

Fabrication of Porous Material Using Glass Abrasive Sludge

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Abstract

A porous material with a surface layer was fabricated using glass abrasive sludge and expanding agents. The glass abrasive sludges were mixed with expanding agents and compacted into pellets. These pellets were sintered in the range of 700-900°C for 20min. The sintered porous materials had a surface layer with smaller pores and inner parts with larger pores. The surface layer and pores controlled the absorption ratio and physical properties.

Keywords : Glass abrasive sludge, Expanding agent, Porosity, Absorption ratio, Specific gravity

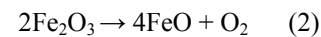
1. Introduction

Porous ceramic materials have characteristics of low specific gravity, high absorption ratio and light weight.[1,2]. These characteristics offer several potential applications for sound absorbers, thermal insulating material, etc. However, some characteristics adversely affect the use of these porous materials. One of these characteristics is the high moisture absorption ratio of more than 10%, and absorption ratio related to pore and surface properties of a porous material.[3,4]. Therefore, research has been directed towards developing a coating on the surface of porous material to control the absorption ratio. However, making a coating layer on the surface of a porous material is not easy.[5,6]. If the pore in the porous material is an open pore, it will affect the absorption ratio. Thus the control of pore is an important factor for making a porous material with low absorptivity. One of the ways to obtain high porosity and low absorption ratio is to choose an appropriate starting materials.

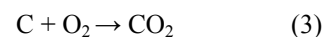
In the present study, attempts were made to fabricate a porous material with a high porosity and low absorption ratio using a glass abrasive sludge and expanding agents. The formation of surface layer, pore and physical properties were also investigated.

2. Experimental and Results

A glass abrasive sludge (by-product of plate glass factory), and expanding agents (CaCO₃, Fe₂O₃ and graphite) were used to form porous materials. The mechanism of pore creation is based on the decomposition of CaCO₃/Fe₂O₃ to produce foaming gases of CO₂ (1)/O₂ (2) gas.



When graphite was used as an expanding agent, it oxidized into CO₂ gas by the following reaction (3):



Dried glass abrasive sludge was used for the chemical analysis and particle size distribution. The result of chemical analysis(wet method) is shown in Table 1. The mean diameter of glass abrasive sludge was 4.71 μm (as determined from particle size analyzer) and specific gravity was 2.51.

Glass abrasive sludge was mixed with each of the expanding agents (CaCO₃, Fe₂O₃ and graphite) in the presence of distilled water in a ball mill for 24h. The amount of expanding agents added were 0.3%, 0.6%, 1.0%, 1.5% (in wt%). Glass abrasive sludge was ground by a disk mill after drying. The ground material was mixed with water and formed into spherical precursors of about 5g. The precursors were sintered in the range of 700-900°C for 20min in air. The microstructures of surface and cutting plane of porous material were observed by scanning electron microscopy (SEM) while the image analyzer (Image-Pro Plus from Media Cybernetics Co.) was used to quantify pores. Physical properties such as absorption ratio and specific gravity were determined by Archimedes principle.

Table 1. Chemical composition of glass abrasive sludge

Comp.	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	SO ₃
wt.%	66.9	1.14	0.16	7.38	3.82	0.28	9.49	0.18

The quantity and size of pores increased with sintering temperature and the amount of expanding agents. The substantial increase in porosity of porous material with

CaCO₃ may be resulted from reduced viscosity of glass by CaO that plays a role of network modifier, breaking the network structure of glass.[7].

The average pore size was about 50–60 μm with 0.3% of all expanding agents sintered at 700°C. However, it was increased to 1800 μm with CaCO₃, 450 μm with Fe₂O₃ and 550 μm with graphite, with same amount of expanding agent, 1.5% and sintered at 900°C. Average pore size in CaCO₃ increased continuously with temperature, perhaps because of the collapse of the pore wall and amalgamation of pores in the material.[8].

