Development of SiC/Zeolite Porous Ceramic

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Abstract

SiC/zeolite porous ceramics were prepared by powder pressing method. In this study, SiC and zeolites of clinoptilolite type were mixed in 3:1 ratio by weight. Meanwhile, yeast was used as pore former agent. Alumina was used as a sintering aids and glycerol as a dispersing agent. The amount of yeast has a strong influence on porosity. The mixtures with 50wt% and 55wt% yeast, sintered at 1300 °C gave a high percentage of porosity which is 85.40% and 84.02% respectively. They exhibit the pore size between 40µm to 100µm. The porous ceramics obtained may have a potential as a filter.

Keywords: porosity, SiC, zeolite, porous ceramic

1. Introduction

In addition to a variety of other industrial fields, micro porous ceramics has become increasingly popular in manufacturing filters for large-volume solid or liquid separation purposes. A filter is a device (usually a membrane or layer) that is designed to block certain objects or substances whilst letting others through. Filters are often used to remove harmful substances from air or water, for example to remove air pollution. Ceramic filter media must have high porosity, narrow pore size distribution and high bend strength as well as high performance in acidic or high temperature environment, depending upon the intended use.

In this study, SiC is used as a main material with zeolites. The outstanding importance of SiC as an industrial ceramic is well known and it is frequently denoted as the most important carbide [1]. Its great hardness, strong oxidation resistance and its small thermal expansion coefficient favor it for many technical applications. SiC is usually considered as the best candidates to produce high melting point metal filter and diesel exhaust filter.

Zeolites are a popular group of mineral that have been used for many years in a wide range of industrial applications because of the very regular and controllable pore sizes within their crystalline structure. Clinoptilolite zeolites are used in this study. The structure resembles microscopic sponges that allow it to trap chemical such as heavy metal, ammonia, calcium, anion, cation, gasses and liquid [2].

Porous ceramics are produced by many ways such as sponge method, pore former method and others. In this study, pores in porous ceramics can be made by burning out the pore former which in sintering process [3]. In general, there are two kinds of pore former, inorganic materials and organic materials. Yeast which is used in this project is a kind of microorganisms and mainly contains C, H, O, N, P, S elements.

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2. Experimental

Silicone carbide (SiC) 99% metal basis (325-mesh powder, black) with zeolites types clinoptilolite were used to produce this porous ceramics. The surface area of zeolite powder was more than 25 m^2/g . The SiC and zeolite were used in the weight ratio of 3:1. Yeast of 50 wt% - 65 wt% was used as a pore former in this porous ceramic. Besides that, 5 wt% of alumina was used as a sintering aids. Meanwhile, a glycerol was used as both a dispersion media and stabilizing agent in the amount of 25 wt%.

The sequence of operation for preparing porous ceramic is depicted in Fig. 1. All of the materials were mixed by using ball milling for 3 hours. The slurry was then dried in an oven for 24 hours at 80 ^{0}C. The dried slurries were then crushed by automatic mortar grinder in order to get it in powder form. These powders were sieved on 500 µm screen. After sieving, the powder was pressed using hydraulic press with 7 tonne loads to form circular samples.

The process was followed by sintering of the samples in furnace at temperature 1000^{0}C, 1100^{0}C, 1200^{0}C and 1300^{0}C for 3 hours. The sintering profile was described in Fig. 2. The porous structure resulting from this process was observed using JEOL JSM-6380LA model scanning electron microscope. Meanwhile the porosity and bulk density were measured by Archimedes principal.

