Characterization and Investigation on Long-term Stability of Sodium Activated Metakaolin-Based Geopolymers

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Geopolymer is a group of newly derived barrier materials for the stabilization of radioactive wastes. In this study, we characterized the sodium activated metakaolin based geopolymer (Na-MKGP) including the base material, metakaolin, and additionally processed sample which is stated as treated Na-MKGP. Furthermore, the long-term stabilities of the Na-MKGP were investigated as a function time to see their mineralogical and structural changes.

Keywords: Metakaolin, Geopolymer, Long Term Stability, Seawater

1. Introduction

Geopolymers (GPs) are defined as chains or networks of inorganic molecules linked with covalent bonds. Their physical and chemical properties like thermal resistance, sorption properties, and structural strength have received great attention. Due to these features, it is possible to apply geopolymers to stabilize intermediate and low-level radioactive wastes in the nuclear sector like cement [1]. For that most of the studies have focused to fly ash-based GPs due to the similarities with cement, while Na activated metakaolin-based GP (MKGP) is reported to have better features as pointed by JAEA through a literature survey[2]. Therefore, in this study, we characterized the base material, metakaolin, original and treated Na-MKGP. Furthermore, the long-term stabilities of Na-MKGP were investigated under three different aqueous environments as a function time in order to see their chemical and mineralogical changes.

2. Experimental

The characterization carried out for metakaolin (Argrical M1000, Imerys), the Na-MKGP and the treated Na-MKGP, was obtained by washing the original Na-MKGP with Milli-Q water and drying in an oven at 60 °C overnight. The alteration studies were conducted for 6 months in three different systems: the seawater system (SWS), the distilled water system (DWS), and the washed sample system (WSS). Sampling of the aqueous and solid phases were done with decreasing frequency. The liquid samples were analyzed by an inductive coupled plasma-optical emission spectroscopy (ICP-OES, Agilent 720 ICP-OES) for Al^{3+} and Si^{4+} concentrations. For the solid samples, X-ray fluorescence (XRF), Fourier transformed infrared (FT-IR, Model 6600, Jasco) spectroscopy, Raman spectroscopy (Micro-RAM 532A, Lambda Vision Inc), and X-ray diffraction (XRD, SmartLab, Rigaku) were performed to study the structural changes and the formation of new phases upon alteration.

3. Results and Discussion

According to the characterization studies, it was revealed that both original and treated Na-MKGP had amorphous structures with a feldspar-like local framework and contained quartz as a crystalline impurity originating from metakaolin. Additionally, there were no significant changes between the original and treated Na-MKGP in terms of their chemical structures and crystal phases through the 6-month period. In general, if Na-MKGP is considered to be applied for waste immobilization, these results point the robustness of Na-MKGP for the long-term stability. Yet further investigations should be done to increase the reliability of this material.

References

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