



HAL
open science

Densification study of Cr-doped UO₂ fuel pellets with addition of fission products surrogates

Antonin de Azevedo, Fabienne Audubert, Nathalie Moncoffre, Jacques Lechelle

► **To cite this version:**

Antonin de Azevedo, Fabienne Audubert, Nathalie Moncoffre, Jacques Lechelle. Densification study of Cr-doped UO₂ fuel pellets with addition of fission products surrogates. NuMAT 2024, Oct 2024, Singapour, Singapore. cea-04911634

HAL Id: cea-04911634

<https://cea.hal.science/cea-04911634v1>

Submitted on 24 Jan 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Densification study of Cr-doped UO₂ fuel pellets with addition of fission products surrogates

Antonin De Azevedo¹, Fabienne Audubert¹, Nathalie Moncoffre², Jacques Lechelle¹

¹ CEA, DES, IRESNE, DEC. Cadarache F 13108 Saint Paul Lez Durance, France

² Univ Lyon, Univ Claude Bernard Lyon 1, CNRS/IN2P3, IP2I Lyon, UMR 5822, F 69622, Villeurbanne, France

In current nuclear power plant reactors, energy is produced by the fission of uranium and/or plutonium isotopes, contained in oxide pellets made of single phase UO₂ or polyphase (U,Pu)O₂ (MOX). The fission reaction creates fission products that are contained inside the fuel. Those fission products are liable to be released out of the reactor in case of severe accident. The released amount depends on the thermodynamic conditions during the accident and on the chemical state of the fission products. This is why a deep knowledge of the fission products behavior in the fuel in case of accident is absolutely needed in order to anticipate and estimate the consequences of the accident. Some studies have been carried out to identify the chemical state and quantify the release of fission products in irradiated UO₂ and MOX fuels under different thermodynamic conditions [1], [2], [3], [4], [5]. However, irradiated fuels are highly radiotoxic, so their characterization is very complex due to the need of biological protections (shielded hot cells, remote manipulators...). In order to overcome these constraints, an innovative approach consists to synthesize simulated fuels (SIMFUELS), using virgin UO₂ and stable isotopes as fission product surrogates. Then the release of fission products under different thermodynamic conditions is studied with the same approach as for irradiated fuels [3], [6], [7].

UO₂ fuel doped with chromium is part of "E-ATF" (Enhanced Accident Tolerant Fuel). It is studied for its optimized behavior in case of accidents (power ramp) due to a larger grain size compared to a classic UO₂ fuel. Nevertheless, the added chromium is likely to react with some fission products and form volatile species that would not be present in non-doped UO₂ fuel. The speciation of fission products in a Cr-doped SIMFUEL is under study within the framework of the BENEFICIA (BEhavior of NEw Fuels In Case of Incidents and Accidents) project, supported by the ANR (French National Research Agency).

Therefore, the sintering process of Cr-doped UO₂ has been studied in order to control the microstructure of the pellets. Thus, some pellets have been synthesized under different conditions. The effect of chromium concentration and thermodynamic conditions during sintering on the pellet's microstructural characteristics will be discussed and compared to literature. Then, the addition of fission product surrogates (Ba, Ce, La, Mo, Sr, Y, Zr, Rh, Pd, Ru, Nd) into Cr-doped UO₂ pellets has been done by conventional sintering. The characteristics of the pellets thus obtained as well as the fission products phases will be also presented.

References :

- [1] H. KLEYKAMP, « The chemical state of the fission products in oxide fuels », Journal of Nuclear Materials, Amsterdam, p. 221 246, 1985.
- [2] Y. Pontillon, G. Ducros, et P. P. Malgouyres, « Behaviour of fission products under severe PWR accident conditions VERCORS experimental programme—Part 1: General description of the programme », Nuclear Engineering and Design, vol. 240, no 7, Art. no 7, juill. 2010,
- [3] C. Le Gall, « Contribution to the study of fission products release from nuclear fuels in severe accident conditions : effect of the pO₂ on Cs, Mo and Ba speciation ». Thèse, Université Grenoble Alpes, 2019
- [4] C. Le Gall et al., « Fission product speciation in the VERDON-3 and VERDON-4 MOX fuels samples », Journal of Nuclear Materials, vol. 530, p. 151948, mars 2020
- [5] E. Geiger et al., « Fission products and nuclear fuel behaviour under severe accident conditions part 2: Fuel behaviour in the VERDON-1 sample », Journal of Nuclear Materials, vol. 495, p. 49 57, nov. 2017
- [6] E. GEIGER, « Study of fission products (Cs, Ba, Mo, Ru) behaviour in irradiated and simulated nuclear fuels during severe accidents using X-ray absorption spectroscopy, SIMS and EPMA » Thèse, Université Paris-Saclay, 2016.
- [7] L. Balice, « Nuclear fuels in severe accidents : caesium speciation in simulated UO₂ fuels densified by SPS », Thèse, Université Grenoble Alpes, 2022