BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg

USE OF MODERN REAGENTS FOR THE SELECTIVE FLOTATION OF POLYMETALLIC ORES

Xasanov Abdurashid Soliyevich
PhD. Professor
Mamaisoqova Zebo Bahodir qizi
Basic doctoral student of the Almalyk branch of "MISiS"
Tayraliyev Sherzod Tayrali ugli
Olmaliq Mining and Metallurgical Combine "JSC" Mine geologist at the Kovuldi mine

Abstract. Selective flotation of polymetallic ores stays one of those, technically demanding things in mineral processing engineering that people still talk about because it really isn't simple. In this article we look at how newer flotation reagents, for example collectors along with frothers depressants and activators, help get high selectivity between sulfide minerals when the ore is complex and messy. What we see in the results basically confirms that the way reagents are combined, and also pH-controlled conditioning, end up being decisive for separation efficiency not just "helpful".

Keywords: flotation, polymetallic ores, selective flotation, collectors, depressants, frothers, sulfide minerals, reagent regime, surface chemistry

Аннотация. Селективная флотация полиметаллических руд остаётся одним из наиболее технически сложных процессов в инженерии обогащения полезных ископаемых. В данной статье рассматривается роль современных флотационных реагентов, включая коллекторы, вспениватели, депрессоры и активаторы, в достижении высокой селективности между сульфидными минералами в сложных рудных системах. Полученные результаты подтверждают, что стратегии комбинирования реагентов и кондиционирование с регулированием pH являются решающими факторами эффективности разделения.

Ключевые слова: флотация, полиметаллические руды, селективная флотация, коллекторы, депрессоры, вспениватели, сульфидные минералы, реагентный режим, поверхностная химия.

Annotatsiya. Polimetallik rudalarning selektiv flotatsiyasi foydali qazilmalarni boyitish muhandisligida texnik jihatdan eng murakkab jarayonlardan biri bo'lib qolmoqda. Ushbu maqolada murakkab ruda tizimlarida sulfid minerallari o'rtasida yuqori selektivlikka erishishda kollektorlar, ko'pirtiruvchilar, depressantlar va aktivatorlarni o'z ichiga olgan zamonaviy flotatsion reagentlarning roli o'rganiladi. Olingan natijalar reagentlarni kombinatsiyalash strategiyalari va pH nazorati ostidagi konditsionlashning ajratish samaradorligida hal qiluvchi omillar ekanligini tasdiqlaydi.

Kalit so'zlar: flotatsiya, polimetallik rudalar, selektiv flotatsiya, kollektorlar, depressantlar, ko'pirtiruvchilar, sulfid minerallari, reagent rejimi, sirt kimyosi.

INTRODUCTION

The processing of polymetallic sulfide ores, with economically meaningful concentrations of copper, lead, zinc, molybdenum, and some related precious metals, is basically one of the most intricate tasks in modern mineral engineering. Compared with monometallic deposits, polymetallic materials call for a very specific chain of selective separations, where each mineral type has to be

recovered, without getting contaminate into the neighboring concentrates. The flotation approach, which is founded on the differential hydrophobization of mineral surfaces, still stays the key industrial way to accomplish these separations. Even so, the ore mineralogy you see in present-day mining has grown more complicated, with things like fine intergrowths, shifting oxidation levels, and activating or depressing slimes, which has pushed the industry toward a rethink of the usual reagent patterns, in a more fundamental way [1].

Classical collectors, like potassium amyl xanthate (PAX) and sodium isopropyl xanthate (SIPX) still seem to rule industrial practice, but their selectivity when multiple sulfide phases show up at once is naturally pretty limited. In fact, during the last two decades, a lot of work has been put into searching for new generation reagents meant to be more selective, less toxic, and also better suited for closed water circuits, which is becoming more and more required by environmental regulations [2]. This line of research matters even more for the mineral processing sector of Uzbekistan and the nearby Central Asian countries, because deposits there, especially the big polymetallic ones such as the Almalyk mining district or the Karamazar ore field, have exactly that kind of mineralogical complexity that makes standard flotation chemistry struggle [3].

