Battery Thermal Data analysis and Battery performance study: A Summer Project 2022

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The research (summer 2022) presented herein was carried out by Mr. Sahil Jain under my supervision.

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Program objective, timeline and interaction with battery researchers

- Objective 1: Experiment to understand affect of particle size of cathode on the cycling performance of a Li-ion battery.
- Objective 2: Analyze thermal release data obtained during battery cycling at different current

- Began on June 6th, and ended on August 12th

- I interacted with two PHD, UD students: Lenin Wung Kum (objective 1), and Nick Vallo (objective 2) and one Postdoctoral Fellow Dr. Deependra Kumar Singh (objective 1).

Objectives

1 Setting up a battery experiment

- Creating the electrode coating for the Anode or Cathode collectors (aluminum or copper)
- Building a coin cell using a coated and uncoated material
- Testing if the constructed battery is healthy
- Running cycles for battery data

2 Analyzing battery data

- Importing Raw Battery data to an Excel file
- Plot the imported data
- Create a Rate of Change graph
- Comparing data sets

Activities from Objective 1

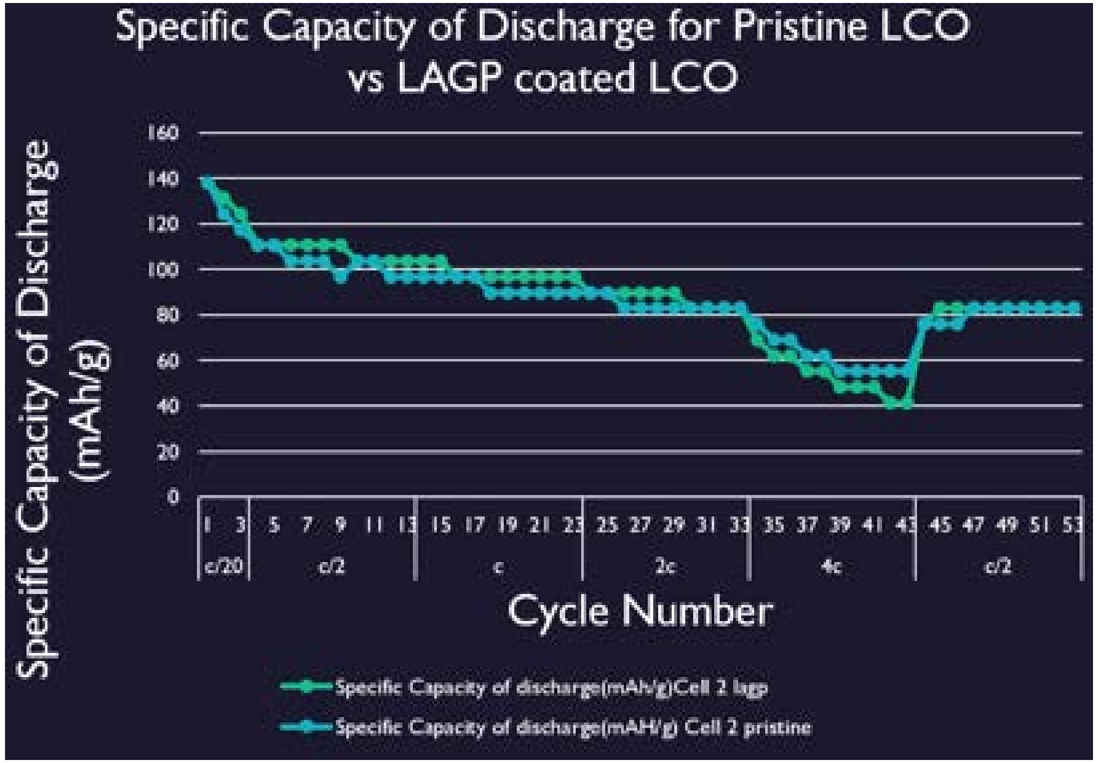
This was the objective I learnt from Lenin. We set up three experiments in the program. The first was a replication of a previous experiment Lenin published. This was the comparison of a ceramic coated Lithium Cobalt Oxide battery (LCO) and a pristine LCO. The second experiment was the effect of a smaller particle size on the performance of the battery with only pristine LCO. Finally, the third experiment was like the second, but with a ceramic coated LCO instead of pristine. I learnt this objective by contributing where I can and watching how the experiment is done.

Experiment 1 (June 14 – June 21)

Topic of experiment: Analyze the specific capacity of discharge for pristine LCO and ceramic coated LCO We hoped that the LAGP coating would help to reduce the resistance of the battery providing a greater discharge.

