UNIVERSITY OF WATERLOO
FACULTY OF ENGINEERING
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WATERLOO INSTITUTE FOR nanotechnology

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

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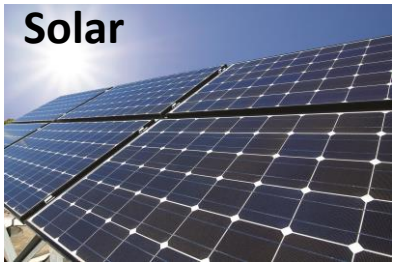
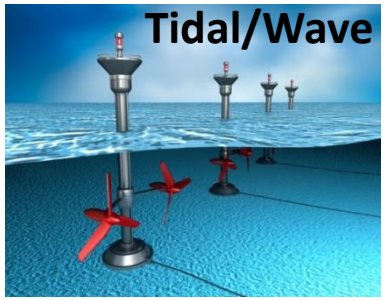
Demand for Rechargeable Batteries



Electronics

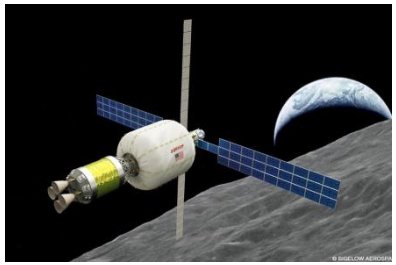
Intermittent Energy Sources



Batteries

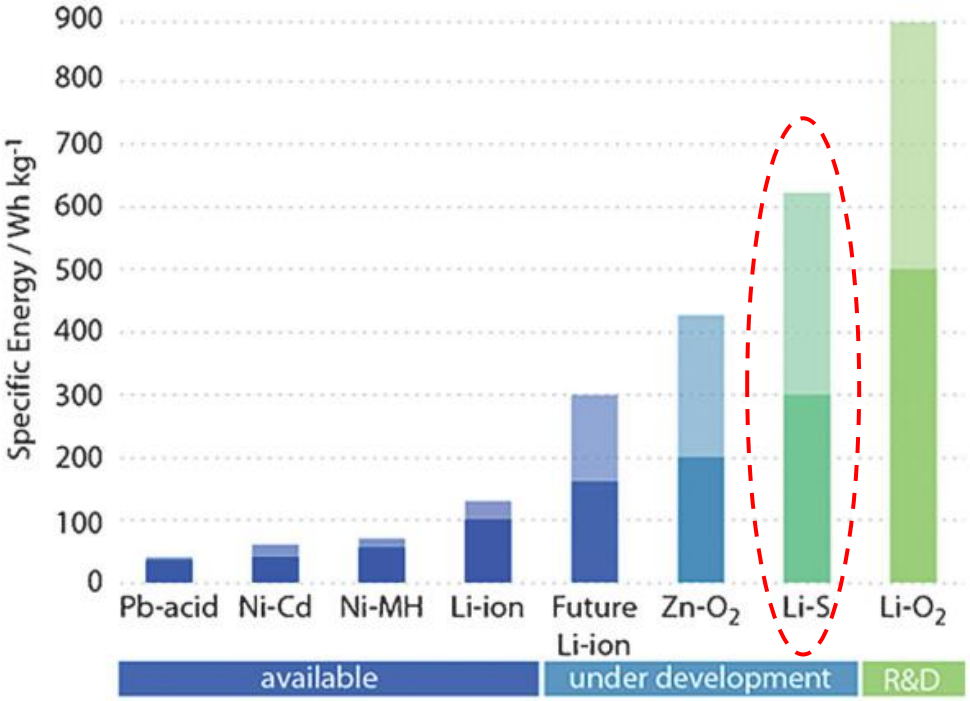
- Energy Density
- Safety
- Life
- Cost

Aerospace



Electric Vehicles (EVs) & Hybrid EVs

Current Status of Batteries

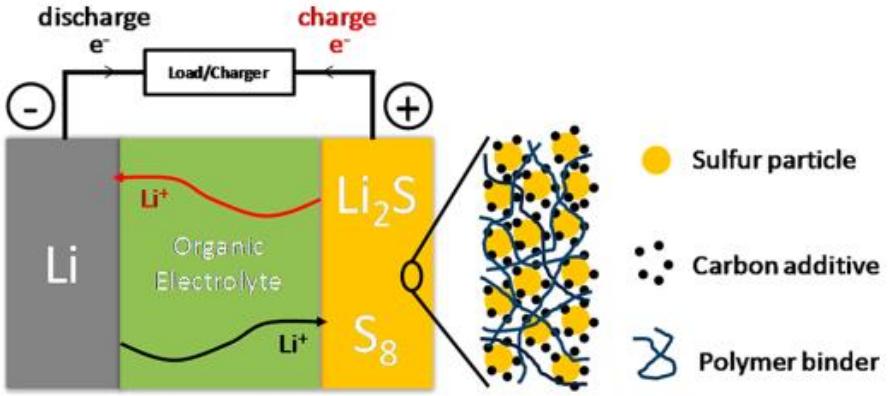


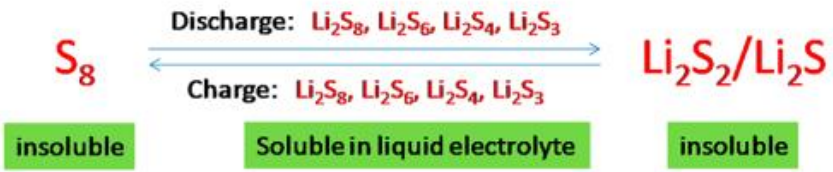
Advantages of Li-S batteries

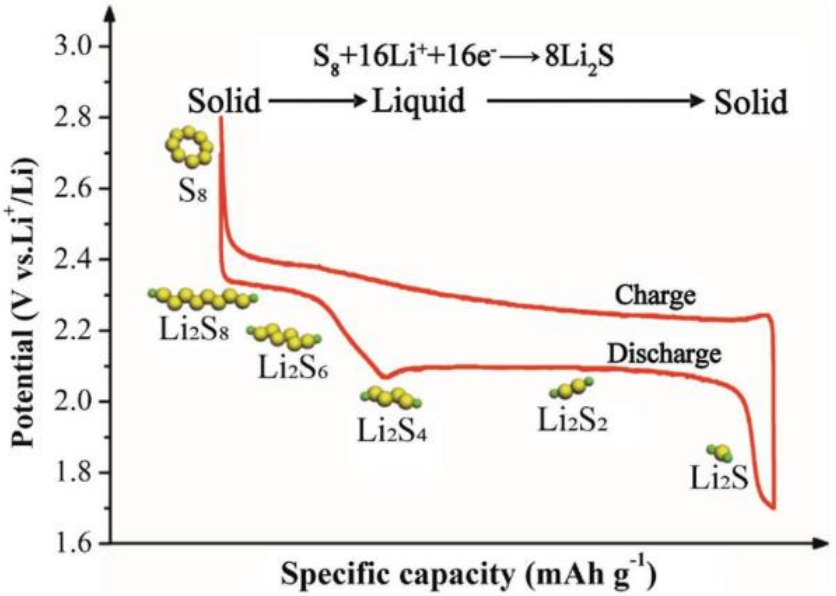
- High theoretical specific energy (2567 Wh kg^{-1} vs 387 Wh kg^{-1} for Li-ion batteries)
- Environmental friendliness
- Low cost

Angew. Chem. Int. Ed. 2012, 51, 9994–10024

Challenges Facing Li-S Batteries







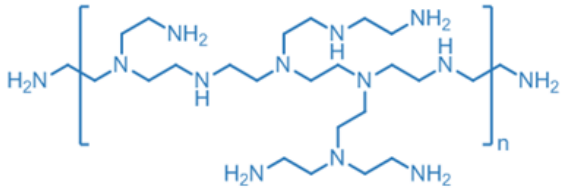
- The insulating nature of sulfur and Li_2S (5×10^{-30} S cm^{-1} at 25 ℃ for sulfur, incorporation of sulfur in conductive carbon matrix lowers specific energy)
- Dissolution of lithium polysulfides in the electrolyte (irreversible loss of active material; shuttle problem lowers charging efficiency; impedance increase and cathode passivation due to sulfur redistribution)
- Volume change from sulfur to Li_2S (density 2.07 g cm^{-3} for octasulfur vs 1.66 g cm^{-3} for Li_2S, 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

