Flotation separation of arsenopyrite from several sulphide minerals with organic depressants

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Abstract: In this paper, the separation of arsenopyrite from chalcopyrite, pyrite, galena with organic depressants (guergum and sodium humic) was discussed, and the functioning mechanism of those organic depressants was discussed. The experimental results of monomineral flotation indicated that both guergum and sodium humic have depressing effect on arsenopyrite in the presence of ethyl xanthate. Guergum and sodium humic showed different depressing ability to pyrite, chalcopyrite and galena, and the higher the pH value in pulp, the stronger the depressing ability. Ultraviolet-Visible Spectrophotometric study showed that the adsorption layer of xanthate on surface of minerals had been desorbed by the two organic depressants, and the selective desorption of the collector layer was found from different minerals. The xanthate cover on minerals surface was set free when dosage of the organic depressants was high enough. For artificially-mixed minerals, the separation of arsenopyrite from other sulphides was successfully realized by controlling dosage of the organic depressants. And sodium humic had been used successfully to decrease arsenic content in sulphide concentrates in a commercial Lead-Zinc concentrator.

Key words: arsenic; arsenopyrite; organic depressant; flotation

1 Introduction

The arsenic contained in sulphide concentrates is very harmful in pyro-metallurgical process. In literature a lot of papers have been found on the separation of minerals containing arsenic from target sulphide minerals[1-3], but less was found about the removal of arsenic from concentrates, which is the topic of this paper.

2 Experiment method

2.1 Sample

The minerals used in experiment were selected by hands firstly, then crashed into grains (less than 5 mm) and ground further into particles between 0.074 mm and 0.038 mm by porcelain mill. The purity of minerals was shown in Table 1.

Table 1 Purity of minerals

Mineral	Content /%	Impurity
Arsenopyrite	95 ~ 96	Gangue
Pyrite	98 ~ 99	Quartz
Chalcopyrite	94 ~ 95	Gangue
Galena	99	Quartz

2.2 Flotation method

2.2.1 Monomineral flotation

In order to decrease the oxidation of mineral surface, the supersonic treatment was used to rinse the samples before flotation experiment. The treated samples were put into flotation cell, and then floated for 3 min after addition of reagents. Every experiment the dosage of ethyl xanthate is 2.00×10^{-4} mol/L before the addition of depressant. The concentrate then is dried by electric control oven and then weighted and analysis.

2.2.2 Artificially-mixed minerals separation

After rinse, two kinds of minerals were mixed together as feed to flotation. With the addition of collector (2.00×10^{-4} mol/L, 2 min) and frother (a little, 1 min), the froth product was obtained as mixed concentrate. The separation flotation was then carried out on this mixed concentrate by conditioning the pulp 3 min with the depressant.

2.2.3 Measurement of reagents

Ultraviolet Visible Spectrophotometer (Lambda 7) and FTIR[4,5] were used to measure the presence of reagents on the mineral surface. After rinse the samples were stirred with ethyl xanthate 2.00×10^{-4} mol/L for 2 min, then added organic depressants and stirred for 3 min, the pulp was put into centrifuge for solid-liquid

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separation, and the solid was used to leach and the extract was taken to UV test. And the surface layer of minerals was extracted by cyclohexane. The samples for FITR test were treated with the same step but without leaching, after solid-liquid separation, the minerals were leaching by distilled water for several times to wipe off the dissociative reagents, then dried by nature and taken for test

3 Results and discussion

3.1 Monomineral flotation

3.1.1 Dosage of depressants

From Fig. 1 to Fig. 2, we can know that both guergum and sodium humic show strong depressing ability to arsenopyrite and the depressing effect increased as the dosage of them increased. The depressing effect of guergum is strong to pyrite and galena in some degree, but weak to chalcopyrite; the depressing selectivity of guergum is weaker than sodium humic.