Our theory was right and the LAGP coating on the battery preformed better as the results from the previous experiment, but during the 4C phase (we are giving it very little time to discharge and at a higher demand), on 6/16/22, there was a major heatwave which caused the pristine LCO to have a greater discharge.

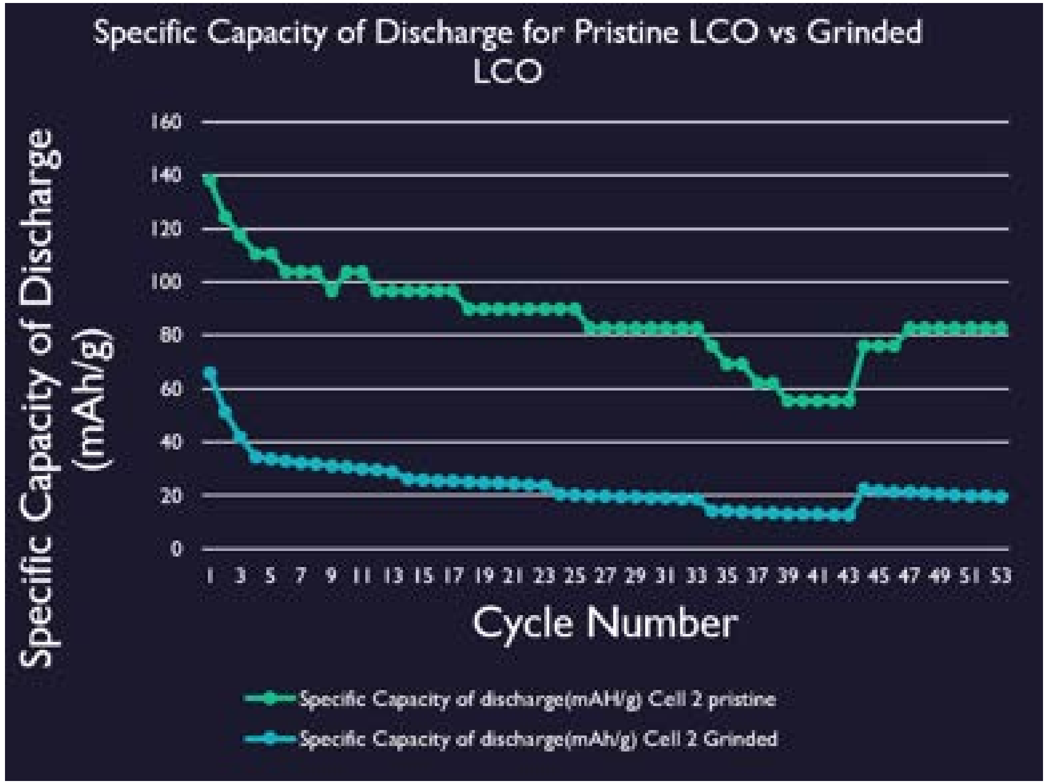
If we replicated the experiment in ideal conditions, the results would match that of Lenin's previous study.



Experiment 2 (June 28 – July 26)

Topic of experiment: Analyze the specific capacity of discharge for grinded LCO and pristine LCO. We hope the smaller particle size helps for a faster electron exchange to optimize fast charging, but at the cost of a higher resistance, decreasing the discharge.

