MINERAL DRESSING

Quantum-Chemical Method for Selection of a Collecting Agent to Recover Zinc and Copper(II) Cations in Flotation of Mine Waste Waters

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Abstract—The authors set forth the well-grounded selection of effective agents: terephthalic esters, distinguished for the optimal set of quantum-chemical parameters of the agent reactivity to recover zinc and copper(II) from the process waste water, propose a new-developed complex collecting agent ROL and report the investigation into the mechanism for recovery of zinc and copper(II) by this agent. The resource-renewable process flow sheet is proposed to treat mine-and-processing waste waters, rich in copper and zinc content to produce a concentrated product.

Keywords: process waste water, quantum-chemical parameters, ion flotation, renewable resource technology

INTRODUCTION

Nowadays the mining industry inextricably implies the pollution and disturbance of the environment, atmosphere, soil, surface and underground waters, accumulation of solid and liquid wastes, inefficient exploitation of mineral resources due to the lack of actually wasteless, safe, mining and mineral processing technologies [1]. Of particular concern are the mineralized acid waters at the Ural copper-pyrite deposits. The waste water yield of about 4 mil m³/day is characterized by the high content of zinc cations of 220-653 up to 9734 mg/dm³, copper(II) cations of 75-644 up to 1884 mg/dm³, iron(II, III) cations of 308-760 up to 18560 mg/dm³ and other toxic metals, what is quite abnormal for dump waters. The grade of hydromineral raw resources, accumulated at mines and ore preparation plants are comparable with the proved reserves of available mineral ore deposits for a number of components.

The high yield of mine waste waters with the appreciable heavy metal content makes the grounds to consider them as the hydromineral resources and to treat them in order to recover valuable technological heavy metals [3].

At the most copper mining and processing plants the neutralization process is employed to treat waste waters in order to extract a metal content as a hydrolytic deposit without further separation and reutilization. The use of other metal-recovering processes: extraction, sorption, hyperfiltration, ultrafiltration, ion-exchange, dialyse, evaporation, crystallization, magnetic separation, electrodialyse, electroflotocorrection of pH, electrocoagulation, and electrolysis, is constrained by their imperfections: a low ion-exchange rate, a high organic-phase loss, high capital and maintenance costs, high fire hazards, need in the complex environmental actions, etc.
The waste water flotation is proved as the most promising, simple, efficient and economical process with a low organic agent loss and good compatibility with other water treatment processes. It combines the advantages of the sorption, extraction, and chemical precipitation with a feasible extraction of suspended particles and provides a deep purification of industrial mineralized waters with the production of the MAC grade water with no secondary contamination at the concurrent heavy metal ion recovery into a 99% concentrated product.

The ion, pneumatic and pressure flotation and electroflotation processes [3] efficiently recover valuable components into a dispersed phase under specific conditions of gas saturation, selective separation and grade of mine waste waters.

The separate quantitative recovery of valuable components in the ion flotation becomes possible by using high-performance collecting agents, exhibiting the selectivity or capability for complex extraction and concentration of metals at the flotation time of no more than 10 min, reutilization of a froth product (sublate), solubility of a flotation agent in water or respective low-toxic solvents (mass fraction of an agent in a solution should be 2% and higher), low sensitivity to the salt content, sound froth-forming properties, compatibility with conventional frothers, insignificant entrapment of a flotation agent with a water phase, minimum agent consumption per a metal recovery unit, low toxicity, and availability, and regeneration capacity.

At present the list of agents used in the ion heavy metal flotation is limited to the ionogenic heteropolar surfactants, capable to form strong bonds with metal cations. Of practical value are sodium hexanenedecanoate, potassium n-dodecylbensolsulphonate, potassium ethylxanthate, potassium butylxanthate, potassium amylxanthate, and sodium diethyldithiocarbamate [1].

Building the basis for a new promising agent generation, selective, adaptable to the specific flotation conditions and a physical-and-chemical state of working solutions should certainly improve the flotation efficiency in extraction and concentration of metal ions at higher performance of waste water treatment circuits. In this connection, it is reasonable and progressive to apply the “structure—property/activity-property” principle as the basic one. In terms of flotation systems this principle runs as follows: molecular structures of agent compounds contain reactive centers, active to components to be recovered (substrates), namely, zinc and copper, which structure and properties enhance the selective action of flotation agents and promote the formation of strong “substrate-agent” bonds in flotation systems. The principle is realized by establishing relations between a structure, quantum-chemical parameters, physico-chemical properties and reactive activity of components to be recovered (Zn$^{2+}$ and Cu$^{2+}$ substrates) and recovering or collecting agents. The system of the reactive capacity parameters (RCP) in Fig. 1 involves quantum-chemical, physical-chemical and structural (form and fragmental) parameters, providing high activity and selectivity of collecting agents relative to substrates in flotation.

The physical-chemical parameters within RCP complex are: for substrates—pH of metal recovery from aqueous solutions in combination with solubility product (SP) of their precipitated forms, which allows that the effective conditions can be established for the substrate recovery from a multicomponent matrix of a technological solution; for collecting agents—specific molecular masses $M_r$, hardening temperature, density, viscosity, $C_{\text{dissocn}}$ is dissociation constant, critical concentrations of micellization (CCM); for “substrate-agent” compounds—the stability constant of a new-formed sublate $C_{\text{stab}}$, optimal pH of complex formation, energy of metal cation stabilization under the ligand field (EMCSLF) effect in the Irving-Williams classification.