TDA Research, Inc.

A Materials and Technology Development Company

Girish Srinivas, PhD, MBA

CEO

gsrinivas@tda.com
303-748-7153

NAATBatt Member Update

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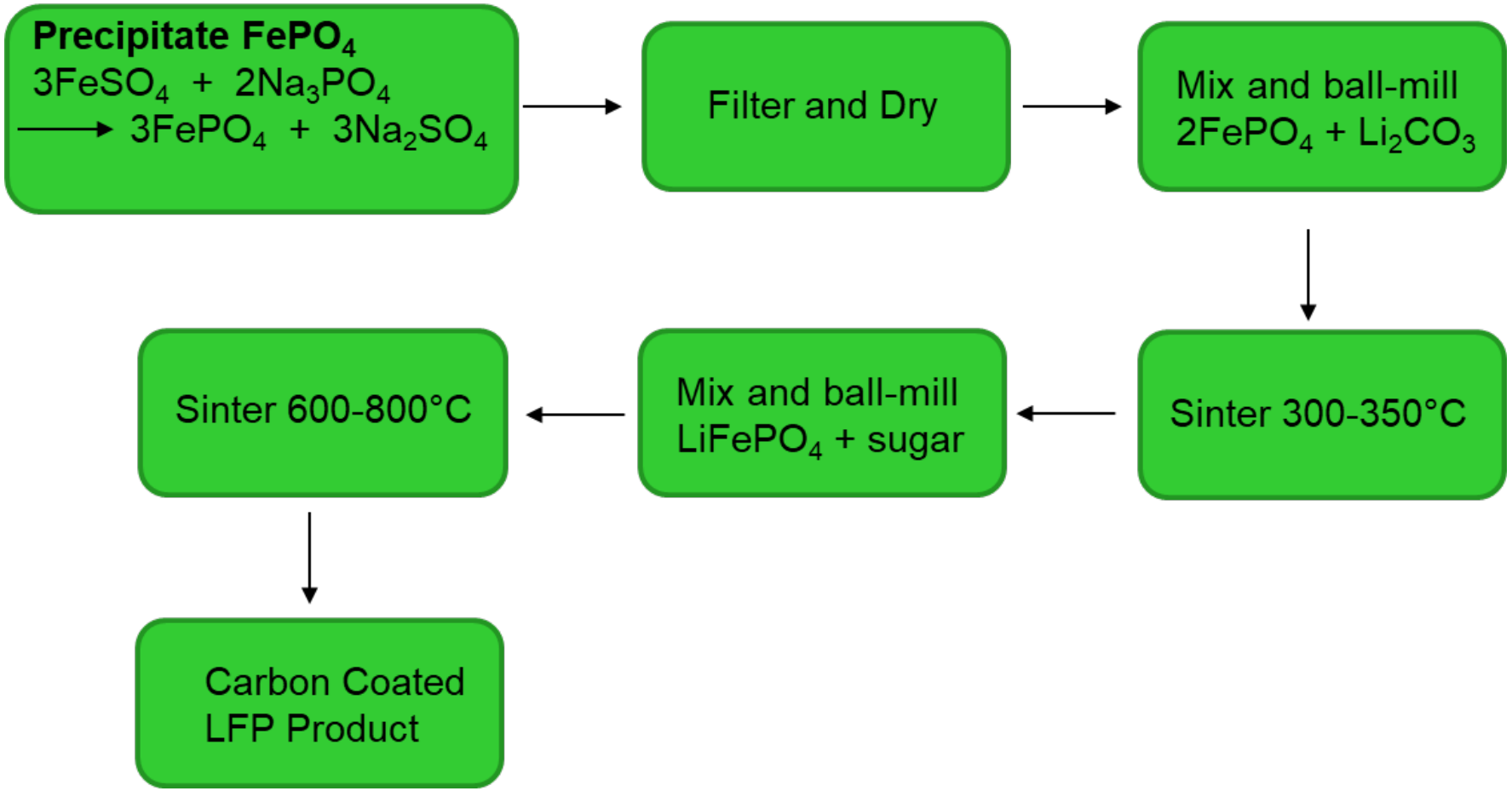
TDA Research, Inc. – Who We Are