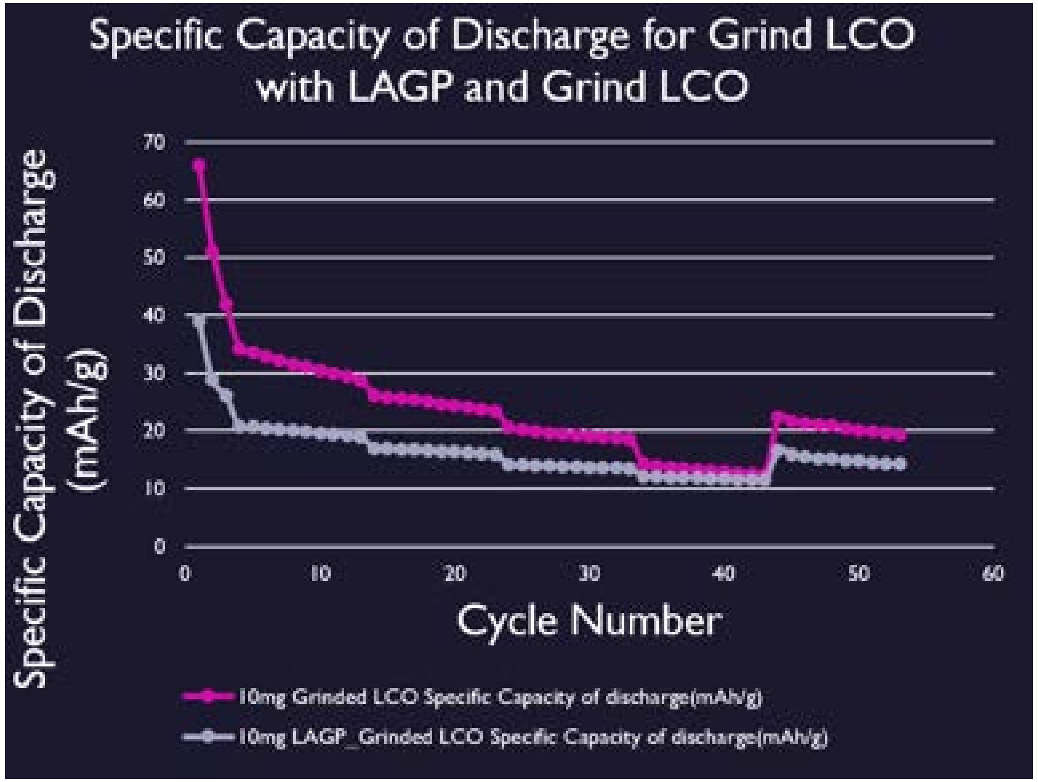
Our theory was right and the grinded LCO battery had a lesser capacity of discharge as the pristine LCO. The smaller particle size did indeed create higher resistance, decreasing the discharge.



Experiment 3 (July 26 – August 9)

Topic of experiment: Analyze the specific capacity of discharge for micro particle ceramic coated LCO and not grinded LAGP coated LCO. We hope the smaller particle size helps for a faster electron exchange to optimize fast charging and the LAGP coating helps in reducing the resistance caused by the small particle size.

Our theory was incorrect. The plain, grinded LCO preformed better than the LAGP coated, grind LCO. This can be seen in how the plain, grinded LCO has a greater capacity of discharge than the LAGP coated, grind LCO. It seems that the coating on the small particle size did not reduce the resistance, it caused more resistance.



