

Effect of Co_2O_3 Addition on the Properties of Acid Resistance of Porous SiC Ceramics

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Abstract. The acid resistance of the support which with Co_2O_3 dopant was studied in this paper. SEM S4800 / TM3000 was used to characterize the corroded support in different natural environment, and the corrosion degree of the support was measured by means of electronic balance. The phase structure of sintered support were analyzed by X-ray diffractometer, the filtration pressure drop of sintered support were measured by filtration pressure drop test system, the bending strength of sintered support were measured by YLN- electronic press. The results show that the new support prepared by adding Co_2O_3 on the basis of the original SiC porous ceramic support has good acid resistance. The corrosion time and solution concentration have effect on the degree of corrosion of the support. While the corrosion time growth and the higher concentration of the solution that the support soaked in, the degree of corrosion of the support is more serious. However, the degree of corrosion decreased after the addition of Co_2O_3 . No matter how serious the degree of corrosion of the support is, there is no effect on the pressure drop of the support.

1. Introduction

SiC porous ceramics have attracted significant attention because they possess the excellent combination of low coefficient of thermal expansion, good thermal-shock resistance, as well as high strength. Moreover, they have excellent mechanical and chemical stability at elevated temperatures [1–3]. Therefore, SiC porous ceramics have been extensively used in molten metal filters, catalyst carrier, hot gas purification, and act as potential candidates for various high-performance industrial applications [4–7].

In order to improvement of high temperature strength, thermal aseismic performance and acid corrosion resistance of support. Co_2O_3 was added as a sintering additive. The Co_2O_3 addition strongly promoted the phase transformation towards mullite and in this study, effect of Co_2O_3 on the phase composition, micro-structure, flexural strength acid of resistance the mullite-bonded porous SiC ceramic was investigated [8-13].

In this Takehiko Hirata [14] has studied the corrosion process and mechanism of ceramics in molten salt. [15] The corrosion behavior of slag ceramics has been studied. Tsugio Sato [16] has studied the corrosion resistance of different materials at high temperature. The acid corrosion resistance of silicon carbide porous ceramic support is studied. The effects of different corrosion time, solution concentration and temperature on the corrosion degree of the support are analyzed in this paper, and the binder composition of the support is improved. In order to improve its acid corrosion resistance. the possibility of using silicon carbide porous ceramics as acid-alkali resistant porous ceramics is discussed, and the feasibility of its application in the filtration of acid-base materials is preliminarily explored.

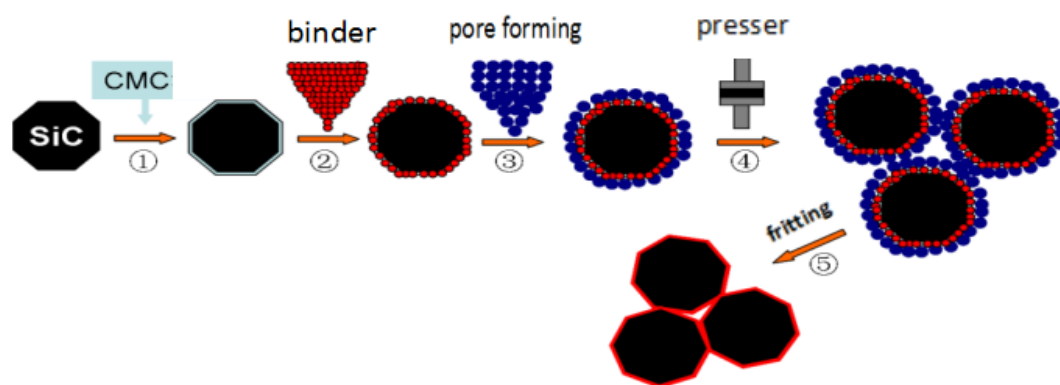


2. Experimental

2.1. Preparation of raw materials and samples

Name	Component	Application
CMC	carboxymethylcellulose sodium (The concentration is 2%)	Uniform distribution of particles
Binder	Potash feldspar (60.31%), Calcined kaolin (11.4%), Quartz (21.75%) Co ₂ O ₃ (6.54%)	To bond the particles together when sintered.
pore former	Graphite (50%) Acticarbon (50%)	To produce voids in the sample when sintered.

