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Heavy ion radiation effect on the SON68 nuclear waste glass and ISG under vapor hydration

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Abstract :

In France, the fission products and minor actinides from the reprocessing of irradiated fuels are confined in a borosilicate glass matrix casts in a stainless steel containers. These packages of high-level waste could be stored in a deep geological disposal in the Callovo Oxfordian clay. In this perspective, the potential release of radioactive elements will begin when the site water comes into contact with the glass. In view of the disposal concepts depending on the chosen scenario, it is envisaged that the glasses will undergo a stage of alteration by water vapour before they are leached in a medium saturated by the ground water. Unlike studies in a saturated medium (i.e. liquid water), those on vapor phase remain more limited.

Studying vapor glass alteration is a challenge due to the very low rates of hydration observed. An alteration gel layer typically forms upon exposure to water vapor for extended time periods between 50 and 90°C [1]–[3]. Within the framework of the long-term geological disposal of nuclear waste glass, the present work investigates the effect of an irradiation damage on the glass chemical durability in the presence of water vapor. The formation mechanisms of the alteration layers as well as its properties are still largely unknown and require further investigations.

SON68 (non-radioactive surrogate for R7T7 glass, the French industrial nuclear glass reference) and ISG (International Simple Glass) were prepared, externally irradiated by heavy ions and vapor-hydrated. Irradiation features at saturation (Au³⁺ ions of 7 MeV at a fluence of 2×10^{14} at/cm²) used generate a ballistic damage on the vitreous structure (leading to a thickness of irradiated glass is around 2 μm) [4]. Glass hydration of SON68 and ISG glasses was investigated at 50 and 90°C under a relative humidity of 95% for a period of 6 months.

Several analytical techniques were performed on irradiated (or not) altered glass. Hydration kinetic was monitored by FTIR (Fourier Transform Infra-Red Spectrometry) and hydration products were characterized using electron microscopy (SEM), Raman spectroscopy and time-of-flight secondary ion mass spectrometry (TOF-SIMS). Thus, those methods provide a better understanding of the influence of the radiation effect on both the vapor hydration rates and the formation mechanisms of the alteration-hydrated layers.

Therefore, the objective of this work is to study the hydration mechanisms of glasses in the vapor phase and their potential influence on the alteration mechanisms in a water-saturated environment. Ultimately, results obtained within this work will permit to propose a mechanistic model of the alteration of nuclear glasses in the vapor phase.

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- [2] R. Bouakkaz, A. Abdelouas, Y. El Mendili, B. Grambow, et S. Gin, « SON68 glass alteration under Si-rich solutions at low temperature (35–90 °C): kinetics, secondary phases and isotopic exchange studies », *RSC Adv.*, vol. 6, n° 76, p. 72616-72633, 2016, doi: 10.1039/C6RA12404F.
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Presentation Summary (50-100 words) :

Within the framework of the long-term geological disposal of nuclear waste glass, the present work investigates the effect of an irradiation damage on the glass chemical durability in the presence of water vapor. Glass hydration of SON68 and ISG was investigated at 50 and 90°C at a relative humidity of 95% for a period of 6 months. The produced hydrated layer was characterized to assess its microstructure and chemical durability.