Solid State Science and Technology, Vol. 16, No 1 (2008) 14-20
ISSN 0128-7389

PREPARATION AND CHARACTERISATION OF FILTER SUPPORT FROM LOCAL SILICA

A. Hamidi, R. Ramli and W.D. Teng

Structural Materials Programme, AMREC, SIRIM Berhad
40911 Shah Alam, Selangor, Malaysia

ABSTRACT

Ceramic filters have been widely is in the filtration and separation processes technology. Due to advantage of the ceramic properties, the ceramic filter can be used from water filtration, molten steel separation even to petrochemical filtration or separation applications. In this study, local silica is selected for the preparation of the fabrication of ceramic filter. It is also to study the suitability of the local silica as the alternative materials for the current alumina filter. Two selected formulation of silica with the characteristic particle sizes distribution and binders were formulated and mixed in a z-blade mixer for 3h respectively. The mixer was extruded using the deairing pugmill. The extrudate was cut into 80mm x 15mm x 10mm and dried. Then, the samples were fired at 2^oCmin^{-1} to maximum temperature from 1000^oC to 1300^oC and held for 30min before cooling. Sintered samples were characterized for the density, microstructures, porosity and flexural strength and the results are presented.

INTRODUCTION

Ceramic water filter is one of the types of water filter, commonly used in a household, which purify water by passing the water through pores in ceramic with the pressure of the tap water. In this way, the undesired materials found in water such as dirt, rust, clay materials and even pathogens are removed and the water is safe for drinking.

As early as 1827, this ceramic water filter had been produced by John Doulton, a fine china manufacturer using various earth and clay materials as the first Doulton water filters for the industrial applications [1]. Alumina filters [2-4] are getting popular due to the excellence of mechanical strength and tolerance to solvents, as well as pH, chemical resistance and high temperature. Later, highly porous activated alumina material with high surface area had been developed for filtration of fluoride, arsenic and selenium in drinking water [5]. However, the cost of the filter is not affordable by the under-developing countries, an ANU materials scientist Mr Tony Flynn had developed simple water filter without the need for a kiln, to remove common pathogens including E-coli for the community of Manatuto in East Timor [6].

Ceramic filter can be formed by various ceramic fabrication route such as slip casting, solid casting, gel-casting, pressing, extrusion and hand forming technique [7]. In this study, local silica is selected for the preparation of the extrusion fabrication of ceramic filter support. Extrusion fabrication technique is used to shape the filter by forcing the

Corresponding Author: wdteng@sirim.my

Solid State Science and Technology, Vol. 16, No 1 (2008) 14-20
ISSN 0128-7389

formulated plastic silica body through the orifice of a rigid die. This process has been widely used for mass production of ceramic products in the industrial manufacturing process [8]. The extrudate obtained is used to study the suitability of the local silica as the alternative materials for the current alumina filter support [1-3].

EXPERIMENT DETAILS

Raw materials

The silica (SM325, Sarawak) was a commercially available powder. The morphology of the powder was examined using a Hitachi scanning electron microscope (SEM). The particle size distribution of the powder was obtained using a Micromeritics Sedigraph 5100 X-Ray Particle Size Distribution Analyser.

Body Preparation

The silica powder was mixed with bentonite clay and carboxymethyl cellulose (CMC) as shown in Table 1. The CMC is premixed with warm distilled water in a ratio of 5.5 to 4.5. The mixture is mixed in a z-blade mixer for 3h to get the homogeneous plastic body. The plastic body was extruded using the deairing pugmill. The extrudate was cut into 80mm x 15mm x 10mm and dried under control humidity condition. Then, the samples were dried and fired at $2^{o}Cmin^{-1}$ to maximum temperature from $1000^{o}C$ to $1300^{o}C$ and held for 30min before cooling.

Raw Materials	Body F1, wt.%	Body F2, wt.%
silica	62	64
bentonite clay	12	9
carboxymethyl cellulose	26	27

Body Characterisation

Sintered samples were characterized for the density, microstructures, porosity and flexural strength. The bulk density of the sintered samples was measured by water immersion method using an electronic balance (Mettler Toledo, Switzerland).