The raw materials used in our experiment are commercially available black SiC powder(230 μ m), Then to preparation of binder, mixing potash feldspar(60.31%), calcined kaolin(11.4%), quartz (21.75%) and Co₂O₃(6.54%) in proportion then milled. Then prepare the sample, Their mass ratio(SiC: CMC: binder: pore former) was 40:4:5:5.then pressed into the press sheet or strip, and finally sintering at high temperature, the heating rate is 2 $^{\circ}$ C /min, first heating to 900 $^{\circ}$ C for 30min, and then heated to 1300 $^{\circ}$ C for 60min and natural cooling to room temperature. The preparation process is shown below.



2.2. Characterization of samples

SEM S4800 / TM3000 were used to characterize the corroded support in different natural environment, and the corrosion degree of the support was measured by means of electronic balance. The phase structure of sintered support were analyzed by X-ray diffract meter, the filtration pressure drop of sintered support were measured by filtration pressure drop test system, the bending strength of sintered support were measured by YLN- electronic press.

2.3. Experimentation

The corrosion effect of hydrochloric acid(8mol/L) on the samples by different soak period (24h, 48h, 72h, 96h, 120h) and the support immersed in different concentrations of hydrochloric acid (4 mol/L, 6mol/L, 8 mol/L, 10 mol/L, 12 mol/L)respectively.

3. Result and discussion

3.1. Testing of binder XRD

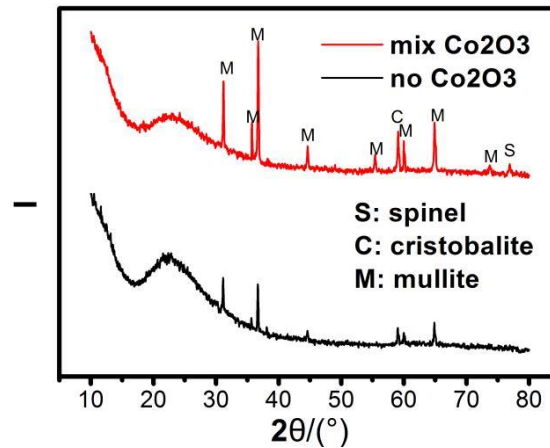


Figure 1. XRD diagram of binder.

It can be seen that the X-ray diffraction patterns of unadulterated and doped Co₂O₃ from the above diagram, after the addition of Co₂O₃, the glass phase decreased, Refer to XRD diffraction peaks of mullite phase, their quantity increased, and the peak of spinel phase appear. The reason is that Co atom can inhibit the formation of glass phase. Co atom in Co₂O₃ can promote the formation of liquid phase, increase the reaction activity of Si-O structure, increase the mullite phase, and combine with Al atom and O atom in liquid phase to form spinel phase. The increase of spinel phase can improve the chemical stability and thermal expansion coefficient, and the increase of mullite phase can improve the high temperature strength, thermal seismic performance and acid resistance.

3.2. Different soaking time

3.2.1. Mass loss of support after immersion and change of flexural strength of support after immersion

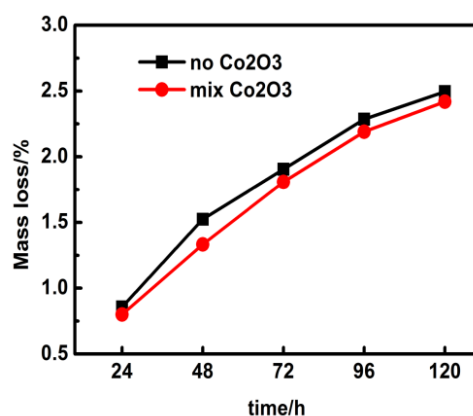


Figure 2. Variation of mass loss.

