Production and Purification of Radiotracer 236gNp for Environmental Applications

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Background
The majority of the United Kingdom’s radioactive waste, approximately 95%, originates from the nuclear power industry (Defra, 2004). This waste occurs not only as a result of the production of nuclear fuel but also from the operation of nuclear reactors, spent fuel reprocessing, research and development activities and decommissioning of old facilities.

What are Radiotracers?
Radioactivity is essentially independent of pressure, temperature, physical and chemical state and can be used under extreme conditions. For most radioisotopes the radiation can be measured independently of the matrix, eliminating the need for calibration curves. In some experiments to estimate chemical recoveries, which require knowledge of the presence and concentration of a specific element or compound at a certain place and at a specific time can only be obtained through the use of a radioactive tracer.

Why produce 236gNp Tracer?
236gNp is used as an isotope dilution tracer for quantifying trace amounts of Np in environmental samples. Each year hundreds of kg of 237Np are released into the environment from nuclear power stations as well as nuclear weapons. Nuclide 237Np is formed from the decay of other transuranium elements hence 237Np isotopes studies are key. Analytically, the accurate determination of transuranic and other alpha-emitting radionuclides in environmental samples requires the use of appropriate means, such as tracers to monitor yields.

The use of 236gNp is attractive as it can be used as isotope dilution tracers for quantifying trace amounts of Np in environmental samples and is measureable by γ and mass spectrometry. By employing mass spectrometric measurement techniques it is possible to use 236gNp to quantify for 237Np.

What is the optimum method of separation?
Chemical Separation of three targets 236U, 236Pu and 236U

The irradiated target cooled for 5 days to reduce operator dose where the short-lived radionuclides decay and initial work was carried out in disposable glove box to minimise risk from contamination.

Ion-Exchange Chromatography
The principle of ion-exchange chromatography is centred on the principle that molecules within the medium are separated according to their respective charge. The column packing consist of charged functional groups covalently bound to an insoluble support, and mobile counterions which are associated with the functional groups because of their opposite charge.

Solvent extraction
An aqueous sample is shaken with TTA-Xylene containing organic extractants. The extractant removes the analyte from aqueous phase, whilst leaving interfering ions. Sample was then placed on a hot plate and fumed to dryness

Conclusions
Regarding yield and purity it is decided that the optimum irradiation condition for production of the radiotracer 236gNp was the irradiation of the 236(d)U target, which yielded the greatest amount of Bq of 236gNp and did so with the highest level of purity in regards to 238Pu.

Regarding the optimum chemical separation technique of the irradiated targets for production of radiotracer 236gNp it was found that ion-exchange resins were the desired method of separation, and that the solvent extraction separation simply did not yield sufficient chemical separation.

Further Work
Decay time after EOB

To improve purity the irradiated target could have potentially been allowed to settle for a few weeks, in order to allow many of the short-lived fusion products to decay away. In order to attain high isotopic purity of 236gNp the chemical separations should be performed as soon as possible after the end of bombardment in order to avoid formation of 238Pu. However the timing of the chemical separation would have also had to take in account the factor of in-growing decay whereby fission products merge.

References