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ORIGINAL ARTICLE

Activated carbon derived from ground nutshell as a metal-free oxygen reduction catalyst for air cathode in single chamber microbial fuel cell

Karthick S[1] · Vishnuprasad S[1] · Haribabu K[1] · Manju N J[2]

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Abstract

A single-chamber microbial fuel cell (SCMFC) was constructed using activated carbon derived from ground nutshells (GAC) as a metal-free cathode catalyst. The prepared cathode catalyst was characterized by X-ray photoelectron spectroscopy (XPS), Brunauer-Emmett-Teller (BET), and Field emission scanning electron microscopy (FE-SEM), which demonstrates the chemical composition and the surface morphology of the synthesized material. The electrochemical characteristics of the cathode were investigated by electrochemical impedance spectroscopy (EIS) and cyclic voltammetry (CV) analysis, which confirmed the high charge transfer capacity and catalytic activity property of GAC catalyst material. The MFC with GAC catalyst produces a maximum output voltage of 0.619 V and which is 1.61 times greater than that of bare carbon cloth (CC). For Pt/C and GAC-modified CC, high power density values of 0.763 W m^{-2} and 0.521 W m^{-2} were obtained at current densities 1.65 A m^{-2} and 1.0 A m^{-2}, respectively at 100 Ω. These results demonstrate that the GAC/CC is a promising cost-effective cathode catalyst for SCMFC.

Keywords Microbial fuel cell · Ground nutshells · High charge transfer · Catalytic activity

1 Introduction

Over the past several years, there has been a drastic increase in energy demand due to the tremendous growth in the global population and energy requirements [1]. This increase in demand has led to the injudicious exploitation of non-renewable sources of energy. The improper use of these resources had severe implications for the environment. Not only has there been an increase in the pace of depletion of these resources, but there has also been an increase in the emission of greenhouse gasses and subsequent issues such as global warming and climate change. The greenhouse gas emissions (GHG) sources are mainly divided into five sectors according to the Environmental Protection Agency (EPA) such as electricity and heat (28%), industry (22%), agriculture (9%), residential (12%), and transportation (29%) [2, 3]. Therefore, it is essential to find environmentally friendly and renewable energy alternatives to alleviate the levels of pollution and restore nature's resources sustainably [4]. To effectively substitute the use of non-renewable sources of energy, the alternatives suggested must also be economically viable and accessible for use. One such energy technology environmentally friendly and sustainable energy is the microbial fuel cell (MFC) [5]. An MFC is a bioelectrochemical device capable of simultaneous energy generation and wastewater treatment by converting organic material present in wastewater into electrical energy using microorganisms as biocatalysts [6]. During the conversion, both electrons and protons are generated in the anodic chamber of the MFC. The electrons travel through an external circuit, thereby producing an electric current. The protons travel across a proton exchange membrane to the cathodic chamber, wherein it combines with an oxygen receptor to form water through the four-electron pathway (O_2 to H_2O) [7]. Therefore, MFCs are a promising alternative to environmentally hazardous non-renewable sources of energy. However, its successful commercialization is still limited by its low power output and high cost [8]. The reason for these

✉ Haribabu K
haribhabu@nitc.ac.in

1 Department of Chemical Engineering, National Institute of Technology Calicut, Kozhikode 673601, India

2 Department of Geology and Environmental Science, Christ College, Irinjalakuda, India

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