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USE OF PACKED BED BIOREACTORS APPLICATION TO ORES BIOLEACHING

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SUMMARY

The behaviour of glass beads, silicagel and activated carbon particles as bacteria supports for using in backed bed bioreactor has been compared. No important difference was found. Additionally the performance of a bioreactor with glass beads was compared with that of a conventional percolating column in the bioleaching of a copper sulphide ore. Results showed higher copper extraction using the bioreactor.

INTRODUCTION

Ores bioleaching is generally applied using piles, percolating columns or agitated tanks (Tuovinen and Kelly, 1972; Torma, 1977; Murr *et al*, 1978; Rossi and Torma, 1983). In these systems microorganisms are in direct contact with the ore and their leaching products. These are frequently toxic for the bacteria and moreover some solid deposits are formed on the ore -i.e. as a consequence of ferric iron hydrolysis- preventing further bacterial attack. In addition some important parameters as pH and temperature cannot be adequally controlled in big columns and piles.

Bioleaching of metallic sulphides or of some reduced species as uranyl ion is done by the bacteria *Thiobacillus ferrooxidans*, wich is a biocatalyzer of the oxidation of these compounds and, consequently, of their dissolution. In a medium containing ferrous ion prevails the

indirect mechanism of the bacteria action, which operates through the ferrous ion oxidation and further by oxidation of the reduced metallic compound of the ore by the ferric ion produced.

As an alternative way to the bioleaching in columns or piles, the use of packed bed bioreactors have been recommended (Lancy and Tuovinen, 1984; Nikolov and Karamanev, 1987; Grishin and Tuovinen, 1988; Nikolov *et al*, 1988; García *et al*, 1989; Armentia and Webb, 1992) . In these systems bacteria are attached to a support and the solution containing ferrous ion is percolated through the support particles, where bacteria oxidize the ferrous ions. Iron (III) solution is then percolated through the ore producing the oxidation and dissolution of the sulphide compounds or, eventually, of some other reduced compounds and it is recycled to the bioreactor.

In this paper we report results obtained with reactors prepared using three different supports, glass beads, silicagel and activated carbon. Additionally, the perfomance of a bioreactor is compared with that of a percolating column in the bioleaching of a copper sulphide ore.

MATERIALS AND METHODS

Bioreactor were prepared using three glass columns of 4 cm diameter and 20 cm length in which the supports were put. Glass beads were cylinders of 2 mm diameter and 4 mm length and the activated carbon and silicagel particles were spheres of 2-3 mm diameter. 62 g of glass beads, 60 g of silicagel and 83 g of activated carbon were used in order to have the same length of solid support on each bioreactor as it is indicated in figure 1.

The preparation of the biofilm was done in this way:

1) 9 K medium (Silverman and Lundgren, 1959) with a *Thiobacillus ferrooxidans* culture in logarithmic stage of growth was added to the support;

2) once the iron(II) of the medium was completely oxidated, it was replaced with fresh medium without inoculation. This procedure was repeated until the maximum iron(II) oxidation rate was reached. This was assumed as indication of the complete formation of the biofilm. Then iron (III) productivity of the bioreactor (rate of iron(III)

production) as a function of flux rate was measured using continuous flux of 9 K medium, regulated by peristaltic pumps. These experiences were done at 30 C, initial pH 1,5 and a total volume of 110 ml.

Comparison of bioleaching techniques were done using an ore having this chemical composition: Cu: 0,86 % ; Fe: 18 % ; S: 2,02 % ; copper sulphides were calcosine, covellite and calcopyrite.

In figure 2 the two procedures are schematically indicated: (2a) is a percolating column system, (2b) is a column-bioreactor system un which the copper sulphide ore, inside a separate column, is oxidated by the iron (III) produced in the bioreactor which contained 240 g of glass beads. The reduced iron ion is then recirculated through the bioreactor and the cycle starts again. 100 g of ore and a total volume of 300 ml of 9 K medium were used in both systems. In the percolating column the 9 K medium was inoculated with 10 % of a culture of *Thiobacillus ferrooxidans*. Flux rate was 1,5 ml.minute^{-1} in both systems.

