engineering proceedings

MDPI

Proceeding Paper

Flocculation of Sulfide Minerals with a Mixture of Potassium Xanthate Butyl and Water-Soluble Polymer †

Dilmurod Makhmarezhabov [1,*], Sokhibjon Matkarimov [1,2], Dilfuza Yavkochiva [1] and Nasiba Yuldasheva [1]

[1] Mining Department, Tashkent State Technical University, #2, University Street, Almazar District, Tashkent 100095, Uzbekistan; sohibtm@gmail.com (S.M.); yavkochiva@tdtu.uz (D.Y.); yuldashevanasiba292@gmail.com (N.Y.)
[2] Uzbek-Japan Innovation Center of Youth, #2b, University Street, Almazar District, Tashkent 100095, Uzbekistan
* Correspondence: dmahmarejabov@mail.ru
† Presented at the 7th Mechanical Engineering, Science and Technology International Conference, Surakarta, Indonesia, 21–22 December 2023.

Abstract: The main task facing modern enrichment scientists is to maintain the quality of final concentrates (FCC) at the proper level. One of the main methods is the use of local reagents during flotation enrichment, the cost of which is many times lower than that of imported reagents. Research on the use of polymers as collecting reagents in the flotation process is the main topic of these studies and of this article.

Keywords: flocculation; sulfide minerals; xanthate; regulator; flotation; polymer; collector

check for updates

Citation: Makhmarezhabov, D.; Matkarimov, S.; Yavkochiva, D.; Yuldasheva, N. Flocculation of Sulfide Minerals with a Mixture of Potassium Xanthate Butyl and Water-Soluble Polymer. *Eng. Proc.* **2024**, *63*, 27. https://doi.org/10.3390/engproc2024063027

Academic Editors: Waluyo Adi Siswanto, Sarjito, Supriyono, Agus Dwi Anggono, Tri Widodo Besar Riyadi and Taurista Perdana Syawitri

Published: 14 March 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Flocculation is understood as the aggregation of mineral particles and the formation of larger aggregates from them under the influence of flocculants. The formation of flocs is known to reduce collector consumption during flotation. The introduction of some water-soluble polymers (regulators) into the flotation process enhances the flocculation of mineral particles.

Aerofloc flotation takes up less space in the collector compared to single-grain flotation, as indicated by the flotation field. A large number of heteropolar surfactant ions are transported by corresponding associates, known as "collector-water molecules—polymer", which are carriers of the abovementioned heteropolar surfactant ions. The association is likely to be reduced to the point of adsorption because the collector molecules interact with the mineral surface cations in a more energy-rich manner than their hydrogen bonding in the association upon adsorption.

Flotation is used as one of the methods for beneficiating minerals based on the difference in the physicochemical properties of the surface of minerals and their ability to be wetted by water. Some minerals in a finely ground state in an aqueous environment under the influence of flotation reagents are not wetted by water, stick to air bubbles, float to the surface of the pulp and are separated from other minerals, the surfaces of which are wetted by water and do not stick to the bubbles. Flotation is carried out using various reagents—chemical substances that act selectively on mineral surfaces, increasing or decreasing their hydrophilic and hydrophobic properties. In ore flotation, one of the areas of practical use of theoretical principles is associated with the influence of various factors on flotation reagents in solution to increase their efficiency. Increasing the dispersion of solutions of sulfhydryl and oxyhydryl collectors, the use of surfactant additives, and various environmental regulators, in some cases allow one to achieve a certain technological effect. Recently, justification has been found for the joint use of dissimilar organic reagents during flotation: preliminary saponification of fatty acids in the presence of surfactants and the order of supply of reagents to the pulp [1–9].

2. Methodology

In the flotation of naturally hydrophobic minerals, the combined use of collectors consisting of diphilic and apolar molecules (for example, oleic acid and kerosene) is common. Recently, this combination has begun to be used in the flotation of sulfide minerals [1,10].

The phenomenon of the flocculation of minerals by water-soluble polymers has been studied by several researchers [11–16]. Most of them believe that the effect of organic flocculants is associated with the following phenomena:

(a) the formation of "bridges" between mineral particles due to the hydrogen bond of polymer molecules with the surface;
(b) electrostatic interaction between the charges of the ionized polymer and the particle;
(c) in some cases, with a reaction between the functional groups of polymers and metal ions on the surface of the mineral.

To study sulfide flocculation, we used two methods. For thin classes (−44 μm), continuous weight determination was performed. The amount of sediment that fell over a given period [3] and flocculation of larger classes (+74 μm) was studied using the Vaxiundsky-Derner device [5] as well as the Slater method [17].

