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Procedia Earth and Planetary Science 1 (2009) 830–837

Procedia Earth and Planetary Science

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The 6th International Conference on Mining Science & Technology

Study of chlorite flotation and its influencing factors

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Abstract

This paper made deep studies on chlorite flotation using anionic/cationic collector, and the following effect factors such as pH,Ca^{2+},Na_2S,NaF,Na_2SiF_6 and $(NaPO_3)_6$ are investigated. In the process of chlorite flotation using oleic acid as anionic collector, pH value increases. The concentration increase of Na_2S and NaF can activate the chlorite flotation. However, Ca^{2+}, Na_2SiF_6 and $(NaPO_3)_6$ can depress the chlorite flotation. In the process of chlorite flotation using lauryl amine as cationic collector, the maximum recovery of chlorite flotation happened in neutral pH condition, and the concentration increase of Ca^{2+} can activate the chlorite flotation; however, NaF and Na_2SiF_6 can depress the chlorite flotation.

Keywords: chlorite; flotation; fluoride; depressor; activator; regulatory

Chlorite is a typical silicate mineral, and widely distributed in the majority of mines. In the purification process for useful mineral, it is very necessary to remove chlorite as gangue. Because of lower hardness of chlorite, it is very easy to generate a lot of sludge which can seriously interfere with the flotation of useful minerals in the girding and mining process; therefore regulator adding is very essential for better flotation result. In the study of silicate flotation, British researcher [1] found that chlorite has better floatability and has wider flotation range. Zhou Zheng[2] also pointed out that lauryl amine can be used as collector of chlorite flotation [2]. Fornasiero D' research indicates that chlorite activated by Cu^{2+} and Ni^{2+}can be floated by Xanthate in pH 7 ~ 10 [3]. Zhen S studied chlorite biological leaching in sulfide minerals [4]. Douillard J made deep study of chlorite surface energy [5]. Indian scholar investigated the characteristics of chlorite in the study of biological leaching of uranium [6].

Chlorite is a layered silicate hydrated, there are changes in chemical composition, the general chemical composition can be expressed as $(Mg, Al,Fe)_{12}[(Si,Al)_8,O_{20}](OH)_{16}$. Classified from the crystal structure, chlorite belongs to the three-layered silicate, in the layer of 'brucite-type', about one-third of Mg^{2+} has been replaced by Al^{3+}, a positively charged layer like $[Mg_2Al(OH)_2]^+$ is formed. When it is crushed, the surface is ruptured, staggered broken sides are formed, it makes it easy for collector ions to adsorb to the side, so that chlorite is a silicate floated easily [7]. In the structure of chlorite , there are a lot of shifts between the films and layers, it results in a variety of disorder arrangement types and many arrangement rules. From the point of view of chemical constituents, Si^{4+} is substituted by Al^{3+} in the tetrahedron, there are more extensive isomorphism displacements in octahedral action , a large number of mineral species and varieties are formed [8]. Generation of chlorite is associated with the role like low-temperature hydrothermal, metamorphic and sedimentary shallow effects. In the shallow water - coastal sedimentary environment which is oxygen-poverty and iron-rich, there are tremendous olitic chlorite mines [9].

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1878-5220
doi:10.1016/j.proeps.2009.09.130

1. Experimental materials and methods

Oleic acid is saponified and diluted to the concentration of 10%. Lauryl amine and hydrochloric acid are mixed on the proportion of 4 to 5 in weight and then the solution is diluted to the concentration of 1% with water for use.

Chlorite used in the experiments comes from Haicheng, Liaoning province of China. The sample is crushed to 100% - 0.038mm. The XRD analysis of raw materials is shown in Fig 1. The qualitative analysis of spectra shows the major components of the sample used in table 1.

Table 1. Main chemical composition of chlorite used

Element	SiO_2	MgO	Al_2O_3	CaO	Fe_2O_3	Others
%	53.10	28.20	11.80	4.66	1.35	0.89

Each experiment used 50g sample. Sulfuric acid and sodium hydroxide are used to regulate the pH of pulp. Laboratory flotation machine of 0.75L is used.

