SEPARATION OF PYRITE FROM CHALCOPYRITE WITH ORGANIC DEPRESSANT CTP①

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ABSTRACT The Cu-S flotation separation using a new organic depressant CTP has been worked out successfully in laboratory and on industrial scale in Dexin Copper Mine. The testing results showed that CTP is a new effective organic depressant of pyrite with good selectivity on Cu-S separation in low alkaline medium; copper indices of the new Cu-S separation process are Cu concentrate with a grade over 24% and Cu recovery above 97%. The CTP dosage is about 45~ 50 g/t, the lime dosage is greatly reduced from 5.14 kg/t to 1.30 kg/t as compared with the traditional reagent system; the recoveries of Au and Mo in the copper concentrate are increased by 1.6% and 23.88%, respectively. In addition, the pyrite can be recovered from Cu tailing by flotation. The interaction mechanism of CTP with sulfide has been studied too. The anion of CTP can selectively interact with the surface of pyrite by chemical adsorption; CTP can disadsorb the xanthate absorbed on pyrite surface in the mixed concentrate pulp.

Key words organic depressant CTP chalcopyrite pyrite flotation separation chemical adsorption

1 INTRODUCTION

The study of depressants on sulfide flotation is one of the important trends because there is no qualified products with selective flotation. Therefore, the development of better selective depressants of sulfide, which can be used to carry out selective flotation of complex sulfides in low alkaline medium, plays an important role in theory and practice for comprehensive utilization of mineral resources. In recent years, the development of inorganic depressants was limited for various reasons; while the studies of organic depressants became more and more important due to its large quantity and variety of polar groups. In fact, one of the major advantages of organic depressant over inorganic depressant is that there is a better flexibility to prepare polar groups for a specific application. The application of both natural and synthetic organic products to depressing the natural flotability of undesirable hydrophobic components, such as talc, graphite, coal, sulfur, carbonaceous silicate and clay, and to flotating complex sulfides as differential depressants has been a well established procedure in the mineral industry for several decades[1-4]. But the principal use of organic depressants in sulfide flotation is mainly to remove gangue minerals, so as to upgrade concentrate[5-7]; However, so far, a few reports have been made on the use of organic depressants in the sulfide flotation separation[8-11].

We developed an organic depressant CTP which possesses some special radicals molecular structure and proper molecular mass, and has strong depressing ability and better selectivity for separation sulfides. It is soluble in water, its main structure unit is benzene ring with many polar groups, the relative molecular mass is about 500~ 1 000, the main interacting groups are phenol hydroxyl, $-COOH$, $-NH_2$, etc. A new process of Cu-S separation using CTP as depressant in low alkaline was developed also.

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2 RESULTS OF Cu-S SEPARATION USING CTP AS DEPRESSANT

The test was performed in laboratory flotation cells with effective volumes of 0.25, 0.5, 0.75 and 1.0L. The flowsheet of laboratory test is shown in Fig. 1. The analyses of ore samples of Dexin Copper Mine are shown in Table 1 and Table 2.

2.1 Fundamental depression behaviors of CTP on mineral surfaces

As shown in Fig. 2, pyrite and chalcopyrite are depressed by CTP at pH 2~ 6; while in alkaline condition, pyrite is merely depressed by CTP, but the flotability of chalcopyrite is kept unchanged, so CTP may be used to separate pyrite from chalcopyrite in alkaline medium. The pulp pH in laboratory test is only adjusted by lime for industrial sake.