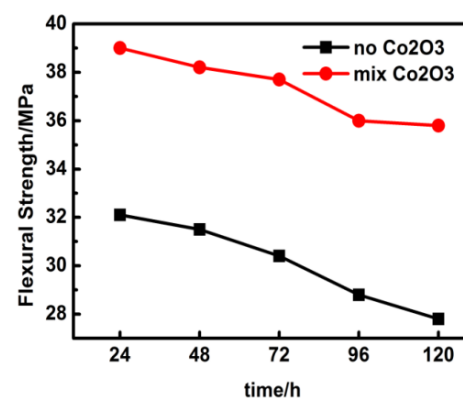
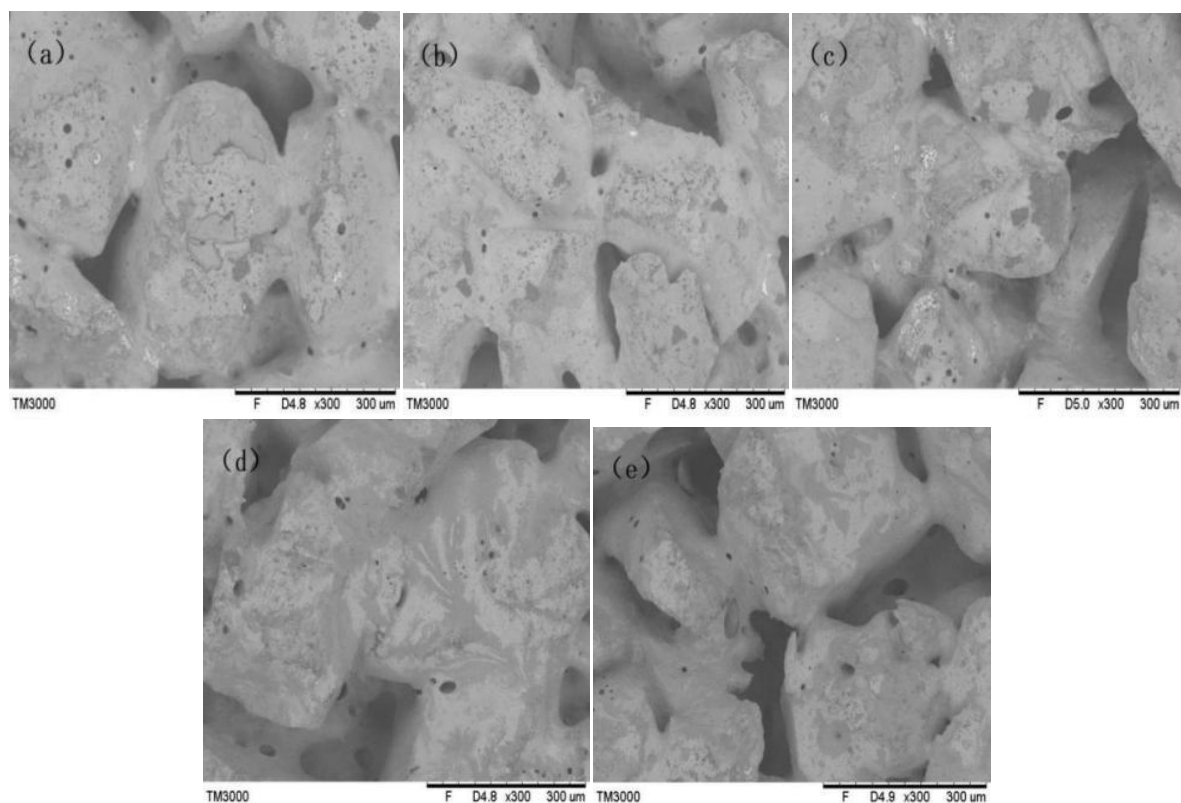


Figure 3. Changes of flexural strength of support.