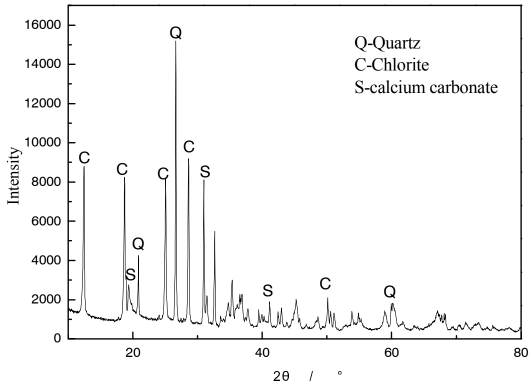

Fig. 1. The analysis of X-ray diffraction of chlorite

2. Results and discussion

2.1. Effect of collector dosages on floatability of chlorite

In the flotation process, the amount of collector used is the primary factor affected flotation recovery. The first experiment is done to investigate the effect of dosages of collector on recovery.

The effects of Sodium oleate and lauryl amine dosages on the recovery of chlorite flotation are showed in Fig.2 and Fig. 3 respectively.

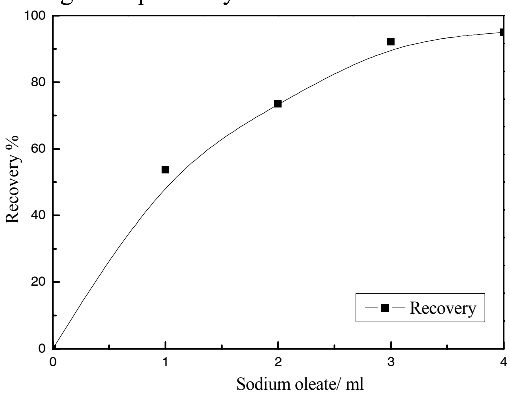

Fig. 2. Effect of NaOL dosages on chlorite floatation recovery

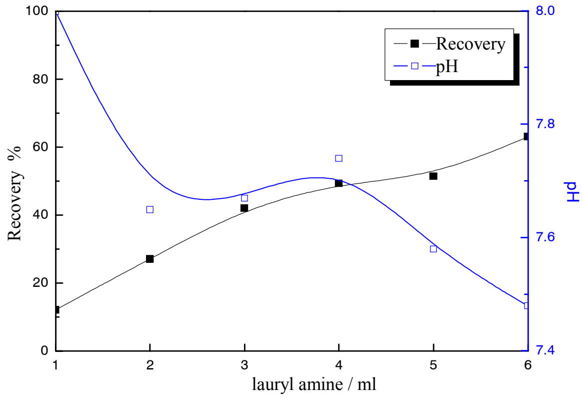

Fig. 3. Effect of lauryl amine dosages on floatability of chlorite

2.2. The Effect of pH value on floatability of chlorite

The Effect of pH value on floatability of chlorite with different collector is shown in Fig.4. The vertical lines in Fig.4 refer to the pH Value of slurry without acid/alkali adjustments added.

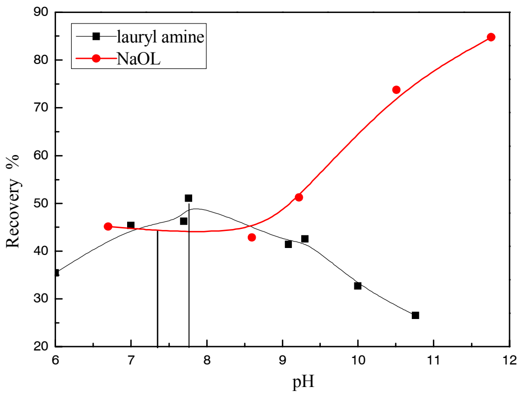

Fig. 4. Effect of pH value on floatability of chlorite

Fig.4 shows that the recovery of chlorite increases with pH increasing when using sodium oleate as collector. This result is consistent with the experiment by M.A.Эигелес[10], but partly inconsistent with the experiment by Liu Cheng-xian.

Dr. M.A.Эигелес measured adsorption capacity of sodium oleate on chlorite in different pH value of pulp. The results show that the increase of pH value makes adsorption capacity of anionic collector increase on the surface of chlorite.

Moreover, increasing in pH value will promote the dispersion of the pulp, and make it easy for bubble flow and flotation.

To raise or lower the pH value of the pulp goes against flotation of chlorite when lauryl amine is used as collector, the maximum recovery of flotation happens in the pH which is not adjusted with acid/alkali regulator. The changing trend is consistent with the result by ZHU Ju-jian. However, in the study by ZHU, the maximum recovery of flotation happens in the pH value 9-10, and the pH scope expands with the increases of the concentration of lauryl amine.

