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Synthesis and Effect of Al_2O_3 Added in Yttrium Barium Copper Oxide $YBa_2Cu_3O_\delta$ by Solid State Reaction Method

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Abstract

The aim of this research was synthesize $YBa_2Cu_3O_\delta$ (YBCO) and to study the effect of Al_2O_3 additions at x= 0.00, 0.10, 0.20, 0.50, 1.50 and 3.50 wt.%. The samples were investigated through Thermogravimetric Analyzer (TGA) and X-Ray Diffraction (XRD). All samples prepared by solid state reaction method with calcination process at 900°C and sintering process at 950°C. The TGA analysis indicated weight loss was complete at 910°C. XRD patterns showed the orthorhombic structure with lattice parameters a=3.821 Å, b= 3.880 Å and c= 11.663 Å, respectively. The Al_2O_3 added samples did not show any new peak however the sharpness and broadening peaks was changed. The crystallite sizes of the samples were calculated from the width of the selected peak and half maximum. The size is slowly increased by increasing the Al_2O_3 addition. These result indicated that addition does not affect on the structure but the crystallite sizes increase affect the morphology images.

1. Introduction

The high temperature superconductor YBCO has generated enormous amount of activities in the field of ceramic superconductor (Paulose et al. 1992). The production of high temperature superconductor has generally been through conventional methods such as solid state, sol gel, spray drying and co-precipitation reaction (Bolzan et al., 1996). The fine powder has assumed a large importance, minimization of processing time and temperature during heating, homogenization and to avoid the constituent oxide are importance criteria to synthesis YBCO (Pathak et al. 2005).

In this paper, we report the synthesize YBCO ceramic and effect of addition Al_2O_3 produced by the solid state method. The research also shown the weight loss and the phase formation temperature of the sample also describe the structure of the ceramics.

2. Materials and Methods

$YBa_2Cu_3O_\delta$ samples were prepared by solid state reaction method. Yttrium oxide Y_2O_3, barium carbonate $BaCO_3$ and copper oxide CuO powder is taken in a stoichiometric ratio (1:2:3). The powders are ball-milling for 24 hours. The mixture will be first calcination at 900°C for 12 hours with intermediate grinding in order to ensure the homogeneity. Lastly, the powders were pressed into pellet and sintered at 950°C for 12 hours. The thermal analysis (TGA) recorded the changes for exothermic and endothermic reaction. The phase identification will be carried out by using X-ray Diffraction (XRD) technique performed by using a Brukers D2Phaser with Cu-K_α radiation source.

3. Results and Discussion

Thermogravimetric analyzer (TGA) used to detect the mass loss as a function of increasing temperature and it has been applied to the study the oxygen diffusion in YBCO powder and polycrystalline. Figure 1 show the TGA curve for the pure samples with increasing temperature up to 1000°C. Base on the research by Khoshnevisan (2002), there was a no weight changes until 400°C and after that different reaction carried out. Meanwhile, from 420°C to 995.62°C, the weight change was at 13.14% for 10.158 mg. From the temperature of 900°C to 950°C, the sample show a stabilize end product which is comparable to past research from (Suan & Johan, 2013). The sample of YBCO with the addition of Al_2O_3 show in the Figure 2, where the TGA curve shows the formation of YBCO at the range temperature of 900°C to 950°C. The Y_2O_3, $BaCO_3$ and CuO powder after this

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massive weight loss were stable up to 900°C. Beyond 900°C, the raw materials became non-stable and believed to be reactive in forming YBCO pure powder. On the other hand, the Al_2O_3 nanoparticles stayed as it was and did not involve in any reaction because it is very stable in that temperature range as a ceramic material (Singh et al., 2007).

