

Enabling High Energy Lithium Metal Rechargeable Batteries for Diverse Applications

A New Era of Electrified Mobility



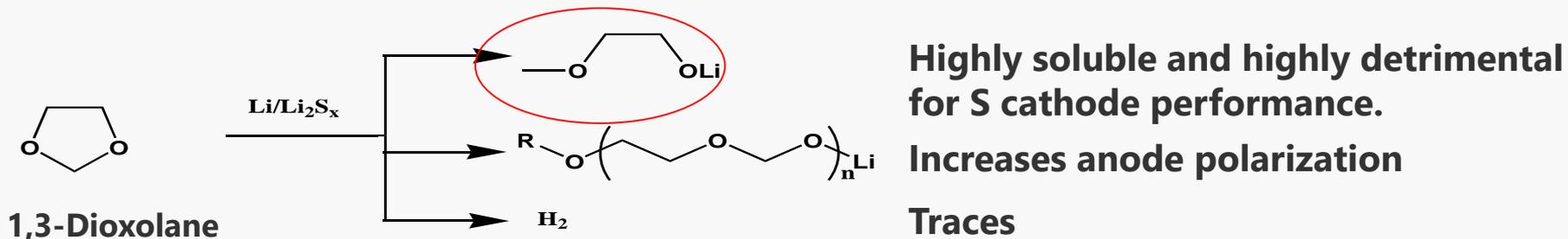
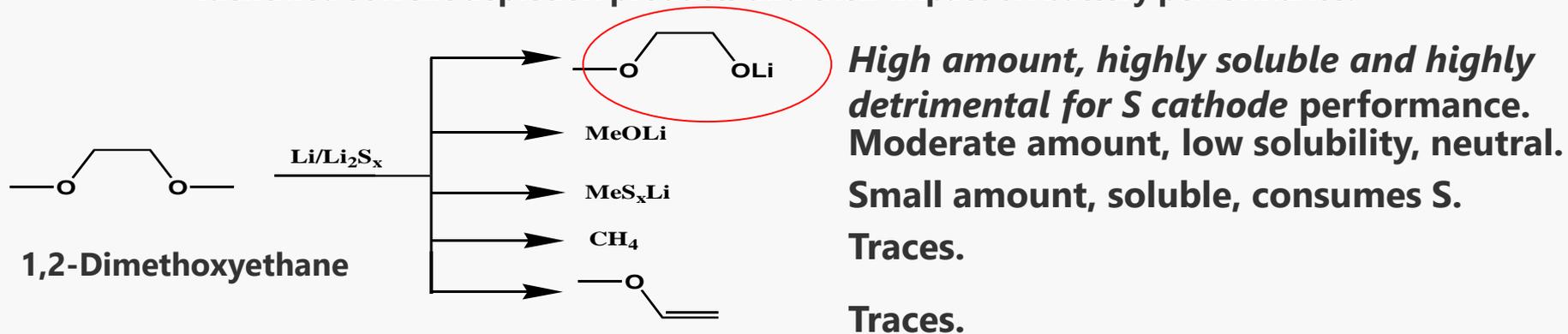
- Sion Power's new *Licerion*[®] technology as a solution beyond Li-Ion and beyond Li-S.
 - Failure mechanisms of rechargeable batteries with metallic lithium anode.
 - Failure mechanisms addressed with *Licerion*[®] technology.
- Sion Power development of *Licerion*[®]-S and *Licerion*[®]-Ion batteries.
 - Li-S and *Licerion*[®]-S for Unmanned Aerial Vehicles (UAV).
 - *Licerion*[®]-Ion for diverse applications.

Failure Mechanisms of Rechargeable Batteries with Metallic Lithium Anode

- Development of rough lithium morphology affecting cycle life and safety.
- Lithium/Electrolyte depletion affecting cycle life and capacity.
- Cross-contamination (poisoning) of cathode and anode with depletion compounds and their transformation products leading to high electrical polarization.
- Shuttle phenomena due to high solubility of depletion products or intermediate discharge compounds resulting in low charge efficiency and capacity (typical for Li-S).

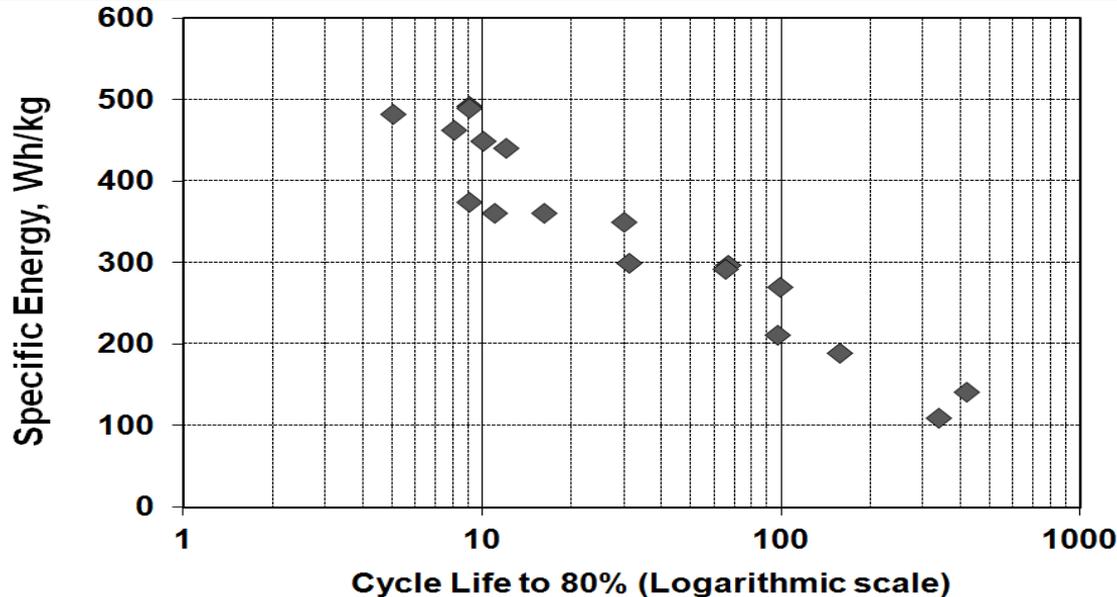
The Chemistry of Electrolyte Solvent Depletion in the Li-S System

