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Categorization and characterization of uranium-bearing materials for nuclear forensic attribution using ICP-MS

The increasing risk of illicit trafficking and misuse of nuclear and radioactive materials has highlighted the importance of nuclear forensics in supporting radiological crime scene investigations and nuclear security. This study focuses on the categorization and characterization of uranium-bearing materials to support nuclear forensic attribution and investigative processes. Uranium materials originating from different stages of the nuclear fuel cycle were analyzed using advanced analytical techniques to determine their physical, chemical and isotopic signatures. Samples including Uranium ore and triuranium octoxide were prepared through crushing,pulverization and microwave digestion prior to analysis. Elemental and isotopic measurements were performed using Inductively Coupled Plasma Mass Spectrometry. These techniques enabled the determination of trace elements concentrations, rare-earth elements (REE) patterns, uranium isotopic ratios and lead isotopic ratios that serve as distinctive nuclear forensic signatures.

The results demonstrate that uranium-bearing materials possess measurable elemental and isotopic characteristics that can be used to distinguish materials originating from different geological sources and processing stages. Rare-earth element distributions, uranium and lead isotopic compositions provided valuable geochemical fingerprints that support source attribution. Overall, the study highlights the importance of combining elemental and isotopic analysis for reliable categorization and characterization of uranium-bearing materials. These signatures provide critical information for nuclear forensic investigations and may contribute to the development of a national nuclear forensic library to assist law enforcement and regulatory authorities in identifying the origin and history of intercepted nuclear materials.

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