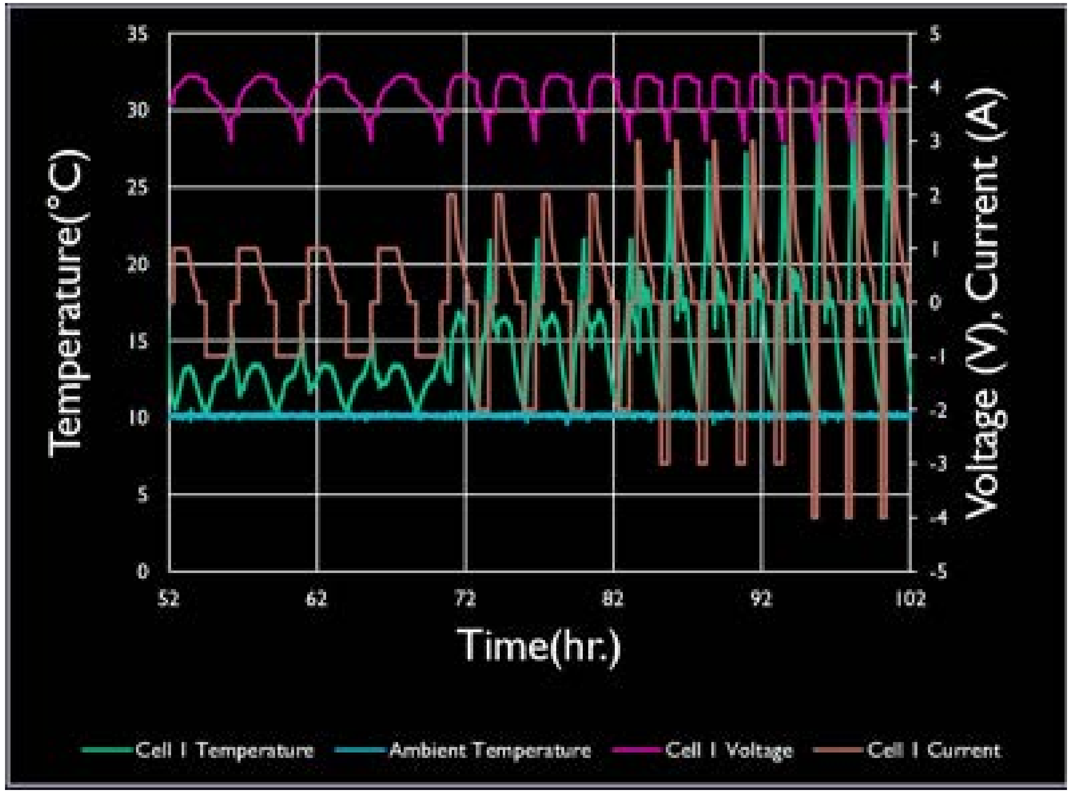
Activities from Objective 2

This was the objective I learnt from Nick. He gave me three projects in the program. The first was an old experiment he did where he placed a cell in a chamber set at a temperature of 10 degrees Celsius and examined the temperature of the cell at different levels of current. In the second project we tested the temperature of the battery in two different casings. Finally, in the third project we saw the heat produced by two different cells. I learnt this objective by retrieving the data from a flash drive and creating excel data charts and temperature change graphs.

Project 1 (June 9 – June 14)

Topic of Interest: A cell is placed in a chamber set at a temperature of 10 degrees Celsius. Examine the temperature of the cell at different levels of current. We hope to establish a relationship with temperature.

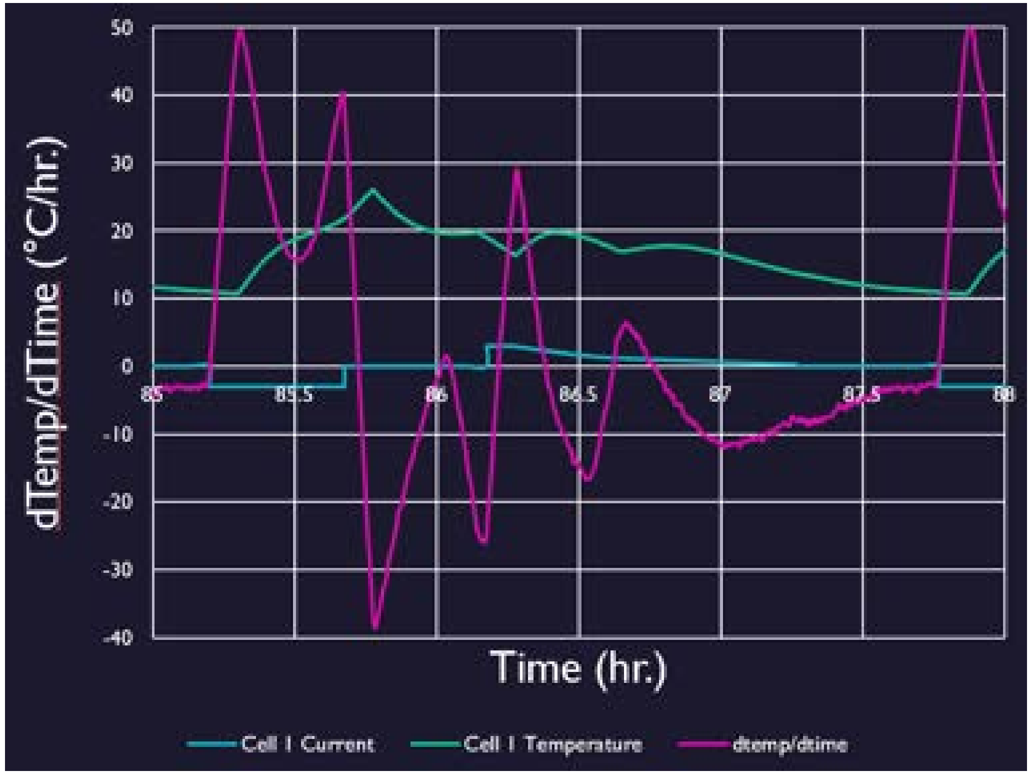
Using the data chart, we see that there is a direct relationship between current and Temperature



Project 1 continued (June 9 – June 14)

Topic of Interest: A cell is placed in a chamber set at a temperature of 10 degrees Celsius. Examine the temperature of the cell at different levels of current. We hope to use a rate of change graph to see deeper into the relationship we discovered.