The fractured surface of the sintered samples of various sintering temperatures were coated with gold film prior to microstructural examination by the use of a scanning electron microscope (SEM - Hitachi S2500, Japan).

The porosity of the sintered sample was computed from the water absorption technique using the following equation (1):

$$\text{Porosity, \%} = \frac{Ww - Ws}{Ww - Wi} \text{ X } 100 \qquad (1)$$

where *Ws* is the weight of dried sample (g)
Ww is the weight of water soaked sample after 24h (g)
Wi is the weight of sample immersed in water (g)

Corresponding Author: wdteng@sirim.my

Solid State Science and Technology, Vol. 16, No 1 (2008) 14-20
ISSN 0128-7389

Flexural strength (3-point bend test) was measured using a universal testing machine (Shimadzu AG-5000E, Japan), and the sample support span was 60 mm.

RESULTS AND DISCUSSION

The mean powder particle size was measured to be about 10.5 µm with a median of about 10.1 µm. The percent finer of the particle size of 2, 5 and 20 µm are 14, 29 and 76% respectively. SEM micrograph of the powder, as shown in Figure 1, illustrates that a wide range of particle size distribution exists.

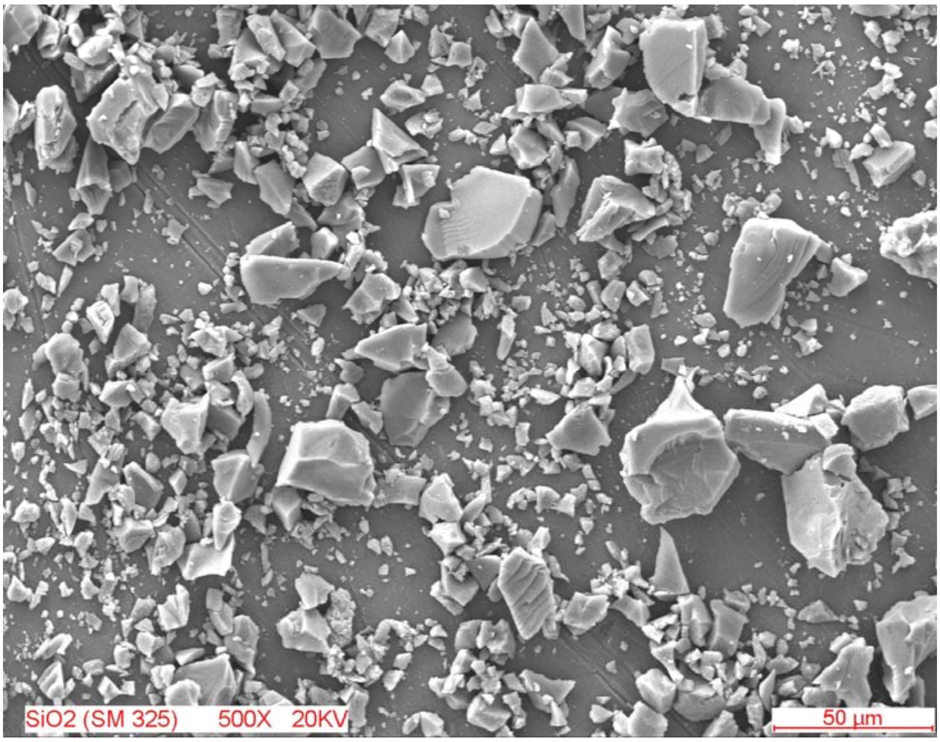
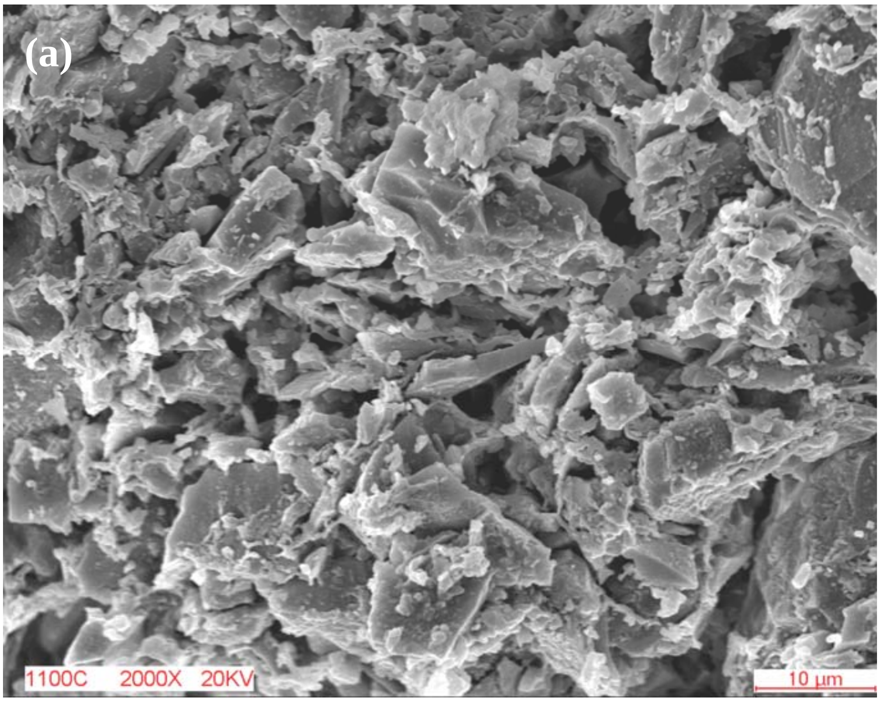


