Eco-Friendly Supercapacitors based on Natural Biopolymer-Derived Electrodes and Gel Polymer Electrolytes

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Abstract

Replacing synthetic components with naturally occurring biomass-derived materials is a critical step in the development of next-generation green electronics. This study presents the design and characterization of supercapacitor components (both gel polymer electrolytes and reduced graphene oxide (rGO) electrodes) derived entirely from natural biopolymer precursors. For the electrolyte, natural biopolymer networks were cross-linked and plasticized with glycerol and sodium sulfate, successfully achieving optimized ionic conductivity on the order of 10^{-3} S/cm. Simultaneously, a green reduction method using a protein-based natural biopolymer was employed to synthesize rGO. The structural integrity and successful reduction of the electrodes were confirmed by XRD, Raman, and FT-IR spectroscopy. Electrochemical evaluations of biopolymer-reduced electrodes in 1M H_2SO_4 electrolyte revealed high specific capacitance of up to 194.19 F/g at 50 mV/s and 151.46 F/g at 0.5 A/g. The fabricated electrode materials exhibited an energy density of 16.95 Wh/kg as well as a very low charge transfer resistance of 5.93 Ω. By integrating biopolymer-based gel electrolytes with green synthesized composite carbon electrodes, this work offers a scalable, sustainable, and highly efficient avenue for advanced electrochemical energy storage applications.

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