2011 International Nuclear Atlantic Conference - INAC 2011
Belo Horizonte,MG, Brazil, October 24-28, 2011
ASSOCIAÇÃO BRASILEIRA DE ENERGIA NUCLEAR - ABEN
ISBN: **978-85-99141-04-5**

DEVELOPMENT OF AN IRIDIUM-192 SEED FOR USE IN OPHTHALMIC BRACHYTHERAPY

Fabio R. Mattos*, Maria Elisa C. M. Rostelato, Carlos Zeituni, João A. Moura, Osvaldo L. Costa, Anselmo Feher, Eduardo S. Moura, Carla D. Souza, Fernando S. Peleias Junior

Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
*** frmattos@ipen.br**

ABSTRACT

The Institute for Energy and Nuclear Research (IPEN), in partnership with the School of Medicine (UNIFESP), created a project that aims to develop and implement an ophthalmic therapeutic treatment for cancer with Iridium-192 seeds. The School of Medicine treats many cancer cases in the SUS (Brazilian Public Health System), and brachytherapy group of IPEN has extensive experience in prototype sources. The seed to be manufactured will perform as follows: a core of iridium-192 is packaged inside small cylindrical seeds consist of a titanium capsule of 0.8 mm outer diameter, 0.05 mm wall thickness and 4 5 mm in length. The core is an alloy of platinum-iridium (20/80) of 3.0 mm in length and 0.3 mm in diameter. Material analysis, neutron activation and activity measurements were carried out.

1. INTRODUCTION

The Institute for Energy and Nuclear Research (IPEN), in partnership with the School of Medicine (UNIFESP), created a project that aims to develop Iridium-192 seeds for ophthalmic cancer treatment [1- 4].

Ophthalmic tumors treatments with brachytherapy sources are widely used for years, as primary or secondary therapy to treat malignant or non-malignant intraocular tumors, for example, choroidal, conjuctival tumors and retinoblastoma.
Retinoblastoma is a cancer that attacks intraocular embryonic cells from retina, it is the most common ocular tumor in childhood, and it can be hereditary and further can also cause metastases [5-7].

Rutenium-106/Rhodium-106, Iodine-125, Palladium-103, Gold-198 and Cobalt-60 are some radionuclides that may be applied to treat ocular and intraocular eye tumors. These sources are presented in small sizes (few millimeters); shapes (rods, wires, discs) and to guarantee high accuracy during the treatment, they are positioned in eye applicators specially designed to fit the tumor surface. High dose radiations in the tumor region, preservation of normal tissues beyond the eye globe and low clinical procedure are some advantages of the brachytherapy technique applied for ocular cancer [5-9].

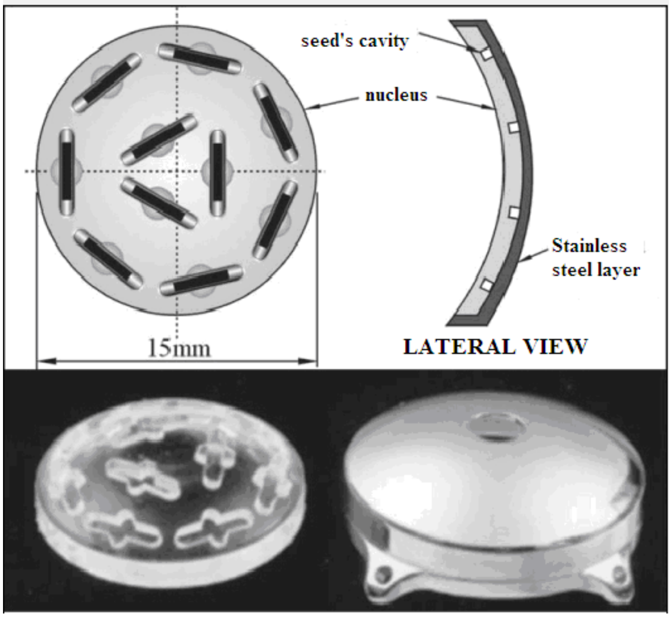

Figure 1: Distribution of seeds in a 15 mm ophthalmic plate.