2.3. The effect of calcium ion on floatability of chlorite

Ca^{2+} is one of the most common ions in water, and is the most major metal ions which increase the hardness of water.

The effects of Ca^{2+} on the recovery of chlorite flotation with anion/cation collector are showed in Fig .5 and Fig .6 respectively. The concentration of calcium chloride concentration is 5% in the experiment.

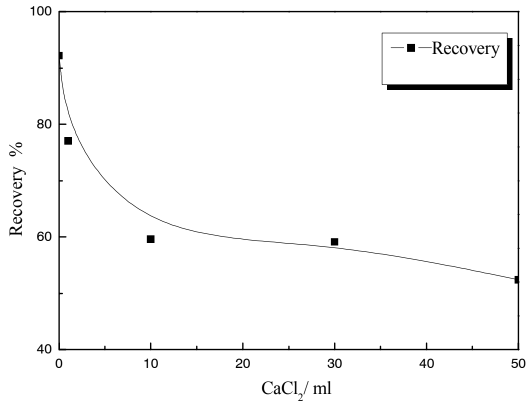

Fig. 5. Effect of calcium ion on floatability of chlorite using NaOL as collector

Fig.5 shows that the Ca^{2+} is harmful to flotation of chlorite, for the generation of insoluble calcium salts consume the Ol^- and recovery decrease with the decrease of concentration of Ol^-.

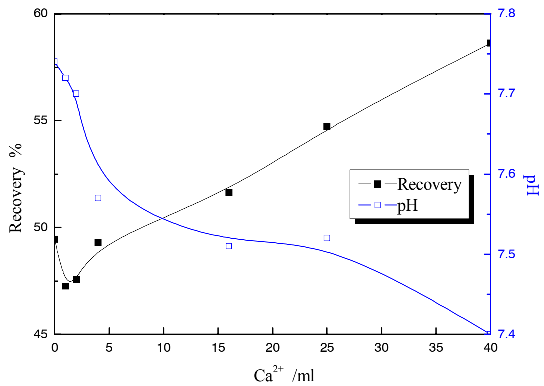

Fig. 6. Effect of calcium ion on floatability of chlorite using lauryl amine as collector

Fig.6 shows that the pH value of the pulp deceases with the increase of concentration of Ca^{2+}. However, recovery of chlorite flotation is increased. The result shows that Ca^{2+} can play the activation role of chlorite flotation with cation collector.

2.4. The effect of Na_2S on floatability of chlorite

The effects of Na_2S on the recovery of chlorite flotation in anion collector are showed in Fig.7. In the experiment the concentration of Na_2S is 1%.

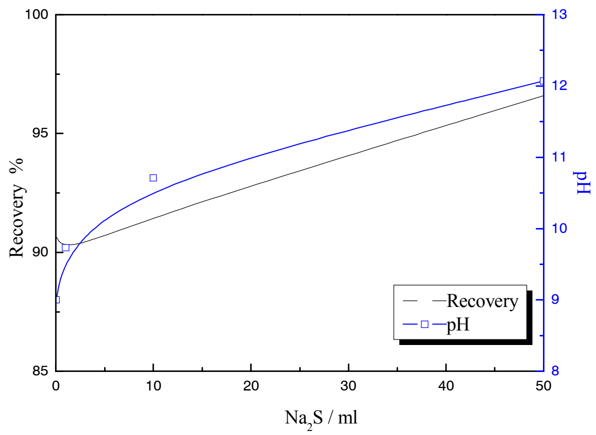

Fig. 7. Effect of Na_2S on floatability of chlorite using NaOL as collector

Fig.7 shows that the increase of recovery of chlorite flotation is accorded with the increase of the pH value of the pulp and with adding of Na_2S.

2.5. The effect of NaF on floatability of chlorite

The effcts of NaF on the recovery of chlorite flotation in anion/cation collector are showed in Fig 8 and Fig 9 respectively.

In the experiment the concentration of NaF is 1%.

