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Exploring the potential of metal tailored imine based covalent organic framework for asymmetric supercapacitor applications

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ABSTRACT

Currently, a fascinating area of research involves the development of stable and efficient materials for energy storage systems. The current work describes the synthesis of imine linked covalent organic framework (COF) using 4,4′,4′′,4′′′-(ethene-1,1,2,2-tetrayl) tetraaniline and terephthalaldehyde (TAT-COF) as precursors through solvothermal method. In addition, cobalt has been integrated to the imine linkage of TAT-COF to generate CO@TAT-COF. The X-ray diffraction study reveals the formation of ordered and crystalline TAT-COF with eclipsed (AA) stacking configuration. Morphological characterization indicated the accumulation of metal species over stick like structured TAT-COF. Energy-dispersive X-ray (EDX) and Fourier Transform Infrared Spectroscopy results shows the successive intercalation of Co to the TAT-COF matrix. TAT-COF and Co@TAT-COF were examined towards electrochemical performance for supercapacitor applications. A two fold higher specific capacitance (C_{sp}) was obtained in Co@TAT-COF (637 F/g) compared to TAT-COF (315 F/g) at 5 mV/s scan rate. The Co@TAT-COF showed an energy density (ED) of 58 Wh/kg at a power density of (PD) of 1500 W/kg. Enhanced electrochemical performance in Co@TAT-COF could be attributed to the structural confinement, conductivity, enhanced interlayer spacing and porosity. Co@TAT-COF has been used as positive electrode to fabricate an asymmetric device (ASD) in using Swagelok cell. The Csp of the fabricated ASD was found to be 95 F/g at 2 mV/s scan rate. ASD showed good stability with 73 % retention of Csp over 5000 charge/discharge cycles. The obtained results indicate the suitability of the engineered COFs towards energy storage devices.

1. Introduction

There is a greater need than ever for effective, sustainable, and high-performing solutions in the rapidly changing field of energy storage technology [1]. Energy storage devices become increasingly important as the world grapples with the effects of climate change and seeks transition to cleaner, renewable energy sources [2,3]. Supercapacitors, one of the numerous competitors, have demonstrated potential and are distinguished from conventional batteries by a variety of unique characteristics [4]. Supercapacitors have a higher power density, a longer cycle life, and faster charge and discharge cycles than regular batteries [5]. These qualities make them perfect for uses requiring short energy bursts, such portable electronics, renewable energy systems, and electric cars [6-8]. The pursuit of technological improvements that can overcome present constraints and unleash the full potential of supercapacitors is what motivates study into this fascinating material [9-11]. Scientists are now exploring novel materials, design strategies, and synthetic procedures aimed at improving the energy density, capacitance, and general efficiency of supercapacitors [12]. Furthermore, there is a rising focus on production of cost-effective and sustainable materials for these devices which is in line with the worldwide effort to create ecologically beneficial technologies [13-15].

Covalent organic frameworks (COFs) have attracted a lot of attention as potentially useful materials for energy harvesting and storage

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