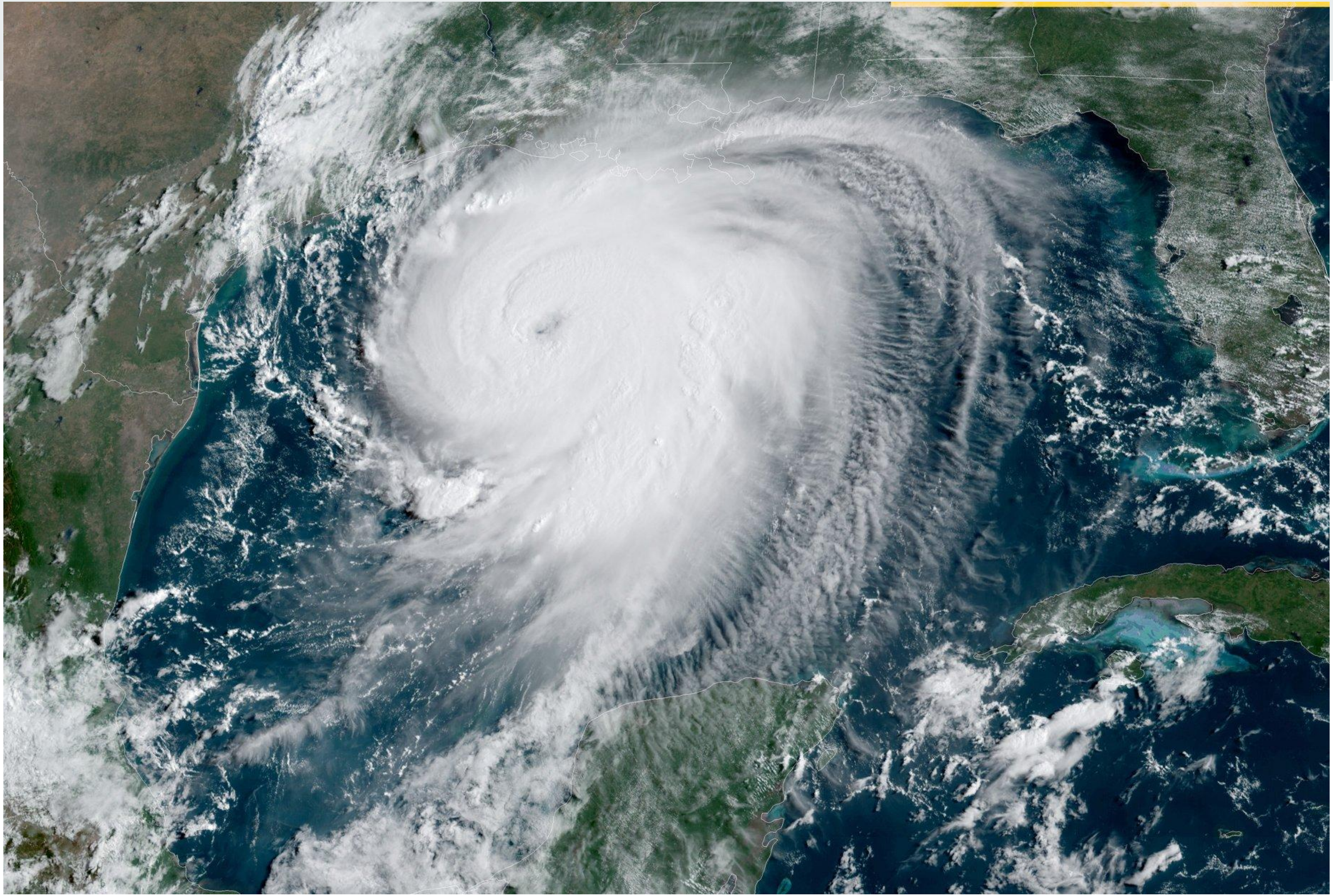
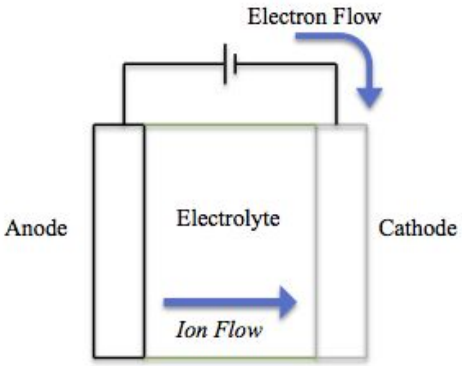
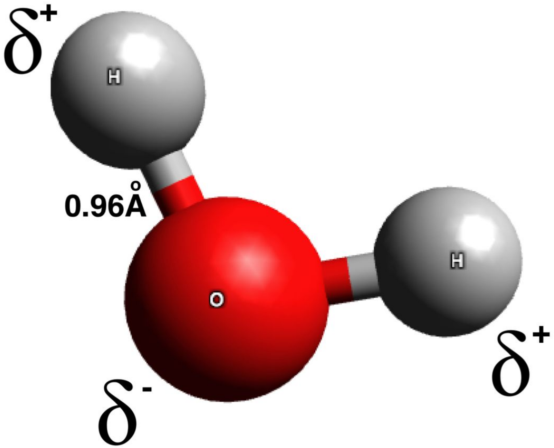
Utilizing Saltwater Batteries to Power USB Devices during Natural Disasters



