

APPLICATIONS OF NEUTRON ACTIVATION ANALYSIS IN THE  
RADIOCHEMISTRY DIVISION OF IPEN-BRAZILIAN NUCLEAR ENERGY  
COMMISSION

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ABSTRACT

This paper describes several applications of neutron activation analysis that are being developed at the Radiochemistry Division of IPEN/CNEN-SP. Both instrumental and radiochemical NAA are being applied to the determination of around 15 to 30 elements in samples of interest to geological, biological, environmental and nutritional studies.

INTRODUCTION

Neutron activation analysis has been one of the relevant applications of the IEA-R1 2MW nuclear research reactor of IPEN/CNEN-SP, since the beginning of its regular operation, in 1957.

Due to its outstanding accuracy, precision, multielemental capability and blank-free characteristics, neutron activation analysis has found widespread applications in many fields of research that are of interest to the community in Brazil, such as geological, biological, environmental and nutritional studies.

Also neutron activation analysis services are offered at IPEN/CNEN-SP, to other research institutions, universities and private enterprises, covering a wide variety of matrixes.

EXPERIMENTAL

General Procedure for Instrumental Neutron Activation Analysis

**1. Short Irradiations**

Short irradiations, of about 1 to 30 minutes, are carried out using two pneumatic stations that are available at the Radiochemistry Division of IPEN/CNEN-SP, with thermal neutron fluxes varying from  $5 \times 10^{11}$  to  $2 \times 10^{12}$  n.cm<sup>-2</sup>.s<sup>-1</sup>.

In these irradiations, and using two series of measurements generally can be determined the elements: Na, Cl, Mn, K, Br, V, Cr, Al, Mn, Ti, V, depending on the composition of the samples.

**2. Long Irradiations**

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Typically irradiation times from 8 to 16 hours are employed for the long irradiations, under thermal neutron fluxes varying from  $10^{12}$  to  $10^{13}$  n.cm<sup>-2</sup>.s<sup>-1</sup> at the present configuration of the IEA-R1 nuclear research reactor.

In this case, a greater number of elements can be determined, using one or two series of measurements at different decay times. Some of the elements determined are: As, Ba, Br, Ca, Co, Cr, Cs, Fe, Hf, K, Ce, La, Lu, Ho, Sm, Eu, Yb, Nd, Na, Rb, Sb, Sc, Se, U, Th, Zn, Zr.

### **3. Measurements**

Measurements are performed after adequate decay times in gamma-ray spectrometers of CANBERRA or ORTEC, comprising hyperpure Ge detectors of the GEM or GMX series typically with 20% relative efficiency and about 2 keV resolution at the 1332 keV peak of <sup>60</sup>Co and associated electronics.

Spectra are analyzed using the VISPECT 2 software developed by D. Piccot, from Saclay, France or SAMPO-90 with the CANBERRA equipments.

Elemental concentrations are calculated using the comparative mode of neutron activation analysis, irradiating multielemental solutions pipetted on filter paper, together with the samples to be analyzed.

Certified reference materials are regularly analyzed for Quality Assurance of the procedures.

## **APPLICATIONS**

In the geological field, most of the studies are directed towards the determination of rare-earth elements and the platinum group elements. In the latter case, generally a pre-concentration step or radiochemical separation are required<sup>(1,2)</sup>.

Environmental studies include multielemental analyses of aerosols of urban and remote areas, rain water, analysis of mercury species in human hair, fish and sediments and multielemental analysis of biomonitors such as lichens and also of plastics<sup>(3-5)</sup>.

Several kinds of biological matrixes are also being analyzed for many important elements, either essential or toxic for organisms, such as foodstuffs, human bones and nails and hair for clinical studies<sup>(6,7)</sup>. In some cases, radiochemical separations have been developed, based mainly on ion-exchange, solvent extraction and retention in inorganic exchangers.

Monitoring of essential and toxic mineral composition has also been made in the following cases: agricultural and agroindustrial by products used in feeding of ruminants; grasses and legumes, one of most important sources of alimentation for animals; animal tissues such as liver, hair and bone<sup>(8,9)</sup>.

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