

WORLD LEADING ANALYTICAL EQUIPMENT FOR LITHIUM-ION BATTERIES



SURFACE AREA



POROSITY



DENSITY



PARTICLE INTERACTIONS



POWDER FLOW



PARTICLE SIZE



Li-ion Battery Component Optimization

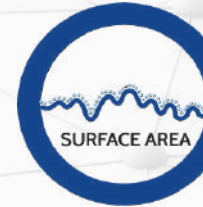


POROSITY

- improve energy / power density
- optimize capacity
- longer cycle life
- critical to safety and reliability



AutoPore



SURFACE AREA

- increase capacity
- facilitates fast charging
- improve charge/discharge performance
- tailor binder needed for adhesion



TriStar



DENSITY

- optimize electrode packing density
- maximize mass/volume density
- minimize irreversible capacity



AccuPyc

GeoPyc



POWDER FLOW

- improve battery efficiency
- optimize electrode packing density
- control slurry agglomerates / dispersibility
- longer battery life



FT4 Powder Rheometer®



PARTICLE SIZE

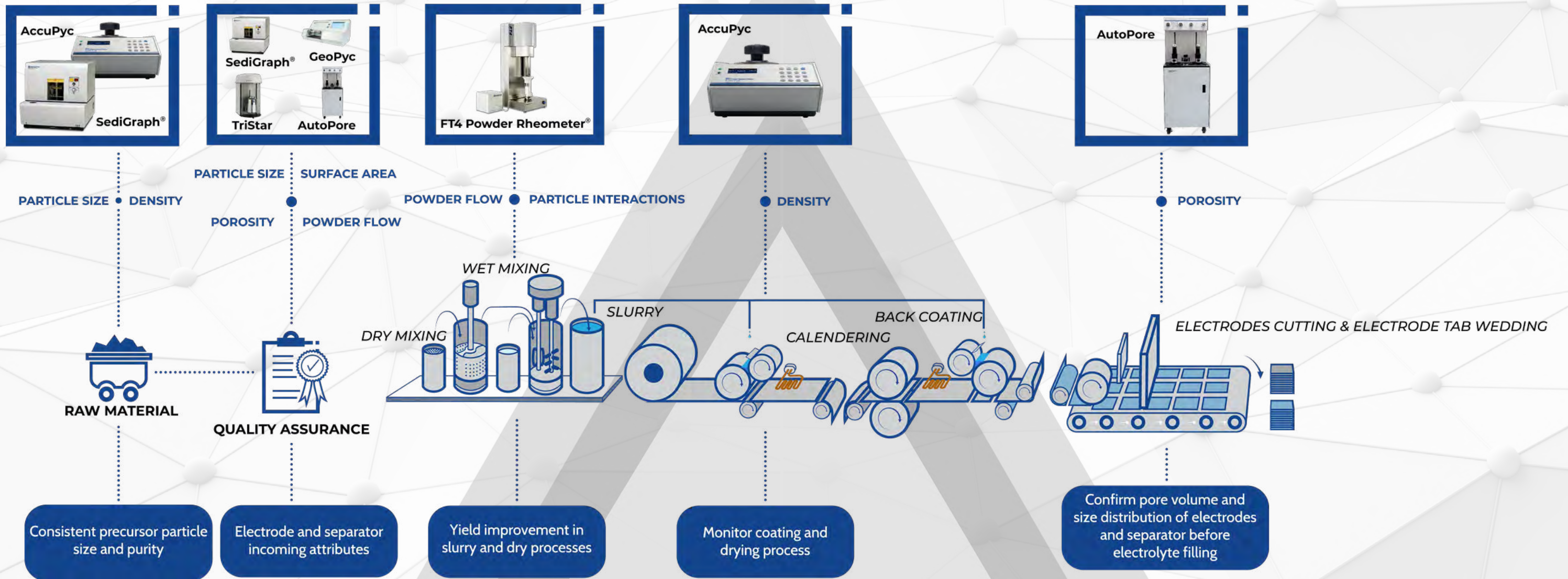
- maximize capacity
- critical for high energy density
- influence coulomb efficiency



SediGraph®



Analytical Equipment for Manufacturing Li-ion Batteries



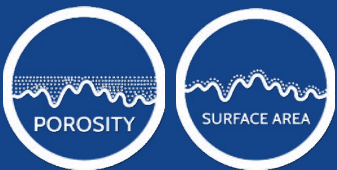


AccuPyc and GeoPyc

The AccuPyc uses Gas Pycnometry and the GeoPyc uses a unique displacement technique to determine the:

- true, absolute, and skeletal density
- apparent volume and density
- envelope volume and density
- bulk volume and density

Combining data from these two techniques enables the determination of the percent porosity and total pore volume.



