XAFS and nuclear fuels

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Closing the nuclear fuel cycle is essential for developing more sustainable nuclear energy systems. In France, plutonium recovered from spent uranium oxide (UOx) fuel is recycled into mixed uranium–plutonium oxide $(U,Pu)O_2$ (MOx) fuels and used in Pressurized Water Reactors (PWR). MOx fuels are also leading candidates for several Generation IV reactor designs, including sodium-cooled fast reactors (SFRs). Because of the complexity and long timescale involved in working with spent fuel samples, the experimental strategy involves first working with fresh MOX fuel and/or surrogate materials. The latter, known as SIMMOx, consists of $(U,Pu)O_2$ doped with up to 12 stable fission products (FPs).

Over the past 30 years, XAFS in combination with other characterization techniques ((SP)-XRD, Raman microscopy, SEM-EDS, SEM-EBSD, EPMA, …) has been used in nuclear fuel studies. In particular, XAFS has recently been applied to investigate the fabrication MOX fuels and their associated microstructural properties[1,2], the behaviour of FPs[3,4,5] and the influence of Pu content on the MOX oxidation processes[6]. Several illustrations will be presented during the talk. It should be emphasized that these studies were made possible only by the development of synchrotron beamlines capable of accommodating highly radioactive samples, such as ROBL at the ESRF[7] and MARS at SOLEIL[8].

Nevertheless, the available beamtime remains limited, and additional constraints, such as the preparation of radioactive samples and their transport to the beamline, have motivated the development of a complementary laboratory-scale X-ray absorption spectroscopy (XAS) apparatus. As part of a collaboration between CEA Marcoule and the University of Helsinki, a new, compact, laboratory-scale XAS apparatus optimised for actinide materials, has been installed in the ATALANTE hotlab facility (CEA Marcoule, France). This setup uses a low-power X-ray tube and a spherical bent crystal analyser. It can operate in both symmetric and asymmetric Johann configurations[9]. The first results obtained with this experimental setup will be presented.

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