

Lithium-Sulfur Technology

Current Performance and Future Potential

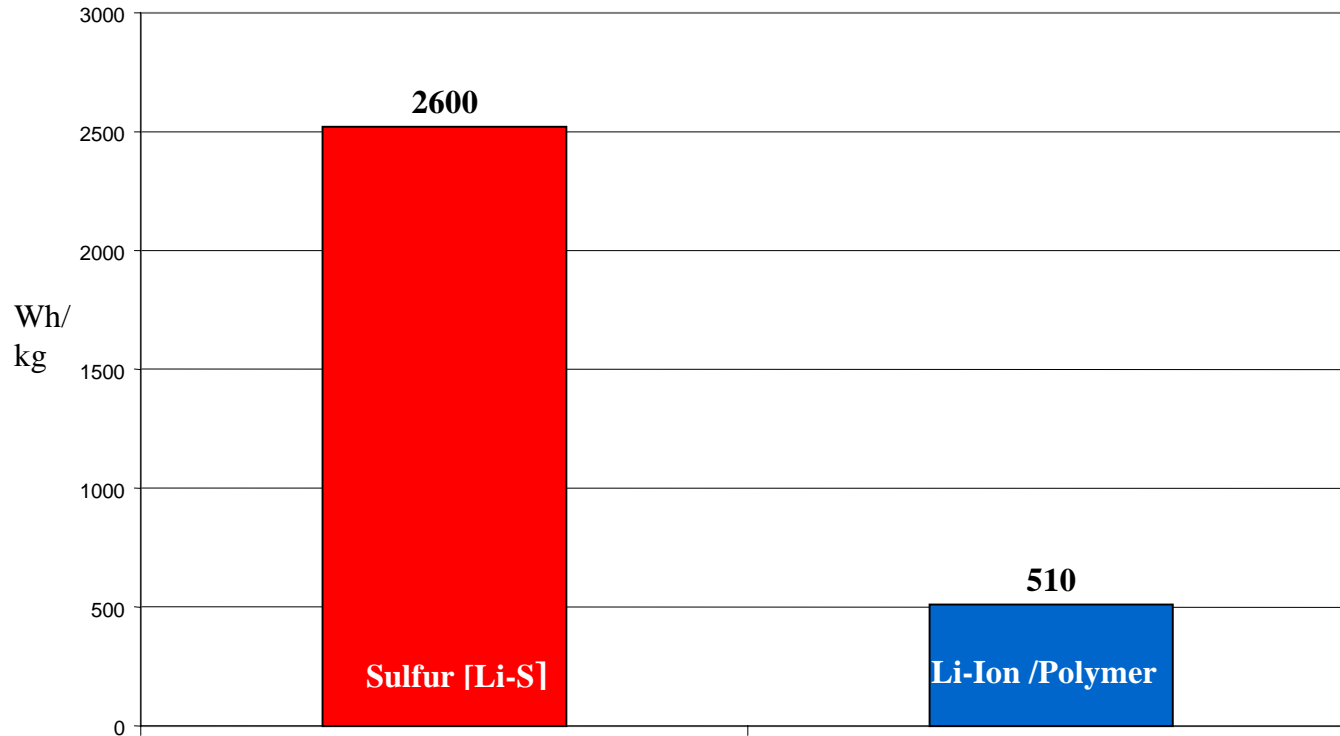
POWER 2001

Moltech Corporation

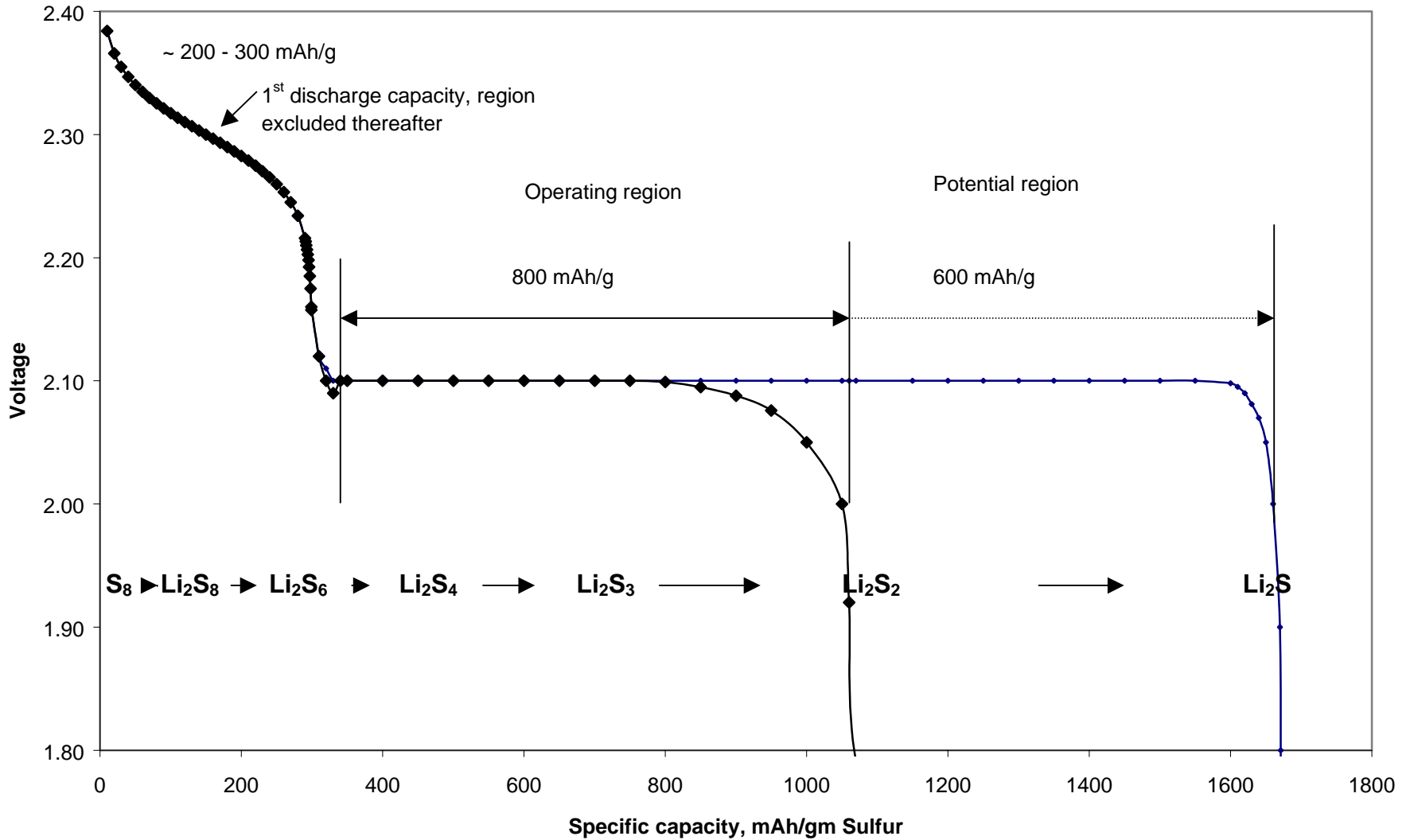
