How Strong Is The Drink?

Topic

Alcohol testing

Introduction

Alcohol consumption affects judgment, and people should not perform certain tasks such as driving and operating dangerous equipment after consuming alcohol. As some people attempt to drink when undertaking such activities, equipment to detect such offenders has been designed. One such device uses a type of fuel cell, which converts the chemical energy in alcohol into electrical energy. In this experiment, you will study the voltage produced by such a fuel cell when it contains different concentrations of alcohol (present in brandy or another spirit). You will do this by adding a range of volumes of alcohol to a fixed volume of the sodium hydroxide used as the electrolyte in the cell. You will then consider how the response of this fuel cell changes with the changing concentration of alcohol.

Time required

1 hour

Materials

600 ml beaker
500 ml tap water
20 g sodium hydroxide pellets
glass rod
fuel cell kit*
graduated eyedropper to measure at least 2 ml in 0.5 ml graduations
multimeter or voltmeter to measure voltage in hundredths of a volt
3.5 ml brandy or other spirit in a small disposable container
weighing scales
watch or clock with a second hand
bucket
paper towel
graph paper
thermometer reading –10 to 110°C
safety glasses

*For example, see:
http://www.intox.com/fuel_cell_explanation.asp
http://www.alcoholtest.com/ecfuel.htm

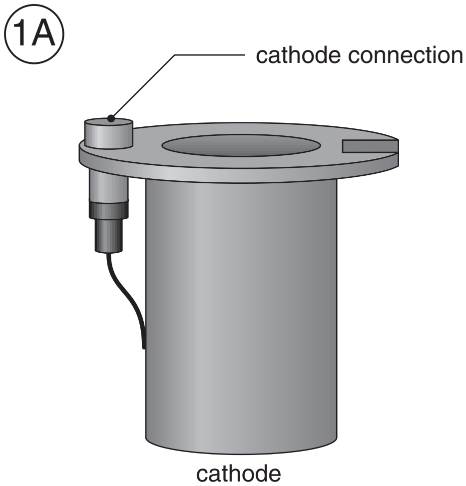
Safety note

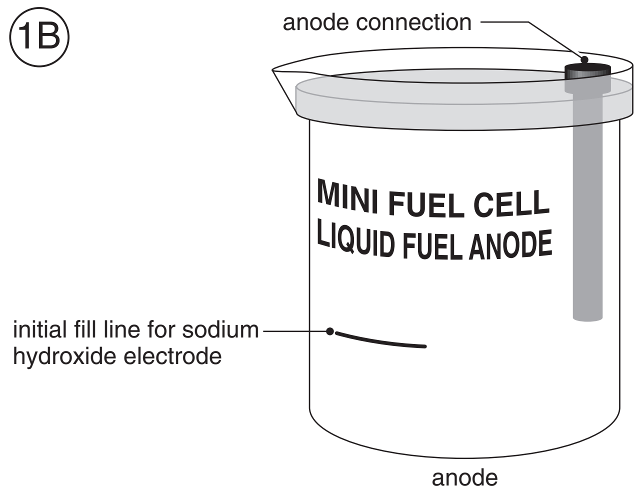
Sodium hydroxide is corrosive. Wear safety glasses. Be careful when disposing of the solutions from the fuel cell.

Procedure

You will need a partner for this experiment.