Identified solvent depletion products and their impact on battery performance.



Lithium/Electrolyte Depletion Limits Cycle Life

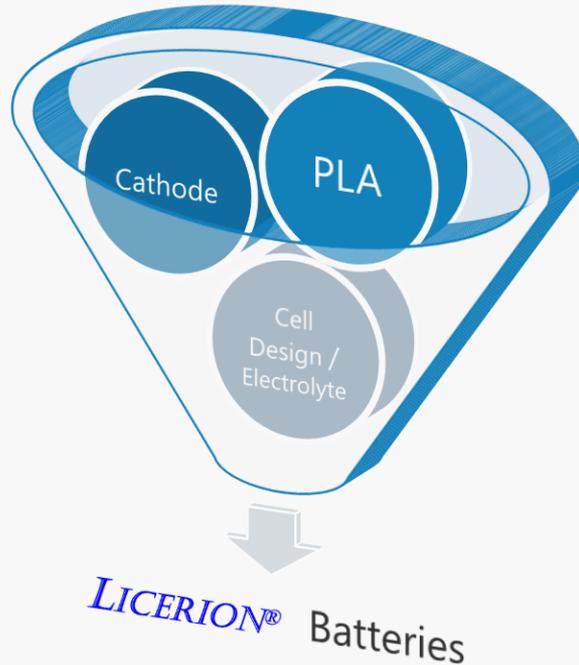
Specific Energy-Cycle Life Relationship for Sion Power Experimental Li-S Cells



- Excess electrolyte and lithium (150 Wh/kg) can extend cycle life beyond 500 cycles.
- Reduced amounts of electrolyte and lithium lead to 500 Wh/kg at the expense of cycle life.
- The key for success is to control electrolyte and lithium depletion.

Licerion[®] is the Next Big Advance in Lithium-Based Batteries

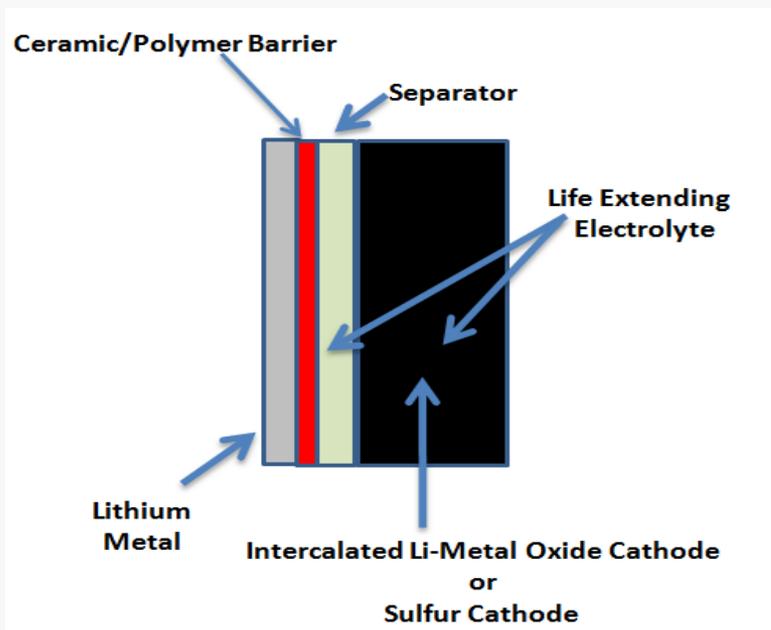
LICERION[®]
by SION POWER[®]



Licerion[®] Batteries:

- Protected lithium anodes (PLA):
 - Highest possible anode capacity.
 - Address safety and cycle life problems that have historically plagued lithium metal electrodes.
 - The only true solution to extended range for electrically powered applications.
- Cell components and design maximize robustness of PLA and cell performance:
 - Cell designs help eliminate dendrite growth.
 - Optimized electrolyte formulations.
- Multiple cathodes:
 - Metal oxide, phosphate and sulfur cathodes.