Figure 2 is Variation of mass loss. It can be seen that the mass loss rate of support increases firstly and then tends to flatten with the increase of the soak period. However, the mass loss rate decreased after incorporation of Co₂O₃. The main reason is the increase of mullite phase after the addition of Co₂O₃, and the better acid corrosion resistance of mullite phase.

Figure 3 is changes of flexural strength of support body over time in hydrochloric acid (8mol/L). It can be seen from the figure, the flexural strength of the supporting body is decrease with the extension of soaking time. However, the flexural strength rate of decline reduced after incorporation of Co_2O_3 . The main reason is the increase of mullite phase after the addition of Co_2O_3 , and the better acid corrosion resistance of mullite phase. The flexural strength of the support mixed with Co_2O_3 is obviously improved. There are two reasons. On the one hand, the glass phase decreases, the liquid fluidity decreases, the viscosity increases, the toughness increases and the flexural strength increases during sintering. On the other hand, because of the decrease of porosity, the support is denser and the flexural strength is higher.

3.2.2. The surface morphology characterization of support doped with Co_2O_3 immersion hydrochloric acid using sem



(a)24h; (b)48h; (c)72h; (d)96h; (e)120h

Figure 4. SEM images after corrosion at different time.

Figure 4 shows the SEM images that support immersed in hydrochloric acid (6mol/L) for 24h, 48h, 72h, 96h and 120h respectively. We can obviously observe that with the increase of immersion time, the increase of corrosion degree. However, the degree of corrosion is not serious. It shows that the addition of Co_2O_3 increases the acid resistance of the support.

3.2.3. Change of filtration pressure drop of support after immersion

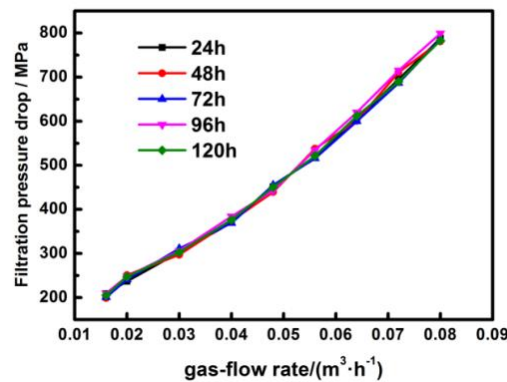


Figure 5. Change of filtration pressure drop.

As shown in the Figure 5, with the increase of corrosion time, the change of pressure drop is not obvious. Because the main influence of the filter pressure drop is distribution formed by the accumulation of SiC particles. And the corrosion of the HCl solution to the support body cannot change the structure of the support body.

3.3. Different concentration of hydrochloric acid(mol/L)

3.3.1. Mass loss of support after immersion

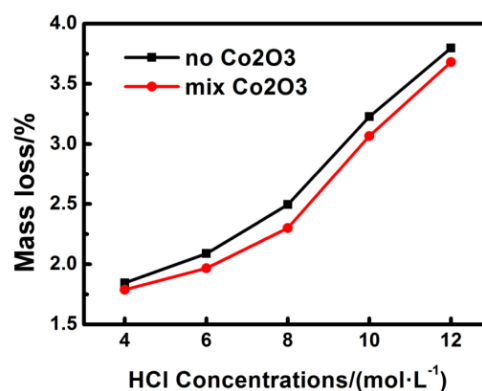


Figure 6. Variation of mass loss.

It can be seen that the increase of soaking time, mass loss increases from the above diagram, the higher the concentration of hydrochloric acid, the higher the mass loss rate. However, the mass loss rate decreased after incorporation of Co_2O_3 . The main reason is the increase of mullite phase after the addition of Co_2O_3 , and the better acid corrosion resistance of mullite phase.

