

Design to improve material properties of sodium-ion batteries

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Sodium-ion batteries have shown great promise for large-scale storage of renewable energy.

In collaboration with the Institute of Physics at the Chinese Academy of Sciences, ANSTO researchers have manipulated the electrochemical properties of a material that could improve the capacity and life of sodium-ion batteries.

The exploding market of hand-held electronic devices powered by

[lithium batteries](#) is raising the cost of lithium raw materials to the extent that providers of large-scale grid energy storage solutions are looking for other battery solutions.

Sodium-ion batteries that operate at room temperature have shown great promise as a cheaper alternative because sodium is one of the most abundant elements on earth.

Although the concept of rechargeable [sodium-ion batteries](#) for energy storage dates back to the 1980s, progress has been stalled by the need to increase energy density and rate performance, lengthen the cycle life and find better [electrode materials](#).

In a recent *Nature Communications* paper, researchers at ANSTO and the Institute of Physics at the Chinese Academy of Sciences in Beijing, proposed a way to improve the properties of a class of electrode materials to be used in sodium-ion (Na^+) batteries by manipulating their electronic structure.

One of the most promising types of crystal structure, the so called "P2-type", consists of layers of Na^+ ions sandwiched between transition metal oxide slabs.

The structure has some attractive features such as high mobility of Na^+ ions and a robust framework but its application has been hindered by the formation of undesirable sodium-ordered superstructures during electrochemical cycling.

"The connection between sodium-ion ordering and charge distribution in the framework was established a long time ago", says Instrument Scientist Max Avdeev, one of the corresponding authors of the paper.

"However, so far most of the research into breaking the connection was

based on combining several electrochemically active transition metals, such as iron, manganese, cobalt and nickel that was either ineffective or had side effects." he continued.

To probe the effect of inactive ions, a compound, $\text{Na}_{0.6}(\text{Cr}_{0.6}\text{TiO}_4)\text{O}_2$ was synthesised and thoroughly investigated electrochemically and by neutron scattering at the Chinese Academy of Sciences and ANSTO, respectively.

"We have demonstrated that doping the structure with electrochemically inactive ions completely suppresses both transition metal charge ordering and sodium-ion ordering"

It was confirmed by neutron diffraction experiments on the Echidna instrument at OPAL which was used to study $\text{Na}_{0.6}(\text{Cr}_{0.6}\text{TiO}_4)\text{O}_2$, in a wide range of temperatures and sodium content.

Understanding all the conditions that led to sodium ordering was critical to design the material with desired properties.

"The approach we proposed opens up a way to design other Na+ disordered P-2 type high-rate materials with long cycle life." said Avdeev.

More information: P2- $\text{Na}_{0.6}[\text{Cr}_{0.6}\text{Ti}_{0.4}]\text{O}_2$ cation-disordered electrode for high-rate symmetric rechargeable sodium-ion batteries, *Nature Communications* 6, Article number: 6954. [DOI: 10.1038/ncomms7954](https://doi.org/10.1038/ncomms7954)

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