The flocculation of lead and zinc sulfides in water, in solutions of surfactants, polymers, and their mixtures, can be judged from the data in Figures 1 and 2. The experiments were carried out at concentrations of reagents that ensured maximum flocculation. It can be seen from the figures that galena flocculates much better when using a collector-regulator mixture.

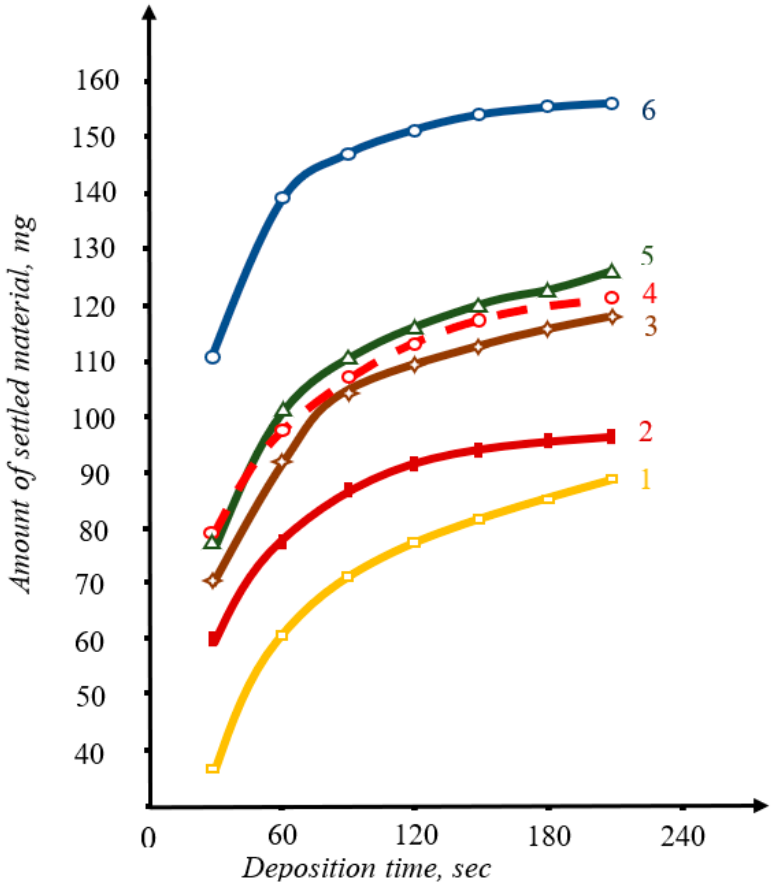

Figure 1. Comparative data on galena flocculation in water and solutions of regulators. 1—mineral in water; 2—in xanthate solution, C = 1 mg/L; 3—in a solution of an organic polymer, C = 1 mg/L; 4—in a solution of inorganic polymer, C = 1 mg/L; 5—in a mixture of xanthate—organic polymer; 6—in a mixture of xanthate—inorganic polymer.

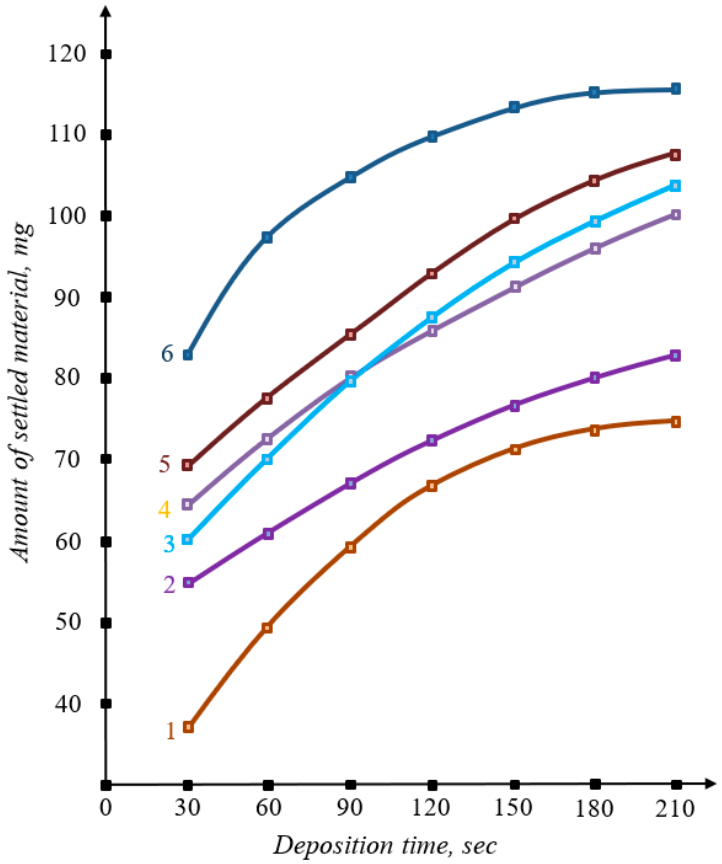

Figure 2. Comparative data on sphalerite flocculation in water solutions of xanthate and regulators. 1—mineral in water; 2—in xanthate solution, C = 1 mg/L; 3—in a solution of an organic polymer, C = 1 mg/L; 4—in a solution of inorganic polymer C = 20 mg/L; 5—in a mixture of xanthate—organic polymer 1:1; 6—in a 1:1 mixture of xanthate and inorganic polymer.