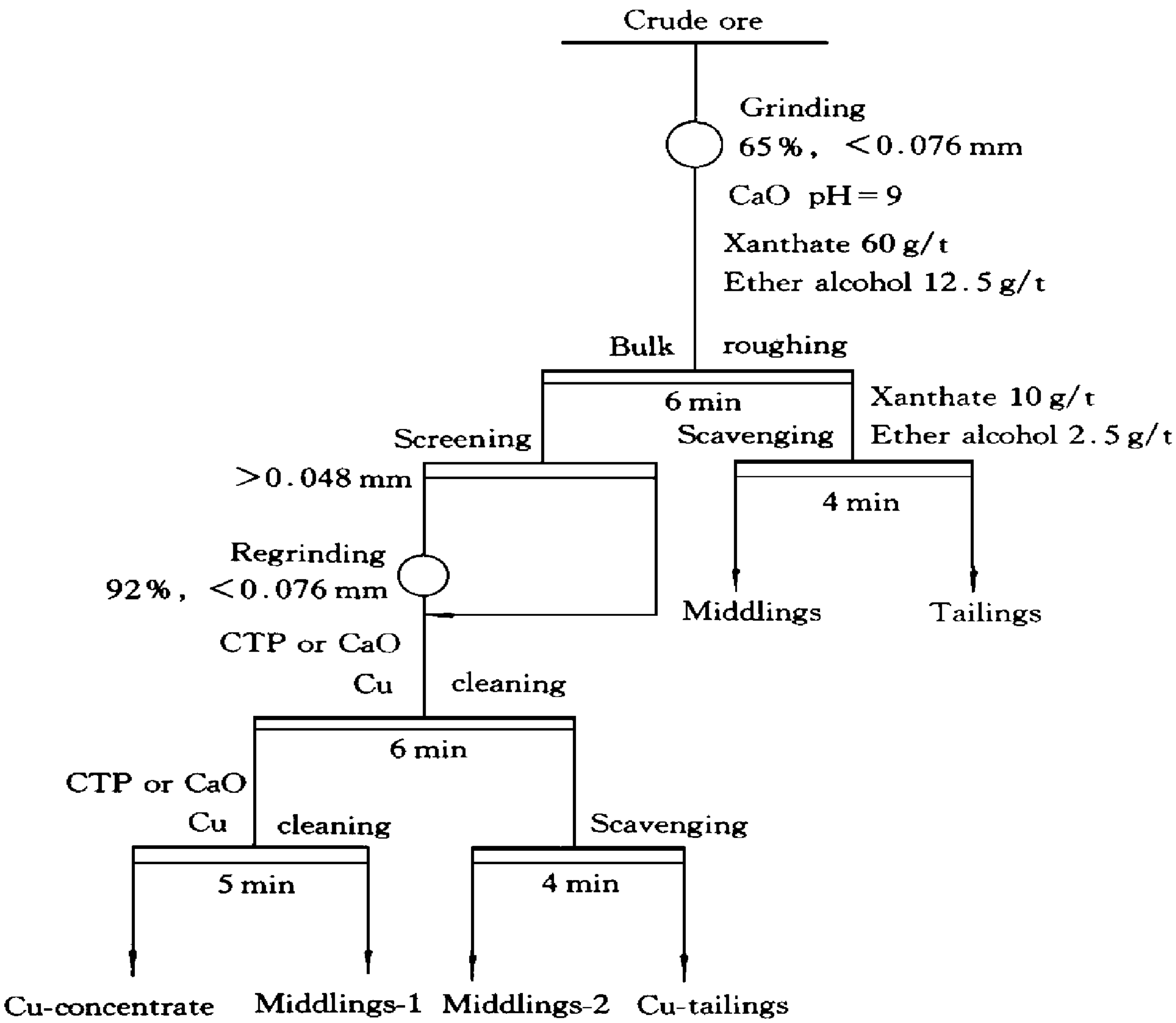

Fig. 1 Flowsheet of laboratory test of Cu-S separation

Table 1 Results of samples analyses

Composition	Cu/ %	S/ %	Au/ g·t^{-1}	Ag/ g·t^{-1}	Mo/ %	Fe/ %	SiO_2/ %	As/ %
Sample 1	0.482	1.667	0.274	1.20	0.009	3.81	68.74	0.0068
Sample 2	0.312	1.613	0.334	0.61	0.005	3.96	65.19	0.0037
Sample 3	0.471	0.907	0.144	0.57	0.003	2.97	64.14	0.0077
Sample 4	0.514	4.538			0.002	7.29	63.41	

