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Discrimination of Different Nuclear Material in the frame of Nuclear Forensics

Nuclear forensics developed over the last decades as a consequence of illicit nuclear material seized outside its fuel cycle. Candidate materials in the back end of the fuel cycle include spent fuel and Pu retrieved from the reprocessing of the fuel. An important challenging task in nuclear forensics is the identification of the origin of the material, which is characterized by the type of the reactor where it was charged, its charge composition and the final burnup attained by the spent fuel.
The required characteristic signature in a fingerprinting approach for the origin determination of a seized nuclear material is its isotopic composition. Then, a comparison of the composition of the seized material with that of materials of known origin covering a range of commercial reactor and fuel types could yield the origin of the seized material. The required origin would be that of the material with which the seized one exhibits the most similar isotopic composition. The comparison can be performed through fingerprinting approaches based on multivariate statistics or 3D isotopic correlations.
This work is a simulation study presenting a 3D isotopic correlation fingerprinting approach, with the axis of the 3D space reflecting ratios of isotopes used as characteristic signatures. In the case of spent fuel as the seized material, these would be ratios of fission products 134Cs, 137Cs and 154Eu measurable by NDA (gamma-spectrometry). In the case of the Pu, as the seized material, retrieved from the reprocessing of the spent fuel, the required ratios would be between the characteristic signatures 239Pu, 240Pu and 241Pu and total Pu measurable by DA (Thermal Ionisation Mass-Spectrometry).
The work assesses the potential of the approach to discriminate the different materials of the known origin considered. This is an important issue since a good discrimination would enhance the correct determination of the origin of the seized material. Different thermal reactors (LWR, AGR, MAGNOX, CANDU, RBMK) charged with different U fuels have been simulated for the purpose of the work, providing the material of known origin. The work focuses on spent fuel of low burnup (<3 GWd/MTU).
The procedure is found to be dependent on the inclusion of 234U and 236U in the charge composition of the fuel and it shows a potential to discriminate the reactor and fuel assembly types considered. Furthermore, the approach is sensitive to the half-lives of the isotopic signatures.

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