

## Introduction

Sodium-ion battery is the focus of research, due to sodium being an abundant resource, and sodium have a very similar property compared to lithium. In this research project, three different liquid electrolytes is tested in symmetrical battery for stability, additionally a substance added to the electrolyte and compare with electrolyte without the substance. Also, the electrolyte is tested in full battery for capacity.

The electrolyte have sulfolane as solvent. Sulfolane have a high boiling point, using this as solvent can make the electrolyte non-flammable. In the solvent, three different salt added to make the different electrolytes, the salts are: NaCF<sub>3</sub>SO<sub>3</sub>, NaClO<sub>4</sub>, and NaPF<sub>6</sub>. The additional substance used is FEC. For the full battery, the cathode used is NVP, the anode is still only sodium.

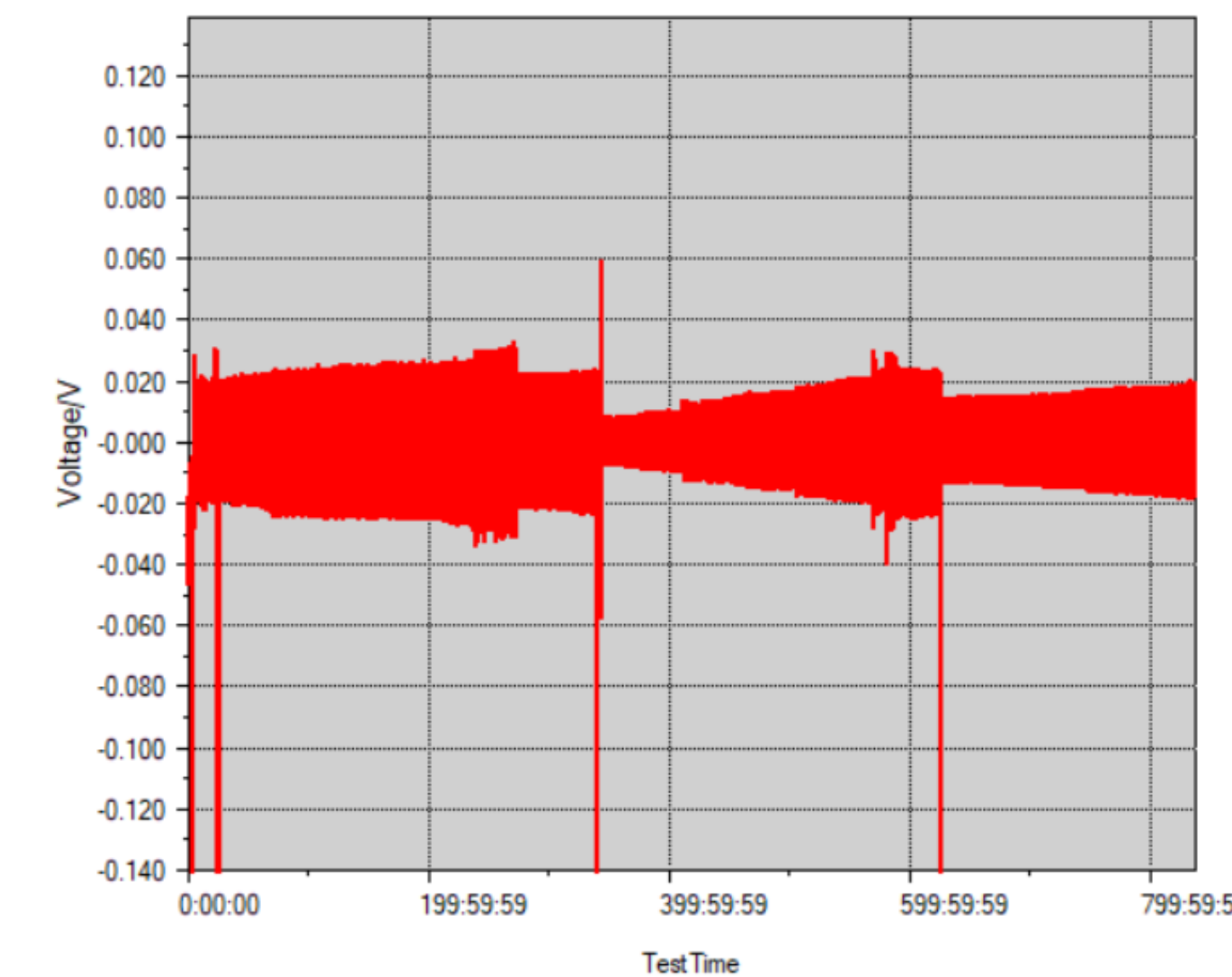
## Methods

- Making electrolyte
  - Measure 10ml of the solvent
  - Find molar mass of the salt
  - Measure equal amount of mole of the salt and add to the solvent
  - Mix with a magnetic stirrer
- Making cathode
  - Weight active material, binder, and conductive material in a ratio of 90:5:5
  - Grind the substances until well mixed
  - Add 34 drops of NMP to the mixture
  - Put the substance into a mixer, run 2000 rpm for 15 minutes, and then 400 rpm for 5 minutes
  - Spread the substance on a piece of tin foil, thickness of 40 um
  - Put in a vacuum oven to dry
  - Cut into small circle pieces when use
- Procedure for building battery
  - Layout the cell casing, on the anode side, put a piece of sodium
  - Drop 20 uL of the electrolyte on the sodium
  - Put a separator on top, make sure the separator is soaked (so the sodium is visible through the separator)
  - Drop another 20 uL of electrolyte
  - For the symmetric battery, add another sodium. For the full battery, add the cathode, make sure the substance side is facing the electrolyte
  - Close the cell casing, put the battery in a press to make sure the casing is closed.
- Testing
  - For symmetric battery, select the charging capacity before start
  - For full battery, calculate the weight of the substance on the cathode

