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Iron oxidation by ferrooxidans cultures. The effect of operational conditions

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INTRODUCTION & AIM

Ferrooxidans is a Gram-negative bacterium capable of obtaining energy through the oxidation of various inorganic compounds. This microorganism is commonly found in acidic mine drainage waters of iron-rich environments and plays a dominant role in bioleaching processes.

$$4Fe^{2+} + O_2 + 4H^+ \xrightarrow{\textit{Ferrooxidans}} 4Fe^{3+} + 2H_2O$$

These microorganisms have developed adaptive mechanisms to survive in highly acidic environments and in the presence of elevated concentrations of heavy metals, making them effective biological agents in AMD remediation.
The objective of this work is to optimize the pH and iron concentration for the cultivation of the strain obtained from the San Quintín mine.

METHOD

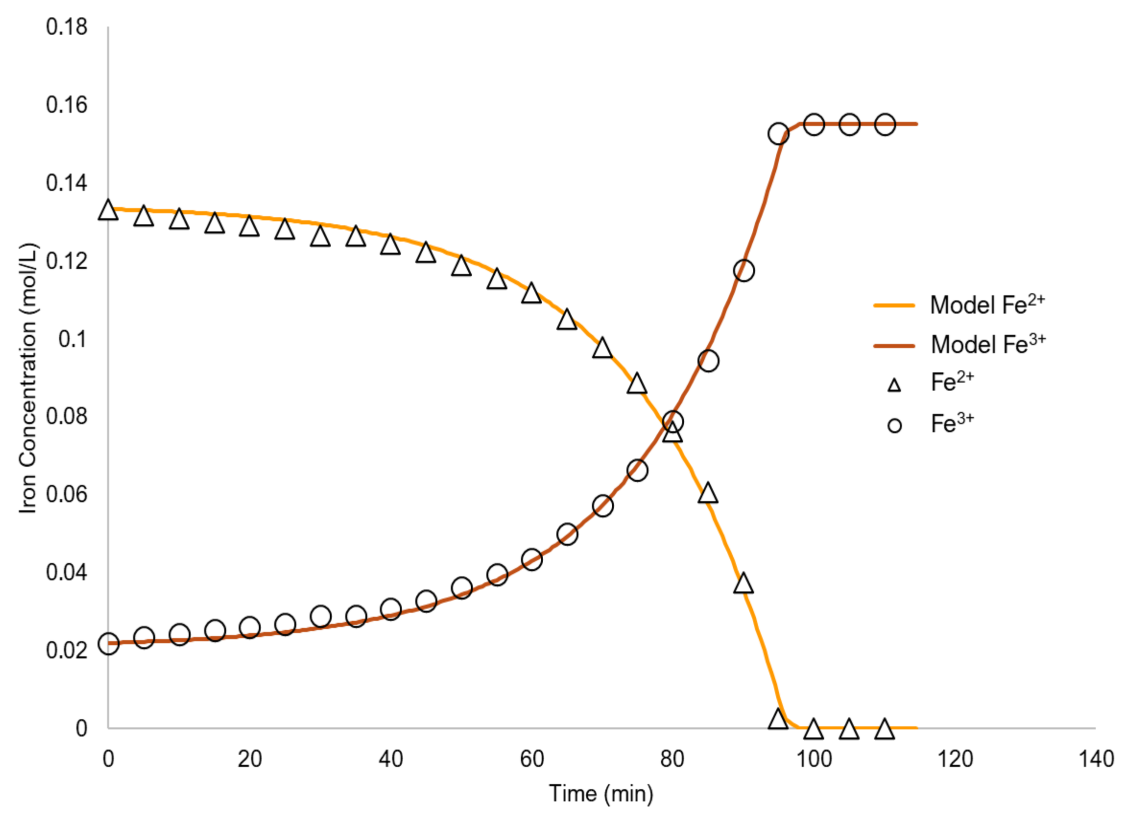
AMD from the San Quintín Mine, located near Ciudad Real (Spain), was used as the source for the microbial culture.

Figure 1. San Quintin Mining site.

A sequencing batch reactor was used to acclimatize the microbial culture. The batch reactor operated with a working volume of 2.4 L and was mixed by means of a mechanical stirrer rotating at 500 r.p.m.
Atmospheric air, 6 L/min, was fed to the batch reactor. In order to avoid medium evaporation, the inlet air was subjected to a pre-humidification step. The sequencing reactor was operated keeping 16 % (v/v) of previous cycle as inoculum source for the subsequent cycle. The medium composition was: $(NH_4)_2SO_4$ 3 g/L, K_2HPO_4 0.5 g/L, $MgSO_4 \cdot 7H_2O$ 0.5 g/L, KCl 0.1 g/L, $Ca(NO_3)_2$ 0.01 g/L and $FeSO_4 \cdot 7H_2O$ 44.22 g/L.
Redox potential was measured to determine the Fe^{3+}/Fe^{2+} ratio. When medium cultured was acclimated, a Monod based mathematical model was fitted to the experimental data set obtained in the steady state operation of the bioreactor, and the parameter values were determined. Experiments with different pH levels and iron concentrations were carried out to optimize these fundamental parameters in the growth of *Ferrooxidans*.

RESULTS & DISCUSSION

One of the steady cycles were modelled by using the Monod based mathematical model developed in this work, results presented in Figure 1. As can be see in this figure, the mathematical model accurately predicts the behaviors of the system.



Parameter
$Y_{s/x}$:0.0359 Cmol/molFe^{2+}
m_{Fe}: 0.25 mol Fe^{2+}/Cmol/h
q_{Fe}^{max}: 1.6529 mol Fe^{2+}/Cmol/h
k_{Fe}: 0.0001

Figure 2. Iron (II) and (III) profiles during the experiment. Lines corresponds to model fitting.

At pH 1.5 and 2.0, the redox potential reaches its maximum value faster than the others, indicating that both pH levels are more optimal for culture performance. The 22 g/L concentration results in the shortest Fe^{2+} to Fe^{3+} oxidation time. Higher and lower concentrations lead to longer processes, and some fail to achieve the maximum redox potential.

CONCLUSION

This study confirms the model's predictive goodness, demonstrating that accurately predicts the iron concentration profiles during the acidophilic microbial culture metabolisms.

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