Light Metals 2014
Edited by: John Grandfield
TMS (The Minerals, Metals & Materials Society), 2014

Effect of Pressure on Alumina Extraction from Low-Grade Bauxite by Acid-Leaching Method

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Keywords: alumina, bauxite, acid-leaching, extraction rate

Abstract

Hydrochloric acid leaching of Low-grade bauxite with high content of iron oxide was studied at atmospheric conditions and pressure conditions. The results indicate that the alumina extraction rate is lower at atmospheric conditions, and the extraction rate less than 51.5% at the condition with 99 ℃ leaching temperature, 180 min leaching time and liquid to solid ratio at 3:1. Under pressure, the alumina extraction rate increased significantly with increasing the leaching temperature. When the leaching time is 60 min, liquid to solid ratio is 4:1, leaching temperature is 160 ℃, the alumina extraction rate reach 98.35%.

Introduction

At the present time, china is the largest producer of alumina in the world, supplying one third of total market needs. However, the bauxite reserve is low, and unable to meet the development needs of Chinese alumina industry. In Guangxi province, the low-grade bauxite ore with high content of iron oxide (high iron bauxite) is more than 220 minllion tons. The high iron bauxite mainly consist of 22%~37% alumina, 35%~48% iron oxide, and 4~13% silica, which is a potential substitute of bauxite for alumina production. Researchers had done many studies to product metallurgical alumina with high iron bauxite [1, 2]. The traditional Bayer process or sintering process is uneconomical and will produce more red mud, which is useless and environmentally harmful. Alumina extraction from low-grade bauxite by acid-leaching method has been given great attention in recent years [3-6]. The acid methods reported, usually leaching bauxite with lower concentration and higher liquid-solid ratio, is not suitable for industrial production.

This research therefore focused on the alumina extraction of high iron bauxite with higher concentration hydrochloric acid and lower liquid –solid ratio at atmospheric conditions and pressure conditions. The objective of this investigation is to provide technical support for utilization of high iron bauxite to product metallurgical alumina by hydrochloric acid leaching.

Experimental

Materials

Low-grade bauxite with high content of iron oxide of this investigation was obtained from Guigang City, Shanxi Province, China. Its main chemical composition is listed in Table 1.

Table 1 Chemical composition of coal fly ash raw material used in this study (mass fraction, %)

Al_2O_3	SiO_2	Fe_2O_3	MgO	CaO	LOI
26.15	8.73	30.45	0.35	0.16	21.85

The of hydrochloric acid with 12 mol/L concentration and other chemicals used in this study were of analytically grade and purchased from National Pharmaceutical Group, China.

Experimental process and analytical methods

The atmospheric conditions tests were carried out by 200ml beaker sealed by plastic film which were immersed in a thermostatically controlled water bath with stirring speed of 250 r/min. The pressure conditions tests were carried out by rotating 100 ml stainless steel bottles which were held by a variable speed motor rotator and immersed in a thermostatically controlled oil bath.

After the leaching reaction was complete, the leach liquor was separated from the residue by a vacuum filtering process. Residue was washed with hot distilled water several times until the pH of wash water is 7. Finally, the residue was dried in static air at 100℃.

X-ray Fluorescence (XRF) spectrometry was used for chemical composition analysis. The alumina extraction rate was obtained by the following formula:

$$\eta = \frac{(A/S)_{CFA} - (A/S)_{residue}}{(A/S)_{CFA}} \times 100\% \qquad (1)$$

where η is the alumina extraction rate, $(A/S)_{CFA}$ and $(A/S)_{residue}$ denote the mass ratio of alumina to silicon dioxide in coal fly ash and leaching residue of sintered coal fly ash , respectively.

Results and Discussion

Effect of leaching temperature

The effect of temperature on alumina extraction rate was studied under atmospheric conditions with 180min leaching time and 4:1 liquid to solid radio (mass radio) and under pressure conditions with 100-160℃, 60min leaching time and 4:1 liquid to solid radio. The corresponding results are shown in Fig.1.

The Fig.1 (a) shows that alumina extraction rate increases with increasing leaching temperature. An extraction rate of 47.6 % was obtained at 85 ℃, 51.0 % at 90 ℃, 51.3 % at 95 ℃, 51.5 % at 99 ℃. The Fig.1 further illustrates that extraction rate increased slightly with leaching temperature beyond 90℃. Compared with atmospheric conditions, the alumina extraction rate increases significantly with increasing temperature under pressure conditions and alumina extraction rate reach 98.35% with leaching temperature at 160 ℃.