2. MATERIALS AND METHODS

2.1. Characterization of the material by EDS (energy dispersive analysis)

Energy Dispersive X-Ray Spectroscopy (EDS or EDX) is a chemical microanalysis technique used in conjunction with scanning electron microscopy. The EDS technique detects x-rays emitted from the sample during bombardment by an electron beam to characterize the elemental composition of the analyzed volume. The EDS analysis was carried out in a Philips XL-30 scanning electron microscopy (10).

2.2. Schematic diagram of iridium-192 seed

The seeds, which have tiny dimensions, consist of a titanium capsule (material inert to human tissue) of 0.8 mm external diameter, 0.05 mm wall thickness and 4.5mm long. The inner capsule houses an Iridium-192 wire, 3 mm long and 0.5 mm diameter. The wire is a platinum-iridium alloy (25/75). Figure 2 shows the schematic drawing of Iridium-192 seeds (11-12).

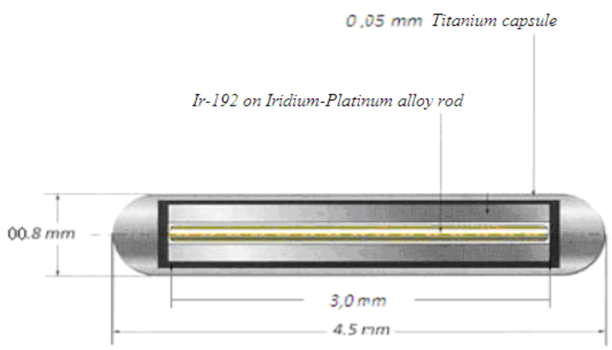

Figure 2: Schematic drawing of the Ir-192 seed.

2.3. Iridium irradiation in the reactor IEA-R1

To achieve the Iridium wire activation, equation 1 was used with the following terms:

$$A = \frac{M \cdot N \cdot \theta \cdot \sigma \cdot \phi}{p} \cdot \left(1 - e^{-\lambda \cdot t}\right) \qquad (1)$$

Where:

A = activity
p = atomic weight
M = mass
N = Avogadro number
θ = isotopic abundance
σ = thermal neutron cross section
ϕ = thermal neutron flux
λ = decay constant
t = irradiation time

To carry out the Iridium neutron activation a 48 cm length wire will be used. The quality control, activity homogeneity measurements along the Iridium-192 wire to prepare the seed the Iridium wire will be cut in rods of 3 mm length.

In order to perform the Iridium wire irradiation, a special device was developed. To guarantee uniform neutron activation on the Iridium wire, this device has an engine rotation with a constant angular velocity [11].

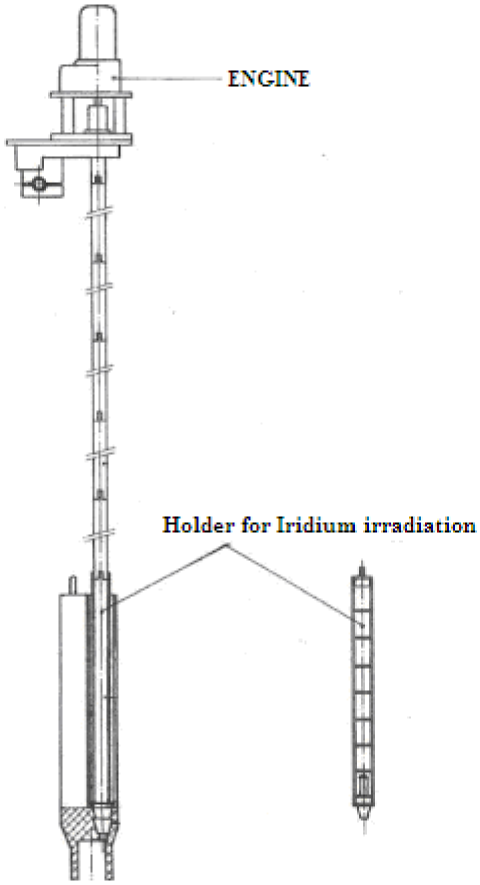

Figure 3: Drawing of the TEI-01 irradiation.