October 2001

Theoretical Energy Density Comparison

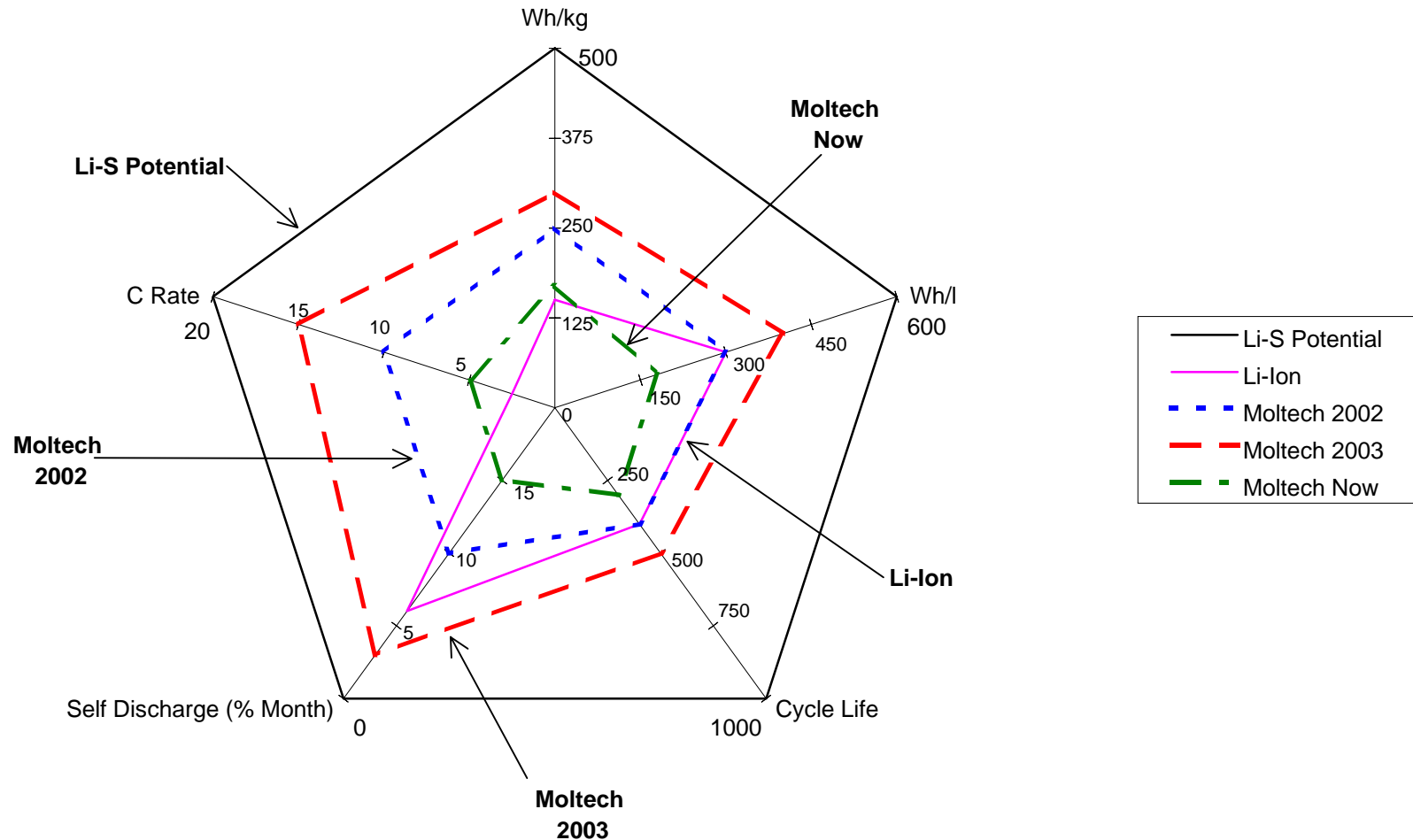
Cathode Active Materials



Lithium/Sulfur Discharge/Charge Chemistry



