High-Efficiency Supercapacitor with Graphene/ Vanadium oxide Nanocomposite Electrodes

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Abstract
Supercapacitors, also known as ultracapacitors, are energy storage devices with significant potential to replace conventional batteries across a wide range of applications. This is due to their high-power density, rapid charge–discharge rates, extended cycle life, enhanced safety, cost-effectiveness, and environmental sustainability. In this study, a CO_2 laser beam was employed as a clean, low-cost method to synthesize graphene/Vanadium oxide nanocomposite films in a single-step process. The CO_2 laser treatment produced mechanically robust films characterized by high electrical conductivity and large specific surface area, making them suitable for direct use as supercapacitor electrodes without the need for additional binders or current collectors. The choice of metal oxides was optimized to facilitate effective intercalation with graphene, thereby enhancing the performance of the supercapacitors. The fabricated supercapacitors were systematically evaluated using cyclic voltammetry (CV), galvanostatic charge/discharge (CD) testing, and electrochemical impedance spectroscopy (EIS).