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Original Research Paper

Fabrication of hierarchical ZnO architectures by a biomineralization process

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ABSTRACT

In this paper, hierarchical structured ZnO particles were successfully synthesized via a facile biomineralization process with the template of histidine at room temperature. Detailed microstructural characterization had been carried out using X-ray diffraction, scanning electron microscopy, and transmission electron microscopy. Role of histidine concentration in the hierarchical ZnO syntheses, including flower-type structure and mineral configuration, had been systematically investigated. Zn^{2+}–histidine interaction was suggested to be the dominant growth factor. The room-temperature Raman spectrum of ZnO flower type revealed good crystal quality and increased Raman scattering. The PL spectrum of ZnO mineral structure showed stronger emission in a wide range of wavelengths.

1. Introduction

Mimicking the natural biomineralization process is a novel, but strikingly attractive approach to the synthesis of inorganic materials. It uses biological molecules as the structure-directing agent to control the nucleation and subsequent crystal growth and eventually to assembly two- and three-dimensional inorganic architectures with predictable and useful properties.

Amino acids, polysaccharide, peptides, proteins and other biomolecules can facilitate the synthesis of inorganic materials at or near room temperature, in aqueous solutions, and at or near neutral pH [1]. For instance, cobalt oxide hybrid nanowires have been fabricated using diphenylalanine biotemplating [2]. Metallic nanoparticles [3] were synthesized in situ when Tubulin was incubated with metal ion precursors, followed by the addition of reducing agents. Alexander J. Mastroianni [4] created discrete pyramids of DNA with Au nanocrystals at the tips and took advantage of the tetrahedral symmetry to demonstrate construction of chiral nanostructures. Peptides with an affinity for metals and semiconductors can also be used to synthesize CdSe or ZnS quantum dots [5,6]. The highlights of our accomplishments are featured in the following report.

In recent years, ZnO nano materials have practical applications due to their promising performances as field effect transistors [7,8], UV photodetectors [9], gas sensors, and fascinating photocatalysts [10]. They are also environmentally friendly semiconductors [11]. Over the past years, substantial research efforts have been directed towards preparing nano ZnO materials with controlled morphologies and exploring the relationship between the structure and performance.

Many synthetic approaches, such as physical vapor deposition [12] and metal organic chemical vapor deposition [13], have been utilized to produce well-defined ZnO materials. Compared with these intricate preparation processes, solution approaches are appealing because of their low growth temperature and good potential for mass production [14].

Proteins or DNA are rarely employed for synthesis of ZnO because of their structural complexity and the demand of extremely strict pH and temperature. In this paper, we reported a facile and environmentally friendly method of preparing ZnO nanostructures without any organic solvent or surfactant. Research has been focused on studying the hierarchical synthesis of ZnO in the presence of histidine, which is able to trigger the morphology of ZnO materials ranging from flower-like to mineral structure. To investigate the function of histidine for the synthesis of ZnO, we attempted to observe the interaction of histidine with ZnO. Under the guidance of this idea, the microstructure and chemical states of these ZnO materials were investigated using a variety of analytical techniques including X-ray diffraction, X-ray photoelectron spectroscopy, transmission electron microscopy (TEM), and scanning electron microscope (SEM). Optical properties were also studied.

2. Experimental

2.1. Materials

Zinc acetate dihydrate and hexamethylenetetramine (HMT) were obtained from China National Pharmaceutical Industry

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