Figure 1: Scanning electron micrograph of the silica powder showing the fracture particles with irregular edges and surface

The average density of 1.5 gcm^{-3} was the same for all sintered samples within these sintering temperature ranges, no significant variation was observed. Thus, there was no effect of the formulation and sintering temperatures toward the density property and this had shown that there was no significant change of size of the sintered sample. However, the microstructure, as shown in Figures 2 and 3, of the sample sintered at 1300^oC is more compact than that of the samples sintered at 1100^oC. This was reflected and agreed with the porosity results as shown in Figure 4.

Corresponding Author: wdteng@sirim.my



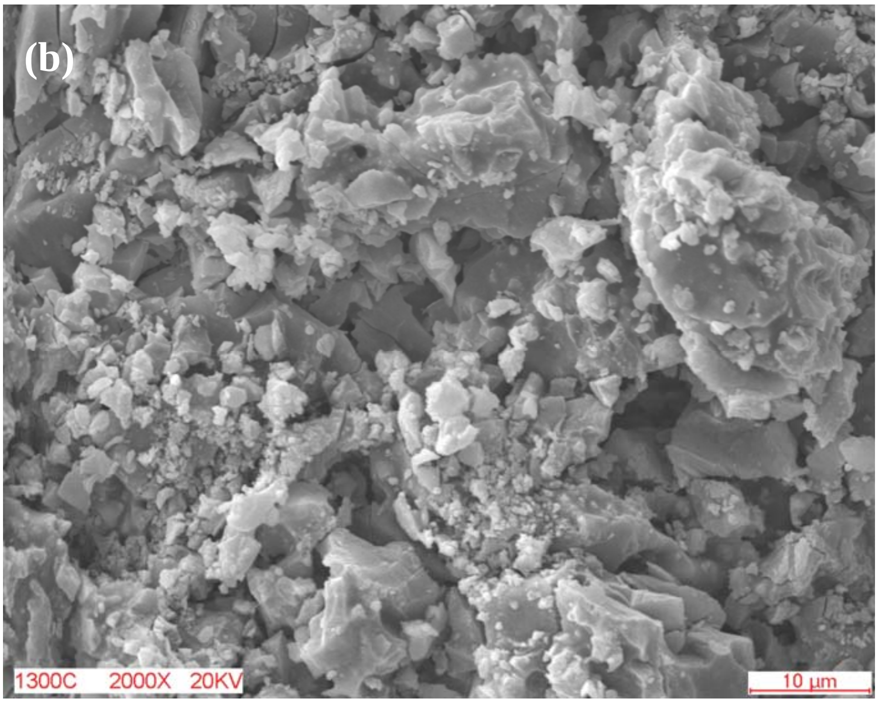


Figure 2: Scanning electron micrograph of the sintered silica F1 body at 1100^{o}C (a) and 1300^{o}C (b) showing the arrangement of the particles and the pores in the body.

