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MANUFACTURING AND TEST OF A LOW COST POLYPROPYLENE BAG TO REDUCE THE RADIOACTIVE GAS RELEASED BY A RADIOPHARMACEUTICAL PRODUCTION FACILITY

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ABSTRACT

The main objective of this work was to evaluate the efficiency of a plastic gas storage bag to reduce the radioactive gas released by the chimney of a radiopharmaceutical production facility during the 2-[^{18}F]fluoro-2-deoxy-D-glucose (^{18}FDG) synthesis. The studied facility was the Development Centre of Nuclear Technology (CDTN/CNEN) in Belo Horizonte, Brazil. The bag was manufactured utilizing foils of polypropylene of 360 x 550 x 0.16 mm and disposable components of the cassette of the synthesizer. Two synthesis of ^{18}FDG were done using the same hot cell and synthesizer to evaluate the efficiency of the bag. The manufactured bag was put in the gas exit of the synthesizer and the activity reported by the online radiation monitoring system in the first synthesis. These results were compared to the activity released in a synthesis performed without the bag. We observed when the bag was used the amount released was about 0.2% in 270 minutes. The second synthesis was performed without the bag, about 7,1% of the input activity was released by the exhaust of the facility in the same time interval. The bag presented a very good efficiency in the reducing of the radioactive gas released by the chimney of the radiopharmaceutical production facility.

1. INTRODUCTION

A new Regulation Law published by Brazilian Federal Government in 2006 excluded from the federal monopoly the production, commerce and use of radioisotopes of short half lives (minor or equal to 2 hours) for medical, agricultural and industrial uses [1]. The publication of this law caused a substantial increase in the number of installations dedicated to PET (Positron Emission Tomography) radiopharmaceutical production [2].

The most important PET radiopharmaceutical used in Nuclear Medicine is the 2-[^{18}F]fluoro-2-deoxy-D-glucose (^{18}FDG). The use of ^{18}FDG along with a PET camera yields excellent quality images of the brain (for studying functional abnormalities), heart (for studying viability function) and tumours (for detection of metastases) [3].

The Brazilian Norm about Radioactive Waste Management from Nuclear Commission of Nuclear Energy [4] establishes a maximum Fluorine-18 concentration of 7,4 x 10^3 Bq . m^{-3} (soluble form) to disposal of radioactive gas in the atmosphere. It is difficult to keep the discharge of radioactive gas to the environment below this limit in a PET radiopharmaceutical facility due to poor performance of commercial available filters to retain some gases usually produced in the FDG synthesis, such as HF, HCN, NH_3, CH_3F [5].

There are some technical solutions generally employed to reduce the radioactive gas released in the chimney of PET facilities: (a) utilization of bags in the gas exit of the FDG synthesizer to storage the radioactive gas generated; (b) utilization of delay lines and (c) the transfer of the radioactive gases to pressurized tanks [5, 6]. The last two options are more difficult to implement than the first one.

The main objective of this work was to evaluate the efficiency of a plastic gas storage bag to reduce the radioactive gas released by the chimney of a radiopharmaceutical production facility during the FDG synthesis. The bag, specially manufactured using disposable materials from synthesizer aims the reduction of radioactive gas exhausted and the compliance with Brazilian Norm requirements.

2. MATERIALS AND METHODS

The studied facility was the Development Centre of Nuclear Technology (CDTN/CNEN) in Belo Horizonte, Brazil. The facility has a cyclotron GE PETtrace 8 (GE HealthCare), capable of accelerate protons up to 16.5 MeV. The cyclotron has two targets dedicated to production of fluorine-18, with a yield of about 9 Ci in 2 hours of dual beam irradiation.

