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Editors:
Nada Štrbac
Dragana Živković
Svetlana Nestorović

16 - 19 October 2013
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ZINC BIOLEACHING FROM POLYMETALLIC TENKA CONCENTRATE

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Abstract

Bioleaching of low grade complex sulfide concentrates "Tenka" from Majdanpek districts of Mining and Smelting Complex Bor – Serbia have been carried out in a reactor for bioleaching in a stream of air by mesophilic mixed bacterial culture of Acidithiobacillus ferrooxidans, Acidithiobacillus thiooxidans and Leptospirillum ferrooxidans. Mesophilic culture was isolated from the mine drainage waters from underground copper mine, Bor, Serbia. A sample of mine water TR-16 was taken from the direct exploitation of the ore body "Tilva Ros." Leaching reactor was filled with 9k nutrient medium and pH was set at 1.6. Particle size distribution was 87.04% d< 10μm with 8% pulp density. Final extraction of 89% Zn fom polymetallic sulfide concentrate was achived. Kinetic analysis of the diffusion-controlled topochemical reaction, showed that changes in leaching correspond to Spencer Topley - kinetic model.

Keywords: Bioleaching; Polymetallic sulfide concentrate; Mesophiles; Acidithiobacillus ferrooxidans;

1. INTRODUCTION

Polymetallic sulfide concentrates from Majdanpek district (Basin RTB Bor, Serbia) contain 4-14% Pb, 8-27% Zn, 2-4% Cu, 170-500 g/t Ag and 3.7-700 g/t Au. Pyrometallurgical processing of these sulfides in copper smelter plan, could not avoid the formation of their oxides and thus the loss of these metals. In addition, zinc concentrate bioleaching, when compared to hydrometallurgy, has the advantage because it does not require roasting, sulfuric acid plants and washing of the gaseous effluents [1]. *Acidithiobacillus (At.) ferrooxidans*, one of the most important bioleaching microorganisms, bases its action on two mechanisms, namely the direct and the indirect mechanisms. The first one refers to sulfur and sulfide oxidation by the bacteria attached to the particle surface. The latter is related to the oxidation of sulfur compounds by ferric ions resulting from the bacterial oxidation of ferrous ions. Although it is not easy to define the predominance of one or another mechanism, the importance of cell attachment to the particles in order to carry out the biooxidation is widely accepted. [2-4]. The aim of this work was experimental investigation of kinetics of polymetallic sulfide concentrates bioleaching [5].

2. EXPERIMENTAL

2.1 Concentrate

Polymetallic sulfide concentrate "TENKA" is taken from the ore Majdanpek districts (Serbia). The sample contained 3.71% Cu, 27.2% Zn, 18.4% Fe, 4.61% Pb, 3.5g/t Au and 178.9g/t Ag. Tenka concentrate is milled in the laboratory of the Technical Faculty in Bor on Siebtechnik vibrating mill. Particle size distribution has been 87.04% d <10μm after fine milling.

2.2 Bacterial culture and nutrients

Mesophilic mixed bacterial culture *A. ferrooxidans, A. thiooxidans* and *Leptospirillum ferrooxidans*, was isolated from the acid mine drainage waters of underground copper mine, Bor, Serbia. The culture was grown in a mineral salts solution 9K [6]. Characterization of microbial species was performed using molecular-based equipment Quantitative Polymerase Chain Reaction (Q-PCR), and their number was analyzed by Bioclear, Netherland, using Q-PCR and T-RFLP method [7].

