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$LiMnO_2$ electrodes could replace Ni/Co in electric vehicle batteries

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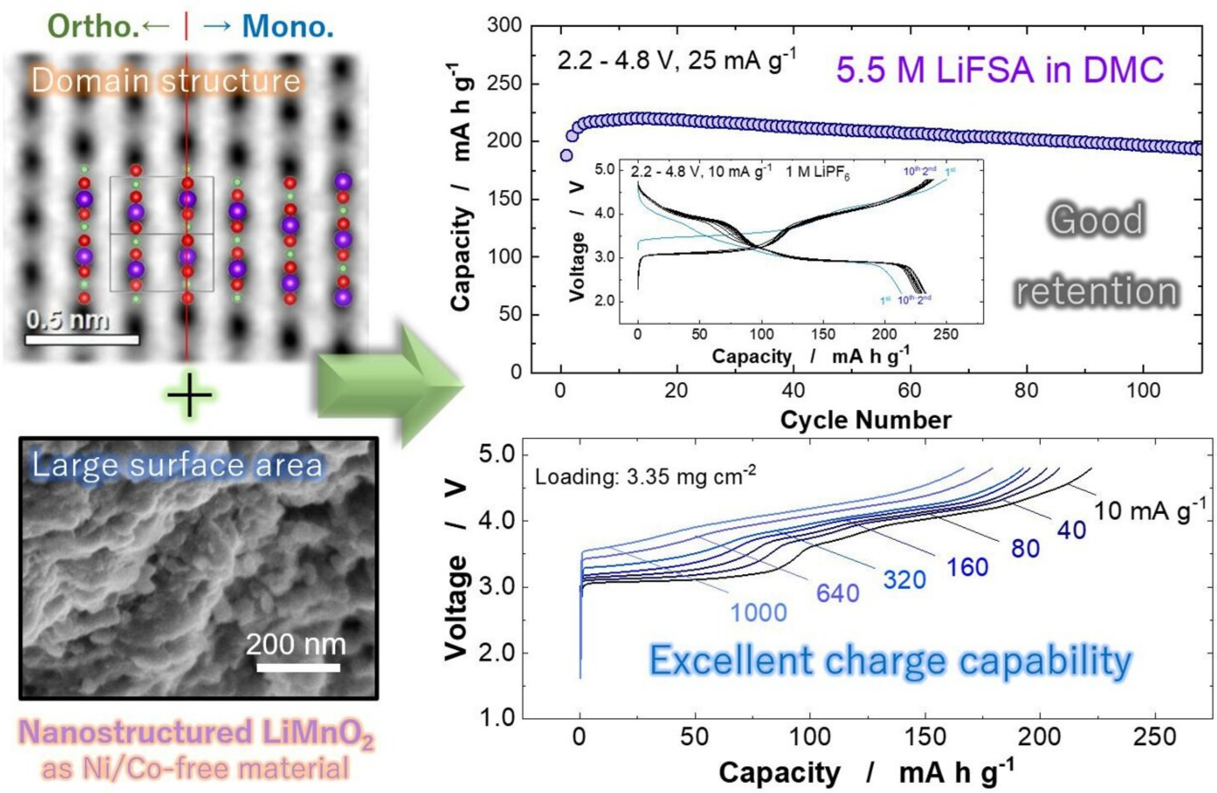

Nanostructured $LiMnO_2$ with domain structures and larger surface area delivers large reversible capacity with good capacity retention with excellent charge rate-capability, which is an essential character for electric vehicle applications. Credit: Yokohama National University

Lithium-ion (or Li-ion) batteries are heavy hitters when it comes to the world of rechargeable batteries. As electric vehicles become more common in the world, a high-energy, low-cost battery utilizing the abundance of manganese (Mn) can be a sustainable option to become commercially available and utilized in the automobile industry.

Currently, batteries used for powering electric vehicles (EVs) are nickel (Ni) and cobalt (Co)-based, which can be expensive and unsustainable for a society with a growing desire for EVs.

By switching the positive electrode materials to a lithium/manganese-based material, researchers aim to maintain the high performance of Ni/Co-based materials but with a low-cost, sustainable twist.

Researchers published their results in *ACS Central Science* on 26 Aug. 2024.

Li-ion batteries are not new players in the field of rechargeable electronics, but there are always ways to innovate and improve already reliable methods. $LiMnO_2$ as an electrode material has been studied in the past but has always been limited by restrictive electrode performance.

"Through the systematic study on different $LiMnO_2$ polymorphs, it is found that the monoclinic layered domain effectively activates structural transition to the spinel-like phase. From this finding, nanostructured $LiMnO_2$ with the monoclinic layered domain structures and high surface area has been directly synthesized by using a simple solid-state reaction," said Naoaki Yabuuchi, author and researcher of the study.

A monoclinic system refers to the type of group symmetry of a solid crystalline structure. A Li/Mn arrangement with the monoclinic symmetry appears to be key in making $LiMnO_2$ a feasible option for a positive electrode material.

Without the structural phase transition the monoclinic domain allows, electrode performance would be limited thanks to the sub-optimal crystalline structure of $LiMnO_2$ and accompanying phase transitions.

After observing and testing the various polymorphs, it was determined the needed structure can be synthesized directly from two components without having to use an intermediary step. The resulting material is competitive with nickel-based layered materials and boasts excellent fast-charging abilities, which is indispensable for electric vehicles.

The nanostructured $LiMnO_2$ with the monoclinic layered domain is synthesized by a simple calcination process to yield a product with a high-energy density, reaching 820 watt-hours per kilogram (Wh kg^{-1}), compared to about 750 Wh kg^{-1} for nickel-based layered materials and 500 Wh kg^{-1} for other low-cost lithium-based materials.

There is also no reported voltage decay using nanostructured $LiMnO_2$, which is common in manganese-based materials.

Voltage decay is a phenomenon in which the voltage decreases gradually, over time reducing the performance and responsiveness of electronics. However, it does not seem to be an observable issue in the case of nanostructured $LiMnO_2$, which is the subject of the study.

Though there are promising results, a practical issue can be observed: the dissolution of manganese. Over time, manganese can dissolve due to many factors, such as phase changes or reacting with acidic solutions. Fortunately, this can be curbed or completely mitigated by the use of a highly concentrated electrolyte solution and a lithium phosphate coating.

Researchers hope their findings contribute to a more sustainable energy source than fossil fuels, especially concerning electric vehicles.

The performance of $LiMnO_2$, with its competitive energy density compared to nickel-based materials, demonstrates the potential alternative materials can have to produce environmentally friendly products that are sustainable both in production and as a long-term investment.

An ideal future for nanostructured $LiMnO_2$-based electrode materials would involve commercialization and industrial production in the luxury electric vehicle industry.

More information: A Practical and Sustainable Ni/Co-free High-Energy Electrode Material: Nanostructured LiMnO2, *ACS Central Science* (2024). DOI: 10.1021/acscentsci.4c00578

Provided by Yokohama National University

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