Aluminosilicate Modifications in Potassium-Metakaolin Geopolymers: A Comprehensive Analysis and Performance Comparison

*Sajedah Yousef [1] , Yaru Yang [2], Thi-Mai Dung Do [1], Fauzia Hanum Ikhwan [3], Tadachika Nakayama [1] and Hisayuki Suematsu [1]

[1]Nagaoka University of Technology , [2]The University of Tokyo , [3]Tokyo Institute of Technology

Abstract: The study investigates the use of aluminum and EFACO silica as substitutes for metakaolin in potassium-based geopolymers, to simulate the radioactive Al compaction in Al-Si-K-O geopolymers. It aims to evaluate their impact on geopolymer structure and behavior while maintaining a the same Al:Si:K:H_2O ratio. The research aims to reveal insights into modified geopolymers' structural, thermal, compositional, and environmental aspects, enhancing understanding of tailored formulations.

Keywords: Geopolymer, Metakaolin, Aluminosilicate, Aluminum waste, Leaching, Decommissioning

1. Introduction

In 2017 the Japan Material Test Reactor (JMTR) was announced as a decommissioned facility where the core structure contains aluminum and beryllium. Thus, the need to further study how aluminum will be disposed of is necessary. One potential way of disposal is through compacting waste in geopolymers, as geopolymers display superior strength, reduced permeability, and heightened resistance to radiation and chemical degradation compared to traditional materials[1]. Additionally, geopolymers can utilize various waste materials like fly ash, slag, and mine tailings, promoting sustainable waste utilization[2]. In this research, to simulate radioactive Al compaction, Al-Si-K-O geopolymer was synthesized from partially substitution of aluminum for metakaolin.

2. Experimental

Metakaolin, EFACO silica, potassium silicate, and potassium hydroxide were utilized as initial products for making a geopolymer in the samples. The process of synthesis included mixing, curing for 24h in i) room temperature ii) 60°C oven, drying, and demolding. The experimental aspect involved substituting aluminum and silica for metakaolin, with the goal of investigating potential effects on the geopolymerization process, structural modifications, and metal incorporation into the geopolymer matrix.

2-1. Sample preparation

The Al:Si:K:H_2O molar ratio for the samples is 1.0:2.1:0.8:8.0, with different samples prepared to achieve 25%, 32%, and 50% reduction in metakaolin (RM). These samples undergo conditions similar to the original geopolymer samples. Aluminum is introduced by reacting it with potassium hydroxide.

3. Results & Discussion:

3-1. Water Loss Measurement:

Weight measurements are shown in Fig. 1 and 2 and the results are summarized in Table 1 - assuming that only free water molecules evaporate during the drying process- reveals that samples with 25% RM and 32% RM experience lower water loss percentages compared to 50% RM due to their well-formed physical structure. The reduced metakaolin samples show lower percentages compared to the original geopolymer, which has about 15% water remaining. This suggests that this method can contribute to the reduction of water content in the geopolymer while maintain a good geopolymer structure.

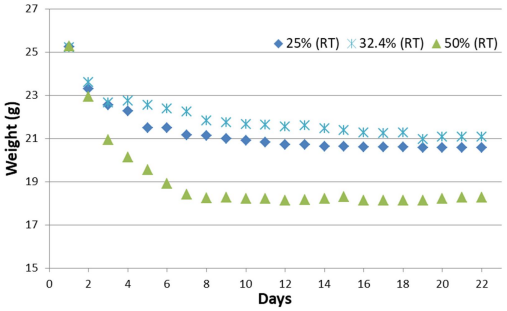

Figure 1 Sample weight loss measurements [cured in RT]

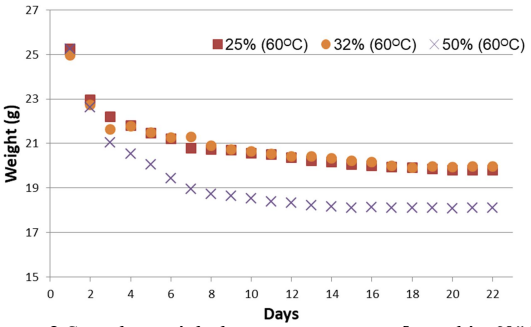

Figure 2 Samples weight loss measurements [cured in 60°C]

Table 1: Water remaining percentage

Samples	RT	60°C
Original	15%	15%
25% RM	7%	4%
32% RM	9%	5%

Conclusions

Samples have been synthesized successfully, showing positive potential where water content can be reduced by this method in synthesizing geopolymers. More testing and analyzing such as leaching properties is needed for further understanding if samples are suited to compact radioactive aluminum waste through this method.

References:

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