Next generation lithium-sulfur battery solves the loss of sulfur problem

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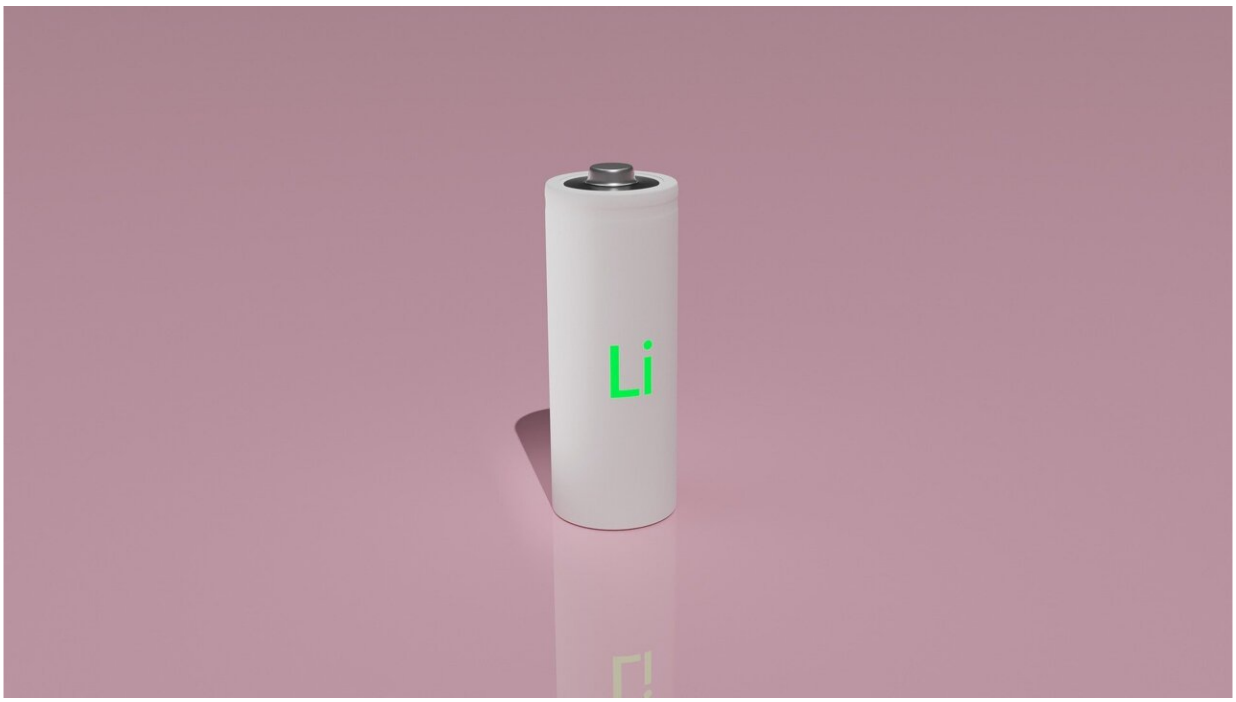

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The research outcome of Korea Electrotechnology Research Institute (KERI) related to "low-cost and flexible high-energy-density lithium-sulfur batteries" was recently published on the front cover of the journal *Small*.

Unlike the existing lithium-ion batteries (LIBs) that use nickel, cobalt, and other expensive rare-earth elements as cathode materials, the lithium-sulfur battery applied sulfur, one of the most abundant elements, contributing to reducing its manufacturing cost significantly. The lithium-sulfur battery is considered as a promising candidate for the next-generation battery as it can theoretically exhibit a specific energy density that is approximately 5 times higher than that of LIBs.

However, there are several challenges to overcome for the commercialization of lithium-sulfur battery. When lithium meets sulfur during charge/discharge process, so-called "lithium polysulfides" are generated as an intermediate product. Owing to its high solubility, it leads to the shuttle phenomena of dissolved lithium polysulfides, resulting in the loss of cathode materials with repeated charge/discharge. Namely, it means the loss of sulfur as it continues to dissolved in the electrolyte. Thus, the polysulfide shuttle was considered as the biggest obstacle to the commercialization of the lithium-sulfur battery as this problem is directly linked to the longevity and safety degradation of battery.

In this regard, KERI applied activated carbon and phosphorus (P). Activated carbon fibers with micropores are largely used in various types of filters and bleaches thanks to its high absorption property. The research team applied activated carbon as a coating material of separator to capture lithium polysulfides physically generated during the charge/discharge cycle. Also, the research team applied highly absorbent P to the carbon material for chemical capturing. This multimodal capturing approach contributed to preventing the performance degradation of lithium-sulfur battery due to the shuttle effect of lithium polysulfides.

Furthermore, the research team successfully increased the usability of the Li-S battery by strengthening its flexibility. The team applied carbon nanotube materials with high conductivity, intensity, and flexibility to the sulfur cathode to eliminate heavy current collector (to increase energy density), while securing the durability with bending property.

The lithium-sulfur battery developed by KERI through the process listed above is considered to have the world's highest energy density of 400Wh/kg. Chances of commercialization of lithium-sulfur battery are high with the combination of its high energy density, performance safety (longevity), flexibility (duration) with the existing benefits including lightweight and low cost. Specifically, it is expected that lithium-sulfur batteries will be largely used in the area of future aviation mobility that requires lightweight and long duration including aerospace, flying car, drone, etc.

"The lithium-sulfur battery is an essential technology for rare-earth elements and resource scarce countries like Korea as it uses abundant and inexpensive sulfur and carbon materials," said Dr. Jun-Woo Park, who led the KERI research team. He also said, "we are planning to combine this research outcome with the 'large scale synthesis of solid electrolyte' technology developed and owned by KERI to secure the original technology for the next-generation solid-state lithium-sulfur battery."

More information: Seong-Chan Jo et al, Multimodal Capturing of Polysulfides by Phosphorus-Doped Carbon Composites for Flexible High-Energy-Density Lithium–Sulfur Batteries, *Small* (2022). DOI: 10.1002/smll.202200326

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