TriStar, Gemini, ASAP, and 3Flex

Our extensive range of gas adsorption analyzers offer convenient solutions to realize your R&D, quality control, and manufacturing needs.

- Pore size can be measured from 0.3nm to 300nm using a variety of different models
- Water vapor adsorption studies allow the investigation of a material's sensitivity towards water



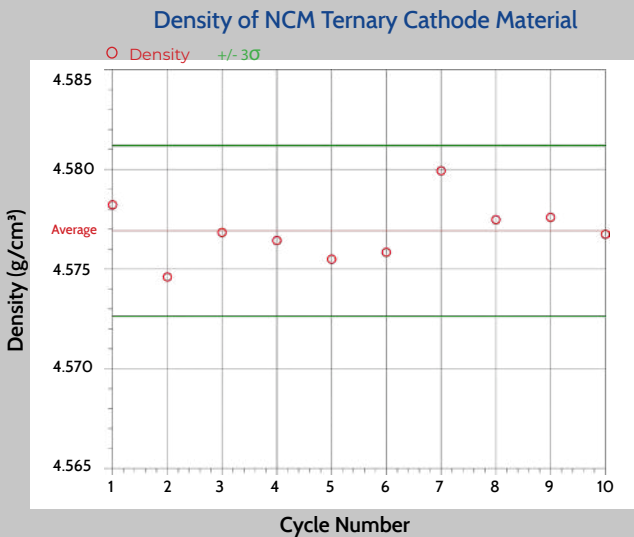
VALUE FOR BATTERY INDUSTRY

- High T.A.P. density of precursors is expected to obtain a high volumetric energy density.
- Monitoring true density of the electrode material ensures stability of the slurry coating and drying process.
- The true density is a good indicator of purity and composition of the cathode which can be used to improve the overall performance of the battery.



VALUE FOR BATTERY INDUSTRY

- Understanding the porosity of the electrode materials is important to guarantee the right ion accessibility and charging speed.
- BET surface area, pore volume and pore size distribution help to optimize your battery components.

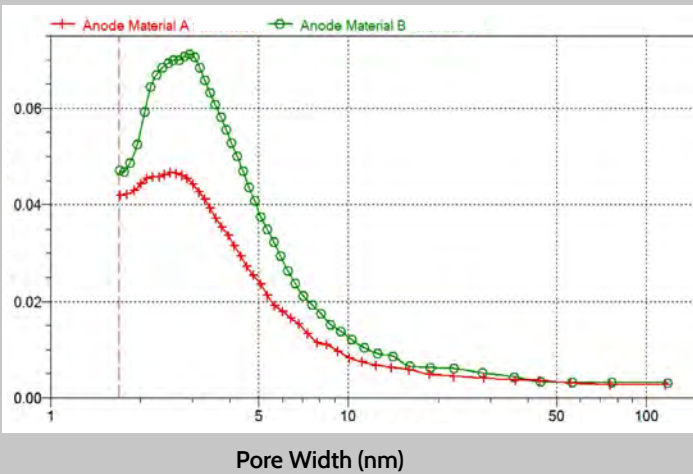
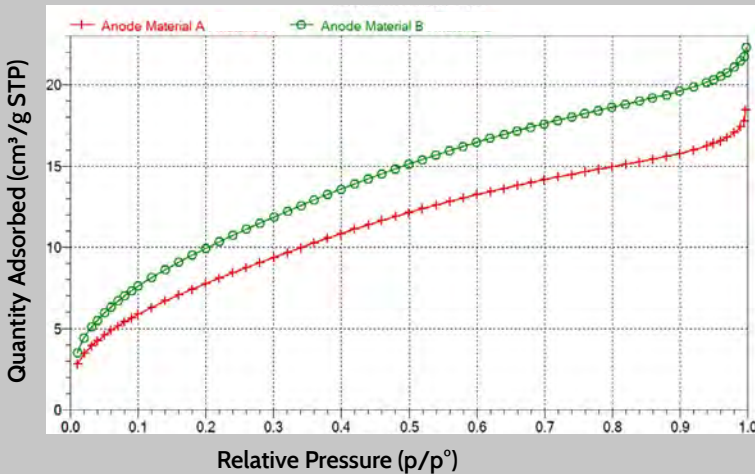


Data Summary

Average: 4.577 g/cm³

Standard Deviation: 0.001 g/cm³

Adsorption Isotherm and Pore Size Distribution for Next Generation Anode Materials A & B





AutoPore

Mercury porosimetry is a uniquely valuable technique which delivers speed, accuracy and the comprehensive characterization of many sample properties:

- pore size, 3nm to 500 μm
- total pore volume
- total pore surface area
- percent porosity
- sample densities (bulk and skeletal)
- particle size



SediGraph[®]

The SediGraph[®] remains the global standard for particle size analysis by sedimentation after five decades, whether in a rugged production environment or a controlled laboratory setting.

