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Emulation of Colonic Oxygen Gradients in a Microdevice

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Abstract:

Gut-on-a-chip in vitro modeling is an emerging field, as the human gut epithelium and gut microbiome have been recently identified as novel drug targets for a wide variety of diseases. Realistic in vitro gut models require a variety of precise environmental cues, such as chemical and gas gradients, in combination with substrates like mucus that support the growth of microbial communities. This technical brief describes microfluidic architecture capable of developing a physiologically relevant oxygen gradient that emulates the oxygen profile proximal to the epithelial inner lining of the human colon. The device generates stable and repeatable defined oxygen gradients from 0 % to 4 % partial pressure O_2 over a length scale of hundreds of microns, and was applied to study the effects of oxygenation on the structure of native mucus that lines the colon wall. Using simulation as a design tool for hybrid gas-liquid microfluidic devices enables on-chip creation of defined, physiologically oxygen gradients. These microfluidic architectures have powerful potential applications for gut physiology, including providing optimal oxygenation conditions for the culture of mammalian epithelial cells in the gut lining, as well as creating a realistic mimic of the oxygen gradient found in the intestinal lumen for complex microbiome cultures.

Keywords: microfluidics, PDMS, COMSOL modeling, oxygen gradient, mucus, human gut