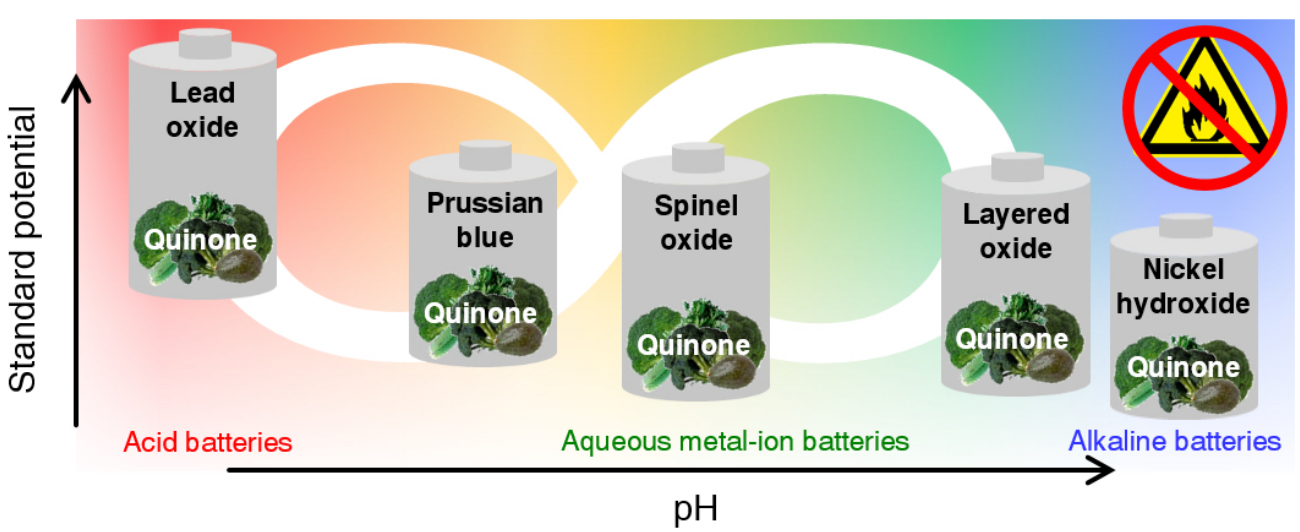
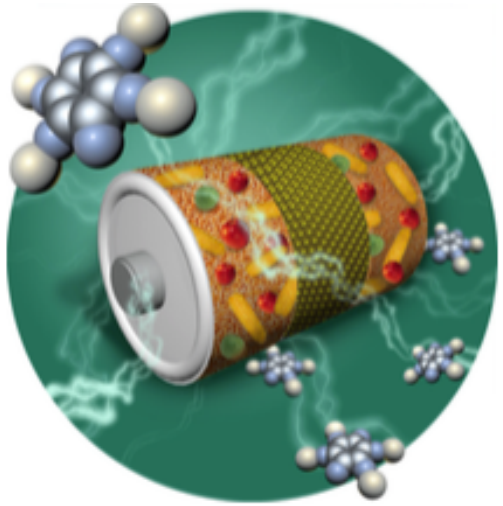
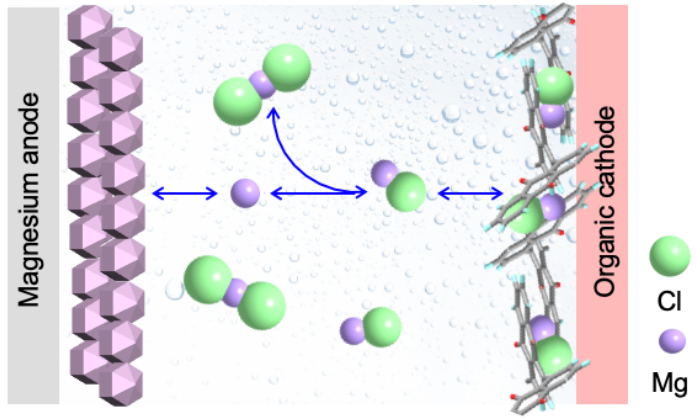
Low Cost Na-ion Based Solid Electrolytes and Organic Electrodes for Grid Storage







Yan Yao

Associate Professor of Electrical Engineering and

Texas Center for Superconductivity

University of Houston

UNIVERSITY of HOUSTON

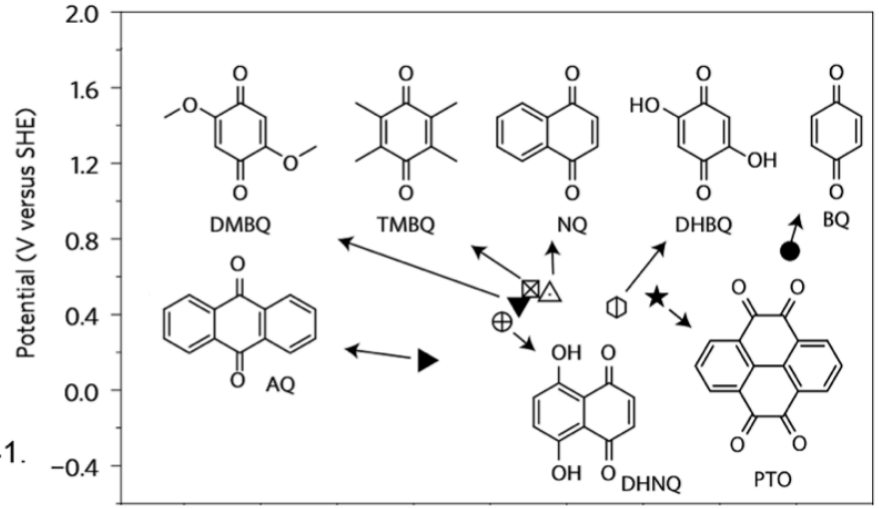
Workshop on Non-aqueous Flow Batteries
Santa Fe, NM. Jan. 29, 2019

YAO Lab

Electrolyte dictated materials design for organic electrode materials

a

Nat. Mater. **2017**, *16*, 841.