FIGURE 1: BIOREACTOR

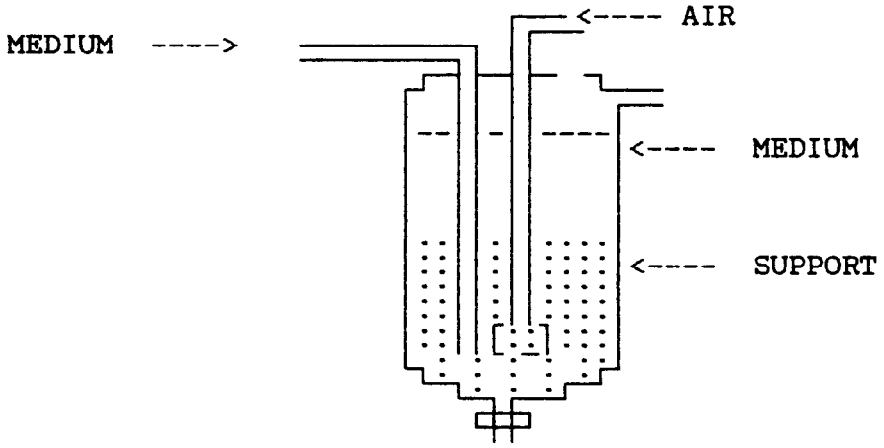
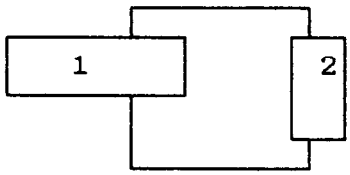
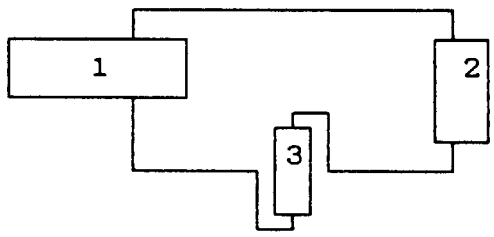


FIGURE 2: BIOLEACHING OF CuS

2a: Percolating column system



2b: Percolating column - bioreactor system



1: PERISTALTIC PUMP 2: PERCOLATING COLUMN 3: BIOREACTOR

RESULTS AND DISCUSSION

In figure 3 iron (III) productivities (expressed as molar concentration.hour^{-1}) are indicated for each of the used supports. These productivities are substantially higler than those obtained in a conventional agitated flask system in which their values are in the range 0,003-0,005 molar.hour^{-1}, perhaps due to the great number of attached bacteria. From this figure it can be calculated the maximum iron (III) productivities per kg of each used support which are as following: glass beads: 0,22; silicagel: 0,21; activated coal: 0,16.

In figure 4 copper concentration in solution as a function of time are indicated for bioleaching in the percolating system and in the bioreactor system. After 40 days of operation the maximum copper extraction was 27,6 % in the column and 47,6 % in the bioreactor system.

The obtained results suggest:

1) No important difference in iron (III) productivities can be obtained using three different bacteria supports as glass beads, silicagel or activated carbon particles.

2) Higher copper extraction from an ore using bioreactor instead of a percolating column may be due to one or both of these causes:

a) great bacterial population in the biofilm;

b) smaller deposits of jarosites (basic iron(II) sulfates) on the ore when a bioreactor is used; in this case most of the iron (III) basic salts are produced when the iron (II) oxidation occurs and deposits are formed on the support.

