

This is an open-access article under the [CC BY-NC-ND](#) license

Issue VII, November 2024

e-ISSN 2707-9481

ISBN 978-601-80473-3-6

Institute of Metallurgy and Ore Beneficiation JSC, Satbayev University, Almaty, Kazakhstan

<https://doi.org/10.31643/2024.08>

Dulatbek Turysbekov

Satbayev University, Institute of Metallurgy and Ore Beneficiation ZhSS, Almaty, Kazakhstan.

E-mail: d.turysbekov@satbayev.university

ORCID ID: <https://orcid.org/0000-0003-0904-1565>

Nessipbay Tussupbayev

Satbayev University, Institute of Metallurgy and Ore Beneficiation ZhSS, Almaty, Kazakhstan.

E-mail: n.tussupbayev@satbayev.university

ORCID ID: <https://orcid.org/0000-0002-6110-0772>

Larissa Semushkina

Satbayev University, Institute of Metallurgy and Ore Beneficiation ZhSS, Almaty, Kazakhstan.

E-mail: l.semushkina@satbayev.university

ORCID ID: <https://orcid.org/0000-0001-8925-5250>

Sabira Narbekova

Satbayev University, Institute of Metallurgy and Ore Beneficiation ZhSS, Almaty, Kazakhstan.

E-mail: s.narbekova@satbayev.university

ORCID ID: <https://orcid.org/0000-0002-7325-754X>

Zhamihan Kaldybayeva

Satbayev University, Institute of Metallurgy and Ore Beneficiation ZhSS, Almaty, Kazakhstan.

E-mail: zh.kaldybaeva@satbayev.university

ORCID ID: <https://orcid.org/0000-0001-5763-9655>

Munira Musina

Satbayev University, Institute of Metallurgy and Ore Beneficiation ZhSS, Almaty, Kazakhstan.

E-mail: m.musina@satbayev.university

ORCID ID: <https://orcid.org/0000-0002-5304-6702>

On the possibility of processing technogenic flotation raw materials of Kazakhstani deposits with the use of a modified collector

Abstract: The purpose of work - flotation processing of copper-lead-zinc tailings using a modified collector - a mixture of modified butyl xanthate and aeroflot in combination with N-allyl-o-isobutylthionocarbamate. According to the results of X-ray fluorescence analysis in the initial sample of flotation enrichment tailings, the content of lead was 0.048%, copper - 0.03%, zinc - 1.501%, iron - 2.863%. The main part of tailings is represented by rock-forming minerals: quartz, calcite, talc, chrysotile, albite, clinocllore, muscovite, dolomite, and pyrite. The optimal basic reagent scheme of tailings flotation was selected: degree of regrind 78% of -0.040 mm class, sodium butyl xanthate consumption 150 g/t, T-92 frother consumption 80 g/t. Under the selected regime, a collective copper-lead-zinc concentrate was obtained containing 2.0% copper at 67.11% recovery; 1.6% lead at 62.02% recovery; 3.2% zinc at 62.02% recovery; 7.0% iron at 41.67% recovery; 4.1 g/t gold at 54.45% recovery. The reagent scheme of flotation of copper-lead-zinc tailings with the application of a modified collector was tested. Its application allows for increased recovery in the collective copper-lead-zinc concentrate: copper - by 9.63%, lead - by 8.41%, zinc - by 9.2%, iron - by 2.73%, gold - by 3.57%. At the same time the consumption of modified collector, compared to butyl xanthate, is reduced by 33%, and the consumption of basic foaming agent T-92 is reduced by 25%.

Keywords: anthropogenic waste, flotation, modified collector, concentrate.

Introduction

Search and development of new more selective reagent-assemblers to improve the flotation process is one of the priority tasks in the creation of innovative technologies for the flotation separation of substances and minerals. Involvement in the processing of large volumes of hard-to-enrich raw materials requires the use of new technological methods and reagent regimes (Wang et al., 2022; Hornn et al., 2021; Wang & Liu, 2021). Uneven dissemination, fine intergrowth of ore minerals among themselves and with rock minerals, unfavorable ratio of separated minerals considerably complicate obtaining high technological parameters of enrichment (Ignatkina & Bocharov, 2010; Kenzhaliyev, 2019; Semushkina & Narbekova, 2021). The analysis of existing enrichment schemes shows that a significant part of metals in tailings (raw materials of complex composition with low metal content) cannot be effectively extracted using the methods used for primary raw materials. In general, ore dressing tailings are represented by finely groundmass, with the lack of a clear structure, heterogeneity of material composition, mutual

X-ray fluorescence analysis of tailings was performed on a Venus 200 PANalytical B.V. (PANalytical B.V., Holland) X-ray fluorescence spectrometer with wave dispersion. The results of the analysis are presented in Table 2.

