Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 52(6) (2020) 363-366
DOI: 10.22060/ceej.2019.15399.5909

Impact of surface dissolution on flotation kinetics and kinetics of collector adsorption on ilmenite ore

O. Salmani Nuri, M. Irannajad*, A. Mehdilo

Department of Mining and Metallurgical Engineering, Amirkabir University of Technology, Tehran, Iran

ABSTRACT: In this study, the effect of surface dissolution by oxalic acid was investigated on the flotation kinetics and kinetics of collector adsorption for ilmenite in the presence of olivine-pyroxene, tremolite-clinochlore and quartz. Fitting of first-order kinetic model on the results of flotation before and after surface dissolution showed that flotation kinetic constant (K) and ultimate recovery (R∞) of ilmenite is increased after surface dissolution and they are decreased for gangue minerals. The results showed that the kinetic selectivity index of ilmenite in the presence of olivine-pyroxene, tremolite-clinochlore and quartz are increased from 1.28 to 1.98, 1.42 to 3.02, and 3.58, respectively, after surface dissolution indicating the positive effect of surface dissolution process. Investigating the kinetics of collector adsorption showed that the collector adsorption is conforming to second-order kinetic model. After surface dissolution, the kinetics of collector adsorption and initial rate of collector adsorption on ilmenite surface is increased from 3.85 to 8.44 g.mol-1 min-1 and it is decreased for olivine-pyroxene, tremolite-clinochlore and quartz from 6.33 to 5.03, 7.3 to 6.22 and 7.77 to 7.37 g.mol-1 min-1, respectively. These results are in good agreement with the results of collector adsorption via UV analysis which the collector adsorption on ilmenite surface is increased and it is decreased for gangue minerals after surface dissolution. The results of SEM showed that the surface of ilmenite becomes smoother and uniform and about the gangue minerals, some cavities are produced due to dissolution of surface cations.

Review History:

Received: 2018-12-05
Revised: 2019-01-31
Accepted: 2019-02-03
Available Online: 2019-03-11

Keywords:

Surface dissolution
Kinetics
Flotation
Collector adsorption
Ilmenite

1. INTRODUCTION

The adsorption of molecules and ions from the solutions on mineral surfaces is an important factor for controlling the flotation process [1, 2]. On the other hand, the adsorption of the collector on the mineral surface is the most important factor in the selectivity of mineral separation through flotation process [3]. Kinetics is one of the most important parameters of flotation [4, 5]. Flotation kinetics is consisted of two parameters, including kinetic constant (K) and ultimate recovery (R_∞) which affect the flotation kinetics simultaneously.

Surface dissolution can dissolve the ions from the surface of minerals and also it can cause adsorption of the collector on the surface of minerals selectively and improve the floatability of minerals [6, 7]. The aim of the study is to pursuit the effect of surface dissolution on the flotation kinetics and kinetics of collector adsorption on ilmenite, olivine-pyroxene, tremolite-clinochlore, and quartz.

2. METHODOLOGY

The surface dissolution of the pure minerals with a size of −150 +45µm before the tests was carried out by mechanical stirring in a 7.5% (w/w) oxalic acid solution for 10 minutes. In each test, 1 g of purified mineral samples was added to the 50 ml of double deionized water and prepared at pH=6.3 and conditioned at the times of 1, 2, 3, 4, 6, 8, and 12 minutes. Then, the adsorption density of collector on the mineral surfaces (qt) at λ = 192 nm [8] is calculated by Equation 1:

$$q_e = \frac{(C_0 - C_e).V}{W.A} \quad (1)$$

Where, C_0 and C_t present the initial and final concentrations of sodium oleate in solution (mol/L), respectively. V is the volume of solution (L), M is the mass of mineral sample (g), A is the specific surface area of mineral sample (m^2/g) and q_e is the adsorption density (mol/m^2). The flotation of minerals has been carried out in 1.5 L Denver cell with 30 solid percentages. The froth skimming was carried out at the times of 0.5, 1, 1.5, 3, 5, 8, 12, and 15 minutes in each 20 second. First-order flotation kinetic model was used to fit the experimental data by the Mathematica software.

$$R = R_\infty \times (1 - e^{-kt}) \quad (2)$$

Where, K and R_∞ present the kinetic constant and

*Corresponding author's email: Iranajad@aut.ac.ir

ultimate recovery, respectively. t is the flotation time.

