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Self-Doped Interwoven Carbon Network Derived from *Ulva fasciata* for All-Solid Supercapacitor Devices: Solvent-Free Approach to a Scalable Synthetic Route

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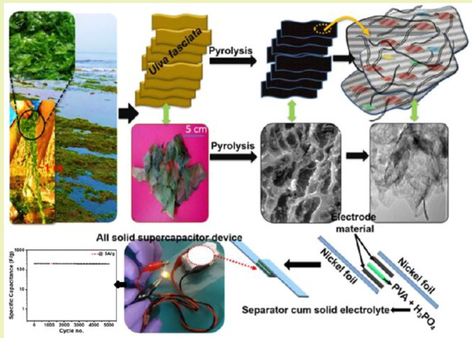
Supporting Information

ABSTRACT: The surging growth of portable and wearable electronics along with increasing demand for electric vehicles has led to an exponential increase in the demand for lightweight, robust power sources with high energy and power density. Here, we demonstrate a single-step conversion process of seaweed *Ulva fasciata* to interconnected nanoporous carbon. Pyrolysis of marine origin green biomass resulted in inherently heteroatom-doped electrochemically active graphene nanocomposite. The present study outlines a simple and easily scalable electrode material production which resulted in a relatively high and stable specific capacitance through a double-layer charge-storage mechanism. Temperature-dependent morphology and texture variation was observed for the pyrolyzed samples, with best synergy between physical properties and application achieved at 800° C (UF-800). The physical characteristics of electrode material highlights high electrical conductivities of ∼9100*m*S/m and BET surface area of >376 m^2/g. An all-solid supercapacitor device using H_3PO_4−PVA film as separator-cum-electrolyte and UF-800 as electroactive material exhibited high gravimetric capacitance of >330 F/g with a power density of 10 kW/kg. Furthermore, the symmetrical two electrode supercapacitor demonstrate ideal electrical double layer capacitive behavior stable up to 5000 cycles (97.5% capacitance retention). A high capacitance of ∼200 F/g at 5 A/g with a nominal loss of 2.5% in gravimetric capacitance reflects the cohesiveness of high electrical conductivity of the composite walls and the micro- and nanopores created during pyrolysis.



KEYWORDS: *All-solid supercapacitor, Ulva fasciata, Graphene composite, Solvent-free synthesis*

INTRODUCTION

Carbon-based nanomaterials (graphitic and activated carbon, graphene and its composites) have been drawing increasing attention owing to its extraordinary high electrical conductivity, mechanical strength, thermal stability and desirable surface texture features.[1,2] These unique properties allow such carbon-based materials to be applied in various fields including biomedical applications,[3] charge-storage devices,[4,5] photovoltaic devices,[6,7] and transistors[8,9] to name a few. Carbon in its different form attracts enormous significance, especially in preparing user-friendly electronic gadgets at affordable prices.

Energy-storage devices like batteries and supercapacitors are one such family hugely contributing to the success of miniature electronic gadgets. The energy-storage device market is projected to have a compound annual growth rate (CAGR) > 35%; the supercapacitor market is projected to reach around $4.2 billion by 2020.[10] As up-to-date technologies have enabled in achieving high-efficiency energy-storage devices, the electronic industry, automobile industry, and consumer product manufacturers have recognized the importance of green energy sources. Growing demand for electric vehicles in Europe, North America, and China and increasing interest in India is driving the global supercapacitor market. Innovations in the consumer electronics industry including mobile phones, electronic gadgets, cameras, defibrillators, and other household electronics have created a demand for smarter energy-storage devices. Wearable electronics in the healthcare sector will demand nontoxic, biocompatible, and flexible energy-storage devices, propelling the growth and demand for green energy material-based supercapacitors/batteries.[11−15]

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