

Scoping Experiments on Processing of Spent TRISO-Coated GEN IV Reactor Fuels

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INTRODUCTION

There has been renewed interest in coated-particle nuclear fuels for high-burnup, high-temperature, and hydrogen production applications.[1,2] In the various applications for reactors using these fuels, there are incentives to close the fuel cycle and recycle the fuel components. For example, in the case of uranium cycles, the fuel is typically enriched to ^{235}U fractions higher than those in light-water reactors and the spent fuel contains a uranium enrichment of up to 2% or more and thus retains a significant economic value. Plutonium-burning reactors achieve higher overall destruction of Pu when the unused portion is recycled for further burning. Any fuel containing fertile materials would produce fuel materials that—when recycled—extend the natural resources.

BACKGROUND

Tri-isotropic (TRISO)-coated fuels are comprised of an oxide, carbide, or oxycarbide fuel kernel coated with a porous carbon layer, a strong pyrolytic carbon layer, and a very tough silicon carbon layer. The SiC layer is usually coated with another pyrolytic carbon layer to provide a bonding surface with the carbon matrix used to fabricate fuel compacts. These fuel compacts are loaded into a machined graphite fuel element. Because there is only a relatively small amount of fuel in a sea of carbon that contains ^{14}C , processing these fuels to recover the fissile materials presents special problems.

Historical approaches to processing TRISO-coated fuel involved crushing and burning operations to reduce the fuel elements (thereby increasing the surface area), breaching the SiC layer, and removing the carbon components from the fuel as gaseous carbon dioxide.[3] The oxide fuel was then easily separated from the remaining SiC fragments by dissolution in nitric acid. The primary disadvantage of this method is the need to capture and sequester the ^{14}C -containing CO_2 . Sequestration using calcium hydroxide results in a large increase in the mass

and volume of waste compared with that of the original carbon.

DESCRIPTION OF THE ACTUAL WORK

A process has been proposed to separate the carbon from the fuel without oxidation of the carbon component.[4] This process relies on removing the fuel compacts from the graphite-block fuel element, grinding the fuel compacts to a very small particle size, and leaching the fuel components from the finely divided carbon, using methods similar to those industrialized for graphite purification.[1] The residual carbon waste and any undissolved residues can be consolidated into a compact waste form that has excellent characteristics.

The objective of this work is to study the feasibility of recovering fuel components from a pulverized fuel matrix. Preseparation of the compacts from the fuel block not only reduces the mass and volume of material to be processed but also eliminates nearly all the graphite, which reacts slowly with nitric acid to produce problematic organic acids.[5, 6] All tests will be performed with surrogates mixed in proportions similar to that of the fuel compacts. The proof-of-principle experiments will include leaching of uranium oxide from the crushed carbon to determine separations and carryover effects. Additional experiments with uranium oxycarbide will be performed to obtain similar data and also to ascertain what, if any, organic compounds might be formed that could interfere with solvent extraction processes (e.g., mellitic acid).

RESULTS

This paper will present a status and preliminary data obtained from the proof-of-principle experiments for the leaching step. Data will be presented on solution carryover and effects caused by organic acid production.

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