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Nanoparticulated (U,Gd)O2 Characterization

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Abstract : The study of actinide nanoparticles (NPs) has attracted the attention of the scientific community not only because the lack of information about their ecotoxicological effects but also because the use of NPs could open a new way in the production of nuclear energy. Indeed, it was recently demonstrated that UO2 NPs sintered pellets exhibit closed porosity with improved fission gas retention and radiation-tolerance , ameliorated mechanical properties, and less detriment of the thermal conductivity upon use, making them an interesting option for new nuclear fuels. In this work, we used a combination of diffraction and microscopy tools to characterize the morphology, the crystalline structure and the composition of UO2 nanoparticles doped with 10%wt Gd2O3. The particles were synthesized by a modified sol-gel method at low temperatures. X-ray Diffraction (XRD) studies determined the presence of a unique phase with the cubic structure and Fm3m spatial group, supporting that Gd atoms substitute U atoms in the fluorite structure of UO2. In addition, Field Emission Gun Scanning (FEG-SEM) and Transmission (FEG-TEM) Electron Microscopy images revealed the presence of micrometric agglomerates of nanoparticles, with rounded morphology and an average crystallite size < 50 nm. Energy Dispersive Spectroscopy (EDS) coupled to TEM determined the presence of Gd in all the analyzed crystallites. Besides, FEG-SEM-EDS showed a homogeneous concentration distribution at the micrometer scale indicating that the small size of the crystallites compensates the variation in composition by averaging a large number of crystallites. These techniques, as combined tools resulted thus essential to find out details of morphology and composition distribution at the sub-micrometer scale, and set a standard for developing and analyzing nanoparticulated nuclear fuels.

Keywords : actinide nanoparticles, burnable poison, nuclear fuel, sol-gel
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