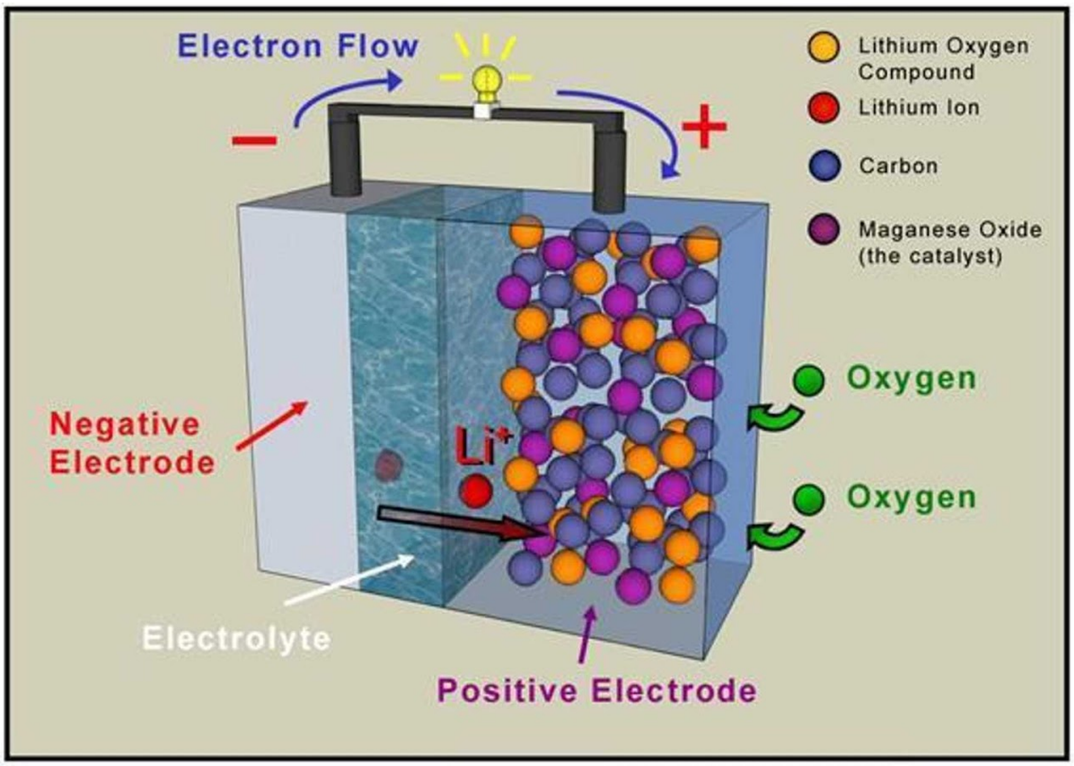
Lithium-Air Battery: Grant Proposal

iCons 1: Independent Case Study



Team C

Lucia, Peter, Rishabh, Dararath

PROJECT SUMMARY

The research will investigate the ability of a dehumidifying agent, sodium polyacrylate, to improve the function of the Lithium-Air batteries in a control lab setting. This experiment will allow scientists to explore creative methods to enhance an existing type of battery to even greater potential. It is understood that the function of Lithium-Air batteries is often hindered by carbon dioxide and water vapor. If sodium polyacrylate is successful in eliminating one of the obstacles (moisture) in our tests, it would be interesting to see exactly how much more efficient Lithium-Air batteries can be.

Research Question: How can we dehumidify the area around Lithium-Air batteries so that the discharge capacity is improved?

