

Symposium on Globalization of Nuclear Activities

June 15-18, 1997, Rio de Janeiro, BRAZIL

-

Determination of Impurities of Titanium Used in Dental Implants by Gamma-Spectroscopy and Neutron Activation Analysis

S.P.Camargo, C.B.Zamboni, V.X.Oliveira, A.M.G.Figueiredo, J.A.G.Medeiros

Instituto de Pesquisas Energéticas e Nucleares - CNEN/SP

CP.: 11049 - Pinheiros

05422-970 - São Paulo - SP

e-mail: czamboni@baitaca.ipen.br , vxolivei@curiango.ipen.br,

grafigue@baitaca.ipen.br jageiros@baitaca.ipen.br

ABSTRACT

Nuclear techniques have been employed to investigate the purity of titanium used in dental implants. This study consists of the irradiation of Ti with neutrons for qualitative identification of the nuclides as well as its quantification. Two samples of titanium, from different origin, were analysed and the concentration of the elements present in them were determined.

INTRODUCTION

In recent years titanium has been used as a biomaterial, in dental implants, due to its chemical and physical properties [1,2]. For this application it is very important to assure its high purity. To make it possible, two nuclear techniques: gamma spectroscopy and neutron activation analysis were employed to the characterization and quality control of titanium. The application of these techniques is appropriate due to nuclear properties of Ti to be favorable to neutron activation.

METHODS

To the development of these studies single measurement of radioactive titanium were made. Two independent gamma-spectrometer systems with 35cm^3 Ge detectors of high resolution (FWHM < 1.9 keV at 1.32 MeV of ^{60}Co) were used. Both detectors were operated with 572 ORTEC amplifier, in pile-up rejection mode. The two gamma-spectrometer system were mounted inside a lead shielded hood in order to reduce the background radiation. The detectors were calibrated for energy and efficiency through the measurements of standard sources (^{57}Co , ^{60}Co , ^{133}Ba , ^{137}Cs and ^{152}Eu)[3].

Two cylindrical pieces of titanium, with 20mm x 5mm dimensions, were irradiated in thermal neutron flux of the $10^{13}\text{n.cm}^2/\text{s}$, in the IEA-R1 reactor at IPEN, for different periods (from minutes to hours). This was made to identify short and long lived nuclides present in the samples. As natural titanium has an isotopic distribution of 8.2% ^{46}Ti , 7.4% ^{47}Ti , 73.7% ^{48}Ti , 5.4% ^{49}Ti and 5.2% ^{50}Ti [4] when it is irradiated with neutrons, the identification of radioactive products provides information about its chemical composition.

Gamma Spectroscopy. In the gamma spectroscopy experiment, the two cylindrical samples of Ti were studied by means of (n, γ), (n,p), (n,n' γ), (n,d), (n,n'p), (n,2n) and (n,nd) nuclear reactions. Each sample was irradiated for periods of 1 minute, 1 hour and 1 day, in the nuclear reactor. The singles spectra were taken with a 35cm^3 Ge detector, in 4096 channels. The identification of the radioisotopes produced were made in two ways: determining the energies of gamma-rays and their disintegration periods ($T_{1/2}$).

Various measurements of one minute each were taken within a period of 2 hours. An example of a gamma ray spectrum for short-lived isotopes, recorded during one minute, is shown in Fig. 1.

