Cheaper positive electrode material improves all-solid-state sodium batteries

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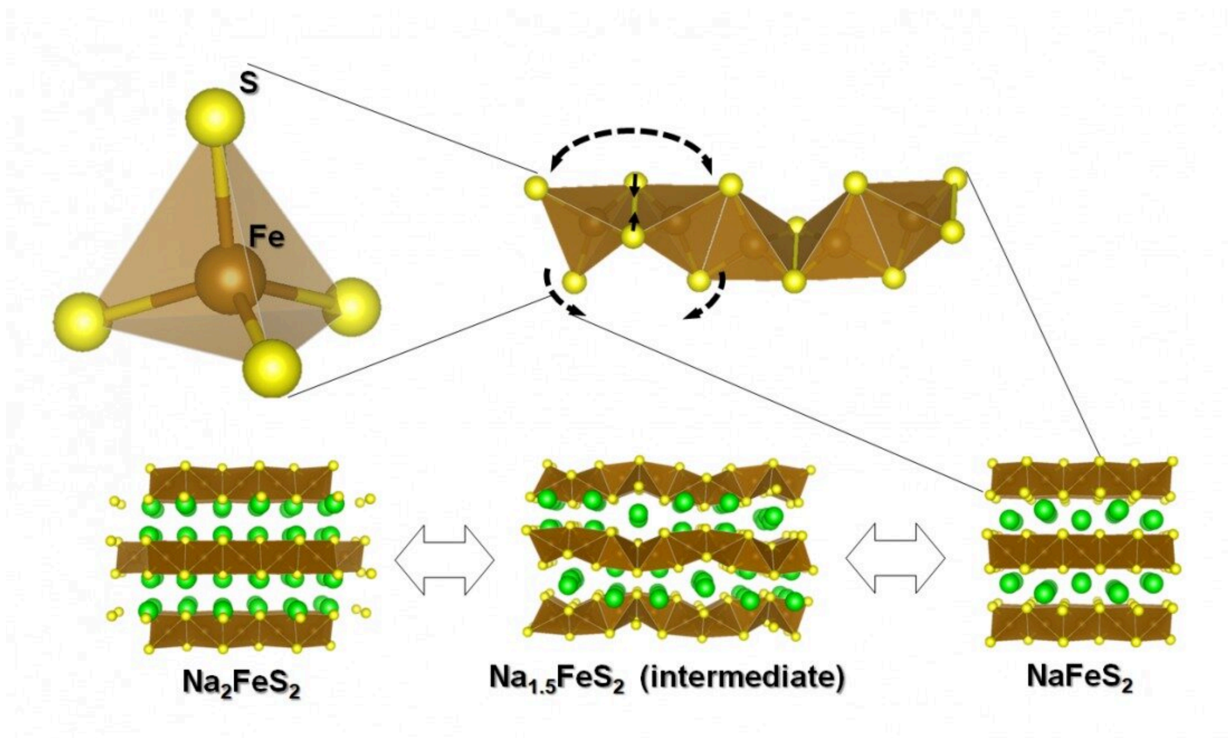

Crystal structures of the new Na_2FeS_2 positive electrode material. Top left: an iron atom sits at the center of a tetrahedron (brown), surrounded by four sulfur atoms (yellow). Top right: multiple tetrahedra can be combined to form long chains, which can lie parallel to one another. Bottom: sodium atoms (green) enter or leave the tetrahedra, during oxidation and reduction, in a highly reversible way to charge or discharge the battery, while keeping the structure intact. Credit: Atsushi Sakuda, OMU

Osaka Metropolitan University scientists have successfully developed a new positive electrode material Na_2FeS_2, consisting of sodium, iron, and sulfur. During testing, batteries using the Na_2FeS_2 positive electrode had a high energy storage capacity and could be charged and discharged for more than 300 cycles. Because the Na_2FeS_2 is made of abundant inexpensive elements, it is expected to be used in all-solid-state sodium batteries with higher capacity and lower costs.

The demand for high energy density rechargeable batteries, such as lithium-ion batteries, increases every year, as society shifts toward becoming carbon neutral. Sodium-ion batteries—which have a resource advantage over lithium-ion batteries—are attracting more attention, as cheap new high-performance materials continue to be developed.

A research group led by Associate Professor Atsushi Sakuda, President Masahiro Tatsumisago, and Professor Akitoshi Hayashi, at the Graduate School of Engineering, Osaka Metropolitan University, has successfully developed a new positive electrode, made of Na_2FeS_2, for all-solid-state sodium batteries. The batteries have a high energy storage capacity, high reversibility and use inexpensive elements that are readily available.

Furthermore, the batteries using the Na_2FeS_2 as a positive electrode can be charged and discharged for more than 300 cycles, due to the unique crystal structure of the Na_2FeS_2 that gives the electrode a long lifespan. Most high-capacity metal sulfide electrodes rely on conversion-type reactions, during which large rearrangements—during charging and discharging—are associated with inhomogeneous reactions and degradation. The Na_2FeS_2, on the other hand, achieves a high degree of reversibility during charging and discharging, by undergoing insertion-type reactions, which allow the electrode to retain its crystal structure over many cycles.

"The new Na_2FeS_2 positive electrodes are well balanced in terms of materials, cost, and lifetime; we expect them to be put to practical use in all-solid-state sodium batteries," Professor Sakuda concluded. "In the future, we will continue our research to develop cheaper all-solid-state sodium batteries with even higher performance, by examining high input and output for rapid recharging, as well as making and testing of superior anode materials."

More information: Akira Nasu et al, Iron Sulfide Na2FeS2 as Positive Electrode Material with High Capacity and Reversibility Derived from Anion–Cation Redox in All-Solid-State Sodium Batteries, *Small* (2022). DOI: 10.1002/smll.202203383

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