Ethanol Fuel Cell Science Kit

ASSEMBLY GUIDE

CE

Model No.: FCJJ-42

⚠ Warning

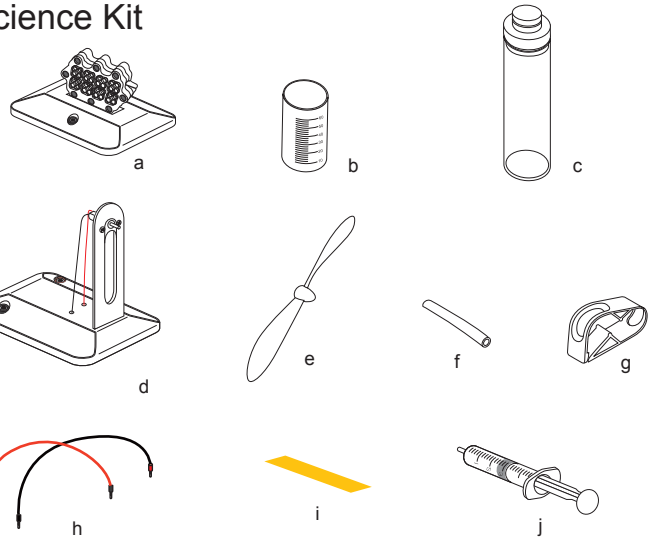
To avoid the risk of property damage, serious injury or death:

1. This kit should only be used by person 14 years old and up, and only under the supervision of adults who have familiarized themselves with the safety measures described in the kit.
2. Read carefully and fully understand the instructions before assembling this kit and have them ready for reference.
3. Keep small children and animals away, because this kit contains small parts which could be swallowed.
4. When assembling this kit, tools may be used. Extra care should be taken to avoid personal injury.
5. Some parts are small and fragile: please be careful when handling and connecting parts to avoid breakage. Handle all parts and components with care.
6. 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.
7. Do not attempt to ingest or drink new or used liquids needed for the purpose of this experiment kit.
8. 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.
9. It is recommended that this kit be operated under the temperature between 5℃ and 40℃.

Ethanol fuel cell science Kit

List of Component

a. Fuel cell module
b. Fuel solution container
c. Fuel tank with lid
d. Fan module
e. Fan blade
f. Silicon tubes
g. Clamp
h. Wires
i. PH paper
j. Syringe



You will also need the following items (not included in this kit):
- Purified or distilled water
- Ethanol
- Scissors

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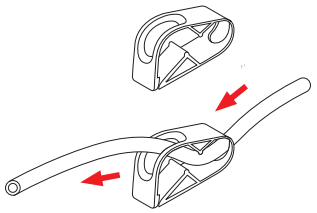
Preparing a 10% ethanol solution:

WARNING:
DO NOT mix the fuel solution in the fuel tank (c), otherwise the fuel tank could be easily damaged.

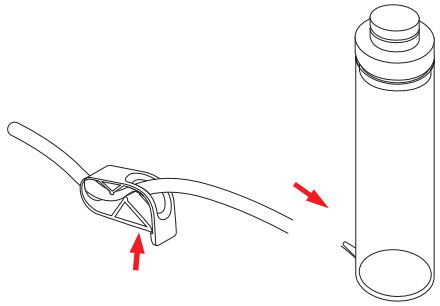
Do not pour pure ethanol in the fuel container (b). The DEFC creates power using 5-15% alcohol only. A concentration higher than 15% could damage the fuel cell and make it stop working. In order to obtain the best performance please use a mixture of 10% ethanol and 90% purified or distilled water. Keep 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 solution container (b) with 10ml of pure ethanol (fill container to the 10ml 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

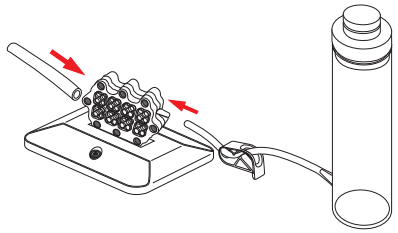
Step1: Cut one 15cm long tube and put it through the plastic clamp,



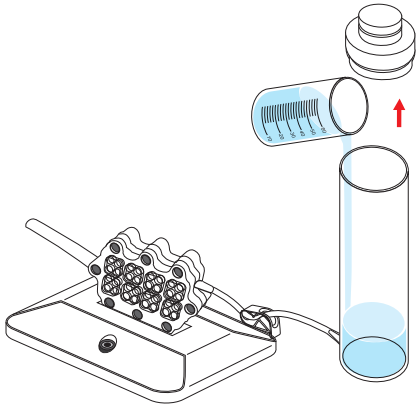
Step 2: Connect the tube to the fuel tank (c) and close the clamp.



Step 3: Connect the other end of the tube to the fuel cell lower fuel inlet. Make sure the connection is tight. Cut a 10cm long tube and connect it to the other outlet of the fuel cell (the remaining nozzle).



Step 4: Pour the fuel solution into the fuel tank (c). Put the lid back to the tank.



