Research on the management of MTR spent fuel in the DMN-CAB-CNEA

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1. Introduction

Argentina is home to a number of research reactors situated across the country. The CNEA atomic centres are home to the most important, including RA-1 in Constituyentes, RA-6 in Bariloche, and RA-3 and RA-10 in Ezeiza, the latter of which is still under construction [1]. The spent fuels from these reactors are stored in pools located within the reactor buildings. RA-3, the radioisotope-producing reactor, requires more frequent fuel element replacements than the others. Initially, the spent fuels were stored in the DCMFEI deposit, but as of 2016, they are now stored in FACIRI [2]. Additionally, Argentina has several critical facilities, including RA-0 at the University of Córdoba, RA-4 at the University of Rosario, and RA-8 at the Pilcaniyeu Technological Complex [1]. In the RERTR program, all of the HEU's spent fuels have been returned to their country of origin [2].

Research Reactor Spent Fuel (RRSF) management is challenging due to the enrichment at discharge higher than 11% of 235U [3]. Due to criticality considerations and susceptibility to materials degradation, direct disposal is not considered a viable option for RRSF management [1]. The main idea of the process consists of the use of natural (or depleted) uranium oxide to achieve the 235U isotope dilution down to 1 wt.% [4].

2. Spent fuel conditioning

The National Radioactive Waste Management Program (PNGRR) established the Strategic Plan for Radioactive Waste Management, which outlined various proposals for managing spent fuels [2]. The DMN was responsible for conducting thermo-mechanical treatment of plates, isotopic dilution via the dry method, and then immobilizing it in glass matrices through sintering and melting, or in a ceramic matrix through sintering.

2.1. Glass matrices

We evaluated borosilicates, Iron borosilicates, and Iron phosphate glasses as potential matrices for immobilizing calcined RRSF. We conducted sintering tests using various loads of calcined and isotopically diluted materials, pressing pellets at 1.5 kg/cm2 and sintering them at temperatures ranging from 510 to 755ºC. We determined density through immersion and geometry, and assessed leaching behavior. The samples were then characterized using electron microscopy and EDS [5, 6].

2.2. Ceramic matrices

The U3O8 was selected for two objectives to achieve the 235U isotope dilution and seeking for a monolithic ceramic wasteform with triuranium octoxide as immobilization matrix [4]. The U3O8 precursor powder was obtained by two experimental Routes: R1_ by calcination of UO2-ex Ammonium uranyl carbonate (AUC) powder; R2_ by nitric dissolution of this UO2 powder, subsequent precipitation of ammonium diuranate (ADU) and final thermal conversion to U3O8. Finally, there were pressed at 752 MPa, in a stainless-steel matrix of 9.2mm of diameter. The “green” pellets were sintered in air at four different temperatures 1100, 1200, 1300 and 1400°C [7]. Then samples were characterized by immersion, ceramography, optical and electronical microscopy, and microhardness [7, 8].

3. Results

3.1. Glass matrices

The results of leaching iron phosphate glass with a treated RRSF loading of 7%, 10%, and 15% are presented in Fig. 1, Fig. 2 displays electronic microscopies of the glass with the load, showing areas with uranium in the glassy matrix. Fig. 3 shows the sample after a leaching test of 28 days [5, 6].

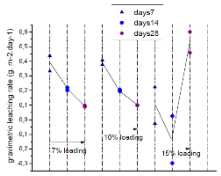

FIG. 1. Gravimetric leaching rate for 7, 10 and 15% loading

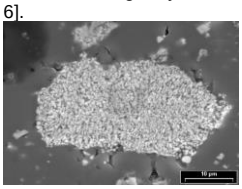

FIG. 2. Iron phosphate glass with uranium, polished sample.

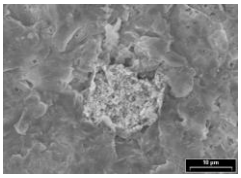

FIG. 3. Iron phosphate glass with uranium, after 28 days leaching.

3.2. Ceramic matrices

The behaviour of precursor powders varies depending on their particle morphology. Fig. 4 compares green density to sintered density, while Fig. 5 displays the ceramographies of pellets made from the two synthesis routes [7, 8].

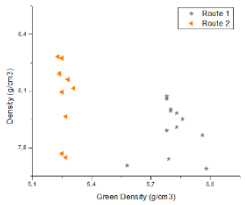

FIG.4. Sintered density vs green density of pellets.

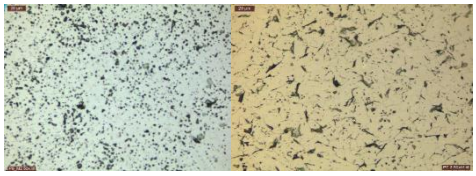

FIG.5. (Izq) pellet Route 1, 1300ºC, 50X. (Der) pellet Route 2, 1300ºC, 50X.

In order to establish the correlation between Vickers and Knoop hardness, we performed microhardness examinations on sintered samples from these two precursor powders. Our findings can be found in Table 1, which showcases the average HV and HK values at varying temperatures, as well as the HV/HK ratio and average HV/HK ratio for each powder. The results of the Knoop and Vickers indentations on the samples are illustrated in Fig. 6 [8].

TABLE 1. AVERAGE VALUES FOR HV, HK AND RATIO HV/HK OF SAMPLES

	T(°C)	HV av (Gpa)	HK av (Gpa)	HV/HK	HV/HK av (mat)	σ (HV/HK av)
Route 2	1100	4,1	3,7	1,10	1,15	0,04
	1200	4,4	3,8	1,15		
	1300	3,7	3,3	1,13		
	1400	3,6	3,1	1,19		
Route 1	1100	3,1	2,5	1,22	1,15	0,06
	1200	3,3	2,9	1,15		
	1300	3,0	2,6	1,13		
	1400	2,6	2,4	1,08		

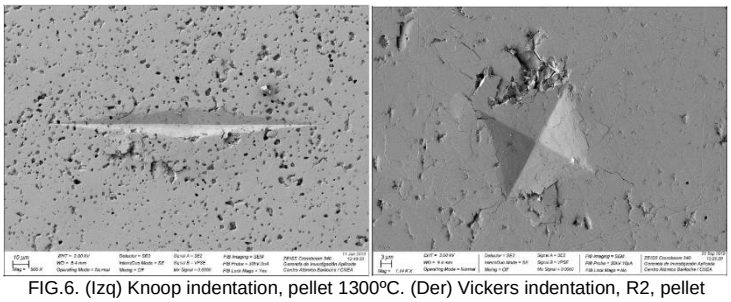

FIG.6. (Izq) Knoop indentation, pellet 1300ºC. (Der) Vickers indentation, R2, pellet 1300ºC.

4. Conclusions and outlook

In Argentina, research reactors are essential for training highly skilled personnel, developing new materials for industry and energy, and providing radioisotopes for radiodiagnosis and disease treatment. These activities align with the UN Sustainable Development Goals, including promoting health and well-being, quality education, affordable and clean energy, work and economic growth, and climate action.

It is important to consider and develop treatments for managing spent fuel from these reactors to ensure proper management and avoid negative impacts on people and the environment. Work related to the back end of spent fuel has been ongoing since the 2000s, focusing on non-irradiated materials. However, future stages should evaluate these processes using irradiated materials in hot cell facilities.

4. Conclusions and Acknowledgements

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