Table 2. Results of X-ray fluorescence analysis of flotation enrichment tailings

Analyte	Calibration status	Compound formula	Concentration	Unit	Calculation method	Status
O	Calibrated	O	51.548	%	Calculate	BgC; DC
Na	Calibrated	Na	0.163	%	Calculate	BgC; DC; LoR
Mg	Calibrated	Mg	3.343	%	Calculate	BgC; DC
Al	Calibrated	Al	4.104	%	Calculate	BgC; DC
Si	Calibrated	Si	26.859	%	Calculate	BgC; DC
P	Calibrated	P	0.035	%	Calculate	BgC; DC
S	Calibrated	S	1.192	%	Calculate	BgC; DC
Cl	Calibrated	Cl	0.008	%	Calculate	BgC; DC
K	Calibrated	K	0.958	%	Calculate	BgC; DC
Ca	Calibrated	Ca	1.933	%	Calculate	BgC; DC
Ti	Calibrated	Ti	0.170	%	Calculate	BgC; DC
V	Calibrated	V	0.010	%	Calculate	BgC; DC; LoR
Cr	Calibrated	Cr	0.027	%	Calculate	BgC; DC
Mn	Calibrated	Mn	0.122	%	Calculate	BgC; DC
Fe	Calibrated	Fe	2.863	%	Calculate	BgC; DC; LoR
Ni	Calibrated	Ni	0.010	%	Calculate	BgC; DC
Cu	Calibrated	Cu	0.030	%	Calculate	BgC; DC
Zn	Calibrated	Zn	1.501	%	Calculate	BgC; DC
Rb	Calibrated	Rb	0.004	%	Calculate	BgC; DC
Sr	Calibrated	Sr	0.007	%	Calculate	BgC; DC
Zr	Calibrated	Zr	0.005	%	Calculate	BgC; DC
Ba	Calibrated	Ba	0.194	%	Calculate	BgC; DC
Pb	Calibrated	Pb	0.048	%	Calculate	BgC; DC

According to the results of X-ray fluorescence analysis in the initial sample of tailings of flotation enrichment, the content of lead was 0.048 %, copper - 0.03 %, zinc - 1.501 %, iron - 2.863 %. Chemical analysis showed that the sample of the studied tailings contained 0.05 % copper; 0.06 % lead; 1.1 % zinc; 52.3 % SiO₂; 2.3 % total iron; 8.1 % Al₂O₃; 2.5 % CaO; 8.7 % MgO.

Samples of investigated tailings were analyzed on electron-probe microanalyzer JXA-8230 of JEOL company. The results of the microanalysis are shown in Figures 2-5.

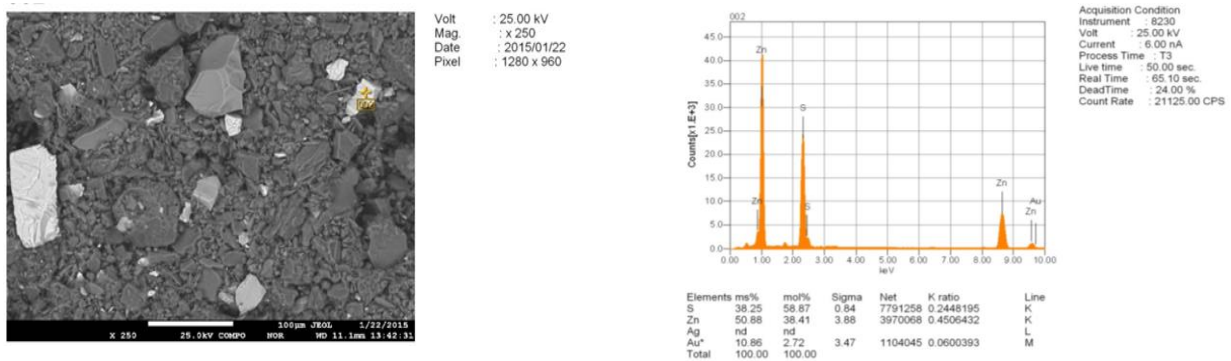


Fig. 2. Analysis of initial tailings of flotation enrichment on electron-probe microanalyzer JXA-8230 by JEOL (zinc minerals)