3. RESULTS AND DISCUSSION

3.1. Flotation of mixed minerals

The results of "Fig. 1" show the flotation recovery occurs quickly in the first 3 minutes after surface dissolution. Also, Ilmenite recovery was increased from 57.7 % to 65.6 % in the presence of olivine-pyroxene after 5 minutes. On the other hand, the recovery of treated olivine-pyroxene was decreased from 40% to 25.9%.

"Fig. 2" presents the fitting of the first-order kinetic model on the cumulative recovery-time curves of ilmenite before and after surface dissolution. The results showed that the classical model has the best fit to the experimental recoveries before and after surface dissolution. The software calculated the ultimate recovery and kinetic constant of flotation.

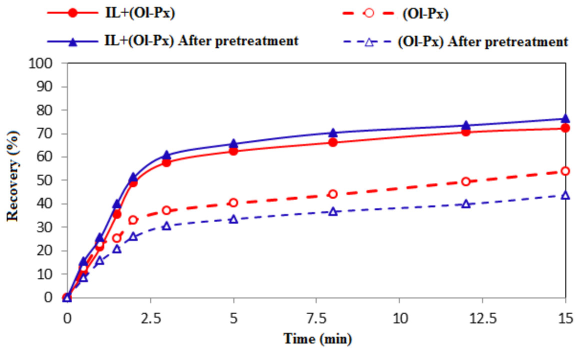

Fig. 1. Flotation recovery of ilmenite in the presence of olivine-pyroxene at pH=6.3 before and after surface dissolution

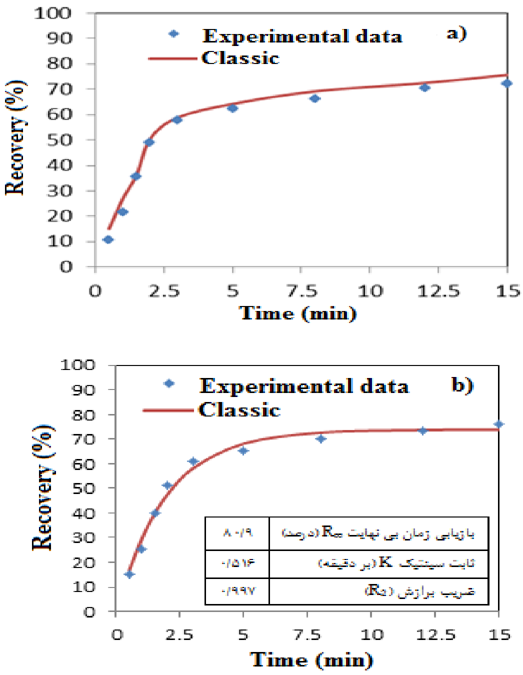

Fig. 2. Fitting the first-order kinetic model on the experimental data a) before and b) after surface dissolution of ilmenite at pH=6.3

Table 1. Kinetic parameters of ilmenite flotation before and after surface dissolution

Feed	Ilmenite+(Olivine-pyroxene)			
Mineral in concentrate	Ilmenite		Olivine-pyroxene	
Kinetic parameters	Before	After	Before	After
Ultimate recovery (R_∞)	72.75	80.9	55.2	44.5
Kinetic constant (k)	0.477	0.516	0.512	0.473
R_2	0.995	0.997	0.991	0.995
Modified Kinetic constant (K_m)	36.15	41.73	28.26	21.06
Selectivity index (S.I)	Before		After	
	1.28		1.98	

