# Solidification of HyBRID Waste Using Geopolymer Waste Form

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## 1. Introduction

The hydrazine based reductive metal ion decontamination (HyBRID) process with sulfuric acid is recently developed and considered as an attractive process consisting of hydrazine, copper ion, and sulfuric acid without any organic chelates. The target radionuclides such as Cobalt and Cesium are separated through HyBRID process from the primary system decontamination and subsequently present in HyBRID wastewater containing high contents of sulfate ion. This HyBRID wastewater is then converted to HyBRID sludge waste through a precipitation process.

The HyBRID sludge, which has the high contents of sulfate ion, makes cement waste form defective due to the potential formation of Ettringite mineral [$Ca_6Al_2(SO_4)_3(OH)_{12}\cdot 26H_2O$] [1]. Therefore, the geopolymer waste form was proposed to immobilize the HyBRID sludge waste with the waste loading (>10%).

## 2. Geopolymer waste forms

### *2.1 materials and methods*

Kaolin was obtained from Sigma Aldrich and calcined at 750 °C for 4 h to transform to the MK. The chemical compositions of MK and HyBRID sludge using X-ray fluorescence (XRF) are shown in Table 1.

Metakaolin (MK) was used as geopolymer precursor and the alkaline activator was prepared by mixing sodium silicate solution ($Na_2O$=10%, $SiO_2$=30%, $H_2O$=60% in mass) and sodium hydroxide solution (~19M). Geopolymer precursor and the alkaline activator were mixed using planetary centrifugal mixer. Subsequently, all paste samples were poured into cylindrical mold (23 mm in diameter x 46mm in height) with a cap. The sealed geopolymer pastes were placed in the clean bench at 20°C for 7 days to cure.

Table 1. Chemical compositions of metakaolin and HyBRID sludge waste (wt%)

| | $SiO_2$ | $Al_2O_3$ | BaO | $SO_3$ | LOI* |
|---|---|---|---|---|---|
| MK | 54.8 | 39.5 | - | - | 4.89 |
| HyBRID sludge | 45.8 | 2.04 | 28.9 | 13.8 | 4.42 |

*LOI: loss of ignition

### *2.2 Geopolymer synthesis with varying conditions*

Geopolymer waste forms were formulated with desired ratio of Si/Al (1.7-2.1) with varying waste loadings [2]. Geopolymer waste forms were successfully synthesized to meet the acceptance criteria (>3.45 MPa). Geopolymers formed with Si/Al molar ratio of 1.7, 1.9, and 2.1 and it achieved the compressive strength of 7.13, 21.7, and 38.0 MPa, respectively. With increasing Si/Al ratio, the final compressive strength also increased.

The result of FT-IR spectra of each geopolymer waste forms is shown in Fig. 1. The absorbance band at 976, 973, and 964 $cm^{-1}$ indicated the vibrations of Si-O-Si and Si-O-Al groups of the geopolymer gel network [3]. The band at 1211 $cm^{-1}$ which indicated the amorphous silica disappeared as Si/Al ratio increased.

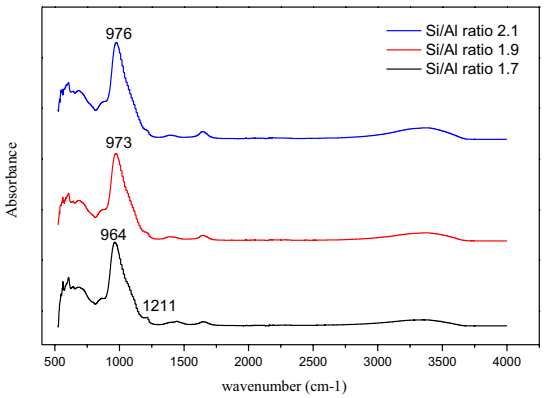


Fig. 1. FT-IR spectra of geopolymer depending on Si/Al ratio.

## 3. Conclusions

Geopolymer waste form was proposed to immobilize the HyBRID sludge waste with high sulfate content. Geopolymer waste forms with HyBRID sludge have met the acceptance criteria. The compressive strength of the geopolymer waste forms was 37.95MP with 16 wt% of HyBRID sludge. The FT-IR result revealed the presence of residual amorphous silica at low Si/Al ratio (Si/Al=1.7). The Si/Al ratio affected the compressive strength of geopolymer in that Si-O-Si absorbance band increased.

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