X-ray absorption spectroscopy at laboratory scale: towards new actinide research opportunities.

R. Bès (Department of Applied Physics, Aalto University, Finland)
rene.bes@aalto.fi
T. Ahopelto, A.-P. Honkanen, S. Huotari (Department of Physics, University of Helsinki, Finland)
G. Leinders, J. Pakarinen (Belgian Nuclear Research Centre (SCK CEN), Belgium)
K. Kvashnina (Rossendorf Beamline at ESRF, France / Helmholtz Zentrum Dresden-Rossendorf (HZDR), Germany)

X-ray Absorption Spectroscopy (XAS) is a well-established nondestructive method for determining both the oxidation state and the local environment of actinide in materials. However, the monochromatic, tunable, and high flux requirements have significantly limited XAS development only to synchrotron radiation facilities. Associated to the high costs of radioactive sample transport, the limited number of dedicated beamlines available and subsequently the limited access to synchrotron beamtime exclude a large number of potentially important actinide research to be performed, especially because of the lack of alternatives.

One possible alternative is based on laboratory-scale sources and crystal optics with typical geometries such as Von Hamos and Johansson and Johann types using cylindrically and spherically bent analyzer crystals. Such approaches are reported since the early 1980’s, but their ability to allow efficient and cost-effective alternative to synchrotron XAS measurements have been demonstrated only recently. However, the reported devices were mainly developed for energies ranging between 5 and 12 keV, i.e. outside the actinide M and L-edges.

Our recent studies at the U L_3-edge shows that it is possible to extend the previously limited energy range towards the actinide L_3-edges. At the expense of longer collection time, but still reasonable for a laboratory scale device, excellent agreement with the synchrotron-based studies is found, opening the way towards new opportunities in actinide research. For example, while the low photon flux in laboratory-scale XAS device increases the statistical noise, it also allows measurements for sensitive samples. One of the main advantages is also the possibilities to highly dedicated sample environments for e.g. in-situ measurements. The laboratory-scale XAS device is also an ideal solution for preliminary investigations prior to synchrotron experiments.

To conclude, the versatile laboratory-scale XAS device complements the synchrotron radiation experiments, allowing many applications to be developed in the field of actinide research, including f-electron chemistry, environmental chemistry and nuclear energy physico-chemistry, such as advanced nuclear fuel development and long-term disposal of nuclear waste.