Corresponding Author: wdteng@sirim.my

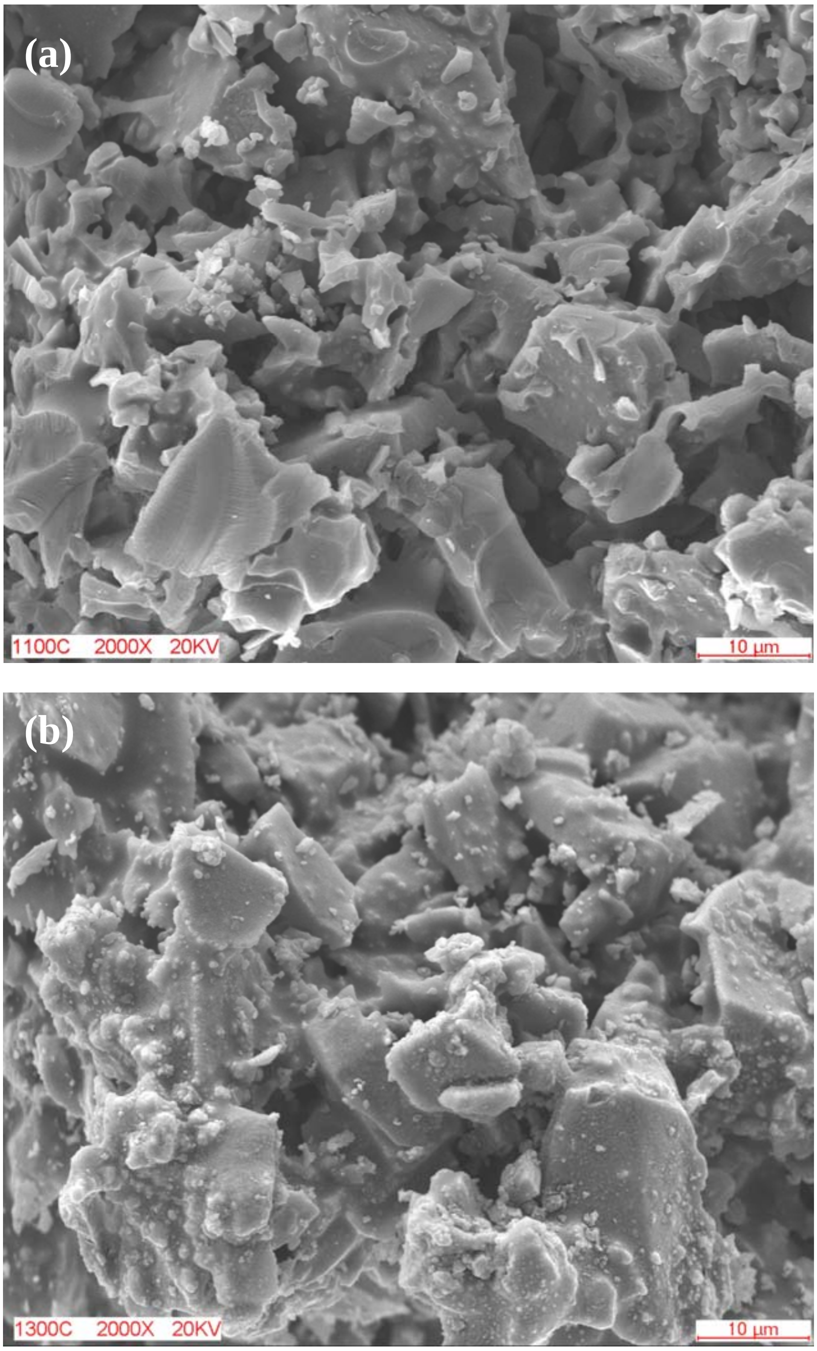


Figure 3: Scanning electron micrograph of the sintered silica F2 body at 1100^{o}C (a) and 1300^{o}C (b) showing the arrangement of the particles and the pores in the body.

