Thesis title:

Manganese (II, III) Oxide Based Electrodes for Application in Supercapacitors

ABSTRACT

Energy storage technologies will be an integral part of renewable based energy landscape. They will ensure efficient energy utilization, grid security and provide means for flexible off-grid electricity distribution networks. An integrated system comprising of batteries and supercapacitors will solve the problem of simultaneous demand for high specific energy and power. This thesis reports the use of few high performing metal oxides (viz. Mn_3O_4, ZrO_2, WO_3, V_2O_5 and Co_3O_4) in supercapacitors. For example, Mn_3O_4 is one of the fast emerging transition metal oxides (TMOs), which can find potential application in supercapacitors. In this thesis, the room temperature synthesis of Mn_3O_4 nanoparticles is presented. Its electrochemical performance, effect of redox additive (KI) and magnetic fields on Mn_3O_4 based supercapacitors are discussed in detail. For integration in devices, it is essential to achieve high capacitive material with good cycling stability with capability to operate over a wide potential window. To tackle the detrimental consequences, owing to low electrical conductivity observed in most metal oxides, PANI (conducting polymer) and graphene were used to coat metal oxides. Conducting polymer (PANI) also provides electron transport pathways and pseudocapacitance. The drawback with PANI is its poor stability due to the polymer back bone damage during charging/discharging. PANI also suffers from volumetric swelling and shrinkage during charge-discharge process, which influences it cycling stability. To overcome these issues, a 2D carbon material (graphene) was used, which can give the pathways for electron transport, increase the mechanical stability and eventually suppress degradation during cycling. Neutral electrolyte 1 M Na_2SO_4 was used to stabilize an extended potential window. Electrochemical performance of symmetric cell fabricated using metal oxide-PANI-Graphene composites are also discussed. It is shown that the specific capacitance can be significantly improved by modifying the electrolyte using optimum concentration of redox additive (like: KI). This strategy has been recently proposed by our group for developing the next generation supercapacitors. The results regarding the synthesis of materials, their characterization and various electrochemical measurements are summarized in 6 chapters. Few major outcomes of the work are: (1) Increasing trend of capacitance during cycling of Mn_3O_4 electrode, which can be attributed to the conversion of Mn_3O_4 to MnO_2. (2) Decreasing capacitance of Mn_3O_4 nanoparticles, in the presence of increasing magnetic field. (3) Extended operating voltage window for most of the metal oxides and their composites using 1 M Na_2SO_4 electrolyte. (4) Use of redox additive (KI) for significantly enhancing the specific capacitance.

Keywords: Metal oxides; Composites; Symmetric supercapacitors; Magnetic field; Redox additives