Types of Sources of Chemical Energy: Batteries



Saltwater Batteries



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Prior Research

- The Royal Society of Chemistry found that when using saltwater batteries for large scale energy storage, the saltwater battery had a discharge capacity of 296 mAh when using a carbon anode, making it acceptable in large scale energy storage.
- Another study conducted by the Royal Society of Chemistry found that a saltwater battery with zinc as the anode and air as the cathode had a theoretical output of 3.1 volts.

Question and Hypothesis

Engineering Goal: The engineering goal of this project is to build a saltwater battery that will be able to power and charge devices that use the USB power standard.

Question: How does the anode and cathode material used in saltwater batteries impact the voltage outputted by these batteries?

Hypothesis: It is hypothesized that a combination of a zinc anode and a copper cathode will be the most effective, as zinc is a good oxidizing agent as well as being conductive while copper is a good reducing agent, allowing for the redox reaction to output the most voltage possible.

Preliminary Testing

Methodology

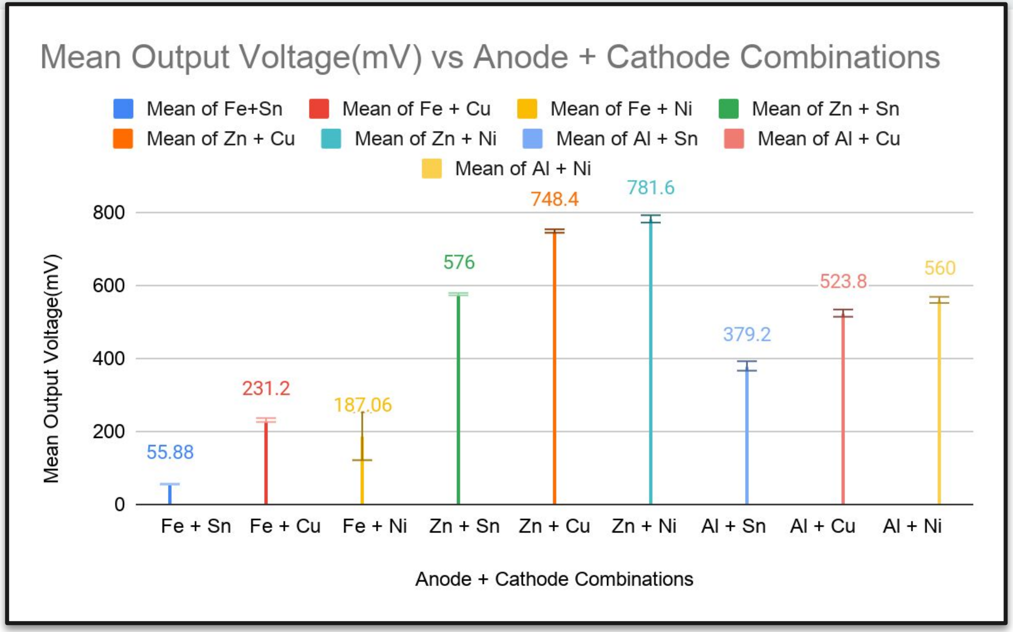
Levels of IV	Fe + Sn	Fe + Cu	Fe + Ni	Zn + Sn	Zn + Cu	Zn + Ni	Al + Sn	Al + Cu	Al + Ni
# of Trials	5	5	5	5	5	5	5	5	5

