Rapid Removal of Cesium from Vermiculite by Collapsing the Interlayers with Hydrothermal Column System

*Xiangbiao Yin [1,2], Yoshikazu Koma [1], Yusuke Inaba[2], Kenji Takeshita [2]

[1] Japan Atomic Energy Agency [2] Tokyo Institute of Technology

Abstract: The decontamination and volume reduction of Cs contaminated soil by efficient Cs removal remains a great challenge after the Fukushima Daiichi Nuclear Power Station accident. In present work, we studied the removal of Cs from the clay soils by treating with hydrothermal cations in a column system. The new results showed that Cs could be selectively removed from its collapsed interlayers in vermiculite by hydrothermally heating at 150°C.

Keywords: Cesium desorption, hydrothermal treatment, volume reduction, ion exchange, decontamination

1. Introduction

Due to the Fukushima accident, radioactive Cs was widely dispersed and contaminated the wide areas around nuclear power station. Subsequently, the topsoil has been stripped within the top 5 cm which is now just being stored in temporary storage sites due to the difficulty of decontamination with the selective Cs adsorption on clay fractions. [1-2] Therefore, it is urgently essential to develop efficient techniques performing Cs desorption from the clay soils.

2. Experiments

Clay of vermiculitized biotite (VB) (1 g) was dispersed in CsCl solution (0.1L) with Cs^+ concentration of 1000 mg L^{-1} for 3 months, reaching a saturated Cs adsorption capacity of 41.32 mg-Cs/g-VB. These adsorbed Cs were confirmed to be fixed in the collapsed interlayers of vermiculite with losing hydrous water molecule, which is comparable for the Cs adsorption on the frayed edge sites of clays in natural soils. [1] Subsequently, 0.5g of as-prepared Cs-VB was loaded into a stainless steel column reactor and flowed with the 0.01M $MgCl_2$ in rate of 0.5 mL/min at different temperatures from 25 to 250°C. The compositional change of the treated VBs was analyzed by XRF.

3. Results

Figure 1 shows the weight ratios of the compositional elements with Si in the VBs before and after hydrothermal treatment. Firstly, Cs/Si ratios decreased from the initial values by 33%, 98%, 99.9% at 25, 150, and 200°C, respectively, indicating nearly all Cs were removed only above 150°C. Secondly, K/Si ratios decreased from the initial value by 0%, 17% at 25, 150°C but 92%, 100% at 200, 250°C, implying most K still remained at 150°C while removed above 200°C. By contrast, Mg/Si ratios increased from the initial value by 2%, 12.5%, and 16.7% at 150, 200 and 250°C, suggesting more Mg entered the interlayers and exchanged with Cs and K by treating at higher temperatures. Aside from the above-mentioned Cs, K, Mg elements, the constituent elements of Al, Ca, Fe, and Ti for VB remained roughly stable, irrespective of the treatment.

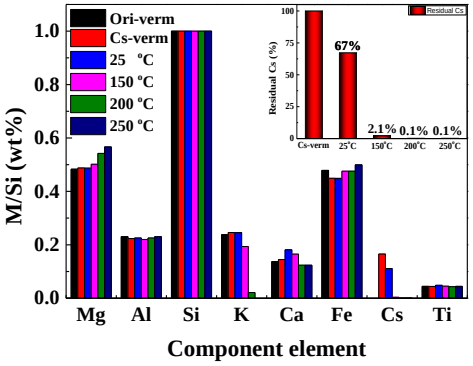

Figure. 1 Composition ratio of VB samples before and after hydrothermal treatment.

4. Conclusion

Hydrothermal treatment of the clay soils in column leaded to a selective removal of Cs but not K from their collapsed interlayers of clays by heating at low temperature of 150°C, which was expected to establish practical technologies for remediation of the Cs-contaminated soils.

References

[1] Yin X., Wang X., Wu H., Ohnuki T., Takeshita K., *Journal of hazardous materials*, **326**, 47-53 (2017).

[2] Yin X., Inaba Y., ... & Takeshita, K., *Chemical Engineering Journal*, **333**, 392-401 (2018).