LOW TEMPERATURE GEO-CERAMICS

INVENTORS

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ABSTRACT

The focus of this study is the fabrication of innovative and sustainable geopolymer-based ceramic with improved low temperatures performances. Kaolin was mixed with liquid sodium silicate (Na2SiO3) and 12M of sodium hydroxide (NaOH) solution using aluminosilicate/activator ratio of 0.24at a ratio of 1:1 and Na2SiO3/NaOH ratio of 0.24 to synthesize kaolin geopolymer. The effect of sintering profile on the microstructure, pore evolution and flexural strength were investigated. The heating exposure aided consolidation and created a fairly uniform microstructure, resulting in a smooth surface texture. In comparison to the unheated geopolymer, 3D pore distribution showed a significant increase in the range size of ~30 μm with the appearance of isolated and intergranular pores. The sintering process has an impact on the final microstructure formation thus improved the characteristic of nepheline ceramic-based geopolymer.

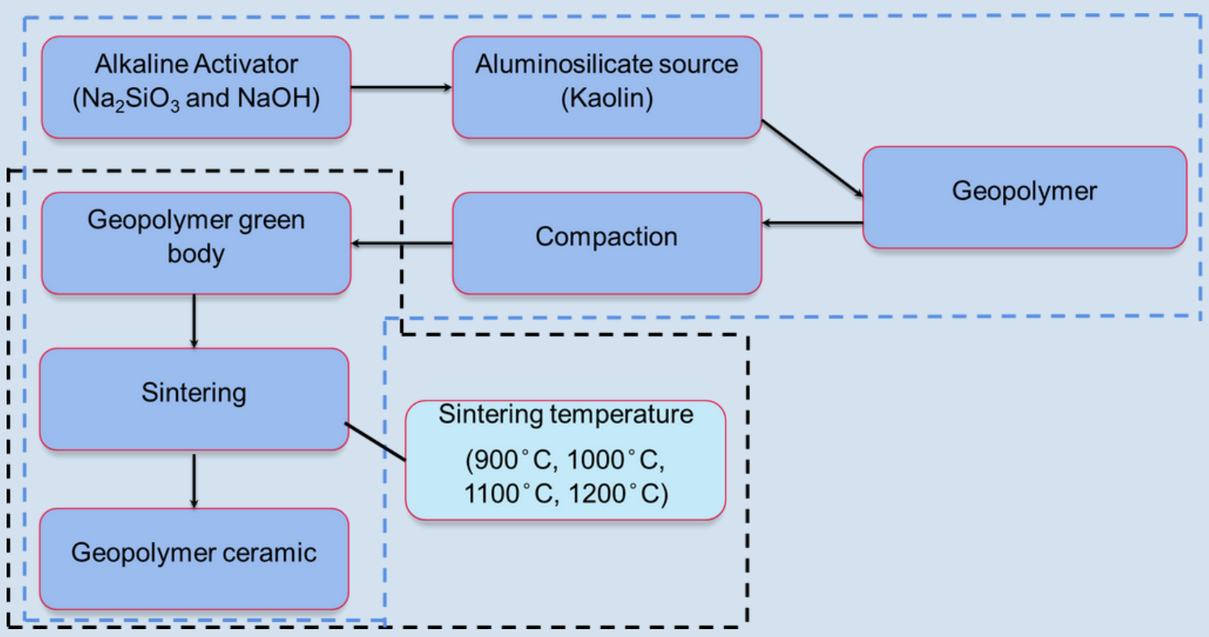
DESCRIPTION

The diverse applications for advanced ceramic have been developed to continue growing at a reasonable rate with the processing and economical tolerance. To feature the required properties, the fabrication of conventional ceramics needs a long heat treatment up to 10 hours with the high sintering temperature up to 1800 °C. The use of geopolymer method is an alternate way in producing ceramic materials since the amorphous to semi-crystalline behavior of geopolymer will transforms into crystalline (nepheline) phases upon sintering. The unique composition of the geopolymer system with the help of geopolymerization reaction will improve the crystallization process as well as reducing the sintering temperature required. The homogeneous of the geopolymer system will influence the structural rearrangement during the phase change hence promote the nucleation and densification of the geopolymer. Besides, the higher content of silica oxide deviating from nepheline (NaAlSiO4) compositions will also facilitate the densification process and provide the system with self-fluxing properties.