3.3.2. The surface morphology characterization of support doped with Co_2O_3 immersion hydrochloric acid using SEM

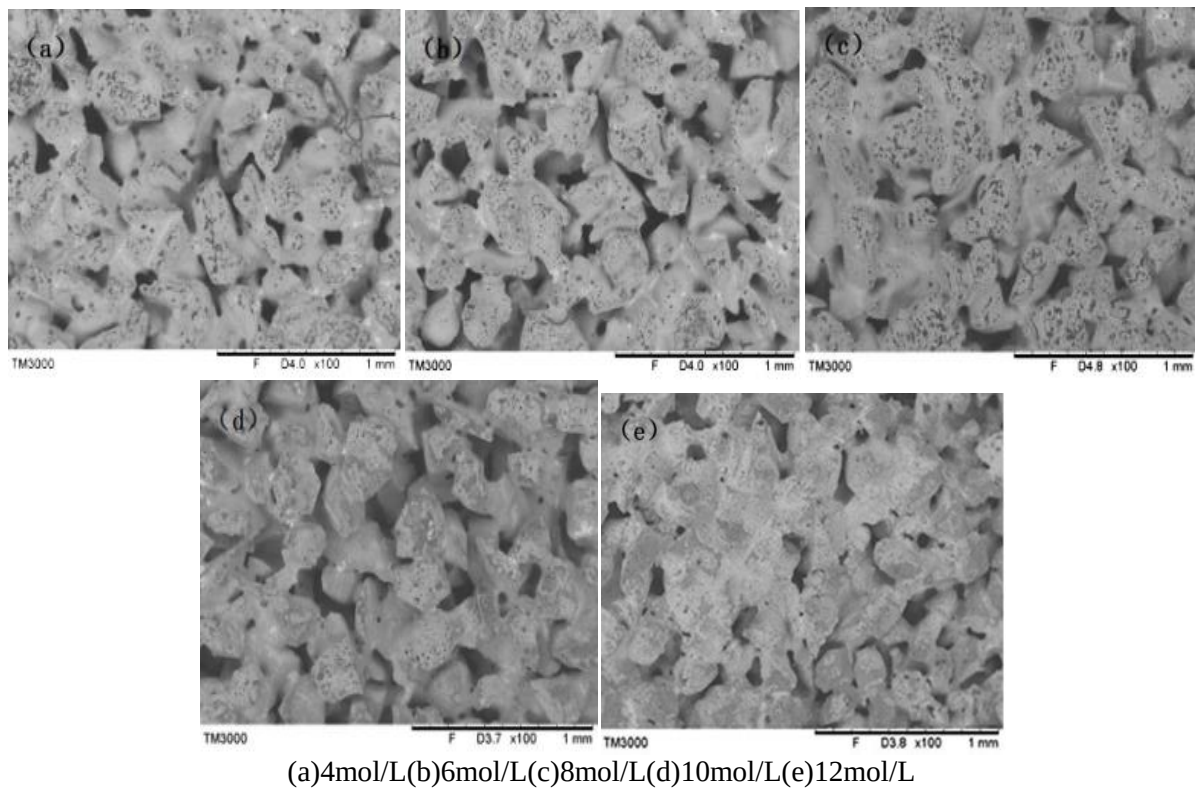


Figure 7. SEM images after corrosion at different concentrations.

Figure 7 shows. We can obviously observe that with the increase of immersion concentrations, the increase of corrosion degree. However, the degree of corrosion is not serious. It shows that the addition of Co_2O_3 increases the acid resistance of the support. The main reason is the increase of mullite phase after the addition of Co_2O_3 , and the better acid corrosion resistance of mullite phase.

4. Conclusion

(1) The new support prepared by adding Co_2O_3 on the basis of the original SiC porous ceramic support has good acid resistance. The main reason is the increase of mullite phase after the addition of Co_2O_3 , and the better acid corrosion resistance of mullite phase.

