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Research Letter

Construction of CuV_2O_6-nanostructured electrode material for supercapacitors

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Abstract

In the present study, copper vanadate (CuV_2O_6) was prepared via a simple precipitation route, followed by calcination. The as-prepared electrode material, CuV_2O_6, was observed to have a surface area of 62 $m^2\ g^{-1}$ by the Brunauer–Emmett–Teller analysis. Further, its capacitance behaviour was assessed using cyclic voltammetry, Galvanostatic charge–discharge studies (GCD) and electrochemical impedance spectroscopy. The electroactive CuV_2O_6 showed a high specific capacitance of 497 F g^{-1} at 1 Ag^{-1}. Furthermore, long-term cyclic stability of 3000 GCD cycles at 2 Ag^{-1} with 92.2% of capacitance retention was attained. Hence, CuV_2O_6 is one of the potential electrode materials for energy storage systems due to its significant properties, such as porous nanostructure and good surface area.

Introduction

The lack of use of alternate energy sources is what has caused the global energy crisis. Because of industrial revolution, population explosion and economic expansion, conventional energy sources meet out roughly 80% of our energy demands and are quickly depleted.[1] Research on Alternate Energy Resources has much focus on environmental friendly methods of producing and storing energy that employs renewable energy sources.[2] Supercapacitors (SCs), fuel cells and solar energy batteries are noted to be the promising solutions to this issue.[3] Solar energy is the most plentiful, clean, consistent and adaptable amongst these energy resources. One of the current interesting solar energy harvesting technologies is energy storage or conversion via electrochemical processes, which mostly uses batteries and supercapacitors (SCs).[4–7]

For the next-generation power storage devices, SCs are noted to be particularly viable possibilities. SCs are considered as significant, sustainable and renewable power sources because of their high-power density, moderate energy density, reversibility, fast charge/discharge capabilities, extended cycle life, safe operation and eco-friendliness.[8,9] In comparison to ordinary capacitors, SCs have greater capacitance and they can deliver more power owing to their stored energy.[10] However, SCs have a lower energy density than batteries, therefore this must be taken into account whilst assembling SCs. The creation of new electroactive electrode materials through simple synthetic processes should aim to increase the energy density in SCs.[11]

The performance of transition metal oxide-based (TMO) SCs is typically better than that of SC, made of carbonaceous materials, making them the best choice.[12] In addition, the development of SCs using novel TMO active materials can result in the achievement of high specific capacitance (C_{sp}), superior cycle stability and high rate functioning.[13] By taking all these considerations, a number of TMOs as well as combined TMO spinels have recently been produced and utilized in the creation of high-performance SCs.[14]

Transition metal vanadates are an important type of materials that have drawn the attention of considerable research recently, due to their distinct size-dependent electrical and magnetic properties.[15] Due to their availability, affordability and variable oxidation states in particular, they exist in different stoichiometry such as $M_3V_2O_8$, MV_3O_8, MVO_4, $M_2V_2O_7$, MV_2O_6 and MV_2O_4 (M=Mn, Fe, Cu, Ni and Zn) and these materials are expected to have potential applications in wide area, including optical devices, catalysis, paramagnetic materials and lithium batteries.[16] Additionally, the multiple oxidation states of vanadium allowed for the creation of compounds with the right electronic structure, which render them as promising electrode materials for SC applications. The better conductivity of CuV_2O_6 over other binary metal oxides including $ZnFe_2O_4$, $CoMoO_4$, $MnMoO_4$, $Zn_3V_2O_8$, ZrV_2O_7, CoV_2O_6 and $NiMnO_4$ has also garnered significant attention. The excellent redox activity, natural availability, affordability, eco-friendliness and