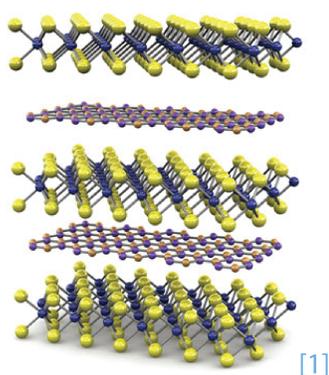
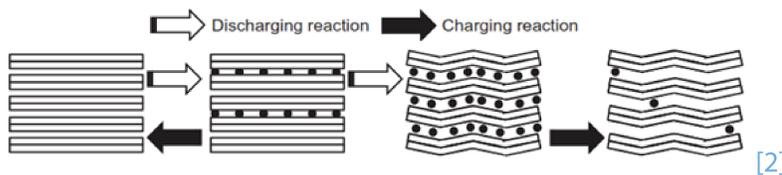


Introduction

Sodium-ion batteries are a potential alternative to current lithium-ion technology. Sodium is globally abundant, meaning that it is cheaper than lithium materials. Although sodium has a larger atomic radius, its reactivity is similar to lithium. Along with this, transition metal dichalcogenides (TMDs) have recently been used as an electrode material due to their layered structure.

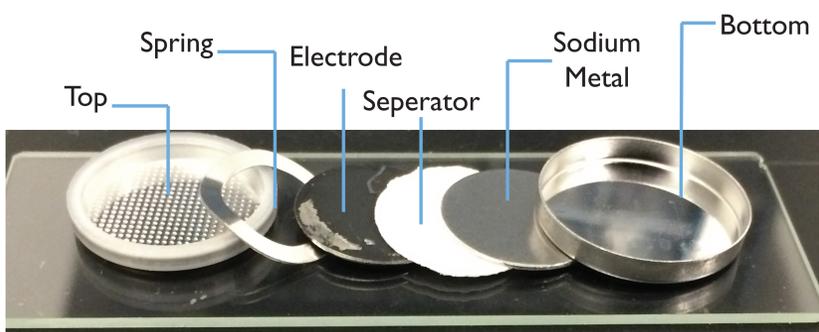


This project explores using the TMD tungsten diselenide (WSe_2) as an electrode for a sodium ion battery. We determine the optimal binder and electrolyte composition for these devices, and explore exfoliation techniques for few-layer WSe_2 .



Methods

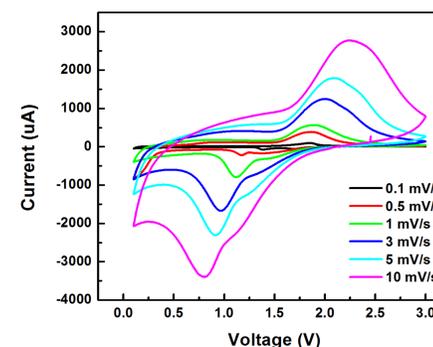
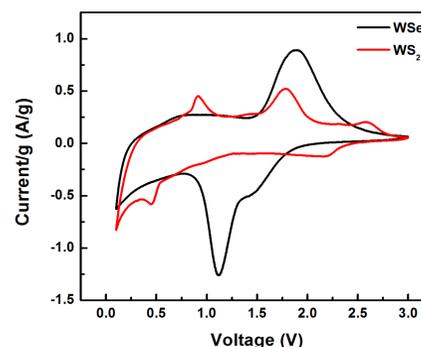
- Batteries are made using coin cells
- A 60/20/20 wt% WSe_2 /binder/carbon electrode solution is drop dried onto a steel disc
- Cells are assembled in an argon filled glove box, where electrolyte is added to the separator
- Sodium covered disc is then placed on top



