ABSTRACT

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Thesis title: "Synthesis and application of metal oxides/sulfides composites with carbon nanomaterials as an electrode of supercapacitor"

One of the strategies for further development of supercapacitors is to address their main drawbacks such as low energy density and limited safety by adapting new electrode materials with improved capacitance operating in aqueous electrolytes. Recently, it has been observed an increased research interest in pseudocapacitive materials including metal oxides and sulfides, which are characterized by few folds higher electrochemical activity in aqueous media compared to the classical activated carbon-based electrodes.

The aim of this study was to obtain manganese oxide and bismuth sulfide composites with carbon nanomaterials (reduced graphene oxide, carbon nanofibers) by solvothermal method and to evaluate their potential in the application as active electrode material for supercapacitors working in aqueous solutions.

The experimental part was devoted to the method elaboration and optimization of composite synthesis by altering solvothermal conditions, including type of solvent, pH of reaction mixture and components mass ratio, and testing different nanostructured carbon materials in order to obtain electrode active material with remarkable electrochemical performance and long-term cycle stability. The effect of physicochemical properties of the synthesized composites, such as chemical structure, morphology, textural properties, on their electrochemical activity in a three-electrode set-up of supercapacitor working either in 1M Na_2SO_4 or 6M KOH electrolyte was determined. The composites which exhibited the best electrochemical properties were subsequently assembled into asymmetric device and tested.

The best electrochemical properties represented MnO_2/rGO-T with 3:1 mass ratio of MnO_2 to rGO and Bi_2S_3/rGO-H composite synthesized from graphene oxide. MnO_2/rGO-T (3:1) was characterized by high rate capability at 5 A/g (114 F/g). While Bi_2S_3/rGO-H exhibited remarkable capacitance performance in the aqueous electrolyte – 493 F/g (0.5 A/g).

Asymmetric supercapacitors assembled with MnO_2/rGO-T_E+N or MnO_2/rGO-T (3:1) had high energy density (24-27 Wh/kg) and excellent cycling performance. Moreover, there wasn't observed any capacitance loss after 5000 cycling work for MnO_2/rGO-T (3:1)//MPK supercapacitor operated at 2.0 V.

The conducted research enabled to establish the optimal synthesis method and composition of manganese oxide and bismuth sulfide-based composites with nanocarbon materials, which provides the maximum synergistic effect reflected by high capacitance and great electrochemical stability. Furthermore, the influence of the solvothermal treatment condtions on the morphology, chemical composition and textural properties of the resultant composites was evaluated.

This study demonstrates the great potential of metal oxide/sulfide-based composites in the supercapacitor application and can be inspiration for further development of high scale synthesis method to enable their commercialization.