Examining the Effects of Phosphazene Additives in Electrolytes for Sodium Ion Batteries

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Abstract

Lithium ion batteries (LIBs) currently dominate the battery market due to their high energy and cycling stability. However, because of lithium's scarcity, the forthcoming demand for large scale energy storage will need to be satisfied by systems that use more abundant resources. Sodium ion batteries (NIBs) are a suitable alternative, but for NIBs to compete with LIBs their stability need to be improved. One way of improving such characteristic is to alter the electrolyte. In this study, the effect of the phosphazene-based additive FM2 was examined by varying the additive percentage in relation to carbonate solvent in a NIB system. The efficiency and specific capacity of cells with the FM2 additive were compared to cells made with the commercially available fluoroethylene carbonate (FEC) additive. The results of this study will add to the ongoing effort to develop more sustainable battery systems.

Methods

1) Anodization Formation of TiO_2 nanotube anode.

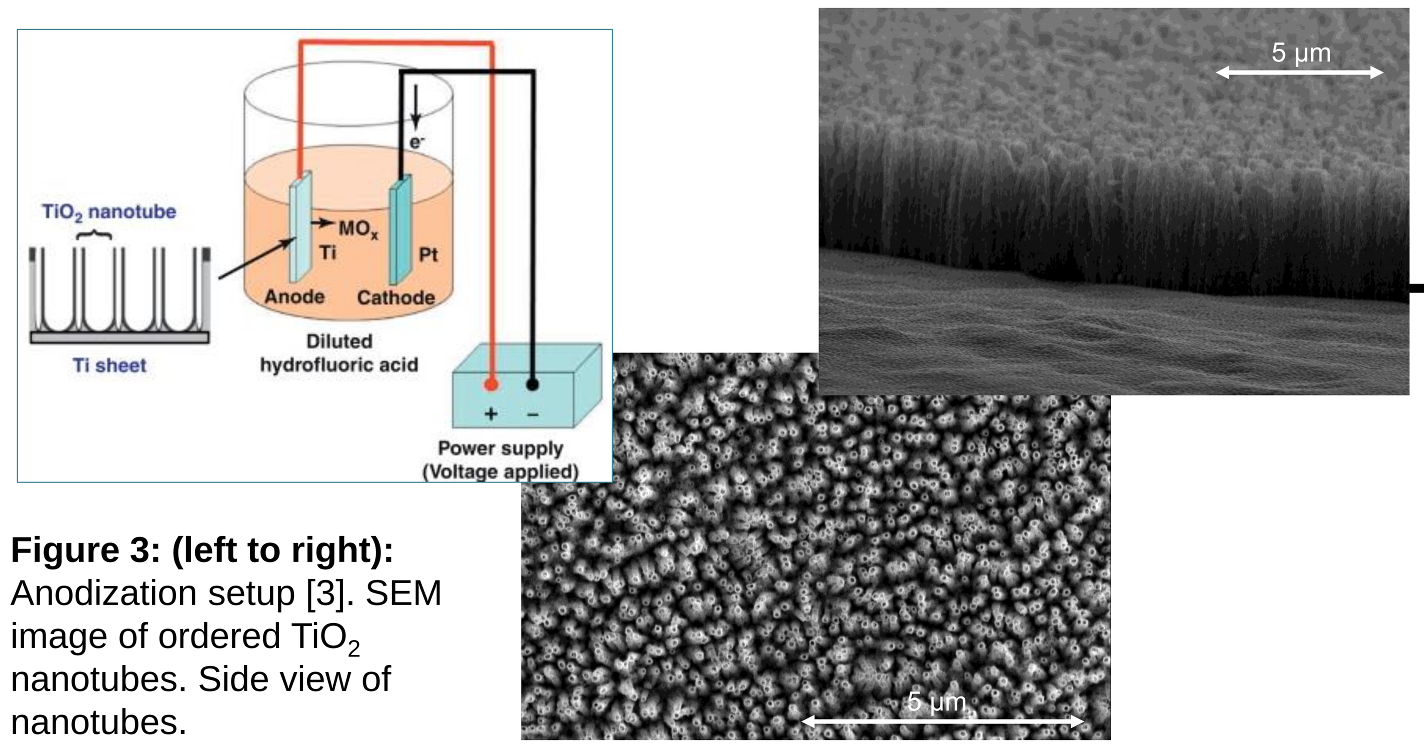

Figure 3: (left to right): Anodization setup [3]. SEM image of ordered TiO_2 nanotubes. Side view of nanotubes.

2) Electrolyte Preparation
EC:EMC plus an additive:
1% FM2, 5% FM2, 10% FM2,
1% FEC, 5% FEC, or 10% FEC.