3. Results and Discussion

The flocculating ability of regulators of quartz is minimal; its flocculation does not improve, and in solution, the collector is a regulator. This indicates that the proposed reagent mixtures are selective and should not violate the selection regime during flotation.

Galena was previously floated using various types of flocculants by other researchers. Aerofloc 550, Separan NP-10, Hercules SMS, KD-40, KMC OS-1, etc., were used as flocculants, which led to a decrease in the extraction of minerals and sometimes to the cessation of flotation altogether. In the experiments described, minerals were treated first with a regulator and then with a collector. We have experimentally proven that polymers attached to a mineral surface impair the collector's adsorption.

A mineral treated with a collector-regulator mixture behaves differently. Galena extraction increases by 5–10%. In general, flocculants can completely prevent the adsorption of collectors if the surface of the mineral is covered by them by almost 90%. This phenomenon occurs at high polymer concentrations. When using reagent mixtures, sufficient space is freed up on the surface for the collector, and air bubbles are fixed only in areas covered by the collector.

The reagent regulator, thanks to a unique bridging mechanism of fixation, binds mineral grains, and the flotation of aeroflocs requires less collector than the flotation of individual grains.

Sphalerite, like galena, intensively flocculates in the collector-regulator mixture and improves, and the consumption of the collector decreases (Figure 3).

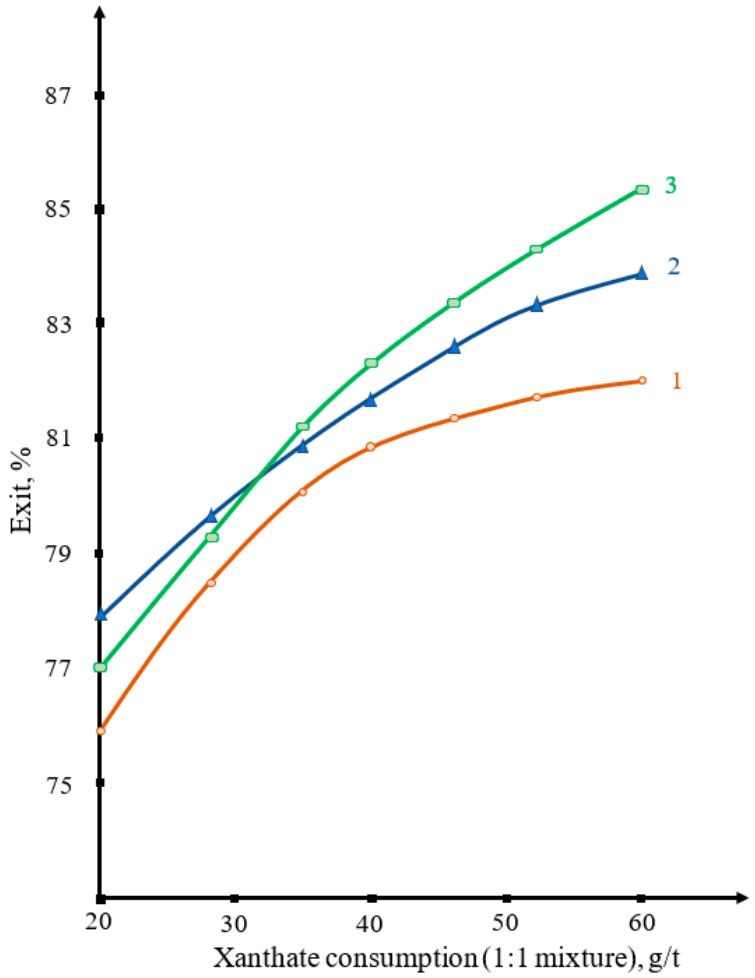

Figure 3. Flotation of sphalerite xanthates and their mixture with regulators. 1—xanthate; 2—xanthate—organic polymer 1:1; 3—xanthate—inorganic polymer 1:1.

Increased flocculation of minerals suggests that the use of the proposed reagent mixtures will help improve technological performance during ore flotation.

4. Conclusions

A mixture of water-soluble polymer and surfactant is an effective flocculant of natural lead and zinc sulfides. The use of a collector-regulator mixture will make it possible to significantly reduce the consumption of the collector and improve flotation performance.

