BIOEXTRACTION OF COPPER FROM PRINTED CIRCUIT BOARDS: INFLUENCE OF INITIAL CONCENTRATION OF FERROUS IRON

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Keywords: bioextraction, ferrous iron, copper, printed circuit boards, Acidithiobacillus ferrooxidans-LR.

Abstract

Printed circuit boards are found in all electric and electronic equipment and are particularly problematic to recycle because of the heterogeneous mix of organic material, metals, and fiberglass. Additionally, printed circuit boards can be considered a secondary source of copper and bacterial leaching can be applied to copper recovery. This study investigated the influence of initial concentration of ferrous iron on bacterial leaching to recover copper from printed circuit boards using Acidithiobacillus ferrooxidans-LR. Printed circuit boards from computers were comminuted using a hammer mill. The powder obtained was magnetically separated and the non magnetic material used in this study. A shake flask study was carried out on the non magnetic material using a rotary shaker at 30°C, 170 rpm and different initial concentrations of ferrous iron (gL⁻¹): 6.75; 13.57 and 16.97. Abiotic controls were also run in parallel. The monitored parameters were pH, Eh, ferrous iron concentration and copper extraction (spectroscopy of atomic absorption). The results showed that using initial concentration of ferrous iron of 6.75gL⁻¹ were extracted 99% of copper by bacterial leaching.

Introduction

Bioleaching is based on microorganism´s capacity to produce Fe⁺³ ion, which is a powerful oxidant (¹). Oxygen availability is fundamental in the bioleaching since the bacterium A. ferrooxidans is aerobic and consumes O₂ in the biological oxidation of ferrous iron, as showed in Equation 1²:

$$2Fe^{2⁺} + 1/2O_2 + 2H⁺ \rightarrow 2Fe^{3⁺} + H_2O$$

(Eq. 1)

Ferric iron oxidizes metals, allowing metal´s dissolution in the acid medium (pH <2.0), e.g. copper (Equation 2):

$$Cu + 2Fe^{3⁺} \rightarrow Cu^{2⁺} + 2Fe^{2⁺}$$

(Eq. 2)

Ferrous iron is regenerated to ferric iron through Fe^{2⁺}/Fe^{3⁺} cycle promoted by bacterial activity. Comparing with conventional recycling processes like hydrometallurgical and pyrometallurgical, bioleaching has advantages, such as mild reaction, low energy consumption, works at room temperature and normal atmospheric pressure, environmentally friendly and suitable for low-grade mine tailing and residues (³,⁴).
Nevertheless, bioleaching is dependent of physical, chemical and biological factors, including composition of waste or ore, pulp density, temperature, pH, ionic composition, Fe$^{3+}$ concentration, oxidation–reduction potential, particle size, concentrations of dissolved oxygen and carbon dioxide, composition of the medium, adaptation process, bacterial strain and cell concentration\(^{(3,5,6)}\).

Effect of each parameter on bacterial leaching is not completely elucidated. Determination of optimal conditions is essential to enhance the metals bioextractions from printed circuit boards.

Printed circuit boards are found in all electrical and electronic equipment being generally composed of polymers, ceramics and metals. Because of the amount that has been accumulated, it has become a prominent environmental problem, but also can be a source of valuable materials, such as metals\(^{(3,7)}\).

Studies performed with/without addition of Fe$^{2+}$ in the bioleaching using shake flasks\(^{(8,9)}\) reported that ferric ion generated by \textit{A. ferrooxidans} activity oxidizes metals through indirect bacterial mechanism\(^{(10)}\).

The primary purpose of this article is to investigate the influence of initial concentration of ferrous iron on bioleaching to recover metals from non-magnetic fraction of printed circuit boards of obsolete computers using \textit{Acidithiobacillus ferrooxidans}-LR bacteria.

### Materials and methods

#### Characterization of printed circuit boards

Characterization of printed circuit boards from computers used in this study is reported in previous paper\(^{(11)}\). Samples from non-magnetic fraction of printed circuit boards from obsolete computers were obtained by comminution and magnetic separation. Figure 1 presents a flowchart of characterization steps.

![Flowchart of printed circuit board characterization](image-url)