Transition Metal Blocking Microporous Polymer Separators for Energy-Dense and Long-Lived Li-ion Batteries

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Sepion Technologies

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This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Overview

Timeline

- Award issued April 2017
- On contract with ANL October 2017
- Project extended April 2020
- Project 65% complete

Budget

	FY 17 Costs	FY 18 Costs	FY 19 Costs	Total Planned Funding (FY 19-Project End Date)
DOE Funded	$250k	$500k	$250k	$1000k
Project Cost Share				

Barriers

- Long qualification times to break into Li-ion products
- Navigating diverse testing protocol, cell components and electrolyte formulations to quickly prove value propositions
- Alignment with contract manufactures

Partners

- Argonne National Lab is the STTR partner. The CAMP facility led by Andy Jansen is key to testing multi-Ah Li-ion cells with Sepion's separator coatings in pouch format.

Project Objectives

Improve durability and energy density of Manganese- and Nickel-rich Li-ion battery technologies to significantly lower battery cost by eliminating Cobalt and reducing the number of cells needed for an entire battery pack.

Problem: Capacity fade associated with well-documented transition-metal crossover mechanisms.

Solution: Sepion is commercializing transition metal blocking coated separators:

- Increases cycle life by >50%
- Drops cost by >10%
- Increases energy density by >10%
- Improves thermal stability

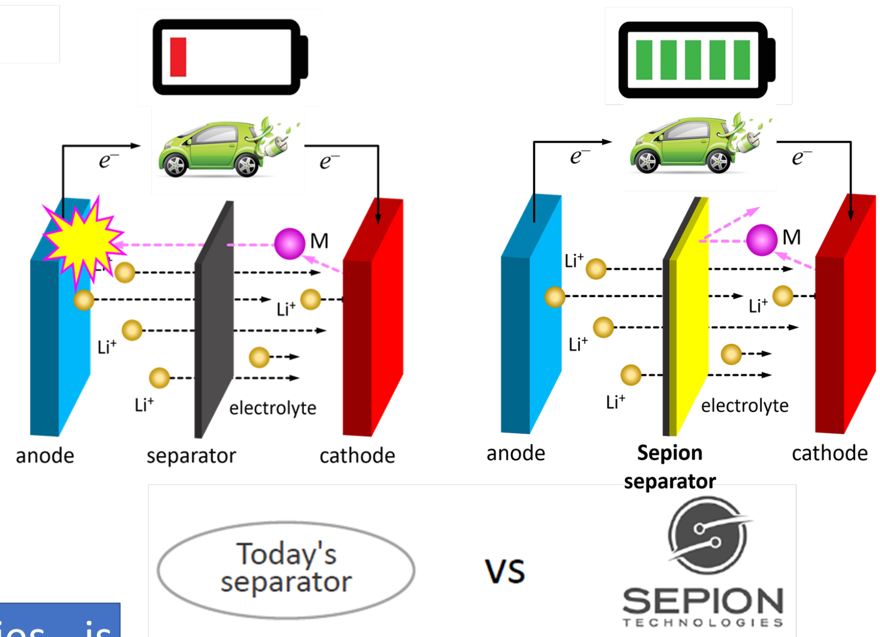

Fig 1. Schematic of transition metal crossover with coated separators and transition metal blocking with Sepion coated separators.

US manufacturing of Lithium-ion batteries is essential in meeting the growing market demand for electric vehicles and securing USA's position among the top Lithium-ion manufacturing nations

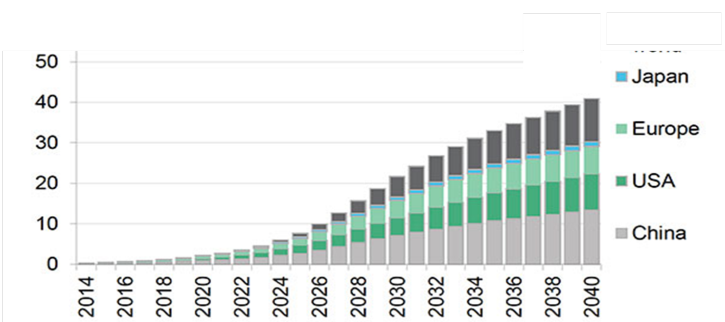

Fig 2. Electric vehicle sales in millions.

