Efficient Cesium Capture Using Potassium-Metakaolin Geopolymer Matrices

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Abstract. The cesium (Cs) capture ability of potassium-metakaolin geopolymer will be studied. Cesium chloride was added to the potassium-based geopolymer with metakaolin and silica fume as the aluminosilicate sources. In the XRD result, potassium chloride was identified, suggesting that the Cs^+ replaced K^+ ion by the ion exchange process. The result of the leaching tests has also shown that cesium is being effectively captured by replacing potassium in the geopolymer matrix.

Keywords: potassium, metakaolin, cesium, capture, geopolymer, severe accident.

1. Introduction

Cesium (Cs), particularly the radioactive isotope Cs-137, is highly soluble in water and poses significant environmental and health risks. The immobilization of cesium in geopolymers is a crucial topic in radioactive waste management [(1)]. Immobilizing cesium in geopolymers can effectively prevent its leaching into the environment. This process involves multiple mechanisms: chemical binding [(2)], physical encapsulation [(1)] and ion exchange [(2)]. The efficiency of cesium immobilization depends on factors like the alkali content, silicon (Si)/aluminum (Al) ratio, curing conditions, and the presence of additives. In this study, a potassium (K)-metakaolin geopolymer with an Al:Si:K:H_2O ratio of 1:2.1:0.8:8 will be utilized to investigate the cesium capture capability both in the short term and long term. The mechanisms of cesium capture will be examined in detail.

2. Experiment

To investigate cesium immobilization, CsCl powder was added to a potassium-metakaolin geopolymer mix before curing. The raw materials for the geopolymer included metakaolin, EFACO silica, KOH, potassium silicate, and distilled water. A control sample without CsCl, consisting only of the original raw materials, was also prepared for comparison.

3. Results and discussion

The X-ray diffraction (XRD) patterns of the synthesized geopolymers are depicted in Fig. 1. These patterns revealed a predominant amorphous phase across all geopolymer samples, indicating successful formation of the Al-Si-O network. A significant finding was the presence of potassium chloride (KCl) in the samples, confirming the replacement of K+ ions by Cs+ ions. The concentration of cesium (Cs) and aluminum (Al) leached from the geopolymer into solution was quantified using ICP-MS analysis. Approximately 4.6% of the initial Cs amount was leached, demonstrating the effective cesium-capturing capability of the potassium-metakaolin geopolymer.

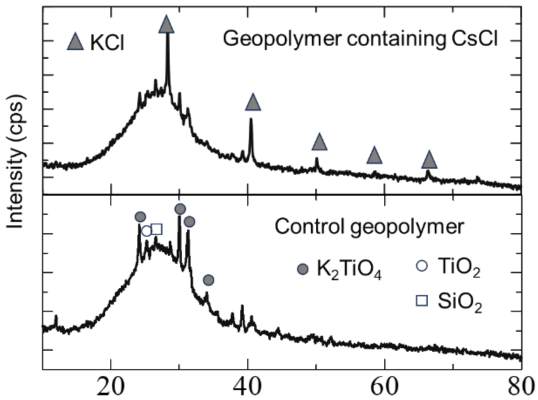

Fig. 1 XRD Patterns of geopolymers.

4. Conclusions

Metakaoline-based geopolymer which had the molar ratio of Al:Si:K:H_2O was 1:2.1:0.8:8 fully met the requirements for capturing the nuclear waste containing Cs ion.

References

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