There are a double hot cell BBS-2 from COMECER, with 2 synthesizers TRACERLAB-MX (one in each shielded compartment) from GE HealthCare and an automatic dispensing unit (THEODORICO, COMECER – Fig. 1), in the production laboratory. The compartments of the hot cell BBS-2 and the THEODORICO have charcoal filters at the exit of the ventilation system. Then, the radioactive gases produced during the syntheses pass first by these charcoal filters before get access to PVC tubes of 200 mm of diameter and about 15 meters long. These PVC tubes connects with the square section tubes (40x40 cm^2) from the bunkers of the cyclotron and external beam line, made of galvanized steel. Before the exit of the chimney there is a group constituted of two HEPA and one charcoal filters, which reduces the radioactive gas released by the installation. The chimney is located 20 meters high from the ground level and 15 meters from places occupied by members of the public. A scintillation detector and a flow meter (ROTEM INDUSTRIES LTDA) are connected to the online monitoring system of the same manufacturer (MEDISMARTS). This system controls the gas released and commands a dumper that is automatically closed when the radiation levels are higher than the set licensed values.

It was put a gas storage bag in the gas exit of the TRACERLAB-MX. This bag was specially manufactured using foils of polypropylene of 360 x 550 x 0.16 mm and disposable components of the cassette of the synthesizer. The Fig. 2 shows details of the bag.

Figure 1. General view of the THEODORICO and hot cell BBS-2 (COMECER). Inside one of the 2 compartments of the BBS-2 is shown 1 of the synthesizers TRACERLAB-MX from GE HealthCare.

An initial test of gas retention capability of the bag was performed. For this, it was insufflated a volume of about 12 liters of nitrogen gas into the bag and the gas leaking was observed during 6 hours. After that, the efficiency of the bag was evaluated by comparing activity released in two FDG syntheses: one synthesis realized with the use of the bag and another one without it. Both of than were done using the same hot cell compartment and synthesizer. In one of the syntheses, the manufactured bag was put on the gas exit of the TRACERLAB and the activity was reported by the online radiation monitoring system (MEDISMARTS – ROTEM) and then compared to the activity released in a synthesis performed without the bag. The yields of both syntheses were about 55%.

