World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:20, No:02, 2026

Effect of Hydrothermal Reaction Temperature on MoO_3 Nanostructure Properties for Enhanced Electrochemical Performance as an Electrode Material in Supercapacitors

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Abstract : This study aims to enhance electrochemical energy storage in supercapacitors by optimizing the synthesis temperature of MoO_3 nanostructures using a hydrothermal technique. MoO_3 nanostructures were synthesized using a hydrothermal technique, with reaction temperatures ranging from 140 to 230 °C for 24 h. The materials were analyzed using various techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), Raman spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, and ultraviolet-visible (UV-Vis) spectroscopy. The findings indicate that at 200 °C, a pure hexagonal phase of MoO3 was obtained, while different temperatures resulted in a combination of orthorhombic and hexagonal phases. The SEM analysis demonstrated that the morphology of the MoO_3 nanostructures varied depending on the synthesis temperature. These variations encompass the particles, spherical planar structures, and nanorods. The prepared samples were subjected to electrochemical analysis to explore their electrochemical properties, including cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and galvanostatic charge-discharge (GCD). The electrochemical performances of the prepared samples varied depending on the temperature at which the MoO_3 samples were prepared, resulting in different morphologies. The sample prepared at 220 °C exhibited the highest specific capacitance (CS) of 330 F/g, a minimal charge-transfer resistance (RCT) of 1800 Ω, an energy density of 16.50 Wh/kg, and a power density of 150 W/kg with symmetric and asymmetric device CS values of 125 and 115 F/g, respectively, compared to the other prepared samples. The observed outcomes can be attributed to the diverse morphology of MoO_3 nanostructures and the high electrochemical active surface area (ECSA) of 7.43x10-5 F/cm2 that were synthesized at different hydrothermal temperatures. This diversity in morphology and ECSA leads to the presence of active surface area sites, thereby enhancing electrochemical activity. These findings highlight the effect of synthesis temperature on the morphology, crystal structure, and electrochemical performance of MoO_3 nanostructures for supercapacitor applications.

Keywords : MoO_3, hydrothermal synthesis, electrochemical energy storage, specific capacitance
Conference Title : ICEECS 2026 : International Conference on Electrochemical Energy Conversion and Storage
Conference Location : Paris, France
Conference Dates : February 22-23, 2026