Bio-sourced electrode materials for all-carbon supercapacitors and Li ion capacitors

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This study explores the development of carbon materials for electrodes in high-power electrochemical energy storage devices (EESDs), with a focus on supercapacitors and Li-ion capacitors. Given the variability of renewable energy sources such as solar and wind, efficient and reversible energy storage technologies are essential. EESDs, including batteries and supercapacitors, provide a broad range of energy storage capabilities and power densities, featuring high reversibility and compact designs. The performance of these devices is largely determined by the properties of the electrode materials, particularly their charge storage capacity, electrical and ionic conductivity, and electrochemical and mechanical stability. Significant advancements in EESDs, especially in lithium-based batteries and supercapacitors, have been driven by innovations in electrode and membrane materials.

This research investigates carbon-based materials derived from sucrose and cellulose, which serve as model components representing key constituents of biomass, including urban and agro-industrial waste. The activated carbons were synthesized by thermochemical activation by KOH of carbon precusors mixed with doping additives. The study assessed the influence of different precursor ratios and drying temperatures on the physicochemical properties of the resulting activated carbons.

The findings reveal that the incorporation of ammonium citrate and the activation process significantly enhance the specific surface area (SSA) and nitrogen content of the materials, leading to improved electrochemical properties for use in electrochemical double-layer capacitors (EDLCs).

Optimized synthesis conditions resulted in substantial improvements in electrochemical performance. Sucrose-derived activated carbon achieved a mass-specific capacitance (Cg) of 308 F/g at 2 A/g and 346 F/g at 0.5 A/g. Similarly, cellulose-based activated carbon exhibited a Cg of 264 F/g at 2 A/g and 287.7 F/g at 0.5 A/g. Additionally, samples with a precursor ratio of ACN (1:2:0.5) K130 demonstrated promising reversible capacity in Li ion capacitors above 150 mAh/g for 100 recharge cycles.

Beyond model biomass components, activated carbons synthesized from raw urban waste materials also exhibited remarkable electrochemical properties. These waste-derived carbons demonstrated high capacitance values in Li-ion capacitors, reinforcing their potential for sustainable and high-performance energy storage applications. The results of this study emphasize the viability of bio-based activated carbons in advancing the efficiency of supercapacitors and Li-ion capacitors, offering a pathway toward environmentally friendly and scalable energy storage solutions.

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