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108mAg activity concentration determination in low and medium level radioactive waste from Angra Nuclear Power Plant

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1. Introduction

Pressurized water reactors, or PWRs, are the main source of nuclear energy in Brazil. During the energy generation, radioactive waste is produced through some of the process required for the reactor operation, such as in the fuel cycle, filtration systems and adjunct laboratories, for example. Such wastes present a wide variety of concentrations and radionuclides chemical and physical properties. Common to all radionuclides, it's potential to cause biological and environmental harm must be exalted and well managed to avoid negative outcomes [1].

To maintain a safe operation, the water that flows through the primary cooling system (where the core is located) must be as pure as possible, therefore, a demineralization system is adopted to ensure that the water remains without any dissolve ion during the operation. This system usually contains three filters, responsible for withhold or adsorb those nuclides: polymer type filter; coal filter and ionic exchange resin [2 - 4]. The development of a proper storage of these materials when they have already achieved their capacity of filtration is essential to proceed with safe and benefic aspects of acquiring energy from nuclear sources.

For proper storage of such materials, Brazil's law nº 10.308, from 20th November 2001 establishes that radioactive waste produced in national territory, including the local selection, construction of facilities, operation, supervision, costs, indemnity, civil responsibility and final destination must be characterized with quantitative analysis in order to evaluate its conformity within the pre-established ranges and classifications [5, 6].

^{108m}Ag is a radionuclide generated mainly by neutron activation of the silver content on control bars and released in the system by drag force constituting a considerable problem once control bars tend to present 85% of its composition of silver (85% Ag, 10% Cd and 5% In) [7].

As a low energy gamma radiation emitter (79KeV), with 418 y half-life, the ^{108m}Ag activity concentration cannot be directly measured by in *sito* gamma spectrometry [8]. Therefore the quantification of this nuclide requires a radiochemical separation process in order to have its activity concentration precisely determined. The objective of this study was to separate and quantify the ^{108m}Ag present in samples of ion exchange resin and evaporator concentrate from the operation of Angra 1 nuclear power plant.

2. Methodology

2.1. Sample preparation

All the samples from Angra's power plant were weighted and digested with aqua regia (HCl 3:1 HNO_3) in glass beaker over a heating plate at 150 ^oC. If any sample presented suspended materials after the acid digestion, further attempts with HF in Teflon beaker at 150^oC were applied until complete digestion, the samples were transferred to a 100 mL volumetric balloon, Milli-Q water was added, diluting the sample to 100 mL.

2.2. Separation of ^{108m}Ag

An aliquot of 40 mL of the ionic exchange resin and evaporator concentrate samples were used separated into individual 50 mL falcon tubes. To each sample 1 mL of 118.18 mg mL^{-1} $AgNO_3$ carrier were added and the precipitation took place with the addition of concentrate HCl. The samples were heated at 60 ^oC in order to agglomerate its particles and centrifuged for 25 minutes with 3500 rpm. After washing and repeating the centrifugation process, the precipitate was filtered and the chemical yield was acquired by gravimetry. The ^{108m}Ag activity was determined by gamma spectrometry using the 79 KeV gamma transition.

3. Results and Discussion

Table 1 shows the chemical yield (%) of the separation process and final results (AC) for ^{108m}Ag obtained from the methodology discussed above.

Table 1: Yield and Activity concentrations of ^{108m}Ag

Sample	Yield (%)	AC (Bq g^{-1})
CE-1	98,64	9,16E-02
CE-2	99,87	1,82E-01
CE-3	99,74	3,51E-01
CE-4	99,66	4,44E-01
CE-5	99,69	4,85E-02
CE-6	96,01	N/A
CE-7	97,73	4,85E-02
CE-8	98,66	1,42E-01
R-1	98,5	1,09+01
R-2	98,03	1,35E+01
R-3	99,27	2,00E+00
R-4	99,77	1,55E+01
R-5	99,54	5,72E+00
R-6	99,57	4,50E+00
R-7	96,57	1,97E+00
R-8	98,36	1,41E+00
R-9	97,4	3,89E+00
R-10	N/D	N/D
R-11	99,96	N/D
R-12	99,36	1,28E+00

Chemical yields obtained are in conformity with previous results of Ag separation trough precipitation processes proving this method to be reliable and reproductive [8].

Sample R-10 suffered huge sample loss during the acid digestion procedure causing it to be unreliable to be analyzed. Samples CE-6 and R-11 couldn't be detected for two most probable reasons: concentration below detection limit or procedure mistake, the exact motive couldn't be achieved.

The results obtained in these samples are within the expected activity range considering analysis from other reactors [9]. Minor variations are expected due different reactor matrixes, resulting different abrasive effects that cause the presence of such nuclides in the primary waster system.

4. Conclusions

The applied methodology has shown itself as fast and safe, providing high yield values and concordant activity results, in accordance to other references.

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