Improved Bioleaching through Electron-Stimulated Bacteria

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Background and Goals

The mobilization of metal cations from often almost insoluble ores by microbiological processes is referred to as **bioleaching**, being now a worldwide established **geobiotechnological process**, mainly employed for copper, cobalt, nickel, zinc, gold, and uranium. The bioleaching **bacteria**, such as *Acididthiobacillus ferrooxidans*, can accelerate sulfide ore dissolution and convert metals into a soluble form [1]. **Chalcopyrite** represents approximately 70 % of the world's copper reserves. However, chalcopyrite is very recalcitrant and bioleaching is inhibited at ambient temperature by the formation of a passivation layer. To date, bioleaching of chalcopyrite has not been successfully commercialized. One hypotheses suggest that very low doses of ionizing radiation can induce a **biopositive effect (radiation hormesis)** [2]. Therefore, we investigated whether **Low Energy Electron Irradiation (LEEI)** can trigger a stimulating effect on bacterial activity and copper bioleaching rates.

LEEI Equipment and Procedure

For the irradiation of the bacterial suspension we developed a novel set-up, based on a vessel on a magnetic stirrer to move the fluid during irradiation [3]. We determined the depth dose distribution by modelling and experimentally (**Fig. 1 A, B**).

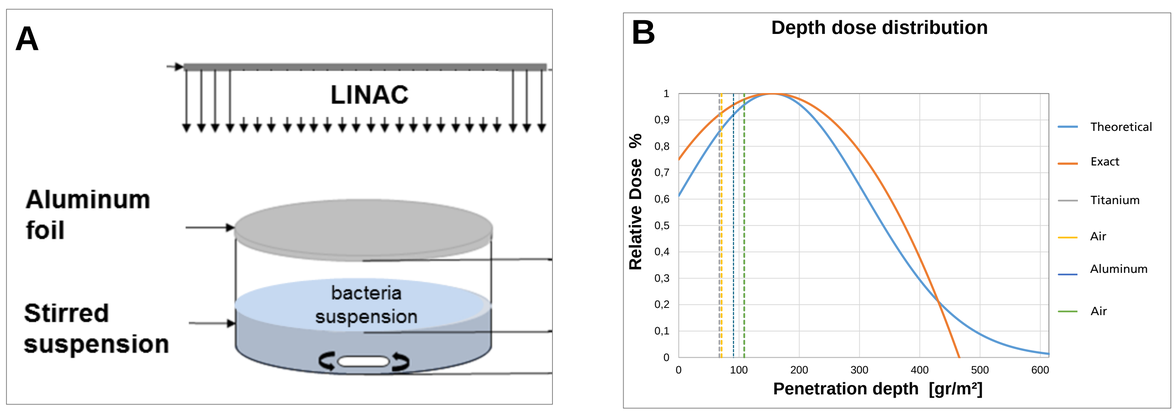

Fig. 1: A: Irradiation set-up; B: Theoretical model of the depth dose distribution

Suspensions were irradiated for different time points (**Fig. 2 A, B**) in the LEEI-research facility REAMODE using a static module (**Fig. 2 D, E**).

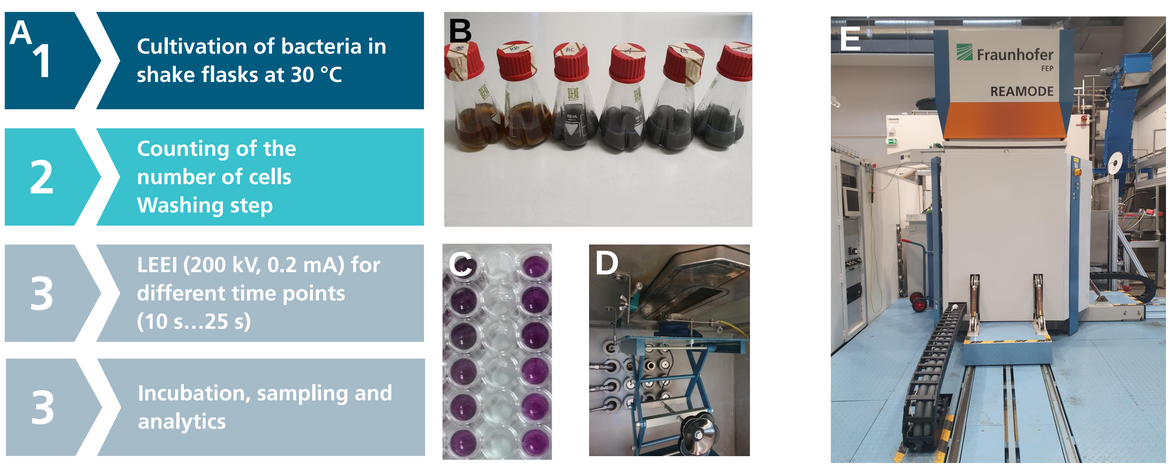

Fig. 2: A: Work-flow for LEEI of bioleaching bacteria [4]; B, C: Cultivation flasks and iron assay; D, E: LEEI facility REAMODE (Reactive Modification with Electrons) and static module.

Bioleaching Results after LEEI of Bacteria

Prior to LEEI, the bacteria were grown, collected, and the number of cells determined. After LEEI, the progress of copper bioleaching was monitored by the concentration of dissolved ferrous, ferric and copper ions. The development of the pH was also recorded (**Fig. 3 A-D**). Our results demonstrated, that the **concentration of dissolved copper** leached by LEEI-treated bacteria was **reproducibly higher** compared to non-irradiated control cultures.

