Preparation and Characterization of Activated Nano Carbon Derived from Bamboo Culms for Sustainable Electrode Applications

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Sustainable energy storage needs have accelerated the development of eco-friendly energy storage drives. This study focuses on the preparation and characterization of activated nano carbon from bamboo culms, a fast growing, renewable, biodegradable biomass that is carbon rich. The preparation process includes carbonization, followed by chemical activation with sodium hydroxide at 900 °C, and mechanical ball milling to improve surface area and reduce diffusion pathways in the activated carbon. Comprehensive characterization showed that this material is viable for use in electrodes. The Fourier Transform Infrared Spectroscopy tests showed peaks at 581, 446, and 421 cm^{-1}, indicating different metal-oxygen functional groups. The Raman study exhibited D and G bands at 1326 and 1602 cm^{-1} with a ratio of 1.48 between intensities (I_D/I_G). This indicates a disordered structure with higher defect density. The results of Particle Size Analysis showed an average particle size of 562.6 nm, which is classified as submicron. The X-ray diffraction analysis of these materials showed broad peaks at $2\theta = 17.72°$ and 43.32°, indicating a semi-crystalline carbon structure. Scanning Electron Microscopy showed a mesoporous morphology. Scanning Electron Microscopy - Energy-dispersive X-ray spectroscopy showed the carbon-containing matrix was (~94.13 wt %), with a few trace elements, including O, Na, and K. This work demonstrates that NaOH activation at 900 °C coupled with ball milling produces a mesoporous, submicron bamboo-derived carbon with high disorder, offering a novel, low-cost pathway for sustainable electrodes. Future work will focus on optimizing activation parameters, improving structural stability, and integrating with natural rubber-based electrolytes.

Keywords: *Natural rubber-based electrolyte, Activated nano carbon, Bamboo-derived carbon, Sustainable energy storage*
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