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A Review on Supercapacitors and Activated Carbon Electrodes: Synthesis, Activation Routes, and Characterization Methods

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Abstract. Electrochemical supercapacitors are increasingly important for applications requiring high power density, rapid charge–discharge, and long cycle life. This review examines the fundamental charge-storage mechanisms of supercapacitors, with emphasis on electrochemical double-layer capacitance and pseudocapacitance, and discusses the role of core device components. Particular focus is placed on activated carbon electrodes, highlighting how precursor selection, activation route, pore structure, and surface chemistry govern electrochemical performance. Physical and chemical activation strategies are compared, and recent examples of biomass-derived activated carbons are summarized to illustrate structure–property–performance relationships. Standard physical and electrochemical characterization techniques used to evaluate supercapacitor electrodes are also reviewed. Finally, key challenges and future research directions are outlined, emphasizing the need for electrode–electrolyte co-optimization, scalable synthesis routes, and environmentally sustainable activation methods to enable high-performance supercapacitor technologies.

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