Accepted Manuscript

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PII: S0022-3115(17)30031-4

DOI: 10.1016/j.jnucmat.2017.07.051

Reference: NUMA 50423

To appear in: *Journal of Nuclear Materials*

Received Date: 4 February 2017

Revised Date: 17 May 2017

Accepted Date: 26 July 2017

Please cite this article as: H. Yang, D. Cui, D. Grolimund, V.V. Rondinella, R. Brütsch, M. Amme, C. Kutahyali, A.T. Wiss, A. Puranen, K. Spahiu, Reductive precipitation of neptunium on iron surfaces under anaerobic conditions, *Journal of Nuclear Materials* (2017), doi: 10.1016/j.jnucmat.2017.07.051.

Reductive precipitation of neptunium on iron surfaces under anaerobic conditions

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Keywords: nuclear waste, neptunium, iron canister materials, disposal, reductive precipitation

Abstract

Reductive precipitation of the radiotoxic nuclide ^{237}Np from nuclear waste on the surface of iron canister material at simulated deep repository conditions was investigated. Pristine polished as well as pre-corroded iron specimens were interacted in a deoxygenated solution containing 10-100 µM Np(V), with 10 mM NaCl and 2 mM $NaHCO_3$ as background electrolytes. The reactivity of each of the two different systems was investigated by analyzing the temporal evolution of the Np concentration in the reservoir. It was observed that pre-oxidized iron specimen with a 40µm Fe_3O_4 corrosion layer are considerably more reactive regarding the reduction and immobilization of aqueous Np(V) as compared to pristine polished $Fe^{(0)}$ surfaces. ^{237}Np immobilized by the reactive iron surfaces was characterized by scanning electron microscopy as well as synchrotron-based micro-X-ray fluorescence and X-ray absorption spectroscopy. At the end of experiments, a 5-8 µm thick Np-rich layer was observed to be formed ontop of the Fe_3O_4 corrosion layer on the iron specimen. The findings from this work are significant in the context of performance assessments of deep geologic repositories using iron as HLW canister material and are of relevance regarding removing pollutants from contaminated soil or groundwater aquifer systems.

1. Introduction

Nuclear energy can play an important role as a sustainable energy source and in alleviating the risk of global climate change [1]. However, the safe disposal of high level radioactive waste (HLW), including spent nuclear fuel (SNF) and glass waste from the nuclear power industry, is still a worldwide challenge. Several aspects need to be investigated in more detail in order to reduce uncertainties associated with proposed