GAMMA RAY SPECTROMETRY OF SAMPLES USING STANDARD ACTIVITY ADDITIONS

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Gamma-ray spectrometry of liquid or finely divided solid samples may be facilitated by incorporating standard activity additions. The count rate rises linearly with added activity, and the intercept and slope of the I.S.F. line permits the intrinsic activity of the sample to be found. Applications of this method in the determination of $^{210}$Pb and Th activity are described.

Introduction

Several long-lived radionuclides of environmental interest emit gamma-rays. Examples include $^{230}$Th, $^{228}$Ac, $^{214}$Bi (from $^{226}$Ra), $^{210}$Pb, and $^{137}$Cs. The conversion of count rates to activity concentrations in the energy region of interest requires the use of accurate values for the geometry factor and correction for self-absorption of gamma-rays within the sample. These values are not always available for the variety of natural matrices in which various activities may be found. The usual solution to such problems is to compare the count rate of the sample to that of a standard which exhibits more or less the same radiometric parameters. An obvious drawback to this method, even if a suitable standard can be found, is the fact that valuable counting time has to be allocated to the standard. In the case of weak samples, this time could be far better used to improve the total count from the sample.

To avoid some of these problems, we have been applying the so-called "method of standard additions" to radiometric determinations of powder samples. The advantages are obvious. Firstly, by placing the standard activity within the sample in a homogeneous fashion, the gamma
rays from both the sample and the standard addition will share the same geometry factor and self-attenuation. Secondly, counting is performed on both the sample and the standard addition simultaneously.

In what follows we examine the application of this technique in the case of gamma-ray spectrometry of two radionuclides $^{228}$Ac for the indirect determination of $^{232}$Th, and $^{210}$Pb. Rather than simply measuring samples with and without standard additions of activity, we have used a series of incremental additions which permits the sample activity to be determined by linear fits to the data.

**Experimental**

A hyperpure Ge coaxial detector nominally of 50 cm$^3$ volume was used. Such detectors permit measurements to be made at the low end of the energy spectrum (e.g. at 46.5 keV for $^{210}$Pb) as well as at higher energies (e.g. 911 keV for $^{228}$Ac). The count rate for a particular gamma-ray emission was obtained by fitting a Gaussian to the photo-peak and a third-order polynomial to the continuum. Details of the curve fitting procedure of the Marquardt type are given in an earlier paper.$^1$

Additions of standard activities to the sub-samples must be homogeneous and not significantly alter the radiometric properties. In the case of $^{210}$Pb, small quantities of anion exchange resin containing absorbed activity were mixed in the sample. For the thorium measurements (via $^{228}$Ac), ThO$_2$ powder was added.

Increasing amounts of activity within the sample should cause a corresponding rise in count rate. If the two parameters display a good linear correlation, then we may proceed to derive the activity in the sample from the equation:

$$S = \frac{a - B}{b}.$$