Argonne's Advanced Battery Materials Synthesis and Manufacturing R&D Program

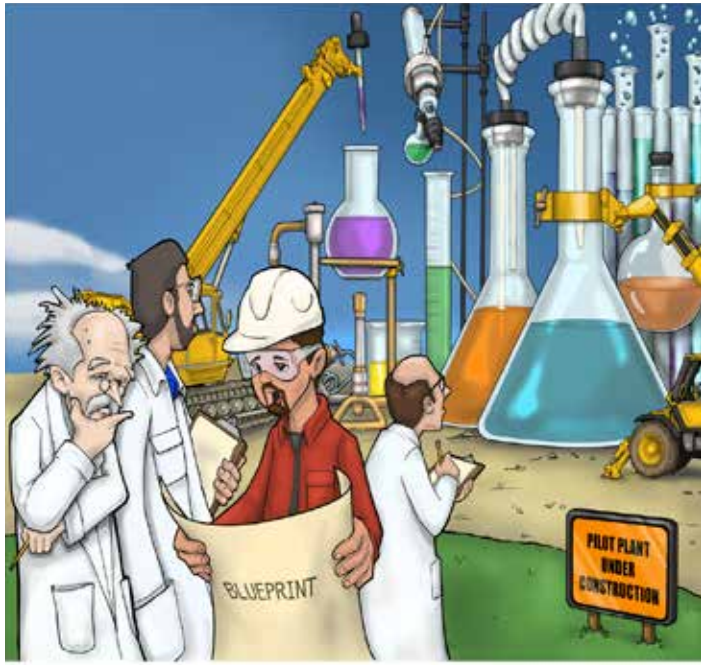
Bridging the Gap Between Research and Commercialization

Argonne NATIONAL LABORATORY

Scale-Up: A Critical Element of Battery R&D

CHALLENGES

Scalable process R&D is essential to support domestic battery manufacturing and to enable the transition of new materials and technology to the market. However, in the battery industry, manufacturers typically don't want to take on the financial risk of process scale-up and development for materials that haven't been validated.



"We've got a few problems with the process scale-up."

Scaling up chemistry may seem like a simple linear process, but that's far from the case. When a small-scale, laboratory-developed process is modified to suit large-scale commercial production, factors like time, temperature, concentration and mixing velocity can all change, and issues not seen on the bench scale may surface.

Most industry requests to validate materials call for quantities of about 10 kg, but battery materials developed in the laboratory for research are usually only made in 1-100 g batch sizes.

BRIDGING THE GAP

The diagram below illustrates the overall battery R&D process. Argonne's Advanced Battery Materials Synthesis and Manufacturing R&D program bridges the gap between discovery and production in the battery manufacturing industry.

Discovery
An Idea in a Creative Mind

CONCEPT VALIDATION	RESEARCH	APPLIED RESEARCH	DEVELOPMENT	ADVANCED DEVELOPMENT
	Scale-up experiments	Lab/prototype cells	Confirm research results	Design initial cell product
Limited exploratory laboratory experiments	Characterize fundamental properties of concept, chemical composition, structure, etc.	Initial map of performance, rate, cycling, temperature, etc.	Establish initial product format	Design and construct unit operations
Establish repeatability of performance	Evaluate size of commercial opportunity	Scale-up of material preparation	Develop unit assembly operations	Scale-up prototype cell fabrication
Is there a market?		Preliminary market scope	Make, test and characterize 5 to 10 cell lots of 100 cells each	Run 3 to 5 sizable pilot line-factory trials
			Construct business plan	Finalize business plan
				Market development
1-3 years	1-3 years	3-4 years	3-5 years	2-4 years
1	2-4	4-10	8-16	12-30
Grams	10-50 g	100 g – 1 kg	1-10 kg	10-100 kg
1	2	5	20	50

TIMING
STAFFING
MATERIALS BATCH
RELATIVE COST INDEX

Production
Battery Manufacturing Industry

* From "Factors Affecting U.S. Production Decisions: Why Are There No Volume Lithium-Ion Battery Manufacturers in the United States?," Ralph Brodd, 2005.

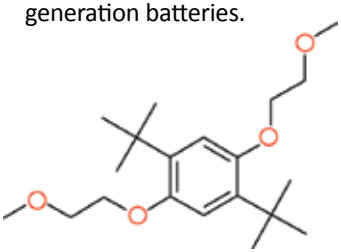
"The United States has continued to lead in developing new technologies and is the major source for new concepts in battery, fuel cell, and other budding technologies supporting the nation's energy and portable communications future. Asian and European companies, however, are developing the manufacturing expertise to commercialize many of these technologies."

