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Oxygen-incorporation in Co_2P as a non-noble metal cocatalyst to enhance photocatalysis for reducing water to H_2 under visible light

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Precious metal-free hybrid photocatalysts with low cost and high efficiency of photocatalytic H_2 evolution are of great significance for clean energy. Herein, we report that oxygen-incorporation in Co_2P, a noble metal-free co-catalyst used for forming a hetero-structure photocatalyst CdS/o-Co_2P, greatly improves the efficiency and durability for photocatalytic hydrogen production from water. Regulating the kinetics of water reduction by different oxygen incorporation levels (determined by phosphorization time) was investigated to optimize the activity of photocatalytic H_2 evolution. The intimate interaction between the CdS nanorods and cocatalyst o-Co_2P enhances the separation of the photo-generated electron–hole pairs. Consequently, the optimal loading content of o-Co_2P is 5 wt% for CdS, phosphorization time is 80 min, giving a photocatalytic H_2 production rate of 184.48 mmol g^{-1} h^{-1}, and the apparent quantum yield at 420 nm over CdS/o-Co_2P-5wt% reaches 22.17%. This study provides a simple method for constructing low cost and high performance photocatalysts, which enhance photocatalytic H_2 evolution.

Key words: photocatalysis, o-Co_2P, non-noble metal, cocatalyst, kinetics

1. Introduction

The production of hydrogen fuels by using sunlight is an attractive and sustainable solution to global energy and environmental problems.[1-3] Light-assisted water splitting into H_2 is of great importance, particularly visible light, and is attracting great interest, driven by the promise of addressing both the energy supply and storage.[4] For the H_2 evolution reaction (HER), the multi-component photocatalysts are usually composed of a photosensitizer and a cocatalyst, while an electron source is needed to allow only the reductive half-reaction to be studied.[5,6] Cocatalysts coupled with the photosensitizer can availably enhance the separation of photo-generated electron-hole pairs, reduce the overpotential of water splitting, and subsequently promote the activities of the photocatalysts.[7] When an appropriate band structure is provided, under the irradiation of light, the holes generated in the valence band of the photosensitizer can oxidize water, whereas the electrons transferred to the conduction band can reduce protons to give H_2 in the presence of suitable cocatalysts.[8] For the reason that precious metal Pt has the lowest