Analysis of Chemical Bonding State of Metakaolin Based Geopolymer by XAFS Measurement

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Geopolymer is mainly amorphous structures containing elements such as Na, K, Al, and Si. It is important to clarify its microstructure. Therefore, these measurements will reveal that the microscopic chemical state differs depending on the material used, and will lead to the development of geopolymers with better performance. The authors have shown that the strength and diffusion properties of geopolymers vary depending on the alkali activators used [1]. Therefore, in this study, geopolymers with different compositions are prepared. Metakaolin containing mainly Al and Si is used as the active filler, and by adding alkali activators (sodium silicate and potassium silicate) with different compositions relative to the aluminum content of metakaolin, geopolymer cured materials with different compositions are prepared and XAFS measurements are performed to clarify the microstructure.

Metakaolin (MK) was used as the aluminosilicate material, and the alkali activator was a mixture of sodium hydroxide, potassium hydroxide, sodium silicate, and potassium silicate in a given molar ratio. The alkali activator was prepared the day before the geopolymer was made and kept at room temperature. The composition of the geopolymers prepared is shown in Table 1. Metakaolin powder and alkali activator were added and mixed for 15 minutes. After mixing, the mixture was placed in a cylindrical mold with a diameter of 50 x 100 mm. Curing was performed by sealing until 28 days. After curing, the samples were coarsely crushed with a hammer and freeze-dried, and ground in a planetary ball mill to produce powder samples. XAFS measurements were performed at BL-10 and TEM observations were also made.

Fig. 1 shows the results of XAFS measurements. In the XANES region, there were some differences between sodium and potassium systems for Al and Si, while in the EXAFS region, there were no differences among the geopolymers. This indicates that the difference in the chemical bonding state of Al and Si due to the difference in the alkali activators used is not significant. Fig. 2 shows an example of the results of TEM observation of the geopolymer, in which the pores appear to be uniformly distributed in K11, while heterogeneous pores are observed in Na11.This suggests that the formation of the pore structure differs depending on whether the alkali activator is potassium or sodium. Therefore, it is suggested that the physical properties of metakaolin based geopolymer are greatly affected by the difference in the pore structure formed by different alkali activators.

Table 1 Composition of geopolymer

	Composition
K11	K_2O ・ Al_2O_3 ・ $3SiO_2$ ・ $11H_2O$
Na11	Na_2O ・ Al_2O_3 ・ $3SiO_2$ ・ $11H_2O$
K9	K_2O ・ Al_2O_3 ・ $3SiO_2$ ・ $9H_2O$
KNa11	K_2O ・ Na2O ・ Al_2O_3 ・ 3SiO2 ・ $11H_2O$
K1.5	K_2O ・ Al_2O_3 ・ $3.5SiO_2$ ・ $11H_2O$

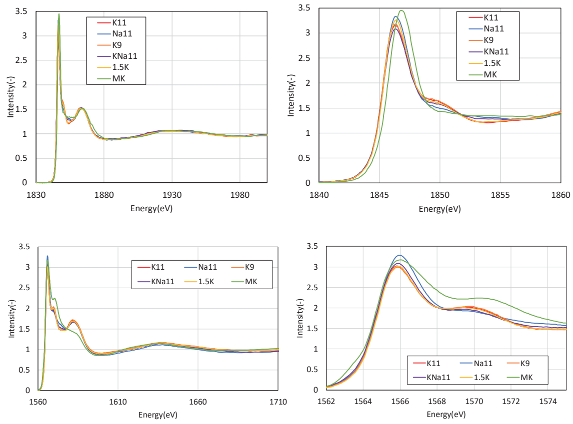

Fig.1 XAFS results of geopolymer (upper:Si, bottom:Al)

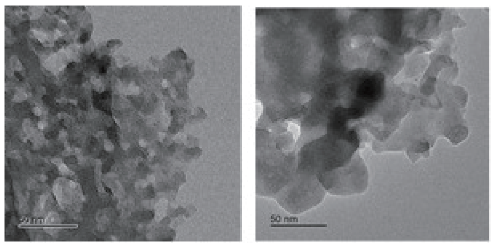

Fig.2 TEM observations

References

[1] Kurumisawa, K., Omatu, H., & Yamashina, Y. (2021). Effect of alkali activators on diffusivity of metakaolin-based geopolymers. Materials and Structures, 54(4), 169.