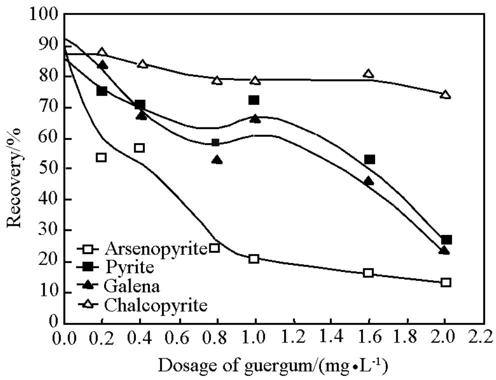


Fig. 1 The effect of guergum dosage on sulphide minerals recovery (pH 5.0)

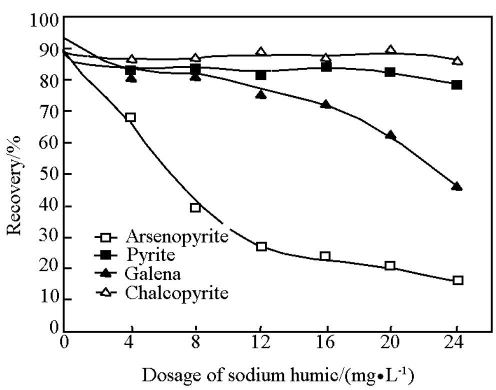


Fig. 2 The effect of sodium humic dosage on sulphide minerals recovery (pH 5.0)

3.1.2 Influence pH value

Based on the experiment of depressant dosage, the dosage of guergum and sodium humic is 1 mg/L and 20 mg/L respectively.

And the influence of pulp pH value on depressing function of the organic depressants was discussed. From Fig. 3 to Fig. 6, it is shown that both guergum and sodium humic have depressing effect on arsenopyrite within the pH-range tested, the depressing ability of them increases as the pH value increases.

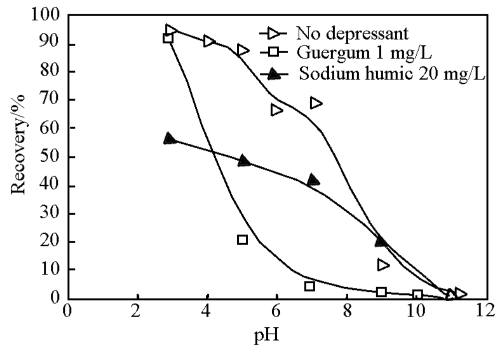


Fig. 3 The effect of pH on arsenopyrite recovery

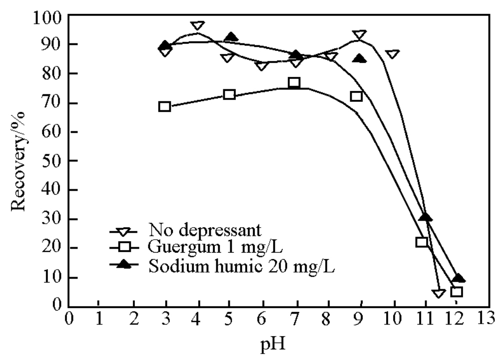


Fig. 4 The effect of pH on pyrite recovery

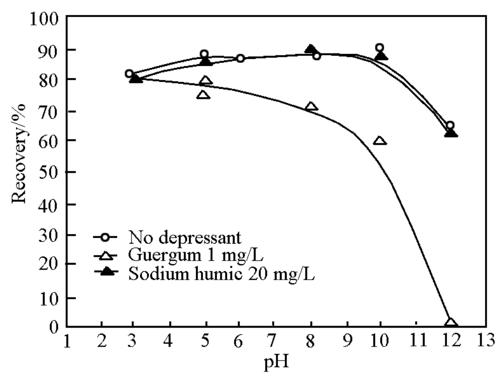


Fig. 5 The effect of pH on chalcopyrite recovery

3.2 Artificially-mixed minerals separation

The depressing ability of depressant may be different as the complexity of-minerals in pulp increases. So artificially-mixed minerals flotation separation was car-

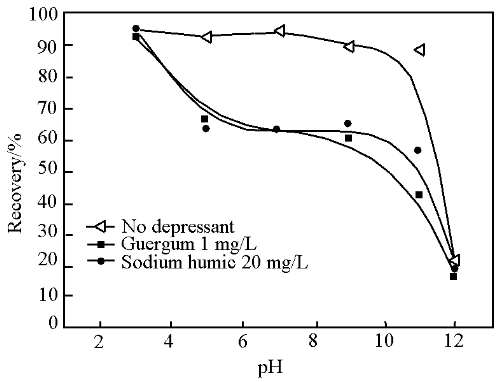


Fig. 6 The effect of pH on galena recovery

ried out to test the depressing effect of the organic depressant. Because the depressing ability of organic depressants is stronger at alkaline condition as the pH-value increases, the flotation pH tested was set at the value of 9.18. The dosage of guergum is 0.8 ~ 1.6 mg/L, while sodium humic is 40 mg/L.