Key Elements of *Licerion*[®] Technology

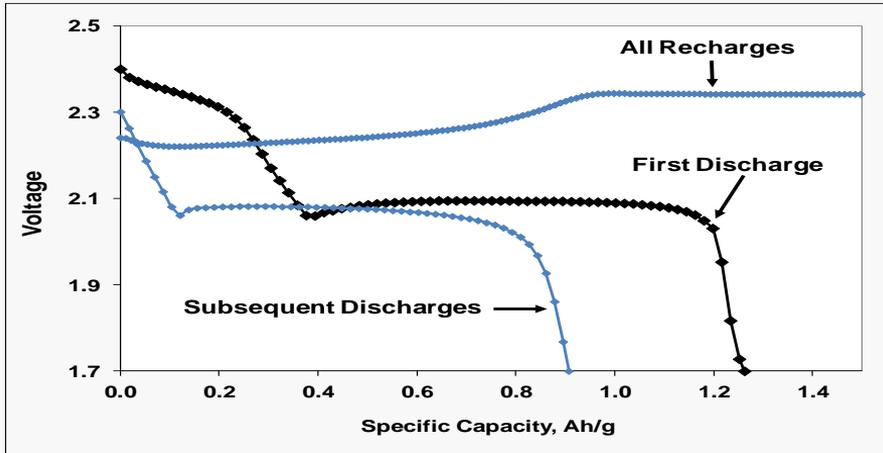


- Physical protection of lithium metal anode with thin, chemically stable and ionically conductive ceramic/polymer barriers.
- Spectra of chemical protections:
 - Electrolyte additives forming protective film on the anode to extend cycle life.
 - Stabilized electrodes enhancing cycle life and increasing energy.
- Cell designs which maximize energy and control lithium morphology during extended cycling.

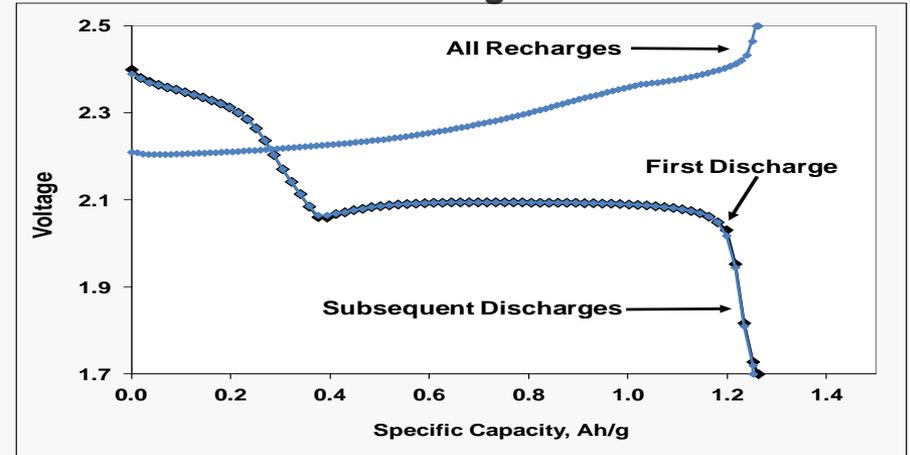
Chemical Protection in *Licerion*[®]-S System

NO_x Compounds Suppress Shuttle

Typical Charge (C/8) and Discharge (C/5) Profiles with Strong Shuttle



Typical Charge (C/8) and Discharge (C/5) for Cells Containing Nitrate

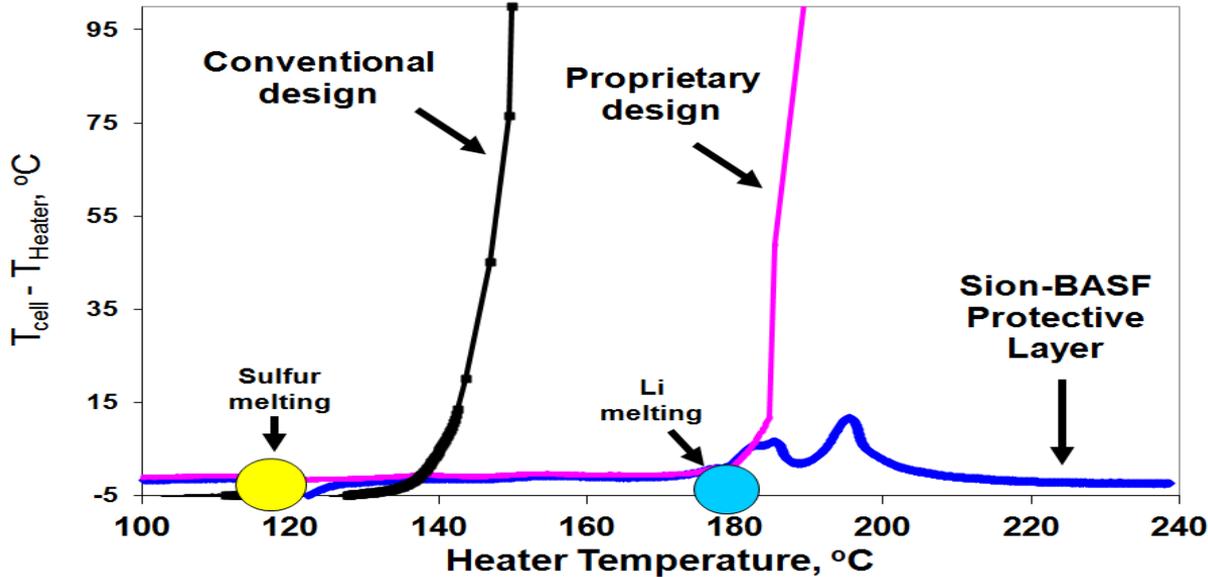


Sion Power's shuttle inhibitors permit near 100% Charge Efficiency and sulfur utilization at the high voltage plateau and up to 75% of total sulfur utilization at C/5 rates.

