Bioelectrochemically assisted synthesis of biosurfactants - towards a new energy-neutral biosynthesis process

Biosurfactants are a high-value product that can be used as an environmentally friendly substitute for synthetic surfactants. They have surface-active properties, such as reducing the surface tension of a liquid. Biosurfactants are easier to break down in the environment and are less toxic to living organisms. However, their competitiveness is limited by the cost of production. Conventional biosynthesis in bioreactors requires energy input for stirring, dosing, flow control, as well as the supply of oxygen as an electron acceptor and downstream processing.

To reduce the cost of biosurfactant production, we will establish, investigate and optimise a new process of bioelectrochemically stimulated synthesis. The research will be conducted by using bioelectrochemical systems based on microbial fuel cells. A microbial fuel cell (MFC) is a device that uses bacteria to generate electrical energy. Bacteria colonise the MFC electrodes and form a thick layer called biofilm. Simple organic compounds, wastewater and various waste products such as food processing waste can be used as fuel and converted into electricity by the bacteria.

The proposed process will therefore lead to the simultaneous production of biosurfactants and electricity. In contrast to conventional biosynthesis, we will use an electrode as a continuous electron acceptor. In addition, such an approach will allow us to precisely control the bacterial metabolism of the species responsible for current and biosurfactant production. To establish and improve the efficiency of the process, we will apply the high-throughput approach, which is particularly challenging for bioelectrochemical systems due to the large number of electrode connections. With the use of a customized high-throughput screening approach we will incorporate an additional electrochemical dimension to unravel the unique features of biosurfactant producers. We will also determine the properties and chemical structure of the biosurfactants produced, and their potential applications. The experimental scenarios planned within the project will allow us to optimise this new process and define its limits for future upscaling of this technology. Our results so far indicate that the process of biosynthesis is directly correlated with the generation of electricity. Further exploitation of this phenomenon may lead to a new method of monitoring synthesis through simple electrical signal measurement.

In wider perspective, the outcomes of the research will lead to the development of novel, energy-neutral technology of biosynthesis where the substrates serve both a fuel to produce energy and to produce added-value biomolecules. This may lead to increasing their cost-efficiency against conventional surfactants. Biosurfactants produced in this self-sustainable process may find their use in chemical industry, cosmetics as well as biomedical industry.

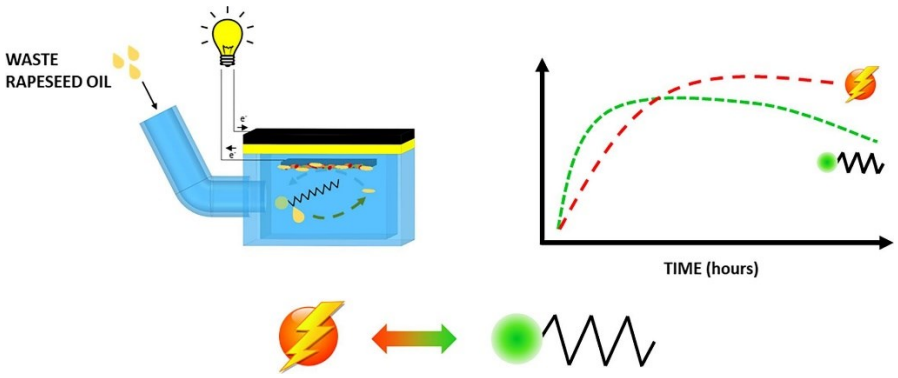

Figure 1. The proof of concept scheme for power production and concomitant biosynthesis of surfactants from waste rapeseed oil, demonstrating dependence of electrical signal and biosurfactant synthesis.