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# ABOUT THE POSSIBILITY OF COPPER-BEARING ORE FLOTATION PROCESSING OF WITH THE USE OF A COMBINED FLOTATION REAGENT

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Preliminary Note – Prethodno priopćenje

The paper includes the results of laboratory studies for the copper-bearing ore flotation with the use of a combined reagent. The combined flotation reagent was preliminarily passed through a UZDN-A1200T ultrasonic disperser before flotation to obtain a reagent microemulsion. The copper content in the concentrate was 21,5 % with extraction of 83,3 % in a closed cycle in the base mode. It was 21,8 % with an extraction of 88,3 % when a combined flotation reagent was used. There is an increase in copper extraction by 5 %. The combined reagent consumption is reduced by 15 % compared to the main technology.

*Keywords:* copper ore, flotation, concentrate, extraction, X-ray analysis

## INTRODUCTION

It is possible to achieve an increase in the extraction of useful components into concentrate with the help of different beneficiation methods using various reagent modes [1-3]. If it take into consideration the fact that the flotation method is the main method to extract non-ferrous metals, the flotation beneficiation efficiency is defined by the improvement of the reagent regime and the methods intended to use flotation reagents. Practically, butyl xanthate is the only collecting agent used in the beneficiation plants of the Republic of Kazakhstan processing non-ferrous metal ores. Amyl xanthate is the most widely used xanthate in non-CIS countries. The reactivity and oxidizability of xanthates increase with the hydrocarbon radical growth. The flotation efficiency can be increased with the use of a combination of different collecting agents [4].

Flotation studies were performed with copper-zinc ore from the Gayskoye deposit using potassium butyl xanthate; sodium butyl dithiophosphate; a mixture of thionocarbamate and dithiophosphate; as well as mixtures of these collecting agents in different proportions. The highest selectivity criterion value was obtained with the use of a composition of thionocarbamate and dithiophosphate as a collecting reagent [5].

Technologically, the use of weak collecting agents reduces the flotation extraction of copper minerals intergrown with other ore minerals resulting in the loss of non-ferrous and precious metal sulfides with waste tailings. It is known that the flotation efficiency of sulfide ores increases when sulfhydryl collecting agents are used in a combination called a combination of strong and weak collecting agents [6-8]. Diisoalkyldithiophosphates are among the best known weak ionic sulfhydryl collecting agents with weak hydrophobizing activity with respect to iron sulfides and sphalerite not activated by copper cations [9].

The effect of the fraction of sulfhydryl ionic collecting agent of butyl xanthate or isobutyl dithiophosphate in combination with thionocarbamates; and the fraction of butyl xanthate in combination with M-TF sulfhydryl collecting agent (combination of thionocarbamate and dithiophosphate) on the flotation rate of non-ferrous metal minerals was studied in works [10, 11]. The highest flotation rate constant corresponds to the combination of M-TF with butyl xanthate in a ratio of 4:1 and 3:1, depending on the ore composition.

The authors of the article are experienced in the development and testing of the beneficiation flow diagrams using various modified reagents (foaming agents, collecting agents, depressing agents) and additional equipment intended to intensify the flotation processes. A modified foaming agent (FA) has been developed. It is used in the form of a microemulsion obtained with the help of a water-air microemulsion generator. The optimal composition of FA particles is selected with a PhotocorCompact particle size analyzer:the average particle size of microbubbles is 38 μm, the content (fraction) of these particles is 65,8 %. In this case, FA molecules become compact due to intramolecular interactions enabling them to fix on the surface of small particles of useful components and improve the combined microflotation. It enables to increase the technological

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parameters for the gold content and extraction into concentrate. The technologies intended to process technogenic raw materials have also been developed, and they enable to reduce the loss of useful components in tailings, reduce the cost of reagents, and reduce the flotation time [12, 13].

## MATERIALS AND METHODS

The following analytical equipment was used in the research:Optima 2000 DV (USA) atomic emission spectrometer; D8 ADVANCE X-ray diffractometer (XRD); Thermo Nicolet Avatar 370 FTIR Spectrometer; Venus 200 PANalyical B.V. (XRS) X-ray fluorescence spectrometer (Holland), JEOL JXA-8230 scanning electron microscope (Japan) (SEM). The following technological equipment was used:DMD160/100 jaw crusher (Kyrgyzstan); 40ML-000PS ball mill (Russia); FML flotation machines (Russia); UZDN-A1200T ultrasonic apparatus (Ukraine); PhotocorCompact particle size analyzer; "pulverisette O" vibrating micro-mill from "FRITISCH" (Germany). Copper-bearing ore of the Kazakhstani deposit and a combined reagent were used as the research objects. The combined flotation reagent is a combination of butyl xanthate, a non-ionogenic collecting agent, with the thioamide group of TS-100 thionocarbamate and higher Reafloat series aerofloat. The base ore was crushed with a laboratory jaw crusher to a size of -2,5 + 0 mm for the research purposes. Then it was ground in a laboratory ball mill up to 92 % grade - 0,074 mm. A set of wire sieves with square holes corresponding to a standard scale was used for sieving. Copper content and distribution were determined in each size class. Flotation studies were performed with laboratory flotation machines with chamber volumes of 3; 1,0; 0,5 liters. Tap water was used in all experiments. The experiments were performed in a closed cycle. The flotation flow diagram included grinding, main flotation, control and three cleaning operations. 8 weighed ore portions of 1 kg were used in the experiment.