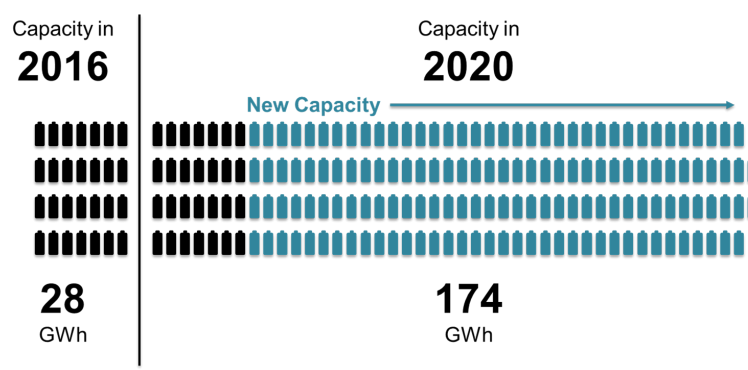

Fig 3. Growth in Li-ion manufacturing capacity

Technical Innovation

New Ion-selective Membranes

- Specialize in monovalent ion transport and polyvalent ion blocking
- Size-exclusion selectivity (tunable pores in 0.5 – 2.0 nm range)
- Acid (< pH 1), base (pH 14) and heat tolerant (>200 °C)
- 20-30% porosity
- Adheres to most surfaces
- Wide voltage stability

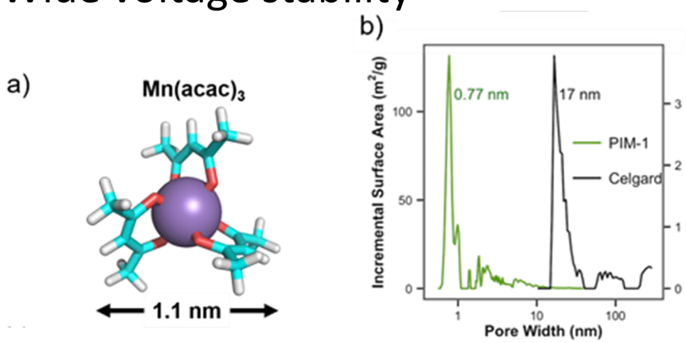

Fig 4. a) Structure of $Mn(acac)_3$.
b) Pore-size distribution for transition metal-blocking PIMs vs. permeable Celgard.

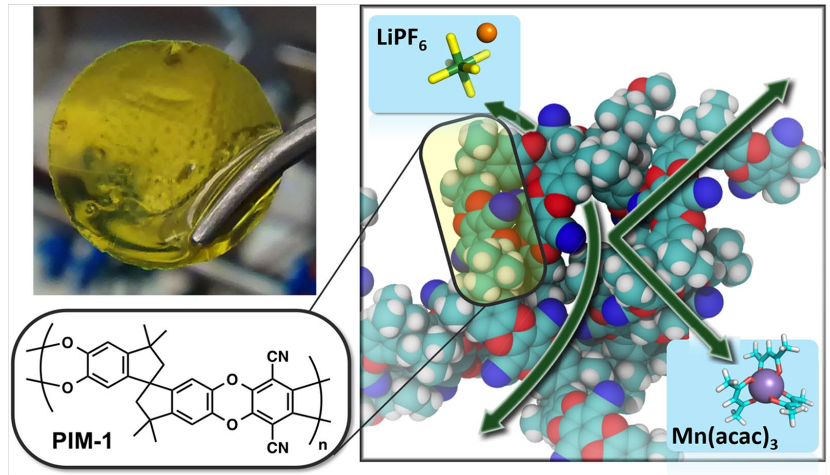

Figure 5. Ion-selective transport across membranes fabricated from polymers of high intrinsic microporosity (PIMs). Inset: Chemical structure of of PIM-1 and physical structure as a cast membrane.

