Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 148 (2016) 243 – 248

Procedia Engineering

www.elsevier.com/locate/procedia

4th International Conference on Process Engineering and Advanced Materials

Fabrication of Superconducting YBCO Nanoparticles by Electrospinning

S. E. Jasim[a,b], M. A. Jusoh[a,*], M. Hafiz[a] and Rajan Jose[a]

[a]*Faculty of Industrial Sciences & Technology, Universiti Malaysia Pahang, UMP, Kuantan-26300, Pahang, Malaysia*
[b]*Electrical dept., Technical Institute/Al Haweejah, Northern Technical University, Al Haweejah-36007, Kirkuk, Republic of Iraq*

Abstract

High temperature superconductor $YBa_2Cu_3O_{7-\delta}$ (HTS YBCO) nanoparticle was successfully prepared by electrospinning and sol-gel techniques. The sol-gel containing a homogeneous solutions of the precursor of Y-Ba-Cu acetate and Poly (vinyl pyrrolidone) PVP. The critical transition temperature (T_c) of the samples have been found using four point probe technique. By optimizing electrospinning, sol-gel process and heat treatment procedure, YBCO nanoparticle with a transition temperature of 78 K was obtained. The surface area measurements of YBCO samples showed, high surface area 2.0 m^2/g for nanoparticle, in comparison with block sample 1.0 m^2/g. The structural Characterizations of YBCO samples demonstrated that, the YBCO nanoparticles have single phase orthorhombic structure which typical crowd nanoparticles diameter were 388 nm. The Individual nanoparticle diameter were found between 20 and 50 nm. The calcination temperature at 950 ^oC does not affect to decrease the surface area of YBCO samples. Electrospinning in combination with a sol-gel techniques are an effective routes to realize different nanostructure morphologies of YBCO superconductor. Production of HTS YBCO nanoparticle by these process promising practical applications.

Peer-review under responsibility of the organizing committee of ICPEAM 2016

Keywords: *Electrospinning; High Temperature; Nanoparticle; Superconductor; YBCO;*

1. Introduction

Superconducting $YBa_2Cu_3O_{7-\delta}$ (YBCO) amongst other 1:2:3 ceramic materials became more popular, because of its outstanding properties, like high transition temperature, current density, magnetic field, and chemical stability[1, 2]. Furthermore, it is easy to fabricate from metal oxides, acetate and nitrite [1-4]. Besides their components are non-toxic, non-volatile, less anisotropic, relatively low cost and capable to have single phase. HTS YBCO has been widely explored to be the most promising cuprate [2, 3]. In point of fact, YBCO is by this time being examined in power transmission [5-7], transformers, motors, generators and extraordinary frequency electronics applications [8-10]. HTS YBCO was successfully fabricated to realize 1D nanostructure with single crystal structure, high performance and uniform, by employing various techniques. Techniques such as Pulsed Laser Deposition (PLD), Citrate Pyrolysis Technique and Soft Chemical Route, were demonstrated to fabricate HTS BCO nanoparticle [4, 11-13].

* Corresponding author. Tel.: +609-5492314; fax:+609-5492766.
E-mail address: ashry@ump.edu.my

Peer-review under responsibility of the organizing committee of ICPEAM 2016
doi:10.1016/j.proeng.2016.06.595

Electrospinning process appears as an efficient technique, versatile, simple, controlled parameters and cheapest incorporation with other techniques [14, 15]. Electrospinning is a powerful technique, generally used in combination with the sol - gel technique followed by calcination process at high temperature [16, 17]. The typical sol-gel solution used with the electrospinning technique consists of a precursor of the desired materials plus polymer and a relative volatile solvent [1, 18]. The solvent is utilized to control the product solution viscosity, conductivity and morphology. Solvents like water, methanol, isopropanol, ethanol and others are widely used as a solution parameters [14, 19]. Although, several researchers have synthesized HTS YBCO with different morphologies in nanoscale diameter and individually by electrospinning technique in combination with sol-gel [1-3, 14, 16, 17]. Morphology of HTS YBCO like nanofibres, nanotube and nanowires have been demonstrated via electrospinning and sol-gel [3]. However, morphologies of HTS YBCO nanoparticles are still not realized up to now by electrospinning. This work presents a practical experiment and process routes to fabricate and characterize HTS YBCO nanoparticles with intrinsic properties by electrospinning the sol-gel solutions followed by heat treatment techniques [19, 20]. The superconducting properties of YBCO nanoparticle samples are experimentally depending on the solution parameters of sol-gel, electrospinning process and heat treatment conditions [14, 21].

