Fission Product Transmutation in Mixed Radiation Fields

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Abstract

This work aims to demonstrate that electron accelerator driven photonuclear reactions are a viable means to transmute a significant portion of US nuclear fission product wastes, particularly ^{99}Tc and ^{129}I. Two teams at two institutions will collaborate in an effort to provide computational and experimental support for this concept. The Advanced Energy Technologies Research Group at Texas A&M (ATERG) will be responsible for calculations, modeling and optimization of transmutation scenarios and The Idaho Accelerator Center at ISU (IAC) will provide basic data acquisition for benchmarking and experimental conformation of transmutation yields as well as tested designs for converter and transmutation target structures. Final results will be quantification of relevant nuclear data and cost benefit uncertainties associated with transmutation scenarios for ^{99}Tc and ^{129}I.

The proposed project explores available transmutation options for FPs taking advantage of radiation fields in photonuclear driven gamma/neutron sources. Multi-kilowatt, electron accelerator driven sources with beam energies of ~ 50MeV can produce copious high energy photons of >10 MeV energy which couple strongly with the giant resonance region in nuclei to produce transmutation reactions. In addition, with proper converter target design, > 10e12/kW fast fission spectrum neutrons can be generated. Thus mixed fields are made available in which neutron to photon ratios may be varied.

^{99}Tc and ^{129}I, the major risk/dose components of used fuel, can be transmuted to shorter half life species in such fields: (n, γ) and (γ, n) reactions are useful for ^{129}I 'burn-up', only (n, γ) with (γ, n) suppressed, is useful for the burn-up of ^{99}Tc. Nuclei whose atomic numbers bracket ^{99}Tc and ^{129}I will serve as surrogates to establish transmutation yields. High power experiments will establish scalable data on thermal issues in converters and transmutation target structures. Basic data can be obtained using specialized facilities for precision nuclear measurements. Radio chemistry facilities are also available.

The irradiation optimization includes quantification of favorable conditions and evaluations of their achievability in accelerator driven schemes. The Texas A&M team has its own codes and computers and has access to A&M's supercomputing facilities as well as computational capabilities and codes in the Department of Nuclear Engineering. The objectives are to: evaluate and optimize mixed accelerator-produced radiation field scenarios and electron beam targets for efficient transmutation of FPs in mixed γ/n fields with calculation and suggest benchmark experiments; and quantify nuclear data uncertainties associated with realistic transmutation scenarios.

This work will explore nuclear physics solutions to the challenge of transmuting high risk fission products in order to reduce the nuclear waste management burden. Success will allow for engineering time scale disposal options vs. traditional geological timescale disposal options. The proposed project is directly relevant to FC-3 goals as it contributes to the advanced nuclear waste management methods. The proposed work scope will be accomplished within 3-years, taking advantage of the project team experience in photonuclear R&D and FP management experience.