The total consumption of the main reagents used is lime (medium regulator) - up to pH 8,0 – 9,0; sodium sulfide (sulfidizer) - 200 g/t; sodium butyl xanthate (collecting agent) - 180 g/t; liquid glass (depressor) - 300 g/t; T-92 (foaming agent) - 120 g/t.

The mixture of sodium butyl xanthate, TC-100 thionocarbamate and reafloat in a ratio of 1:1:1 was used as a combined flotation reagent. The preliminary combined flotation reagent was passed through a UZDN-A1200T ultrasonic disperser, then fed into the flotation machine chamber.

The mineral suspension was mixed with a combined reagent (3 min) and with a T-92 foaming agent (3 min) without air supply at a rotor speed of 1 500 rpm. Then atmospheric air (3,3 l/min) was supplied, and flotation treatment of the pulp was performed under the applied beneficiation flow diagram. Liquid glass was added to three recleaning operations to depress waste rock.

## RESULTS AND DISCUSSION

The studied copper-bearing ore sample contains 0,45 % copper; 0,07 % sulfur; 3,8 % iron; 3,8 % CaO; 15,4 % $Al_2O_3$; 69,2 % $SiO_2$; 5,5 % MgO; 0,4 % Ti under the chemical analysis results. An X-ray phase analysis of the ore sample was performed. The diaphragms of the samples were made with a D8 Advance apparatus (Bruker), α - Cu, the tube voltage is 40/40.

XRD phase analysis showed that the main rock-forming minerals in the ore are quartz – 71,48 %, kaolinite – 15,13 %, muscovite – 5,92 %, etc.

Copper is a valuable component in the base ore sample under the results of X-ray fluorescence analysis with the content of 0,462 %. The main mass is oxygen – 54,653 %, silicon – 23,114 %, aluminum – 13,149 %, iron – 2,083 %, potassium – 1,235 %.

Microscopic examination showed that copper minerals account for about one percent and are represented by chalcopyrite. There are rare inclusions of sphalerite. The sizes of ore minerals range from thousandths to 0,04 – 0,07 mm in cross section.

SEM of the base copper-bearing ore was performed with a JXA-8230 electron probe microanalyzer made by JEOL. Chalcopyrite is present in the form of free grains and inclusions in the nonmetallic mass. Its properties are usual. It has a characteristic brass-yellow color and high reflectivity. Its composition is as follows /%: Cu - 34-35; Fe - 30-31; S - 34-35 (Figure 1).

Dispersion analysis of the ore showed that most part of the copper 92 % ground with the – 0,074 mm class (55,47 %) is distributed into the - 20 + 0 micron classes. The - 20 + 10 micron class contains 29,35 % copper; there is 26,12 % copper in the – 10 micron class.

The reagent mode of copper-bearing ore flotation with the use of main and combined reagents has been developed. The copper flotation cycle consisted of main and control copper flotation and three copper concentrate re-cleanings. A combination of butyl xanthate, a non-ionogenic collecting agent with a thioamide group - TS-100 thionocarbamate and higher aerofloat (Reafloat series) was used as a combined flotation reagent.

Figure 2 shows the results of the particle size of the combined reagent emulsion when it was processed with the disperser.

