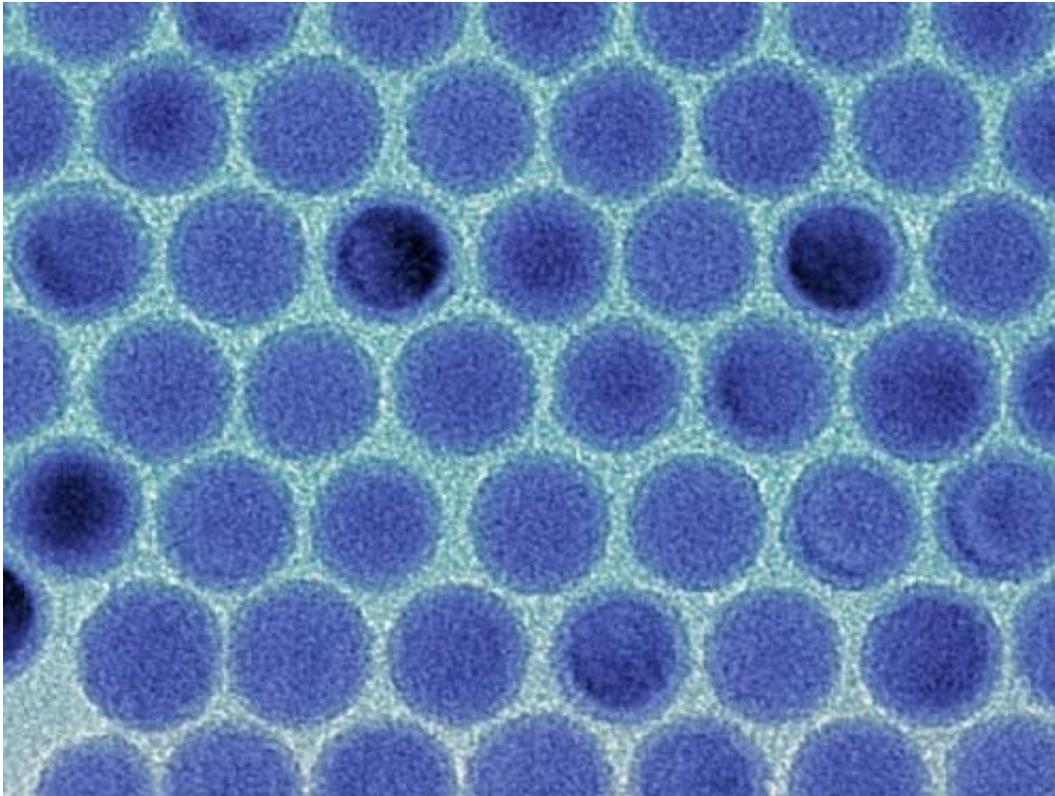


Tin nanocrystals for the battery of the future

April 8 2013, by Fabio Bergamin



Monodisperse tin nanodroplets in an electron microscopic image. Credit: Maksym Kovalenko / ETH Zürich

(Phys.org) —More powerful batteries could help electric cars achieve a considerably larger range and thus a breakthrough on the market. A new nanomaterial for lithium ion batteries developed in the labs of chemists at ETH Zurich and Empa could come into play here.

They provide power for [electric cars](#), [electric bicycles](#), Smartphones and laptops: nowadays, [rechargeable lithium ion batteries](#) are the [storage media](#) of choice when it comes to supplying a large amount of energy in a small space and lightweight. All over the world, scientists are currently researching a new generation of such batteries with an improved performance. Scientists headed by Maksym Kovalenko from the Laboratory of [Inorganic Chemistry](#) at ETH Zurich and Empa have now developed a nanomaterial which enables considerably more power to be stored in [lithium ion](#) batteries.

The nanomaterial is composed of tiny [tin](#) crystals, which are to be deployed at the minus pole of the batteries (anode). When charging the batteries, lithium ions are absorbed at this electrode; while discharging, they are released again (see box). "The more lithium ions the electrodes can absorb and release – the better they can breathe, as it were – the more energy can be stored in a battery," explains Kovalenko.

Uniform crystals

The element tin is ideal for this: every tin atom can absorb at least four lithium ions. However, the challenge is to deal with the volume change of tin electrodes: tin crystal becomes up to three times bigger if it absorbs a lot of lithium ions and shrinks again when it releases them back. The scientists thus resorted to nanotechnology: they produced the tiniest tin nanocrystals and embedded a large number of them in a porous, conductive permeable carbon matrix. Much like how a sponge can suck up water and release it again, an electrode constructed in this way can absorb lithium ions while charging and release them when discharging. If the electrode were made of a compact tin block, this would practically be impossible.

During the development of the [nanomaterial](#), the issue of the ideal size for the nanocrystals arose, which also carries the challenge of producing

uniform crystals. "The trick here was to separate the two basic steps in the formation of the crystals – the formation of as small as a crystal nucleus as possible on the one hand and its subsequent growth on the other," explains Kovalenko. By influencing the time and temperature of the growth phase, the scientists were able to control the size of the crystals. "We are the first to produce such small tin crystals with such precision," says the scientist.

Larger cycle stability

Using uniform tin nanocrystals, carbon and binding agents, the scientists produced different test electrodes for batteries. "This enables twice as much power to be stored compared to conventional electrodes," says Kovalenko. The size of the nanocrystals did not affect the storage capacity during the initial charging and discharging cycle. After a few charging and discharging cycles, however, differences caused by the crystal size became apparent: batteries with ten-nanometre crystals in the electrodes were able to store considerably more energy than ones with twice the diameter. The scientists assume that the smaller crystals perform better because they can absorb and release lithium ions more effectively. "Ten-nanometre tin crystals thus seem to be just the ticket for lithium ion batteries," says Kovalenko.

As the scientists now know the ideal size for the tin [nanocrystals](#), they would like to turn their attention to the remaining challenges of producing optimum tin electrodes in further research projects. These include the choice of the best possible carbon matrix and binding agent for the electrodes, and the electrodes' ideal microscopic structure. Moreover, an optimal and stable electrolyte liquid in which the lithium ions can travel back and forth between the two poles in the [battery](#) also needs to be selected. Ultimately, the production costs are also an issue, which the researchers are looking to reduce by testing which cost-effective base materials are suitable for [electrode](#) production. The aim is

to prepare batteries with an increased energy storage capacity and lifespan for the market, including in collaboration with a Swiss industrial partner.

More information: Kravchyk, K. et al. Monodisperse and Inorganically Capped Sn and Sn/SnO₂ Nanocrystals for High-Performance Li-Ion Battery Anodes. *Journal of the American Chemical Society*, 2013, advance online publication, [doi: 10.1021/ja312604r](https://doi.org/10.1021/ja312604r)

Provided by ETH Zurich

Citation: Tin nanocrystals for the battery of the future (2013, April 8) retrieved 22 September 2024 from <https://phys.org/news/2013-04-tin-nanocrystals-battery-future.html>

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