Yttria totally stabilized zirconia nanoparticles obtained through the pyrosol method

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It is well known that zirconia based ceramics, partially or totally stabilised, have a wide use in many fields, such as biomedical, sensors, catalysts, cutting tools and abrasives, components with high thermo-mechanical properties, filters or solid oxide fuel cells technologies. The use of totally stabilised zirconia in fuel cells technologies is due mainly to the very good ionic conductivity of cubic zirconia at medium and high temperature [1, 2, 3].

The pyrosol method consists in the formation of an aerosol from a diluted solution of precursors, using a high frequency ultrasounds generator. The formed aerosol is carried trough a furnace, in a quartz tube, by a carrier gas. During the passage of the aerosol through the furnace, some reactions occur such as evaporation, calcination and densification of the powder. At the end of the tube, a high voltage wire collects the powder.

In this work, 10 mole percent yttria stabilised cubic zirconia is obtained through the pyrosol method, starting from a diluted solution of zirconia nitrate (N_2O_7Zr x $6H_2O$) and yttrium nitrate ($Y(NO_3)_3$ x $4H_2O$) [1]. The pyrosol method was used in order to obtain reactive powders, with dimensions in the nanometers range.

The main factors which are influencing the parameters of the obtained powders are concentration of the precursors' solutions, soluble salts type, synthesis temperature, vibration frequency, etc. In the present paper, it was investigated the influence of the concentration of solutions ($5x10^{-2}$ M, $2.5x10^{-2}$ M and $1.25x10^{-2}$ M) and of the thermal treatment temperature (700, 800 and 900^0C) on the dimensions, morphology and composition of powders.

The analyses used to characterise the obtained powders were X-ray diffraction, scanning electron microscopy (SEM), atomic force microscopy (AFM) and high resolution transmission electron microscopy (HRTEM).

The only crystallographic phase identified through X-ray diffraction, for powders prepared at 800^0C and higher and for all concentrations, is cubic zirconia.

From SEM images it was observed that there were obtained perfect spherical particles. By increasing the thermal treatment temperature the particle sizes increases, reaching 0.6 microns, but by decreasing the concentration of the precursors' solutions, the particle size reaches a medium size of approximately 85 nm.

The profiles extraction of topography images from AFM reveal that more than 90 % of particles are below 90 nm.

From HRTEM images it can be seen that the spherical particles are formed from an agglomeration of nanocrystalites, reaching even a mean dimension of 4 nm for $1.25x10^{-2}$ M concentration of the starting solutions, which is the lowest concentration used, synthesized at 800^0C. The maximum size of nanocrystalites is of approximately 9 nm, for the $5x10^{-2}$ M starting solutions, treated at 900^0C.

We may conclude that the pyrosol process is a relatively simple method, which is allowing the preparation of reactive cubic zirconia powders, with dimensions in the nano domain and spherical morphology, with valuable application in main industrial fields.

References:
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[4] Manuel Gaudona, Elisabeth Djurado, Norbert H. Menzler, Morphology and sintering behaviour of yttria stabilised zirconia (8-YSZ) powders synthesised by spray pyrolysis, Ceramics International 30 (2004) 2295–2303.

Figures:

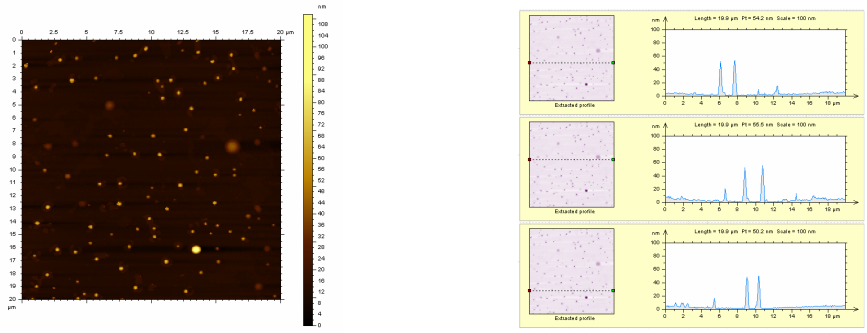

Figure 1 – A topography AFM image of 20µm and the extracted profile obtained on cubic yttria stabilised zirconia synthesised from the concentration of precursor solution of $1.25x10^{-2}$M at 800°C

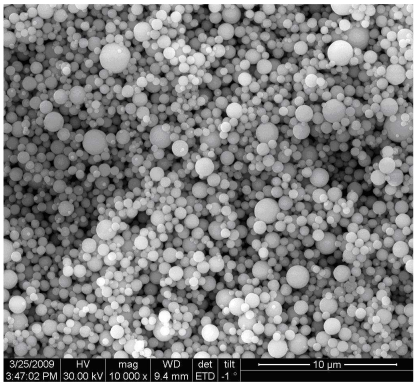

Figure 2 – SEM image on cubic yttria stabilised zirconia synthesised from the concentration of precursor solution of $1.25x10^{-2}$M at 800°C

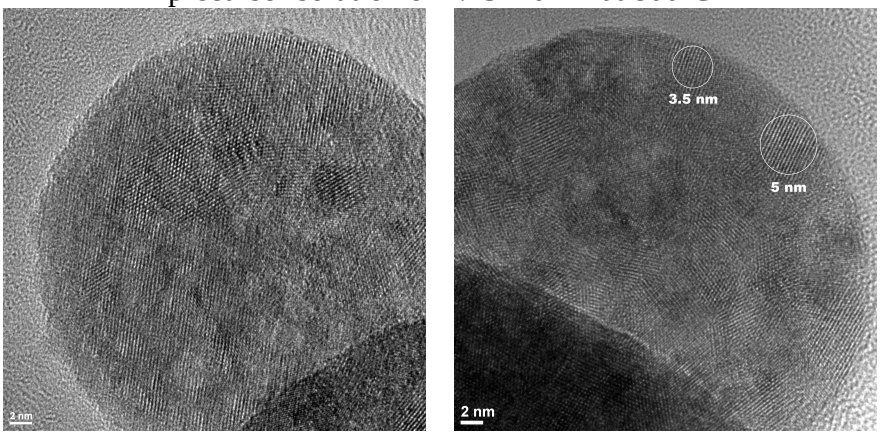

Figure 3 – TEM (HRTEM) image obtained on cubic yttria stabilised zirconia synthesised from the concentration of precursor solution of $1.25x10^{-2}$M at 800°C