- **In Business for 35 years**
  - Privately held
  - 125 employees, 30+ PhDs in Chemistry, Materials and Engineering
  - $30 million in annual revenue
- **Facilities**
  - 78,000 ft^2 laboratory and office space in Golden, CO
  - Pilot and Manufacturing
  - Carbons, Catalysts Sorbents, Process and Equipment,
- **What we do!**
  - Identify opportunities with industry
  - Develop technology
  - Secure intellectual property
  - Manufacture, spinoff, license, joint ventures

Battery Technologies at TDA

- $LiFePO_4$ (LFP) and LMFP
- Nanoporous Polymer Electrolytes for Lithium Batteries
- Nanoporous Anion Exchange Membranes
- Cathode Materials for Li-S Batteries (specialty carbons)

Current Solid-State Manufacture of LFP



Disadvantages

- Batch production
- 2 ball-milling steps
- 3 mixing steps
- Energy Intensive

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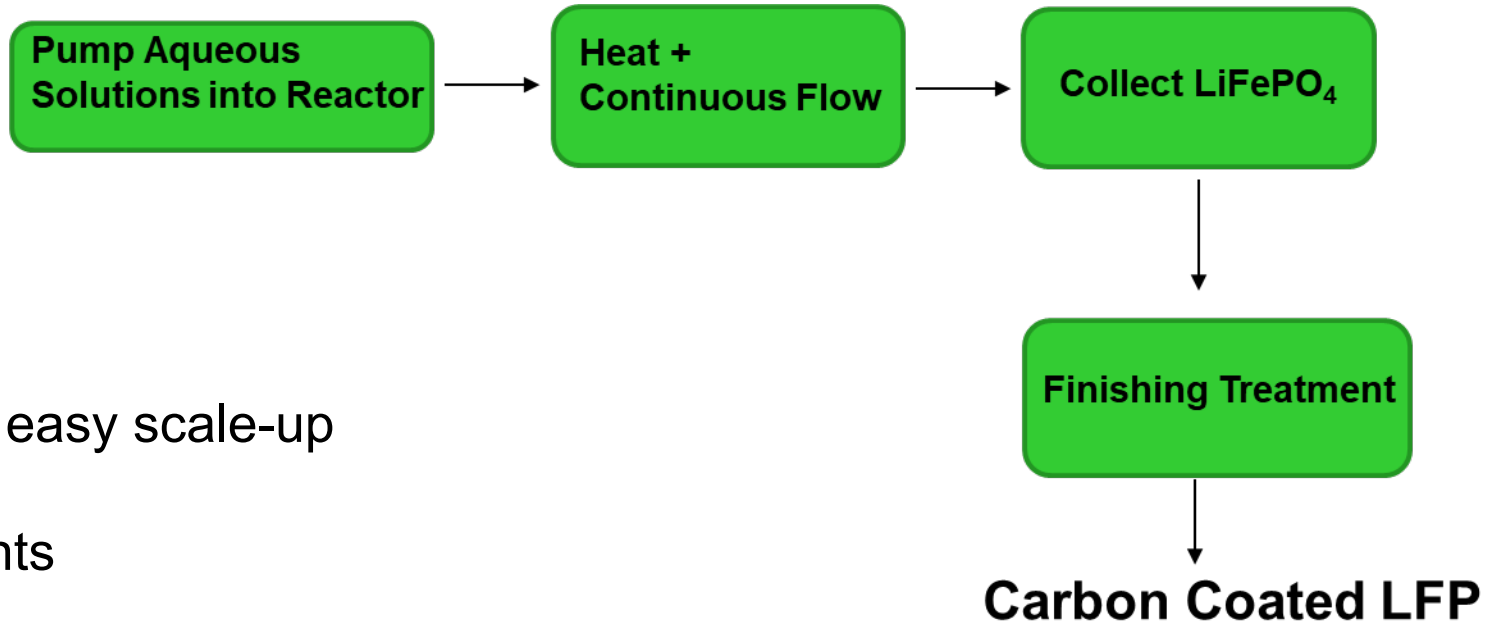
TDA's Hydrothermal Manufacture of LFP



Advantages

- Continuous Production – easy scale-up
- Proven Unit Operations
- Lower energy requirements
- Smaller particle sizes

We welcome collaboration opportunities from chemical and battery manufacturers.