Physical Protection in *Licerion*[®]-S System

Safety Improved by Sion Power's *Licerion*[®]-Technology

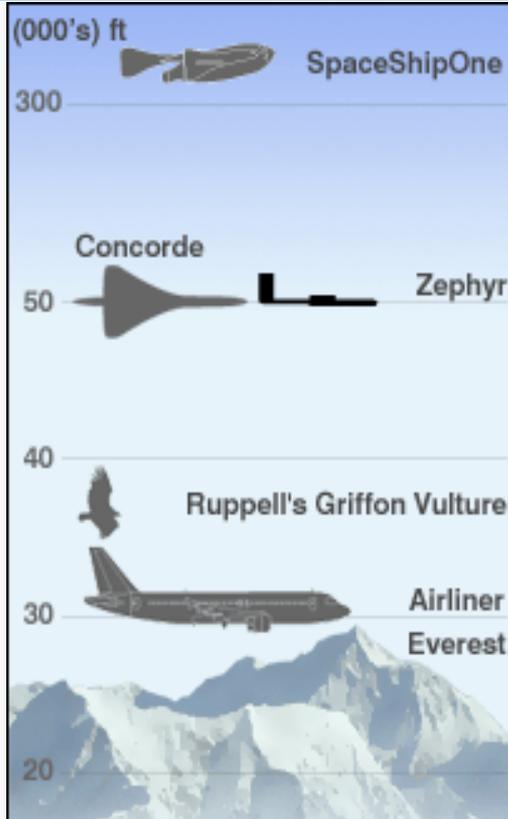
Fully Charged Experimental Li-S Cells Ramped at 5°C/min After 10 Cycles



- No thermal runaway for cells surpassing the melting point of metallic lithium.
- Cells with protected lithium experienced only about 3-8 °C temperature rise.

Sion Li-S is Enabling Technology for High Altitude Unmanned Aerial Vehicles

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Zephyr 7 UAV Captures World Record for Longest Duration Unrefueled Flight

- Flew to >70,000 ft where temperature is < -60°C.
- Used solar power to fly & recharge batteries by day.
- Flight was powered by Sion Li-S batteries at night.
- World Record: > 14 days of continuous flight.
- Airbus in collaboration with Sion now developing next generation of Unmanned Aerial Pseudo-Satellite vehicles.



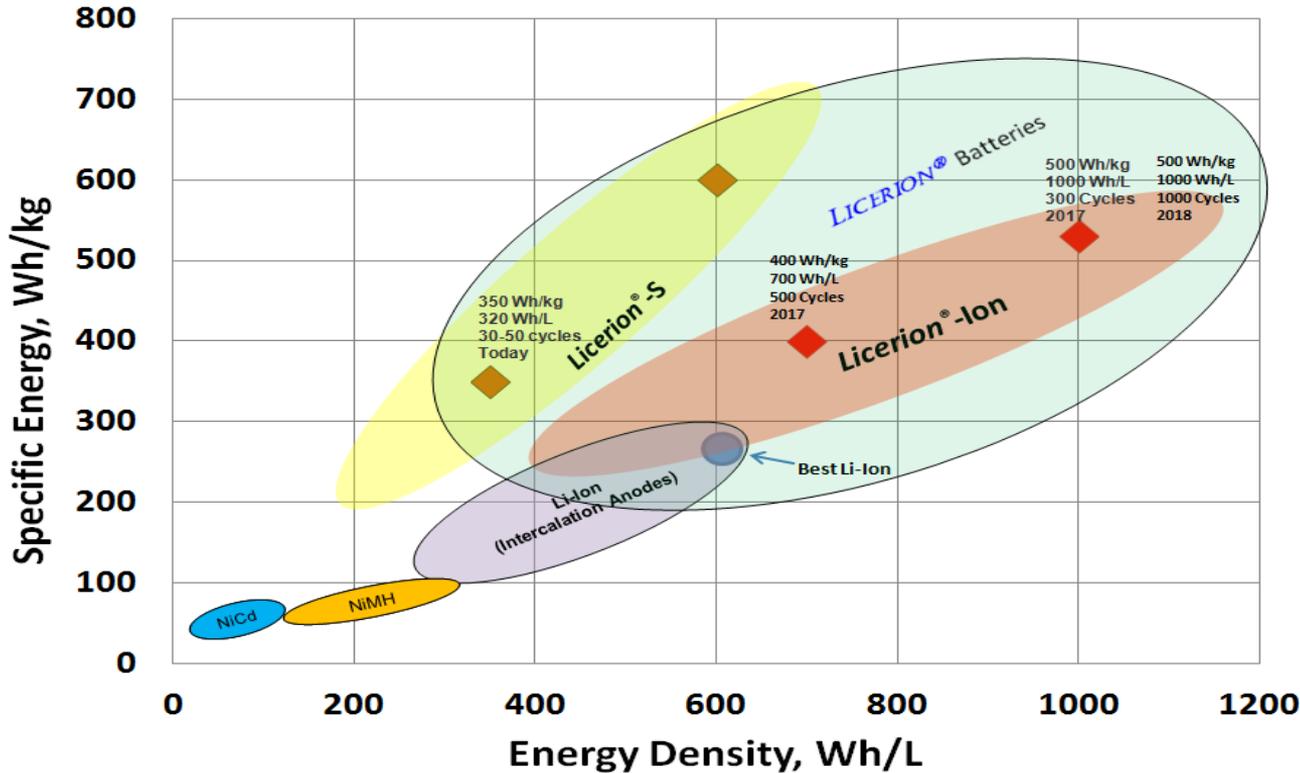
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Extending *Licerion*[®] Technology Beyond *Licerion*[®]-S

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- Introducing Protected Lithium Anode into variety of electrochemical systems including intercalation cathodes.
- Intercalation Li-metal oxide and Li-metal phosphate cathodes are well developed by Li-Ion battery industry and have reached technological maturity.
- High quality intercalation cathodes are available from variety of sources.
- *Licerion*[®]-Ion battery production is compatible with existing Li-ion manufacturing processes.

