DETERMINATION OF URANIUM IN ORES USING INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS

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An instrumental neutron activation analysis method based on the measurement of $^{239}$Np has been developed for the determination of uranium in ores. The samples after 5 sec irradiation were cooled for 3 days and the gamma-ray spectra were measured with a 30 cm$^3$ Ge(Li) detector. The precision and accuracy of the proposed method were determined by analysing IAEA Standard Uranium Ore samples.

Introduction

Uranium ore prospecting programme involves analyses of a large number of ore samples. Such measurements require relatively simple and rapid analytical techniques having reasonably good precision and accuracy so that a large number of analyses can be performed on a routine basis. A number of chemical$^{1-6}$ and instrumental techniques such as delayed neutron counting,$^{7}$ fission track analysis,$^{8}$ direct gamma-ray spectroscopy of the ore$^{9}$ and thermal neutron activation analysis$^{10-14}$ have been employed for uranium measurement.

The chemical methods are generally cumbersome and involve time consuming dissolution and separation steps. The non-destructive techniques do not require such steps and therefore are more useful for ore prospecting programme. Instrumental neutron activation analysis is relatively simple and rapid and can be used for analysis of uranium in various types of ores. This technique has been used for the determination of trace quantities of uranium in certain samples by measuring low energy photons either from $^{239}$Np (17.8 keV X-rays) or from $^{239}$U (74.0 keV). The measurement of low energy photons in ore samples becomes difficult due to self absorption. MANTEL et al.$^{11}$ reported a procedure in which the samples were irradiated from 30 min to several hours and the amount of uranium was determined from the activities of the fission fragments and $^{239}$Np.

In the present investigation studies have been made to develop a simple non-destructive neutron activation analysis procedure for the determination of uranium
in ore samples utilizing short irradiation time from 5 sec to 30 sec. Certain simple criteria were applied to check the purity of the 228.2 keV and 277.6 keV photo-peaks of $^{239}$Np and the amount of uranium was determined independently from each peak by the comparative method.

**Experimental**

*Preparation and irradiation of samples*

The uranium bearing ore samples were ground to a fine powder and the fraction which passed through a 100 mesh sieve was homogenised by the coning and quartering technique. The samples and the standard were oven dried for 5 hrs at $110^\circ$C to a constant weight. Appropriate amounts of the samples and the standard were hermetically sealed in polythene vials. Four samples and a standard sandwiched between them were packed in another polythene container for irradiation. Samples containing upto 0.05% uranium were irradiated for 5 sec whereas those of lower concentrations were irradiated for 30 sec. All the irradiations were carried out in the pneumatic tube facilities of the 5 MW swimming pool type reactor PARR-1 at a neutron flux of $2 \times 10^{13} \text{ n cm}^{-2} \text{ sec}^{-1}$. The irradiated samples were cooled for 3 days to allow the decay of short lived matrix activities. However a few samples with higher activities were cooled for 5 days.

*Gamma-ray spectrum measurements*

The gamma-ray measurements were carried out with a 30 cm$^3$ semi-planar Ge(Li) detector (Canberra Inc.) coupled to a charge sensitive preamplifier (Canberra Model 970-D) and a spectroscopic amplifier (Ortec Model 451). The amplifier incorporates a pole-zero cancellation system which helps in obtaining better peak shapes. The pulses from the amplifier were analysed by a Nuclear Data ND-4410 computerised multichannel analyzer having an 8 K memory. The system has an over all energy resolution (FWHM) of 4.5 keV for 1332.5 keV gamma-ray of $^{60}$Co and a peak to compton ratio of 25 : 1.

A few measurements were also made with a 3" $\times$ 3" NaI(Tl) detector coupled to a linear amplifier (Ortec Model 410). This system has an 8% energy resolution measured as FWPM of 661 keV gamma-rays from $^{137}$Cs.

The gamma-ray spectra were measured by placing the radioactive samples directly on top of the Ge(Li) detector. In a few cases a 0.01 inch thick lead absorber was used to reduce the activity from low energy gamma-rays and X-rays. A counting time of 10 minutes was found to be sufficient for most of the measurements, however a few weak samples required a 30 min counting time.