ABSTRACT

Supercapacitors, also sometimes called as electrochemical capacitors, have nowadays emerged as the high-performance environmentally viable energy storage devices from alternative sustainable energy sources. Supercapacitors have considerably drawn researchers' attention as these can uniquely act as the bridge between normal dielectric capacitors and batteries exhibiting a higher energy density than the capacitors and higher power density than the batteries. Moreover, supercapacitors can be rapidly charged and discharged through absorption and desorption of the charges on the surface of the electrodes and can show long shelf life. These above goodness about supercapacitors have enabled them to serve as the next-generation energy storage devices. The chief component of any supercapacitor is the electrode material which should be designed in such a way that it can exhibit high power density along with appreciably high energy density. It should also essentially be environmentally benign, cheap, structurally stable and of light weight. Hence, it is highly desirable to use hybrid electrode materials which synergistically combine both the electrical double-layer capacitors (EDLCs) and pseudocapacitors in a supercapacitor device to meet the requirements of high power for next-generation portable and wearable electronics.

In this thesis, efforts have been put forward to design, synthesize and characterize several nanocomposites based on high surface area carbonaceous nanomaterials (graphene nanoplatelets (GNP) and reduced graphene oxide (RGO)) and faradaic transition metal based oxide, selenide, hydroxide or salt and porous conducting polymers (polyaniline and polypyrrole), to be employed as the hybrid electrode materials for supercapacitors. Use of porous conducting polymers and carbonaceous nanomaterials boosts up reaction kinetics in the electrode materials by minimizing polarization and the ion transport path and hence, the power density is enhanced. Then again, faradaic materials like transition metal oxides/hydroxides/complex salts and conducting polymers etc. with substantially higher specific capacitances enhance the energy density of the electrode materials. Faradaic materials combined with highly conducting carbonaceous nanomaterials demonstrate improved conductivity and rate capability accompanied by high cycle life and also form light weight electrode materials. The structural, morphological and electrochemical properties of the synthesized composite electrode materials have been investigated and thoroughly discussed in this thesis. Furthermore, flexible asymmetric supercapacitors with extended cell voltage have been fabricated using new suitable anode and cathode active materials and experimentally verified their potential for state-of-art futuristic applications as the advanced energy storage systems in next-generation smart portable electronics.

KEYWORDS: Supercapacitor, Nanocomposites, Conducting polymers, Energy density, Power density.