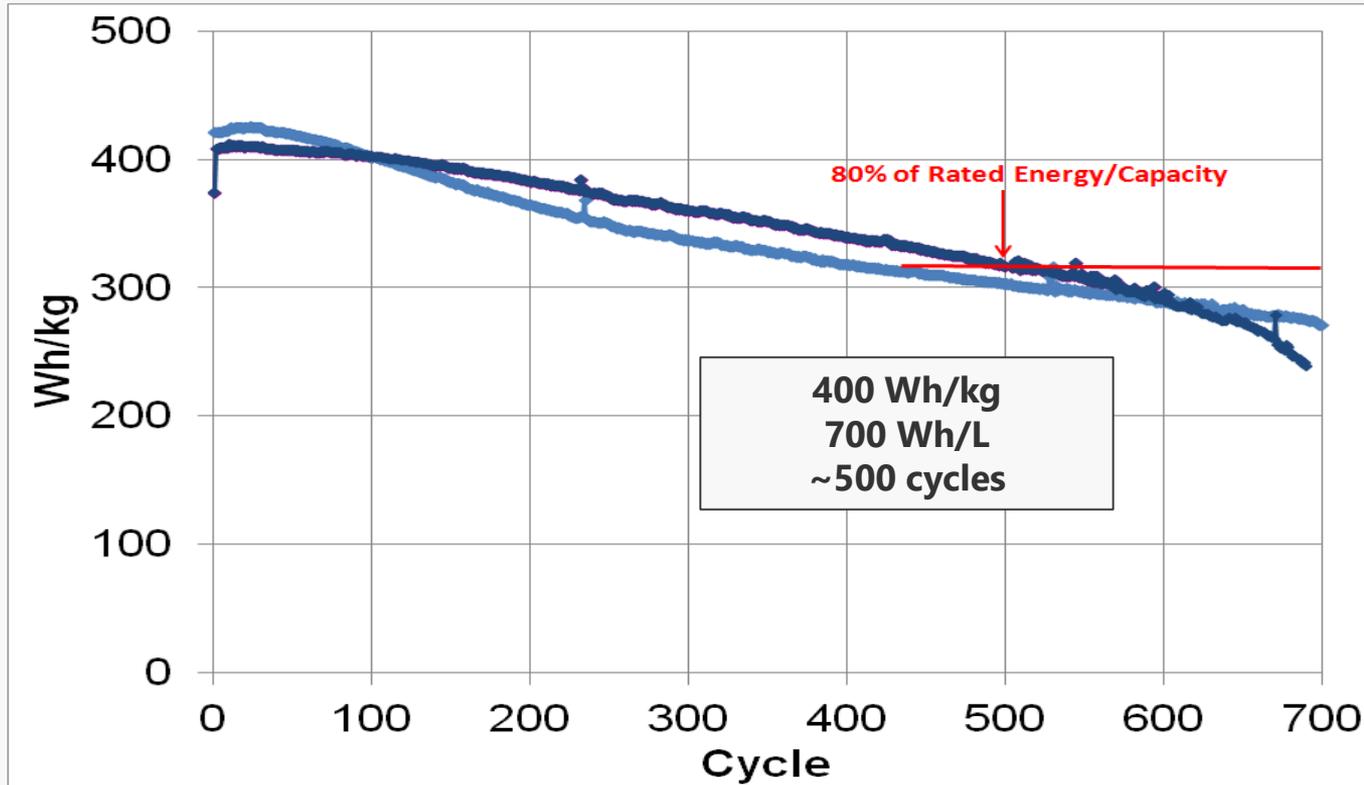
Roadmap to Ultra High Energy Density



- Intercalation cathodes coupled with *Licerion*[®] protected Li offer higher energy density compared with other systems.

Licerion[®]-Ion Offers Highest Combination of Specific Energy and Longest Cycle Life

