Asian Journal of Chemistry Vol. 16, No. 2 (2004), 937–941

Application of Novel Flotation Process for Removal of Feldsphatic Minerals from Quartz Sands

İLGIN KURŞUN, ŞAFAK G. ÖZKAN*, KENAN ÇINKU and M. FARUK ESKİBALCI

Istanbul University, Engineering Faculty, Mining Engineering Department
Avcilar, Istanbul, Turkey
E-mail: ilginkur@istanbul.edu.tr, sgozkan@istanbul.edu.tr, kenan@istanbul.edu.tr, eskibal@istanbul.edu.tr

In this study, conventional flotation process using hydrofluoric acid was compared to a novel flotation process without using hydrofluoric acid for separation of feldspar from quartz sands. In the new method, feldspars are floated from quartz sands using two different reagents; sodium oleate and dodecyl amine acetate together as collectors for satisfactory and environment friendly beneficiation without using hydrofluoric acid.

Key Words: Feldspars, Feldphatic minerals, Quartz sands, Froth flotation, Beneficiation.

INTRODUCTION

Quartz sands and feldsphatic minerals are the most important industrial minerals generally used in glass and ceramic industries. High quality quartz sands should not contain impurities with iron and feldspathic minerals. Gangue minerals containing iron are usually separated from quartz sands by combination of magnetic separation and flotation processes, whereas feldspars are removed from quartz sands by a conventional froth flotation process using aliphatic amine salts as a collector and hydrofluoric acid which is harmful for the environment, as an activator.

Turkey and several other countries have enough quartz sand deposits for industrial applications. However, according to the various specifications of their use areas, mineral processing is the only method to produce a raw material requiring very special properties. Generally, a silica mineral to be used for glass making should include at least 99% or more SiO_2 content. The major criterion is to decrease the amount of gangue minerals to reasonable levels[1].

The main concern of the oxide compound of the silica sand is given below:

SiO_2: increases viscosity, thermal shocks, strength against the acidic environment and gives glassy view; CaO: improves the mechanical properties; Na_2O: decreases the melting point; B_2O_3: decreases the melting ability and increases the chemical strength; K_2O: effects similar to Na_2O however, efficiency of the viscosity and thermal expansion is not as high as Na_2O; Al_2O_3: increases the strength of glass; Fe_2O_3: gives unexpected colours to the glass; PbO: when 30% of PbO is used in glass production, an easy melting of leaded glass crystals is produced. Besides, it is also used in the manufacturing of high electrical resistant light bulbs[2].

Alkali materials, *e.g.*, Na_2O, K_2O in the silica sand create negative effects by decreasing the melting points and viscosity. Therefore, quartz sands should not contain more than 0.02–0.09% Na_2O and 0.03–0.08% K_2O. Several separation methods, including magnetic separation, gravity separation and flotation are conducted on the samples to remove the gangue minerals from the main component[3]. The magnetic separation and flotation are the major separation methods to be able to decrease iron content and the other colour creating minerals[4]. The feldspathic minerals found in quartz sands used for the glass production can be extensively removed by the flotation method.

Amine type collector is used for direct flotation. It is known that quartz particles cannot be floated by the amine type surfactant since the pH is lower than 3.5; therefore, sand particles remains in the flotation cell in the presence of hydrofluoric acid (HF). This acid is used for the pH adjustment, activation of feldspar and depression of the quartz particles. Pine oil, methyl isobutyl carbinol (MIBC) and poly propylene glycol (PPG) are usually selected as frothers for this flotation[5–7]. The only difference between mica and feldspar flotation is that HF is used in the feldspar circuit. In contrast, the main problem of the flotation is that high recovery and selectivity cannot be exactly obtained. In addition to that, HF is a harmful liquid to the environment, which is used for the depression of the quartz particles[8].

Previous researchers have developed a new technique to get rid of the harmful effects of HF in the feldspar and quartz separation[9]. This method also increases the flotation recovery of the quartz sands. In this flotation technique, both anionic and cationic collectors are employed at the same time. A general representation of conventional and novel flotation techniques are given in Fig. 1 separately.

