hoped that such doping will make it more hospitable to hydrogen absorption.

Another element to fuel cell efficiency is the pH at each electrode. During the electrolysis performed in the preceding laboratory activity, the pH of the water changes, forming an acidic solution at the anode as well as a basic solution at the cathode. According to the Nernst Equation, the greater the pH difference between the anode and the cathode, the greater the voltage of the fuel cell.

For this lesson, students should already be familiar with oxidation and reduction, as well as voltaic cells and the electrolysis of water.

Name_____

Date: _____

Per. _____

Introduction:

In the previous lab, you created a miniature version of a hydrogen fuel cell. Now it's time to find out some quantitative information about that fuel cell, measuring the resistance and current of our control, as well as when we vary the materials of the electrodes and the pH of the solutions.

Procedure:

A. The Control Fuel Cell

1. You should have the miniature fuel setup from the previous lab. If not, you must rebuild this fuel cell, and preform the electrolysis reaction.

2. Carefully connect a voltmeter to the graphite electrodes and measure the voltage.

3. Record this measurement in the data section below.

B. Various Materials

1. Carefully take out the graphite rods by *gently* pulling on them from the top of the pipette bulb. Remember that graphite is a particularly brittle material. Make sure that the bulb is constantly submerged, or gas will escape.

2. Quickly, but carefully, insert platinum rods into the bulb through the top of the bulb.

3. Measure the voltage in the data section below.

4. Optional: Repeat steps 2 and 3 with any other material provided by your instructor.

C. Buffered Solution

1. Obtain a buffered solution from your instructor.

2. Empty the bulbs of any remaining solution and allow the gases to escape. Empty and clean the petri dish used, as well.

3. Fill the petri dish and the bulbs with buffered solution of water.

4. Perform the electrolysis described in the first lab.

5. Once both hydrogen and oxygen have been produced, connect a voltmeter as before and measure the voltage. Record below.

Data:

Voltage in Various Solution	
Control	
Platinum Rods	
Buffered Solution	

Questions:

1. Which type of material served as the best electrode?

2. What difference (if any) occurred with the buffered water solution.