

Novel anode for next-generation batteries in electric vehicles

This has double the capacity of graphite anode-containing lithium ion batteries

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One of the factors that determine the success of electric vehicles is the availability of batteries that can be charged quickly and retain enough charge to make long distance travel possible per charge. Researchers at the Indian Institute of Science Education and Research (IISER) Pune have synthesised a new type of anode material to make such a battery possible.

Unlike graphite anode-containing lithium ion batteries that have capacity of just 372mAh/gram, the anode synthesised by IISER researchers has double the capacity of about 720mAh/gram. The capacity remained the same even after 1,000 charge-discharge cycles.

The high capacity was seen when the rate of charging/discharging was 100mA/gram. But when the battery was charged quickly (1A/gram), the capacity reduced by about 20% (about 580mAh/gram).

"So even when the battery is charged quickly, it can still store about 80% charge," says Prof. Ramanathan Vaidhyanathan from the Department of Chemistry at IISER Pune.

"And even when the battery was charged rapidly (2A/gram), the capacity was still around 500mAh/gram, which is much higher than the graphite-containing battery." He is one of the corresponding authors of a paper published in the journal *Advanced Energy Materials*.

"The performance of the anode material is good in terms of capacity and stability," says Dr. Satishchandra Ogale from the Department



"Even when the battery is charged quickly, it can still store about 80% charge," says Ramanathan Vaidhyanathan (right) ■ SPECIAL ARRANGEMENT

of Physics at IISER Pune and the other corresponding author. "Graphite is cheaper and lithium ions can easily be inserted into graphite. But unlike the novel anode material, graphite can't be tuned."

Testing the anode

The researchers tested the capacity by replacing the graphite anode with the novel material (covalent organic framework) and used lithium metal as the cathode and not lithium cobaltate (LiCoO₂), which is normally used as the cathode.

"We had tested the anode using a half-cell configuration. To realise the full potential of the novel material it has to be tested in a full-cell configuration," he says.

When tested in a full-cell configuration, the charge will be lower than what has been observed by the researchers. This is because the kinetics of lithium diffusion will be different depending on the cathode material used and the

configuration of the battery.

"The capacity of a graphite anode in a full-cell configuration will be only about 150mAh/gram if the battery is charged quickly (rate of charge is 1A/gram). So with our anode material, even if the capacity drops by 50% in a full-cell configuration, the capacity will be about 360mAh/gram, which is much higher than graphite. This can be confirmed only when we carry out an experiment using full-cell configuration," says Prof. Vaidhyanathan.

The anode made of a few-layer thick (6-8 layers) nanosheets has pores lined by functional groups capable of interacting with lithium ions. The pores provide an easy path for diffusion of lithium ions and helps access the functional groups, which are sites of lithium ion interaction.

"Optimal interactions allow lithium ions to go in and come out of the nanosheets

with ease allowing the anode to discharge easily," says Sattwick Halder from the Department of Chemistry, IISER Pune and first author of the paper.

Charging and capacity

The ease with which lithium ions go in and come out of the nanosheet anode changes when the time taken to charge the battery changes. When it is charged quickly, the efficiency of lithium ions diffusion drops and capacity of the battery reduces. "In our case, whether the battery charging time is short or long (50mA/gram or 2A/gram), the capacity does not change much," says Prof. Vaidhyanathan.

The anode was tested in a coin cell and not a bigger battery that would typically be used in electric automobiles. The researchers are trying to scale-up the battery so that it can potentially be used for applications that need higher battery output.