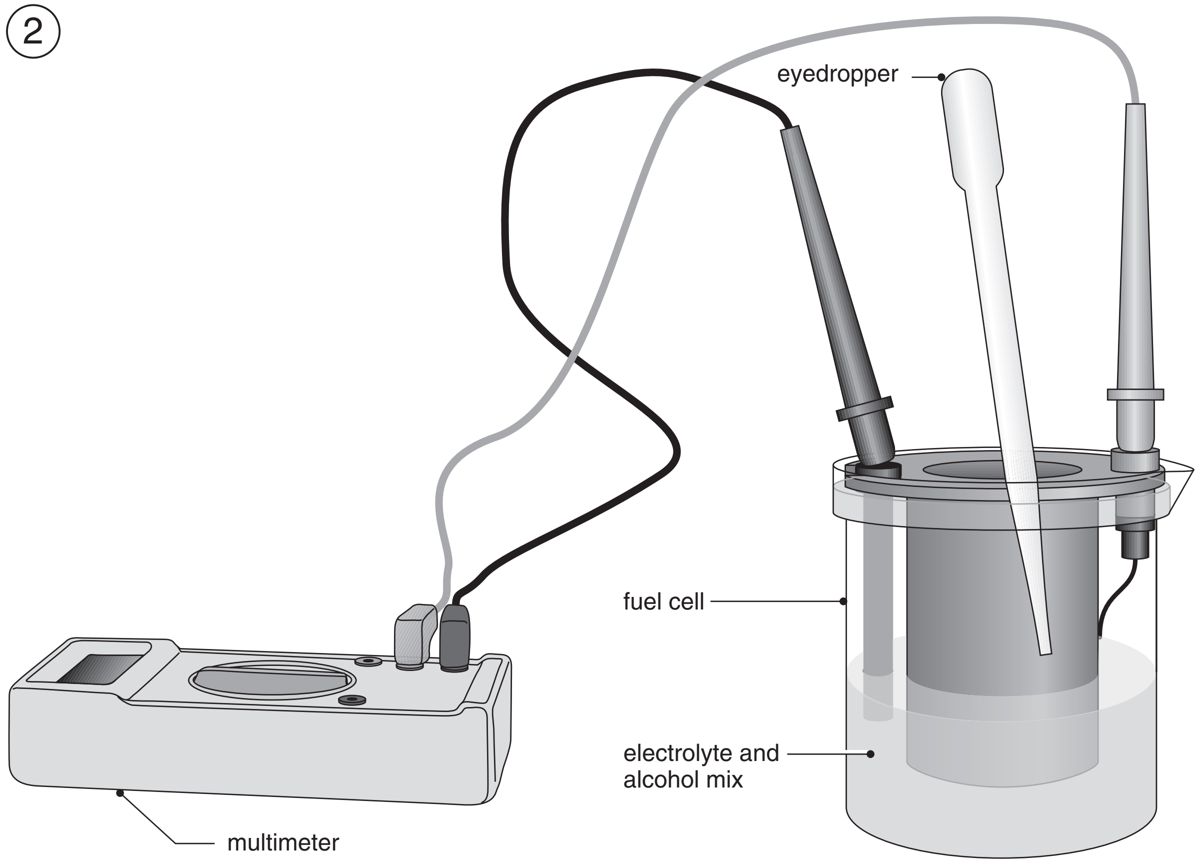
1. To make the sodium hydroxide electrolyte solution, put 20 g sodium hydroxide pellets in the beaker. Add the water to the beaker and stir with the glass rod until the pellets dissolve.
2. Pour the electrolyte into the anode beaker of the fuel cell up to the fill line (see diagram 1B below).
3. Prepare to take voltage readings. Decide who is to be responsible for measuring and adding the alcohol to the fuel cell (person 1), and who is to time and record the voltage readings from the multimeter (person 2).
4. Insert the cathode into the anode beaker of the fuel cell. Insert the probes of the multimeter into the anode and cathode connections as shown in diagram 2 on the next page.
5 Insert the thermometer into the hole in the rim of the cathode (in diagram 2, this is the hole in which the eyedropper is inserted). Read the temperature and enter in the data table on page 4.08–4 in the column headed "0.5 ml alcohol added." Record the reading on the multimeter in the data table for this column at time zero. Remove the thermometer.
6. Draw up 0.5 ml alcohol (brandy or another spirit) into the eyedropper. While person 1 adds the alcohol to the fuel cell and gives the cell a gentle swirl, person 2 takes voltage readings from the multimeter every 10 seconds for the first 2 minutes and then every 30 seconds for the next 3 minutes. Person 1 enters these values in the data table.





Cathode (A) and anode (B) of fuel cell

7. When you have taken the readings, remove the cathode from the fuel cell and pour the liquid from the anode beaker into a bucket for later disposal.
8. Rinse the parts of the fuel cell thoroughly in cold tap water and dry carefully with paper towel.
9. Repeat steps 2 to 8 but adding 1 ml alcohol.
10. Repeat steps 2 to 8 but adding 2 ml alcohol.



Connecting the multimeter to the fuel cell

Analysis

1. Draw a graph to display your results. What shape are the curves?
2. Are the curves different for different concentrations of alcohol?
3. How could these results be used to judge the strength of an alcoholic drink?
4. Was each initial reading the same?

Want to know more?

