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DEVELOPMENT OF IRRADIATION SUPPORT DEVICES FOR PRODUCTION OF BRACHYTHERAPY SEEDS

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ABSTRACT

Ophthalmic tumors treatment with brachytherapy sources has been widely used as a primary or secondary therapy for non-malignant or malignant tumors, for example, choroid melanoma, and retinoblastoma. Ruthenium-106, Iodine-125, Palladium -103, Gold-198 and Iridium-192, are some radionuclides that can be applied for treatment of ocular tumors. These sources are in small sizes (a few millimeters) and different shapes (rods, wires, disks). To ensure high accuracy during treatment, they are positioned in eye applicators, specially designed to fit on the surface of tumor. The Nuclear and Energy Research Institute (IPEN/CNEN) in a partnership with Paulista Medicine School (UNIFESP) created a project that aims to develop a prototype of Iridium-192 seeds for treatment of eye cancer. This seed consists in a core of Ir -Pt alloy (20%-80%) with a length of 3 mm, to be activated in IPEN's IEA-R1 Reactor, and a titanium capsule sealing the core. It was imperative to develop a sustainer device for irradiation. This piece is used to avoid overlapping of one cores and, therefore, avoiding the "shadow effect" that does not allow full activation of each core due to the high density of the material.

1. INTRODUCTION

Brachytherapy seeds have been used for years as an alternative form of cancer treatment. These seeds are sealed with the radioactive material inside the core. Several radionuclides are used in those seeds such as iodine-125, iridium-192, ruthenium-106, gold-198, and they are characterized by their half-life, type and energy of radiation and shape of the source. Natural elements can become radioactive by neutron activation in a nuclear reactor, such as Iridium. Among applications of this element in the medicine area, one can mention HDR (high dose rate) and ophthalmic brachytherapy treatment [1,2,3,4].

Ophthalmic tumors treatment with brachytherapy sources has been widely used as a primary or secondary therapy for non-malignant or malignant tumors, for example, choroidl melanoma, and retinoblastoma. To ensure high accuracy during treatment, they are positioned in eye applicators, specially designed to fit on the surface of tumor [5,6].

The Nuclear and Energy Research Institute (IPEN/CNEN) in a partnership with Paulista Medicine School (UNIFESP) created a project that aims the development of an Iridium-192 seed prototype for eye cancer treatment. This seed consists in a core of Ir-Pt alloy (20%-80%) with a length of 3 mm, to be activated in IPEN's IEA-R1 Reactor, and a titanium capsule sealing the core. It was imperative to develop a sustainer device for irradiation [1,4,7]. Because Iridium present high cross section for neutrons absorption (910 barns) and high density (22.65 g/cm^3) [8], it can cause irradiation overlapping, reflecting a lack of activity uniformity along the irradiated cores. To address this issue, this paper aims to study uniformity using three (3) supporting devices for irradiation of iridium cores. After the irradiation process, sources activity has measured by a Capintec CRC 15W.

2. METHODOLOGY

- **Device 1**

It was developed using Teflon (tetrafluoroethylene) cylinder, with approximately 1.8 cm diameter. Using a pneumatic drill, 18 holes of 0.5 mm diameter and 1.5 mm was made in the tube, so each core can be placed (Figure 1). The system also has a lid (Teflon material) to prevent core shifting during irradiation and an aluminum handle for manipulation of “rabbit” system (aluminum container that enters the tubes systems used for irradiation inside the reactor).

