World Academy of Science, Engineering and Technology
International Journal of Energy and Environmental Engineering
Vol:17, No:12, 2023

Designing Nickel Coated Activated Carbon (Ni/AC) Based Electrode Material for Supercapacitor Applications

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Abstract : Supercapacitors (SCs) have emerged as auspicious energy storage devices because of their fast charge-discharge characteristics and high power densities. In the current study, a simple approach is used to coat activated carbon (AC) with a thin layer of nickel (Ni) by an electroless deposition process to enhance the electrochemical performance of the SC. The synergistic combination of large surface area and high electrical conductivity of the AC, as well as the pseudocapacitive behavior of the metallic Ni, has shown great potential to overcome the limitations of traditional SC materials. First, the materials were characterized using X-ray diffraction (XRD) for crystallography, scanning electron microscopy (SEM) for surface morphology and energy dispersion X-ray (EDX) for elemental analysis. The electrochemical performance of the nickel-coated activated carbon (Ni-AC) is systematically evaluated through various techniques, including galvanostatic charge-discharge (GCD), cyclic voltammetry (CV), and electrochemical impedance spectroscopy (EIS). The GCD results revealed that Ni/AC has a higher specific capacitance (1559 F/g) than bare AC (222 F/g) at 1 A/g current density in a 2 M KOH electrolyte. Even at a higher current density of 20 A/g, the Ni/AC showed a high capacitance of 944 F/g as compared to 77 F/g by AC. The specific capacitance (1318 F/g) calculated from CV measurements for Ni-AC at 10mV/sec was in close agreement with GCD data. Furthermore, the bare AC exhibited a low energy of 15 Wh/kg at a power density of 356 W/kg whereas, an energy density of 111 Wh/kg at a power density of 360 W/kg was achieved by Ni/AC-850 electrode and demonstrated a long life cycle with 94% capacitance retention over 50000 charge/discharge cycles at 10 A/g. In addition, the EIS study disclosed that the Rs and Rct values of Ni/AC electrodes were much lower than those of bare AC. The superior performance of Ni/AC is mainly attributed to the presence of excessive redox active sites, large electroactive surface area and corrosive resistance properties of Ni. We believe that this study will provide new insights into the controlled coating of ACs and other porous materials with metals for developing high-performance SCs and other energy storage devices.

Keywords : supercapacitor, cyclic voltammetry, coating, energy density, activated carbon
Conference Title : ICSEEE 2023 : International Conference on Sustainable Energy Engineering and Environment
Conference Location : London, United Kingdom
Conference Dates : December 11-12, 2023

Open Science Index, Energy and Environmental Engineering Vol:17, No:12, 2023 publications.waset.org/abstracts/175609.pdf