Li-S and Li-ion Cell Performance Comparison



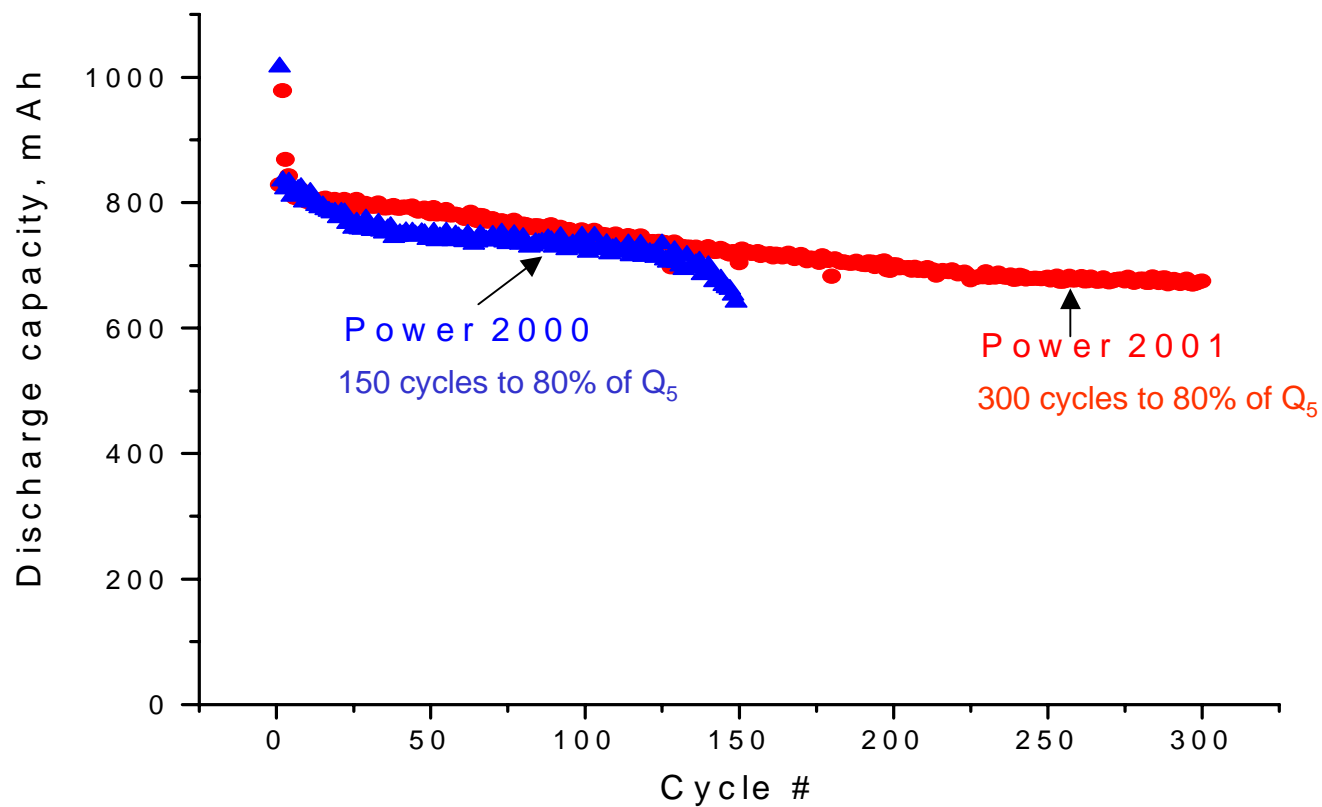
Alpha Cell Development Plan

- Alpha 1-3 Metal foil cells (MFC)
- Alpha 4 MFC with low impedance
- Alpha 5 Spray metal tabs at cathode and anode
- Alpha 6 PET substrate for cathode
- Alpha 7 Coated Separator on cathode
- Alpha 8 Thin film plastic cell

