A new electrolyte that increases the stability of high-voltage sodium-ion batteries

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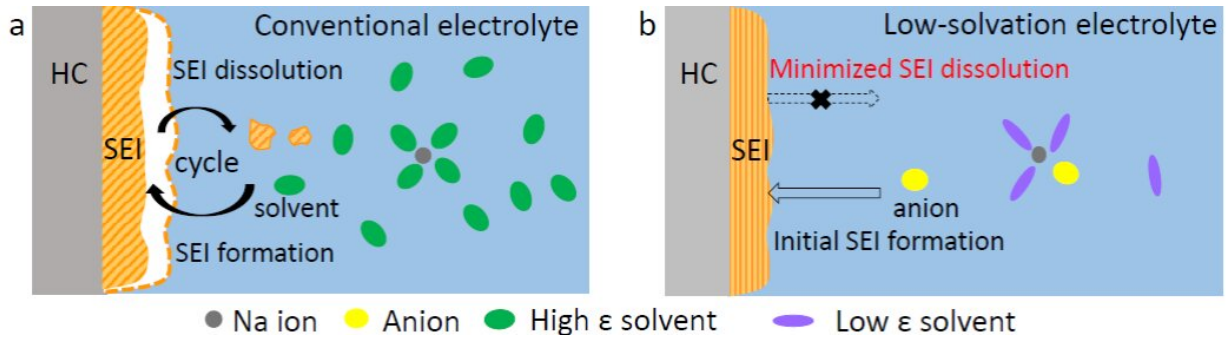

The new electrolyte design principles to suppress the SEI dissolution for highly stable high-voltage sodium-ion batteries introduced by the researchers. a, In the conventional electrolyte, SEI dissolution leads to continuous side reactions and irreversible capacity loss. b. In the low-solvation electrolyte, SEI dissolution is suppressed and the cycle life of batteries can be improved. Credit: Jin et al.

In years to come, sodium-ion batteries (NIBs) could potentially be a great alternative to current energy storage systems. Despite their advantages, including the abundance of sodium and a potentially long cycle life, these sodium-based batteries are often less stable than lithium-based batteries, due to the instability of the solid-electrolyte interphase (SEI), a passivation layer that forms on electrode surfaces after repeated battery operation cycles.

Past studies have showed that in NIBs with a high voltage cathode, the

SEI dissolves more rapidly than that in lithium-ion batteries (LIBs). This causes a series of side reactions, as well as the rapid depletion of the electrolyte and an irreversible loss of capacity, dramatically decreasing the stability and performance of NIBs.

Researchers at the Pacific Northwest National Laboratory have recently developed a new electrolyte that lowers the solvation ability of the SEI on the anode of NIBs batteries, while also forming a stable protective layer to protect the cathode. This electrolyte, introduced in a paper published in *Nature Energy*, could enable the development of high-voltage sodium-ion batteries that are both stable and reliable.

"Our recent paper is about a novel electrolyte that can stabilize the anode in a high voltage (4.2V) sodium ion battery and extent its cycle life," Ji-Guang Zhang, one of the researchers who carried out the study, told TechXplore. "Existing electrolytes typically lead to a short cycle life when used at more than 4V. The primary objective of our work was to allow sodium ion batteries to operate at higher voltage and increase its energy density."

For an NIB to retain its stability over time, the anode (i.e., negatively charged electrode in a battery) inside it requires a protection layer, known as the SEI, with a long lifecycle. If this layer is dissolved while a battery is operating, as observed in past studies, the battery's performance will decrease dramatically. To overcome the limitations of previously developed NIBs, Zhang and his colleagues thus set out to design a new electrolyte that would extend the lifecycle of SEIs.

"Our new electrolyte suppresses the dissolution of the anode's protection layer," Zhang explained. "The electrolyte is made of a more stable salt (sodium bis(fluorosulfonyl)imide (NaFSI)) and a solvent with a lower dielectric constant. Unlike the conventional electrolytes that forms a protection layer which is rich in organic components and easy to

dissolve, the new electrolyte leads to the formation of a protection layer that is rich in inorganic components, so it's more stable during cycling and storage."

The researchers tested their electrolyte in an HC||NaNMC full cell and found that it attained remarkable results. Specifically, the cell could retain over 90% of its capacity after 300 cycles when charged to 4.2 V. These findings suggest that the electrolyte could potentially enable production of more stable and better performing sodium-based energy storage solutions.

"We successfully reduced the solvability of the anode protection layer and therefore enabled the long-term operation of high voltage sodium ion batteries," Zhang added. "In our next studies, we plan to further increase the operation voltage of sodium-based batteries and improve their cycle life."

More information: Yan Jin et al, Low-solvation electrolytes for high-voltage sodium-ion batteries, *Nature Energy* (2022). DOI: 10.1038/s41560-022-01055-0