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PREPARATION OF WATER-EQUIVALENT RADIOACTIVE SOLID SOURCES

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ABSTRACT

The development of water-equivalent solid sources in two geometries, cylindrical and flat without the need of irradiation in a strong gamma radiation source to obtain polymerization is described. These sources should have density similar to water and good uniformity. Therefore, the density and uniformity of the distribution of radioactive material in the resins were measured. The variation of these parameters in the cylindrical geometry was better than 2.0% for the density and 2.3% for the uniformity and for the flat geometry the values obtained were better than 2.0 % and better than 1.3%, respectively. These values are in good agreement with the literature.

1. INTRODUCTION

Radioactive water-equivalent standard solid sources in different geometries are used for radiation instrument calibration and checking in many areas such as nuclear medicine, environmental sample analysis and radioprotection. These sources are suitable for performing constancy and accuracy tests daily and to be used as standard sources in environmental liquid sample analyses and food contamination using gamma-ray spectrometry systems [1].

In recent years the Nuclear Metrology Laboratory (LMN) at IPEN-CNEN/SP has been involved in the development of radioactive water-equivalent solid sources to be used as check sources to calibrate ionization chambers in Nuclear Medicine Services [2],[3]. These sources were prepared in cylindrical geometry by means of acrylamide resin polymerized by high dose gamma radiation from a Co-60 irradiator [3]. However, the experimental procedure to produce the solid sources in a gamma irradiator is laborious, dangerous and time consuming.

In order to solve this problem, the LMN developed an alternative methodology to obtain water-equivalent solid volume sources without the need of irradiation to generate the polymerization process. These sources should have density similar to water and good uniformity. In this paper the procedure to prepare sources in acrylamide resin in two geometries: cylindrical and flat, is presented.

2. EXPERIMENTAL PROCEDURE

a) Cylindrical geometry solid source

The cylindrical source was prepared in a plastic container with 2.7 cm in diameter, 5.8 cm high (external dimensions) and 0.13 cm wall thickness, containing 19 ml of solution (Fig.1).

The alternative procedure consists of obtaining a solid matrix-polyacrylamide from an aqueous solution composed by acrylamide, catalysers and an aliquot of 10µl ^{133}Ba radionuclide, all mixed together, in order to obtain good uniformity in the distribution of radioactive material inside the polymer. All these aqueous solutions are completely miscible. After the end of polymerization the plastic containers were sealed due to the fact that water still contained in the solid matrix evaporates in time [1]. The final resins have a clear, soft and rubbery texture, free from voids inside the active volume.

One of the most important aspects of a volume source is to have a good uniformity. The destructive test consisted in cutting the polymerized cylindrical volume in three sections and the uniformity was checked by their activity comparisons. Fig. 1 shows the cylindrical source obtained by polymerized acrylamide resin before the cutting process.

The uniformity of the cylindrical resin was verified by measuring the activity of each section in both bottom and top faces, in an HPGe spectrometer previously calibrated with a ^{133}Ba standard source supplied by IAEA.

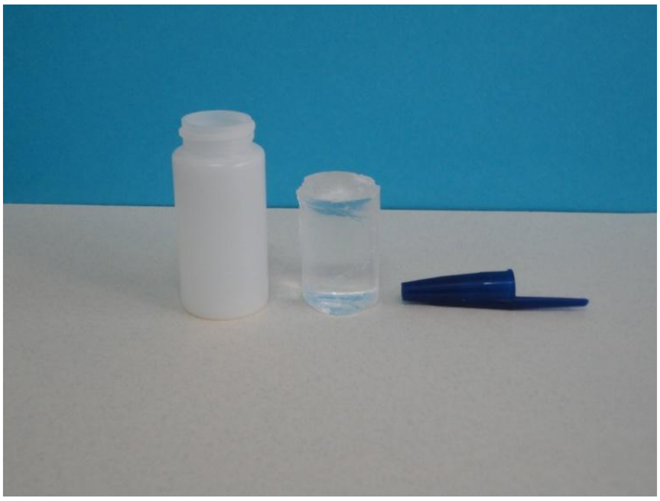

Figure 1. The plastic container and the cylindrical acrylamide polymerized resin.

b) Flat geometry solid source

The flat source was prepared in a 20 x 20 cm square glass container, with 0.27 cm thick containing 77 ml of solution. (Fig. 2).

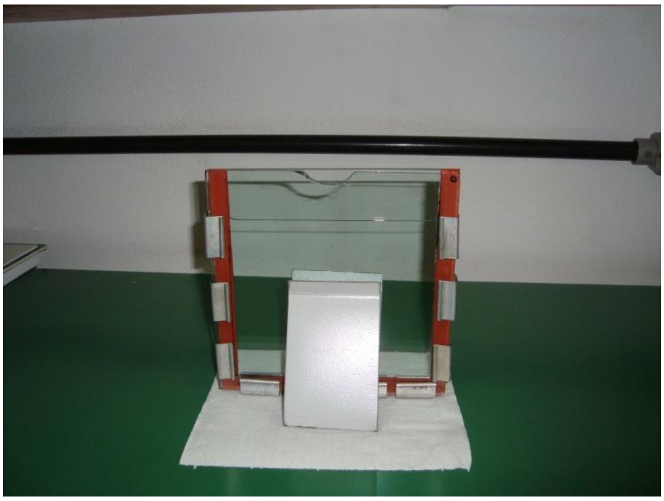

Figure 2. Sample holder for the flat solid source.

