

ABSTRACT

The increasing global demand for energy necessitates the development of efficient, rapid, and environmentally friendly energy storage systems. Supercapacitors have emerged as promising candidates due to their high power density, long cycle stability, and fast charge–discharge capability. However, the performance of supercapacitors strongly depends on the electrode material. Titanium dioxide (TiO₂) is a promising electrode material owing to its high thermal and chemical stability, low cost, and environmental friendliness. This research aims to analyze the effect of hydrothermal temperature variation on the crystal structure, morphology, and electrochemical properties of commercial TiO₂ modified into nanorod structures as supercapacitor electrodes. TiO₂ was synthesized using the hydrothermal method at temperatures of 140°C, 160°C, 180°C, and 200°C in 10 M NaOH solution, followed by calcination at 600°C for 1 hour. The samples were characterized using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and electrochemical tests including Cyclic Voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS), and Galvanostatic Charge–Discharge (GCD).

XRD analysis revealed that increasing hydrothermal temperature led to a phase transition from pure anatase to a mixed anatase–rutile–brookite phase at 160–180°C, and reverted to pure anatase at 200°C due to Na⁺ and Cl⁻ ion stabilization. SEM images showed the gradual formation of well-defined nanorods with increasing temperature. Electrochemical testing indicated that higher hydrothermal temperatures enhanced conductivity and specific capacitance. The TiO₂ HT 200°C sample exhibited the best performance, with a specific capacitance of 145.10 F/g, energy density of 72,57 J/g, and power density of 1,25 W/g. In conclusion, TiO₂ modification through the hydrothermal method effectively improves electrochemical performance, making TiO₂ nanorods a promising electrode material for efficient and environmentally friendly supercapacitors.

Keywords: *Titanium dioxide (TiO₂), hydrothermal, nanorods, supercapacitor*