KINETICS OF LEACHING SPHALERITE WITH PYROLUSITE SIMULTANEOUSLY BY MICROWAVE IRRADIATION①

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ABSTRACT The kinetics of leaching sphalerite with pyrolusite simultaneously by microwave irradiation was investigated under different conditions of temperature, concentrations of H_2SO_4 and $Fe_2(SO_4)_3$ and particle size of sphalerite. According to the experimental data, the leaching rate of zinc by microwave irradiation is faster than that by conventional heating.

Key words microwave irradiation sphalerite pyrolusite leaching kinetics

1 INTRODUCTION

Although the kinetics of leaching sphalerite with pyrolusite simultaneously by conventional heating has been studied, the kinetics by microwave irradiation was scarcely reported. In this paper, the kinetics of leaching sphalerite with pyrolusite simultaneously in the microwave field was experimentally investigated for considering the advantageous characteristics of microwave heating (such as internal heating, high frequency and no additional stirrer, *etc.*) and improving hydrometallurgical techniques.

2 EXPERIMENTAL

Experiments were carried out in a 650 W and 2 450 MHz refitted commercial microwave oven. As soon as microwave irradiation was finished, the temperature was measured immediately by inserting a thermometer into the solution. According to the blank test, the error factor of the temperature measured by this method is in the range of ±1 ℃[1-3].

The main compositions of sphalerite are: Zn 48.40%, S 25.18%, Fe 6.49%, Pb 1.03%; and pyrolusite: MnO_2 53.81%, Fe 6.40%, Zn 0.061%, Pb 0.021%. The partical size of pyrolusite was -98+76 μm. The amount of MnO_2 was 2.5 times of stoichiometric relation[3]. Leaching solutions were prepared using chemical pure $Fe_2(SO_4)_3$, H_2SO_4 and distilled water.

3 RESULTS AND DISCUSSION

3.1 Comparison of leaching rate of microwave irradiation and conventional heating

The comparison of leaching rate of microwave irradiation with that of conventional heating under the same condition of temperature, particle size, H_2SO_4 concentration and the amount of MnO_2 is shown in Fig. 1.

It can be seen from Fig. 1 that the leaching rate of zinc by microwave irradiation is much faster than that by conventional heating. Leaching 90 min, the leaching rate of zinc by microwave irradiation reaches 92%, whereas that by conventional heating only reaches 41%. The former is 2.27 times as fast as the latter.

3.2 Effect of temperature

The leaching rate of zinc *vs* leaching time is

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shown in curve 1 of Fig. 2.

The temperature of solution *vs* leaching time is shown in curve 2 of Fig. 2.

The leaching rate of zinc *vs* the temperature of solution is shown in Fig. 3.

As shown in Fig. 2 and Fig. 3, with microwave irradiation heating, the temperature of solution rises fast and the leaching rate of zinc increases quickly. The leaching process in the microwave field is in a nonisothermal state below the boiling point of the solution.

According to the microwave irradiation heating characteristics, the liquid-solid reaction can be considered as a chemical reaction[1-3].

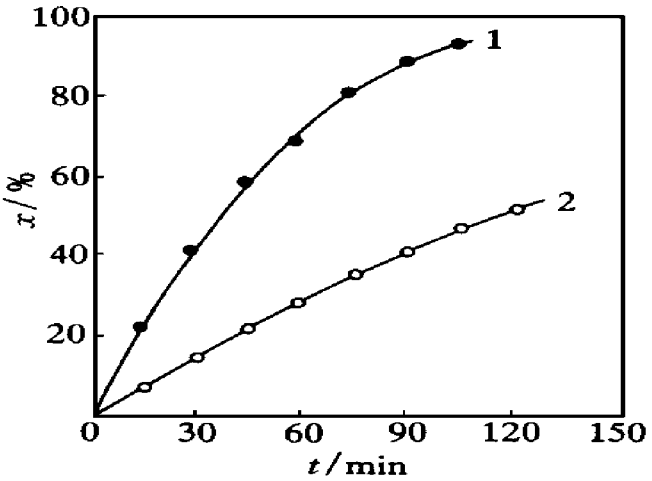

Fig. 1 Comparison of microwave heating and conventional heating

(MnO_2: 2.5 *a*, H_2SO_4: 1.8 mol/L, *T*: 368 K, particle size(ZnS): -98+76 μm)
1—microwave heating; 2—conventional heating

