הטכניון - מכון טכנולוגי לישראל

TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY

הפקולטה להנדסה כימית
ע״ש וולפסון
The Wolfson Department of Chemical Engineering

Wolfson Department of Chemical Engineering Special Seminar
Hall #6, Wolfson Department of Chemical Engineering,
Tuesday February 26th at 2:00pm

Prof. Dr. Uwe Thiele
Institut für Theoretische Physik, Universität Münster
Münster, Germany

Long-wave modelling of spreading biofilms

First, we review recent experiments on and biophysical modelling approaches for the early stages of osmotically spreading biofilms at an agar-air interface (e.g. [1,2]). Doing so, we highlight important experimental features and successes/limitations of the various models. In particular, it is pointed out that modelling has paid little attention to the physico-chemical interactions of the film and the agar (adhesion, wettability, etc) [3]. We propose to incorporate these surface forces in the form of a wetting potential that accounts for finite contact angles at the three-phase contact line where biofilm, agar and gas phase meet.

Second, we establish the basic modelling principles of thin-film hydrodynamics for the dynamics of free surface films of mixtures and suspensions where all aspects of capillarity and wettability may, in principle, depend on the local film composition. We argue that in a passive (non-bioactive) limit one has to be able to write all such models in the form of a gradient dynamics. The passive model is then extended by bioactive terms like bacterial proliferation and matrix or biosurfactant production to reach a set of simplified models for the growth dynamics of biofilms [4].

Finally, we employ such models to investigate two phenomena: (i) It is shown that surface forces determine whether a biofilm can expand laterally over a substrate. In particular, we discuss modelling results and experimental evidence related to a transition between continuous and arrested spreading for Bacillus subtilis biofilms [5]. In the case of arrested spreading, the lateral expansion of the biofilm is confined, albeit the colony is biologically active. However, a small reduction in the surface tension of the biofilm is sufficient to induce spreading. (ii) As second phenomenon we discuss the relation of fingering instabilities of an advancing biofilm edge and the production of biosurfactant within the biofilm. As a result we distinguish four dynamical (morphological) modes of biofilm growth [6]. We conclude with an outlook.

[1] Fauvart, M. et al., Surface tension gradient control of bacterial swarming in colonies of Pseudomonas aeruginosa, Soft Matter, 2012, 8, 70-76.
[2] Seminara, A. et al., Osmotic spreading of Bacillus subtilis biofilms driven by an extracellular matrix, Proc. Natl. Acad. Sci. U. S. A., 2012, 109, 1116-1121.
[3] Tuson, H., Weibel, D. Bacteria-surface interactions, Soft Matter, 2013, 9, 4368-4380.
[4] Trinschek, S.; John, K.; Thiele, U., From a thin film model for passive suspensions towards the description of osmotic biofilm spreading, AIMS Materials Science, 2016, 3, 1138-1159.
[5] Trinschek, S.; John, K.; Lecuyer, S.; Thiele, U., Continuous vs. arrested spreading of biofilms at solid-gas interfaces - the role of surface forces, Phys. Rev. Lett., 2017, 119, 078003.
[6] Trinschek, S.; John, K.; Thiele, U.; Modelling of surfactant-driven front instabilities in spreading bacterial colonies Soft Matter, 2018, 14, 4464-4476.

Refreshments will be served at 1:45 pm