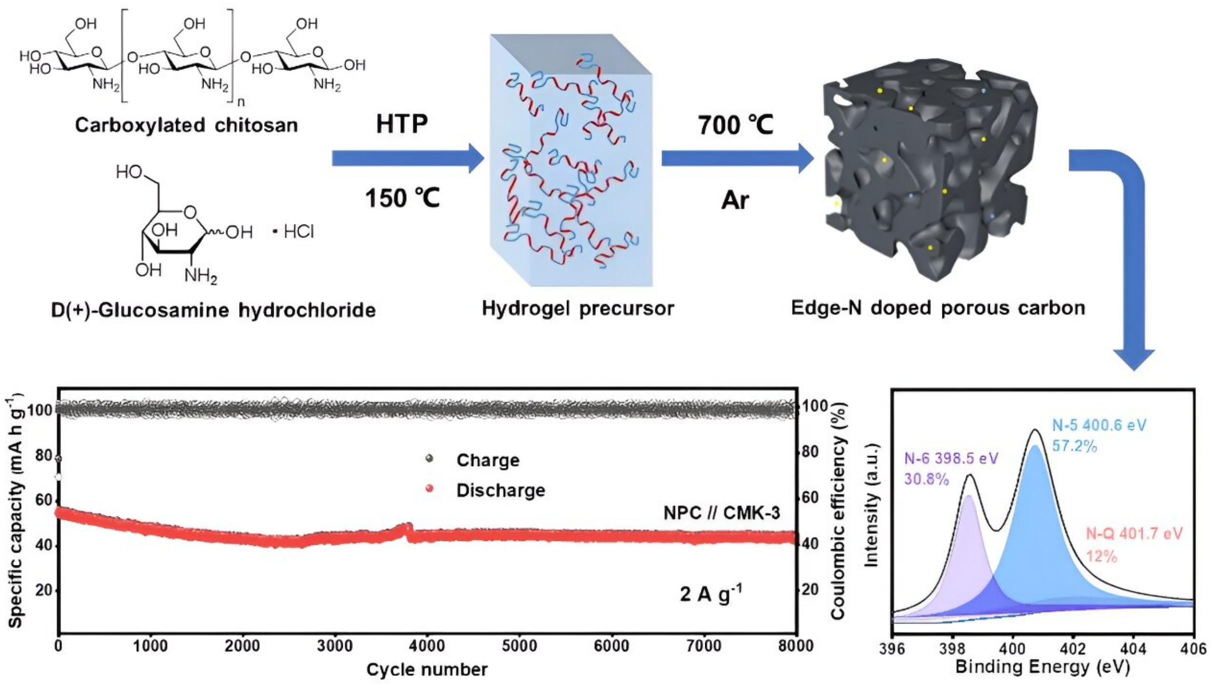
Edge-nitrogen doped porous carbon for energy-storage potassium-ion hybrid capacitors

March 6 2024



A High-Concentration Edge-Nitrogen Doped Porous Carbon Anode via Template Free Strategy for High-Performance Potassium-ion Hybrid Capacitors. Credit: [TOC, USTC]

A research team has published new research on edge-nitrogen doped porous carbon for energy-storage potassium-ion hybrid capacitors in

Energy Material Advances.

"The development of cost-effective and high-performance electrochemical energy storage devices is imperative," said paper's corresponding author Wei Chen, a professor in the School of Chemistry and Materials Science, University of Science and Technology of China (USTC). "Currently, lithium-ion batteries still dominate the market, but they are limited in both lithium as a resource and in their power densities."

Chen explained that potassium-ion hybrid capacitors (PIHCs) have several significant advantages as an alternative to lithium-ion batteries, especially to dual-carbon potassium ion hybrid capacitors (DC-PIHCs) with capacitive carbon cathode and battery-type carbon anode due to their low cost and high power/energy density.

"Currently, for battery-type carbon anodes, the slow reaction kinetics and huge volume expansion result in poor rate performance and short long-cycle lifespan, which fail to match with those of capacitive cathodes," Chen said. "Therefore, it is significant to develop carbonaceous anodes with superior rate performance and long cycle life for DC-PIHCs."

Various strategies have been developed for adjusting the microstructure of carbonaceous materials, such as heteroatom doping and porous structure construction to improve electrochemical performance. Nowadays, the synthesis methods of porous carbon usually adopt various templates, which increase the cost and generate a lot of byproducts.

Moreover, different types of nitrogen doping exhibited distinct roles in carbon materials. It was widely accepted that pyrrolic nitrogen and pyridinic nitrogen are electrochemically active sites in carbon materials, while graphitic nitrogen doped into the carbon lattice has no effect on K^+

adsorption. Therefore, it is necessary to explore facile and economical strategies for the synthesis of high-concentration edge-nitrogen (pyrrolic nitrogen and pyridinic nitrogen) doped porous carbons.

Chen said, "In this paper, we developed a template-free strategy for preparation of high-concentration edge-nitrogen doped porous carbon (NPC) anode of DC-PHIC derived from D (+)-glucosamine hydrochloride (DGH) and carboxylated chitosan (CC), which includes two steps of hydrothermal polymerization and high-temperature carbonization. Our aim is to provide inspiration for future research in the field."

"BET and XPS analysis demonstrated that NPC presents large specific surface area (523.2 m^2/g) and exhibits high edge-nitrogen doping level of 5.19 at%, which improved K^+ adsorption and intercalation capabilities," Chen said.

"As a result, the NPC anode displayed a high capacity of 315.4 mA h g^{-1} at 0.1 A g^{-1} and a capacity of 189.1 mA h g^{-1} at 5 A g^{-1} over 2,000 cycles," Chen said. "The assembled NPC//CMK-3 PIHC delivers a high energy density of 71.1 W h kg^{-1} with only 0.0025% capacity decay per cycle at the power density of 771.9 W kg^{-1} over 8,000 cycles."

More information: Zhen Pan et al, A High-Concentration Edge-Nitrogen-Doped Porous Carbon Anode via Template Free Strategy for High-Performance Potassium-Ion Hybrid Capacitors, *Energy Material Advances* (2024). DOI: 10.34133/energymatadv.0080

Provided by Beijing Institute of Technology Press Co., Ltd

(2024, March 6) retrieved 27 April 2024 from https://techxplore.com/news/2024-03-edge-nitrogen-doped-porous-carbon.html