Important factors for the control of absorption ratio are surface condition and surface layer of the porous material. If surface layer is composed of closed pores, the absorption ratio decreases. Pore connectivity and isolation also affect the absorption ratio. These phenomena were observed in the SEM photographs(Fig. 1) and the absorption ratio data in Table 2. All of the porous materials had a surface layer “a” for the control of absorption ratio, the thickness of which was 30-200 μm. The region “b” which was 1000-3000 μm from the surface layer was composed of larger pores than the surface layer “a.” This phenomenon was observed in all of the porous materials.

Absorption ratio of porous material with surface layer is shown in Table 2. Porous material sintered at 900°C with CaCO₃ had a high absorption ratio because the pore wall in porous material tends to collapse and several small pores become one large pore.

Table 2. Absorption ratio of porous material

Temp.	Agent	Absorption Ratio (%)			
		0.3%	0.6%	1.0%	1.5%
700 °C	CaCO ₃	3.6	3.8	4.3	5.1
	Fe ₂ O ₃	1.0	1.3	1.7	2.1
	Graphite	1.6	2.0	2.7	3.7
800 °C	CaCO ₃	5.2	6.2	7.8	10.1
	Fe ₂ O ₃	1.2	1.7	2.2	2.6
	Graphite	2.3	2.8	3.5	4.5
900 °C	CaCO ₃	8.6	10.3	14.2	20.2
	Fe ₂ O ₃	2.0	2.7	3.4	3.9
	Graphite	4.6	5.2	6.2	7.9

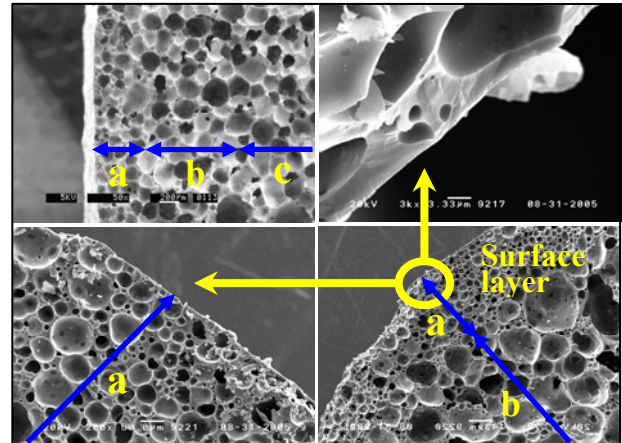


Fig. 1. Photographs of the outer part of material

3. Summary

1. The porosity and pore size increased with sintering temperature and expanding agent fraction. This was especially observed when using CaCO₃ where in the average pore size increased continuously with sintering temperature, perhaps because of the collapse of the pore wall and amalgamation of pores in porous material.
2. Some pores in the surface layer were open pores and connected with inside pores. But some pores in the surface layer were closed pores which easily control moisture absorption.
3. The porous materials with Fe₂O₃ had the lowest absorption ratio (less than 3%) while the porous material with graphite had a low absorption ratio of 3% or lower below 800°C.

4. References

1. V. Ducman, A. Mladenovic and J. S. Suput, *CCR*, **223**[32] (2002)
2. S. Grandjean and J. Absi, *Eu. Ceram. Soc.*, (2005)
3. S. Mindess, J. F. Young and D. Darwin, *Concrete* (2003)
4. J. A. Rossignolo and V. C. Agnesini, *CCR*, **329**[32] (2002)
5. I. K. Jun and J. H. Song, *submitted to Material Letters* (2006)
6. X. Zhu, D. Jing, S. Tan and Z. Zhang, *Am. Ceram. Soc.*, **1654**[84] (2001)
7. Y. S. Kim and T. M. Yun, *Kor. Ceram. Soc.*, **1132**[40] (2003)
8. J. Pan, H. N. Ch'ng and A. C. F. Cocks, *Mechanics of Material*, **705**[37] (2005)