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Biomass-derived porous activated carbon from *anacardium occidentale* shell as electrode material for supercapacitors

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The cashewnut (*Anacardium occidentale*) is extensively used worldwide as an important nutrients source. Herein, we propose a simple, low-cost approach for producing activated carbon (AC) from a biomass source. *Anacardium occidentale* shell (AOS) biowaste was chemically activated using KOH at various temperatures (600 °C, 700 °C, 800 °C and 900 °C) to produce AC. The surface functional groups, disordered nature and morphology of the ACs were examined by different physico-chemical tools. The FESEM analysis of AOS–PCC showed a normal flat surface without any pores, whereas AOS-6 to AOS-9 displayed a flat surface with abundant pores due to KOH impregnation and activation, which facilitated the formation of such a distinctive structure. The electrochemical studies of these carbon materials confirmed their promising characteristics for applications in supercapacitors (SCs). The electrochemical characteristics of AOS–AC samples were tested in 1 M KOH in a potential window between 0 and 1 V using different electroanalytical techniques in a three-electrode system. The as-prepared AOS-9, possessing a large specific surface area (854.31 $m^2\ g^{-1}$) displayed an outstanding electrochemical performance for SCs, with a high capacitance (393 F g^{-1} at 1 A g^{-1}) and great cycle stability (92.6% capacitance retention even after 8000 cycles at 1 A g^{-1}). The study demonstrated a promising low-cost, easily scalable manufacturing method for advanced electrode materials for SCs.

1. Introduction

Energy storage technology that can support the storage of sustainable and renewable energy as well as releasing energy when needed has gained momentum due to the energy crisis and environmental pollution.[1,2] The grave situation in the development of alternative energy storage and conversion technology has been driven by the depletion of fossil resources.[3] Flexible/wearable electronic devices are highly bendable and stretchable, allowing them to work or be installed in more difficult settings than traditional rigid electronic devices. In recent years, they have received a great deal of attention for developing next-generation smart and portable electronic devices.[4,5] However, to fulfil increasing energy demands for the next generation in developing portable and flexible devices, the energy density of energy storage devices (ESDs) needs to be considerably higher without losing power density and cycle life.[6,7] Thus, SCs or ultracapacitors are considered the cutting-edge of technology because of their unique ability to bridge the gap between capacitors and batteries.[8,9] They have a potential set of characteristics, such as high power density, quick charge–discharge rate, long cycling life and safe operation. These unique features have sparked people's curiosity in using SCs in heavy electric vehicles and consumer electronics as well as in industrial power management.[10,11]

Based on their fundamental mode of operation in energy storage technology, SCs can be classified into two types. Many aspects must be addressed while building electrodes for SCs: surface area, electrical/ionic conductivity and mechanical/chemical stability are all key aspects to consider.[12,13] In an electric double-layer capacitor (EDLC), electrical energy is stored *via* the accumulation of charges electrostatically.[14,15] Pseudocapacitors (PCs) store charges by quick and reversible redox reactions.[16,17] A hybrid capacitor consists of two electrodes that have two different charge-storage mechanisms: one capacitive and one battery-type faradaic.[18] The development of nanostructured electrode materials could aid the construction of advanced SCs. The excellent performance of SCs in terms of

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