Name: _____ Class: _____ Date: _____

Chemistry | High School | 6 hours

Objective

Run experiments with an ethanol fuel cell learn about chemical reactions, electricity, and renewable energy.

Materials

- Horizon's Ethanol Fuel Cell Science Kit
- Ethanol solution
- Distilled water
- Stopwatch
- Horizon Renewable Energy Monitor (optional)

Background

Fig. 1: This car runs on ethanol, not gasoline.

Ethanol is one of the most practical sources of renewable energy on the planet. It can be made from corn or sugar, which are already produced by the ton. It's also carbon negative: it adds less carbon dioxide into the atmosphere than is trapped by the plants which were grown to supply the fuel.

Ethanol is a product of decomposing plants during a process called fermentation. Ethanol is being used to power cars (Figure 1) and as a heat source for homes. It can also be used by our fuel cell to produce electricity. You can learn more by reading Introduction to Ethanol.

With the right mixture of ethanol, our fuel cell will provide enough electricity to power a small motor on a fan. But it won't always produce the same amount of electricity. We can change how well the fuel cell works by changing things like how hot the fuel is or how much ethanol we mix with water.

What concentrations of ethanol are better for the fuel cell? At what temperature should it run? When scientists are building cars and machines that run on ethanol, they have to ask these kinds of questions

to make sure they get the most energy out of their ethanol fuel. Now we'll use the ethanol fuel cell to explore these questions and more during this activity.

Method

We will be using the ethanol fuel cell to power a small fan. We will run experiments to understand more the most efficient way to make our ethanol fuel cell work.

Procedure

As you assemble your fuel cell and run your experiments, write down any interesting observations you have in the **Observations** section below.

1. Open the purging valve on the bottom of the fuel cell by pushing it towards the back, away from the fan.
2. Make sure the tubing connecting the fuel cell, purging valve, and fuel container is secure.
3. Open the fuel container and pour the ethanol solution in, then close the lid.
4. Wait 5-10 minutes for the fuel cell to begin the chemical reaction.
5. Attach the red and black alligator clips to the fuel cell and observe what happens.
6. When you're finished, disconnect the alligator clips.

Observations:
Write down anything interesting you observe while running the ethanol fuel cell.

Experimentation: Concentration of Ethanol

Will the fuel cell run better if the ethanol is more concentrated? Prepare solutions of ethanol in the following concentrations and run the fuel cell as you did in the **Procedure** section.

Each time you run it with a different concentration, write down any observations below.

Concentration	***Observations***
5%	
7%	
10%	
12%	
15%	

What happened when you used different concentrations of ethanol in your fuel cell? *Construct an explanation* of what you observed.

Experimentation: Temperature

How does the fuel cell work with fuel at different temperatures? Using a hot plate to heat samples (up to 60ºC) choose what temperatures you want to test and run the fuel cell as you did in the **Procedure** section. Record any observations below:

Temperature (ºC)	***Observations***

Did the temperature of the fuel affect how fast the fan was spinning? *Construct an explanation* of what you observed.

Analysis

Make a *scientific claim* about your ethanol fuel cell. What are the conditions that would generate the most electricity from this fuel cell? To help you write a claim statement, see Stating a Scientific Claim.

Claim

What evidence can you use from your observations of the car to back up your claim? State the reasoning you used to make your claim.

Evidence

State the reasoning you used to make your claim.

Reasoning

Use the data you collected to *design an experiment* that you could run to test the effect of air temperature on the fuel cell. Explain the steps of your experiment here:

Does it matter if the fuel cell is attached to something other than the fan? *Design an experiment* that would test what happens when other electric machines are powered by the ethanol fuel cell. Explain the steps of your experiment here:

Conclusion

1. What happens if you attach the wires to the fan backwards (red to black and black to red)? *Construct an explanation* of what you observe.

2. Could you use an ethanol fuel cell to provide power to your house? *Develop an argument* to support your position using evidence you observed during this activity and defend your argument if there are different points of view in your group.

3. Was energy made or used up during this activity? *Construct an explanation* of what happened to the energy and why.

4. What would you do to improve the electricity production of your ethanol fuel cell? *Design a solution* that would increase the amount of electricity you would get from your fuel cell.

5. As explained in “Introduction to Ethanol,” your fuel cell is possibly producing an acidic product when it runs. Use some pH paper to determine whether your fuel cell is working more or less efficiently than your classmates’. Then discuss with your group: what kinds of questions could help you investigate these differences?

6. (Optional) If you have a multimeter or the Horizon Renewable Energy Monitor, compare your amperage and voltage data with your classmates who have more or less efficient fuel cells. Does the electrical data match with your pH data? *Construct an explanation* of what you find.

7. Besides concentration and temperature, what other characteristics might have an effect on this reaction? Choose another variable you could test and *design an experiment* that explains how you'd determine its effect.

Measurement

How much electricity is running through our circuit? To find out, we'll need to use an ammeter like the Horizon Renewable Energy Monitor to measure the amount of electric current being produced by the generator. Read Measuring Current in a Circuit for more information on how to set this up.

When your ammeter is connected to your circuit, run the ethanol fuel cell to power the fan. Use a stopwatch and measure the amount of current in the circuit at different times. If you have the Horizon Renewable Energy Monitor, you can also measure the volts. Record your data below:

Time (min)	***Amps (A)***	***Volts (V)***
0		
2		
4		
6		
8		
10		

Does the amount of electricity produced by the fuel cell change? *Construct an explanation* of what you observed.