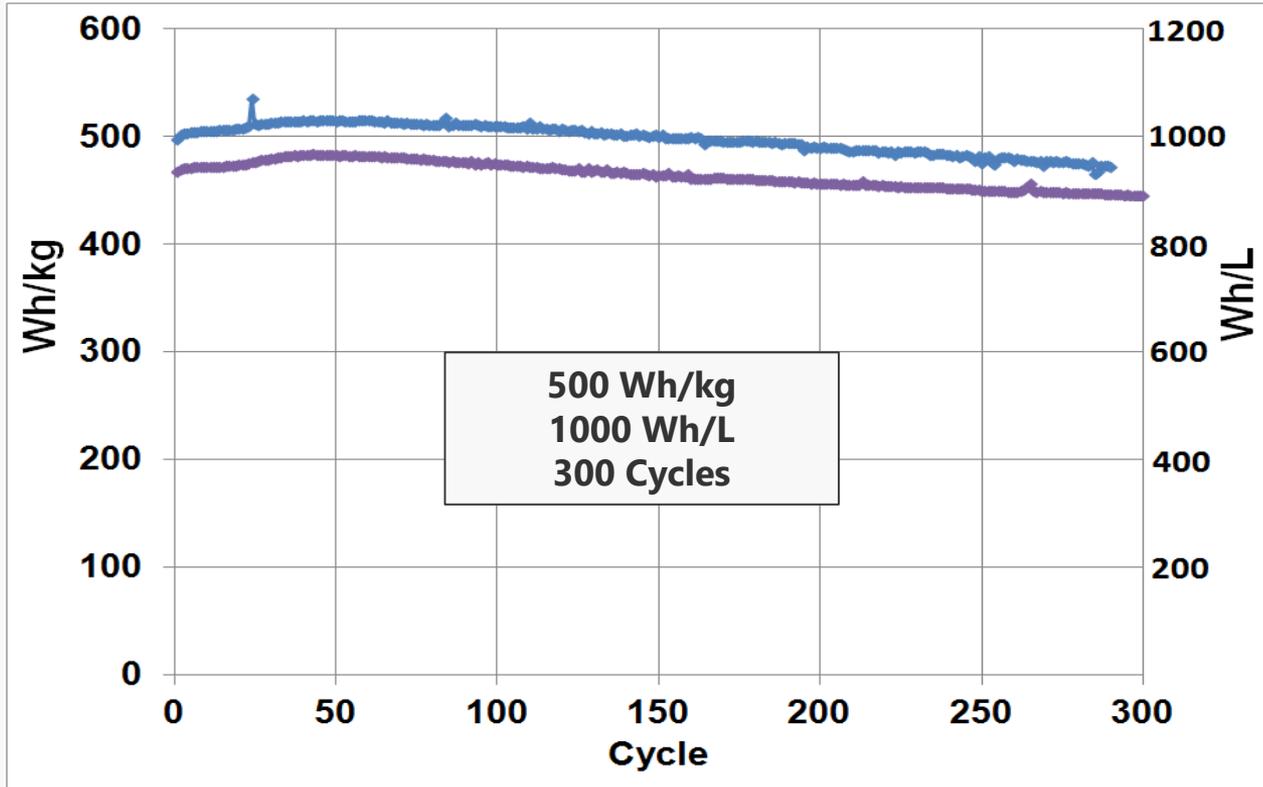
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Specific Energy and Energy Density projected to 10x10x1cm large cell design using same active materials balance as laboratory 0.4 Ah cells and accounting for weight and volume of all large cell components.

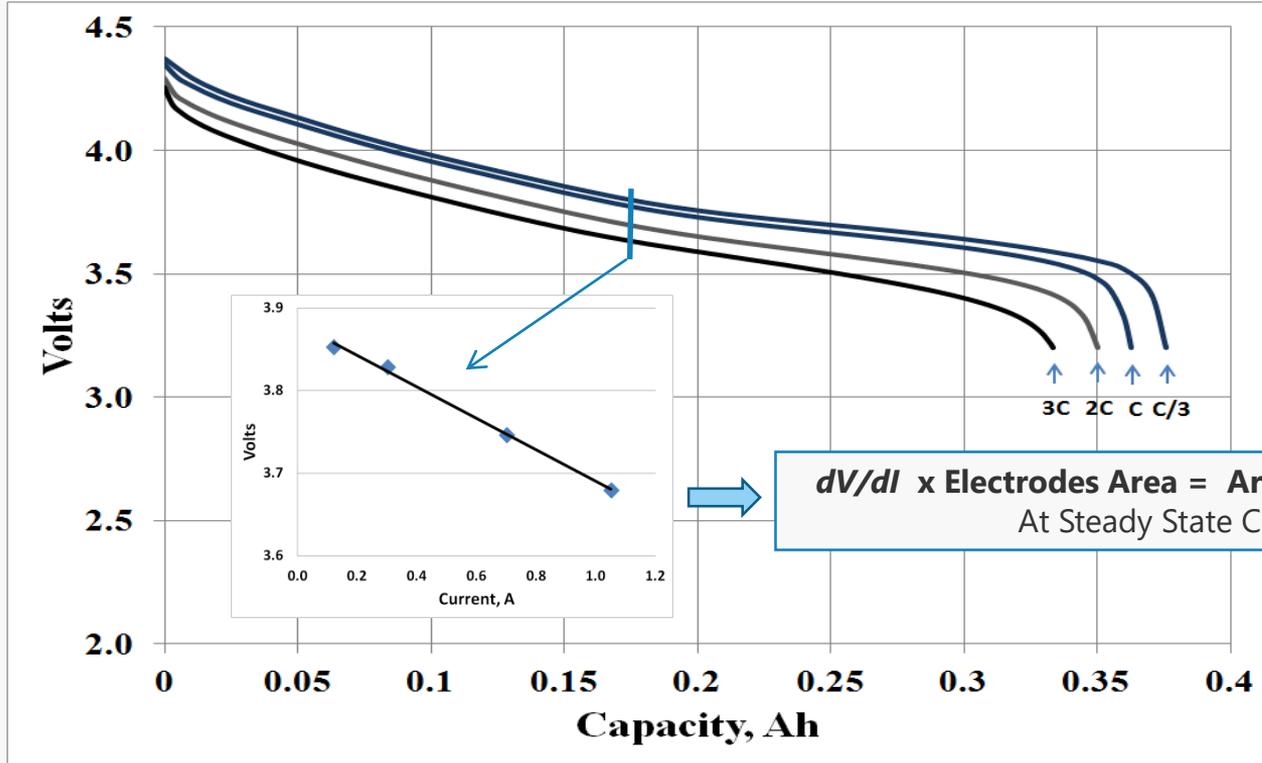
Licerion[®]-Ion Offers Highest Specific Energy and Energy Density with Longest Cycle Life

