ACTINIDE CHARACTERIZATION USING ULTRA HIGH ENERGY X-RAY FLUORESCENCE

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Ultra high energy X-ray fluorescence (UHEXRF) has been demonstrated as a feasible means for characterizing actinide elements which would be present in spent nuclear fuel. Depleted uranium (dU) samples have been characterized using the 1-ID-C beam line of the Advanced Photon Source (APS) at Argonne National Laboratory. The dU samples included both pressed pellets of UO2 and dried spots of an aqueous uranium solution. The excitation energy was 117 keV which is above the absorption edge for the U Ka line with varying spot sizes from 1 mm to 18 micrometers. The XRF emission of the U Ka1 line at 98.428 keV was detected using a liquid nitrogen cooled high purity Ge detector. The samples were measured with and without a 1.2 millimeter Zircaloy shield in front of the samples which is twice the thickness of the normal fuel pin cladding. Although there was a decrease in U Ka XRF signal, sufficient intensity was obtained with as little as 5 live second dwell time resulting in several hundred counts for the smallest samples. The pressed pellets covered a concentration range from 0% to 90% dUO2 and the dried spots were 10, 5 and 1 micrograms respectively. Elemental maps of the dried spots showed the heterogeneity of the dried material. The dried spot characterization illustrates the potential for sub-microgram sensitivity. The significance of using ultra high energy XRF for actinide characterization demonstrates the feasibility for direct actinide composition measurement through the nuclear fuel cladding nondestructively. Such measurements would reduce the uncertainty obtained with passive measurements such as gamma spectroscopy and neutron counting. Although this work was done with a synchrotron, it is conceivable that this measurement could be accomplished in the laboratory using a high power x-ray tube source and appropriate x-ray optics to provide quasi-monochromatic X-rays for excitation. The demonstration of uranium detection through container walls nondestructively, offers new opportunities for applying this technology for on-line through pipe characterization, field analyses of samples and increased reliability for international safeguards measurements.