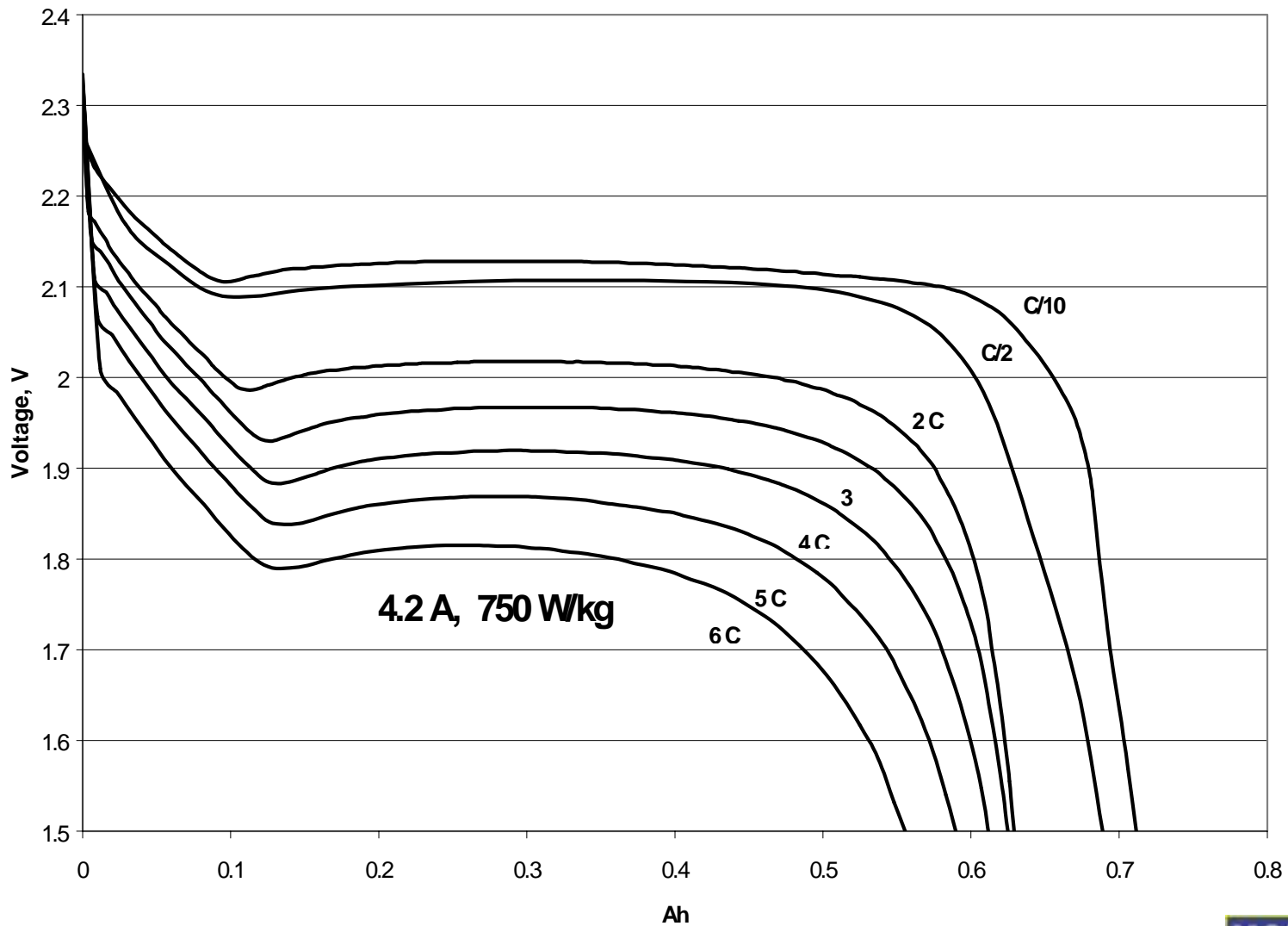
Li-Polymer vs. Lithium-Sulfur

Items	Li-polymer	Lithium-Sulfur	
		Prototype (α -6)	Product in 2003 (α -8)
Operation Voltage [V]	3.6	2.1	2.1
Cycle Life to 80% at 100% DoD Discharge	>400	>300	>500
Specific Energy (Wh/kg)	120 -180	180	300
Volumetric Energy (Wh/l)	250 -350	180	400
Cell Capacity (mAh)	450 -900	800	1000 -2400
Operating Temperature [°C]	-10 to 65	-40 to 65 60% of RT at -40°C	-40 to 65 Same or Better
Power (W/kg)	-	750W/kg or higher	same
Discharge Rate Capability	2C	>6C	same
Charge Rate [hr @ RT]	2	4	2.
Size and shape	Prismatic	Prismatic	Prismatic

