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Modeling of Bituminized Waste Products swelling due to water uptake

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Bituminized Waste Products (BWPs) were produced by conditioning in bitumen the co-precipitation sludge that resulted from the industrial reprocessing of nuclear spent fuel. For the long-lived intermediate level categorized BWPs, the reference solution for the long-term disposal of these wastes is geological disposal inside the deep geological repository Cigéo, which is foreseen to be constructed in the Callovo-oxfordian (Cox) clay formation. In this context, after a period in the order of magnitude of a hundred thousand years, the water from the host rock will completely saturate the disposal cells containing these packages. Water in contact with Bituminized Waste Products could cause their swelling by an osmotic phenomenon made possible by the semi-permeable capacity of the bituminous matrix.

The objective of this work is to better understand the mechanisms of water uptake by bituminized waste products by modeling the experimental free leaching tests carried out on simplified samples (bituminous matrix containing one or two salts).

The model is extended from an existing one that takes into account transfer mechanisms (diffusion, permeability, osmosis, and dissolution of salts) coupled with mechanics via Maxwell's viscoelastic model [1,2]. The extension incorporates large strains and porosity dependent coupled transfer coefficients through the Mori-Tanaka homogenization scheme.

The model is calibrated on free leaching tests performed on simplified samples. Taking into account the uncertainties of measurement, the model allows to well reproduce the experimental results. The model is valid for the entire leaching process, it particularly shows the capability of reproducing the end of the leaching process (stabilization phase).

The perspectives of this work are the modeling of leaching tests carried out in confined conditions as well as a better understanding of the role of the poorly soluble salts.

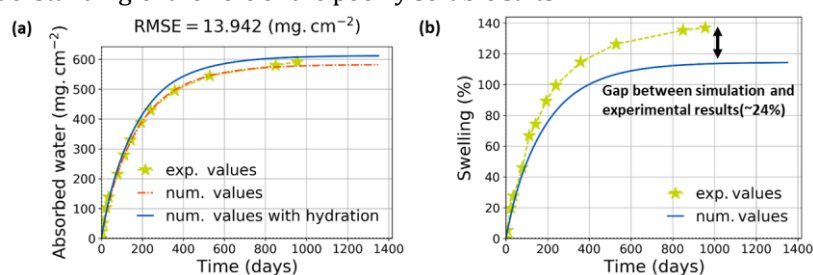


Figure 1 Comparison of experimental and numerical results on (a) water uptake; (b) swelling.

Keywords: radioactive wastes, bituminized waste products, chemical-hydro-mechanical modeling, homogenization

References

- [1] G. Mélot, Modélisation poromécanique du gonflement d'enrobés bitumineux par reprise d'eau, 2019.
- [2] G. Melot, P. Dangla, S. Granet, S. M'Jahad, J.B. Champenois, A. Poulesquen, Chemo-Hydro-Mechanical analysis of Bituminized waste swelling due to water uptake: Experimental and model comparisons, J. Nucl. Mater. 536 (2020) 152165. <https://doi.org/https://doi.org/10.1016/j.jnucmat.2020.152165>.