ROLE OF THE COLLECTING AGENT SORPTION FORMS IN THE ELEMENTARY ACT OF FLOTATION

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A new hypothesis of flotation is substantiated based on the well-known hypotheses, theoretical analysis of the elementary act, and experimental results. The hypothesis presented allows the processes of flotation activation, depression, and intensification to be explained and optimized.

Flotation theory and technology, ore dressing, coal concentration

INTRODUCTION

According to the contemporary studies, apolar and heteropola organic compounds that are used as collecting agents can be both in chemically attached and physically sorbed forms in a sorption layer on mineral surface [1].

Chemical attachment of a collecting agent results from interaction between its ions or molecules and chemically nonsaturated atoms or radicals on the mineral surface and formation of ionic, covalent, or coordinate bonds between them. The interaction is accompanied with electron transition between adsorbent and adsorbate that generate a unit electron quantum mechanical system [2].

Physical sorption of a collecting agent is governed by the intermolecular interaction of Van der Walls forces, electrostatic polarization, and reflecting forces between adsorbent and adsorbate. Adsorbed compound is unaltered in this case. Adsorbed ions or molecules of the collecting agent and the mineral lattice may be considered as two independent systems interacting in the form of a weak disturbance [2].

The problem on the role of the collecting agent sorption forms in attachment and flotation of mineral particles on gas bubbles is to be solved. This is required not only for successful synthesis of new higher-effective reagents and their diminished consumption during flotation, but also for explanation and substantiation of optimal conditions and experimentally determined methods of flotation intensification. Synergism of action of the reagents does not reveal the reasons of the effects observed and the ways of further improvement in flotation.

Up to now there was practically no deep experimental testing conducted for the role of chemical and physical sorption forms of the collecting agents. Known are only the results of experiments on air bubble attachment to polarized lead and galena electrodes at xanthate presence [3] and the investigations into flotation activity of the collecting agent sorption forms [4].

This paper is aimed at considering the requirements of the existing flotation hypotheses and the elementary flotation act theory for the desired state of floatable mineral surface and the role of the collecting agent sorption forms in flotation.

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FLOTATION HYPOTHESES

The investigations conducted on high-precision equipment showed that the basic sorption forms of a collecting agent on mineral surface are chemisorption, origination of valence-saturated products of inhomogeneous chemical reaction, as well as physical sorption of ions and molecules. The flotation hypotheses proposed are usually based on one of the sorption forms disregarding the influence of the rest [1, 3].

According to an analysis of the well-known flotation hypotheses, they are not only conflicting, but inapplicable to substantiation of the mineral surface state needed in flotation. For example, the chemical theory stipulates that mineral flotation is successful due to inhomogeneous chemical exchange reaction with formation of difficultly soluble metal compounds of the type of xanthates, oleates, etc. However, this theory cannot explain apatite and pyrite flotation efficiency when insolubility of calcium oleate and iron xanthate is not yet reached [3, 5] or at nonfloatability of oxidized copper and lead minerals [6] even in case when solubility product of lead and copper xanthates is multiply exceeded and chemical reaction is altogether impossible [1].

Shvedov’s hypothesis and the ion-exchange hypotheses, which inform that chemisorption of the collecting agent on mineral surface is sufficient for flotation, cannot substantiate the absence of flotation of nonactivated chemisorbed xanthate-covered blende and the flotation of minerals with a single apolar collecting agent.

The hypotheses of wetting action of dixanthogen, hydrolytic formation of xanthic acid, reversible adsorption of molecules (for example, oleic acid) or reversible joint sorption of ions and molecules (for example, amine) are not confirmed either.

At the same time, proceeding from the analysis of the proposed hypotheses, experimental flotation tests, as well as the theoretical analysis of elementary flotation act (attachment) and flotation of mineral particle on air bubble, it may be assumed that in flotation each form of the collecting agent attachment on mineral surface plays its own part reflected by the discussed hypotheses [1].

REQUIREMENTS OF THE ELEMENTARY FLOTATION ACT THEORY FOR THE DESIRED STATE OF MINERAL PARTICLE SURFACE ON ITS ATTACHMENT ON A BUBBLE

The results of thermodynamic analysis of elementary flotation act and experimental studies indicate that attachment and flotation of a mineral particle on a bubble is realized when the following three conditions are simultaneously satisfied.

1. The particle is hydrophobic, and when the particle is attached on the bubble, the flotation system transition from position 1 to position 2 (Fig. 1) is accompanied with a decrease in the free energy of the system \((E_1 - E_2 > 0)\), i.e. if the contact wetting angle \(\theta\) and floatability index \(F\) are more than zero:

\[
F = \frac{E_1 - E_2}{S_{g-s}} = \sigma_{l-g} \left( \frac{S'_{l-g} - S_{l-g}}{S_{l-g}} - \cos \theta \right) = \sigma_{l-g} (1 - \cos \theta) > 0. \tag{1}
\]

The higher are \(\theta\) and \(F\), the greater is thermodynamic probability of the particle being attached on the bubble (Fig. 1).