

Graphite flotation in the presence of sodium acetate*

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Graphite was subjected to flotation in the presence of increasing concentration of sodium acetate. A comparison of graphite flotation with the surface tension, both as a function of the sodium acetate concentration in the aqueous solution, revealed a similar pattern of both relations. It seems to confirm one of the theories of salt flotation claiming that for hydrophobic materials the change of flotation recovery with the salt concentration is mostly determined by the surface tension of the aqueous solution. It was found that graphite recovery increases when the surface tension of the solution and decreases as the surface tension decreases. At a low salt concentration this rule is not obeyed due to, very likely, the so-called Jones-Rey effect.

1. INTRODUCTION

Flotation of particles in the presence of inorganic salts is known as the salt flotation [1]. Previous studies of salt flotation conducted by many researchers showed that flotation is improved when the material subjected to flotation is hydrophobic [2-6], that is having contact angle greater than zero [7]. It was also established that inorganic salts do not change the hydrophobicity of the floating material [8]. The reason of the increased flotation recovery, due to salts, is yet fully understood and different hypotheses are available. Most of them claim that salt flotation is caused by increasing dehydration of hydrophobic surfaces [2, 9] while other point to either decreasing coalescence of bubbles [10] or increasing formations of microbubbles on hydrophobic surfaces [5].

* This paper is dedicated to Professor Dr. Emil Chibowski to celebrate his 65th birthday

Salt flotation was recently investigated by Ratajczak [11] and presented in a monograph [6]. There are at least two regions of different response of flotation systems to salt presence in the solution (Figure 1).

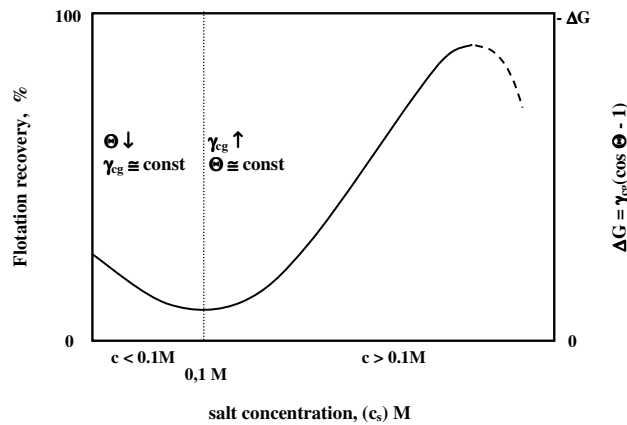


Fig. 1. Two regions of flotational behavior of hydrophobic particles. Up to about 0.1 M there is a decrease in flotation while above this concentration most salts improves flotation.

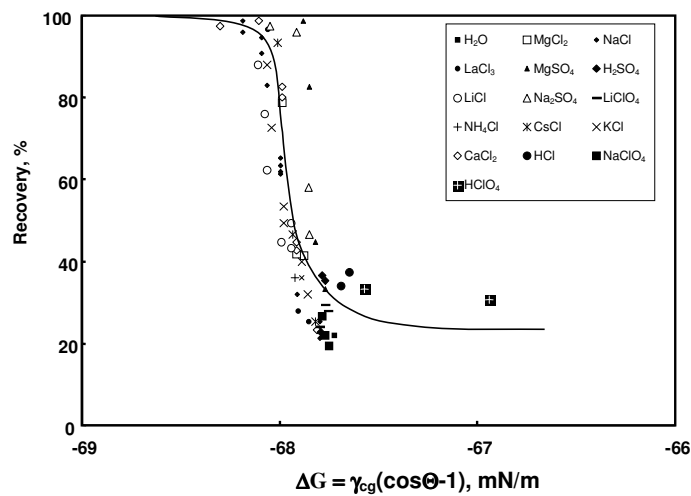


Fig. 2. Change of graphite recovery seems to be governed by the thermodynamics (free enthalpy ΔG of flotation) and results from the surface tension of the solution γ_{cg} . Data from [3-5] for graphite (its hydrophobicity was assumed to be $\theta = 86^\circ$).

The first one, at a low salt concentration (up to about 0.1M), represents usually a drop in flotation. This effect very likely result from surface charge, formed at the solid /water interface with salt concentration and very likely is a consequence of

the so-called Jones-Ray effect [6, 12]. The second region starts roughly above 0.1 M, where flotation increases with the salt concentration. However, the increase depends significantly on the electrolyte used in flotation. It was shown by Ratajczak [11] (Figure 2) that the improvement of flotation is mainly caused by the increasing interfacial tension of the aqueous solution (Figure 2) while the hydrophobicity of the solid is constant.

