ELECTROKINETIC BEHAVIOUR OF SULPHIDE MINERALS: 
A Contribution to the Chemistry of Flotation

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ABSTRACT. Sulphide minerals occur usually as mixed or complex minerals; studying their electrokinetic behaviour, under various conditions, interesting conclusions from the fundamental point of view arose for the separation technology, conventionally being carried out by (froth) flotation. The extent of oxidation of sulphide minerals can be easily investigated by electrokinetic studies and such properties are also of significance to the chemistry of flotation. The electrokinetic measurements may provide useful indications on mineral processing, which are usually followed by floatability experiments. A brief literature review is presented in this paper, coupled by a discussion of the extensive Laboratory's work, mainly on iron sulphides electrokinetic behaviour.

1. Introduction

The flotation of minerals from their ores in flotation cells involves understanding many chemical and physical processes ranging from electronic events in the bulk mineral and in the mineral surface regime, molecular events at interfaces, the statics and dynamics of thinning and rupture of microscopic to molecular interfacial films, the fluid dynamics of bubble-particle events, the dynamics of air-water-solid colloid states in a flotation machine, etc. [1]. Significant advances have occurred in the use of electrochemical techniques particularly for sulphide mineral flotation research; the challenge lies in the utilization of this knowledge in plant operations so as to increase the overall efficiency of flotation separations [2].

The electrochemical methods provide a means to control the state of oxidation of the surface of sulphide minerals. The interactions of thio-collectors, conventionally applied (such as the xanthates), with sulphide minerals have been examined by many researchers - see, among others, ref. [3].
Electrochemistry is accepted as the basis to explain in-depth the mechanisms of sulphide minerals flotation [4].

1.1. THE ZETA-POTENTIAL

The investigation of surface potential changes and in general, of the electrokinetic behaviour of a system can give many information on the ways the different existing ions may function. The basic applications in flotation are classified in the:

i) study of the method of collector adsorption,
ii) selection of the appropriate flotation reagents and
iii) examination of activation mechanisms.

An excellent review, in this area, for metal sulphides behaviour was presented [5] in A.M. Gaudin Memorial Flotation Symposium, who was the pioneer and in particular, he sought a correlation between the zeta-potential and flotation properties, in 1946. Interesting points were raised, as: little attention was given in the past to experimental details, as to adequate analysis of the sulphide, conditioning effects, sample equilibration, preventing measures to control oxidation, etc. It concluded that electrokinetic measurements can be an excellent tool for observation and description of surface reactions at the mineral-water interface.

The following four basic methods exist [6] for the measurement of zeta-potential value:

1) electrophoresis,
2) streaming potential,
3) electro-osmosis and
4) sedimentation potential.

The bulk and surface chemistry of metal ion hydrolysis and precipitation and the redox chemistry of metal ions, sulphur, and other species is central to an understanding of flotation. A model of natural and collector-induced flotation of sulphides was constructed [7]. It was suggested that if dissolved Mn, Cu or Zn in a flotation pulp is precipitated by a pH increase, the surfaces of the gangue and the sulphide minerals all assume the surface properties of the metal hydroxide coating; the latter was represented by a surface potential versus pH diagram.

Nevertheless, electrokinetic measurements have been used in laboratory studies of other minerals, under typical processing conditions, except sulphides: for instance, of oxides and silicates [8], of cerussite [9] or of magnesium carbonate ores [10]; a theoretical examination of the accuracy of the later measurements (conducted by a Micromeritics electrophoretic mass transfer apparatus) was earlier reported by Gallios et al. [11].