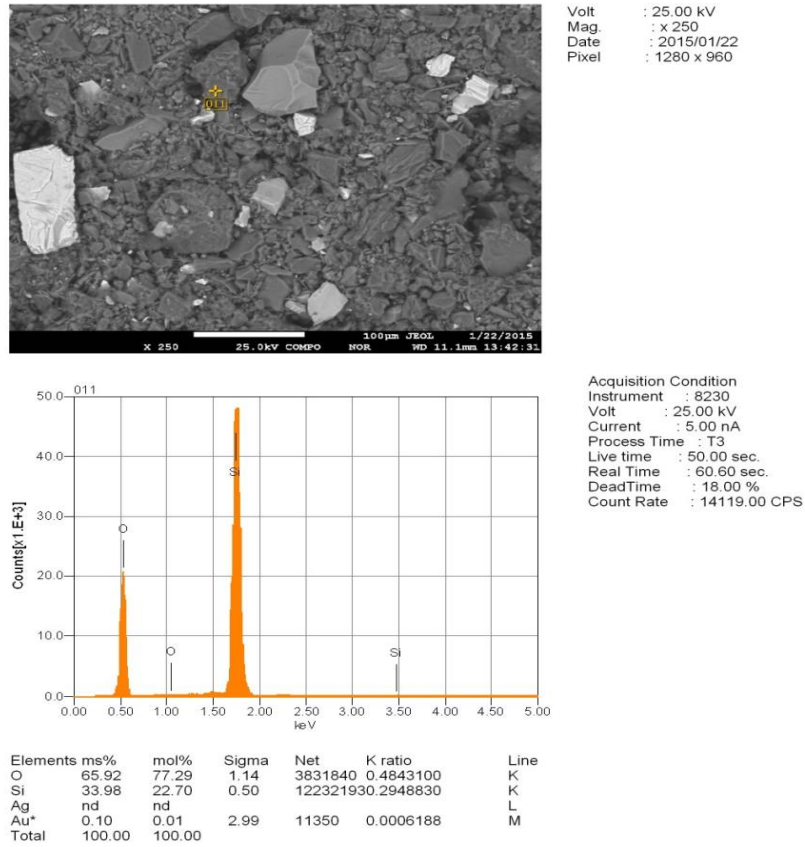


Fig. 3. Analysis of initial tailings of flotation enrichment on electron-probe microanalyzer JXA-8230 by JEOL (silica)

