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Research papers

Synergistic nanostructuring of CoNi-carbide/reduced graphene oxide derived from porous coordination polymers for high-performance hybrid supercapacitors

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ABSTRACT

Porous coordination polymers (PCPs) and metal-organic frameworks (MOFs) have emerged as promising materials for nanostructuring inorganic functional materials with applications in energy storage. In this study, our aim was to synthesize CoNi-carbide (CoNi-C)/reduced graphene oxide (rGO) hybrids by annealing CoNi-cyanide bridged coordination polymers (CoNi-CP) under a nitrogen atmosphere. The resulting CoNi-C/rGO hybrids exhibited exceptional electrochemical performance, surpassing the individual components (CoNi-C and rGO). The hybrids demonstrated a specific capacitance of 1177 F g^{-1} and an electroactive surface area of 130.87 m^2 g^{-1}. By optimizing the CoNi-C/rGO ratio, we achieved the highest specific capacitance. Furthermore, we constructed a coin cell using CoNi-C/rGO-2 as the positive electrode and rGO as the negative electrode, which showed excellent performance with an energy density of 31.6 Wh kg^{-1} at a power density of 750 W kg^{-1} and capacitive retention of 84 % over 8000 charging cycles. Our findings provide valuable insights into designing and developing high-performance electrode materials for energy storage, with potential applications in various devices.

1. Introduction

Researchers focus on renewable and environmentally acceptable energy resources in response to the depletion of energy supplies and environmental harm caused by the combustion of fossil fuels and natural gases [1,2]. Supercapacitors (SCs) have emerged as a crucial electrochemical energy storage technology, with advantages over batteries and fuel cells in power densities, life-span cycles, and safety [3,4]. Two main mechanisms of energy storage in SCs are electric double-layer capacitors (EDLCs), which store charges electrostatically, and pseudocapacitors (PCs), which store energy through a Faradic redox reaction [5,6]. The capacitance of an EDLC is influenced by the surface area and surface characteristics of the electrode materials, in addition to their electrical conductivity, leading to higher power density and stability. In contrast, PCs rely on rapid and reversible Faradic redox processes to store charges, demonstrating performance around 100 times higher than EDLCs [7–10].

A new type of capacitor called hybrid supercapacitors was developed by merging the advantages of EDLCs and PCs. It is a composite of the materials employed individually for constructing EDLCs and PCs, thereby endowing hybrid capacitors with the properties of both supercapacitors with new properties [11,12]. Among numerous electrode materials, Coordination polymers (CPs) grabbed extensive attention in research, which are produced by connecting inorganic and organic compounds or linkers with metal centres to constitute a novel family of porous materials [13,14]. Besides, the availability of many compounds

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