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Science Fair Report

Virtual Science Fair

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# Problem

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## UNDERSTANDING THE PROBLEM

Global warming is defined as the increase of the average temperature on Earth (Yahoo, 2009). As the Earth gets warmer, we increase the chances of natural disasters occurring, such as hurricanes and floods. According to scientists, the Earth's average temperature has always risen and fallen, but not in as significant and sustained way as it has in the past 100 years. Where it used to take thousands of years for a temperature variation of 1 degree, it has now taken the past one hundred years. Over the past one hundred years, the average temperature on our Earth has increased by 1 degree Celsius (Yahoo, 2009). Given that it used to take tens of thousands of years for the Earth's average temperature to increase or decrease by that amount, there is obviously something new that is contributing to this wild swing in average temperature. Seeing how much technology has advanced and how much energy we have used in the past one hundred years, we can draw the conclusion that man is responsible.

But how exactly have we caused global warming? Well, when we burn fossil fuels, such as crude oil, natural gas and coal, they emit a gas called carbon dioxide into the atmosphere. The burning of fossil fuels produces approximately twenty-one billion tons of carbon dioxide each year. The Greenhouse effect takes place when there is too much carbon dioxide in the Earth's atmosphere. The Sun's rays that heat up our planet are not able to leave the atmosphere due to the carbon dioxide blocking it. Due to this, the Sun's rays cannot escape, and are constricted to our atmosphere. Over time with all the extra Sun rays, our temperature increases, and global warming occurs.

President Barrack Obama has seen the importance of global warming, and has voiced his opinions on the importance of regulating carbon emissions, even recently proposing a cap-and-

trade system which would have huge implications for the North American economy. In reflecting society's need and desire to reduce petroleum dependency, I would like to do more research into alternative energies that are renewable, and that will reduce our world's dependency on petroleum and fossil fuels.

#### **OBJECTIVES OF THE EXPERIMENT**

Motor vehicles contribute to more than a quarter of the United States' carbon dioxide emission and emit six hundred ninety-three million seven hundred fifty thousand (693,750,000) tons of carbon dioxide into the atmosphere (Wikipedia 2009). While the United States has the biggest carbon emissions, it is safe to say that developing countries such as China and India, which have three times the amount of people that there are in the U.S., will certainly pass them in the next decade. During the past ten years, the automobile industry has been working hard to introduce new methods to make new cars more fuel efficient. There have been many different results from this work and research, most notably, the hybrid car which runs on electricity and that you can plug in such as the Chevrolet Volt. I would like to do my own research in the realm of fuel cells, an old form of renewable energy that has recently attracted attention in the media because it needs only water to run. For my science project, I will try using variants of water, and hopefully be able to add to scientific knowledge and be able to make this form of energy more efficient. The purpose of my experiment is to make the common fuel cell more efficient.

## **The Fuel Cell**

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#### **PRINCIPLES IN PLAY**

This fuel cell takes hydrogen as its main source of fuel. Because there is not a source of hydrogen readily available in my area, we have to make hydrogen, or literally, break it down from the water we use as fuel. We use the electricity from a battery to undertake a process called

electrolysis. Electrolysis is where the hydrogen and oxygen atoms in water are separated from each other using electricity. The result is little bubbles of hydrogen and oxygen gas in the water of the fuel cell. These bubbles are respectively attracted to the negatively and positively charged electrodes (made out of platinum coated nickel wire). When the battery is removed, the catalytic (a catalyst is a substance that causes chemical reaction without being affected itself) characteristic of the platinum makes the hydrogen atoms break up (Dictionary 2009). This makes separate hydrogen protons and electrons. At the other electrode, the oxygen takes electrons from the metal and electrons from the old hydrogen atom, and form water. The electrons at the hydrogen electrode are attracted to the oxygen electrode. It's easier for the electrons to go through the wire than the water, so it goes along the wire, and while passing, could power a load, or light a light bulb, or in the case of my experiment, be measured by a volt meter.