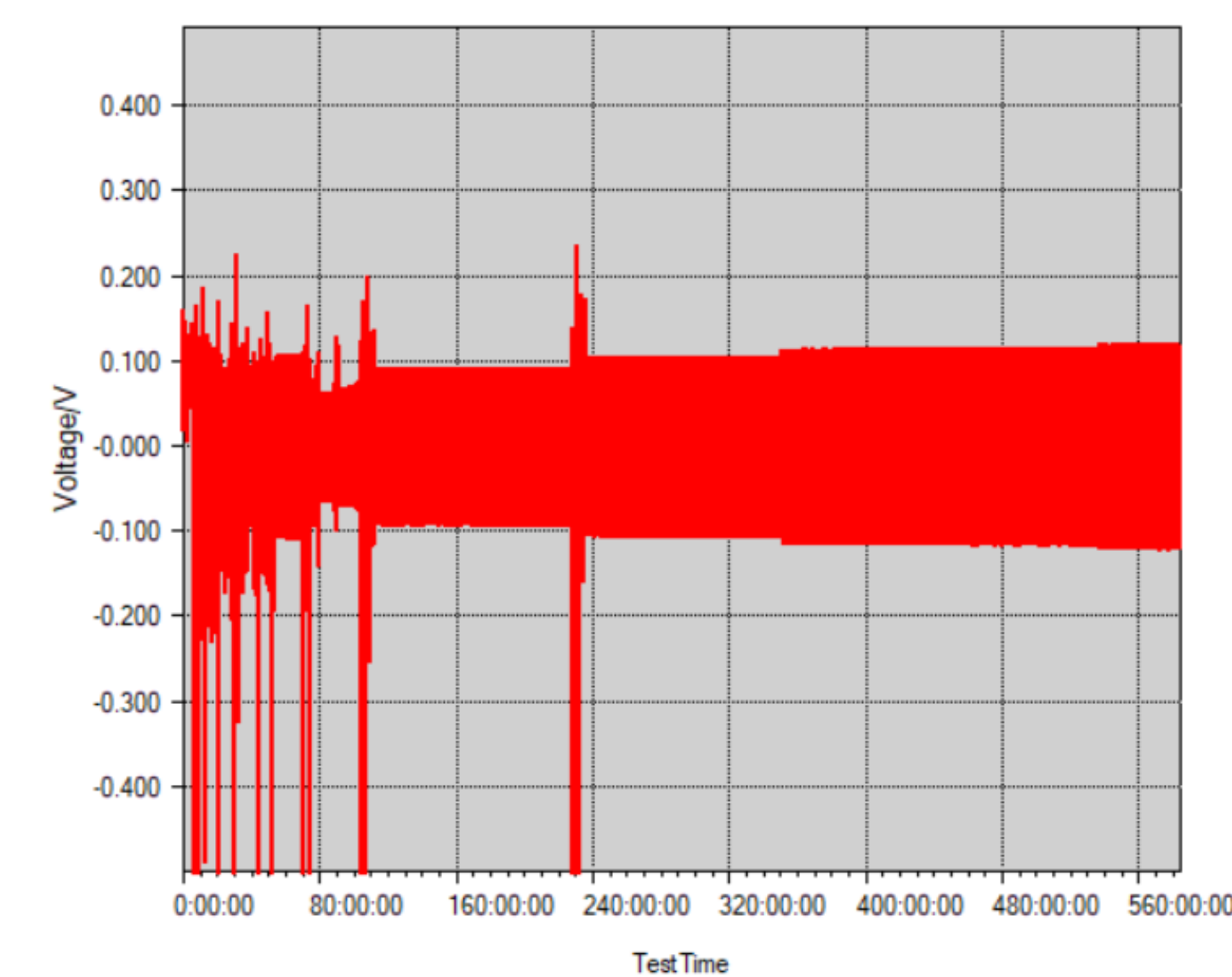
## Results

The following three graphs are the test result of the three different salts in the electrolyte. As the result shown, the electrolyte with NaCF<sub>3</sub>SO<sub>3</sub> have the best performance.