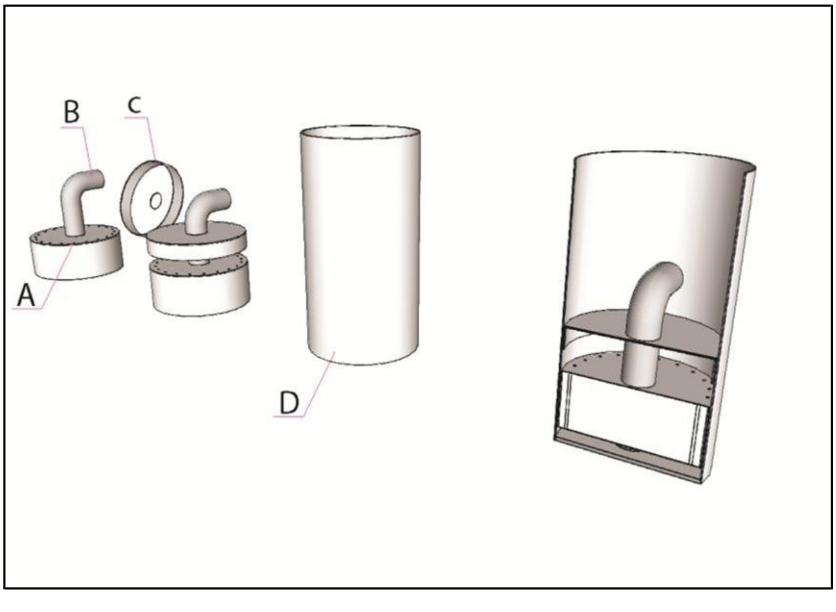

Figure 1: Diagram of the device used to support the cores. A) Teflon-piece used as a support of the nucleus, B) aluminum handle used to manipulate the system, C) Teflon lid used to prevent displacement of the cores, D) ”rabbit” container.

- **Device 2**

Device 2 was developed using a Teflon cylinder with a diameter of approximately 1.8 cm. At the center of this cylinder, a sagittal cut was made resulting in two arcs of equal measures. In these arcs surface small cavities was made in four columns and five rows to deposit the iridium cores (Figure 2). The two were bonded to each other in such way that cores suffers no displacement during irradiation in the reactor.

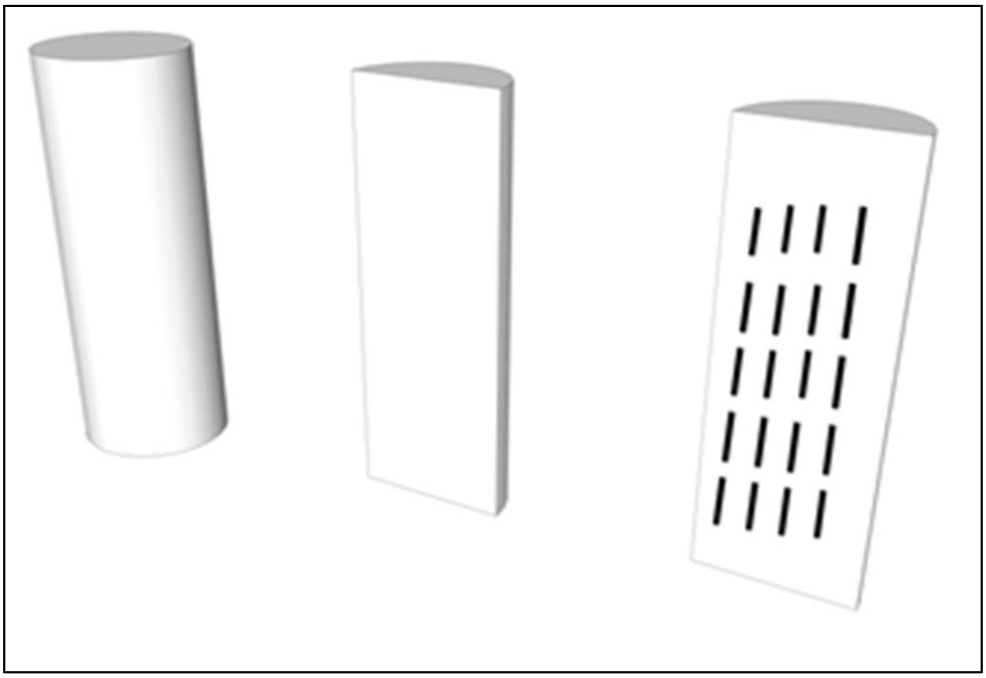

Figure 2: Schematic design of the device used to support the cores. From left to right: Teflon cylinder; sagittal cylinder; cavities arranged in a "matrix" form (rows and columns) for accommodation of the cores.

- **Device 3**

It was developed using an aluminum cylinder with a diameter of approximately 1.8 cm. At the center of this cylinder a sagittal cut was made resulting in two arcs of equal measures. Cavities have been made for the deposition of the iridium cores at the surface of one of the arcs (Figure 3). To ensure a fixed position of the cores inside the holder, the device was sealed with a thin aluminum sheet (0.5 mm).

