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

1. Introduction

Geopolymers(GPs) are defined as chains or networks of inorganic molecules linked with covalent bonds where their physical and chemical properties like thermal resistance, sorption properties, and structural strength have received great attention[1]. Due to these features, it is possible to apply geopolymers to stabilize intermediate and low-level radioactive wastes in the nuclear sector like cement[2]. Yet, this material needs to prove itself in terms of stability and robustness. For that most of the literature, studies focus to fly ash-based GPs due to the similarities with cement, while Na activated meta-kaolin based GP(MKGP) has better features for the nuclear field as pointed by JAEA through a literature survey[3]. Therefore, in this study, we characterized the base material, metakaolin, original and treated Na-MKGP. Furthermore, long-term stability of Na-MKGP were investigated under three different aqueous environments as a function time in order to see its chemical mineralogical stability.

2. Experimental

The characterization were carried out using the Na-MKGP, which was made from metakaolin(Agrical M1000, Imerys) and sieved under 1 μm by an agate mortar and pestle. Additionally, the Na-MKGP powders were washed with Milli-Q water and dried in an oven at 60 $^{\circ}\text{C}$ overnight. The alternation studies were conducted for 6 months in three different aqueous 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. A total of 20 supernatant liquid samples and 3 solid samples were taken. The liquid samples were analyzed by an inductive coupled plasma-optical emission spectroscopy (ICP-OES, Agilent 720 ICP-OES) for Al and Si concentrations. For the solid samples, X-ray fluorescence (XRF), Fourier transformed infrared(FTIR, Model 6600, Jasco) spectroscopy, Raman spectroscopy(Micro-RAM 532A, Lambda Vision Inc), and X-ray diffraction (XRD, SmartLab, Rigaku) were performed to study structural changes and formation of new phases upon alternation.

3. Results & Discussion

According to the characterization studies, it was revealed that Na-MKGP has an amorphous structure having 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. Furthermore, alternation studies showed that Na-MKGP was largely stable through the 6 month period under seawater and pure water environments. In general, if Na-MKGP is considered to be applied for waste immobilization, these results points the robustness of Na-MKGP for long-term stability.

Do you wish to participate as a Young Professional?

Yes

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