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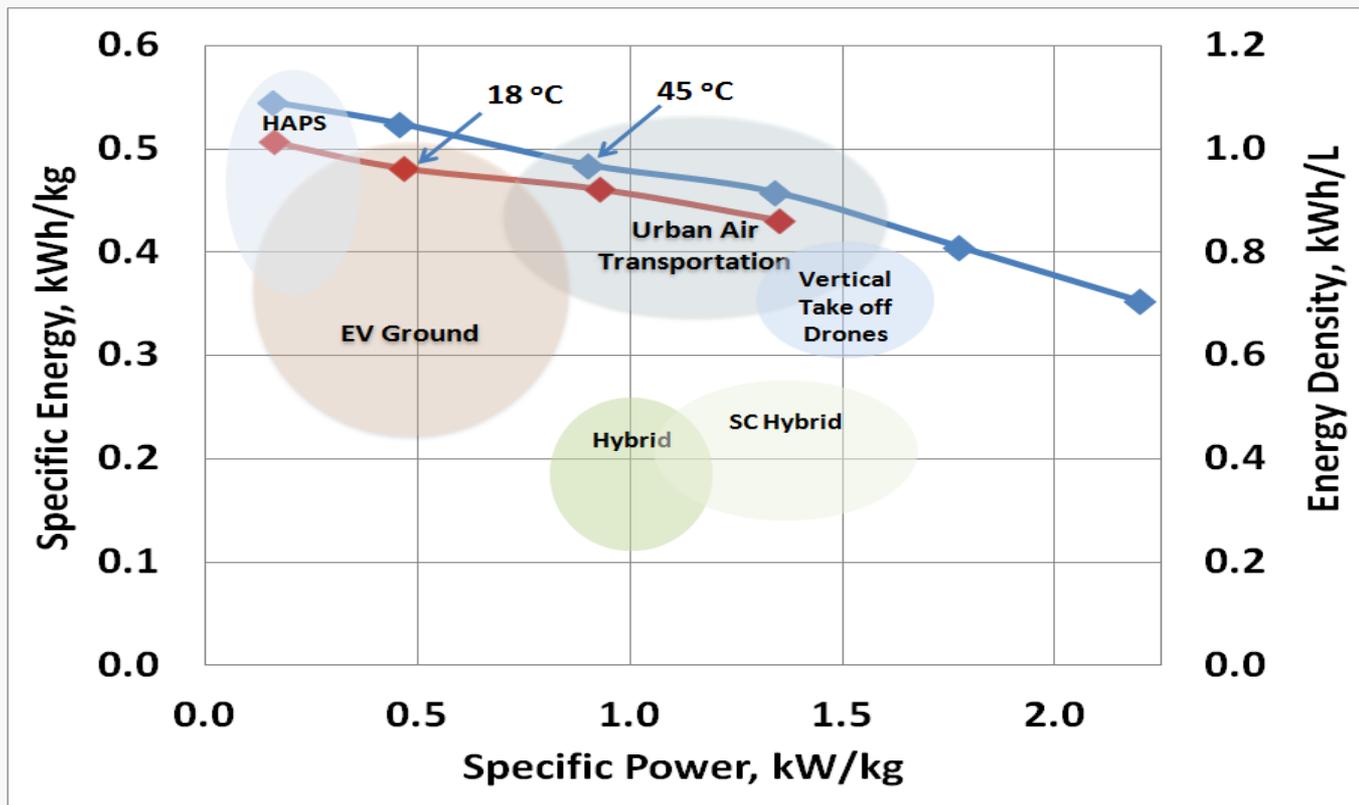
Specific Energy and Energy Density projected to 10x10x1cm large cell design using same active materials balance as laboratory 0.4 Ah cells and accounting for weight and volume of all large cell components.

Licerion[®] Li Anode Protection Leads to Low Cell Electrical Resistance



Licerion[®] protected Li anode coupled with Metal Oxide Intercalation cathode has Area Specific Resistance of 18 Ohm*cm².

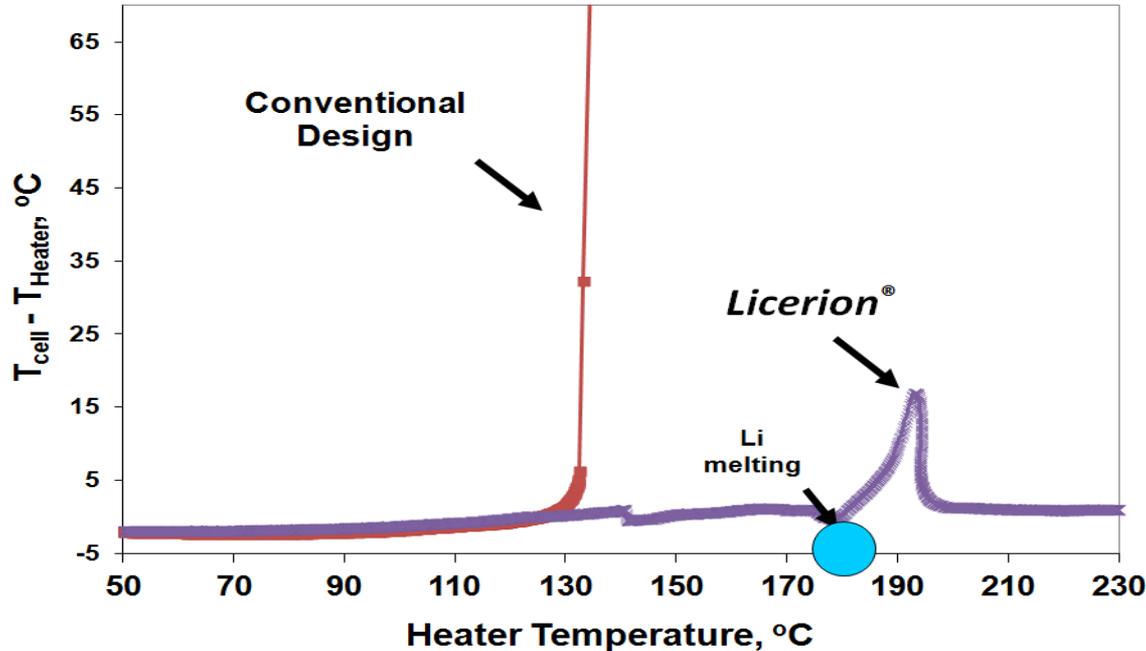
Licerion[®]-Ion Offers Highest Combination of Specific Energy and Specific Power