2.3 Adaptation of the culture

After isolation and enrichments prepared bacterial culture is adapted for the oxidation of polimetallic "Tenka" (Cu-Zn-Pb-Fe-Ag-Au) sulfide concentrate. Processing was performed in a 2l glass reactor with magnetic stirring at 150 r/min and temperature at 30 ° C in the presence of air enriched with (0.15%) CO_2. The total solution volume was 1l. A solution which contained 5% inoculum, 9K nutrient medium and 5g/l polymetallic concentrate was prepared for the adaptation of microorganisms. Initial pH value is adjusted to pH 1.6. using 1M H_2SO_4. Daily measurements of pH and oxidation-reduction potential (ORP) with platinum pin Ag/AgCl combination electrode were performed during the process. Complete oxidation of ferrous iron was in the period of six days. Oxidation-reduction potential (ORP) value in this period gradually increased from 380 to 550 mV. During the period of 6-8 days the ORP value remained at the maximum level of 550 mV.

2.4 Experimental setup of laboratory bioleaching test

After adaptation by adding fresh quantities of polymetallic concentrates 75 g/l total solids content of the pulp was 8% (w/v) with particle size 87 % and d<10μm. ORP was lowered to initial value of 380mV. The test was continued under the same conditions, in 2l glass reactor. Volume of solution was 1L, temperature was set up at 30 °C with 150 r/min, as well as the adaptation of culture. Air enriched with CO_2 (0.15%) was injected into the reactor through an air diffuser. Acidity was adjusted to pH 1.6 by adding 1M H_2SO_4. Distilled water was added to the reactor to recompense evaporation of process water.

3. RESULTS AND DISCUSSION

3.1 Analysis of the kinetics of bioleaching

Measurement showed that the ORP value gradually increased from 380 to 550mV. Changing the ORP value was followed by an increase concentrations of Zn in solution. After 40 days leaching percentage remained the same level. During this period, final concentration of 19.6 g/L Zn was obtained.

Since the spherical particles have three equal geometric coordinates, they have the largest surface area change (assuming that the reaction rate is the same in all directions). Figure 1, shows the leaching coefficient, α, for zinc as a function of time. It can be seen that for a period of 40 days a maximum zinc leaching was achieved. Extending the bioleaching duration over 40 days, did not led to higher leaching efficiency.