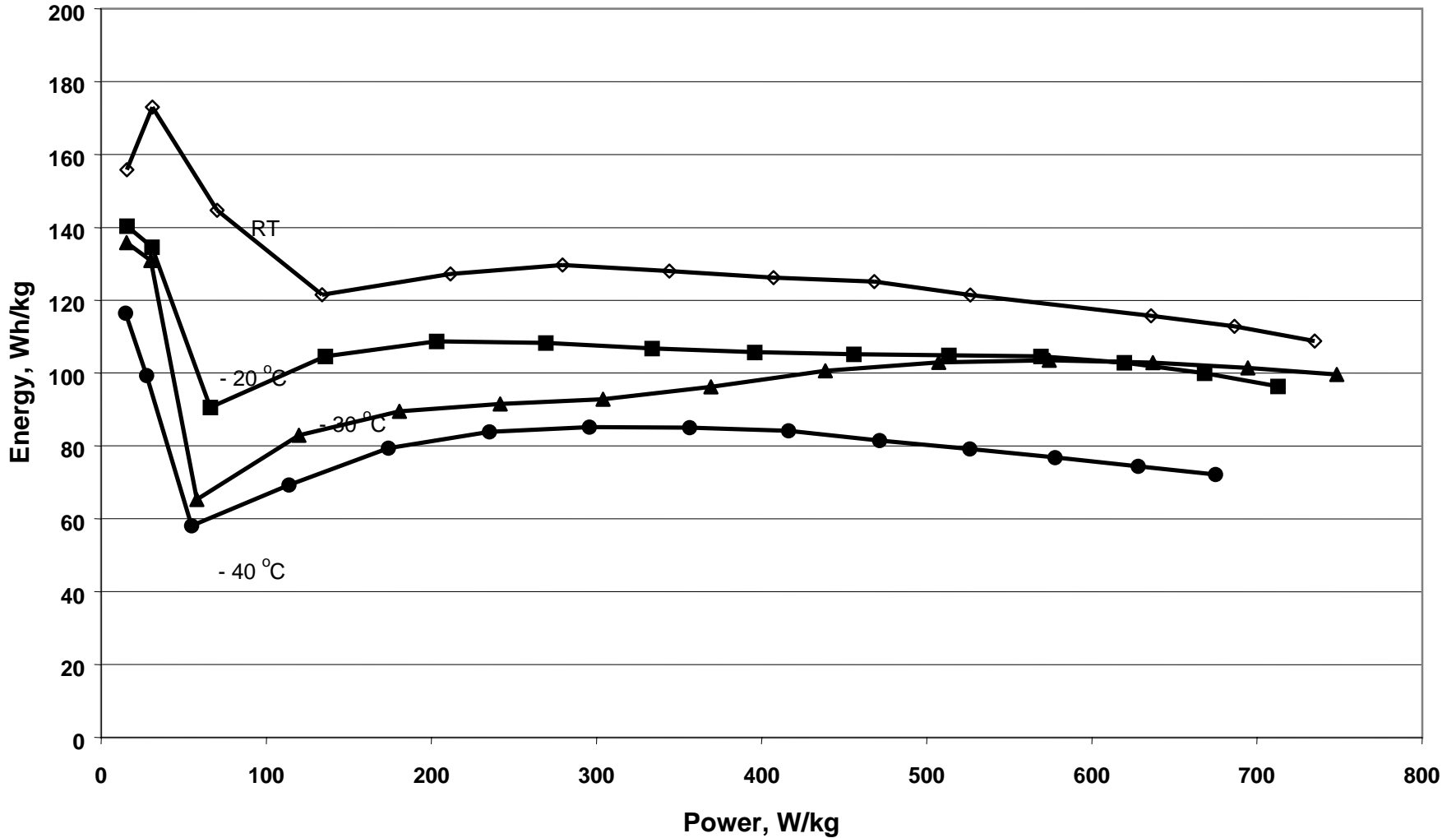
Cycle Life Evolution of α -6 Prototype Li-S Cell



