Available online at www.sciencedirect.com
ScienceDirect
Trans. Nonferrous Met. Soc. China 25(2015) 4167−4174
Transactions of Nonferrous Metals Society of China
www.tnmsc.cn

Oxidation roasting of molybdenite concentrate

Lu WANG, Guo-hua ZHANG, Jie DANG, Kuo-chih CHOU

State Key Laboratory of Advanced Metallurgy, University of Science and Technology Beijing, Beijing 100083, China

Received 26 January 2015; accepted 20 May 2015

Abstract: In order to investigate the oxidation roasting of molybdenite concentrate in pure oxygen atmosphere, experiments at 673, 723, 773, 873 and 973 K were carried out. The phase transitions and morphology evolutions of the samples obtained at different temperatures after reacting for different time were analyzed by X-ray diffraction (XRD) and scanning electron microscopy (SEM). The results showed that molybdenite concentrate was oxidized directly to MoO_3 in pure oxygen atmosphere. There were remarkable changes of the morphologies of products with the increase of the roasting temperature. It was also found that sintering phenomenon occurred during the roasting process in pure oxygen when the temperature was above 873 K. The composition of sintered sample was mainly comprised of MoO_3 and some unreacted MoS_2.

Key words: oxidation roasting; molybdenite concentrate; morphology; sintering

1 Introduction

Molybdenite concentrate has excellent properties in catalysis and lubrication [1,2]. Also, molybdenite concentrate (about 90% MoS_2) is the essential ore mineral of the molybdenum industry for the production of technical grade molybdenum trioxide, which is further used to produce molybdenum dioxide [3], molybdenum, ferromolybdenum alloy and other pure molybdenum compounds, such as ammonium paramolybdate, sodium and calcium molybdate. The oxidation roasting of molybdenite concentrate is necessary to generate molybdenum trioxide. At present, the oxidation roasting of molybdenite concentrate has been commercially carried out in multiple heart furnace and fluidized bed furnace. The main reaction during the oxidation process is

$$MoS_2+3.5O_2=MoO_3+2SO_2 \quad (1)$$

The change of the standard free energy of Reaction (1) is given by the following equation [4]:

$$\Delta G/(\mathrm{J\cdot mol^{-1}})=-1074744.08+61.38T\lg T-2.26\times10^{-2}T^2+2.60\times10^{-6}T^3+57.74T \quad (2)$$

The equilibrium constant K of Reaction (1) at temperature T can be calculated by the following equation:

$$\lg K_T=-\frac{\Delta G}{2.303RT} \quad (3)$$

Owing to the large equilibrium constant of the above reaction, for instant, up to 10^{52} when the temperature is 873 K, the oxidation reaction of molybdenite concentrate in air or pure oxygen could be considered to be an irreversible one.

Many investigations have been done to study the oxidation roasting of molybdenite concentrate. ŽIVKOVIĆ and ŠESTÁK [5] studied the roasting process of MoS_2 synthesized in the laboratory and determined the kinetic parameters using the Kissinger and the Ozawa methods. SHIGEGAKI et al [6] investigated the oxidation mechanism of pure MoS_2 using the TG−DTA method, and reported that oxidation process of MoS_2 powder is controlled by a three-dimensional boundary reaction. MARIN et al [7] carried out oxidation roasting using a thin layer of sample in a muffle furnace in air in order to simulate the reactions taking place in the multiple heart furnace. The results showed that the rate of oxidation was very slow below 713 K, and then it increased and remained constant from about 813 K to 913 K. A kinetic model involving the intermediate phase of MoO_2 was proposed ($MoS_2\rightarrow MoO_2\rightarrow MoO_3$). UTIGARD [8] conducted a large number of experiments about the oxidation roasting of molybdenite concentrate using a thermal gravimetric

Foundation item: Projects (51474141, 51174022) supported by the National Natural Science Foundation of China
Corresponding author: Guo-hua ZHANG; Tel: +86-10-62333703; E-mail: ghzhang_ustb@163.com
DOI: 10.1016/S1003-6326(15)64067-5

unit on a small scale both in air and oxygen atmosphere. The solid-state reaction between MoS_2 and MoO_3 to form MoO_2 was found to take place. WILKOMIRAKY et al [9] studied the reaction of molybdenite concentrate with oxygen and air in a hot-stage microscope and reported that acicular crystals of MoO_3 grown rapidly outward from the molybdenite. KIM et al [10] reported that the rate of mass loss decreases as the particle size increases when roasting the low grade Mongolian molybdenite concentrate in dried air. However, the particle size effect was slight when the molybdenite particle size was less than 67 μm. Very recently, a looping oxidation process with the aim to decrease energy consumption has been proposed by MCHUGH et al [11].

