

PbTe Nanostructures: Novel Precursors for Solvothermal Synthesis of Dendrite-like

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Thermoelectric (TE) technology is the technology that exchanges heat and electricity, which contains power generation and electronic refrigeration. Studies demonstrate that reducing the size of the building blocks of TE materials is an effective approach to improve TE properties. Hence exploration of facile synthetic routes for producing various forms of low dimensional thermoelectric nanostructures has concerned a lot of attention. 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. PbTe has a large Bohr excitation radius (46 nm) compared to other semiconductors. Due to these features, PbTe exhibits excellent electrical transport properties. And moreover, they show low thermal conductivities at high temperature. Controlling the form and the size of crystal has a lot of attention to improve the efficiency application of PbTe in various fields. Up to now, many routes 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.

In our group, we have been concerned for a few years in the synthesis of semiconductor nanostructures, using new inorganic precursor and organometallic chemistry. 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 . 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 of PbTe nanostructures was 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.

SEM images shown in Fig. 1 pertained to change reaction time from 6 to 24 h on 150°C with [Pb(salen)] as-precursors. In Fig. 1a, SEM image illustrated that the product has not been formed and by increasing the time to 12 h, the product was achieved (Fig. 1b). By increasing the reaction time from 12 h to 18 and 24 h the products grew together and it seems the growth stage overcomes to nucleation stage by raising the reaction time, which is confirmed with Ostwald ripening process. This exemplifies that the nanostructures size can be effectively controlled by determining the growth time. SEM images shown in Fig. 2a-c represented the morphology of as-obtained PbTe on different reaction temperature at 12 h. Results showed that at 120°C the structures of the products were similar to a big ball (Fig. 2a), these agglomerated structures may be formed because this temperature differed from boiling point of PG and the pressure of PG steam was very low but in 180°C which is above the boiling point of the solvent, PbTe was arrayed in a dendrite-like nanostructures with a hierarchical geometry (Fig. 2b). By increasing the temperature to 210°C , nanostructures were incorporated and they formed many small balls which were comparable with flowers and a few nanorods were similar to flower stalks (Fig. 2c). It seems that these structures are formed from coalescing hierarchical nanostructures. In the presence of [Pb(salophen)] as precursor the morphology of the product was globular nanostructures (Fig. 2d).

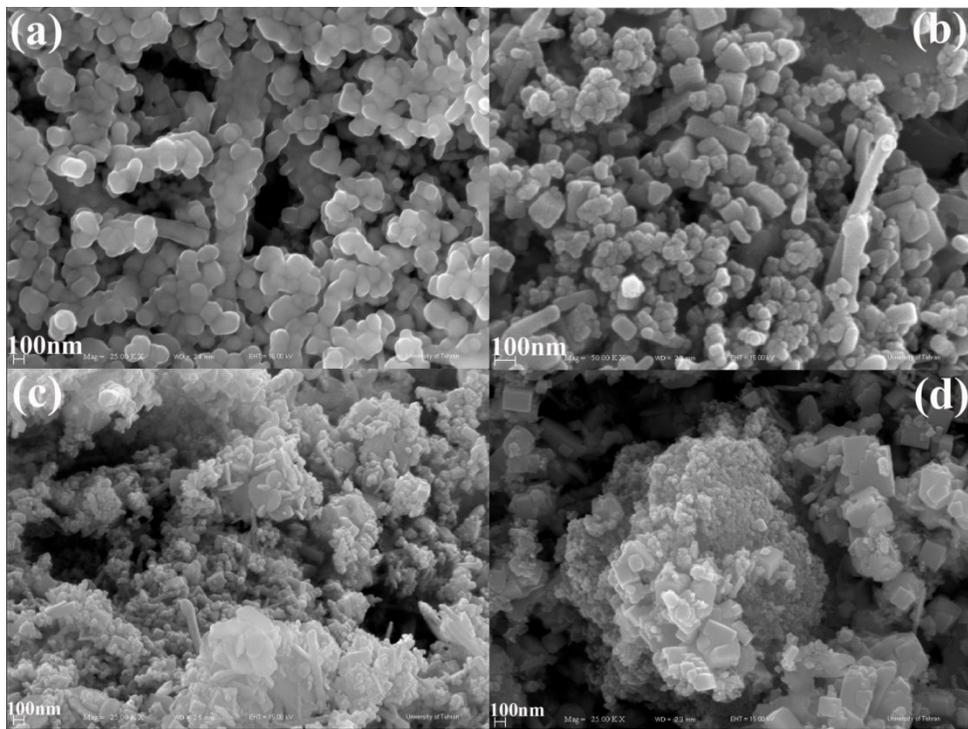


Fig. 1. SEM images of Sample. No (a) 6h (b) 12h (c) 18h (d) 24h at 150 °C.

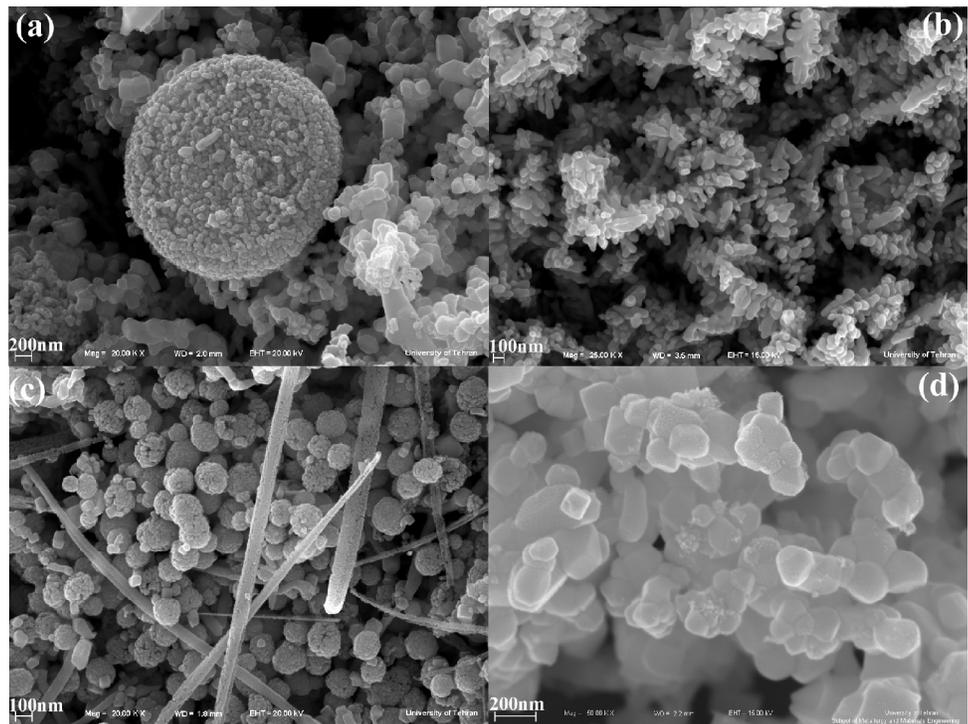


Fig. 2. SEM images of Sample. No (a) 120 °C (b) 180 °C (c) 210 °C (d) Pb(salophen).