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Development of energy storage supercapacitors using activated carbon derived from used water filters

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As the demand for clean energy grows, advanced technological advancements in energy storage like supercapacitors have gained significant attention due to their rapid charge-discharge capabilities, high power density, and long cycle life. The electrode material strongly influences the supercapacitor performance. Before selecting the electrode material, evaluating its availability, production cost, and environmental sustainability is essential. In this study, the potential of activated carbon derived from discarded carbon water filters, commonly found in household water purifiers, was investigated for supercapacitor electrodes. First, the waste filter carbon (WFC) was dried overnight at 110 °C, then activated by heating it to 900 °C for 20 minutes in a low oxygen environment, followed by quenching in distilled water. The activated filter carbon (AFC) was then dried and ground into a fine powder. After that, 0.5 g of powdered AFC and 0.05 g of polyvinylpyrrolidone (PVP) as a binder were thoroughly mixed with isopropanol as the solvent. Next, the resulting solution was coated on preheated titanium plates (current collectors) at 150 °C for 5 minutes using the spray pyrolysis method. Then, the electrodes were annealed at 200 °C for 20 minutes to optimize their performance. After that, a medium retention filter paper (separator) was sandwiched between the two fabricated electrodes. Finally, the electrodes were clipped together, and the separator was wetted with 2.5 M H_2SO_4 electrolyte. The performance of the supercapacitor cell was investigated using cyclic voltammetry (CV) and galvanostatic charge-discharge (GCD) analysis. AFC electrode-based supercapacitors showed a specific capacitance of 20.50 F g^{-1}, which was three times higher than the value of WFC electrode-based supercapacitors; 7.33 F g^{-1}. Furthermore, the AFC-based supercapacitor resulted in an energy density of 2.85 W h kg^{-1} and a power density of 9.41 kW kg^{-1}, further underscoring the potential of AFC as a supercapacitor electrode material.

Keywords: Activated carbon, Supercapacitors, Energy density, Power density