Hypothesis: If we dehumidify the area around Lithium-Air batteries, then the Li-Air batteries can have a discharge capacity larger than traditional Lithium-Ion batteries. We hypothesized that by placing sodium polyacrylate around the battery frame, it will better enhance the battery's discharge capacity because more solubility of oxygen and less solubility of water enhances discharge capacity. (Imanishi & Yamamoto, 2014)

BACKGROUND

- The reason why Li-Air batteries are so effective is that half the battery is air, which is not counted as part of the battery specification (Li & Ishizaki, 2018).
- Li-Air batteries allow for a screen to absorb the air. This allows for a cut in weight and volume by one-half because only half the chemicals are included and the other half is sucking the air (Li & Ishizaki, 2018).
- Cutting the weight and volume in half will double the power and energy densities (Li & Ishizaki, 2018).
- Lithium-Air batteries have the potential to process nearly 5 to 15 times of specific energy and almost 3 times the power as compared to traditional lithium-ion batteries ("What Is the Future of Lithium-Air Batteries?").
- Has the potential to store over 40 times the charge as a normal Li-ion battery of similar weight ("What Is the Future of Lithium-Air Batteries?").
- The rechargeable Li-O2 batteries feature ultra-lightweight and high energy density (which makes them a preferred choice for electric cars and portable electronic devices) ("What Is the Future of Lithium-Air Batteries?").
- Metal-air batteries use the reduction of ambient oxygen, it has the highest energy density because most of the cell volume is occupied by anode while cathode

material is not stored in the battery (Liu, 2019).

- Flaw/Challenge: the presence of moisture reduces the cell performance due to their strong reaction with Li metal. (Balaish, Moran, et al., 2013).

METHODS

Overview of study design

We are proposing a lab experiment that tests the capability of using Lithium-air batteries to power electric vehicles. Its capacity is often hindered by the presence of moisture. We propose that to place a framework of sodium polyacrylate as a type of dehumidifying agent around the battery and test if it will absorb much of the moisture and increase the battery's ability to function.

Data collection procedures

Control:

For our control, we will be conducting the experiment in an area that does not have any humidity. This is because the amount of humidity is our independent variable and we want to make that 0 to see what happens when there is none

Measure:

The batteries will be placed in a controlled environment to see if sodium polyacrylate is a sufficient dehumidifying agent. The independent variable would be the battery without the dehumidifying agent and battery with the dehumidifying agent. The dependent variable is the humidity (grams/cubic meter). Then the effect on discharge capacity is measured after placing the batteries in a controlled environment for 24 hours. The independent variable would be the battery without the dehumidifying agent and battery with the dehumidifying agent. The dependent variable would be the discharge capacity.

Sources of Error:

An error may arise when sufficient time isn't given for the filter to work in the battery. Another error of measurement may arise when the dehumidifying agent absorbs the humidity to its maximum capacity and loses its function. This error may cause a discrepancy in measuring battery capacity. Therefore, one way to control it is to place it in a controlled vent where the pure Oxygen, pure Nitrogen, water vapor, and time the battery is placed in the vent is kept at a certain amount of our liking. The test for each battery would be run 10 times.

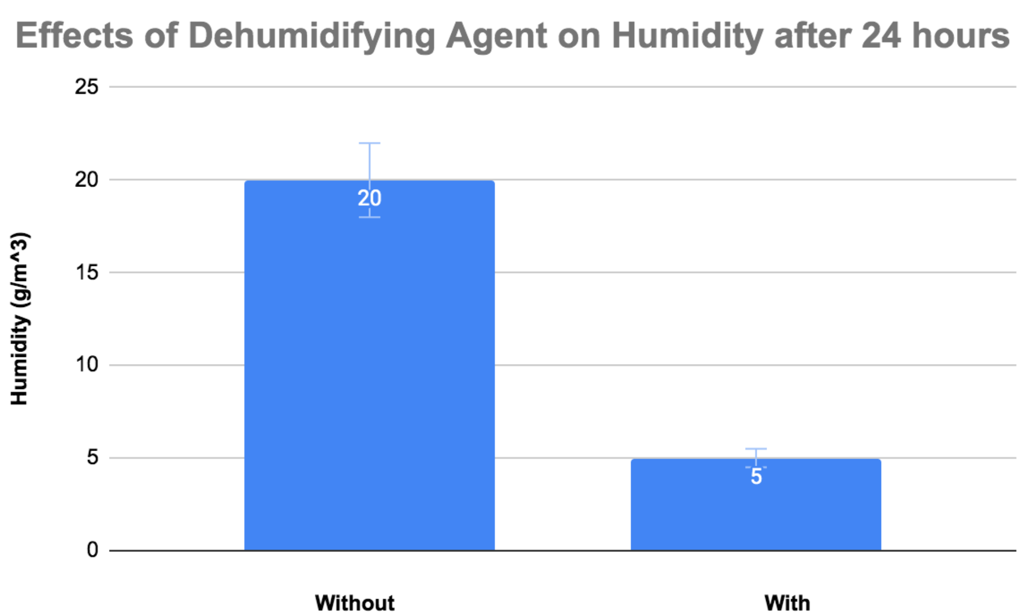
Where will it be analyzed:

