

SECTION A. Project Title: Redox Chemistry of UO₂ under Repository Relevant Conditions in the Presence of Zircaloy and Waste Canister Material – University of California, Irvine**SECTION B. Project Description**

The University of California, Irvine (UCI) proposes to investigate how the redox chemistry of UO₂ in contact with cladding and waste container material determines the matrix corrosion of spent nuclear fuel (SNF) in a deep geological repository. By advancing the macroscopic and microscopic understanding of UO₂ redox chemistry in a deep geological repository (DGR), the proposed project will advance the current state of the art for waste isolation in a generic deep geological environment and thus support the DOE mission of investigating and evaluating the safety of a DGR. The proposed research will evaluate a later stage of a DGR after waste canister corrosion has occurred and SNF is in contact with groundwater. To derive an understanding of processes governing the immediate near-field of SNF, this project aims to study UO₂ ceramics mimicking SNF in the presence of cladding material (Zircaloy-4) and waste container material (316 SS) in deionized (DI) water and synthetic ground water. To unravel the different influences of e.g., the waste container material, the backfill material, as well as the alpha radiolysis of SNF towards the SNF corrosion behavior under repository relevant conditions in case of canister failure, corrosion studies of each of the individual parameters are necessary. Only if the role of the individual parameters on UO₂ corrosion are understood, the data for a complex system in which all of the effects overlap with each other can be reliably evaluated. A bottom-up approach of hydrothermal corrosion experiments including cladding material, waste container material and both material classes in contact with UO₂ will enable researchers to gain insights into how the redox chemistry of uranium is influenced by the presence of iron species originating from the corrosion of the waste container material. Analysis of changes in the fluid composition due to corrosion will reveal insights about the evolving redox conditions. In addition, the corrosion behavior of UO₂, Zircaloy-4, and 316 SS in contact with DI water and synthetic Mont Terri ground water at elevated temperatures and pressures will be followed by structural and microstructural analysis of the formation of secondary phases at the fuel groundwater, fuel/cladding and canister material interfaces. The experimentally derived data about secondary phase formation will be utilized for phase relationship analysis to decipher the redox conditions. These will contribute to closing knowledge gaps about the aqueous mobility of uranium as well as other redox sensitive fission products (FP) present in SNF which are dependent on the prevailing redox conditions and buffer capacities of the system.

SECTION C. Environmental Aspects / Potential Sources of Impact

Small quantities (<100 g) of depleted and/or natural uranium bearing material will be handled at UCI to fabricate UO₂ specimens for the experiments. The radiochemistry laboratories of the PI are designed for and equipped with the infrastructure, e.g., radiological fume hoods for handling these amounts of UO₂ safely. The samples will also be characterized at UCI where all instruments are covered under a Radiation Use Authorization plan to ensure safe handling of the specimens which is approved by the Environmental Health and Safety Department at UCI. The radioactive material use, and waste generation will be authorized under a Radioactive Material License under the State of California and follow approved procedures. The vendor which is used by UCI to dispose radioactive waste is Thomas Gray & Associates, Inc. Furthermore, part of these samples will be shipped to Oak Ridge National Laboratory using approved methods and protocols for Focused Ion Beam and Transmission Electron Microscopy measurements. All procedures for material handling and disposal will be approved by the Environmental Health and Safety departments at all sites, and work will be conducted according to approved procedures. Secondary and tertiary containment will be used for shipping to prevent material release in case of a mishap. Material will be disposed of according to approved protocols. No release or significant environmental impact is expected from the use of radioactive material. All Chemicals will be stored in appropriate areas of the labs. Chemical waste will be disposed using existing Chemical Waste Generation systems at UCI. Chemicals used for this work will include lab grade salts of low hazard and dilute (<5%) acids. Quantities used will be less than 20 L. Hazardous waste generated will be below 25 L and will be disposed of using existing Hazardous Waste Generation systems at the University of California, Irvine.

SECTION D. Determine the Level of Environmental Review (or Documentation) and Reference(s): Identify the applicable categorical exclusion from 10 CFR 1021, Appendix B, give the appropriate justification, and the approval date.

Note: 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, including requirements of DOE orders; 2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities; 3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; 4) adversely affect environmentally sensitive resources. In addition, no extraordinary circumstances related to the proposal exist which would affect the significance of the action, and the action is not “connected” nor “related” (40 CFR 1508.25(a)(1) and (2), respectively) to other actions with potentially or cumulatively significant impacts.

References: 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); and small-scale 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 or developed area (where active utilities and

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currently used roads are readily accessible). For purposes of this category, “demonstration actions” means actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment. Demonstration actions frequently follow research and development and pilot projects that are directed at establishing proof of concept.

Justification: The activity consists of an investigation of the conditions that control corrosion of UO₂ in the presence of cladding and waste container material in a generic DGR.

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 09/17/2021.