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Novel Mass Spectrometric Techniques for the Rapid Characterisation and Fingerprinting of Nuclear Fuel Materials

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This paper explores two somewhat novel mass spectrometric analysis techniques to characterise nuclear safeguards materials. The first uses Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) to perform rapid elemental analyses of trace components in uranium-bearing particles. We demonstrate this approach by measuring trace elements in eight different samples containing uranium-bearing particles, including three uranium oxide reference materials, two uranium doped glass reference materials, two actual IAEA swipe samples, and an ore sample. Principal component analysis was used to classify particles based on relative abundance of 16 elemental peaks or molecular peaks. Five principal components explained 86% of the total variance between samples and all samples could be distinguished using some combinations of the principal component scores. Analysis of loading factors indicated which elements were important in distinguishing different samples. Of particular interest is the fact that the two IAEA swipe samples could be distinguished from one another based on relative abundance of strontium and barium suggesting different processes or trace contaminants might be used in fingerprinting specific facilities or processes. High mass resolution analysis of the positive spectrum from the uranium-bearing polymer from one of the IAEA swipe samples revealed that the particle was comprised largely of nylon 66. A second technique employs oxygen isotope analyses using large geometry SIMS (LG-SIMS)to potentially distinguish geographical location of production. Preliminary data indicate that 18O/16O ratios of one-micron-sized particles can be estimated with a precision of about one part in a thousand. This precision is adequate for the analyses to be useful for establishing provenance. We will discuss the utility of the techniques, potential pitfalls and the work that needs to be achieved to move forward.

Country or International Organization

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