(2) No matter the degree of corrosion of the support, there is no effect on the filter pressure drop of the support. Because the main influence of the filter pressure drop is distribution formed by the accumulation of SiC particles.

5. Acknowledgments

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6. Reference

- [1] G. CelebiEfe, T. Yener, I. Altinsoy, M. Ipek, S. Zeytin, C. Bindal, The effect of sintering temperature on some properties of Cu–SiC composite, *J. Alloys Compd.* 509 (2011) 6036 – 6042.
- [2] P.C. Rojas, G.J. Piderit, P. Toro, Development of open-pore silicon carbide foams, *Key Eng. Mater.* 132–136 (1997) 1731–1734.
- [3] N. Popovska, E. Alkhateeb, A.P. Froba, A. Leipertz, Thermal conductivity of porous SiC composite ceramics derived from paper precursor, *Ceram. Int.* 36 (2010) 2203 – 2207.

- [4] P.H. Pastila, V. Helanti, A.P. Nikkila, T.A. Mantyla, and Effect of crystal-lization on creep of clay bonded SiC filters, *Ceram. Eng. Sci. Proc.* 19 (1998) 37– 44.
- [5] J.H. She, J.F. Yang, N. Kando, T. Ohji, *J. Am. Ceram. Soc.* 85 (2002) 2852–2854.
- [6] A.R. Studart, et al., Processing routes to macroporous ceramics: a review, *J. Am. Ceram. Soc.* 89 (6) (2006) 1771 – 1789.
- [7] Y.H. Choi, Y.W. Kim, I.S. Han, S.K. Woo, Effect of alkaline earth metal oxide addition on flexural strength of porous mullite-bonded silicon carbide ceramics, *J. Mater. Sci.* 45 (2010) 6841– 6844.
- [8] K.K.Cham, A.M.Brownstein, Ceramic membranes growth prospects and opportunities, *Am. Ceram. Soc. Bull.* 70 (1991)703-707.
- [9] Zhang D S, Aunan K, Seip H M, et al. The assessment of health damage caused by air pollution and its implication for policy making in Taiyuan, Shanxi, China. *Energ Policy*, 2010, 38:491-502.
- [10] Li Ying, Huang Fengping, Liang Zhenhai. Properties and Application of Silicon Carbide Ceramics [J]. *Ceramics*, 2007, 5: 36 - 41.
- [11] Wu Qide, Wang Youbing, Ji Xiaoli, et al.. Chemical corrosion resistance of SiC with high density reaction sintering [J]. *Lubrication Engineering*, 2007, 32: 40 - 43.
- [12] Sanchita Baitalik, Nijhuma Kayal, Processing and properties of cordierite-silica bonded porous SiC ceramics, CSIR-Central Glass and Ceramic Research Institute, 196, Raja S. C. Mulick Road, Kolkata 700032, India.
- [13] Hwan-Sup Lee, Jun-Gyu Kim, Doo-Jin Choi. The effects of SiC whisker and a SiC film coating deposited by chemical vapor infiltration (CVI) on a porous cordierite substrate. *Science+ Business Media, LLC*, 2008.
- [14] Hriata T., Ota S., Morimoto T. Influence of impurities in Al₂O₃ ceramics on hot corrosion resistance against molten salt [J]. *Journal of the European Ceramic Society*. 2003, 23:91-97.
- [15] Hirata T., Morimoto T, Ohta S., et al. Improvement of the corrosion resistance of alumina chromia ceramic materials in molten slag [J]. *Journal of the European Ceramic Society*. 2003, 23: 2089 - 2096.
- [16] Sato T., Sato S., Okuwaki A. The improvement in the corrosion resistance of alumina in caustic alkaline solutions obtained by dispersing ceria-doped tetragonal zirconia particles [J]. *Corrosion Science*. 1992, 33(4): 581- 590.