If indeed salt flotation can be regulated by the surface tension of the salt solution there should be a decrease in flotation of hydrophobic materials in the presence of salts which decrease the surface tension. However, the number of inorganic salts which reduce surface tension of water is limited. One of them is sodium acetate, which surface tension initially slightly increases and then decreases. The aim of this paper is to present the results of investigation conducted with graphite and sodium acetate by Grabowski [13] for the determination of the role of the surface tension of the aqueous salt solutions in flotational properties of mineral systems.

2. EXPERIMENTAL

The flotation tests [13] were carried out in a Mechanobr laboratory flotation machine equipped with a 0.5 dm³ cell. The rotor speed was 600 rpm while the air flow was 0.4 m³/h. Graphite used for flotation tests was a natural material having particles 100 μm in size. Its hydrophobicity, measured by the sessile drop method, was high and equal to 8.6°. The flotation tests were run for each salt concentration separately using 50 grams of graphite.

3. RESULTS AND DISCUSSION

The results of flotation, in the form of flotation recovery of graphite as a function flotation time are shown in Figure 3.

The graph indicates that depending on concentration, the flotation recovery of graphite can be slightly better or worse than that in distilled water. To see the extent of flotation change with sodium acetate concentration, the same results were plotted in the form of graphite recovery after 4 minutes of flotation vs. salt molar concentration (Figure 4). Also the surface tension data were added to the figure. It results from the graph that flotation and surface tension patterns, to a great extent, are similar. It suggests that indeed the surface tension of the aqueous solution is the main parameter governing salt flotation of minerals. A stronger conclusion is not possible due to a significant scattering of the flotation experimental data.

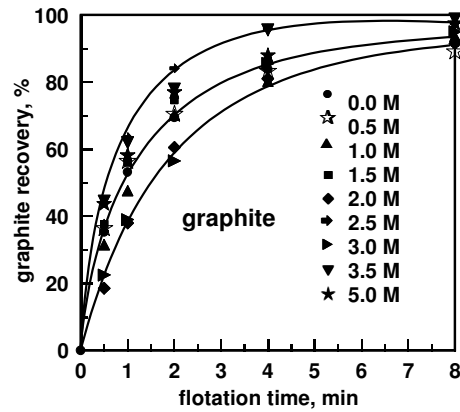


Fig. 3. Recovery of graphite as a function of flotation time at different concentrations of sodium acetate in the aqueous solution. For clarity only three (medium, lower and upper) lines were drawn in the graph.

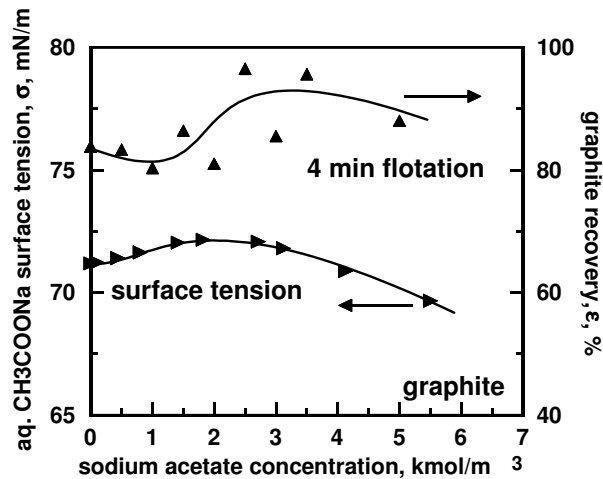


Fig. 4. A comparison between recovery of graphite after 4 minutes of flotation and surface tension of sodium acetate aqueous solutions both as a function of sodium acetate concentration. Surface tension data after Abrazon and Gaukhberg [14] based on Pavlov [15] while sodium acetate solutions densities were taken from CRC handbook [16].

4. CONCLUSIONS

The data presented in this paper seem to confirm one of the theories of salt flotation claiming that for hydrophobic materials the change of flotation with the salt concentration is mostly determined by the surface tension of the aqueous

solution. It was found that when the surface tension of sodium acetate solution increases the flotation of graphite increase and next, when the surface tension of sodium acetate decreases, flotation also drops. This conclusion should be considered tentative because the flotation data are somewhat scattered and therefore the correlation between surface tension and flotation requires further verification in the future. In addition to that the proposed correlation between surface tension and flotation is not obeyed a low salt concentration very likely due to the so-called Jones-Rey effect [17].

5. REFERENCES

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