Low-Cost R2R Manufacturable

- Capital-light manufacturing (contract) & thin film processable (1 µM)
- Easily scalable by Roll-to-Roll processing
- Drop-in compatibility with existing battery manufacturing

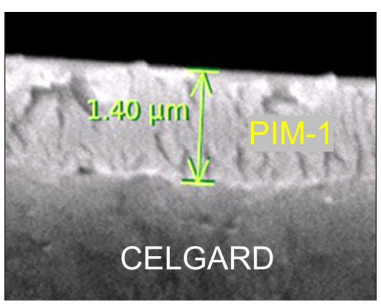

Figure 6. SEM Image of PIM-1 on Celgard

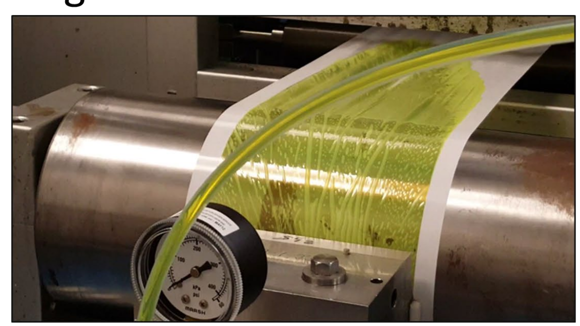

Figure 7. Slot Die Production Coating of PIM-1

Results

Milestones and Accomplishments

- Area-specific resistance <10 Ohm-cm^2 : **5.26 Ohm-cm^2**
- Transition metal D_{eff} decrease by >100-fold: 62-fold
- >20% Longer cell life versus uncoated Celgard: **>20%**
- Analogous capacity retention at high cycling rates (1C-5C): 2C

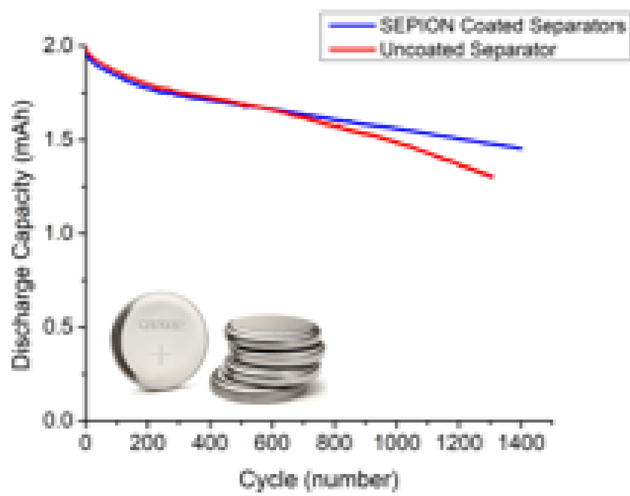

Figure 8. Coin Cell cycling data at 4.2 Volts

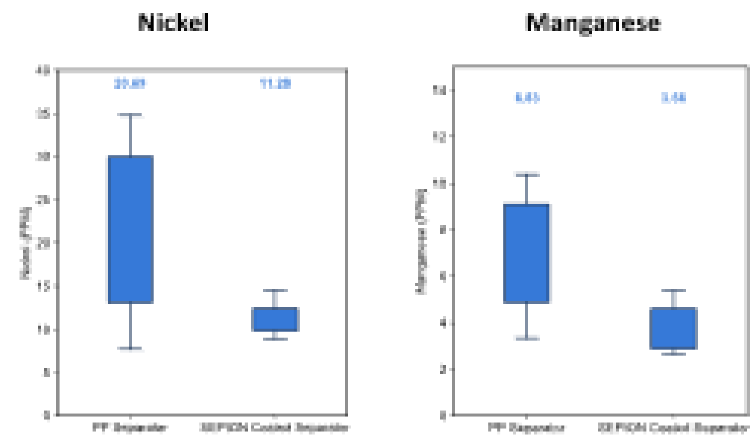

Figure 9. 1-3 fold less Nickel and Manganese found at the Anode with Sepion coated separators