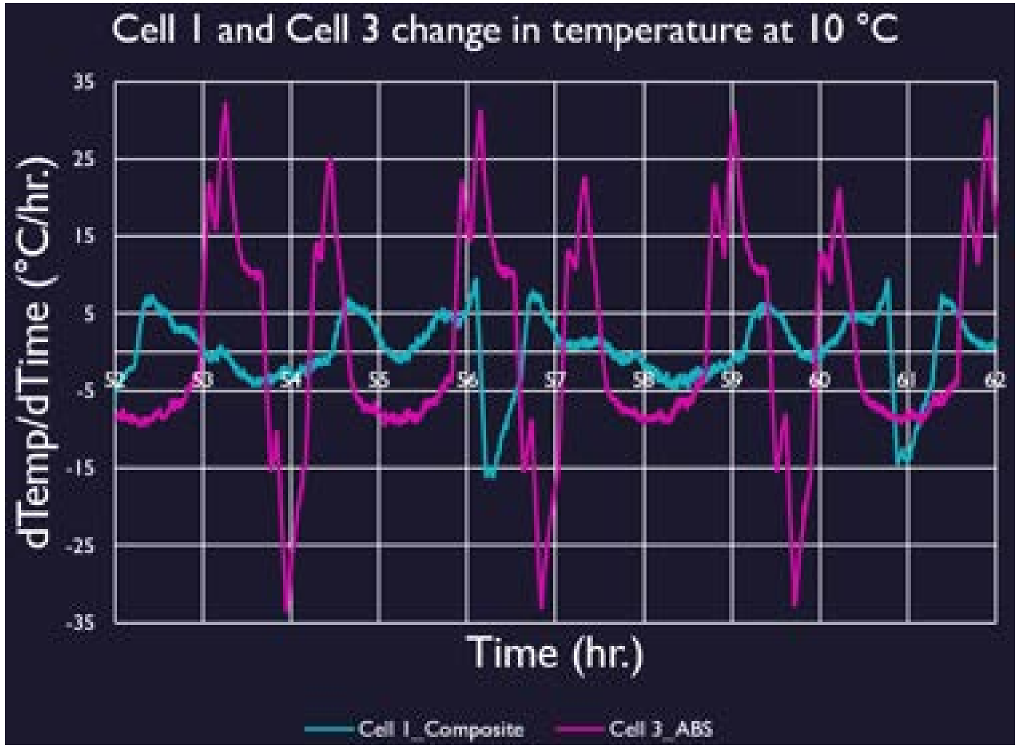
I learnt that negative current (discharge) causes temperature to increase drastically, slow down, positive spike again, and finally slow down. When current is close to zero, the cell enters a cooling state and decreases the temperature, following a similar pattern as the positive, just with cooling. During positive current (charging), the cell's heat release from the chemical reactions gets absorbed and eventually the temperature of the cell becomes as hot or hotter than the outer temperature, making it cool down a bit. This exchange continues while the current is positive and not very close to zero.



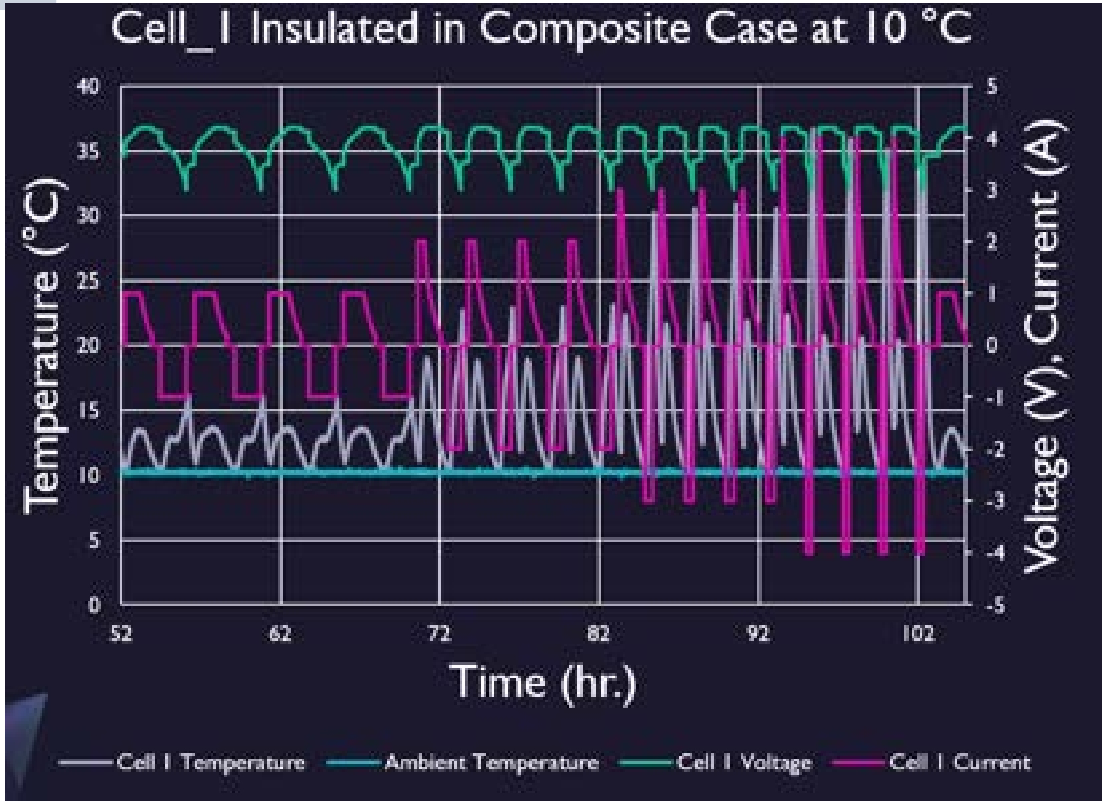
Project 2 (July 5 – July 7)

