

ID 3012

# Final Disposal in a Glass of a Solid Residue from the Purification of an Effluent Loaded With Sr, K and Hf

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## ABSTRACT

This Vitrification is a process used for the final disposal of toxic waste for various unit operations for the decontamination of both toxic and radioactive effluents. The aim of this study is the vitrification of natural clay issued from a column extraction of the elements Sr, K and Hf. These last are from a water effluent containing:  $10^{-3}$  mmol/L Sr,  $3 \cdot 10^{-2}$  mmol/L K and  $2 \cdot 10^{-5}$  mmol/L Hf. The effluent was purified by column extraction filled with a KT3 type kaolin mixed with 10% of silica. After 06 cycles, the elemental extraction yields are 27.28% of Sr and 5.28% of K. the Hf can't be quantified due to the low values. The loaded kaolin is dried and vitrification tests are performed by double melting at 1400°C in a borosilicate glass of chemical formula:  $44\%SiO_2-7\%Al_2O_3-20\%Na_2O-18\%B_2O_3-1\%Cs_2O-8.5\%MoO_3-1.5\%Nd_2O_3$ , with a clay content varying between 0 to 15%. The final compact glasses are characterized by both XRD and FTIR spectroscopic analyses. The results show that for 5% of clay, the glass is homogeneous and does not contain any mineral residues. For both 10 and 15% clay contents, minor ceramic phases are identified inside the glass. The FTIR analysis of the materials allows identifying the glass main groups' vibrations of: O-Si-O from  $SiO_4$  around  $1016\text{ cm}^{-1}$  and B-O bond of  $BO_3$  around  $1200\text{ cm}^{-1}$ . Such an innovative process (extraction/vitrification) made it possible to purify the effluent by using an abundant natural material in Algeria and thus definitively isolate toxic and radioactive elements from both man and environment, using a glass ready to be disposal.

**Keywords:** Glass, vitrification, clay, disposal, radioactive waste.

## 1 Introduction

The glass is the most material used until now for storing the radionuclides in the nuclear industries [1]. It was able to storage the thirty radionuclides of the effluent solution, this through the existence of chemical links with glass network trainers. The aim of this study is to confine a solid purification residue for an effluent containing K, Sr, Ba, Al, Co and Hf, in a alumino-borosilicate glass of chemical formula  $SiO_2-Al_2O_3-Na_2O-B_2O_3-Cs_2O-MoO_3-Nd_2O$ , synthesized by double melting at 1450°C for 6 h. The solid residue is based on KT3 kaolin from a continuous extraction of the effluent on a column. Its added to the glass with various percentage (5, 10 and 15%). The choice of kaolin  $Si_2Al_2O_5(OH)_4$  for effluent purification is motivated by its specific physico-chemical properties, as its specific area, its satisfactory exchange capacity and ionic adsorption, that facilitate purification of effluent [2]. The characterization of the glass by XRD and FTIR analysis methods is performed.

## 2 Experimental

After 06 extraction cycles on column in semi-continuous mode of aqueous effluent containing 0,2173 ppm of Al; 0,3332 ppm of Ba; 0,1140 ppm of Co; 0,2088 ppm of Hf; 0,0975 ppm of K and 0,2073 ppm of Sr, the contaminated KT3 kaolin is dried at 50°C and then powdered in manual agate mortar. A glass composition with the chemical formula:  $44\%SiO_2-7\%Al_2O_3-20\%Na_2O-18\%B_2O_3-1\%Cs_2O-8.5\%MoO_3-1.5\%Nd_2O_3$ , is prepared. And several mixture of glass-KT3 are prepared at various KT3 percentage (5, 10 and 15%). They are homogenized 5 h and melt at 1450°C during 6 h. The glasses' X-ray diffraction XRD analysis is performed by a Philips X'Pert PRO diffractometer. The analysis conditions are:  $V=40\text{ kV}$ ,  $I=40\text{ mA}$ ,  $\lambda(Cu)=0,15406\text{ nm}$ . The FTIR spectroscopic analysis is made on a Thermo NICOLET 380 spectrometer.



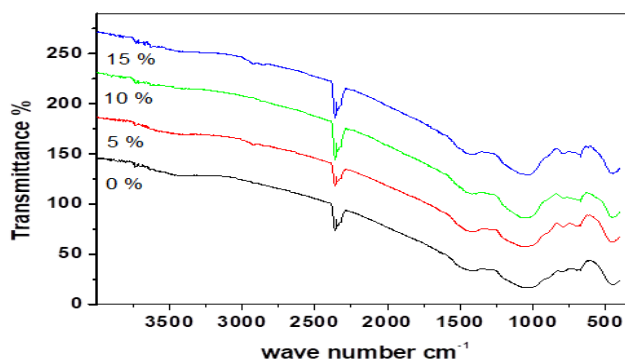
### 3 Results and Discussion

#### 3.1 X-ray diffraction analysis

The materials XRD phases' identification was performed by Xpert High Score software. It shows the presence of : kaolinite  $\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4$  of JCPDS file (01-075-1593), 24% Quartz  $\text{SiO}_2$ , 43% Kyanite  $\text{Al}_2\text{SiO}_5$  and 4% Silicate Baryum  $\text{Ba}_4(\text{Si}_6\text{O}_{16})$  [3]. The analysis of the matrix after double fusion confirms that the pure glass as well as the 5% KT3-glass material is amorphous. The materials loaded with 10 and 15% of KT3 in the glass show the formation of the orthorhombic mullite skeleton nuclei, of chemical formula  $\text{Al}_4.5\text{Si}_{1.5}\text{O}_9$ , (JCPDS 98-009-9327).

#### 3.2 FTIR Analysis

The FTIR spectra of the synthesized materials (figure below) show a band of stretching vibration for B-O in  $\text{BO}_3$  unit at  $1411\text{cm}^{-1}$  [5], a band of stretching vibration of Si-O link at  $1058\text{cm}^{-1}$ . The band present in the region  $950$  to  $1000\text{cm}^{-1}$  is due to bending vibration of Si-O-B bonds, that links the tetrahedra of  $\text{SiO}_4$  and  $\text{BO}_4$  [6]. The band at  $792\text{cm}^{-1}$  corresponds to the vibration of Al-O bonds of  $\text{AlO}_4$  unit [4], and that at  $453\text{cm}^{-1}$  to Si-O and Si-O-Si bonds [6].



**Figure 1:** FTIR spectra of glass with various percentages of kaolin : 5, 10, 15%

### 4 Conclusions

An aqueous effluent was purified by column extraction loaded with KT3 type kaolin. After 06 extraction cycles, the charged KT3 solid was confined by vitrification in a borosilicate glass  $\text{SiO}_2\text{-Al}_2\text{O}_3\text{-Na}_2\text{O-B}_2\text{O}_3\text{-Cs}_2\text{O-MoO}_3\text{-Nd}_2\text{O}$ , at various percentages between 5 to 15%. The XRD analysis confirms the formation of amorphous structure with the formation of a nucleus of mullite (30%) for both 10 and 15% KT3 contents in the glass. The FTIR analysis reveals the main bonds of the glass namely those of  $\text{SiO}_4$  and  $\text{BO}_3$  units. Such an innovative process (extraction/vitrification) makes it possible to purify the effluent by using a natural material abundant in Algeria and thus to definitively isolate many toxic elements from man and environment. In perspective, leaching tests should confirm the chemical stability of the studied glass.

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