Advanced Powder Technology xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Advanced Powder Technology

journal homepage: www.elsevier.com/locate/apt

Original Research Paper

Novel precursors for synthesis of dendrite-like PbTe nanostructures and investigation of photoluminescence behavior

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ARTICLE INFO

Article history:
Received 20 November 2013
Received in revised form 1 May 2014
Accepted 12 May 2014
Available online xxxx

Keywords:
Nanostructures
Solvothermal
PbTe
Complex
Schiff-base

ABSTRACT

Using solid organic molecular precursor "[bis(salicylaldehyde)ethylenediiminelead(II)]; [Pb(salen)]" and "[bis(salicylaldehyde)phenylenediiminelead(II)]; [Pb(salophen)]" as precursors, for a surfactant-free method to synthesis PbTe nanostructures were proposed. The effect of time and temperature on the morphology of the products was investigated. Results showed that the main factor on formation of different morphologies of PbTe nanostructures was temperature, but by increasing the time the nanostructures grew together. It was found that the as-obtained PbTe nanostructures exhibit a strong PL peak at room temperature.

1. Introduction

Thermoelectric (TE) technology is the technology that exchanges heat and electricity, which contains power generation and electronic refrigeration [1]. Studies demonstrate that reducing the size of the building blocks of TE materials is an effective approach to improve TE properties [2–4]. Exploration of facile synthetic routes for producing various forms of low dimensional thermoelectric nanostructures has concerned a lot of attention [5,6]. PbTe and its alloys have carried out a main role in the thermoelectric power generation application for more than 50 years, specifically in the deep space exploring projects [7–8].

PbTe has a large Bohr excitation radius (46 nm) compared to other semiconductors. Due to this feature, PbTe exhibits excellent electrical transport properties [1]. And moreover, it shows low thermal conductivities at high temperature [8–10]. In order to improve the efficiency application of PbTe in various fields, a lot of attention has been paid to the controlling the form and the size of crystal. Up to now, many routs have been used to synthesis of PbTe, but there are still various challenges in the synthetic methods. One is the tendency of PbTe to grow into bigger or irregular particles in short time and low temperature. To impede these unwanted procedures, organic surfactants were accustomed to control the growth [10–14].

PbTe nanostructures were synthesized by different methods such as microwave, sonochemical, hydrothermal, solvothemal and electrochemical methods and so on. In these approaches, microwave, sonochemical and electrochemical method have a short time for formation PbTe nanostructures, but in these methods, particular in sonochemical and microwave approaches controlling the morphology and particle size of product are very hard. Most of morphologies that prepared in these methods are nanoparticles. In electrochemical approaches different morphologies could produced but in this method controlling the pH and concentration and other conditions of reaction are very hard. There for hydrothermal methods provides preferred orientation morphologies because of some particular conditions such as high temperature and pressure. In this method, various shapes grow in situ and form different morphologies. On the other hand, hydrothermal is a low cost, and high efficiency method and have many potential for large-scale production [8,14–23]. There for among different methods for preparation of PbTe hydrothermal has attracted a lot of attention. Guo et al. were prepared PbTe in a two step hydrothermally method. In first step, Te nanowire were made up in 180 °C for 24 h in presence of PVP and in second step PbTe were

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http://dx.doi.org/10.1016/j.apt.2014.05.007
0921-8831/

Table 1
Reaction conditions with $TeCl_4$ on PG.

Sample no	Effect	Precursors	Time (h)	Temperature (°C)
1	Time	[Pb(salen)]	6	150
2		[Pb(salen)]	12	150
3		[Pb(salen)]	18	150
4		[Pb(salen)]	24	150
5	Temperature	[Pb(salen)]	12	120
6		[Pb(salen)]	12	180
7		[Pb(salen)]	12	210
8		[Pb(salophen)]	12	180
9	Reductant	[Pb(salen)]	12	180
10	Synthetic rout	[Pb(salen)]	12	180

prepared by using of as-synthesized Te nanowire and $Pb(NO_3)_2$ in 180 °C for 12 h [17]. Zhoa and coworkers were synthesized PbTe by an alkaline reducing chemical routs via hydrothermally approach in 150 °C for 12 h by different solvent [20]. Yu et al. were synthesized PbTe nanowire by a tow step process. In their synthetic approach Te nanowire were made in 180 °C for 3 h by a hydrothermal reaction. After preparation of Te nanowire, this product was used as precursors for formation of PbTe in a hydrothermally procedure in 140 °C for 12 h [18]. Zhang and co workers were synthesized PbTe nanowire by a tow step method similar to Yu approach, but in first step, they synthesized Te nanowire in 180 °C for 6 h and in second step they prepared PbTe in 160 °C for 6 h [19]. Zhu et al. were prepared PbTe 3-D nanostructure hierarchical super structure via an alkaline hydrothermal method in 160 °C for 24 h in presence of in presence of different surfactant such as CTAB, SDS, PVP [24]. Ni and co workers were prepared PbTe nanocrystals in 140 °C for 15 h and investigated different factors on synthetic approach [25]. PbTe nanostructures were prepared by Zhu et al. in a simple chemical rout in alkaline condition at 100 °C for 48 h [21]. Zhu et al. were synthesized Cubic nanoparticles and nanosheets of PbTe in presence of various surfactants at 160 °C for 24 h [22]. Chen and coworkers were used a hydrothermally method for preparation of 3-D flower like nanostructures of PbTe in alkaline condition at 200 °C for 24 h. These nanostructures have about 4 μm sizes [13].

