ARTICLE IN PRESS

Ceramics International xx (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Ceramics International

journal homepage: www.elsevier.com/locate/ceramint

Development of Magnesia–Yttria nanocomposite powder by new non-alkoxide sol-gel method

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ARTICLE INFO

Keywords:
Magnesia–Yttria nanocomposite
Non-alkoxide sol-gel method

ABSTRACT

Magnesia–Yttria nanocomposite powder was synthesized by new non-alkoxide sol-gel method. In this method, $Y(NO_3)_3 \cdot 6H_2O$, $Mg(CH_3COO)_2 \cdot 4H_2O$, Ethylene diaminetetraacetic acid (EDTA), Ethylene glycol (EG) were used as Y^{3+}, Mg^{2+}, chelating agent and solvent source, respectively. The influences of pH value and calcination temperature on phase evolution of samples have been investigated. As-synthesized magnesia– yttria nanocomposite powders were characterized by X-ray diffraction (XRD), field-emission scanning electron microscope (FESEM), energy dispersion spectrum (EDS), inductively coupled plasma (ICP), thermal gravimetric-differential thermal analysis (TG/DTA), the Brunauer-Emmett-Teller (BET) method and Fourier transform infrared (FTIR) analysis. The as-synthesized magnesia–yttria nanocomposite powder was consolidated by the cold press technique and sintered at 1400 °C for 2 h. The FESEM micrographs of sintered Magnesia– Yttria composite showed a uniform distribution of MgO and Y_2O_3 phases.

1. Introduction

Several materials have been suggested to make transparent ceramics in the mid-infrared range of the electromagnetic spectrum, spinel, alumina, Y_2O_3, YAG, and AlON [1–5]. MgO-Y_2O_3 is an excellent ceramic material candidate and finds potential applications because of its high melting point with excellent high corrosion resistivity, chemical stability, and low instability in the vacuum [6–8]. The cubic crystal structure of MgO-Y_2O_3 composite is desired for IR transparent ceramic applications [9–11]. For this application, the powder of MgO-Y_2O_3 composite must have characteristics such as cubic phase nano grain size, spherical morphology, and uniform distribution of phases [10]. Chemical methods such as combustion method, sol-gel, and spray pyrolysis have been used for the preparation of MgO-Y_2O_3 nanocomposite powder [27,28]. The sol–gel type Pechini method synthesis is an attractive method for the preparation of MgO-Y_2O_3 nanocomposite powder. Furthermore, the Pechini route utilizes lower temperatures and offers a greater degree of control over elemental ratios and homogeneity [12–14]. However, in the conventional Pechini method, each molecule of citric acid can be chelated by three metallic ions, but in the EDTA assisted modified Pechini method, each molecule of EDTA can be chelated by six bonds. Thus, EDTA has a stronger chelating power to metal ions as compared to citric acid molecules. The greater ability of EDTA anions to chelate metal cations, and the formation of very stable and soluble complexes led to controlling the composition and a high degree of homogeneity [15–17]. Ethylenediaminetetraacetic acid (EDTA), related aminopolycarboxylic acids, and their salts form watersoluble complexes with alkaline-earth and heavymetal ions. These complexes greatly alter the reactivity of the metal ion, thus making them useful in many important industrial processes. On the laboratory scale EDTA is preferably used in analytical chemistry, especially for titrimetric purposes. However, it is also used for many other scientific investigations. This chelating compound can be applied for: dissolution of mineral oxides, dealumination of zeolites catalysis, materials science, medicine and biochemistry, and environmental science [20–25].

In this study, the synthesis of MgO-Y_2O_3 nanocomposites was developed by EDTA assisted Pechini method. The effect of different EDTA to transition metals (TM), pH value, and calcination temperature have been investigated in order to determine the influence on the morphology, particle size, and phase of MgO-Y_2O_3 nanocomposite powders.

2. Experimental

2.1. Preparation of the MgO-Y_2O_3 nanocomposite powder

Reagents of Yttrium (III) nitrate hexahydrate ($Y(NO_3)_3 \cdot 6H_2O$, 99.9%), magnesium acetate tetrahydrate ($Mg(CH_3COO)_2 \cdot 4H_2O$, 98–

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http://dx.doi.org/10.1016/j.ceramint.2016.10.066
Received 5 September 2016; Received in revised form 9 October 2016; Accepted 10 October 2016
Available online xxxx

Please cite this article as: Vaez, S.H., Ceramics International (2016), http://dx.doi.org/10.1016/j.ceramint.2016.10.066

Table 1
Experimental Parameters for the synthesis of $MgO-Y_2O_3$ nanopowder with modified sol-gel Pechini method.