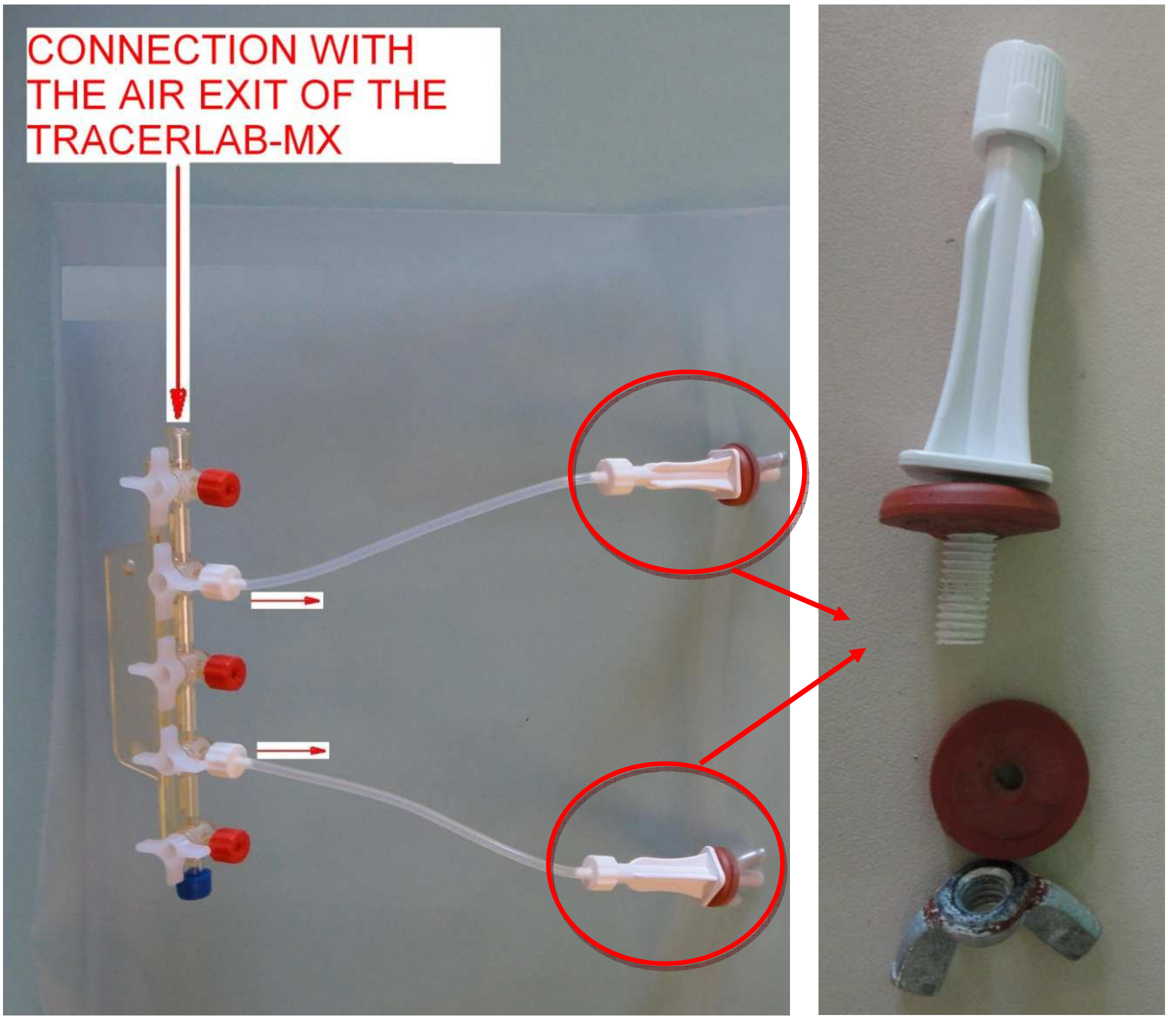

Figure 2. View of the gas storage bag and details of the adapted device utilized to enable the entrance of the gas into the bag.

3. RESULTS AND DISCUSSIONS

During the period of 6 hours monitoring nitrogen gas leaking from the bag it was not verified the decrease of the insufflated gas volume (< 5%). This proves that the connections, valves and materials used in the bag manufacturing are capable of retaining efficiently the nitrogen gas for more than 6 hours (> 3 half lives of ^{18}F). The gas retention for this period is sufficient to reduce the activity of the gas exhausted by a factor higher than 8 and even if the leaking occurs after this time, the gradual release of collected gas volume could help in its dilution.

After the synthesis performed with the bag, a visual analysis through the lead glass helped to confirm the increase of the bag volume. This volume remained almost the same after the synthesis and quality control tests. Even on the next day, after approximately 22 hours of the synthesis, when the hot cell was opened, it could be verified a small volume of gas. It proves a good gas retention capability of the bag.

The Fig. 3 shows a comparison of the mean activity released in the two syntheses (with and without the bag), normalized to the initial activity produced by the cyclotron, respectively equal to 1364 mCi (synthesis with the bag) and 799 mCi (synthesis without the bag). The bag presented a good efficiency in the reducing of the radioactive gas released by the chimney of the radiopharmaceutical production facility. In the synthesis was performed without the bag, about 7.1% of the input activity was released by the exhaust of the facility in 270 minutes. For another synthesis the amount released was about 0.2% in the same time interval. The mean rate of activity released in both cases, with and without the bag, were, respectively, 2390 Bq . m^{-3} and 53600 Bq . m^{-3}. However, for the synthesis performed with the bag, the time necessary to reduce the exhausted activity to levels minor than 1.5 times the background level was less than 40 minutes. In this period, the mean activity rate released was about 7247 Bq . m^{-3}.

Although in the synthesis performed without the bag, the main activity exhausted during the period mentioned (270 minutes) was higher than limits established by Brazilian Regulatory Authority, the total effective doses estimated are less than 0.5 µSv, for the distance of the chimney to the buildings occupied by public individuals (> 15 meters). In this distance, the fluorine-18 concentration on air is minor than 2000 Bq . m^{-3} [7]. In one year, considering in a conservative manner, 600 productions using the same conditions, the total effective doses would be less than 0.3 mSv that is the dose constraints established by CNEN [8].

