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Facile hydrothermal synthesis of Cu_2SnS_3 nanoparticles for photocatalytic dye degredation of mythelene blue

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ABSTRACT

Ternary copper tin sulfide Cu_2SnS_3 (CTS) has been effectively amalgamated by hydrothermal method. The crystal structure, surface morphology and optical properties of the primed sample have been studied. XRD pattern of synthesized CTS shows the triclinic crystal structure. The SEM images confirm the uniform spherical grain like structure. The photocatalytic activity of the as synthesized CTS was tested under visible light irradiation by measuring the degradation of methylene blue (MB). CTS show a broad absorption in the visible and the IR region. The optical bandgap of CTS nanoparticles (2.2 eV) has been determined. A more realistic mechanism for the photocatalytic activity of CTS is proposed.

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1. Introduction

Now a days water pollution became a foremost universal issue. Diverse sources of water pollution are mostly industrial sources such as textile, leather, pharmaceutical, plastics and paper, food and dye industries. The wastewater released from these industries involves an unusual organic dyes which are toxic and hurtful to human being and the environment as well. So the removal of these dyes from the polluted water became a challenge. Photocatalysis is the most hopeful technique to resolve such problem. A semiconductor photocatalysts getting a lots of attention owing to its outstanding performance as semiconductor catalysts. It degrade a wide range of toxic compounds under the solar irradiation [1]. Along with the semiconductor catalysts, titanium dioxide (TiO_2) and zinc oxide (ZnO) have been acknowledged the most awareness in research and development of photocatalysis technology caused by their electronic, chemical and thermal properties [2,3]. However TiO_2 has the band gap of 3.2 eV and ZnO has 3.37 eV, hence are active in only ultra-violet region of light, which is only of 4–5% of the total solar energy spectrum. It is not responsive to visible light (λ > 400 nm) [3]. Hence the semiconductors like cadmium sulfide (CdS) and Indium sulfide (In_2S_3) with the narrow bandgap has been getting used [4,5]. Unfortunately, they suffer from the downsides like, the production and use of Cd and In, in relevant compounds are dangerous to human health, include toxic elements, high cost because of Cd and In are the rare earth elements. So it is pleasing to have photocatalysts amid earth abundant elements, economical, non-toxicity, high constancy and also susceptible to visible light region. These necessities turned the researchers towards the commercial, earth abundant, non-hazardous ternary group semiconductor with small or mid band gap. In the ternary Cu-Sn-S system, Cu_2SnS_3 (CTS) semiconductor of I-IV-VI group, for the reason that of their attractive, outstanding optical–thermal–mechanical properties attracted a great deal of attention. CTS is a ternary compound ideal as an admirable absorbing material for photovoltaic applications because of its high absorption coefficient (>10^4 cm^{-1}) and tunable bandgap (1.2 to 1.4 eV) [6]. However, CTS is the most hopeful compound in the Cu-Sn-S system because of its wide stability range and lack of Fermi level pinning [7].

Moderately a plenty of synthesis approaches have been incorrigible to be appropriate for fabricating CTS nanoparticles. Physical methods contain vacuum evaporation [8], solid state reaction [9], co-evaporation [10,11], pulsed laser deposition (PLD) [12,13], electron beam evaporation [14,15] and sputtering [16]. Similarly, some chemical methods such as chemical bath deposition (CBD) [17],

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