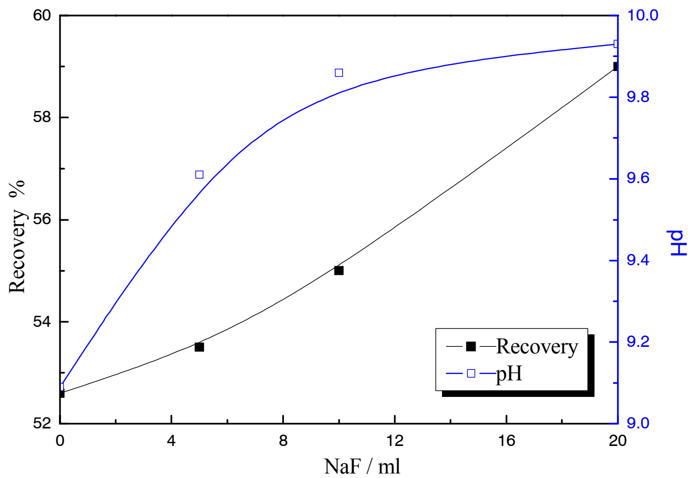

Fig. 8. Effect of NaF on floatability of chlorite using NaOL as collector

NaF can completely dissolve in water, and part of F^- ions hydrolyzed as following:

$$F^- + H_2O \leftrightarrow HF + OH^-$$

It results in increase of pH values in solution. Despite the increase in pH is propitious to the chlorite flotation, it is one-sided to attribute the increase of chlorite recovery to the increasing of pH value. Both CaF_2 and MgF_2 are difficult to dissolve in water, that is, the addition of F^- is an effective way to reduce the concentration of metal ions like Ca^{2+} and Mg^{2+}, which reduces the precipitation of $Ca(Ol)_2$ and $Mg(Ol)_2$, thus flotation recovery is increased .

M.A.Эигелес[10] also mentioned that the fluoride ion plays an activation role in chlorite flotation using anionic collector.

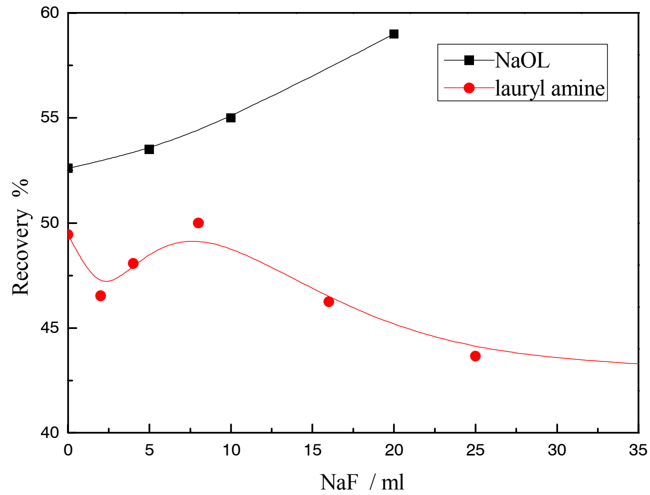

Fig. 9. Effect of NaF on floatability of chlorite using different collector

It can be seen from Fig.9 that NaF depressed the flotation of chlorite when lauryl amine is used as collector. Notable contrary is made from Fig.9 on the effect of NaF in anion/cation collector system.

2.6. The effect of Na_2SiF_6 on floatability of chlorite

The effects of Na_2SiF_6 on the recovery of chlorite flotation in anion/cation collector are showed in Fig 10 and Fig 11 respectively.

In the experiment the concentration of Na_2SiF_6 is 1%.

