RESEARCH PROJECT BRIEF

Meeting the Electrical Transformation Through Academic, Government and Private Collaboration

The American Battery Research Group (ABRG) has launched a project in cooperation with the Department of Energy's (DOE) Argonne National Laboratory and the University of Toledo to examine the molecular structure of lead battery expanders, lignosulfonates, which can dramatically improve battery performance. The project is financially supported by five U.S. lead battery industry manufacturers: Clarios, Crown Battery, East Penn Manufacturing, Ecobat, and EnerSys.

Molecular Design of Lead Battery Model Expanders: Lignosulphonate

The purpose of this program is to better understand the atomic structure of lignosulphonate molecules so that they can be improved or substituted with other naturally-derived elements. Understanding the complex interactions between lead, lead sulfate and lignosulfonates is key to guide the design of additive molecules that can promote fast-charging and prolong the lifetime of the battery and thus provide improved service across many applications, including long duration energy storage.

The design of tailored additives used in the negative electrodes of lead batteries can address key performance limitations found in the current state-of-the-art systems: poor material utilization, limited fast charging ability and short cycle life. The lignosulfonate expander additive (LS), a complex organic macromolecule, is known to improve discharge capacity but limit recharging rates. Its undefined structure and the presence of too many and different organic functional groups prevents a clear identification of how this material affects battery performance on an atomic level, in turn making it almost impossible to tailor natural expanders for optimal battery performance.

> "This partnership can help industry meet society's demanding requirements in vital industries like transportation and electric power."
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> — Rep. Marcy Kaptur (OH) U.S. House of Representatives

Overview

In recent years the lead battery industry has seen a resurgence in interest in lead battery basic science research. The industry has worked with Argonne National Laboratory and the Pacific Northwest National laboratory to provide impactful results to lead battery companies who have joined those projects.

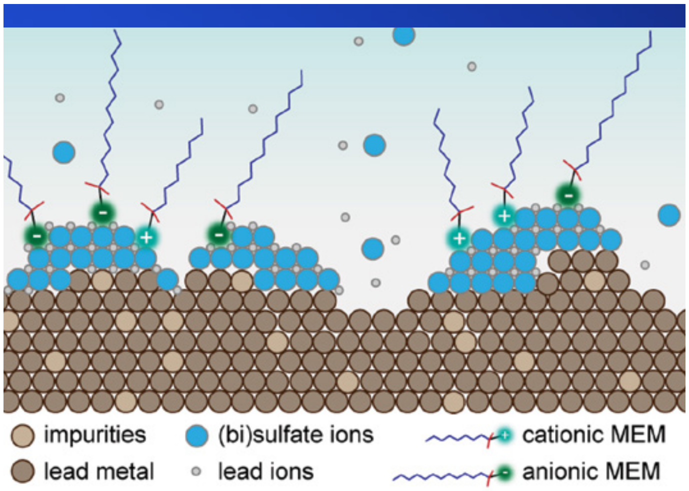
That investment and recognition has opened the door for additional research opportunities, including within the U.S. Department of Energy. In Executive Order 14017 issued February 24, 2021, President Biden directed the Department of Energy and other federal agencies to strengthen America's supply chains for critical products, including batteries. The lead battery industry, with its 160-year-old history of performance and reliability has responded with a project designed to increase the performance of lead batteries, a battery technology that already exists in the U.S. with a track record of reliability and performance. With its domestic infrastructure across 38 states, it has a network of materials, manufacturing and recovery for recycling to help meet the nation's energy needs.

The lead battery industry for many years has known that while lignosulfonate facilitates the flow (or discharge) of power from the battery, it nevertheless has the opposite effect when the battery recharges. Simply put, the battery discharges more efficiently than it can recharge. This limits both fast recharging and overall cycling capability, which in turn limits battery life.

While the performance of lead batteries has dramatically improved over the past 20-30 years, researchers have discovered that there is untapped potential in lead batteries that can contribute to even greater energy density and cycle life.

The key to extending the life of lead batteries is investigating the interaction among materials and the formation of crystals that, if accumulated without proper management, ultimately limit battery life span. During the past three years, the lead battery industry has worked with Argonne and Pacific Northwest National Laboratory to identify several critical battery additives for intensive research, including carbon, barium sulfate and lignosulfonate. Scientists are increasingly intrigued by the underutilized potential of materials that could lead to more efficient performance in lead batteries.

For this new project, UToledo and Argonne will target lignosulfonate, an organic material used in the lead battery's negative plates to maintain the optimum flow of energy from the battery.



Understanding the complex interactions between lead, lead sulfate and lignosulfonates is paramount for guiding the design of advanced additive molecules.

Aerial view Advanced Photon System, Argonne National Laboratory. Credit: DOE

Summary of Work

Scope. The University of Toledo will identify and characterize candidate materials, which in turn will undergo high-level examination at Argonne National Laboratory Material Science Division. It is part of a larger, more comprehensive program for a public-private-academic partnership to carry out basic and applied scientific research.

Work scope for the Additive Modeling Program includes:

1. Investigate how the design of organic molecules with selected structural and ionic/dipolar functional groups can simplify the complexity of LS expanders, enabling an easier evaluation of how different portions of the molecule can affect the negative electrode reactivity.
2. Investigate the synthesis, physico-chemical characterization, and high-precision electrochemical performance Model Expander Molecules (MEM) to provide insights on the nature of the organic molecule interactions with both lead ions and (bi)sulfate species that are inherently part of the negative electrode charge/discharge mechanism.
3. Explore anionic, cationic, or dipolar head groups bound to aliphatic, alkyl-aryl or polyethyleneglycol derived long chain structures to define a rich parameter space to which trends in negative electrode reactivity can be related.
4. Recommend design rules for expander materials to be used in advanced lead batteries.

Duration. The program is structured over two years. The scope of work is divided into five milestones, each comprised of subtasks to better delineate project execution and progress.

1. Synthesis of model lignosulphonate subunit compounds
2. Develop suite of *ex situ* and *in situ* analytical and physico-chemical characterization tools
3. High-precision electrochemical evaluation of lead surface charge/discharge reactivity
4. Evaluate chemical and electrochemical stability of most promising model expander molecules (MEMs)
5. Evaluation of targeted promising MEMs by industrial partners in real-world batteries

Nuclear Magnetic Resonance Facility at the University of Toledo.

Partners

- Department of Energy's Argonne National Laboratory Material Science Division
- University of Toledo Department of Chemistry and Biochemistry
- Clarios, Milwaukee, Wisconsin
- Crown Battery, Fremont, Ohio
- East Penn Manufacturing, Lyon Station, Pennsylvania
- Ecobat, Dallas, Texas
- EnerSys, Reading, Pennsylvania

American Battery Research Group (ABRG)

The ARBG, comprised of U.S. lead battery manufacturers and suppliers, was created to identify areas of scientific research to further the performance of lead batteries to meet U.S. energy storage goals. It operates under the auspices of Battery Council International.

Links

- News Release

Contact

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