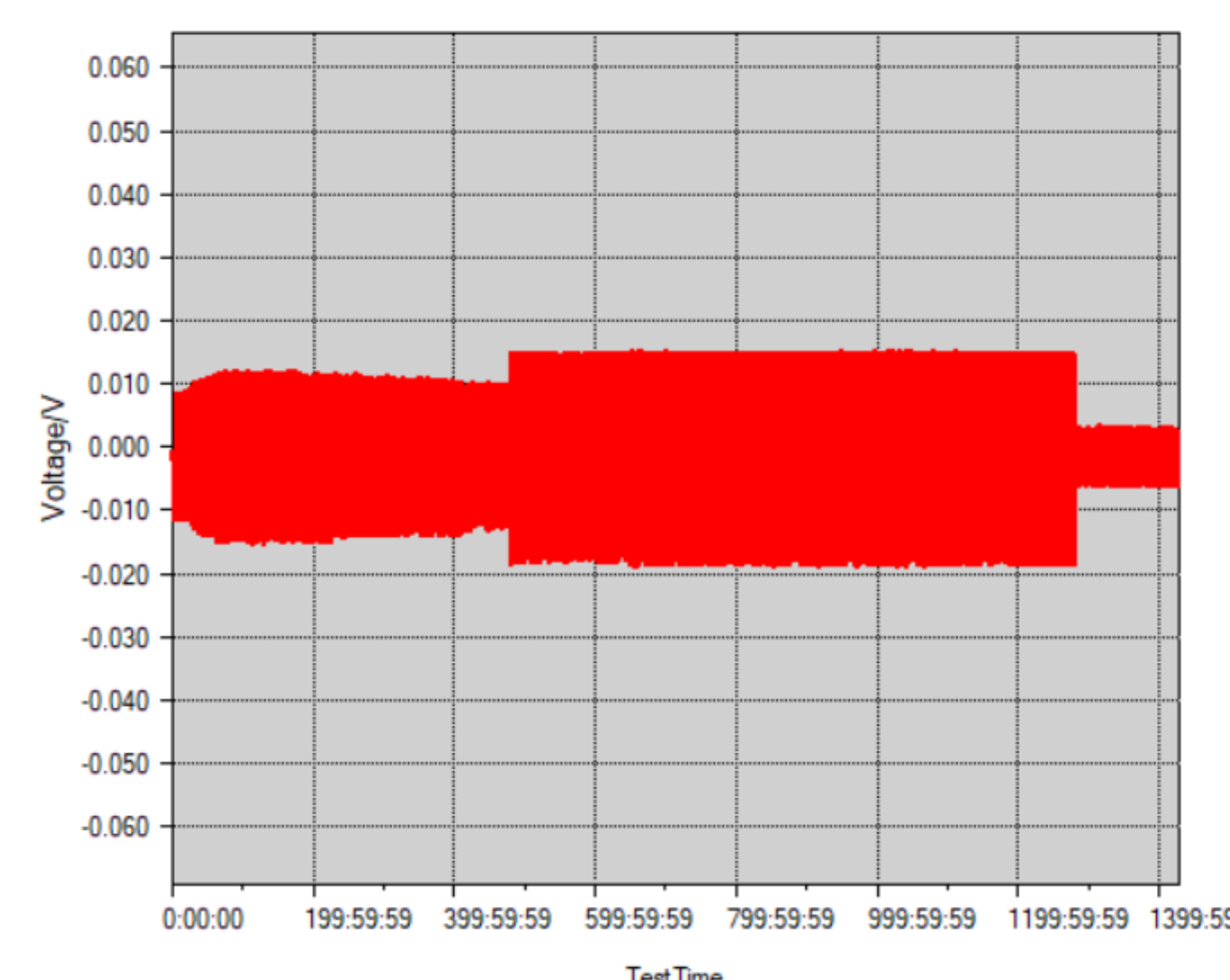
The electrolyte with NaPF<sub>6</sub> have some voltage spikes, and change in voltage in between, with a run time of 800 hours, otherwise the voltage is stable around 0.02 volts.