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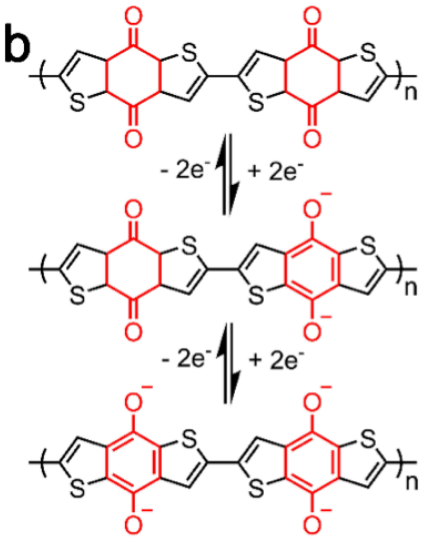
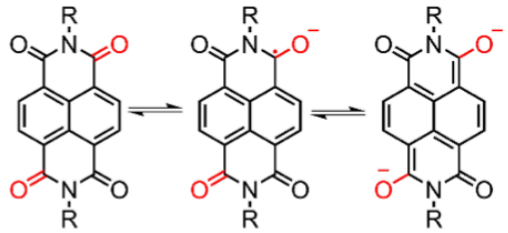


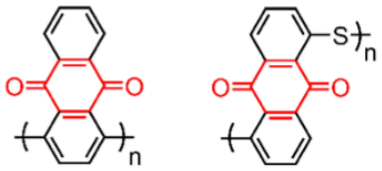
Nano Energy **2017**, *37*, 46.

c



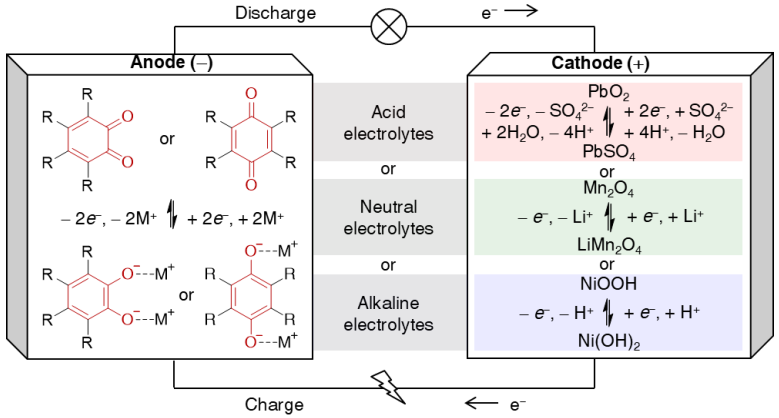
J. Am. Chem. Soc. **2015**, *137*, 4956.

d

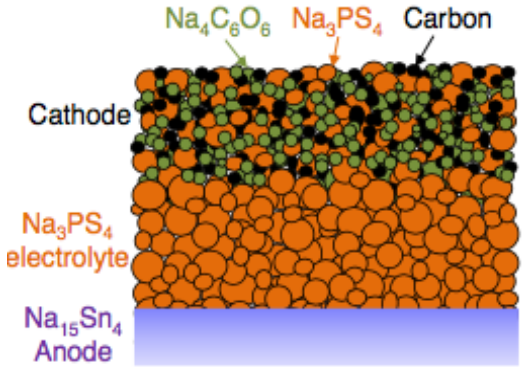


Joule **2019**, *3*, 1.

