Laser-Induced One-Step Green Synthesis of Graphene Nanoparticles for Fabrication of All-Solid-State Ultracapacitor

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Drastic increases in energy demand have led to the quest for developing efficient energy-storage devices. The main research pursuit is in fulfilling global requirements for storing renewable energy using ultracapacitors (UCs). In this research, the electrode material was synthesized by converting naturally occurring graphite into high-purity graphene nanoparticles via a novel, green, catalyst-free, and single-step laser irradiation technique. This work resolved three inherent UC problems including inadequate energy density, low potential window, and high cost. The adopted synthesis method overcame the difficulties associated with graphene production by conventional methods. Characterizations like Raman, XRD, FESEM, TEM, BET, and XPS proved the selectivity of the material after the laser irradiation treatment by revealing the defected graphene with an extensive surface area. Using cyclic voltammetry and galvanostatic charge-discharge calculations, the fabricated ultracapacitor functioned as a battery and a supercapacitor simultaneously indicating an exceptional specific capacitance of 219F/g. The device also retained 92% of its total capacitance after 15000 cycles at a wide potential window of 3.5V, exhibiting a superior energy density of 83.56Wh/kg and a remarkable power density of 15.3kW/kg, outperforming several recent reports. All experimental procedures were repeated 7 times to ensure the reproducibility of these findings. A liquid-free ultracapacitor was successfully constructed resulting in reduced leakage, enhanced efficiency by 54%, and decreased cost by 89%. There is enormous potential for this technology as a sustainable power source for future electronics, portable gadgets, and intermittent power supplies in both miniaturized and large-scale appliances.

Awards Won:

Second Award of $2,000