



Brazilian Journal of Physics

ISSN: 0103-9733

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Sociedade Brasileira de Física
Brasil

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Brazilian Journal of Physics, vol. 34, núm. 3A, september, 2004, pp. 811-813

Sociedade Brasileira de Física

São Paulo, Brasil

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Use of Thermal Neutrons to Perform Analyses in Body Organs of Small Sized Animals

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Received on 25 September, 2003

The absolute neutron activation analysis (ANAA) technique was used for the determination of some elements on body organs, such as, kidney, heart, muscles and spleen of small-sized animals used on experiments in health area. The advantages and limitations of using this nuclear methodology were discussed.

1 Introduction

Usually small-sized animal as guinea-pig are used on experiments that involves testing new medicines, medical diagnostic studies, and mainly in health area to check anomalies in body organs. Particularly, the Wistar rats are selected as a convenient animals for these studies in function of the cost, handling and medico-legal implications [1]. In the last years the ANAA technique has been applied in experiments involving investigation of a prolonged duration, using a larger number of small and medium size guinea-pig, to perform clinical analyses in many different biological materials such as urine, serum, blood, bones and some body organs [2, 3, 4, 5, 6, 7] with success, suggestion this method could be used as tool in the health field in order to identify anomalies in body organs. In this study we want to extend its application to other biological materials, particularly, to determine the concentration of the elements identified in some body's organs in Wistar .

2 Experimental Procedure

To perform this study one female Wistar rat was sacrificed and dissected. Each biological sample of kidney, heart, muscles and spleen was calcinated, ground and homogenized. Considering that this animal weights about 300g, after the incineration processing the mass reduced to approximately 60g consequently the weight for each organ result in small quantities of biological material. The amount of each biological samples (ashes) obtained in the end of this procedure was about 0.7g for kidney and heart, ~ 1.3 g for muscles and 0.5g for spleen. To verify the accuracy and precision of the method, the samples (~ 10 mg each) were prepared in duplicate.

The cadmium ratio technique was used for the measurement of neutron flux distribution. In this technique gold foils (~ 5 mg each one), bare and cadmium covered (1mm thick), are irradiated with neutrons at IPEN facilities, and the γ -ray activities induced in the gold foils by both thermal and

epithermal neutrons could be obtained [8].

To determine the concentration of the elements in these body organs, each biological sample was sealed into an individual polyethylene bag and irradiated together with the gold foils, in a pneumatic station in the IEA-R1 nuclear reactor for few minutes, allowing the simultaneous activation of these materials under the exact same irradiation conditions. After that, the gamma spectra for both the gold foils and biological samples were obtained in order to determine the neutron flux and the concentration of the activated elements in the biological material. A HPGe detector connected to an ADCAM multichannel analyzer and to a PC computer was used to measure the induced gamma-ray activity. All the gamma spectra were analyzed and the concentration of the activated elements were obtained by using computer codes [9, 10].

3 Results and Discussion

The time optimization to perform these analyses in a fast and economic way (irradiation time of 2 minutes; counting time of 5 minutes for each gold foil and 30 minutes for the biological sample and background radiation) permitted us to conclude each analysis in about two hours or less. The concentration of the Al, Br, Cl, K, Mn and Na were determined in all the samples but some elements as Ca, Mg, and I were not be activated, in this optimized conditions, for some of the samples.

The concentration of the all activated elements as well as the detection limit for spleen, muscle, heart and kidney are shown in tables 1, 2, 3 and 4, respectively.

As Fe was not activated in short-time irradiation and its quantitative analysis is very important, mainly in biological samples of kidney to check for hepatic anomalies, all the samples were also submitted to a long irradiation time (8 hours) near the core of the nuclear reactor. However it was not possible to identify Fe in any of the biological samples; only the elements Br, Ca and Na could be quantified in all of them permitting us to compare the concentration values of

TABLE 1. The Concentration of Al, Br, Cl, K, Mg, Mn, Na and Ca in spleen sample.

