SAND2022-13147C

Sandia National Laboratories

Rechargeable Alkaline Zn–Cu Batteries Enabled by Carbon Coated Cu/Bi Particles

Noah B. Schorr, David J. Arnot ,Igor V. Kolesnichenko, Timothy N. Lambert*
Sandia National Laboratories, Albuqeurque, New Mexico, 87185

Background

Current MnO_2 cathodes for alkaline cells suffer from reversibility issues, especially at high utilization.[1]

- Irreversibility of cathode
- Susceptibility to zinc poisoning
- Phase changes

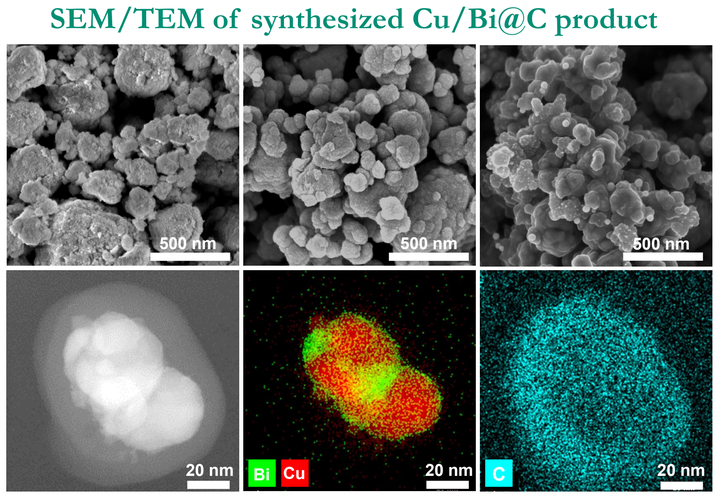
Developments in our group have shown Cu and CuO represents a new class of material for reversible cathodes in alkaline Zn batteries.[2-3]

- Tolerant to $Zn(OH)_4^{2-}$
- Bi enables over 100+ cycles
- High capacity (674 mAh/g)

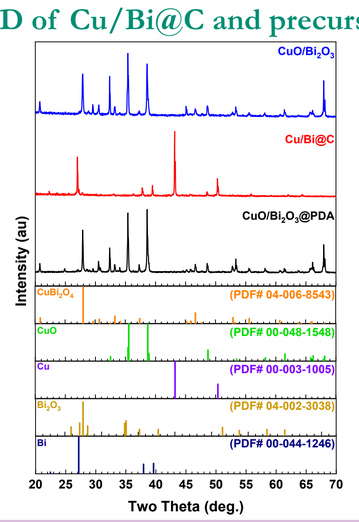
Synthesizing Cu/Bi Nanoparticles

Carbon coated Cu/Bi particles (Cu/Bi@C) were synthesized though annealing of polydopamine coated CuO/Bi_2O_3 powder in order to understand role of carbon in cycling.[3]

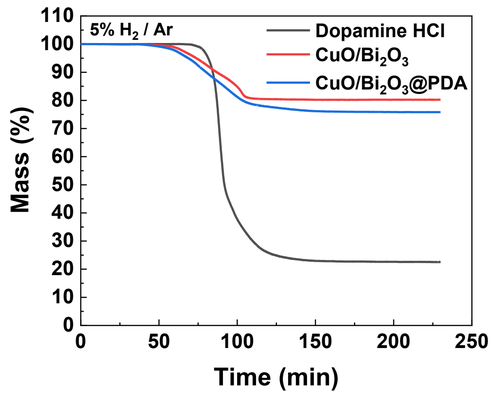
SEM/TEM of synthesized Cu/Bi@C product



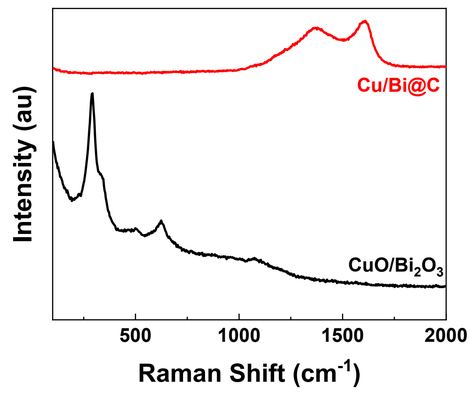
XRD of Cu/Bi@C and precursors



TGA of Cu/Bi@C and precursors



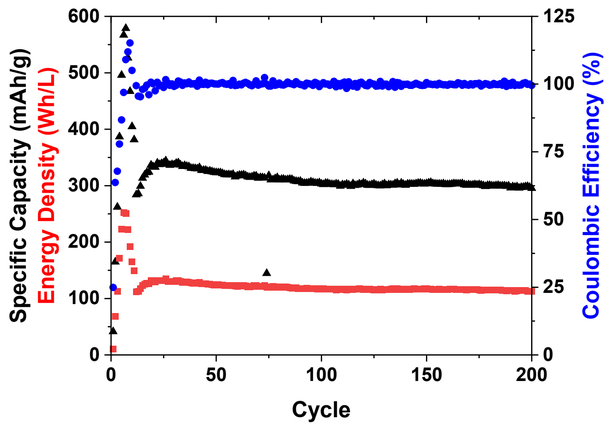
Raman spectroscopy of Cu/Bi@C and precursor