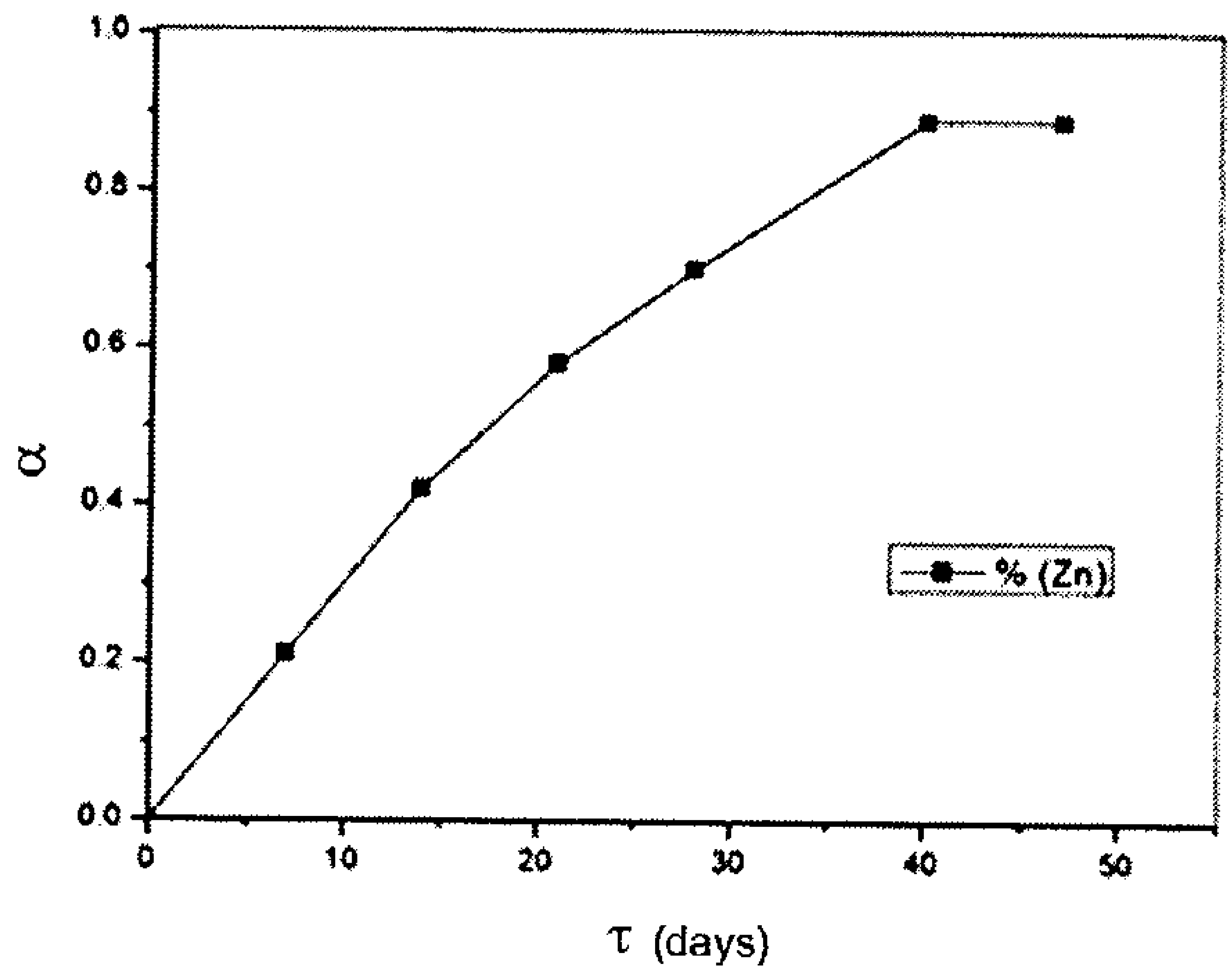

Figure 1. *Dependence of α-fraction of metals reacted Zn, from the time in II system at 30°C temperature with 8% (w/v) pulp density*

In order to determine the kinetic model, the results of leaching as a function of time, $\alpha = f(\tau)$, have been brought into drafting that correspond to different possible reaction mechanisms. Best linearization was obtained by Spencer-Topley equation (1):

$$1-(1-\alpha)^{1/2}=k\cdot t \qquad (1)$$

were is: α-fraction of metals extracted, k-specific rate constant (s^{-1}), t-reaction time (days)

The reaction rate controlled by surface contact reactant-product, indicates that this is a system which is controlled by the geometry and the topochemical reaction in which with decreasing the reaction surface, the reaction rate decreases. Graphical presentation of the experimental data in the coordinate system corresponding to the dependence $1-(1-\alpha)^{1/2}$ in a function of the time is shown in (Figure 2).