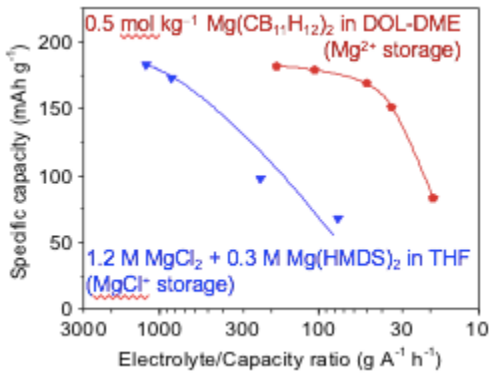
Aqueous electrolyte



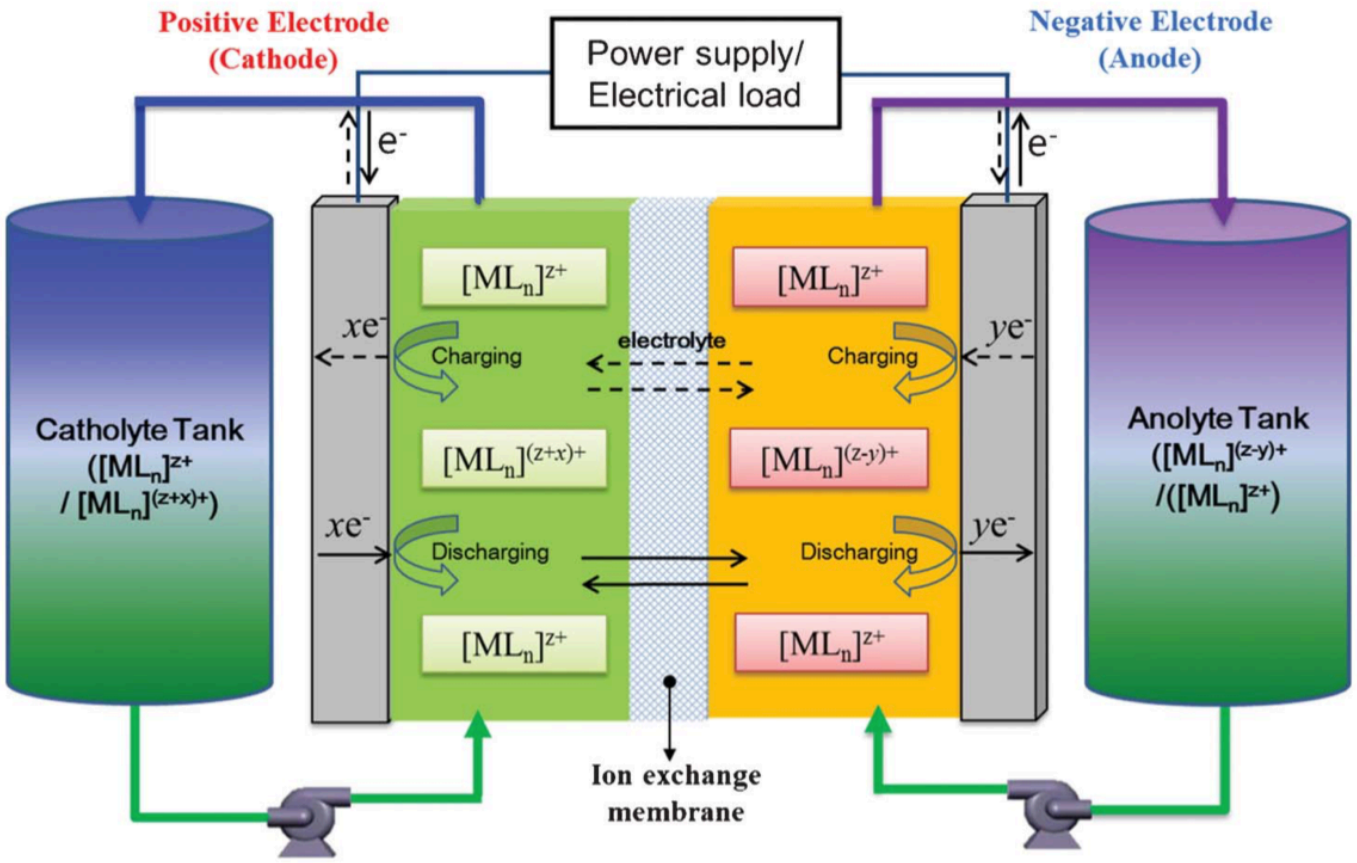
Solid Na electrolyte



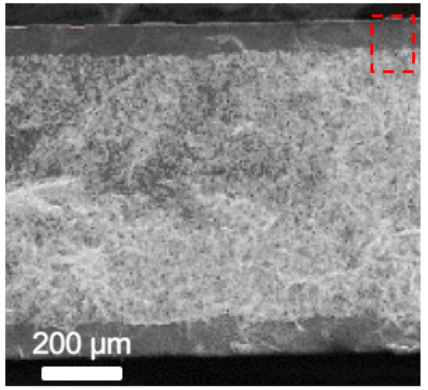
Non-aqueous Mg electrolyte



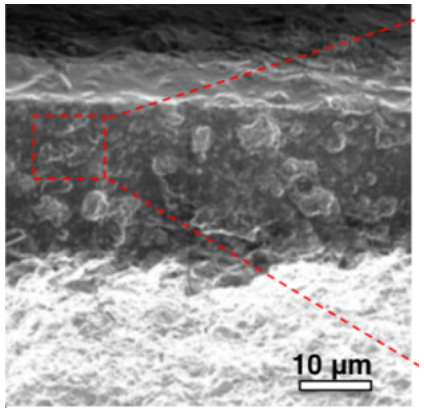
Na solid electrolytes as potential membranes for NRFBs



S.H. Moon et al. RSC Adv., 2013, 3, 9095–9116



Glassy sulfide electrolyte



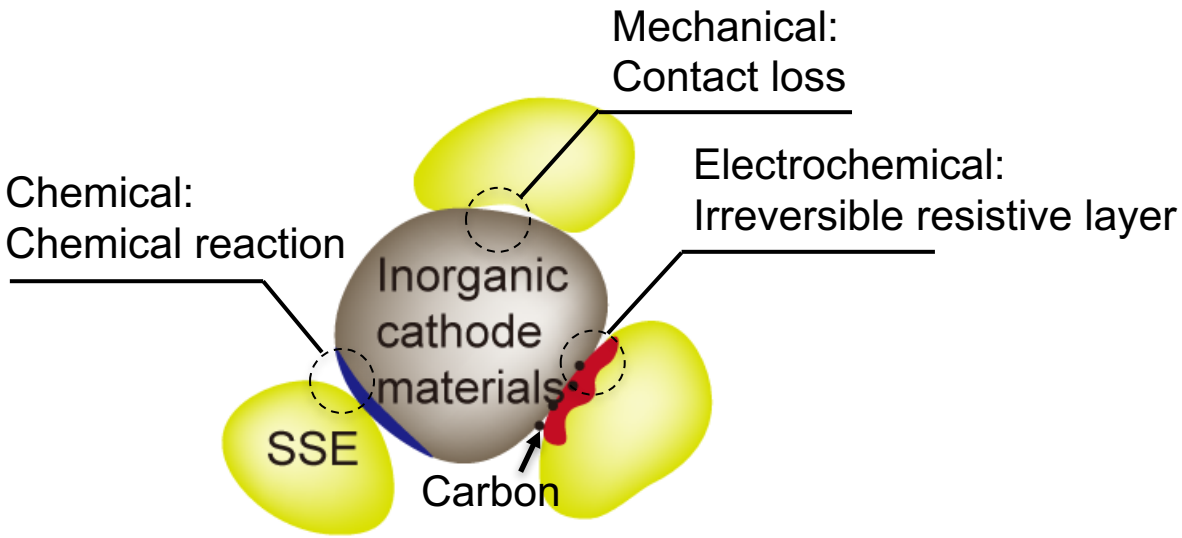
β''-Al2O3 electrolyte

Dense solid electrolytes may function as membranes for NRFBs

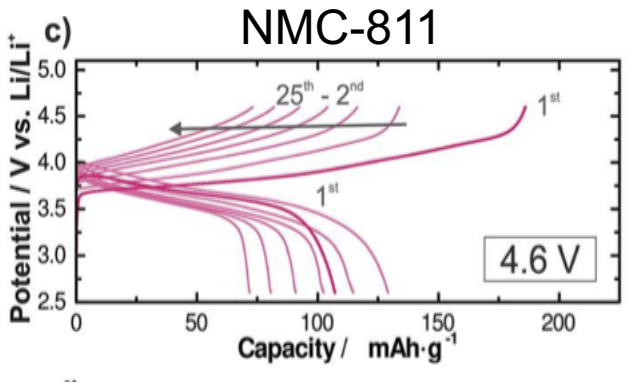
- single ion conductors
- no cross-cover issues
- Chemically stable

