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Microwave assisted cobalt incorporated covalent organic frameworks as cathode material for asymmetric supercapacitor device

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ABSTRACT

Nitrogen-rich covalent organic frameworks (COF) with crystallinity and porosity are finding applications in electrochemical energy storage applications. The present work aims at developing a microwave-assisted synthetic method for the synthesis of COF using benzene-1,3-diamine and terephthalaldehyde (BDT-COF) through imine bond. BDT-COF modification was through the incorporation of cobalt (BDT@Co-COF). The morphological, structural and electrochemical properties of BDT-COF and BDT@Co-COF were examined and compared. Enhanced electrochemical performance was observed in BDT@Co-COF with a specific capacitance of 445 F/g compared to BDT-COF (196 F/g) at 2 mV/s. The density functional theory (DFT) shows a decreased bandgap in BDT@Co-COF (1.12 eV) compared to BDT-COF (1.70 eV). Asymmetric supercapacitor device (ASD) was fabricated using BDT@Co-COF and BDT-COF as positive and negative electrodes, respectively. The specific capacitance of ASD is found to be 220 F/g at 2 mV/s. A coin-type cell, model CR 2016, was also fabricated using the above-mentioned electrodes and used to power two red LEDs in parallel with a 1.45 V turn-on voltage for 10 min. The good stability and results of device fabrication tells about the well-confined structural arrangement in BDT@Co-COF.

1. Introduction

The use of renewable energy to replace fossil fuels in power generation, transmission, distribution, and storage is growing rapidly. Therefore it is desirable to develop a flexible, portable electronic gadget with improved electrochemical performance to meet the high energy demand [1,2]. Batteries and Supercapacitors (SCs) have garnered a lot of attention globally due to their distinctive qualities, such as their high power capacity, prolonged cycling stability, broad working temperature range, and simplicity of use [3–9]. Due to these outstanding characteristics, especially SCs are regarded as promising energy storage devices for modern electronic applications in the aerospace, load levelling, and hybrid electric car industries. However, the charge transfer mechanism on and near the electrode surface is depends on the surface-controlled electrochemical processes of SCs, which results in a poorer energy storage capacity than the present lithium-ion batteries. Future advancements in the SC field depend on preserving other aspects like power density, calendar and cycle life, and production cost while obtaining further improvements in the energy density [10,11]. Use of different anode and cathode electrode materials at various working potentials in the same electrolyte is one of the most proficient approaches to develop SCs with increased energy density.

Covalent organic frameworks (COF) are the class of crystalline organic porous polymers constituted of light-weight elements through strong covalent bonds [12,13]. COFs display great stability since they are fully connected through covalent bonds in contrast to MOFs, which

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