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Production of ²⁶Al, ⁵⁹Ni, ⁴⁴Ti, ⁵³Mn and ⁶⁰Fe from proton irradiated copper beam dump

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The station for pions cancer therapy was operated at PSI from 1980 to 1992. For this period the copper beam dump of the facility received a total dose of approx. 0.16 Ah of 590 MeV protons. The sampling collected about 500 g of high active copper chips that can be used for separation of exotic radionuclides. The γ analyses showed main nuclides present to be ⁶⁰Co, ⁵⁴Mn, ²²Na, ⁶⁵Zn and long lived ⁴⁴Ti with a daughter nuclide ⁴⁴Sc. Further analyses by LSC and AMS demonstrated that significant amounts of ²⁶Al, ⁵³Mn, ⁵⁹Ni, ⁶³Ni, ⁵⁵Fe and ⁶⁰Fe are present in the copper beam dump. The analytical results estimate that about 100 MBq ⁴⁴Ti, 500 MBq ⁵³Mn, 7 kBq ²⁶Al, 8 MBq ⁵⁹Ni and 5 kBq ⁶⁰Fe are available in the collected copper chips [1].

Due to the high activity of ⁶⁰Co, approx. 5 GBq in total, the separation should be implemented using a hot cell. The purpose of this work is to develop a simple, selective, efficient and easy method for the separation of ²⁶Al, ⁵⁹Ni, ⁵³Mn, ⁴⁴Ti and ⁶⁰Fe from gram amounts of the copper beam dump.

For the separation of the exotic radionuclides from the copper beam dump, a procedure combining selective precipitation, ion exchange and solvent extraction was developed. Copper as the main matrix element interferes with the separation of all elements of interest. For this reason, after the copper dissolution in 7 M HNO₃ the solution is conditioned to 1 M HNO₃ and Cu (II) is precipitated selectively by saturation with H₂S, while the exotic radionuclides remain in the solution. Further the solution is transferred in 12 M HCl and passed on Dowex 1x8 anion exchange column. Al and Ni are not retained and are washed out of the column with 12 M HCl. The remaining ions are eluted consequently in the following way, Mn–10 M HCl, Ti–8 M HCl, Co–5 M HCl, Cu–2.5 M HCl and finally Fe with 0.5 M HCl. Finally Al is separated from Ni on Dowex 50x4 cation exchange column and Ni is purified with Eichrom Ni resin based on the traditional dimethylglyoxime precipitation chemistry. The proposed separation procedure is easy for remote controlled implementation in a hot cell. The ion exchange separation of Ni, Al, Mg, Ti and Fe is complete and high decontamination factors for copper and cobalt were achieved.

The full scale system is installed in a hot cell where high activity levels could be handled. During the test period 13.86 g in total of the proton irradiated copper beam dump were processed for separation of ²⁶Al, ⁵⁹Ni, ⁴⁴Ti, ⁵³Mn and ⁶⁰Fe. The results showed the system is operational and the radionuclides separation is selective with high chemical yield. The procedure manages as well the generated liquid wastes containing high level of 60Co activity, reducing drastically their volume.

1. D. Schumann et al., Radiochim. Acta, 97 (3) 2009

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