Data table			
	0.5 ml alcohol added	**1 ml alcohol added**	**2 ml alcohol added**
Initial temperature (°C)			
Time elapsed after adding alcohol	**Voltage reading**		
0			
10 seconds			
20 seconds			
30 seconds			
40 seconds			
50 seconds			
60 seconds			
1 minute 10 seconds			
1 minute 20 seconds			
1 minute 30 seconds			
1 minute 40 seconds			
1 minute 50 seconds			
2 minutes			
2 minutes 30 seconds			
3 minutes			
3 minutes 30 seconds			
4 minutes			
4 minutes 30 seconds			
5 minutes			

1. Each of the curves rises rapidly at first and then levels off.
2. The readings for the more concentrated solutions (the larger amounts of alcohol added) show a steeper initial rise in voltage recorded and a more rapid leveling off.

In each case, if the experiment is left to run for longer (say, 20 minutes to an hour), the reading for a solution of lower concentration will eventually reach the same reading as for stronger solutions.

3. If a certain amount of a strong drink is added to a fuel cell like the one used here, it will produce a more rapid rise in voltage than the same amount of a weaker drink.
4. The voltage produced by the fuel cell is dependent on temperature. If the starting temperature was the same, the initial voltage should be similar. However, even if the initial temperatures differ slightly, the rise in voltage is far more rapid for electrolytes with a higher alcohol concentration.

In this cell, the cathode (the positive electrode) attracts electrons from the solution; these electrons react with oxygen in the air according to the following equation:

$$4e^- + O_2 + 2H_2O \rightarrow 4OH^-$$

At the anode (the negative electrode), the reaction with ethanol (the alcohol used) loses electrons:

$$C_2H_5OH + 2OH^- \rightarrow CH_3CHO + 2H_2O + 2e^-$$

You could repeat this experiment using different alcohols such as methanol and isopropyl alcohol (propan-2-ol), or any solution containing alcohol.

Special Safety Note To Experimenters

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely essential that you read, copy, and remain mindful of the General Safety Precautions that follow this note. Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Be prepared for unexpected dangers by following basic safety guidelines the entire time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will remember them. Except in rare instances, the general precautions listed below will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say **BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE** does not mean that you should be careless when boiling water or cutting a section of a stem for microscope work. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out from a qualified adult that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the individual experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:

—Clear all surfaces before beginning experiments
—Read the instructions before you start
—Know the hazards of the experiments and anticipate dangers

PROTECTING YOURSELF:

—Follow the directions step-by-step; only do one experiment at a time
—Locate exits, fire blanket and extinguisher, gas and electricity shut-offs, eyewash, and first-aid kit
—Make sure there is adequate ventilation
—Act sensibly at all times
—Wear an apron and safety glasses
—Do not wear open shoes, loose clothing, or loose hair
—Keep floor and workspace neat, clean, and dry
—Clean up spills immediately, being careful to follow the recommended procedure for dealing with the spilt substance
—Never eat, drink, or smoke in the laboratory or workspace
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:

—Set up apparatus far from the edge of the desk
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs

—Don't use your mouth to pipette liquids; use a suction bulb
—Check glassware is clean and dry before use
—Check glassware for scratches, cracks, and sharp edges
—Report broken glassware immediately so that it can be cleaned up by a responsible person
—Do not use reflected sunlight to illuminate your microscope
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders

USING CHEMICALS AND BIOLOGICAL MATERIALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear safety glasses, lab apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly
—Use sterile procedures when handling even common and harmless microorganisms
—Avoid contact with human blood
—Treat all living organisms with appropriate respect

HEATING SUBSTANCES:
—Wear safety glasses, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Use test tubes, beakers, and other glassware made of Pyrex™ or borosilicate glass
—Use alcohol-filled thermometers (do not used mercury-filled thermometers)
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—If your laboratory does not have heat-proof workbenches, put your Bunsen burner on a heat-proof mat before lighting it
—Take care when lighting your Bunsen burner; use a Bunsen burner lighter in preference to wooden matches
—Turn off hot plates, Bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Keep sheets of paper and other flammable objects away from your Bunsen burner
—Have a fire extinguisher on hand

FIELDWORK:
—Be aware of environmental dangers (e.g., do not carry out fieldwork near dangerous roads, cliffs, or water)
—Remember that strong sunlight can be dangerous – pack sunscreen and a good supply of drinking water if you will be outside all day
—Never carry out fieldwork in areas where you cannot find your way to safety easily and quickly and never wander off on your own in search of new areas to study

FINISHING UP:
—Clean your work area and glassware (follow any instructions given by a supervising adult)
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residues and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws
—Dispose of all microbiological cultures by treatment with an appropriate disinfectant

BE SAFETY CONSCIOUS AT ALL TIMES