# ALTERNATIVE MATRICES FOR SODIUM BEARING WASTE

## Background

Radioactive waste form immobilisation converts raw waste, usually containing mobile contaminants, into a solid and stable form. The properties of the waste form enable it to be handled, stored and disposed of safely and conveniently, significantly reducing potential release of radionuclides into the environment. For long-term storage and disposal, waste immobilisation should avoid release of contaminants from the matrix during storage and disposal. Estimating the chemical durability during disposal of a waste matrix is a key consideration in assessing an immobilisation method.

Vitrification of high-level radioactive waste has received the greatest attention world wide, compared to any other HLW (High Level Waste) immobilisation process. Borosilicate glasses are currently the first choice of material world wide for immobilising HLW, and are being considered for LILW (Low and Intermediate Level Waste). Vitrification techniques, equipment and processes and their remote operation have been developed and studied for almost fifty years and have reached technical maturity. Empirical studies have provided guidelines for formulation of acceptable nuclear waste glasses with excellent chemical durability, relative low processing temperature, and which are capable of incorporating a large amount of nuclear waste.

## Objectives

Besides the limitations of vitrification, legacy waste streams and new emerging waste streams are known for which vitrification is inadequate. Furthermore new immobilisation techniques are also useful for different small waste categories with very different characteristics. In the frame of the latter, SCK•CEN elaborated an experimental program, in cooperation with ANSTO (Australia) to enhance the amount of sodium bearing waste that can be incorporated in the matrix while maintaining high resistance against leaching.

## Principal results

In the frame of the experimental program, the sodium bearing waste immobilisation potential of different ANSTO matrices (Synroc and glass ceramic matrices by hot isostatic pressing (HIP)) with an adapted formulation is compared to the traditional borosilicate glass. This program comprised standard leach experiments on simulated waste (MCC-1 & PCT-B), and optical microscopy, SEM and XRD to look for and verify gross effects, phase development, microstructure and microscopic homogeneity.

The main result of the first phase of the program, which mainly focussed on sodium immobilisation and leaching, is that a durable waste form can efficiently be made with a small and flexible immobilisation technique as hot isostatic pressing. Surprisingly the delivered Sodium Zirconium Phosphate (NZP) full ceramic waste form with adjusted formulation, made by HIP, performed up to seventy times worse than the reference borosilicate glass, mainly because its unexpected increased porous structure. On the other hand, the refractory glass-ceramic prepared by HIP showed a fifteen times greater leaching resistance when compared to the reference borosilicate glass. Retention times of other elements (Zr, Al, Si,…) have also proven to be much higher.

## Future work

Further research is necessary to continue the evaluation and to optimise the Synroc and glass ceramic formulation for sodium bearing waste. A final step could be the implementation of experiments on genuine sodium bearing waste containing minor actinides and to test the flexibility of the HIP as a waste immobilisation technique for sodium bearing waste.

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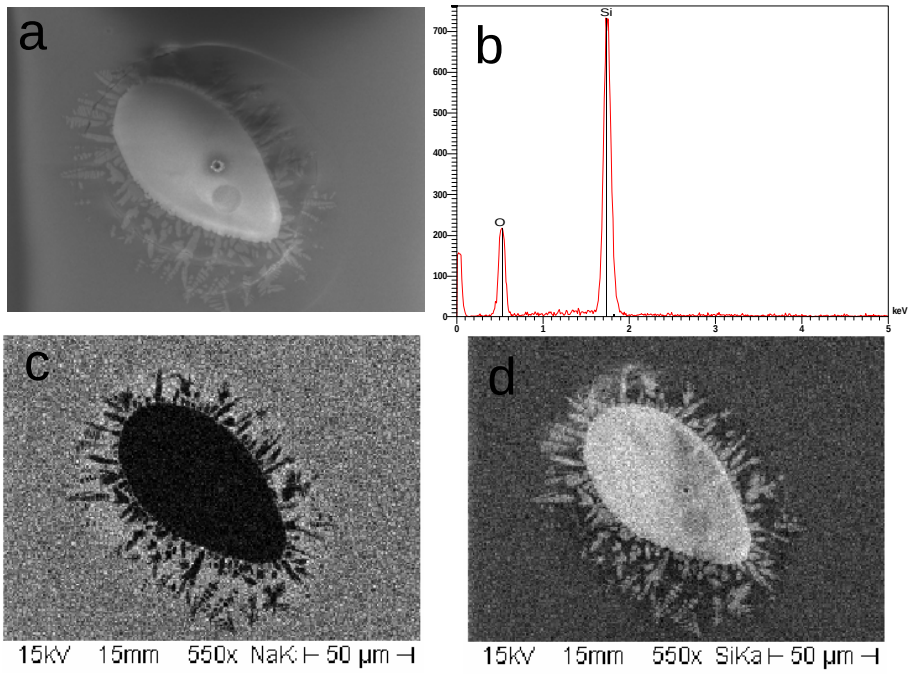
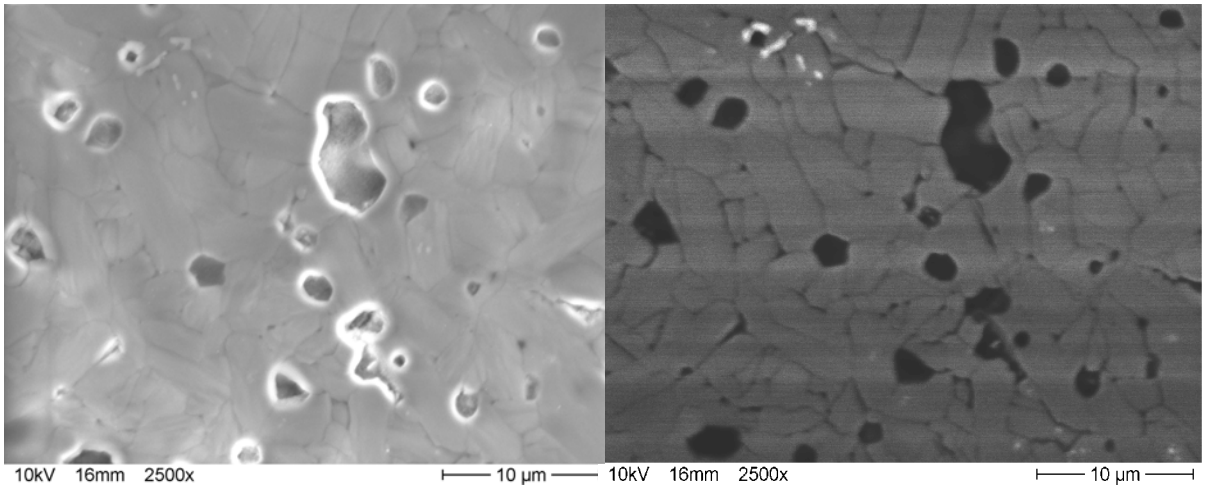
## Main reference

J. Seghers, J. Braet, K. Lemmens, B. Begg, A. Day, ' Alternative matrices for sodium bearing waste', 233rd ACS National Meeting, Chicago, IL, March 25-29, 2007, to be presented.




*Secondary electron microscopy (SEM) image (a) of a particle found in ANSTO's glass-ceramic. The energy dispersive X-ray (EDX) spectrum shows that it consists of $SiO_2$. The Na K and Si K X-ray mappings (c,d) of the particle supports this finding.*




*Secondary (left) and backscattered (right) electron image of the surface of the ANSTO NZP full ceramic waste form, revealing the inhomogeneous and porous structure.*