OBJECTIVE

- To produce geopolymer-based ceramic with low sintering temperature
- To study the effects of sintering mechanism on the crystallisation kinetic of geopolymer ceramics during sintering process.

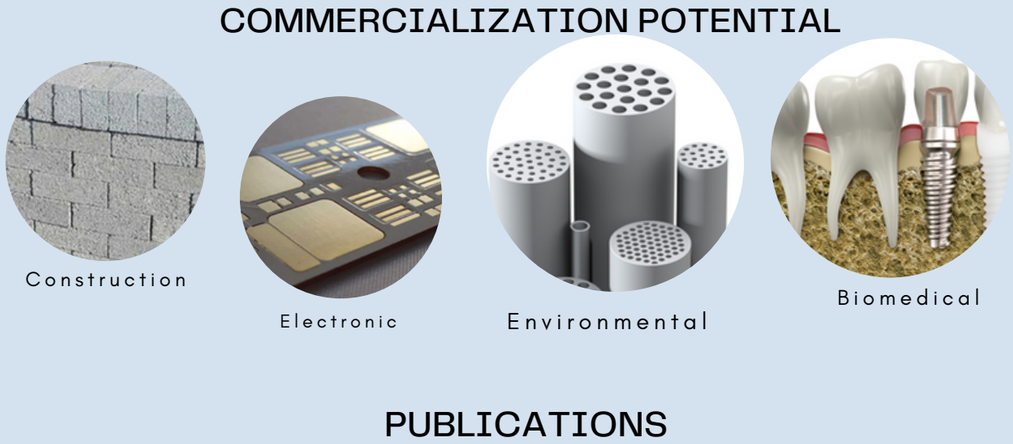
METHODOLOGY



NOVELTIES

- Producing ceramic materials using geopolymer technology require lower temperature compared to conventional ceramics
- Powder metallurgy method used in fabrication of geopolymer based ceramics produce better properties.