Although many investigations on the oxidation roasting of molybdenite concentrate have been done, most of them were preceded in air atmosphere. Nowadays, oxygen-enriched air technology has been widely used to the iron-making process in blast furnace and it greatly improves the smelting efficiency. Similarly, the present study aims to investigate the oxidation roasting of molybdenite concentrate in pure oxygen in order to explore a new way of treating molybdenite. The phase transitions and morphology evolutions during the oxidation process will be analyzed.

2 Experimental

2.1 Sample preparation

The molybdenite concentrate from Jinduicheng Molybdenum Industry Co., Ltd., Xi'an, China, was used as the raw material. The mass fraction of Mo content is about 54.89%. The main impurities in the molybdenite concentrate are sulfides or oxides of lead, copper, calcium, iron and silicon, etc. The chemical composition of the studied molybdenite concentrate is given in Table 1.

Table 1 Chemical composition of molybdenite concentrate (mass fraction, %)

Mo	S	Pb	Si	Cu	Ca
54.89	33.27	0.08	1.83	0.07	0.28
Fe	**Al**	**K**	**Ti**	**C**	**P**	**Total**
1.12	0.19	0.14	0.04	0.17	0.01	92.09

The X-ray diffraction (XRD) pattern of molybdenite concentrate sample is shown in Fig. 1. The main peaks are well-defined to be MoS_2. From Fig. 2, it can be seen that molybdenite concentrate particle has a layer structure and a wide particle size distribution ranged from several microns to 100 μm.

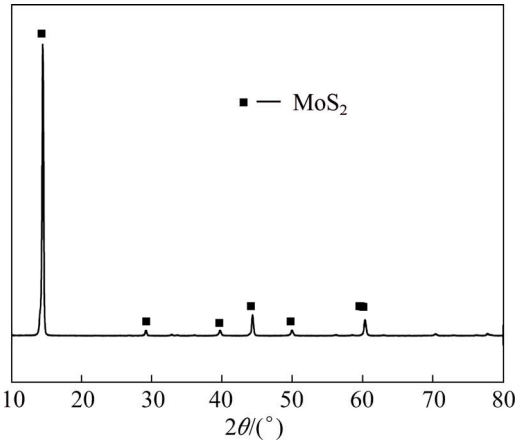

Fig. 1 XRD pattern of studied molybdenite concentrate

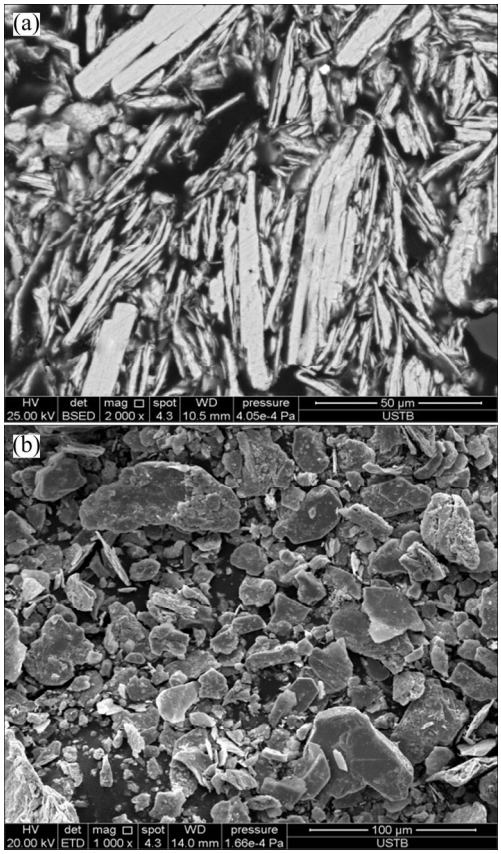

Fig. 2 SEM images of molybdenite concentrate sample: (a) Polished; (b) Unpolished

2.2 Apparatus and procedure

Figure 3 shows the schematic diagram of the apparatus. Alumina crucibles with 50 mm in length, 25 mm in width and 20 mm in height were used. At first, molybdenite concentrate was dried at 383 K in the oven for 12 h. In each experimental run, a sample of about 3 g (about 5 mm in thickness) was used and filled into the alumina crucible. After the crucible with the sample was placed into the quartz tube, argon was purged to remove air from the quartz tube. Then the quartz tube was put