X-ray speciation studies of materials and processes related to the nuclear fuel cycle

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Synchrotron-based X-ray techniques, including X-ray absorption Spectroscopy (XAS) offer a number of advantages for investigation of radioactive materials aimed at elucidating determinant factors in processes and materials performance relevant to the nuclear fuel cycle. Extremely useful XAS 'speciation' methods provide information on the molecular, chemical and physical form of radioelements in a wide range of matrices and forms, as well as being applicable to studies of mixtures and of systems under in situ conditions. One major advantage is that molecular-scale speciation investigations of radioactive material can provide information otherwise not easily obtainable, often without having to separate the radioelement of interest out of its matrix. The penetration capability of the X-rays used in these techniques renders it possible to investigate systems safely within a radiological containment. Most recently XAS and related techniques are providing benchmark data for honing quantum chemical theoretical methods used to predict the chemical and physical behaviour of the heavy, relativistic actinide elements. Growing sophistication of the available tools, advances in X-ray focusing methods, the high brilliance delivered by modern facilities and the increasing speed, sensitivity and resolution of detectors are driving advances in X-ray scattering and spectroscopic techniques in general, which find application to studies of radioactive material in particular. In this presentation, I will give a personal overview of the developments over the past 25 years of application of synchrotron-based techniques to nuclear fuel cycle research and an outlook of potential future directions.