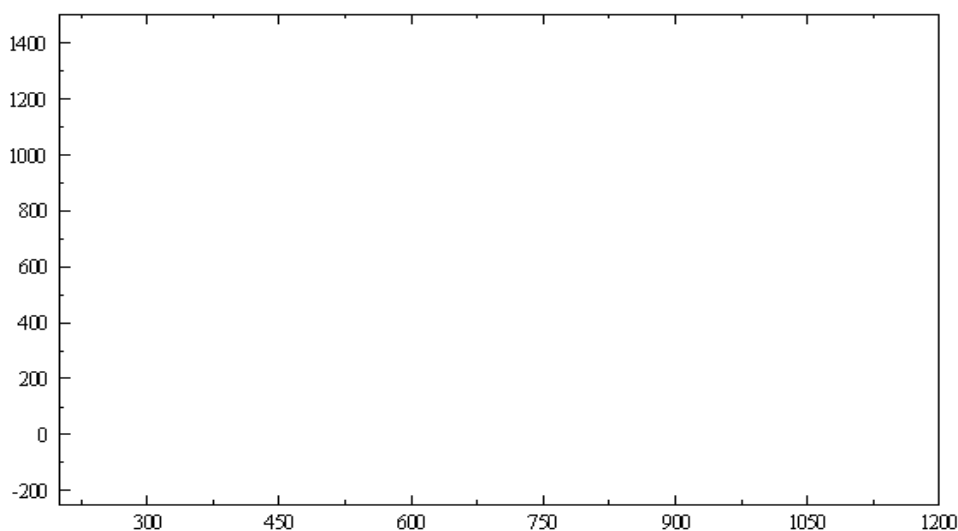


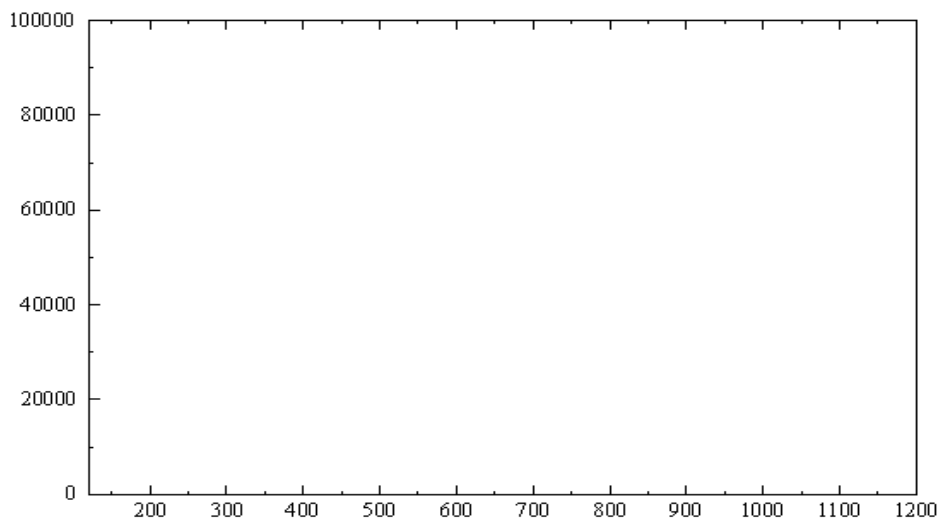
Figure 1.
Spectrum of
Short-Lived
Isotopes.

The analysis of our data revealed the presence of Titanium and evidence of Manganese (^{56}Mn) and Arsenic (^{76}As), in the two

samples.

Gamma-ray spectrum was taken for long irradiation, too. Various measurements of one hour, were done within a period of hours as well as days. Systematically, this procedure was repeated during two months. An example of a gamma-ray spectrum, recorded during one hour of live counting time, are shown in Fig. 2.

Figure.2. Spectrum of Long-Lived Isotopes.



In this case, the radioactive isotope of Scandium ($A = 46, 47, 48$ and 49) confirmed the presence of Titanium in the two samples.

Contributions from Arsenic was also identified. Finally, after three months, the two samples were gamma-

counted again and we have noticed only the presence of ^{46}Sc ($T_{1/2}=83\text{d}$).

The radiosotopes of Manganese and Arsenic were produced through the $^{55}\text{Mn} (n,\gamma)^{56}\text{Mn}$ ($T_{1/2}=2.59\text{h}$) and $^{75}\text{As} (n,\gamma)^{76}\text{As}$ ($T_{1/2}=26.3\text{h}$) reactions.

The measured energies of short and long lived isotopes, present in the two samples, (including Ti isotopes) are shown in Table 1.

The time dependence of the number of counts of all the transitions identified were analysed using the PANORAMIX program [4].

TABLE 1. Gamma Ray Energy of All Isotopes Identifid, in the Two Samples, and Its Desintegration Period.

Isotope ($T_{1/2}$)	γ -transition (keV)
^{51}Ti (5.8 min)	320, 609, 929
^{46}Sc (83,8 d)	889, 1121
^{47}Sc (3.3 d)	159
^{48}Sc (43,7 h)	983, 1037, 1312
^{49}Sc (57.3 min)	1762
^{56}Mn (2.6 h)	847, 1811, 2113
^{76}As (26.3 h)	559, 563, 657,

1212, 1216, 1228, 1439, 2096

Instrumental Neutron Activation Analysis. Instrumental neutron activation analysis (INAA) was used to determine the concentration of the manganese and arsenic in the samples of titanium.

The two samples of Titanium (sample A and sample B)were weighed and sealed in plastic envelopes. Aliquots of standard solutions with well known concentration of Mn and As were pipetted onto 1 cm² pieces of Whatman N^o.40 filter paper, evaporated to dryness under an infrared lamp, and sealed in plastic envelopes. Samples and standards were irradiated for one minute at a thermal neutron flux of about 5 10¹¹ n /cm².s at the nuclear reactor.

The measurements of the induced gamma - ray activity were performed 1 hour after irradiation, after the decay of the radioisotope ⁵¹Ti (T_{1/2} = 5.8 min). The gamma - ray spectra were processed by using the VISPECT program [5]. The radioisotopes used to calculate the concentrations of the analysed elements were ⁵⁶Mn (T_{1/2} = 2.6 h) and ⁷⁶As (T_{1/2} = 26.3h).

To evaluate the concentrations of the elements present in the samples, the counting rates (area of photopeaks) corresponding to the the gamma rays of the radioisotopes from samples and standards were compared. The results are presented in Table 2.

TABLE 2. Concentrations of Mn and As by INAA.

Sample (mg)	Mn (μ g)	As (μ g)
Sample A 425.140± 0.005	10.19± 0.68	3.78± 0.40
Sample B 365.146± 0.003	4.04± 0.28	6.40± 0.60

REFERENCES

- [1] Ratner, B. D.,Johnston, A.B. and Lenk, T.J., Biomaterial surface. J. of Biomaterial Mat. Res. : Applied Biomaterials, vol. 21, A1, p.59-90, 1987.
- [2] Steinemann, S., As propriedades do Titânio, in Schroeder, A., Sutter, F., Krekeler, G., Implantologia Dental, Panamericana, 1994.
- [3] IAEA - International Atomic Energy Agency, X-Ray and Gamma-Ray Standards for Detectors Calibration, Viena (1991) IAEA - TECDOC-619.
- [4] Ledere, C. M. and Shirley, V.S., eds. Table of isotopes. 7 ed. New York, Wiley, 1978.

[5] Piccot, D., Private Communication, IPEN, 1989.

[Return Techical Posters](#)

[Return Index of Authors](#)

[Return Index of Works](#)