Bio-Energy Kit
ASSEMBLY GUIDE

CE

Model No.: FCJJ-22

⚠ Warning

To avoid the risk of property damage, serious injury or death:

This kit should only be used by persons 12 years old and up, and only under the supervision of adults who have familiarized themselves with the safety measures described in the kit. Keep small children and animals away, as it contains small parts that could be swallowed. Read the instructions before use and have them ready for reference.

1. Read carefully and fully understand the instructions before starting assembly of this kit.

2. This kit is intended only for use by persons 12 years old and up, and only under the supervision of adults who have read and understood the instructions in this user manual.

3. When assembling this kit, tools may be used. Extra care should be taken to avoid personal injury.

4. Some parts are small and fragile: please be careful when handling and connecting parts to avoid breakage. Handle all parts and components with care.

5. Do not attempt to use any part, item, or component provided in this kit for any other purpose than what is instructed in this manual. Do not attempt to disassemble any part, item or component in this kit.

6. Do not attempt to ingest or drink new or used liquids needed for the purpose of this experiment kit.

7. Keep ethanol away from the fire or flame source while you are mixing the solution. Igniting the ethanol and the ethanol solution is strongly forbidden.

8. It is recommended that this kit be operated under the temperature between 5°C and 40°C.

Bio-Energy Kit ASSEMBLY GUIDE

What you need: ● Kit ● Water ● Ethanol

Preparing a 10% ethanol solution:

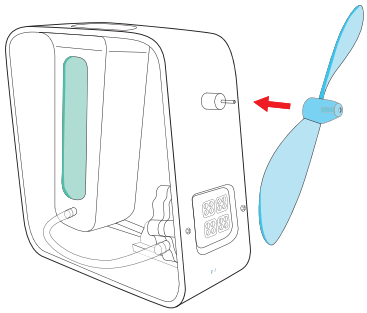
Warning!

Do not allow pure ethanol to enter the fuel cell. The DEFC creates power using 5-15% alcohol only. A concentration higher than 15% could damage the fuel cell and cause it to stop working correctly. For best operation please use a mixture of 10% ethanol and 90% Water. Keep ethanol away from the fire or flame source while you are mixing the solution. Igniting the ethanol and the ethanol solution is strongly forbidden.

Step 1: Fill the container with 6ml of pure ethanol (fill container to the 6ml level).
Step 2: Fill the remainder of the container with water to the 60ml level.
Step 3: Stir the liquid in the container thoroughly.

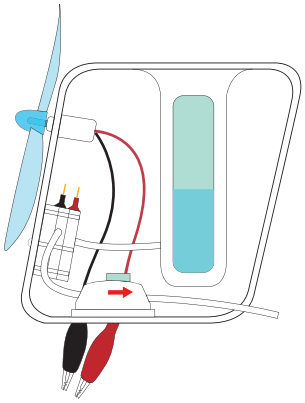
Experiment 1: Create electricity from ethanol and water

STEP 1



Remove the fan blade from the box.
Push the blade onto the axis of the motor slowly and carefully.

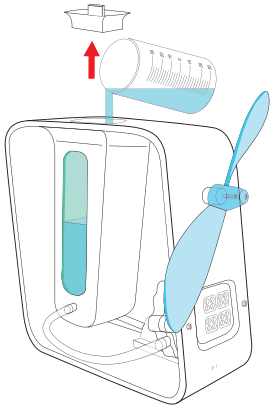
STEP 2



Open the purging valve by pushing the switch to the right side.

Make sure that the tubing connecting the container to the fuel cell is securely attached.
Make sure the tubing connecting the tubing with purging valve is securely connected to the fuel cell and the switch on the purging valve is positioned at the right side close to the solution tank.

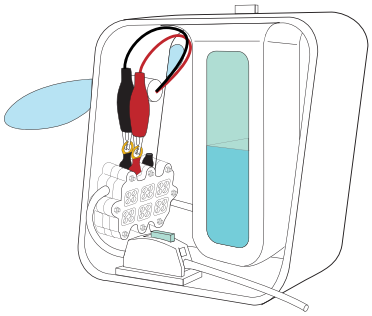
STEP 3



Pour the solution into the ethanol container.
Put the lid back to the container.

Note: When the solution starts dripping out of the tube, close the purging valve by pushing the switch to the left side. Then wait for 5 to 10 minutes before connecting the wires.

