Development of a Flow-Free Microfluidic Gradient Generator

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Microfluidic technology has flourished since its emergence over thirty years ago, allowing for rapid scientific advances in a wide variety of fields. Microfluidics allows for precise spatial and temporal control of the chemical and physical microenvironment and has numerous applications ranging from DNA analysis to inkjet printing. In microfluidics, all fluid flow is laminar, forcing mixing to occur via length-scale diffusion. In the case of a microfluidic gradient generator, this allows for a chemical gradient to develop perpendicular to the direction of fluid flow. Applications of microfluidic gradient generators include quantifying cell migration in response to gradients chemical cues (chemotaxis) and culturing of cells for extended periods of time. However, many of the available devices require direct flow through the fluidic channels and are, thus, incompatible with non-adherent cells like bacteria and algae. To address this issue, we developed a double-layer microfluidic device consisting of a top PDMS-layer, imprinted with the fluidic channels, on top of a bottom layer of agarose, allowing for rapid diffusion of chemical cues. One disadvantage of this PDMS/agarose system is that the two layers do not readily adhere, requiring an external chamber to create a tight seal. In an effort to overcome this limitation, we fabricated devices with a PDMS-alternative polymer made using thiol-ene chemistry. Both devices were characterized using fluorescent tracers and numerical simulations to evaluate the mass transfer dynamics. As a proof-of-principle, the device was used in preliminary studies to culture the model algae *Chlamydomonas reinhardtii* for several days by continuous nutrient perfusion.

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