MICROSCALE STUDY OF BIOFILM DYNAMICS AT THE OIL-WATER INTERFACE

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Abstract

The recent Deepwater Horizon incident in the Gulf of Mexico exposed significant challenges towards controlling and cleaning oil spills that originate from deep-sea releases of crude oil. Among those challenges remains the elucidation and quantification of the physical mechanisms involved in the natural biodegradation of crude oil droplets by marine microbes. Certain bacterial species produce biosurfactants (e.g., rhamnolipids) which enable them to attach on the hydrophobic oil-water interface, to access and assimilate hydrocarbons, and to proliferate so as to form cell monolayers or even three-dimensional biofilms. Understanding of the fundamental mechanisms that control the physical and biochemical interactions between bacterial communities and oil droplets will permit the reliable prediction of crude oil dispersion and contamination risk assessment, and will also enable the successful development of effective bioremediation techniques for confining oil spills in marine ecosystems.

The focus of this work is on the investigation and quantification of physical interactions between marine bacteria and crude oil droplets at the single-droplet scale of observation (from several micrometers to a few millimeters). The primary scope is the development of controllable microfluidic platforms that permit real-time, long-term, minimally invasive observation of microbe-scale phenomena (locomotion, proliferation, clustering) and biofilm-scale pattern formation in controllable and reproducible in vitro environments, under flow conditions. A first device that has been developed for this purpose is presented in Figure 1. Furthermore, an indicative snapshot of the association of marine bacteria with weathered crude oil droplets is presented in Figure 2. Ongoing research is also focused on modeling the formation of biofilms over the oily substrates.

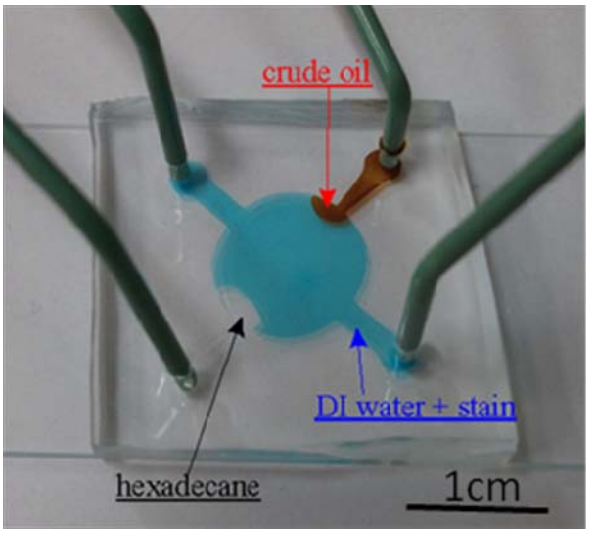

Figure 1: A simple millifluidic device for the study of physical interactions between bacterial cells and multiple oil-water interfaces. The device consists of a PDMS chamber (polydimethylsiloxane) etched on a glass slide.

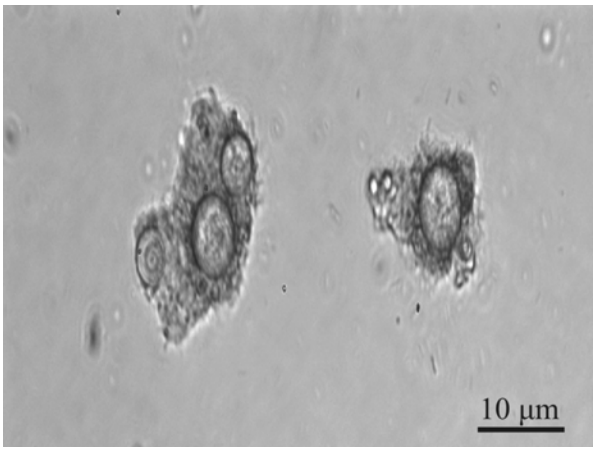

Figure 2: Aggregates of *Marinobacter hydrocarbonoclasticus* cells over crude-oil droplets.

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