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RESEARCH

Nanoarchitectonics with improved supercapacitive performance of jering-derived porous activated carbon electrodes in aqueous electrolyte

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Abstract

The global shift from non-renewable to renewable energy sources demands advancements in energy storage solutions to effectively mitigate carbon footprints. Towards this direction, this study envisages the utilisation of activated carbon (AC) derived from jering pods (JP) synthesised at three different temperatures as supercapacitor (SC) electrode material. The physicochemical properties of the material were studied using X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), Fourier transform infrared spectroscopy (FTIR), and nitrogen (N_2) gas adsorption studies. In a half-cell study conducted in a 6 M aqueous KOH electrolyte, the best-performing AC delivered a specific capacitance (C_S) of 301 F/g at 0.5 A/g. A full device assembly demonstrated a C_S of 71 F/g at 0.5 A/g, energy density (E_D), and power density (P_D) of ~ 14 Wh/kg and ~ 9000 W/kg, respectively. The device showed excellent cyclic stability of ~ 96% of its initial capacitance after 3000 cycles. These findings present the viability of the valorisation of JP as a sustainable electrode material for SC application.

Keywords Biomass · Supercapacitors · Electrochemical capacitor · Energy storage · Electrochemistry

Introduction

The rising reliance on intermittent renewable energy resources such as solar, wind, and tidal energy has paralleled escalating demand for rapid energy storage devices. Supercapacitors (SCs) differ from conventional energy storage devices such as batteries with higher P_D, faster charge–discharge, longer cycle life, and eco-friendliness [1–4]. The electrochemical characteristics of SCs are governed mainly by the nature of the charge storage mechanism occurring at the electrode material. If a faradaic reaction occurs near the electrode surface, it is categorised as pseudocapacitance. In contrast, if electrostatic adsorption of the electrolytic ions occurs on the electrode surface, it is categorised as an electrical double-layer capacitance (EDLC) [5, 6]. Studies suggest that materials with high surface area, porosity, and good conductivity can adsorb electrolytic ions onto the polarised electrode surface to form electrical double layers [7, 8]. Carbon-based materials are renowned for their EDLC behaviour, with AC gaining much attention due to its ability to be derived from various biomass.

Biomass utilisation to produce AC has gained significant interest due to these raw materials' abundant availability, cheaper cost, and eco-friendliness. However, the mismanagement of biomass through landfill disposal or incineration in several developing countries results in resource negligence and environmental pollution, emphasising the importance of adopting circular economy principles for waste management. According to recent data from the International Energy Agency, biomass contributes ~ 6% to the global energy supply, further highlighting the need to discover sustainable avenues for its utilisation [9] Using biomass-derived AC for

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