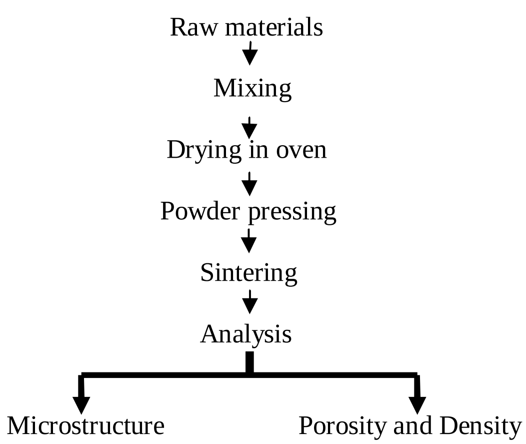


Fig. 1**:** Flow chart for the sample preparation and testing of porous ceramic

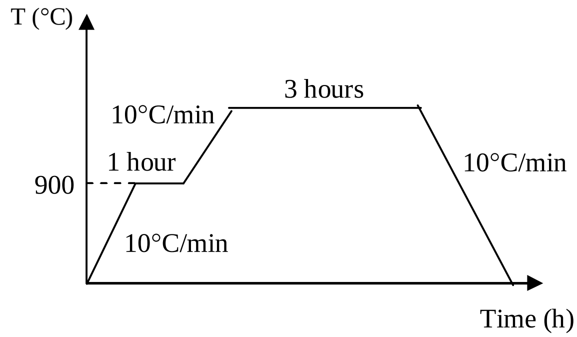


Fig. 2: Sintering profile of porous ceramic

3. Results and Discussion

3.1 Porosity

Fig. 3 shows the graph of apparent porosity versus sintering temperature. As can bee seen from the graph, at 1200^{0}C and 1300^{0}C, the percentage of porosity of the ceramics with 60 wt% and 65wt% yeast have started to decrease due to pore shrinkage during sintering process [4,5]. Thus, from the overall overview, the increase in sintering temperature will caused the reduction in porosity.

Meanwhile, the relationship between apparent porosity and yeast composition is shown in Fig. 4. The maximum porosity, 85.40% is obtained from the addition of 50% yeast in ceramic mixture which is sintered at 1300^{0}C. However, other compositions still exhibit the higher and outstanding values of porosity in the range of 75 – 85%. This phenomenon is caused by burning out of pore formers and leaved behind the pore in the ceramic structures [6].

Table 1 : Porosity of porous ceramics with different composition of yeast

Yeast	Apparent porosity (%)			
(wt%)	1000^{0}C	1100^{0}C	1200^{0}C	1300^{0}C
50	80.72	78.95	78.33	85.40
55	82.88	80.85	85.92	84.02
60	84.29	84.84	84.69	80.82
65	84.39	84.55	81.94	75.80

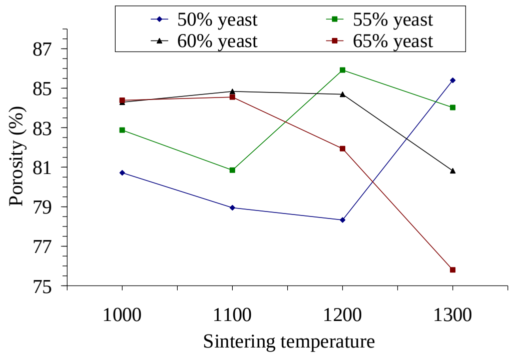


Fig. 3: Apparent porosity of porous ceramics versus sintering temperature

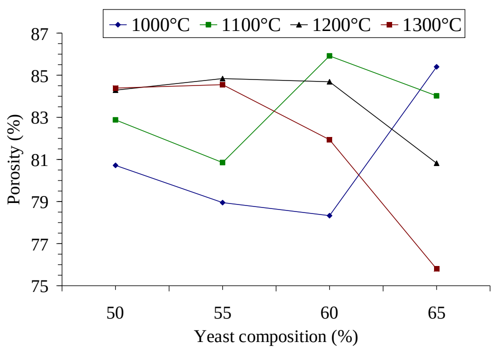


Fig. 4: Apparent porosity of porous ceramics versus different yeast percentage

3.2 Density

Figure 5 shows the relationships of bulk density with sintering temperature and yeast composition. Generally, bulk density will increase with the sintering temperature. The higher the sintering temperature, the more the liquid phase is and the lower its viscosity. Thus, the liquid phase fills in pores and makes the product compact. The graph shows the different result as the bulk density is decreased at 1200^{0}C and 1300^{0}C for 60 wt% and 65 wt% yeast. It is caused by the different densifying rate due to inhomogenities in the sample [7]. The density of these porous ceramics is between 1.27 g/cm^3 to 2.13 g/cm^3. The sample with 50% yeast and sintered at 1300^{0}C exhibits the highest density value.