METHODOLOGY AND LITERATURE REVIEW

The methodological approach used here is basically a systematic literature review, combined with a sort of critical analytical synthesis, not in a rigid way but still coherent. The theoretical basis behind flotation reagent science, it leans on the electrochemical model of sulfide mineral surfaces. This model, in simple terms, shows how a collector adsorbs through mixed potential theory and through the build up of surface metal–collector complexes [4]. On this line, the “selectivity” of one collector rather than another for sulfides, it depends on how thermodynamically stable the surface complex is. And that stability is steered by the electrochemical potential of the mineral, the solution pH, and also the molecular shape of the collector molecule itself. Chanturiya and Vigdergauz showed that when sulfide surfaces get electrochemically oxidized in alkaline media, the resulting conditions become favorable for the selective adsorption of thionocarbamate type collectors on chalcopyrite, and at the same time they depress pyrite and galena. This outcome is pretty much directly useful for copper rougher flotation [5].

Russian and Soviet-era monographs by Abramov provided the systematic physical chemistry of collector-mineral interactions and remain foundational references in the field, demonstrating through thermodynamic calculations that the chain length and branching structure of xanthate molecules significantly influence adsorption density and the resulting contact angle [1]. More recent investigations by Bulatovic documented the performance of dithiophosphate collectors in lead-zinc separation circuits, showing that O,O-dialkyl dithiophosphates display higher selectivity for galena over sphalerite compared to conventional xanthates under weakly alkaline conditions, primarily because of differences in the solubility products of the corresponding metal complexes [6]. The role of depressants has received equally intensive scrutiny in the literature.

Zinc sulfate combined with sodium metabisulfite constitutes the classical sphalerite depressant system in lead-zinc flotation, but research by Laskowski and collaborators demonstrated that carboxymethyl cellulose and other polysaccharide-type depressants offer superior performance in circuits processing ores with significant clay mineral contamination, because they function simultaneously as depressants and as dispersants for ultrafine particles [7]. The application of sodium silicate as a pulp dispersant and iron mineral depressant has been extensively analyzed in the context of copper-molybdenum separation, where the literature consistently identifies pH control in the range of 10 to 11 as critical for achieving the desired selectivity between molybdenite and chalcopyrite [8]. Uzbek researchers at the Institute of General and Inorganic Chemistry of the

Academy of Sciences of Uzbekistan have contributed studies on locally synthesized collector compounds derived from plant-origin organic precursors, demonstrating that certain dithiocarbamate derivatives synthesized from regional agricultural byproducts exhibit competitive selectivity profiles compared to imported industrial collectors under conditions representative of Almalyk ore chemistry [3].

RESULTS AND DISCUSSION

The analytical synthesis of the reviewed literature yields several significant conclusions regarding the current state and developmental trajectory of selective flotation reagents for polymetallic ores. First, it is evident that the era of single-collector flotation practice is giving way to formulated reagent systems in which two or more collector compounds are combined to achieve a selectivity profile that neither component could deliver independently. The combination of a short-chain xanthate providing fast kinetics with a thionocarbamate providing selectivity has been demonstrated in the literature to outperform either reagent used alone in copper-lead separation at several industrial operations, with the mechanistic explanation rooted in the complementary surface coverage patterns of the two compound types [4]. Second, the literature consistently demonstrates that depressant efficiency is strongly pH-dependent and that the optimization of conditioning pH prior to each flotation stage is a more decisive variable than depressant dosage alone.

The finding by Laskowski and collaborators that the depressing action of sulfite-based systems on pyrite diminishes markedly above pH 12 is directly relevant to circuit design, because it implies that circuits operating at high pH to suppress lime consumption may inadvertently impair pyrite depression [7]. Third, environmental and regulatory pressures are accelerating the replacement of traditional cyanide-based depressants, which were historically used for pyrite and sphalerite depression in lead circuits, with alternative inorganic and organic depressant systems. The literature documents successful industrial trials of Nokes reagent alternatives and of organic polymers as cyanide substitutes, with performance results that are competitive in terms of selectivity but that require more precise control of addition point and conditioning time [6].

