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Microwave-assisted rapid synthesis of antimony dendrites

Bo Zhou[a,b], Jian-Min Hong[a], Jun-Jie Zhu[a,*]

[a]Department of Chemistry, Lab of Life Analytical Chemistry, Nanjing University, Nanjing, 210093, China
[b]College of Chemistry and Environment Science, Nanjing Normal University, China

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Abstract

Antimony dendrites have been successfully synthesized by a microwave-assisted method under ambient air from the solution containing antimony sodium tartrate. In the reaction, zinc powders were selected as a reductant for the fabrication. The as-prepared products were characterised by X-ray powder diffraction, transmission electron microscopy, and selected area electron diffraction. The dendrites were found to be composed of well-crystallized nanoflakes with size of 20–40 nm.

Keywords: Antimony; Dendrite; Nanoflakes; Microwave-assisted preparation

1. Introduction

The control of the morphology and architecture of the inorganic substances with nano- to macroscopic-scale dimensions has attracted more and more attention due to their fundamental and technological importance [1]. Among various morphologies, fractal structures, including dendrites, funnel-like structures, and the hierarchical structures, are particularly attractive. The study for their formation provides a natural framework for the disordered system, because fractals are generally observed in far-from-equilibrium growth phenomena [2]. Fractal growth phenomena are also closely related to many processes of practical importance [3]. Fractal structures can be prepared by a vapor transport and condensation technique or wet chemistry approaches [4–6]. Most of synthesis strategies involved the use of hard templates or organic additives, although a large amount of fractal structures formed in natural world do not need their direction and control. Some theories [7,8] have been developed to interpret fractal growth, such as diffusion-limited aggregation (DLA) model, ballistic aggregation (BA) model, and reaction-limited aggregation (RLA) model.

Antimony is a semimetal like bismuth. Both of them, and their alloys, are of interest because of their small effective mass and large mean-free length, which makes their nanostructures interesting for studying quantum confinement effects [9–12]. In addition, these nanomaterials are suggested to perform enhanced thermoelectric effect comparing with their bulk materials [13,14]. Recently, some studies involved the syntheses of antimony nanoparticles. The synthesis was mainly based on the electrodeposition, the solvothermal, and self-assembled technique [15–20]. However, it is still a challenge to develop a rapid technique to prepare antimony nanoparticles.

Recently, microwave irradiation has been found to be a fast and effective technique to the formation of nanoparticles [21,22]. Microwave heating has unique effects compared with the conventional heating, such as rapid volumetric heating, selective heating and energy saving considerations. These effects make microwave heating a promising technology that can increase reaction rates, shorten reaction time, and enhance reaction selectivity. In addition, some researchers think that microwave irradiation may have some "non-heating effects" [23].

* Corresponding author. Tel./fax: +86 25 83594976.
E-mail address: jjzhu@nju.edu.cn (J.-J. Zhu).

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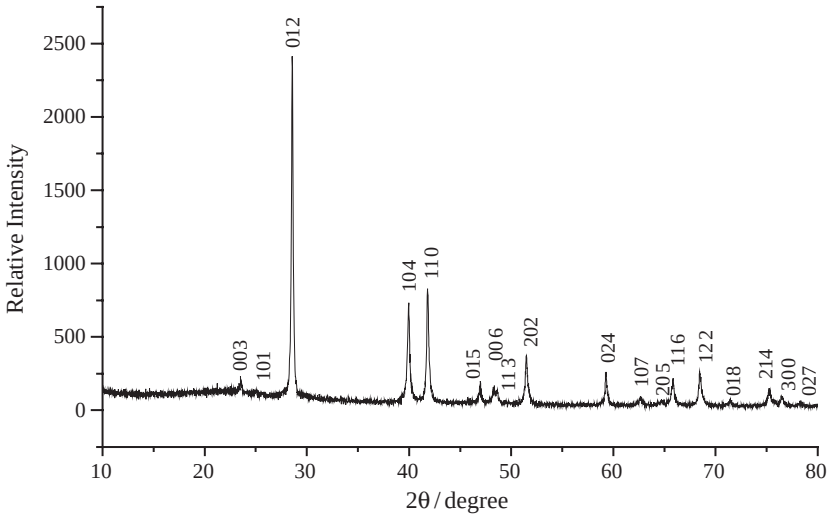

Fig. 1. XRD pattern of the as-prepared products.

Herein, we have developed a solution-phase growth method to fabricate antimony dendrites in presence of microwave. The as-prepared products were characterised by X-ray diffraction (XRD), transmission electron microscopy (TEM), selected area electron diffraction (SAED). The dendrites were found to be composed of well-crystallized nanoflakes with size of 10–20 nm.

2. Experimental procedure

2.1. Materials

All reagents were of analytical purity and were used without further purification. Antimony sodium tartrate and zinc powders were purchased from Shanghai Chemical Reagent Factory (China). Distilled water was used throughout.

2.2. Instruments

The X-ray diffraction (XRD) patterns of the products were recorded with a Philips X'pert X-ray diffractometer (using Cu-Kα radiation, $\lambda = 0.15418$ nm, the patterns were referenced to a Si (111) standard.). The transmission electron microscope (TEM) images and selected area electron diffraction (SAED) images were obtained using a JEM-200CX (JEOL, 200 kV) instrument. The samples used for TEM observations were prepared by dispersing some products in ethanol followed by ultrasonic vibration

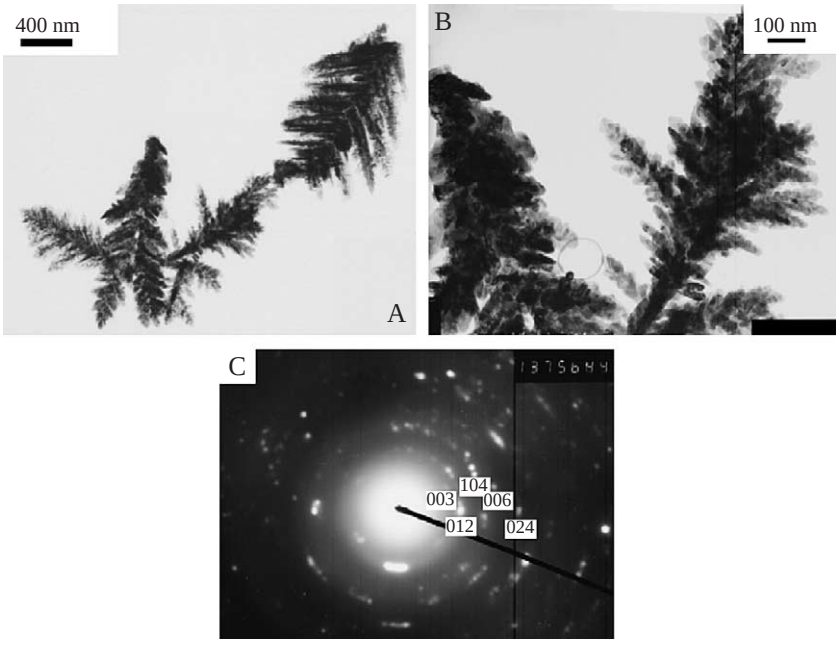

Fig. 2. TEM (A, B), and SAED (C) images of the as-prepared Sb dendrites.