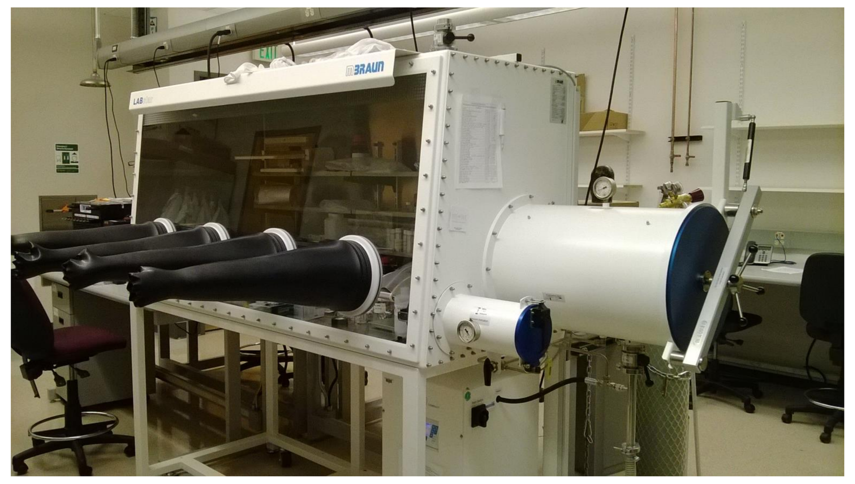

Figure 4: Argon glove box where electrolytes and coin cells were prepared.

3) Coin Cell Preparation

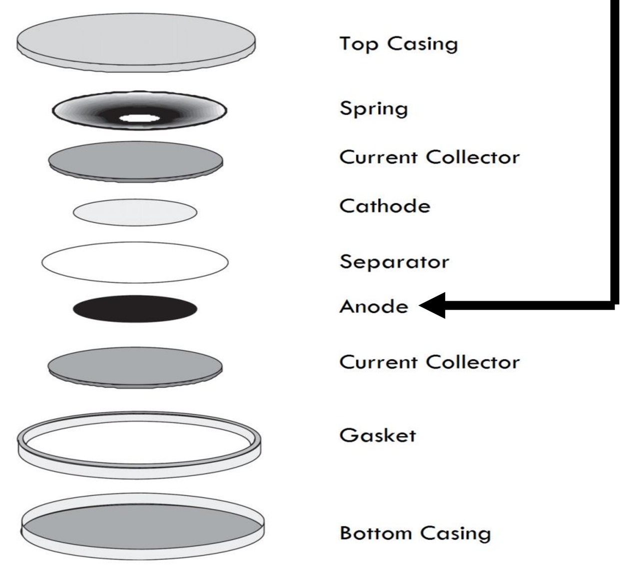

Figure 5: Construction of coin cells.

4) Cycling The cells were then cycled galvanostatically at a rate of C/18.

