Contribution ID: **12** Type: **POSTER**

Uranium recovery from liquid waste composed of uranyl nitrate solution

The nuclear fuel cycle operates producing uranium in power generation, in use in medicine and industry, among other areas. This cycle produces various kinds of radioactive waste. Among these, uranyl nitrate solutions with enriched uranium are produced, mainly in the chemical decontamination of parts and materials with fixed contamination. Uranyl nitrate, as addressed in this paper, has inherent risks as it is a hazardous material in addition to risks of radioprotection, proliferation and nuclear criticality, requiring strict control. Until November 2020, there were 3 m^3 of uranyl nitrate awaiting treatment at the nuclear facility and an average enrichment content estimated at 3.05% of U-235 in solution. The solution to be treated has a concentration of 15% HNO3. The volumetric reduction of this waste, reducing the concentration of uranium contained in the solution, removing the characteristic of radioactive waste is the main objective of this paper. A secondary objective is recovery of enriched uranium for reintroduction into the production process, and finally, the proper disposal of the nitrate solution. Among the methods studied, chemical precipitation with hydrogen peroxide was chosen to remove uranium in solution. Preliminary experiments were carried out to evaluate responses and then a rotational central composite design (RCCD) was carried out to find the optimum point for treating this solution, considering the greatest uranium precipitation and consequent removal in the solution as optimal. All analyses to identify uranium were performed by means of plasma optical emission spectrometry - ICP OES. As a result, maximum removal was achieved by precipitation with hydrogen peroxide at 200 g/L, pH 1.75, with a reaction time of 8 hours, where 99.7% of the uranium solution was removed. Thus, the initial solution had 13.9 g·L-1 and 36·10-3 g·L-1 of uranium enriched in solution remained. The precipitation with hydrogen peroxide was efficient in removing uranium in uranyl nitrate solution. With the treatment applied, it was possible to economically recover uranium, previously in solution, since it can be returned to the production process for the production of UO2 tablets, estimating the possibility of recovering up to 63 kg of enriched uranium, which corresponds to approximately US$ 4,000.00. The release value for liquid solutions containing uranium is 5·10-3 g·L-1. For future studies, there is the possibility of carrying out a new stage of precipitation treatment for final polishing of this solution, with the application of ion exchange to achieve the release value as non-radioactive waste.

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Session Classification: Solutions for Specific Wastes

Track Classification: 3. Solutions for Specific Wastes