Table 2 Results of mineralogical phase analyses of samples

Sample	CuO/ %	Primary CuS/ %	Secondary CuS/ %	Total Cu/ %
Sample 1	0.045	0.334	0.103	0.482
Sample 2	0.062	0.116	0.134	0.312
Sample 3	0.061	0.345	0.065	0.471
Sample 4	0.0169	0.480	0.017	0.514

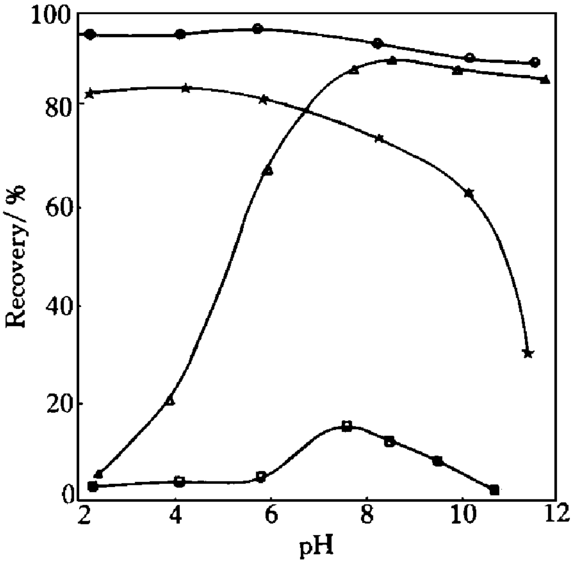

Fig. 2 Depression behavior of CTP on minerals at different pH adjusted by HCl and CaO

○—Chalcopyrite, CTP 0; ★—Pyrite, CTP 0;
△—Chalcopyrite, CTP 50 mg/ L;
□—Pyrite, CTP 50 mg/ L;
Bu-xanthate: 2.5×10^{-5} mol/ L; 2# oil: 35 mg/ L

2.2 Effect of CTP dosage

The effect of the CTP dosage on the indices of Cu-S flotation separation is shown in Fig. 3. The grade of copper concentrate is improved with the increase of CTP dosage at pH 9~ 10; the Cu recovery is not affected by the dosage of CTP. A concentrate with 24% Cu in grade with no decrease in copper recovery is obtained when CTP dosage is kept at 80 g/ t.

2.3 Effect of pulp pH on Cu-S separation

Fig. 4 illustrates the results of Cu-S separation using CTP at different values of pH. With the increase of pH, the grade of concentrate is improved; but when pH value is over 11.5, the recovery of copper starts to decrease for the reason that chalcopyrite may be depressed by lime.