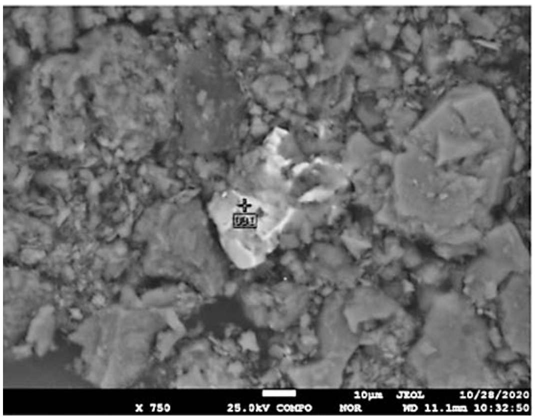


**Figure 1** Dispersions of chalcopyrite in quartz

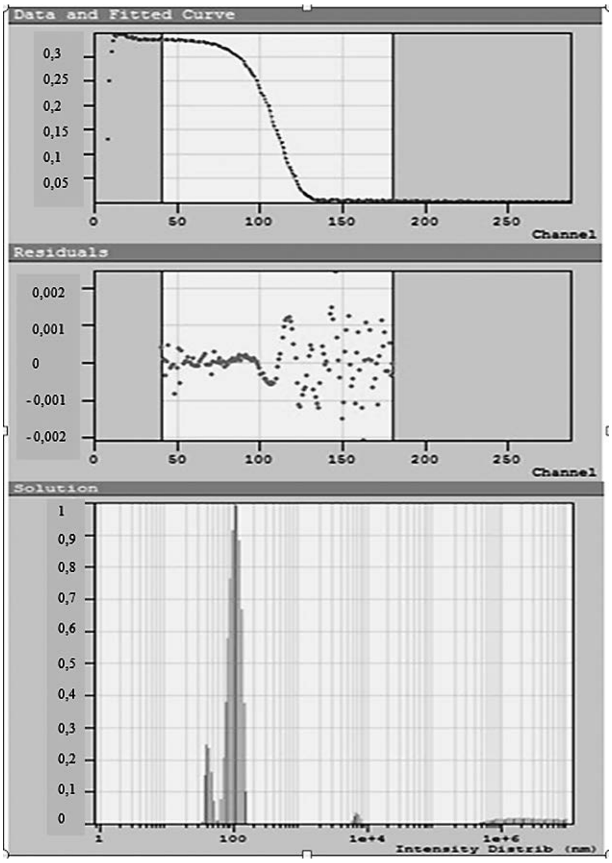


**Figure 2** Distribution of the emulsion particles of the combined reagent dispersed with the UZDN

The ratio of the combined reagent components was 1:1:1. The combined flotation reagent was preliminarily passed through a UZDN-A1200T ultrasonic disperser before flotation to obtain the reagent microemulsion.

The optimal dispersion time was determined to be 3 minutes. In this case, the number of the emulsion mixture particles sized 104 nm is 82,4 %, 41,6 nm – 10,4 %.

When a combination of collecting agents was used in flotation, the mechanism of their interaction with the mineral surface was determined by the mineral surface characteristics and the activity of each component of the collecting agent. A microemulsion is formed in addition to microbubbles during dispersion. When this microemulsion collides with slime particles of minerals it spreads and hydrophobizes their surface improving their flotation process. Microbubbles, in their turn, attach to such hydrophobized surfaces of slime particles much easier. The results of copper-bearing ore flotation using a combined reagent in a closed cycle as compared with the base mode are presented in Table 1.

Table 1 **Results of copper-bearing ore flotation with the use of a combined reagent in a closed cycle**

| Name of the sample | Yield/ % | Content Cu/ % | Extraction Cu/ % |
|---|---|---|---|
| Base Mode | | | |
| Cu concentrate | 1,6 | 21,5 | 83,3 |
| Tails | 98,4 | 0,07 | 16,7 |
| Base ore | 100,0 | 0,413 | 100,0 |
| With the use of a combined reagent | | | |
| Cu concentrate | 1,7 | 21,8 | 88,3 |
| Tails | 98,3 | 0,05 | 11,7 |
| Base ore | 100,0 | 0,42 | 100,0 |

A copper concentrate was obtained with 21,5 % copper content and with an extraction of 83,3 % in the base cycle. The combination of butyl xanthate, TS-100 thionocarbamate and reafloat enables to increase the copper extraction into copper concentrate from 83,3 to 88,3 % as compared with the base mode. The combined reagent consumption is reduced by 10-15 % as compared with the main technology. The use of non-ionogenic collecting agents and aerofloats in addition to xanthogenates enables to increase the copper extraction due to the more selective action and ability of aerofloats to effectively float slime particles of sulfide minerals.

## CONCLUSION

The material composition of the copper-bearing ore has been studied. Chalcopyrite is the main copper-bearing mineral. The ore contains 0,45 % copper according to the chemical analysis results. The main rock-forming minerals in the ore are quartz – 71,48 %, kaolinite – 15,13 %, muscovite – 5,92 %, etc. The mode of copper-bearing ore flotation has been developed with the use of main and combined reagents. A combination of butyl xanthate, TS-100 thionocarbamate and reafloat was used as a combined flotation reagent. The ratio of the combined reagent components was 1:1:1. A copper concentrate was obtained with a copper content of 21,5 % with extraction of 83,3 % in the optimal base mode (grinding 92 % with – 0,074 mm class, with the consumption of sodium butyl xanthate 120 g/t). The optimal consumption of the combined reagent is 100 g/t. In this case, a copper concentrate was obtained with a copper content of 21,8 % with an extraction of 88,3 %. It is shown that the combination of butyl xanthate, TS-100 thionocarbamate and reafloat enables to increase the extraction of copper into the concentrate by 5 % in comparison with the base regime. The consumption of the combined reagent is reduced by 15 % as compared to the main technology.

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**Note:** The responsible for English language is Kurash A.A., Almaty, Kazakhstan