UNGG Waste Retrieval – Comparison of general and galvanic corrosion of Magnesium alloy coupled to graphite in ordinary Portland cement and alkali-activated slag binders

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Abstract

Graphite and magnesium alloys wastes were generated during the reprocessing phase of spent fuel assemblies of the former nuclear reactors in France. Conditioning of these low to intermediate level wastes in cementitious materials is being addressed here. The study is aiming to develop a numerical model able to predict the generation of stresses in such waste packages during their lifetime. Magnesium is one of the most reactive metals with a standard potential of -2.37V/SHE [1]. Once embedded in a hydraulic binder with alkaline pH and high internal humidity, oxidation reactions occur. The subsequent formation of corrosion products around the alloy may result in tensile stresses development in the surrounding binder that could lead to cracking risks. Thus, general and galvanic corrosion (when coupled with graphite) of the metal in the packages should be properly addressed.

Hence, weight losses, electrochemical techniques and microscopic observations together with chemical analysis methods (Raman and SEM/EDX) are used to characterize the metal's corrosion in three binders. These latter consist of two different ordinary Portland cement and an alkali-activated blast furnace slag mortars [2]. The results prove that the use of alkali-activated slag (AAS) is beneficial for the metal's galvanic corrosion while the general corrosion behavior is comparable in all studied mortars.

Additionally, the electrical conductance of the hydraulic binders was determined using electrochemical impedance spectroscopy technique (EIS). These tests were performed on graphite and magnesium electrodes embedded in the binders, from 7 to 180 days of hydration. The analysis of the results, using an equivalent electrical circuit, showed that the electrical conductance of AAS binder was lower than ordinary Portland cement binders, at a given hydration age.

In order to explain this lower conductance of the AAS binder, an investigation of its porosity (total porosity and porosity size distribution) and a characterization of the pore solution are undertaken. Therefore, on one hand, mercury intrusion porosimetry and BET nitrogen adsorption tests are performed on the different binders in order to compare the pore structure. On the other hand, pH measurements and liquid ion chromatography techniques are used to monitor the evolution of the AAS binder's pore solution. The latter results are compared to those for OPC binders found in the literature.

Keywords: Mg alloy, general corrosion, galvanic corrosion, alkali activated slag

References

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