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LFP ($LiFePO_4$) for Li-Ion Batteries

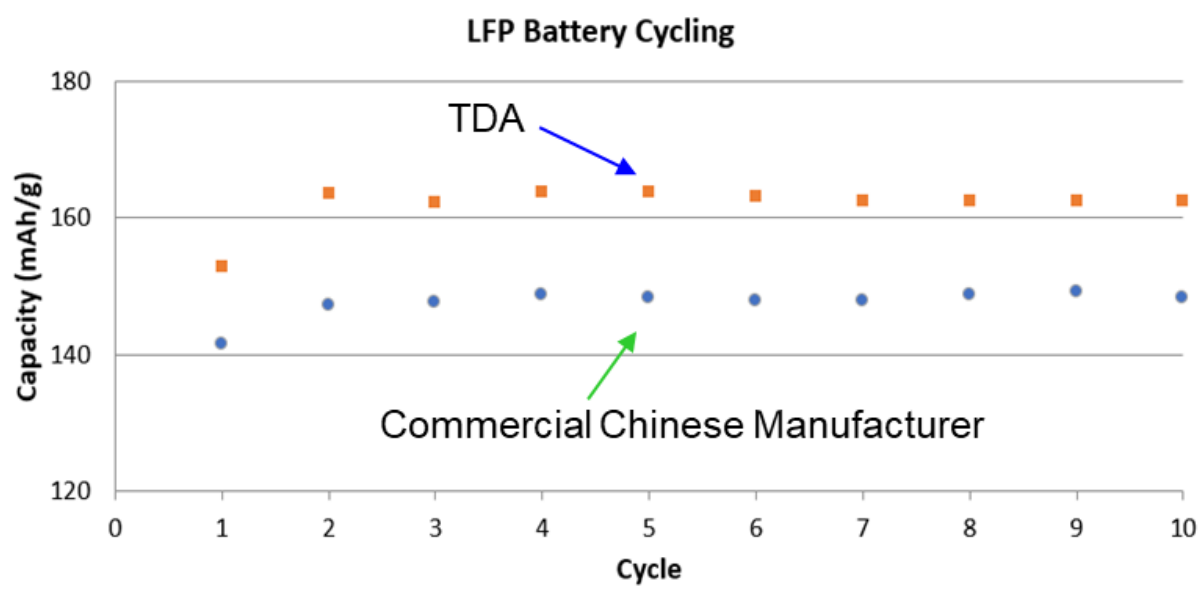
- **We are currently scaling up our continuous LFP/LMFP manufacture – fully funded by the DoD.**
- **TDA's LFP has been evaluated in independent tests with a military battery manufacturer with excellent results.**

- Our goal is not to develop a new material, but to engineer a higher quality LFP using a lower cost continuous production method that can be manufactured in the US.
- Patent pending

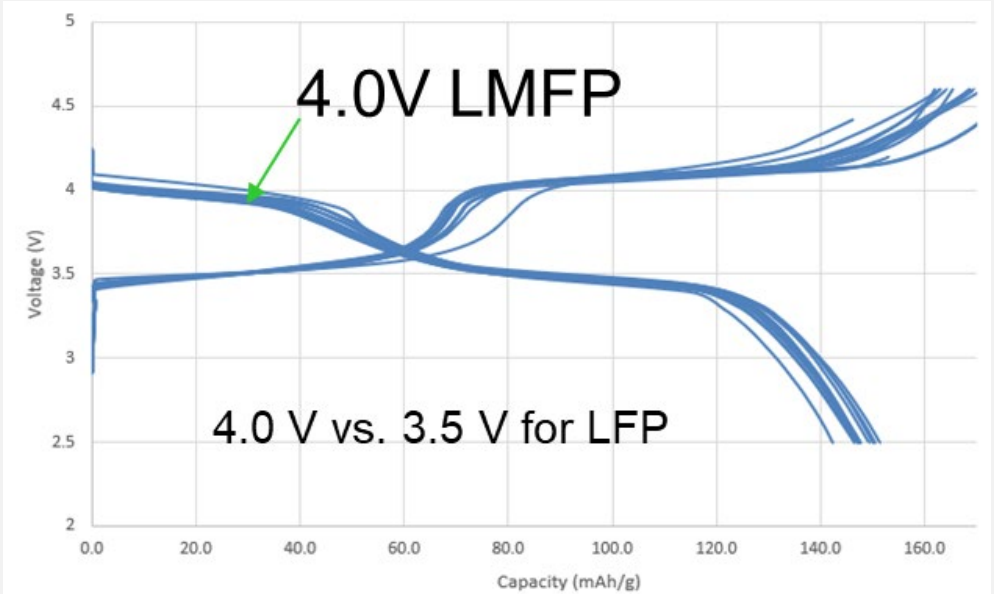
Our LFP ($LiFePO_4$) and LMFP Performance

