Synthesis of Molochite Using Fly Ash from Fused Brown Corundum

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The research results concerning the effects of different temperature on synthesis of molochite by using treated fly ash from fused brown corundum. Examined by XRD, SEM and EDM, the results shows that when the temperature is 1600 °C, the main phase of the sample is mullite except for amorphous glassy phase.

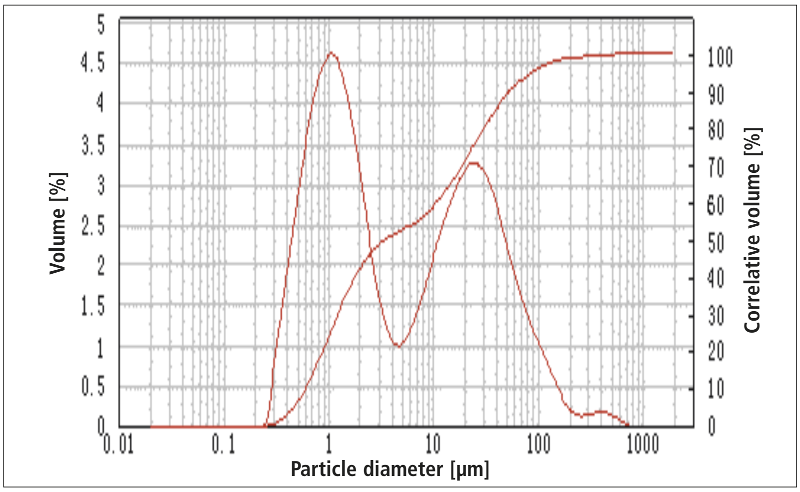

Fig. 1 Particle size distribution of the fly ash

1 Introduction

Fused brown corundum has been mass-produced with the development of its applications because of good performance. Fly ash emerges as a by-product from producing fused brown corundum. This industrial waste presents serious problems of storing and environmental pollution. According to the yield of fused brown corundum, in China approximately 4 – 6 Mt/a fly ash were discharged. Therefore, the effective utilization of waste fly ash not only decreases pollution of the environment, but also produces high value-added products [1]. Molochite is the trade name of an aluminosilicate refractory aggregate. It has excellent thermal shock resistance, and more than 30 % of it is used for investment casting. Its low ferric oxide content and absence of nodular iron make it ideal for applications such as refractories for electric-element supports, refractory insulation brick and glass furnace refractories [2, 3]. In recent years, there were some researches on the synthesis of molochite. However, the majority of them focus on using natural material [4, 5]. In this study, however, fly ash from fused fused brown corundum was used as raw material to synthesize molochite.

2 Experimental

In this work, fly ash from fused brown corundum and quartz powder were used as the starting materials for the synthesis of molochite. The particle size distribution of the fly ash is shown in Fig. 1. According to particle size analysis, most particles are centralized between 1 µm and 25 µm respectively, and the d_{90} value is less than 100 µm. After acid pickling, the fly ash was wet-mixed with quartz powder (based on stoichiometric ratio of Al_2O_3 and SiO_2) in a QM-BP planetary ball mill for 40 – 50 min. Afterwards, the mixture was dried and cylinder of 20 mm diameter and 20 mm thickness were formed.

The spe-cimens were fired at 1400, 1450, 1500, 1550 and 1600 °C respectively with a holding time of 3 h. The particle size distribution of the fly ash was determined using a laser particle size analyzer. Relative density and porosity of the sintered specimens were measured with a conventional method using Archimedes' principle in distilled water as medium. Sintered specimens were characterized using XRD (Philips X'Pert diffractometer with cobalt anticathode, 60 kV, 55 mA), SEM and EDS.

Tab. 1 Chemical composition of the as-received fly ash from fused fused brown corundum and that after acid pickling

Materials	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	LOI
As-received fly ash	42,34	35,1	2,99	0,41	1,08	9,57	1,79	1,33	1,11	3,68
After acid pickling	21,88	61,52	5,58	0,23	0,43	1,61	0,30	3,31	0,25	4,69

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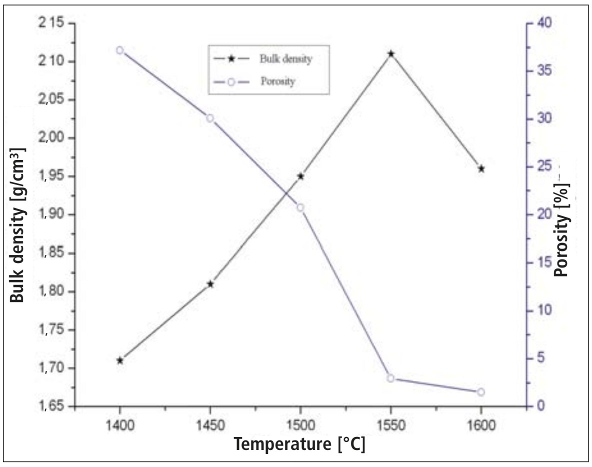

