Nuclear forensic methodologies for americium

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Pre-detonation nuclear forensics has historically focused on analyses of plutonium and of uranium from every step in the nuclear fuel cycle, from natural ore to reactor fuel. Other nuclear materials are underrepresented, including americium, a minor actinide of some proliferation attractiveness [1, 2]. While americium is a widely-proliferated nuclear material with relatively easy acquisition routes, little research is available on nuclear forensics of americium [3, 4]. This project aims to adapt existing nuclear forensic techniques to americium-based samples to establish their readiness ahead of a potential time-sensitive real-world investigation.

In the fall of 2022, an aged teaching source of ^{241}Am labeled in 1967 as 10^4 decays per minute (dpm) was acquired with no supporting documentation, and was used as a representative sample approximating a smoke detector source; 10^4 dpm is approximately 4 nCi, and is well below the legal limit on a commercial smoke detector's activity. At this small activity level, the primary nuclear forensic question is whether any daughter species can be measured so that radiochronometry can be performed, and if not, what minimum starting activity is needed before such an investigation is viable. Table I shows the results of γ- and α-spectrometry for the characterization of the americium source.

Table I. Activity of ^{241}Am Button Source.

	Activity (nCi)	***Activity (Bq)***
Labeled Activity (decay corrected to 6/6/23)	4[b]	150[b]
α-Spectrometry	4.71 ± 0.17	174.3 ± 6.2
γ-Spectrometry	4.76 ± 0.35	176 ± 13
Average Activity	**4.74 ± 0.39**	**175 ± 14**
Corrected Initial Activity (04/1967)	5.18 ± 0.43	192 ± 16

[a]Uncertainty quoted at 3σ. [b]Labeled activity does not include uncertainties.

The labeled activity of the source has an error of at least 25%, as confirmed by good agreement across γ- and α-measurements. However, these γ- and α-measurements were unable to detect any daughter nuclides in the ^{241}Am decay chain, which prevents any chronometric analysis. Table II shows the estimated minimum starting activity of ^{241}Am needed to detect daughter species in a source from 1967, given the rate of background in the spectra taken.

Table II. Lower Limits of Detection Estimates for ^{241}Am Daughters.

Measurement Type	Nuclide	2x Background[a]
γ	^{237}Np	2.2 μCi
γ	^{233}Pa	3.4 μCi
α	^{237}Np	70. nCi

[a]Value equal to the activity needed to produce a measured signal that is twice the background in the spectra recorded

Preliminary results from these measurements indicate that small americium sources such as smoke detector sources are difficult to age-date unless they have activities close to the upper limit of activity allowable in commercial smoke detectors, which are unlikely in any modern smoke detector sources.

We are working to acquire larger samples of americium. Planned analyses include the measurement of daughter radionuclides for chronometry, trace metal analysis, and trace fission product analysis for reactor-type discrimination.

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