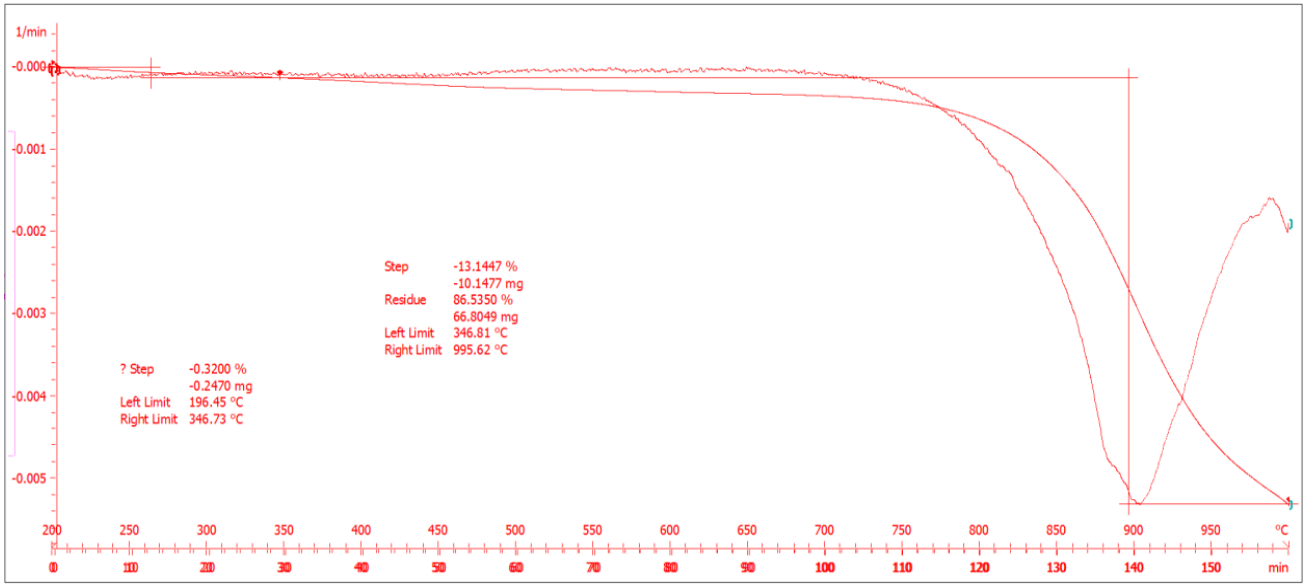

Figure 1: The TGA curve of YBCO sample before calcination process

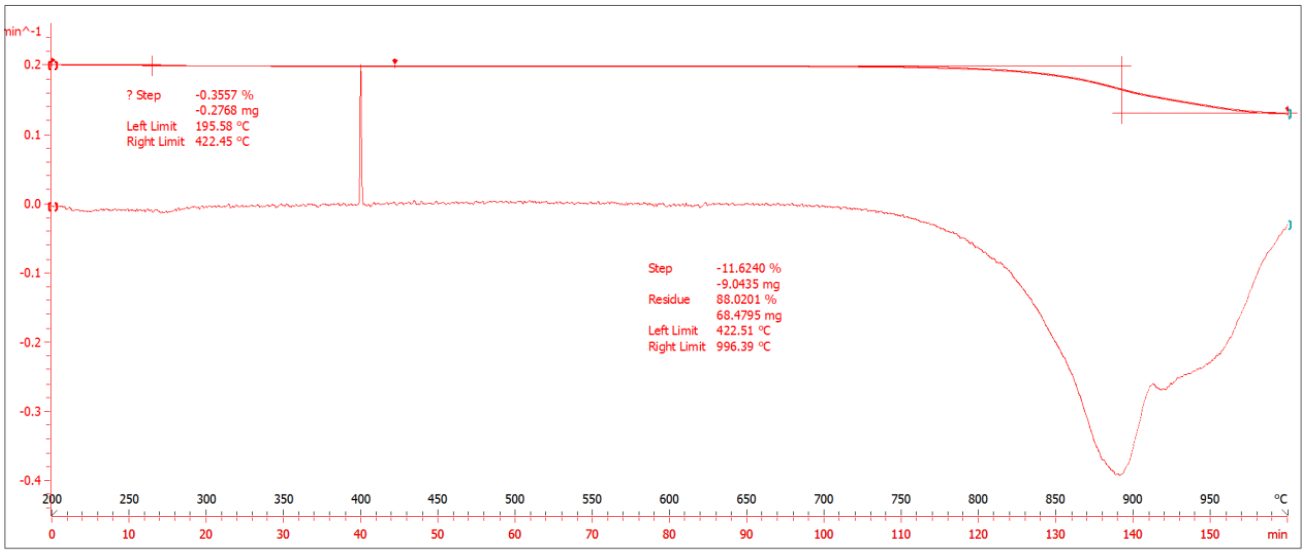

Figure 2: The TGA curve of YBCO with Al_2O_3 nanoparticles addition

The XRD patterns of pure YBCO along with Al_2O_3 addition have been shown in Figure 3. It is clear to see that the intensity for YBCO increases at elevated addition of Al_2O_3. The same additional phase that exist in the sample after calcination does not shows any changes in term of intensity with increases addition of Al_2O_3 nanoparticles (Widad et al., 2012). The lattice constant parameters for prepared specimens are nearly same with average values of a = 3.821 Å, b = 3.880 Å and c =11.663 Å which are comparable with the literature for Y-123 (Benzia et al, 2004). The Al_2O_3 addition samples did not show any changes in terms of structural properties and is quite similar as observed in the XRD patterns of pure YBCO. This is attributed to the fact that in these compositions Al_2O_3 nanoparticles were existed as another phase and uniformly distributed in YBCO matrix (Suan et al., 2013). Thus, the Table 1 shows the unit cell parameter and the unit cell volume for $YBa_2Cu_3O_{7x}$ with Al_2O_3 addition.

