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Short communication

Enhancing the photo-electrocatalytic properties of g-C_3N_4 by boron doping and ZIF-8 hybridization

Mahmood Riyadh Atta [a], Maizatul Shima Shaharun [a,*], Md. Maksudur Rahman Khan [b], Bawadi Abdullah [c], Akram Fadhl Al-Mahmodi [d], Nur Diyan Mohd Ridzuan [a], Thurga Devi Munusamy [b], Lim Jun Wei [a]

[a] Department of Fundamental and Applied Sciences, Universiti Teknologi PETRONAS, Seri Iskandar 32610, Perak, Malaysia
[b] Department of Chemical Engineering, College of Engineering, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia
[c] Chemical Engineering Department, Universiti Teknologi PETRONAS, Seri Iskandar 32610, Perak, Malaysia
[d] Center for Energy & Industrial Environment Studies (CEIES), Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400 Johor, Malaysia

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ABSTRACT

Developing the ideal catalyst for photo-electrocatalysis applications is attracting wide interest. In this study, the photo-electrocatalytic properties of metal-free catalyst g-C_3N_4 modified with ZIF-8 and boron doping were investigated. Bulk g-C_3N_4 was synthesized by thermal decomposition of melamine; boron doping was performed via co-condensation, while the ZIF-8 hybridization was performed by in-situ heterogeneous deposition method. The physicochemical properties of the catalysts were characterized by X-ray diffraction analysis, Fourier-transform infrared spectroscopy, UV–VIS, X-ray photoelectron spectroscopy, field emission scanning electron microscopy and elemental mapping. The band gap energies increased from 1.878 eV for g-C_3N_4 to 2.36, 2.28 and 2.42 eV for B-g-C_3N_4, g-C_3N_4/ZIF-8 and B-g-C_3N_4/ZIF-8, respectively. Moreover, CO_2 reduction in a PEC cell using the prepared catalysts as working electrodes was conducted to evaluate the photo-electrocatalytic properties using cyclic voltammetry, electrochemical impedance spectroscopy and linear sweep voltammetry. Incorporation of ZIF-8 significantly influenced the photocatalysis properties by increasing current density from a -1.08 mA/cm^2 for g-C_3N_4 to a -1.52 mA/cm^2 in g-C_3N_4/ZIF-8, and slightly increased the electrical conductivity from a -0.846 mA/cm^2 to a -1.235 mA/cm^2. In the other hand, boron doping only influenced the electrical properties of g-C_3N_4 where its reductive current increased from 0.065 mA (g-C_3N_4) to a 0.34 mA (B-g-C_3N_4) at -0.404 V potential voltage. As a result, merging these modifications noticeably enhanced the photo-electrocatalytic activity and light sensitivity of the main catalyst, which opens a wider range of applications and future research.

1. Introduction

Nowadays, with the increase of scholars' interest in reducing the energy consumption in chemical reactions, chemical scientists seek for developing new technology that produces high yield of targeted product and high efficiency [1]. One of the potential catalytic technologies is the photo-electrocatalysis, an integration of electrocatalysis with photocatalysis by the usage of both energy sources of light and electricity potential [2]. The photo-electrocatalysis exploits semiconductor electrodes instead of the usual conductor electrodes that are used in electrocatalysis [3].

The photo-electrocatalysis is far from being applicable in the industrial scale, due to the limitations and challenges that need more attention by engineers and scientists. Hence, the enhancing of the reduction rate, controlling the photo-electrocatalysis products selectivity and increasing the solar energy utilization are the major challenges that should be resolved [4]. Meanwhile, the photo-electrocatalysis is more efficient compared to the photocatalysis

* Corresponding author.
E-mail addresses: Mahmood_20000275@utp.edu.my (M. Riyadh Atta), maizats@utp.edu.my (M. Shima Shaharun), mrkhan@ump.edu.my (Md. Maksudur Rahman Khan), bawadi_abdullah@utp.edu.my (B. Abdullah), Akram.gmx@yahoo.com (A. Fadhl Al-Mahmodi), nur_17007454@utp.edu.my (N. Diyan Mohd Ridzuan), thurgadevi_munusamy@yahoo.com (T. Devi Munusamy), Junwei.lim@utp.edu.my (L. Jun Wei).

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