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

Durham University · University of Kent · Manchester 1824 The University of Manchester · Biotechnology and Biological Sciences Research Council

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BIVE3B001 BB/S009787/1

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JM Johnson Matthey Inspiring science, enhancing life

Developing a novel chemo-enzymatic catalytic cascade for producing stereoselective high-value chemicals

"This project was beneficial to Johnson Matthey for a number of reasons. Colleagues were able to get hands-on experience with the facultative anaerobe used in the project, for example, observing its colour change in low-oxygen environments. Reduction of metal salts by these bacteria is of interest as a new way to recover and recycle platinum group metals, and discussions about the project raised some interesting questions about the mechanism of bio-nanoparticle formation. Chemoenzymatic synthesis of high-value molecules is another area we may explore further following this successful interaction."

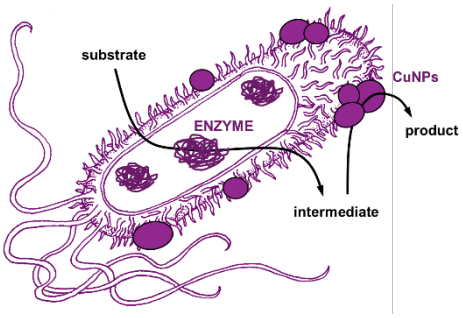
PROJECT AIMS: This project combined biotechnologists from the University of Manchester (UoM) and industrial catalysis experts at Johnson Matthey (JM), a multinational speciality chemicals and sustainable technologies company. The aim was to develop a novel chemo-enzymatic catalytic cascade for production of stereoselective, high-value chemicals. The first aim was to optimise reaction conditions for a two-pot sequential process (biocatalyst followed by NP catalyst). The next aim was to combine both catalysts in a single-pot, reducing operation time and waste. An additional focus was to select solvent systems compatible with the novel bio-metallic whole cell systems, and the substrates/products involved.

RESULTS: Multistep catalysis reactions have been optimised and tested as components of one-pot novel chemo-enzymatic catalyst. Initial, experiments targeted improving Cu and Pd NP catalyst synthesis using *Shewanella oneidensis*. For Cu, highly toxic and challenging to bioreduce, we were able to uncover Cu-bioreduction mechanisms and double the concentration of Cu recovered as catalytically active CuNPs (tested in an archetypal click reaction). For Pd, we optimised metal NP synthesis and metal-loading on cells, then confirmed high catalytic activity in a model Suzuki coupling reaction. Following successful NP-catalyst synthesis, *S. oneidensis* was engineered to overproduce an enzyme biocatalyst - *Shewanella* old yellow enzyme (SoYE) confirming that: a) this enzyme is overexpressed and b) SoYE overexpression does not interfere with synthesis of the Cu or Pd-NP chemo-catalysts. Working with JM at their laboratory in Cambridge, we screened and benchmarked the enzyme biocatalyst activity of our strain, against numerous JM ene-reductase expressing whole-cell biocatalysts (under a confidentiality agreement). During this work, access to JM laboratories, knowledge exchange and open discussions about potential cascades and solvent choices were critical to success. Overall, via this BIV we were able to demonstrate proof-of-concept of individual components of the novel catalyst and generate a framework for finalising the one-pot system.

Change in technology readiness level: 1 to 2.

OUTCOMES & NEXT STEPS:

- Aspects of this work will be continued under recently awarded funding from a BBSRC Engineering Biology programme. Work is ongoing to demonstrate activity of the chemo-enzymatic catalyst in a one-pot cascade. We are also focusing on bio-compatible solvent selection to further optimise substrate conversion and product yield.
- Some aspects of this work will be pursued via new Engineering Biology funding, and a University of Manchester-funded PhD project. Other opportunities with JM will be pursued as they arise.
- A collaborative paper for publication in a high impact journal is being drafted.



Schematic of an industrial process coupled to the catalytic properties of biologically synthesised metal nano-particles.