Physical Protection in *Licerion*[®]-Ion System

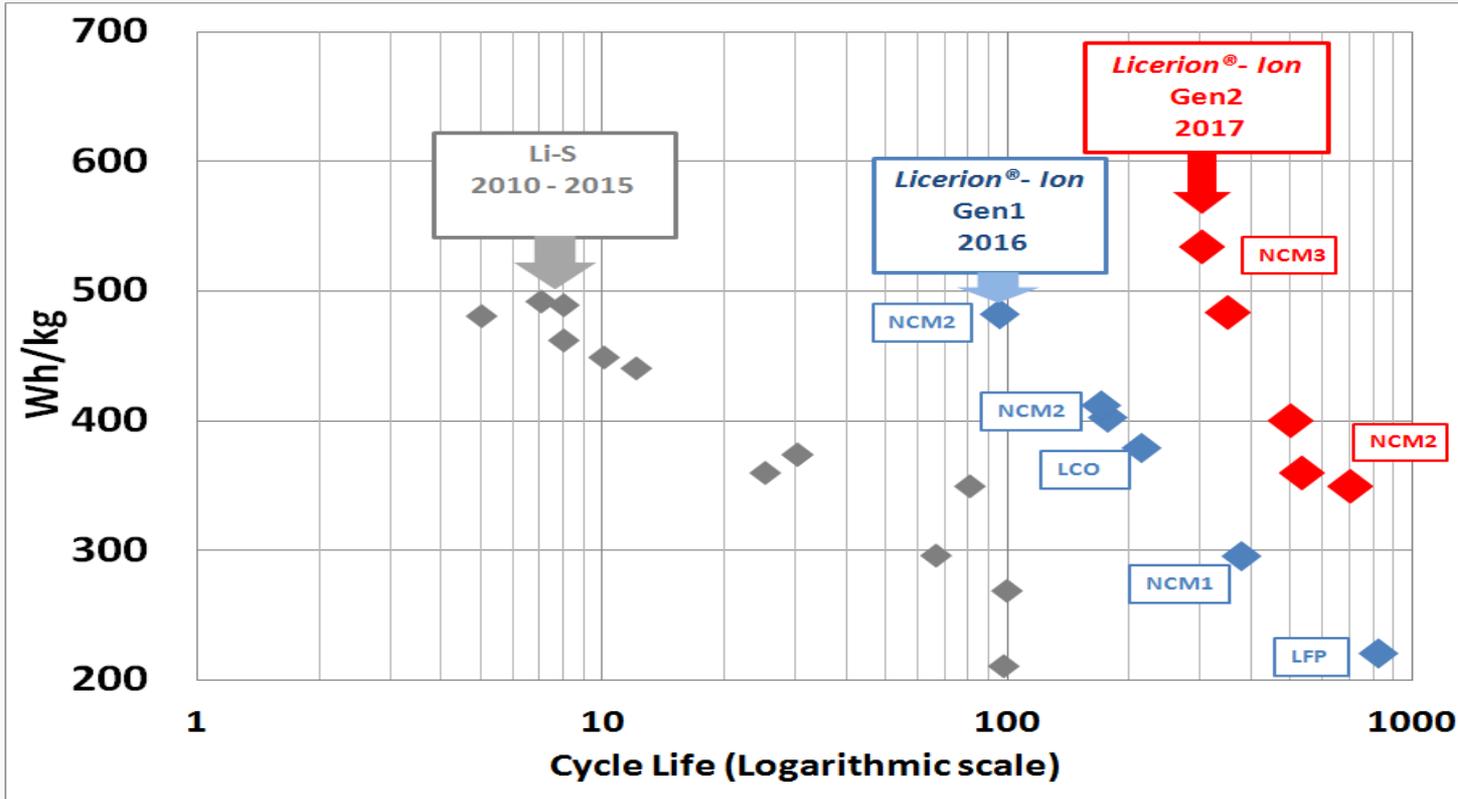
Safety Improved by Sion Power's *Licerion*[®] Technology

Fully Charged Experimental *Licerion*[®]-Ion Cells
Ramped at 5°C/min After 10 Cycles



- No thermal runaway for cells surpassing the melting point of metallic lithium.

Licerion[®]-Ion Progressing Rapidly



Summary

- Sion Power's Li-S already is the enabling technology for high altitude UAV platforms such as Airbus's Zephyr.
 - Sion Power is positioned to be the premier supplier of ultra-high energy batteries enabling this market segment.
- Lithium anode protection leads to new generation of *Licerion*[®]-S and *Licerion*[®]-Ion batteries.
- *Licerion*[®] metallic lithium protection technology offers extended driving and flying ranges for diverse electrified mobility applications
- Sion Power is creating partnerships for commercialization and volume manufacturing to supplement in-house production capacities for a variety of markets.

MESSAGE



Sion Power's core *Licerion*[®] technology represents the future of rechargeable batteries and is enabling a new era of electrified mobility.