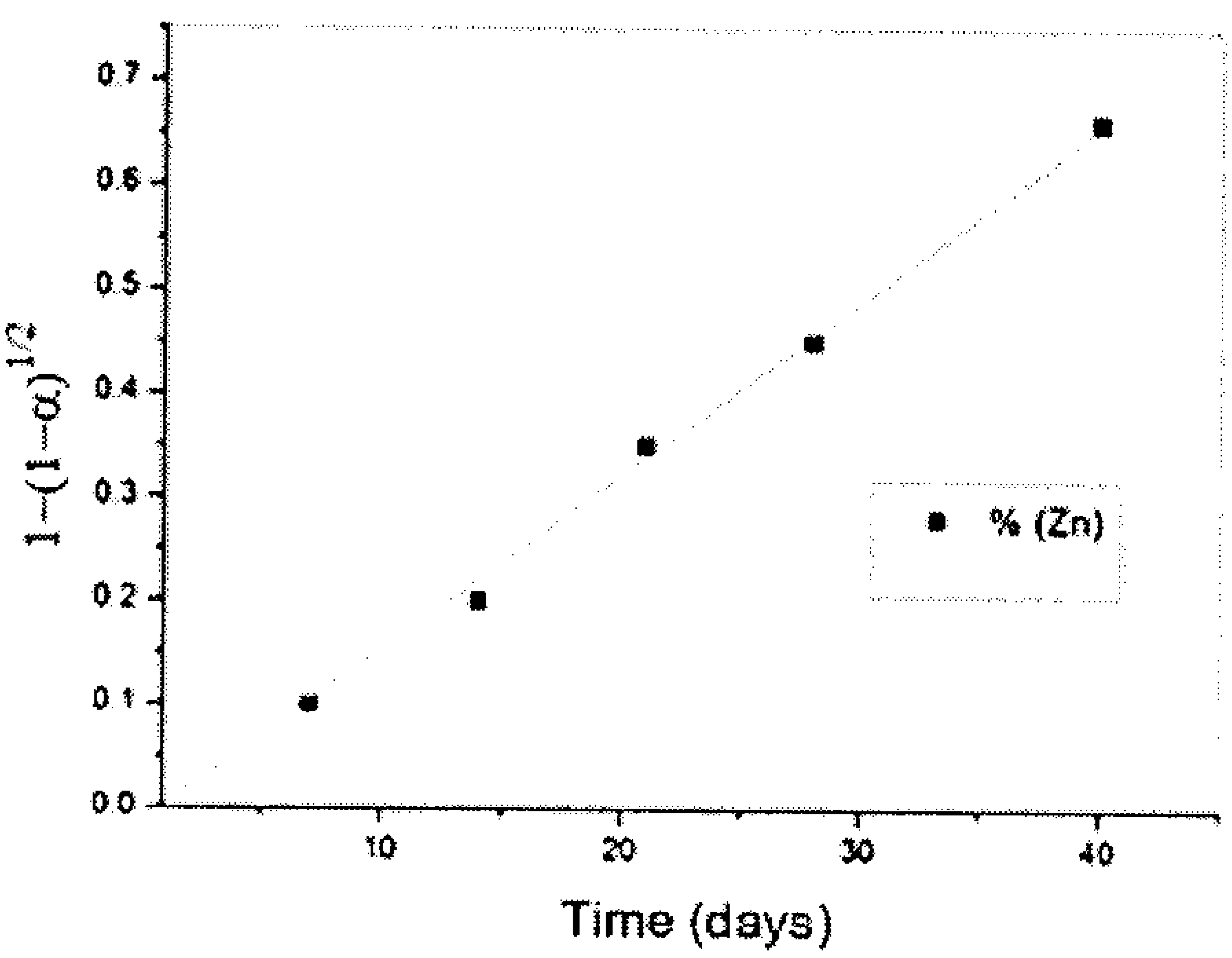

Figure 2 *- 1-(1- α)1/2 versus time from bioleaching Tenka concentrate according to data in Figure 1*

Good linearization exists for the analyzed metal with a straight-line crossing trough the origin of coordinates. The slope of this line corresponds to the rate constant of reaction. In linearization the last point in Figure 1. is not taken into account because there is a saturation after 40th day. Obtained linearization shows that the bioleaching obeys the proposed diffusion Spencer-Topley model. Specific rate constant, k, for Zn calculated from Figure 2 equals $1.6 \times 10^{-7}\ s^{-1}$.

4. CONCLUSION

Mesophilic mixed bacterial cultures, *At. ferrooxidans, At. Thiooxidans* and *Leptospirillum ferrooxidans*, proved to be effective for leaching of polymetallic sulfide concentrate "Tenka" from the Majdanpek ore body, RTB Bor, Serbia. This paper shows that mesophilic mixed bacterial cultures can be used for bioleaching of polymetallic concentrate with 89% Zn eficiency of leaching. Kinetics considerations show that the process of bioleaching of polymetallic sulfide concentrates obeys the Spencer-Topley model for topochemical reactions on the spherical particles in which all three dimensions are equally developed.

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