DETERMINATION OF $^{227}\text{Ac}$ IN ENVIRONMENTAL SAMPLES BY ION-EXCHANGE AND ALPHA SPECTROMETRY

R. BOJANOWSKI, E. HOLM, N. E. WHITEHEAD

*International Atomic Energy Agency, International Laboratory of Marine Radioactivity
Monaco-Ville (Principality of Monaco)*

(Received April 13, 1987)

A new method of $^{227}\text{Ac}$ determination is based on total sample decomposition, followed by preconcentration as oxalate and hydroxides, and purification from thorium isotopes and rare earths on ion-exchange columns with nitric acid. The actinium is electroplated on stainless-steel discs with near 100% yield from a water/propanol medium and measured by alpha spectrometry. $^{228}\text{Ac}$ is used as a yield monitor. An immediate first count gives overall tracer recovery (typically around 80%). A second count two months later gives a sensitive measure of $^{227}\text{Ac}$ through its decay products at 5.5–6.1 MeV. Analysis of reference samples gave satisfactory results.

Introduction

$^{227}\text{Ac}$, a member of the $^{235}\text{U}$ decay chain with a half-life of 21.8 years has several interesting properties which make it attractive as a tracer for studying geochemical processes in aquatic environments. As a naturally occurring homologue of trivalent man-made transuranic elements it offers the possibility of studying their comparative geochemical behaviour in relation to disposal and containment of radioactive wastes at selected dump sites. Its potential has so far been little explored and the reason for that seems to be the lack of a simple and reliable measurement technique suitable for such low activity levels as are normally encountered in the natural environment.

The existing analytical methods are mostly concerned with the extraction of $^{227}\text{Ac}$ from uranium ores, and its separation from thorium and radium isotopes after neutron irradiation of $^{226}\text{Ra}$ targets\(^1,2,3\). In environmental samples low concentrations of $^{227}\text{Ac}$ are accompanied by much higher activities of other radionuclides which interfere with radiochemical measurements and must be eliminated prior to measurement. An additional analytical problem is caused by the rare-earth elements which follow actinium.
R. BOJANOWSKI et al.: DETERMINATION OF $^{227}$Ac

in all classical separation schemes. The radiation characteristics of $^{227}$Ac also offer no advantage for specific counting, as it decays by beta emission with over 98% probability. Some of these problems can be avoided by measuring its short-lived decay products $^{227}$Th ($T_{1/2} = 18.718$ d) and $^{223}$Ra ($T_{1/2} = 11.435$ d) by high resolution gamma spectrometry $^4,5$. This method however, lacks sensitivity, and can be applied only when sufficient activity, or large samples are available. The few procedures described for $^{227}$Ac measurements are based on more or less extensive sample purification from interfering radionuclides, letting the $^{227}$Th grow in and separating it on metallic planchettes for alpha spectrometry $^6,7,8$. While the $^{227}$Th yield is monitored using $^{230}$Th tracer, the recovery of $^{227}$Ac is assumed 100% or inferred from the recovery of the auxiliary iron carrier. Because of spectral interference caused by $^{223}$Ra only approximately half of the $^{227}$Th alpha emissions (those in higher energy regions around 6 MeV) can be utilised for $^{227}$Ac assessment, with detriment to the sensitivity of the determination.

We have developed a method that leads to the obtention of radiochemically pure actinium sources suitable for alpha spectrometry. Preliminary separation is made with oxalic acid. Thorium is removed on Dowex AG 1X8 resin from 8M nitric acid. Actinium is separated on Dowex 50WX8 from 3M nitric acid and electrodeposited from dilute nitric acid/propanol solution. Chemical recovery is measured immediately upon deposition, using $^{225}$Ac as a tracer and the main count is made a few months later after the tracer has decayed and the $^{227}$Th and $^{223}$Ra have grown in to a suitable level. There is a nearly fourfold gain in sensitivity in comparison with the existing methods thanks to integrating the counts from both the $^{227}$Th and $^{223}$Ra decay products.