FIGURE 3: FERRIC IRON PRODUCTIVITY
AT DIFFERENT FLUX RATES

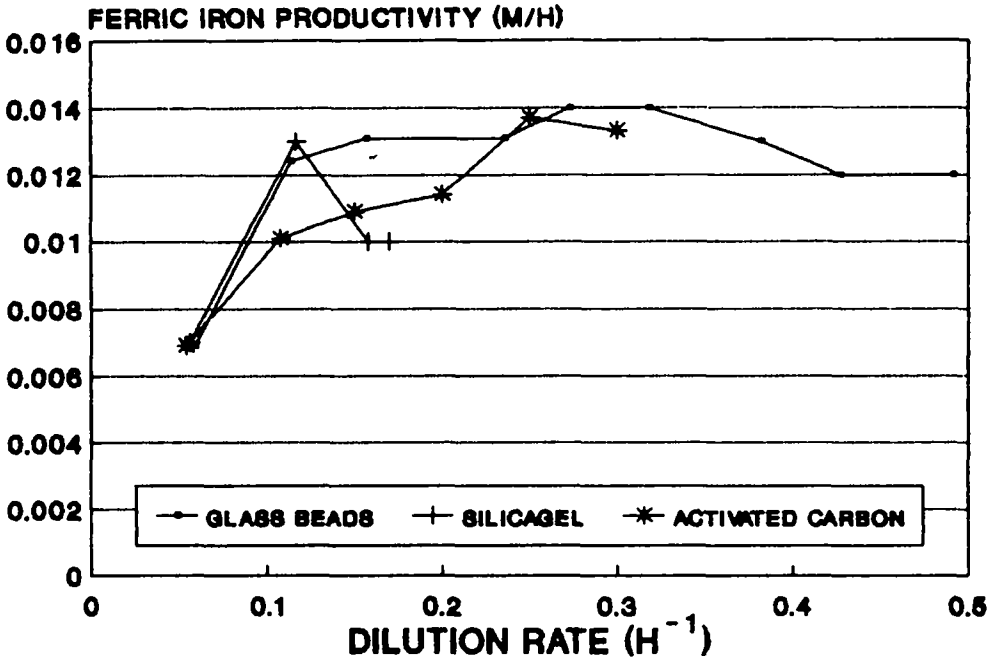
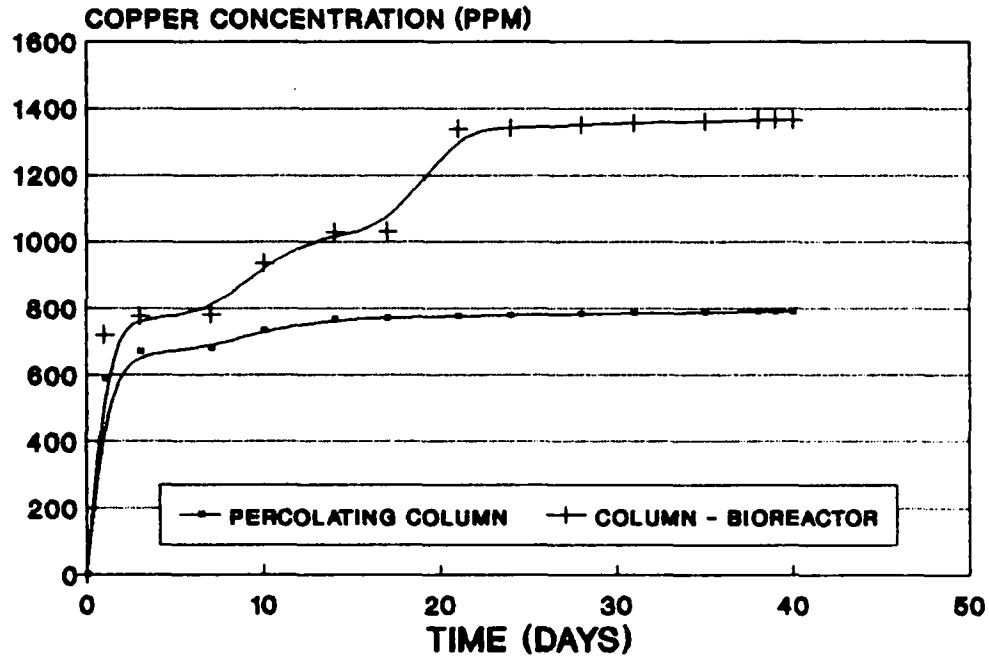


FIGURE 4: BIOLEACHING OF COVELLITE
COMPARISON OF TECHNIQUES



CONCLUSIONS

A better knowledge of the interacting forces between bacteria and support and the influence of the specific surface of this one are needed to explain behaviour of different supports. In our case we tested three different supports with very alike specific surfaces and quite similar iron (III) productivities. It should be noted that according to figure 3, glass beads show an early washout, which perhaps can be due to samller interacting forces. In any case, from a technological point of view, it seems that with similar behaviour the prize of the support should be the criterium of selection.

The comparison of percolating columns and bioreactors show a clear advantage of the last with a greater extraction efficiency and the possibility to separate toxic dissolved species before contact of the solution with the bacteria.

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