The electrolyte with NaClO<sub>4</sub> also have some voltage spikes, and it is unstable in the beginning, but later stabilized at 0.1 volts.

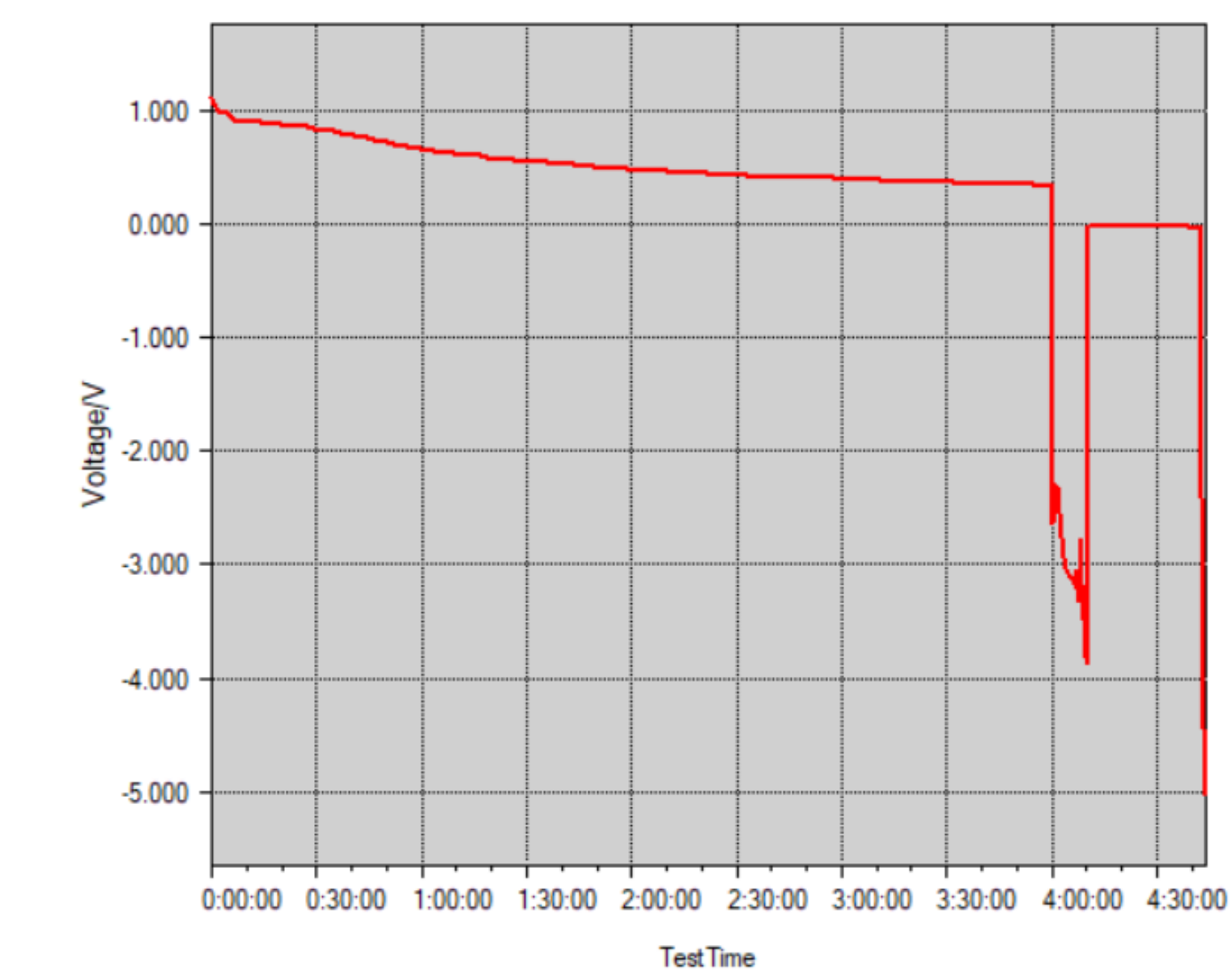


The result for NaCF<sub>3</sub>SO<sub>3</sub> don't have any voltage spikes, and it has the longest runtime of about 1300 hours before short circuit. The voltage is around 0.015 volts.