2. Experimental

2.1. Materials

Poly (vinyl pyrrolidone), PVP [Mw = 160,000 g/mole] were purchased from Adrich,. Yttrium (III) acetate tetrahydrate [99.9% (REO), powder $Y(OOCCH_3)_3.4H_2O$], Barium acetate [ACS 99.0%, crystalline $Ba(OOCCH_3)_3$] and Copper (II) acetate monohydrate [powder $C_4H_6CuO_4.H_2O$] were purchased from Alfa Aesar. Solvents were used Propionic acid ($C_3H_6O_2$), Acetic acid ($C_2H_4O_2$) and Methanol (CH_4O) used (purity, 99%) supplied commercially. All the material were used without any purification.

2.2 Sample preparation

The sample was prepared by dissolving 4.0 g of Y-Ba-Cu acetate and 3.0 g of PVP powder in 25.0 ml mixture of propionic acid, acetic acid and methanol. The propionic acid utilized successfully to dissolve metallic acetate of (Y, Ba and Cu) [3, 16]. The addition of Acetic acid was very important to avoid any hydrolysis of the polymers [2, 3, 16]. Moreover, Acid medium was suitable to create a stabilization of the solution and to prevent the hydrolysis of the sol–gel precursor. Finally, Methanol was added as a Polymer solvent and to tune the viscosity [3].

2.3 Sol-gel method

The sol-gel solution was conducted by dissolving separately the polymer and precursor acetate solutions. The polymer solution was prepared by melting 3.0 g of PVP polymer in 10 ml of methanol and then stirred at 70 ^oC for 1 h in a closed beaker. The precursor solution of metal acetate was made by dissolving the components of Y-Ba-Cu acetate with a stoichiometric ratio of 1:2:3 molar mass among acetate in 10 ml of propionic acid. Then the result stirred at room temperature in a covered beaker for 12 h. The two solutions were collected with the addition 5.0 ml of acetic acid, then stirred at room temperature for 12 h. The addition of polymer and adjustment of viscosity was maintained to achieve the nanostructure shapes [2, 3, 14]. The viscosity of the solutions were controlled by the addition of polymer and solvent. Different weight ratio and solvents quantity could be adopted to change the viscosity, leading to a new results. Both viscosity and conductivity were determined to be consistent with the literature of electrospinning process [15, 22].

2.4 Electrospinning

The electrospinning processes set up are supported by a syringe (14 cm diameter, 5 ml volume), needle (20 gauge, stainless steel), ground collector (10 cm diameter, 30cm length, stainless steel and controlled speed), high power supplier and controlled injection pump [14, 19, 21]. The resultant sol-gel solutions were loaded by a syringe and electrospun at 20 kV with 16 cm tip-collector distance, 1 ml/h flow rate injection and collector speed at 1200 rpm. All the electrospun samples were deposited on flat $LaAl_2O_3$ (100) substrate and aluminium foil covered the collector, in order to remove it easily from the collector. The electrospinning process was carried out at room temperature and closed environment. All samples produced by the electrospinning were placed in a closed desiccator to dry for 48 h.

2.5 Heat treatments

The heat treatment process was divided in two steps, the first was to burn out the polymer and the second was to carry out the single structure of HTS YBCO nanoparticle. The electrospun sample was firstly transferred to the box furnace (Nabertherm, 30-3000 ^oC) and heated from room temperature up to 500 ^oC for 3 h at a heating rate of 50 ^oC/h. The second heat treatment was