Separation of molybdenum and technetium

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Introduction

• After the production of 99mTc via the 99Mo(2n)99mTc reaction, there is a requirement to separate 99mTc from bulk 99Mo. There are two challenges with this compared to commonly used generator systems; (i) the large amount of 99Mo with respect to the 99mTc and (ii) the necessity of separating the expensive, highly enriched 99mTc in a pure state for quantitative recycling.
• Although a number of separation methods (Liquid – liquid extraction, thermochromatographic separation etc.) have been demonstrated, the possibility of using a cartridge based system is particularly attractive for routine use in a GMP regulatory environment.
• Aqueous Biphasic Extraction Chromatography (ABEC™) was developed for selective ion (TeO₂⁻) removal from nuclear waste [1]. Long polyethylene glycol chains bonded onto a water insoluble backbone yielded a Solid Phase Extraction (SPE) resin where pertechnetate was selectively adsorbed onto the resin from the strongly ionic solution while other more hydrophilic ions were not retained. Elution of the adsorbed pertechnetate was accomplished with deionized water according to Hydrophobic Interaction Chromatography (HIC) theory [2].
• This work uses ABEC™ as a starting and reference to explore a variety of other synthetic and commercially available hydrophobic resins.

Results

Solid Phase Extraction: Pertechnetate Adsorption and Desorption

• PS-DVB-PEG Resin synthesis [1]. The synthesis consists of grafting polyethylene glycol (PEG) to polystyrene beads.
  1. Pre-swell the PS beads in diglyme (or THF) RT 15 min
  2. Add PEG
  3. 50°C 1 hour
  4. Add sodium hydride at 35°C
  5. Heat to 70°C for 17 hours

Methods

PS-DVB-PEG resin synthesis [1].

• Loading solution consisted of 1.5M (NH₄)₂CO₃ 99mTc pertechnetate in NaCl eluted from a generator.
• Elution was performed with 10 ml DI H₂O unless otherwise stated.
• All cartridges were conditioned according to manufacturers instructions and subsequently with 3M (NH₄)₂CO₃

Degradation Analysis: PS-DVB-PEG

Polyethylene glycol is reported to be susceptible to free radical oxidation which leads to low molecular weight degradation products [3].

Method:
The same PS-DVB-PEG-5000 cartridge was used in a series of experiments. The loading solution consisted of 1.5M (NH₄)₂CO₃ 6% H₂O₂, and 99mTc-pertechnetate in NaCl eluted from a generator H₂O₂ content was experimentally measured to mimic the residual after the target plate dissolution step. The cartridge was washed with 1M Na₂CO₃ before the elution step.

Results:
• No effect was observed on adsorption or desorption of pertechnetate.
• After seven loadings the back-pressure from the cartridge increased, leading to longer loading and elution times.
• Ammonium salts might be deposited in the resin.
• For the last data point (Run #9) the elution was never finished due to the resin resistance.

Conclusions

• Both adsorption and desorption of pertechnetate on Analig® Tc-02 (IBC Advanced Technologies Inc.) were found unsatisfactory under these non-optimized conditions. Hot H₂O was found to increase desorption, however not to completion.

Molybdenum Breakthrough Analysis

• As expected the PEG resins all exhibited very low 99Mo retention and thus low breakthrough to the Tc fraction. The highest breakthrough observed was 0.08% for any PS-DVB-PEG resin.
• Analig® Tc-02 had a breakthrough of 0.2%, while the H-P cartidge adsorbed 0.4% of the 99Mo.
• Oasis® HLB did not adsorb 99Mo molybdate.

• HIC-SPE with PEG as stationary phase is an efficient and easily automated method to separate molybdate and pertechnetate.
• PEG degradation does not affect the performance of the resin.
• RP-SPE using Waters Oasis HLB shows promise for successful separation of molybdenum and technetium and work continues to extend this technology to readily available commercial SPE cartridges.

References


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