

EXPLORING THE POTENTIAL OF COCONUT SHELL CHARCOAL IN CEMENT-BASED SUPERCAPACITOR FABRICATION

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Abstract

In this study, we report the fabrication and performance evaluation of an eco-friendly, low-cost supercapacitor in which coconut shell charcoal serves as the active carbon material blended with cement to create the electrode. Coconut shell charcoal is readily available, renewable, and microporous, and was produced via controlled low-oxygen combustion. This carbon–cement supercapacitor material could revolutionize multifunctional infrastructure such as residential energy storage, self-charging roads, remote/off-grid shelters, wind turbines, and tidal power systems. The finely milled activated charcoal was mixed with ordinary Portland cement at various weight ratios. The carbon black (CB) was prepared from cleaned coconut shells that were crushed and sieved to a 0.1 mm particle size prior to carbonization at 550 °C inside a box furnace. Then, CB was chemically activated with potassium hydroxide (KOH) in a 1:2 weight ratio of CB: KOH. CB ratio used as 12, 14, 16% and 18% cast into thin electrodes (~2 mm thick), followed by standard curing and drying. Electrochemical testing was conducted in a symmetric cell using aqueous electrolytes of 1 M KCl. Cyclic voltammetry exhibited quasi-rectangular profiles indicative of electric double-layer capacitance behaviour, and increasing the ratio of CB in cement-based supercapacitors enhances their electrochemical performance. As the CB content rises, the areal capacitance improves, attributed to the increased surface area and conductivity provided by the carbon network. The specific capacitance varied from 42 to 191.7 $\mu\text{F/g}$, and the areal capacitance 1.52 to 6.65 $\mu\text{F/cm}^2$, obtained in the electrode sample containing 12 to 18% content of CB. These findings illustrate how agricultural waste (burnt coconut shell) can be upcycled into a functional carbon-cement electrode, potentially enabling scalable, structurally embedded energy storage solutions for infrastructure.

Keywords: *Coconut Shell Activated Carbon, Carbon–Cement Supercapacitors, Electrochemical Performance, Sustainable Materials, Energy Storage Applications*