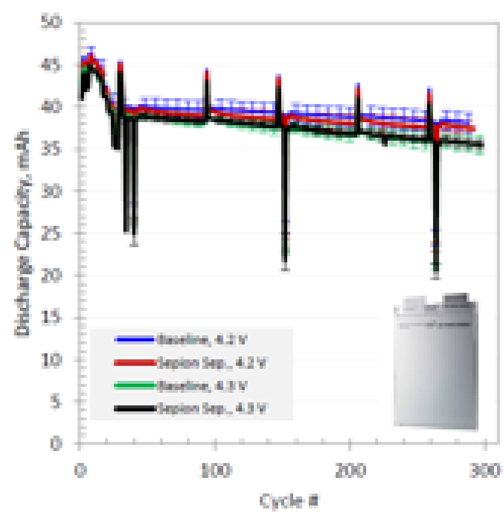

Figure 10. Pouch Cell cycling data at 4.2 & 4.3 Volts

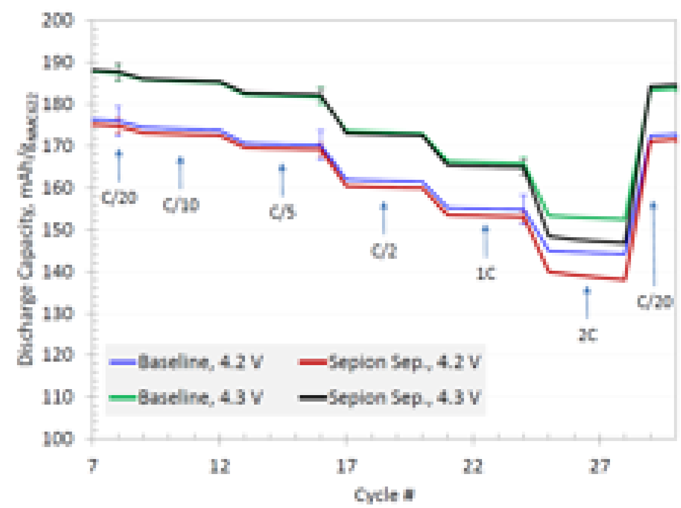

Figure 11. Pouch Cell rate data

Go-To-Market Transition

STTR Team and Workflow

SEPION TECHNOLOGIES

Materials Development
Project Management
Technical De-risking

ABPDU → WASHINGTON Clean Energy Testbeds → Argonne NATIONAL LABORATORY

Polymer Scale-up | **Roll-to-Roll Production** | **Battery scale-up & 3rd party validation**

2017

- **JUN 2017** Phase II STTR start
- **SEP 2017** Filed PCT on metal sieving membranes
- **DEC 2017** Deliver first samples to customers

2018

- **JAN 2018** Achieved >20% longer cycle life in coin cell
- **MAY 2018** Gen 2 samples delivered to customers
- **AUG 2018** Moved into a larger lab space
- **NOV 2018** Single-layer pouch cells built at ANL

2019

- **FEB 2019** First results from ANL
- **MAR 2019** PCT converted to National Phase
- **JUN 2019**
  - >Kg synthesis
  - >500m roll-to-roll coatings
- **AUG 2019** Multi-layer pouch cells built at ANL
- **NOV 2019** JDA Signed

Li-ion Coated Separator - Ecosystem

Acknowledgements

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California Clean Energy Fund
MANUFACTURING
CalSEED