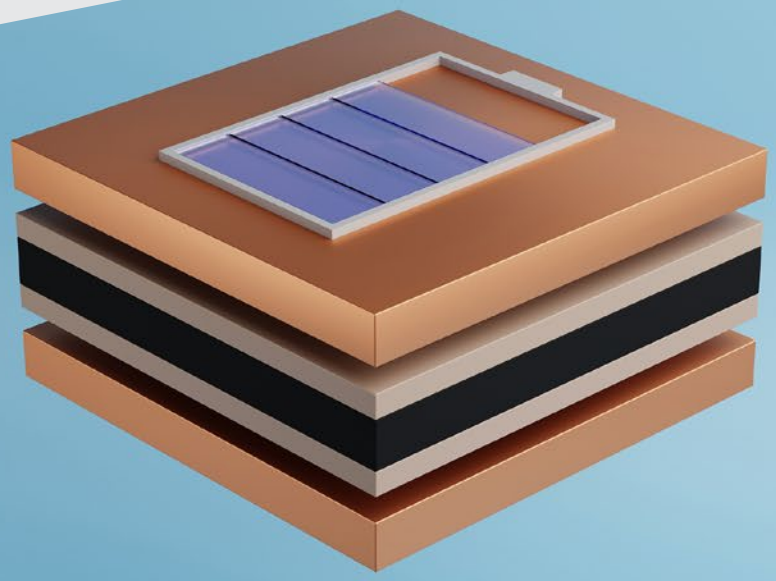
Pacific Northwest
NATIONAL LABORATORY



Pacific Northwest National Laboratory's air-stable sulfide solid-state electrolyte coating and film significantly improve material handling for battery cell manufacturers and greatly reduce associated processing costs.

THIN AND FLEXIBLE, AIR-STABLE SULFIDE SOLID-STATE ELECTROLYTES

Achieving superior energy density and high ionic conductivity

PROTECTIVE COATING AND FLEXIBLE BINDER

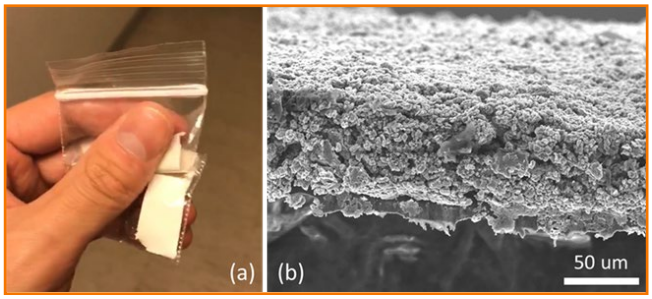
Researchers from Pacific Northwest National Laboratory (PNNL) have developed two innovations toward large-scale production of promising sulfide-based solid-state electrolytes (SSEs). A moisture-repellent coating and ultrathin polymeric binder provide the stability, flexibility, and high ionic conductivity needed for batteries used in electric vehicles and electronic devices.

REDUCING GAS BUILDUP

Conventional sulfide-based SSEs suffer from poor stability when exposed to air and can generate toxic hydrogen sulfide gas during the manufacturing process. PNNL's innovations overcome these drawbacks, supporting the scalable synthesis, storage, transfer, and processing of SSEs and fabrication of solid-state lithium batteries under ambient conditions.

TECHNOLOGY FEATURES

- High ionic conductivity provides all-solid-state battery charge/discharge rates similar to the best lithium-ion batteries under ambient temperatures but with added safety.
- High flexibility and structural integrity can accommodate or adapt to battery deformations or custom manufacturing shapes.
- High stability simplifies manufacturing and eliminates the need for capital-intense processing in a controlled environment.



PNNL's air-stable SSE film is produced in rolls (a). A scanning electron microscope image (b) shows the film layers and polymeric binder fiber that provide both stability and flflexibility.

A COMPATIBLE PAIRING

In the battle to conquer safety issues associated with lithium-ion batteries, sulfide-based SSEs possess highly favorable traits, such as high ionic conductivity, good electrode contact, and processing capability at low temperatures. However, sulfide-based SSEs also suffer from poor stability when exposed to air and generate toxic hydrogen sulfide gas during manufacturing.

PNNL's reversible surface protection agent for SSEs repels moisture. This attribute greatly reduces the reaction potential between sulfide and water in the air, improving SSE stability under ambient processing conditions. The air-stable coating could be simply removed from the SSE particle surface—through evaporation or washing with other solvents, for example—without sacrificing ionic conductivity.

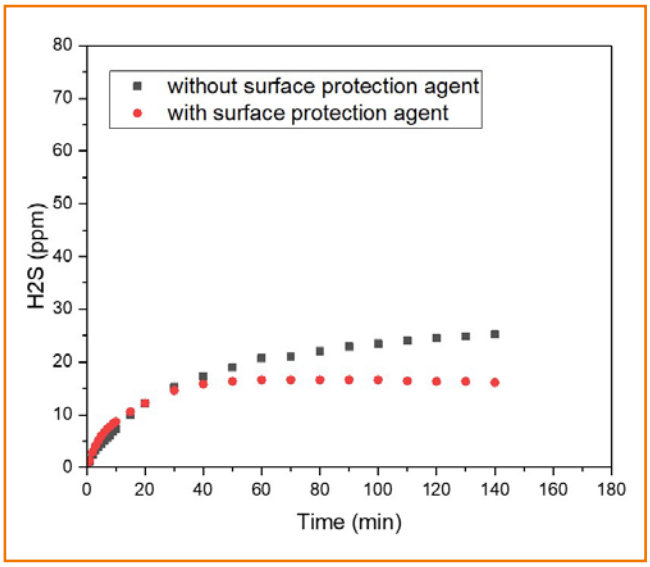
In addition, sulfide-based SSEs, with or without the protective coating, can pair with PNNL's new, chemically compatible polymeric binder to form an ultrathin (< 60 microns), flexible film, about the width of a human hair. The binder assures uniform distribution and stability of the SSEs throughout the battery electrodes, and the ultrathin form provides the high structural integrity and flexibility needed for the SSE layers to adapt to any deformations during battery cell operation. The key is to achieve just enough contact between the binder and SSE particles to maintain both a flexible film and high ionic conductivity.

DIFFERENTIATORS/COMPETITIVE COMPARISON

A competing, patented process for flexible polymer-based SSE films using lithium salts suffers from low ionic conductivity at room temperature and flammability issues associated with the binding polymers. PNNL's air-stable sulfide SSE coating and film significantly improve material handling for the cell manufacturer and greatly reduce associated processing costs.

INDUSTRY APPLICATIONS

Air-stable and ultrathin sulfide SSEs show great promise for improving the manufacturing of all-solid-state batteries, with superior energy density and high ionic conductivity for electric vehicles and electronic devices. PNNL's novel SSE development strategy could also be applicable to other moisture-sensitive lithium-ion conductors, such as sulfides and oxides, and active electrode materials.



In laboratory tests, PNNL's reversible SSE coating limited hydrogen sulfide gas generation to less than 15 ppm over two hours under ambient processing conditions.

AVAILABLE FOR LICENSING

PNNL's reversible air-stable coating and compatible ultrathin film enable large-scale production of desirable sulfide-based SSEs for lithium-ion batteries. The technology is available for licensing in all fields. View all of PNNL's technologies available for licensing at pnnl.gov/available-technologies.

LET'S CONNECT

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