Microbial bioprocessing and functional magnetic nanomaterials

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Research group: Energy & Bioproducts Research Institute (EBRI)

Degree Program: Chemical Engineering

Project Aim and Objectives

The main focus of the project is to develop novel bioprocessing strategies for the production of magnetosomes. The two main challenges of this work are to (i) identify what process parameters lead to MTB cease growing and hence stop magnetosome production and (ii) develop alternative production strategies to achieve higher magnetosome yields. Processing of magnetosomes presents similarities to that of biopharmaceutical protein products. They need to be produced in a cellular host, purified and subsequently formulated. To achieve the research objective, the carefully planned programme will comprise three work packages, each with a single overriding goal:

Goal 1 (WP1, 10 months): Methodology development: set up of the magnetosome production strategy and analytical methods to measure relevant parameters (i.e. magnetosome amount, cell physiology, consumption of substrate) to ensure process quality and robustness.

Goal 2 (WP2, 10 months): Based on findings in WP1, definition of new bioprocess conditions for improved magnetosome production focusing on effect of process parameters (air supply and operational strategy) and supply of iron/nutrients.

Goal 3 (WP3, 10 months): Utilisation of novel fluorescent methods to monitor process quality. Conditions established in WP2 will be used to test the suitability of using flow cytometry and confocal/fluorescence microscopy to measure indirectly the production of magnetosomes.

Project Description

Many types of bacteria are studied scientifically and used industrially to make products such as medicines, plastics and fuels, and to clean waste streams. There exists a family of bacteria called magnetotactic bacteria (MTB) that make tiny crystals of iron called magnetosomes (MS) that allow them to function like a compass, and point to the earth’s magnetic north pole.
Magnetosomes can be extracted from MTB and used in a wide range of biotechnological applications such as cancer treatment, MRI contrast agents or diagnostics. MS represent an alternative to chemically-synthesized magnetic nanoparticles (MNPs) and this is advantageous as MNPs often require synthesis at high temperatures, use of organic solvents and generate hazardous waste. Therefore, MS have the potential to become the next generation of biologically-made magnetic nanoparticles produced using environmentally friendly routes. However, magnetosomes account only for up to 4% of the total microbial biomass and their commercialisation is hindered by high production and recovery costs. However, future widespread applications of MS, to a large extend, depend on the challenging development of intensified high-yielding biomanufacturing platforms.

We have recently developed a fermentation strategy for MS production and developed methods for MS characterisation in whole-cell biomass. Hence, the proposed studentship has a solid scientific background.

In this project, we will expand upon our expertise and aim to (i) understand the growth conditions in which MS are optimally produced and to (ii) identify and elucidate the dynamics of key molecules that affect MS production. We will employ bioanalytical tools such as confocal microscopy and flow cytometry to understand microbial molecular dynamics and physiology, respectively, and how these correlate with MS production in lab-scale bioreactors.

We expect that the outcomes of the project will contribute to the development of sustainable bioprocesses and products respectful with the environment and with the beneficial impact into our society and healthcare.

**Knowledge and skills required in applicant**

- BSc or MSc qualification in Biochemical Engineering, Biotechnology or Environmental Sciences
- Experience in experimental work, intermediate use of Microsoft Office and use of statistical analysis tools
- Knowledge of aseptic techniques, handling microorganisms and biocatalysis/enzymology
- Knowledge in bioreactors, fermentation technology or genetic engineering is an asset.
o Good communication skills and motivated to work individually and as part of a team.

o Willingness to get involved in broader EBRI/AIMR activities (public engagement, assist in lab demonstration, etc...)