Effect of liquid to solid radio

The effect of liquid to solid radio on alumina extraction rate was studied under atmospheric conditions with 99 ℃, 180 min leaching time and under pressure conditions with 140℃, 60 min leaching time. The corresponding results are shown in Fig.2.

The Fig.2 (a) shows that alumina extraction rate increases with increasing liquid to solid radio. An extraction rate of 51.3% was obtained at 2.5:1, 51.5 % at 3:1, 51.5 % at 4.5:1. The Fig.3 further illustrates that extraction rate increased slightly with different liquid to solid radio. Compared with atmospheric conditions, the alumina extraction rate increases over 40 % with pressure conditions.

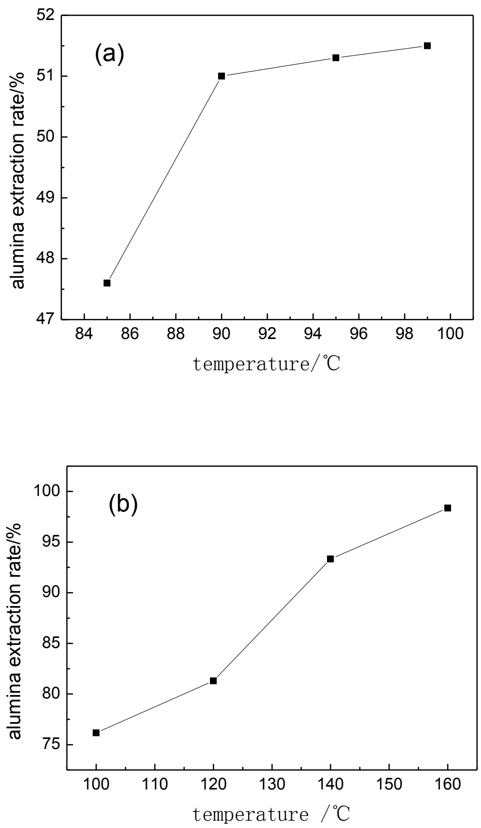


Fig. 1 Effect of leaching temperature on alumina extraction rate: (a) at atmospheric conditions, (b) at pressure conditions

<u>Effect of leaching time</u>

The effect of temperature on alumina extraction rate was studied under atmospheric conditions with 160℃and liquid to solid radio (mass radio) at 4:1 and under pressure conditions with 140℃ and liquid to solid radio (mass radio) at 4:1. The corresponding results are shown in Fig.3.

The Fig.3 (a) shows that alumina extraction rate increases with increasing leaching temperature. An extraction rate of 37.5 % was obtained at 90 min, 41.6 % at 120 min, 48.4% at 150 min, 51.0% at 180 min and 51.1% at 210 min. The Fig.3 (b) shows that alumina extraction rate increases lineally with increasing leaching temperature. An extraction rate of 83.95 % was obtained at 30 min, 87.65 % at 40 min, 89.27% at 50 min and 93.33% at 60 min. Compared with atmospheric conditions, Fig.3 (b) further illustrates that the pressure can enhance alumina extraction rate and reduce the leaching time.

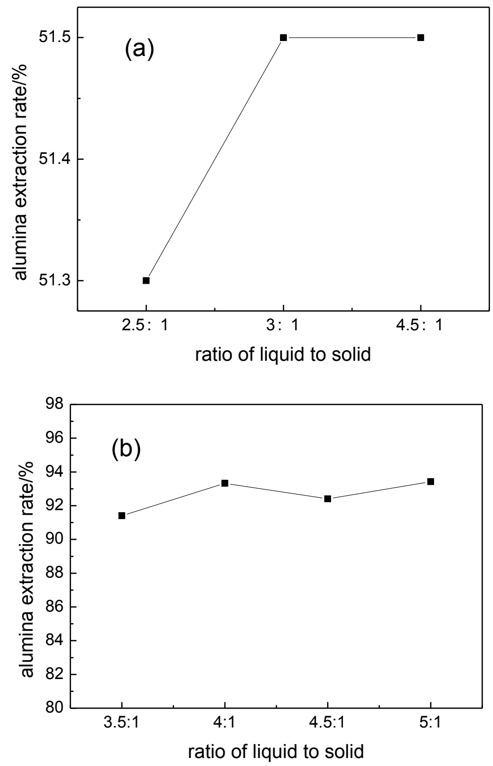


Fig. 2 Effect of liquid to solid radio on alumina extraction rate: (a) at atmospheric conditions, (b) at pressure conditions

