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Chemistry of fission products and actinides on nuclear fuel using high energy resolution XAS

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One of the most challenging research in nuclear energy concerns nuclear fuel and its behavior under irradiation during both normal and off-normal conditions in nuclear power plants. In each case, nuclear fuel behavior and its interaction with cladding materials strongly depend on the chemistry of fission products and actinides during corresponding process. In particular, speciation data are key parameters to establish accurate thermodynamics modeling. Such information can be supplied using X-ray Absorption Spectroscopy (XAS). But, due to the very high radioactivity of the sample (>200 Mbq/mg), and the impossibility to isolate the fluorescence line of one element (background interference of radioactivity, Bragg peaks due to the actinide matrix and fluorescence from other nearer Z elements), implementation of this analysis is impossible.
To overcome these difficulties, the XAS experiment can be performed by using a multi-crystal analyser spectrometer which is based on the use of silicon or germanium crystals in the Rowland circle geometry. By diffracting the emitted X-rays, this instrument allows simultaneous focusing and energy discrimination with higher resolution than a conventional solid detector.
The comparison between High Energy Fluorescence Detected XANES (HERFD-XANES) and Total Fluorescence Yield XANES (TFY-XANES) shows large benefits of this approach to collect good spectra, especially in diluted radioactive materials. Some latest results obtained on uranium based materials such as virgin nuclear fuel UO2 will be discussed.

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