– Ralph Brodd *

Argonne's Approach: Getting from Laboratory to Industry

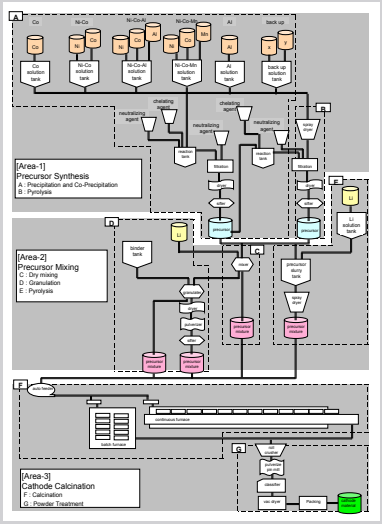
DISCOVERY

Basic research on new molecules and materials designed for electrolytes, electrodes and interfaces is the first step in the development of next-generation batteries.



PROCESS MODELING

To help guide process development, Argonne researchers use proven industrial software programs to create simulations and unit operation models to generate cost estimates and provide a better understanding of process economics.



PROCESS SCALE-UP

Argonne has established battery materials scale-up facilities to foster the development of production-ready processes for electrode and electrolyte materials. These new facilities are equipped to run a wide range of chemical processes and allow researchers to conduct 1-10 kg process scale-up work.

MATERIALS CHARACTERIZATION

A dedicated battery materials characterization lab has been established adjacent to the process scale-up labs. Equipped with a full suite of state-of-the-art analytical instrumentation, this lab helps provide a rapid turnaround for process development and quality assurance testing.

CELL FABRICATION

A climate-controlled Cell Fabrication Facility allows researchers to take Argonne-developed materials and fabricate pouch cells, 18650 cells and electrodes for detailed performance evaluation. This facility gives Argonne the means to rapidly assess novel battery chemistries in industrial standard cell formats.

PERFORMANCE TESTING

At Argonne's Electrochemical Analysis and Diagnostic Laboratory, researchers can test everything from a quarter-sized coin cell to an 800-kilogram automotive battery pack. Battery material performance testing provides information on a battery's life cycle, calendar life and many other factors.

INDUSTRY

Argonne's ultimate goal is to transfer battery innovations to the marketplace. The laboratory has the capabilities to provide industry with tested scalable processes, bulk materials with full quality assurance analysis, performance testing results and finished cells for their own validation testing.

New Facilities Enhance Argonne's Scale-Up Capabilities

Argonne's **Materials Engineering Research Facility** (MERF) supports the laboratory's Advanced Battery Materials Synthesis and Manufacturing R&D program by enabling the development of manufacturing processes for producing advanced battery materials in sufficient quantity for industrial testing.
By bridging the gap between small-scale laboratory research and high-volume battery manufacturing, the MERF is helping to speed the development, validation and ultimate commercialization of advanced battery materials chemistries.

The facility includes high-hazard ("Group H" rated) pilot- and high-bay laboratory spaces and appropriately sized modular process equipment to enable batch and continuous production of the necessary quantities of materials for subsequent validation and/or evaluation in prototypes cells. As an ISO 9001 and ISO 14001 certified laboratory, the MERF adheres to the internationally recognized standards for business practices and environmental management.

While the facility supports Argonne's R&D program in batteries and ultracapacitors, it is also structured as a user facility open to outside organizations, including other national laboratories, universities and industry for the validation of new materials and materials processing.

The Materials Engineering Research Facility (MERF) is located within the existing Building 370.

Process R&D Lab

Process Scale-up Lab

Analytical Lab

High Bay

The Kentucky-Argonne Battery Manufacturing R&D Center is another important component of Argonne's Advanced Battery Materials Synthesis and Manufacturing R&D program. It is the result of a partnership between Argonne, the Commonwealth of Kentucky, the University of Louisville and the University of Kentucky.

The center's goal is to re-establish the United States as a world leader in battery manufacturing technologies through:

- Development of manufacturing processes
- Evaluation of advanced battery materials
- Development of new process equipment
- Development of technical readiness level for military and commercial applications

Scaled-up materials produced at the MERF will be used at the Kentucky-Argonne Battery Manufacturing R&D Center for process design and engineering; bulk materials production and component/prototype manufacturing for evaluation; and limited cell fabrication and testing for quality assurance.

"The ultimate goal of this facility is to help establish a strong and profitable U.S.-based battery industry by helping domestic manufacturers bridge the gap between research and commercialization of advanced batteries for electric vehicles."

– Argonne Director Eric Isaacs

For more information, visit:
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