The composition of manual mixed minerals is 3∶2 by monomineral quality (here the proportion of chalcopyrite, pyrite and galena is 3, while the proportion of arsenopyrite is 2). And the results of flotation separation are given in Table 2 to Table 7. It is shown that the flotation separation of arsenopyrite from other sulphide minerals is realized by using the organic depressant guergum and sodium humic and the depressing selectivity of sodium humic is better than guergum.

Table 2 The separation result of artificially-mixed minerals (chalcopyrite: arsenopyrite, guergum)

Type	Grade/%		Recovery/%	
	Cu	As	Cu	As
Concentrate	31.04	1.43	81.28	4.25
Tailings	8.62	38.85	18.72	95.75
Feed	20.87	18.40	100.00	100.00

Table 3 The separation result of artificially-mixed minerals (chalcopyrite: arsenopyrite, sodium humic)

Type	Grade/%		Recovery/%	
	Cu	As	Cu	As
Concentrate	29.07	2.77	81.53	8.81
Tailings	9.29	40.46	18.47	91.19
Feed	20.87	18.40	100.00	100.00

Table 4 The separation result of artificially-mixed minerals (galena: arsenopyrite, guergum)

Type	Grade/%		Recovery/%	
	Pb	As	Pb	As
Concentrate	71.53	7.07	82.56	23.05
Tailings	7.96	34.48	17.44	76.95
Feed	46.09	18.40	100.00	100.00

Table 5 The separation result of artificially-mixed minerals (galena: arsenopyrite, sodium humic)

Type	Grade/%		Recovery/%	
	Pb	As	Pb	As
Concentrate	73.90	5.05	89.18	17.06
Tailings	0.42	39.37	10.82	82.94
Feed	46.09	18.40	100.00	100.00

Table 6 The separation result of artificially-mixed minerals (pyrite: arsenopyrite, guergum)

Type	Grade/%		Recovery/%	
	S	As	S	As
Concentrate	46.66	6.11	78.13	21.58
Tailings	15.21	44.35	21.87	78.42
Feed	32.00	18.40	100.00	100.00

Table 7 The separation result of artificially-mixed minerals (pyrite: arsenopyrite, sodium humic)

Type	Grade/%		Recovery/%	
	S	As	S	As
Concentrate	52.45	2.64	84.61	7.38
Tailing	10.35	35.03	15.39	92.62
Feed	32.00	18.40	100.00	100.00

3.3 Depressing mechanism of depressants

In order to reveal the depressing mechanism, experiments were carried out under the condition of variation in dosage of the depressants (The a, b and c in Fig. 4 ~ Fig. 7 means the dosage of guergum is 0 mg/L, 1.6 mg/L and 8.0 mg/L; To sodium humic, a, b and c means 0 mg/L, 20 mg/L and 60 mg/L respectively).

From Fig. 7 to Fig. 14, it is shown that the collector layers on the surface of arsenopyrite and chalcopyrite were desorbed more easily than on the surface of pyrite and galena when using guergum as depressant. The higher the dosage of guergum, the more collector layers were desorbed. And similar result was found by using sodium humic as depressant.

For the sake of explaining the functioning mechanism of the organic depressants more clearly, FTIR experiments were carried out.

From Fig. 15 to Fig. 22, it is shown that both guergum and sodium humic have been adsorbed to surface of the minerals. There is obvious characteristic wave crest to arsenopyrite and galena which were first processed by xanthate and then conditioned with the depressants. While the characteristic wave crest of collector was distinct to chalcopyrite and pyrite. And both guergum and sodium humic have been adsorbed to surface of the minerals. There is obvious characteristic wave crest of depressant (1 542 ~ 1 574 cm^{-1} for sodium humic and 800 cm^{-1} and 1 080 cm^{-1} for guergum) to arsenopyrite which were first processed by xanthate and then conditioned with the depressants.

