Y_2O_3 Nanophosphors Synthized by Combustion and Thermal Decomposition Techniques

D. Tatar[***], H. Kaygusuz[*,**], F. Tezcan[**], B. Erim[*], ML Ovecoglu[***] and G. Ozen[**]

Istanbul Technical University, Maslak-Istanbul, Turkey 34469
[*]Department of Chemistry, Faculty of Science & Letters,
[**]Department of Physics, Faculty of Science & Letters
[***]Department of Metallurgical & Materials Engineering,
Faculty of Chemical & Metallurgical Engineering,

ABSTRACT

The combustion and chemical decomposition techniques were used to synthesize Y_2O_3 nanophosphors that are high quality powders as promising materials for the next generation of the display technology. Combustion technique focused on an exothermic reaction between Yttrium nitrate and glycine as fuel. The thermal decomposition technique (to our knowledge, a new technique used to synthesize Y_2O_3 nanocrystalline phosphors) is based on the thermal decomposition of Yttrium alginate gels. The gels in this technique were produced in the form of beads by ionic gellation between a yttrium solution and sodium alginate. Both the wet beads and the Y_2O_3 powders obtained by using the former technique were annealed at 600, 800 and 1000 °C for various annealing times. The products were characterized by X-ray diffraction (XRD) and the crystal size distribution of each product was measured by BET technique. The results explicitly illustrate that the size of the nanocrystalline Y_2O_3 phosphors is influenced by the technique, annealing temperature and the duration of the annealing process. We found that the size of the nanocrystalline Y_2O_3 phosphor varies from a 9nm to about 200nm nanometers.

Keywords: Y_2O_3 nanophosphors, chemical decomposition, combustion, XRD.

1 INTRODUCTION

Significantly improved performance of displays and light emitting devices demands high-quality phosphors having sufficient brightness and long term stability[1]. Lanthanide activated rare earth oxides such as Eu^{3+} and/or Tm^{3+} doped Y_2O_3, remain as promising materials for the next generation display technology because of the following important properties:

1. They are stable in vacuum,
2. They give corrosion-free gas emission under electron bombardment compared with red phosphors used in current field-emission displays and,
3. They are damage resistant and high reflection materials when used in the light-emitting diodes and/or high power UV lasers.

The size of the nanocrystals is significantly influenced with the technique used for preparation as well as the annealing temperature and duration of the annealing process [2]. In the present project we report that the size of the nanocrystalline phosphor material was varied from a few nanometers to several hundred nanometers by annealing the samples at varied temperatures and using two different preparation techniques.

2 EXPERIMENTAL

The combustion and chemical decomposition techniques were used to synthesize Y_2O_3 nanophosphors. Yttrium nitrate, glycine and low viscosity (250 cps % 2 solution in water) acid sodium salt purchased from Sigma-Aldrich. 0,2 M Yttrium nitrate solution and %1 (w/v) alginate solution were prepared by dissolving in ultra pure water. Yttrium-alginate beads were produced by drop wise addition of 30 ml alginate solution in 60 ml of yttrium nitrate solution by means of stainless steel needle. Prepared yttrium-alginate beads were shaken for 30 min with the rate of 150 rpm. After this process, beads were separated from the solution and placed in a silica crucible and heated at 450 ^{0}C for 24 hour. Finally beads were heat treated at 600-800-1000 ^{0}C and at each temperature for 2-4-8-16 hours. X-ray diffraction (XRD) measurements were performed using a Bruker^{TM} D8 Advanced Series powder diffractometer to confirm the formation of Y_2O_3 crystalline phase. All traces were recorded using CuKα and the diffractometer setting in the 2θ range from 20^o to 60^o by changing the 2θ with a step size of 0.02^o. All samples were ground to fine powder for investigation and Eva Software was used to label peaks in the sample.

3 RESULTS AND DISCUSSION

Fig.1 (a) and (b) show the x-ray diffraction patterns (XRD) of the Y_2O_3 powder samples which were synthesized using the combustion and the chemical decomposition techniques. The diffraction patterns were compared with the data from ICDD and a good agreement was found between the diffractogram obtained and the cubic Y_2O_3 (File # 71-5970). The XRD patterns were obtained by annealing the Y_2O_3 powders at 600°C for the different duration of annealing times. As it can be seen from both figures, no appreciable effect neither of the method used to synthesize the powders nor the time duration of the heat treatment exists on the peaks position and the full-width at the half of the maximum intensity (FWHM).

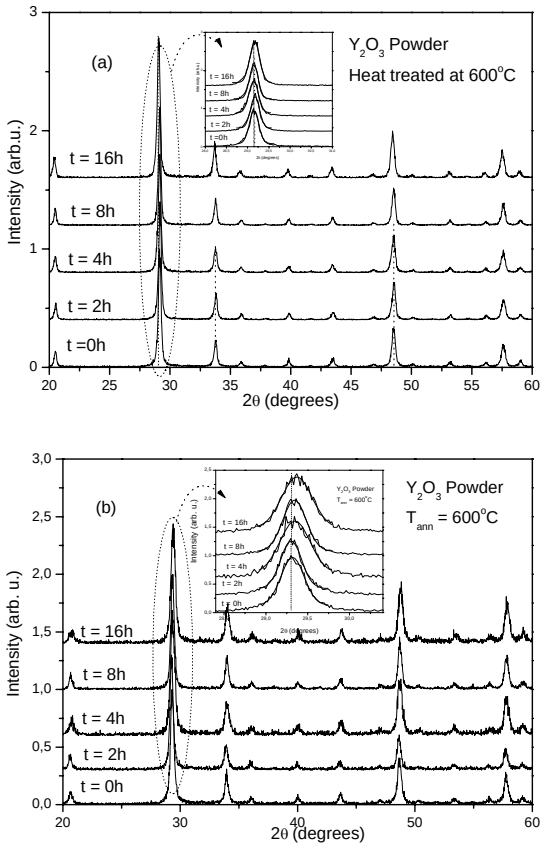

Figure 1: XRD patterns of the Y_2O_3 powders annealed at 600°C for 16-hours synthesized with (a):combustion (b): chemical decomposition techniques.