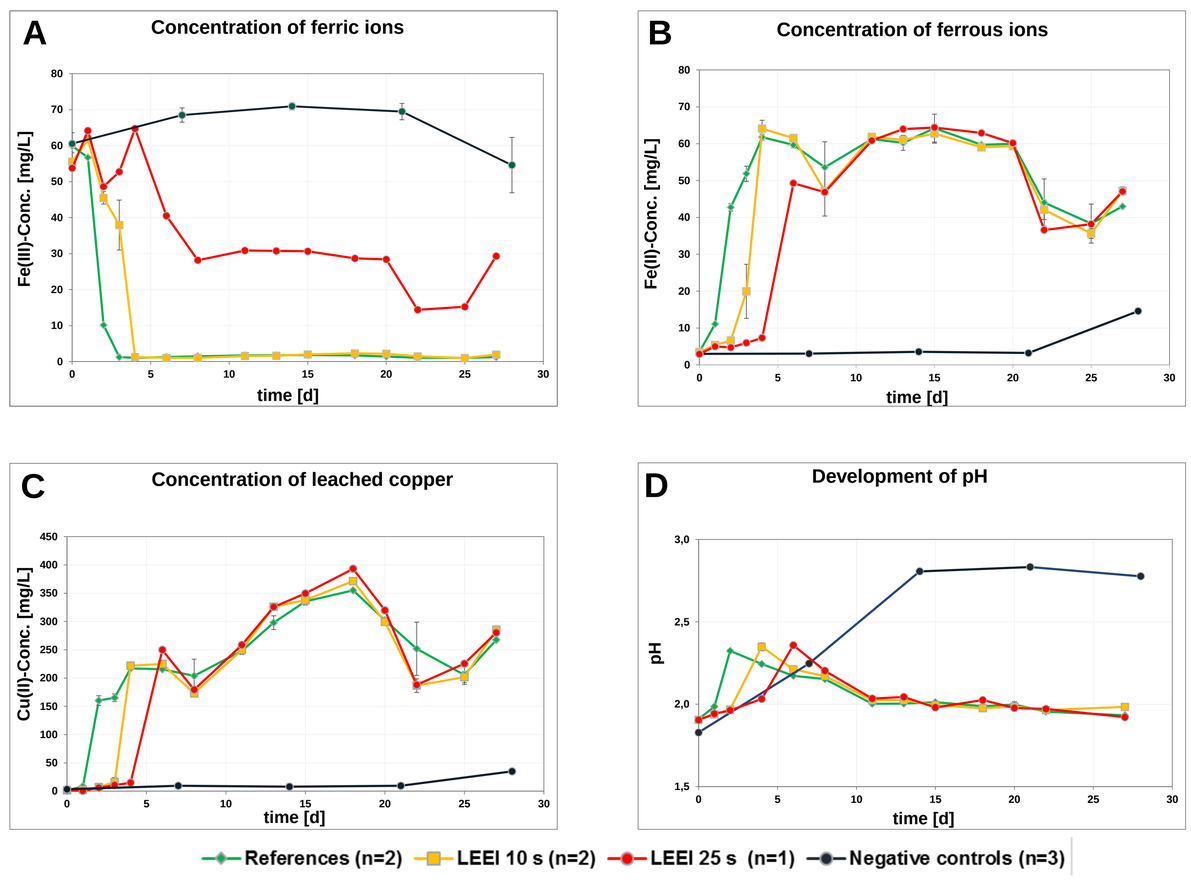

Fig. 3: Process monitoring of copper bioleaching. A, B: Development of ferric and ferrous ions; C: Concentration of dissolved copper; D: Development of the pH.

Conclusion

With regard to LEEI of bioleaching bacteria for the winning of copper the major findings were:

- 10 s LEEI-treated bacteria showed a 1.4 - fold higher copper leaching rate compared to non-irradiated cultures (**Fig. 4**)
- 25 s LEEI treatment had no positive effect on copper bioleaching
- LEEI-treated bacteria showed growth delay

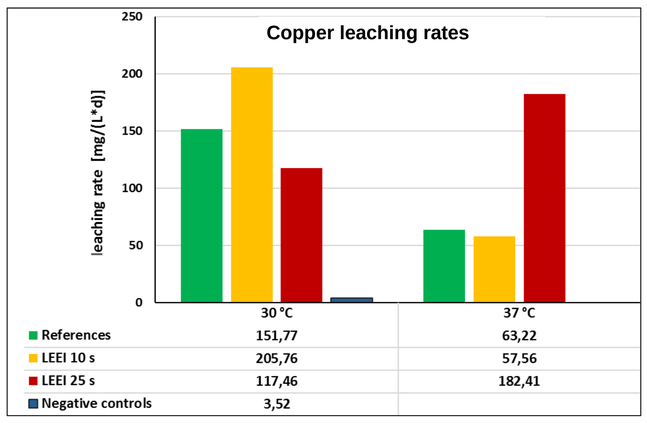

Fig. 4: Comparison of absolute copper leaching rates

Outlook

To optimize the system we are developing:

- an automated irradiation process for suspensions in the low dose range
- A technology for the upscaling of the process in a bioreactor
- Improved methods for the determination of the metabolic activity

Kontakt
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