DEPARTMENT OF CHEMICAL ENGINEERING
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Artificial Microniches for High Throughput Study of Microbial Communities

Wednesday November 9
105 Shillman
11:45am-1:00pm

Sponsored by the Department of Chemical Engineering

Microbes self-organize in microcolonies while transitioning to a sessile form within a protective biofilm matrix. This stage of development has received scant attention, in spite of the importance of community dynamics in determining microbe fate. To enable the detailed study of microbial dynamics within microcolonies, new sessile culture systems are needed that sequester cells and mimic their complex growth conditions. We have developed a nanoliter-scale sessile culture system that is easily implemented via microfluidics-enabled fabrication. Hundreds of thousands of these nanocultures can be easily generated and imaged using conventional or confocal microscopy. Each nanoculture begins as a several nanoliter droplet of suspended cells, encapsulated by a polydimethylsiloxane (PDMS) membrane. The PDMS nanocultures provide long-lasting mechanical support, enabling long-term study. The PDMS membrane is selectively permeable to small molecules including antibiotics, signaling molecules and functional fluorescent probes. As microcolonies mature, they can be stressed or interrogated using selected probes to characterize cell physiological properties, antibiotic susceptibilities, and antagonistic interactions. We demonstrate this platform by investigating broad ranges of microcolony dynamics, including direct and indirect bacterial-fungal interactions. This versatile new tool has broad potential for addressing biological questions associated with drug resistance, chronic infections, microbiome dynamics, and antibiotic discovery. It also sets a precedent for the creation of upstream bioprocessing technologies through functional membranes capable of encapsulating probiotics or unculturable microbes, which could facilitate high-throughput screening and characterization of bioactive molecules.

Dr. Tagbo H. R. Niepa is a Postdoctoral Fellow for Academic Diversity at the Penn department of Chemical and Biomolecular Engineering (University of Pennsylvania), working with Professors Kathleen Stebe and Daeyeon Lee. He received an Associate Degree in Food science, and worked at the Pasteur Institute (Ivory Coast) as a research associate, before moving to University of Dortmund (Germany) in 2004 to study Bioengineering. He transferred to Syracuse University, NY, where he received a Bachelor of Science in Biomedical Engineering (2009) and a Ph.D. in Chemical Engineering (2014). His doctoral study on the Electrochemical Control of Bacterial Persister Cells (ECCP) revealed new means to control the electrophysiology of highly drug-tolerant bacterial cells and sensitize pathogenic persister and biofilm cells to antibiotics, which was awarded US patents and the Syracuse University All Doctoral Prize. Dr. Niepa currently focuses on interfacial phenomena associated with bacterial films, and is developing artificial microniches to model microbial communities relevant to antibiotic discovery, encapsulation of probiotics, and to study microbiome dynamics. Dr. Niepa is a co-founded Helios Innovative Technologies Inc. (PurpleSun Inc.), a medical device company that develops automated sterilization systems to fight bacterial cross-contamination.