Adv. Mater. 2017, 1606823

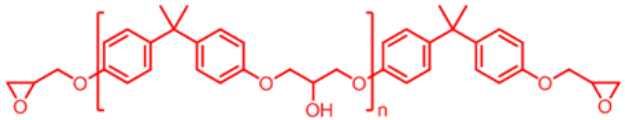
PEI-ER Binder vs Conventional PVDF Binder

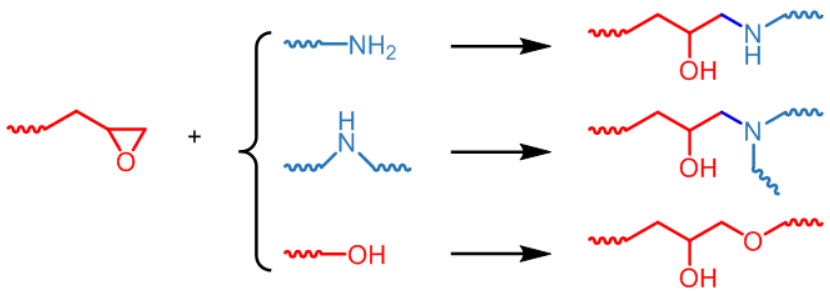
PEI



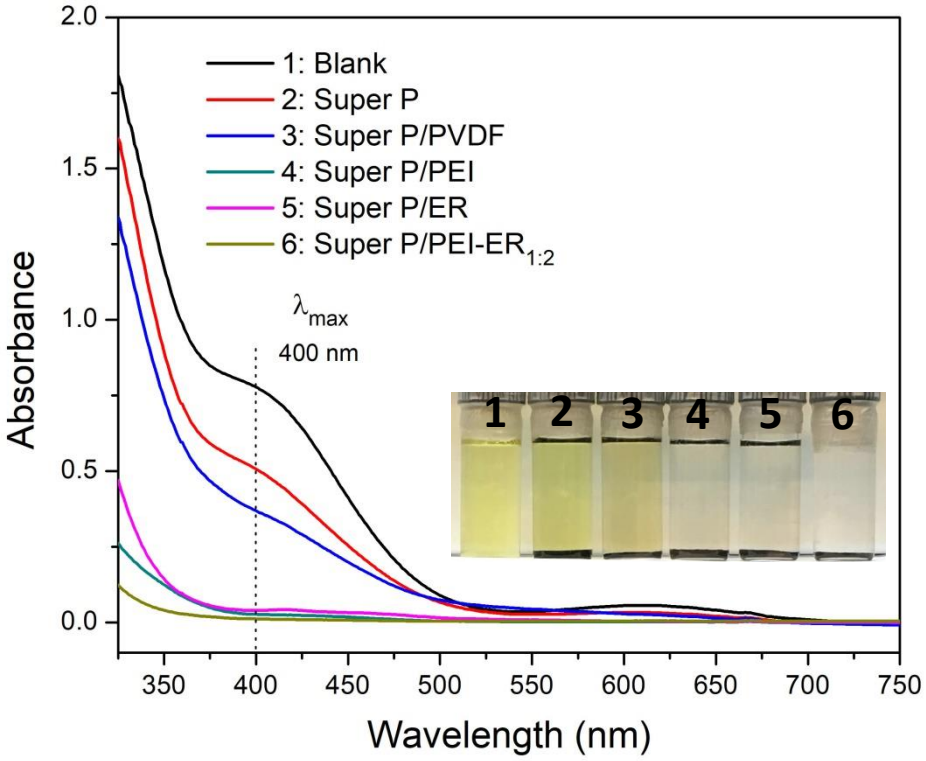
ACS Nano 2016, 10, 1050−1059

ER





Li_2S_6 adsorption experiment



Conclusions

- Both PEI and ER have stronger binding effect toward Li_2S_6 than PVDF
- Crosslinked PEI-ER polymer inherited the Li_2S_6 adsorption ability from its parent components
- The newly-developed PEI-ER binder has the potential to mitigate the deleterious lithium polysulfides shuttle problem

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