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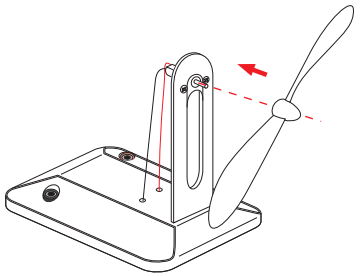
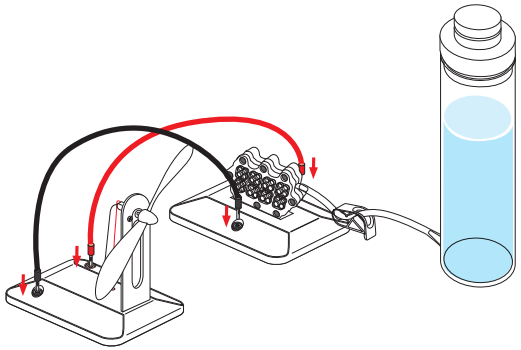
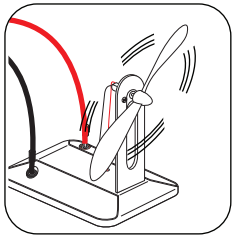
Step 5: Remove the fan blade from the box. Push the blade onto the axis of the motor slowly and carefully.



Step 6: Use the wires to connect the fuel cell module to the fan module. Make sure you respect the color code when you plug wires into the sockets.



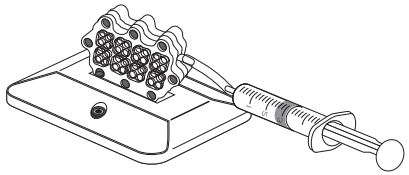
Step 7: Open the clamp. You can notice the liquid flows out of the tube through the fuel cell. Once you see the liquid flows out of the tube, close the clamp.
Wait for 5-10 minutes, you will notice the fan starts to rotate.



Note: Once the fan stops rotating, open the clamp to purge some solution out of the fuel cell. Wait for 5-10 minutes with the cable disconnected from the fan module, 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.

IMPORTANT NOTES:

After the first use of the fuel cell, you have to cut a 2 cm long tube on the remaining tube and to connect this one to the syringe. You will use it to clean the system after every use of the product.
After each usage, you have to fill the syringe with purified water. Then, remove the fuel inlet tube and replace it by the syringe tube. Inject the water into the fuel chamber to flush out the methanol solution out of the system. Disconnect the syringe and fill it with some air. Make the connection again and inject the air into the system in order to completely purge the remaining water out. The fuel cell then could be stored until the next use.

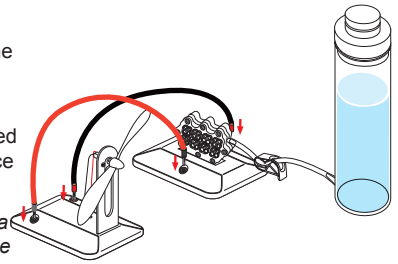


Experiment 2: Exploring polarity

Step 1: Connect the red cable to the red socket of fuel cell and the fan module.
You will notice the fan will turn clockwise.

Step 2: Now repeat the process, this time however connect the red socket of the fan module into the fuel cell black one. 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.



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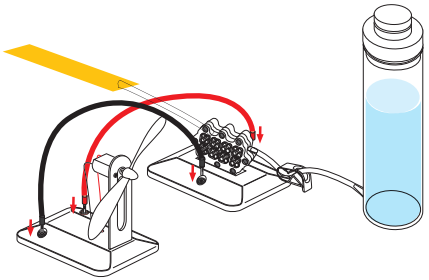
Experiment 3: Ethanol fuel consumption

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 outlet tube.

Step 2: Open the clamp slowly , and release drops of the solution onto the pH paper, and then close the clamp. 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 showing 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 to obtain a continuous functioning of the fan, "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 REM 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 this 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 open the clamp to purge out all solution in the fuel cell and pour purified or distilled water in the fuel tank. Make sure all of the purified or distilled water flows out of the fuel tank. Do not let the solution stay in the fuel cell otherwise it will damage the fuel cell.

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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 REM 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 for each kind of alcohol you use.

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 (temperature under 60℃ are 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 fuel 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 fuel celll module from any load. Place the outlet tube above a container or suitable receptacle. Open the clamp to let a few drops of acetic acid flow out, allowing the mixture of the fresh ethanol solution to re-enter the fuel cell.
b. If the solution level is too low in the fuel tank and it can not flow into the fuel cell chamber, mix new solution and pour it into the tank to reach proper level. Or you can lift the fuel tank up to make the solution level in the tank higher than the inlet nozzle on the fuel cell.
d. Wait for 5-10 minutes before reconnecting the loads 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 wires are connected correctly.
b. Make sure that the tube from the fuel tank is well connected to the fuel cell inlet.
c. Make sure there is enough ethanol solution to circulate into the fuel cell and that the tubing is not blocked.

C. I opened the clamp, but no soluiton flows out of the tube.
Solution:
a. Add fresh fuel solution to the fuel tank.
b. Lift the fuel tank up to make the solution level in the tank higher than the inlet nozzle on the fuel cell.