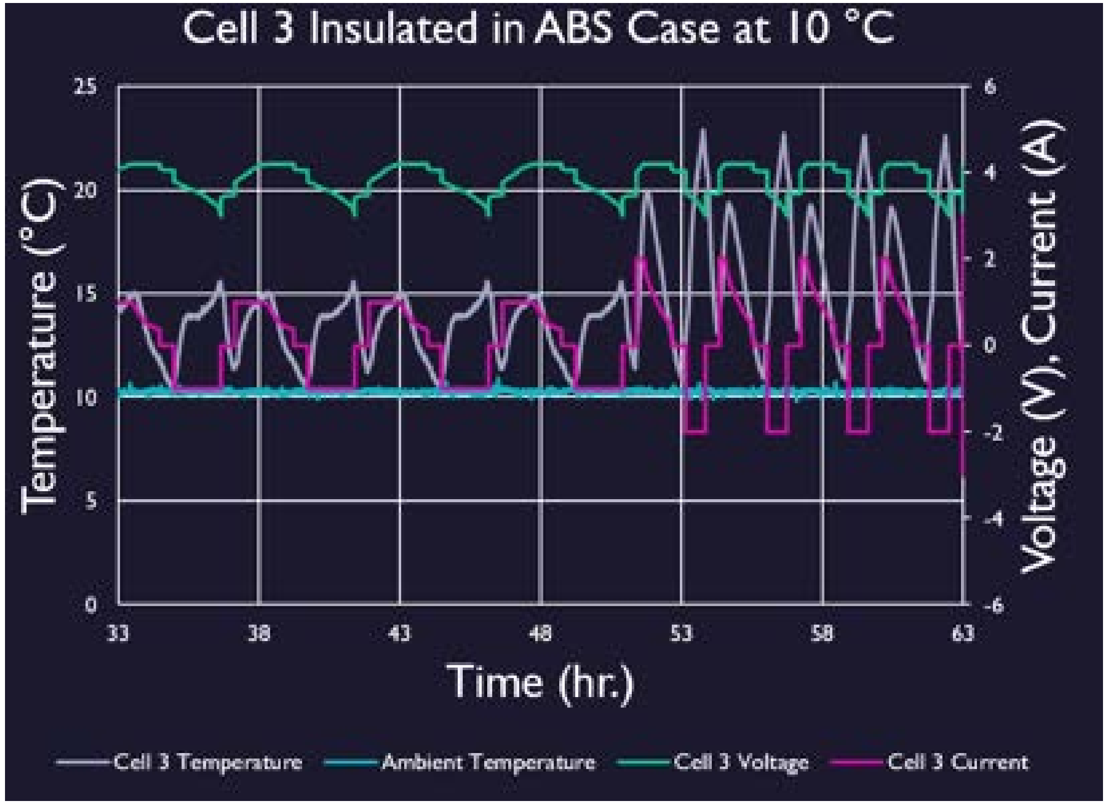
Topic of Interest: Two cells were placed in two different casings: ABS (A specific combination of different plastics) and composite (A combination of unique materials with the purpose of balancing a weakness). Both of the cases were exposed to a constant ambient temperature of 10 degrees Celsius. We examined the temperature change of each cell within the casings at different levels of current. We hope to use a rate of change graph to see the temperature changes within both casings to find the better insulator for the battery.

We learnt that the composite case is cooling faster than the ABS case, but this is not certain because from our previous project, we saw a relationship between current and temperature, and here the current is different for the cells due to the ageing of the battery used for experimenting.