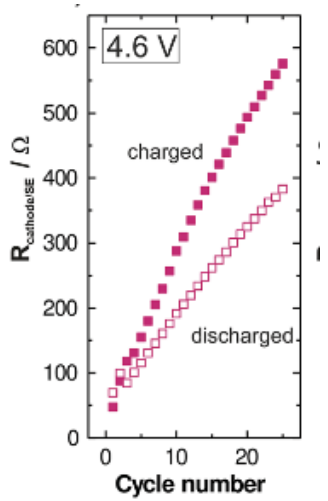
Challenges in cathode-solid sulfide electrolyte interface

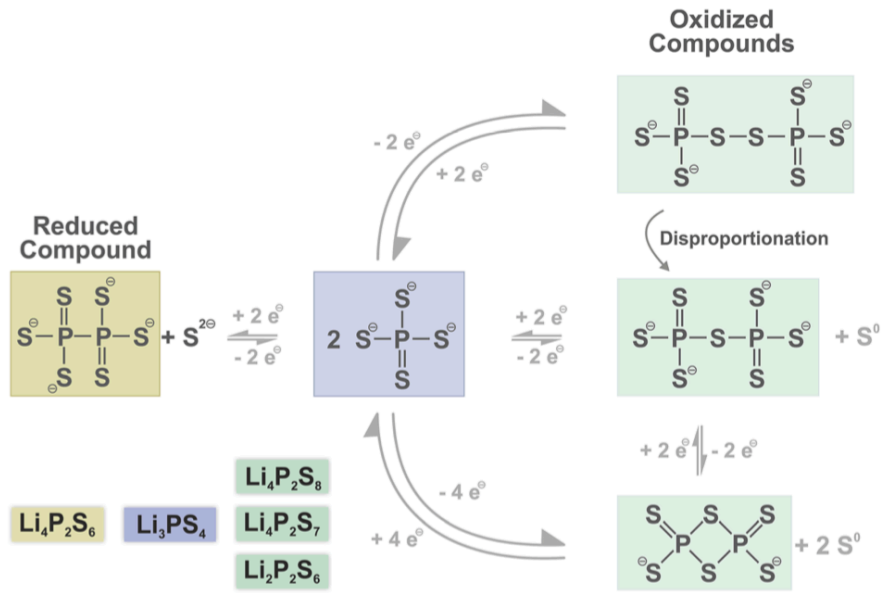
Unfavorable electrode-electrolyte interface