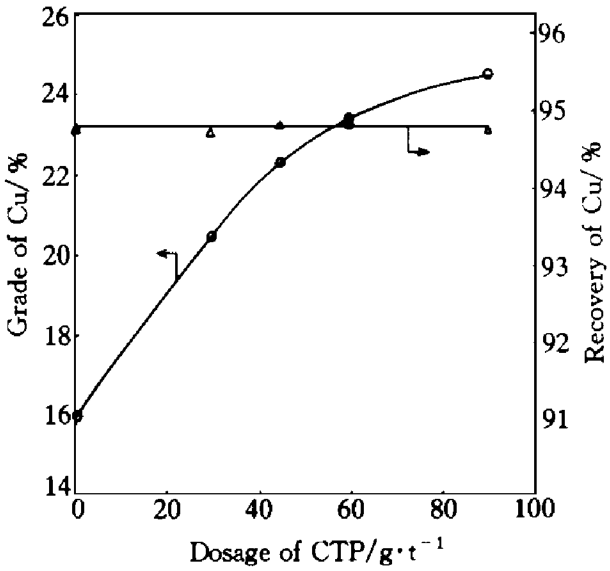

Fig. 3 Effect of CTP dosage on indices of Cu-S separation at pH 9.5

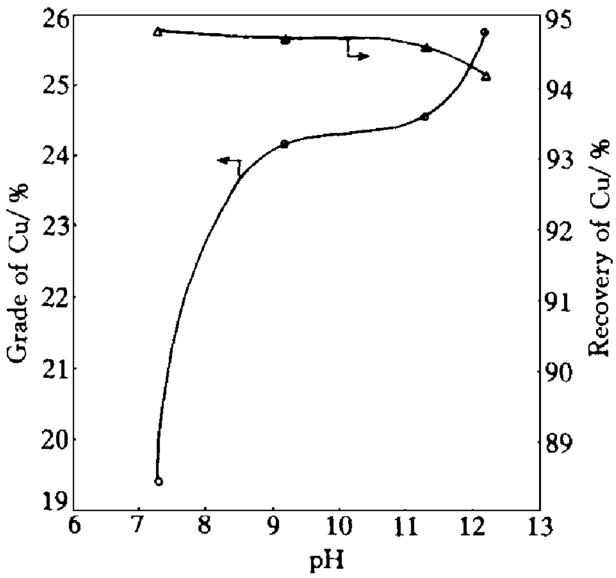

Fig. 4 Results of Cu-S separation using CTP at different pH

The results of Cu-S separation using lime case and CTP case at different CaO contents in the pulp of Cu-tailing are shown in Fig. 5. A copper concentrate with 24% Cu in grade has been obtained using CTP as pyrite depressant when the content of CaO in the tailing pulp is 200 mg/L. So the case of CTP can successfully perform the Cu-S flotation separation in low alkaline as compared with the case of lime.

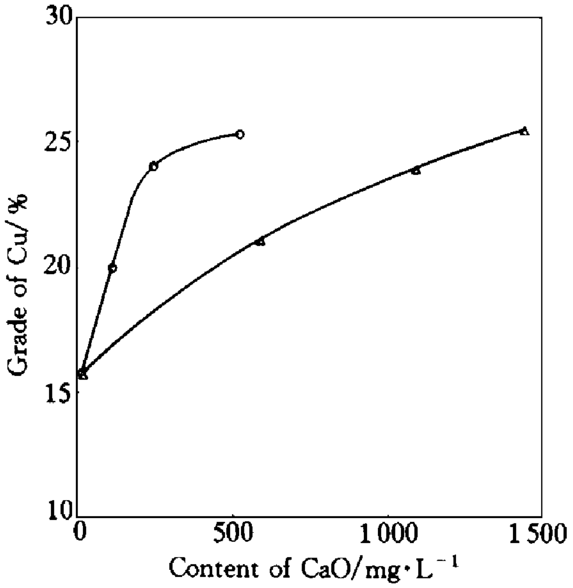

Fig. 5 Indices of Cu-S separation at different CaO contents in pulp of Cu-tailing
○—CTP process; △—Lime process

2.4 Cu-S separation results of laboratory test

The indices of close circuit of Cu-S separation for the process of lime and the process of CTP are shown in Table 3.

A concentrate with a grade of 25.89% Cu and 97.29% Cu recovery from a feed assayed is gained using CTP to depress pyrite when pH is adjusted to 9.5 by CaO, in addition, the results of Au, Ag and Mo in the Cu concentrate by means of CTP are better than that of lime. The results shown in Table 4 indicate that CTP is advantageous to recover pyrite from Cu tailing with flotation as compared with the case of lime; the recovery of S for the case of CTP is 29.3% more than that of case lime.

2.5 Test of different samples

The results of three samples with different oxidization ratio and different contents of pyrite are shown in Table 5. The good results of Cu-S separation using CTP as pyrite depressant may be obtained for the ore with different oxidization rate and the ore with different ratios of Cu/S.

2.6 Industrial test

Based on the results of the laboratory tests, the industrial test has been carried out on a scale of 30 000 t/d in the Dashan Concentrator, a subunit of Dexin Copper Mine with a capacity of 60 000 t/d for two systems.

The contrast results of industrial test for two cases showed that a 24.29% Cu concentrate grade with 97.26% Cu recovery from a feed assayed was obtained using the new separation process when the dosage of CTP was 52.46 g/t and the dosage of lime was 1.30 kg/t; the lime dosage of 3.84 kg/t was reduced as compared with the old reagent system of the lime process.