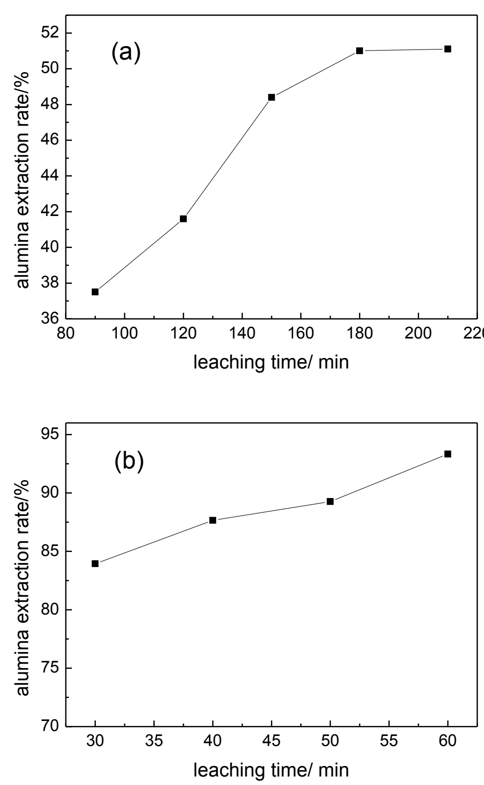
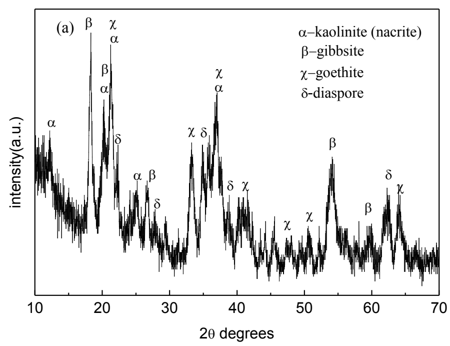


Fig. 3 Effect of leaching time on alumina extraction rate: (a) at atmospheric conditions, (b) at pressure conditions

XRD characterization

Fig.4 (a) shows XRD pattern of the high iron bauxite as raw. Fig.7 (b) shows XRD pattern of leaching residue. It can be observed from Fig.4 (a) that the raw mainly consist of kaolinite, gibbsite, gethite and little diaspore. After leaching, the peaks of gibbsite and goethite disappear, and diaspore enhance, as shown in Fig.4 (b). The results indicate that the higher bond energy of Al-Si-O in kaolin and diaspore maybe cause the lower alumina extraction rate at atmospheric conditions.



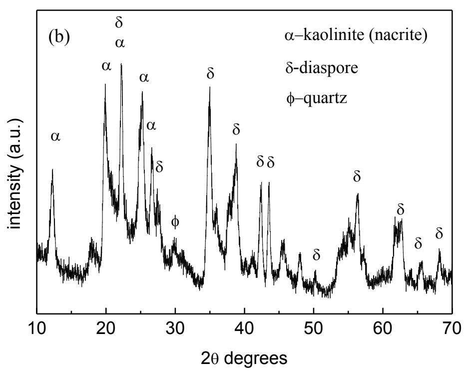


Fig. 4 XRD patterns: (a) high iron bauxite as raw; (b) leaching residue

Conclusion

The hydrochloric acid leaching of high iron bauxite at pressure conditions to produce alumina is easy to scale up in industrial application. The alumina extraction rate increased significantly with increasing the leaching temperature under pressure conditions. When the leaching time is 60 min, liquid to solid ratio is 4:1, leaching temperature is 160 ℃, the alumina extraction rate reach 98.35%. The higher bond energy of Al-Si-O in kaolin and diaspore cause the lower alumina extraction rate at atmospheric conditions.

Acknowledgements

This work was financially supported by Special Project for Liaoning Excellent Talents in University (LJQ2011011), National Natural Science Foundation of China (51004071, 50804031).

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