

ANALYSIS OF RADIONUCLIDES

The characteristic half lives and radiation types and energies have been used to some advantage in analysing mixtures of radionuclides. Mixtures of beta emitting radionuclides can be analysed by the absorption of beta radiations in aluminium, but spectrometric techniques have generally been found to be more useful than absorption method. Mixtures of alpha emitting radionuclides have been analysed by spectrometers equipped with a gridded ionisation chamber or a semiconductor detector. Scintillation spectrometers equipped with organic phosphors have also been used to measure mixtures of beta emitting radionuclides. Beta emitting mixtures have also been measured by making use of liquid scintillators and scintillation spectrometers. Mixtures of electron capture radionuclides have been analysed by using proportional counters by measuring the X-rays associated with the decay of these radionuclides.

Since many radionuclides decay with gamma radiations, many measurements have been made by **gamma ray scintillation spectrometry**. Generally a crystal detector, such as sodium iodide crystal, is connected to a spectrometer. The gamma ray interacts with the crystal to produce light pulses which are converted to electrical pulses by a photomultiplier tube. The gamma rays of various energies are sorted out by the pulse height analyser of the spectrometer. From this operation, a spectrum of the radionuclide's gamma rays can be obtained as the **photopeak** of full

energy pulses and the continuum of low energy pulses associated with the decay of the radionuclide. The photopeak or photopeaks in a gamma ray spectrum can be used to identify and quantitatively measure the radionuclide. Mixtures of gamma emitting radionuclides can be analysed because the spectra are additive. Techniques for **stripping off** the spectrum of each component and the ultimate processing of the data by a computer - integrated approach are now available.

Some elements contain naturally radioactive isotopes, and because some of these elements have long half lives, the isotopic concentrations remain constant. Thus radioactivity in effect is relative to the weight of the element or compound, so that a measurement of the radioactivity is a measure of the amount of the element present in the sample. All of the natural radioactivities can be analysed for either by alpha or gamma detectors. Potassium, rubidium, samarium, lutecium, rhenium, francium, thorium and uranium can be analysed in this way.

The measurement of added radioactivity involves the following important techniques.

(a) **Carrier technique.** (b) **Radioactive reagents.** (c) **Isotopic dilution.**

Carrier technique is a qualitative tool used to identify the chemical form of small amounts of radioactive labelled materials. The method involves the addition of unlabelled material in the same chemical form (as a carrier) to a solution of the radioactivity and then isolating it in pure form. The radioactivity of the isolated compound is then determined. If the isolated compound is radioactive, then it is certain that the unknown and the added carrier are identical.

If an element is labelled with a radioisotope and the radioactivity is determined per unit weight, and if the specific radioactivity remains constant throughout the experiment, then the radioactivity observed is directly proportional to the amount of the element involved. This type of technique, known as **radioactive reagent technique**, has been used to determine solubilities, co-precipitation, in elemental analysis, and in the separation of one species from another. For example, ^{131}I has been used in a radioactive isotopically labelled reagent in the determination of small amounts for Ag^+ ions in solution.

The basic principle involved in the **isotopic dilution method** is to measure the change in the isotopic composition of the added tracer. The method involves the addition of a tracer (element or compound) of known specific activity (counts per minute per mg) to the sample under test. Some fraction of the material to be determined is recovered and its weight as well as radioactivity are measured. The basic equation for isotopic dilution is.

$$W = W_f \left[\frac{A_0}{A_f} \right] - W_0$$

where, W = Unknown weight of the material in the sample.

W_f = Weight of the material recovered.

W_0 = Weight of the material added with the tracer.

A_0 = Amount of radioactivity added.

A_f = Amount of radioactivity recovered.

Neglecting the insignificant amount W_0 , the above equation becomes,

$$W = W_f \left[\frac{A_0}{A_f} \right]$$

This equation represents simplest form of isotopic dilution. It has been found that more

precise results can be obtained by measuring the radioactivity of the unreacted fraction rather than measuring the radioactivity of the dissolved fraction.

Reverse isotope method has also been used. In this method the material to be determined is already associated with a radioactive tracer, the amount of which can be determined by adding a known weight of the inactive material. For this method to be effective, the specific radioactivity of the material in the sample is necessary to be known.

A method of **double isotope dilution** analysis has also been proposed. The principal advantages in using isotope dilution methods are their speed, sensitivity, and the possibility of making non-quantitative separations. Exchange between the radioactive and inactive species can be obtained by making use of such treatments as

(a) Boiling with acids. (b) Oxidation and/or reduction. (c) Complexing agents etc.

FATE OF RADIOISOTOPES IN THE ENVIRONMENT