

Applicability of Activation Analysis into Medicine

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Since successful application of activation analysis for determination of rare earth elements in 1931, the activation analysis has widely been applied in the field of analytical chemistry because of its extremely high sensitivity and characteristic reaction. Especially, high flux of neutron in reactor helped to popularize this method.

In the other hands, remarkable improvements of gamma ray pulse height analyser and computer technique etc. are brought to get an accurate result and simplified this technique also. These improvements are offered also to apply this method into the field of medicine. The reliable reports of activation analysis in medicine hitherto been published are summarised here.

The principle of this method is just the same as the method to produce radioisotopes—to make nuclear reactions between the element to be detect, and the particles such as neutrons, protons or the gamma rays from the apparatus, and the weight of target element is calculated on radioactivities from radioisotopes.

In this method (n, r) capture reaction by thermal neutrons in reactor is the most popular and simple procedure. The weight of the target element is calculated by the following formula:-

$$A = Nfas = \frac{WK}{M}(6.02 \times 10^{23})fa(1 - e^{-0.693 \frac{t}{T}}) = C \cdot W$$

- A: activity just after irradiation
- f: density of the neutron flux
- a: activation cross section
- s: saturation factor
- N: number of the target element
- W: weight of the target element
- M: atomic weight of the target element
- K: abundance
- T: half life of the product
- t: irradiation time

$$C: \text{constant} - \frac{K}{M}(6.02 \times 10^{23})fa(1 - e^{-0.693 \frac{t}{T}})$$

Here, "A" has a linear correspondence with "W" theoretically. But practically, it is extremely difficult to estimate the constant value of "C". So "relative method" is usually applied in medical field instead of "absolute method" as mentioned above. This is a method to compare the activity of the standard sample of known weight with that of the unknown samples which are irradiated simultaneously and both the samples are placed at the same position in reactor.

An "undestructive method" is thought to be the most simple method of application in medicine. This undestructive method is applied to the samples which are not permitted to change the nature and figure of them, just as the samples in the field of crinology. For example, the estimation of the arsenic in Napòleon's hair is reported. This undestructive method is also applied into the analysis of histological specimens. Distribution of gold in the human body treated by colloidal gold, and the sodium content in the blood serum are easily determined by this technique. With the higher neutron flux, applicability of this method into medicine is increased. There are several reports about the determination of small amounts of sodium, potassium and phosphor in muscle. In this analysis the highest gamma ray energy of ^{24}Na (2.4 mev), highest beta ray energy of ^{42}K (3.2 mev) and the longest half life of ^{32}P (14.5 days) in muscle sample are discussed how to analyse these three elements in muscle each other.

The undestructive method is applicable in very small number of limited element, because the interfere due to activated ^{24}Na is unavoidable in almost all of medical samples. For these reasons, any chemical procedures

must be added to select the target materials in most cases. Even the exclusion of sodium by using an ion exchange resin leads to be able to determine the considerable numbers of element in medical materials.

By these techniques, many rare materials in medical samples are detected, and for instance, the change of the quantity of copper, selenium and manganese in liver diseases, of calcium in bone, of magnesium in muscle, are detected as an index of human condition. Decreased serum zinc content is also noted in the case of attack of angina pectoris. However, in present time, it is not clearly be recognized that the analysis of these elements has any obvious relation with diseases, but at the same time, it is considered that this method will be brought a helpful hand to the development of medicine in near future.

Paper-chromatography and radio-autography are also applied to detect the trace amount of materials in connection with the activation analysis.

Lately, several topical techniques using this method, by means of tracer technique, has been introduced.

The dynamics of non-radioactive iron in human body is examined by the use of activation. Blood serum is withdrawn with some intervals after injection of non-radioactive iron (^{58}Fe). Each sample is activated by the thermal neutrons with the reaction of $^{58}\text{Fe}(n,r)^{59}\text{Fe}$ by capture. From the activity of ^{59}Fe , the dynamics of ^{58}Fe in human is discussed. If the result is just the same as seen in the tracer study by radioisotope, this method would be very superior one, and this method would be applied to the pregnant women and newborns without any risk of radiation hazards.

The metabolism of iodine is also examined by the use of non-radioactive iodine ^{127}I . The half life of activated ^{128}I from the result of

$^{127}\text{I}(n,r)^{128}\text{I}$ capture reaction is so short (25 min) that it is not desired to spend a time for chemical procedures after irradiation. In this report, only ^{127}I in the sample is attached to a certain ion exchange resin before irradiation and the resin is exposed to neutrons. The ^{128}I activity in resin is directly counted immediately after the irradiation.

In our Department, liver flow index is determined by the use of non-radioactive colloidal gold. Blood samples withdrawn periodically after the injection of non-radioactive colloidal gold ^{197}Au are activated, and then the concentration of gold in the blood at the time is calculated from the peak value of gamma rays from the activated ^{198}Au . Here, our new idea of Au/Na ratio is discussed in our technique.

To avoid the direct weighting of blood samples, the weight of samples are determined by the peak value of ^{24}Na correspond with the weight of blood samples. Then, the ratio $^{198}\text{Au}/^{24}\text{Na}$ of the samples become to be corresponded with the concentration of colloidal gold in the blood at that instance theoretically. Our experimental results are shown good correspondence with this theory.

This idea will make the technique more accurate and more simple. This idea will be applied into any other cases to avoid the unreliable weighing of small amount of samples.

At the end of this report, our impression about the unsatisfactory management of reactors in Japan is stated. Last but not least, our best hope is to build the medical reactor for users only, not for the interest to build or control of the reactor.

It is not enough well equipped with facilities for this research, although Japan is in urgent need of developing these researches in the future.

(References and details are published on "Clinical Science" 1(10) Oct. 1965)