2.4. Measurement of source activity

For the Iridium-192 wire quality control, the whole wire will be measured in 1 cm step along, in a special ionization chamber with a 1 cm window. This procedure allows the activity homogeneity analysis.

Iridium-192 wire total activity will be realized with an ionization chamber Capintec, model CRC-12.

Further the quality control, the Iridium-192 wires will be cut in rods of 3 mm length to prepare the Iridium-192 seeds.

3. RESULTS AND DISCUSSIONS

3.1. EDS (Energy Dispersive Spectroscopy)

Platinum iridium alloy wire analysis was performed using EDS to determine the wire elements composition.
As the wire is formed by a platinum iridium alloy coated with platinum - 100%, to realize the EDS analysis, it was necessary to immerse the wire in liquid nitrogen so that they could get a crack in the lining desirable in order to realize the analysis.

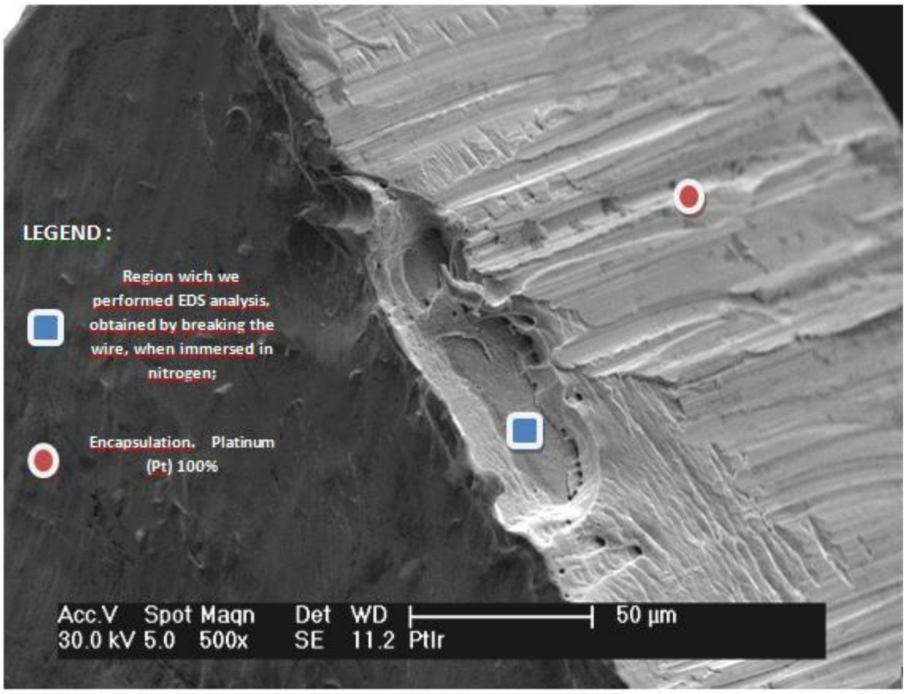

Figure 4: Platinum iridium wire after its break in nitrogen for EDS analysis.

The spectrum analysis is shown and the results are presented by weight percentage, atomic percentage and atomic percentage uncertainty:

- 25,35%, 25,64%, 6,10%, for Iridium;
- 74,65%, 74,36%, 3,13%, for platinum.

