

Retardation of Cs and Sr leachings by geopolymer matrices with zeolite and titanate adsorbent

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After the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS) that occurred due to the Tohoku big earthquake in 2011, contaminated water with radioactive nuclides such as cesium (Cs) and strontium (Sr) have been continuously generated due to cooling of fuel debris by water. Zeolite or titanate adsorbents have been used for removing Cs or Sr from the contaminated water. The spent adsorbents would probably be solidified for the safety storage and disposal. Glass and cement have been proposed for solidifying binder. However, they have some disadvantages such as generation of secondary radioactive waste during vitrification and large amount of waste volume limited by bigger free water volume. Recently, geopolymer is considered as new binder which has potential to solve the above disadvantages for safety disposal of the spent adsorbent. Geopolymer has the potential to decrease total volume of solidified substances comparing cement because amount of containing free water is less than that containing cement. Primary phases of geopolymer such as calcium silicate hydrate (C-S-H) or potassium aluminosilicate hydrate (K-A-S-H) may have property for sorbing radioactive nuclides. Furthermore, it is possible to obtain the desirable phases by changing the type and ratio of the starting materials. So, the appropriate primary phases could be designed depending on the type of the radioactive nuclide in disposed radioactive waste. However, there are few data about leaching behavior of radioactive nuclides from geopolymer in real disposal condition. In this context, this study was conducted leaching and sorption experiments to understand the leaching behavior from geopolymer with zeolite or titanate containing Cs or Sr.

In this study, geopolymer samples from mixing of KOH, metakaoline and water glass were investigated in leaching experiments. From the leaching experiments of Cs and Sr from geopolymer with titanate, most of Sr was tightly remained after 90 days even without titanate. This means that K-A-S-H matrix formed after the mixing has high capacity for Sr storage. On the other hand, small part of Cs (around 4%) was leached out after 90 days. However, although it is well known that Cs and Sr are easily leached out from cement matrix (A. El-Kamash, et al., 2006, and M. Takaoka, et al., 2015), K-A-S-H matrix is better in terms of Cs and Sr storage. From sorption experiments of Cs and Sr by using powder C-S-H and K-A-S-H samples as matrix components of cement and geopolymer, it is cleared that K-A-S-H has higher sorption capacity than that of C-S-H. From desorption experiment of Cs and Sr using deionized water from the C-S-H and K-A-S-H, it is cleared that almost of Cs was desorbed from C-S-H even for one day, while 90% of Cs was remained in K-A-S-H under the same condition. Consequently, K-A-S-H matrix in geopolymer has higher retention capacity than that of C-S-H matrix in cement. We conducted safety assessment for geopolymer and cement waste form in pit type disposal system using leaching ratio obtained in this study. From results of the assessment, K-geopolymer would be applicable for safety encapsulation and disposal of Cs and Sr as waste form.

Keywords: Geopolymer, Disposal of radioactive waste, Potassium aluminosilicate hydrate, Calcium silicate hydrate