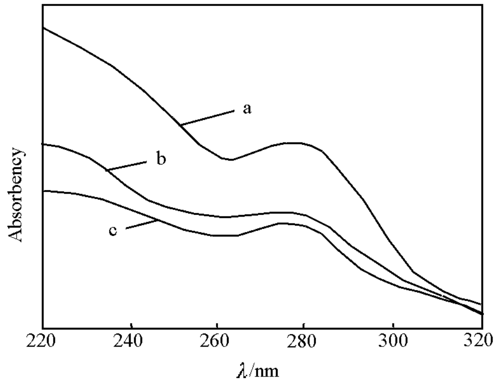


Fig. 7 The effect of guergum dosage on collector layer on arsenopyrite

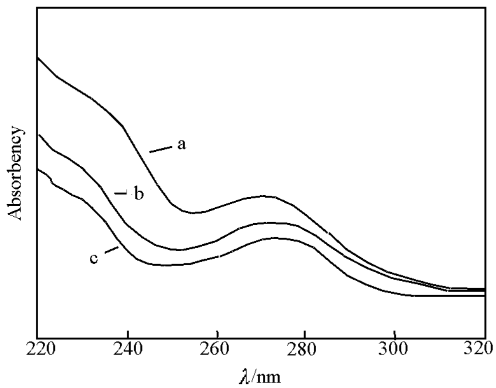


Fig. 8 The effect of guergum dosage on collector layer on chalcopyrite

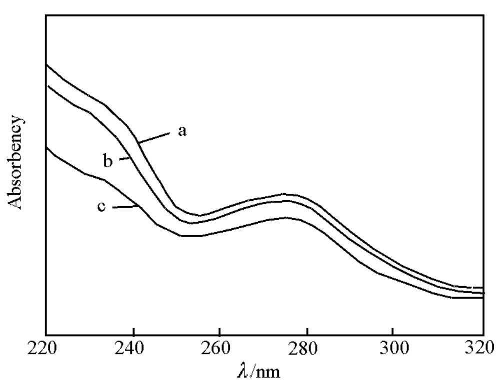


Fig 9 The effect of guergum dosage on collector layer on pyrite

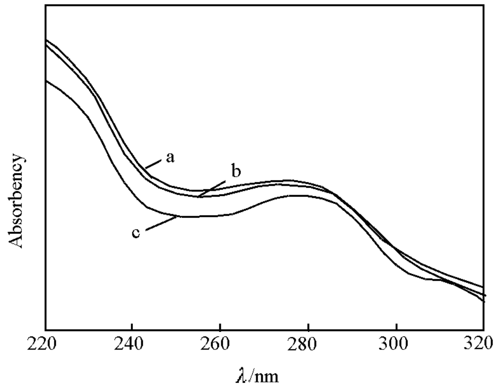


Fig. 10 The effect of guergum dosage on collector layer on galena

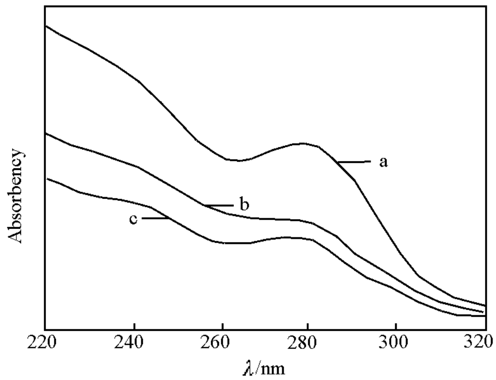


Fig. 11 The effect of sodium humic dosage on collector layer on arsenopyrite

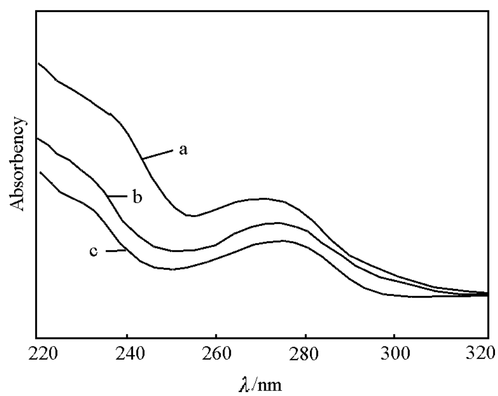


Fig. 12 The effect of sodium humic dosage on collector layer on chalcopyrite

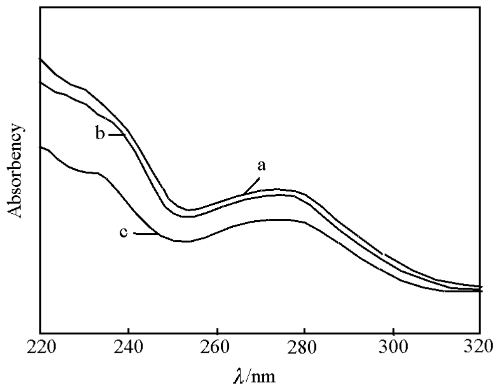


