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Recent progress and emerging challenges of transition metal sulfides based composite electrodes for electrochemical supercapacitive energy storage

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Abstract

The need for clean energy production and utilization is urgent and continues to grow due to the serious issues of human population growth and environmental pollution. The energy crisis is driving the demand for novel and innovative materials for the development of alternative energy sources and the fabrication of innovative energy storage devices. Supercapacitors are emerging electrochemical energy devices for future clean energy technologies. Supercapacitors have several distinctive features, such as rapid charging rates, high power densities, long cycle lives, and simple configurations. Thus, supercapacitors can serve as bridges to span the power gap between conventional capacitors and batteries or fuel cells. The current state of supercapacitor research is summarized in this review, and rapid progress in the basic development and practical application of supercapacitors is highlighted. A concise review of the technologies and working mechanisms of different supercapacitors is presented along with recent developments in the application of transition metal sulfide-based materials in electrochemical supercapacitors. Nanostructured transition metal sulfides have gained prominence as advanced electrode materials for an electrochemical supercapacitor due to their outstanding properties. These include good electrical conductivity, high specific capacity, low electronegativity, unique crystal structures, and high redox activity. The electrochemical performance of transition metal sulfides is superior to that of transition metal oxides which is attributed to the replacement of oxygen atoms with sulfur atoms. In this context, special emphasis is placed on nickel, cobalt, molybdenum, tin, manganese, and tungsten metal sulfides and their composites as advanced electrode materials for supercapacitor applications. Finally, the benefits and challenges of using transition metal sulfide-based electrode materials for future clean energy storage are discussed.