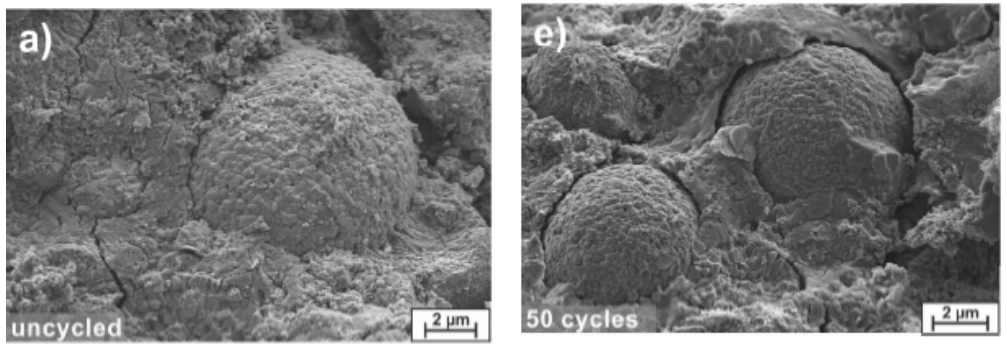
I. Irreversible resistive layer







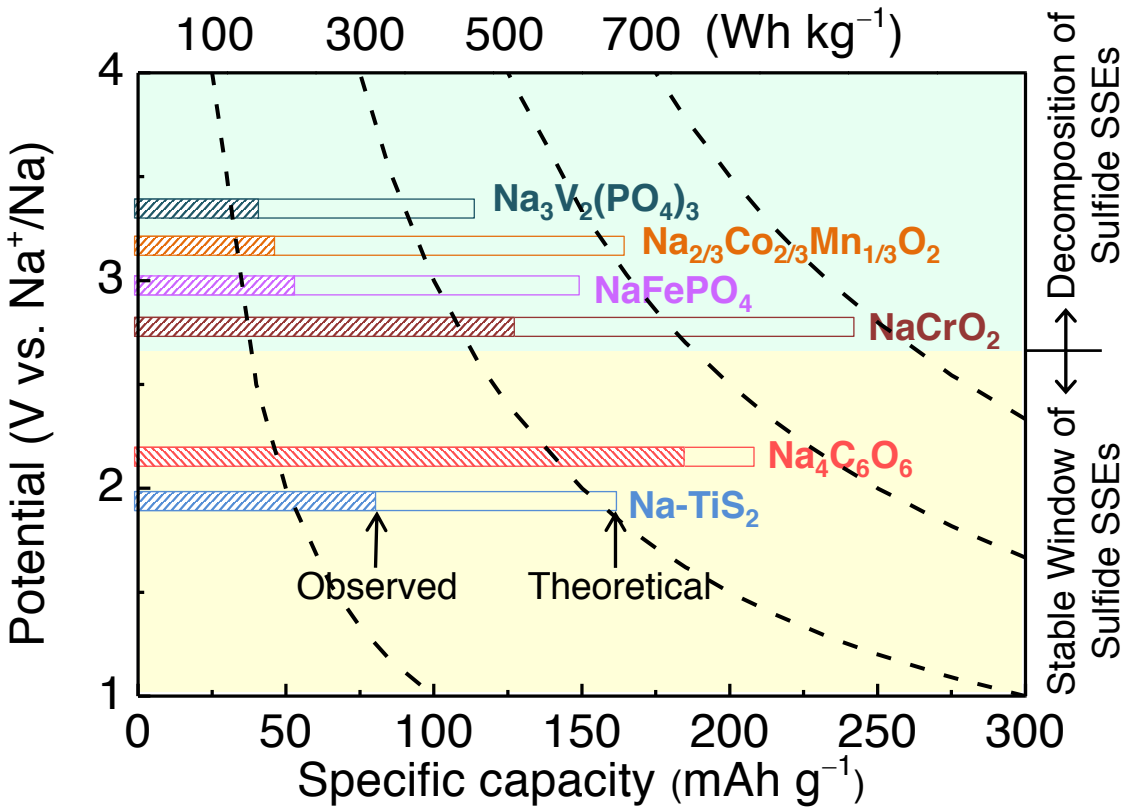
II. Mechanical contact loss

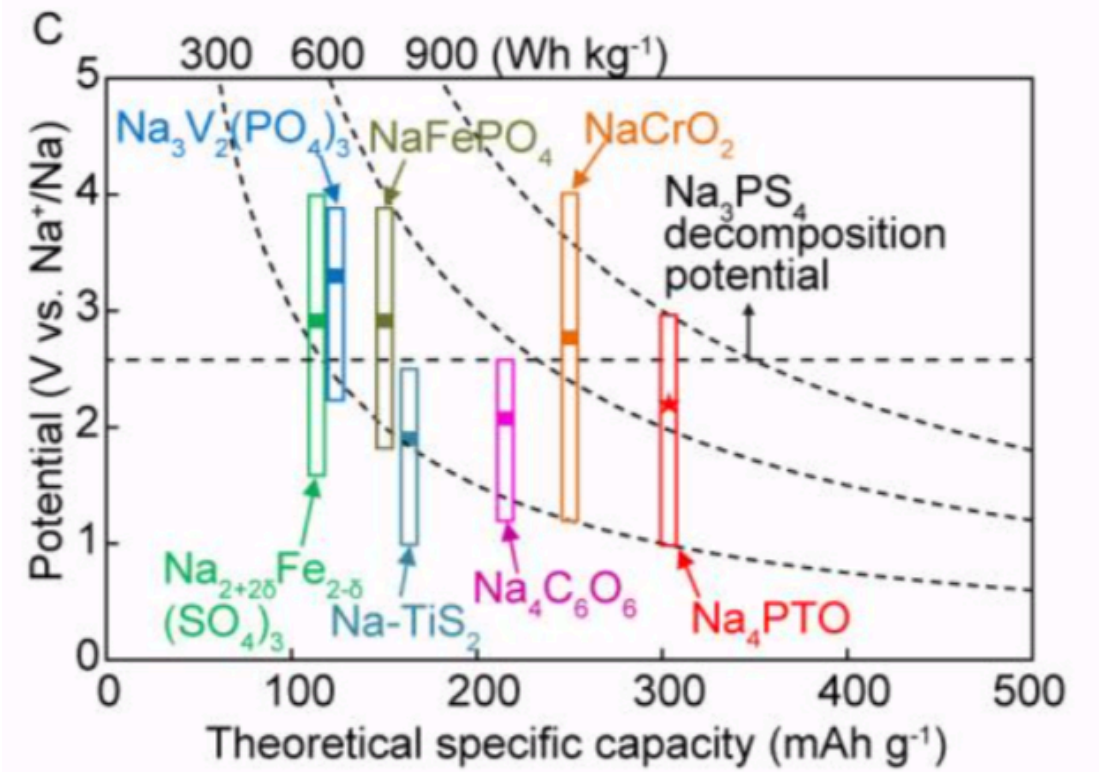


J. Janek et al. *Chem. Mater.*, 2017, 29, 5574

J. Janek et al. *J. Mater. Chem. A.*, 2017, 5, 22750

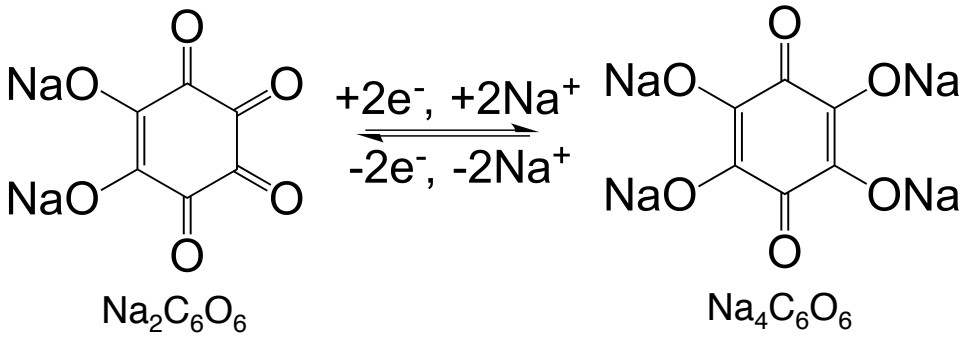
Cathode materials in all-solid-state sulfide electrolyte batteries