Background

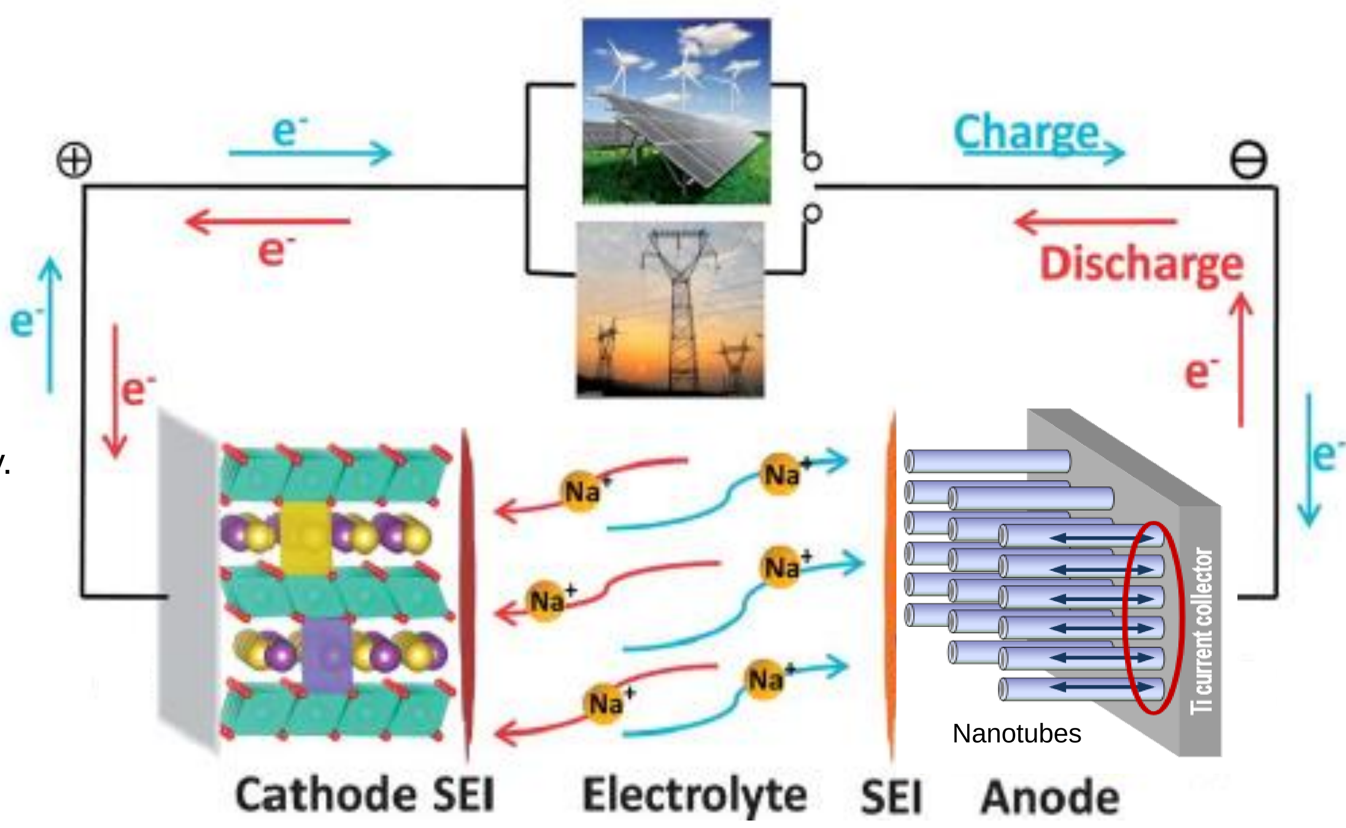

Figure 1: Working principles of NIB technology. Adapted from [1].

The inherent intermittency with some forms of renewable energy (e.g., solar and wind power) has led to interest in the ability to store large amounts of energy. For NIBs to be a viable storage solution their electrolytes need to have high thermal and electrochemical stability, good ionic conductivity, and no electron conductivity. Using electrolyte additives in NIBs can help meet those criteria.

