Locating neutron beam position using neutron activation analysis

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Introduction

In various experimental studies, the qualitative and quantitative analysis of samples become important. Out of the various methods used for such analysis, activation analysis technique has gained wide acceptance as it has many desirable advantages over other methods in use as listed below:

(a) The analysis is non-destructive and as such the sample remains in its original form
(b) A very small amount of sample(100mg) is required for analysis.
(c) It being fast takes a few seconds or hours depending on half-life of the resulting nuclei and interfering reactions
(d) Mult elemental analysis is possible simultaneously
(e) The analysis can be highly automised reducing manual errors
(f) Online analysis is possible
(g) One important aspect is sensitivity which for most of the elements is in ppm level.
(h) Analysis can be done for any chemical form of the sample.

In this technique of analysis, energetic charged or uncharged particles are bombarded on the sample under study. The sample is activated(made radioactive) by this method and radiations thus emitted are analyzed. The particles used for bombarding can be neutrons, protons or some other particle. Mostly neutrons are used as neutron activation is simpler than the energetic charged particle activation. Also with charged particle activation there are problems of interfering reactions, limited range of particles and heating of bombarded sample . There are mainly three types of neutron source. They are radioisotopes, nuclear reactors and accelerator ion source. The present work uses an accelerator ion source. The 14 MeV neutron generator[1] at the University of Pune gives a neutron flux of about 10^7n/cm^2-sec of neutrons of energy about 14 MeV. The ions produced by the radio frequency oscillator is accelerlated through a potential obtained from the Cockroft-Walton voltage multiplier where the input is given by a step up transformer. The generator is based on $_1H^3(d,n)_2He^4$ reaction for production of neutrons. The samples to be analyzed using this beam is fixed in a sample holder or transferred through a pneumatic transfer system or stuck on the irradiation head which has a diameter of about 12cm. The sample size is usually 1cm^2. To get the most of the neutron flux the knowledge of exact beam position of about the same size(1cm^2) was estimated using neutron activation analysis[2] using Aluminium foil.

Experiment

The sample was prepared from pure(99.99%) Aluminium foil.

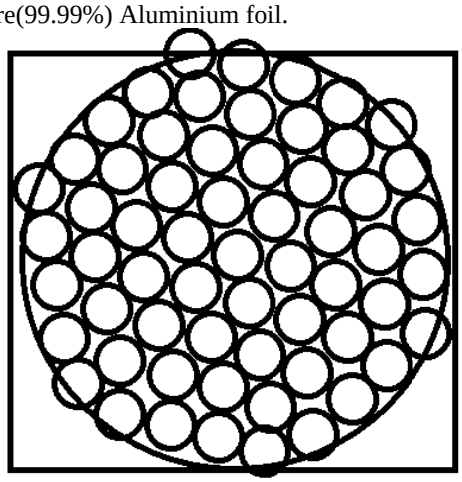

Figure 1: Marked beam positions

The foil was folded manifold to get a thickness of about 1mm and stuck on the

irradiation head with marked circular positions of about 1cm^2 each as shown in Figure 1.

The deuterium beam of around 175keV was allowed to fall on the tritium target to generate the neutrons.

It was irradiated for one hour to induce activity through the following reaction[3,4]:

$$Al^{27}(n,\alpha)Na^{24}$$

with $t_{1/2}$=14.96 hours, Eγ=1.369 MeV(100%), and 2.73 MeV(100%). To avoid interference due to the gamma-ray emitted by other radioisotopes a cooling time of 30 minutes was given. The area under the photopeak 1.369 MeV was measured by a NaI(Tl) detector for 10 minutes and stored in the computer based MCA for each cut and weighed circular sample(~0.3gm).

Results and Analysis

The activity of each sample was taken as the area under the spectrum curve. The correction due to decay constant, number of target nuclei, self absorption coefficient, decay ratio, cross-section, time of irradiation, time of cooling and time of counting was given to get normalized activity from each sample This experiment was repeated 5 times. The beam position was found in the fourth quadrant of the irradiation head as shown in the figure 2 below and varied within 1mm for different samples.

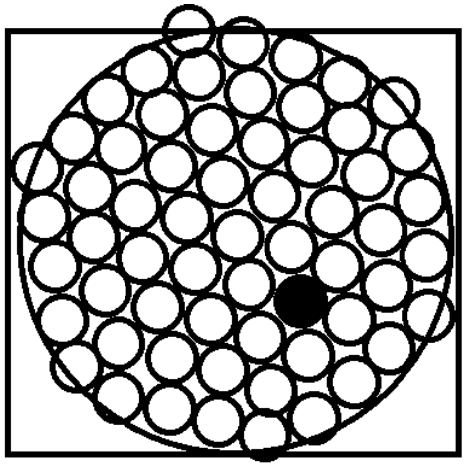

Figure 2: Exact beam position

In order to confirm the position obtained, an aluminium closing flange was substituted for the irradiation head (which contained the tritium target and the water cooling system) and the deuterium beam was allowed to fall on the flange. It was found that a bluish–yellow spot was formed at a particular position on the flange. When this position was compared with the beam position found from the activation analysis , it was found to coincide.

The reasons to account for lowering of beam position from the centre could be any one of the following:

(a) Uneven alienation of beam due to the port of emission of deuterium beam
(b) Higher vacuum inside the system required.
(c) Uneven alienation of the accelerating column.

A mark was made on the irradiation head at the most probable beam position and the samples were put for irradiation at this particular position.

This method can be effectively used to determine the exact beam position for any type of beam particle with a suitable sample and knowledge of the reaction and experimental parameters like cross-section, decay constant, time of irradiation, time of cooling , time of counting etc.

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