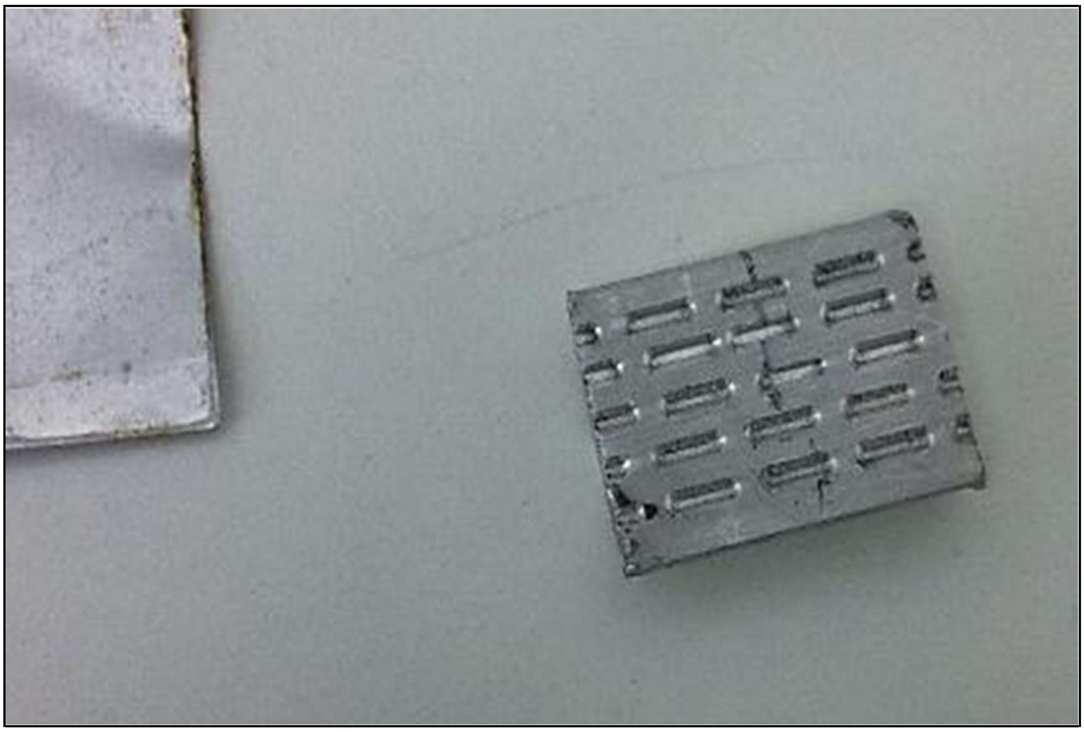

Figure 3: Photography of device 3.

3. RESULTS

Figures 4, 5 and 6 show the cores activities and the average value for each device.

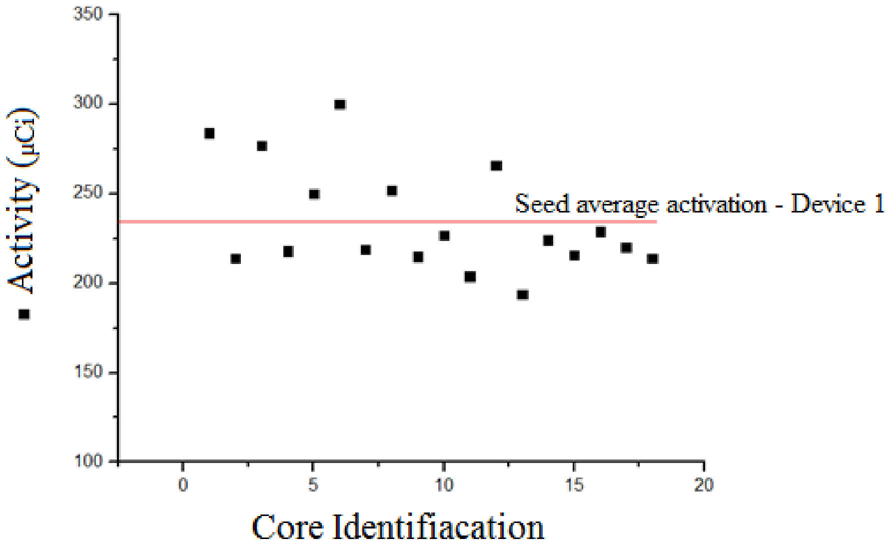

Figure 4: Iridium cores activities using device 1. Seed average activation 230,5 µCi with 35.1% variation.