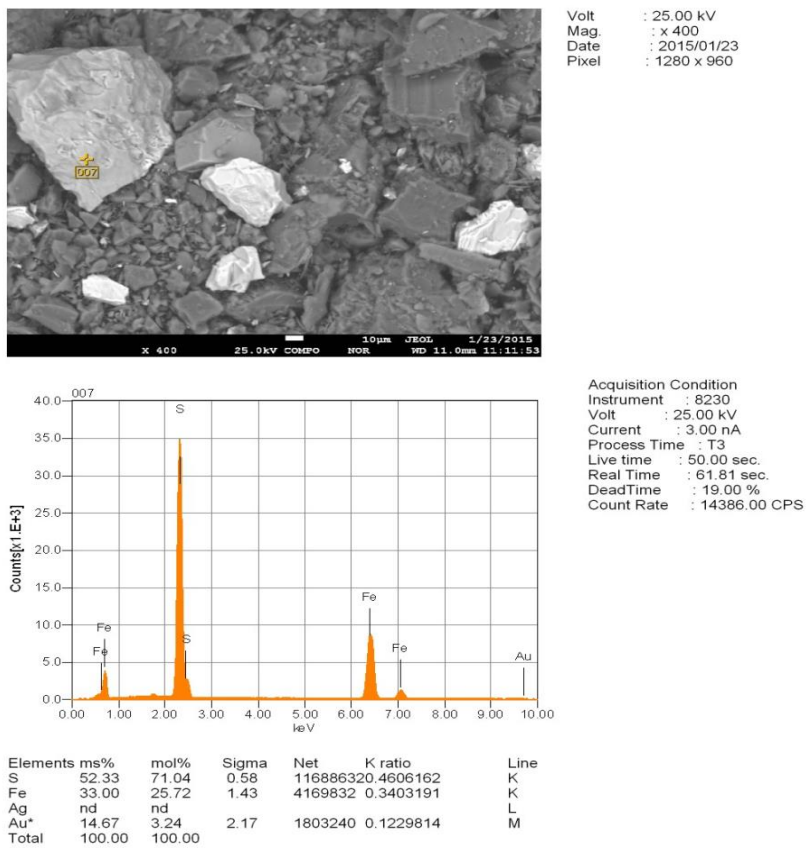


Fig. 4. Analysis of initial tailings of flotation enrichment on electron-probe microanalyzer JXA-8230 by JEOL (pyrite)

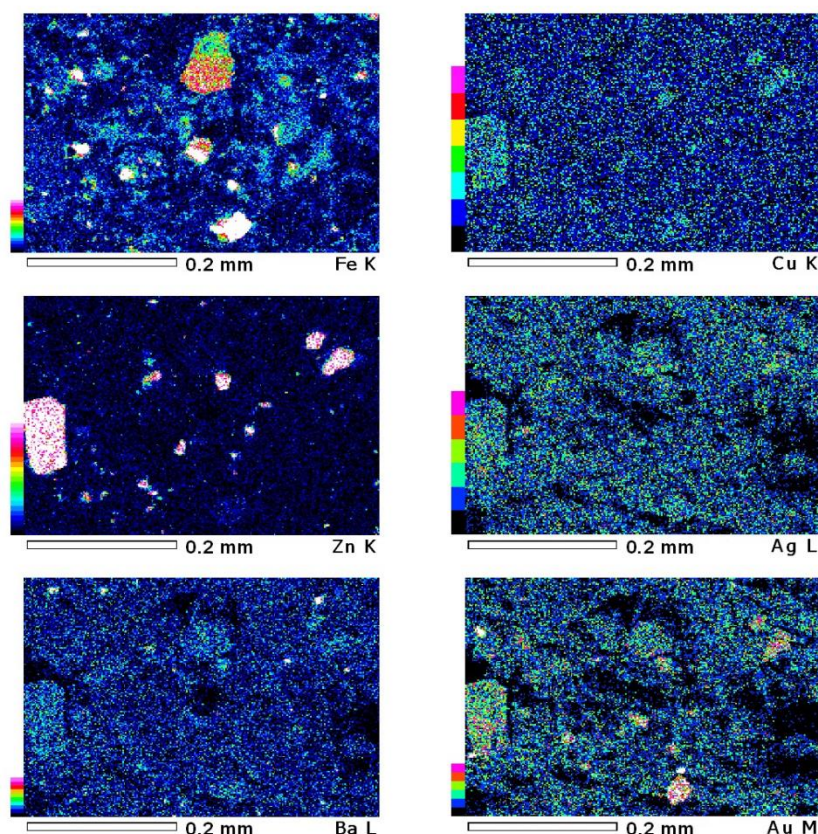


Fig. 5. Distribution of Fe, Cu, Zn, Ag and Au in a sample of flotation tailings sample

To determine the particle size distribution of the initial sample of flotation enrichment tailings, the analysis of variance was carried out, which showed that most of the useful components - copper, lead and zinc are concentrated in the fraction 0-10 microns. The reagent mode of enrichment tailings flotation with the use of basic reagents was tested. The optimum grinding mode, and costs of basic reagents - butyl xanthate and frother - were selected. The scheme of tailings flotation included tailings regrinding, main, control flotation and four recleanings of the collective copper-lead-zinc concentrate. The initial size of flotation tailings by class -0.040 mm was 71.6 %. It follows from the results of studies that additional grinding of flotation tailings up to 78 % of -0.040 mm class allows to increase the degree of extraction of copper, lead, zinc, iron and gold in the froth product by 10-15 %.

The results of studies have shown that the optimal consumption of basic reagents - collector is the consumption of 150 g/t, foaming agent T-92 80 g/t. The use of a modified collector in the flotation cycle of tailings allows to reduce the consumption of frother T-92 by 25 % and increases the recovery of copper, lead, zinc and gold in the collective concentrate. Table 3 shows the results of tailings processing with the modified collector in comparison with the basic mode.