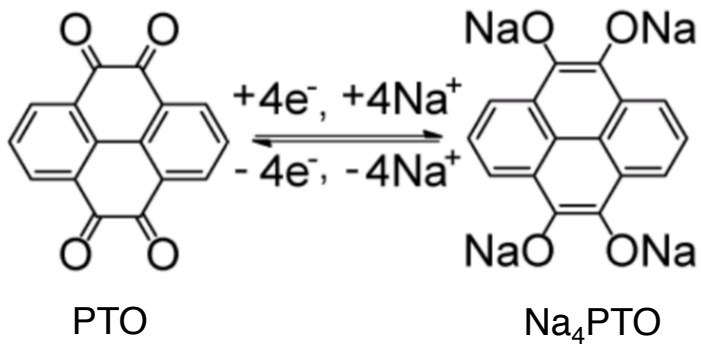


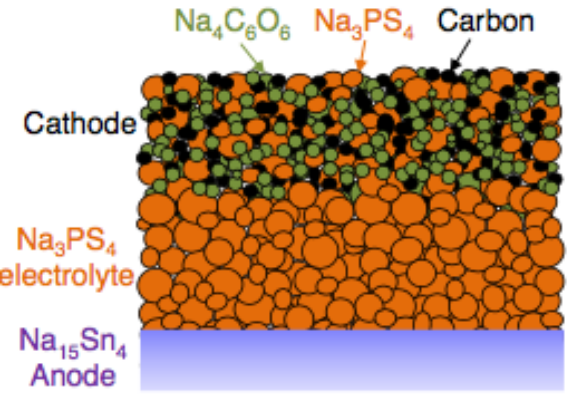


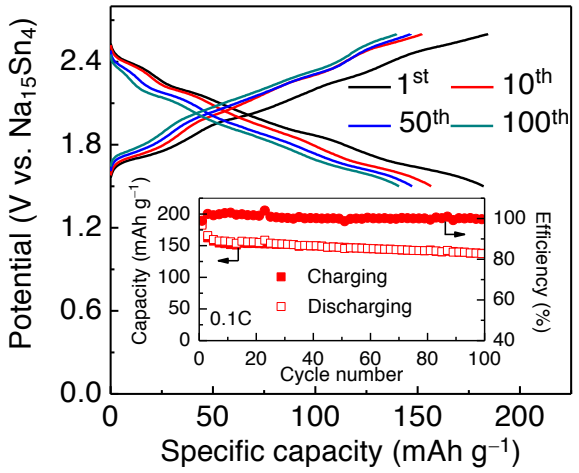
- Most intercalation cathodes operate at potentials above the anodic decomposition potential of SSEs (low capacity and 10-50 cycles)
- Solution: High-capacity organic cathodes with moderate redox potential
  - Na_4PTO 90% capacity retention after 500 cycles at a capacity of 300 mAh/g

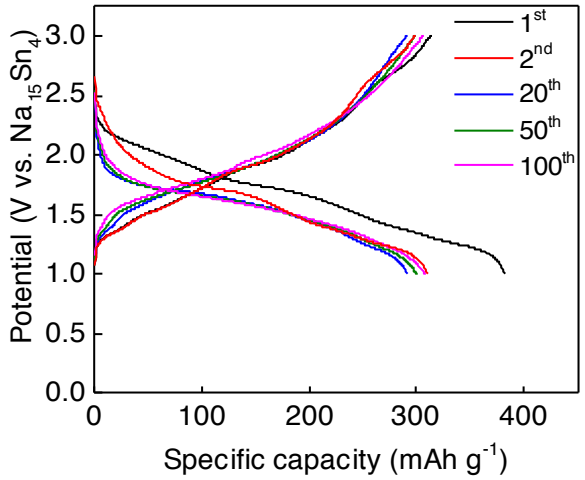
Organic cathodes with unprecendented cycle life

