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Titania/reduced graphene oxide composite nanofibers for the direct extraction of photosynthetic electrons from microalgae for biophotovoltaic cell applications

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Abstract

Titanium oxide (TiO_2)/reduced graphene oxide (rGO) composite nanofibers were synthesized via an electrospinning technique and its potential electrochemical activity constructed its realization as an efficient anode catalyst in biophotovoltaic cells (BPV) with *Chlorella vulgaris*. The uniform adherence of GO sheets over the hydrolyzed Ti^{4+} ions, followed by its simultaneous reduction and crystallization, yielded the TiO_2/rGO composite nanofibers. The strong interconnection among the nanofibers and the intimate contact between rGO and TiO_2 in TiO_2/rGO composite improved the efficient electron transportation paths, facilitating the higher oxidation and continuous and stable currents as substantiated, respectively, from the cyclic voltammetry and chronoamperometry studies. By coupling the continuous electron conduction paths, proficient cell interaction, and elevated structural and chemical stabilities, TiO_2/rGO demonstrated the BPV power density of 34.66 ± 1.3 mW m^{-2} with excellent durability, outperforming the BPV performances of previous reports. Thus the fundamental understanding achieved on the influences of nanocatalytic system in green energy generation opens up the new horizon of anticipation towards the development of sustainable and high-performance BPVs.

1 Introduction

Global energy demand coupled with the rapid consumption of limited oil reserves and greenhouse effect necessitates the development of prodigious energy technologies for harnessing energy from the renewable energy resources [1]. Among the various renewable energy resources including solar, pure water, wind, and geothermal, the prospective solution for energy crisis is achieved with solar, owing to its massive availability, safe, renewable, clean, and cost-effective characteristics [2]. The annual irradiance level of sun that strikes on Earth (1300 ZJ; 1 ZJ = 1015 J) is ≈ 2300 times higher than that of global energy consumption (0.56 ZJ) [3]. Hence, a number of photovoltaic devices including silicon solar cells [4], polycrystalline thin film solar cells [5], heterojunction [6], and heteroface structure cells [7] have been widely exploited for the generation of electricity from sun light. However, the aforementioned photovoltaic devices exhibit certain constrains including high manufacturing cost, tedious fabrication processes, and limited operational lifespan, delivering a negative impact toward their wide utility [4–7].

To successively encounter the aforesaid obstacles, the biophotovoltaic cell (BPV), a potential green energy device

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