Project 2 data charts (July 5 – July 7)

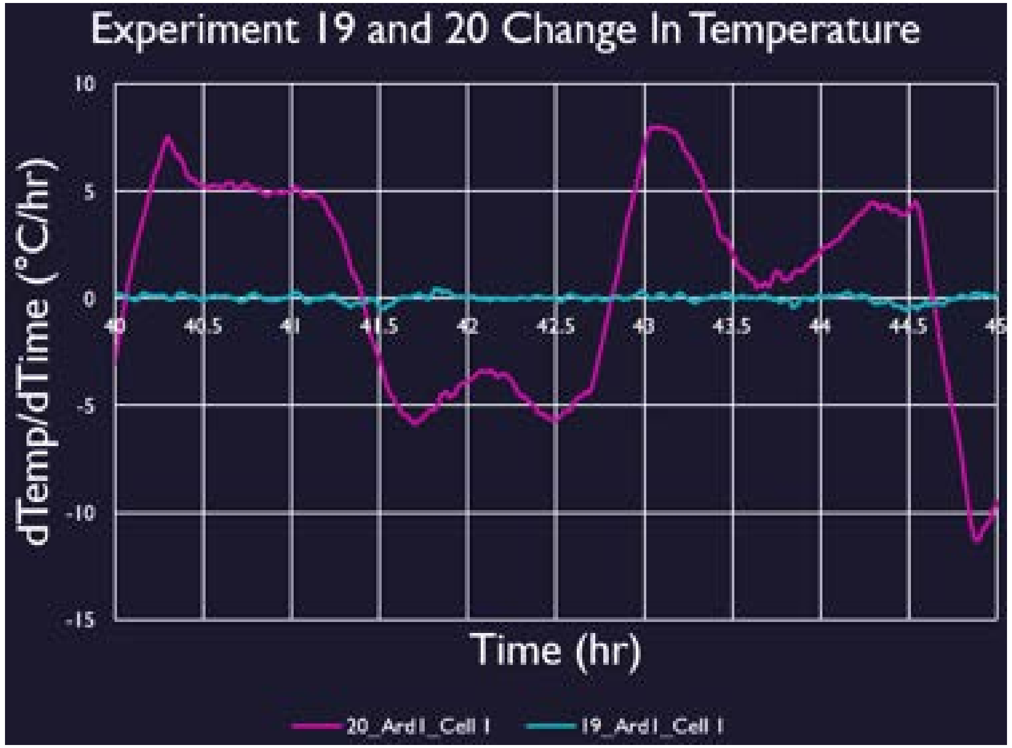




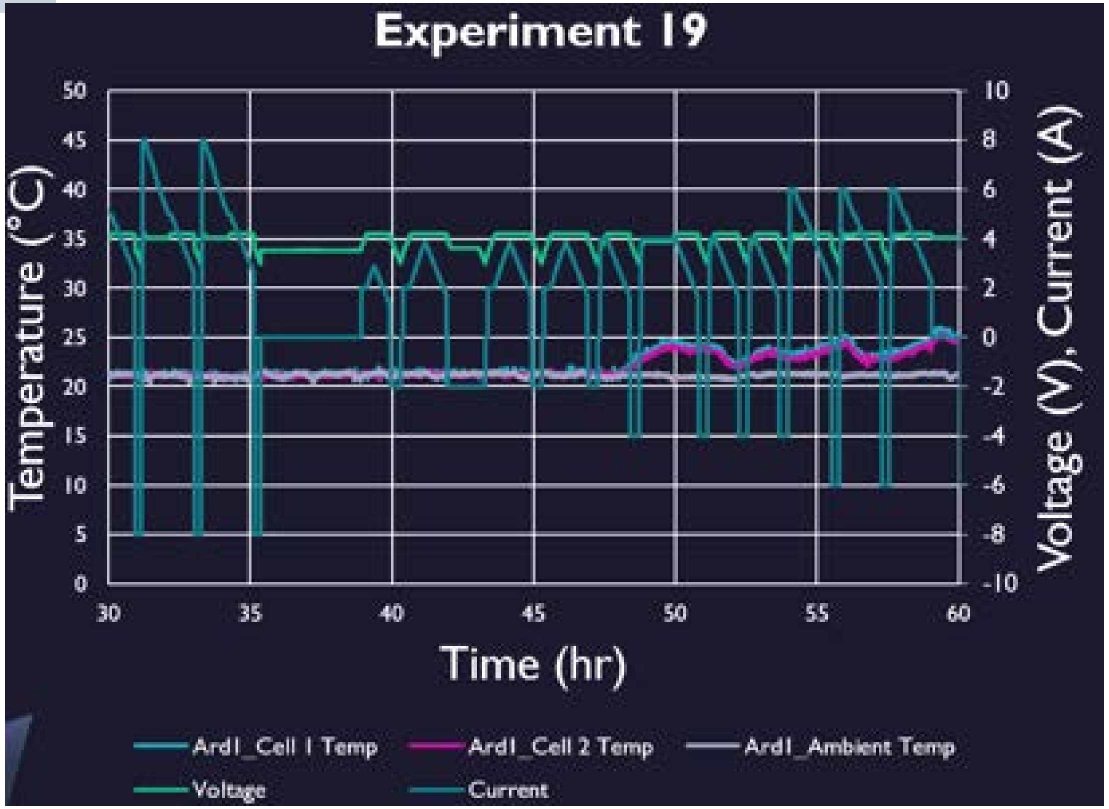
Project 3 (July 19 – July 21)