Fig. 13 The effect of sodium humic dosage on collector layer on pyrite

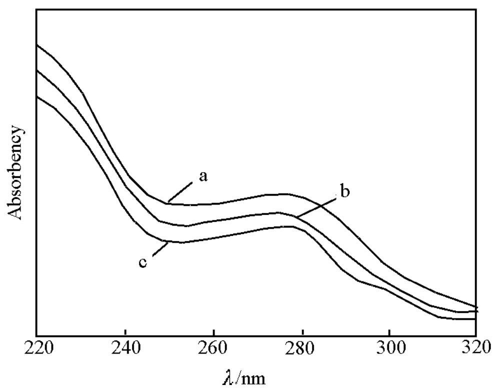
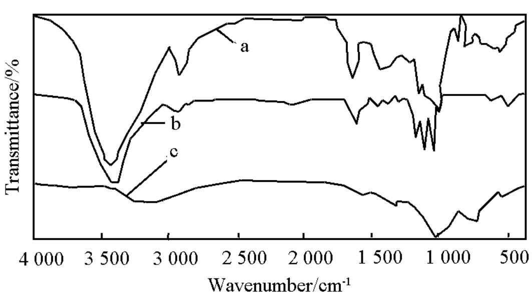


Fig. 14 The effect of sodium humic dosage on collector layer on galena



a—Guergum; b—Ethyl xanthate; c—The difference chart of arsenopyrite after the processing of reagents

Fig. 15 The FTIR difference chart of the arsenopyrite before and after processing of reagents and standard charts of reagents

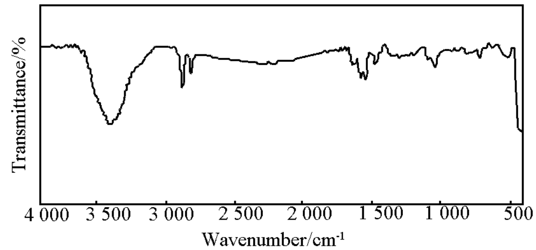


Fig. 16 The FTIR difference chart of the chalcopyrite before and after processing of reagents

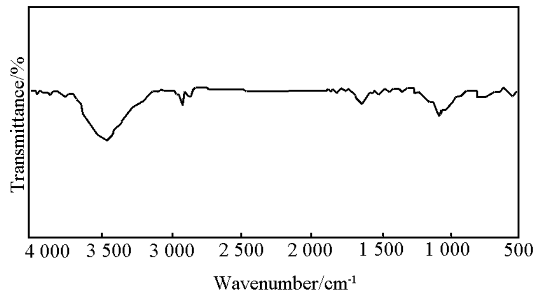


Fig. 17 The FTIR difference chart of the pyrite before and after processing of reagents