- Sedimentation uses well understood physical laws and easy to measure properties that do not require trial and error modeling
- Provides complete sample mass accountability and quantifies the fine content outside the measurement range
- Uses higher material concentration than many other techniques ensuring a representative sample



VALUE FOR BATTERY INDUSTRY

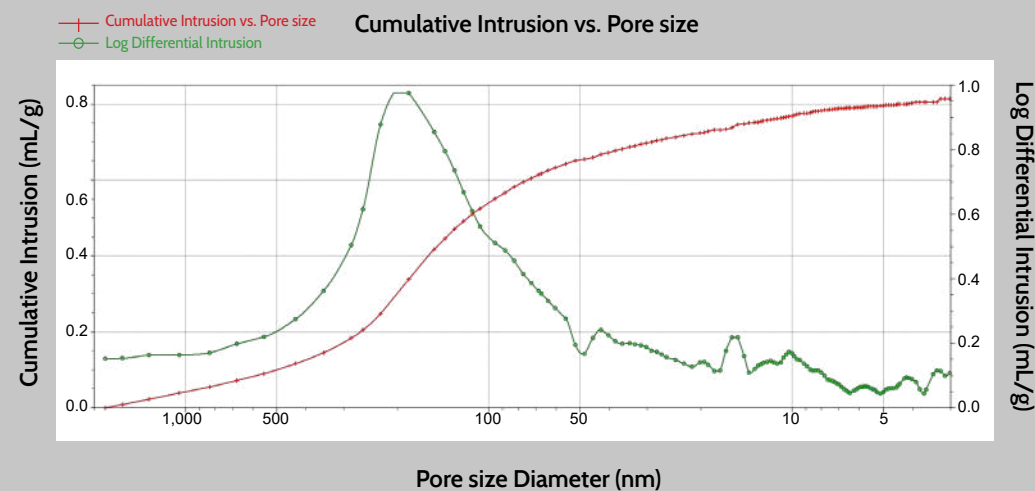
- Study and optimize separator pore size distribution, a key safety consideration.
- Quality control of final electrodes and separator.



VALUE FOR BATTERY INDUSTRY

- The SediGraph is the only instrument that can precisely report weight percent of particles $<0.1\mu\text{m}$
- Industry leader for rough electrode and other precursor materials.
- Optimize particle size ratio of cathode and solid electrolyte to maximize the energy density

