19.3 Fuel Cell Cars

Subject: Electrochemistry, electrolysis, fuel cells

Description: A fuel cell car is demonstrated.

Materials:
2 Fuel Cell cars
DI Water
2 syringes
Solar panel (only one works well)
Light source (use sun or desk lamp with a 75 W bulb on desk)
Or Hand electricity generator to produce current
Instruction book

Pre-Class Preparation:
1. Following the directions in the instruction manual, fill the water reservoir at the rear and using the syringe pull water through each side of the fuel cell. Continue to pull water through until there are no more air bubbles in the fuel cell and the gas tanks are full of water.

Procedure:
1. Using either the solar cell or hand generator, charge the fuel tanks with H_2 and O_2. Be sure to disconnect the motor first. Connect the solar panel or the generator to the strip. Crank the generator or shine the light on the solar panel. The current generated by either will cause the electrolysis of water within the fuel cell. The O_2 and H_2 gases generated will displace the water in the fuel tanks. Continue filling the tanks until both are full. Twice as much hydrogen is produced as oxygen. The tanks are sized proportionally so that the level of gas in each tank should be the same.
2. Once the tanks are full of gas, unplug the generator or the solar cell and plug in the motor. Be sure the front wheels are off of the floor while plugging the motor in. Oxygen and hydrogen will recombine in the fuel cell to produce water. The reaction generates an electric current that powers the motor.

Discussion:
There are several different types of fuel cells. The car in this experiment uses a Proton Exchange Membrane (PEM) fuel cell. The membrane separates the anode from the cathode and is made of a polymer called Nafion. The electrolysis taking place in this fuel cell is reversible; the cell can operate as a fuel cell and as an electrolysis apparatus.

The anode is where neutral hydrogen atoms enter the fuel cell. Here they are oxidized to a positively charged proton and a negatively charged electron. The proton travels through the membrane toward the cathode. The electron takes a different path through an external circuit towards the cathode. This electrical current is used to power the motor of the fuel cell. The cathode is where oxygen

atoms enter the fuel cell. Here the oxygen molecules react with the protons that migrated through the membrane and the electrons that flowed into the cathode through the external circuit to produce water.

The reactions that are occurring are given below:

Anode: $2\ H_2 \rightarrow 4\ H^+(aq) + 4e^-$ (Oxidation – electron donation)

Cathode: $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$ (Reduction – electron uptake)

Use the opportunity to discuss the issues and problems of alternative energy and hydrogen fuel technology in particular, including the processes of producing, storing and using hydrogen. The electrolysis of water in order to produce hydrogen requires considerable energy. "The only way to obtain hydrogen from water in the amounts that would be needed and in an economically favorable way is to use a cheap and abundant source of energy to drive the process"[1]. Solar energy is an option but not yet practical.

Safety: None

Disposal: Pour any water remaining in the storage tank down the sink. The cells should be stored with water.

References:

1. Kotz, Treichel, Townsend; *Chemistry and Chemical Reactivity*; 7th Ed; 2009; page 263