IV: Cathode and Anode Combinations
DV: Voltage Produced
Controls: Electrolyte Solution, Multimeter, Size of Electrodes

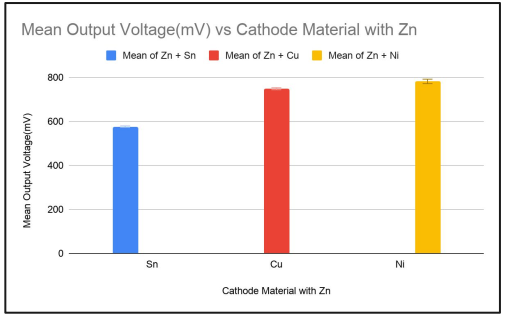
Methodology

- First, a NaCl(aq) solution will be prepared by adding 379.9 g of NaCl to 1 liter of distilled water. This solution will then be poured into a 279.9 mL container.
- One of the anode materials will then be placed into the container along with one of the cathode materials.
- The positive probe will be attached to the cathode while the negative probe will be attached to the anode.
- A timer for 2 minutes will be set, and the highest voltage output will then be denoted at the end of the 2 minutes.

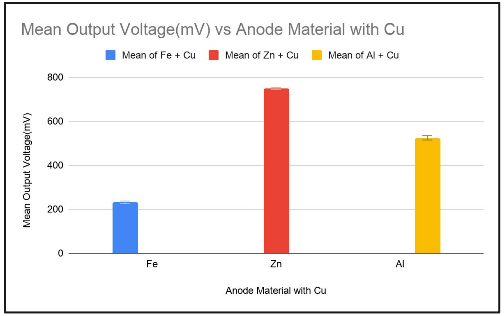
Results



Mean Output Voltage(mV) vs Anode + Cathode Combinations
Mean of Fe+Sn
Mean of Fe + Cu
Mean of Fe + Ni
Mean of Zn + Sn
Mean of Zn + Cu
Mean of Zn + Ni
Mean of Al + Sn
Mean of Al + Cu
Mean of Al + Ni
Mean Output Voltage(mV)
800
600
400
200
0
55.88
231.2
187.06
576
748.4
781.6
379.2
523.8
560
Fe + Sn
Fe + Cu
Fe + Ni
Zn + Sn
Zn + Cu
Zn + Ni
Al + Sn
Al + Cu
Al + Ni
Anode + Cathode Combinations



Mean Output Voltage(mV) vs Cathode Material with Zn
Mean of Zn + Sn
Mean of Zn + Cu
Mean of Zn + Ni
Mean Output Voltage(mV)
800
600
400
200
0
Sn
Cu
Ni
Cathode Material with Zn