Due to the lower dosage of lime, it is advantageous to recover Au, Mo, and S forthe new separation process; the recoveries of Au and Mo in the copper concentrate have been increased by 1.6% and 23.88%, respectively. In addition, the pyrite can be recovered from Cu tailings by flotation with the S concentrate of 43% in grade and recovery of 91%. A great economic profits can be obtained from the new process using CTP as depressant.

3 MECHANISM OF CTP INTERACTING WITH MINERAL

There are several actions on the mechanism

Table 3 Results of close circuit laboratory test of Cu-S separation

Process	Product	Grade				Recovery/%			
		Cu/%	Au/g·t⁻¹	Ag/g·t⁻¹	Mo/%	Cu	Au	Ag	Mo
Lime process	Cu-Conc.	23.65	9.17	26.80	0.359	97.52	83.77	64.36	90.27
	Feed	7.09	3.20	12.17	0.116				
CTP process	Cu-Conc.	25.89	10.72	28.10	0.407	97.29	92.29	63.44	96.94
	Feed	6.58	2.87	10.95	0.104				

Table 4 Indices of S flotation from Cu tailings

Process	Feed assay/ %	S conc. grade/ %	S recovery / %
CaO	25.85	40.03	55.65
CTP	23.37	38.46	84.95

of CaO depressing pyrite. On one hand, pH value of the pulp increases while adding CaO, so $Fe(OH)_2$ or $Fe(OH)_3$ will be formed on the surface of pyrite; on the other hand, Ca^{2+}, $Ca(OH)_2$ and CaO can be adsorbed on the surface of pyrite, therefore pyrite is depressed due to the high hydrophilicity of its surface. The mechanism of CTP interacting with mineral is different from that of CaO, it interacts with mineral by chemical adsorption, due to the interaction of polarizing groups, so the surface of mineral becomes hydrophilic.

3.1 Effect of CTP on Zeta-potential of mineral surface

Fig. 6 shows that the Zeta-potential of pyrite surface becomes more negative in the presence of CTP, which can interact with pyrite surface in the form of anion; the Zeta-potential of chalcopyrite changes slightly in the presence of CTP, which has weak chemical interaction with chalcopyrite. This indicates that CTP has good selectivity as depressant in the pyrite and chalcopyrite separation.

3.2 Effect of CTP on adsorbing xanthate

CTP will be adsorbed competitively with xanthate on the surface of mineral in the mixed concentrate system, and the results (Fig. 7) show that the concentration of adsorbed xanthate on the pyrite surface decreases with increasing dosage of CTP, however the concentration of absorbed xanthateson the chalcopyrite surface keeps unchanged. Pyrite will be depressed and chalcopyrite will keep good flotability in the Cu-S mixed concentrate pulp, so CTP has good depressing ability and selectivity as depressant in the Cu-S separation.

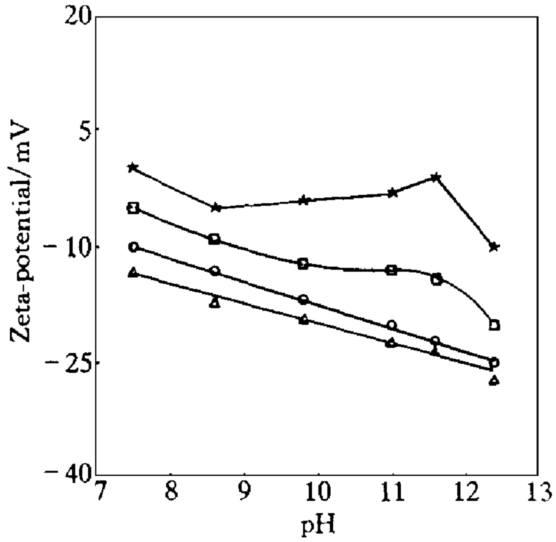

Fig. 6 Effect of CTP on Zeta-potential of mineral surface (pH is adjusted by CaO)
○—Chalcopyrite, CTP 0; ★—Pyrite, CTP 0;
△—Chalcopyrite, CTP 50 mg/ L;
□—Pyrite, CTP 50 mg/ L

