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Exploring Multi-electron Redox for Na-ion Battery Electrodes

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Introduction:

- Multi-electron redox offers a possible solution for traditional Li-ion batteries approaching theoretical limit
- Na_2CoSiO_4 is a cathode material capable of this process, which drastically increases the theoretical capacity.
- Na instead of Li is used as the intercalating species, being a more cost-effective alternative which could support implementation on a large scale.

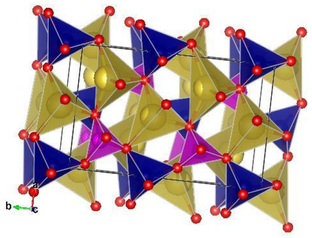

Figure 1: Unit cell of Na_2CoSiO_4 Na (yellow), Co (blue), Si (pink), O (red)

Synthesis:

- Pure phase Na_2CoSiO_4 was synthesized using the solid-state synthesis method.
- X-ray diffraction was used to collect data about the structure.
- Rietveld Refinement shows that the material is 95% Na_2CoSiO_4, and 5% impurities (CoO, Co).

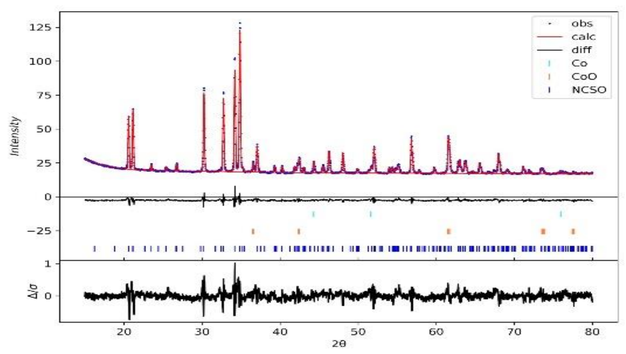

Figure 2: Rietveld Refinement of Na_2CoSiO_4

Results:

- Electrochemical studies showed a reversible intercalation of 1 sodium up to 3.8V

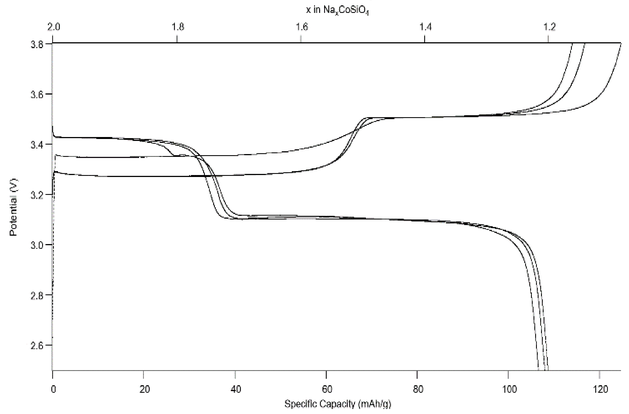

Figure 3: Galvanostatic charge/discharge at C/50

- High voltage region where 2nd Na is removed shows brief plateau at 4.5V before oxidation of electrolyte

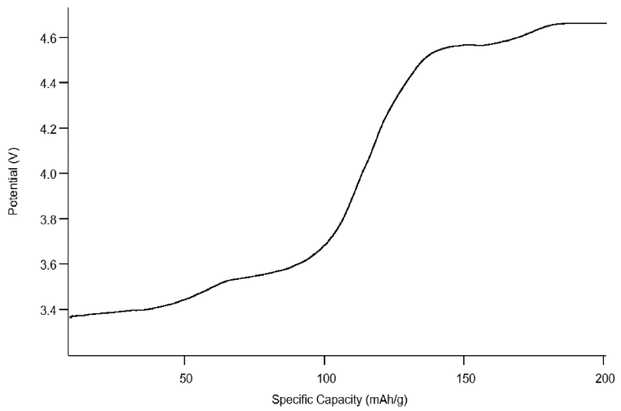

Figure 4: High voltage region of galvanostatic charge to 4.8V at C/50

- Understanding the possible structure change during the second Na extraction is the goal

Results:

- Samples were charged to various voltages to investigate possible structure changes

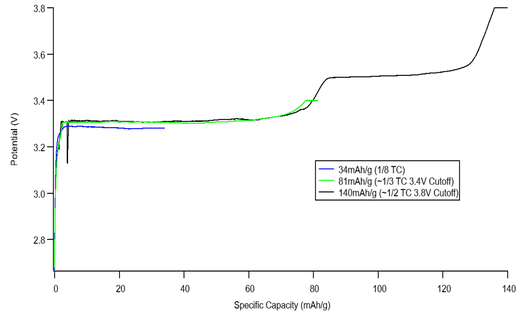

Figure 5: Galvanostatic charge to 3.4V and 3.8V

- Lattice parameters of unit cell change as well as volume expansion/contraction

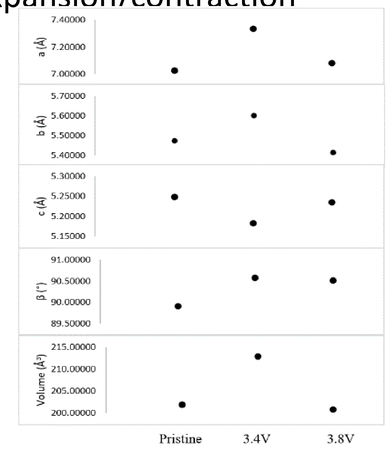

Figure 6: Lattice parameters from ex-situ x-ray diffraction

Future Work:

- Ex-situ x-ray diffraction to further investigate upper voltage region
- Use Pair Distribution Function to analyze synchrotron x-ray data
- Improve electrochemical performance to achieve greater capacity by adjusting particle size and electrolyte composition

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