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CONTROL OF ORE ACTIVATION BY DIELECTRIC METHOD

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ABSTRACT

A method for measuring the dielectric characteristics of a solid in suspension in an ionic solution is described. A dielectric model of the composite medium is developed and the contribution of the solid is separated from this of the liquid in the total dielectric response. As an application to ore benificiation processes, it has been clearly shown that there is a conductivity change of the sphalerite during its activation by cupric ions.

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SUMMARY

Ore particles must often be activated before floatation in the selective recuperation process. Analysis of the surface structure during this latter process is important so as to understand the mechanisms of the reaction between solid and liquid phases and be able to control them. We have developed a method based on dielectric measurements in order to gain information on the surfacic reaction directly in the diphasic medium.

The sample is placed in a measuring cell built with a parallelepiped silica tank on which two electrodes are glued. A recording is made of the complex impedance of the cell versus frequency in the H.F. range (50kHz - 50MHz).

The cell equivalent circuit was first obtained from an impedance analysis of the cell filled with a liquid of known dielectric characteristics. It was found that the cell was equivalent to a capacitance C_1 in series with a complex capacitance C_2^* proportional to the sample dielectric permittivity ε^*:

$$C_2^* = C_o \varepsilon_o \varepsilon^*$$

The capacitance C_1 is small, so that the imaginary part of the impedance is almost independent of the sample.

A dielectric response η of the cell can be defined as the ratio of the imaginary part to the real part of the impedance. For a homogeneous medium, a plot of η versus frequency presents a maximum; at this points, the frequency is proportional to the conductivity and the amplitude is related to the real permittivity.

DIELECTRIC STUDY OF SUSPENSIONS

A suspension of sphalerite in a cupric solution (concentration 10^{-3}Mole/l) was placed in the cell and the impedance was recorder versus frequency. The same measurements were performed with a suspension of sphalerite in distilled water and with the curpic solution. The dielectric responses are presented on figure 1.

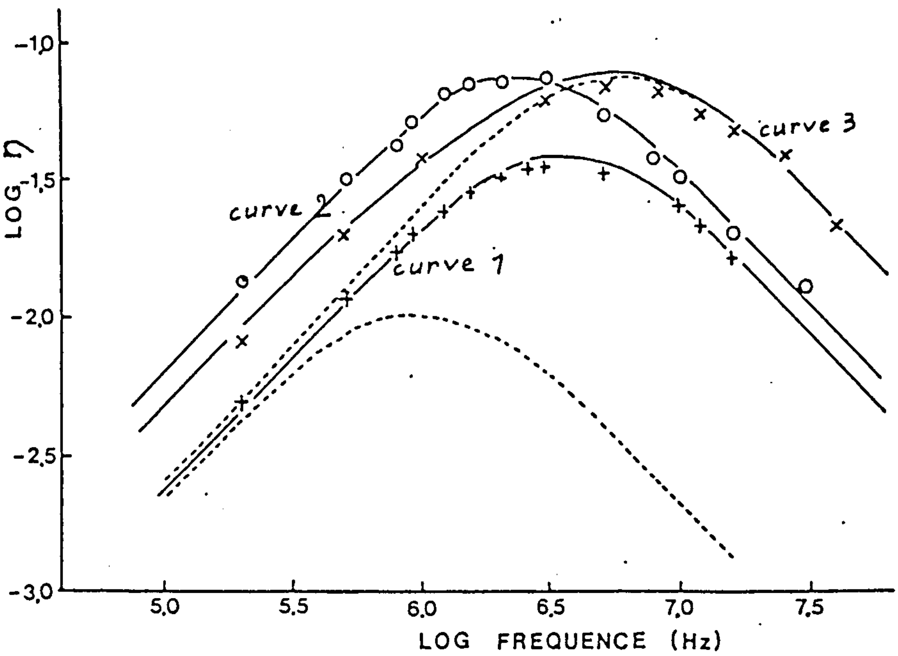

FIGURE 1 : *Dielectric response of sample*
curve 1 : cupric solution
curve 2 : suspension of sphalerite in distilluted water
curve 3 : suspension of sphalerite in cupric solution

An analysis of the experimental results was carried out.The basis of a dielectric model for a diphasic medium was developed by WAGNER [1]. The complex dielectric permittivity ε^* can be written as a function of the real permittivities σ_2 and σ_3 of the liquid and solid phases respectively, the corresponding conductivities 2 and 3 and the volume fraction of the solid part ϕ by relation 1 :

$$\varepsilon^* = (\varepsilon_2 - j\frac{\sigma_2}{\varepsilon_o\omega})\frac{2(\varepsilon_3 - j\frac{\varepsilon_3}{\varepsilon_o\omega}) + (\varepsilon_2 - j\frac{\varepsilon_2}{\varepsilon_o\omega})(1+2\phi)/(1-\phi)}{\varepsilon_2 - j\frac{\sigma_2}{\varepsilon_o\omega} + (\varepsilon_3 - j\frac{\sigma_3}{\varepsilon_o\omega})(2+\phi)/(1-\phi)}$$

Taking into account the equivalent circuit formulated above, the dielectric response of the cell is given by relation 2 :

$$\eta = \frac{C_1 \omega R'_2}{1+R'^2_2 C'^2_2 \omega^2} + \frac{C_1 \omega R'_3}{1+R'^2_3 C'^2_3 \omega^2} \qquad (2)$$

with

$$C'_2 = \frac{1+2\phi}{1-\phi} \varepsilon_2 C_o \qquad (3)$$

$$C'_3 = (2\varepsilon_2 + \frac{1+2\phi}{1-\phi} \varepsilon_3) \frac{(1+2\phi)(1-\phi)}{9\phi} C_o \qquad (4)$$

$$1/R'_2 = \frac{1+2\phi}{1-\phi} \frac{\sigma 2}{\varepsilon_o} C_o \qquad (5)$$

$$1/R'_3 = (2\sigma_2 + \frac{1+2\phi}{1-\phi} \sigma_3) \frac{(1+2\phi)(1-\phi)}{9\phi} \frac{C_o}{\varepsilon_o} \qquad (6)$$

The first term of the dielectric response depends only on the liquid part and can be evaluated from the experimental data relative to cupric solution. After having removed the contribution of the first term in the dielectric response, the conductivity and dielectric permittivity of the solid particles can be evaluated from the equations (4)-(7).

Numerical analysis of curve 2 (suspension in water) gives $\sigma_3 = 9.6$ and $\sigma_3 = 6.5\ 10^{-3} \Omega^{-1}\ m^{-1}$. Analysis of curve 3 relative to the suspension in cupric solution gives the same permittivity but $\sigma_3 = 11\ 10^{-3} \Omega^{-1}\ m^{-1}$. The change of conductivity in a ratio of about 2 proves that a reaction has taken place between solid and cupric ions with a conductive deposit on the surface, probably CuS.

When the cupric solution is replaced by a Na_2SO_4 solution, no variation in solid conductivity or permittivity was detected. This result is in accordance with the well known fact that a solution of Na_2SO_4 does not react with ZnS. The solid dielectric characteristics can be extracted from the dielectric response of the suspension as long as the solution is not too concentrated. For higher concentrations the total dielectric response depends only on the liquid conductivity.

A more exact model such as that of HANAI [2] could be used in place of Wagner's model. The final result of an increased conductivity by activating sphalerite would not be altered. The Wagner model retains the advantage that it can be used in an analytic form, whereas Hanai's model necessitates numerical analysis.