Immobilization of High-Sulfate Radioactive Waste Solution by Metakaolin-Based Geopolymer Wate Form

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Presence of high sulfate content in radioactive waste solution can cause to form secondary mineral phase such as ettringite [$Ca_6Al_2(SO_4)_3(OH)_{12}\cdot 26H_2O$] in cement waste form. Late formation of ettringite mineral is known to cause cement matrix to expand, leading to formation of crack and disintegration of cement waste forms. Therefore, calcium-free waste form is necessary to solidify the radioactive solution waste with high sulfate (or sulfur) ions. Here, we proposed metakaolin-based geopolymer waste form to solidify the radioactive waste containing high sulfate content generated by the Hydrazine Based Reductive metal Ion Decontamination (HyBRID) process in Korea Atomic Energy Research Institute (KAERI).

Cement and geopolymer waste forms were formulated for HyBRID sludge waste and tested for mineralogy, compressive strength, and leachability. The XRD results revealed that HyBRID sludge waste consisted of cristobalite (SiO_2) and barite ($BaSO_4$) as major components. Despite of low solubility of barite, ettringite mineral was formed only in the cement waste form, but not found in geopolymer waste form because of the lack of Ca source. The maximum waste loading of 53.8 wt% was achieved with the matrix composition of $K_2O\cdot 2.8SiO_2\cdot Al_2O_3\cdot 15.2H_2O$ and showed high compressive strength of 14.3 MPa enough to meet the waste form acceptance criteria in repository. In addition, leaching results showed that less than 1.0% of sulfate and Ba ions were leached from geopolymer waste form. Based on the results of this study, metakaolin(MK)-based geopolymer can be used as a promising low-termperature waste form candidate for safe and economic immobilization of HyBRID sludge waste as well as any other sulfate-rich radioactive wastes.