Characterisation of Dense Metakaolin Based Geopolymer

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Abstract

Syntheses of dense metakaolin based geopolymer for mechanical property tests after irradiation were carried out in this study. With compositions of Al:Si:K:H_2O to be 1:2:1:8 and 1:2:1.5:8, crack formation not only in air but also in water was successfully suppressed. The data will be used to apply for hydrogen recombining catalyzer support applications.

Keywords: geopolymer, potassium, crack, irradiation.

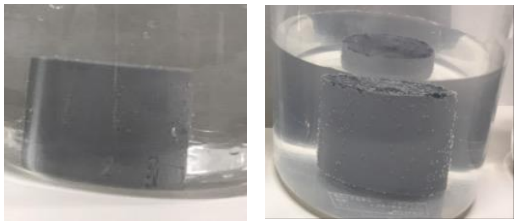
1. Introduction

After Fukushima Daiichi Power Station accident, radioactive slurry is generated and stored in a container. In aim to control the generated hydrogen, that may cause a hydrogen explosion, in a stable storage of the radioactive slurry, a recombination catalyst which should be developed at low cost and stable over a long period of time is required. To meet this demand, novel hydrogen catalysts with known convection properties are being developed [1]. One of candidate supports for the catalyst is geopolymer, and geopolymer has been though to be a candidate material for nuclear or waste containment applications [2]. In this work, dense and crack-free geopolymer samples were synthesized for mechanical tests.

2. Experiment and Results

Metakaolin and potassium based geopolymer of different Si/Al and K/Al molar ratios were prepared, varied from 2 to 3 and from 1 to 2 respectively. At first, potassium silicate solution, deionised water and potassium hydroxide were mixed. Then, metakaoline and micro silica powders were mixed with the above solution for 3 min. The slurry was poured into a polypropylene cylindrical cup. The geopolymers were cured under different schedules at RT, 40^0C and 70^0C for 7 days. In order to suppress the crack formation, some samples were covered by a cap and then opened the cap on the 5^{th} day. All these samples were removed from the cup to ambient atmosphere after the curing. The best samples with molar ratio Al:Si:K:H_2O= 1:2:1:8 and 1:2:1.5:8 was chosen for the experiment analysis.

XRD and TG-DTA was carried out on geopolymer samples ground to powder. Each geopolymer sample was observed by an optical microscope for measurements of pores size after 21 days. The area fraction of pores was calculated from images through a software Image J. Sample 1:2:1:8 had the average pore size larger than sample 1:2:1.5:8. The average diameter of pores and % area of pores were 163μm and 83μm, 7.4% and 6.2% corresponding.



a) 1:2:1:8 b) 1:2:1.5:8

Fig.1. Samples immersed to water; the measured pH were a)10.97 and b)10.57; a few little bubbles released; no crack appeared.

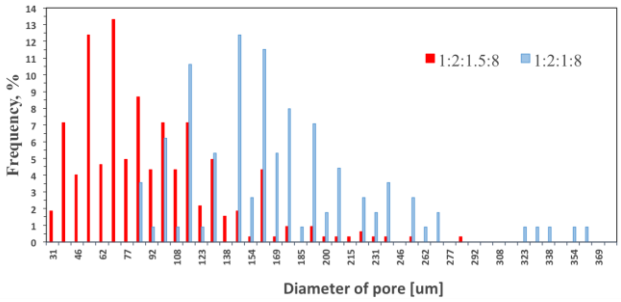


Fig.2. The frequency of pore diameter.

The number of pore of sample 1:2:1:8 was less than but the number of large pores was more than that of sample 1:2:1.5:8. It means when increased the K/Al ratio, the pore size and % area of pore decreased but the number of pore increased.

Geopolymer samples were measured the hardness after ground and polished by a diamond paste to become mirrors. At 10kgf load, the Vickers hardness of sample 1:2:1:8 was 0.28 GPa, higher than that of sample 1:2:1.5:8 was 0.17 GPa.

3. Conclusions

In this study, the dense potassium based geopolymer was fabricating, and the cracking during curing process was suppressed. The best samples with molar ratio Al:Si:K:H_2O= 1:2:1:8 and 1:2:1.5:8 have no cracks after curing and even as immersing in water. These samples will be irradiated with an electron beam to investigate the effect of irradiation on the mechanical property of geopolymer samples.

References

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