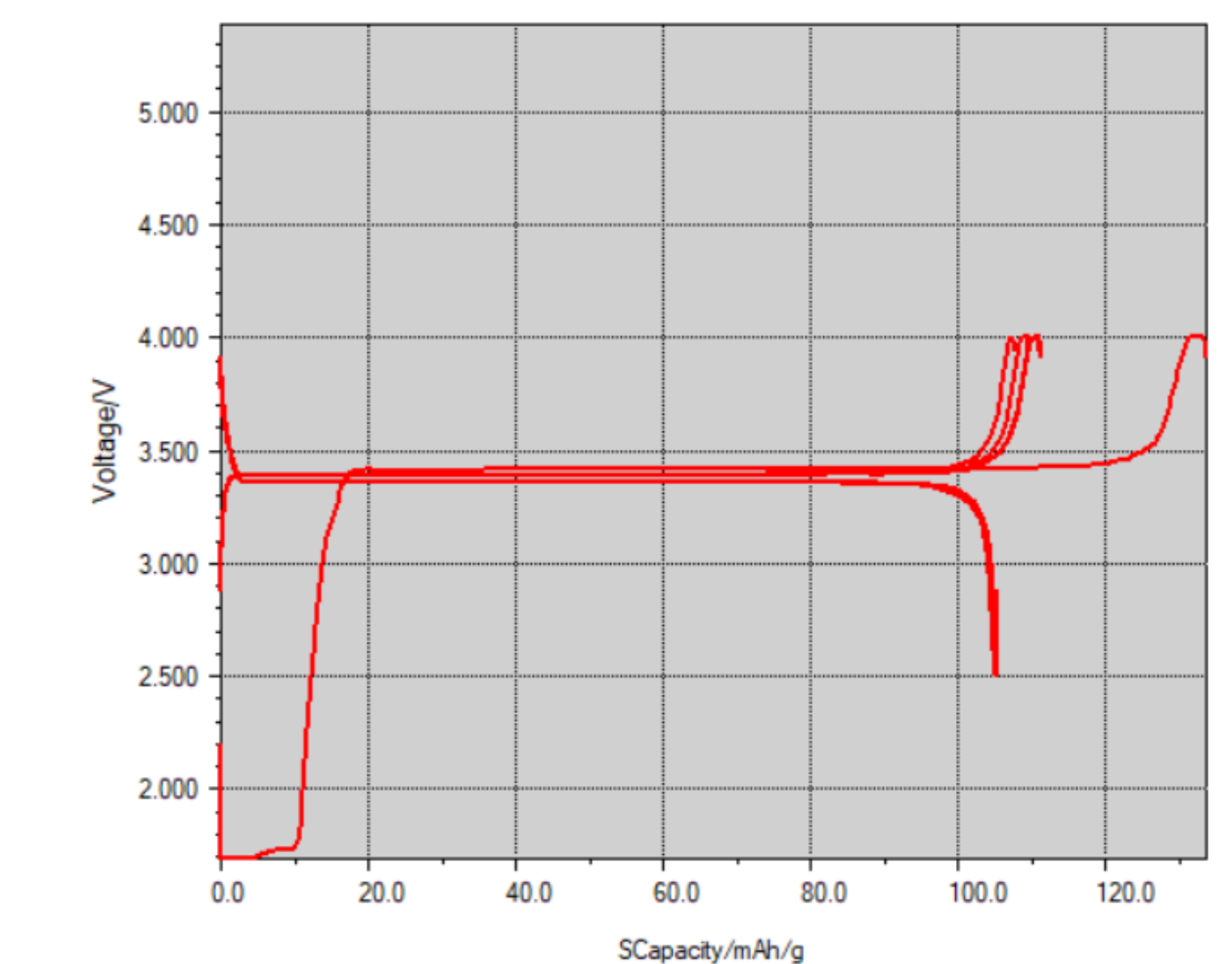


## Results Cont.

The previous three results are electrolytes added FEC, without FEC, the voltage is unstable. The graph shown below is the electrolyte with NaCF<sub>3</sub>SO<sub>3</sub>, and no FEC added, the test is interrupted when the voltage reach -5 volts, continue testing might cause damage to the machine.



The following graph is the result for testing full battery. The specific capacity is about 100 mAh/g, and running at 3.4 volts. The graph show promising result for only first few cycles, after these few cycles, the results are not good.



## Conclusions

In conclusion, the electrolyte with NaCF<sub>3</sub>SO<sub>3</sub> and FEC have the best performance in stability. This electrolyte should be tested for more conditions, such as using different amount of electrolyte during assembly, testing with different charging capacity.

The full battery did not show a good result, and needs further optimizing, such as using different cathodes.

## Acknowledgement

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## References

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