Sample. No	EDTA: EG:TM	pH
S1	1:1:1	5
S2	1:1:1	7
S3	1:1:1	10
S4	3:1:1	5
S5	3:1:1	7
S6	3:1:1	10

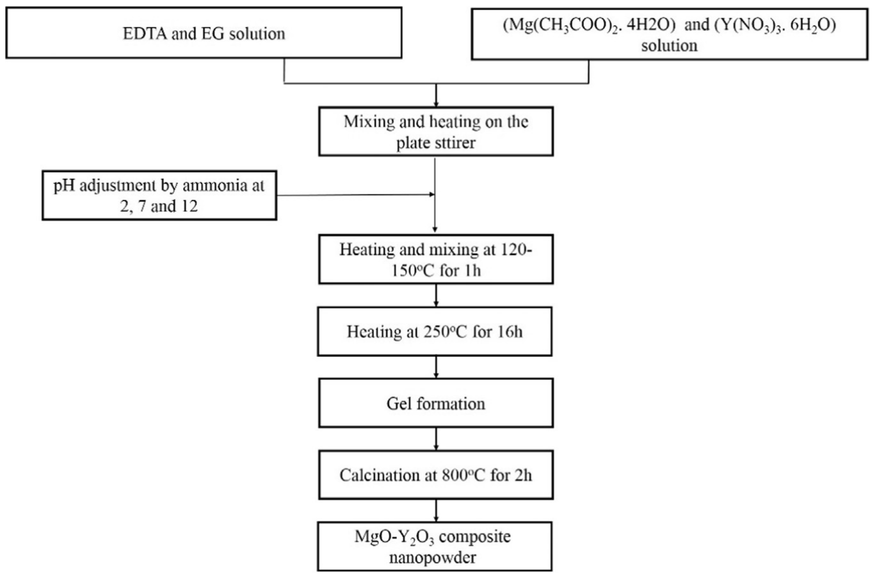

Fig. 1. The schematically of synthesis of $MgO-Y_2O_3$ nanocomposite Pechini sol-gel method.

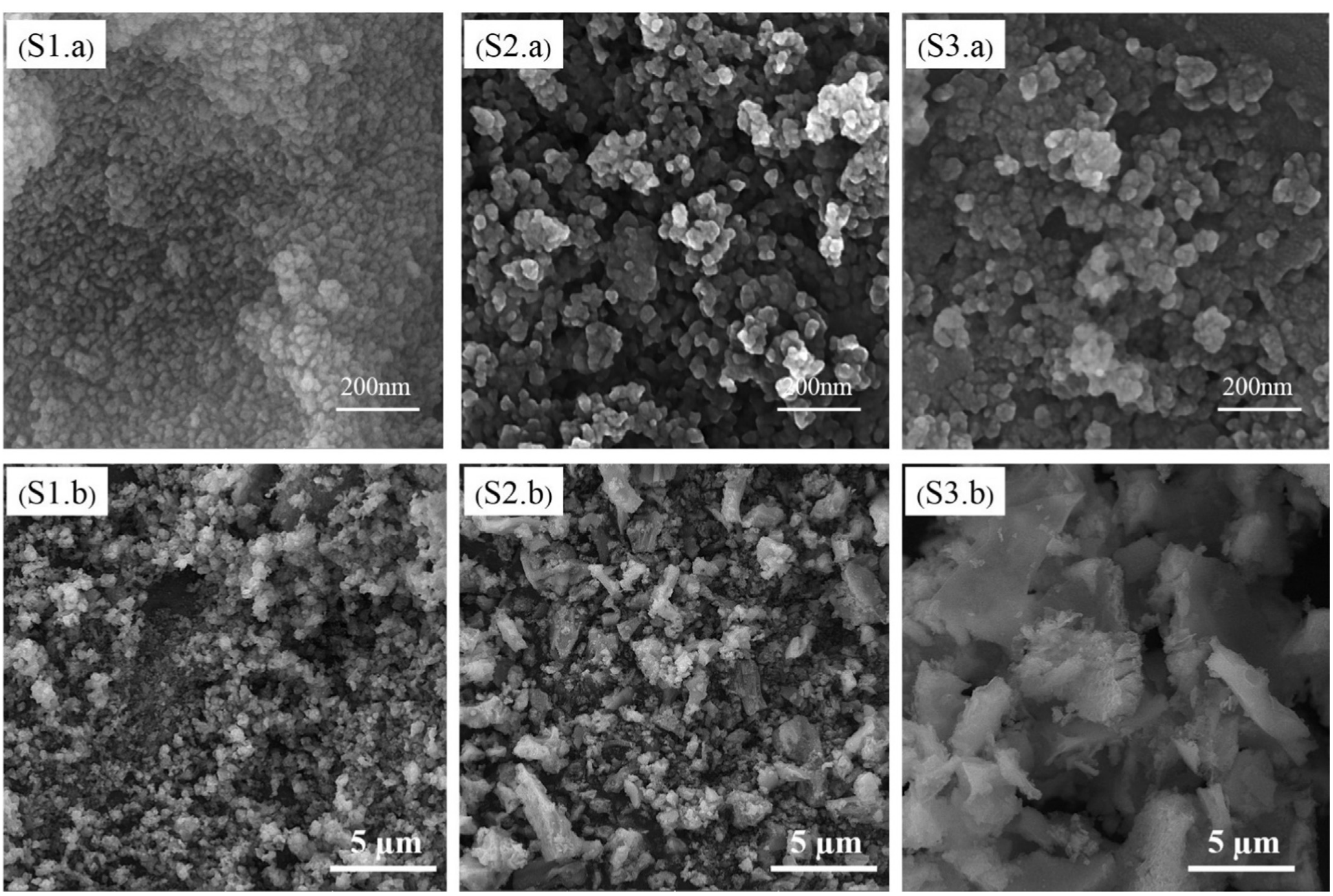

Fig. 2. The FESEM images of the Y_2O_3–MgO nanocomposite powders synthesized with mole ratio of EDTA to total metal ions and EG=1:1:1 according Table 1.