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Overview of molybdenum disulfide based electrodes for supercapacitors: A short review

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ABSTRACT

In recent years, transition metal dichalcogenides (TMDs) have gained significant attention in the field of supercapacitors due to their unique properties. Different TMDs like MoS_2, WS_2, $MoSe_2$, WSe_2 have been studied in the past few years. In this review we focus on different synthesis approaches and supercapacitive performance of MoS_2 based electrodes. Nanocomposites of MoS_2 offering various advantages like high electrical conductivity and improved electrochemical performance due to synergistic effects. This review provides the detailed information about the development of MoS_2 based nanocomposites (with carbon derivatives, conducting polymers, metal sulfides and other materials) in the field of electrochemical energy storage. Future perspectives and challenges faced by MoS_2 electrodes are discussed.

1. Introduction

In the post-world war era, rapid industrialization has resulted in an exponential increase in energy demand worldwide. Combined with the rising living standards that raise energy demand for personal use and hence industrialization induced demand has contributed to the growth of power requirement. Until the end of 19th century, the power demand was mostly met with the help of fossil fuel related resources. As it is worldwide known, that these crude oil resources are limited and depleting rapidly due to their high rate of extraction, it is evident to focus on other sources of energy [1]. There are serious environmental implications related to the use of fossil fuel related energy resources. These multiple factors posed a worldwide threat to the use of fossil fuels as an energy source in the future. To fulfil energy demand worldwide, scientific community is consistently making efforts to develop advanced devices so that maximum benefit of renewable energy sources can be taken. The most prominent renewable energy sources such as solar, wind, tidal energy are weather dependent and hence along with these energy conversion devices, efficient energy storage devices are also required. This has given a way to the development of energy storage devices. The scientific community has recognized batteries and electrochemical supercapacitors as the most important electrochemical energy storage devices. Long cycle life, wide operating temperature range and high power density induced by fast charging and discharging rates attracted the attention of researchers as well as industry experts towards electrochemical supercapacitors commonly known as ES.

Electrochemical supercapacitors are classified into three basic categories based on energy storing mechanisms viz, electrochemical double-layer capacitors (EDLCs), pseudocapacitors, and hybrid capacitors [2]. Similar to conventional capacitors the charge storage mechanism of EDLCs is electrostatic and non-Faradic i.e., no charge transfer between electrode and electrolyte takes place. When supercapacitor is charged, due to potential gradient electrons from positive electrode move towards the oppositely charged negative electrode. As a result, electrolyte ions diffuse across the separator and concentrates on the surface of oppositely charged electrodes. Formation of EDL at electrode surface avoids recombination of charges. As the charge storage mechanism is non-Faradic, there is no redox reaction involved and therefore electrode does not undergo any volume and morphology change, this increases the stability of the electrode. Due to high surface area and abundancy, various carbon-based materials like carbon nanotubes, activated carbon, carbon aerogels, etc. are used as electrode materials in EDLCs [3,4]. Despite that, EDLC has low performance in aqueous and organic electrolytes because the double layer and physically stored charges are fewer. Pore size distribution, pore volume, surface area, and conductivity of the material are the key parameters which affects the performance of EDLCs [5,6]. Pseudocapacitors stores charge faradically due to fast and reversible redox reactions and are non-electrostatic in nature. In

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