## **HISTORY**

Before we go into detail about my experiment, I would like to give a brief history about fuel cells. The Fuel cell was discovered by Sir William Grove 1839, who was doing research into the process of electrolysis, which we will discuss later. He used platinum as his electrodes (just like mine), and put the ends into sulfuric acid. He put the other two ends of the electrodes into separate containers of hydrogen and oxygen. Grove realized that there was a constant flow of energy, and the fuel cell was born. Over time, the fuel cell was improved, until finally, two scientists, by the names of Thomas Grubb and Leonard Niedrach teamed up with General Electric and NASA to create a completely fuel cell operated shuttle, call the Gemini project. Today, we have begun to apply the fuel cell science to cars, and BMW and other major car manufacturers have working fuel cell cars that run on hydrogen, and emit pure odourless water.

# Hypothesis and Variables

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## **HYPOTHESIS**

If the source of fuel for the fuel cell is changed, then the amount of energy produced from the fuel cell will change. I think that the distilled water will be the most efficient, and will create the most energy, because there are only hydrogen and oxygen atoms with very few impurities. I believe that the water with other chemicals, or impurities such as the tap water, salt water, and vinegar water will perform worse the hydrogen and oxygen atoms might have a difficult time getting to the two electrodes (the platinum coated nickel wire) due to the high concentration of other molecules such as sodium and chloride.

## **VARIABLES**

My experiment contains all the necessary variables. The independent variable is something that the experimenter changes by himself. For my experiment, it will be the fuel type that will be used in the fuel cell. They will all be variants of water; I will have tap water, distilled water, salty water, soap water, and vinegar water. The dependant variable is something that changes due to the independent variable, in my experiment; it will be the number of volts that is produced from the fuel cell. The control is the variable that stays the same. In my experiment, the control will be the fuel cell itself, which I never alter, except for the fuel which is my independent variable and the temperature of both the fuel cell and the fuel, which will always be room temperature.

# Process

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## **PROCESS TO BUILD FUEL CELL**

In order to build the fuel cell, you need to get several different materials. One foot of platinum coated nickel wire, a 9v battery, a 9v battery clip, transparent tape, a piece of plastic (which will form a bridge), a glass, water and a volt meter. First we cut the wire into two equal parts. We wrap both of them along a nail, so that they are small and efficient. We take the battery clip, and we cut the leads of the cut ends. We twist the bare battery lead wires onto the coiled wire, and attach another two wires to the coiled wire, which we will attach to the volt meter. We tape this Electrode, as it is now called, to the “bridge”, and hang it over water. Make sure that the coiled wire is completely in the water. Fill it with water, and when you are ready attach the battery to the clip to see what happens.