Element	$g \cdot kg^{-1}$	$\mu g \cdot g^{-1} (3\sigma)$
Al	0.42 ± 0.03	14.8
Br	0.07 ± 0.01	25.7
Ca	0.88 ± 0.20	82.4
Cl	0.94 ± 0.05	11.3
K	0.92 ± 0.16	224
Mg	1.25 ± 0.12	155
Mn	0.014 ± 0.001	1.1
Na	0.24 ± 0.01	6

TABLE 2. The Concentration of Al, Br, Ca, Cl, I, K, Mg, Mn and Na in muscle sample.

Element	$g \cdot kg^{-1}$	$\mu g \cdot g^{-1} (3\sigma)$
Al	0.42 ± 0.03	38
Br	0.019 ± 0.002	2.2
Ca	0.95 ± 0.25	122
Cl	2.43 ± 0.11	27
I	$(1.53 \pm 0.52) \times 10^{-3}$	1
K	15.7 ± 0.8	538
Mg	3.25 ± 0.24	411
Mn	0.010 ± 0.001	2.3
Na	1.86 ± 0.20	16

TABLE 3. The Concentration of Al, Br, Ca, Cl, K, Mn and Na in heart sample.

Element	$g \cdot kg^{-1}$	$\mu g \cdot g^{-1} (3\sigma)$
Al	0.20 ± 0.02	14.6
Br	0.031 ± 0.013	23.6
Ca	0.88 ± 0.21	75.8
Cl	0.59 ± 0.03	12.2
K	1.2 ± 0.2	222
Mn	0.053 ± 0.003	1.4
Na	0.48 ± 0.03	7.3

TABLE 4. The Concentration of Al, Br, Cl, K, Mn and Na in kidney sample.

Element	$g \cdot kg^{-1}$	$\mu g \cdot g^{-1} (3\sigma)$
Al	0.083 ± 0.015	11.5
Br	0.012 ± 0.002	1.7
Ca	0.68 ± 0.55	nd
Cl	0.52 ± 0.03	10.8
K	0.74 ± 0.17	178
Mn	0.008 ± 0.001	1.2
Na	0.36 ± 0.02	5.7

the samples in short and long irradiation times. The results were compatible except for the Ca determination in Kidney, although it has been activated only in a long irradiation time the result is not precise in function of poor counting statistics (large uncertainties, see table IV). The concentration of the elements Al, Cl, I, K, Mg, and Mn could not be obtained either because in a long time irradiation it is necessary to wait at least few hours to have access the samples in function of the high activity induced in the samples. Considering the short half-life of these elements [11], there was no activity when the samples could be handled.

4 Conclusions

According to the present results, using the absolute method it is possible to obtain the concentration of activated elements Al, Br, Cl, K, Mn and Na in one irradiation of each biological material studied. This way this technique can be considered an economic and agile alternative for diagnosing anomalies in body organs mainly when there are a lot of samples to be analyzed and/or when small quantity of the biological material is available.

There are other analytical methods to perform these measurements as the biochemical analyses traditionally used, which need chemical reactants to prepare the biological samples but, particularly using neutrons, we can compare ANAA with the comparative one (INAA) and some advantages could be pointed out such as the possibility to eliminate the use of standards (which are imported and expensive), thus reducing the cost, as well as the possibility to perform simultaneous analyses mainly when elements of short half-life are involved, which in the comparative method demand much more time (or several irradiations), due to the necessity to analyze the standards and the sample separately and, consequently, some of these elements can decay before being gamma counted. Moreover, associated with the short time irradiation and with the use of small amount of biological material, it's important to notice that this procedure induces low activity ($<0.1\mu\text{Ci}$), what reduces the radiation exposure during the handling process of the active material besides, the disposal of the biological sample can be made just 48 hours after the irradiation; furthermore, no treatment have to be made prior to the discarding these materials, which can, after 48 hours, be treated as regular biohazard or be stored for future reexamination in regular storage bays, without the need for any specific shielding.

This methodology also presents limitations such as the necessity to perform the measurement of the neutron flux for each sample activation, as well as to determine the absolute efficiency of the gamma detector. Besides using this nuclear technique it is not possible to determine the concentration of beta emission elements, for example Phosphor in bone, although Iron has been determined with success in blood in a short time irradiation [10]; the main limitation of this method is, though, that it is necessary to have access to a nuclear reactor to perform the neutron activation in the samples.

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