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High carbon containing biomaterial offering honeycomb morphology as a charge storing electrode in aqueous alkaline electrolytes

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ABSTRACT

Research on unconventional carbon structures and morphologies obtainable from renewable sources are a way forward in realizing sustainable materials for the next-generation industry. Herein, renewable porous carbon from a biomass (coconut rachis) with high carbon content (~81 %) and honeycomb morphology (inner diameter ~60 µm and wall thickness ~500 nm) is developed as an electrochemical capacitor electrode. The coconut rachis upon chemical activation yield a surface area ~1,630 $m^2 \cdot g^{-1}$ and desirable pore characteristics for storing aqueous cations. The electrochemical charge storability of the porous carbon electrodes in 1 M KOH, NaOH and LiOH electrolytes showed specific capacitances ~320, ~140 and ~102 $F \cdot g^{-1}$, respectively. Electrochemical impedance spectra validated the higher capacitance in the KOH electrolyte. Besides, symmetric supercapacitor full cells were fabricated using the present electrode in 1 M KOH electrolyte with desirable charge storage properties. Given the abundance of the precursor and desirable charge storage characteristics, the present work could be useful in developing the coconut rachis-resourced honeycomb-shaped porous carbon as a charge storing electrode.

1. Introduction

Technological advancements, high quality of life, and other existential concerns necessitate sourcing essentials (i.e., food, water, and energy) from clean and sustainable sources [1]. Electrical energy generation and storage are heavily invested areas, both intellectually and economically, in recent times because of its undoubted role in shaping modern life. Recently, storing electrical charges in electrodes as a method of using renewable energy to decarbonize the major emitting sectors; many charge storing electrodes are in use and also under intensive investigation [2–5]. Among the industrial materials, carbons are one of the widely explored material because of the processability with high surface to volume ratio, porosity, resource abundance and low-cost, desirable mechanical, electrical and electrochemical properties [6–12].

One of the compelling aspects of biomass-derived carbon is its unique surface morphology, which can be harnessed to create a wide range of carbon materials with distinct properties and applications [13,14]. The porous carbon offers a highly interconnected network of pores, which contribute to a significantly increased surface area (>1000 $m^2 \cdot g^{-1}$) compared to non-porous materials [15–17]. This high surface area enables enhanced adsorption capacity, making it ideal for applications such as gas adsorption, energy storage, and filtration [18–21]. Among these traditional porous carbon materials, honeycomb-structured carbon holds specific importance due to its distinctive characteristics and advantages [22–26]. Das et al. studied the electrochemical performance of polymer-derived honeycomb-like carbon nanostructure and reported a specific capacitance of ~580F$\cdot g^{-1}$ in electrochemical capacitor (EC) electrodes coupled with a specific surface area of ~690 $m^2 \cdot g^{-1}$ [27]. The high surface area of this carbon is

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