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LITHIUM-SULFUR BATTERIES: LIGHT AND SAFE?

Lithium-sulfur technology (Li-S) promises an increase in energy density; however, many essential cell properties demand further investigation. In the "SepaLiS" project, Fraunhofer IWS worked with partners to develop and evaluate Li-S prototype cells. In initial safety tests, another advantage of lithium-sulfur cell chemistry emerged.

The expectations to be met by future energy storage for electric cars are ambitious and complex. The researchers have to focus on the crucial criteria, such as range, quick chargeability, lifetime, costs, and – most of all – safety. The scientists can evaluate new cell chemistry in terms of these demands only if it is possible to fabricate suitable prototype cells in a reproducible manner. As a rule, tests of button cells or other laboratory cells do not provide any insight into the properties in the case of real application. As a result, there is a clear gap between academic research results and the need for industry-relevant data on future battery systems.

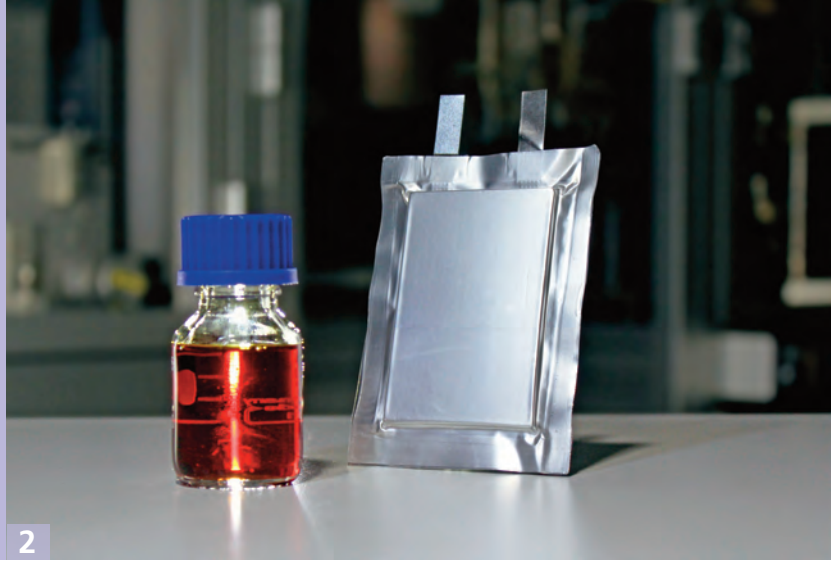
Fraunhofer IWS brings the cell chemistry of the next generation into prototype manufacturing

This is where Fraunhofer IWS comes in with its Center for Battery Research. Its labs, the institute has established the equipment and techniques required to implement the overall process chain – from material engineering to the fabrication of the battery cells. Coating techniques for electrode fabrication, tailoring by means of laser cutting, automated assembling of cell stacks, and bonding by laser welding are essential elements of this chain. Within the scope of the "SepaLiS" project funded by the Federal Ministry for Education and Research BMBF, a consortium consisting of four industrial enterprises and two Fraunhofer Institutes has now developed a cell design that will be implemented through the IWS process line for providing test series of prototype cells. IWS researchers make use of coated separators, engineer new cathodes, and fabricate these components using the roll-to-roll technology. Another key component is the patented electrolyte system by means of which the characteristics of Li-S cells can be redefined. Using solvents based on sulfones and fluorinated ethers, the IWS electrolyte enhances Li-S cells in terms of lifetime, energy density, and safety. Prototype cells with this electrolyte composition have already achieved more than 100 charging and discharging cycles with only minor losses in capacitance (< 10 percent). Ion transport in this electrolyte system also functions in strongly compacted cathodes so that it is possible to build compact cells with high volumetric energy density that achieve more than 400 watt-hours per liter.

How safe are lithium-sulfur cells?

Only a few facts are known about the safety of Li-S cells. While some well-known battery experts warn about the risks of using Li-metal anodes, developers of Li-S technology advertise safe cell chemistry. Fraunhofer IWS has now fabricated Li-S prototype cells of 3.5 ampere-hours capacity and allowed them to be evaluated by its industrial project partner for safety. The partner subjected the cells to standard tests that are necessary for approval in the automotive industry. The temperature characteristics are monitored, and visual modifications are recorded by a camera. The tests include:

– Overcharging (the cell is charged to 200 percent of the voltage limit not to be exceeded during charging)
– External short circuit (the cell is grounded at low impedance)



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- Simulated internal short circuit (the cell is penetrated by means of a ceramic nail)
- Artificial overheating (the cell is heated to 150 degrees centigrade by means of a defined ramp)

The results were better than expected. The Li-S cells achieved a "hazard level" (HL) less than or equal to three. That means that the cell opens, and electrolytes evaporate under specific conditions, but in no case did the tests result in thermal runaway or even in explosion. Cells of similar design based on lithium ions may explode just by overcharging or in case of a short circuit. A temperature of more than 180 degrees centigrate is critical in itself for Li-S cells: at this temperature metallic lithium melts, which can result in a vigorous combustion of the cell. Fortunately, the team did not reach this temperature under the standardized test conditions, so that it can certify the Li-S cells are altogether very safe.

Summary and Outlook

The results showed increased safety as an essential feature of Li-S technology. The new electrolyte made by the IWS also contributes to achieving high energy density values up to 400 watt-hours per liter. This result clearly outstrips any previously measured results for Li-S cells. With these intermediate results, the Fraunhofer IWS team and its "SepaLiS" project partners embarked upon the next phase, aimed at the automated fabrication of large-sized pouch cells that will then undergo additional tests. They aim to refine the electrolyte and the new membrane technology to enhance the cells' cycle stability.

1 Equipment for automated separation of electrode films by means of laser cutting.

2 New electrolyte system and lithium-sulfur cell prototype.

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