Separator Pore Size Distribution



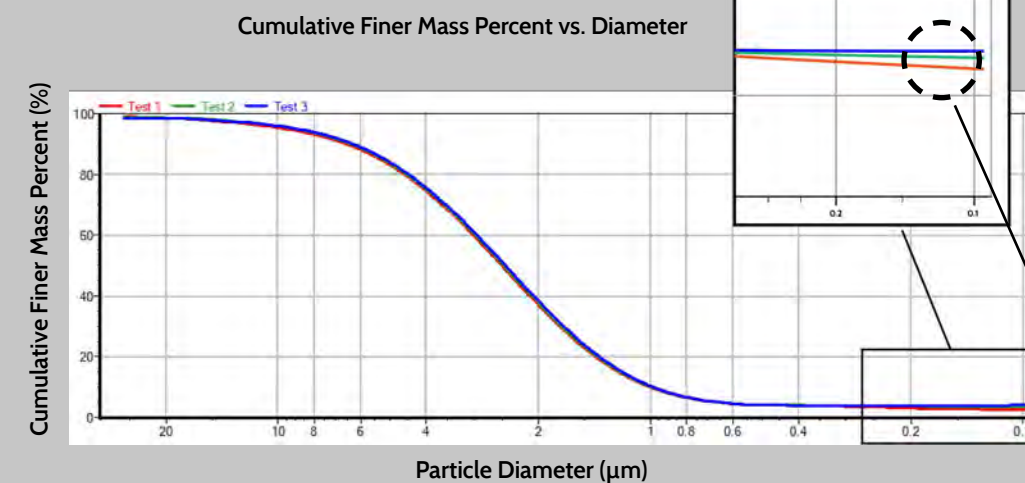
Intrusion Data Summary

Total intrusion volume: 0.813 mL/g

Median pore diameter: 155 nm

Porosity: 53.1%

Solid Electrolyte Sample Material



Particle Size Summary

Mean $3.25 \pm 0.06 \mu\text{m}$

Mode $2.37 \pm 0.08 \mu\text{m}$

Median $2.46 \pm 0.03 \mu\text{m}$

D90 $6.3 \mu\text{m}$

D50 $2.46 \mu\text{m}$

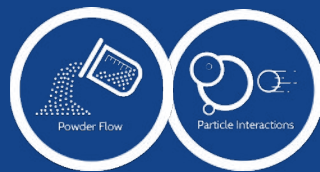
D10 $0.99 \mu\text{m}$

$< 5.0 \mu\text{m}$ 84.0 %

$< 1.0 \mu\text{m}$ 10.3

$< 0.50 \mu\text{m}$ 4.1 %

$< 0.10 \mu\text{m}$ 3.9 %



FT4 Powder Rheometer

MATERIALS CHARACTERIZATION SERVICES

WORLD-CLASS ACCREDITED LABORATORY

The FT4 provides comprehensive flow property characterization of a powder and is now established as a universal powder tester. Optimize manufacturing processes by quantifying a powder's:

- resistance to flow in motion
- shear strength
- shear against the wall
- bulk density
- compressibility
- permeability

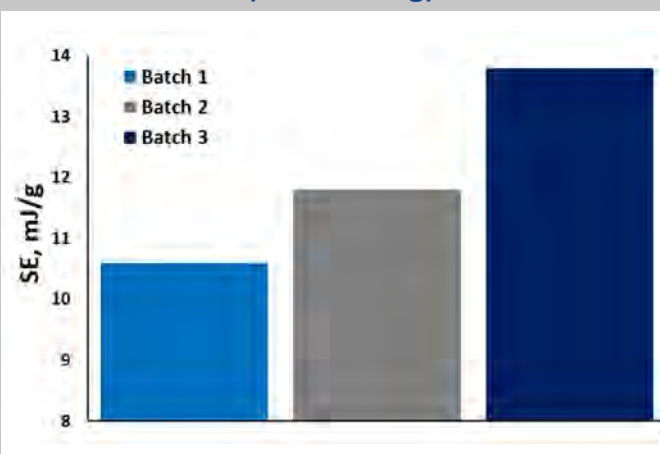


VALUE FOR BATTERY INDUSTRY

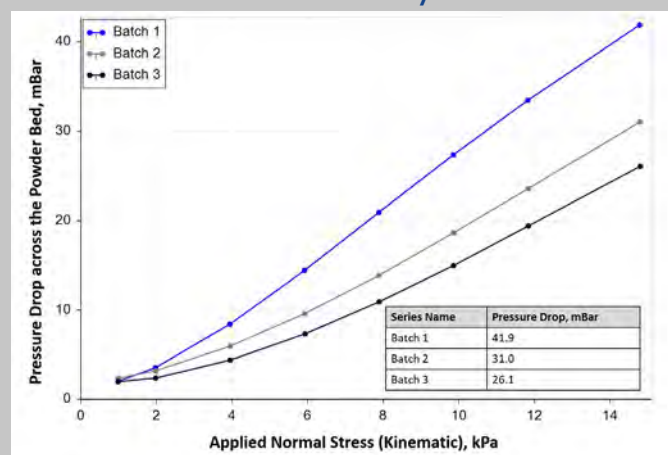
- Understanding a powder's Specific Energy, an indicator of inter-particle friction and mechanical interlocking, can help reduce agglomerates in the electrode slurry.
- Determining and optimizing Permeability, a measure of a powder's ability to release air, can improve slurry dispersion and cavity filling in wet or dry systems.

Optimize LiFePO₄ Cathode Powder for Slurry Preparation

Specific Energy



Permeability



Need to characterize your materials or supplement your current lab's capabilities? Want access to top-of-the-line instruments and expert scientists?

PARTICLE TESTING AUTHORITY

The Micromeritics PTA lab is the leading contract laboratory for the characterization of anodes, cathodes, separators, and solid electrolytes. The same engineers and scientists that develop and support our market-leading technologies are available to help you develop methods, test samples, and analyze the results.

- ISO 17025 accredited and FDA registered.
- Globally recognized scientists.
- Typical turnaround time: 7 business days
- Over 25 analytical techniques.

Contact PTA today to learn how our world-class laboratory can advance the development of your materials for Advanced Batteries.

Micromeritics products are 3rd party tested to conform to the highest level of compliance and safety. Visit micromeritics.com/compliance/ for full details by product.



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