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Possible new phosphorus-32 source for paraspinal brachytherapy

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1. Introduction

The tumors of Central Nervous System (CNS) cancer arise from the abnormal growth of cells in the tissues of the brain, cranial nerves, and meninges. This type of cancer accounts for 1.4% to 1.8% of all malignant tumors worldwide. Despite its relatively low incidence, this type of cancer contributes to global morbidity, representing approximately 4% of all malignant neoplasms worldwide and ranking 11th in mortality, according to the World Health Organization [1]. Brachytherapy is a specialized form of radiotherapy wherein one or more radioactive sources are positioned in proximity or directly in contact with the tumor. The primary benefit of this treatment lies in its ability to deliver a precise dose to the target area, thereby facilitating the preservation of surrounding healthy tissues [2, 3].

A promising source for brachytherapy is phosphorus-32, especially for intracavitary brachytherapy (IBT). This radionuclide decays purely on β radiation and its maximum penetration on soft tissue is below 8 mm, with less than 50% of its energy reaching beyond 0.8 mm [4, 5]. To treat specifically CNS tumors, yttrium-90 was initially used on a titanium base. However, a polymeric based plaque was developed that had advantages over the yttrium-90 and titanium composition. This plaque is made with phosphorus-32 immobilized in a polycarbonate base, making it a simpler and cheaper option to manufacture [6]. The aim of this work is to determine the possibility of a Brazilian production of this source, and to evaluate flexible resin candidates for its polymeric base.

2. Methodology

As phosphorus-32 is presented in the liquid form of orthophosphoric acid ($H_3{}^{32}PO4$), it is needed to find a polymeric substrate that can incorporate the acid properly. Several resins were tested to evaluate its cure with the acid mixed in it, for example, polyvinyl butyral (PVB), industrial latex, silicone, and polyvinyl alcohol (PVA). Each test was repeated at least five times to ensure its result.

Two variables were checked to evaluate the results: whether the resin cured or not, and if the final product was flexible. If the acid-resin mixture cured entirely, it was considered a positive result. However, if the mixture, after the proper curing time, was sticky or did not cure at all, then it was considered a negative result. Also, if the resin was not flexible, it would also be considered a negative result. All tests were conducted with the selected resin being poured in molds of 5.0 x 5.0 cm with 0.4 mm of depth.

After checking those two variables, the thickness of the resulting film was measured using a digital micrometer. It should be less than 5.0 mm to avoid self-absorption since the radionuclide used decays in β radiation and, therefore, has low penetration.

3. Results and Discussion

Table I shows the main results of the tests made. From the selected resins, the best candidate to produce phosphorus-32 polymer sources is PVA. Even with the incorporation of the acid into the resin, its malleability was not altered, and its physical properties were maintained.

Table I: List of some of the resins tested, their results (whether they were positive or negative) and the reason for the result shown.

Resin	Results	Reason
Polyvinyl butyral	Negative	The resin did cure; however, it was not flexible.
Industrial latex	Negative	The acid coagulated when in contact with the latex.
Silicone rubber	Negative	The acid reacted with the catalyst; thus, it did not cure.
Polyvinyl alcohol	Positive	The resin cured and it was flexible.

Figure 1 shows the outcome of the experiment with the PVA, and it is possible to observe the malleability of the film. The thickness mean value measured was ≈ 0.015 mm.

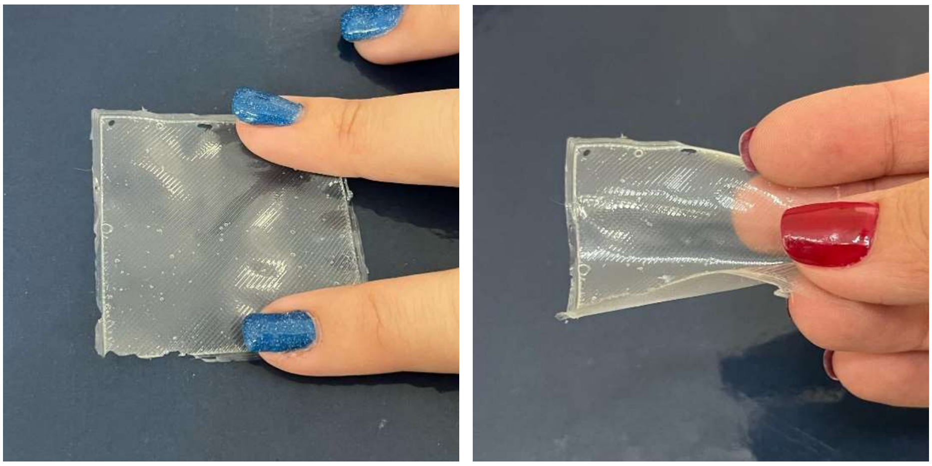

Figure 1: PVA film made with the addition of orthophosphoric acid. It is possible to observe that it cured completely, and its flexibility was maintained.

4. Conclusions

It is possible to have a Brazilian production of phosphorus-32 polymeric sources for intracavitary brachytherapy, and PVA is a strong candidate for the polymeric base.

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References

[1] H. Sung et al., “Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries”, CA: A Cancer Journal for Clinicians, vol. 71, pp. 209-249 (2021).

[2] A. Kemıkler, “History of brachytherapy”, Turk Onkoloji Dergisi, vol. 34, pp. 1-10 (2019).

[3] Y. Lim, D. Kim, “Brachytherapy: A Comprehensive Review”, Progress in Medical Physics, vol. 32, pp. 25-39 (2021).

[4] X. Yu, S. Christ, R. Liu *et al.*, “Evaluation of Long-Term Outcomes and Toxicity After Stereotactic Phosphorus-32–Based Intracavitary Brachytherapy in Patients with Cystic Craniopharyngioma,” *International Journal of Radiation Oncology Biology Physics*, vol. 111, pp. 773–784 (2021).

[5] K. Kobayashi, N. Kageyama, K. Ohara, “Internal irradiation for cystic craniopharyngioma,” *Journal of Neurosurgery*, vol. 55, pp. 896-903 (1981).

[6] M. Folkert, M. Bilsky, G. Cohen *et al.*, “Intraoperative 32P High-Dose Rate Brachytherapy of the Dura for Recurrent Primary and Metastatic Intracranial and Spinal Tumors,” *Neurosurgery*, vol. 71, pp. 1003-1011 (2012).