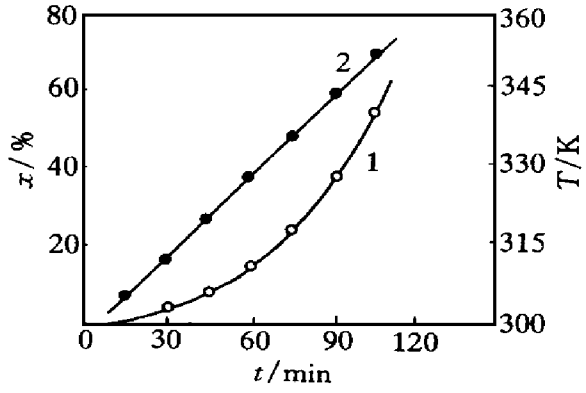

Fig. 2 The leaching rate of zinc and the temperature of solution *vs* time

(MnO_2: 2.5 *a*, H_2SO_4: 1.2 mol/L, particle size (ZnS): -98+76 μm)
1—*x vs t*; 2—*T vs t*

Plotting $\ln\{[1-(1-x)^{1/3}/T^2]\}$ against $1/T$[1-4], we obtain

$$\ln\{[1-(1-x)^{1/3}/T^2]\} = 7.8163 - 7373.1055/RT$$

where the relative coefficient is 0.9973, so E = 61.32 kJ/mol.

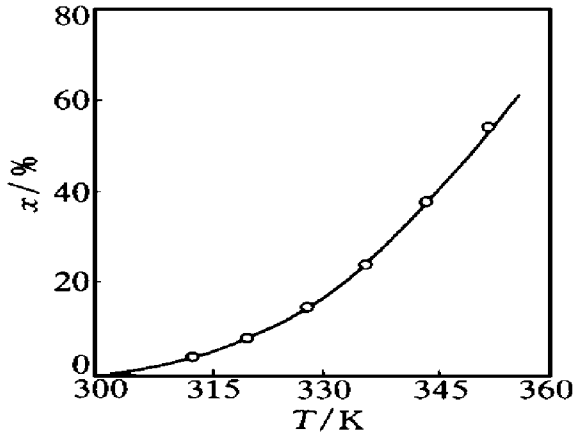

Fig. 3 The leaching rate of sphalerite *vs* temperature

3.3 Effect of H_2SO_4 concentration

The leaching rate increases with H_2SO_4 concentration. By plotting $1-(1-x)^{1/3}$ *vs t*, it is found that all the lines pass through the origin (see Fig. 4). The experimental rate constants *k* are 2.9804×10^{-3}, 3.7616×10^{-3}, 4.2679×10^{-3}, 5.5851×10^{-3} min^{-1} in 0.5, 0.8, 1.2, 1.8 mol/L H_2SO_4, and the relative coefficients are 0.9771, 0.9980, 0.9990, 0.9995, respectively. Plotting $\ln k$ *vs* $\ln C(H_2SO_4)$ a reaction order of 0.47 is obtaind, thus the relative coefficient is 0.9918.

3.4 Effect of particle size of sphalerite

A smaller particle size of sphalerite results in a faster leaching rate, and the data are found to agree with the chemical reaction model (see Fig. 5). From Fig. 5, the value of *k* is obtained as 6.5667×10^{-3}, 4.2679×10^{-3}, 3.2168×10^{-3}, 2.2521×10^{-3} min^{-1} for particle size of -65+55, -98+76, -125+98, -180+154 μm, and the relative coefficients are 0.9997, 0.9990, 0.9985, 0.9990, respectively. Plotting *k vs* $1/r_0$, a linear relationship yields. Fur-

ther results confirm that the leaching reaction is controlled by the chemical reaction.

3.5 Effect of $Fe_2(SO_4)_3$ concentration

The leaching rate of zinc *vs* time at different $Fe_2(SO_4)_3$ concentrations is shown in Fig. 6.