Adding polymers and collectors can lead to increased flotation efficiency by increasing collector efficiency through the use of polymers and their combined use.

Author Contributions: Conceptualization D.M.; draft writing, paper framework concept, revision of the paper, conduct the study and results analysis, S.M.; supervised the conducted study and checked the study results, D.Y. and N.Y. supervised the conducted study and checked the study results. All authors have read and agreed to the published version of the manuscript.

Funding: We are grateful to Tashkent State Technical University for financing this research under Grant number AL-592102410 and MIRAI Fund of Japan for UJICY (No. APPL-02-2022).

Institutional Review Board Statement: This research results in this article were carried out in the "Mining and deep processing of mineral resources laboratory" Uzbek-Japan Innovation Center of Youth.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created. All data were presented in the manuscript.

Acknowledgments: The authors acknowledge the support of the Agency of Innovative Development under the Ministry of Higher Education, Science and Innovation, a joint scientific-technical project (No. AL-592102410) and research project to be conducted under the MIRAI Fund of Japan for UJICY (No. APPL-02-2022).

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Aminzhanova, S.I.; Mishareva, M.E. Research on the technology of using water-soluble polyelectrolytes as flotation reagents. *Sci. Prog.* **2022**, *3*, 369–377.
2. Mishareva, M.E. Study of the use of water-soluble polymers in flotation beneficiation of ores. *Sci. Prog.* **2021**, *2*, 879–887.
3. Menkovsky, M.A. On a method for studying the kinetics of sedimentation of coarse sludge. *Min. J.* **1966**, *2*, 73.
4. Abramov, A. Innovative technologies for environmental protection during processing and enrichment of minerals. *Subsoil Use XXI Century* **2009**, *6*, 61–67.
5. Berger, G.S.; Lerner, V.N. A new device for determining the flocculation of mineral grains in aqueous suspensions. In *Colloquium on the Theory of Flotation*; Alma-Ata, "Science": Moscow, Russia, 1970; pp. 254–256.
6. Bragin, V.I. *Development of Physical and Chemical Methods for Preparing Mineral Raw Materials for Enrichment: Dis*; Siberian Federal University: Krasnoyarsk, Russia, 2014.
7. Wright James, T.; White Karl, R.; Gabrielson, K.; Hines John, B.; Arthur Lisa, M.; Kausin Michael, J.; Georgia-Pacific Chemicals, L.C. Modified Amino Aldehyde Resins and Their Application in Separation Processes. Russia Patent RU2432998C2, 10 November 2011.
8. Komogortsev, B.V.; Varenichev, A.A. Improving technologies for flotation enrichment of finely dispersed sulfide gold ores. *Min. Inf. Anal. Bull. (Sci. Tech. J.)* **2018**, *10*, 180–190.
9. Chanturia, V.A. New reagents for the extraction of noble metals from difficult-to-process ores and products. *Phys.-Tech. Probl. Miner. Dev.* **2010**, *1*, 78.
10. Pearse, M.J. An overview of the use of chemical reagents in mineral processing. *Miner. Eng.* **2005**, *18*, 139–149. [CrossRef]
11. Berdiyarov, B.T. Technological processes of receiving metals in the conditions of moderate temperatures. *Int. J. Innov. Technol. Explor. Eng.* **2019**, *8*, 1826–1828. [CrossRef]
12. Kholikulov, D.B. Pilot tests of processing technologies of process solutions of copper production by ozonation. *Mater. Today Proc.* **2021**, *45*, 4987–4992. [CrossRef]
13. Somasundaran, P.; Nagaraj, D.R. Chemistry and applications of chelating agents in flotation and flocculation. *Reag. Miner. Ind.* **1984**, *96*, 209–219.
14. Bulatovic, S.M. *Handbook of Flotation Reagents: Chemistry, Theory and Practice: Volume 1: Flotation of Sulfide Ores*; Elsevier: Amsterdam, The Netherlands, 2007.
15. Pugh, R.J. Macromolecular organic depressants in sulfide flotation-a review, 1. Principles, types and applications. *Int. J. Miner. Process.* **1989**, *25*, 101–130. [CrossRef]
16. Umarova, I.K.; Matkarimov, S.T.; Makhmarezhabov, D.B. Development of flotation technology for gold-bearing ores of the Amantaytau deposit. *Obogashchenie Rud* **2020**, *2*, 29–33. [CrossRef]
17. Uzoni, L.; Rinelli, G. Selective properties of flocculants and the possibilities of their use in the flotation of fine ores. In Proceedings of the VII International Congress on Mineral Processing, Moscow, Russia, 20–24 September 1968; p. 72.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.