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Research Papers

Biowaste-derived hierarchical activated porous carbon with heteroatom-doping (N/S) for efficient symmetrical supercapacitors: A cow urine approach

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ABSTRACT

The continuous accumulation of biowaste in the environment over extended periods can pose considerable ecological challenges. Hence, the conversion of natural biowaste into value-added products is essential. In this study, for the first time, carbon materials derived from cow urine, an animal waste, were explored as potential electrode materials for supercapacitors (SCs). Hierarchical, highly porous carbonaceous materials containing heteroatoms such as N and S were synthesized using a simple, template-free pyrolysis method, involving the direct carbonization of cow urine as a single precursor at 700 °C (CCUR-700) and pre-KOH activation of the resulting cow urine deposit pyrolyzed at 700 °C (A-CCUR-700) with a removal of inherent mineral salts. The resulting porous carbon materials were then employed as electrode materials for SC applications. The A-CCUR-700 electrode, with its abundant surface functionalities, high specific surface area (2651.7 m^2/g), high porosity, good conductivity, and self-doped heteroatoms (N and S), demonstrated better charge storage performance compared to the CCUR-700 electrode. Notably, a two-electrode symmetric SC assembled using the A-CCUR-700 electrode demonstrated an excellent specific capacitance of 165 F/g at a current density of 0.5 A g^{-1}. Furthermore, the A-CCUR-700 symmetric SC device achieved a high energy and power density of 22.9 Wh/kg and 5100 W/kg, respectively, with a capacitance retention of 95.3 % over 5000 cycles. Overall, the results of this study suggest that the synthesis of functionalized carbonaceous materials from cow urine may open up new possibilities for producing inexpensive electrode materials for electrochemical value-added applications.

1. Introduction

Waste management and sustainable energy development represent two critical challenges encountered by contemporary society. One major contributor to these challenges is the heavy reliance of current energy production technologies on traditional fossil fuels, which not only adversely impact the environment but also deplete natural resources [1]. To mitigate the impacts of fossil fuels and address issues such as energy shortages, environment pollution, and climate change, developing new clean and sustainable energy storage systems for future generations is essential. In response to this need, researchers and industry professionals are focusing on advanced technologies such as solar cells, fuel cells, supercapacitors (SCs), hydrogen storage systems, and lithium-ion batteries for energy production and storage [2–4]. Among these, SCs stand out as promising electrochemical energy storage devices owing to their rapid charging capabilities, long lifespans, wide operational temperature range, high power densities, and ease of manufacturing [5]. These characteristics have led to the widespread

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