In our group we investigated different method for preparation of PbTe nanostructures by different morphologies. According our experiments and our publishing results PbTe nanoparticles can synthesized on sonochemical, microwave, solvothermal and hydrothermal reactions in a relatively short time. But controlling the morphology is very hard and most of the products have particle shape. Just in presence of different surfactant in 160 °C for 6 h PbTe by different morphologies were synthesized but a little of surfactant on surface of product were remained there for we used from coordination precursors on a solvothermally reaction to prepared PbTe nanostructures [26–29].

we have concerned for a few years in the synthesis of semiconductor nanostructures, using new inorganic precursor and organometallic chemistry [30–33]. Using of the novel compounds has opened a new way for preparing nanomaterials that control shape and size. Herein we have reported the solvothermally synthesis for PbTe by using two organolead precursors with $TeCl_4$. Table 1 has shown the summarized reaction conditions.

2. Experimental

2.1. Materials and methods

All the chemical reagents used in our experiments were of analytical grade and were used as received without further purification. X-ray diffraction (XRD) patterns were recorded by a Philips, X-ray diffractometer using Ni-filtered Cu Kα radiation. Scanning electron microscope (SEM) images were obtained using a LEO instrument model 1455VP. FT-IR spectra were recorded on Galaxy series FT-IR5000 spectrophotometer. Room temperature photoluminescence (PL) was studied by a Perkin Elmer fluorescence instrument.

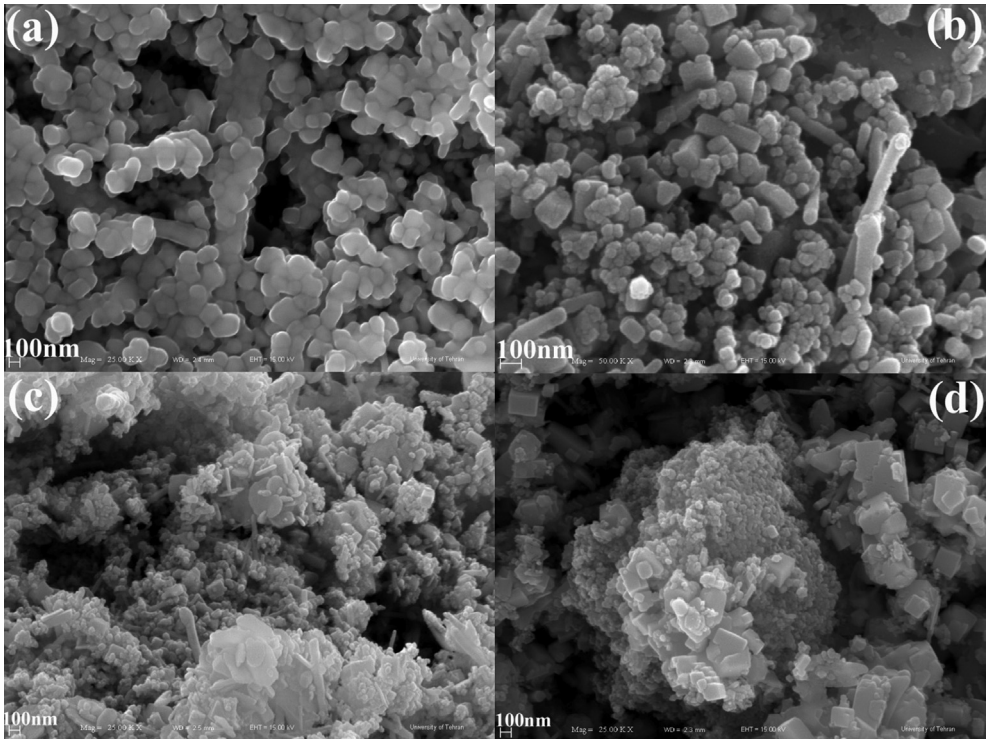

Fig. 1. SEM images of Sample nos 1–4.

Please cite this article in press as: S. Gholamrezaei et al., Novel precursors for synthesis of dendrite-like PbTe nanostructures and investigation of photoluminescence behavior, Advanced Powder Technology (2014), http://dx.doi.org/10.1016/j.apt.2014.05.007