The data will be collected in a laboratory because it is a controlled environment with readily accessible equipment. After many consistent runs, the data on the discharge capacity will be averaged and analyzed on excel sheets to compare the effectiveness of the filters around the Li-Air batteries.

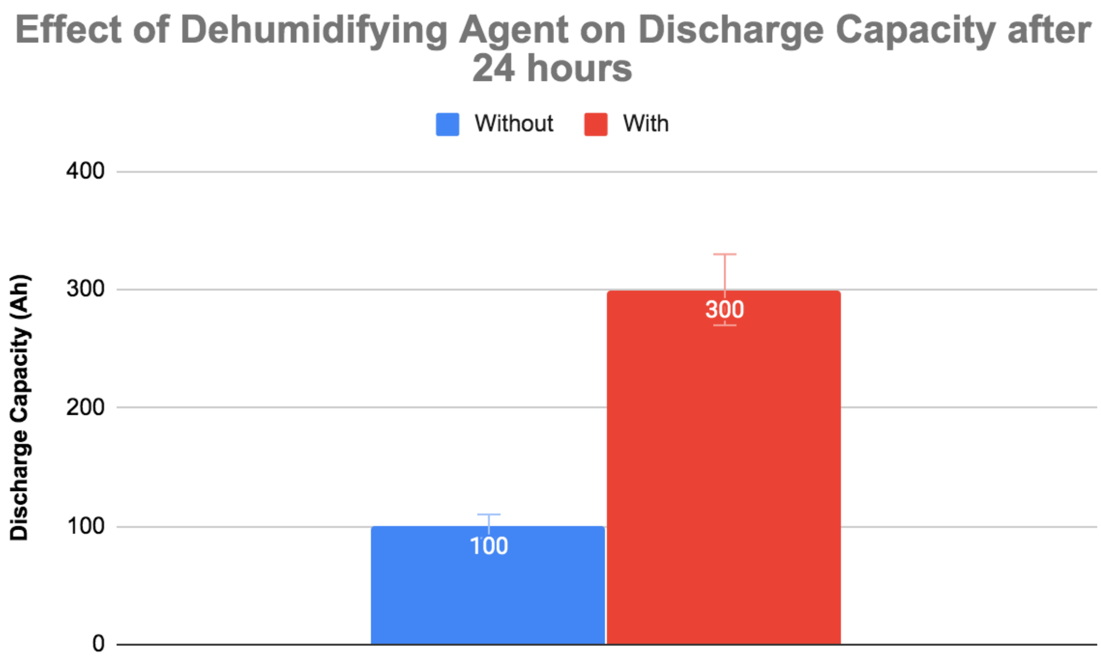
We will analyze and interpret results using the chi-square test. The null hypothesis is that all the batteries, with and without dehumidifying agent, will have the same units of Ah. The alternative hypothesis is that the battery with the dehumidifying agent will have a different unit of Ah than the battery without the dehumidifying agent. If the p-value is less than 0.05, we reject our null hypothesis.

ANTICIPATED RESULTS

This graph represents how humidity in the controlled environment is expected to change with respect to whether the battery has dehumidifying agents or not. The battery with the dehumidifying agent is expected to decrease the humidity in the controlled surrounding.



This graph represents how the discharge capacity is affected with respect to the presence of dehumidifying agents in the batteries. It is expected that batteries with the dehumidifying agent will be able to decrease moisture, allowing for more oxygen solubility, and thus greater discharge capacity.



