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Americium 242m in nuclear test debris

DIAMOND *et al.*[1] discussed the production, in a thermonuclear explosion, of isobars of mass numbers 239 and greater by neutron reactions on uranium, followed by β decay; much the same arguments seem to apply to phenomena in plutonium devices. Both cases, viewed in this way, suggest that mass number 241 will be represented by both ^{241}Pu and ^{241}Am, mass number 242 only by ^{242}Pu, and mass number 243 only by ^{243}Am. Such considerations neglect, however, the fact that weapons-grade plutonium is always more or less contaminated by ^{241}Am, and that this nuclide has an appreciable cross section (100 barn for thermal neutrons and slightly larger for epithermal neutrons) for neutron capture leading to ^{242}Am; about 10% of such captures yield ^{242m}Am, the others going to the ground state. It seems, then, that one should expect to find in the debris from nuclear explosions not just two, but all three, of the long lived americium nuclides: ^{241}Am, ^{242m}Am and ^{243}Am.

We have been led to this consideration by our finding of a small but readily measurable amount of ^{242}Cm in samples of seawater that had been contaminated by close-in fallout from an isolated, low yield nuclear test in 1962. The 60-l samples had been sealed in polyethylene containers from collection until being opened for radiochemical analysis in 1974. Americium 241 was separated from other nuclides, and prepared for α spectrometry, by radiochemical procedures[2,3]; in this scheme curium isotopes accompany americium almost quantitatively. The americium plates from the samples in question were counted in a low-level α spectrometer for 8,000 min, in a special effort to detect any ^{244}Cm remaining from that produced in the test. Because the two samples represented different water depths, and thus different dilutions of the test debris, the concentrations of transuranic nuclides were very different, but the ratios among them were similar (Table 1).

Table 1 Concentrations in disintegrations per minute per 100 kg

	^{239,240}Pu	^{241}Am	^{242}Cm	^{244}Cm	^{242}Cm/^{241}Am
Sample *A*	216±11	37.8±0.7	0.21 ±0.02	0.01±0.004	0.54%
Sample *B*	18± 3	2.67±0.06	0.013±0.004	ND	0.49%

ND, Not detectable.

α-Emissions of energy corresponding to those of possible naturally occurring contaminants were absent, confirming the cleanness of the radiochemical separation.

The ^{242}Cm cannot, after more than 25 half lives, represent curium originally in the samples; we believe there is little likelihood it represents laboratory contamination. Great care was taken in the radiochemistry, and we have never before seen ^{242}Cm in americium plates, except in samples expected to have this nuclide from waste disposal; also the uniformity of ^{242}Cm/^{241}Am ratio in two samples of different activity level argues against accidental contamination.

It seems to us necessary to conclude that the ^{242}Cm observed is the daughter of ^{242m}Am produced in the original nuclear event, probably by neutron capture of ^{241}Am. Direct observation of ^{242m}Am, at the concentrations indicated, would be quite impossible: detector backgrounds are too high for measurement either of its own X-ray emission, or of the β particles from its daughter ^{242}Am. Because detector backgrounds can be maintained, for solid state α spectrometry, at extremely low levels, it should be practicable to measure ^{242m}Am in a variety of other samples, by searching for ^{242}Cm that is supported by a longer lived precursor. Actually we have remeasured one sample contaminated by fuel-reprocessing waste, and found that about 3% of the ^{242}Cm it contained was supported in this way.

The conclusion that ^{242m}Am has been produced, measurably, in nuclear tests, has some interesting consequences:

The ^{242}Cm daughter supported by decay of ^{242m}Am, in addition to being readily measurable in most areas of high fallout, should have, as a consequence of its generation by two rapidly successive radioactive decays (^{242m}Am decays, with a half life of 152 yr to ^{242g}Am, which decays with a half life of 16 h to ^{242}Cm), unusual environmental mobility, separating from other fallout transuranics much as ^{234}U has been found to separate from ^{238}U and ^{235}U.

Since ^{242}Cm decays to ^{238}Pu, its presence represents not merely an unevaluated additional source of this transuranic, but of a moiety of ^{238}Pu that would be expected to be more mobile than the fraction of that nuclide produced in the original event.

In plutonium the content of ^{241}Pu is greater in proportion to the fraction of Pu that has come as byproduct from electric power generation[4,5]; ^{241}Pu will, however, be a less important constituent of breeder reactor plutonium[6]. These considerations suggest that americium 242m will be a significant component of the debris from future nuclear tests, or peaceful nuclear explosions, although diminishing in proportion to the increasing use of breeder reactor plutonium.

We urge our colleagues in environmental radiochemistry to make a careful search for ^{242m}Am, both to establish baseline data describing its present distribution in nature, and to set limits on the influence of this nuclide on the environmental behaviour of its descendants, ^{242}Cm and ^{238}Pu.

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Tree remains in southern Pennine peats

RECENT work in Ireland[1-3], Wales[4], and south-west England[5] has demonstrated the coincidence in time of the onset of blanket peat accumulation with increased levels of prehistoric human activity in the vicinity; since many upland blanket bog areas in the British Isles have remains of trees embedded within the basal peat layers, it has been suggested that these tree remains represent a former forest cover, the deliberate clearance of which led directly to blanket peat formation. That is to say, the tree remains are assumed to immediately predate the oldest blanket peat layers.