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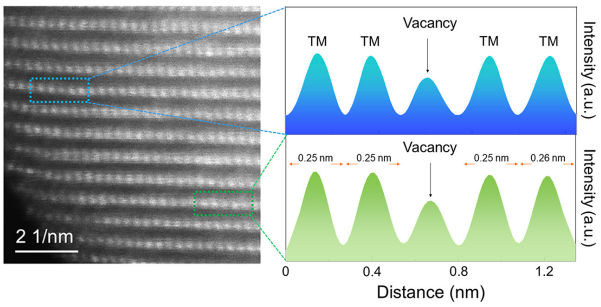
Introducing vacancies and adding titanium to the transition metal layer suppresses phase changes, enables stable reactions



Lithium-ion batteries are the most used energy storage material but are limited in supply because of the scarcity of their raw materials. In contrast, sodium-ion batteries make use of resources abundant on Earth.

However, Na-ion batteries experience large volume and crystal structure changes during operation. They also have a lower voltage and energy density. To overcome these problems, the batteries require a cathode material that enhances efficiency and structural stability.

Lee et al. improved the structural stability of a layered Na-ion battery through vacancy substitution and heterogeneous element doping in the transition metal layer.

In layered cathode materials, it is common to dope the transition metal layer for better electrochemical performance. Introducing the vacancy means that the ratio of metals to oxygen is less than one. This induces an anion redox reaction and suppresses phase changes.

“Furthermore, the introduction of titanium improves structural stability and enables the stable anion redox reaction with a fixed oxidation state and strong bonding with oxygen,” said author Sangyeop Lee. “Through the synergy of vacancy and titanium, we made efforts to develop an anion redox based cathode material that can react stably.”

The structural changes were confirmed with X-ray diffraction analysis. In cathodes with the vacancy, the phase change that normally occurs was not present. But the titanium doping played a key role: without it, the material containing only vacancies could not retain its differential capacity versus voltage profile.

The researchers plan to continue developing Na-ion cathode materials with improved electrochemical performance.

Source: “High-energy P2-type Na-layered oxide cathode with sequentially occurred anionic redox and suppressed phase transition,” by Sangyeop Lee, Jungmin Kang, Min-kyung Cho, Hyunyoung Park, Wonseok Ko, Yongseok Lee, Jinho Ahn, Seokjin Lee, Eunji Sim, Kyuwook Ihm, Jihyun Hong, Hyungsub Kim, and Jongsoon Kim, *Applied Physics Reviews* (2022). The article can be accessed at https://doi.org/10.1063/5.0100108.