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BATTERIES & SUPERCAPS

Cover Profile

Valence-Tuned Lithium Titanate Nanopowder for High-Rate Electrochemical Energy Storage

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The front cover artwork highlights work from the Robert Bosch GmbH and the INM–Leibniz Institute for New Materials (Germany). The image illustrates the effect of hydrogen annealing on lithium titanate: creating oxygen vacancies in the crystal structure not only makes the white powder become dark blue, but also electrically much more conductive. As a result, lithium titanate allows for ultrahigh charge and discharge rates of lithium-ion batteries. Read the full text of the article at 10.1002/batt.201700007.

What prompted you to investigate this topic/problem?

Fast and efficient energy storage devices are in high demand with the digital world and mobile computing having become ubiquitous in our daily life. Yet, today's fast batteries are still too slow for many applications and we all have experienced growing impatience when recharging our smartphones or an electric vehicle. Therefore, we need to find ways, figuratively speaking, to shift lithium-ion batteries into overdrive.

What was the starting point of your work?

Lithium titanate (LTO) is a widely used anode material for lithium-ion batteries. This is for a good reason: LTO combines high coulombic efficiency and cost-effectiveness with inherent safety and a negligible volume change during electrochemical operation. The initial low electrical conductivity complicates the use of LTO and requires the addition of rather large amounts of conductive additive, which does not contribute to the energy storage capacity. Therefore, it would be highly attractive to target directly the crystal structure of LTO and to enhance the intrinsic electrical properties.

What is the most significant result of this study?

Using commercially available LTO nanopowder, our work demonstrates the effectiveness of hydrogen annealing to modify the crystal structure and to adjust the Ti^{3+}/Ti^{4+} valence ratio. There are optimum annealing conditions: too low temperatures will only yield a small improvement of the power handling, whereas too high temperatures lead to deterioration of the LTO structure and cause amorphization. The best treatment conditions resulted in a material capable of ultrahigh rates up to 100C and allowed us to reduce the amount of conductive additive (carbon black) to just 5 mass%.

What are the main challenges in the broad area of your research?

The development of next-generation energy storage technologies is highly challenging and requires key contributions from different fields. In particular, we show the power of collaboration between chemists, physicists, material scientists, and engineers: our high-power devices required the combination of crystal structure tailoring, optimized electrode fabrication, suitable electrolyte selection, and careful cell engineering. Also, only systematic and thorough investigation of structure/property correlations allow us to identify key issues and to develop tools to unlock the true potential of electrode materials.

What will the future bring for this line of research?

Fast is never fast enough, especially when we consider the ever-growing requirements for energy storage technologies. We also need to find ways to further enhance the energy storage capacity and, if possible, explore more green synthesis routes for the large-scale fabrication of electrode materials and electrolytes.

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