Results

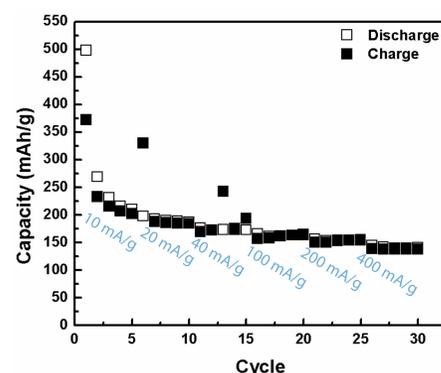
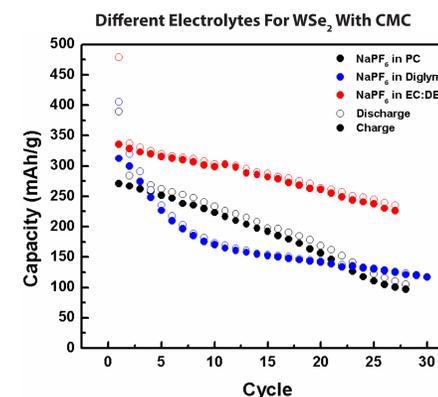
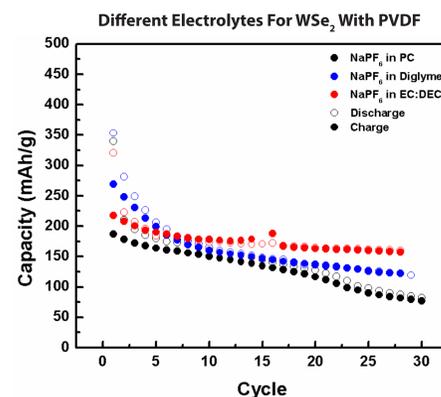
We looked at two binders, CMC and PVDF, as well as three electrolytes. We focused on two electrochemical tests; cyclic voltammetry and galvanostatic charge/discharge.

Cyclic Voltammetry (CV)



- CV does a linear voltage sweep, in the forward and backward direction.
- WSe_2 shows peaks that are closer together, meaning that it has a lower overpotential
- Reactions don't change much when scan rate is increased.

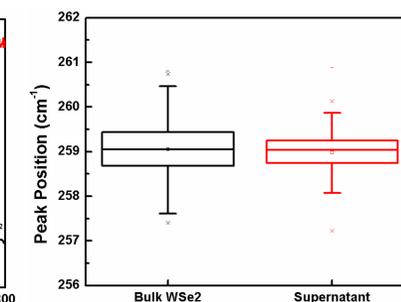
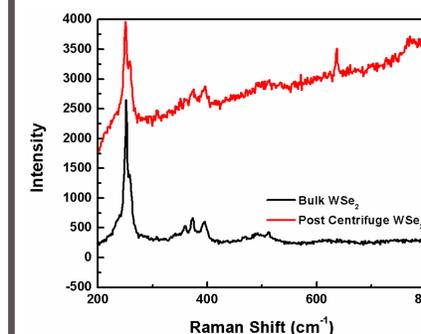
Charge/Discharge Cycling



- Cycle the cell at constant current from 0.1 to 2.5 V
- Optimal composition of CMC with $NaPF_6$ in EC:DEC had second discharge capacity of 335 mAh/g and retention of 70% after 25 cycles
- Did not degrade much when tested under higher current densities

Results Continued

Exfoliation



- L. Niu, et al. [3] reported a simple liquid exfoliation process for yielding few-layer WSe_2
- Repeated this experiment and used Raman spectroscopy to create a map and compare the product to bulk
- No noticeable shift yet; need to develop better filtering methods

Conclusions and Future

Final Remarks

- The combination of CMC with $NaPF_6$ in EC:DEC showed the best overall performance
- Rate testing showed that it could also handle higher rates well
- Exfoliation shows promise, but process needs to be refined

Future Goals

The next step is to make the electrodes using exfoliated and nanostructured WSe_2 . Other research has shown that nanostructured material can increase the capacity dramatically. Atomic layer deposition (ALD) could also be used to coat the electrode with a thin film and improve cyclability.

[1] Q. Wang, et al., "Electronics and optoelectronics of two-dimensional transition metal dichalcogenides", *Nature Nanotechnology* 2012.
[2] J. Park, et al., "Discharge mechanism of MoS_2 for sodium ion battery", *Electrochimica Acta*, 2013.
[3] L. Niu, et al., "Salt-Assisted High-Throughput Synthesis of Single- and Few-Layer Transition Metal Dichalcogenides and Their Application in Organic Solar Cells", *Small* 2014