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Investigating Macro- and Micro-scale Material Provenancing Signatures in Uranium Ore Concentrates/Yellowcake

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Nuclear Forensics is a developing discipline pivotal to dealing with nuclear security events. Still in its comparative infancy, the current goal is to develop material signatures which are capable of identifying seized materials with the greatest degree of confidence and determine the origin/provenance of such materials.

Australia possesses the world's largest resources of uranium bearing ore, and consequently it is of interest to ensure the safe extraction and export of this high value fungible commodity.

Currently, no singular analysis technique has been capable of elucidating the origins of all materials. The Australian Nuclear Science and Technology Organisation's Nuclear Forensics Research Facility (ANSTO-NFRF) is in the process of examining diffuse reflectance spectroscopy of yellowcake materials in the range of the far-infrared (700-20 cm-1) to the near-infrared wavelengths (800-2500 cm-1). Investigations using DRS of the far-infra-red to measure UO2, U3O8 and γ-UO3 began as early as 1989[1], but it is only relatively recently that the Vis/NIR region was examined by Klunder et al.[2]. We seek to investigate IR to distinguish between UOC of known ore/mining/extraction age containing different species and polymorphs of uranium (confirmation of uranium structure will be achieved by XRD). The data will then be interrogated with chemometric/multivariate data analysis. Such analyses at the macro-scale have been shown[2] to proffer a methodology which achieves a high degree of class distinction, requires minimal sample preparation and is non-destructive. UV-VIS-NIR spectroscopy almost uniquely provides chemical speciation information without consuming or contaminating the sample, and could be used to inform uncompromised, subsequent and supplemental destructive analyses.

A second stage of this work involves the provenance characterisation of micro-particulates of blended uranium ore concentrates via a high flux-infra-red beam of synchrotron radiation at the Australian Synchrotron (AS). The Australian synchrotron and the Infrared Microspectroscopy (IRM) beamline combines the high brilliance and high collimation of the synchrotron beam with a Bruker V80v Fourier transform infrared (FTIR) spectrometer and a Hyperion 2000 IR microscope to reach high signal-to-noise ratios at diffraction limited spatial resolutions; between 3-8 μm. This makes the beamline ideally suited to the analysis of microscopic samples e.g. small particles and thin layers within complex matrices, or thin coatings on surfaces. In addition, a Hyperion 3000 Focal Plane Array (FPA) FTIR microscope is also installed offline at the beamline. This allows users to collect large area overview IR images from their samples prior to high resolution mapping using the beamline instrument.

1. Yu BZ, Hansen WN, Ward J (1989) The Far-Infrared Spectra of UO2, Alpha-U3O8, and Gamma-UO3 Using the Light Pipe Reflection Method. Appl Spectrosc 43 (1):113-117
2. Klunder GL, Plaue JW, Spackman PE, Grant PM, Lindvall RE, Hutcheon ID (2013) Application of Visible/Near-Infrared Reflectance Spectroscopy to Uranium Ore Concentrates for Nuclear Forensic Analysis and Attribution. Appl Spectrosc 67 (9):1049-1056

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