The square solid matrix (Fig. 3) was obtained using the same chemicals as in the cylindrical source and its uniformity was determined by using an aliquot of 100 µl of ^{177}Lu. Radioactive solution causes contamination in many laboratory utensils. Thus, the reason to choose this radioisotope was due to its short half-life in order to allow reuse the square glass container in an adequate period of time.

The destructive test consisted in cutting randomly nine small pieces from the flat surface using a stainless steel cylindrical tool with 1.72 cm inner diameter. Therefore, those nine parts had the same size and shape and the uniformity was also checked by their activity comparisons.

The uniformity of this flat source was verified by measuring the activity of those nine pieces in an HPGe spectrometer previously calibrated with ^{152}Eu standard source supplied by IAEA. Fig. 3 shows the flat source obtained by polymerized acrylamide resin before the cutting process.

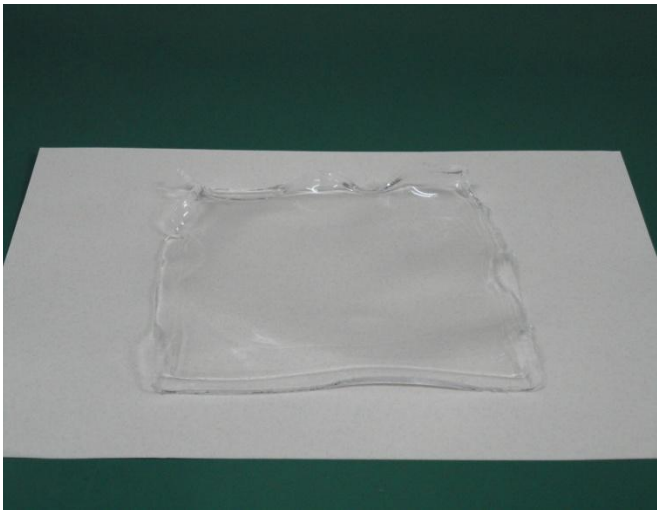

Figure 3. The flat acrylamide resin.

3. RESULTS

a) Cylindrical Source

The uniformity of the cylindrical source was determined by preparing three volume solid sources. After polymerization, each of them was cut by hand in three sections, approximately with the same size. Afterwards, those nine pieces were weighted and the height measured. Their activities were measured in both faces using an HPGe spectrometer previously calibrated.

The relative deviation to the average of the measurements for each source, all them cut in three sections, is presented in Fig. 4. The maximum difference from the average was 1.47% for the source 1; 1.58% for the source 2 and 2.24% for the source 3. The uniformity obtained for this geometry was better than 2.3%, in good agreement with the literature [1].

The density value was determined by measuring mass and volume of the 9 pieces and the average density obtained was (1.05±0.02) g $cm^{-3,}$ also in good agreement with the literature [1], [4], [5].

