Flat, diamond-shaped plates of lithium iron phosphate improve discharge voltages

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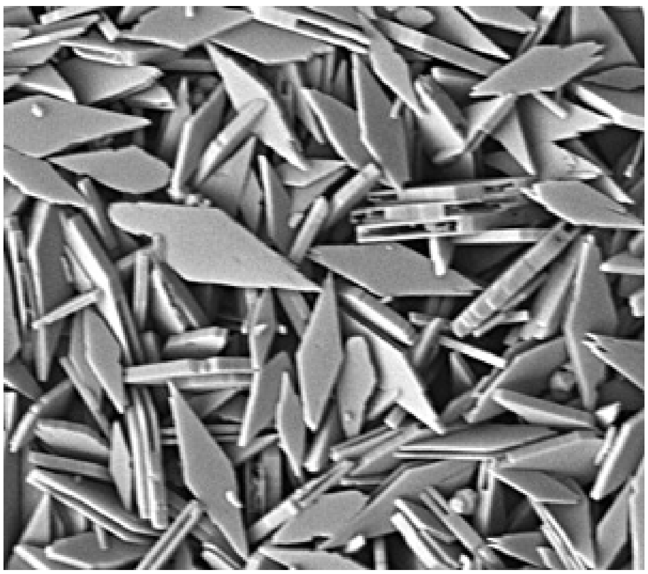

Cathodes made from hollow plates of lithium iron phosphate improve the performance of lithium-ion batteries. Credit: WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

Hollow, crystalline particles of lithium iron phosphate can enhance the performance of lithium-ion batteries by enabling an easier flow of lithium ions, A*STAR researchers have found.

Lithium-ion batteries are ubiquitous in cell phones, laptops and other portable electronic devices, and are increasingly used in electric cars. During charging, lithium ions inside the battery leave the positive cathode, travel through a liquid electrolyte and enter the negative anode (often made of carbon). This flow of ions reverses during discharging.

But conventional cathode materials have serious drawbacks: lithium cobalt oxide, for example, is toxic and expensive, and while lithium iron phosphate is cheaper and nontoxic, it suffers from low electrical conductivity.

Jackie Ying of the A*STAR Institute of Bioengineering and Nanotechnology in Singapore and colleagues have now developed a form of lithium iron phosphate particles that act as a cathode for better performance. The diamond-shaped particles, which look like miniature melon seeds, are hollow, and have a crystalline structure that is easier for lithium ions to enter (see image).

The team shaped their particles using tetra(ethylene glycol) (TEG), which contains oxygen atoms that bind to iron atoms in the growing crystal. This suppresses the growth of the crystal along one of its axes, ultimately giving lithium ions a shorter distance to travel as they diffuse into the material. Since the particles are hollow, the lithium ions may interact with both outer and inner surfaces of the cathode material, thus increasing the reaction area.

The team made particles that were about 3.5 micrometers long and 1.5 micrometers wide by mixing solutions of lithium dihydrogen phosphate and iron sulfate with TEG, adding lithium hydroxide, and then heating the mixture at 180°C for 10 hours.

Scanning electron microscopy and transmission electron microscopy images showed that the particles were hollow, with thin walls. X-ray diffraction experiments confirmed that crystal growth had been constrained as expected. When tested in a battery, these particles had a comparable capacity and better stability than commercial lithium iron phosphate nanoparticles.

The team found that using more TEG and higher temperatures produced smaller particles that were less likely to be hollow. By adding lithium hydroxide before iron sulfate, they could create smaller particles—less than one micrometer in length—that were still hollow, yielding higher discharge voltages. "Our submicro plates have higher capacity and comparable stability compared to commercial nanomaterials," says Ying.

Her team is developing other cathode materials, such as lithium manganese orthosilicate, that also have hollow structures and an even higher electrical capacity.

More information: Yang, X.-F., Yang, J.-H., Zhong, Y. L., Gariepy, V., Trudeau, M. L. et al. Hollow melon-seed-shaped lithium iron phosphate micro- and sub-micrometer plates for lithium-ion batteries. *ChemSusChem* 7, 1618–1622 (2014). dx.doi.org/10.1002/cssc.201400152

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