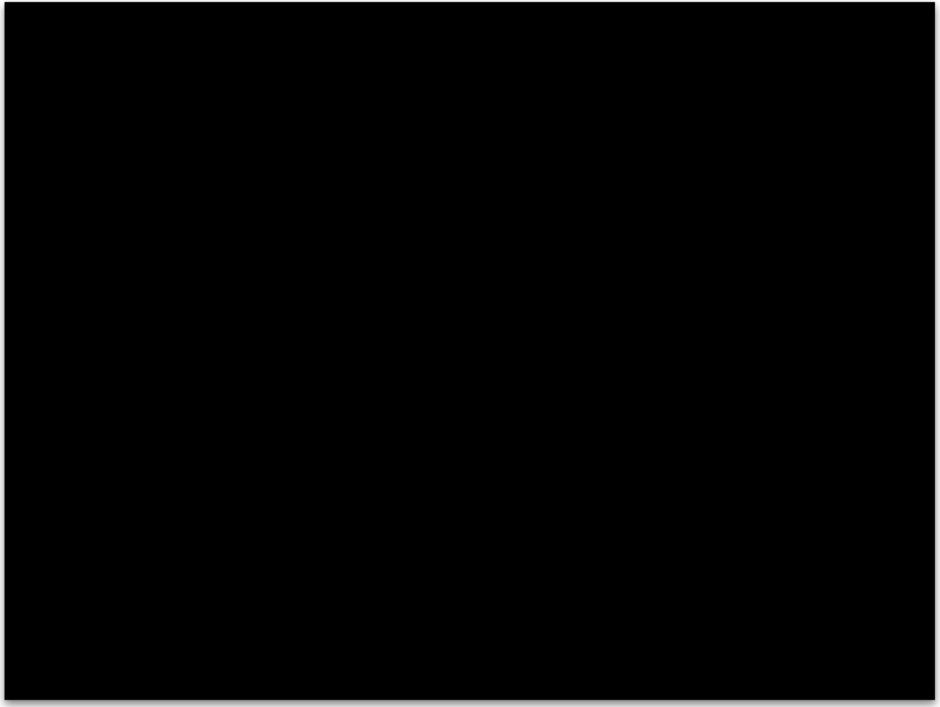
Mean Output Voltage(mV) vs Anode Material with Cu
Mean of Fe + Cu
Mean of Zn + Cu
Mean of Al + Cu
Mean Output Voltage(mV)
800
600
400
200
0
Fe
Zn
Al
Anode Material with Cu

Results

- When an ANOVA Test was conducted, a F value of 599.94 was produced. Since 599.94 is greater than 2.1802, the null hypothesis of all of the cathode and anode combinations yielding similar results was rejected.
- While the Zn + Ni combination did output the maximum mean voltage, the Zn + Cu combination was used in the engineering device due to the large variances that were seen.

Construction of Engineering Device

CAD Model



Final Product

Discussion

- While the nickel cathode had produced the highest amount of voltage compared to the other cathodes, it had a very large variance as well.
- As a result, zinc and copper were used.
- The null hypothesis was rejected and the alternate hypothesis was accepted, meaning that there was a statistically significant difference between all of the individual cathode and anode combinations.

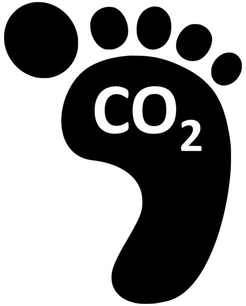
Discussion

- The battery outputted a stable 2.97 volts before suddenly no longer being able to produce that much voltage, making it unable to be further tested.

Further Research

- Analyzing how differences in isotopes impact the amount of voltage and current that is produced in a saltwater battery.
- Analyzing how different ionic compounds in an aqueous solution perform as an electrolyte.
- Analyzing how rechargeable saltwater batteries are.
- Prototyping a smaller and lighter design.
- Utilizing a current amplifier to increase the output voltage of the battery.

Potential Implications



Acknowledgements

I would like to thank Mr. Timothy Gornet, the manager at the Additive Manufacturing Institute of Science and Technology, or AMIST, for 3D printing the parts required for the engineering portion of this project.

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