Table 3. Table 3 shows the results of tailings processing with the modified collector in comparison with the basic mode

Name of Products	Yield, %	Content, %, g/t				Recovery, %				Note
		Cu	Pb	Zn	Au	Cu	Pb	Zn	Au	
Collective concentrate	2.0	2.0	1.6	3.2	4.1	67.1	62.0	62.0	54.45	Basic technology
Dump tailings	98.0	0.02	0.02	0.04	0.07	32.9	38.0	38.0	45.55	BKx-150 g/t T-92-80 g/t
Initial tails	100.0	0.060	0.052	0.103	0.151	100.0	100.0	100.0	100.0	
Collective concentrate	2.2	2.2	1.8	3.3	4.3	76.7	70.4	71.2	58.02	Modif. collector
Dump tailings	97.8	0.015	0.017	0.03	0.07	23.3	29.6	28.8	41.98	100 g/t T-92-60 g/t
Initial tails	100.0	0.063	0.056	0.102	0.163	100.0	100.0	100.0	100.0	

The basic technology produced a collective copper-lead-zinc concentrate containing 2.0 % copper at 67.11 % recovery; 1.6 % lead at 62.02 % recovery; 3.2 % zinc at 62.02 % recovery; 7.0 % iron at 41.67 % recovery; and 4.1 g/t gold at 54.45 % recovery.

Flotation using a modified collector produced a collective copper-lead-zinc concentrate containing 2.2 % copper at 76.74 % recovery; 1.8 % lead at 70.43 % recovery; 3.3 % zinc at 71.22 % recovery; 7.1 % iron at 44.4 % recovery; and 4.3 g/t gold at 58.02 % recovery.

Conclusions

The paper presents the results of laboratory studies on flotation processing of copper-lead-zinc tailings using a modified collector. The modified collector is a mixture of modified butyl xanthate and aeroflot in combination with N-allyl-o-isobutylthionocarbamate. Application of the modified collector allows increasing the extraction of useful components in the collective copper-lead-zinc concentrate obtained from the tailings: copper - by 9.63 %, lead - by 8.41 %, zinc - by 9.2 %, iron - by 2.73 %, gold - by 3.57 %. At the same time the consumption of modified collector, in comparison with butyl xanthate, is reduced by 33 % (from 150 to 100 g/t), the consumption of basic frother T-92 is reduced by 25 % (from 80 to 60 g/t).

CRedit author statement: **D.Turysbekov:** Conceptualization; **L.Semushkina:** Methodology, Software, Editing; **Zh.Kaldybayeva:** Data curation, Visualization, Investigation; **N.Tussupbayev:** Supervision, Validation; **S.Narbekova:** Writing draft preparation; **M.Musina:** Reviewing.

Acknowledgement. The work was executed at the Institute of Metallurgy and enrichment in Almaty, the Republic of Kazakhstan with the financial support of the Committee of Science of the Ministry of Education and Science of the Republic of Kazakhstan under grant No AP23487524.

Cite this article: Turysbekov, D., Semushkina, L., Kaldybayeva, Zh., Tussupbayev, N., Narbekova, S., Musina, M. (2024). On the possibility of processing technogenic flotation raw materials of Kazakhstani deposits with the use of a modified collector. *Challenges of Science*. Issue VII, pp. 57-64. <https://doi.org/10.31643/2024.08>

