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IMPROVING ALKALINE ZINC-COPPER OXIDE BATTERIES THROUGH CHEMICAL MODIFICATIONS

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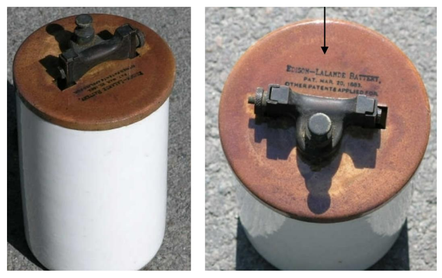
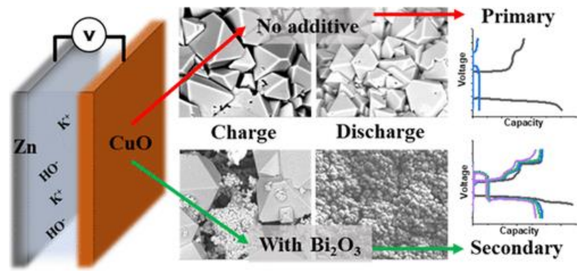
Background

1883, Primary



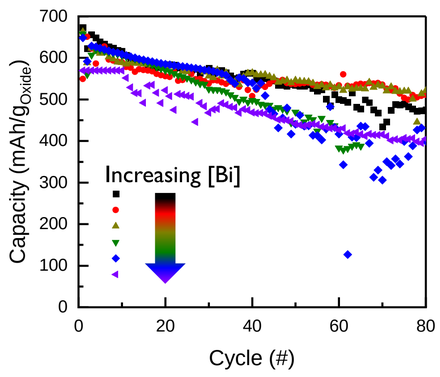
2021, Secondary

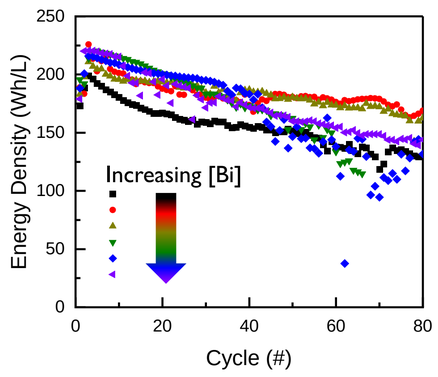


Schorr *et al., ACS Appl. Energy Mater.*, **2021**, *4*, 7073-7082

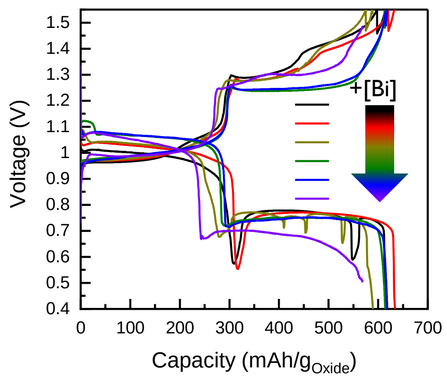
- Zn-CuO has long been known as a high capacity, low voltage primary battery, but recent work has shown the chemistry is reversible in the presence of Bi_2O_3
- Optimization of Bi_2O_3 quantity, as well as other chemical modifications, expected to yield further improvements to battery performance

Impact of Bi Content on Cycling





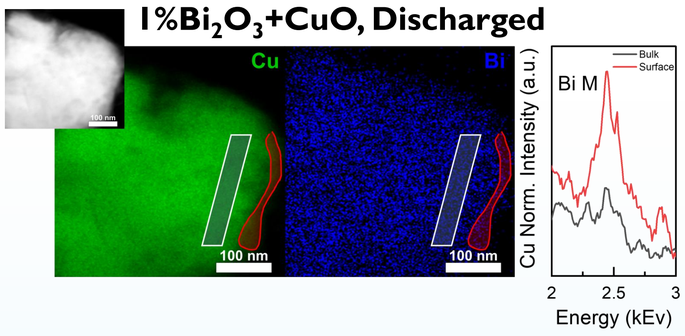
- Tuning the total concentration of Bi_2O_3 (solid and soluble) has a small, but notable, impact on both the capacity and energy density of the Zn-CuO battery



- Total quantity of solid Bi_2O_3 (in cathode) appears to impact charge/discharge behavior
- ~1 wt% Bi_2O_3 appears to be reasonable balance of all performance metrics

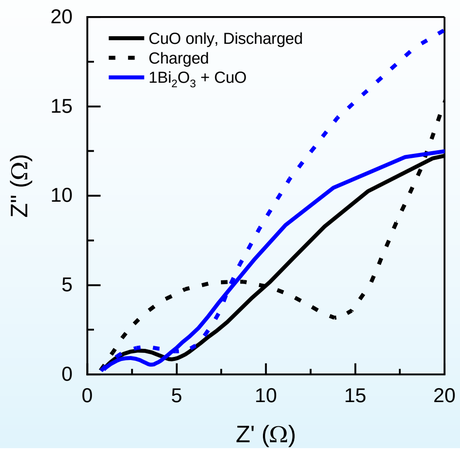
Where Does the Bi Go?

