Title : Development of Microwave-Synthesized Peanut Shell–derived Porous Carbon as Sustainable Anode Materials for Sodium-ion Batteries.

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ABSTRACT

This research investigates the development of porous carbon derived from peanut shells via microwave-induced carbonization combined with potassium hydroxide (KOH) activation, utilizing agricultural waste as a sustainable anode material for sodium-ion batteries (SIBs). The influence of biomass-to-KOH activation ratios ranging from 1:0 to 1:3 was systematically evaluated to understand their effects on structural evolution, elemental composition, and physicochemical properties. X-ray diffraction (XRD) and Raman spectroscopy confirmed the successful transformation of the crystalline biomass precursor, originally dominated by cellulose and KCl phases, into a low-crystallinity disordered carbon structure. This transition was evidenced by the disappearance of sharp crystalline peaks and the emergence of broad diffraction humps in XRD patterns, along with broadened D and G bands in Raman spectra, indicating a high density of structural defects. These defects provide abundant active sites favorable for sodium-ion storage. Energy-dispersive X-ray spectroscopy (EDS) confirmed successful carbonization, with carbon content ranging from 59.52 to 88.88 wt%, where the 1:1 ratio yielded the highest carbon purity. Higher KOH ratios increased oxygen and silica content, consistent with morphological evolution and hierarchical porosity

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observed by scanning electron microscopy (SEM). Brunauer–Emmett–Teller (BET) analysis revealed that the 1:2.5 ratio produced the highest specific surface area of 562.11 m^2/g These results demonstrate that optimizing the KOH activation ratio in combination with microwave carbonization is an effective strategy for producing porous carbon (PS-NPC) with desirable structural properties for sustainable sodium-ion battery anodes.

Keyword: Peanut shell, Anode materials, Sodium-ion batteries, Microwave carbonization, KOH activation, Porous carbon, Sustainable energy storage

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