References

- Bocharov, V.A., Ignatkina, V.A., Puntsukova, B.T. (2010). Investigation of the use of ionogenic and non-ionogenic collectors to increase the selectivity of sulfide ore flotation. *Mining information-analytical bulletin*, No.1, P.234-240.
- Bulaev, A.G., Melamud, V.S. (2015). Extraction of non-ferrous metals from flotation tailings of polymetallic ore. *Proceedings of the Inter. meeting "Modern processes of complex and deep processing of hard-to-enrich mineral raw materials", Plaksin readings*, pp. 425-428.
- Horn, V., Park, I., Ito, M., Shimada, H., Suto, T., Tabelin, C. B., Jeon, S. Hiroyoshi, N. (2021). Agglomeration-flotation of finely ground chalcopyrite using surfactant-stabilized oil emulsions: Effects of co-existing minerals and ions. *Minerals Engineering*, Vol. 171, 107076. <https://doi.org/10.1016/j.mineng.2021.107076>
- Ignatkina, V.A., Bocharov, V.A. (2010). Schemes of flotation of nonferrous metal sulfides based on the use of a combination of selective collectors. *Mining journal*, No.12, P.58-64.
- Ignatkina, V.A., Abrytin, D.V., Kayumov, A.A., Kayumova, V.R. (2022). Effect of sulfoxide-based modifiers on sulfide mineral floatability and on production data of ore flotation. *Mining Informational and Analytical Bulletin*, Vol.12, pp.20-33. https://doi.org/10.25018/0236_1493_2022_12_0_20
- Ignatkina, V.A., Bocharov, V.A., Puntsukova, B.T., Alekseychuk, D.A. (2010). Studies of selectivity of the action of the combination of xanthogenate and dithiophosphate with thionocarbamate. *Physico-technical problems of mineral development*, No.3, P.105-115.
- Ignatkina, V.A. (2011). Selection of selective collectors in flotation of minerals with close flotation properties. *Izvestiya Vuzov. Non-ferrous metallurgy*, No. 1, P.1-7.
- Ignatkina, V.A. (2016). Selective reagent regimes of flotation of non-ferrous and noble metal sulfides from refractory sulfide ores. *Tsvetnye Metally*, Vol.11, pp.27-33. <https://doi.org/10.17580/tsm.2016.11.03>
- Kondratyev, S.A., Rostovtsev, V.I., Bochkarev, G.R., Pushkareva, G.I., Kovalenko, K.A. (2014). Scientific substantiation and development of innovative technologies of complex processing of hard-to-enrich ores and technogenic raw materials. *Physico-technical problems of mineral resources development*, No. 5, P.187-202.
- Kenzhaliyev, B. (2019). Innovative technologies providing enhancement of non-ferrous, precious, rare and rare earth metals extraction. *Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources*, 310(3), 64–75. <https://doi.org/10.31643/2019/6445.30>

- Ryaboy, V.I. (2011). Problems of use and development of new flotation agents in Russia. *Non-Ferrous Metals*, No.3, P.7-14.
- Semushkina, L.V., Narbekova, S.M. (2021). On the possibility of flotation processing of technogenic gold-containing waste from enrichment plants. *Challenges of Science*. Issue IV, 2021, pp. 40-47. <https://doi.org/10.31643/2021.06>
- Semushkina, L.V., Tussupbayev, N.K., Turysbekov, D.K., Narbekova, S.M., Kaldybayeva, Zh.A. (2023). Flotation processing of copper-containing technogenic raw materials using a composite flotation reagent. *Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources*, Vol.1, Issue 324, pp.34-42. <https://doi.org/10.31643/2023/6445.05>
- Semushkina, L.V., Abdykairova, G.Zh., Turysbekov, D.K., Narbekova, S.M., Kaldybayeva, Zh.A. (2021). On the possibility to process copper-molybdenum ore using a combined flotation reagent. *Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources*, Vol.4, Issue 319, pp.57-64. <https://doi.org/10.31643/2021/6445.41>
- Turysbekov, D.K., Tussupbayev, N.K., Semushkina, L.V., Narbekova, S.M., Mukhamedilova, A. (2022) Determination of factors effecting the properties of water-air micro dispersion. *Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources*, Vol.3, Issue 322, pp.5-13. <https://doi.org/10.31643/2022/6445.23>
- Wang, C., Deng, J., Tao, L., Sun, W., Xiao, Q., Gao, Z. (2022). Enhanced flotation of chalcopyrite particles by grinding with short cylinder media. *Minerals Engineering*, Vol. 188, 107827. <https://doi.org/10.1016/j.mineng.2022.107827>
- Wang, D., Liu, Q. (2021). Hydrodynamics of froth flotation and its effects on fine and ultrafine mineral particle flotation: A literature review. *Minerals Engineering*, Vol. 173, 107220. <https://doi.org/10.1016/j.mineng.2021.107220>
- Zharolla, N.D., Yergeshev, A.R., Ignatkina, V.A. (2020). Estimation of selectivity of sulfhydryl collectors on a dithiophosphate basis. *Mining Informational and Analytical Bulletin*, Vol.11, pp.14-26. <https://doi.org/10.25018/0236-1493-2020-11-0-14-26>