INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Energy storage systems are essential for the practical implementation of renewable energy systems because the majority of renewable energy sources are intermittent in nature. Supercapacitors (SCs) are one of the most promising energy storage devices owing to their performance characteristics, viz. high power density, rapid charge–discharge, and ultra-long cycle life. However, their usage is significantly limited by the drawbacks of low energy density. The main aim of this work is to develop advanced electrode materials for supercapacitors with improved energy density while maintaining high power density and long cycle life. This thesis reports investigations on the synthesis of four electrode materials for supercapacitors, including nanocomposites (Fe_3O_4/rGO and MWCNT/MnO_2/rGO), and carbon materials (rGO and PC–*x*). The two nanocomposites were synthesized by facile ultrasound–assisted synthesis methods. The reduced graphene oxide (rGO) was synthesized via chemical reduction of highly oxidized graphene oxide. Lastly, oxygen-enriched porous carbon (PC–*x*) was prepared by co–pyrolysis and KOH activation process from a ternary blend of biomass. These materials have been extensively characterized using standard techniques and the electrochemical performances were investigated using cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectrometry (EIS) techniques. The fabricated supercapacitors have been demonstrated to possess excellent electrochemical properties as follows: (1) The Fe_3O_4/rGO based all–solid–state supercapacitor with PVA/KOH polymer–gel electrolyte exhibited an energy density of 8.46 W h kg^{-1} at a power density of 338 W kg^{-1}. Ternary MWCNT/MnO_2/rGO nanocomposite based supercapacitor with commercial–level mass loading (~12 mg cm^{-2}) demonstrated high specific capacitance (314.6 F g^{-1} at 5 mV s^{-1}), energy density

(21.2 W h kg^{-1} at 150 W kg^{-1}) and excellent cycle stability at a wide cell voltage of 1.5 V in 1 M Na_2SO_4 electrolyte. (2) The rGO based aqueous supercapacitors (rGO–SCs) with commercial–level electrode mass loadings achieved energy densities of 15.39 W h kg^{-1} (at 180 W kg^{-1}, 1.8 V), 21.42 W h kg^{-1} (at 180 W kg^{-1}, 1.8 V), and 22.87 W h kg^{-1} (at 210 W kg^{-1}, 2.1 V) in 1 M Li_2SO_4, redox–additive electrolyte (0.1 M Na_2MoO_4 + 1 M Li_2SO_4), and water–in–salt (11 M $NaNO_3$) electrolyte, respectively. (3) Oxygen–enriched porous carbon (PC–*x*) based aqueous supercapacitors with commercial–level mass loadings exhibited an energy density of 22.75 W h kg^{-1} (at 200 W kg^{-1}, 2 V) and 96.8% capacitance retention over 10000 cycles in 1 M Li_2SO_4. The energy density of the device was enhanced to 37.24 W h kg^{-1} (at 200 W kg^{-1}, 2 V) in a redox–additive electrolyte (0.1 M Na_2MoO_4 + 1 M Li_2SO_4). On a whole, the results of this thesis have demonstrated the efficacy of the fabricated supercapacitors with concurrent high energy and power densities. Therefore, these materials have tremendous potential for the development of high-performance supercapacitors for commercial applications.