Results

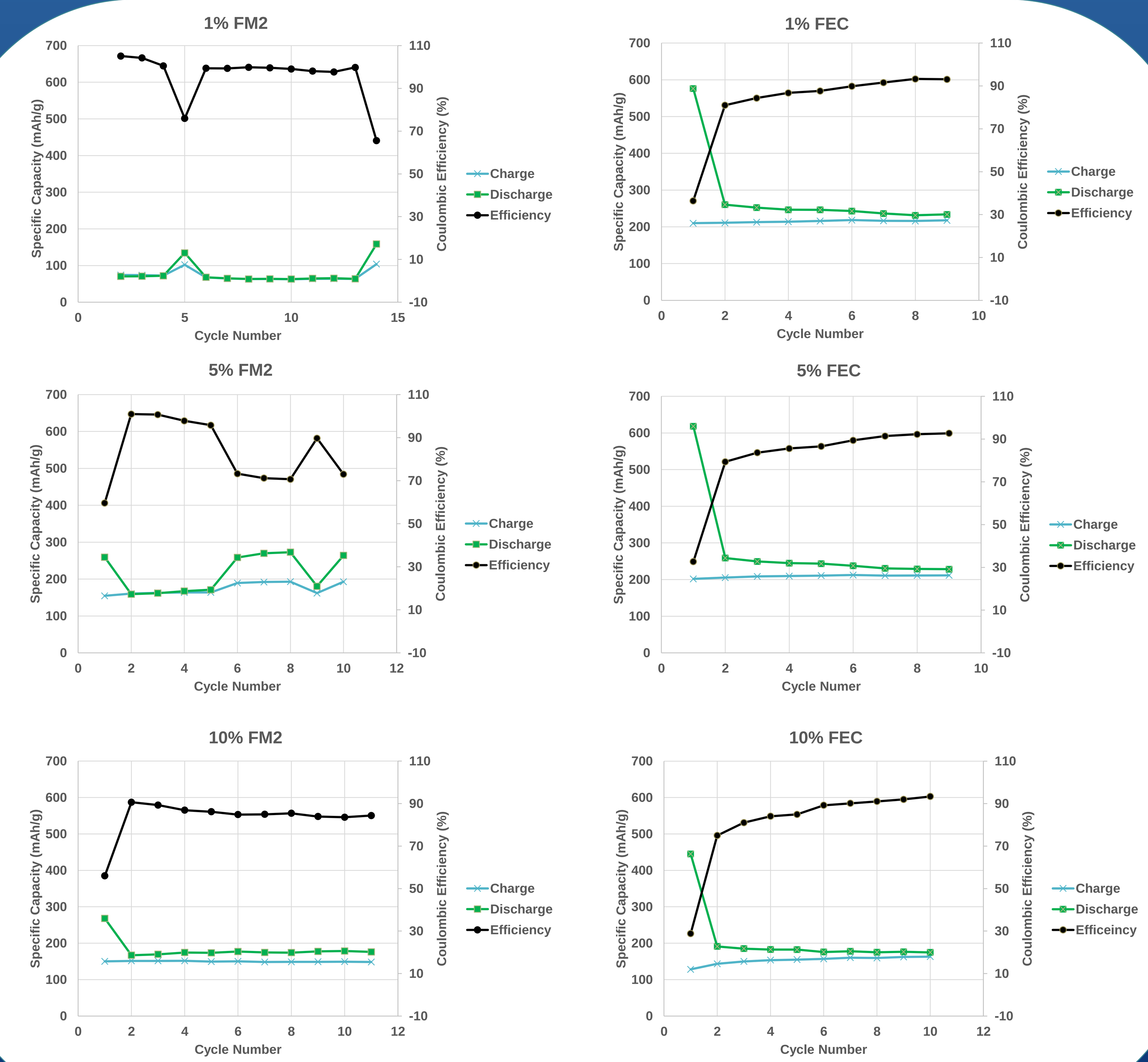

Figure 6: Electrochemical data from cycled cells.

Sodium vs Lithium

Sodium Systems

Pros
- Cheap
- Abundant
- Widely distributed
- Promising for large scale energy storage

Cons
- Lower capacity
- Poor cycling stability
- Troublesome reactions between electrodes and electrolyte

Lithium Systems

Pros
- Higher capacity
- Higher energy density
- Already marketed and extensively researched

Cons
- Expensive
- Not abundant
- Unevenly distributed

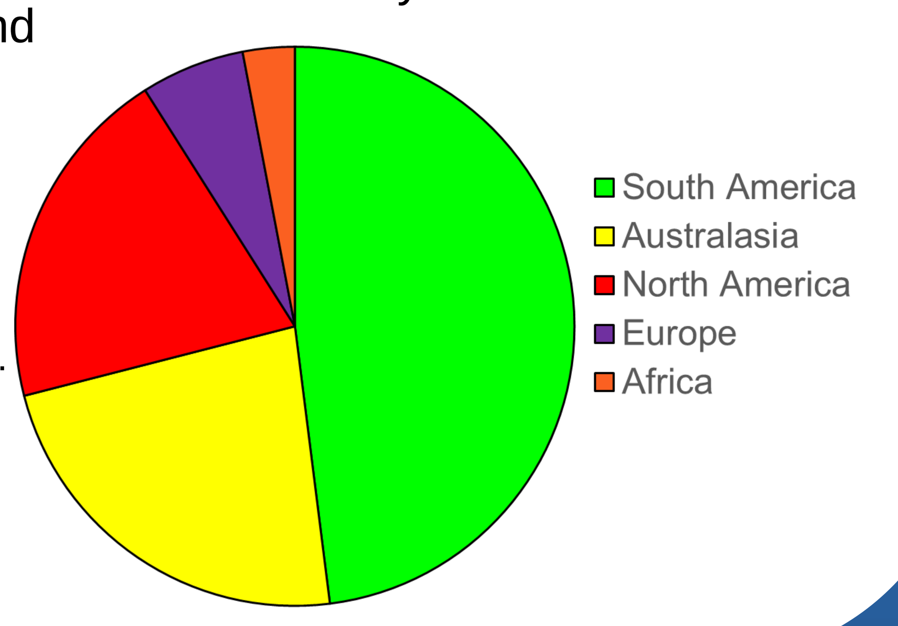

Figure 2: Global lithium distribution. Adapted from [2].

Discussion and Conclusion

The experiments completed in this study indicate that while 1% of FM2 appears to reduce specific capacity, overall the changes to capacity in both electrolyte systems are within the margin of error.

However, it is notable that the observed efficiency of cells with FM2 additive are approximately 98%, 98%, and 82% for 1% FM2, 5% FM2, and 10% FM2 (respectively) while the efficiency of cells containing FEC range from 70-90% during cycling for all three percentages indicating side reactions taking place.

Future Research
- Re-test all cells under stable conditions
- Cycle cells at high rates for long periods of time to test cycle life and capacity retention
- Cycle cells at different temperatures

Acknowledgements

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References

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