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Fabrication and characterization of electrodeposited nano structured copper oxide-based supercapacitors

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The increasing consumption of limited energy sources, primarily based on fossil fuels, and the resulting environmental issues, such as global warming and climate change, drive researchers to develop environmentally friendly and renewable energy conversions and storage systems. Supercapacitors (SCs) have emerged as a promising solution to meet the increasing global demand for efficient energy storage. The performance and efficiency of a supercapacitor depend directly on the electrode materials used. Nanostructured materials provide new and exciting approaches to developing supercapacitor electrodes for high-performance electrochemical energy storage applications. Interest in pseudocapacitive materials, particularly copper oxide, has grown due to its advantageous properties and application as electrode materials in energy storage devices. In this research, nano cuprous oxide thin films were used as supercapacitor electrodes, and Polyvinyl Alcohol-Potassium Hydroxide (PVA-KOH) gel polymer was used as both the electrolyte and separator for supercapacitors. The nano cuprous oxide films were synthesized on Ti substrates using the electrodeposition technique by controlling the pH of the deposition bath. For comparison, microstructured cuprous oxide thin films were also deposited on Ti substrates as electrodes using the electrodeposition technique. Structural and surface morphological properties of the fabricated electrodes were investigated using high-energy X-ray diffraction (HEXRD) and scanning electron microscopy (SEM). The HEXRD analysis showed the formation of a single-phase polycrystalline cuprous oxide film on the Ti substrate. The SEM revealed that the morphology of the electrodeposited cuprous oxide thin films strongly depends on the pH value of the deposition bath. The performance of cuprous oxide as an electrochemical supercapacitor electrode was analysed using cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS) techniques. In comparison to microstructured electrodes, the nano cuprous oxide electrodes demonstrate better electrochemical performance in terms of specific capacitance, energy density, and power density. The $Cu_2O//Cu_2O$ supercapacitor with nano-Cu_2O electrodes, prepared at pH 7.9, exhibited the highest specific capacitance of 176.02 mF/g, energy density of 61.4 mWh/kg, and power density of 44.23 W/kg. In contrast, the supercapacitor with microstructured electrodes, prepared at pH 6.3, exhibited a specific capacitance of 7.37 mF/g, energy density of 2 mWh/kg, and power density of 1.4 W/kg. The significant improvement is mainly attributed to the increased film surface area associated with cuprous oxide nanostructures. Therefore, nano copper oxide-based supercapacitor electrodes show great potential for supercapacitor applications.

Keywords: Supercapacitors, Nanostructures, Electrodeposition, Nano cuprous oxide, High-Energy X-ray diffraction