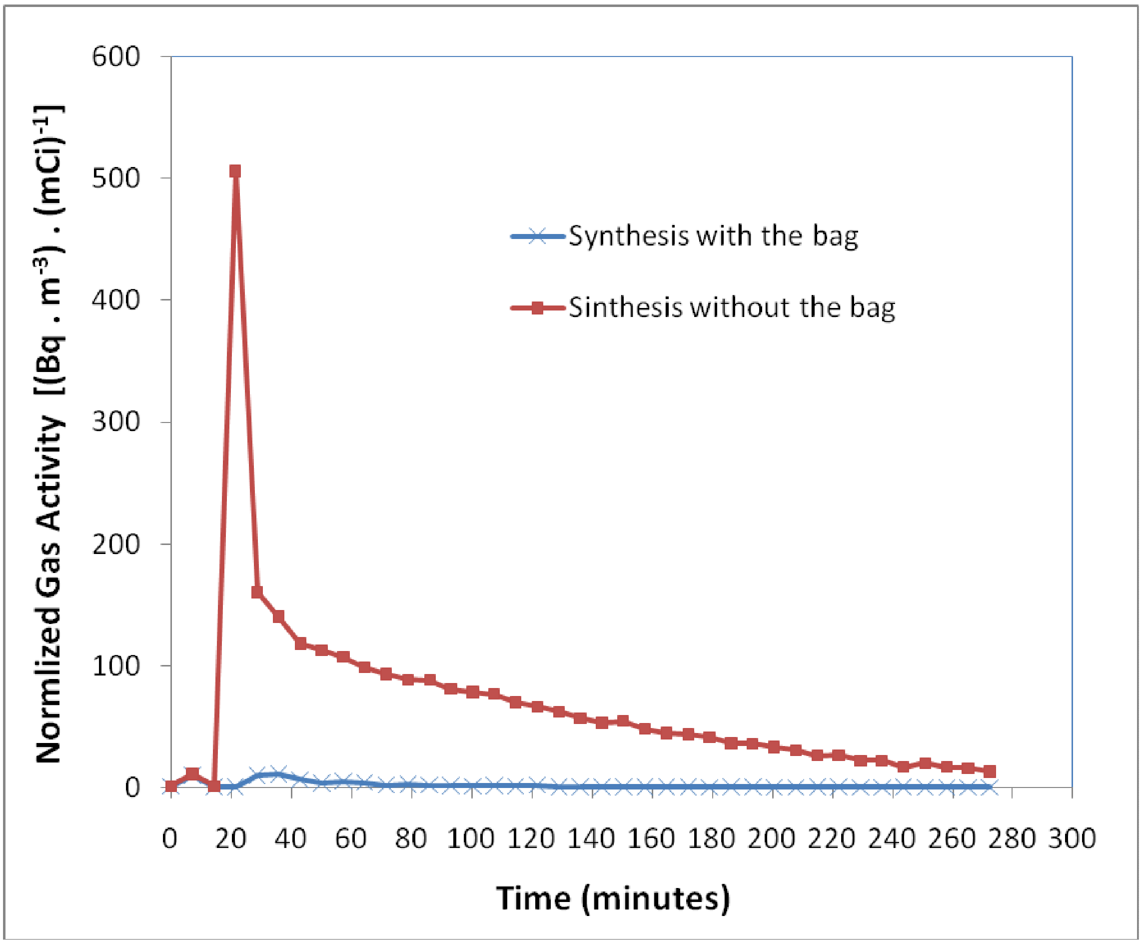

Figure 3. Normalized gas activity released for the both synthesis: with and without the utilization of the bag.

3. CONCLUSIONS

The bag has proved to be a simple and low cost solution and attends the needs of the gas retention efficiently. Levels reported after use of the bag were lower than expected. We could observe the bag is capable to retain efficiently the gas for more than 6 hours, demonstrating a good efficiency in the reducing of the radioactive gas released by the chimney of the radiopharmaceutical production facility.

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