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Abstract

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Corresponding Member of the Academy of Sciences of the USSR I. N. PLAKSIN and R. Sh. SHAFEEV

ON THE INFLUENCE OF GALENA PARTICLE SIZE ON THE FIXATION OF FLOTATION COLLECTOR REAGENTS

Determining the influence of mineral particle size on the fixation of flotation collector reagents, in particular xanthate, is important for characterizing the floatability of minerals in a flotation pulp. The floatability of slimy mineral particles, along with the influence of other factors (for example, flocculation under the action of surface-active substances), depends to a large extent on the amount of collector reagent fixed per unit surface of the mineral particle. The question of the influence of particle size on the fixation of flotation reagents has been studied by various authors; however, the results of the investigations have been quite contradictory ([1]–[3]). As a result of numerous experiments, we have established that, as the size of galena particles decreases, the adsorption capacity of a unit surface of the mineral with respect to xanthate decreases. In these experiments, contact autoradiography of the surface of galena particles was used in order to determine the amount of butyl xanthate with radioactive sulfur (S^{35}) fixed on these particles.

The concentration of the solution of potassium butyl xanthate in distilled water was taken to be somewhat elevated (1 g/l) so that, after treatment of the galena particles, some residual concentration of xanthate would remain in the solution. The galena particles were stirred in this solution, thoroughly washed with distilled water, dried, and sprinkled onto the surface of a NIKFI-MR nuclear emulsion. After exposure, the galena particles were removed from the surface of the emulsion, and the plate was developed.

The amount of xanthate per unit surface of the mineral was determined by microphotometry of the autoradiographic imprint of a particle using an MF-2 microphotometer with a somewhat modified optical scheme. (A magnifying objective of type 40 × 0.65, a tube of 160, and an FÉSS-U10 photoelement with an integral sensitivity of 7600 mA/lumen were installed.) A calibrated grid scale was placed on the screen of the microphotometer; this made it possible to determine the sizes of galena particles from their autoradiographic imprints, while simultaneously monitoring the degree of darkening of the emulsion caused by the radioactive radiation of the xanthate fixed on the surface of the mineral particle. The size of the autoradiographic imprint practically coincides with the

size of the mineral particle.

Figure 1 (see insert, p. 67) shows a microphotograph (a) and an autoradiographic imprint (b) of a galena particle. Comparison of the imprints shown in Fig. 1 makes it possible to judge the close agreement between the size of the mineral particle and that of its imprint. During photometry of the autoradiographic imprint, the size of the mineral particle was simultaneously recorded with the aid of the square grid on the microphotometer screen, which made it possible to measure the average degree of darkening of the emulsion by xanthate fixed on the average specific surface of galena particles of a narrow size class. The number of measurements was established experimentally, until close agreement of the results of parallel experiments was obtained.

The results of microphotometry of autoradiographic prints of galena particles of various sizes showed (a –average particle size, μ; b –amount of xanthate on the mineral particles (reading on the logarithmic scale of the MF-2)):

a	0–5	5–10	10–15	15–20	20–40	40–50	50–75	75–100	100–125	125–150	150–175
b	51	60	64	68	75	99	116	119	137	167	176

On the other hand, radiometric measurement of galena fractions of different sizes on the B-2 apparatus with an MST-17 end-window counter gave the following results (a –average particle size, μ; b –amount of xanthate fixed on the mineral particles, impulses/min.): the amount of fixed xanthate per unit weight of the galena particle fraction increases as the particle size decreases (the total surface area of the mineral particles increases).

a	0–44	44–74	74–104	104–150
b	2231	1833	1363	1311

The reasons for the decrease in the adsorption capacity of galena with decreasing size of the mineral particles may be of two kinds.

Larger particles of natural galena (from tens to hundreds of microns in size) are not single crystals, but are polycrystalline formations with different orientations of the microcrystallites. The specific surface energy of a polycrystalline surface is considerably higher than that of a single-crystal surface ([4]). The surface of a crystal is usually intersected by cracks from 100 to 10000 Å in size, arising under the action of electrostatic forces of the surface ([5]). During grinding of mineral particles, microcrystallites are naturally liberated and the specific fissuring of the mineral surface decreases, which is accompanied by a corresponding decrease in the adsorption activity of the surface as the size of the mineral particles decreases.

In addition, on the surface of sulfide minerals, owing to the presence of various imperfections of the crystal lattice commensurate with the size of the mineral particles, and to the presence of crystallites of different orientation, one should expect the appearance of electrochemical nonuniformity of the mineral surface. The electrochemical nonuniformity will decrease as particle size decreases, which is accompanied by a decrease in the adsorption capacity of the specific surface of the mineral particles with respect to ions and molecules of the liquid phase of the flotation pulp. On finer galena particles (up to ten microns in size), the cause of the decrease in the adsorption capacity of the particles is that, during adsorption of xanthate in the surface layers of mineral particles, the electron concentration changes. An increase in electron concentration makes electron transitions between xanthate anions and lattice components unfavorable, as a result of which the formation of a strong bond of xanthate with the surface of galena particles is hindered.

During adsorption of xanthate the galena surface becomes negatively charged, and the density of the surface charge depends on the amount of xanthate fixed on the surface. If the initial surface of the mineral is conventionally taken to be electrically neutral, and the charge of the xanthate anion to be uniformly distributed over the surface, then the change in charge from the surface to the volume of the particle is expressed by Poisson' s equation:

$$\frac{d^2\varphi}{dx^2} = -\frac{4\pi ne}{\varepsilon},$$

where φ is the change in charge along the x axis, n is the concentration of electrons in the volume of the mineral, e is the electron charge, and ε is the dielectric constant of the mineral (for PbS $\varepsilon = 17.9$). Near the galena surface at $x = 0$

the magnitude of the charge is equal to φ, and at a depth x the charge is zero. x—the depth of charge penetration into the volume of the particle (the Debye screening length)—is calculated from the formula

$$x = \sqrt{\frac{\varepsilon \cdot kT}{8\pi ne^2}},$$

where

$$n = \frac{2(2\pi mkT)^{3/2}}{h^3} \exp -E/2kT,$$

for galena $n = 0.0386 \cdot 10^{20} \exp -E/0.0235$ (at 20°); E is the width of the forbidden band, which in each case is determined experimentally; m is the effective mass of the electron; k is Boltzmann' s constant; h is Planck' s constant. If a galena particle has a size smaller than $2x$, then the volume of the particle

deviates from electroneutrality and a phenomenon is observed similar to the overlap of double electric layers inside mineral particles.

In this case the level of the chemical potential of the electrons increases, which is accompanied by a decrease in the adsorption capacity of a unit of the mineral surface.

Thus, the study of the fixation of flotation reagents on mineral particles as a function of their fineness will make it possible to refine the flotation characteristics of slimy mineral particles in the flotation pulp.

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CITED LITERATURE

1. V. A. Glembotskii, *Izv. AN SSSR, OTN*, No. 2, 253 (1950).

2. S. I. Mitrofanov, O. A. Ratnikova, *Collected Volume: Beneficiation and Metallurgy of Nonferrous Metals*, Moscow, 1957, p. 20.

3. O. S. Bogdanov, A. K. Podnek et al., *Problems of the Theory and Technology of Flotation*, 1959, p. 98.

4. R. N. Povloff, *Zs. phys. Chem.*, **88**, 316 (1920).

5. Zwicky, *Proc. Nat. Acad. Sci.*, **15**, 253, 816 (1929).

Note: Figure translations are in progress. See original paper for figures.