2024 年度

創発的研究支援事業　年次報告書【公開版】

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研究課題名	Elucidating Physical Communication in Bacterial Communities to Direct Self-Assembly
研究実施期間	2024 年 10 月 1 日～2025 年 3 月 31 日

研究成果の概要

Theme 1 – Biofilm formation at the Oil/Water interface:

This year, we began laying the groundwork for exploring how bacteria deform soft-materials using physical communication of forces. We have begun some redesigning of previous iterations of our microfluidic channels to accommodate a direct flow of on-demand generated droplets. This work is ongoing.

In addition, we have begun using mixtures of oil in anticipation of future tests to compare bacterial traction on liquid versus soft interfaces. To this end, we have begun confirming that our previously observed phenotypes that form dendritic biofilm (DB) structures and spherical biofilm (SB) structures retain their phenotypes whether or not we use an oil that is entirely or partially metabolizable. A strong physical component that affects interfacial behavior of the bacteria is the interfacial tension. Thus, we also have begun measuring the surface tension of the oil mixtures using various methods such as pendant drop method, the Du Nouy ring method, and a microfluidic method. This final method, if successful, is promising since it will enable us to measure the active surface tension of the biofilm directly, which is a key unknown parameter.

Theme 2 – Bacterial Self-Assembly:

From late in the fiscal year 2024, I hired a postdoc to work with me. I have been training him in microbiology and in microfluidic design and imaging analysis. We have tested designs and have begun to measure important parameters such as the biofilm thickness under flow. We have obtained images of our wild-type (WT) strain's biofilms showing mono- and bi-layer biofilms depending on the flow speed. We hypothesize that these structures depend on the shear flow in the channels, which likely carry away the cells, leaving only a monolayer of cells in our microfluidic devices. We are also testing growth conditions to be able to fully control the system. In addition, we applied this to our micro-channel-grown biofilms.

Furthermore, in our image processing of live-cell biofilms, we are developing a pipeline for clear cell segmentation to enable cell tracking, and reconstructions of the biofilms. In preliminary results, we have calculated the important structural indicator, the radial distribution function, which describes the local-to-long range order in colloidal systems, demonstrating the crystalline order in our system. We will determine ways to modify and modulate these structures.

Relating to both topics, I have written a review article in *Current Opinions in Solid State and Material Science* (published in May 2025) related to the topics being explored in *Sohatsu*, particularly in using interfaces and other physical means to assemble bacteria. This topic is not only related to Themes 1 and 2, but also has particular relevance to Theme 3 (Biomolecule mediated Assembly and Disassembly).