Fig.2 (a) and (b) show the x-ray diffraction patterns (XRD) of the Y_2O_3 powder samples which were synthesized using two techniques of the samples annealed at 1000°C for 16-hours. As it can be seen from the figures, both of the method used to synthesize the powders and the time duration of the heat treatment has an observable effect on the peaks position and the FWHM.

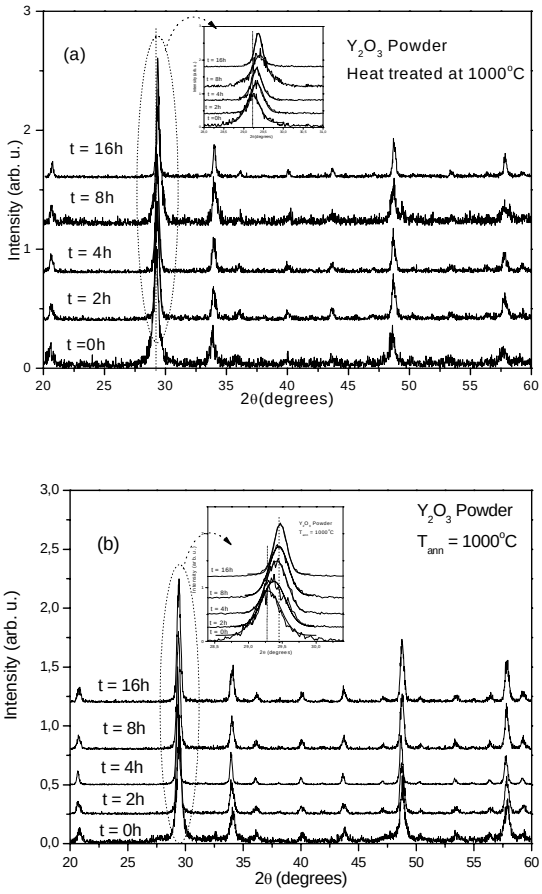

Figure 2:XRD patterns of the Y_2O_3 powders annealed at 1000°C for 16-hours synthesized with (a):combustion (b): chemical decomposition techniques.

The crystalline size of the powder samples were determined from the XRD peaks using the Scherrer equation [3] which is given as follows;

$$L = \frac{K\lambda}{\beta Cos(\theta)}$$

where K and λ are the Scherrer shape factor taken as 0.89 and the X-ray wavelength of the CuKα taken as 1.54°A, respectively; θ is the Bragg angle and the β is the pure line broadening. The crystallite size of the Y_2O_3 powders is influenced by both the annealing temperature and the method used to synthesize the powders. The crystalline is determined to be 21±2nm and 35±2nm when the annealing temperature was below 800°C for the powders produced by chemical deposition and the combustion methods as can be seen in Fig. 3. The crystalline size grows much faster above this temperature when the combustion method was used.

NSTI-Nanotech 2008, www.nsti.org, ISBN 978-1-4200-8503-7 Vol. 1

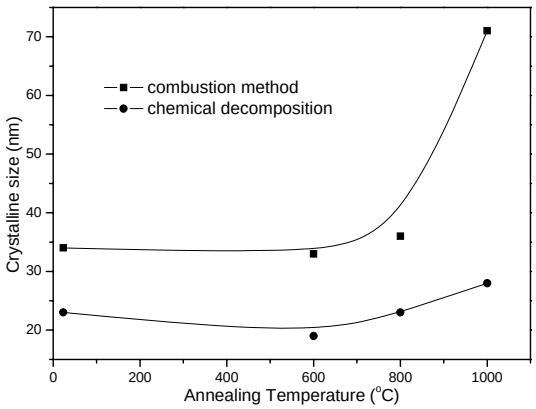

Figure 3:Variation of the crystalline size with the annealing temperature (■):combustion (●): chemical decomposition techniques.

4 CONCLUSIONS

Y_2O_3 nanophosphors powders were synthesized using the combustion and chemical decomposition techniques and heat treated at 600, 800 and 1000oC for 16-hours. The variation of the crystallite sizes were determined using the Scherrer equation to the peaks observed in the XRD patterns. According the experimental results the following conclusions can be made;

1. The crystalline sizes are smaller at each annealing temperature when the powders were prepared using the chemical decomposition technique than those obtained with the combustion method.
2. The crystalline sizes of the powders prepared by both methods do not vary appreciably with the annealing temperature below 800°C.
3. The crystalline size grows much faster above 800°C when the combustion method was used.

REFERENCES

[1] H. Huang, G. Qin-Xu, W.S. Chin, L.M. Gan and C.h. Chew " Synthesis and characterization of Eu:Y2O3 nanoparticles" Nanotehnology 13 318 – 323 (2002).

[2] C.A. Kodaira, R. Stefani, A.S. Maia, M.C.F.C. Felinto, H.F. Brito, J. Lumin.., 127, 616-622, 2007.

[3] C. Suryanarayana, M.G. Norton, "X-Ray Diffraction: A Practical Approach", Plenum Press, 207-220, 1998.