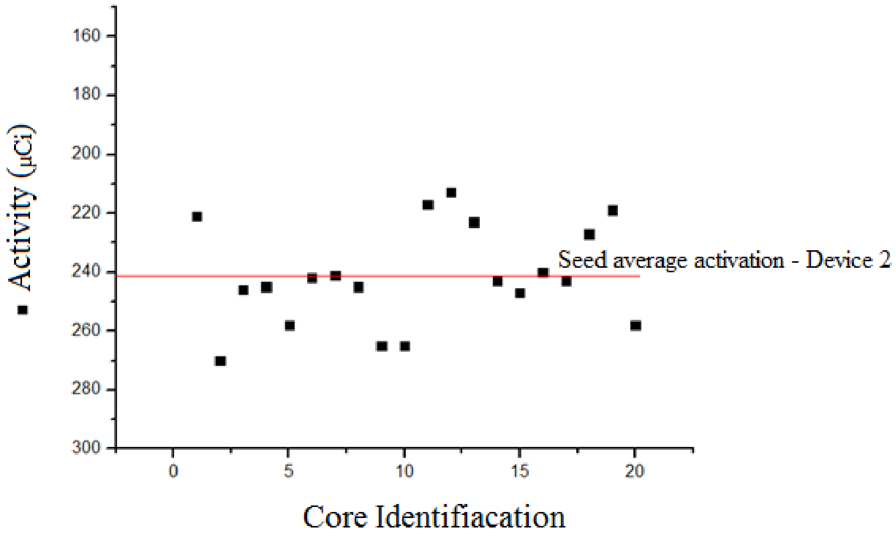

Figure 5: Iridium cores activities using device 2. Seed average activation 250 µCi with 12.3% variation.

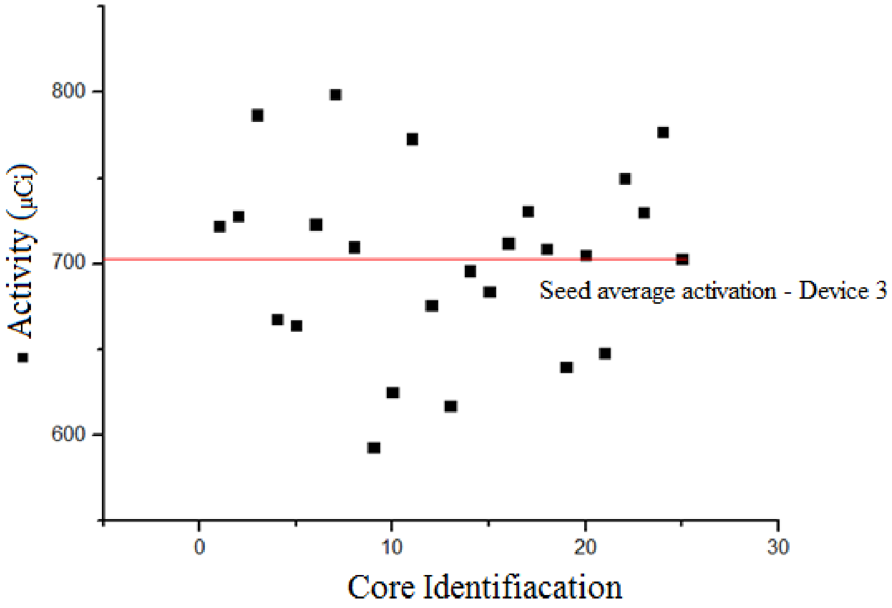

Figure 6: Iridium cores activities using device 3. Seed average activation 704 µCi with 11.4% variation.

4. DISCUSSION AND CONCLUSION

Analysis of the activation cores made with devices 1, 2 and 3 shows that activation is enhanced depending on the position of the cores during irradiation. Devices 1 and 2 were made with Teflon material. It was noted that the cores did not maintain their initial positions because the Teflon does not support the influence of radiation, compromising its structure. However, some improvement was observed regarding the scattering of activity measurements when comparing the cores from device 2 with those from device 1. Probably, the position at which the cores were arranged during irradiation on the device 2 provided better results.

Aluminum was used to construct the device 3. As it does not change its structure when exposed to radiation, good results in terms of homogeneity and activation were observed.

We must mention the existence of various uncertainties in this process, not quantified, which may contribute to a high dispersion of values, such as uncertainties of the ionization chamber, the neutron flux, irradiation times, nuclei masses and length considering that the material is activated by the number of atoms present.

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