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Original Research Paper

Synthesis and characterization of nanoplate-based SnS microflowers via a simple solvothermal process with biomolecule assistance

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ABSTRACT

A biomolecule-assisted mild solvothermal process has been successfully developed to synthesize the SnS microflowers with nanoplates, in which L-cysteine was used as the sulfur source and complexing agent. The phase structure, morphology, composition and optical properties of the as-prepared product were characterized by XRD, FE-SEM, TEM (HRTEM), SAED, XPS, TGA and UV–vis spectrum. Results demonstrated that the as-synthesized product is comprised of microflowers with nanoplates, and the nanoplates are 50 nm in average thickness. And a possible mechanism for the growth of the SnS microflowers with nanoplates was put forward and briefly discussed. The proposed solvothermal method using L-cysteine as the sulfur source and complexing agent is very promising for the low cost and large-scale synthesis of other tin chalcogenide compounds.

1. Introduction

Metal chalcogenides compounds have been received increasing attention owing to their interesting properties and potential applications. Among them, tin sulfide is one of the most important chalcogenides showing a variety of phases, such as SnS, Sn_2S_3, Sn_3S_4 and SnS_2, due to the versatile coordinating characteristics of tin and sulfur [1]. Of these compounds, tin monosulfide (SnS) is a narrow band gap IV–VI semiconductor with an orthorhombic structure, where the Sn and S atoms are tightly bonded in a layer, which interacts with the neighboring layers by weak Van der Waals forces [2]. In addition, it has the advantage that the constituent elements are abundant in nature and environment-friendly. Therefore, SnS has potential applications in the fields of thin film solar cell [3], near-infrared detector [4], and photovoltaic materials with high conversion efficiency [5,6]. Nanomaterials with different morphologies, which have the same chemical composition, may exhibit different physical properties. Over the past several years, considerable effort has been devoted to the preparation of various SnS nanostructures, such as nanoflowers [7], dendrite-like nanoparticles [8], nanorods and nanosheets [9], belt-like nanocrystals [10] via hydro/solvothermal route. Although great progress has been achieved on the synthesis of nanostructured SnS, present synthesis process usually accompanied by a great amount of pungent H_2S as a result of the employment of familiar sulfur source (sulfur powder, thioacetamide, thiourea, CS_2, Na_2S and H_2S). From the viewpoints of green chemistry and large-scale production, it is therefore necessary to develop a simple and efficient approach to fabricate SnS nanomaterials.

More recently, biomolecule-assisted green synthesis methods have been developed to prepare different nanomaterials owing to its convenience and strong function in morphology control [11]. As a small biomolecule, L-cysteine not only has special structure and novel self-assembling functions, but also serves as sulfur source for the fabrication of metal sulfides. Inspired by this, various shapes of metal sulfide nanostructures including one-dimensional copper sulfide nanocrystallites [12], antimony sulfide nanowires [13], CdS nanowires [14], indium sulfide microflowers [15], manganese sulfide microtubes [16], nanocube-based pagoda-like lead sulfide hierarchical architectures [17], silver sulfide nanospheres [18], ZnS nanostructured spheres [19] and Bi_2S_3 flowerlike patterns with well-aligned nanorods [20] have been successfully prepared in the presence of L-cysteine. To our knowledge, the synthesis of flowerlike tin chalcogenides microstructures via L-cysteine-assisted solvothermal route has not been reported although flowerlike nano or microstructures for different materials have been synthesized using solvothermal method [21–24]. Here we developed a simple and mild solvothermal method for large-scale synthesis of the SnS microflowers made up of nanoplates with the assistance of L-cysteine. This synthetic method can provide a universal green chemistry route to prepare other tin chalcogenide compounds.

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