

# Synergetic Effect of In and Ag Co-doped ZnS for Enhanced Photocatalytic Hydrogen Evolution under Visible Light Irradiation

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**Abstract.** In (Indium) and Ag (Argentum) co-doped ZnS photocatalysts were successfully prepared by hydrothermal method to extend the light absorption of ZnS to the visible light region. The concentration of In was constant while for Ag was varied to optimize the photocatalytic activity. The In and Ag co-doped ZnS (Zinc Sulfide) photocatalysts showed smaller band gap energy compared to single doped In(0.1)-ZnS and undoped ZnS. The photocatalytic activity of In and Ag co-doped ZnS photocatalysts was evaluated from the amount of hydrogen produced. The hydrogen evolution rate from aqueous solution containing Na<sub>2</sub>SO<sub>3</sub> (Sodium Sulfite) and Na<sub>2</sub>S (Sodium Sulfide) as sacrificial reagent under visible light irradiation obtained from In and Ag co-doped ZnS is higher compared to the single doped In(0.1)-ZnS when optimum amount of Ag dopant was added. The highest photocatalytic activity is observed for In(0.1),Ag(0.01)-ZnS with hydrogen production rate of 26.82 μmol/h. The higher performance of this photocatalyst is ascribed to the extended visible light absorption, efficient charge separation as well as improved electron transfer associated with synergistic effect of appropriate amount of In and Ag co-doped ZnS.

## Introduction

Hydrogen production under solar light irradiation with the assistance of semiconductor photocatalyst is one of the potential solutions to resolve the depletion of fossil fuels [1]. ZnS possesses high conduction band that is essential for photocatalytic hydrogen production [1] but ZnS is not active under visible light irradiation. Indium based sulfide material has gain interest due to the visible light active properties which can utilize most of the solar light energy. The In<sub>2</sub>S<sub>3</sub> (Indium Sulfide) has showed good efficiency for hydrogen production under visible light irradiation [2]. Thus, indium can be doped into ZnS to improve the absorption properties. Ag dopant is frequently used as electron trap, enhancing electron-hole separation and promoting the interfacial electron transfer processes [3]. The addition of Ag increases the ability of a photocatalyst to absorb visible light, due to localized surface Plasmon resonance [4]. Studies on Ag doped ZnS for hydrogen production has also been done previously [5]. It would be beneficial if both In and Ag are doped into ZnS to improve the visible light absorption and also enhance the photocatalytic activity by inhibiting fast electron-hole recombination. In this study, In(0.1),Ag(x)-ZnS was successfully synthesized by hydrothermal method. The amount of Ag was varied to optimize the performance of the photocatalysts and systematically studied the physical-chemical properties and photocatalytic activities under visible light irradiation. The effects of co-doping on the photocatalytic activities were also discussed.