Scandia-stabilized zirconia (ScSZ) obtained by the polyacrilamide technique

G. C. C. Costa and R. Muccillo

Centro Multidisciplinar para o Desenvolvimento de Materiais Cerâmicos – CMDMC
CCTM – Instituto de Pesquisas Energéticas e Nucleares
Av. Lineu Prestes, 2242, Cidade Universitária
S. Paulo, SP, Brazil 05508-900

Abstract – Nanocrystalline scandia-stabilized zirconia (ScSZ) ceramic powders were prepared via the polyacrilamide technique. The amount of Sc_2O_3 in the ScSZ was varied in the range of 8-12 mol%. Electrical and structural properties of ScSZ have been evaluated by means of XRD, TG, DTA, DRIFT, dilatometry, and impedance spectroscopy.

Stabilized zirconia compounds have been developed for applications in electrochemical devices such as solid oxide fuel cells (SOFCs), oxygen sensors, catalytic membrane reactors and structural materials due to their advantages in the electrical and mechanical properties.[1-2] Among the stabilized zirconia compounds, scandia-stabilized zirconia (ScSZ) possesses the highest electrical conductivity, which has been attributed to the low association enthalpy of the defect reactions and the similarity between the ionic radii of Sc^{3+} and Zr^{4+} ions.[3] Therefore, this also means that for the same value of conductivity of yttria-stabilized zirconia electrolytes (YSZ), the working temperature for ScSZ electrolytes can be lowered about 100 K.[4] From a materials science point of view, it is of great advantage to operate fuel cells at lower temperatures. Several routes have been exploited to develop stabilized zirconia electrolytes with high performance for the fabrication of commercial SOFCs with high-energy-converting efficiency and extended operating lifetime. Therefore, synthesis using wet chemistry can bring many advantages for fabrication of components for SOFCs because mixing the reagents occurs at the molecular level in solution, resulting in a product with high homogeneity. The resulting oxide powders have a high specific surface area and, consequently, a high reactivity, decreasing the final temperature and time of synthesis. Different chemical routes exist to form fine ceramic powders, such as co-precipitation, spray drying, freeze drying, and sol-gel. Unfortunately, these methods are time consuming if large quantities of fine powders are required. Moreover, achieving high homogeneity for complex compositions (involving a large number of cations) might become very difficult owing to the generally different chemical behavior of each cation.[5] Thus, in this study, ScSZ powders of various compositions (8-12 mol% Sc_2O_3) were prepared using a different chemical route that proceeds by a way of a chain reaction (polymerization), which is a combination of an initiator with the acrylamide and bisacrylamide (crosslinker agent) to form a gel (Figure 1) that consist of long polymeric chains, crosslinked to create a three-dimensional tangled network, soaked with a solution of cations.[5] The acrylamide sol-gel process proposed in the work reported here, is a fast, cheap, reproducible, and easily scaled up chemical route for obtaining scandia stabilized-zirconia powders. Furthermore, ScSZ was also prepared by the polymeric precursor technique for comparison purposes. The polyacrilamide gel and precursor solution obtained by the polymeric precursor technique were analyzed by simultaneous (TG and DTA) thermal analysis and the calcined powders were analyzed by X-ray diffraction, gas adsorption (BET), scanning electron microscopy and diffuse reflectance infrared Fourier transform absorption spectroscopy. Non-isothermal sintering behavior of cold-pressed powders was determined via dilatometry (Figure 2). The cold-pressed powders were sintered at 1500 ^{o}C for 2 h and analyzed by XRD, SEM and impedance spectroscopy.

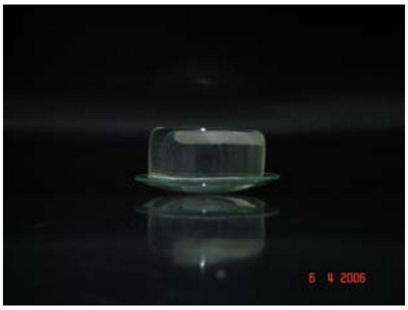

Fig. 1. Photograph of a polyacrilamide gel.

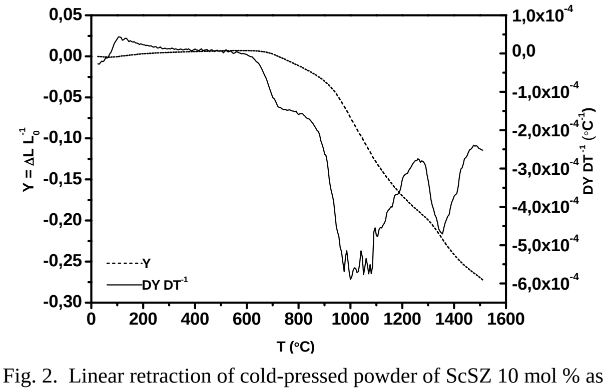

Fig. 2. Linear retraction of cold-pressed powder of ScSZ 10 mol % as a function of temperature; dot curve: derivate curve.

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