Corresponding Author: wdteng@sirim.my

For sintered body F1, at 1100°C and 1300°C, the porosity were 37% and 32% respectively; and for sintered body F2, at 1100°C and 1300°C, the porosity were 38% and 35% respectively. This indicated that the F2 body had better porosity as required by the filtration parameter. The strength of the filter is an important parameter to support the pressure of the incoming purifying water. The strength of the ceramics increases with the increase of sintering temperature. In this case, the sintered body F1, at 1100°C and 1300°C, had the flexural strength of 5.5MPa and 14.6MPa respectively; and for sintered body F2, at 1100°C and 1300°C, the flexural strength were 11MPa and 26MPa respectively as shown in Figure 4. The higher flexural strength of body F2 gave better body for the filtration and it also exhibited the higher porosity for the flow of the water.

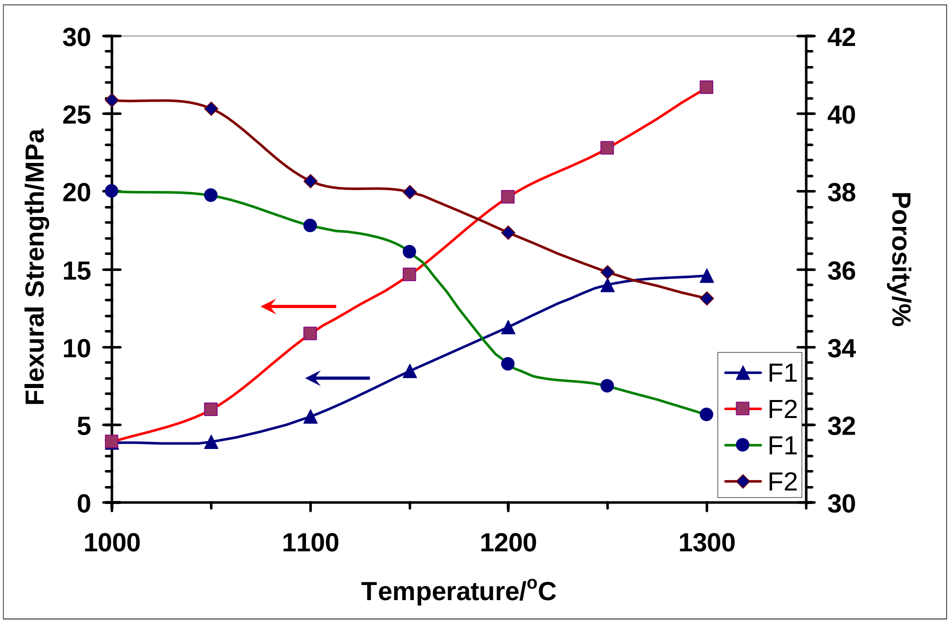


Figure 4: The porosity and flexural strength of the filter samples versus the respective sintering temperatures.

CONCLUSION

The local silica body F2 had shown better filtration parameter required by the material choice for the ceramic filter support. The strength of above 25MPa and 35% in porosity had been shown by the sintered body F2 at 1300°C.

ACKNOWLEDGEMENTS

This work was supported under the MOSTI-SF grant No. 03-03-02-SF0026. The authors gratefully acknowledged the technical assistance provided by Zalena, Azura, Hanaffi and Ahmad Sabata.

Corresponding Author: wdteng@sirim.my

REFERENCES

[1]. History of the Doulton Ceramic Filter Candle, *Doulton Water Filters / H2O International Inc. Product Catalogue*, Copyright © 1997 H2O International Inc.

[2]. G.J. Zhang et.al., (Jun 2001), *J. Am Ceram. Soc*., Vol. **84**, 1395-97.

[3]. S. Sokolov et.al., (Sep 2003) *J. Am Ceram. Soc*., Vol. **86**, 1481-86.

[4]. Z. Abdul Wahid, et.al., (2005) *Proc. Advanced Processes and Systems in Manufacturing*, 113-116.

[5]. Vivek S.C., et.al., (Jan 2007) *Journal of Hazardous Materials*, Vol.139, 103-107.

[6]. Tony Flynn, (Wed 19 Jan 2005) *ANU Marketing & Communications*, The Australian National University,.

[7]. Reed, J.S. (1995). *Principles of ceramic processing*, Second edition, John Wiley & Sons Inc., New York.

[8]. Isobe, T., et.al., (2006) *Journal of the European Ceramic Society*, 26, 957–960.

Corresponding Author: wdteng@sirim.my