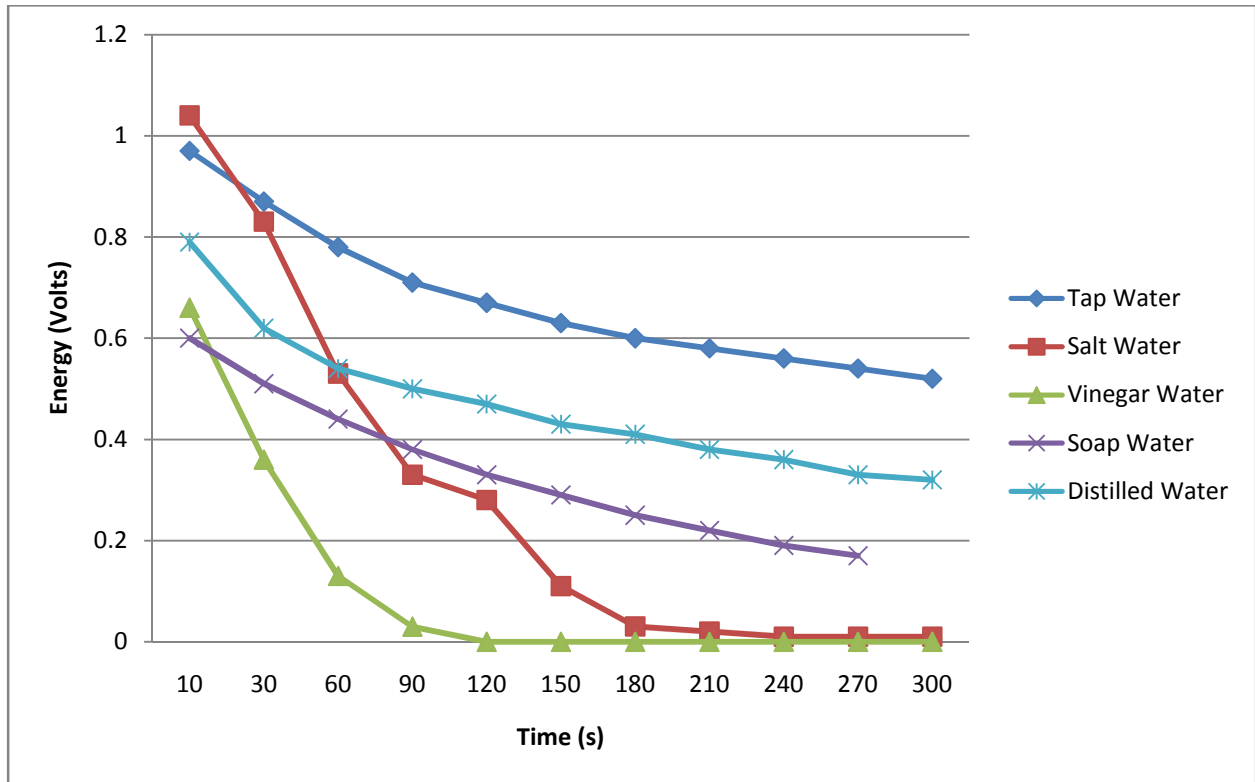
#### **PROCESS FOR THE EXPERIMENT**

First, we fill the glass with tap water to the top. We clip the 9v battery to the clip, and then unclip it after ten seconds. Write down the energy in volts that is written on the volt meter after ten seconds. After thirty seconds, write down the amount of volts. Keep writing down the voltage in increments of thirty seconds until five minutes have passed. Next, dissolve 50 ml of salt into tap water, and fill the glass to the top. Clip the battery to the clip for ten seconds, and then remove it. Record the voltage in the same manner as before. Put 50 ml of vinegar in normal tap water. Clip and un-clip the battery, and measure the different voltages in the same way as before. Mix in 50 ml of soap into normal tap water, Clip and un-clip the battery and write down the voltages in the same way as before. Finally, fill the glass with distilled water. Repeat the battery process. Record the voltage as well. Make sure to wash the glass after every experiment.

# Results

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TIME (s)	VINEGAR			DISTILLED	
	TAP WATER	SALT WATER	WATER	SOAP WATER	WATER
10	0.97	1.04	0.66	0.73	0.79
30	0.87	0.83	0.36	0.6	0.62
60	0.78	0.53	0.13	0.51	0.54
90	0.71	0.33	0.03	0.44	0.5
120	0.67	0.28	0	0.38	0.47
150	0.63	0.11	0	0.33	0.43
180	0.6	0.03	0	0.29	0.41
210	0.58	0.02	0	0.25	0.38
240	0.56	0.01	0	0.22	0.36
270	0.54	0.01	0	0.19	0.33
300	0.52	0.01	0	0.17	0.32



# Analysis

## TAP WATER

The fuel cell that used tap water as its source of fuel was the best out of all the different solutions. After looking at the graph, the trend is that the voltage drops rather fast at the beginning of the experiment, but later begins to output energy at a more steady rate. I hypothesized that the impurities within the water might reduce the voltage by slowing down the hydrogen and oxygen molecules from reaching the electrodes. It turns out that I was wrong, because the distilled water outputted less voltage than the tap water. I would go as far as to say that the impurities in the water might have helped the fuel cell to transmit energy, but obviously that would not work when the impurities are in large amounts, because the salt water solution did not provide much energy. To end this analysis, I will say that the tap water did the best because

of the right amount of impurities that might have been helping the process, but also because it was not so overloaded with these same impurities that could have slowed it down.