It is expected that the a and c lattice parameter increase slightly in that amounts of Al_2O_3 addition whereas b parameter almost remains constant. The a and c lattice parameters are noticed to increase as the Al_2O_3 nanoparticles content was increased in samples from the Figure 4, respectively. The increments are believed because O^{2-} ions try to fill in its deficiencies site and incorporation of Al^{3+} ions at the Y site as shown by the $YBa_2Cu_3O_7$ molecular structure (Suan & Johan, 2014).

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These alterations illustrate that the Al^{3+} ions occupy in both Y and Cu sites. The addition of Al_2O_3 slightly decreases the difference between a and b parameters and thus reduces the orthorhombic.

Table 1: The lattice parameter and the volume of the unit cell for $YBa_2Cu_3O_{7x}$ with Al_2O_3 additions

Al_2O_{3x} addition (wt%)	Cell Parameters			V(Å^3)
	a (Å)	*b* (Å)	*c* (Å)	
0.00	3.8410	3.8830	11.6710	174.0683
0.10	3.8424	3.8810	11.6821	174.2076
0.20	3.8177	3.8836	11.6827	173.2126
0.50	3.8360	3.8830	11.6860	174.0652
1.50	3.8250	3.8864	11.6945	173.8443
3.50	3.8184	3.8857	11.7010	173.6096

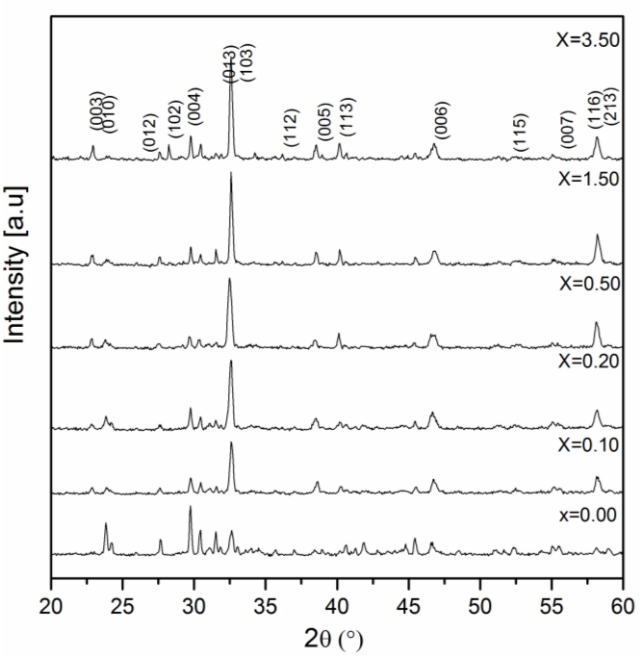

Figure 3: XRD pattern of $YBa_2Cu_3O_7$ added with Al_2O_3 at different x =0.00, 0.10, 0.20, 0.50, 1.50, 3.50

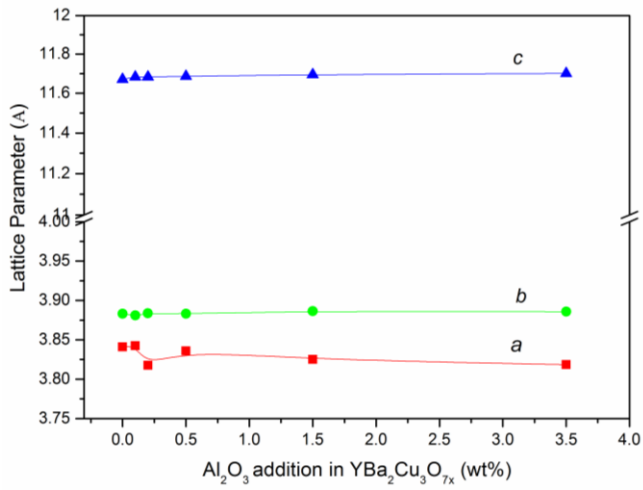

Figure 4: Evolution of lattice parameters versus Al_2O_3 addition

4. Conclusion

The YBCO pure powder was successfully synthesize and confirmed its phase and quality of the samples. On top of that, Al_2O_3 nanoparticles addition were successfully introduced and well distributed into YBCO superconductor through solid state reaction. In this paper a systematic study on the addition of Al_2O_3 nanoparticles with different weight percentage to $YBa_2Cu_3O_7$ was the orthorhombic structure and the is no structure change in the superconducting YBCO compound due to Al addition, a few additional peaks located at 2θ = 29.82° and 30.50°, compared to pure YBCO.

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