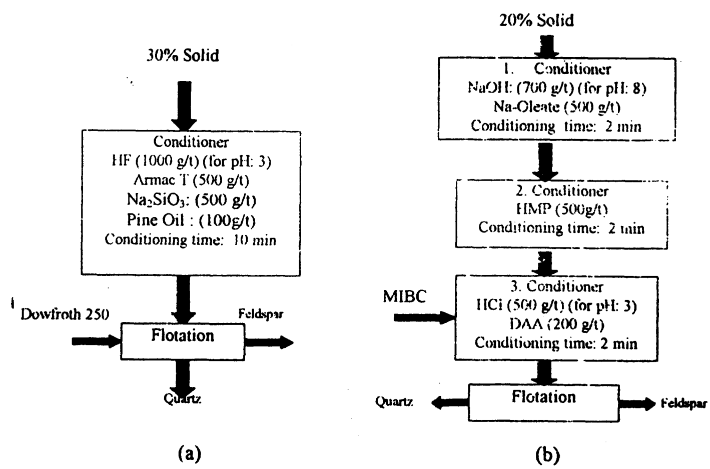

Fig. 1. Sample flowsheets of conventional (a) and novel (b) feldspar/quartz flotation

In the first step of the novel flotation, pH of the slurry is increased to 8 using NaOH. A 500 g/ton sodium oleate (Na-oleate) is added to the pulp to be able to make a hydrophobic surface for the feldspar particles. 2 min conditioning time is given to the collector. In the second step, to depress the quartz particles, sodium hexametaphosphate is poured to the same flotation cell with 2 min conditioning time[10]. After that, diamine acetate is used as a collector for the flotation of the feldspar minerals with further 2 min conditioning time. Finally, a certain amount of frother is added to the cell for feldspar flotation. The unfloated particles are the valuable quartz product. The previous experimental studies showed that this flotation technique always gave high recovery in terms of selectivity[11].

EXPERIMENTAL

In these experiments, the quartz sample in Thrace Region, Turkey, which was obtained after the high intensity wet magnetic separation, was subjected to the flotation tests. The chemical composition of the sample is given in Table-1. As a result of chemical analysis, it is seen that the sample consists of low SiO_2 (96%) and high alkali materials (Na_2O: 1.56%, K_2O: 1.38%) contents. Therefore, it was decided to lower the amount of alkali material and to increase the silica content.

TABLE-1
CHEMICAL COMPOSITION OF THE SAMPLE USED IN THE TESTS

Compounds	% Values	Compounds	% Values
SiO_2	96.00	CaO	0.03
Al_2O_3	0.86	MgO	0.10
Fe_2O_3	0.03	Na_2O	1.56
TiO_2	0.03	K_2O	1.38
Cr_2O_3	0.0005	ZrO_2	0.003

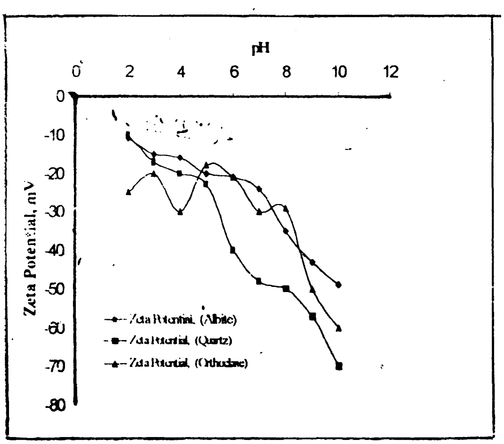

Fig. 2. Zeta potential of quartz and feldspathic minerals as a function of different pH

Zeta potentials of the samples of pure quartz and feldspar (albite and orthoclase) were measured against different pH values of the slurry in order to reveal surface characteristics. According to these measurements, the surface of the samples has negative charges between pH: 2–12 values as shown in Fig. 2.

Flotation tests: A series of quartz-feldspar flotation tests were carried out on the sample to increase the SiO_2 content and to decrease the alkali contents ($K_2O + Na_2O$). In order to compare the conventional and novel flotation techniques, two different flotation tests were conducted on the present samples.

Conventional Flotation Tests: In this section, cationic collectors were used in the flotation tests at pH 2. The feldspathic minerals were floated by depressing the quartz minerals with HF. The flotation conditions and obtained results (Table-2) are submitted below:

Solid/liquid ratio	:	30%
Collector	:	Armac T (500 g/t)
Depressant	:	HF (500 g/t)
pH	:	(1000 g/t HF) (for pH 3)
Frother	:	Dowfroth 250 (50 g/t)
Total conditioning time	:	10 min

Table-2 below illustrates that a silica concentrate containing 98.30% SiO_2, 0.90% Na_2O and 0.20% K_2O was received by using HF with 76% recovery.

