Measurement of the Activation Product ^{93}Mo via AMS

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Radioactive waste has to be characterized qualitatively and quantitatively before further processing or final disposal. For the long-term characterization of waste, nuclides with half-lives $> 100 - 1000$ yr have to be considered in the first place. Some of them are decaying only via β^--decay or EC (electron capture). It is a challenging task to measure these nuclides at low concentrations, i.e. in the order of mBq. Many of these nuclides are only estimated mathematically on the basis of models which use nuclide vectors that are linked to so-called key nuclides. One of the radionuclides in this framework is ^{93}Mo [1].

Radioisotopes in nuclear waste can be classified as fission and activation products. ^{93}Mo is a pure activation product because it is shielded from fission by the stable isobar ^{93}Nb. Molybdenum is widely-used in steel alloys and ^{93}Mo can be produced mainly via the (n,γ) reaction on ^{92}Mo (14.84 % nat. abundance). It decays with a half-life of $(4.0 \pm 0.8) \cdot 10^3$ yr via pure EC into ^{93}Nb [2].

Therefore we aimed to develop a method to measure ^{93}Mo by AMS.

As a first sample we measured steel (20NiMoCr36) from the dismantled pressure vessel of a nuclear power plant. The mass fraction of molybdenum in this material is 0.6 %. We developed an efficient chemical separation scheme on the basis of ion chromatography to extract Mo from the steel (Fig. 1). The best chemical form for AMS was MoO_3 which was pressed volumetrically 1:1 with pure copper powder, see [3].

As AMS normally is used as a method to determine isotope ratios relative to a standard we had to prepare a reference standard. We irradiated enriched ^{92}Mo (97.37 %) at position "Strang 2" at the FRM II for 1800 s. Data for the thermal cross section (σ_{th}=0.019 barn) and the resonance integral (σ_{epi}=0.81 barn) were taken from [4]. The thermal neutron flux was determined by gold foils to $1.52 \cdot 10^{13}$ $s^{-1}cm^{-2}$, the epithermal flux to $9.6 \cdot 10^8$ $s^{-1}cm^{-2}$. Thus the standard yields a ratio of $4.7 \cdot 10^{-10}$ ^{93}Mo/^{92}Mo. Only 5 mg were irradiated in this test experiment.

The blank material as well as the sample showed a contamination with the isobar ^{93}Nb of more than a factor of 100 in comparision to commercial blank material. The upper limit of this blank was $4.5 \cdot 10^{-10}$. The achieved isobaric suppression of the ionisation chamber was about $5 \cdot 10^4$. We deduce an upper limit for ^{93}Mo/^{92}Mo of $< 2 \cdot 10^{-9}$ for the steel sample where we had only very little material available at that time.

Until now the chemical procedure has not been optimized for a separation of the interfering isobar ^{93}Nb. The comparison with the commercial blank shows however that there is room for improvement. A handicap of this first test was the lack of large amounts of reference material. This will be overcome in a future experiment.

The measured upper limit ^{93}Mo/^{92}Mo of $< 2 \cdot 10^{-9}$ is in the range of the estimation via the standard programs used for the calculation of the ^{93}Mo activity. Further experiments will give more precise values for the production of ^{93}Mo.

The project is funded by the BMBF (signature 02S8376).

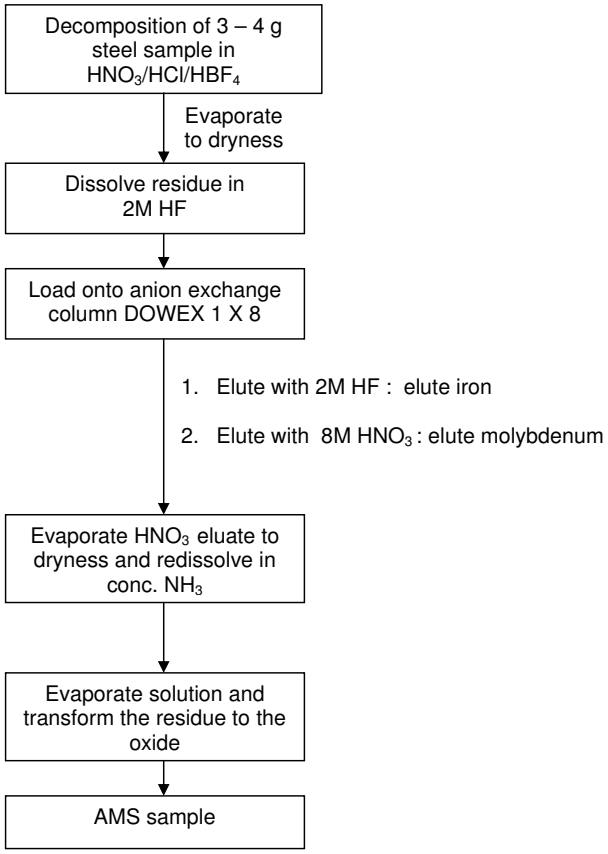

Fig. 1: Flow chart of the applied chemical separation [3].

References

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