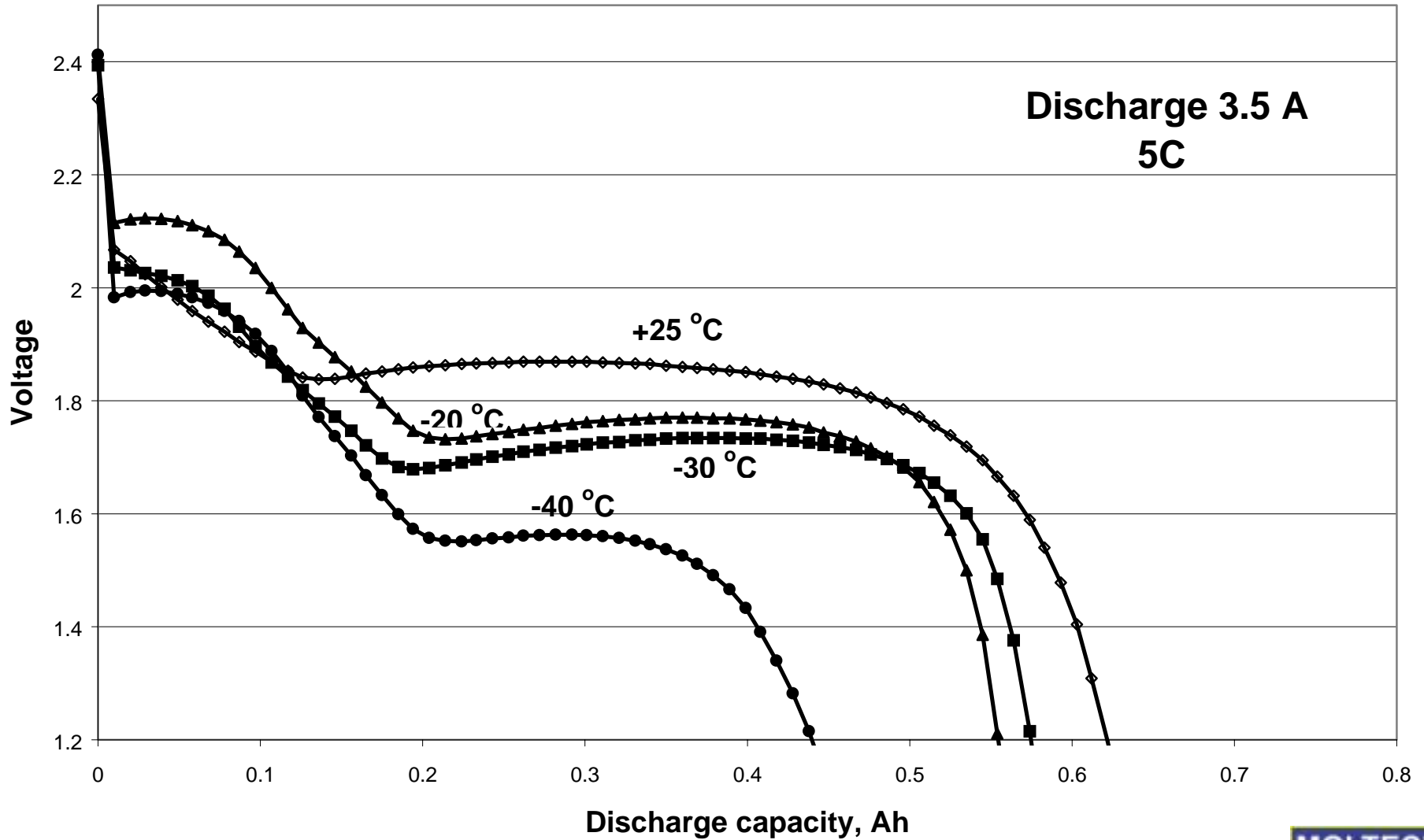
Voltage vs Ah At Various Discharge Rates
Alpha-6 Improved Design



Cell Utilizing New Electrolyte Additive Ragone Plots At Various Temperatures



Voltage vs Discharge capacity at different temperatures



Self-Discharge

- Recoverable Self-Discharge : 20% in 1st month then <5%/month after. All capacity is recoverable within 2 cycles.
- Non Recoverable Self-Discharge : total of less than 8 % due to corrosion of lithium anode by polysulfide. Protection of lithium surface by anode stabilization layer will solve this issue.

Safety

- Building fundamental understanding of materials, design, and interactions related to safety behavior.
- Testing each alpha design as developed per UL standards.
 - Bare cells pass all tests except marginal on hot box at 150°C and >300% overcharge.
- Designing to extend limits of safety.

Li-S Compared to Other Systems

