ABSTRACT

Recent advances in portable, flexible and wearable electronics, hybrid electric vehicles, defense innovation and space technology are due to the development of efficient energy storage devices. Electrochemical energy storage devices, such as supercapacitors having high power density and moderate energy density with excellent cyclic stability as compared to batteries (low power density) and capacitors (low energy density), are important for applications in these fields. This work is focused on the synthesis of MnO_2 based nanomaterial and its composites such as MnO_2/rGO, $CrAlO_3$/MnO_2, and Cu-doped MnO_2 as electrode materials for supercapacitors. Synthesis of the electrode materials was carried out using a microwave-assisted hydrothermal method for the growth of MnO_2 nanostructures and their composites. The morphology of MnO_2 was found to play an important role for the enhancement of supercapacitor performance with an increase in specific surface area for maximum access of electrolytic ions. Branched MnO_2 nanostructures (synthesized with $KMnO_4$ and weak acetic acid) well-distributed on and in between the layers of rGO show enhanced electrochemical performance. This is due to the increased specific surface area and the conductivity of the composite sample. Furthermore, MnO_2 nanostructures, synthesized using $KMnO_4$ and $MnSO_4 \cdot H_2O$ precursors have a higher yield and surface area than $KMnO_4$ with acid precursor and its composite with $CrAlO_3$ performs more effectively as a supercapacitor than pure MnO_2 because of higher specific surface area and porosity. Loading of active material mass on the electrode has a particular impact on the performance of supercapacitors as high mass loading slows down the diffusion process and thereby reduces the supercapacitor performance. Therefore, during electrode fabrication, initially the supercapacitor performance has been studied with higher mass loading of electrode active material and then the best performing composite sample has been studied with a lower mass loading. Additionally, Cu-doped MnO_2 nanostructures show morphology variation from nanorods to nanoflowers upon reducing the microwave power from 400 W to 250 W which improves supercapacitor performance. To summarize, this thesis work is focused on the development of MnO_2 and MnO_2 based nanocomposites for supercapacitor applications.

Keywords: MnO_2, MnO_2/rGO, $CrAlO_3$/MnO_2, Cu-doped MnO_2, electrochemical energy storage devices, supercapacitor