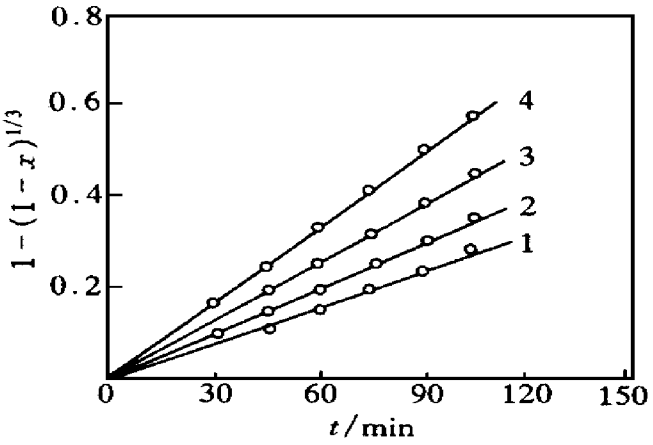

Fig. 4 Plot of $1-(1-x)^{1/3}$ *vs* time at different H_2SO_4 concentrations

(MnO_2: 2.5 *a*, *T*: 368 K, particle size: -98+76 μm)
1—0.5 mol/L; 2—0.8 mol/L;
3—1.2 mol/L; 4—1.8 mol/L

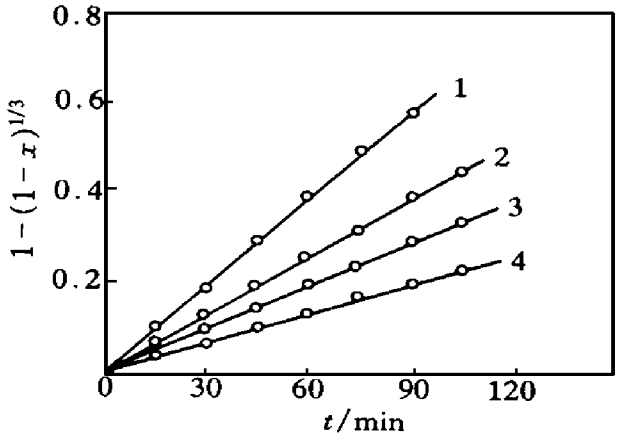

Fig. 5 Plot of $1-(1-x)^{1/3}$ *vs* time at different particle size

(MnO_2: 2.5 *a*, *T*: 368 K, H_2SO_4: 1.2 mol/L)
1—-65+55 μm; 2—-98+76 μm;
3—-125+98 μm; 4—-180+154 μm

As shown in Fig. 6, below $Fe_2(SO_4)_3$ concentration of 1.1 mol/L, the leaching rate of zinc increases with $Fe_2(SO_4)_3$ concentration; above 1.1 mol/L, there is little effect of $Fe_2(SO_4)_3$ concentration on the leaching rate of zinc.

Plotting *k* at different $Fe_2(SO_4)_3$ concentrations *vs* $\ln C(Fe_2(SO_4)_3)$, the reaction orders of 0.34 and 0 are obtained below and above 1.1 mol/L $Fe_2(SO_4)_3$ respectively.

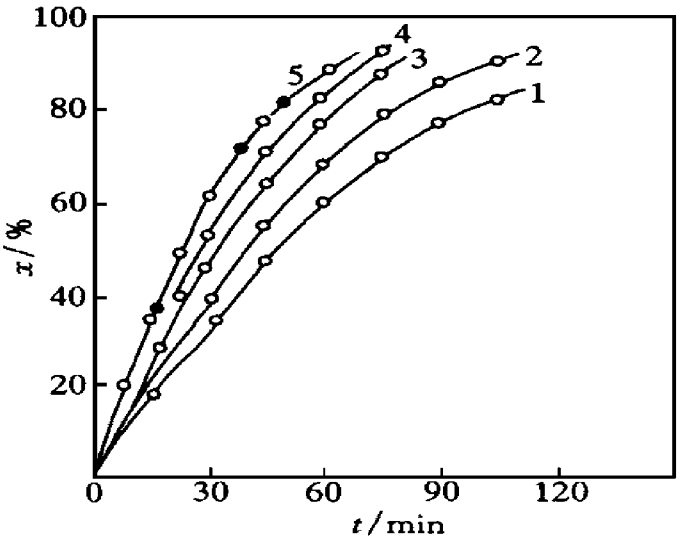

Fig. 6 The leaching rate (x%) of zinc *vs* time (t) at different $Fe_2(SO_4)_3$ concentrations

(MnO_2: 2.5 *a*, H_2SO_4: 1.2 mol/L,
T: 368 K, particle size: -98+78 μm)
1—0 mol/L; 2—0.3 mol/L; 3—0.6 mol/L;
4—0.9 mol/L; 5—● 1.1 mol/L, ○ 1.3 mol/L

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