Cobalt Disulfide embedded TiO_2 Nanocomposites for Hydrogen Production under UV Irradiation

S. Shanmugaratnam [1], A. A. Christy [2], Dhayalan Velauthapillai [3], P. Ravirajan [1], S. Rasalingam [4]

[1]*Clean Energy Research Laboratory, Department of Physics, University of Jaffna, Jaffna, Sri Lanka*
[2]*Department of Natural Science, University of Agder, Kristiansand, Norway*
[3]*Faculty of Engineering and Science, Western Norway University of Applied Sciences, Bergen, Norway*
[4]*Department of Chemistry, University of Jaffna, Jaffna, Sri Lanka*

Email: srtharsha12@gmail.com

Abstract

Hydrogen gas is greener and reliable energy source, which can contribute to fill the gap between the energy demand and energy supply. Several photocatalyst materials, such as TiO_2, ZnO, CdS, WS_2, mixed oxides, perovskites, dye and metal doped oxide materials have been used as phototcatalysts for energy production, such as water splitting applications and environmental remediation. Development of efficient non-toxic photocatalyst has opened a new avenue for several other applications, such as in lithium ion batteries, solar cells, etc. The production of hydrogen through water splitting is a green route for converting solar energy directly in to clean fuel. Recently, the transition metal chalcogenides have intensively been focused on hydrogen production due to their stronger edge and the quantum confinement effect. This work mainly focuses on synthesis of cobalt disulfide (CoS_2) embedded TiO_2 nanocomposites using hydrothermal approach; and, the hydrogen production efficiencies of pure CoS_2, pure TiO_2, and different wt% of CoS_2 in TiO_2 were compared under UV irradiation. Nanocrystalline TiO_2 having 10 wt% CoS_2 exhibits higher hydrogen production of 2.5492 mmol/$g_{catalyst}$ in comparison with the pure CoS_2 or TiO_2 used in this study. The bare CoS_2 material was found to be inactive due to its very low bandgap energy of 2.5 eV; however, the enhanced activity of the CoS_2 loaded nanocomposite may be due to the heterojunction frame work that causes the effective electron-hole pair separation. In summary, the metal dichalcogenide, CoS_2, acts as an effective co-catalyst, whereas titania serves as active site by effectively separating the photogenerated electron-hole pair. This study lays down a new approach to develop transition metal dichalcogenide materials with significant bandgaps that can effectively harness solar energy for hydrogen production.

Keywords: Transition metal chalcogenides, titania, hydrothermal, hydrogen, water splitting