COMMERCIALIZATION POTENTIAL

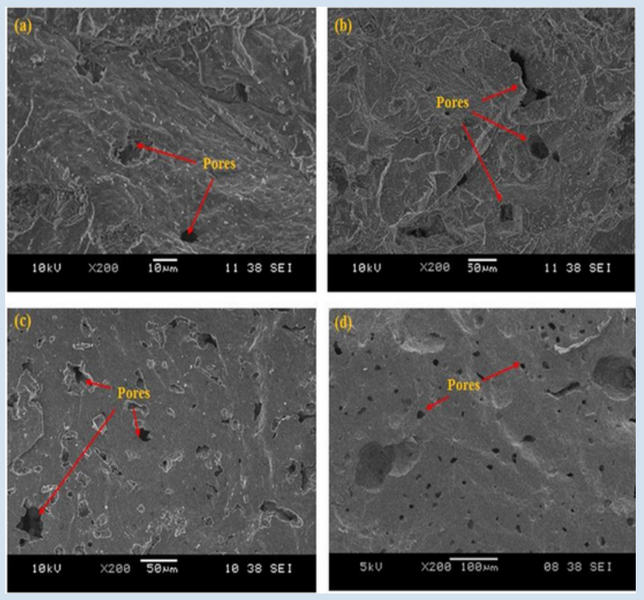


PUBLICATIONS

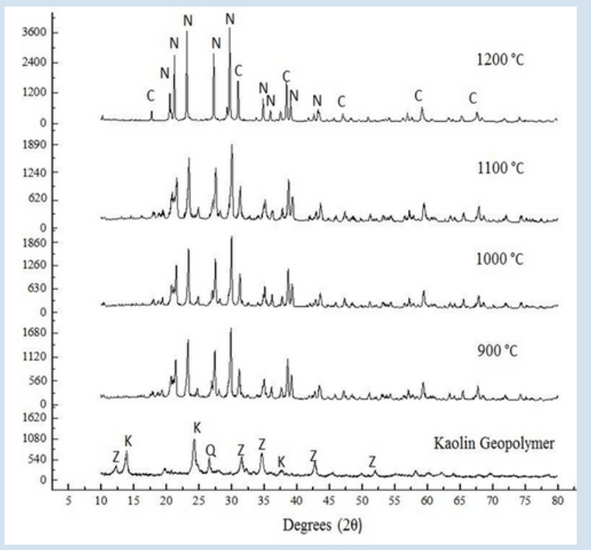
1. Ahmad, R., Abdullah, M. M. A. B., Ibrahim, W. M. W., Hussin, K., Ahmad Zaidi, F. H., Chaiprapa, J., ... & Nabiałek, M. (2021). Role of Sintering Temperature in Production of Nepheline Ceramics-Based Geopolymer with Addition of Ultra-High Molecular Weight Polyethylene. Materials, 14(5), 1077.
2. Ahmad, R., Abdullah, M. M. A. B., Hussin, K., & Ibrahim, W. M. W. (2021). Fabrication of lightweight ceramic materials using geopolymer technology. In Sustainable Waste Utilization in Bricks, Concrete, and Cementitious Materials (pp. 167-189). Springer, Singapore.
3. Ahmad, R., Ibrahim, W. M. W., Abdullah, M. M. A. B., Pakawanit, P., Vizureanu, P., Abdullah, A. S., ... & Ahmad Zaidi, F. H. (2022). Geopolymer-Based Nepheline Ceramics: Effect of Sintering Profile on Morphological Characteristics and Flexural Strength. Crystals, 12(9), 1313.

PRODUCT PROPERTIES

Sintering Temperature	900 °C		1000 °C		1100 °C		1200 °C	
	Average	SD	Average	SD	Average	SD	Average	SD
Flexural Strength (MPa)	42.35	1.81	50.12	1.71	65.65	1.82	92	1.51
Theoretical density (g/cm^3)	2.53	0.02	2.21	0.03	2.05	0.02	1.88	0.02
Total Porosity (%)	25.35	0.5	26.93	0.42	28.23	0.3	34.01	0.61
Volumetric Shrinkage (%)	10.02	0.62	13.54	0.32	16.55	0.54	18.32	0.63
Water Absorption (%)	6.32	0.63	8.54	0.32	13.26	0.51	17.31	0.63



SEM micrograph of geopolymer-based nepheline ceramic at different sintering temperature (a) 900 °C, (b) 1000 °C, (c) 1100 °C, and (d) 1200 °C



XRD pattern of kaolin geopolymer and kaolin geopolymer ceramic at different sintering temperatures (N= Nephaline, C= Carbon, K= Kaolinite, Q= Quartz, Z= Zeolite)

INTERLECTUAL PROPERTIES

PI2021004551
A Method of Manufacture Thereof for Geopolymer Based Ceramic Materials

CONCLUSION

The geopolymer-based nepheline ceramic were successfully fabricated using geopolymer method at 900 °C – 1200 °C. The role of sintering on the physical, mechanical and microstructural properties of nepheline ceramics based geopolymer was investigated. A compacted and smooth surface microstructure with the highest strength of 92 MPa and lowest density of 1.88 g/cm3 were obtained at the sintering temperature of 1200 °C. Structural consolidation was achieved and resulted in a relatively uniform and smooth microstructure at higher sintering temperatures. The presence of pores shows a significant contribution to the improvement of properties, due to phase transformation occurring during the sintering process. The sintering profile will promote material densification while diffusion is the matter transport mechanism that promotes densification and grain growth. The sintering profile of geopolymer materials is important in understanding the effort to improve the mechanical and microstructure properties of geopolymer ceramics.