#### **SALT WATER**

The fuel cell that used salt water as its fuel really surprised me. According to the results and trends in the graph, the energy that the fuel cell was giving off was higher than that of the tap water, but then quickly dropped off. I had hypothesized that the salt water would not do so well because of the extra salt molecules within the solution that might have slowed down the process. I was at the same time right and wrong, because the voltage started off high, but then quickly dropped. I think this is because the salt in the water made it possible for more  $\text{H}_2\text{O}$  molecules to be broken down into hydrogen and oxygen atoms. This overload of fuel in the fuel cell led to the bloated voltage being output by the fuel cell. The reason it dropped so quickly is that the fuel ran out. I think that the salt might have special characteristics that might have affected the platinum in such a way as to make the hydrogen get used up all at once and the result being an explosion of energy that was quickly put out, instead of it being regulated, and used constantly, like in the case of the tap water.

#### **VINEGAR WATER**

The vinegar water fuel cell was the one that hit zero first. I think that this one is easier to explain than the salt water solution. My hypothesis for this one was the same as that for the tap water and salt water. Unlike both of those, this one was accepted. The results and the trends in the graph show that the vinegar basically hindered the fuel cell from giving off energy. Right from the start, it was lower than the tap water, and the line in the graph seems to be related to that for the tap water albeit this one goes down exponentially while being compared to that one.

This one hits zero very fast, and I consider it the worst out of all the different solutions. In conclusion, I think that the vinegar really slows down the fuel cell from taking in the hydrogen fuel cells. This might be because vinegar is a bit acidic, and due to its nature, attracts hydrogen molecules from the electrodes.

#### **SOAP WATER**

The soap water that was used as the fuel for the fuel cell did as I had predicted. The impurities in the water slowed down the process, but it had the same characteristics as the tap water. Their lines are almost exactly the same, except for the actual values. This leads me to believe that the soap water is a more extreme case of that with the vinegar. I think that through the results, we can draw the conclusion that the soap water only hinders the actual hydrogen atoms getting to the electrodes. I was afraid that the bubbles might have affected the voltage, and maybe they did, but I did my best to try and pop all the ones that came in mixing the two liquids, the rest were natural that came after, and I decided to keep them, because they were part of the solution. In conclusion, the soap slows down the fuel cell voltage, but does not stop it like the vinegar does.

#### **DISTILLED WATER**

After the salt water solution, the distilled water was the biggest surprise in my experiment. I hypothesized that the distilled water would be the best out of all the solutions, and that it would output more voltage than the rest of the solutions, but this was not the case. I think that the reason why the distilled water did not do as well as the tap water is because of just that, it was distilled, it was too perfect, it did not have any impurities that could have otherwise helped the fuel cell process, such as salt that might have increased the voltage. My hypothesis was

rejected. The distilled water is just too simple, and contrary to my idea of pure being better, my experiment and results have proved that the impurities that we drink everyday are actually helping the fuel cell to give off energy.

#### **IN CONCLUSION**

For my final analysis, I would just like to say that the tap water is the best. I have come to the conclusion through my other experiments that this is because of the impurities within the water that help the hydrogen and oxygen get to the electrodes. I established this information through different links in my research. In the salt water solution, the voltage spiked at the beginning, but then dropped later. I think that this is because the salt has special characteristics that help feed the platinum lots of hydrogen, but the fuel is used up faster. The output of voltage is not as stable as the tap water. This shows me that the impurities in large amounts make the voltage large at first, and lower in the long run. With the tap water, there are small impurities, so there is a lot of voltage early, and it is stable. In the distilled water, there was relatively low voltage, but it made up for that by being more stable. The tap water takes characteristics from both of these different solutions, and ends up beating both in terms of voltage produced over time.

#### **POSSIBLE FOLLOW-UPS**

I have learned a lot during my experimentation, but have also seen the potential where further experimenting could help expand scientific knowledge. Over my experiment, there have been many instances where I might have written down in my logbook, or thought to myself “hey, wouldn’t that be cool to try out?” Well anyways, here are a couple of different experiments that could be done, that I feel are really good. When clipping on the battery to perform the

electrolysis process, I wondered how long I should clip it on for. I settled for ten seconds, but I think that if someone did research into the different lengths of clipping on the battery, and the effects, such as the amount of hydrogen and oxygen produced. Experiments could also be done to find out the voltage for a certain amount of hydrogen and oxygen. Finally, I think that an experiment could be done to figure out when the voltage reaches zero for each solution, and which one is the longest.

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