STEP 4

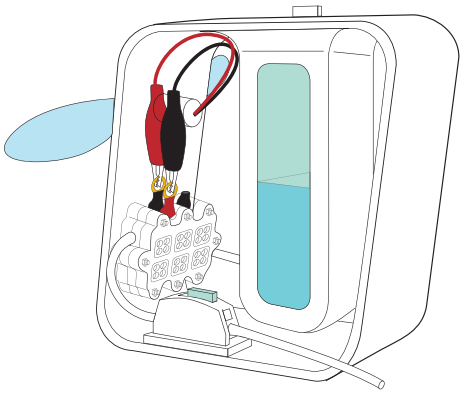


After waiting for 5-10 minutes, connect the two crocodile clips that are attached to the motor to the two terminal plates of the fuel cells current collector, which are both located on the upper part of the fuel cell.

If you have waited for 5-10 minutes with the clips disconnected from the fuel cell, the fan should start rotating by itself once connected. Make sure you repeat the waiting period of 5-10 minutes after each purging. Since the reaction is slow, the fan can run for up to several hours without purging (see Experiment 3).

Horizon Fuel Cell Technologies

Experiment 2: Exploring polarity

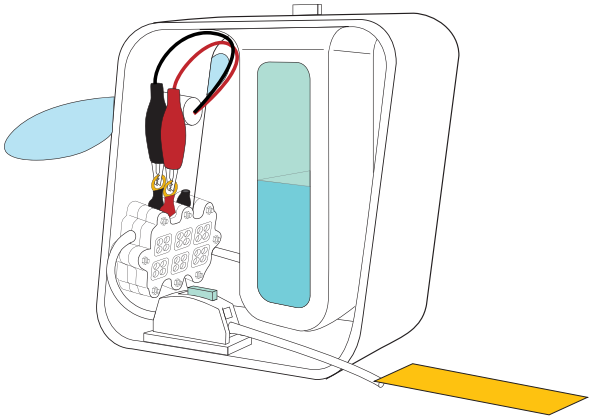


Step 1: Connect the positive (red) crocodile clip to the positive side of the fuel cell (red "+" mark), then connect the negative (black) crocodile clip to the negative side of the fuel cell (black "-" mark).
You will notice the fan will turn clockwise.

Step 2: Now repeat the process, this time however connect the positive (red) crocodile clip to the negative side of the fuel cell (black "-" mark) and connect the negative (black) crocodile clip to the positive side of the fuel cell (red "+" mark). You will notice the fan will turn counter-clockwise.

Conclusion: The current flows from positive to negative, creating a clockwise spin of the fan. By inverting the polarity connections, the current flow reverses and makes the fan spin in the opposite direction.

Experiment 3: Ethanol fuel consumption



When the fan begins to run slower or stops running completely, this means the ethanol present in the fuel cell chamber is mostly consumed. In normal temperature conditions, the majority of the ethanol inside the fuel cell chamber turns into acetic acid, which is the main component of vinegar.

Let's investigate the consumed fuel (acetic acid) when the fan begins to run slowly.

Step 1: Place a piece of PH paper under the outlet of the purging tube.

Step 2: Open the valve slowly by sliding the switch towards right side, and release a drop of the solution onto the pH paper, and then close the valve. You can see the paper color changing to a reddish color quickly.

Step 3: Dip a new pH paper into the solution container. You will notice that the color of the PH paper changes very little.

The difference in pH paper coloring indicates the change of the acidity level. Ethanol turns into acetic acid during the reaction taking place at anode side of the fuel cell, and the pH of the solution noticeably changes from pH level 6 to pH level 2 showing a red color. The chemical reactions taking place at the anode and summarized on page 8 show that acetic acid is formed as hydrogen protons depart from the ethanol molecule and the water molecule. These hydrogen protons cross the fuel cell membrane, and the liberated electrons form the electricity that is able to propel the fan.

Conclusion: The Direct Ethanol Fuel Cell creates electricity by chemically converting the ethanol solution into an acid solution, which is close to common vinegar. In order for the fuel cell to function continuously, "spent" fuel must be replaced with new fuel regularly.

Experiment 4: Exploring the effect of varying fuel concentrations

You can make the different concentrations of ethanol fuel in the initial mix. For a 15% solution, add 9 ml of pure ethanol and fill water to the level of 60 ml. You can use a multi-meter or Horizon's fuel cell software adaptor product ref. FCJJ-24 to measure the voltage difference produced by the fuel cell. Through experimentation, you will find that increasing or decreasing the concentration of the Ethanol does not noticeably make the fan run faster.

The reason for this is that the capability of the catalyst used on proton exchange membrane in the fuel cell is limited. Similarly to many people going through a narrow door, the speed of people going through the door is determined by the width of the door, but not by the amount of people.