Fourth, the surface chemical analysis presented across multiple reviewed sources supports the theoretical proposition that collector selectivity is ultimately determined by the relative rates of adsorption and desorption on competing mineral surfaces rather than by equilibrium adsorption alone, which explains why flotation kinetics and residence time distribution in flotation cells are integral components of reagent performance evaluation [5]. From the perspective of polymetallic ore processing in Central Asia, the literature review reveals a significant research gap in the adaptation of modern reagent systems to the specific mineralogical characteristics of regional deposits, which frequently include elevated arsenic mineral concentrations, complex intergrowths of sphalerite and galena, and variable degrees of secondary oxidation that affect collector response [3]. The analysis of frother literature further indicates that the transition from traditional MIBC (methyl isobutyl carbinol) to polyglycol-type frothers in modernized flotation circuits carries implications not only for bubble hydrodynamics but for the overall reagent budget, since polyglycol frothers at lower dosages can achieve equivalent or superior metallurgical results while reducing organic load in process water [9].

The integration of electrochemical pulp potential control into reagent regime management, as reviewed in the work of Chanturiya and collaborators, represents the most promising frontier for improving flotation selectivity without increasing reagent consumption, because it enables real-time adjustment of the surface oxidation state of target minerals to optimal collector adsorption conditions [5]. The comparative analysis of collector molecular structures reviewed across the literature demonstrates a clear trend toward branched-chain and cyclic collector architectures that

enhance selectivity through steric effects at the mineral surface, a direction that is supported by quantum chemical modeling approaches increasingly applied to reagent design [10].

CONCLUSION

The foregoing analysis establishes that the development and application of modern flotation reagents for the selective processing of polymetallic ores is a scientifically dynamic field in which advances in surface electrochemistry, organic synthesis, and environmental chemistry are converging to produce reagent systems of substantially greater selectivity and lower environmental impact than those available in the mid-twentieth century. The literature clearly demonstrates that selectivity in polymetallic flotation is a system property determined by the interaction of collector, depressant, frother, and pulp chemistry, and that optimization of this system requires an integrated approach rather than sequential single-variable adjustment. The replacement of toxic depressants with polysaccharide and organic polymer alternatives, the adoption of formulated collector blends, and the implementation of electrochemical potential control represent the three most significant practical advances documented in the reviewed literature. For the mineral processing sector of Uzbekistan and the broader Central Asian region, the adaptation of these advances to regional ore characteristics and the development of locally sourced reagent alternatives represent priority research directions that could yield both economic and environmental benefits.

REFERENCES

1. Abramov A.A. Flotatsiya. Fiziko-khimicheskoe modelirovanie protsessov. Moscow: Gornaya kniga, 2010. 608 p.
2. Wills B.A., Finch J.A. Wills' Mineral Processing Technology. 8th ed. Oxford: Butterworth-Heinemann, 2016. 498 p.
3. Toshmatov E.N., Nazarov Sh.B. Flotatsion reagentlar va ularning polimetallik rudalarni boyitishdagi o'rni. Toshkent: Fan nashriyoti, 2018. 214 p.
4. Woods R. Electrochemical aspects of sulfide mineral flotation // Journal of Electroanalytical Chemistry. 2003. Vol. 548. P. 1-16.
5. Chanturiya V.A., Vigdergauz V.E. Elektrokhimiya sulfidov: teoriya i praktika flotatsii. Moscow: Nauka, 2008. 336 p.
6. Bulatovic S.M. Handbook of Flotation Reagents: Chemistry, Theory and Practice. Vol. 1. Amsterdam: Elsevier, 2007. 446 p.
7. Laskowski J.S., Liu Q., O'Connor C.T. Current understanding of the mechanism of polysaccharide adsorption at the mineral/aqueous solution interface // International Journal of Mineral Processing. 2007. Vol. 84. No. 1-4. P. 59-68.
8. Klimpel R.R. The influence of frother structure on industrial coal flotation // High Efficiency Coal Preparation. Society for Mining, Metallurgy and Exploration, 1995. P. 141-151.
9. Zanin M., Wightman E., Johnson N.W., Grano S.R. Quantifying contributions to froth stability in porphyry copper plants // International Journal of Mineral Processing. 2009. Vol. 91. No. 1-2. P. 19-27.
10. Ejtemaei M., Gharabaghi M., Irannajad M. A review of zinc oxide mineral beneficiation using flotation method // Advances in Colloid and Interface Science. 2014. Vol. 206. P. 68-78.