TABLE-2
THE RESULTS OF FELDSPAR-QUARTZ FLOTATION WITH HF

Products	% W	% SiO_2 recovery		% Na_2O recovery		% K_2O recovery	
Concentrate	74.00	98.30	76.00	1.90	90.10	1.70	91.10
Tailing	26.00	89.45	24.00	0.59	9.90	0.47	8.90
Feed	100.00	96.00	100.00	1.56	100.00	1.38	100.00

Novel Flotation Tests: In these tests, anionic (Na-oleate) and cationic (dodecyl aminoacetate) collectors were used together to float the feldspathic minerals. The experimental conditions are shown below. Table-3 below shows the recovery values. In these flotation tests, it is seen that a silica concentrate was obtained with 83% silica recovery. The product consists mainly of 99.40% SiO_2, 0.08% Na_2O and 0.05% K_2O contents.

Solid/liquid ratio	:	20%
Collector 1	:	Na-Oleate (500 g/t)
Collector 2	:	DAA (200 g/t)
Depressant	:	HMP (500 g/t)
First step pH	:	NaOH (700 g/t) (for pH 8)
Final step pH	:	HCl (500 g/t) (for pH 3)
Frother	:	MIBC (50 g/t)
Total conditioning time	:	6 min

TABLE-3
THE RESULTS OF FELDSPAR-QUARTZ FLOTATION WITH TWO COLLECTORS

Products	%W	% SiO_2 recovery		% Na_2O recovery		% K_2O recovery	
Concentrate	80.00	99.40	82.83	1.90	97.43	1.70	98.50
Tailing	20.00	82.40	17.17	0.20	2.57	0.10	1.50
Feed	100.00	96.00	100.00	1.56	100.00	1.38	100.00

RESULTS AND DISCUSSION

In the present tests, a Dune quartz sand sample located in the western part of Turkey was subjected to the flotation tests. The sample is a product of the high intensity wet magnetic separation. The product obtained from the magnetic separation has contents of low silica (96% SiO_2) and high alkali materials (Na_2O: 1.56%, K_2O: 1.38%).

A series of flotation tests were conducted on the sample to receive high quality sand product. Therefore, the conventional and novel flotation methods were applied to the sample to compare the results to each other.

In the former method, a silica concentrate was obtained from the tests including 98.30% SiO_2, 0.90% Na_2O and 0.20 K_2O% contents with 76% recovery

In the latter tests, the novel method was applied to the sample and a 99.40% SiO_2, 0.08% Na_2O and 0.05% K_2O content of product was received with 83% recovery.

Finally, it was found that the new method yielded a silica concentrate which has much better quality than the product of the previous method.

REFERENCES

1. E. Atature, Removal of Ferrous Minerals from Quartz Sands, Istanbul University, Mining Eng. Dept., Graduation Project, Istanbul (1996).
2. I. Kursun and B. Ipekoglu, A General Overview to Turkish Quartz Sand Potential, The 1st Industrial Raw Materials Symposium, Izmir (1995) (in Turkish).
3. I. Bayraktar, O.Y. Gulsoy and M. Can, Feldspar Concentration, The 4th Industrial Raw Materials Symposium, Izmir (2001) (in Turkish).
4. K. Atangsaputra and N. Ardha, *Asian Ceramics* (6 October 1997).
5. I. Kursun, Y. Kaytaz, B. Ipekoglu and M.S. Celik, Flocculation Behaviour of Albite Concentrate with Various Polymers, The 6th International Mineral Processing Symposium, Kusadasi, Turkiye (1996).
6. I. Kursun and B. Ipekoglu, Concentration of Potassium Feldspars from Granite and Syenite Rocks, The 5th Southern Hemisphere Meeting on Mineral Technology, Argentina (1997).
7. ———, Removing the Fine Quartz Particles from the K-feldspars Concentrate by Flotation, The 7th Balkan Conference on Mineral Processing, Romania (1997).
8. S.G. Ozkan, I. Kursun and B. Ipekoğlu, A New Flotation Approach for Feldspar-Quartz Flotation from Trakya Region, The 4th Industrial Raw Materials Symposium, Izmir (2001) (in Turkish).
9. O. Gulsoy and F. Kilavuz, *Mining J.*, **41** (2002) (in Turkish).
10. J. Shimoizaka, K. Nakatsuka and T. Katayanagi, Separation of Feldspar from Quartz by a New Flotation Process, World Mining and Metals Technology, USA (1997).
11. T. Utine, *Mining J.*, **26** (1987) (in Turkish).

(*Received*: 04 August 2003; *Accepted*: 15 December 2003) AJC-3295