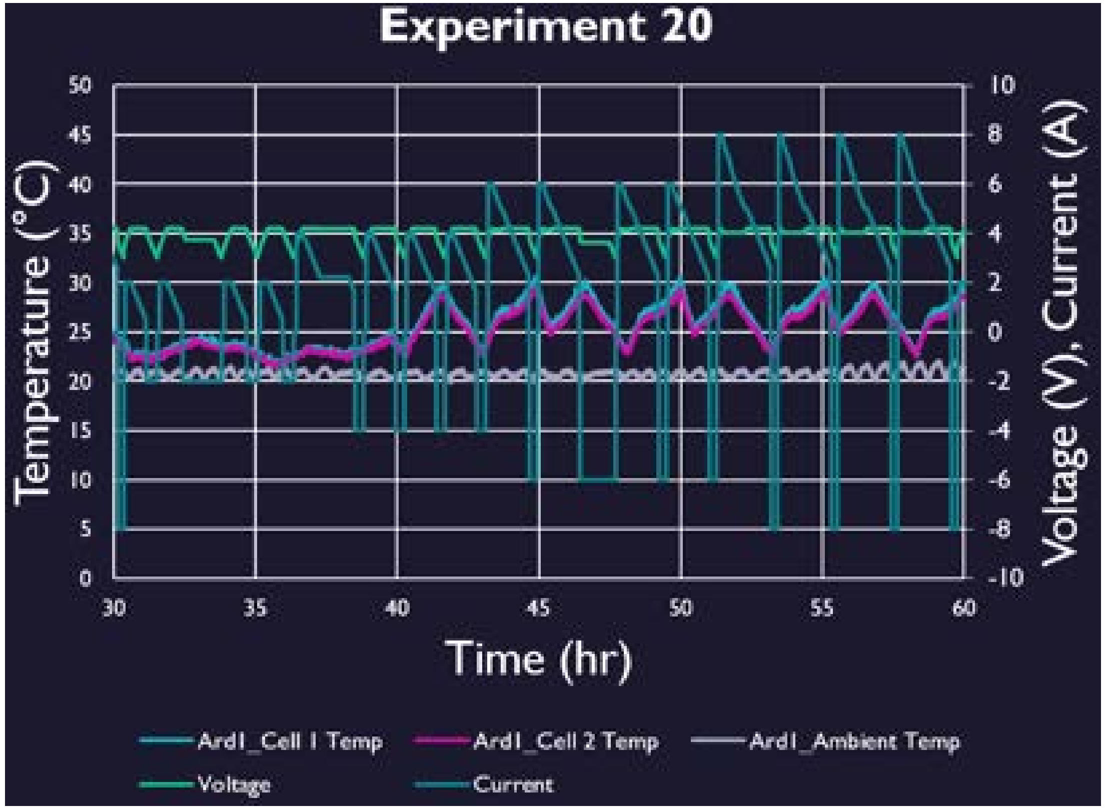
Topic of Interest: Two unique cells (called experiment 19 and experiment 20) were placed in a chamber set at a temperature of 20 degrees Celsius. We examined the temperature of the cell at different levels of current. We hope to use a rate of change graph to see the temperature changes within both batteries to find the better makeup for the battery.

We learnt that experiment 20 heats and cools faster than experiment 19. Although, while the rate of change charts shows this, the current for experiment 19 shows an abnormal pattern as the other experiments we have done and experiment 20. Since we have determined that Temperature and current have a direct relationship, we can not arrive at a conclusion since the current too linear.



Project 3 data charts (July 19 – July 21)





My Future Plans After This Experience

Entering the program, I already knew I wanted to do electrical engineering because it sounded interesting. As the program went on, I began to get real experience on a branch of the large career of electrical engineering: battery making and analysis. Leaving the program, I feel that I have learnt a lot about how electricity is formed and the different parts that go into making the most convenient thing in modern life and the future of planet earth. I hope to pursue electrical engineering in college to explore more branches of electrical engineering and maybe even do a PHD like Deependra, Lenin, and Nick to contribute more into the exploration of electricity and everything it can do.