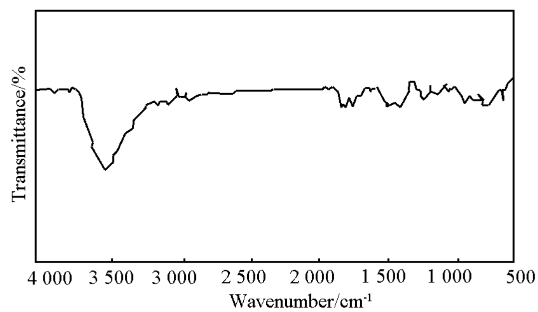
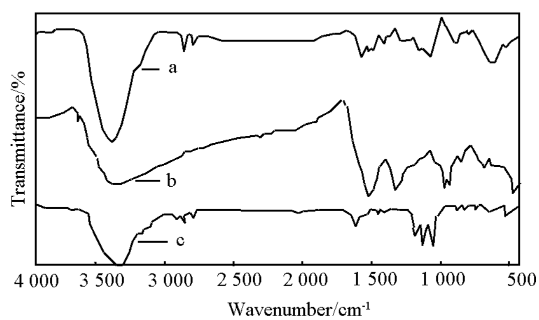


Fig. 18 The FTIR difference chart of the galenabefore and after processing of reagents



a—The difference chart of arsenopyrite after the processing of reagents; b—Sodium humic; c—Ethyl xanthate

Fig. 19 The FTIR difference chart of the arsenopyrite before and after processing of reagents and standard charts of reagents

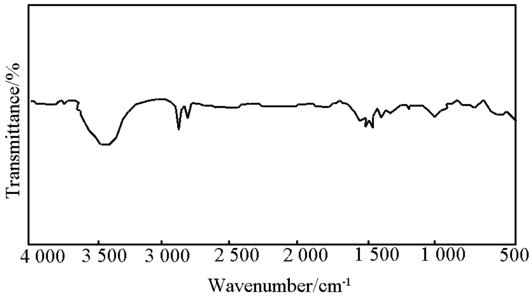


Fig. 20 The FTIR difference chart of the chalcopyrite before and after processing of reagents

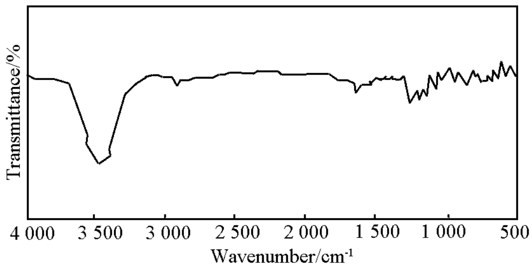


Fig. 21 The FTIR difference chart of the pyrite before and after processing of reagents

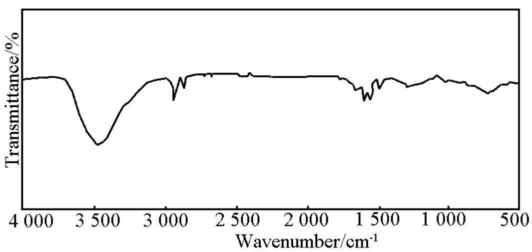


Fig. 22 The FTIR difference chart of the galena before and after processing of reagents

From Fig. 15 to Fig. 18, it is shown that the characteristic wave crest of guergum on arsenopyrite is obvious and fuzzy to collector, but distinct characteristic wave crest of collector on chalcopyrite, pyrite and galena is found with hazy wave crest of guergum. From Fig. 19 to Fig. 22, there are characteristic wave crests of sodium humic and collector on arsenopyrite and it is a corporate adsorption, while the characteristic crest of collector is found on chalcopyrite, pyrite and galena with fuzzy depressant crest.

Now it can be concluded that to guergum, the main reason is desorption of the collector layer on arsenopyrite selectively with proper dosage, while to sodium humic, it is both desorption of the collector and adsorption of depressant on the arsenopyrite.

4 Conclusions

Experimental results show that the flotation separation of arsenopyrite from chalcopyrite, pyrite and galena is successfully realized by the addition of organic depressant guergum and sodium humic. From UV and FTIR, we know that with selective adsorption and desorption, guergum and sodium humic has the selectively depressing function to arsenopyrite.

Sodium humic had been used successfully to decrease arsenic content in sulphide concentrates in a commercial Lead-Zinc concentrator.

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