Catalysis Today xxx (xxxx) xxx

Contents lists available at ScienceDirect

Catalysis Today

journal homepage: www.elsevier.com/locate/cattod

Metal organic frameworks (MOFs) as potential anode materials for improving power generation from algal biophotovoltaic (BPV) platforms

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ARTICLE INFO

Keywords:
Microalgae
Biotechnology
Metal organic framework
Biophotovoltaic
Green energy
Anode material

ABSTRACT

Microalgae based biophotovoltaic (BPV) cells are substantiated as innovative renewable energy generation devices, owing to their ability in mimicking the catalytic activity of microorganisms for water splitting reaction along with an effectual reduction of carbon footprint in our environment. As the direct contact between algal cells and anodic surface effectually governs the electron transfer and overall BPV performance, the development of electrochemically active and stable catalysts is crucial for the evolution of high performance BPVs. Accordingly, the monoclinic structured copper (Cu) metal organic framework (MOF) is prepared through the simple ageing process and the consequent bimetallic (Cu-Nickel(Ni)) MOF is developed via the partial substitution of Cu^{2+} with Ni^{2+} nodes without any variation in the chemical structure of Cu-MOF. The as-formulated MOFs loaded indium tin oxides (ITOs) are exploited as BPV anodes and their influences on green energy generation by using the freshwater microalgae *Chlorella* sp. UMACC 313 as a catalytic system are scrutinized in detail. The electrochemical activeness and robust stability of as-fabricated BPV anodes are enunciated, respectively, from the cyclic voltammetry and chronoamperometry techniques. Cu-Ni MOF/ITO equipped BPV establishes the power density of 40 μWm^{-2}, which is substantially higher than those of Cu-MOF/ITO and ITO. The substantial features of Cu-Ni MOF including the elevated structural integrity, existence of different metallic ions with the rational electrical conductivity, and supplemental functionality accelerate its maximum green energy generation performance. Thus, these verdicts establish a distinctive approach in tailoring the electrochemically active and stable MOF anode materials for the evolution of ecologically benevolent fuel cells.

1. Introduction

As the adverse effects of global warming have become more evident, the necessities of shifting the entire energy structure away from fossil fuels have become a first priority for energy researchers and policy makers [1]. However, the existing energy sources are not adequate enough to substitute the utilization of fossil fuels. Recently, the global community has shown immense commitment towards the use of renewable energy as a strategy to accomplish the significant objectives of United Nation Sustainable Development Goals (SDGs) including affordable and clean energy, sustainable cities and communities, and responsible consumption and production [2]. In this regard, algal biophotovoltaic (BPV) fuel cells have recently been endorsed as an attractive integrated solution to meet the energy demand of low electricity consumption appliances with a great environmental concern.

Upon the absorption of solar energy, microalgae catalytically splits water molecules and generates electricity along with the formation of oxygen, protons, and electrons [3–6]. Microalgae are the apparent solar energy converter in photosynthetic fuel cell technology, owing to its high photosynthetic efficiency (3–8%) over the other terrestrial autotrophs (0.5%) [7–9]. As the Earth receives 236 W/m^{-2} [7] or 885 million TWh yr^{-1} of irradiance from the sun [4], microalgae are substantiated as

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https://doi.org/10.1016/j.cattod.2021.07.020
Received 17 April 2021; Received in revised form 30 June 2021; Accepted 14 July 2021
Available online 21 July 2021