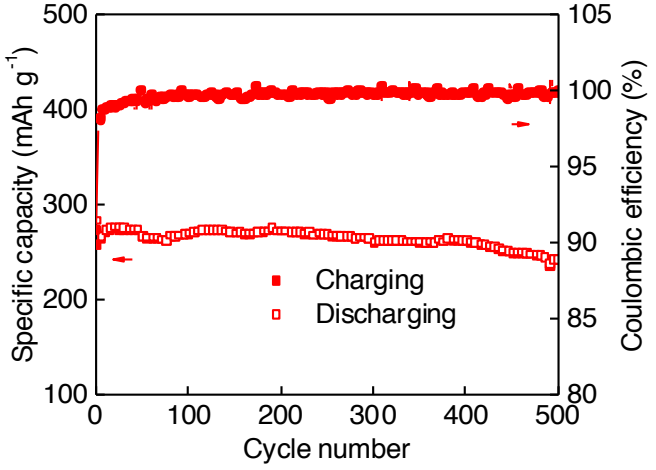






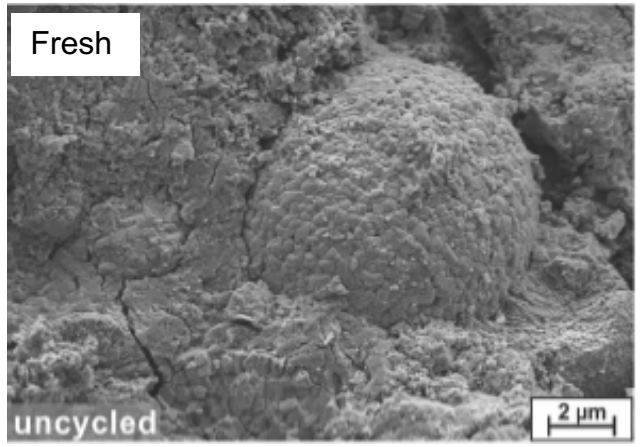


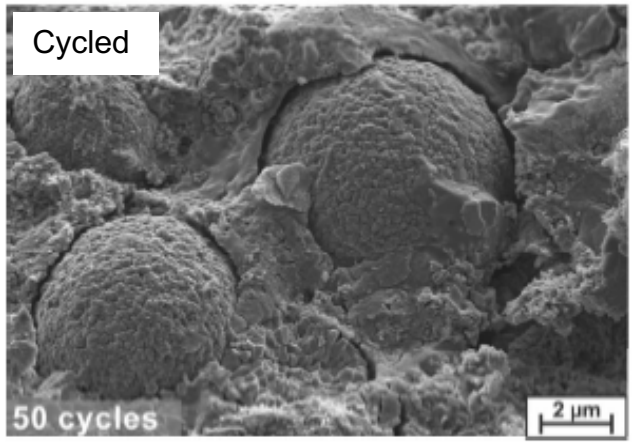


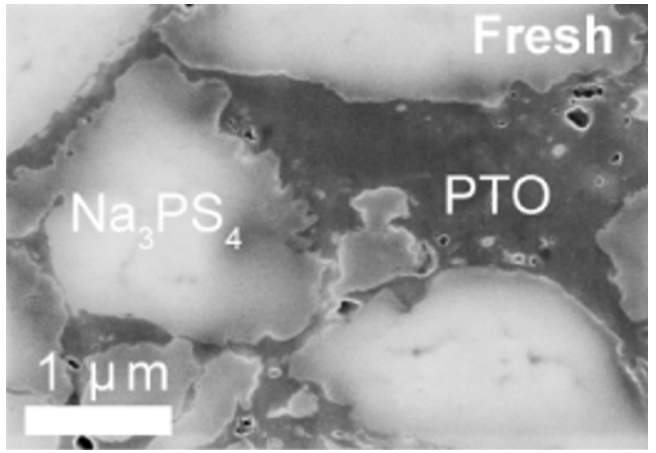


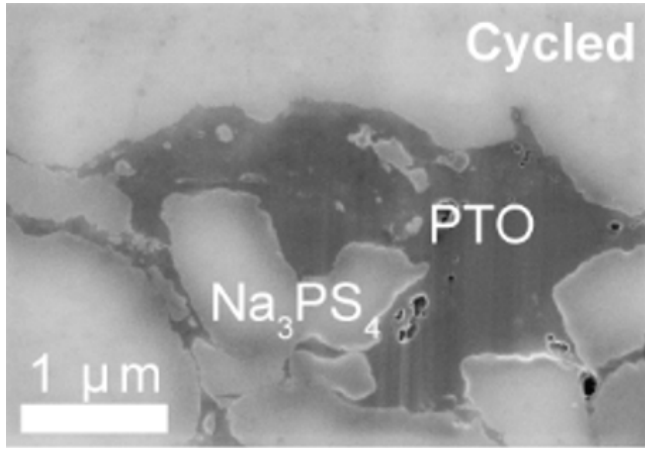
Chi *et al.*, *Angew. Chem. Int. Ed.*, **2018**, *57*, 2630;
Fang, Yao, *under review*

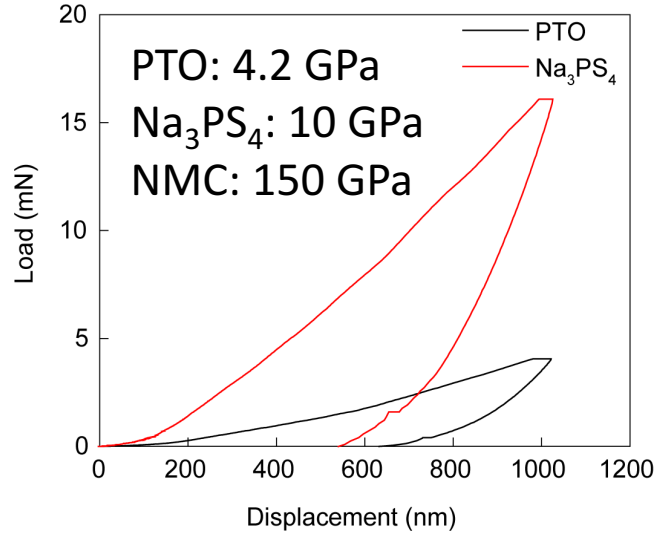
Intimate contact between organic cathodes and electrolytes

