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Professor Jaeyoung Lee's team develops a lightweight and long-lasting lithium-sulfur battery

□ GIST (Gwangju Institute of Science and Technology, President Kiseon Kim) School of Earth Science and Environmental Engineering Professor Jaeyoung Lee improved the performance and durability of lithium-sulfur batteries*, which are attracting attention as next-generation energy storage technology.

> * lithium-sulfur batteries: Lithium-sulfur batteries are the closest technology to commercialization among current next-generation batteries, and the energy density of the unit weight reaches up to 2,100 Wh/kg, making it an ultra-high-capacity next-generation battery with a theoretical capacity of 5.4 times that of a lithium-ion battery.

◦ The research team introduced cobalt oxalate* as an electrochemical catalyst for the first time at the anode interface of a lithium-sulfur battery and succeeded in identifying the electrochemical catalyst reaction during the charging and discharging process.

> * cobalt oxalates: As an inorganic compound with the formula of CoC_2O_4, it is mainly used in a wide range of industries to make other substances including cobalt. In particular, it is a material that is frequently used in the field of recycling anode materials such as $LiCoO_2$ in waste lithium ion batteries.

- Theoretically, lithium-sulfur batteries not only have five times more energy density than conventional lithium-ion batteries, but they are also attracting attention as next-generation batteries to replace lithium-ion batteries because they are economical and eco-friendly. Competition for development is fierce in countries around the world as it can be used not only for medium and large energy storage devices such as electric vehicles but also for portable electronic devices and ultra-light and ultra-small special equipment. However, low life expectancy due to the non-conductive properties of sulfur and the elution of lithium polysulfides* generated during the charging and discharging process act as a major obstacle to commercialization.

  * polysulfides: Solid sulfur (S_8) is generated from the positive electrode of a lithium-sulfur battery through electrochemical charging and discharging. At this time, polysulfide (Li_2S_x, $2<x<8$), an intermediate product (liquid), is eluted into the organic electrolyte and inside the cell. It is the main cause of long-term performance decrease by causing electrolyte contamination and self-discharge of the lithium anode, which is the main cause of long-term performance decline.

  - Recently, catalyst research has been underway to improve the performance of lithium-sulfur batteries, but to improve the performance more efficiently, high-efficiency conversion of sulfur, which has low production costs and is non-conductive, is needed. There is a lack of research to identify electrochemical reaction mechanisms that enable this transformation.

- The research team synthesized cobalt oxalate as an electrochemical oxidation/ reduction catalyst using a very simple chemical precipitation method to produce gram units and applied it to the positive electrode of a lithium sulfur battery.

  - The cobalt oxalate electrochemical catalyst-based anodes was able to minimize the self-discharge generated by the lithium polysulfide moving inside the cell by absorbing the generated lithium polysulfide on the catalyst and the surface of the positive electrode. In addition, it was confirmed that cell performance continued without performance degradation due to self-discharge even if the battery was left for about a week at about 1.5 times the level of conventional lithium-sulfur batteries.

- Professor Jaeyoung Lee said, "The research results are most significant in securing capacity improvement and durability of lithium-sulfur batteries, which can implement high energy density at low cost through electrochemical catalyst reactions. Subsequent research is expected to contribute greatly to the development of next-generation energy storage technologies by gradually improving the durability of lithium-sulfur batteries."

- This research was conducted by GIST Professor Jaeyoung Lee with support from the GIST Research Institute (GRI) and was published as the cover paper on January 19, 2021, in *ChemSusChem*, a world-renowned academic journal in the field of green technology and sustainable energy.

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