DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-21-056

SECTION A. Project Title: Multi-Principal Alloy Fuels for Fast Reactors

SECTION B. Project Description and Purpose:

Project description/abstract:

This project will explore the fabrication and microstructure of a uranium bearing multi-principal element alloy (MPEA) for use as a high-assay low enriched uranium fuel material. The incentive of these compositions is to create an alloy system that remains single phase from room temperature through anticipated operation temperatures as to improve fuel performance and predictability The alloy samples will be fabricated from a variety of means using depleted uranium, including spark plasma sintering and arc melting. Samples will be characterized in the as cast/sintered conditions as well as after annealing heat treatments. The objective of the characterization will be to determine the stable and meta-stable phases of the material as a result of fabrication methods and heat treatment. Characterization will include scanning electron microscopy (SEM), x-ray diffraction (XRD), indentation hardness measurements, and energy dispersive x-ray spectroscopy (EDS/EDX).

The purpose of this LDRD is to explore ways to increase the temperature window of stability by introducing U as an alloying component in an MPEA that is also neutronically favorable for use as a fuel.

Research Plan:

Task 1: This work assesses potential alloys. It is currently expected that the use of certain elements (Mo, Nb, Ti, V, & Zr) could result in a stable BCC structure with U throughout the temperature range of interest. However, there are likely other elements that could also be included in this. This task will assess the materials based upon existing phase diagrams, literature surveys, and possibly thermodynamic analysis using the CALPHAD method (calculation of phase diagrams) to determine phases with U and potential MPEA elements (both refractory and 3D transition metals). This assessment will also utilize information from the Evaluated Nuclear Structure Data File (ENSDF) databases for alloy compatibility within a reactor environment (e.g., cross section, transmutation, and fission yield data). This task should recommend the fabrication of at least two potential alloys with U (input to Task 2) and potential future alloys with Th. A secondary output of this task will be to identify two different temperatures to perform annealing based upon potential meta-stable phases or phase transitions within the composition systems (input to Task 4).

Task 2: Alloys will be fabricated using multiple methods. The first emphasis will be to explore the differences between spark plasma sintering and arc melting. Additional sample fabrication may be attempted using the LENS additive manufacturing system. All three of these methods will be performed at the Materials and Fuels Complex (MFC) at either the Fuels and Applied Science Building (FASB) or the Advanced Fuels Facility (AFF). The initial powders and as-fabricated materials will all be characterized in Task 3.

Task 3: As-fabricated materials characterization will include x-ray diffraction (XRD) and scanning electron microscopy (SEM) analysis at the Irradiated Materials Characterization Laboratory (IMCL) located at MFC. These methods will document the crystal structure, phase homogeneity, and chemical homogeneity of the materials from all fabricated materials. The results of this task will determine any differences between fabrication method and any potential differences in material performance as a result of differing microstructures and homogeneity.

Task 4: All materials will undergo two different heat treatments to determine the stability of the as-fabricated materials. Each material will be split into two separate groups for two different heat treatments as determined by Task 1.

Task 5: Post-annealing characterization will include XRD and SEM analysis. These methods will complement the results from Task 3 and will validate any of the assumptions from the thermodynamic assessment in Task 1. The results from this task will also provide a final assessment for the viability of the alloys as a potential fuel. Successful compositions will be recommended for further testing using irradiation methods (i.e., a drop-in capsule irradiation in the Advanced Test Reactor).

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

The spark plasma sintering (SPS) process will take place in MFC-784 (AFF). The exhaust of the SPS furnace is tied into our facility radiological exhaust system. The facility exhaust is ran through several series of HEPA filter banks prior to its emission. Arc melting will take place in MFC-787 (FASB). The arc melting furnace is contained within a radiological glovebox in FASB. The exhaust of the glovebox is again tied into that facility radiological exhaust system, which is again ran through several series of HEPA filter banks prior to its emission. These minor emissions would be covered by the facilities existing APADs.

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

N/A

Generating and Managing Waste

Small amounts of low level and industrial waste may be generated (estimated at ~2 ft3) from personal protective equipment, wipes, and sample debris.

Releasing Contaminants

When chemicals are used during the project there is the potential for spills that could impact the environment (air, water, soil).

Using, Reusing, and Conserving Natural Resources

All materials would be reused and recycled where economically practicable. All applicable waste would be diverted from disposal in the landfill where conditions allow. The project would practice sustainable acquisition.

SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification: Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not “connected” to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

References:
10 CFR 1021, Appendix B to subpart D, items B3.6, "Small-scale research and development, laboratory operations, and pilot projects"

Justification:
The proposed R&D activity is consistent with CX B3.6 "Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); smallscale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed area (where active utilities and currently used roads are readily accessible). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment."

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) ☐ Yes ☒ No

Approved by Jason Anderson, DOE-ID NEPA Compliance Officer on: 04/21/2021