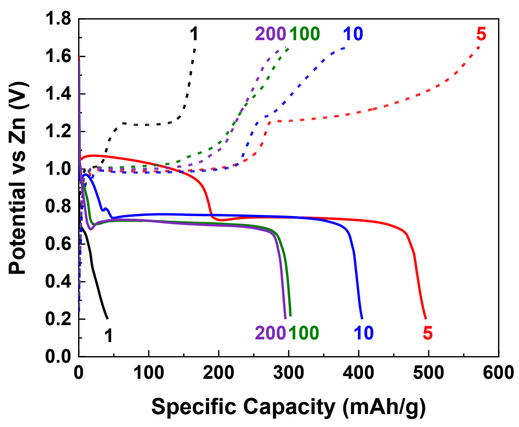
Cu/Bi Electrochemical Properties

Cu/Bi@C display stable cycling for hundreds of cycles when paired with a Zn anode. The C coating proved essential for high capacity utilization, although Cu/Bi still cycled.

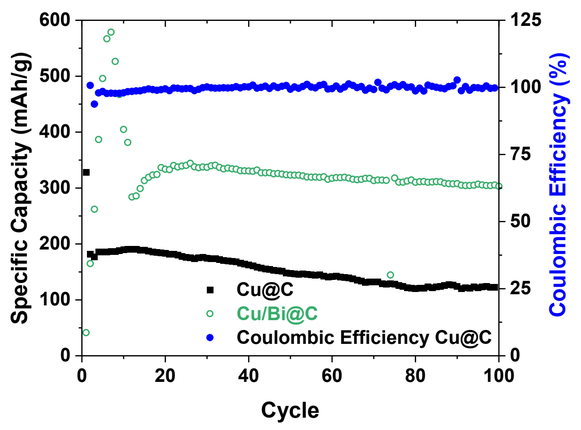
Cycling metrics of Cu/Bi@C vs Zn



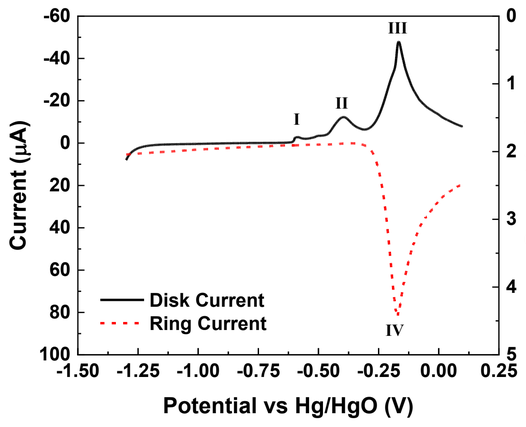
Voltage profile of Cu/Bi@C vs Zn



Comparison of Cu/Bi@C and Cu@C vs Zn



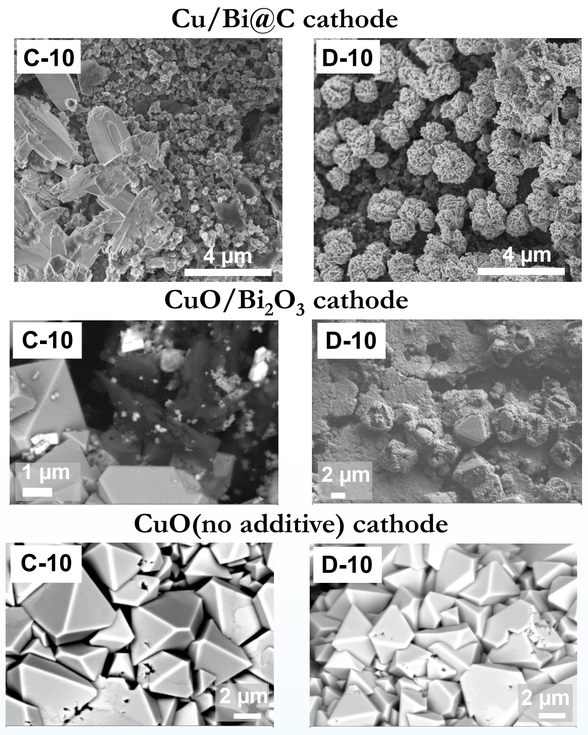
RRDE of Cu/Bi@C



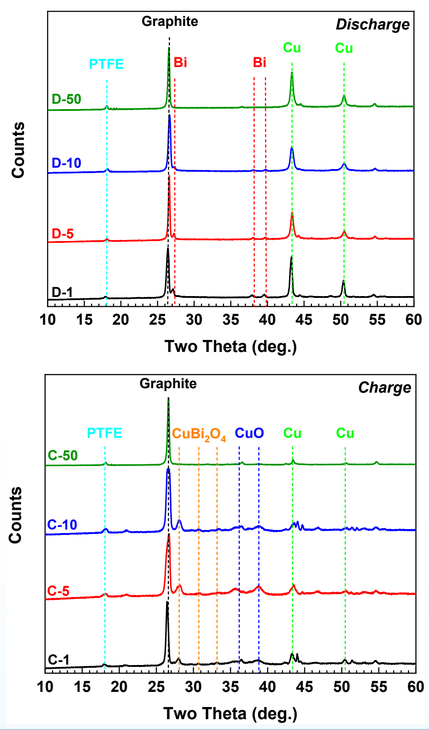
Visualizing Cu/Bi Benefits

When discharged or charged the Cu/Bi@C does not show signs of Cu_2O the species that proved detrimentally passivating to previous Cu cells.

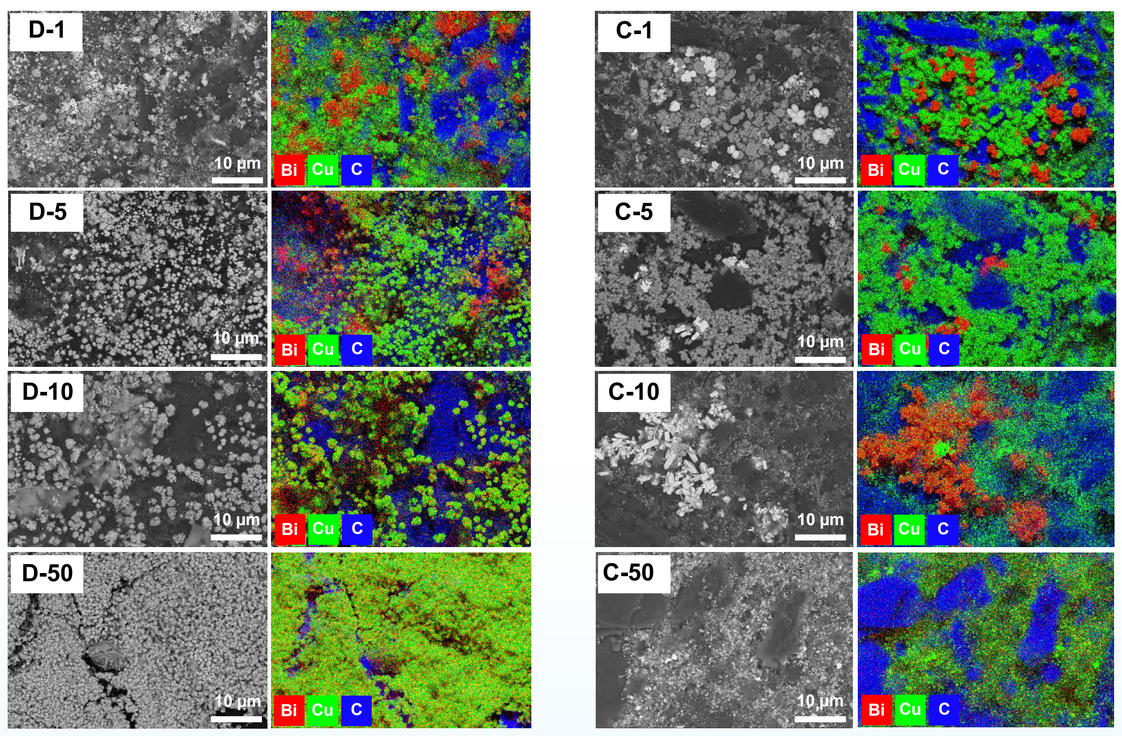
SEM of three types of Cu cells



XRD Cu/Bi@C cathode



SEM and EDS of Cu/Bi@C cathode



Conclusions

Carbon coating enables excellent cycling performance preventing detrimental Cu_2O structures found in passivated Zn/CuO batteries. This work exemplifies the benefits of nanoscale carbon coatings for Cu particles providing further insight into methods for realizing a Cu based cathode for rechargeable alkaline Zn batteries.

Acknowledgements

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.
SAND No. _____

References

1. M. B. Lim; et al. Mater. Sci. Eng. R Rep. 2021, 143, 100593.
2. Schorr, N.B.; et al. ACS Appl. Energy Mater. 2021, 4, 7, 7073–7082.
3. Arnot, J.A; et al. J Power Sources 2022. 529, 231168.

Sandia National Laboratories