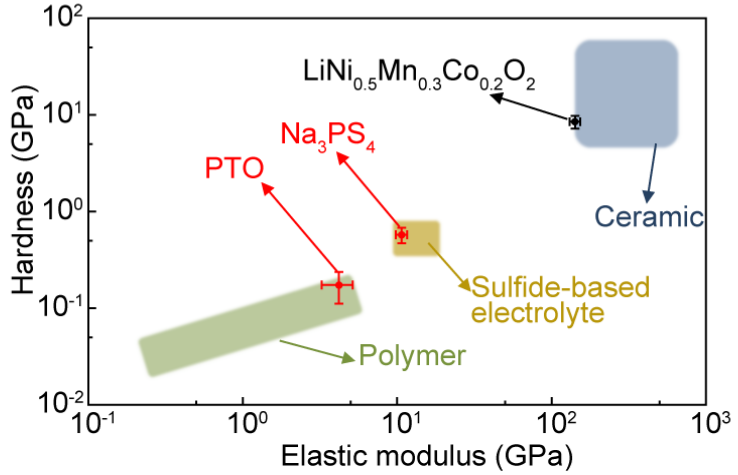








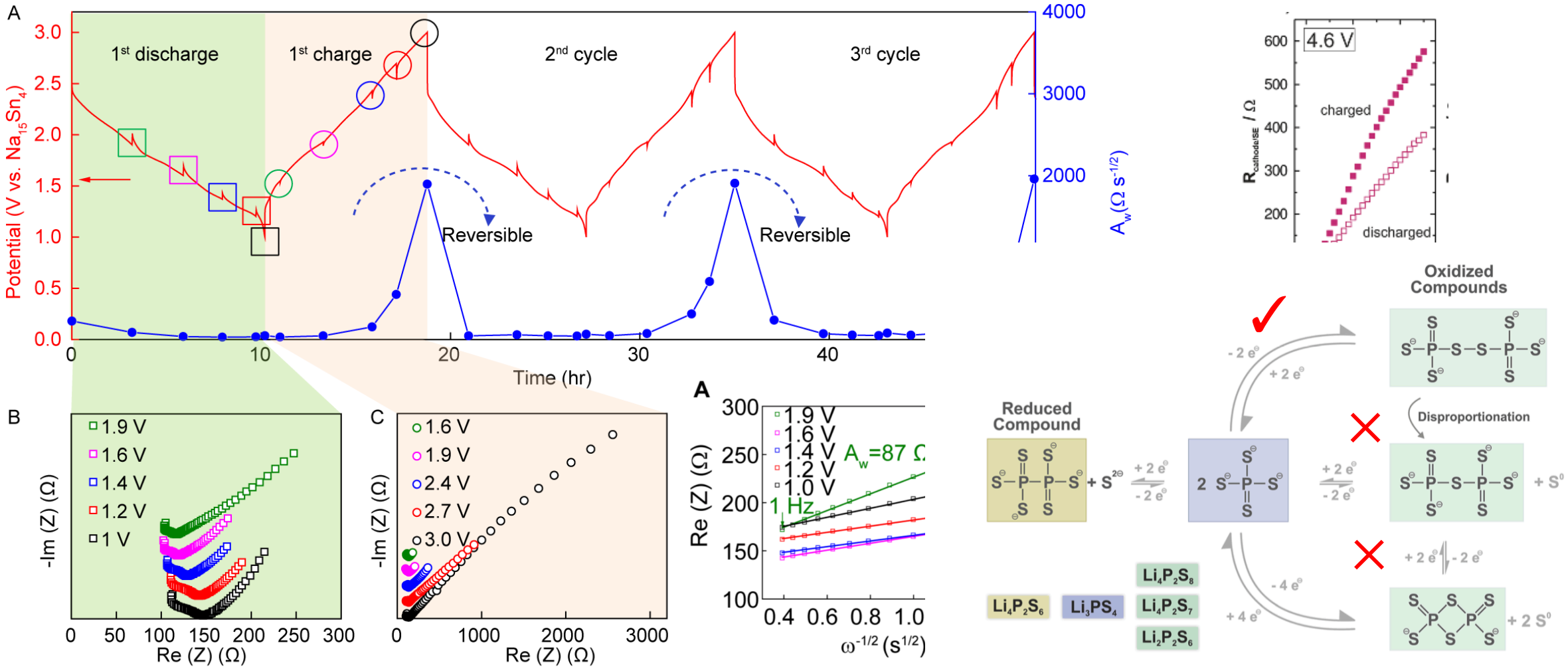




J. Janek et al. *Chem. Mater.*, 2017, 29, 5574

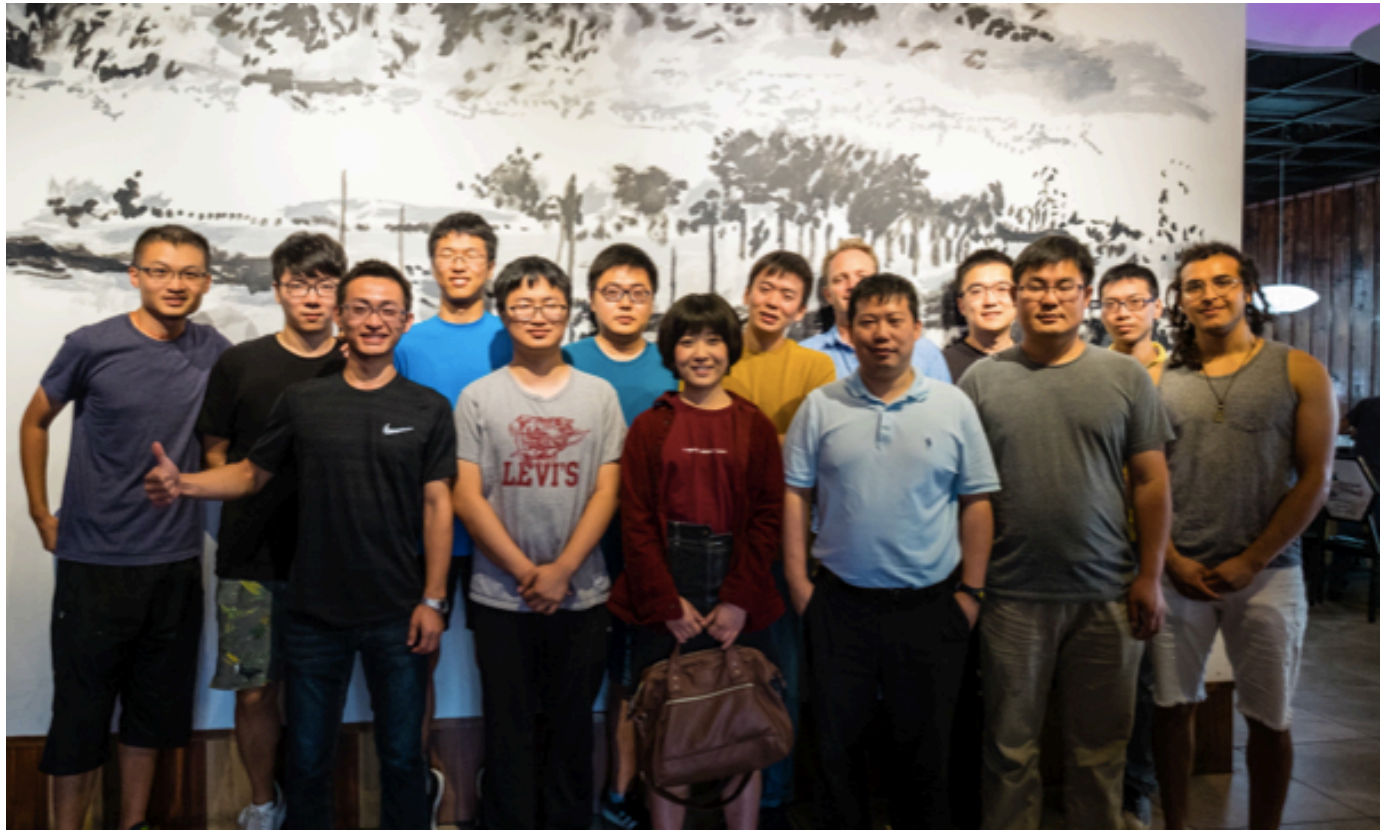
Fang, Yao, *submitted*

Formation of reversible resistive layer at cathode-solid interface



Moderate redox potential of organic cathodes that aligns with stable window of sulfide electrolytes.

Acknowledgements



Funding Support

Aqueous battery

✓ DOE/ARPA-E

✓ Research Corp.

Solid battery

✓ **DOE/ARPA-E**

✓ DOE/EERE (Battery500)

✓ NASA

Mg battery

✓ ONR YIP

✓ NSF

Thanks to the organizers, the funding agency, and the audience for your attention.