1%Bi_2O_3+CuO, Discharged



- STEM/EDX imaging of discharged cathodes shows that the Bi is evenly co-located with the Cu, and but is likely concentrated at the particle surface
- Bi electrochemistry likely mediated through the soluble $Bi(OH)_4^{2-}$ species

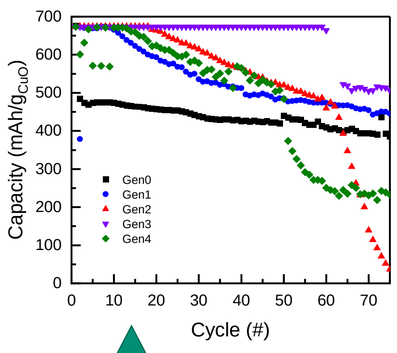
- Presence of Bi (Bi^0 or Bi_2O_3) reduces charge transfer resistance, improves cathode conductivity



Other Routes to Improvement

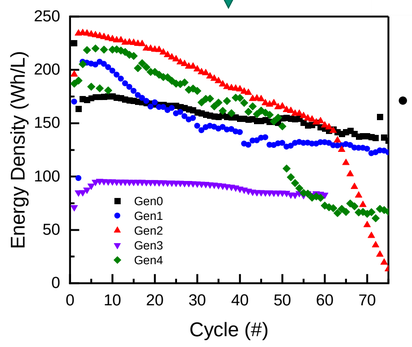
- In addition to changes to the quantity of the Bi_2O_3 additive, there are several other ways to further affect Zn-CuO battery performance and lifetime. These include alternative **additives**, novel **coatings**, and modifications to the **electrolyte**.

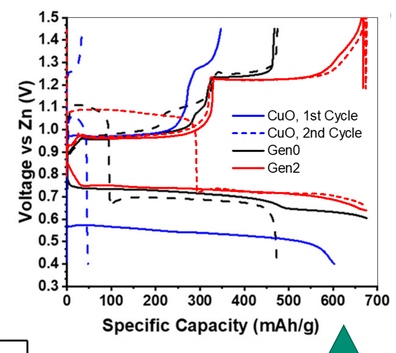
Additives



- Various types/quantities of chemical additives can have a significant impact on battery cycling

- Comparable capacity can disguise significant differences in energy density, however





- More work needed to understand how additives influence the (electro)chemical states within the cathode

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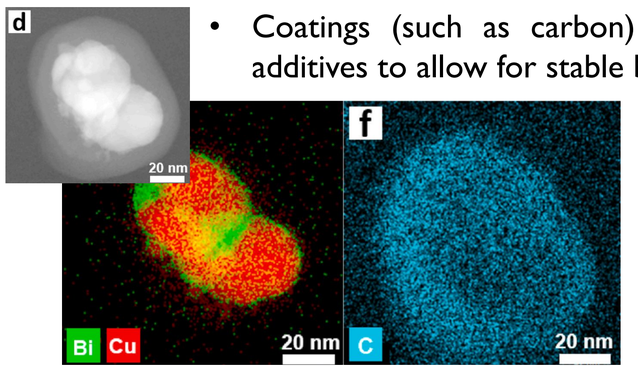
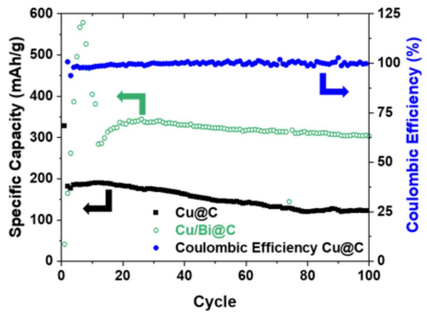
Coatings

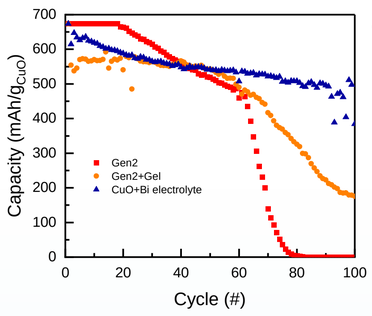


- Coatings (such as carbon) can be used together with Bi additives to allow for stable battery cycling

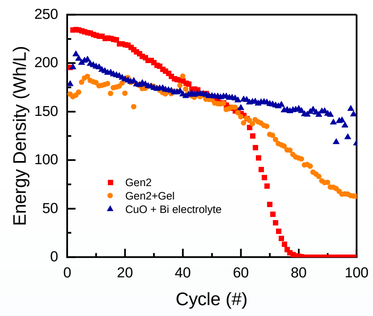


Arnot *et al., J. Power Sources*, **2022**, *529*, 231168

Electrolyte



- Use of gelling agents in the electrolyte and chemical additives like Bi can also influence the capacity/energy density and cycling performance of Zn-CuO batteries



Conclusions

1. Reducing Bi quantity improves energy density while retaining capacity benefits
2. Both soluble and solid Bi play a role in mediating Zn-CuO battery cycling
3. Other additives, the use of coatings, and electrolyte modifications can also impact/improve battery performance
4. Understanding capacity decay and improving battery lifetimes are important next steps

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525. This work was supported by the U.S. Department of Energy Office of Electricity. Dr. Imre Gyuk, Director of Energy Storage Research at the U.S. Department of Energy Office of Electricity, is thanked for his financial support of this project. This work was performed, in part, at the Center for Integrated Nanotechnologies, an Office of Science User Facility operated for the U.S. Department of Energy (DOE) Office of Science.

SAND2023-10686C