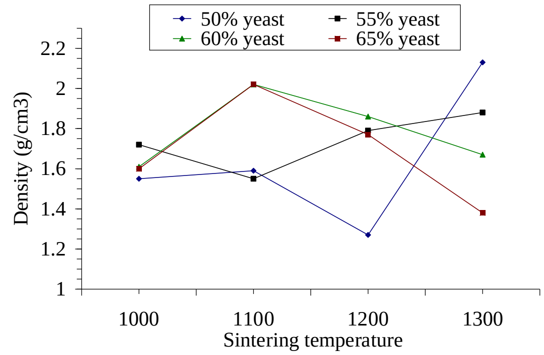
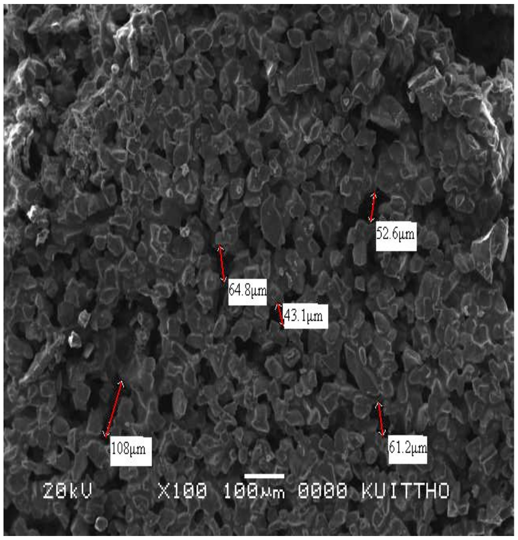


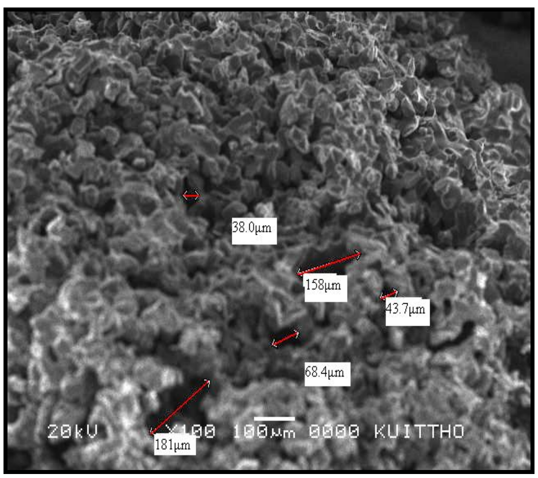
Fig. 5: Bulk density of porous ceramics versus sintering temperature

3.3 Microstructure Analysis

The procedure for mixing does not provide the high shear stress known to be needed to break up agglomerates in ceramic powders [2,8]. Therefore, the microstructure can be expected to contain undispersed agglomerates. The pores size and distribution after sintering process were investigated using SEM (Fig.6). From the micrograph, samples which are sintered at 1300^{0}C exhibit the uniform pores distribution compared to other samples. The obtainable pores size diameter is between 40 µm to 200 µm. This result shows a good agreement with the mean pore size that has been obtained from others previous research which was 30 µm – 100 µm [9,10].



(a)



