

Controlling lignin-derived carbon's morphology by utilizing its thermally reactive functional groups for supercapacitor electrode application

Supercapacitor, a viable energy storage solution of the future, faces challenges in its wider adoption due to its low energy density and high cost. Lignin, a biorefinery byproduct, can be a low-cost alternative for supercapacitor electrode, which accounts for half of a device's raw material cost. However, because of lignin's structural complexity and low processability, challenges exist for its wider utilization. By exploiting lignin's abundant thermally sensitive linkages, its degree of crosslinking can be tailored using a simple thermal stabilization step in air. By further combining it with 10% acrylonitrile-butadiene rubber (NBR), the resulting morphology of the compound can be controlled. Upon carbonization and activation with potassium hydroxide, NBR served as a sacrificial template, induced macroporosity, and improved the lignin-derived carbon surface area from 1750 m²/g to 2120 m²/g. On the contrary, thermal stabilization decreased lignin-derived carbon's surface area to 1585 m²/g, potentially due to the change in lignin's molecular weight and the resulting shrinkage force from the added crosslinking. When made into supercapacitor electrodes, the controlled porosity in lignin-derived carbon directly translated into supercapacitor performance. With the highest porosity among our samples, NBR-doped lignin-derived carbon electrode exhibited a capacitance of 215 F/g, as opposed to 175 F/g without NBR doping. A 100% capacitance retention was observed after cycling for 5000 cycles, revealing strong electrochemical stability and reversibility.