E3B The Elements of Bioremediation, Biomanufacturing & Bioenergy
Metals in Biology

Durham University | University of Kent | Manchester | UKRI Biotechnology and Biological Sciences Research Council

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E-TECH RESOURCES | BGS British Geological Survey

Selection of rare earth elements through uptake by methylotrophs (SERUM)

"Collaborating on this project allowed us to evaluate a novel bioleaching approach to recover rare earth elements. The work carried out here is already being followed up in other projects and we hope that in future this can be developed into a commercially viable method" British Geological Survey

PROJECT AIMS: Rare earth elements (REE) are needed for many hi-tech and green technologies such as catalytic converters, batteries and wind turbines. Bacteria offer a potential solution to the challenge of recovering and separating REE from ores, liquids and electronic waste. For example, methylotrophs — bacteria that consume single-carbon compounds — can selectively take-up light REE into their cells. This project aimed to:
- Isolate methylotrophs that could be used in bioleaching from acid environments and then:
- Test the methylotrophs for their ability to selectively uptake REE from solution.
- Test the methylotrophs for their ability to selectively leach and uptake REE from monazite, a rare-earth phosphate ore that contains REE.

OUTCOMES & NEXT STEPS:

- Research will continue within an EPSRC-funded project called Met4Tech. The work will include use of beneficial strains identified in this study and will extend the research to leaching of electronic waste.
- Further work with the methylotroph strains to leach rare earth elements from lamp phosphor waste was funded by the EPSRC Met4Tech project (EP/V011855/1).
- An abstract was presented at the Biomining '23 conference, and a paper will be submitted to an associated issue of *Minerals Engineering*.
- The PIs are in discussions with industrial partners about developing this technology for recovering rare earth elements, and preparing a proposal for the Innovate UK CLIMATES 'Circular Critical Materials Supply Chains' programme.

RESULTS:

Removal of REE from solution:
- All the tested methylotrophs could remove REE from solution, but removal was also observed in control experiments.
- REE were returned into solution after acidification (which desorbs REE from cell surfaces). The amount of heavy REE released was higher than light REE.
- These results suggest that the most likely mode of action for REE removal was through sorption to the extracellular surfaces of the rather than selective uptake into the cells.

Monazite bioleaching
- Methylotrophs could leach REE from monazite, although the amount of leached REE was modest.
- Bioleaching released REE from the monazite into solution during the experiment. Additional REE was released after acidification.
- The different methylotroph strains had different abilities to leach REE from monazite.
- Bioleaching of REE occurred at neutral pH and most of the REE was then sorbed to cell surfaces.
-Results did not suggest a major role for the uptake of REE via the lanthanide dependent methanol dehydrogenase pathway, but cannot be ruled out without further investigations.

Change in technology readiness level from: 1 to 2
The project showed that methylotroph strains are involved in leaching REE from monazite and adsorption onto cell surfaces. The technology is now ready for further optimisation, investigating the molecular mechanisms involved and applying it to other materials for leaching.

The volcanic mud pool on Vulcano Island, Italy from where samples were collected for the isolation of acidophilic methylotrophs. It was not possible to isolate methylotrophs from these samples, so experiments were carried out using a collection of mesophilic methylotrophic strains held by the British Geological Survey.
Photo credit: Cinzia Federico, Instituto Nazionale di Geofisica e Vulcanologia