3.2. Modified kinetic constant and selectivity index

The modified rate constant (K_m=k×R_∞) and the kinetic selectivity index (S.I=K_{m_1}/K_{m_2}) can be used to compare the results where the K_{m1} and K_{m2} are the modified rate constants of ilmenite and gangue minerals [9, 10]. The results of the comparison between K_m and S.I values for the ilmenite are shown in "Table 1" before and after surface dissolution. The results showed that the modified constant kinetic (K_m) of ilmenite was increased from 36.15 to 41.73 after pretreatment, while in the case of Olivine-pyroxene, it was decreased from 28.26 to 21.06. On the other hand, the kinetic selectivity index for the separation of ilmenite from olivine-pyroxene is increased from 1.28 to 1.98. This shows that the surface dissolution improves the kinetics of ilmenite flotation.

4. CONCLUSIONS

This study investigates the effect of surface dissolution as a surface modification pretreatment as well as study flotation kinetics and kinetics of collector adsorption.

➢Surface dissolution improves the ilmenite floatability, while the flotation recoveries of Ol-Px, Tr-Cch, and Q are decreased after pretreatment.

➢The flotation rate constant and ultimate recovery of treated ilmenite in the presence of all gangue minerals was improved, while it decreased those parameters for the treated gangue minerals.

➢The modified rate constant and kinetic selectivity indices are increased for treated ilmenite. In the case of Ol-Px and Tr-Cch, and Q as the gangue minerals, these parameters were decreased after surface dissolution.

➢The kinetics of collector adsorption on the ilmenite surface was improved and it was decreased for Ol-Px and Tr-Cch, and Q.

REFERENCES

[1] S.Y. Cho, S.J. Kim, T.Y. Kim, H. Moon, S.J. Kim, 2003, Adsorption characteristics of 2, 4-dichlorophen oxyacetic acid and 2,

4-dinitrophenol in a fixed bed adsorber, Korean Journal of Chemical Engineering, 20(2) 365-374.

[2] P. Somasundaran, 1979, Physicochemical Aspects of Adsorption of Surface-Active Agents on Minerals, Croatica Chemica Acta, 52(2) 67-86.

[3]B. Rezai, Flotation Technology, Nahre Danesh Publishing, Tehran, 1394. (In Persian).

[4]M. Brozek, A. Mlynarczykowska, Wydaw. Insty. Gospo. Suro. Mine. i Ene. PAN (Krakow, 2009)

[5]O. Guven, M. S. Celik, W. Drelich, 2015, Flotation of methylated roughened glass particles and analysis of particle–bubble energy barrier, Miner. Eng., 79, 125.

[6]Y.G. Zhu, G.F. Zhang, Q.M. Feng, D.C. Yan, W.G. Wang, 2011, Effect of surface dissolution on flotation separation of fine ilmenite from titanaugite, Trans. Nonferrous Met. Soc. China. 21 1149-1154.

[7] P. Semsari Parapari, M. Irannajad, A. Mehdilo, 2016, Modification of ilmenite surface properties by superficial dissolution method, Minerals Engineering. 92 160–167.

[8] R. Zheng, Z. Ren, H. Gao, Y. Qian, 2017, Flotation Behavior of Different Colored Fluorites Using Sodium Oleate as a Collector, Minerals, 7 159.

[9] Agar, G.F., Stralton-Crawly, R., Bruce, T.J. 1986, Optimising the design of flotation circuits. CIM Bulletin 73 173– 181.

[10]M. Xu, 1998, Modified flotation rate constant and selectivity index. Miner Eng. 11 271–278.

HOW TO CITE THIS ARTICLE

O. Salmani Nuri, M. Irannajad, A. Mehdilo, Impact of surface dissolution on flotation kinetics and kinetics of collector adsorption on ilmenite ore, Amirkabir J. Civil Eng., 52(6) (2020) 363-366.

DOI: 10.22060/ceej.2019.15399.5909