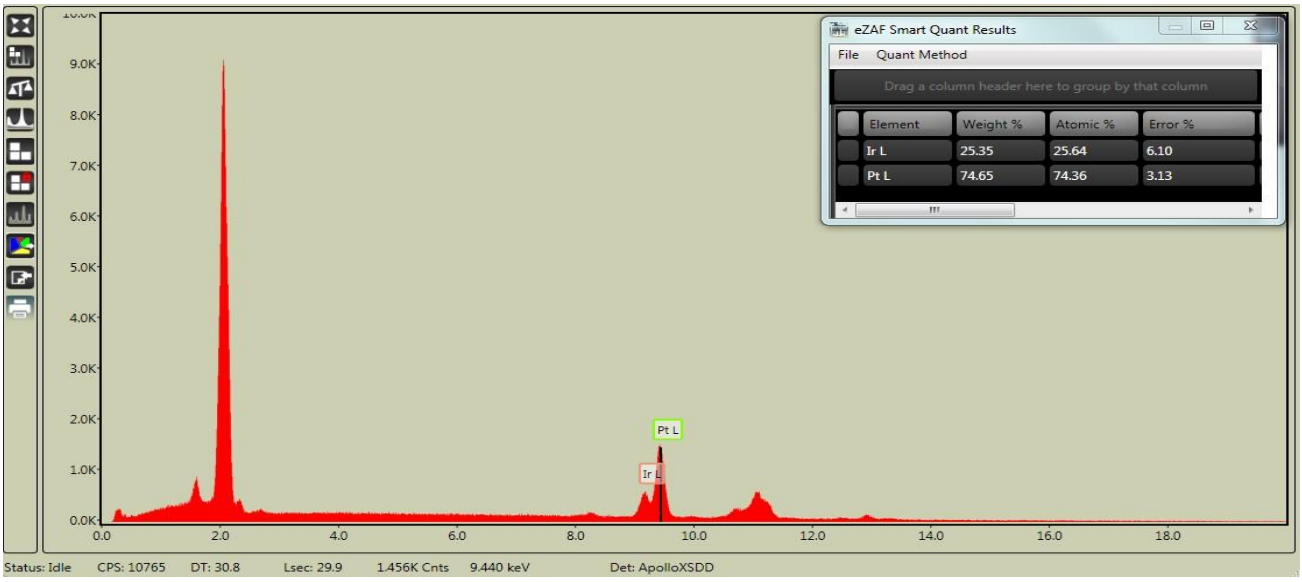

Figure 5: Spectrum from EDS analysis.

3.2. Iridium Wire Activation

The wire was irradiated in the IEA-R1 nuclear reactor for 40 h, reactor core position number 48 and a neutron flux of 1.96 × 10^{13} $n.cm^{-2}.s^{-1}$.
Activity homogeneity measurements are presented in table 1.

Table 1: Iridium-192 wire activity measurements for quality control purposes.

Position	nC/2min	Position	nC/2min	Position	nC/2min	Position	nC/2min
1	1,7587	13	1,8256	25	1,7928	37	1,8093
2	1,7857	14	1,8303	26	1,7948	38	1,8017
3	1,8184	15	1,8582	27	1,8029	39	1,8005
4	1,7736	16	1,9040	28	1,8191	40	1,7987
5	1,7989	17	1,8033	29	1,8378	41	1,8261
6	1,8025	18	1,8042	30	1,8325	42	1,8261
7	1,8017	19	1,8618	31	1,8148	43	1,8517
8	1,8181	20	1,8793	32	1,7945	44	1,8333
9	1,8132	21	1,8538	33	1,8279	45	1,8298
10	1,8117	22	1,8331	34	1,8036	46	1,7671
11	1,8151	23	1,8692	35	1,8146	47	1,8472
12	1,8051	24	1,8564	36	1,8183	48	1,7721

