**Ph.D. Dissertation Proposal: Paul Mendoza**

**Dissertation Title:** Experimental Characterization of Pu Separation by PUREX Process on a Low-Burnup, Pseudo-Fast-Neutron Irradiated DUO2 for Product Decontamination Factors and Nuclear Forensics

1. **Introduction**

In the wake of the Iran deal, North Korea’s pursuit of nuclear weapons, and the onset of the Islamic State of Iraq and Syria, considerations for nuclear proliferation reemerge. A nonproliferation focal point is the control and accounting of weapons useable material. Nuclear safeguards have long been the responsibility of the International Atomic Energy Agency with the express goal of promoting the safe and peaceful use of nuclear technologies1. Although these efforts, backed by an “atoms for peace” mentality and the treaty on the non-proliferation of nuclear weapons, have hindered the development of weapons in some states2, efforts beyond safeguards prevention are necessary due to “the awful arithmetic of the atomic bomb”3. An effort, a few steps after, or potentially outside of, safeguards, but before detonation, is interdicted material origin attribution.

Previously, computational studies have indicated that analysis of contaminants in Plutonium Uranium Recovery by Extraction (PUREX) processed plutonium could give indications of material origins.4 Unlike enrichment of U235, Pu239 “enrichment” involves neutron irradiation, which introduces radioactive fission products and hence, purification by some means. Purification by PUREX is most common for low enriched uranium fuel5 - important because U238 converts to Pu239 upon neutron capture. Material attribution is complicated by purification due to varying and unknown elemental decontamination factors (DFs, a measure of purification).

The problem of attribution for unpurified material has been previously studied4, 6, 7, ideally, if elemental DFs for interdicted plutonium were determined, then these previous methodologies could be used to narrow material origins by applying these correction factors, assuming DFs for different isotopes of the same element are equal.

1. **Objectives**

The objective of this research is to determine DFs and distribution coefficients (DCs, the ratio of concentrations between organic and aqueous phases) for a developed benchtop scale PUREX process for important attribution elements noted in previous research (Cs, Eu, Rb, Sr, Nd, Pm, Sm, U, and Pu).4 Both DCs and DFs will be determined for this process so that the two parameters will be experimentally connected to the specific PUREX process utilized. This establishment is important because mathematically, DC values, coupled with process information, can be used to calculate a reasonable estimate of a DF8-11, but experimentally, this connection has never been publically discussed for the PUREX process.

(I think this is mostly due to complications in bridging the gap between controlled experiment and practice. Most reported numbers from experiments are for steady state, equal contact volumes systems. Also practical reprocessing plants have constantly changing concentrations – this precise point is what makes mathematically determining DFs for systems so difficult, the number is measured, and reported.)

Further, this research purposes to determine DCs for the above elements at 4 different concentrations of nitric acid starting solution, and for two different aqueous/organic mixing times with the original nitric acid concentration.

These are important because if the above connection were established, these numbers are all that are neede.

1. **Present Status of the Question**

Summarize your literature review. What is the pertinent previous research in this field? Include citations.

While DCs for the various process steps of PUREX have been previously reported, details about elemental DFs for PUREX cycles have been largely limited to the major activity contributors, such as 106Ru and 95Zr12, or the heavy metal elements (Th, U, Pu)13.

1. **Procedure**

Describe your general solution method. If your work is experimental, give the nature of the data you will collect and how you will analyze it. If your work is computational, include a description of how you will verify your methodology (test cases, simulations, sensitivity analysis, etc.).

1. **Expected Results**

Include work already done and what you expect to see in the remaining work. Also talk about risk management – if something doesn’t work as expected, are there alternative soluitons?

1. Fischer D. History of the International Atomic Energy Agency. The First Forty Years. 1997.

2. Mozley R. The Politics and Technology of Nuclear Proliferation: University of Washington Press; 1998.187-188

3. Eisenhower DD. Atoms for Peace speech. Voices of Democracy. 1953.

4. Chirayath SS, Osborn JM, Coles TM. Trace Fission Product Ratios for Nuclear Forensics Attribution of Weapons-Grade Plutonium from Fast and Thermal Reactors. Science & Global Security. 2015;23(1):48-67.

5. Benedict M, Levi H, Pigford T. Nuclear chemical engineering. 2nd ed: McGraw-Hill Pulishing; 1982.477

6. Scott MR. Nuclear forensics: attributing the source of spent fuel used in an RDD event: Texas A&M University; 2005.

7. Glaser A. Isotopic Signatures of Weapon-Grade Plutonium from Dedicated Natural Uranium-Fueled Production Reactors and Their Relevance for Nuclear Forensic Analysis. Nuclear Science and Engineering. 2009;163(1):26-33.

8. Colburn AP. Simplified calculation of diffusional processes. general consideration of two-film resistances. 1939;35:211-36.

9. Sherwood TK, Pigford RL. Absorption and extraction. 2d ed: New York : McGraw-Hill; 1952.

10. Long JT. Engineering for nuclear fuel reprocessing: New York : Gordon and Breach Science Publishers; 1967.162-272

11. Perry RH, Green DW. Perry's chemical engineers' handbook. 8th ed. New York: McGraw-Hill; 2008.

12. Stoller S, Richards R. Reactor handbook, volume II, fuel reprocessing. Inter science Publishers, Inc, New York. 1961:107-234.

13. Siddall TH, Prout WE, Parker SG, Commission USAE, Savannah River L, Nemours EIdPd, et al. Equilibrium distribution data for purex and similar extraction processes: E.I. du Pont de Nemours & Co., Explosives Dept., Atomic Energy Division, Technical Division, Savannah River Laboratory; 1957. 27 p. p