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Research papers

Niobium doped triazine based covalent organic frameworks for supercapacitor applications

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ABSTRACT

Covalent organic frameworks (COFs) are gaining high importance in energy storage systems due to their uniform porosity and versatile functionality. The present work deals with the fabrication of triazine-based COF through Schiff base formation. The method involves the polycondensation reaction between melamine and terephthalaldehyde. In addition, the COF was also decorated with Niobium to generate Nb@COF. The morphological, elemental mapping, X-ray photoelectron spectroscopy, C^{13} NMR results show the effective doping of Nb to the COF and provide insights into the nature of bond formation. The obtained experimental XRD results are in good agreement with Materials Studio simulated results. COF and Nb@COF have been used for supercapacitor applications in a three-electrode system. Enhanced specific capacitance was observed in Nb@COF (367 F g^{-1}) compared to pure COF (244 F g^{-1}) at a scan rate of 2 mV s^{-1}. The superior electrochemical performance in Nb@COF could be due to the increased porosity and interlayer spacing. COF and Nb@COF exhibited good stability towards charge and discharge and managed to retain 82 and 89 % specific capacitance, respectively even at 5000 cycles. COF and Nb@COF were assembled in a coin cell and fabricated an asymmetric supercapacitor device as negative and positive electrodes, respectively. The results obtained were satisfactory and shows a specific capacitance of 87 F g^{-1} at a scan rate of 2 mV s^{-1}.The good stability, specific capacitance and reliability of Nb@COF indicate its potential application in energy storage devices.

1. Introduction

Population growth, Industrialization, and urbanization across the globe are demanding an enormous amount of energy which is usually reached by fossil fuels. These fossil fuels are non-renewable sources of energy that leads to the deterioration of the environment in near future [1,2]. So, an alternative to these exhaustible sources are on high demand and gaining the attention of researchers [3]. Electrochemical energy storage devices like Li-ion batteries, supercapacitors, fuel cells, H_2 as fuel, and solar cells' efficiency enhancement is an important feature for their commercialization [4–6]. Supercapacitors (SCs) acquired superiority over other energy storage devices due to fast charge/discharge rate, enhanced energy and power density, prolonged cycle life and economical [7–9]. The energy storage system in SCs mainly involves two different mechanisms. One is electrical double-layer capacitors (EDLCs) which store energy through the formation of positive and negatively charged layers at the electrolyte/electrode junction [10]. Another one is faradic capacitors which store the energy due to reversible redox reactions. The materials serve the purpose of energy storage and their mechanism in SCs is different. Carbon-related materials like CNTs, Graphene, boroncarbonitride etc. are used in EDLCs [11]. Metal oxides like Ta_2O_5, Fe_2O_3, ZnO, $LaAlO_3$, SnO, In_2O_3, polyaniline, polypyrrole, etc. are used in redox capacitors [12,13]. In addition research on hybrid capacitors is also quite interesting since it involves the combination of

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