- **Our efficient, low-cost continuous LFP/LMFP manufacturing process can be scaled to produce commercial quantities of LFP/LMFP.**

> 99% Purity, > 96% Yield,
~ 30 nm Particle Size



Higher capacity
than commercial LFP



LMFP has higher voltage
Greater energy density

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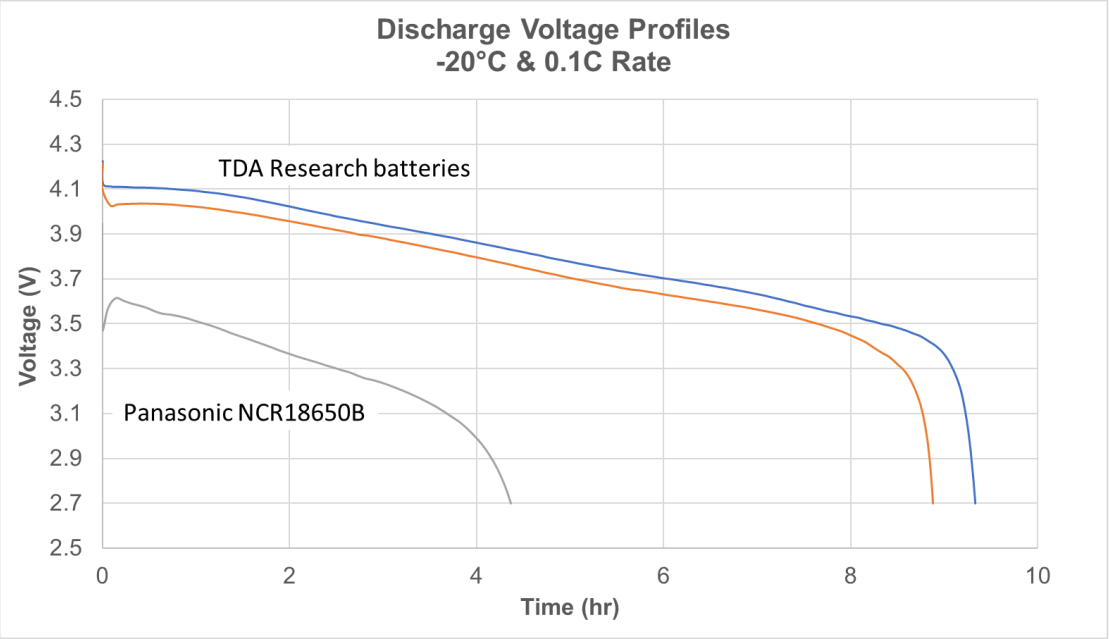
TDA's Nanoporous Polymer Electrolyte

- **Patented technology**
- **Ion conducting polymers (Li^+, Na^+, H^+, OH^-)**
- **3-dimensionally interconnected nanopores**
- **High thermal stability (+70 °C)and a high conductivity at low temperatures (-60 to - 20 °C)**
- **Solid electrolyte for all solid-state batteries**



Typical 18650 Li cells (like NCR18650B) are not designed to operate from -60 to -40 °C.

A submicron thick layer of our solid polymer electrolyte on the cathode greatly increases low temperature discharge

> 250 Wh/kg at -40 °C
> 100 Wh/kg at -60 °C

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