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ORIGINAL PAPER

Synthesis and characterization of lead oxide nano-powders by sol–gel method

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Abstract Our goal in this research was to obtain lead oxide nano-powders by sol–gel method. In this method, lead oxide nano-powders were synthesized through the reaction of citric acid ($C_6H_7O_8{\cdot}H_2O$) solution and lead acetate [$Pb(C_2H_3O_2)_2$] solution as stabilizer and precursor, respectively. The effect of different parameters including calcination temperature, (molar ratio of citric acid to lead acetate) and drying conditions were investigated. The prepared lead oxide nano-powders were characterized by FT-IR spectroscopy, X-ray diffraction, thermogravimetric analysis and scanning electron microscopy. The prepared PbO samples consist of the particles in the range of 50–120 nm or the thick plate like structures with thickness of 53 nm depending on the drying conditions.

Keywords Sol–gel · PbO · Nano-powder · Plate

1 Introduction

In recent year, the synthesis of nanomaterials is an important research in the various scientific and industrial fields [1, 2]. Nanomaterials have attracted the attention of researchers not only by their particular physical and chemical properties but also by their potential application in many domains such as gas sensors, fuel cells, paints, rechargeable batteries, pigments and so on [3–5].

Lead oxides include four fundamental types (PbO, Pb_2O_3, PbO_2, and Pb_3O_4). PbO itself has two forms: yellow β-PbO, which is stable at high temperature and red α-PbO, which is stable at low temperature. The α-PbO phase transformation to β-PbO takes place at about 490 °C [3]. Lead oxide (PbO), is an important industrial material due to its unique electronic, mechanical and optical properties and its potential applications in nanodevices and functionalized materials [6] such as active materials of lead-acid batteries, valve-regulated lead acid (VRLA) batteries, and lithium secondary batteries [7–10]. Because of the simplicity of design, low cost of manufacture, reliability and relative safety when compared to other electrochemical systems of lead-acid batteries, there is a high interest to improve and develop lead oxide characteristics to obtain more discharge capacity and more cycle-life. Therefore, research to improve discharge capacity of lead oxide and lead dioxide is still in demand [11–14]. On the other hand, a variety of physicochemical methods, including thermal decomposition [3, 15], spray pyrolysis [16], selected-control synthesis [17, 18], hydrothermal synthesis [6], sonochemical [19–23], microwave irradiation [24, 25], synthesis by coordination polymers [26–28] and pulsed current electrochemical methods [29] have been used to produce nanometer-sized lead oxides. However, sol–gel method which provides a low cost, simple, non-hazardous method for preparing of different nano oxides has not been investigated for nano-sized lead oxides yet. Sol–gel method shows considerable advantages relatively to the customary methods because it allows controlling the size and morphology of the crystallized particles [30, 31] and lead to production powders with percent of more crystallization phase and high density. In this work, lead oxide nano-powders were synthesized through the reaction of citric acid and lead acetate solution by sol–gel methodology. The prepared lead oxide nano-powders were characterized by FT-IR spectroscopy, TGA, XRD and SEM.

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