TIMELINE

1. **Week 1: Development of Filter**
    a. Testing out various materials to identity best filter to use for the experiment
    b. Experimenting with various layer so filter to find the best thickness for the filter
2. **Week 2: Testing the efficiency of the filter**
    a. Conducting the experiment
3. **Week 3: Analysis of data**
    a. Data collection
    b. Data Analysis
    c. Beginning to construct digestible data (e.g. graphs and charts) for readers
4. **Week 4: Interpretation of results**

a. Discussion
b. Future Implementation
c. Future Outcomes
d. Take-aways

MATERIALS AND BUDGET

Supplies	**Cost**
Lithium-air battery	$1000
100 grams of sodium Polyacrylate	$21 (Amazon)
Hygrometer	$33 (Lab Depot)
Ammeter	$40
Total	**$1074 - $1094**

KEY PERSONNEL

Lucia: Supervisor and overlook the safety of the lab.

Peter: Design product, analyze data, conduct experiments to make Li-air a viable option.

Rishabh: Physics expert in batteries explanation and how they work; Design filter

Dararath: Research background to establish the research gap and context. Explaining the basics of redox reactions.

RELEVANCE OF PROPOSED STUDY AND BROADER IMPACT

Powered devices can be improved with advancements in research in Li-Air batteries ranging from small scale to large scale operations. Time, money, energy can be conserved and produce outputs that are more efficient than previous methods such as Lithium, Magnesium, Aluminum Ion batteries.

A. Who may benefit from the outcomes of your work?

Companies who are interested in energy storage would largely benefit from this work, especially those interested in Lithium-Air batteries. For example, the electric car industry (e.g. Tesla, Coda Automotive, Wheego Electric Cars, Think) may find it very beneficial because they seek alternative ways to maximize energy input and output for their cars. Toy companies that require batteries for their toys may be interested as well. Anyone looking for creative alternative energy and storage would find interest in this. One of the most widely used items is Lithium-ion batteries. Lithium-ion batteries are the most used in technology such as electric cars, phones, tablets, and laptops. In summary of the following research links, lithium-ion batteries—although widely used—are not the most efficient types of batteries to use, as there are better alternatives that are safer and more reliable. We are trying to model the batteries that are the most optimal in terms of cost, specific use (renewable energy storage), and safety (Rathi).

B. How might your work be meaningful to the general public (not just scientists)?

It gives the general public a more optimal alternative battery to use. For example, by having a better battery, companies such as Tesla can give their customers a better experience driving their cars with longer driving range, faster battery charge time, and the ease of not having to connect the plug into the car. If Li-air is implemented into smartphones, laptops, or other small scale operations, the general public will thrive off the efficiency of Li-Air batteries while saving money and energy transitioning from Li-Ion to Li-Air.

REFERENCES

Balaish, Moran, et al. “A Critical Review on Lithium-Air Battery Electrolytes.”

Physical Chemistry Chemical Physics, The Royal Society of Chemistry, 26 Nov. 2013, pubs.rsc.org/en/content/articlelanding/2014/cp/c3cp54165g#!divAbstract.

Common Battery Types, butane.chem.uiuc.edu/pshapley/GenChem2/C6/3.html.

“Industry News.” What Is the Future of Lithium-Air Batteries?

www.techsciresearch.com/news/3014-what-is-the-future-of-lithium-air-batteries.html.

Imanishi, Nobuyuki, and Osamu Yamamoto. “Rechargeable Lithium–Air Batteries:

Characteristics and Prospects.” *Materials Today*, Elsevier, 11 Feb. 2014, www.sciencedirect.com/science/article/pii/S1369702113004586.

Liu, Binghe, et al. “Safety Issues and Mechanisms of Lithium-Ion Battery Cell

upon Mechanical Abusive Loading: A Review.” Energy Storage Materials, Elsevier, 3 July 2019, www.sciencedirect.com/science/article/pii/S2405829719308608.

Oi Lun Li, Takahiro Ishizaki. ”Development, challenges, and Prospects of Carbon-Based

Electrode for Lithium-Air Batteries”. Sciencedirect, 2018

https://www.sciencedirect.com/topics/engineering/lithium-air-battery

Rathi, Akshat. “How we get to the next big battery breakthrough. Quartz.

https://qz.com/1588236/how-we-get-to-the-next-big-battery-breakthrough/