MASTER INTERNSHIP M2 CDM (5 months, Feb. - June)

2024-2025

Title of the project: Densification of apatites for nuclear waste conditioning

Supervisor(s): S. Le Gallet

Laboratory / Department / Team : ICB / Axe PMDM / MaNaPI

Collaborations: CEA Marcoule / CEA Saclay / CIRIMAT Toulouse

Summary:

This internship is part of the D-Clic project (France 2030), which aims to propose innovative solutions for the management of radioactive materials and waste.

The D-CLIC (Déchets ChLorés, Iodés, Carbonatés) project aims to develop an original method for immobilising three long-lived radionuclides: 14C, as well as 36Cl and 129I, which are major contributors to the dose at the outlet of geological disposal sites in a clay medium containing stabilised medium- or high-level long-lived nuclear waste. The challenge is to use a calcium phosphate matrix with an apatitic structure, a mineral whose remarkable durability properties are well established, while avoiding the traps of existing solutions that use noble metals or high added value metals such as silver, or toxic metals such as lead. The D-CLIC project also aims to develop a flexible matrix that can accommodate these radionuclides alone or in a mixture.

Whatever the method used to obtain apatite from a solution containing iodine, chlorine or carbon, it is essential to limit the exchange surfaces with the external environment in order to reduce release under storage conditions. To this end, a study of different shaping processes aimed at reducing the porosity of materials obtained by cementing or reducing the surface area of solid/gas interfaces by sintering will be carried out. Ideally, a low level of porosity, corresponding to a porosity dominated by closed porosity, will be targeted.

The aim of the internship is to provide dense iodinated, carbonated or chlorinated apatites, while avoiding the deterioration of the apatitic phase under the action of heat during sintering. To achieve this objective, the work will be divided into 2 parts:

1) a preliminary study of the thermal stability of the various apatites in a reducing environment, since this is directly related to the radionuclide substituted in the apatite and its sensitivity to the sintering environment, and will determine the sintering temperature range;

2) a parametric study of the SPS sintering of different apatites in order to determine the sintering conditions that will enable a high densification rate to be obtained. The influence of classical sintering parameters (temperature, dwell time, temperature rise and pressure) on the microstructure will be studied. Powder milling may be considered in a wet environment in a high-energy mill if it proves impossible to densify while avoiding the volatilisation of radionuclides. This is a way of lowering the sintering temperature by introducing crystalline defects.

The sintered samples will be characterised by Archimedes' method, X-ray Diffraction and Scanning Electron Microscopy.

Type of project (theory / experiment): Experimental

Required skills: Materials Science. Inorganic chemistry profile. Good communication skills to work collaboratively with the different partners of the project.

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