Epoxy Resin Enabled Robust and Multifunctional Binders for High Energy Lithium-Sulfur Batteries

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May 9, 2018

2018 IPR Symposium, University of Waterloo, Waterloo, Ontario
Demand for Rechargeable Batteries

Intermittent Energy Sources

- Solar
- Wind
- Tidal/Wave
- Aerospace

Batteries

- Energy Density
- Safety
- Life
- Cost

Electronics

Electric Vehicles (EVs) & Hybrid EVs
Current Status of Batteries

Advantages of Li-S batteries

- High theoretical specific energy
  
  (2567 Wh kg\(^{-1}\) vs 387 Wh kg\(^{-1}\) for Li-ion batteries)

- Environmental friendliness

- Low cost

Challenges Facing Li-S Batteries

- The insulating nature of sulfur and Li$_2$S ($5 \times 10^{-30}$ S cm$^{-1}$ at 25 °C for sulfur, incorporation of sulfur in conductive carbon matrix lowers specific energy)
- Dissolution of lithium polysulfides in the electrolyte (irreversible loss of active material; shuttle problem lowers charging efficiency; impedance increase and cathode passivation due to sulfur redistribution)
- Volume change from sulfur to Li$_2$S (density 2.07 g cm$^{-3}$ for octasulfur vs 1.66 g cm$^{-3}$ for Li$_2$S, resulting in 80 % volume expansion)
- The use of metallic lithium anode (lithium dendrites formation, inactive dead Li formation, etc.)

Acc. Chem. Res. 2013, 46, 1125-1134
PEI-ER Binder vs Conventional PVDF Binder

**Conclusions**

- Both PEI and ER have stronger binding effect toward Li$_2$S$_6$ than PVDF
- Crosslinked PEI-ER polymer inherited the Li$_2$S$_6$ adsorption ability from its parent components
- The newly-developed PEI-ER binder has the potential to mitigate the deleterious lithium polysulfides shuttle problem
Acknowledgement

Group members:

Jenner Ngai, Arthur Hendsbee, Xiaocheng Zhou, Han Meng,
Jiaxin Zhu

Funding source:

NSERC