Measurement of Low Levels of Alpha in $^{99}$Mo Product Solutions

Cliff Conner, Matthew Liberatore, Jake Sedlet, and George F. Vandegrift

Argonne National Laboratory

Background

- RERTR -- Reduced Enrichment for Research and Test Reactors
- Goal: Substitute Low Enriched Uranium (LEU) for High Enriched Uranium (HEU)
- LEU contains <20% $^{235}$U
DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
99Mo Production

- 99mTc (t_{1/2} = 6 hr) the daughter of 99Mo (t_{1/2} = 2.7 day) is currently used in 3 million medical procedures annually in the U.S.
- 99Mo is produced by a 6.1% 235U fission yield. Currently HEU targets containing 93% 235U are used.

99Mo Production

- Process:
  - Uranium targets are irradiated in a reactor
  - Irradiated targets are dissolved
  - 99Mo is separated from uranium and fission products
  - Purified 99Mo is sent to generator manufacturer
99Mo Production

- Generator manufacturers load 99Mo onto alumina column and ship to hospitals
- Hospitals elute 99mTc off alumina column using saline solution leaving 99Mo behind

99Mo Production

- Product purity requirements for 99Mo are very stringent:
  <10^{-7} \mu Ci \alpha per mCi 99Mo
  <10^{-3} \mu Ci \beta/\gamma per mCi 99Mo
99Mo Production

- Problems associated with switching to an LEU target
  - Targets must contain ~5x more uranium than an HEU target to obtain the same amount of 99Mo
  - Targets generate ~30x more plutonium than HEU due to increased amount of 238U

99Mo Production

- Benefits of switching to LEU target
  - LEU targets contain ~50% less 234U than HEU targets
  - LEU targets require significantly less stringent safeguards measures
Measurement of $\alpha$

- Measurement of alpha in the $^{99}\text{Mo}$ product is difficult:
  - Sample for alpha contamination measurement contains $\sim 185\text{mCi}^{99}\text{Mo}$ and thus must contain $<41\text{dpm} \alpha$
  - $185\text{mCi}^{99}\text{Mo}$ has a significant radiation field

Separation of $\alpha$

- Separation of the alpha from the $^{99}\text{Mo}$ would make analysis much easier
- We have shown that the alpha emitting isotopes can essentially be quantitatively separated from $^{99}\text{Mo}$ on EiChrom’s TRU-Select resin using a modified EiChrom procedure
Standard Procedure

- Spike 10µL aliquot into 10mL 3M HNO₃/1M Al(NO₃)₃; add 1mL 0.6M Ferrous Sulfamate; add 200mg Ascorbic Acid; add variable amounts H₂C₂O₄
- Condition column using 5mL 2M HNO₃
- Load the column
- Scrub the column using 5mL 2M HNO₃
- Strip the column using 10mL 0.1M NH₄HC₂O₄

99Mo Profile (Standard Procedure)
99Mo Profile (Increased Oxalate)

- Spike 10μL aliquot into 10mL 3M HNO₃/0.2M Al(NO₃)₃/2.4M NaNO₃; add 1mL 0.6M Ferrous Sulfamate; add 200mg Ascorbic Acid; add variable amounts H₂C₂O₄
- Condition column using 5mL 2M HNO₃
- Load the column
- Scrub the column using 5mL 2M HNO₃
- Strip the column using 10mL 0.1M NH₄HC₂O₄

99Mo Profile (Increased Oxalate)
**99Mo Profile (Oxalate Scrub)**

- Load the column (reduced volume)
- Scrub the column using: 20mL 3M HNO₃/1M Al(NO₃)₃; add 2mL 0.6M Ferrous Sulfamate; add 400mg Ascorbic Acid; make 0.1M in H₂C₂O₄
- Scrub the column using 5mL 2M HNO₃
- Strip the column using 10mL 0.1M NH₄HC₂O₄
Actinide Profile (Oxalate Scrub)

Future Experiments

- Verify neptunium follows uranium and plutonium
- Verify that technetium follows molybdenum
- Verify quantitative electrodeposition of actinides from column strip solution
Conclusions

- Molybdenum can effectively be separated from uranium and plutonium using TRU-Resin.
- Separation of the $^{99}$Mo from the actinides will reduce the analyst’s exposure and simplify analysis for the actinide elements.