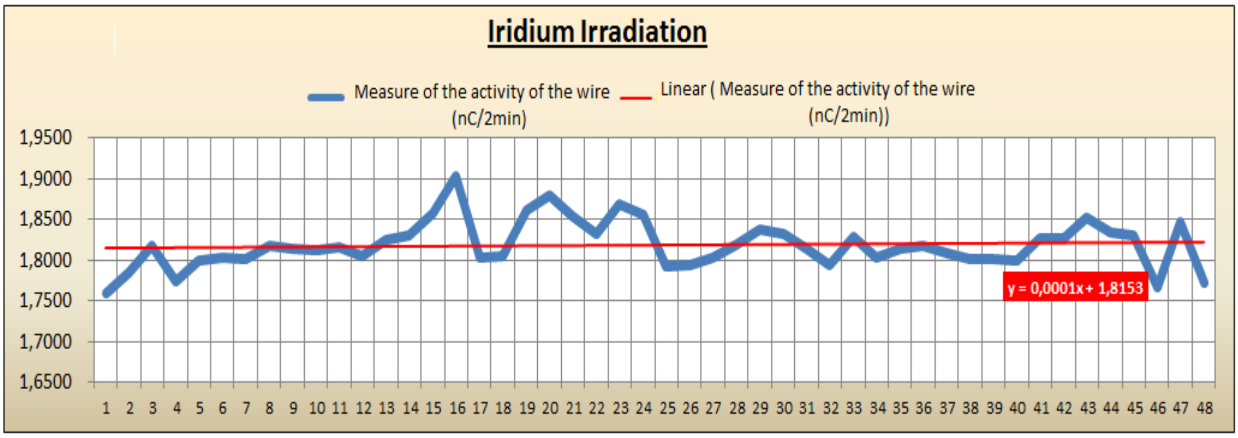

Figure 6: Iridium-192 wire activation distribution

The total wire activity was 2223.7 MBq (60.1 mCi) for 48 cm length. The wire was cut with 3 mm length and the activity of each cut wire was 14.8 MBq (0.4 mCi).

4. CONCLUSIONS

The Iridium-Platinum wire EDS analysis permit to use them for brachytherapy seeds because the wire did not present any impurities that would contribute for other isotopes activation. Activity distribution showed a good homogeneity along the wire. The average value for the distribution was 1.82 nC with a standard deviation around 0.03 nC (~ 4.7 %).

Further studies will be done in order to enable the Ir-192 ophthalmic seeds production.

ACKNOWLEDGMENTS

The authors thank the EDS research group staff for the Iridium-Platinum wire analysis.

REFERENCES

1. C. D. Souza, M. E. C. M. Rostelato, C. A. Zeituni, J. A. Moura, E. S. Moura, K. A. F. Hilário, A. Feher. "Analysis of the necessary radioprotection procedures in manufacture of iodine-125 sources used in brachytherapy: A preliminary study". *Progress in Nuclear Energy (New series)*, **V. 53**, pp. 66-72 (2011).
2. Brasil. Ministério da Saúde. Instituto Nacional do Câncer**. Estimativa de Incidência de Câncer no Brasil 2010.** Rio De Janeiro; (2010).
3. **SIS SAÚDE**.**Retinoblastoma**. http://www.sissaude.com.br/sis/ (2010).
4. D. A. Wilkinson, M. Kolar, P. A. Fleming, A. D. Singh. "Dosimetric comparision of Ru-106 and I-125 plaques for treatment of shallow (≤ 5 mm) choroidal melanoma lesions**." Vol. 81,** *Br. J. Radiol*. (2008).
5. J. Chhablani, A. Romanzo, A. Balmer, A. Pica, M. Gaillard, R. Cozza, R. Moeckli, F. L. Munier. "106 - Ruthenium brachytherapy for ciliary recurrence with supraciliary effusion in retinoblastoma." *Ophthalmic Genetics*. **Vol. 31**, pp. 190-192. (2010).
6. C. A. Regueiro, "Brachytherapy: basic concepts, current clinical indications and future perspectives". *Rev Oncol*. **Vol. 4**, pp. 512-516 (2002).
7. R. Lawrence, M. D Moia, J. D. Moylan. *Introduction to Clinical Radiation Oncology***.** Medical Physics Publishing. Third Edition. Madison, Wisconsin (2007).
8. T. J. Godden, *Physical Aspects of Brachytherapy*. Medical Physics Handbooks 19. Bristol: Adam Hilger. (1988).
9. L. D Hanke, *Handbook of analytical methods for materials*. Material Evaluation and Engineering, (2001).
10. M. E. C. M. Rostelato, **Preparação de fontes de Irídio - 192 para uso em braquiterapia.** Dissertação (Mestrado) - Instituto de Pesquisas Energéticas e Nucleares, São Paulo. (1997).
11. M.E.C.M. Rostelato, P. Rela, C. A. Zeituni, A. Feher, J. E. Manzoli, J. A. Moura, E. S. Moura, C. P. Silva, Development and production of radioactive sources used for cancer treatment in Brazil. *Nukleonika*. **Vol. 53**, pp. S99−S103 (2008).