Unlocking the biosynthetic machinery for biosurfactants in deep-sea and hydrothermal vent microbialcommunities: metagenomic and metabolomic approaches to biotechnological production

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Project Summary

Surfactants are amphiphilic molecules, with natural tendency to form self-aggregates and lower surface tension. Due to a wide range of household, industrial and pharmaceutical applications, surfactants are extremely important from an industrial perspective. Today, exhaustible fossil resources are the starting material for surfactant production. Therefore, faced with the increasing demand from industry, there are both economic and ecological reasons to find alternative renewable sources for surfactants. In this scenario, biosurfactants (surfactants from natural sources) have raised significant attention, as being less toxic, active at lower concentrations, and more resistant to extreme conditions as compared to the synthetic ones. Moreover, biosurfactants are endowed with several pharmacological properties, such as antimicrobial, antitumoral, antiviral and anti-inflammatory activities.

The present project aims to exploit the biosynthetic potential of deep-sea and hydrothermal vent microbial communities in the Gulf of Naples (Mediterranean Sea), for the sustainable production of marine biosurfactants, including, among the other chemical classes, marine siderophores (iron chelating agents). So far, marine extremophilic bacteria have been acknowledged as a prolific factory of biosurfactants, featuring unusual chemical architectures with no counterpart in the terrestrial environment. However, the genomic era has unveiled that cultured bacteria represent a very small fraction of the total estimated bacterial biodiversity. The advent of metagenomics, i.e., genomic analysis of a mixed population of organisms, has given access to uncultivated bacteria, thus providing insights into previously overlooked biosynthetic pathways for natural products and circumventing current limitations in traditional cultivation technologies.

To explore microbial communities inhabiting extremophilic niches, this project proposes a ground-breaking approach, combining

a) mass-spectrometry-based molecular networking analysis with b) homology- and functional-based screening of environmental metagenomes, to identify novel marine biosurfactants and the relevant biosynthetic gene clusters.

In the frame of this genome-directed lead discovery pipeline of unprecedented chemical entities, harnessing the natural

biosynthetic machinery is expected to be of interest for biotechnological applications, as inspiring concepts to develop genetic platforms for heterologous production of biosurfactants. With this regard, the ultimate challenging goal of this PhD project is the cloning and heterologous expression of a biosurfactant/siderophore gene cluster from uncultivated extremophilic bacteria into a culturable host, thereby paving the way for sustainable and eco-friendly production through microbial fermentation.

GRAPHICAL ABSTRACT