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Study of the conditioning of aluminum-magnesium alloys in magnesium potassium phosphate cement

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Abstract

The reprocessing of spent fuel designed for natural uranium – graphite – gas reactors has produced some radioactive wastes containing aluminum-magnesium alloys, which need to be stabilized and solidified before their final disposal. Portland cement (PC) is extensively used for the conditioning of low- or intermediate-level radioactive wastes; however, its high alkalinity is a serious obstacle to aluminum stabilization, this metal being oxidized by the pore solution, with production of dihydrogen. Its passivation due to the formation of a protective layer of alumina only occurs for pH values within the range 3-9. This work aims at investigating a new option consisting in using magnesium phosphate cement (MPC) instead of PC.

The corrosion rate of several aluminum-magnesium alloys (Mg content varying from 0 to 5%) in a MPC matrix is investigated using two experimental techniques: measurement of the dihydrogen (produced by corrosion) by gas chromatography, and investigation of the electrochemical behavior of Al-Mg metal using electrochemical impedance spectroscopy (EIS) at open circuit potential (OCP). A specific cell is designed, comprising 4 electrodes (1 in Al-Mg alloy and 3 in Pt) embedded in the cement matrix, and making it possible to get information both on the corrosion of the metal and on the evolution of the matrix over time. An equivalent electrical circuit is proposed to fit the impedance spectra, and is then used to determine the kinetic parameters linked to the corrosion mechanism. The corrosion rate is finally calculated using these parameters and compared to the corrosion rate inferred from gas production. The results confirm that:

- EIS at OCP is a non-destructive technique well adapted to monitor the corrosion of metals in a cementitious material,
- using MPC instead of PC strongly mitigates the corrosion of Al-Mg alloys,
- the Mg content in the Al alloy has limited influence on its corrosion rate in the MPC matrix.