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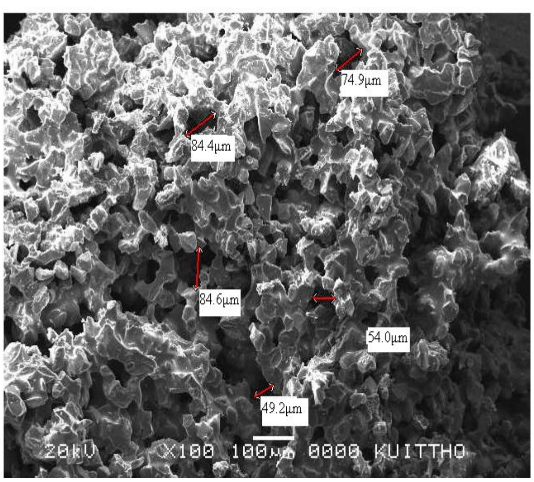
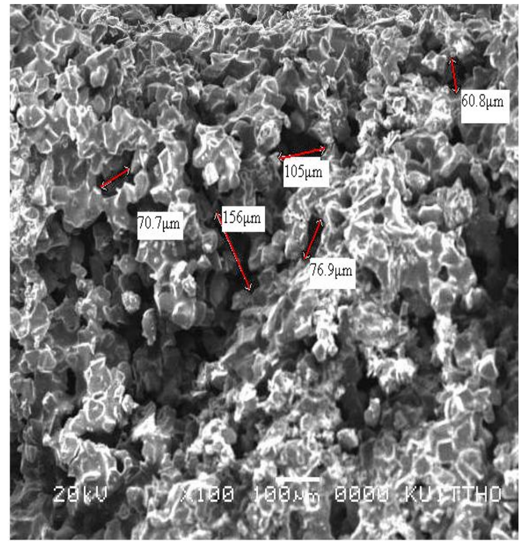


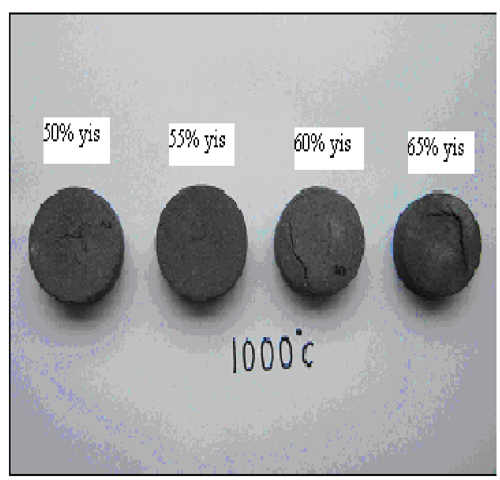
(c)



(d)

Fig. 6: Scanning electron micrograph of porous ceramics sintered at 1300°C with yeast composition of (a) 50% (b) 55% (c) 60% and (d) 65%

From visual inspection there were cracks at almost all of the samples after sintering process. The crack was slowly eliminated with the increasing in sintering temperatures as shown in Fig. 7 (a) – (d). At 1300^0C, the sample with 50 wt% and 55 wt% yeast shows a smooth surface without crack. This may be due to a suitable combination of yeast composition and the selected sintering temperature.



(a)

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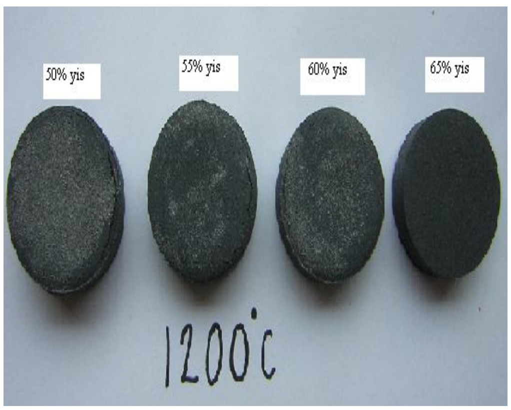

(c)

(d)

Fig. 7 : Samples after sintering at (a) 1000°C, (b) 1100°C, (c) 1200°C and (d) 1300°C

4. Conclusion

The SiC/zeolite porous ceramic with yeast as a pore former was produced successfully by the powder pressing method. The properties of this porous ceramic were analyzed in terms of porosity; bulk density and pores characteristic. Based on the results obtained, a higher percentage of porosity which is more than 80% and the range of pore size between 40µm to 100µm give it a potential to function as a filter. This is according to a statement from previous researcher that the suitable porosity for a filter is 45% to 80% with the mean pore size range from 31µm to 92µm [9]. As an example, for metal infiltration at least 75% porosity is needed [11]. Therefore, porous ceramics have an important potential of development. Nethertheless many others applications may emerge in the near future.

Acknowledgement

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