

DECIMAL - Phenomenological description of the corrosion and its impact on the durability of encapsulated magnesium wastes in hydraulic binders

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Abstract

The reprocessing of spent fuels from UNGG (Uranium Natural Graphite Gas) nuclear reactors in France has generated cladding wastes mainly made of Mg alloys [1]. The waste will be conditioned in a waste-package, ensuring durability, handling capability, and confinement of the radionuclides during further storage period and final disposal [2]. The embedding and conditioning of magnesium waste are based on their immobilization in a hydraulic binder. Several binders have been tested: OPC, cement with blast furnace slag, cement with fly ash, geopolymer, etc. In any case, they imply that the waste will be exposed to a very basic environment ($\text{pH} > 12$). Corrosion of magnesium could have consequences on the structural integrity of a cemented long-term package, due to the expansive corrosion products that form and cause stress within the coating matrix. In addition, corrosion leads to H_2 production, which has to be taken into account to ensure the safety of the storage of conditioned waste packages.

The DECIMAL project (October 2017 – September 2021) focuses on the validation of a corrosion study methodology for a Mg/binder alloy pair. The approach is illustrated and tested via the concept envisaged by the CEA: MgZr/Geopolymer. An alloy and a reference binder will be used: Mg-0.5%Zr and a geopolymeric cementitious matrix. To study parameters that may differ from one waste package producer to another, the effects of alloys will be studied with MgZr, MgMn and MgAl. The presence of passivating agent (NaF) in the cement matrix, ions contained in the pore solution, chlorides (water pollution of COx for example) as well as the pH of the solution will also be taken into account. The impact of irradiation will be evaluated on model and industrial materials. The intrinsic properties of the geopolymer will be characterized and the impact of Mg corrosion on its durability determined.

The novelty of this project is the originality of the partnership bringing a wealth of complementary skills to study in depth the mechanisms of corrosion at the interface metal/matrix and its impact on the mechanical behavior of the package. This will allow the acquisition of new fundamental data currently unknown in this field: electrochemistry of metal/matrix interfaces, composition, morphology, microstructure of a layer of corrosion products in the presence of a geopolymer; the stability of this layer in time out and under irradiation, the impact of this layer and the release of H_2 and on the mechanical behavior of the geopolymer.

This work is performed within the Future Investments Program of the French Government and operated by the French National Radioactive Waste Management Agency (Andra).

Keywords: magnesium, corrosion, geopolymer, irradiation, galvanic coupling, alkaline media, UNGG

References

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