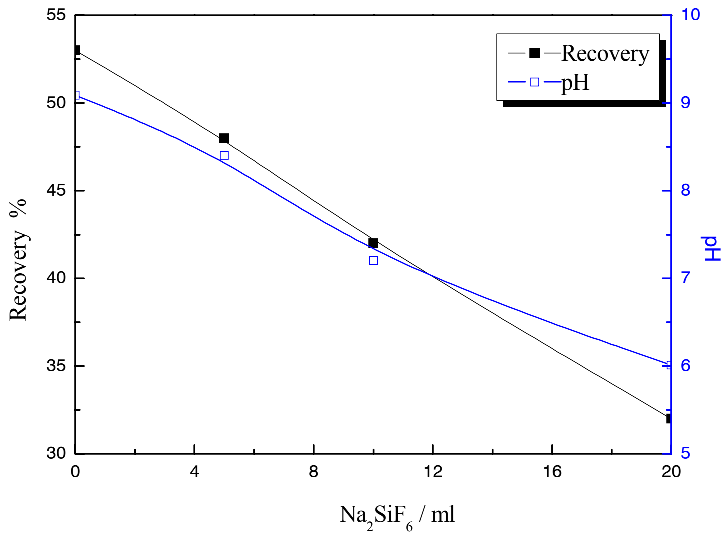

Fig. 10. Effect of Na_2SiF_6 on floatability of chlorite using NaOL as collector

Fig.10 shows that the pH value and recovery of chlorite flotation decease with the increasing of Na_2SiF_6. Dr. М.А.Эигелес[10] thinks that the depression role of Na_2SiF_6 can be attributed to the following three aspects: SiF_6^{2-} anion adsorption, H^+ adsorption caused by the decrease of pH value ,and adsorption capacity of collector. The three factors above make the surface of chlorite hydrophilic.

Other researcher [7] pointed out that Na_2SiF_6 is a strong activator for quartz in the neutral pH conditions with sodium oleate as collector, so it can be used to separate chlorite and quartz mixture.

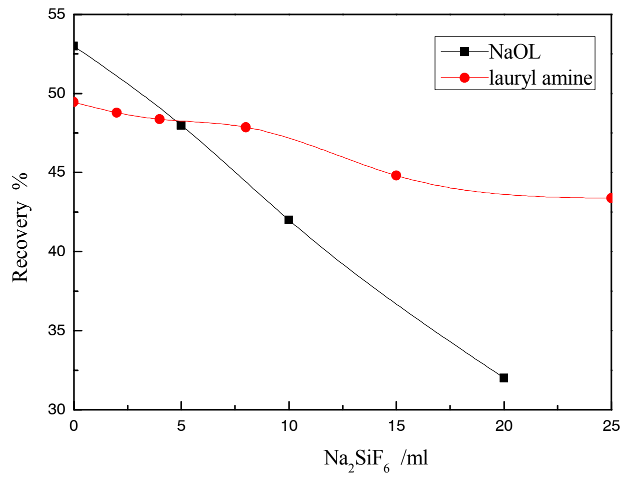

Fig. 11. Effect of Na_2SiF_6 on floatability of chlorite using different collector

From Fig.11 we can see that the Na_2SiF_6 is an effective depressor of chlorite not only for anion collector, but also for cation collector. This is coherent with the collusion of the former Soviet Union researcher that 'in the medium in conditions, Na_2SiF_6 can be used as strong depressor for the flotation of chlorite '.

2.7. The effect of $(NaPO_3)_6$ on floatability of chlorite

$(NaPO_3)_6$ is used widely as a effective sludge dispersant in flotation. In our experiment, the result of Fig.12 clearly shows that the $(NaPO_3)_6$ deceases the pH value of the pulp significantly and depress the flotation of chlorite.

In the experiment the concentration of $(NaPO_3)_6$ is 1%.

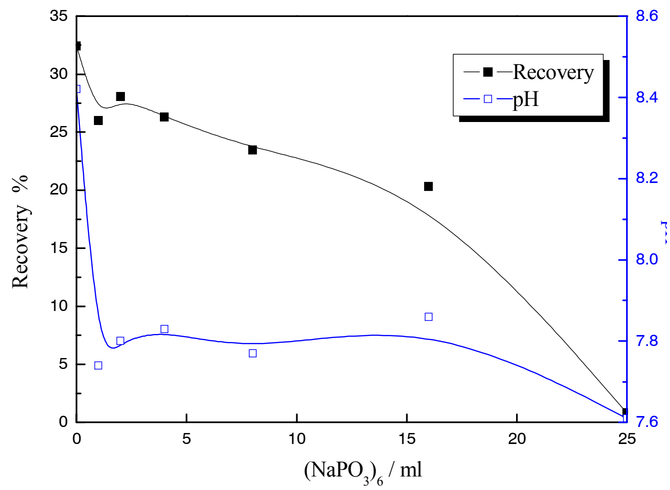

Fig. 12. Effect of $(NaPO_3)_6$ on floatability of chlorite using NaOL as collector

3. Conclusions

1. Chlorite is a kind of silicate floated easily by anion/cation collector.
2. Ca^{2+} makes depression role and activation role when using sodium oleate and lauryl amine as collector respectively.

3. NaF makes activation role and depression role when using sodium oleate and lauryl amine as collector respectively.
4. Na_2SiF_6 makes depression role using both sodium oleate and lauryl amine as collector.
5. $(NaPO_3)_6$ makes depression role when using sodium oleate as collector.

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