Warning: The safe experimentation range for the Bio-Energy Kit is within ethanol concentrations ranging from 5-15%. Please note that the concentration cannot be higher than 15-20% otherwise it will permanently damage the fuel cell.

Tip: If the device will not be used for more than one day, first pour out the solution in the container and then purge out all the remaining solution in the fuel cell by pouring purified or distilled water in the container. Make sure the purging valve is switched to the right side. Make sure all of the purified or distilled water flows out of the container. Do not let the solution stay in the fuel cell otherwise it will damage the fuel cell.

Experiment 5: Create electricity from wine or beer

Try using different types of alcohol such as wines made from grapes or rice instead of the ethanol/water solution.
Follow up the steps in the experiment 1: create electricity from ethanol and water to create electricity.

Warning:
1. Alcohols used should stay within the range of 5-15% alcohol. If you are using an alcohol that has a higher concentration than 20% please mix the adequate amount of water into the alcohol to keep the required concentration range of 5-15%.
2. Using impure ethanol can damage the performance of the fuel cell. You may want to conduct experiments using impure ethanol once all other experiments using pure ethanol are completed.

When you have finished all the steps as in experiment 1, you may notice the fan may run very slowly, or may not run. When using different alcohol types, this can affect performance. This has to do with the purity of the solution, since some alcohols such as wine contain elements that can clog the membrane on the fuel cell, limiting its permeability. Use a multi-meter or Horizon's fuel cell software adaptor ref. FCJJ-24 to measure the voltage or current produced by the fuel cell under various conditions and slowing the speed of the chemical reaction.

See experiment 6: You will be able to prove that at different temperature conditions, different voltages are produced, and you can plot these results into a chart to determine the optimal temperature conditions for the fuel cell to generate the best results.

Experiment 6: Exploring the effects of temperature.

Note: Before you blow warm air towards the fuel cell, feel the air temperature with your hand first to make sure the air is not too hot (below 60°C is preferred).

Step 1: Use a hair drier to blow warm air towards each side of the fuel cell or place a warmer ethanol/water solution into the ethanol storage tank. You will observe that the motor and fan will be operating at a faster speed.
Step 2: Use a multi-meter or Horizon's fuel cell software adaptor product ref. FCJJ-24 to measure the voltage produced by the fuel cell. You will be able to test that at different temperature conditions, different voltages are produced, and you can plot these results into a chart to determine the optimal temperature conditions for the fuel cell.

At higher temperatures, atoms tend to move faster and are more likely to interact with the catalysts located on the surface of the membrane. With more interactions, the reaction accelerates and more electricity can be produced, which means the fan starts to turn faster.

Conclusions:
(1) Higher temperature will make it more likely for ethanol molecules to interact with the catalysts located on the surface of the membrane, which accelerates the speed of the chemical reaction.
(2) High temperature can also make the membrane more active, so it will demonstrate an increased ability of proton exchange within the membrane and an increase the speed of the fan motor. Increasing the power capability of ethanol fuel cells can be done by increasing their operating temperature, or the temperature of their fuel.

Troubleshooting

A. The fan begins to run slower or stops running completely

Solution:

a. Disconnect the motor connector wires from the fuel celll. Place the purge tube (exhaust tube) over a container and empty the contents of the acetic acid solution. Open the valve to let a few drops of acetic acid flow out, allowing the mixture of the fresh ethanol solution to re-enter the fuel cell. Wait for 5-10 minutes. Then connect the motor connector wires to the fuel cell. Tap the fan's blade to get it started and watch it go at constant speed.

b. If the solution level is too low in the container and it can not flow into the fuel cell chamber, mix new solution and pour it into the container to reach the proper level.

c. You can also try the following steps:

Step 1: Disconnect the wires from the fuel cell

Step 2: Place the exhaust tube (connected to the purging valve) over a container or suitable receptacle.

Step 3: Open the purging valve by sliding the switch to the right side, purging out the used solution in the fuel cell chamber and allowing a new volume of ethanol solution to re-enter the fuel cell chamber, then close the valve (see the picture below).

Step 4: Wait for 5-10 minutes before reconnecting the motor wires to the fuel cell. Once reconnected, watch the fan start rotating again at constant speed. The fuel cell is able to start the reaction once more (and more hydrogen protons can permeate through the membrane).

B. After all the wires and tubes have been connected, the fan still cannot run.

Solution:

a. Make sure that the red and black clips are connected on the two terminals located on the fuel cell.

b. Make sure that the tube from the solution container is well connected to the nozzle of the fuel cell.

c. Make sure the ethanol solution is able to circulate into the fuel cell and that the tubing is not blocked.