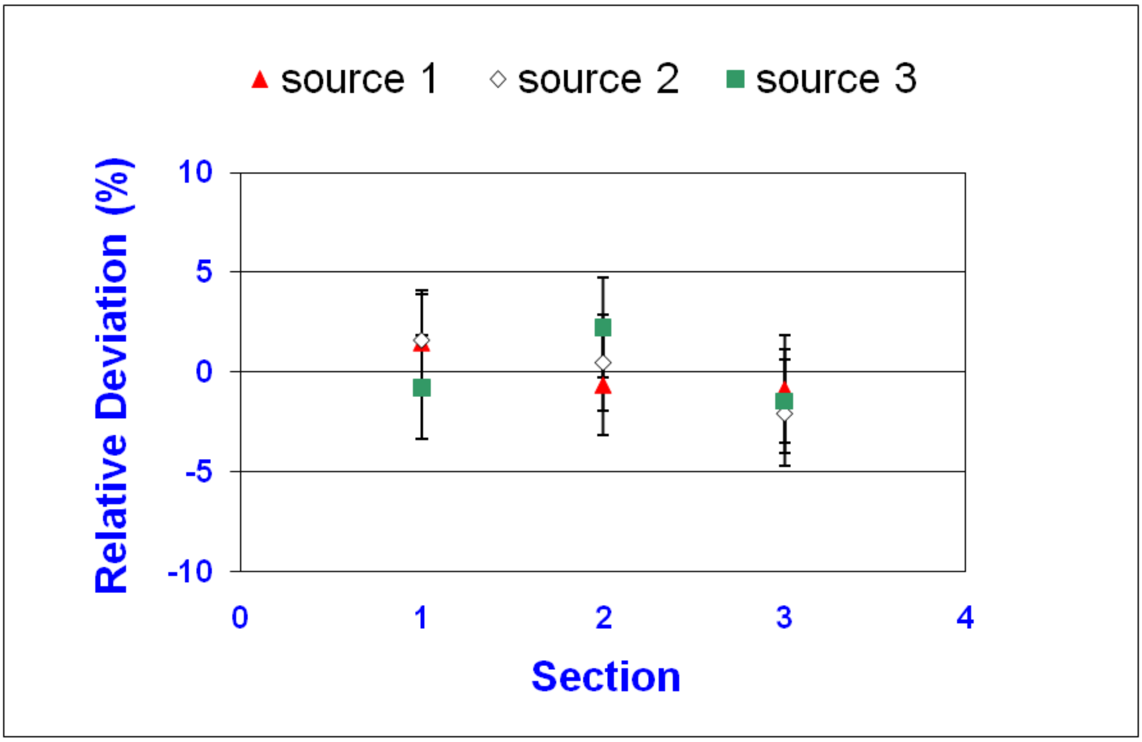

Figure 4. Relative deviation from the average activity of acrylamide cylindrical sources.

b) Flat Source

The nine round flat pieces sampled throughout the polymerized surface were weighted, the thickness was measured and the activity measured only in one face because they were all thin, around 0.27 cm.

The relative deviation to the average of the activities is presented in Fig. 5. The maximum difference from the average of the flat source was 1.26%. The uniformity obtained for this geometry was better than 1.3%, in good agreement with the literature [1].

The density value for the flat resin was determined by measuring mass and volume of the nine pieces and the average density obtained was (1.03±0.02) g cm^{-3}, once more in good agreement with the literature [1], [4], [5].

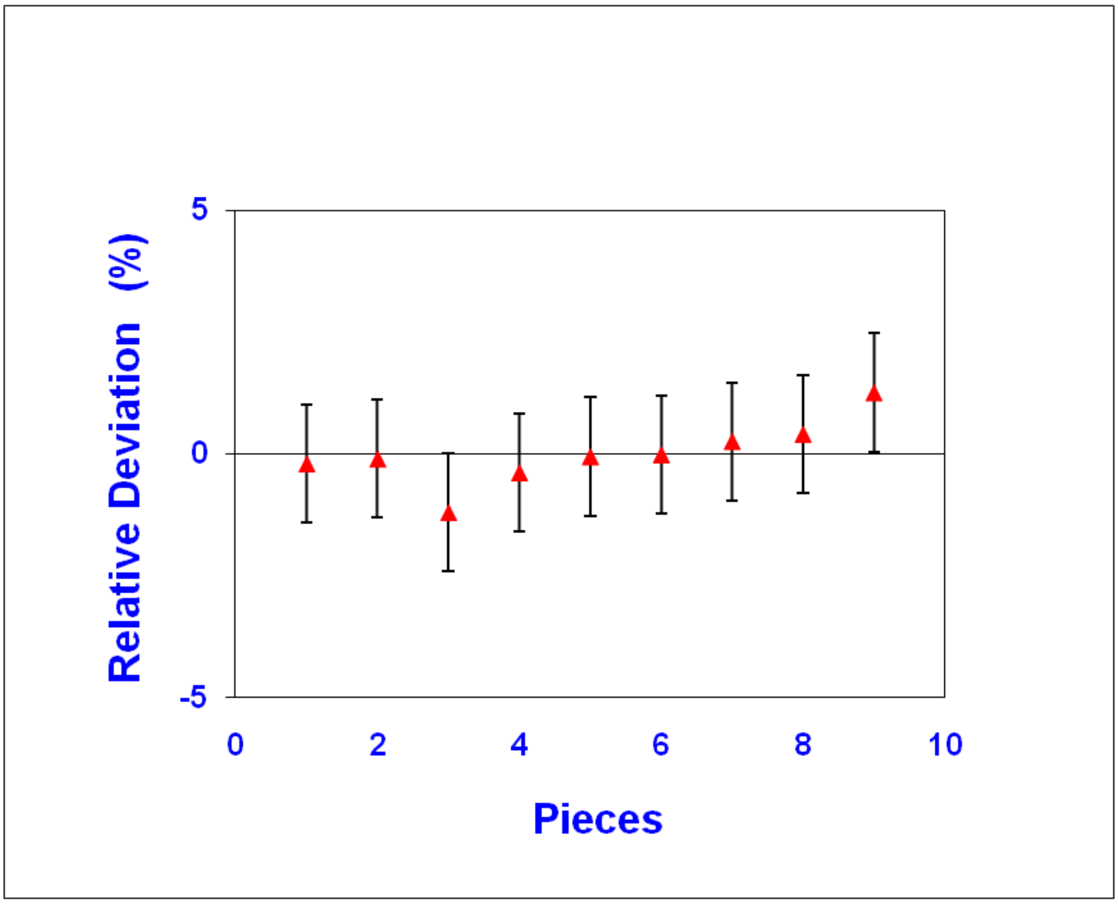

Figure 5. Relative deviation from the average activity of flat acrylamide source.

4. CONCLUSIONS

The results presented in this paper for cylindrical and flat source showed that the method for preparing water-equivalent solid sources without the need of irradiation to generate the polymerization process in two geometries developed by the LMN was succeeded. The both solid sources prepared have good uniformity and density, in good agreement with the values presented in the literature.

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