Abstract

- The Facility for Rare Isotope Beams (FRIB) produces high-purity radioactive ion beams for nuclear science experiments
- During the beam purification process, byproduct radionuclides will accumulate along the beamline
- Collecting, purifying, and using these radionuclides is called isotope harvesting
- Preliminary isotope harvesting efforts on the aqueous collection of $^{92}$Zr, $^{95}$Y, $^{88}$Zr, and $^{97}$Zr have been performed
- In this work, the viability of isotope harvesting using solid collection of $^{92}$Zr was examined when $^{92}$Zr beam was stopped in a series of collectors comprising of Al, Cu, W, and Au
- $^{92}$Zr was radiochemically recovered from the collectors with yields exceeding 80% and decontamination factors on the order of $10^4$
- For elements of interest that readily hydrolyze in near-neutral pH aqueous conditions, such as Zr, harvesting through solid-phase collection has been shown to result in higher recovery yields compared to aqueous harvesting

Introduction

- FRIB will accelerate beams of nuclides up to uranium for nuclear science research
- A large variety of isotopes will accumulate from normal operation
- Byproduct isotopes can be purified for other uses, called isotope harvesting
- Many exotic radionuclides will become available for use in applications such as:
  - Fundamental nuclear physics
  - Nuclear medicine
  - Astrophysics
- Up to 90% of unreacted primary beam deposits into aqueous beam dump when in use
- Radionuclides will accumulate at various points that can allow for harvesting
- Radionuclides that have difficult aqueous chemistry may be harvested better from solid components

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8$^2$Zr Beamtime

1. $^{92}$Zr beam generated from fragmentation of a stable 140 MeV/u $^{48}$Mo beam
2. $^{92}$Zr implanted into targets containing Al, Cu, W, and Au foil stacks
3. Foils analyzed with HPGe detector
4. Radiochemical separations performed on foils to isolate $^{92}$Zr and $^{94}$Y

Harvesting $^{92}$Zr from Al

1. Al foil with $^{92}$Zr dissolved in HCl and HNO$_3$
2. Al reconstitution and precipitation
3. Anion exchange column to separate Al and $^{92}$Zr
4. TODGA column to separate Cu and $^{94}$Y

Harvesting $^{92}$Zr from Cu

1. Cu foil with $^{92}$Zr dissolved in HNO$_3$
2. TOPO in n-dodecane solvent extraction of $^{92}$Zr
3. $^{92}$Zr in organic layer washed
4. $^{92}$Zr back extracted in 1 M HCl
5. TODGA column to separate Cu and $^{94}$Y

Conclusion

- $87\% \pm 5\%$ $^{92}$Zr recovered from Al and Cu
- $>3$x increase in $^{92}$Zr recovery compared to aqueous harvesting efforts
- $92 \% \pm 4\%$ $^{94}$Y recovered from Al and Cu
- Another tool for harvesting from decommissioned parts from RI Beamlines

Future Work

- Harvesting methodologies for $^{92}$Zr will be adapted to a microfluidics liquid-liquid extraction system for rapid Zr isotope harvesting
- Valuable, short-lived isotopes of Zr, such as $^{92}$Zr or $^{94}$Zr, can be harvested from FRIB, but will require rapid separation methods

Acknowledgments

This research is supported by the US Department of Energy Isotope Program, managed by the Office of Science for Isotope R&D and Production under contract DE-SC0020161 and DE-SC0021220. This work was performed under the auspices of the US Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. At MSU, this work was supported by the Core R&D Support for Isotope Harvesting at FRIB as part of the DOE SC-Isotope Program under Contract DE-SC0021220. This work was supported in part by Department of Energy Isotope Program’s Grant DE-FC02022550, the Horizon-broadening Isotope Production Pipeline Opportunities (HIPPO) program.