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Experimental studies of barium titanate nanofibers prepared by electrospinning

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This paper reports the fabrication and characterization of $BaTiO_3$ nanofibers prepared by the electrospinning method. The X-ray diffraction (XRD) pattern revealed the formation of tetragonal phase corresponding to the Bragg angle $2\theta = 31^\circ$ and 45°. The formation of metal oxide is confirmed by the FTIR measurement. SEM study evidenced the smooth and randomly grown nanofibers with their average sizes 472 and 515 nm with respect to the samples BT1 and BT2 prepared at 8 and 12 kV dc voltages. TG/DTA analysis was performed to study the heating behavior of the composite $BaTiO_3$/PVP mat and 49 % weight loss was observed at 725 °C.

Keywords: electrospinning, barium titanate, scanning electron microscopy, X-ray diffraction.

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1. Introduction

Barium titanate ($BaTiO_3$) has excellent ferroelectric and piezoelectric properties. This material has been utilized in several industrial applications like capacitors, actuators, non-volatile RAM etc. [1–4]. In the absence of an external field, $BaTiO_3$ possess ferroelectric polarization. Over $BaTiO_3$ particles, nanofibers are reported to be promising one due to their large dielectric permittivity. Electrospinning technique has been reported to be as the simplest method for the fabrication of composite nanofibers of $BaTiO_3$. It consists of mainly three parts such as power source, collector and the syringe pump. Upon applied dc voltage, the loaded solution flows under the region of strong electrostatic field which experiences a repulsive force and as a result fine jet formed [5].

Several literature have been reported on the fabrication and characterization of $BaTiO_3$ nanofibers by the electrospinning method [6–8]. Study of $BaTiO_3$ nanofibers was reported after the calcination of as-prepared fiber mat at different temperatures followed by drying at 80 °C under vacuum condition [9]. The investigation by electron scanning microscopy (SEM) showed the fibers diameters from 160 – 300 nm. The X-ray diffraction (XRD) study endorsed the presence of tetragonal perovskite structure while Fourier transform infrared spectroscopy (FTIR) confirmed the various bonds corresponding to the $BaTiO_3$ nanofibers. The O–H stretching peaks at 3430 and 1425 cm^{-1} was found to be weak with respect to the increased calcination temperature while Ti–O peak at 570 cm^{-1} became strong. Remarkably, $BaTiO_3$ nanofibers calcined in nitrogen environment could convert the tetragonal phase to cubic perovskite structure which has been attributed to the elimination of carbonate content. Electrospun fiber mats of PVDF/$BaTiO_3$ nanocomposites were studied [10]. By SEM analysis the prepared fibers were noticed to be well grown in random directions with diameter from 200 – 400 nm. The XRD study revealed the presence of both α and β phases in PVDF whereas enhanced β phase was noticed in PVDF/$BaTiO_3$ sample. Further, the thermal emissivity was studied for both the samples and found to be reduced for the PVDF/$BaTiO_3$ sample. An approach of controlled morphology of barium titanate nanofibers has been reported [11]. The prepared nanofibers were investigated and observed to be polycrystalline in nature. The morphology was found to be ribbon-like form with their diameter and grain size 200 and 30 nm respectively. $BaTiO_3$ fibrils were obtained with the increased precursor with their diameter below 50 nm while the morphology was the same as ribbon-like. Further, fibers calcined at temperature 700 °C were observed to be in tetragonal phase as identified by XRD analysis. $BaTiO_3$ nanofibers calcined at temperature at 750 °C showed the fibers diameter from 80 – 190 nm [12]. This investigation was claimed to the stand-alone formation of ferroelectric nanofibers.

Here, we present the fabrication and characterization of $BaTiO_3$ nanofibers prepared at two distinct dc voltages (8 and 12 kV). In Section 2, the experimental approach is presented and the obtained results are discussed in Section 3. Finally, the work is summarized in Section 4.