4 CONCLUSIONS

The CTP is a new organic depressant of pyrite with good selectivity. The pyrite can be depressed selectively in the Cu-S separation at pH 8~ 11 by adding CTP. Studies of interaction of CTP with mineral show that CTP can be ad-

Table 5 Results of separation of different samples

Sample	Oxidization ratio of ore/ %	Process of separation	Feed grade		Conc. grade		Recovery	
			Cu/ %	S/ %	Cu/ %	S/ %	Cu/ %	S/ %
Sample 1	19.87	Lime	6.35	16.99	28.70	33.18	87.56	37.74
		CTP	5.96	17.05	25.03	36.27	89.30	45.39
Sample 2	12.95	Lime	8.31	19.10	27.66	31.90	93.28	46.88
		CTP	7.79	18.52	26.51	35.17	94.25	53.01
Sample 3	3.29	Lime	4.52	34.90	20.84	31.52	81.70	16.03
		CTP	4.22	35.81	20.63	33.69	85.00	16.37

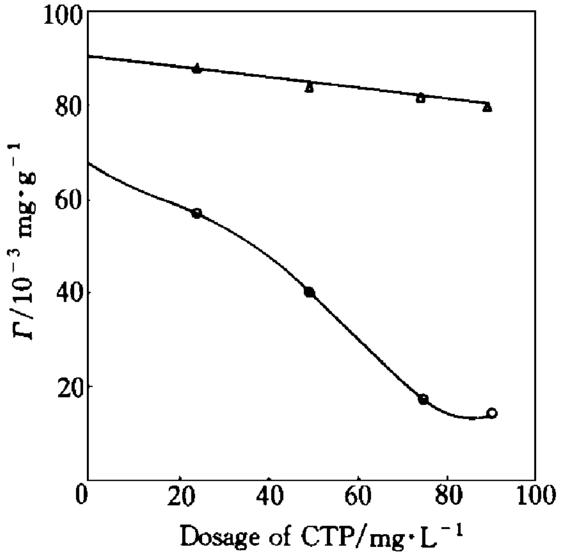

Fig. 7 Effect of CTP on adsorbate concentration of Bu-xanthate on mineral surface at pH 9.5
○—Pyrite; △—Chalcopyrite

sorbed on the pyrite surface by chemical adsorption in the form of anion, in addition, CTP can disadsorb the xanthate of pyrite surface. CTP has weak action with chalcopyrite surface.

A higher grade copper concentrate may be obtained without reducing the Cu recovery using CTP as the pyrite depressant. Due to the large decrease of dosage of lime, the new Cu-S separation process using CTP as pyrite depressant is advantageous to recover Au, Mo, S over the traditional lime case. A great economic profit can be gained from the new Cu-S separation process using CTP as pyrite depressant in low alkaline medium.

REFERENCES

1 Paugh R J. International Journal of Mineral Processing, 1989, (25): 101- 131.
2 Pattison I G and Woodcock J T. Australias Inst Min Metall, 1974, 250: 25.
3 Marabin A M, Barbaro M and Alesse V. Int J Miner Process, 1991, 33: 291- 306.
4 Iwasaki I and Lai R W. Trans AIME, 1965, 232: 364- 371.
5 Booth R B. US2211686. 1940.
6 Bakinov K G, Vaneev I I *et al*. In: Arbiter N ed, 7th Int Miner Process Congr. New York: 227- 238.
7 Bolin N J and Laskowski J S. Int J Miner Process, 1991, 33: 235- 241.
8 Liu Q and Laskowski J S. Int J Miner Process, 1989, 27: 147- 155.
9 Lin Qiang. Journal of Central South Institute of Mining and Metallurgy, (in Chinese), 1991, 22(3): 37.
10 Nagaraj D R *et al*. Trans IMM, 1986, 2: 17.
11 Qi Dingding. Mining and Metallurgical Engineering, (in Chinese), 1991, 11(3): 32.

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