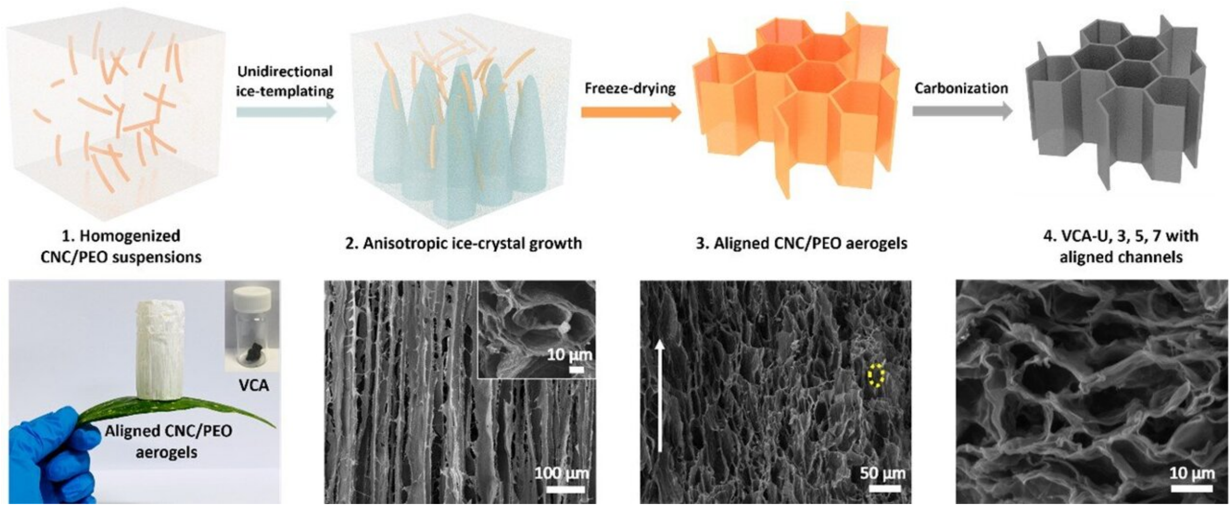
Scientists develop a novel strategy for sustainable post-lithium-ion batteries

January 6 2022



Credit: University of Bristol

Researchers at Bristol have developed high-performance sodium and potassium ion batteries using sustainably sourced cellulose.

Scientists at the Bristol Composites Institute have developed a novel controllable unidirectional ice-templating strategy which can tailor the electrochemical performances of next-generation post-lithium-ion batteries with sustainability and large-scale availability. The paper is published in the journal *Advanced Functional Materials*.

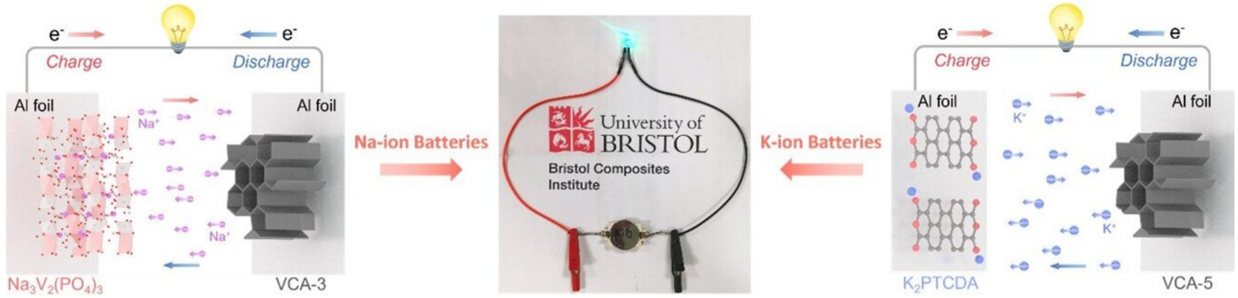
There is a rapidly increasing demand for sustainable, ethical and low-cost energy-storage. This is due in part to the drive towards developing battery-powered transport systems—mostly replacing petrol and diesel-based engines with electric vehicles—but also for hand-held devices such as mobile phones. Currently these technologies largely rely on lithium-ion batteries.

Batteries have two electrodes and a separator, with what is called an electrolyte between them which carries the charge. There are several problems associated with using lithium for these batteries, including build-up of the metal inside the devices which can lead to short circuits and overheating.

Alternatives to lithium, such as sodium and potassium batteries have not historically performed as well in terms of their rate performance and the ability to use them lots of times. This inferior performance is due to the larger sizes of sodium and potassium ions, and their ability to move through the porous carbon electrodes in the batteries.

Another issue associated with these batteries is they cannot be easily disposed of at end-of-life, as they use materials that are not sustainable. The cost of the materials is also a factor and there is a need to provide cheaper sources of stored energy.

Additionally, lithium is mined in countries such as Chile, Bolivia and Argentina. This mining is very destructive, and there are poor human rights records associated with it.



Credit: University of Bristol

Work at the University of Bristol in the Bristol Composites Institute, published in *Advanced Functional Materials*, and in collaboration with Imperial College, has developed some new carbon electrode materials based on an ice-templating system. These materials are called aerogels, where cellulose nanocrystals (a nano-sized form of cellulose) are formed into a porous structure using ice crystals that are grown and then sublimated. This leaves large channels within the structure that can carry the large sodium and potassium ions.

The performance of these new sodium and potassium ion batteries has been shown to outperform many other comparable systems, and it uses a sustainably sourced material—cellulose. Corresponding author, Steve Eichhorn, Professor of Materials Science and Engineering at the University of Bristol and a world-leader in cellulose-based technologies, said:

"We were astounded with the performance of these new batteries. There is great potential to develop these further and to produce larger scaled devices with the technology."

Jing Wang, lead author and a Ph.D. student in the Bristol Composites

Institute, said: "We proposed a novel controllable ice-templating strategy to fabricate low-cost cellulose nanocrystals/polyethylene oxide-derived carbon aerogels with hierarchically tailored and vertically-aligned channels as electrode materials, which can be utilized to well-tuning the rate capability and cycling stability of sodium- and potassium-ion batteries.

"Benefiting from the renewability of the precursor and scalability at relatively low cost in the environmentally benign synthesis process, this work could offer an appealing route to promote large-scale applications of sustainable electric vehicles and large-scale energy storage grids in the near future."

The schematic illustration of unidirectional ice-templated and vertically aligned carbon aerogels (VCAs) and their corresponding morphology and structure.

"In light of these findings, we now hope to collaborate with industries to develop this strategy on an industrial scale and to explore whether this unique technology can be easily extended to a variety of other energy storage systems such as zinc-, calcium-, aluminum- and magnesium-ion batteries, thus demonstrating its universal potential in next-generation energy storage systems," said Professor Eichhorn.

More information: Jing Wang et al, Ice-Templated, Sustainable Carbon Aerogels with Hierarchically Tailored Channels for Sodium- and Potassium-Ion Batteries, *Advanced Functional Materials* (2022). DOI: 10.1002/adfm.202110862

Provided by University of Bristol