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Small angle X-ray study of nanostructured samaria-doped ceria

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Abstract – Nanostructured pure and doped ceria ceramics have attracted much attention both from scientific and technological viewpoints, because of their diverse range of applications. These ceramic materials have been proposed for use in solid oxide fuel cells, superconductor and catalyst supports, semiconductor gate material, wafer processing, solar cells, and even in healthcare. In this work, samaria-doped ceria nanoparticles were synthesized by a kinetically controlled chemical method, and the surface and structural characteristics of the prepared nanostructures were studied by small-angle X-ray scattering.

Samaria-doped ceria (SDC) has received much attention over the last two decades due to its high ionic conductivity compared to the traditional yttria-stabilized zirconia solid electrolyte [1,2]. The possibility of reducing the operation temperature of a solid oxide fuel cell by the use of SDC as electrolyte thereby reducing the cost of this device has been one of the main research goals.

Improvement of the solid electrolyte characteristics like chemical and structural homogeneities, strict control of the additive content, reactivity of the particulate material, chemical purity, particle size, shape and size distribution, and agglomeration control along with a suitable choice of the processing steps, are expected to play a role in the maximization of the electrical conductivity and overall device performance.
Cerium nitrate and samarium nitrate of high purity were used as precursor materials. Solid solutions containing 20 mol % $SmO_{1.5}$ were synthesized by a soft chemistry route using different alcoholic solvents. The dried material was characterized by several techniques. Small-angle X-ray scattering, SAXS, experiments were carried out at the SAXS-D11A beamline of the Brazilian National Synchrotron Light Laboratory. Two series of experiments were performed. In the first series, samples prepared in different solvents were thermally treated at 500 ºC. In the second series, powder samples prepared in water/ethyl alcohol (water/EtOH) solvent were thermally treated at 300, 500 and 700ºC. Fig. 1 shows the ln [I(q)] versus ln q plots for samples prepared in water/EtOH solvent and thermally treated at several temperatures. All scattering curves present, in general, two power-law in which the intensity shows an exponential dependence on q, and a crossover region between them. The ln [I(q)] versus ln q plots of these samples show features of surface fractals. Table 1 lists calculated values of D_s (surface fractal dimension). Fig. 2 shows the volumetric size distribution curves $D_V(R) = (4\pi/3)R^3N(R)$, where N(R) is the density of particles, for all samples. The main results indicate that the surface roughness of the particles changes continuously with the temperature of thermal treatment towards a soft surface situation.

Table 1: Fractal dimension of samples before and after thermal treatments.

Sample treatment	Ds
As-prepared	2.62
300ºC	2.54
500ºC	3.47
700ºC	3.91

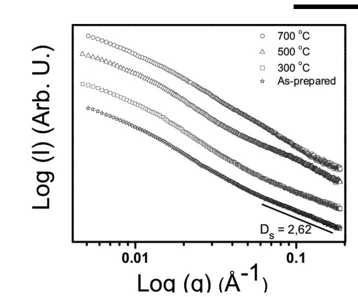

Figure 1: ln [I(q)] versus ln q plots for samples prepared in water/EtOH solvent and thermally treated at several temperatures..

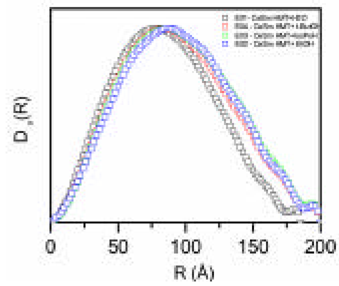

Figure 2: Volumetric size distribution curves $D_V(R)$ for all samples.

References
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