Abstract

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"DEVELOPMENT OF MANGANESE BASED NANOMATERIALS FOR ENERGY STORAGE AND PHOTOCATALYTIC APPLICATIONS"

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Supercapacitor, also known as electrochemical capacitor or ultracapacitor, has attracted great attention from the material-researchers due to its unique properties like high specific power, moderate specific energy, short charging time, high cyclic stability, etc. Based on their charge-storage mechanism supercapacitors are classified into two types. The electrical double layer capacitor (EDLC) is the one which mainly stores the charge electrostatically. Another one is pseudocapacitor in which the capacitance originates from fast Faradaic redox reactions. Carbonaceous materials like activated carbon, graphene, carbon nanotube etc. are used as capacitive materials. On the other hand, transition metal oxides, hydroxides, sulfides and conducting polymers are used as pseudocapacitive materials. Manganese-based nanomaterials are promising in the area of energy research. Being a second row transition element Mn can implement some properties like electron mobility, good conductivity, excellent charging-discharging profile and high cycle life.

In this thesis manganese oxides such as MnO_2, Mn_3O_4, bimetallic hydroxide $MnSn(OH)_6$, bimetallic sulfides (MnCoS) and co-ordination complex like $Mn[Fe(CN)_6]$ have been described and their electrochemical performances have been investigated. The as-synthesized materials were structurally characterized by XRD, FTIR, XPS techniques; the morphology was identified with the help of FESEM and TEM images; the surface area and porosity was measured form the BET study. Finally, the electrochemical performances were investigated in terms of CV, GCD and EIS study. Due to low conductivity of the manganese oxide, it was combined with highly conductive material such as carbon nanotube to synthesize a composite. An assymetric supercapacitor has been constructed using Mn_3O_4-MWCNT and rGO. The as-fabricated capacitor has achieved high specific energy with high power delivery rate along with high cyclic stability. A combinatorial transition metal oxide also has been used to get high electroactive surface area and the high electrochemical performances thereof. The electrochemical performances of a supercapacitor device not only

depend on the active electrode materials solely, but also on the electrolyte, separator, and design of the supercapacitor fabrication also. Therefore, a redox system has been incorporated in conventional electrolyte. This redox system surpluses the electron density of the mother electrolyte and enhances the charge storage also. The bimetallic sulfides have also been prepared on nickel foam via electrodeposition. The electrodeposition is a single step technique by which large area nanostructured materials can be synthesized without going through a harsh reaction condition. Additionally, the nickel foam can be directly used as current collector. Although carbonaceous materials are used as negative electrode of supercapacitor, these materials suffer from low capacitance. Few pseudocapacitive materials like V_2O_5, Mn_3O_4 have shown the efficiency to be the promising negative electrode for supercapacitor. A bimetallic hydroxide such as $MnSn(OH)_6$ has been prepared and its electrochemical performance has been investigated as negatrode for the supercapacitor. Recently, the coordination complexes like metal hexacyanoferrates have gained attention due to their semiconducting nature with narrow band gap. Hence these compounds show promising applications in energy storage and conversion, photocatalysis, ion sensing etc. Manganese hexacayanoferrates along with some other metals like cobalt, copper and zinc have been prepared and their electrochemical performances and photocatalytic activity on the reduction of highly toxic Cr(VI) have been studied. The as-synthesized materials have been used for photocatalytic reduction of Cr(VI) and it showed good reducing capability.

It has been realized how the electrochemical activity of different manganese-based nanomaterials depends on the nature, architecture, dimension and electrolyte. Hope the obtained results will be useful in practical application in the field of supercapacitors.

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