Fig. 2 Volume density and porosity of the sintered specimens

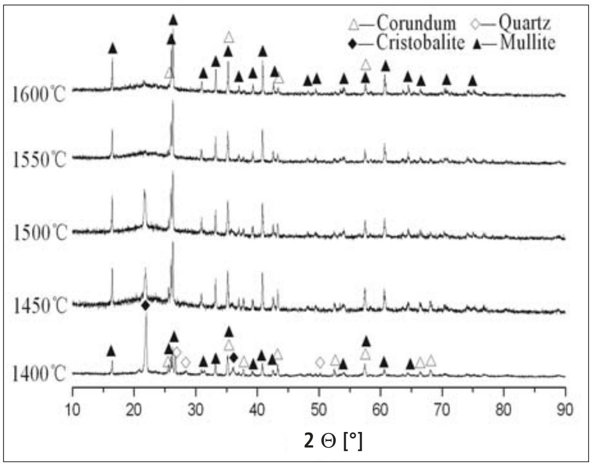

Fig. 3 XRD patterns of sintered specimens

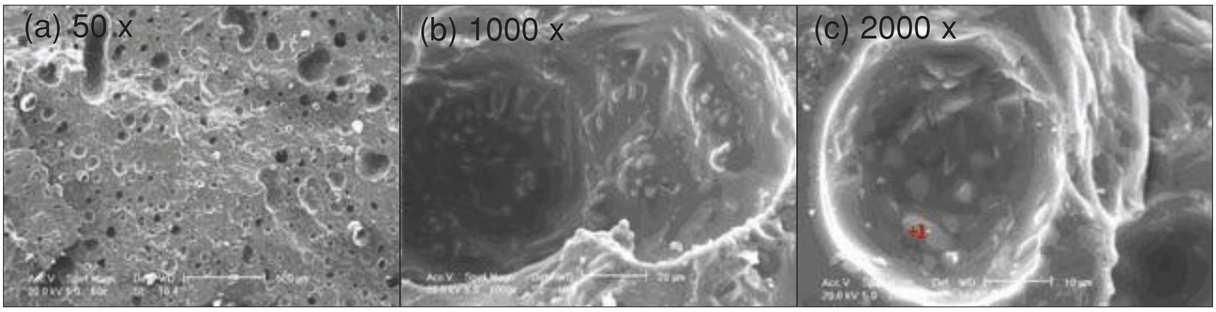

Fig. 4 SEM micrographs of specimens sintered at 1600 °C / 3 h; a) 50x, b) 1000x, c) 2000x

3 Results and discussion

Tab. 1 lists the chemical composition of the as-received fly ash from fused brown corundum and that after acid pickling. As shown in Tab. 1, the amounts of co-existing alkali- and alkaline-earth metal oxides such as Na_2O, K_2O, MgO, CaO decreased, but transition metal oxides such as Fe_2O_3 and TiO_2 increased. Fig. 2 shows bulk density and porosity of the specimens. When the firing temperature was less than 1550 °C, the bulk density of the specimens gradually increased while the porosity decreased. This phenomenon indicates that the specimens had been completely sintered when the temperature had reached 1550 °C. Meanwhile the apparent porosity is less than 5 %. Above 1550 °C, an expansion phenomenon occurred and the porosity decreased accordingly, which indicated that more closed pores were formed.

Fig. 3 shows the XRD patterns of the specimens sintered at different temperature. The diffraction peaks corresponding to corundum, mullite, quartz and cristobalite are observed at 1400 °C. Amorphous glassy phase emerges between 20° to 25°, which shows that the sintered specimens were rich in glassy phase due to co-existing alkali- and alkaline-earth metal oxides. With rising the firing temperature, the diffraction peaks corresponding to corundum, quartz and cristobalite became weakened while strengthening the diffraction peaks corresponding to mullite. This phenomenon is probably ascribed to two factors:

- The interreaction of corundum, quartz and cristobalite formed mullite
- Corundum dissolved into glassy phase gradually and that resulted in precipitation of mullite. When the temperature reached 1600 °C, it shows that there are mainly mullite in addition to minor corundum, which occurred because the firing temperature or the holding time led to incomplete firing.

Fig. 4 presents the microstructure of the specimens at 1600 °C with a holding for 3 h. Closed porosity is observed for the specimens sintered at 1600 °C. Grain grows in form of rod-like shapes. Through EDS it is proved to be mullite.

4 Conclusions

Fly ash from fused brown corundum has been used as raw material to synthesize molochite. The following conclusions could be drawn:

- Closed porosity is formed in the structure, and rod-like mullite grows better in the pores.
- The main phase of the specimens is mullite when the sintering temperature was 1600 °C, meanwhile amorphous glassy phase is observed in specimens sintered at lower temperatures.

It could be proved that the fly ash is considered to be usable for synthesising molochite.

References

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