Yi Wen Phuan, J Material Sci Eng 2017, 6:3 (Suppl)
DOI: 10.4172/2169-0022-C1-064

A novel ternary Ergo/NiO/α-Fe_2O_3 nanostructured photoanode with enhanced charge transfer properties for efficient solar hydrogen energy conversion in a photoelectrochemical cell

Yi Wen Phuan
Monash University, Malaysia

In this study, a novel ternary hematite (α-Fe_2O_3)-based nanostructured photoanode with excellent Photoelectrochemical (PEC) performance consisting of 2D-electrochemical reduced Graphene Oxide (eRGO) and Nickel Oxide (NiO) was successfully developed through electrodeposition method. The surface morphology and structural properties of the nanostructured photoanode were characterised by using field emission-Scanning Electron Microscopy (FE-SEM), and High-Resolution Transmission Electron Microscopy (HRTEM). Results showed that the flexible eRGO sheets provide intimate and coherent interfaces between α-Fe_2O_3, NiO and eRGO, promoting charge transfer over their interfaces and thus, lowering the photogenerated electron-hole pairs recombination rate. X-Ray Diffraction (XRD) patterns, Raman spectra and X-ray photoelectron (XPS) spectra validated that both eRGO and NiO were successfully electrodeposited onto the ternary eRGO/NiO/α-Fe_2O_3 nanostructured photoanode. As evidenced from the ultraviolet-visible (UV-vis) diffuse reflectance spectra, the incorporation of eRGO and NiO has endowed α-Fe_2O_3 nanostructured photoanode with a wider spectral absorption range where the light absorption intensities in the visible light and near infared regions are improved. Electrochemical Impedance Spectroscopy (EIS) further confirmed that the ternary eRGO/NiO/α-Fe_2O_3 nanostructured photoanode possesses the lowest charge transfer resistance, indicating that the combined effects of eRGO and NiO could improve the electron mobility by impeding the recombination process of photogenerated charge carriers and resulting in superior PEC performance. This is because eRGO sheets act as surface passivation layer and electron transporting bridge that increase the electron transfer at the semiconductor/liquid junction. Whereas, NiO serves as hole acceptor that effectively hinders the recombination of photogenerated electron-hole pairs and accelerate the interfacial charge transfer. The solar hydrogen evolution rate of the ternary eRGO/NiO/α-Fe_2O_3 nanostructured photoanode was about 3-fold higher than the bare hematite. It is expected that the fundamental understanding gained through this study is helpful for the rational design and construction of highly efficient ternary nanostructured photoanodes for application in solar hydrogen energy conversion through PEC process.

Biography

Yi Wen Phuan received her BE (Hons 1A) in Chemical Engineering from Monash University, Malaysia. She continued her postgraduate studies under the supervision of Associate Professor Dr. Meng Nan Chong and Associate Professor Dr. Eng Seng Chan. Her research focuses on the electrochemical synthesis and modification of nanostructured hematite (α-Fe2O3) as an efficient semiconductor photoanode material for application in Photoelectrochemical (PEC) water splitting.

phuan.yi.wen@monash.edu

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